COLUMBIA WORKSHOP MANUAL

Models: CL112
CL120

STI-410, S21 (6/10P)

Published by
Daimler Trucks North America LLC
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Foreword

The purpose of this manual is to assist the service technician when the vehicle is serviced. Major drivetrain component service information is not included in this manual, but is located in each manufacturer's service manual.

Instructions and procedures are those recommended by Freightliner Trucks or the component manufacturer.

Maintenance schedules and additional service information are included in the *Columbia™ Maintenance Manual*.

IMPORTANT: Descriptions and specifications in this manual were in effect at the time of printing. Freightliner Trucks reserves the right to discontinue models, and to change specifications or design at any time without notice and without incurring obligation. Descriptions and specifications contained in this publication provide no warranty, expressed or implied, and are subject to revision and editions without notice.

Refer to **www.Daimler-TrucksNorthAmerica.com** and **www.FreightlinerTrucks.com** for more information, or contact Daimler Trucks North America LLC at the address below.

Environmental Concerns and Recommendations

Whenever you see instructions in this manual to discard materials, you should attempt to reclaim and recycle them. To preserve our environment, follow appropriate environmental rules and regulations when disposing of materials.

NOTICE: Parts Replacement Considerations

Do not replace suspension, axle, or steering parts (such as springs, wheels, hubs, and steering gears) with used parts. Used parts may have been subjected to collisions or improper use and have undetected structural damage.

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Descriptions of Service Publications

Daimler Trucks North America LLC distributes the following major service publications in paper and electronic (via ServicePro®) formats.

Workshop/Service Manual — Workshop/service manuals contain service and repair information for all vehicle systems and components, except for major components such as engines, transmissions, and rear axles. Each workshop/service manual section is divided into subjects that can include general information, principles of operation, removal, disassembly, assembly, installation, specifications, and troubleshooting.

Maintenance Manual — Maintenance manuals contain routine maintenance procedures and intervals for vehicle components and systems. They have information such as lubrication procedures and tables, fluid replacement procedures, fluid capacities, specifications, and procedures for adjustments and for checking the tightness of fasteners. Maintenance manuals do not contain detailed repair or service information.

Driver's/Operator's Manual — Driver's/operator's manuals contain information needed to enhance the driver's understanding of how to operate and care for the vehicle and its components. Each manual contains a chapter that covers pretrip and post-trip inspections, and daily, weekly, and monthly maintenance of vehicle components. Driver's/operator's manuals do not contain detailed repair or service information.

Service Bulletins — Service bulletins provide the latest service tips, field repairs, product improvements, and related information. Some service bulletins are updates to information in the workshop/service manual. These bulletins take precedence over workshop/service manual information, until the latter is updated; at that time, the bulletin is usually canceled. The service bulletins manual is available only to dealers. When doing service work on a vehicle system or part, check for a valid service bulletin for the latest information on the subject.

IMPORTANT: Before using a particular service bulletin, check the current service bulletin validity list to be sure the bulletin is valid.

Parts Technical Bulletins — Parts technical bulletins provide information on parts. These bulletins contain lists of parts and BOMs needed to do replacement and upgrade procedures.

Web-based repair, service, and parts documentation can be accessed using the following applications on the AccessFreightliner.com website.

ServicePro — ServicePro® provides Web-based access to the most up-to-date versions of the publications listed above. In addition, the Service Solutions feature provides diagnostic assistance with Symptoms Search, by connecting to a large knowledge base gathered from technicians and service personnel. Search results for both documents and service solutions can be narrowed by initially entering vehicle identification data.

PartsPro — PartsPro® is an electronic parts catalog system, showing the specified vehicle's build record.

EZWiring — EZWiring™ makes Freightliner, Sterling, Western Star, Thomas Built Buses, and Freightliner Custom Chassis Corporation products' wiring drawings and floating pin lists available online for viewing and printing. EZWiring can also be accessed from within PartsPro.

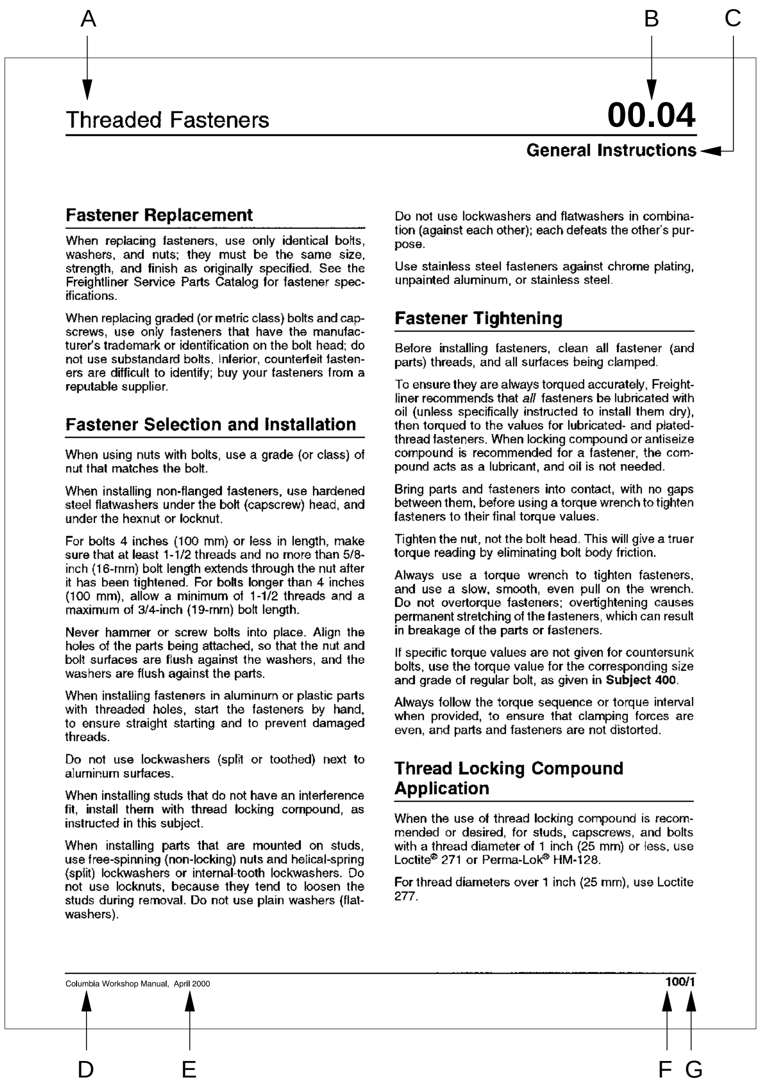
Descriptions of Service Publications

Warranty-related service information available on the AccessFreightliner.com website includes the following documentation.

Recall Campaigns	Recall campaigns cover situations that involve service work or replacement of parts in connection with a recall notice. These campaigns pertain to matters of vehicle safety. All recall campaigns are distributed to dealers; customers receive notices that apply to their vehicles.
Field Service Campaigns	Field service campaigns are concerned with non-safety-related service work or replacement of parts. All field service campaigns are distributed to dealers; customers receive notices that apply to their vehicles.

Page Description

For an example of a *Columbia Workshop Manual* page, see **Fig. 1**.



Threaded Fasteners **00.04**

General Instructions

Fastener Replacement

When replacing fasteners, use only identical bolts, washers, and nuts; they must be the same size, strength, and finish as originally specified. See the Freightliner Service Parts Catalog for fastener specifications.

When replacing graded (or metric class) bolts and capscrews, use only fasteners that have the manufacturer's trademark or identification on the bolt head; do not use substandard bolts. Inferior, counterfeit fasteners are difficult to identify; buy your fasteners from a reputable supplier.

Fastener Selection and Installation

When using nuts with bolts, use a grade (or class) of nut that matches the bolt.

When installing non-flanged fasteners, use hardened steel flatwashers under the bolt (capscrew) head, and under the hexnut or locknut.

For bolts 4 inches (100 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extends through the nut after it has been tightened. For bolts longer than 4 inches (100 mm), allow a minimum of 1-1/2 threads and a maximum of 3/4-inch (19-mm) bolt length.

Never hammer or screw bolts into place. Align the holes of the parts being attached, so that the nut and bolt surfaces are flush against the washers, and the washers are flush against the parts.

When installing fasteners in aluminum or plastic parts with threaded holes, start the fasteners by hand, to ensure straight starting and to prevent damaged threads.

Do not use lockwashers (split or toothed) next to aluminum surfaces.

When installing studs that do not have an interference fit, install them with thread locking compound, as instructed in this subject.

When installing parts that are mounted on studs, use free-spinning (non-locking) nuts and helical-spring (split) lockwashers or internal-tooth lockwashers. Do not use locknuts, because they tend to loosen the studs during removal. Do not use plain washers (flatwashers).

Do not use lockwashers and flatwashers in combination (against each other); each defeats the other's purpose.

Use stainless steel fasteners against chrome plating, unpainted aluminum, or stainless steel.

Fastener Tightening

Before installing fasteners, clean all fastener (and parts) threads, and all surfaces being clamped.

To ensure they are always torqued accurately, Freightliner recommends that *all* fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or antiseize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Bring parts and fasteners into contact, with no gaps between them, before using a torque wrench to tighten fasteners to their final torque values.

Tighten the nut, not the bolt head. This will give a truer torque reading by eliminating bolt body friction.

Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench. Do not overtorque fasteners; overtightening causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

If specific torque values are not given for countersunk bolts, use the torque value for the corresponding size and grade of regular bolt, as given in **Subject 400**.

Always follow the torque sequence or torque interval when provided, to ensure that clamping forces are even, and parts and fasteners are not distorted.

Thread Locking Compound Application

When the use of thread locking compound is recommended or desired, for studs, capscrews, and bolts with a thread diameter of 1 inch (25 mm) or less, use Loctite® 271 or Perma-Lok® HM-128.

For thread diameters over 1 inch (25 mm), use Loctite 277.

Columbia Workshop Manual, April 2000 **100/1**

11/02/1999 f020045a

A. Section Title
B. Section Number (made up of the Group Number—first two digits, followed by a sequence number—last two digits)
C. Subject Title
D. Manual Title
E. Release (Supplement) Date
F. Subject Number
G. Subject Page Number

Fig. 1, Example of a Columbia Workshop Manual Page

Workshop Manual Contents

Group No.	Group Title
00	General Information
01	Engine
09	Air Intake
13	Air Compressor
15	Alternators and Starters
20	Engine Cooling/Radiator
25	Clutch
26	Transmission
30	Throttle Control
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32	Suspension
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98	Paint

List of Abbreviations

The following is a list of definitions for abbreviations and symbols used in Freightliner publications.

A .... amperes
AAVA ...... auxiliary air valve assembly
ABS .... antilock braking system
ABS .... acrylonitrile-butadiene-styrene
A/C .... air conditioner
AC .... alternating current
acc .... accessories
ACM .... aftertreatment control module
ACPU ..... air conditioning protection unit
ADLO ..... auto-disengagement lockout
AGM .... absorbed glass mat
AGS .... automated gear shift
AG2 .... Aluminum Generation 2
a.m. .... *ante meridiem* (midnight to noon)
AM .... amplitude modulation
amp(s) .... ampere(s)
AMT .... automated mechanical transmission
AMU .... air management unit
ANSI ...... American National Standards Institute
API .... American Petroleum Institute
API .... application programming interface
ARI .... Air Conditioning and Refrigeration Institute
ASA .... American Standards Association
ASF .... American Steel Foundries
ASR .... automatic spin regulator
assy. ...... assembly
ASTM ..... American Society for Testing and Materials
ATC .... automatic temperature control
ATC .... automatic traction control
ATC .... automatic transmission control
ATD .... aftertreatment device
ATF .... automatic transmission fluid
ATS .... aftertreatment system
attn .... attention
aux. .... auxiliary
av .... *avoirdupois* (British weight system)
AWD .... all-wheel drive
AWG ...... American wire gauge
AWS .... American Welding Society
BAT .... battery
BBC .... bumper-to-back-of-cab
BHM .... bulkhead module
BOC .... back-of-cab
BOM .... bill of material
BTDC ...... before top dead center
Btu(s) ..... British thermal unit(s)
C .... common (terminal)
CAC .... charge air cooler
CAN .... controller area network
CARB ..... California Air Resources Board
CAT .... Caterpillar
CB .... circuit breaker
CB .... citizens' band
CBE .... cab behind engine
CCA .... cold cranking amperes
CCR .... California Code of Regulations
CD-ROM .. compact-disc/read-only memory
CDTC ...... constant discharge temperature control
CEL .... check-engine light
CFC .... chlorofluorocarbons (refrigerant-12)
cfm .... cubic feet per minute
CFR .... Code of Federal Regulations
CGI .... clean gas induction
CGW ...... central gateway
CHM .... chassis module
CIP .... cold inflation pressure
CLDS ...... cab load disconnect switch
CLS .... coolant level sensor
cm .... centimeters
cm^3 .... cubic centimeters
CMVSS .... Canadian Motor Vehicle Safety Standard
Co. .... company
COE .... cab over engine
Corp. ...... corporation
CPC .... common powertrain controller
CPU .... central processing unit
CRT .... cathode ray tube
cSt .... centistokes (unit of measurement for describing the viscosity of general liquids)
cu ft .... cubic feet
cu in ...... cubic inches
CUM .... Cummins
CVSA ...... Commercial Vehicle Safety Alliance
CWS .... collision warning system
DC .... direct current
DCA .... diesel coolant additive
DCDL ...... driver-controlled differential lock
DDA .... Detroit Diesel Allison (obs)
DDC .... Detroit Diesel Corporation
DDDL ...... Detroit Diesel Diagnostic Link
DDE .... Detroit Diesel Engines
DDEC ..... Detroit Diesel Electronic (engine) Control
DDR .... diagnostic data reader
DDU .... driver display unit
def .... defrost
DEF .... diesel exhaust fluid
DFI .... direct fuel injection
DGPS ..... differential global positioning system
DHD .... dealer help desk
dia. .... diameter
DIAG ...... diagnosis
DIP .... dual inline package (switch)
DIU .... driver interface unit
DLA .... datalink adaptor
DLM .... datalink monitor
DLU .... data logging unit
DMM ...... digital multimeter
DOC .... diesel oxidation catalyst
DOT .... Department of Transportation
DPF .... diesel particulate filter
DRL .... daytime running lights
DRM .... dryer reservoir module
DSM .... district service manager
DTC .... diagnostic trouble code
DTC .... discharge temperature control
DTNA ...... Daimler Trucks North America
DVOM ..... digital volt/ohm meter
ea. .... each
EBS .... electronic braking system
ECA .... electric clutch actuator
ECAP ...... electronic control analyzer programmer
ECAS ...... electronically controlled air suspension

List of Abbreviations

ECI .... electronically controlled injection
ECL .... engine coolant level
ECM .... electronic control module
ECT .... engine coolant temperature
ECU .... electronic control unit
EDM .... electronic data monitor
EEPROM .. electrically erasable programmable read-only memory
EFG .... electric fuel gauge
EFPA ...... electronic foot pedal assembly
EGR .... exhaust gas recirculation
ELC .... extended-life coolant
EMC .... electromagnetic compatibility
EMI .... electromagnetic interference
EOA .... electric over air
EP .... extreme pressure (describes an antiwear agent added to some lubricants)
EPA .... Environmental Protection Agency
EPS .... engine position sensor
ESC .... electronic stability control
ESC .... enhanced stability control
ESD .... electrostatic discharge
ESS .... engine syncro shift (transmission)
etc. .... *et cetera* (and so forth)
ETEC ...... electronic truck engine control
EUI .... electronic unit (fuel) injectors
EVA .... electronic vibration analyzer
EXM .... (chassis) expansion module
E85 .... 85% ethanol fuel
FAS .... Freightliner air suspension
FCCC ...... Freightliner Custom Chassis Corporation
FCU .... forward control unit
FET .... field effect transistor
Fig. .... figure
fl oz .... fluid ounces
FLA .... post-1984 advancements Freightliner COE
FLB .... enhanced Freightliner FLA COE
FLC .... steel-cab Freightliner 112 Conventional
FLD .... post-1984 advancements Freightliner 112/120 aluminum-cab Conventional
FLR .... forward-looking radar
FM .... frequency modulation
FMCSA .... Federal Motor Carrier Safety Administration
FMEA ..... failure mode effects analysis
FMI .... failure mode indicator
FMSI ...... Friction Materials Standards Institute
FMVSS .... Federal Motor Vehicle Safety Standard
FRP .... fiberglass reinforced plastic
FSA .... field service authorization
FSM .... fleet service manager
ft .... feet
ft^3 .... cubic feet
ft^3/min ..... cubic feet per minute
FTL .... Freightliner
F.U.E.L. .... fuel usage efficiency level
g .... grams
gal .... gallons
GAWR ..... gross axle weight rating
GHG .... greenhouse gas
GHG14 .... greenhouse gas and fuel efficiency regulations
GL .... gear lubricant
GND .... ground
gpm .... gallons per minute
GPS .... global positioning system
GVWR ..... gross vehicle weight rating
HBED ..... hard-braking event data
HCM .... hybrid control module
HCOE ..... high cab over engine
HCU .... hydraulic control unit
HD .... heavy-duty
HDU .... hybrid drive unit
HEPA ...... high-efficiency particulate air (filter)
HEST ...... high exhaust system temperature
HEV .... hybrid electric vehicle
HFC .... hydrogenated fluorocarbons (refrigerant-134a)
hp .... horsepower
hp .... high pressure
HRC .... Rockwell "C" hardness
hr(s) .... hour(s)
HSA .... hill start aid
HSD .... high-side driver
htr. .... heater
HVAC ...... heating, ventilating, and air conditioning
HVLP ...... high velocity, low pressure
H/W .... hardware
Hz .... hertz
IAD .... interaxle differential
ICS .... integrated child seat
ICU .... instrumentation control unit
i.d. .... inside diameter
ID .... identification
IFI .... Industrial Fasteners Institute
IFS .... independent front suspension
IGN .... ignition
ILB .... intelligent lightbar
ILO .... *in lieu of* (in the place of)
in .... inches
in^3 .... cubic inches
Inc. .... incorporated
inH_2O ..... inches of water
inHg .... inches of mercury
I/O .... input/output
IP .... instrument panel
ISO .... International Organization for Standardization
IVS .... idle validation switch
k .... kilo (1000)
kg .... kilograms
km .... kilometers
km/h .... kilometers per hour
kPa .... kilopascals
kW .... kilowatts
L .... liters
lb .... pounds
LBCU ...... lightbar control unit
lbf·ft .... pounds force feet
lbf·in ...... pounds force inches
LCD .... liquid crystal display
LCOE ...... low cab over engine
LED .... light-emitting diode
LFL .... lower flammability limit
LH .... left-hand
LHD .... left-hand drive
LH DR ..... left-hand-drive
LHK .... liters per hundred kilometers
LHS .... low-hydrogen steel
LIN .... Local Interconnect Network
LLC .... limited liability company
L/min ...... liters per minute
LNG .... liquefied natural gas
LPG .... liquefied petroleum gas

List of Abbreviations

LPG .... liquid propane gas
LPI .... liquid propane injection
LPR .... low pressure reservoir
LRR .... low-rolling resistance
LSD .... low-side driver
LVD .... low-voltage disconnect
m .... meters
max. .... maximum
M-B .... Mercedes-Benz
MCM ...... motor control module
MESA ..... Mining Enforcement Safety Act
mfr. .... manufacturer
mi .... miles
MID .... message identifier
MIL .... malfunction indicator lamp (light)
MIL .... military specification
min. .... minutes
min. .... minimum
misc. ...... miscellaneous
mL .... milliliters
mm .... millimeters
mod. ...... module
mpg .... miles per gallon
mph .... miles per hour
MSF .... modular switch field
MMT .... methylcyclopentadienyl manganese tricarbonyl
MSHA ..... Mining Safety and Health Administration
MVDA ..... Motor Vehicle Dealers Association
n .... negative (front axle wheel alignment specification)
N .... nitrogen
N/A .... not applicable
N·cm ...... Newton-centimeters
NC .... normally closed (terminal or switch)
NCG .... noncondensable gases
NHTSA .... National Highway Traffic Safety Administration
NIOSH ..... National Institute for Occupational Safety and Health
NITE .... no idle thermal environment
NLA .... no longer available
NLGI ...... National Lubricating Grease Institute
N·m .... Newton-meters
NO .... normally open (terminal or switch)
NOAT ...... Nitrited Organic Acid Technology
NOx .... nitrogen oxides
no. .... number
NPT .... national pipe thread
NPTF ...... national pipe thread fitting
NT .... nylon tube or nylon tubing
NTSB ...... National Transportation Safety Board
OAT .... Organic Acid Technology
OBD(s) .... on-board diagnostic(s)
obs .... obsolete
OC .... open circuit
OCV .... open circuit voltage
o.d. .... outside diameter
O.D. .... overdrive
OEM .... original equipment manufacturer
OPD .... overfill protection device
OSHA ..... Occupational Safety and Health Administration
oz .... ounces
ozf·in ...... ounces force inches
p .... positive (front axle wheel alignment specification)
PACE ...... programmable electronically controlled engine
PAG .... polyalkylene glycol (oil)
parm ...... parameter
PAS .... passenger advisory system
PC .... personal computer
PCB .... printed circuit board
PDC(s) .... parts distribution center(s)
PDI .... pre-delivery inspection
PDM .... power distribution module
PEC .... power electronics carrier
PEEC ...... programmable electronic engine control
PID .... parameter identifier
PKP .... Purple-K powder
PLC .... power line carrier
PLD .... *Pumpe-Linie-Düse* (pump-line-nozzle)
PNDB ..... power-net distribution box
PM .... particulate matter
p.m. .... *post meridiem* (noon to midnight)
p/n .... part number
PO .... purchase order
POE .... polyol ester
PRD .... pressure relief device
PRD .... product requirements document
PSA .... pressure-sensitive adhesive
PSG .... pressure sensor governor
psi .... pounds per square inch
psia .... pounds per square inch, atmosphere
psig .... pounds per square inch, gauge
pt .... pints
PTCM ..... pressure time control module
PTO .... power takeoff
PTP .... powertrain protection
PTPDM .... powertrain power distribution module
pvc .... polyvinyl chloride
PWM ...... pulse width modulation
pwr .... power
qt .... quarts
qty. .... quantity
R & O ..... rust inhibitors and oxidants
R–12 ...... refrigerant-12 (CFC)
R–134a .... refrigerant-134a (HFC)
RAM .... random access memory
RC .... reserve capacity
recirc. ..... recirculation
Ref(s). ..... reference(s)
regen ...... regeneration
RELS ...... reduced engine load at stop
RFI .... radio frequency interference
RH .... right-hand
RHD .... right-hand drive
RH DR ..... right-hand-drive
R/I .... removal and installation
RMA .... return material authorization
ROM .... read-only memory
rpm .... revolutions per minute
R/R .... removal and replacement
RSA .... roll-stability advisor
RSG .... road speed governor
RSM .... regional service manager
RTS .... ready-to-spray
RTV .... room temperature vulcanizing
RV .... recreational vehicle
SA .... source address
S-ABA ..... self-setting automatic brake adjusters

List of Abbreviations

SAE	Society of Automotive Engineers
SB	service bulletin
SBT	seat back thickness
SBW	shift-by-wire
SCA(s)	Supplemental Coolant Additive(s)
SCR	selective catalytic reduction
SCU	system control unit (speedometer)
SD	severe-duty
SDU	step deployment unit
SEL	shutdown engine light
SEM	switch expansion module
SEO	stop engine override
SHM	switch hub module
SI	service information
SI	*Système International*
SID	subsystem identifier
SM	system malfunction
SMC	sheet molded compound
S/N	serial number
SOC	state-of-charge
SPACE	seat pretensioner activation for crash survival enhancement
SPG	special purpose grease
SPN	suspect parameter number
sq in	square inches
SRP	seating reference point
SRS	supplemental restraint system
SRS	synchronous reference sensor
SRT	standard repair time
SSD	side sensor display
SSID	smart switch identification
SST	stainless steel
std.	standard
S/W	software
SW	switch
TAM	thermocouple amplifier module
TBB	Thomas Built Buses
TBS	turbo boost sensor
TCM	transmission control module
TCU	transmission control unit
TDC	top dead center
TDR	technician diagnostic routine
TEM	truck equipment manufacturer
temp	temperature
TIG	tungsten inert gas
TIR	total indicator reading
TMC	Technology and Maintenance Council
TPMS	tire pressure monitoring system
TPS	thermal protection switch
TPS	throttle position sensor
TRS	timing reference sensor
TSO	truck specification order
TSU	transmission shift unit
TXV	thermal expansion valve
U.D.	underdrive
ULSD	ultralow-sulfur diesel
UNC	unified national coarse
UNF	unified national fine
U.S.	United States
U.S.A.	United States of America
USC	United States customary (measures)
V	volts
VCU	vehicle control unit
VDC	vehicle data computer
Vdc	volts, direct current
VIMS	vehicle information management system
VIN	vehicle identification number
VIP	vehicle instrumentation and protection (Kysor)
VIW	vehicle interface wiring (connector)
VOC	volatile organic compounds
VOM	volt-ohmmeter
VRS	variable resistance sensor
VSG	variable speed governor
VSS	vehicle speed sensor
VSU	vehicle security unit
WB	wire braid
WI	work instructions
WIF	water-in-fuel
WOT	wide open throttle
–	minus or negative
+	plus or positive
±	plus-or-minus
>	greater than
<	less than
x	by (used in fastener size descriptions)
"	inches
°	degrees (of an angle)
°C	degrees Celsius (centigrade)
°F	degrees Fahrenheit
#	number
%	percent
&	and
©	copyright
™	trademark
®	registered trademark

General Information

U.S. Customary to Metric			Metric to U.S. Customary	
When You Know	**Multiply By**	**To Get / When You Know**	**Multiply By**	**To Get**
Length				
inches (in)	25.4	millimeters (mm)	0.03937	inches (in)
inches (in)	2.54	centimeters (cm)	0.3937	inches (in)
feet (ft)	0.3048	meters (m)	3.281	feet (ft)
yards (yd)	0.9144	meters (m)	1.094	yards (yd)
miles (mi)	1.609	kilometers (km)	0.6215	miles (mi)
Area				
square inches (in^2)	645.16	square millimeters (mm^2)	0.00155	square inches (in^2)
square inches (in^2)	6.452	square centimeters (cm^2)	0.15	square inches (in^2)
square feet (ft^2)	0.0929	square meters (m^2)	10.764	square feet (ft^2)
Volume				
cubic inches (in^3)	16387.0	cubic millimeters (mm^3)	0.000061	cubic inches (in^3)
cubic inches (in^3)	16.387	cubic centimeters (cm^3)	0.06102	cubic inches (in^3)
cubic inches (in^3)	0.01639	liters (L)	61.024	cubic inches (in^3)
fluid ounces (fl oz)	29.54	milliliters (mL)	0.03381	fluid ounces (fl oz)
pints (pt)	0.47318	liters (L)	2.1134	pints (pt)
quarts (qt)	0.94635	liters (L)	1.0567	quarts (qt)
gallons (gal)	3.7854	liters (L)	0.2642	gallons (gal)
cubic feet (ft^3)	28.317	liters (L)	0.03531	cubic feet (ft^3)
cubic feet (ft^3)	0.02832	cubic meters (m^3)	35.315	cubic feet (ft^3)
Weight/Force				
ounces (av) (oz)	28.35	grams (g)	0.03527	ounces (av) (oz)
pounds (av) (lb)	0.454	kilograms (kg)	2.205	pounds (av) (lb)
U.S. tons (t)	907.18	kilograms (kg)	0.001102	U.S. tons (t)
U.S. tons (t)	0.90718	metric tons (t)	1.1023	U.S. tons (t)
Torque/Work Force				
inch-pounds (lbf·in)	11.298	Newton-centimeters (N·cm)	0.08851	inch-pounds (lbf·in)
foot-pounds (lbf·ft)	1.3558	Newton-meters (N·m)	0.7376	foot-pounds (lbf·ft)
Pressure/Vacuum				
inches of mercury (inHg)	3.37685	kilo Pascals (kPa)	0.29613	inches of mercury (inHg)
pounds per square inch (psi)	6.895	kilo Pascals (kPa)	0.14503	pounds per square inch (psi)

When You Know	Subtract	Then Divide By	To Get / When You Know	Multiply By	Then Add	To Get
degrees Fahrenheit (°F)	32	1.8	degrees Celsius (°C)	1.8	32	degrees Fahrenheit (°F)

Vehicle Receipt

Prior to signing for vehicle delivery from a transporter company, the dealer is responsible for checking for transporter-related shortages or damages, and noting these discrepancies on the transporter's delivery receipt.

The dealer is also responsible for ensuring that the vehicle was built according to the Truck Sales Order/ Invoice.

Refer to Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for details.

Vehicle Storage

There may be times when a vehicle is stored for long periods before customer delivery. To protect all vehicles from deterioration and weather, they must be properly maintained. Adequate protection and storage of new vehicles is the responsibility of the dealer.

Claims arising from loss and damage to improperly stored vehicles will not be reimbursed.

See Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for instructions on storage of new vehicles.

Pre-Delivery Information

All pre-delivery inspections and services must be performed at an authorized Daimler Trucks North America LLC facility, assigned to fully qualified service personnel and recorded on the "New Vehicle Pre-Delivery Inspection" form.

Refer to Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for details.

It is recommended the pre-delivery inspection be performed within 30 days of vehicle receipt.

Cooling System

1. Cooling system hoses must clear all moving parts by a minimum of 1/4 inch (6 mm).
2. The 1-inch (25-mm) hose from the surge tank to the engine must be free of sumps and have allowance for engine torque.
3. All hoses from the engine hard pipes must be wrapped in convoluted tubing.
4. Hoses that are protected with convoluted tubing may be secured with tie straps to clear the inner fenders.
5. Cooling system hoses should not be twisted or kinked.
6. Cooling system hoses must be routed at least 6 inches (152 mm) from a heat source if the heat source does not have a heat shield. If a heat shield is provided, the hose must be routed at least 3 inches (76 mm) from the heat source.

HVAC System

1. Cushion clamps are required to support all A/C lines. Butterfly or figure-8 clamps (two cushion clamps) may be used to prevent rubbing or chafing.
2. Heater hoses that are protected with convoluted tubing may be fastened with tie straps. If not protected with convoluted tubing, only cushion clamps or butterfly clamps may be used for heater hoses.
3. A/C lines cannot be secured to air lines, fuel lines, or electrical wires.
4. HVAC hoses should be protected from damage by routing them away from hazards of heat, wheel splash (water, gravel, ice), human traffic, and moving parts of the vehicle.
5. HVAC hoses should be routed away from sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing.

NOTE: If hoses are covered with convoluted tubing, they may touch any of the above.

6. Hoses that are protected with convoluted tubing may come in contact with the bends on frame rails and filters.
7. HVAC hoses must be routed at least 6 inches (152 mm) from a heat source if the heat source does not have a heat shield. If a heat shield is provided, the hose must be routed at least 3 inches (76 mm) from the heat source.
8. All HVAC hoses must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove the hoses.
9. All A/C hoses in the engine compartment must have convoluted tubing.
10. If cushion clamps are used over convoluted tubing at existing clamp points, no additional tie straps or tape is needed.
11. When convoluted tubing is installed on the heater hose where it routes past the splash shield on the front right-hand side of the firewall, and if it uses existing clamps, no additional tie straps or tape is needed.

Auxiliary Heater

All auxiliary heater lines are deck-mounted hard piping with rubber hose at both ends. No additional tie straps are required.

Engine Plumbing

1. On vehicles equipped with the Cummins ISM engine and power steering, no additional tie straps or tape are needed if convoluted tubing is installed on the power steering hose where it routes under the frame rail.
2. The engine oil pressure line should not rub or chafe against the Teflon® discharge line.

Electrical Wiring

1. Wires that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305

mm) apart, a tie strap must be used between the anchor clamps.

2. Bundles of wires that are located in an exposed area, such as under the cab or outside the frame rail, need to be fastened with heavy-duty cable ties.
3. Any wiring that will be exposed to water or heat must be covered with either loom or convoluted tubing. Loom or convoluted tubing need not butt up against Weather Pack® connectors.
4. Any wiring routed across the vehicle, on the engine crossmember, or across the rear of the engine, must be secured with a clamp or tie strap, and covered with either convoluted tubing or a loom.
5. Any wiring that may come into contact with sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing, must be protected by either a loom or convoluted tubing.
6. Unprotected breakouts (individual wires) of up to 8 inches (203 mm) are acceptable as long as these wires are routed safely away from sharp points and edges, moveable parts, and sources of abrasion, cutting, pinching, or crushing.
7. Gray, flame-retardant convoluted tubing may be used to protect wiring in the cab or the chassis. Black nylon convoluted tubing may only be used in the chassis.
8. All wiring must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove any wiring.
9. In exposed locations, such as the road light harness near the headlights, loose loops of wire must be secured with tie straps.
10. All wiring should be routed a minimum of 4 inches (102 mm) from the exhaust. In situations where the wiring is less than 4 inches (102 mm) from the exhaust, a heat shield must be placed between the wiring and the exhaust.

Battery Cables

1. Battery cables must be routed along an unobstructed path from the starter to the battery box. The cables must **not** rub or chafe on brackets, tanks, air lines, or fuel lines.
2. Battery cables and electrical wiring cannot be tied or secured to fuel lines, discharge lines, or air lines.
3. Battery cables must have support brackets no more than 30 inches (762 mm) apart. Tie straps must be within 6 inches (152 mm) of both sides of the support brackets, and every 12 inches (305 mm) between the brackets.
4. Battery cables must have convoluted tubing from the frame bracket to the batteries, and from the frame bracket to the starter.

Fuel Lines

1. Fuel lines must not be clamped to A/C lines, battery cables, jumper cables, or any other electrical wiring.
2. Stand-off brackets or clamps may be used to prevent fuel lines from rubbing against the frame.
3. Fuel lines must be routed at least 6 inches (152 mm) from a heat source. If a heat shield is provided, the fuel line must be at least 3 inches (76 mm) from the heat source.
4. Fuel lines that are parallel may be fastened together. Fuel lines that cross or that rub on metal, plastic, or electrical parts, need to be separated with butterfly clamps.

Chassis Air Lines and Brake Hoses

1. Hoses may come in contact with each other if they are parallel, or if they are bundled together.
2. If the hoses lie on the curve or flat surface of a bracket or crossmember, they do not need convoluted tubing.
3. Brake hoses may be clamped at the top of the axle housing, and touch or lie against the axle housing in its path to the brake chamber as this assembly moves together.

4. Brake hoses must have slack between the last clamping point on the frame rail and the brake chamber to allow for full range of suspension travel.
5. Brake hoses should have butterfly clamps at breakout points.
6. Air lines and brake hoses that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305 mm) apart, a tie strap must be used between the anchor clamps. Tie straps may be closer than 12 inches (305 mm) apart.
7. Hoses or lines that may come into contact with the sharp edge of a bracket or frame rail are to be protected by convoluted tubing.
8. Air lines and brake hoses that are parallel may be fastened together. Air lines and brake hoses that cross or that rub on metal, plastic, or electrical parts need to be separated with butterfly clamps.
9. Nylon or STX (wire braid) chassis air lines may be fastened together to prevent rubbing, as long as the lines are stationary.

Threaded Fastener Types

The majority of threaded fasteners used throughout the vehicle have U.S. customary threads (diameter and pitch are measured in inches). See **Fig. 1**. However, the engine and some items attached to the cab use metric fasteners (diameter and pitch are measured in millimeters).

Most threaded fasteners used on the vehicle that are 1/2-inch diameter or larger are plain hex-type fasteners (non-flanged); *all* metric fasteners are non-flanged. Special hardened flatwashers are used under the bolt head, and between the part being attached and the hexnut, to distribute the load, and to prevent localized overstressing of the parts. The washers are cadmium- or zinc-plated, and have a hardness rating of 38 to 45 HRC.

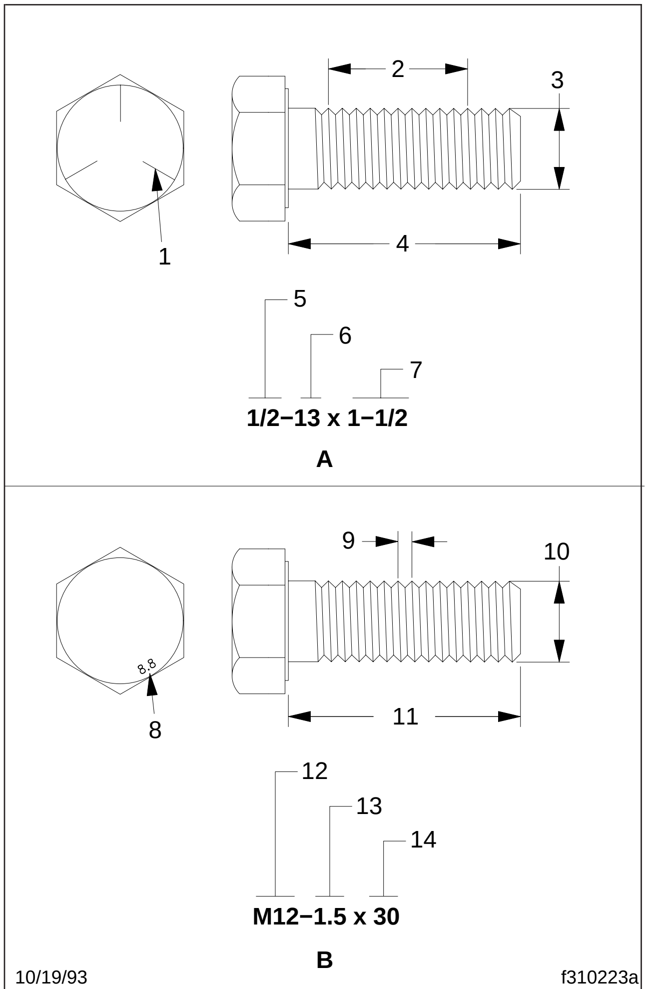
Some fasteners smaller than 1/2-inch diameter are flanged fasteners, which have integral flanges that fit against the parts being fastened. The flanges eliminate the need for washers.

NOTE: The standard fasteners used to assemble the vehicle frame and to attach components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in **Section 31.00.**

Fastener Grades and Classes

Fasteners with U.S. customary threads are divided into grades established by the Society of Automotive Engineers (S.A.E.) or the International Fastener Institute (I.F.I.). The fastener grades indicate the relative strength of the fastener; the higher the number (or letter), the stronger the fastener. Bolt (capscrew) grades can be identified by the number and pattern of radial lines forged on the bolt head. See **Fig. 2**. Hexnut (and locknut) grades can be identified by the number and pattern of lines and dots on various surfaces of the nut. See **Fig. 3.** Nearly all of the bolts used on the vehicle are grades 5, 8, and 8.2. Matching grades of hexnuts are always used: grade 5 or grade B hexnuts are used with grade 5 bolts; grade 8, grade C, or grade G (flanged) hexnuts are used with grade 8 or 8.2 bolts.

Fasteners with metric threads are divided into classes adopted by the American National Standards Institute (ANSI). The higher the class number, the



A. Bolt with U.S. Customary Threads
B. Bolt with Metric Threads

1. S.A.E. Grade Marking
2. Thread Pitch
3. Nominal Diameter
4. Bolt Length
5. Nominal Diameter in Inches
6. Thread Pitch in Threads per Inch
7. Bolt Length in Inches
8. Metric Class Marking
9. Thread Pitch
10. Nominal Diameter
11. Bolt Length
12. Nominal Diameter in Millimeters
13. Thread Pitch (thread width from crest to crest in millimeters)
14. Bolt Length in Millimeters

Fig. 1, Fastener Size and Thread Identification

stronger the fastener. Bolt classes can be identified by the numbers forged on the head of the bolt. See **Fig. 4**. Hexnut (and locknut) classes can be identified by the marks or numbers on various surfaces of the

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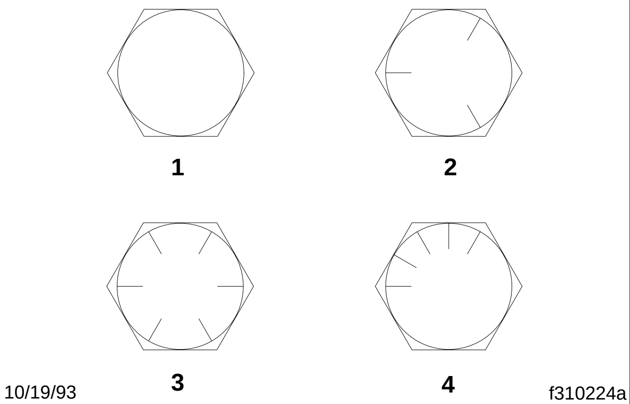


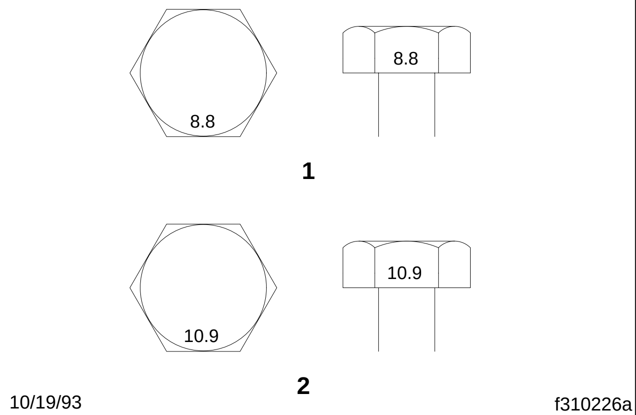
NOTE: Grade 2 bolts have no grade marking; grade 2 bolts are rarely used by Freightliner.

These grade markings are used on plain hex-type and flanged bolts (capscrews). In addition to the grade markings, the bolt head must also carry the manufacturer's trademark or identification.

1. Grade 2
2. Grade 5
3. Grade 8
4. Grade 8.2

Fig. 2, Bolt Grades

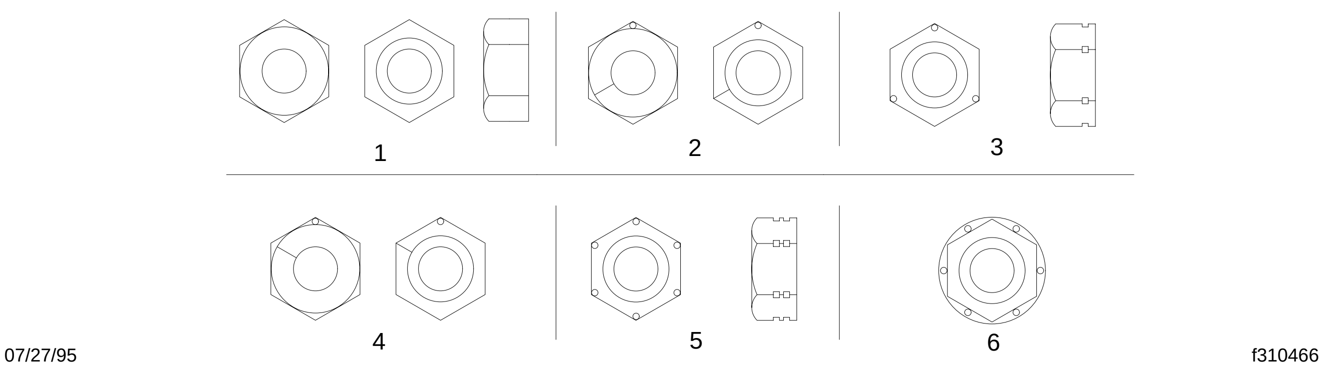
nut. See **Fig. 5**. Class 8 hexnuts are always used with class 8.8 bolts; class 10 hexnuts with class 10.9 bolts.



NOTE: In addition to the class markings, the bolt head must also carry the manufacturer's trademark or identification.

1. Class 8.8
2. Class 10.9

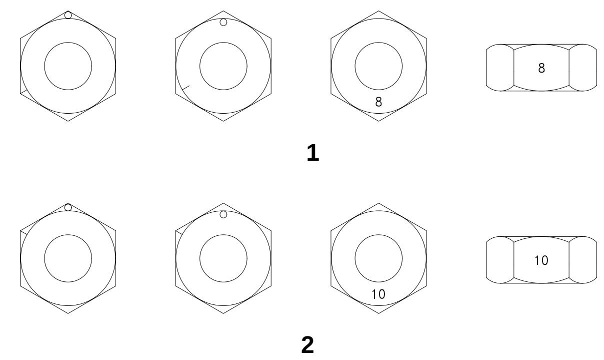
Fig. 4, Bolt Classes



NOTE: Grade 2 (S.A.E.) and grade A (I.F.I.) nuts have no identification marks or notches; they are rarely used by Freightliner. Grade B (I.F.I.) nuts have three identification marks at 120 degrees, or 6 notches. Grade C (I.F.I.) nuts have three identification marks at 60 degrees, or 12 notches. Grade G (I.F.I.) flanged nuts have six identification marks as shown; each identification mark may be a dot, line, pair of dots or lines, or any other symbol at the manufacturer's option.

1. S.A.E. Grade 2 or I.F.I. Grade A Nut (strength compatible with grade 2 bolt.)
2. S.A.E. Grade 5 Nut (strength compatible with grade 5 bolt.)
3. I.F.I. Grade B Nut (strength compatible with grade 5 bolt.)
4. S.A.E. Grade 8 Nut (strength compatible with grade 8 or grade 8.2 bolt.)
5. I.F.I. Grade C Nut (strength compatible with grade 8 or grade 8.2 bolt.)
6. I.F.I. Grade G Nut (flanged locknut; strength compatible with grade 8 or grade 8.2 bolt.)

Fig. 3, Nut Grades



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1. Class 8 Nut
2. Class 10 Nut

Fig. 5, Nut Classes

Frame Fasteners

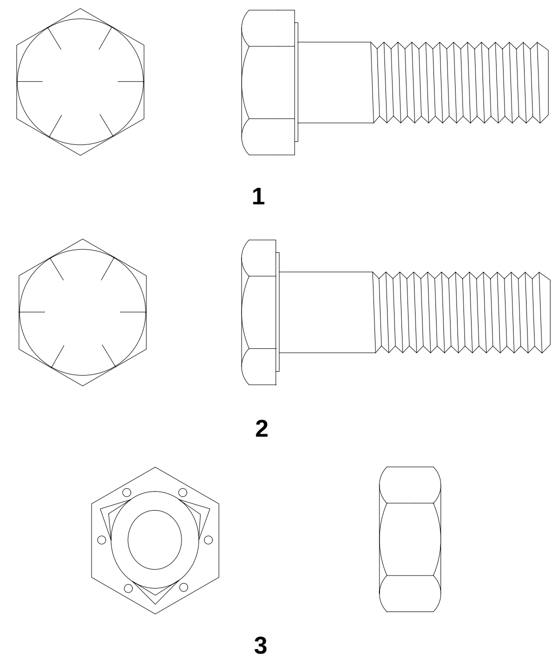
The standard fasteners used to assemble the vehicle frame and to attach most components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in **Section 31.00.**

For some other components attached to the frame, grade 8 and 8.2 phosphate-and oil-coated hexhead bolts and grade C cadmium-plated and wax-coated prevailing torque locknuts are used. The prevailing torque locknuts have distorted sections of threads to provide torque retention. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. See **Fig. 6**.

Tightening Fasteners

When a capscrew is tightened to its torque value in a threaded hole, or a nut is tightened to its torque value on a bolt, the shank of the capscrew or bolt is stretched slightly. This stretching (tensioning) results in a preload that reduces fatigue of the fasteners. The torque values given in the tables in **Specifications, 400** have been calculated to provide enough clamping force on the parts being fastened, and the correct tensioning of the bolt to maintain the clamping force.

Use of a torque wrench to tighten fasteners will help prevent overtensioning them. Overtensioning causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.



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1. Grade 8 Hexhead Bolt
2. Grade 8 Low-Profile Hexhead Bolt
3. Grade C Prevailing Torque Locknut

Fig. 6, Frame Fastener Identification

When torquing a fastener, typically 80 to 90 percent of the turning force is used to overcome friction; only 10 to 20 percent is used to stretch the capscrew or bolt. About 40 to 50 percent of the turning force is needed to overcome the friction between the underside of the capscrew head or nut and the washer. Another 30 to 40 percent is needed to overcome the friction between the threads of the capscrew and the threaded hole, or the friction between the threads of the nut and bolt.

The amount of torque required to tighten a fastener is reduced when the amount of friction is reduced. If a fastener is dry (unlubricated) and plain (unplated), the amount of friction is high. If a fastener is wax-coated or oiled, or has a zinc phosphate coating or cadmium plating, the amount of friction is reduced. Each of these coatings and combinations of coatings has a different effect. Using zinc-plated hardened flatwashers under the bolt (capscrew) head and nut reduces the amount of friction. Dirt or other foreign

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material on the threads or clamping surfaces of the fastener or clamped part also changes the amount of friction.

Even though each different condition affects the amount of friction, a different torque value cannot be given for each different condition. To ensure they are always torqued accurately, Freightliner recommends that all fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or anti-seize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Fastener Replacement

When replacing fasteners, use only identical bolts, washers, and nuts; they must be the same size, strength, and finish as originally specified. See the Freightliner Service Parts Catalog for fastener specifications.

When replacing graded (or metric class) bolts and capscrews, use only fasteners that have the manufacturer's trademark or identification on the bolt head; do not use substandard bolts. Inferior, counterfeit fasteners are difficult to identify; buy your fasteners from a reputable supplier.

Fastener Selection and Installation

When using nuts with bolts, use a grade (or class) of nut that matches the bolt.

When installing non-flanged fasteners, use hardened steel flatwashers under the bolt (capscrew) head, and under the hexnut or locknut.

For bolts 4 inches (100 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extends through the nut after it has been tightened. For bolts longer than 4 inches (100 mm), allow a minimum of 1-1/2 threads and a maximum of 3/4-inch (19-mm) bolt length.

Never hammer or screw bolts into place. Align the holes of the parts being attached, so that the nut and bolt surfaces are flush against the washers, and the washers are flush against the parts.

When installing fasteners in aluminum or plastic parts with threaded holes, start the fasteners by hand, to ensure straight starting and to prevent damaged threads.

Do not use lockwashers (split or toothed) next to aluminum surfaces.

When installing studs that do not have an interference fit, install them with thread locking compound, as instructed in this subject.

When installing parts that are mounted on studs, use free-spinning (non-locking) nuts and helical-spring (split) lockwashers or internal-tooth lockwashers. Do not use locknuts, because they tend to loosen the studs during removal. Do not use plain washers (flatwashers).

Do not use lockwashers and flatwashers in combination (against each other); each defeats the other's purpose.

Use stainless steel fasteners against chrome plating, unpainted aluminum, or stainless steel.

Fastener Tightening

Before installing fasteners, clean all fastener (and parts) threads, and all surfaces being clamped.

To ensure they are always torqued accurately, Freightliner recommends that *all* fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or antiseize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Bring parts and fasteners into contact, with no gaps between them, before using a torque wrench to tighten fasteners to their final torque values.

Tighten the nut, not the bolt head. This will give a truer torque reading by eliminating bolt body friction.

Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench. Do not overtorque fasteners; overtightening causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

If specific torque values are not given for countersunk bolts, use the torque value for the corresponding size and grade of regular bolt, as given in **Specifications, 400**.

Always follow the torque sequence or torque interval when provided, to ensure that clamping forces are even, and parts and fasteners are not distorted.

Thread Locking Compound Application

When the use of thread locking compound is recommended or desired, for studs, capscrews, and bolts with a thread diameter of 1 inch (25 mm) or less, use Loctite® 271 or Perma-Lok® HM-128.

For thread diameters over 1 inch (25 mm), use Loctite 277.

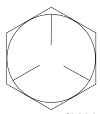
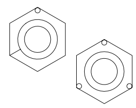
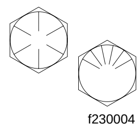
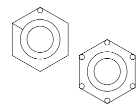
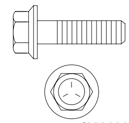
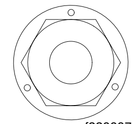
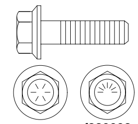
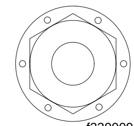
General Instructions

NOTE: Follow the safety precautions given on the locking compound container.

1. Clean the male and female threads of the fasteners, removing all dirt, oil, and other foreign material. If parts are contaminated, use Stoddard solvent for cleaning; then allow the fasteners to air dry for 10 minutes. Be sure solvent is completely gone before applying adhesive.
2. Transfer a small amount of the locking compound from the container to a paper cup or small non-metal dish.
3. Using a plastic brush (a metal brush will contaminate the compound), apply a small amount of compound to the entire circumference of three or four of the male threads that will be covered by the nut after it has been tightened. Be sure enough compound is applied to fill the inside of the nut threads, with a slight excess.
4. Install and torque the nut. Readjustment of the nut position is not possible after installation is complete, without destroying the locking effect.

NOTE: To disassemble the fasteners, heat the bond line to 400°F (200°C) before removing the nut. Every time the fasteners are disassembled, replace them. If any parts are damaged by overheating, replace the parts.

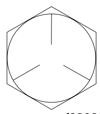
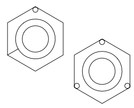
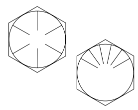
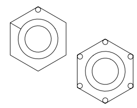
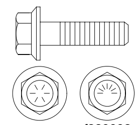
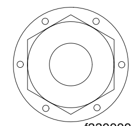
Specifications

Torque Values for U.S. Customary Thread Fasteners With Lubricated* or Plated Threads†								
Thread Diameter–Pitch	Regular Hex				Flanged			
	Grade 5 Bolt	Grade 5 or B Nut	Grade 8 or 8.2 Bolt	Grade 8 or C Nut	Grade 5 Bolt	Grade B Nut	Grade 8 or 8.2 Bolt	Grade G Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)	
	 f230002	 f230003	 f230004	 f230005	 f230006	 f230007	 f230008	 f230009
1/4–20	7 (9)		8 (11)		6 (8)		10 (14)	
1/4–28	8 (11)		9 (12)		7 (9)		12 (16)	
5/16–18	15 (20)		16 (22)		13 (18)		21 (28)	
5/16–24	16 (22)		17 (23)		14 (19)		23 (31)	
3/8–16	26 (35)		28 (38)		23 (31)		37 (50)	
3/8–24	30 (41)		32 (43)		25 (34)		42 (57)	
7/16–14	42 (57)		45 (61)		35 (47)		60 (81)	
7/16–20	47 (64)		50 (68)		40 (54)		66 (89)	
1/2–13	64 (87)		68 (92)		55 (75)		91 (123)	
1/2–20	72 (98)		77 (104)		65 (88)		102 (138)	
9/16–12	92 (125)		98 (133)		80 (108)		130 (176)	
9/16–18	103 (140)		110 (149)		90 (122)		146 (198)	
5/8–11	128 (173)		136 (184)		110 (149)		180 (244)	
5/8–18	145 (197)		154 (209)		130 (176)		204 (277)	
3/4–10	226 (306)		241 (327)		200 (271)		320 (434)	
3/4–16	253 (343)		269 (365)		220 (298)		357 (484)	
7/8–9	365 (495)		388 (526)		320 (434)		515 (698)	
7/8–14	402 (545)		427 (579)		350 (475)		568 (770)	
1–8	—		582 (789)		—		—	
1–12	—		637 (863)		—		—	
1–14	—		652 (884)		—		—	

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.
† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

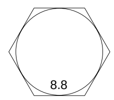
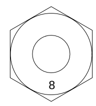
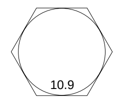
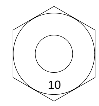
Table 1, Torque Values for U.S. Customary Thread Fasteners With Lubricated or Plated Threads

Specifications

Torque Values for U.S. Customary Thread Fasteners With Dry (Unlubricated)* Plain (Unplated) Threads†						
Thread Diameter–Pitch	Regular Hex				Flanged	
	Grade 5 Bolt	Grade 5 or B Nut	Grade 8 or 8.2 Bolt	Grade 8 or C Nut	Grade 8 or 8.2 Bolt	Grade G Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)	
	 f230002	 f230003	 f230004	 f230005	 f230008	 f230009
1/4–20	8 (11)		10 (14)		—	
1/4–28	9 (12)		12 (16)		—	
5/16–18	15 (20)		22 (30)		22 (30)	
5/16–24	17 (23)		25 (34)		—	
3/8–16	28 (38)		40 (54)		40 (54)	
3/8–24	31 (42)		45 (61)		—	
7/16–14	45 (61)		65 (88)		65 (88)	
7/16–20	50 (68)		70 (95)		—	
1/2–13	70 (95)		95 (129)		95 (129)	
1/2–20	75 (102)		110 (149)		—	
9/16–12	100 (136)		140 (190)		140 (190)	
9/16–18	110 (149)		155 (210)		—	
5/8–11	135 (183)		190 (258)		190 (258)	
5/8–18	155 (210)		215 (292)		—	
3/4–10	240 (325)		340 (461)		340 (461)	
3/4–16	270 (366)		380 (515)		—	
7/8–9	385 (522)		540 (732)		—	
7/8–14	425 (576)		600 (813)		—	
1–8	580 (786)		820 (1112)		—	
1–12	635 (861)		900 (1220)		—	
1–14	650 (881)		915 (1241)		—	

* Threads may have residual oil, but will be dry to the touch.
† Male and female threads (bolt and nut) must both be unlubricated and unplated; if either is plated or lubricated, use Table1. Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

Table 2, Torque Values for U.S. Customary Thread Fasteners With Dry (Unlubricated) Plain (Unplated) Threads

Torque Values for Metric Thread Fasteners With Lubricated* or Plated Threads†				
Thread Diameter–Pitch	**Class 8.8 Bolt**	**Class 8 Nut**	**Class 10.9 Bolt**	**Class 10 Nut**
	Torque: lbf·ft (N·m)		**Torque: lbf·ft (N·m)**	
	 8.8 f230010	 8 f230011	 10.9 f230012	 10 f230013
M6	5 (7)		7 (9)	
M8	12 (16)		17 (23)	
M8 x 1	13 (18)		18 (24)	
M10	24 (33)		34 (46)	
M10 x 1.25	27 (37)		38 (52)	
M12	42 (57)		60 (81)	
M12 x 1.5	43 (58)		62 (84)	
M14	66 (89)		95 (129)	
M14 x 1.5	72 (98)		103 (140)	
M16	103 (140)		148 (201)	
M16 x 1.5	110 (149)		157 (213)	
M18	147 (199)		203 (275)	
M18 x 1.5	165 (224)		229 (310)	
M20	208 (282)		288 (390)	
M20 x 1.5	213 (313)		320 (434)	
M22	283 (384)		392 (531)	
M22 x 1.5	315 (427)		431 (584)	
M24	360 (488)		498 (675)	
M24 x 2	392 (531)		542 (735)	
M27	527 (715)		729 (988)	
M27 x 2	569 (771)		788 (1068)	
M30	715 (969)		990 (1342)	
M30 x 2	792 (1074)		1096 (1486)	

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.
† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

Table 3, Torque Values for Metric Thread Fasteners With Lubricated or Plated Threads

VIN for Vehicles Built through April 30, 2000

IMPORTANT: See **Subject 060** for the vehicle identification numbering system for vehicles built May 1, 2000, or later.

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Freightliner VIN, 1FUYSTEBXVPA99999.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the left frame rail over the front axle about 2 inches (50 mm) from the top of the web or on the top flange of the left frame rail at frame station 30.

NOTE: For Freightliner vehicles assembled and sold in Mexico, the VIN appears on a plate or label attached to the driver's door. Also, a data card placed in the glove box shows the Mexican VIN as the "CHASSIS" number. The "CABIN" number is part of the Freightliner VIN, the last six digits of which are the Freightliner serial number.

IMPORTANT: A new VIN-code structure will be used for all vehicles built after April 30, 2000. Character positions 1 through 4 and 9 through 17 are nearly the same in both versions, but positions 5 through 8 have been assigned slightly different parameters. As a result, the build date of a vehicle must be determined before the VIN can be decoded.

For all vehicles, a check digit (9th character) is determined by assignment of weighted values to the other 16 characters. These weighted values are processed through a series of equations designed to check validity of the VIN and to detect VIN alteration.

NOTE: Always specify the VIN when ordering parts.

Seventeen-Character Vehicle Identification Number (VIN)									
Typical VIN	**1 F U**	**Y**	**S**	**T E**	**B**	**X**	**V**	**P**	**A 9 9 9 9 9**
Character Position	**1, 2, 3**	**4**	**5**	**6, 7**	**8**	**9**	**10**	**11**	**12 thru 17**
Decoding Table*	**Table 2**	**Table 3**	**Table 4**	**Table 5**	**Table 6**	—	**Table 7**	**Table 8**	—
Code Description									
Manufacturer, Make, Vehicle Type									
Chassis, Front Axle Position, Brakes									
Vehicle Model Series, Cab									
Engine Model, Horsepower Range									
Gross Vehicle Weight Rating (GVWR)									
Check Digit									
Vehicle Model Year									
Plant of Manufacture									
Production Number									

* For corresponding decoding information, see the applicable tables in this subject.

Table 1, Seventeen-Character Vehicle Identification Number (VIN)

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
1FU	Freightliner, U.S.A.	Freightliner	Truck-Tractor

VIN for Vehicles Built through April 30, 2000

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
1FV	Freightliner, U.S.A.	Freightliner	Incomplete Vehicle
2FU	Freightliner, Canada	Freightliner	Truck-Tractor
2FV	Freightliner, Canada	Freightliner	Incomplete Vehicle
3FE	M-B, Mexico (before April 1996)	Freightliner	Truck-Tractor
3FF	M-B, Mexico (before April 1996)	Freightliner	Incomplete Vehicle
3AK	M-B, Mexico (after April 1996)	Freightliner	Truck-Tractor
3AL	M-B, Mexico (after April 1996)	Freightliner	Incomplete Vehicle
AFV	M-B, South Africa	Freightliner	Truck
KFB	AIL, Israel	Freightliner	Truck
RSA	NAI, Saudi Arabia	Freightliner	Incomplete Vehicle
RSB	NAI, Saudi Arabia	Freightliner	Truck-Tractor

Table 2, VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)

VIN Position 4 (Chassis, Front Axle Position, Brakes)			
Code	**Chassis**	**Front Axle Position**	**Brakes**
A	4 x 2 Truck	Forward	Hydraulic
B	8 x 4 Truck-Tractor	Setback	Air
C	6 x 6 Truck-Tractor	Setback	Air
D	4 x 4 Truck	Setback	Hydraulic
E	4 x 4 Truck	Setback	Air
F	8 x 4 Truck	Forward	Air
G	8 x 4 Truck-Tractor	Forward	Air
H	4 x 2 Truck	Forward	Air
J	10 x 4 Truck	All	Air
K	4 x 2 Truck-Tractor	Forward	Air
L	6 x 2 Truck	Forward	Air
M	6 x 2 Truck-Tractor	Forward	Air
N	6 x 4 Truck	Forward	Air
P	6 x 4 Truck-Tractor	Forward	Air
R	10 x 6 Truck	Forward	Air
S	10 x 6 Truck-Tractor	Forward	Air
T	6 x 6 Truck	Setback	Air
U	8 x 6 Truck	All	Air
V	8 x 6 Truck-Tractor	All	Air
W	4 x 2 Truck-Tractor	Setback	Air

VIN Position 4 (Chassis, Front Axle Position, Brakes)			
Code	**Chassis**	**Front Axle Position**	**Brakes**
X	6 x 4 Truck	Setback	Air
Y	6 x 4 Truck-Tractor	Setback	Air
Z	6 x 2 Truck	Setback	Air
1	4 x 2 Truck *	Forward	Air/Hydraulic
	10 x 6 Truck †	Setback	Air
2	4 x 4 Truck	Setback	Air
3	4 x 2 Truck	Setback	Hydraulic
4	8 x 4 Truck	Setback	Air
5	6 x 2 Truck-Tractor	Setback	Air
6	4 x 2 Truck	Setback	Air
7	Glider	Setback	Air
8	Glider	Forward	Air
9	4 x 2 Truck	Setback	Air/Hydraulic
0	Glider	Setback	Air

* Starting August 1998.

† Through July 1998; included in code R starting August 1998.

Table 3, VIN Position 4 (Chassis, Front Axle Position, Brakes), January 18,1988 through April 30, 2000

VIN for Vehicles Built through April 30, 2000

VIN Position 5 (Model Series, Cab)	
Code	Vehicle Model, Cab
A	FLA High COE
B	FLB High COE
C	120 Conventional XL
D	FLD120 Conventional, Highway
E	FL50 Short Conventional
F	FLD120SD Conventional, Construction
G	FL60 Short Conventional
H	FL70 Short Conventional
J	FL80 Short Conventional
L	112 Conv., Alum. Cab, Hwy., 48RR94MY *
	Argosy High COE
M	120 Conventional, Military
N	Century Class 112 Conventional
P	120 Conv., Alum. Cab, Hwy., 48RR94MY
	Columbia 120 Conventional
R	112 Conventional, Steel Cab, Hwy., RH Drive
S	Century Class 120 Conventional
T	High COE (through 88MY)
	FL112 Conventional
U	120 Conventional XL, 48RR94MY

VIN Position 5 (Model Series, Cab)	
Code	Vehicle Model, Cab
V	MB60 Short Conventional (to 95MY)
	Legacy FL112 (00MY)
W	FC80 Freightliner Cargo COE
X	MB70 Short Conventional (to 97MY)
	Legacy FLD120 (00MY)
Y	MB80 Short Conventional (through 98MY)
Z	112 Conventional, Steel Cab, Highway
1	FLC112 Conv., Steel Cab, Constr. (to 98MY)
2	FLC120 Conventional (to 91MY)
	FC60 Freightliner Cargo COE
3	FLD112 Conventional, Alum. Cab, Highway
4	Low COE, Aluminum Cab
5	MB50 Short Conventional
6	FLD112SD Conv., Alum. Cab, Construction
7	FLD120 Conventional, SilverAero (91MY)
	FC70 Freightliner Cargo COE
8	FL106 Short Conventional
9	RIV

* MY = Model Year

Table 4, VIN Position 5 (Model Series, Cab)

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	Engine Manufacturer	Engine Model	HP Range
AY	Cummins	NTC / N14	207–251
BD	Mercedes-Benz	MBE4000	353–407
BE	Mercedes-Benz	MBE4000	408–495
BX	Mercedes-Benz	MBE4000	288–352
BY	Cummins	NTC / N14	254–310
CX	Detroit Diesel	S-60, 11.1 L	331–402
CY	Cummins	N14	315–385
DY	Cummins	NTC / N14	389–475
DZ	Cummins	N14	476–580
EB	Caterpillar	C10 / 3176J	225–275
EC	Caterpillar	C10 / 3176J	276–335
ED	Caterpillar	C10 / 3176	336–407

VIN for Vehicles Built through April 30, 2000

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
F4	Cummins	B5.9 (propane)	185–224
FA	Cummins	6BT 5.9 (diesel) / ISB	185–224
FB	Cummins	6BT 5.9 (diesel) / ISB	225–275
FF	Cummins	6BT 5.9/ ISB	153–184
FH	Cummins	6BT 5.9–195G (natural gas)	185–224
FV	Cummins	6BT 5.9–195G (natural gas)	126–152
GA	Mercedes-Benz	OM 366LA	185–224
GB	Mercedes-Benz	OM 366LA	225–275
GF	Mercedes-Benz	OM 366LA	153–184
HB	Detroit Diesel	S–50	225–275
HC	Detroit Diesel	S–50	276–335
HD	Detroit Diesel	S–50	336–407
JA	Caterpillar	CFE / 3126 (diesel)	185–224
JB	Caterpillar	CFE / 3126 (diesel)	225–275
JC	Caterpillar	CFE / 3126 (diesel)	276–335
JF	Caterpillar	CFE / 3126 (diesel)	153–184
KY	Cummins	L10	225–275
LA	Cummins	6C 8.3 (diesel) / ISC	185–224
LB	Cummins	6C 8.3 (diesel) / ISC	225–275
LC	Cummins	6C 8.3 (diesel) / ISC	276–335
LD	Cummins	L10	336–407
LE	Cummins	ISC	336–407
LL	Cummins	C 8.3 (natural gas) / ISC	225–276
LY	Cummins	L10	276–330
MC	Cummins	M11 / ISM	276–335
MD	Cummins	M11 / ISM	336–407
ME	Cummins	M11 / ISM	408–495
MW	Cummins	ISM	496–605
NT	Cummins	4B 3.9–130 hp (diesel)	126–152
PY	Detroit Diesel	S-60, 11.1 L	275–330
RY	Caterpillar	3406	270–330
SE	Detroit Diesel	S-60, 12.7 L	408–495
SM	Detroit Diesel	S-60, 12.7 L	276–335
SY	Caterpillar	3406	333–407
SZ	Detroit Diesel	S-60, 12.7 L	496–605

VIN for Vehicles Built through April 30, 2000

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	Engine Manufacturer	Engine Model	HP Range
TD	Detroit Diesel	S-55	336–407
TE	Detroit Diesel	S-55	408–495
TJ	Dodge	Magnum V8 (gasoline)	207–253
TR	Dodge	Magnum V10 (gasoline)	270–330
TY	Caterpillar	3408	383–467
UY	Caterpillar	3306	225–275
VY	Caterpillar	3406	225–269
WC	Caterpillar	CFE/3126	276–335
WD	Caterpillar	C12 / 3176L	336–407
WE	Caterpillar	C12 / 3176L	408–495
WY	Caterpillar	3306	276–335
XY	Caterpillar	3406	408–495
XZ	Caterpillar	3406	496–605
YY	Detroit Diesel	S-60, 11.1 L	225–274
ZY	Detroit Diesel	S-60, 12.7 L	333–407
1B	Detroit Diesel	6L–71	225–275
1C	Detroit Diesel	6L–71	276–335
2W	Detroit Diesel	S-60, 14.0L	496–605
3A	Mercedes-Benz	MB904	185–224
4Y	Detroit Diesel	6V–92	239–287
5Y	Detroit Diesel	6V–92	288–352
6A	Mercedes-Benz	MB906	185–224
6B	Mercedes-Benz	MB906	225–275
6C	Mercedes-Benz	MB906	276–335
6Y	Detroit Diesel	8V–92	365–446
7D	Cummins	ISX Signature	336–407
7E	Cummins	ISX Signature	408–495
7W	Cummins	ISX Signature	496–605
8Y	Detroit Diesel	8V–92	302–364
9Y	Detroit Diesel	8V–92	447–522
0Y	No Engine	—	—

Table 5, VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)

VIN for Vehicles Built through April 30, 2000

VIN Position 8 (Gross Vehicle Weight Rating)		
Code	lb	kg
A	26,001–33,000	11 794–14 968
B	33,001 or over	14 969 or over
C	19,501–26,000	8846–11 793
D	16,001–19,500	7258–8845
2	6001–10,000	2722–4536
3	10,001–14,000	4537–6350
4	14,001–16,000	6351–7257
9	N/A: Incomplete Vehicle or Glider	

Table 6, VIN Position 8 (Gross Vehicle Weight Rating)

VIN Position 10 (Vehicle Model Year)	
Code	Model Year
J	1988
K	1989
L	1990
M	1991
N	1992
P	1993
R	1994
S	1995
T	1996
V	1997
W	1998
X	1999
Y	2000
1	2001
2	2002

Table 7, VIN Position 10 (Vehicle Model Year)

VIN Position 11 (Plant of Manufacture)	
Code	Plant of Manufacture
A	St. Thomas, Ontario
B	Mercedes-Benz, South Africa
C	Gaffney, South Carolina
D	Mercedes-Benz, Mexico, Santiago
F	AIL, Israel
H	Mt. Holly, North Carolina
L	Cleveland, North Carolina
M	Mercedes-Benz, Monterrey
N	Mercedes-Benz, Australia
P	Portland, Oregon
R	American LaFrance, Cleveland, NC
V	Burnaby, British Columbia
W	NAI, Saudi Arabia

Table 8, VIN Position 11 (Plant of Manufacture)

VIN for Vehicles Built from May 1, 2000

IMPORTANT: See **Subject 050** for the vehicle identification numbering system for vehicles built before May 1, 2000.

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Freightliner VIN, 1FUPABAV11PA12345.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the left frame rail over the front axle about 2 inches (50 mm) from the top of the web or on the top flange of the left frame rail at frame station 30.

NOTE: For Freightliner vehicles assembled and sold in Mexico, the VIN appears on a plate or label attached to the driver's door. Also, a data card placed in the glove box shows the Mexican VIN as the "CHASSIS" number. The "CABIN" number is part of the Freightliner VIN, the last six digits of which are the Freightliner serial number.

IMPORTANT: A new VIN-code structure will be used for all vehicles built after April 30, 2000. As a result, the build date of a vehicle must be determined before the VIN can be decoded.

Character positions 1 through 4 and 9 through 17 are nearly the same in both versions, but positions 5 through 8 have been assigned slightly different parameters.

Another new feature is that each product line has its own model list; that is, positions 5 and 6 are will be product-specific in the new system. For example, the code AB in positions 5 and 6 for a Freightliner vehicle indicates an FLD112. Code AB in the same position for a Sterling vehicle represents an SC7000 Cargo.

For all vehicles, a check digit (9th character) is determined by assignment of weighted values to the other 16 characters. These weighted values are processed through a series of equations designed to check validity of the VIN and to detect VIN alteration.

NOTE: Always specify the VIN when ordering parts.

Seventeen-Character Vehicle Identification Number (VIN)								
Typical VIN	**1 F U**	**P**	**A B**	**A V**	**1**	**1**	**P**	**A 1 2 3 4 5**
Character Position	1, 2, 3	4	5, 6	7, 8	9	10	11	12–17
Code Description	World Manufacturer Identification	Chassis Configuration	Model, Cab, GVWR	Engine, Brakes	Check Digit Calculation	Model Year	Build Location	Production Serial Number
Decoding Table*	**Table 2**	**Table 3**	**Table 4**	**Table 5**	—	**Table 6**	**Table 7**	—

* For corresponding decoding information, see the applicable tables in this subject.

Table 1, Seventeen-Character Vehicle Identification Number (VIN)

VIN Positions 1, 2, and 3 (World Manufacturer Identification)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
1FU	Freightliner, U.S.A.	Freightliner	Truck-Tractor
1FV	Freightliner, U.S.A.	Freightliner	Incomplete Vehicle
3AK	Daimler AG, Mexico	Freightliner	Truck-Tractor
3AL	Daimler AG, Mexico	Freightliner	Incomplete Vehicle
RSA	NAI, Saudi Arabia	Freightliner	Incomplete Vehicle

VIN for Vehicles Built from May 1, 2000

VIN Positions 1, 2, and 3 (World Manufacturer Identification)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
RSB	NAI, Saudi Arabia	Freightliner	Truck-Tractor

Table 2, VIN Positions 1, 2, and 3 (World Manufacturer Identification)

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
A	4 x 2 Truck
B	4 x 2 Truck-Tractor
C	8 x 8 Truck
D	4 x 4 Truck
E	4 x 4 Truck-Tractor
F	6 x 2 Truck
G	6 x 2 Truck-Tractor
H	6 x 4 Truck
J	6 x 4 Truck-Tractor
K	6 x 6 Truck
L	6 x 6 Truck-Tractor
M	8 x 4 Truck
N	8 x 4 Truck-Tractor

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
P	8 x 6 Truck
R	8 x 6 Truck-Tractor
S	10 x 4 Truck
T	10 x 4 Truck-Tractor
U	10 x 6 Truck
V	10 x 6 Truck-Tractor
W	12 x 4 Truck
X	Glider
Y	8 x 2 Truck
Z	14 x 4 Truck
1	12 x 6 Truck

Table 3, VIN Position 4 (Chassis Configuration)

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**GVWR**
AA	FLB Glider	COE	Glider
AB	FLD112	Conventional	Class 7
AC	FLD112	Conventional	Class 8
AD	FLD112 Glider	Conventional	Glider
AE	FLD112 SD	Conventional	Class 8
AF	FLD112 SD Glider	Conventional	Glider
AG	FLD120	Conventional	Class 7
AH	FLD120	Conventional	Class 8
AJ	FLD120 Glider	Conventional	Glider
AK	FLD120 SD	Conventional	Class 7
AL	FLD120 SD	Conventional	Class 8
AM	FLD120 SD Glider	Conventional	Glider
AN	FLD132 XL Classic	Conventional	Class 7
AP	FLD132 XL Classic	Conventional	Class 8
AR	FLD132 XL Glider	Conventional	Glider

VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**GVWR**
AS	FLD120 Military	Conventional	Class 7
AT	FLD120 Military	Conventional	Class 8
AU	FLD120 Military Glider	Conventional	Glider
AV	Argosy	COE	Class 7
AW	Argosy	COE	Class 8
AX	Argosy Glider	COE	Glider
AY	C112	Conventional	Class 7
AZ	C112	Conventional	Class 8
A1	C112 Glider	Conventional	Glider
A2	C120	Conventional	Class 7
A3	C120	Conventional	Class 8
A4	C120 Glider	Conventional	Glider
A5	Columbia 120	Conventional	Class 7
A6	Columbia 120	Conventional	Class 8
A7	Columbia 120 Glider	Conventional	Glider
A8	CST112	Conventional	Class 7
A9	CST112	Conventional	Class 8
A0	CST112 Glider	Conventional	Glider
BA	CST120	Conventional	Class 7
BB	CST120	Conventional	Class 8
BC	CST120 Glider	Conventional	Glider
BD	FLD120 Classic Legacy	Conventional	Class 8
BE	FLS112 Legacy	Conventional	Class 8
BF	FL112	Conventional	Class 7
BG	FL112	Conventional	Class 8
BH	FL112 Glider	Conventional	Glider
BJ	FL50	Conventional	Class 4
BK	FL50	Conventional	Class 5
BL	FL50	Conventional	Class 6
BM	FL50	Conventional	Class 7
BN	FL60	Conventional	Class 5
BP	FL60	Conventional	Class 6
BR	FL60	Conventional	Class 7
BS	FL70	Conventional	Class 6
BT	FL70	Conventional	Class 7
BU	FL70	Conventional	Class 8

VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	Model	Cab	GVWR
BV	FL80	Conventional	Class 6
BW	FL80	Conventional	Class 7
BX	FL80	Conventional	Class 8
BY	FL106	Conventional	Class 6
BZ	FL106	Conventional	Class 7
B1	FL106	Conventional	Class 8
B2	FC70 Cargo	COE	Class 6
B3	FC70 Cargo	COE	Class 7
B4	FC70 Cargo	COE	Class 8
B5	FC80 Cargo	COE	Class 6
B6	FC80 Cargo	COE	Class 7
B7	FC80 Cargo	COE	Class 8
B8	RIV	None	Class 8
B9	Sport Chassis	Conventional	Class 6
B0	Sport Chassis	Conventional	Class 7
CA	FL106 Glider	Conventional	Glider
CB	FL60 Glider	Conventional	Glider
CC	FL70 Glider	Conventional	Glider
CD	FL80 Glider	Conventional	Glider
CE	Condor	COE	Class 7
CF	Condor	COE	Class 8
CG	FLD120/84" Sleeper MY2001	Conventional	Class 7
CH	FLD120/84" Sleeper MY2001	Conventional	Class 8
CJ	FLD120 Glider/84" Sleeper MY2001	Conventional	Glider
CK	FLD132 XL Classic/84" Sleeper MY2001	Conventional	Class 7
CL	FLD132 XL Classic/84" Sleeper MY2001	Conventional	Class 8
CM	FLD 132 XL Glider/84" Sleeper	Conventional	Glider
CN	FL112	Conventional	Class 6
CP	FLD120 Military Reman	Conventional	Class 8
CR	Coronado CC132	Conventional	Class 8
CS	M2 100	Conventional	Class 4
CT	M2 100	Conventional	Class 5
CU	M2 100	Conventional	Class 6
CV	M2 106 Medium Duty	Conventional	Class 5
CW	M2 106 Medium Duty	Conventional	Class 6
CX	M2 106 Medium Duty	Conventional	Class 7

VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**GVWR**
CY	M2 106 Medium Duty	Conventional	Class 8
CZ	M2 106V Heavy Duty	Conventional	Class 5
C1	M2 106V Heavy Duty	Conventional	Class 6
C2	M2 106V Heavy Duty	Conventional	Class 7
C3	M2 106V Heavy Duty	Conventional	Class 8
C4	M2 112 Medium Duty	Conventional	Class 7
C5	M2 112 Medium Duty	Conventional	Class 8
C6	M2 112V Heavy Duty	Conventional	Class 7
C7	M2 112V Heavy Duty	Conventional	Class 8
C8	M2 106 Medium Duty	Conventional	Class 4
C9	Sport Chassis	Conventional	Class 5
F1	Sport Chassis 112	Conventional	Class 6
F2	FLB High COE	COE	Class 8
F3	Sport Chassis 112	Conventional	Class 7
F4	Coronado CC132	Conventional	Class 7
F5	Classic 120	Conventional	Class 7
F6	Classic 120	Conventional	Class 8
F7	Condor Glider	Conventional	Glider
F8	M2 106 Medium Glider	Conventional	Glider
F9	Columbia 112	Conventional	Class 7
F0	Columbia 112	Conventional	Class 8
FA	Columbia 112	Conventional	Glider
FB	Coronado CC132 Glider	Conventional	Glider
FC	M2 106 Sport Chassis	Conventional	Class 5
FD	M2 106 Sport Chassis	Conventional	Class 6
FE	M2 106 Sport Chassis	Conventional	Class 7
FF	M2 112 Sport Chassis	Conventional	Class 5
FG	M2 112 Sport Chassis	Conventional	Class 6
FH	M2 112 Sport Chassis	Conventional	Class 7
FJ	Classic 120	Conventional	Glider
GA	Cascadia 113 Day Cab	Conventional	Class 7
GB	Cascadia 113 Day Cab	Conventional	Class 8
GC	Cascadia 113 Sleeper Cab	Conventional	Glider
GD	Cascadia 125 Day Cab	Conventional	Class 7
GE	Cascadia 125 Day Cab	Conventional	Class 8
GF	Cascadia 125 Sleeper Cab	Conventional	Glider

VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**GVWR**
GG	Cascadia 113 Sleeper Cab	Conventional	Class 7
GH	Cascadia 113 Sleeper Cab	Conventional	Class 8
GJ	Cascadia 132	Conventional	Glider
GK	Cascadia 125 Sleeper Cab	Conventional	Class 7
GL	Cascadia 125 Sleeper Cab	Conventional	Class 8
GM	Coronado 132	Conventional	Class 8
GN	Coronado SD 122	Conventional	Class 8
GP	Coronado 122	Conventional	Class 8
GR	Coronado 122	Conventional	Glider
GS	Coronado SD 122 Glider	Conventional	Glider
GT	Coronado 132	Conventional	Glider
GU	M2 106V Glider	Conventional	Glider
GV	Coronado 122 RHD	Conventional	Class 8
GW	Coronado 122 RHD Glider	Conventional	Glider
GX	Coronado 132	Conventional	Class 7
GY	Coronado SD 122	Conventional	Class 7
GZ	Coronado 122	Conventional	Class 7
G1	M2 112 Glider	Conventional	Glider
G2	MD109 Military	Conventional	Class 8
G3	114SD	Conventional	Class 8
G4	114SD	Conventional	Glider
G5	108SD	Conventional	Class 8
G6	108SD	Conventional	Glider
G7	Coronado 114 RHD	Conventional	Class 8
G8	Coronado 114 RHD	Conventional	Glider
G9	114SD	Conventional	Class 7
G0	108SD	Conventional	Class 7
HA	Cascadia 113 Day Cab	Conventional	Glider
HB	Cascadia 125 Day Cab	Conventional	Glider
HC	108SD	Conventional	Class 6
HD	M2 100	Conventional	Class 7

Table 4, VIN Positions 5 and 6 (Model, Cab, Class/GVWR)

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement**	**Configuration**	**Brakes**
AA	Caterpillar 3176	Diesel	10.3 Liter	I-6	Air
AB	Caterpillar 3176	Diesel	10.3 Liter	I-6	Hydraulic
AC	Caterpillar 3176	Diesel	10.3 Liter	I-6	Air/Hydraulic
AD	Caterpillar 3406	Diesel	14.6 Liter	I-6	Air
AE	Caterpillar 3406	Diesel	14.6 Liter	I-6	Hydraulic
AF	Caterpillar 3406	Diesel	14.6 Liter	I-6	Air/Hydraulic
AG	Caterpillar 3406 E	Diesel	15.8 Liter	I-6	Air
AH	Caterpillar 3406 E	Diesel	15.8 Liter	I-6	Hydraulic
AJ	Caterpillar 3406 E	Diesel	15.8 Liter	I-6	Air/Hydraulic
AK	Caterpillar 3126/CFE	Diesel	7.2 Liter	I-6	Air
AL	Caterpillar 3126/CFE	Diesel	7.2 Liter	I-6	Hydraulic
AM	Caterpillar 3126/CFE	Diesel	7.2 Liter	I-6	Air/Hydraulic
AN	Caterpillar C10	Diesel	10.3 Liter	I-6	Air
AP	Caterpillar C10	Diesel	10.3 Liter	I-6	Hydraulic
AR	Caterpillar C10	Diesel	10.3 Liter	I-6	Air/Hydraulic
AS	Caterpillar C12	Diesel	12.0 Liter	I-6	Air
AT	Caterpillar C12	Diesel	12.0 Liter	I-6	Hydraulic
AU	Caterpillar C12	Diesel	12.0 Liter	I-6	Air/Hydraulic
AV	Caterpillar C15	Diesel	14.6 Liter pre 2008/15.2 Liter	I-6	Air
AW	Caterpillar C15	Diesel	14.6 Liter pre 2008/15.2 Liter	I-6	Hydraulic
AX	Caterpillar C15	Diesel	14.6 Liter pre 2008/15.2 Liter	I-6	Air/Hydraulic
AY	Caterpillar C16	Diesel	15.8 Liter	I-6	Air
AZ	Caterpillar C16	Diesel	15.8 Liter	I-6	Hydraulic
A1	Caterpillar C16	Diesel	15.8 Liter	I-6	Air/Hydraulic
A2	Cummins L10	Diesel	10.8 Liter	I-6	Air
A3	Cummins L10	Diesel	10.8 Liter	I-6	Hydraulic
A4	Cummins L10	Diesel	10.8 Liter	I-6	Air/Hydraulic
A5	Cummins M11	Diesel	10.8 Liter	I-6	Air
A6	Cummins M11	Diesel	10.8 Liter	I-6	Hydraulic
A7	Cummins M11	Diesel	10.8 Liter	I-6	Air/Hydraulic
A8	Cummins ISM	Diesel	10.8 Liter	I-6	Air
A9	Cummins ISM	Diesel	10.8 Liter	I-6	Hydraulic
A0	Cummins ISM	Diesel	10.8 Liter	I-6	Air/Hydraulic
BA	Cummins NTC	Diesel	14 Liter	I-6	Air

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement**	**Configuration**	**Brakes**
BB	Cummins NTC	Diesel	14 Liter	I-6	Hydraulic
BC	Cummins NTC	Diesel	14 Liter	I-6	Air/Hydraulic
BD	Cummins N14	Diesel	14 Liter	I-6	Air
BE	Cummins N14	Diesel	14 Liter	I-6	Hydraulic
BF	Cummins N14	Diesel	14 Liter	I-6	Air/Hydraulic
BG	Cummins ISX	Diesel	14.9 Liter	I-6	Air
BH	Cummins ISX	Diesel	14.9 Liter	I-6	Hydraulic
BJ	Cummins ISX	Diesel	14.9 Liter	I-6	Air/Hydraulic
BK	Cummins C 8.3	Diesel	8.3 Liter	I-6	Air
BL	Cummins C 8.3	Diesel	8.3 Liter	I-6	Hydraulic
BM	Cummins C 8.3	Diesel	8.3 Liter	I-6	Air/Hydraulic
BN	Cummins B5.9	Diesel	5.9 Liter	I-6	Air
BP	Cummins B5.9	Diesel	5.9 Liter	I-6	Hydraulic
BR	Cummins B5.9	Diesel	5.9 Liter	I-6	Air/Hydraulic
BS	Cummins ISC	Diesel	8.3 Liter	I-6	Air
BT	Cummins ISC	Diesel	8.3 Liter	I-6	Hydraulic
BU	Cummins ISC	Diesel	8.3 Liter	I-6	Air/Hydraulic
BV	Cummins ISB	Diesel	5.9 Liter	I-6	Air
BW	Cummins ISB	Diesel	5.9 Liter	I-6	Hydraulic
BX	Cummins ISB	Diesel	5.9 Liter	I-6	Air/Hydraulic
BY	Cummins B5.9	Propane	5.9 Liter	I-6	Air
BZ	Cummins B5.9	Propane	5.9 Liter	I-6	Hydraulic
B1	Cummins B5.9	Propane	5.9 Liter	I-6	Air/Hydraulic
B2	Cummins B5.9	Natural Gas	5.9 Liter	I-6	Air
B3	Cummins B5.9	Natural Gas	5.9 Liter	I-6	Hydraulic
B4	Cummins B5.9	Natural Gas	5.9 Liter	I-6	Air/Hydraulic
B5	Cummins C8.3	Natural Gas	8.3 liter	I-6	Air
B6	Cummins C8.3	Natural Gas	8.3 liter	I-6	Hydraulic
B7	Cummins C8.3	Natural Gas	8.3 liter	I-6	Air/Hydraulic
B8	Detroit Series 50	Diesel	8.5 liter	I-4	Air
B9	Detroit Series 50	Diesel	8.5 liter	I-4	Hydraulic
B0	Detroit Series 50	Diesel	8.5 liter	I-4	Air/Hydraulic
CA	Detroit Series 55	Diesel	12.Liter	I-6	Air
CB	Detroit Series 55	Diesel	12.Liter	I-6	Hydraulic
CC	Detroit Series 55	Diesel	12.Liter	I-6	Air/Hydraulic
CD	Detroit Series 60	Diesel	11.1 Liter	I-6	Air

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement**	**Configuration**	**Brakes**
CE	Detroit Series 60	Diesel	11.1 Liter	I-6	Hydraulic
CF	Detroit Series 60	Diesel	11.1 Liter	I-6	Air/Hydraulic
CG	Detroit Series 60	Diesel	12.7 Liter	I-6	Air
CH	Detroit Series 60	Diesel	12.7 Liter	I-6	Hydraulic
CJ	Detroit Series 60	Diesel	12.7 Liter	I-6	Air/Hydraulic
CK	Detroit Series 60	Diesel	14.0 Liter	I-6	Air
CL	Detroit Series 60	Diesel	14.0 Liter	I-6	Hydraulic
CN	Mercedes-Benz MBE-900	Diesel	4.3 liter	I-4	Air
CP	Mercedes-Benz MBE-900	Diesel	4.3 liter	I-4	Hydraulic
CR	Mercedes-Benz MBE-900	Diesel	4.3 liter	I-4	Air/Hydraulic
CS	Mercedes-Benz MBE-900	Diesel	6.4 liter	I-6	Air
CT	Mercedes-Benz MBE-900	Diesel	6.4 liter	I-6	Hydraulic
CU	Mercedes-Benz MBE-900	Diesel	6.4 liter	I-6	Air/Hydraulic
CV	Mercedes-Benz MBE4000	Diesel	12.8 Liter	I-6	Air
CW	Mercedes-Benz MBE4000	Diesel	12.8 Liter	I-6	Hydraulic
CX	Mercedes-Benz MBE4000	Diesel	12.8 Liter	I-6	Air/Hydraulic
CY	Cummins ISL	Diesel	8.9 Liter	I-6	Air
CZ	Cummins ISL	Diesel	8.9 Liter	I-6	Hydraulic
C1	Cummins ISL	Diesel	8.9 Liter	I-6	Air/Hydraulic
C2	Cummins B 3.9	Diesel	3.9 Liter	I-4	Air
C3	Cummins B 3.9	Diesel	3.9 Liter	I-4	Hydraulic
C4	Cummins B 3.9	Diesel	3.9 Liter	I-4	Air/Hydraulic
C5	Cummins ISB 3.9	Diesel	3.9 Liter	I-4	Air
C6	Cummins ISB 3.9	Diesel	3.9 Liter	I-4	Hydraulic
C7	Cummins ISB 3.9	Diesel	3.9 Liter	I-4	Air/Hydraulic
C8	John Deere 6081H	CNG	8.1 Liter	I-6	Air
C9	John Deere 6081H	CNG	8.1 Liter	I-6	Hydraulic
DA	Caterpillar C9	Diesel	8.8 Liter	I-6	Air
DB	Caterpillar C9	Diesel	8.8 Liter	I-6	Hydraulic
DC	Caterpillar C7	Diesel	7.2 Liter	I-6	Air
DD	Caterpillar C7	Diesel	7.2 Liter	I-6	Hydraulic
DE	Caterpillar C13	Diesel	12.5 Liter	I-6	Air
DF	Caterpillar C13	Diesel	12.5 Liter	I-6	Hydraulic
DG	Mercedes-Benz MBE-900	Diesel	4.8 Liter	I-4	Air
DH	Mercedes-Benz MBE-900	Diesel	4.8 Liter	I-4	Hydraulic
DJ	Mercedes-Benz MBE-900	Diesel	7.2 Liter	I-6	Air

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement**	**Configuration**	**Brakes**
DK	Mercedes-Benz MBE-900	Diesel	7.2 Liter	I-6	Hydraulic
DL	Caterpillar C11	Diesel	11.1 Liter	I-6	Air
DM	Caterpillar C11	Diesel	11.1 Liter	I-6	Hydraulic
DN	Cummins L Gas Plus	Natural Gas	8.9 Liter	I-6	Air
DP	Cummins L Gas Plus	Natural Gas	8.9 Liter	I-6	Hydraulic
DR	Detroit DD15	Diesel	14.8 Liter	I-6	Air
DS	Detroit DD15	Diesel	14.8 Liter	I-6	Hydraulic
DT	Cummins ISB	Diesel	6.7 Liter	I-6	Air
DU	Cummins ISB	Diesel	6.7 Liter	I-6	Hydraulic
DV	Detroit DD13	Diesel	12.8 Liter	I-6	Air
DW	Detroit DD13	Diesel	12.8 Liter	I-6	Hydraulic
DX	Cummins ISL G	Natural Gas	8.9 Liter	I-6	Air
DY	Cummins ISL G	Natural Gas	8.9 Liter	I-6	Hydraulic
D1	Detroit DD16	Diesel	15.6 Liter	I-6	Air
D2	MDEG 7.7	Diesel	7.7 Liter	I-6	Air
D3	MDEG 7.7	Diesel	7.7 Liter	I-6	Hydraulic
D4	Cummins ISX12	Diesel	11.9 Liter	I-6	Air
D5	Detroit DD15 EV	Diesel	14.8 Liter	I-6	Air
D6	Detroit DD15 STD	Diesel	14.8 Liter	I-6	Air
D7	Detroit DD15 EV	Diesel	14.8 Liter	I-6	Hydraulic
D8	Detroit DD15 STD	Diesel	14.8 Liter	I-6	Hydraulic
D9	Cummins ISX12	Natural Gas	11.9 Liter	I-6	Air
00	NO ENGINE				

Table 5, VIN Positions 7 and 8 (Engine and Brakes)

VIN Position 10 (Model Year)	
Code	**Model Year**
Y	2000
1	2001
2	2002
3	2003
4	2004
5	2005
6	2006
7	2007
8	2008

VIN Position 10 (Model Year)	
Code	**Model Year**
9	2009
A	2010
B	2011
C	2012
D	2013

Table 6, VIN Position 10 (Model Year)

VIN for Vehicles Built from May 1, 2000

VIN Position 11 (Build Location)	
Code	**Plant of Manufacture**
L	Cleveland, North Carolina
P	Portland, Oregon
D	Daimler AG, Santiago, Mexico
S	Daimler AG, Saltillo, Coahuila Mexico
H	Mt. Holly, North Carolina

Table 7, VIN Position 11 (Build Location)

Decking Devices

⚠ WARNING

The lift brackets are intended only for undecking trucks. Do not use them for vehicle towing or recovery. If used improperly, personal injury or property damage could result.

To avoid damaging vehicles during undecking, follow the instructions below for installing and removing decking devices.

Two lift brackets are required for undecking. See **Fig. 1**.

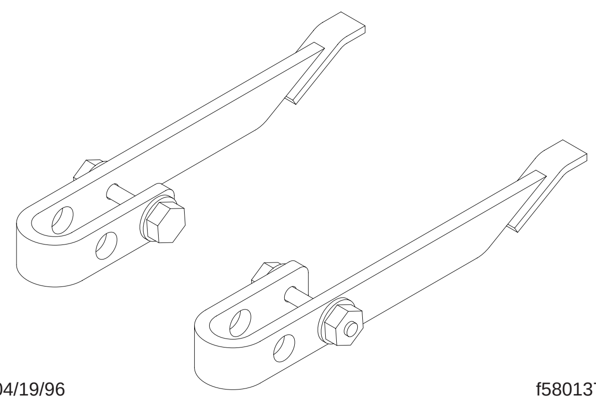


Fig. 1, Lift Brackets

Installation

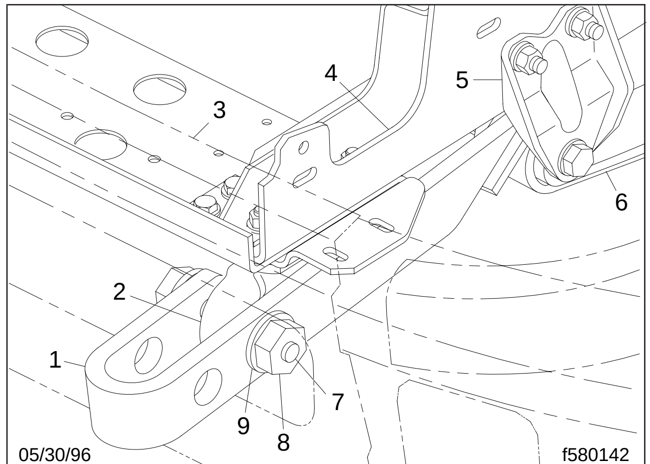
1. Insert the decking device in the tow hook cutout in the front bumper and slide it to the rear until its rear extension/flange rests on top of the front springs. See **Fig. 2**.

⚠ CAUTION

When installing the lifting brackets, be sure that they do not contact or interfere with any air lines. Improper installation could result in component damage.

2. Insert the bolt through the lift bracket to secure it around the tow hook and securely tighten the nut on the bolt.

3. The vehicle can now be safely hoisted for undecking. Make sure the undecking area is free of



1. Lift Bracket
2. Tow Hook
3. Front Bumper
4. Frame Rail
5. Front Spring Bracket
6. Front Spring
7. Bolt
8. Nut
9. Washer

Fig. 2, Lift Bracket Attachment

obstacles, has a vertical clearance of at least 14 feet (4.3 m) and a width of at least 12 feet (3.7 m).

Removal

1. Remove the nut and bolt securing lifting bracket to the tow hook.

2. Remove the lifting bracket from the tow hook cutout.

General Information

A bypass oil filter is a remote-mounted oil filter plumbed to the engine. Not all of the engine oil runs through a bypass filter, the filter bleeds some of the oil from the engine, the rest of the oil "bypasses" the filter and stays within the engine.

Normal engine operation produces a variety of contaminants such as resins, gums, and acids. The bypass oil filter -- sometimes used with a full-flow filter (an engine-mounted filter that *all* the oil must run through) -- traps these contaminants and prevents excessive wear of engine parts. The filtered oil then returns to the engine crankcase or sump.

Freightliner uses the following models of bypass oil filters:

- Fleetguard® Model LF 750™
- Luber-finer® Model 750-CT
- Spinner II®

FLEETGUARD MODEL LF 750 (Fig. 1)

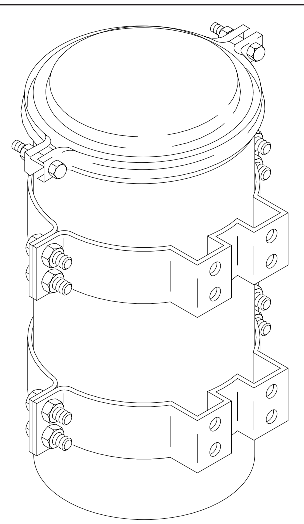


Fig. 1, Fleetguard Model LF 750 Bypass Oil Filter

Engine oil enters the Fleetguard Model LF 750 through the inlet check valve and fills the filter housing around the filter element. Oil pressure within the housing builds until oil is forced through the filter. Inside the filter, the filtered oil moves through openings in the filter hold-down assembly, and collects in the outlet tube. From the outlet tube, the oil goes back to the engine through the outlet check valve assembly.

An engine equipped with the Model LF 750 needs three gallons (11.3 liters) more oil than an engine without a bypass oil filter.

LUBER-FINER MODEL 750-CT (Fig. 2 and Fig. 3)

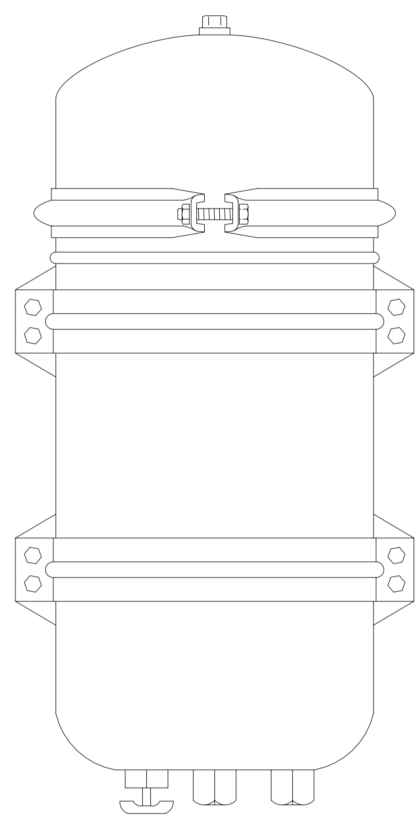
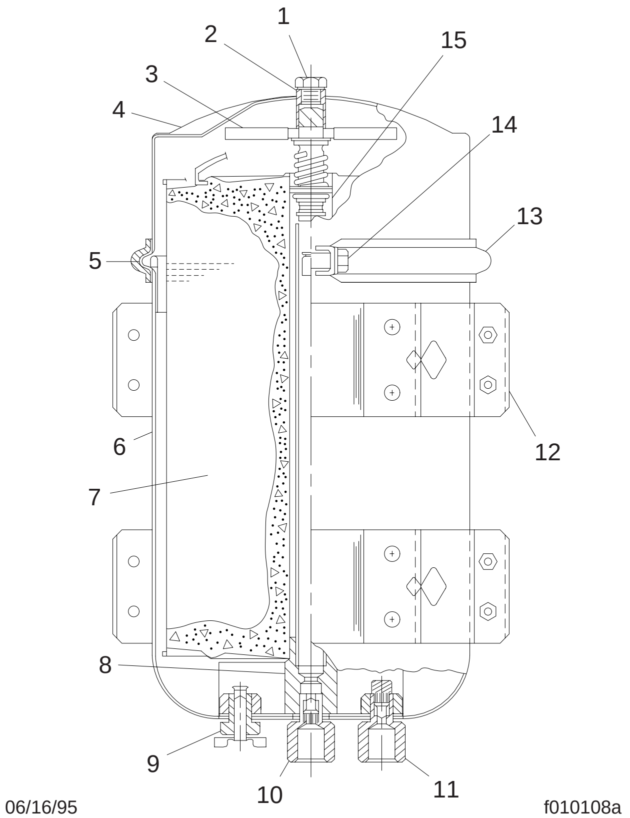


Fig. 2, Luber-finer Model 750-CT Bypass Oil Filter

To prevent thick, cold oil from clogging the filter, a thermostat within the Luber-finer model 750-CT allows engine oil to flow through the filter only after the oil has warmed to a specified temperature. The thermostat is inside the T-handle assembly that holds the filter pack in place.

Engine oil enters through the inlet check valve assembly on the bottom of the filter housing, and fills the filter housing around the filter pack (element). Inside the housing, oil pressure forces the oil through the sides of the filter pack. Inside the filter pack, fil-

General Information



1. Vent Plug Capscrew
2. Washer
3. T-Handle
4. Cover
5. Cover Gasket
6. Housing
7. Filter Element
8. Outlet Tube
9. Drain Cock
10. Outlet Check Valve Assembly
11. Inlet Check Valve Assembly
12. Mounting Bracket
13. Clamping Ring
14. Clamp-Ring Capscrew
15. Hold-Down Assembly

Fig. 3, Luber-finer Model 750-CT (sectional view)

tered oil travels through openings in the T-handle hold-down assembly, then collects in the outlet tube. From the outlet tube, filtered oil goes back to the engine through the outlet check valve assembly.

The inlet and outlet valves normally have #8 orifices.

Normal continuous operating oil pressure is about 65 psi (448 kPa). An engine equipped with the Model 750-CT needs 3 1/2 gallons (13.2 liters) more oil than an engine without a bypass oil filter. Flow rate through the filter is about one or two gallons (3.7 or 7.5 liters) per minute at normal operating pressure.

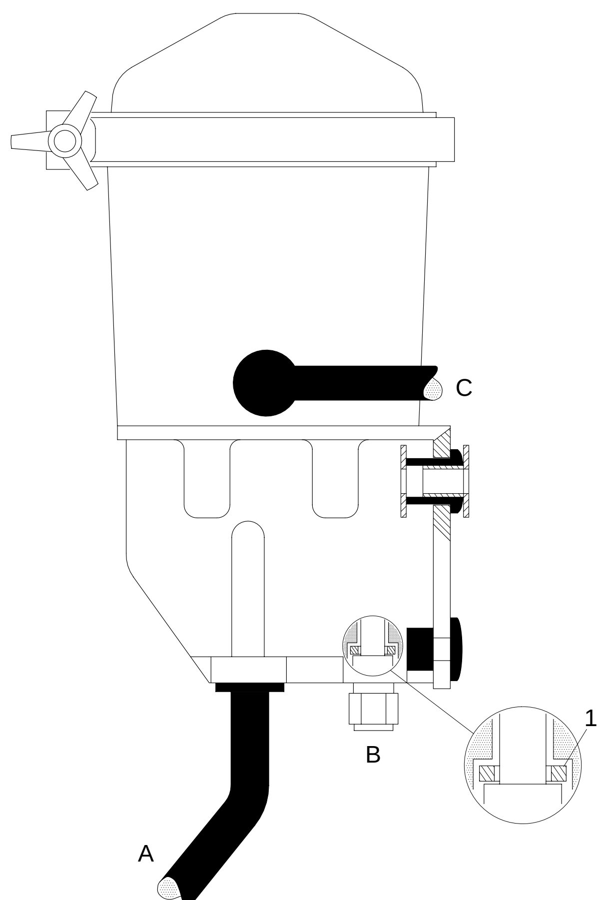
SPINNER II (Fig. 4 and Fig. 5)

The Spinner II uses centrifugal force to separate contaminants from the oil, and uses air pressure to force the filtered oil back to the engine.

Engine oil enters the top half of the filter housing, and travels up through a spindle in the center of a cylindrical centrifuge turbine lined with an optional paper lining. At the same time, the pressure of the oil entering the filter housing makes the centrifuge spin. The oil sprays out of the top of the spindle, and the centrifugal force of the spinning centrifuge drives the oil contaminants against the inside of the centrifuge turbine. The contaminants cake inside the centrifuge turbine, and the clean oil runs into the bottom half of the filter housing.

The clean oil collects in the bottom half of the filter housing where it lifts a float. The float opens a valve that allows brake system air to enter the housing, and the air pressure forces the cleaned oil out of the housing and back to the engine.

Normal continuous operating oil pressure is about 60 psi (413.6 kPa). An engine equipped with the Spinner II doesn't need any extra oil. Flow rate through the cleaner is about 2 gallons (7.5 liters) per minute at normal operating pressure.



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A. Oil Out
B. Air In
C. Oil In
1. Air Valve Cartridge Seal

Fig. 4, Spinner II Bypass Oil Filter

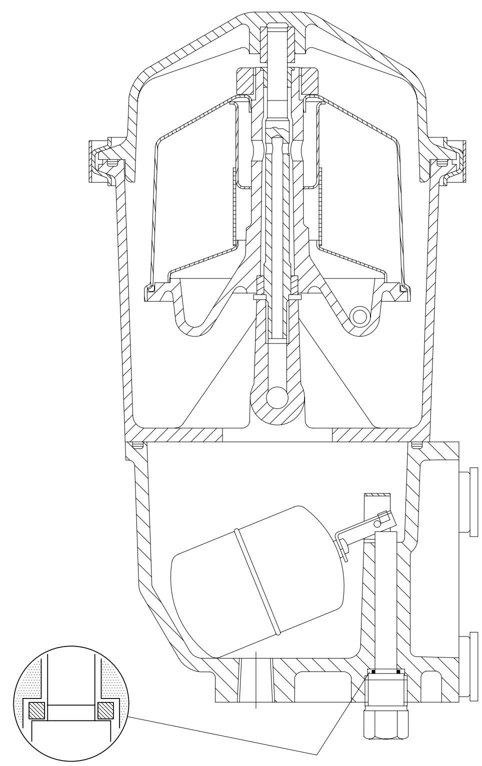

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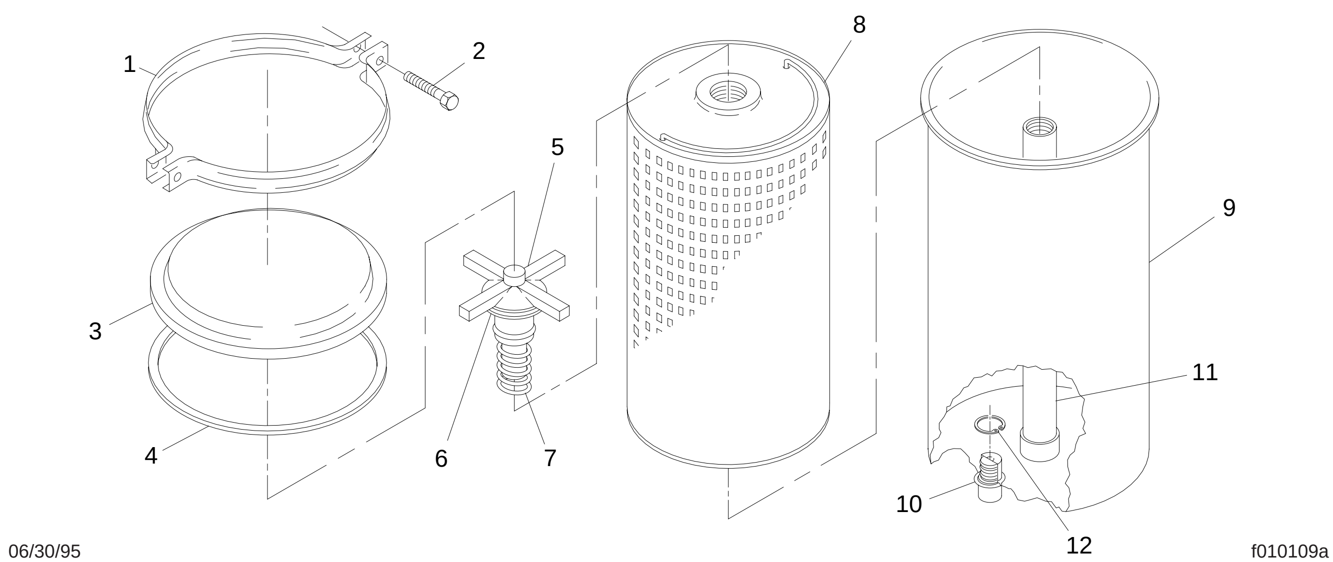
Fig. 5, Spinner II Bypass Oil Filter (sectional view)

Oil Filter Element Replacement, Fleetguard® Model LF 750™

Replacement (See Fig. 1)



1. Clamp Ring
2. Clamp-Ring Capscrew
3. Cover
4. Cover Gasket
5. T-Handle
6. O-Ring
7. Spring
8. Filter Element
9. Housing
10. Inlet Check Valve Assembly
11. Outlet Tube
12. Retaining Ring

Fig. 1, Fleetguard Model LF 750 (exploded view)

IMPORTANT: Do the following at every scheduled engine oil change. Refer to the engine maintenance manual for the quantity of oil that must be added to the lubrication system when replacing the bypass filter.

1. Remove the oil filter element.
   - 1.1 Remove the drain plug and allow the oil to drain.
   - 1.2 Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.
   - 1.3 Unscrew the hold-down assembly T-handle and remove the assembly from the housing. Check the O-ring and spring for damage. Replace if needed.
   - 1.4 Remove and discard the oil filter element.
2. Clean the inside of the housing, and the hold-down assembly, with solvent.
3. Assemble the filter.
   - 3.1 Install the drain plug.
   - 3.2 Install a new filter element.
   - 3.3 Install the hold-down assembly and securely tighten the T-handle.
   - 3.4 Check the cover gasket for damage, and replace it if needed. Position the gasket on the housing.
   - 3.5 Position the cover on the housing. Install the clamp ring and capscrews. Alternately tighten the capscrews to ensure a uniform seal between the cover and gasket.

CAUTION

Make sure the engine oil level is correct. Operating the engine with the oil level below the low ("L") mark, or above the high mark, could result in engine damage.

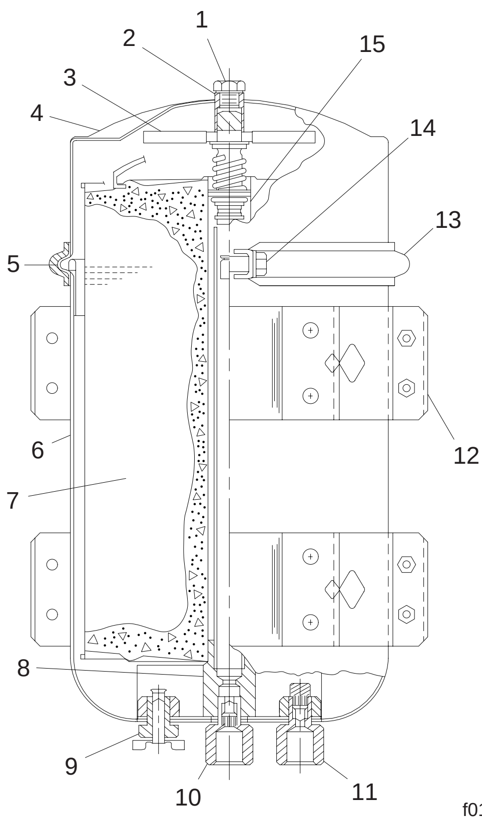
   - 3.6 Start the engine and let it idle until normal operating oil pressure is reached.

Oil Filter Element Replacement, Fleetguard® Model LF 750™

4. Shut down the engine and add oil as needed to bring the oil level up to the high ("H") mark on the dipstick.

Oil Filter Element Replacement, Luber-finer® Model 750-CT

Replacement (See Fig. 1)



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1. Vent Plug Capscrew
2. Washer
3. T-Handle
4. Cover
5. Cover Gasket
6. Housing
7. Filter Element
8. Outlet Tube
9. Drain Cock
10. Outlet Check Valve Assembly
11. Inlet Check Valve Assembly
12. Mounting Bracket
13. Clamping Ring
14. Clamp-Ring Capscrew
15. Hold-Down Assembly

Fig. 1, Luber-finer Model 750-CT Bypass Oil Filter

IMPORTANT: Do the following procedure at every scheduled engine oil change. Refer to the engine maintenance manual for the quantity of oil that must be added to the lubrication system when replacing the bypass filter.

1. Remove the old filter element.
   1.1 Loosen the vent plug capscrew, then open the drain cock and allow the oil to drain.
   1.2 Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.
   1.3 Unscrew the hold-down assembly T-handle and remove the assembly from the housing.
   1.4 Remove and discard the oil filter element.
2. Clean the inside of the housing, and the hold-down assembly, with solvent.
3. Assemble the filter.
   3.1 Close the drain cock.
   3.2 Install a new filter element.
   3.3 Check the cover gasket for damage, and replace it if needed.
   3.4 Install the hold-down assembly and securely tighten the T-handle.
   3.5 Position the cover on the housing. Install the clamp ring and capscrews. Alternately tighten the clamp capscrews to ensure a uniform seal between the cover and gasket.
   3.6 Add oil to the crankcase, then start the engine and let it idle until normal operating oil pressure is reached.
   3.7 Loosen the vent plug capscrew and bleed any trapped air from the filter housing. Tighten the vent plug capscrew as soon as oil appears at the fitting.

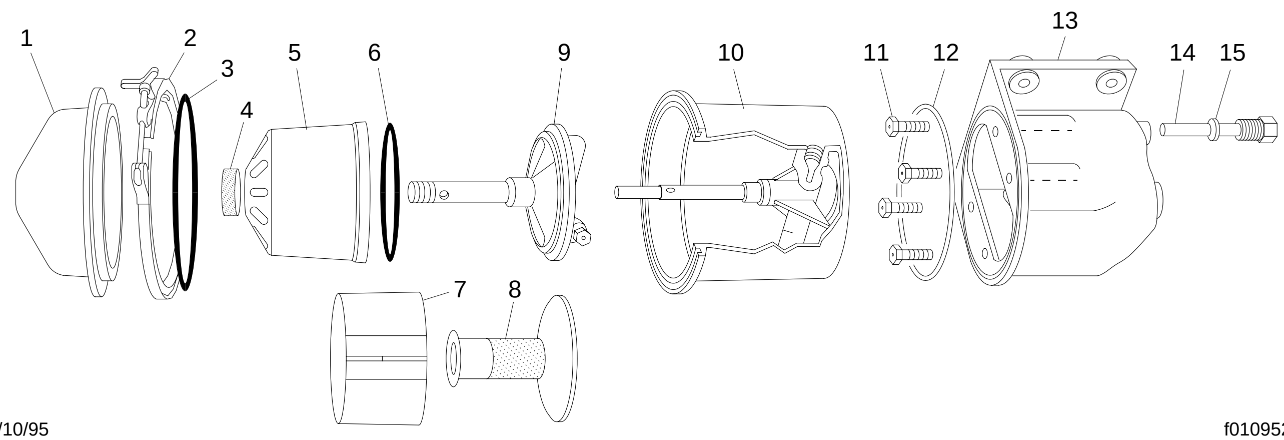
CAUTION

Make sure the engine oil level is correct. Operating the engine with the oil level below the low ("L") mark, or above the high mark, could result in engine damage.

4. Shut down the engine and add oil as needed to bring the oil level up to the high ("H") mark on the dipstick.

Centrifuge Bowl Cleaning, Spinner II

Cleaning (See Fig. 1)



1. Cover
2. Clamp
3. Cover Seal
4. Nut, Centrifuge Bowl
5. Centrifuge Bowl
6. Seal, Centrifuge Bowl
7. Paper Insert
8. Baffle/Screen
9. Centrifuge Turbine
10. Housing Assembly
11. Capscrew, M10 x 35 mm
12. Seal, Control Mechanism
13. Control Mechanism
14. Air Valve Cartridge Assembly
15. Seal, Air Valve Cartridge

Fig. 1, Spinner II Bypass Oil Filter

IMPORTANT: Do the following procedure at every scheduled engine oil change. Refer to the engine maintenance manual for the quantity of oil that must be added to the lubrication system when replacing the bypass filter.

1. Clean the centrifuge bowl.

 1.1 Shut off the engine, and let the centrifuge turbine assembly come to a complete stop.

 1.2 Loosen the handle on the clamp, disengage the tee bolt and remove the cover, using a coin in the gap to separate the cover from the housing.

 1.3 Partially withdraw the centrifuge turbine assembly from the housing and allow oil to drain from the nozzles before removing the assembly completely.

 1.4 Hold the centrifuge turbine assembly in one hand and loosen the knurled nut several turns until the face of the nut projects beyond the bronze bushing face.

 1.5 Carefully separate the centrifuge bowl from the turbine base by striking the face of the nut with the palm of one hand while holding the bowl in the other. *Do not strike the nut or the bushing with or against a hard surface or you will damage them.* Finish removing the nut and then remove the bowl and baffle/screen.

 1.6 Replace the dirty centrifuge bowl with a new one, or carefully remove the cake of dirt from the bowl with a wooden spatula or other non-damaging tool. Wipe out the bowl with solvent

NOTE: To save time cleaning the bowl, an optional die-cut Bristol paper insert is available for lining the bowl so the compressed cake of dirt can be removed quickly.

 1.7 Wash the baffle/screen and turbine base, removing and discarding the black Nitrile bowl seal.

2. Inspect and assemble the centrifuge turbine assembly.

 2.1 Inspect the top and bottom bushings of the centrifuge turbine base, and replace the turbine assembly if the bushings show severe wear.

Centrifuge Bowl Cleaning, Spinner II

2.2 Place the baffle/screen over the stem of the turbine base and seat the baffle/screen evenly over the shoulder on the base.

2.3 Install the bowl seal in the recess in the outer edge of the turbine base.

2.4 Slide a new centrifuge bowl over the stem and seat it uniformly over the bowl seal.

2.5 Install and tighten the knurled bowl nut securely, *using finger pressure only.*

3. Clean and inspect the oil filter housing.

3.1 Inspect the housing assembly, paying special attention to the journal areas of the spindle.

3.2 Clean and inspect the cover.

3.3 Remove the old cover seal, and clean the groove in the housing and the mating surface of the cover.

3.4 Replace the cover seal with a new black Nitrile seal.

4. Check the air valve control mechanism. See **Fig. 2**.

4.1 Make a hook out of stiff wire, according to the measurements in **Fig. 2**.

4.2 Insert the hook at the spot shown in **Fig. 2**, and hook the float arm.

Lifting the float should release air into the filter housing.

Lowering the float should stop the flow of air into the filter housing.

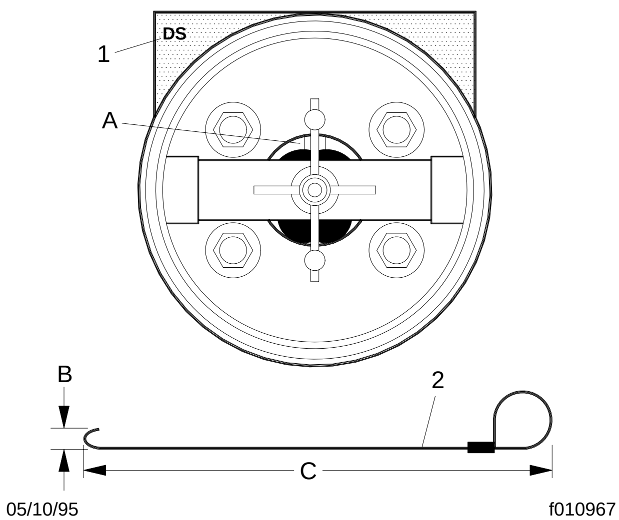
5. Install the centrifuge turbine assembly.

5.1 Install the centrifuge turbine assembly, and make sure it rotates freely.

5.2 Replace the cover, and position the clamp uniformly over the cover and housing flanges.

5.3 Tighten the clamp handle securely *by hand pressure only.*

6. With the engine running, check all the oil filter connections and joints for leaks.



NOTE: This is a view, downward into the housing assembly, with the centrifuge turbine assembly removed.

A. Use the hook at this point to hook the float arm.
B. 3/8 Inch (10 mm)
C. 9 Inches (229 mm)

1. Manufacturer Date Code
2. Hook

Fig. 2, Check The Air Valve

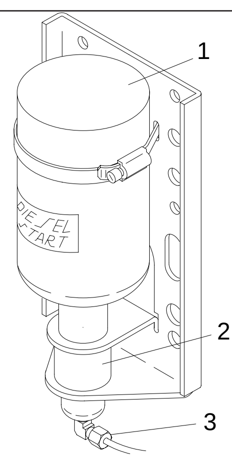
General Information

During cold weather starts, the KBi starting fluid system injects vaporized ether into the engine manifold to help ignite the diesel fuel in the cylinders. The diesel normally ignites on the compression stroke of each piston, when the compressed air within the cylinder reaches about 725°F (385°C). However, during cold weather starts, the heat of the compressed air dissipates into the surrounding engine block so the diesel may never reach the temperature it needs to ignite. Ether ignites at 360°F (182°C). Therefore, ether vapor injected with the engine intake air ignites at the lower cylinder temperature, and the burning ether ignites the diesel.

Using the starting fluid system reduces the necessary cranking time in cold weather, and it prevents excessive wear on the battery and starter.

When the engine is cold, the KBi system begins injecting ether when the starter is cranked. The system continues injecting ether vapor into the manifold for a short time to prevent stalling. The system consists of the starting fluid cylinder, the ether injection nozzle in the engine manifold, and the engine temperature sensor.

The starting fluid cylinder (**Fig. 1**) is mounted on the frame rail. It fits into the Dieselmatic® valve and Blockor® fitting that measure, hold, and release a controlled amount of fluid for each start attempt.



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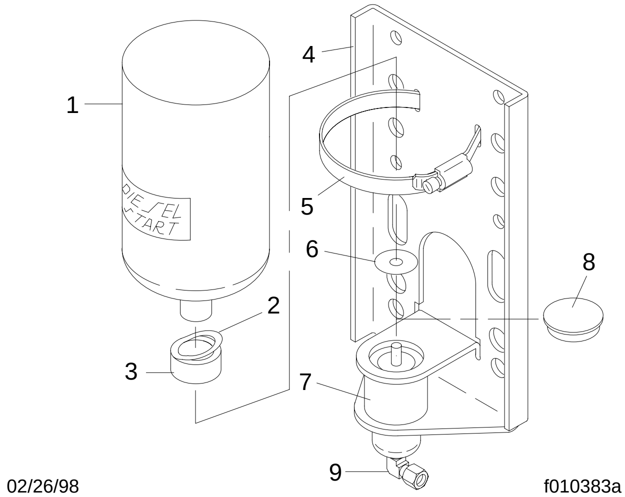
1. Starting Fluid Cylinder
2. Dieselmatic Valve
3. Blockor Fitting

Fig. 1, KBi Ether Start System

Ether travels through plastic tubing to the engine manifold where it sprays through the injection nozzle into the engine intake air. Inside the manifold, vaporized ether fills the cylinders and ignites.

If the weather is warm, or the engine is already warmed, the engine temperature sensor mounted in the engine water jacket prevents the KBi from injecting ether vapor. The system will inject ether only if the engine is cooler than about 40°F (4°C).

Replacement (See Fig. 1)



1. Starting Fluid Cylinder
2. Paper Backing
3. Dirt Eliminator Collar
4. Mounting Plate
5. Cylinder Clamp
6. Valve Gasket
7. Dieselmatic Valve
8. Valve Cap
9. Blockor Fitting

Fig. 1, KBi Ether Start System

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

WARNING

Service starting fluid systems only in a well-ventilated area away from sparks and open flames. The ethyl ether in these systems is flammable and toxic. Wear protective gloves and glasses, and avoid breathing ether fumes. Failure to take these precautions could result in personal injury or property damage.

3. Remove the old cylinder.
   - 3.1 Clean all dirt from the neck of the cylinder and the top of the Dieselmatic® valve before removing the cylinder.
   - 3.2 Loosen the cylinder clamp.
   - 3.3 Pry the dirt eliminator collar off the neck of the cylinder.
   - 3.4 Unscrew the cylinder from the Dieselmatic valve.

NOTE: If not replacing the cylinder immediately, place the valve cap in the valve to prevent dirt or other debris from entering the system.

4. Remove the old dirt eliminator collar from the valve assembly.
5. Replace the Dieselmatic valve gasket. Spread the new gasket with a light film of clean oil.
6. Place a new dirt eliminator collar, adhesive-side up, on the valve assembly. Peel off the collar's paper backing to expose the adhesive.
7. Install the new cylinder.
   - 7.1 Place the new cylinder into the Dieselmatic valve and hand tighten it firmly.
   - 7.2 Slide the dirt eliminator collar up so it sticks to the cylinder.
   - 7.3 Tighten the clamp around the cylinder 60 lbf·in (680 N·cm).
8. If the ambient temperature is below 40°F (4°C), test the starting fuel system.
9. Lower the hood, and remove the chocks from the tires.

Troubleshooting

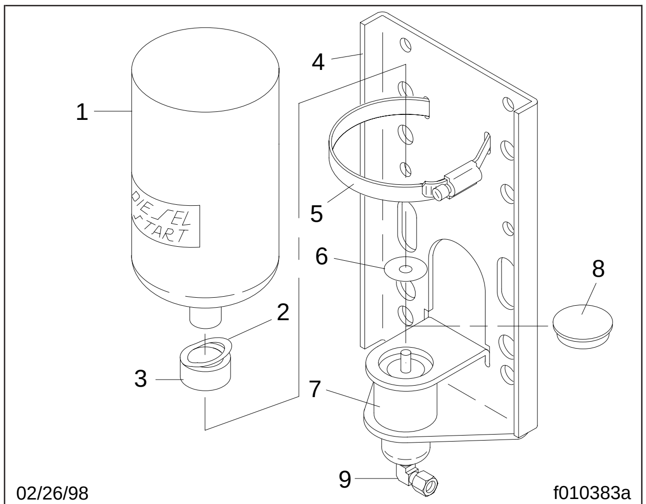
Use the following procedures to check for most common problems that may prevent starting fluid delivery.

WARNING

Service starting fluid systems only in a well-ventilated area away from sparks and open flames. The ethyl ether in these systems is flammable and toxic. Wear protective gloves and glasses, and avoid breathing ether fumes. Failure to take these precautions could result in personal injury or property damage.

EMPTY FLUID CYLINDER (See Fig. 1)

1. Remove the old cylinder.
   1.1 Clean all dirt from the neck of the cylinder and the top of the Dieselmatic® valve before removing the cylinder.
   1.2 Loosen the cylinder clamp.



1. Starting Fluid Cylinder
2. Paper Backing
3. Dirt Eliminator Collar
4. Mounting Plate
5. Cylinder Clamp
6. Valve Gasket
7. Dieselmatic Valve
8. Valve Cap
9. Blockor Fitting

Fig. 1, KBi Ether Start System

   1.3 Pry the dirt eliminator collar off the neck of the cylinder.
   1.4 Unscrew the cylinder from the Dieselmatic valve.
   1.5 Remove the cylinder from the mounting plate. Cover the top of the valve after the cylinder is removed.
   1.6 Remove the old dirt eliminator collar from the valve assembly.
2. Weigh the cylinder to see if it is empty. See Table 1 for the weight of each cylinder size.

Ether Cylinder Weights		
Cylinder Size: oz (g)	**Weight**	
	Empty: oz (g)	**Full: oz (g)**
21 (595)	16 (455)	37 (1050)
18 (510)	15 (425)	33 (935)
8 (225)	10 (285)	18 (510)

Table 1, Ether Cylinder Weights

3. Replace the Dieselmatic valve gasket. Spread the new gasket with a light film of clean oil.
4. Check that the fluid cylinder has at least 120 psi pressure at 68°F (20°C).
5. If the cylinder is good, install it; if not, replace it.
   5.1 Place a new dirt eliminator collar, adhesive-side up, on the valve assembly. Peel off the collar's paper backing to expose the adhesive.
   5.2 Place the new cylinder into the Dieselmatic valve and hand-tighten it firmly.
   5.3 Slide the dirt eliminator collar up so it sticks to the cylinder.
   5.4 Tighten the clamp around the cylinder 60 lbf·in (680 N·cm).

ELECTRICAL PROBLEMS

1. Check for a blown fuse, and for loose wiring connections, shorts, and broken wires.
2. Check that the black ground wire from the valve assembly is connected to the engine temperature sensor, and that the ground wire from the sensor is connected to a good ground.

Troubleshooting

3. Check that the second wire from the valve assembly is connected to the "M" terminal of the starter.

WARNING

When testing the starting fluid system, wear protective gloves and glasses, and spray the vaporized ether into a container. Failure to do so could result in personal injury.

4. Test the valve.
   - 4.1 Remove the starting fluid cylinder.
   - 4.2 If the ambient air temperature is over 40°F (4°C), remove the black ground wire from the engine temperature sensor, and ground it.
   - 4.3 Crank the starter, and look for the valve plunger (see **Fig. 2**) to move up and stay up while the starter is cranked.

CAUTION

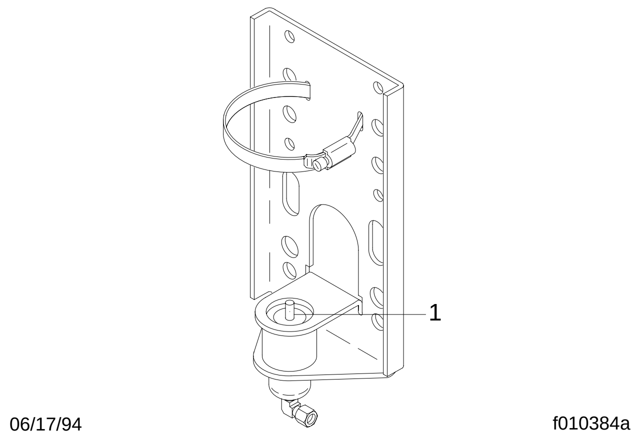
Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

5. If the plunger does not move, disconnect both valve assembly wires and momentarily touch the leads across battery terminals. If the valve plunger still does not move up, replace the valve.
6. If the valve operates correctly, check the engine temperature sensor.
   - 6.1 Connect the appropriate wire to the "M" terminal of the starter.
   - 6.2 Remove the sensor from the engine water jacket, and chill it to below freezing for at least ten minutes.
   - 6.3 Install the sensor, grounding it at a good ground.
   - 6.4 Connect the black ground wire from the valve assembly to the sensor.
   - 6.5 Crank the engine, and look for the valve plunger to move up and stay up while the starter is cranked.

CAUTION

Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

7. If the plunger does not move, replace the sensor.



1. Plunger

Fig. 2, Valve Plunger

CLOGGED ETHER NOZZLE

1. Disconnect the ether tubing from the nozzle, and cover the nozzle fitting.
2. Disconnect the black ground wire from the engine temperature sensor, and ground it.

WARNING

When testing the starting fluid system, wear protective gloves and glasses, and spray the vaporized ether into a container. Failure to do so could result in personal injury.

3. Start the engine, and look for ether to spray from the tubing.

CAUTION

Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

4. If no ether sprays from the tubing, disconnect the tubing at the Blockor® fitting in the base of the cylinder assembly. See **Fig. 1**.

5. Start the engine, and look for ether to spray from the Blockor fitting in the base of the cylinder assembly.

CAUTION

Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

6. If ether sprays from the fitting, but not from the tubing, check for kinks or blockages in the ether tubing and the nozzle. Repair or replace the tubing and nozzle, as needed.

   If no ether sprays from the fitting or tubing, check the Blockor fitting for blockages. Repair or replace the fitting, as needed.

Specifications

Description	Torque: lbf·in (N·cm)
Cylinder Clamp	60 (680)

Table 1, Ether System Torques

General Information

Jacobs engine brake housings are installed on the engine rocker housings. Model 760A (used on Detroit Diesel Series 60 11.1-liter engines) and Model 765 (used on Detroit Diesel Series 60 12.7-liter engines) have three engine brake housings that operate two cylinders each. Each engine brake housing has a solenoid valve, control valves, ball check valves, master pistons, and slave pistons. See **Fig. 1**.

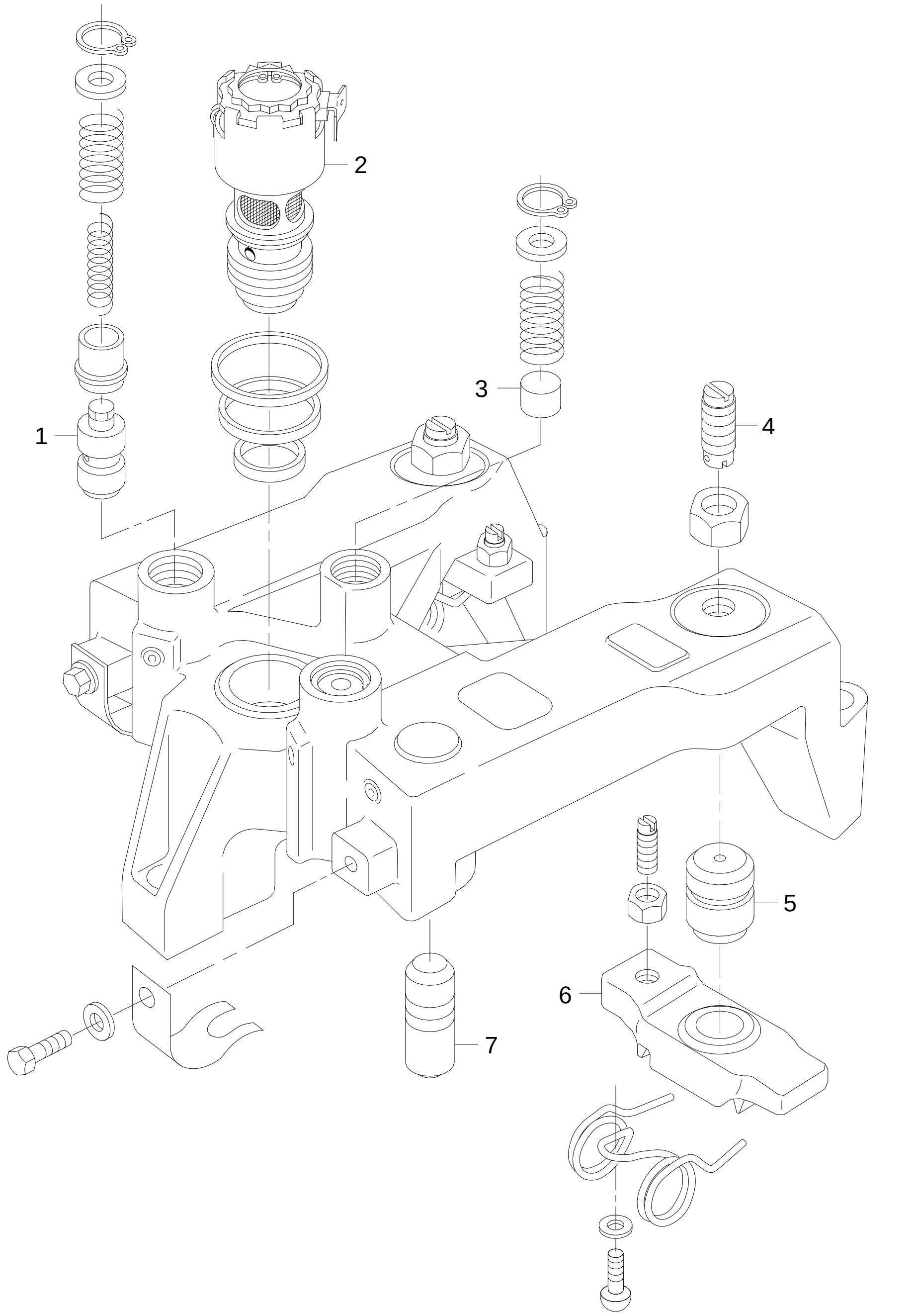
Engine brake controls consist of: dash switches and a clutch switch. The clutch switch is mounted under the dash. The engine brake is activated when the dash switches are on and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully.

The engine brake can be operated at one-third, two-thirds, or full capacity (two, four, or six cylinders).

When activated, the engine brake converts a power-producing diesel engine to a power-absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (see **Fig. 2**):

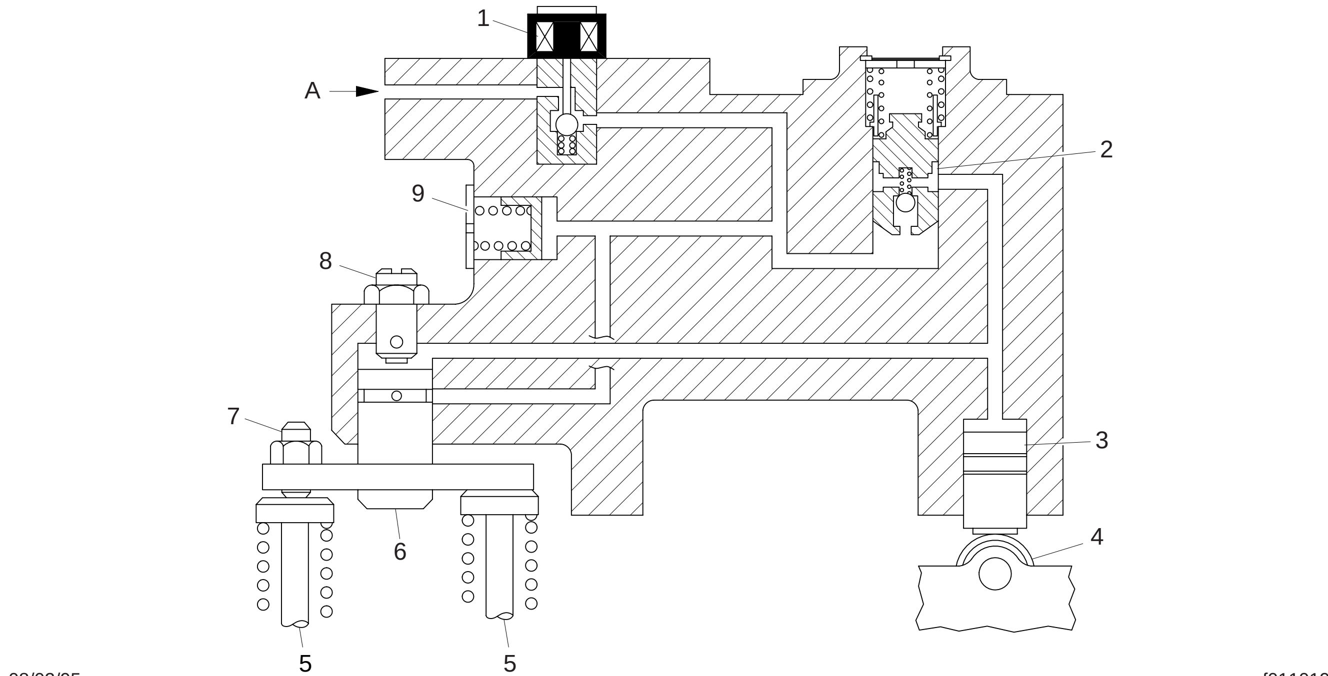
1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm roller.
3. The injector rocker arm begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. At the bottom of its stroke the slave piston separates from the valve in the slave piston reset adjusting screw, allowing high-pressure oil to flow into the accumulator. This reduces the pressure in the high-pressure circuit, permitting the slave piston to retract and the exhaust valves to close in preparation for the normal exhaust valve cycle. The oil pressure reserved in the accumulator ensures that the hydraulic circuit is fully charged for the next cycle.
6. Compressed air escapes to the atmosphere completing a compression braking cycle.

General Information



1. Control Valve
2. Solenoid Valve
3. Accumulator Piston
4. Slave Piston Adjusting Screw (Reset)
5. Slave Piston
6. Bridge
7. Master Piston

Fig. 1, Model 760A or 765 Housing Assembly (exploded view)



A. Oil In

1. Solenoid Valve
2. Control Valve
3. Master Piston
4. Injector Pin and Roller
5. Exhaust Valve
6. Slave Piston Assembly
7. Leveling Screw
8. Slave Piston Adjusting Screw (Reset)
9. Accumulator

Fig. 2, Cross-Section View of Engine Brake Housing

Accumulator Removal, Inspection, and Installation

Removal

⚠ WARNING

The accumulator spring is under strong compression. Be careful when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally released, personal injury could result.

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 130**.
2. Push down on the accumulator cover and remove the retaining ring. See **Fig. 1**.

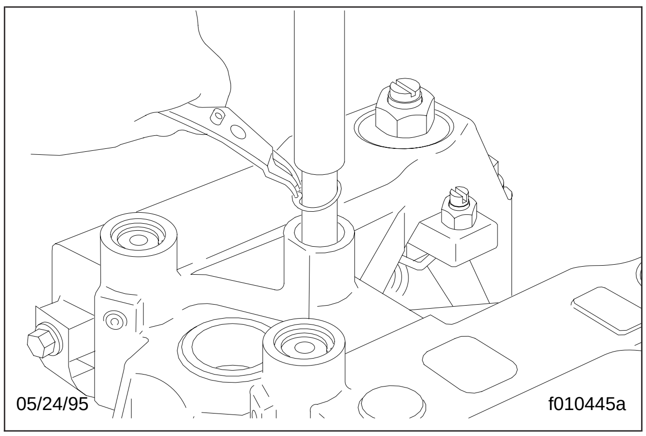


Fig. 1, Remove the Retaining Ring

3. Remove the cover and spring. See **Fig. 2**.

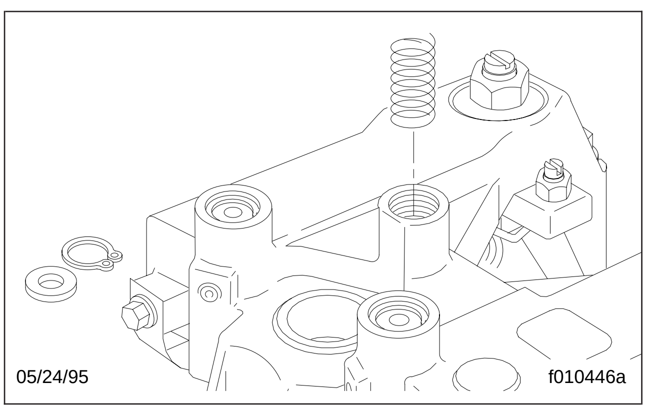


Fig. 2, Remove the Spring

4. Using a magnet, remove the piston from the accumulator bore. See **Fig. 3**.

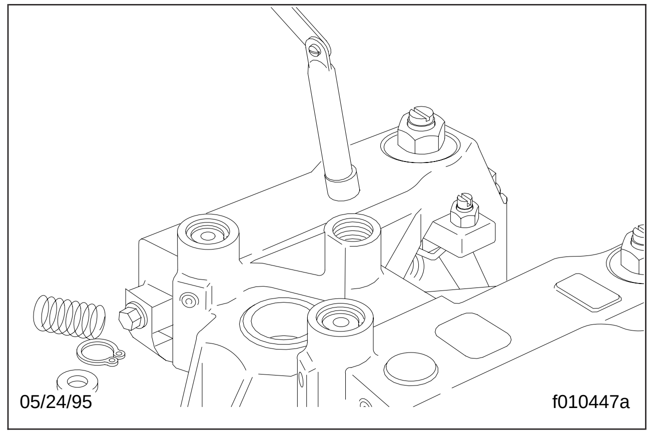


Fig. 3, Remove the Piston

Inspection

Inspect the parts for wear and damage. Replace parts as needed.

Installation

1. Install the piston, spring, cover, and retaining ring.
2. Install the engine brake housing. For instructions, refer to **Subject 130**.

Solenoid Valve Removal and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Tilt the hood.
4. Wipe the engine brake housing area clean, and remove the valve cover. For instructions, refer to the engine manufacturer's service literature.
5. Disconnect the solenoid harness.
6. Using a 7/8-inch socket and extension, unscrew the solenoid valve. See **Fig. 1**.

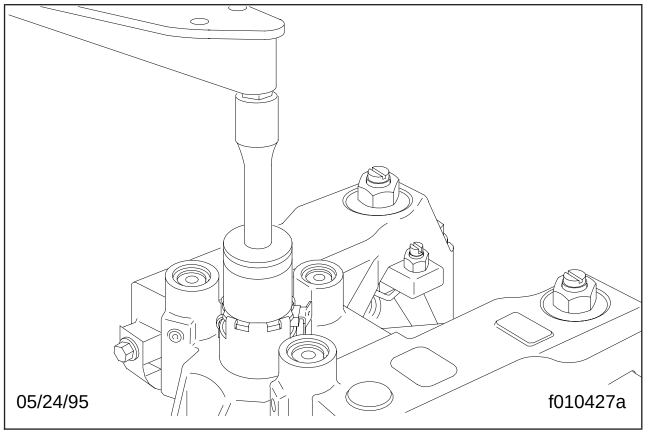
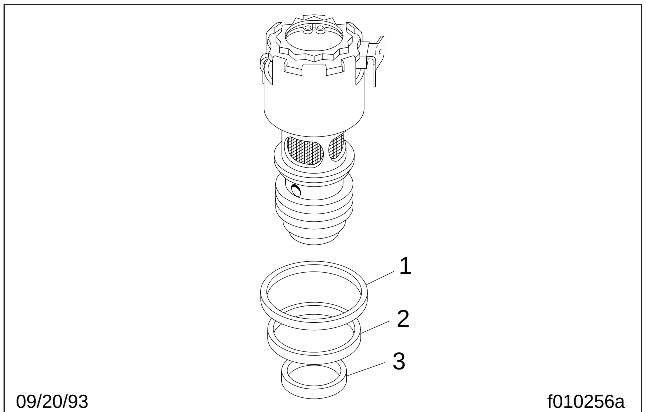


Fig. 1, Unscrew the Solenoid Valve

CAUTION

Do not disassemble or tamper with the solenoid valve. Engine damage could result.

7. Remove and discard the three rubber seal rings. See **Fig. 2**. If the lower ring stays in the bottom of the solenoid bore in the housing, remove it with a piece of wire.
8. Wash out the solenoid valve with a cleaning solvent that meets OSHA guidlines. Use a brush to clean the oil screen.
9. Dry the valve with compressed air.
10. Using clean paper towels, clean out the solenoid valve bore in the housing. Do not use rags, since they can leave lint and residue, which can plug the oil passageways.



1. Upper Seal Ring
2. Center Seal Ring
3. Lower Seal Ring

Fig. 2, Solenoid Seal Rings

Installation

1. Coat a new set of solenoid seal rings with clean lubricating oil. Install the upper and middle seal rings on the solenoid body and the lower seal ring into the bottom of the solenoid bore in the housing. See **Fig. 3**.

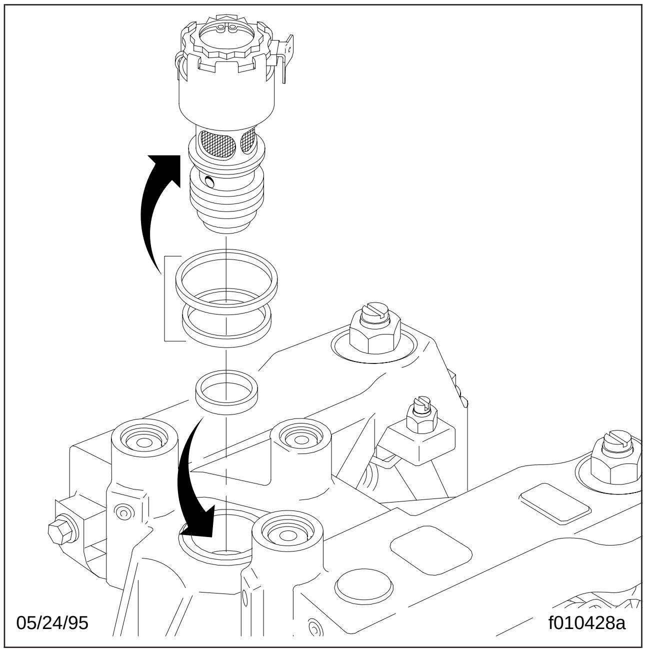


Fig. 3, Install the Seal Rings

Solenoid Valve Removal and Installation

2. Make sure the seals are seated properly and not twisted. Carefully screw the solenoid into the housing without unseating the seals.
3. Tighten the valve to the torque shown on the top of the solenoid.
4. Connect the solenoid harness.
5. Install the valve cover. For instructions, refer to the engine manufacturer’s service literature.
6. Close the hood, connect the batteries, and remove the chocks from the tires.

Control Valve Removal, Inspection, and Installation

Removal

⚠ WARNING

Never remove any engine brake component with the engine running. Hot oil spray may cause personal injury.

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Tilt the hood.
4. Wipe the engine brake housing area clean, and remove the valve cover. For instructions, refer to the engine manufacturer's service literature.
5. Press down on the control valve cover to relieve spring pressure. See **Fig. 1**.

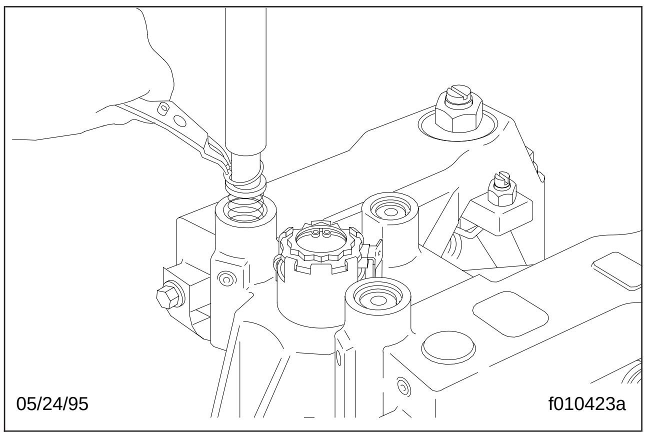


Fig. 1, Press the Control Valve Cover

6. Remove the retaining ring using retaining ring pliers.
7. Slowly remove the cover until the spring pressure is released; then, remove the two control valve springs and the collar. See **Fig. 2**.
8. Using needle nose pliers, reach into the housing bore and grasp the stem of the control valve. Remove the control valve. See **Fig. 3**.

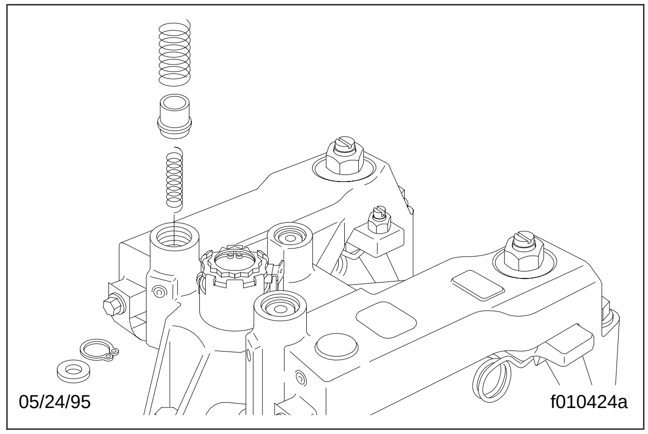


Fig. 2, Remove the Springs and the Collar

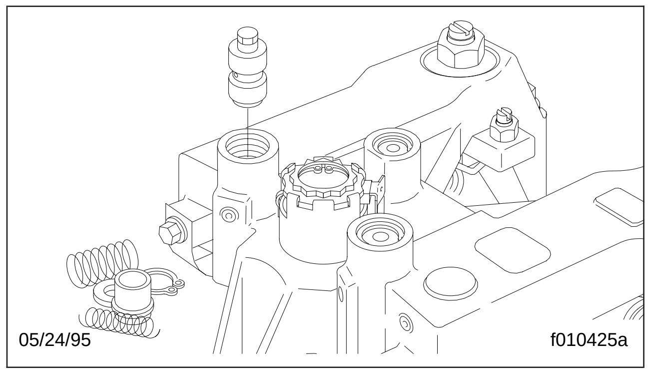


Fig. 3, Remove the Control Valve

Inspection

1. Wash the control valves with a cleaning solvent that meets OSHA guidelines.
2. Push a wire through the hole in the base of the valve to make sure the ball check is free. The ball should lift with light pressure on the wire.
3. Dry the valve with compressed air and wipe it clean with a paper towel.
4. Using clean paper towels, thoroughly clean the control valve bore in the housing.
5. Dip the control valves in clean lubricating oil. Holding the valve by the stem, let the valve drop into its bore. If it binds or if the ball is stuck in the valve, replace the control valve.

Installation

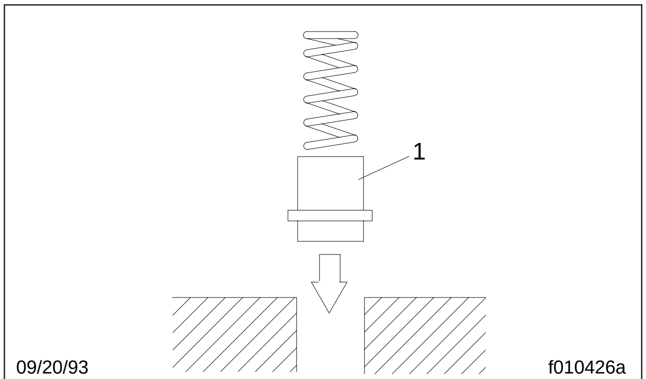
IMPORTANT: Be sure to coat all parts with clean lubricating oil before installing them.

1. Install the control valve reversing the removal procedure.

Control Valve Removal, Inspection, and Installation

NOTE: Make sure the control valve collar is installed with the longer sleeve area up. See **Fig. 4**. If the collar is installed upside down, the engine brake cylinder will not operate.

2. Make sure the retaining ring ears are rotated 90 degrees after installation.



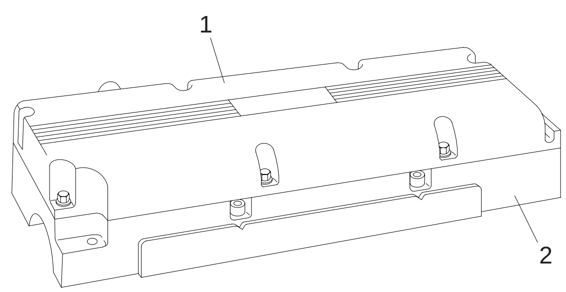
1. Longer Sleeve Area Up

Fig. 4, Check the Valve Collar

3. Install the valve cover. For instructions, refer to the engine manufacturer's service literature.
4. Close the hood, connect the batteries, and remove the chocks from the tires.

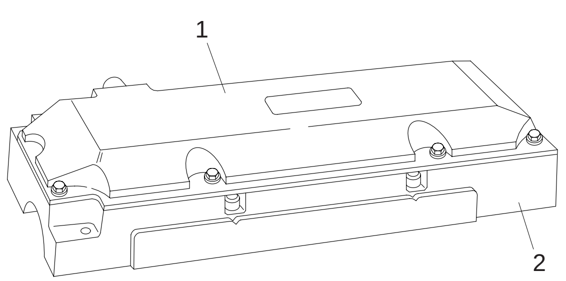
Removal

NOTE: The engine brake has been designed to fit on the Series 60 engine with no additional valve cover spacers. On engines equipped with aluminum valve cover caps (**Fig. 1** and **Fig. 2**), it is not necessary to remove the valve cover bases to remove and install the engine brake housings.



1. Valve Cover Cap, Aluminum Style 1
2. Valve Cover Base

Fig. 1, Valve Cover Cap and Base (Style 1)



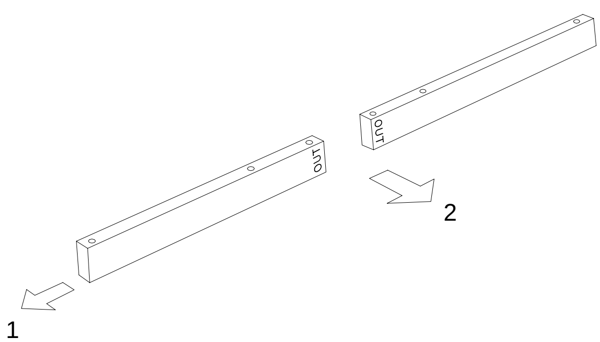
1. Valve Cover Cap, Aluminum (Style 2)
2. Valve Cover Base

Fig. 2, Valve Cover Cap and Base (Style 2)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Disconnect the batteries.
4. Remove each valve cover and gasket.
5. Remove the engine brake housing hold-down capscrews. There is one capscrew per housing on the camshaft side of the engine. There are two capscrews per housing on the exhaust manifold side of the engine.
6. Remove the spacer bar between the exhaust side of each head and each engine brake housing mounting pad.
7. Lift each engine brake housing off the rocker shaft.

Installation

1. Place the spacer bars between the cylinder head and the engine brake mounting pads on the exhaust manifold side of the head. See **Fig. 3** and **Fig. 4**.



1. Rear
2. Exhaust Manifold

Fig. 3, Spacer Bar Positions

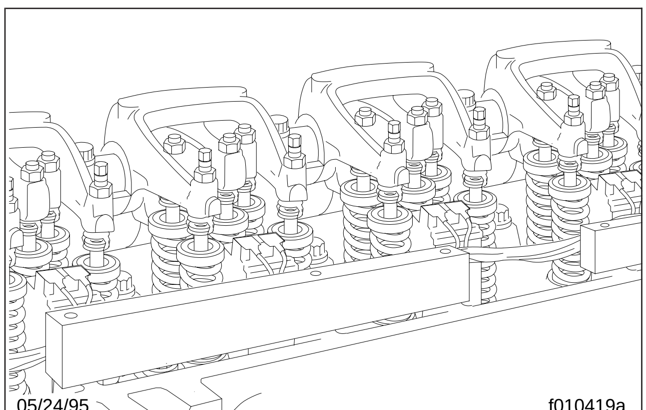


Fig. 4, Spacer Bar Placement

Engine Brake Housing Removal and Installation

2. Place each engine brake housing over the rocker shaft with the solenoid valves toward the camshaft side of the engine. Make sure the housings don’t interfere with the wiring harness.
3. Apply "Never Seize" to the threads and underside of the head of the housing hold-down capscrews.
4. Install a 4-3/8 inch (110 mm) long capscrew and its washer into each engine brake housing. See **Fig. 5** and **Fig. 6**. There are three capscrews per housing.

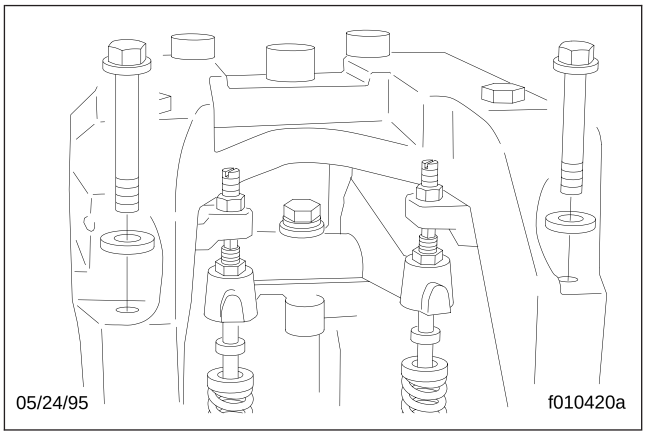


Fig. 5, Capscrews on the Exhaust Manifold Side

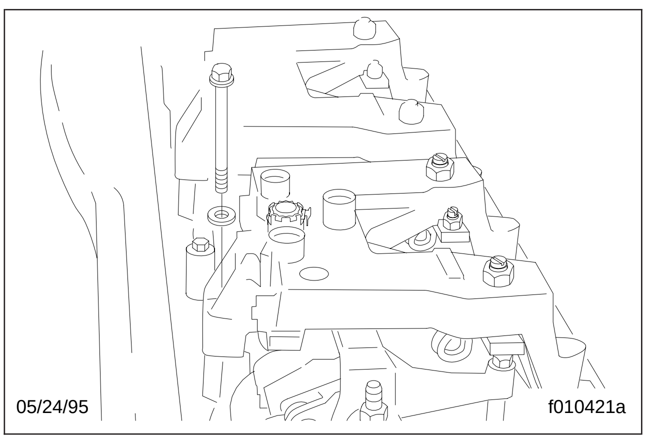


Fig. 6, Capscrew on the Camshaft Side

5. Before tightening the engine brake hold-down capscrew, move the housing from side to side, and then locate the housing in the center of the range. See **Fig. 7**.

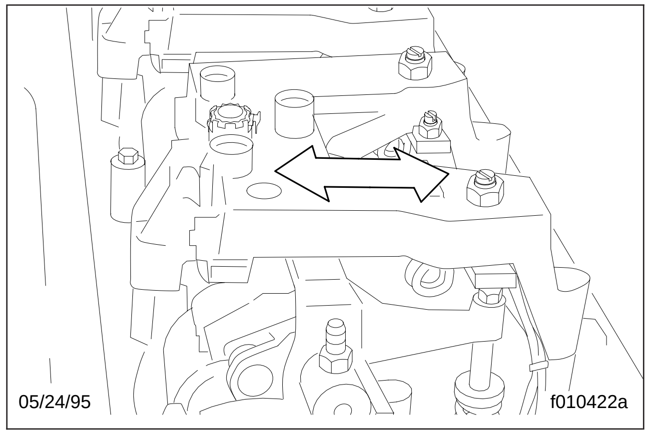


Fig. 7, Center the Housing

6. Tighten the engine brake housing hold-down capscrews.
   - 6.1 Tighten the three capscrews on the camshaft side of the engine 40 lbf·ft (55 N·m).
   - 6.2 Tighten the six capscrews on the exhaust manifold side of the engine 40 lbf·ft (55 N·m).
   - 6.3 In the same sequence, tighten all capscrews 100 lbf·ft (135 N·m).
7. Using plastic ties, secure the wiring harnesses to the spacer bars.
8. Adjust the slave piston lash. For instructions, refer to **Subject 150**.
9. Install the valve covers. For instructions, refer to the engine manufacturer’s service manual.
10. Close the hood, connect the batteries, and remove the chocks from the tires.

Master Piston Removal, Inspection, and Installation

Removal

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 130.**
2. Remove the screw, washer, and master piston spring from the housing. See **Fig. 1**.

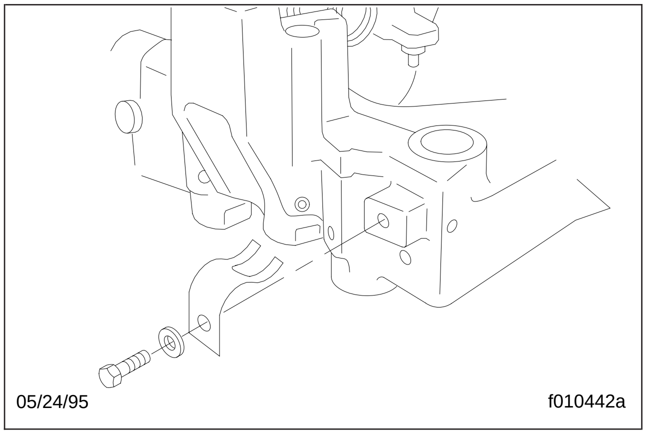


Fig. 1, Remove the Master Piston Spring

3. Using needle nose pliers if necessary, pull out the master piston. See **Fig. 2**.

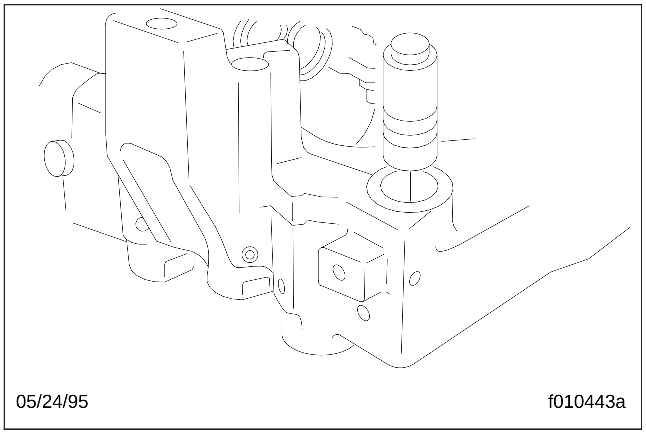


Fig. 2, Remove the Master Piston

Inspection

1. Clean the piston in a cleaning solvent.
2. Inspect the piston for excessive wear and for damage. Replace the piston if necessary.

Installation

1. Install the master piston, spring, washer, and screw in the housing. See **Fig. 3**.

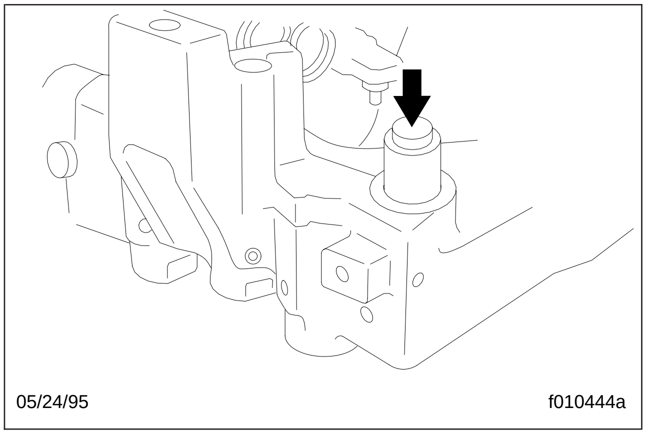


Fig. 3, Install the Master Piston

NOTE: Make sure the spring legs are centered around the master piston boss.

2. Tighten the screw 100 lbf·in (1120 N·cm).
3. Install the engine brake housing on the vehicle. For instructions, refer to **Subject 130**.
4. Reset the engine brake lash. For instructions, refer to **Subject 160**.

Slave Piston Adjusting Screw (Power-Lash®) Removal, Inspection, and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Tilt the hood.
4. Wipe the engine brake housing area clean, and remove the valve cover. For instructions, refer to the engine manufacturer's service literature.
5. Loosen the slave piston adjusting screw locknut and remove the adjusting screw from the housing. See **Fig. 1**.

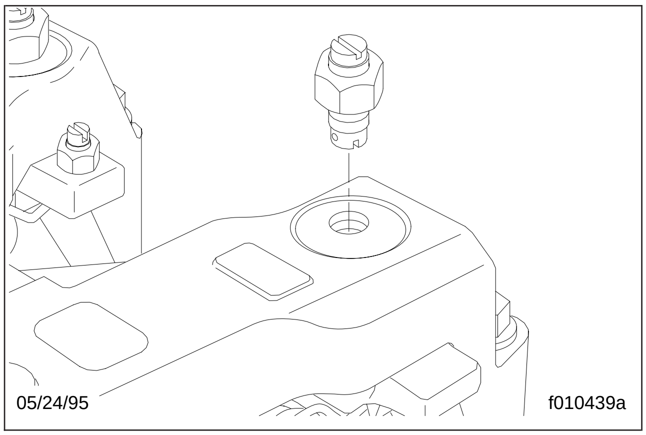


Fig. 1, Remove the Adjusting Screw

Inspection

1. Clean the adjusting screw in cleaning solvent.
2. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw. There should be light spring pressure when the plunger is depressed, and the plunger should move freely. See **Fig. 2**. Be sure the retaining ring is fully engaged in its groove. If any defect is found, replace the entire screw assembly.

CAUTION

Do not disassemble or tamper with the slave piston adjusting screw assembly. Engine damage could result.

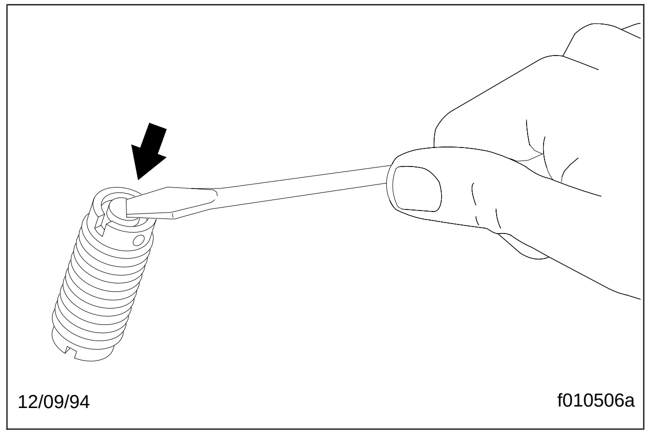


Fig. 2, Check the Plunger

Installation

1. Screw the slave piston adjusting screw into the housing.
2. Reset the engine brake lash. For instructions, refer to **Subject 160**.

Slave Piston Removal, Inspection, Installation, and Adjusting

Removal

1. Remove the engine brake housing from the vehicle using the instructions in **Subject 130**.
2. Remove the screw and spring that retain the slave piston assembly. See **Fig. 1**.

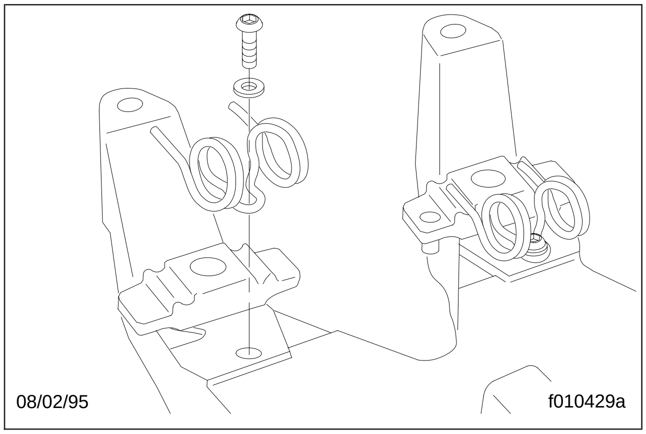


Fig. 1, Remove the Screw and Spring

3. Remove the bridge and the slave piston. See **Fig. 2**.

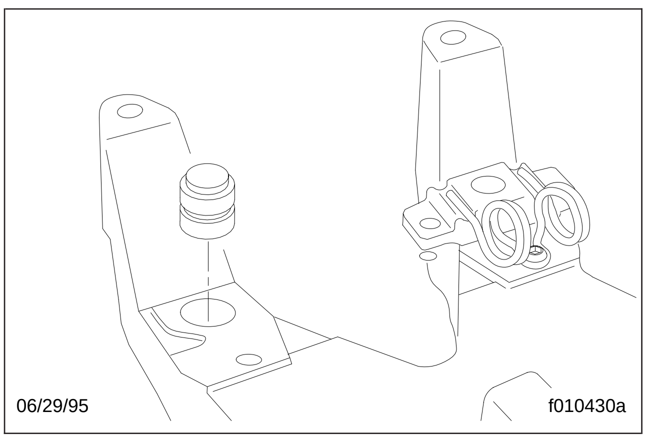


Fig. 2, Remove the Slave Piston

4. Loosen the leveling screw locknut and remove the leveling screw from the bridge. See **Fig. 3**.

Inspection

1. Inspect all components for excessive wear and for damage.
2. Replace parts as needed.

Installation

1. Install the leveling screw in the bridge. See **Fig. 3**. Tighten the locknut 25 lbf·ft (35 N·m).

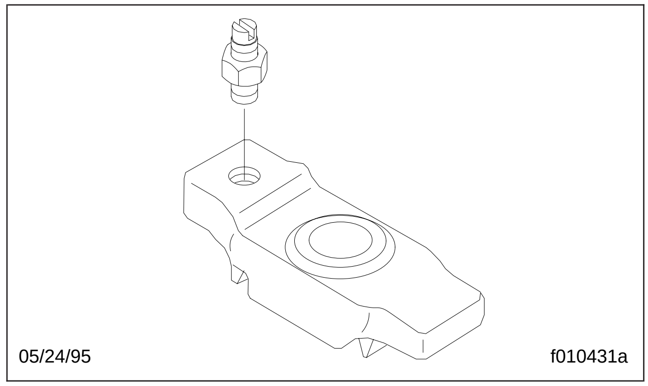


Fig. 3, Remove the Leveling Screw

2. Install the slave piston and the bridge with the leveling screw toward the center of the housing. See **Fig. 4**.

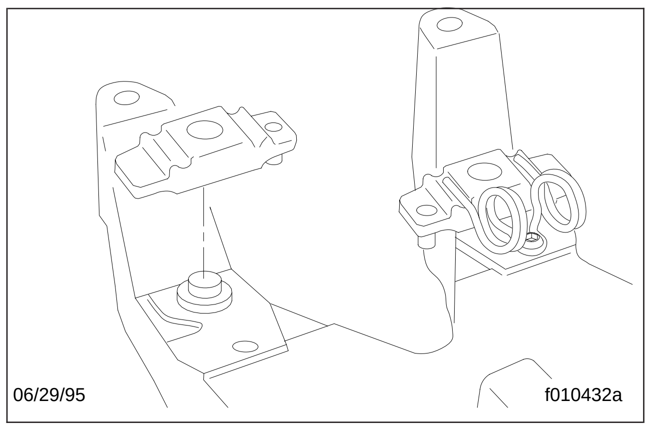


Fig. 4, Install the Slave Piston and Bridge

3. Install the slave piston assembly retaining spring with the ends over the bridge. See **Fig. 5**.
4. Install the screw over the center part of the spring. Tighten the screw 15 lbf·ft (20 N·m).
5. Install the engine brake housing on the engine using the instructions in **Subject 130**.

Slave Piston Removal, Inspection, Installation, and Adjusting

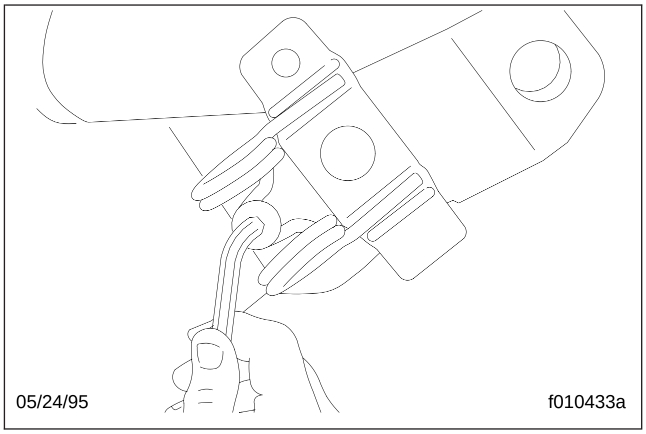


Fig. 5, Install the Retaining Spring

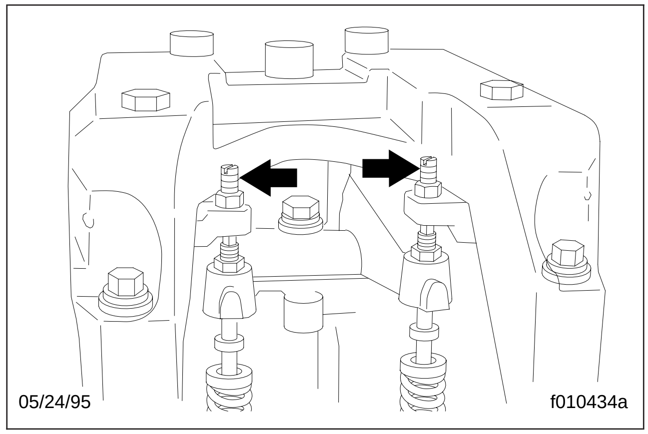


Fig. 6, Back Out the Leveling Screw

Adjusting

CAUTION

Follow the slave piston adjustment procedure exactly. Failure to use the correct adjustment procedure will result in poor engine brake performance and serious engine damage.

NOTE: Make the following adjustment with the engine stopped and the oil temperature 140°F (60°C) or lower. Rotate the engine until the exhaust valves on the cylinder to be adjusted are closed (rocker arm is loose).

1. Back out the *leveling screw* in the slave piston assembly until the end of the screw is beneath the surface of the bridge in the slave piston assembly. See **Fig. 6**.

NOTE: The leveling screw is the screw located in the bridge member of the slave piston assembly.

2. Place the correct feeler gauge between the solid side of the *bridge* (the side without the leveling screw) and the exhaust rocker arm adjusting screw. See **Fig. 7**. See **Table 1** for the correct feeler gauge.

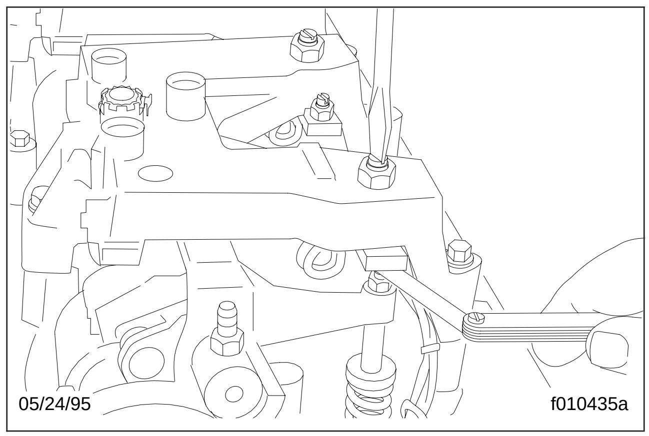


Fig. 7, Check With the Feeler Gauge

Engine Model (Displacement)	Feeler Gauge inches (mm)
12.7 liter 11.1 liter	0.026 (0.6)

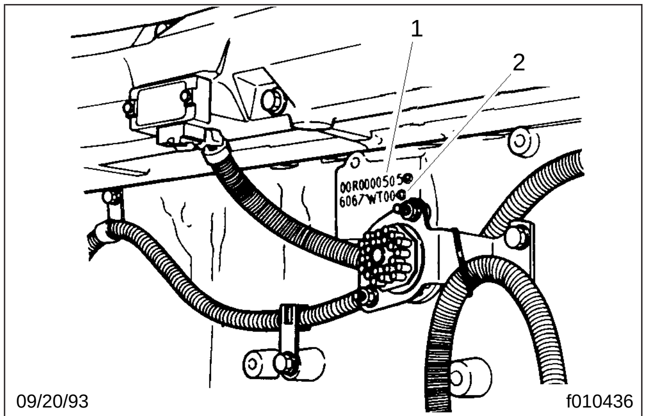
Table 1, Feeler Gauges

NOTE: A "G" in position 5 of the model number indicates a 12.7 liter engine; "W" indicates an 11.1 liter engine. Typical model numbers: 6067GU40 or 6067WU40. The model number is stamped on the engine block beneath the intake manifold. See **Fig. 8**.

3. Turn the slave piston adjusting screw clockwise until a light drag is felt on the feeler gauge.

4. While holding the screw in this position, tighten the locknut 25 lbf·ft (35 N·m). See **Fig. 9**.

Slave Piston Removal, Inspection, Installation, and Adjusting



1. Serial Number
2. Model Number

Fig. 8, Engine Brake Identification

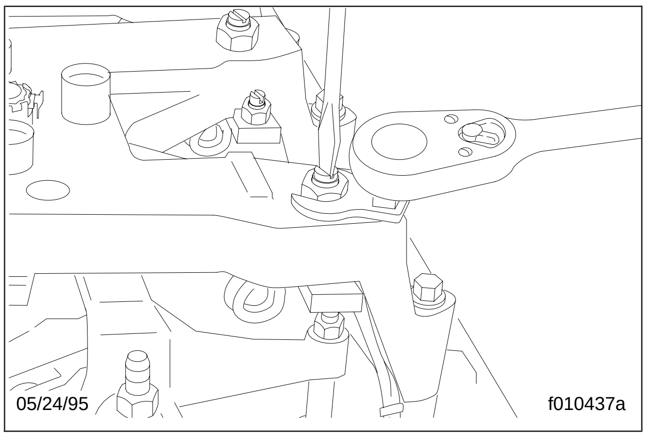


Fig. 9, Tighten the Adjusting Screw Locknut

IMPORTANT: The slave piston adjusting screws used in the Model 760 Engine Brake are Reset® screws. Do not disassemble these Reset screws in the field.

5. Following the same procedure, set 0.020-inch (0.5-mm) clearance between the slave piston leveling screw and the rocker arm adjusting screw. See **Fig. 10**.
6. While holding the leveling screw in this position, tighten the locknut 35 lbf·ft (47 N·m).
7. Repeat the steps above for slave pistons of the remaining cylinders. Rotate the engine to close the exhaust valves for the cylinder being adjusted.

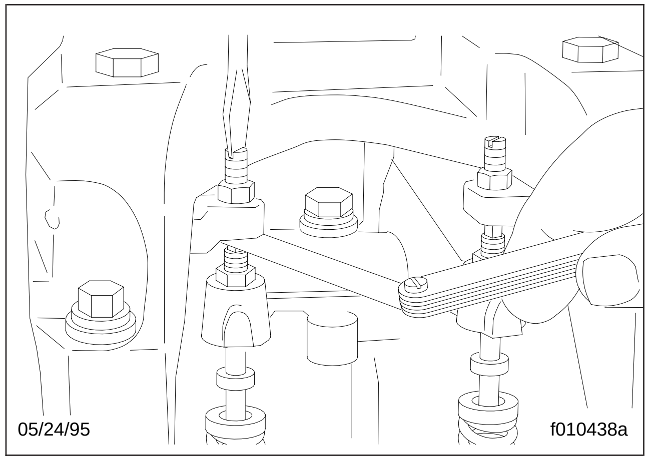


Fig. 10, Check the Clearance

Troubleshooting Tables

Problem—Engine Will Not Start

Problem—Engine Will Not Start Possible Cause	Remedy
The solenoid valve is stuck in the "on" position.	Make sure the electrical current to the engine brake is off. If the solenoid valve stays "on" (cap down) with the current off, replace the solenoid valve.

Problem—Engine Brake Will Not Function

Problem—Engine Brake Will Not Function Possible Cause	Remedy
An electrical lead is open.	Replace any broken wires.
The clutch switch is malfunctioning.	**WARNING** **Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Use a volt/ohmmeter to make sure there is electrical current at both terminals of the switch. If voltage will not pass through the switch, replace it.
The engine oil pressure is too low.	Determine the oil pressure at the engine brakes. Refer to the applicable section for your engine brake. If the oil pressure is below specifications, repair the engine following the manufacturer’s procedures.
The throttle switch is malfunctioning.	Check for correct operation of the throttle.

Problem—Engine Brake Engages With the Switches Off

Problem—Engine Brake Engages With the Switches Off Possible Cause	Remedy
The solenoid valve center seal ring is damaged.	Remove the solenoid. Replace all the seal rings.
The engine brake is incorrectly wired.	Check the wiring against the Jacobs wiring diagram.

Problem—Engine Brake Weak or Slow to Engage

Problem—Engine Brake Weak or Slow to Engage Possible Cause	Remedy
The lubricating oil is too cold and thick.	Allow the engine to warm up before operating the Jake Brake.

Troubleshooting

Problem—Engine Brake Weak or Slow to Engage	
Possible Cause	**Remedy**
The slave piston is adjusted incorrectly or is binding in its bore.	**WARNING** **Slave piston springs are under heavy compression. Remove the slave piston carefully when disassembly is necessary. Use either an arbor press or C-clamp. Failure to follow this procedure could result in personal injury.** Adjust the slave piston.Make sure it responds smoothly to the adjusting screw— loosen the jam nut and screw the adjusting screw through its full range for full slave piston travel. Make sure the piston travels the full range without binding or sticking.
The solenoid lower seal is damaged, allowing oil to escape the housing.	Remove the solenoid valve and replace all the seal rings.
The solenoid screen is clogged, stopping the supply of oil to the engine brake.	Remove the solenoid valve; clean or replace the screen.
The master piston is not moving in its bore.	Inspect the master piston and bore for scoring or burrs. If any are present, clean the surface with a crocus cloth. If the burrs cannot be removed, replace the piston or housing. Inspect the lubricating oil for signs of contaminants. If any are present, replace the oil and filters, and correct the cause of the contamination.
The control valves are binding in the housing bores.	Remove each control valve. If the body is scored, replace the valve. Check for contaminants in the lubricating oil. Clean the housing and control valve. If it still binds, replace the housing.
The control valves are malfunctioning.	Remove each control valve. Make sure the check ball is seating in the bore and that it can be moved off the seat. Make sure there is spring pressure against the ball. Flush the valve in diesel fuel. Replace the control valve if needed.
Dash switches, clutch switch, or throttle switch has sluggish operation.	Adjust or replace the switch. Check the throttle or clutch return springs for proper operation.
The electrical insulation of the solenoid valve is breaking down.	**WARNING** **Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Make sure the solenoid valve meets electrical specifications. If not, replace the solenoid valve.
The engine brake housing plugs are leaking.	Check the plugs for signs of leaks. If leaks are found, remove the plugs, clean the threads, and install the plugs. Thread locking compound may help. Tighten the plugs 115 lbf·in (1300 N·cm).
The outer control valve spring is broken, or the engine oil pressure is extremely high.	Replace the outer control valve spring. Refer to the engine manufacturer’s service manual for causes of high oil pressure.
The upper solenoid seal ring is damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the solenoid. Inspect the seal rings and replace them if needed.

Troubleshooting

Problem—Engine Brake Weak or Slow to Engage Possible Cause	Remedy
The oil supply seals under or between the housings are damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the housings and replace the seals. Check for cracked or broken oil connectors. Replace the seals.
There is air in the lubricating oil, causing oil pressure to drop below the minimum required for engine brake operation.	Check for aeration of the oil. Turn the engine brake on, then off. Watch the escape oil coming from under the control valve cover. If the oil has bubbles or is foamy, air is present in the system. Aeration can be caused by an over-or underfilled crankcase, by cracks in the oil pickup tube, or by leaks in the oil suction tube or hose. Refer to the engine manufacturer’s service manual for corrective measures.
The lubricating oil is being diluted by diesel fuel, causing oil pressure to drop below the minimum required for engine brake operation.	Have the lubricating oil analyzed to determine if fuel is present. Refer to the engine manufacturer’s service manual for corrective measures.
The engine oil is low, causing oil pressure to drop below the minimum required for engine brake operation.	Refer to the engine manufacturer’s service manual for specifications. Add oil or recalibrate the dipstick as required.
The engine rocker arm bushings are worn, causing oil pressure to drop below the minimum required for engine brake operation.	Replace the bushings. Refer to the engine manufacturer’s service manual for instructions.
Oil is leaking around the cylinder heads, causing oil pressure to drop below the minimum required for engine brake operation.	Repair the cause of the leaks. Refer to the engine manufacturer’s service manual for instructions.
Restrictions in the oil passage leading to the engine brake are causing oil pressure to drop below the minimum required for engine brake operation.	Inspect all the passageways; remove anything restricting the oil flow.

Problem—Engine Stalls or One or More Cylinders Continue Braking With the Dash Switches Off

Problem—Engine Stalls or One or More Cylinders Continue Braking With the Dash Switches Off Possible Cause	Remedy
The control valve inner spring is broken.	Replace the inner spring.
One or more control valves are stuck in the "on" (up) position.	Check the control valves for binding. Remove and clean or replace them if necessary. Inspect the lubrication oil for contaminants.
The solenoid valve is sticking in the "on" position.	If the solenoid valve cap remains down with no electric current being supplied, replace the solenoid valve.
The center solenoid seal ring is damaged, allowing oil to enter the engine brake with the solenoid valve closed.	Remove the solenoid and replace all the seal rings.
The solenoid valve exhaust is plugged.	Remove any restrictions at the exhaust (bottom) of the solenoid valve.
The dash switch is stuck in the "on" position.	Check for correct switch operation. Replace the switch as needed.

Troubleshooting

Problem—Engine Misses or Loses Power

Problem—Engine Misses or Loses Power	
Possible Cause	**Remedy**
The slave piston is adjusted too tight.	Adjust the slave piston. Refer to the **applicable section** for the engine brake model.

Problem— Sudden Drop in Engine Lubrication Oil Pressure

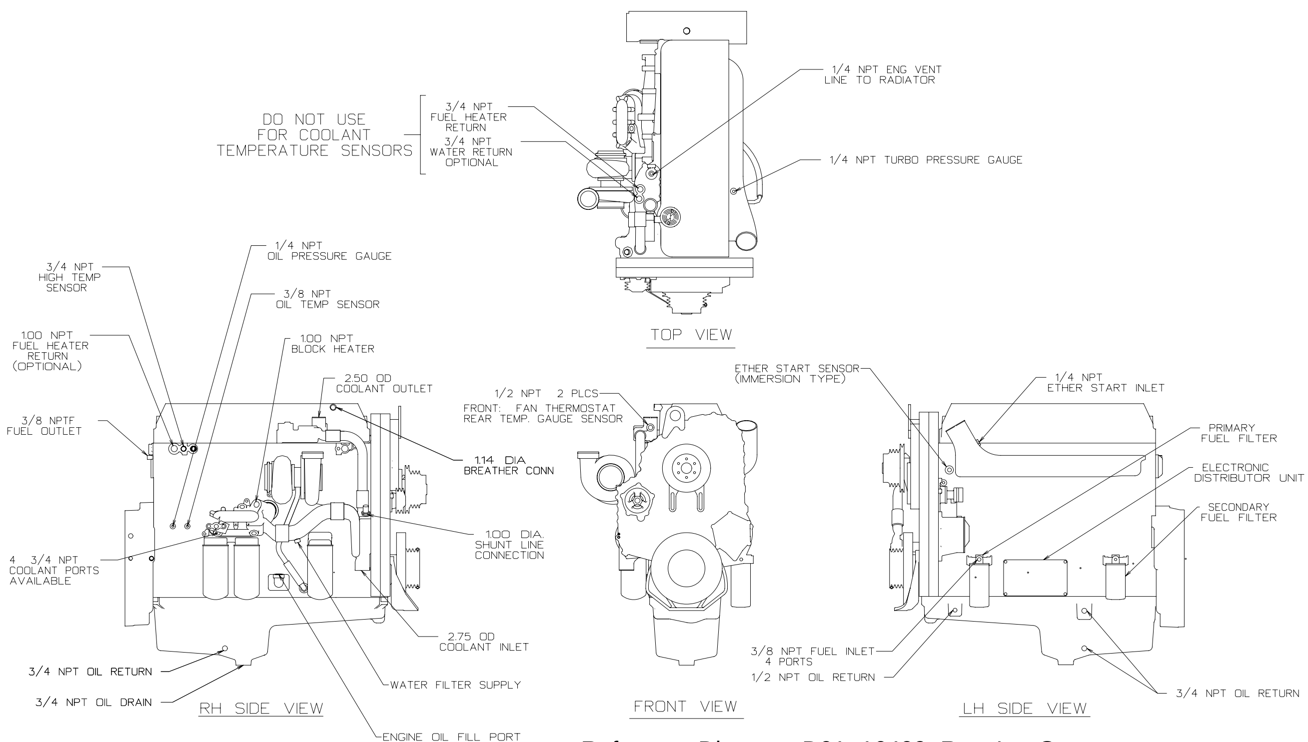
Problem— Sudden Drop in Engine Lubrication Oil Pressure	
Possible Cause	**Remedy**
The oil inlet supply seal is missing or damaged.	Replace the seal.
The upper solenoid valve seal is missing or damaged.	Remove the solenoid and replace all the seal rings.
The external oil supply hoses or fittings are cracked and leaking.	Inspect all hoses and fittings for tightness, chafing, or cuts.

Engine Port Diagram

NOTE: For engine brake information for the Detroit Diesel Series 60, refer to **Section 01.02**.

For engine wiring diagrams, refer to the applicable section in **Group 54**.

Use **Fig. 1** to identify the engine ports.



04/26/96

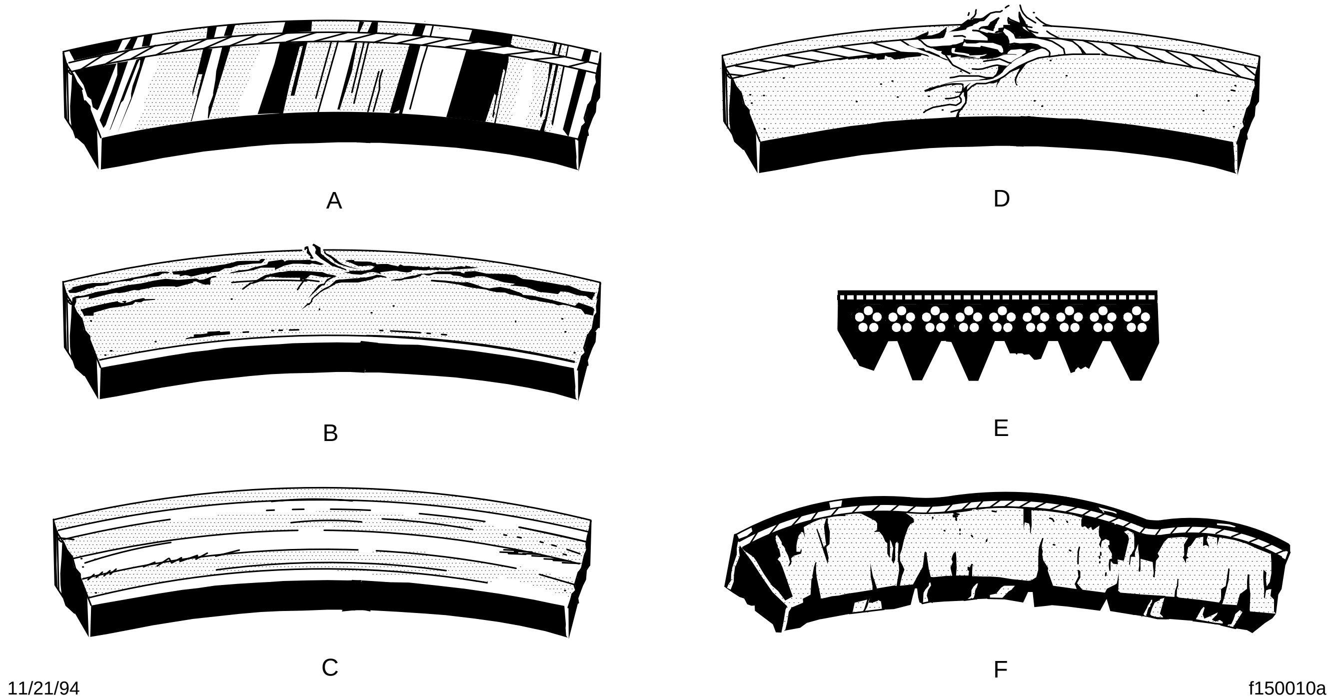
Reference Diagram: D01−16409, Rev. Ltr. G

f011070

Fig. 1, Detroit Diesel Series 60 Engine Ports

Inspection

1. Inspect all used drive belts (including those that are being replaced) for the following conditions (see **Fig. 1**):



A. Glazing
B. Separating Layers
C. Streaked Sidewalls
D. Tensile Break
E. Uneven Ribs
F. Cracks

Fig. 1, Drive Belt Problems

NOTE: For an installed belt, gently twist the belt about 90 degrees so you can see the sidewalls and bottom.

1.1 Inspect for glazing (shiny sidewalls). Glazing is caused by friction created when a loose belt slips in the pulleys. It can also be caused by oil or grease on the pulleys.

1.2 Inspect for separating layers. Oil, grease, or belt dressings can cause the belt to fall apart in layers. If engine parts are leaking, repair the oil leaks. Do not use belt dressings on any belt.

1.3 Check for jagged or streaked sidewalls. These are the result of a foreign object (such as sand or small gravel) in the pulley, or a rough pulley wall surface.

1.4 Check for tensile breaks (breaks in the cord body). Cuts in a belt are usually caused by large foreign objects in the pulley, or by prying or forcing the belt during installation or removal.

1.5 On poly-V belts, check for uneven ribs. Foreign objects in the pulley will erode the undercord ribs, causing the belt to lose its gripping power.

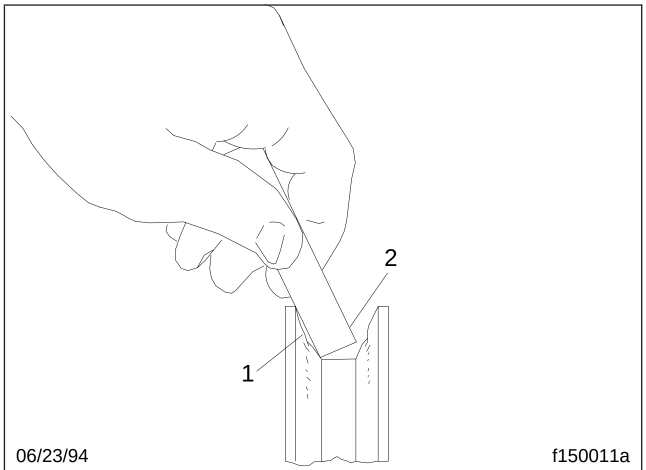
1.6 Inspect for cracks. Small, irregular cracks are usually signs of an old belt.

Replace the belt if any of the above conditions are found. Replace both belts of a set, at the same time. Matched belts must be from the same manufacturer.

2. Check all pulley bearings for roughness. Replace the bearings if they're rough.

Pulley and Drive Belt Inspection

3. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a nonflammable cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.
4. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls (**Fig. 2**), or use your little finger or fingernail to find grooves in the inner walls. If there are any grooves, replace the pulley.



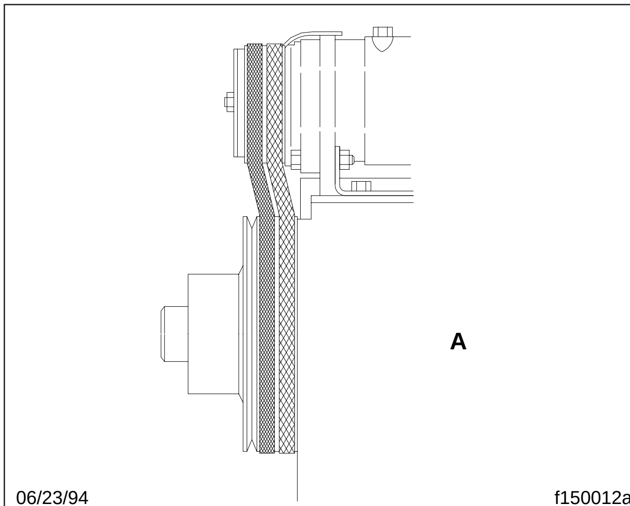
1. Groove in Pulley Wall
2. Small Straightedge

Fig. 2, Check for Pulley Wear

5. Check alignment of pulleys.Use a thin straightedge that is longer than the longest span between the pulleys. Place the straightedge into the V-grooves of two pulleys at a time. The straightedge should be parallel to the outer edges of the pulleys; if not, the pulleys are misaligned.

   Pulley misalignment must not be more than 1/16-inch for each foot (1.5 mm for each 30.5 cm) of distance between pulley centers.

   If there is misalignment of the pulleys, adjust the pulleys or brackets if their positions are adjustable. See **Fig. 3**. Replace bent or broken pulleys, pulley brackets, or shafts.
6. Check all drive component mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners. Repair or replace cracked or damaged brackets.



A. Side View of Misaligned Pulleys.

Fig. 3, Check for Misaligned Pulleys

Detroit Diesel Series 60 Engine Removal and Installation

Removal

1. Apply the parking brakes, chock the tires, and drain the air system.
2. Disconnect the batteries.
3. Drain the oil from the engine.

WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

4. Drain the coolant from the lower radiator hose and the radiator. For instructions, refer to **Section 20.01**.
5. Remove the hood and the bumper. For instructions, refer to **Group 88** in this manual.
6. Remove the air cleaner housing and ducting along with the heat shield between the cleaner and the turbocharger. For instructions, refer to **Group 09** in this manual.
7. Disconnect the wiring from the back of the alternator.
8. Move the air conditioning components out of the way without breaking the refrigerant lines.
   - 8.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser.
   - 8.2 Free the refrigerant lines from all routing clamps and stand-off brackets between the receiver-drier and the condenser.
   - 8.3 Remove the condenser mounting fasteners, and move the condenser aside.
   - 8.4 Remove the refrigerant compressor and move it aside.
   - 8.5 Use tie straps to secure the refrigerant compressor out of the way.
   - 8.6 Using cardboard and tie straps, wrap the condenser to protect it.
9. Remove the air recirculation shields around the radiator and the charge air cooler. For instructions, refer to **Section 20.01** in this manual.
10. Remove the radiator and charge air cooler. For instructions, refer to **Section 20.01** in this manual. Remove the radiator mounting bracket with the radiator.

    Make sure the charge air cooler hoses are disconnected from the turbocharger and intake manifold.
11. Remove the power steering fluid pump, and move the pump out of the way without breaking the lines or draining the fluid. For instructions, refer to **Group 46**.
12. Remove the surge tank and its coolant hoses. For instructions, refer to **Section 20.01** in this manual.
13. Remove the windshield wiper pan. For instructions, refer to **Group 60** in this manual.
14. Remove the windshield wiper linkage. For instructions, refer to **Group 82**.
15. Disconnect or remove the remaining ducts and lines.
    - 15.1 Disconnect the outlet line and the signal line from the air compressor.
    - 15.2 Disconnect the air line from the fan clutch solenoid, and free the line from routing clamps.
    - 15.3 Disconnect the heater supply and return hoses from the right side of the engine and move them out of the way.
    - 15.4 If so equipped, disconnect the ether injection line from the intake manifold.
16. Label and disconnect the wiring.
17. Remove the clutch linkage.
18. From under the vehicle, disconnect the transmission shift linkage.
19. Disconnect the driveline from the transmission. For instructions refer to **Group 41** in this manual.
20. If so equipped, mark and disconnect the transmission oil cooler lines.
21. If present, disconnect the air line from the transmission.
22. Remove the overslung crossmember.

Detroit Diesel Series 60 Engine Removal and Installation

23. Under the engine, disconnect or remove the remaining components.
    23.1 To gain access to the rear engine mounts, remove the section of exhaust ducting that runs from the turbocharger.
    23.2 Disconnect the fuel return lines at the rear of the transmission. For instructions, refer to **Group 47** in this manual.
    Leave the fuel lines installed on the engine.
    23.3 Disconnect the starter motor and solenoid power cables. Disconnect any ground straps present.
    23.4 Remove the bolts that hold the engine legs to the rear engine mounts.
24. If so equipped, remove the transmission oil cooler from the underslung crossmember.

WARNING

The crane and lifting chains used to remove the engine and the transmission must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

25. Remove the engine from the vehicle.
    25.1 Attach the chain to the lifting eyes at the front and the rear of the engine.
    25.2 With the engine lifting eyes connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.
    25.3 Remove the nuts from the bolts that fasten the front engine support bracket to the underslung crossmember.
    25.4 Put a jackstand under the front of the engine.
    25.5 Remove the underslung crossmember.
    25.6 Using the crane, lift the engine and the transmission as a unit and pull them forward.
    25.7 Once the engine and transmission are clear of the vehicle, place them on engine stands.
26. If installing a new engine, remove all the applicable components and transfer them to the new engine.
    Disconnect the transmission from the engine. Refer to **Group 26** for instructions. Be sure to disconnect the fuel lines at the rear of the engine.

Installation

1. If installing a new engine, connect the transmission to the engine. Refer to **Group 26** for instructions.

WARNING

The crane and lifting chains used to install the engine and transmission must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely supported on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Install the engine in the vehicle.
    2.1 Attach the chain to the lifting eyes at the front and the rear of the engine.
    2.2 With the engine lifting eyes connected by chain to the crane, lift the engine and the transmission together, and position the engine on the rear engine mounts.
    Install the bolts and nuts. Tighten finger tight.
    2.3 Place a jack under the front of the engine. Install the underslung crossmember. Tighten the fasteners 68 lbf·ft (92 N·m).
    2.4 Assemble the lower isolator under the underslung crossmember and the front engine support bracket, and secure the front engine mount with nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).
    2.5 Tighten the bolt that runs down through each engine leg, rubber isolators, and

rear engine mount 213 to 269 lbf·ft (289 to 365 N·m).

2.6 Once the engine is securely installed in the vehicle, remove the lifting chains.

3. If so equipped, install the transmission oil cooler.
4. Connect and install components under the engine.

   4.1 Connect the power cables to the starter motor and solenoid. Connect any ground straps.

   4.2 Connect the exhaust pipe to the turbocharger. Tighten 85 lbf·in (940 N·cm).

   4.3 Connect the fuel lines. For instructions, refer to **Group 47** of this manual.

5. Install the clutch linkage. For instructions, refer to **Group 25** in this manual.
6. From under the vehicle, install the overslung crossmember. Tighten the fasteners 136 lbf·ft (184 N·m).
7. Connect the driveline to the transmission.
8. Connect the transmission shift linkage. For instructions, refer to **Group 26** in this manual.
9. If applicable, connect the oil cooler hoses and air lines to the transmission. For instructions, refer to **Group 26** in this manual.
10. Install the power steering fluid pump. For instructions, refer to **Group 46** in this manual.
11. Connect the wiring. For wiring harness information, refer to **Group 54** in this manual.
12. Connect or install the ducts and lines.

   12.1 Connect the air compressor outlet and signal lines.

   12.2 Connect the air line to the fan clutch solenoid.

   12.3 Connect the heater supply and return lines.

   12.4 If so equipped, connect the ether injection line to the intake manifold.

13. Install the radiator, fan shroud, and charge air cooler. For instructions, refer to **Group 20** in this manual.

   Connect the charge air cooler tubing to the turbocharger and the intake manifold.

14. Install the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Group 20** in this manual.
15. Install the air conditioning components without breaking the refrigerant lines.

   15.1 Install the condenser. For instructions, refer to **Group 83** of this manual.

   15.2 Install the refrigerant compressor.

   15.3 Route and clamp the refrigerant lines between the compressor and the condenser.

   15.4 Route and clamp the refrigerant lines between the receiver dryer and the condenser.

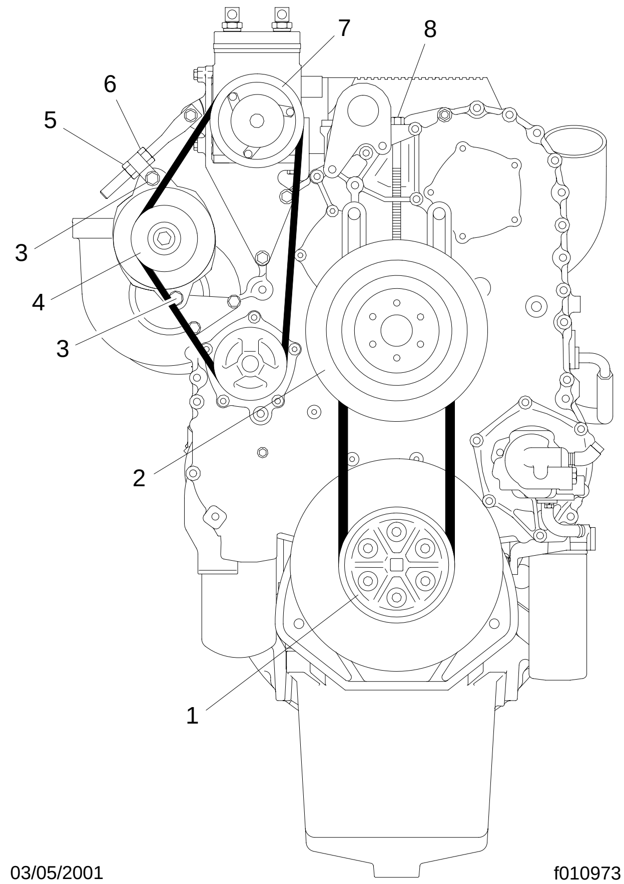
16. Connect the wiring to the back of the alternator.
17. Install the windshield wiper pan. For instructions, refer to **Group 60**.
18. Install the wiper linkage. For instructions, refer to **Group 82** in this manual.
19. Install the surge tank and its coolant lines. For instructions, refer to **Section 20.01** in this manual.
20. Install the heat shield below the air cleaner.
21. Install the air cleaner housing and the ducting for the turbocharger. For instructions, refer to **Group 09** in this manual.
22. Install the hood and the bumper. For instructions, refer to **Group 88** in this manual.
23. Fill the radiator.
24. Fill the engine with the correct amount of oil.
25. Check the level of the transmission oil. If needed, fill it to the correct level.
26. Connect the batteries.
27. Start the engine, and check for leaks. Repair any leaks found.
28. Test drive the vehicle.

NOTE: On a joined belt, the Krikit gauge will have a low accuracy of approximately +/– 30 percent. The Kent-Moore gauge is inherently a more accurate device. The belt tension gauge must grip the full width of the belt to get an accurate reading. If the gauge grips only one of the two V's in a Powerband belt, it will not give an accurate reading. The actual tension in the belt will likely be greater than the tension indicated by the gauge. In this case, the Kent-Moore gauge will be no more accurate than the Krikit gauge.

Belt Replacement Without an Automatic Belt Tensioner

Alternator and Refrigerant Compressor Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 1**.
   - 2.1 Back off the alternator adjusting nut.
   - 2.2 Loosen the alternator pivot bolts.
   - 2.3 Turn the alternator jam nut to rotate the alternator up and toward the engine. Turn the nut until the alternator is close enough to the engine to allow belt removal.
   - 2.4 Remove the belt by slipping it off the pulleys. Do not roll or pry the belt off the pulleys. The distance between the pulley centers must be short enough to allow belt removal without using force.
3. Install the belt.
   - 3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 100**.
   - 3.2 Install the belt on the pulleys without prying or rolling it into place.
   - 3.3 While keeping the belt seated in the pulley grooves, turn the adjusting nut to rotate the alternator away from the engine and to increase belt tension.



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1. Vibration Damper
2. Fan Pulley
3. Alternator Pivot Bolt
4. Alternator Pulley
5. Alternator Jam Nut
6. Alternator Adjusting Nut
7. Refrigerant Compressor Pulley
8. Fan Adjusting Rod

Fig. 1, Drive Belts Without an Automatic Belt Tensioner

4. Adjust the belt.
   - 4.1 Install a belt tension gauge at the center of the belt's longest free-span.

   IMPORTANT: Do not overtighten the belt. Too much tension shortens belt and bearing life.

   - 4.2 Turn the adjusting nut to rotate the alternator out, away from the engine until the belt is tensioned 100 lbf (445 N) per belt, 200 lbf (890 N) if using a joined belt.

4.3 Tighten the alternator jam nut 130 lbf·ft (176 N·m).

4.4 Tighten the alternator pivot bolts 70 lbf·ft (95 N·m).

4.5 Remove the chocks from the tires.

4.6 Operate the engine for about 30 minutes or 15 miles (24 km) and recheck the belt tension. Re-tension to a minimum of 75 lbf (334 N) per belt, 150 lbf (668 N) if using a joined belt. Check again after 8 hours of operation or 250 miles (400 km). Adjust the belt tension as needed.

Fan Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 1**.

   2.1 Loosen the four mounting capscrews that attach the fan hub to the engine.

   2.2 Loosen the fan adjusting rod to relieve tension from the belt.

   2.3 Remove the belt by slipping it off the pulleys and working it over one fan blade at a time. On some vehicles, it may be necessary to remove the fan. For instructions, see **Section 20.01**. Do not roll or pry the belt off the pulleys. The distance between the pulley centers must be short enough to allow belt removal without using force.

3. Install the belt.

   3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 100**.

   3.2 Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without rolling or prying it into place.

   3.3 While keeping the belt seated in the pulley grooves, turn the adjusting rod to increase belt tension.

4. Adjust the belt.

   4.1 Install a belt tension gauge at the center of the belt's longest free-span.

IMPORTANT: Do not overtighten the belt. Too much tension shortens belt and bearing life.

   4.2 Turn the adjusting rod to increase belt tension to 100 lbf (445 N).

   4.3 Tighten the fan hub mounting capscrews 75 to 83 lbf·ft (100 to 112 N·m).

   4.4 Check the belt tension and adjust it if needed.

   4.5 Remove the chocks from the tires.

   4.6 Operate the engine for about 30 minutes or 15 miles (24 km) and recheck the belt tension. Re-tension to a minimum of 75 lbf (334 N). Check again after 8 hours of operation or 250 miles (400 km). Adjust the belt tension as needed.

Belt Replacement With an Automatic Belt Tensioner

Alternator and Refrigerant Compressor Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 2**.

   2.1 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner away from the accessory drive belt.

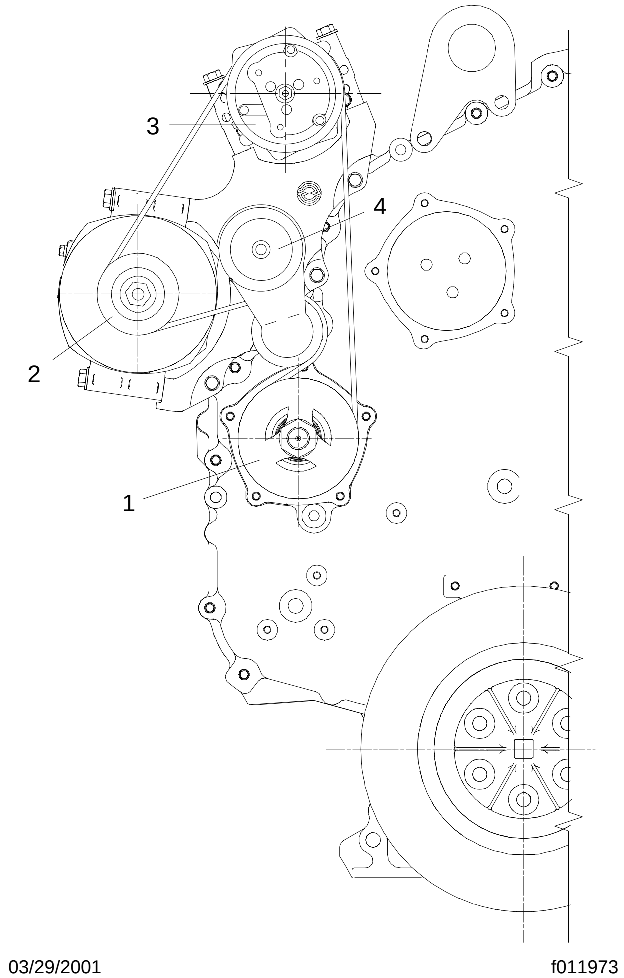
   2.2 Holding the belt tensioner down, remove the belt from the alternator pulley.

   2.3 Remove the belt from the refrigerant compressor pulley and the engine pulley.

   2.4 Slowly release the belt tensioner and remove the breaker bar.

3. Install the belt.

   3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 100**.



1. Engine Pulley
2. Alternator Pulley
3. Refrigerant Compressor Pulley
4. Automatic Belt Tensioner

Fig. 2, Alternator and Refrigerant Compressor Belt With an Automatic Belt Tensioner

3.2 Install the belt onto the engine pulley and the refrigerant compressor pulley.

3.3 Insert a 1/2-inch breaker bar into the belt tensioner and rotate it out while installing the belt onto the alternator pulley.

3.4 Slowly release the belt tensioner and remove the breaker bar. The belt tensioner will automatically apply the correct tension on the belt.

4. Remove the chocks from the tires.

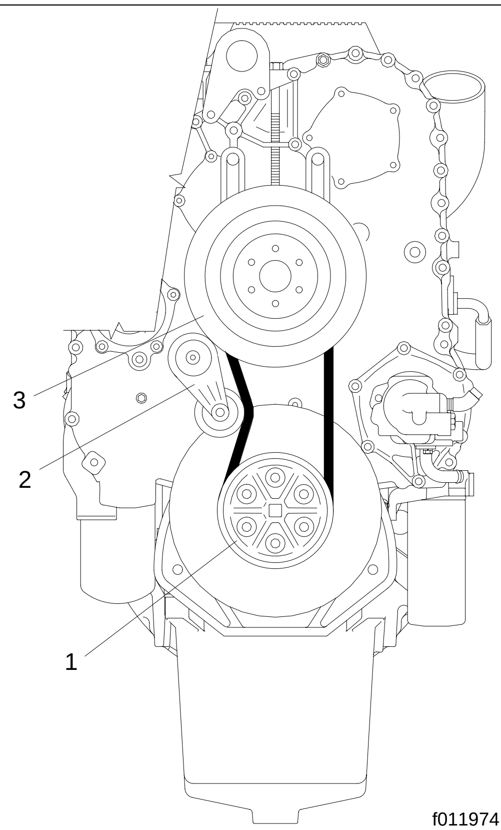
Fan Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 3**.

   2.1 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner away from the fan drive belt.

   2.2 Holding the belt tensioner down, remove the belt from the fan pulley and the engine pulley.

   2.3 Slowly release the belt tensioner and remove the breaker bar.



1. Vibration Damper
2. Automatic Belt Tensioner
3. Fan Pulley

Fig. 3, Fan Belt With an Automatic Belt Tensioner

3. Install the belt.

Drive Belts Replacement

3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 100**.

3.2 Install the belt onto the fan pulley.

3.3 Insert a 1/2-inch breaker bar into the belt tensioner and rotate it out while installing the belt onto the engine pulley.

3.4 Slowly release the belt tensioner and remove the breaker bar. The belt tensioner will automatically apply the correct tension on the belt.

4. Remove the chocks from the tires.

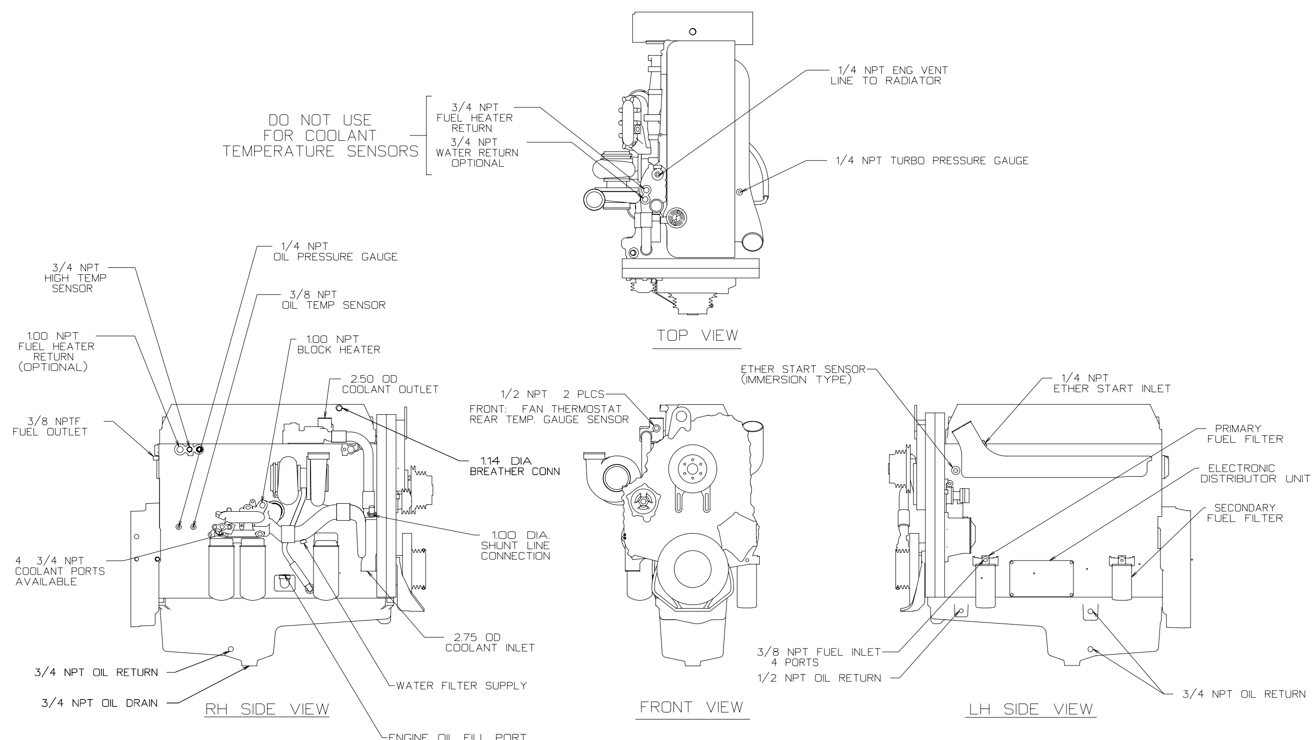
Component	Belt Tension, New Belt lbs (kg)	Belt Tension, Used Belt lbs (kg)
Alternator and Refrigerant Compressor*	60–80 (27–36)	60–80 (27–36)
Fan	60–80 (27–36)	60–80 (27–36)

* Without an automatic belt tensioner.

Table 1, Drive Belt Tensions

Fastener	Torque: lbf·ft (N·m)
Rear Engine-to-Mount Bolts	213–269 (289–365)
Front Engine-to-Mount Bolts	
Engine Leg-to-Flywheel Housing Bolts (5/8–11 x 1-3/4 inches)	136 (184)

Table 2, Fastener Torques



04/26/96 Reference Diagram: D01−16409, Rev. Ltr. G f011070

Fig. 1, Detroit Diesel Series 60 Engine Ports

General Information

General Description

Three mounts support the engine and transmission, holding a total of almost 3800 lb (1724 kg). Two of the engine mounts support the rear of the engine and transmission assembly. The third supports the front of the assembly.

Each of the rear engine mounts (**Fig. 1**) is bolted to the inside of the frame rail near the flywheel housing. These mounts support legs which are bolted to the flywheel housing. The V-shaped rear engine leg sets into a V-shaped rear engine mount. See **Fig. 2**.

The front engine mount is an underslung crossmember under the front of the engine. It supports a bracket (**Fig. 3**) that is bolted to the engine at each side of the vibration damper pulley.

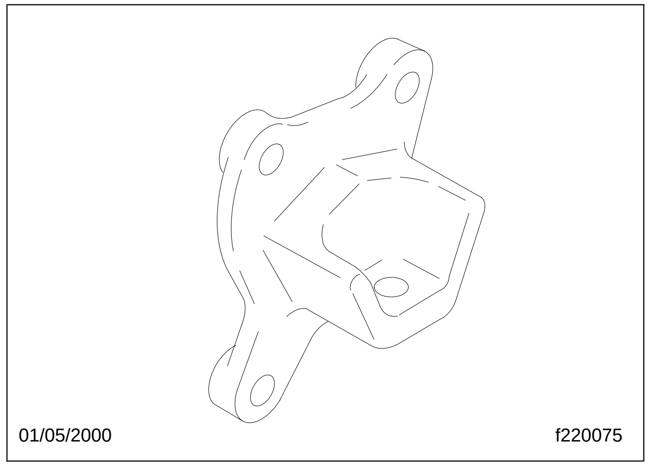
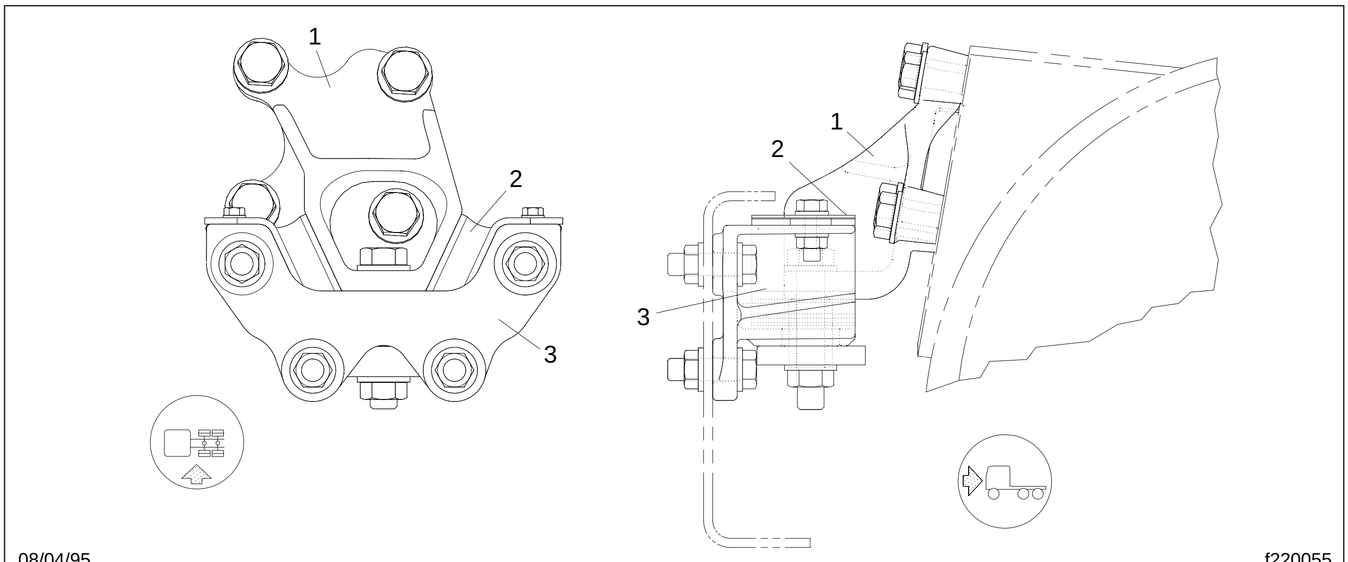


Fig. 2, Engine Legs (Detroit Diesel Series 60)



1. Engine Leg (bolted to the engine)
2. Rubber Isolator
3. Engine Mount (bolted to the frame rail)

Fig. 1, Rear Engine Mount (typical)

To isolate the engine and transmission from road shock, and to isolate the vehicle frame from engine vibration, the engine mounts are sandwiched between rubber isolator cushions (sometimes called restriction pads). Steel snubbers protect the cushions from wearing on the engine support brackets, and bolts run through the mount, cushions, and snubbers to hold the assembly together and hold the engine on the mount.

General Information

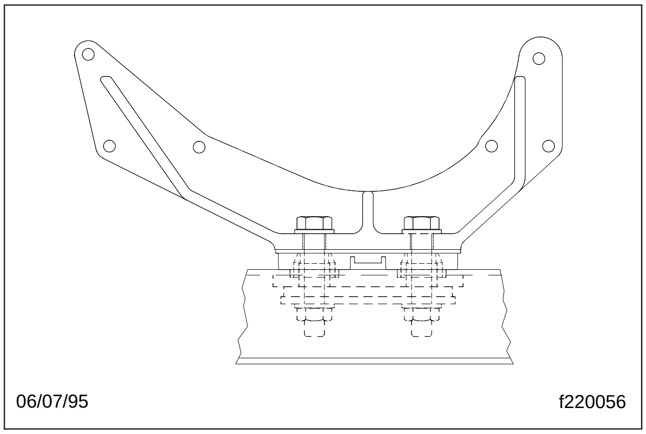


Fig. 3, Front Engine Support Bracket (typical)

Replacement

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

WARNING

The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the right rear engine mount. See **Fig. 1**.

   2.1 Place a jack under the rear of the engine, and raise the jack until it's braced against the engine.

   NOTE: To remove the bolt that connects the engine leg and the engine mount, you may have to disconnect and move the exhaust ducting. To do this, refer to the instructions in **Section 49.00**.

   2.2 Remove the bolt from the right rear engine mount. Save the fasteners, rubber isolator cushions, and snubbers.

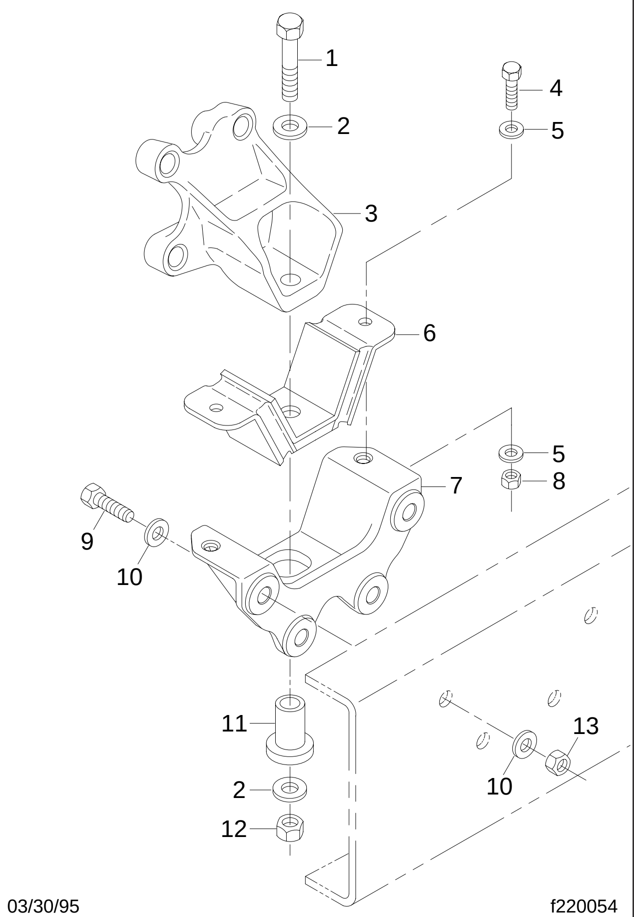
   2.3 Lift the engine slightly to take its weight off the right rear engine mount. Place engine stands under the engine to keep it off the engine mount.

3. Remove the bolts which secure the mount to the frame rail. Remove the mount from the frame rail.

   If necessary, remove the four bolts which secure the right engine support bracket to the flywheel housing, and remove the bracket from the engine.

4. Place a new engine mount against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts 120 to 152 lbf·ft (163 to 206 N·m).

5. If removed, install the engine leg on the right side of the flywheel housing. Apply thread lock compound to the bracket mounting bolts, and tighten them to the torque values in **Table 1**.



1. Hexbolt, 3/4-10 x 4.5 Inch, Grade 8
2. Washer
3. Engine Leg
4. Hexbolt, 5/16-18 x 1 Inch, Grade 8
5. Washer
6. Upper Isolator
7. Rear Engine Mount
8. Nut, 5/16-18
9. Hexbolt, 5/8-11 x 2.5 Inch, Grade 8
10. Washer
11. Lower Isolator
12. Nut, 3/4-10
13. Nut, 5/8-11

Fig. 1, Rear Engine Mount Assembly (typical)

Rear Engine Mount Replacement

Engine Leg-to-Flywheel Bolt Torques		
Engine Model	**Bolt Size**	**Torque lbf·ft (N·m)**
MBE4000	M16 x 1.5 x 50 mm (upper) M16 x 1.5 x 40 mm (lower)	175 (237)
Detroit Diesel Series 60	5/8–11 x 1-3/4 inches	136 (184)
Caterpillar C10/12/13/15/16	3/4–10 x 2 inches	190 (258)
Cummins ISM/ISX	3/4–10 x 2 inches	
Cummins N14	3/4–10 x 1-3/4 inches	

Table 1, Engine Leg-to-Flywheel Bolt Torques

6. Inspect the engine mount rubber isolators for wear or damage and replace them if necessary.

CAUTION

Do not lubricate the components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

7. Install the upper isolator in the engine mount. In order for the isolator holes to align with the holes in the engine mount, the painted side of the isolator must be towards the engine. Fasten the isolator to the mount, and tighten the hexbolts 14 to 18 lbf·ft (19 to 24 N·m).

WARNING

The jack used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

8. Secure the engine to the engine mounts.
   - 8.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.
   - 8.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   - 8.3 Holding the lower isolator and snubber in place, install the bolt in the right rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 213 to 269 lbf·ft (289 to 365 N·m).
9. Repeat this procedure for the other rear engine mount.
10. Remove the jack from under the engine, and remove the chocks from the tires.

Replacement

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

WARNING

The lifting device and chain used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the front engine mount. See **Fig. 1**.

   2.1 Attach a chain to the front engine lifting hook(s), and position a lifting device to lift the engine. Attach the chain to the lifting device, and raise the chain to remove any slack.

   2.2 Remove the bolt(s) from the front engine mount. Save the fasteners, rubber isolator cushions, and snubber(s).

   NOTE: In order to raise the front of the engine, you may have to loosen the bolts that run through the rear engine mounts.

   2.3 Lift the engine slightly to take its weight off the front engine mount. Place engine stands under the engine to keep it off the engine mount.

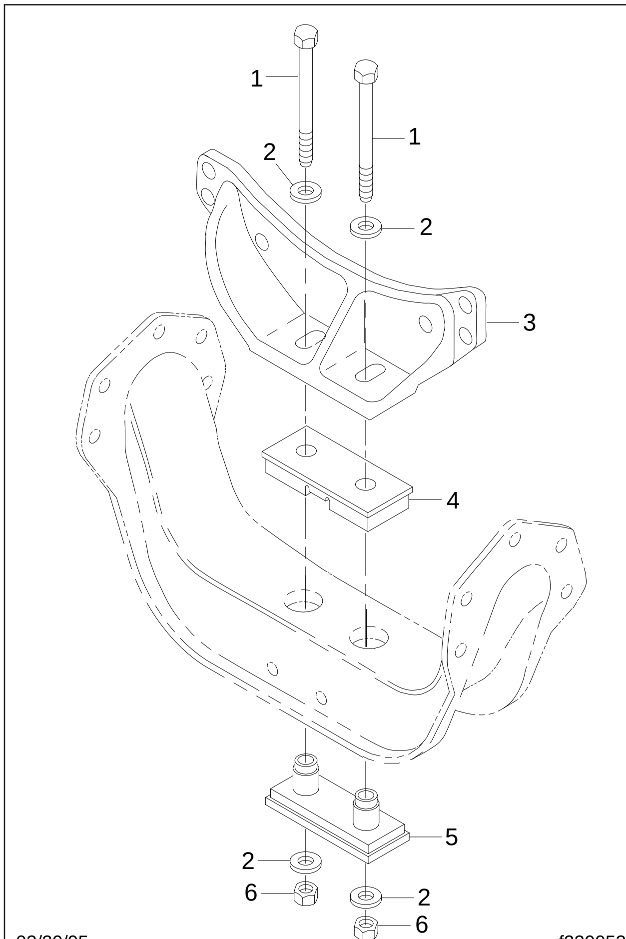
3. If you're replacing the front engine support bracket, refer to the engine manufacturer's service literature.

4. Inspect the engine mount rubber isolators for wear or damage and replace them if necessary.

CAUTION

Do not lubricate the components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

5. Install the upper isolator(s) in the engine mount. If applicable, place the snubber(s) on the isolator(s).



1. Hexbolt, 3/4-10 x 4 Inch, Grade 8
2. Washer
3. Front Engine Support Bracket
4. Upper Isolator
5. Lower Isolator
6. Nut, 3/4-10

Fig. 1, Front Engine Mount Assembly (typical)

WARNING

The lifting device and chain used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

Front Engine Mount Replacement

6. Secure the engine to the front engine mount.

   6.1 Attach a chain to the front engine lifting hook(s). Attach the chain to a lifting device, and raise the chain to remove any slack.

   6.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.

   6.3 Holding the lower isolator in place, install the bolts in the front engine mount and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

   NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 213 to 269 lbf·ft (289 to 365 N·m).

   6.4 Remove the lifting chain from the engine lifting hooks.

7. Remove the chocks from the tires.

Replacement

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

WARNING

The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the right rear engine mount. See **Fig. 1**.

   2.1 Place a jack under the rear of the engine, and raise the jack until it's braced against the engine.

   NOTE: To remove the bolt that connects the engine leg and the engine mount, you may have to disconnect and move the exhaust ducting. To do this, refer to the instructions in **Section 49.00**.

   2.2 Remove the bolt from the right rear engine mount. Save the fasteners.

   2.3 Use the jack to raise the engine slightly, and secure it with jack stands.

   2.4 Remove the two hexbolts that hold the ends of the isolator to the engine mount.

   2.5 Remove the engine mount from the frame rail. For instructions, refer to **Subject 100**. Remove and discard the isolator.

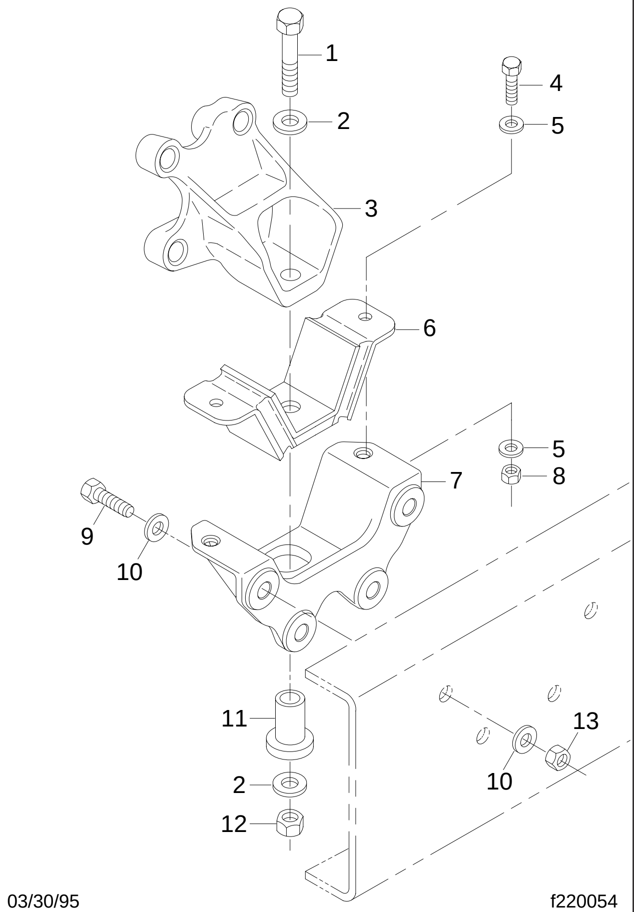
3. Inspect the new engine mount rubber isolators for wear or damage and replace them if necessary.

CAUTION

Do not lubricate the new components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

4. Install the new isolator in the engine mount, and install the engine mount on the frame rail. In order for the isolator holes to align with the holes in the engine mount, the painted side of the isolator must be towards the engine. For instructions, refer to **Subject 100**.

   Secure the isolator to the mount with two hexbolts and locknuts, tighten the locknuts 14 to 18 lbf·ft (19 to 24 N·m).



1. Hexbolt, 3/4-10 x 4.5 Inch, Grade 8
2. Washer
3. Engine Leg
4. Hexbolt, 5/16-18 x 1 Inch, Grade 8
5. Washer
6. Upper Isolator
7. Rear Engine Mount
8. Nut, 5/16-18
9. Hexbolt, 5/8-11 x 2.5 Inch, Grade 8
10. Washer
11. Lower Isolator
12. Nut, 3/4-10
13. Nut, 5/8-11

Fig. 1, Rear Engine Mount Assembly (typical)

Rear Engine Mount Isolator Replacement

⚠ WARNING

The jack used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

5. Secure the engine to the engine mount.
   - 5.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.
   - 5.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   - 5.3 Install the bolt in the right rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 213 to 269 lbf·ft (289 to 365 N·m).
6. Repeat this procedure for the other rear engine mount.
7. Remove the jack from under the engine, and remove the chocks from the tires.

Front Engine Mount Isolator Replacement

Replacement

1. Apply the parking brakes, chock the tires, and drain the air brake system.

WARNING

The lifting device and chain used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the front engine mount. See **Fig. 1**.

   2.1 Attach a chain to the front engine lifting hook(s), and position a lifting device to lift the engine. Attach the chain to the lifting device, and raise the chain to remove any slack.

   2.2 Remove the bolt(s) from the front engine mount. Save the fasteners, tube(s), and snubber(s). Discard the rubber isolator cushions.

   NOTE: In order to raise the front of the engine, you may have to loosen the bolts that run through the rear engine mounts.

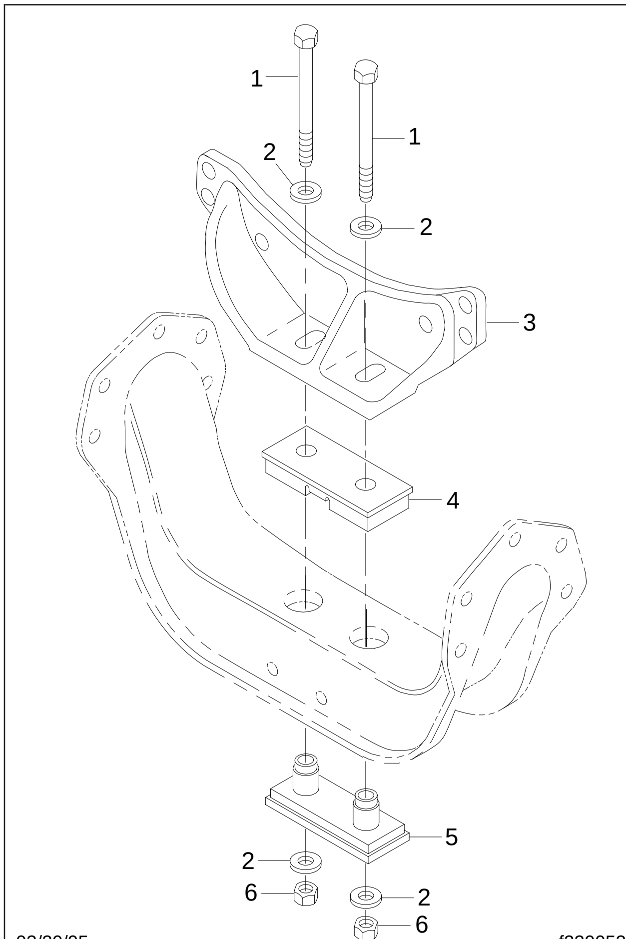
   2.3 Lift the engine slightly to take its weight off the front engine mount. Place engine stands under the engine to keep it off the engine mount.

3. Inspect the new front engine mount rubber isolators for wear or damage and replace them if necessary.

CAUTION

Do not lubricate the new components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

4. Install the upper isolator(s) in the engine mount.



1. Hexbolt, 3/4-10 x 4 Inch, Grade 8
2. Washer
3. Front Engine Support Bracket
4. Upper Isolator
5. Lower Isolator
6. Nut, 3/4-10

Fig. 1, Front Engine Mount Assembly (typical)

WARNING

The lifting device and chain used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

Front Engine Mount Isolator Replacement

5. Secure the engine to the front engine mount.
   5.1 Attach a chain to the front engine lifting hook(s). Attach the chain to a lifting device, and raise the chain to remove any slack.
   5.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   5.3 Holding the lower isolator in place, install the bolts in the front engine mount and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

   NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 213 to 269 lbf·ft (289 to 365 N·m).

   5.4 Remove the lifting chain from the engine lifting hook(s).
6. Remove the chocks from the tires.

Rear Engine Mount Replacement, EPA07 Engines

Removal

NOTE: The rear engine mounts for EPA07 engines are designed to last for the life of the vehicle, and should not normally need replacing. The isolators are bonded to the brackets and cannot be replaced separately.

If the rear engine mounts need replacing due to damage, or if you are removing and installing the engine, use this procedure.

In the past, substituting softer isolators from the MBE4000 engine was a way to sometimes remedy engine vibration problems with other engines. This will not work with the EPA07 engines, because all the engine isolators now have the same durometer hardness.

1. Shut down the engine, set the parking brake, and chock the tires.
2. Drain the air tanks.
3. Disconnect all the cables from the batteries. Cover them, using dry rags and tie straps.
4. Remove the battery mega-fuse block from the left-side frame rail, underneath the cab. The mounting nuts are inboard of the frame rail.
5. Open the hood.
6. If present, remove the two tow hooks from the right frame rail.
7. Remove the rain tray.
   - 7.1 Mark, then remove the wiper arms.
   - 7.2 Disconnect any hoses or drains from the bottom of the rain tray.
   - 7.3 Remove the fasteners that hold the rain tray to the frontwall.
   - 7.4 Remove the rain tray from the vehicle.
8. Remove the right and left quarter fenders and the inner splash shields.
9. Remove the air intake canister assembly.
10. Remove the mounting bracket for the air intake canister.
11. Remove the turbocharger heat shield.
12. Disconnect the air lines from the primary air tank, then remove the tank from the vehicle.

DANGER

Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine has been shut down.

To avoid potentially serious burns or material damage:

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

13. Make sure the aftertreatment device (ATD) is cool, then remove it from the vehicle.

CAUTION

The ATD assembly weighs from 125 to 150 pounds (57 to 68 kg) and must be protected from impact or sharp jolts. Dropping the ATD, or subjecting it to jarring impact can crack the diesel particulate filter (DPF) inside, which is built on a ceramic substrate. If that happens, the DPF is ruined and must be replaced.

A secure support is necessary to remove and install the ATD safely. The ATD must be held securely to protect it from falling, or hitting hard against something else.

The horizontal ATD lifting device (TLZ00785) is designed for the job on a horizontal ATD. Vertical ATDs require a shop hoist secured to the lifting ears on top.

   - 13.1 Put a transmission jack (or equivalent) under the ATD, and strap the ATD to the jack.
   - 13.2 Disconnect the five sensors from the ATD.

WARNING

Wear adequate eye protection, such as safety goggles or a face shield, when working with the ATD mounting bands. The mounting bands are

Rear Engine Mount Replacement, EPA07 Engines

under spring tension, and can cause eye injury or other personal harm if they spring out of control.

13.3 Remove the Marmon clamps from each end of the ATD.

13.4 Disconnect the ATD from the exhaust tubing, and remove it from the vehicle. Keep the ATD strapped to the jack, and make sure it is placed away from any combustible materials.

14. Remove the cab skirts from both sides of the vehicle.
15. Disconnect and remove the exhaust tubing from the turbocharger.
16. As applicable, remove the steps, air fairings, fuel tank(s), and/or the battery box.

    For instructions on removing the fuel tank(s), refer to **Group 47** in this workshop manual.
17. Remove the fasteners that hold the driveline midship-bearing bracket to the frame crossmember.
18. Using suitable straps, secure the driveline and the midship bearing to the frame crossmember. Make sure the driveshaft is supported loosely enough so that the slip joint aft of the midship bearing will be able to extend when the engine is raised.
19. Remove the overslung crossmember from the transmission housing.

    19.1 If present, remove the standoff bracket for the A/C refrigerant line from the top of the overslung crossmember. Leave the line attached to the bracket.

    19.2 Remove the fasteners that hold the overslung crossmember to the transmission housing, then remove it.
20. Disconnect both ends of the clutch linkage and remove it from the vehicle.
21. Remove the shifter and shifter boot from the transmission.
22. Raise the front of the vehicle so the tires are off the ground, and support it with safety stands. Put the safety stands behind the rear spring hangers for the front suspension.

WARNING

Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, allowing the vehicle to fall, which could result in serious injury or death.

23. From underneath the vehicle, install a suitable lifting bracket or stand, such as an engine shipping stand (for Detroit Diesel Series 60 engines) on the rear of the engine. See **Fig. 1**.

    If using the Detroit Diesel engine shipping stand, there should be two holes on each side of the engine block, just forward of the bell housing. These should match up with the holes in the engine shipping stand. When any stand or bracket is installed correctly, it should not be touching the floor, and should be wide enough and strong enough to support a jack to raise the engine.

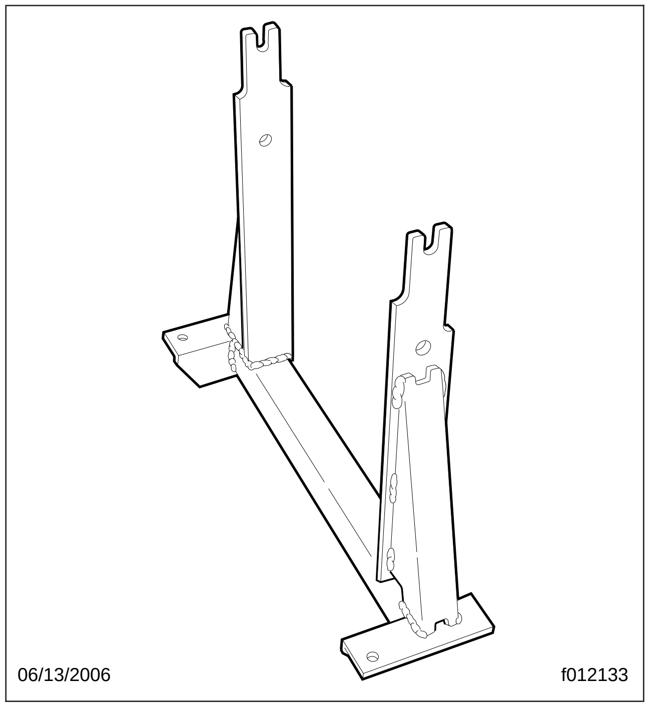
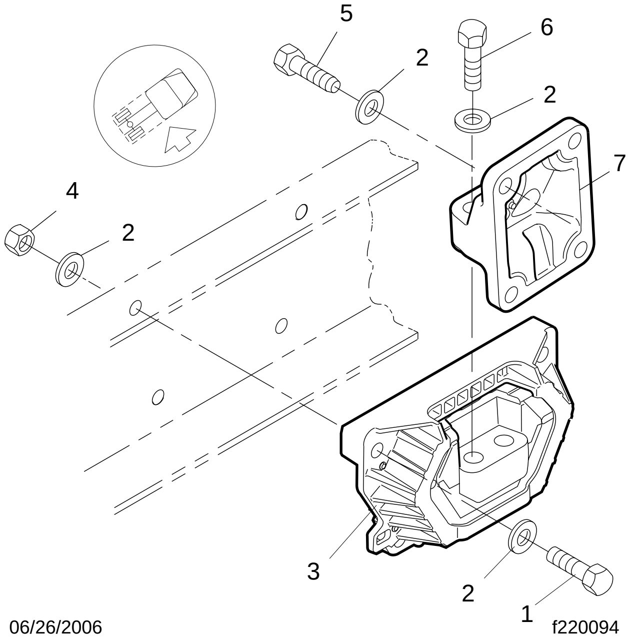


Fig. 1, Engine Shipping Stand, Detroit Diesel Series 60 Engine

24. If present, remove the starting aid bottle from the left-side frame rail.
25. On one side of the vehicle, remove the two mounting hexbolts that hold the engine leg to the

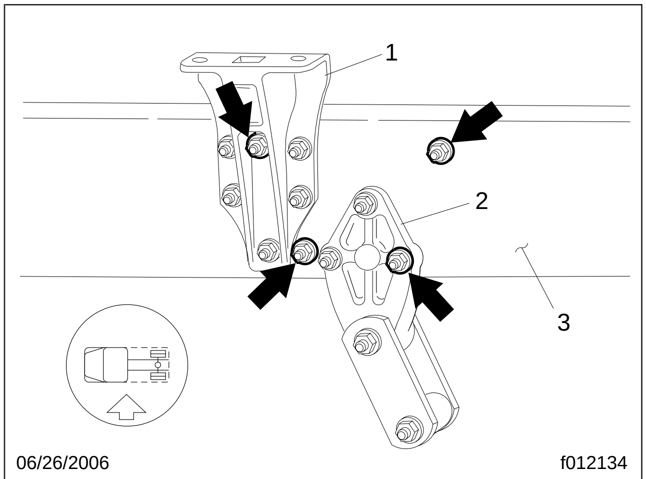
frame-rail engine mount. See **Fig. 2**. If needed, repeat the procedure on the other side of the vehicle.



1. Hexbolt, 5/8–11
2. Hardened Washer
3. Rear Engine Mount Assembly
4. Hexnut, 5/8–11
5. Capscrew, 5/8–11
6. Capscrew, 3/4–10
7. Engine Leg

Fig. 2, Rear Engine Mount and Engine Leg

26. Place a jack under the engine shipping stand (or other suitable stand/bracket) attached to the rear of the engine, and gradually raise that side of the engine until the bottom of the engine leg is above the top of the frame rail.
27. Remove the four fasteners that hold the rear engine mount to the frame rail. See **Fig. 3**.
28. Remove the rear engine mount from the vehicle.
29. If needed, remove the four bolts that hold the engine leg to the transmission housing. Remove the engine leg.



NOTE: The engine mount is not visible in this view.

1. Cab Mounting Bracket
2. Front Spring-Shackle Hanger
3. Frame Rail

Fig. 3, Engine Mount-to-Frame Rail Fasteners

Installation

1. If applicable, install the engine leg on the bell housing. Apply Loctite® 271 (or equivalent) to the threads of the capscrews, and tighten to 320 lbf·ft (434 N·m).
2. With the engine supported, install the rear engine mount on the frame rail. Install the four 5/8–11 hexbolts with the bolt heads inboard. Tighten the hexnuts 136 lbf·ft (184 N·m).
3. If applicable, repeat the above procedure on the other side of the vehicle.
4. Lower the engine onto the rear engine mount.
5. Apply Loctite 271 to the threads of the two 3/4–10 hexbolts. Install them and the hardened washers in the holes of the engine leg and the rear engine mount and tighten to 320 lbf·ft (434 N·m).
6. Remove the fasteners that hold the engine shipping stand to the side of the transmission, and remove the stand.
7. Install the clutch linkage.
8. Install the overslung crossmember.
9. Install the shifter and shifter boot on the transmission.

Rear Engine Mount Replacement, EPA07 Engines

10. Install the standoff bracket for the A/C refrigerant line, then attach the line to the bracket.
11. If it was removed, install the starting aid bottle to the left-side frame rail.
12. Attach the driveline midship bearing and its bracket to the frame crossmember.
13. Connect the exhaust tubing to the turbocharger.
14. Install the cab skirts to the bottom of the cab.
15. Install the ATD to the exhaust tubing. As previously marked, connect the wiring to the sensors on the ATD.
16. Install the primary air tank and connect the air lines to it.
17. In the engine compartment, install the turbocharger heat shield.
18. Install the mounting bracket for the air-intake canister.
19. Install the air-intake canister to the mounting bracket.
20. Install the right and left inner splash shields.
21. Install the right and left quarter fenders.
22. As applicable, install the steps, air fairings, fuel tank(s), and/or the battery box.

    For instructions on installing the fuel tank(s), refer to **Group 47** in this workshop manual.
23. Using the previously removed fasteners, install the rain tray on the frontwall.
24. Connect the hoses and drains to the bottom of the rain tray.
25. As previously marked, install the wiper arms.
26. If they were removed, install the two tow hooks on the side of the right frame rail.
27. Close the hood.
28. Install the battery mega-fuse block on the left-side frame rail, underneath the cab.
29. Connect the battery cables.
30. Remove the chocks.

Specifications

Engine Mount Torques, Pre EPA07 Engines			
Description	**Fastener Size**	**Grade/ Class**	**Torque: lbf·ft (N·m)**
Engine Mount-to-Frame Rail Capscrew	5/8–11 x 2.5 Inch	8	120–152 (163–206)
Engine Leg-to-Flywheel Housing Bolts:			
Cummins Engines	3/4–10 x 2 Inch	8	190 (258)
Detroit Diesel Series 60 Engines	5/8–11 x 1-3/4 Inch	8	136 (184)
MBE4000 Engines	M16 x 1.5 x 50 mm (upper) M16 x 1.5 x 40 mm (lower)	10.9	175 (237)
Caterpillar Engines	3/4–10 x 2 Inch	8	170–210 (230–285)
Isolator Capscrew	5/16–18 x 1 Inch	8	14–18 (19–24)
Engine Leg-to-Engine Mount Capscrew	3/4–10 x 4.5 Inch	8	213–269 (289–365)
Front Engine Bracket-to-Front Engine Mount Capscrew	3/4–10 x 4 Inch	8	213–269 (289–365)

Table 1, Engine Mount Torques, Pre-EPA07 Engines

Engine Mount Torques, EPA07 Engines			
Description	**Fastener Size**	**Grade/ Class**	**Torque: lbf·ft (N·m)**
Engine Mount-to-Frame Rail Capscrew	5/8–11	8	120–152 (163–206)
Engine Leg-to-Flywheel Housing Bolts:			
Detroit Diesel Series 60 Engines	5/8–11 x 2-1/4 Inch	8	136 (184)
MBE4000 Engines	M16 x 1.5 x 60 mm (upper) M16 x 1.5 x 50 mm (lower)	10.9	175 (237)
Caterpillar Engines (C13 & C15)	3/4–10 x 2-3/4 Inch	8	170–210 (230–285)
Engine Leg-to-Engine Mount Capscrew	3/4–10	8	300 (407)
Front Engine Bracket-to-Front Engine Mount Capscrew	3/4–10	8	213–269 (289–365)

Table 2, Engine Mount Torques, EPA07 Engines

Inspection

1. Inspect all used drive belts — including those being replaced — for the following conditions (see **Fig. 1**):

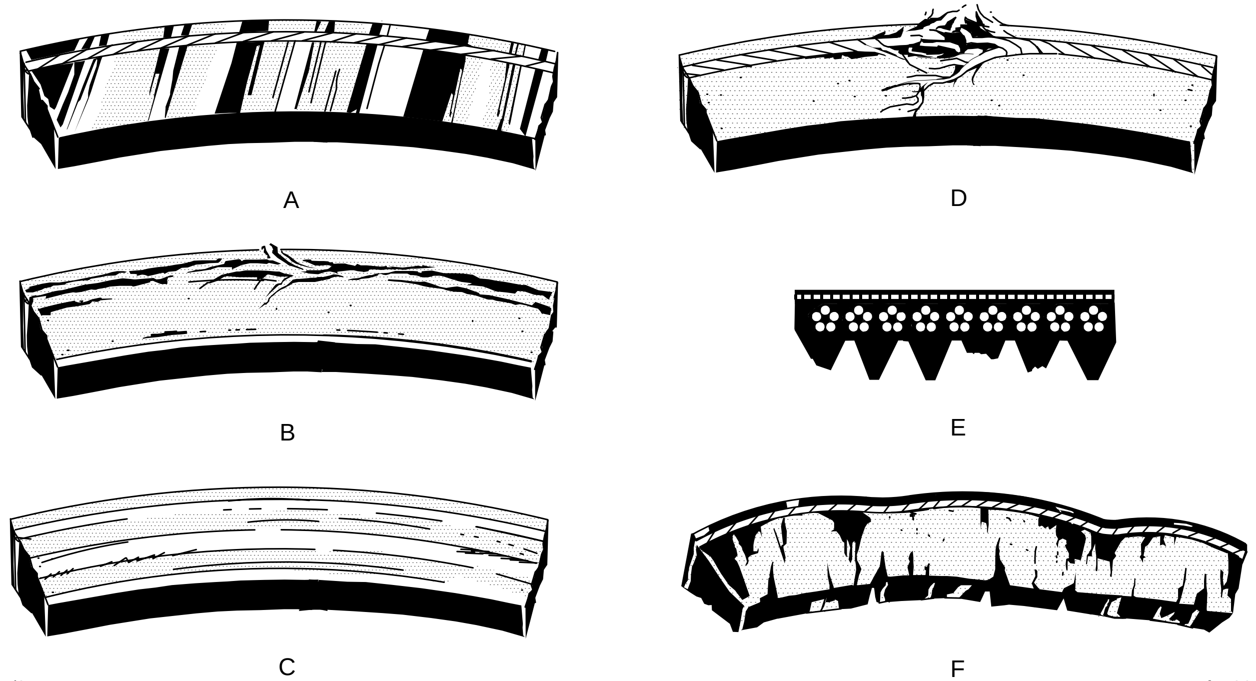
   NOTE: For an installed belt, gently twist the belt about 90 degrees so you can see the sidewalls and bottom.

   1.1 Inspect for glazing (shiny sidewalls). Glazing is caused by friction created when a loose belt slips in the pulleys. It can also be caused by oil or grease on the pulleys.

   1.2 Inspect for separating layers. Oil, grease, or belt dressings can cause the belt to fall apart in layers. If engine parts are leaking, repair the oil leaks. Do not use belt dressings on any belt.

   1.3 Check for jagged or streaked sidewalls. These are the result of a foreign object (such as sand or small gravel) in the pulley, or a rough pulley wall surface.

   1.4 Check for tensile breaks (breaks in the cord body). Cuts in a belt are usually caused by large foreign objects in the pulley, or by prying or forcing the belt during installation or removal.



A. Glazing
B. Separating Layers
C. Streaked Sidewalls
D. Tensile Break
E. Uneven Ribs
F. Cracks

Fig. 1, Drive Belt Problems

   1.5 On poly-V belts, check for uneven ribs. Foreign objects in the pulley will erode the undercord ribs, causing the belt to lose its gripping power.

   1.6 Inspect for cracks. Small, irregular cracks are usually signs of an old belt.

   Replace the belt if any of the above conditions are found. Replace both belts of a set, at the same time. Matched belts must be from the same manufacturer.

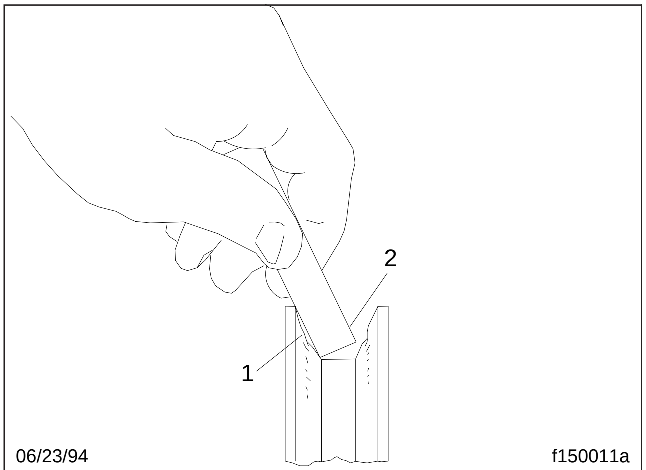
2. Check all pulley bearings for roughness. Replace the bearings if they are rough.

3. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a nonflammable

Drive Belt Inspection, Caterpillar C-10

cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.

4. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls (see **Fig. 2**), or use your little finger or fingernail to find grooves in the inner walls. If there are any grooves, replace the pulley.



1. Groove in Pulley Wall
2. Small Straightedge

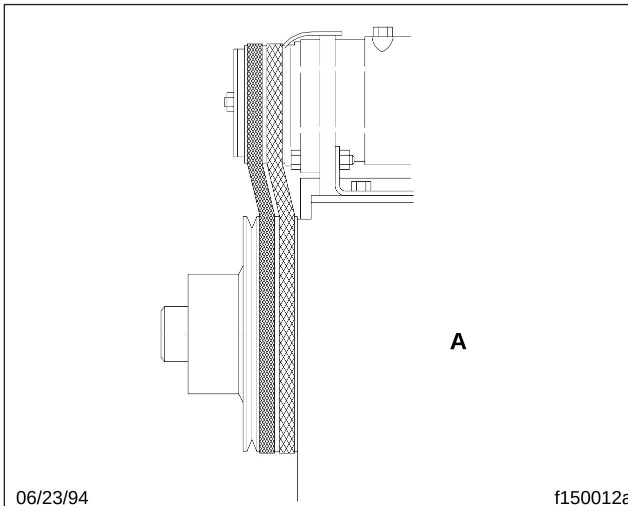
Fig. 2, Checking for Pulley Wear

5. Check alignment of pulleys.Use a thin straightedge that is longer than the longest span between the pulleys. Place the straightedge into the V-grooves of two pulleys at a time. The straightedge should be parallel to the outer edges of the pulleys; if not, the pulleys are misaligned.

   Pulley misalignment must not be more than 1/16-inch for each foot (1.5 mm for each 30.5 cm) of distance between pulley centers.

   If there is misalignment of the pulleys, adjust the pulleys or brackets if their positions are adjustable. See **Fig. 3**. Replace bent or broken pulleys, pulley brackets, or shafts.

6. Check all drive component mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners. Repair or replace cracked or damaged brackets.



A. Side View of Misaligned Pulleys.

Fig. 3, Checking for Misaligned Pulleys

Belt Replacement

Fan/Alternator Belt

NOTE: See **Fig. 1** for this procedure

1. Remove the fan/alternator belt.
    1.1 Remove the belt from the refrigerant compressor pulley and let the belt rest on the fan hub. For instructions, see "Refrigerant Compressor Belt" in this subject.
    1.2 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner down and off the belt.
    1.3 Holding the belt tensioner down, remove the belt from the alternator pulley.
    1.4 Slowly release the belt tensioner, and remove the breaker bar.
    1.5 Lower the belt, and take it off the vibration damper. Raise the belt, and take it off over the fan. Remove the belt from the engine compartment.
2. Install the fan/alternator belt.
    2.1 Inspect the pulleys and used belts (even if installing new belts). For instructions, see **Subject 100** in this section.
    2.2 If the fan or fan hub was removed to remove the compressor belt, install the fan or fan hub with the compressor belt in the fan pulley groove. Do not attach the compressor belt to the compressor at this time.
    2.3 Loop the fan/alternator belt around the fan and align it in the rear channel of the fan pulley.
    2.4 Loop the belt down and around the vibration damper pulley.
    2.5 Install the refrigerant compressor belt on the compressor. Refer to the refrigerant compressor belt installation instructions in this subject.
    2.6 Insert a 1/2-inch breaker bar in the belt tensioner, and rotate the tensioner down while installing the belt on the alternator pulley.
    2.7 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.
    2.8 Remove the breaker bar from the tensioner.

NOTE: The Caterpillar belt tensioner automatically adjusts the fan-and-alternator belt to the correct tension.

If the belt slips, repair or replace the tensioner. For instructions, refer to the *Caterpillar C-10 Truck Engine Service Manual.*

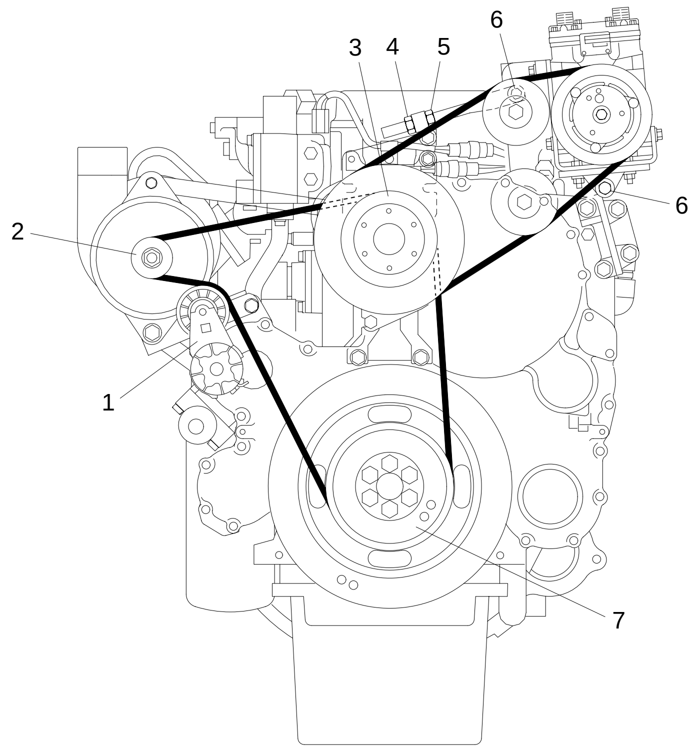
Refrigerant Compressor Belt

NOTE: See **Fig. 1** for this procedure.

1. Remove the refrigerant compressor belt.
    1.1 Loosen the refrigerant compressor jam nut, back off the adjusting nut, and loosen the compressor mounting bolts. Move the compressor towards the fan pulley until the belt can be removed from the compressor.
    1.2 Remove the compressor belt from the fan pulley. If necessary, remove the fan from the fan pulley. For instructions, see **Section 20.01** of this manual.
2. Install the refrigerant compressor belt.
    2.1 Inspect the pulleys and used belts, even if installing new belts. For instructions, see **Subject 100** in this section.
    2.2 Install the belt around the fan and the compressor pulleys.

        If the fan was removed, install it according to the instructions in **Section 20.01** of this manual.
    2.3 While keeping the belt seated in the pulley grooves, move the compressor away from the fan pulley to increase belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the longest belt free-span to check the tension. When belt deflection is about 1/2 to 3/4 inch (13 to 19 mm), stop, and adjust the belt tension.
3. Adjust the belt tension.

Drive Belt Replacement, Caterpillar C-10



1. Belt Tensioner
2. Alternator Pulley
3. Fan Pulley
4. Refrigerant Compressor Jam Nut
5. Refrigerant Compressor Adjusting Nut
6. Refrigerant Compressor Pivot Bolt
7. Vibration Damper

Fig. 1, Drive Belts, Caterpillar C-10 Engine

3.1 Install a belt tension gauge at the center of the belt's longest free-span.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

3.2 Turn the adjusting nut to adjust the tension to a reading of 100 lb (45 kg).

Tighten the jam nut 155 lbf·ft (210 N·m).

Tighten the compressor pivot bolts 70 lbf·ft (95 N·m).

Check the belt tension and adjust it if needed.

3.3 If any new belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

If the compressor belt tension is not 100 lb (45 kg), adjust the tension to 100 lb (45 kg).

Specifications

Engine	Component	Belt Tension, New Belt lbs (kg)	Belt Tension, Used Belt lbs (kg)
3176	Refrigerant Compressor	80 to 100 (36 to 45)	80 to 100 (36 to 45)
3406	Alternator and Refrigerant Compressor	115 to 125 (52 to 57)	80 to 100 (36 to 45)
	Fan	115 to 125 (52 to 57)	80 to 100 (36 to 45)
C-10	Refrigerant Compressor	100 (45)	100 (45)

Table 1, Drive Belt Tensions

Engine	Fastener	Torque: lbf·ft (N·m)
All Models	Rear Engine-to-Mount Bolts	213 to 269 (289 to 365)
	Front Engine-to-Mount Bolts	
	Engine Leg-to-Flywheel Housing Bolts (3/4–10 x 2 inches)	190 (258)

Table 2, Fastener Torques

Principles of Operation

The Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2006 meet lower exhaust emissions levels:

- 1.1 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx)
- 0.01 g/bhp-hr of particulate matter (PM)

To meet the EPA07 requirements, most engine manufacturers developed an aftertreatment system (ATS). The ATS varies according to engine and vehicle configuration, but instead of a muffler, an ATS has an aftertreatment device (ATD) that outwardly resembles a muffler.

Inside the ATD on Cummins, Detroit Diesel, and Mercedes-Benz engines, the exhaust first passes over the diesel oxidation catalyst (DOC), which uses a chemical process to break down pollutants into less harmful components. The exhaust then passes through the diesel particulate filter (DPF), which traps soot particles. See **Fig. 1**.

Caterpillar ATDs have a DPF, but do not have a DOC. Instead, CAT engines burn diesel fuel at the regeneration head to superheat the exhaust and reduce it to less harmful components. CAT engines also utilize Clean Gas Induction (CGI), a process in which some of the exhaust gas downstream of the DPF is recirculated into the air intake system. See **Fig. 2**.

The DPF core in all ATDs is comprised of ceramic channels that are blocked off at alternate ends to force the exhaust through the porous walls.

As soot accumulates in the DPF, it periodically needs to be converted to its basic parts: carbon dioxide, water, and ash. The conversion takes place through an event in the ATD referred to as regeneration (regen). If the exhaust temperature is high enough, the trapped soot is reduced to ash in a process called passive regen, which occurs as the vehicle is driven normally.

Passive regen, however, cannot always keep the DPF clean, so the ATD must also periodically undergo active regen. During active regen, extra fuel is injected into the exhaust stream to superheat and reduce the soot trapped in the DPF to ash. Active regen happens only when the vehicle is moving above a certain speed, as determined by the engine manufacturer.

Both active and passive regen happen automatically, without driver input. When operating conditions do not allow for active or passive regen, the vehicle may require a driver-activated parked regen, which takes 20 to 60 minutes, depending on ambient conditions.

Over time, ash collects in the ATS and needs to be removed through cleaning at specific intervals. For ATS maintenance and repair information, see the engine manufacturer's service literature.

Service Literature Coverage

Engine service procedures in this manual are limited to components installed by Daimler Trucks North America. See the following sections for information on EPA07-compliant parts and systems installed by Daimler Trucks North America:

- **Section 01.04**, Engine Mounts
- **Section 09.02**, Charge Air Cooler
- **Section 20.01**, Radiator Assembly
- **Section 30.00**, Electronic Throttle Control
- **Section 49.01**, Aftertreatment System, EPA07
- **Section 88.00**, Hood

Complete engine coverage including engine adjustment, preventive maintenance, and engine repair are covered in each engine manufacturer's service literature:

- Caterpillar: **www.cat.com**
- Cummins: **www.cummins.com**
- Detroit Diesel: **www.detroitdiesel.com**
- Mercedes-Benz: **www.detroitdiesel.com**

Periodic inspection of the ATS is required. For instructions, see the *Columbia Maintenance Manual*.

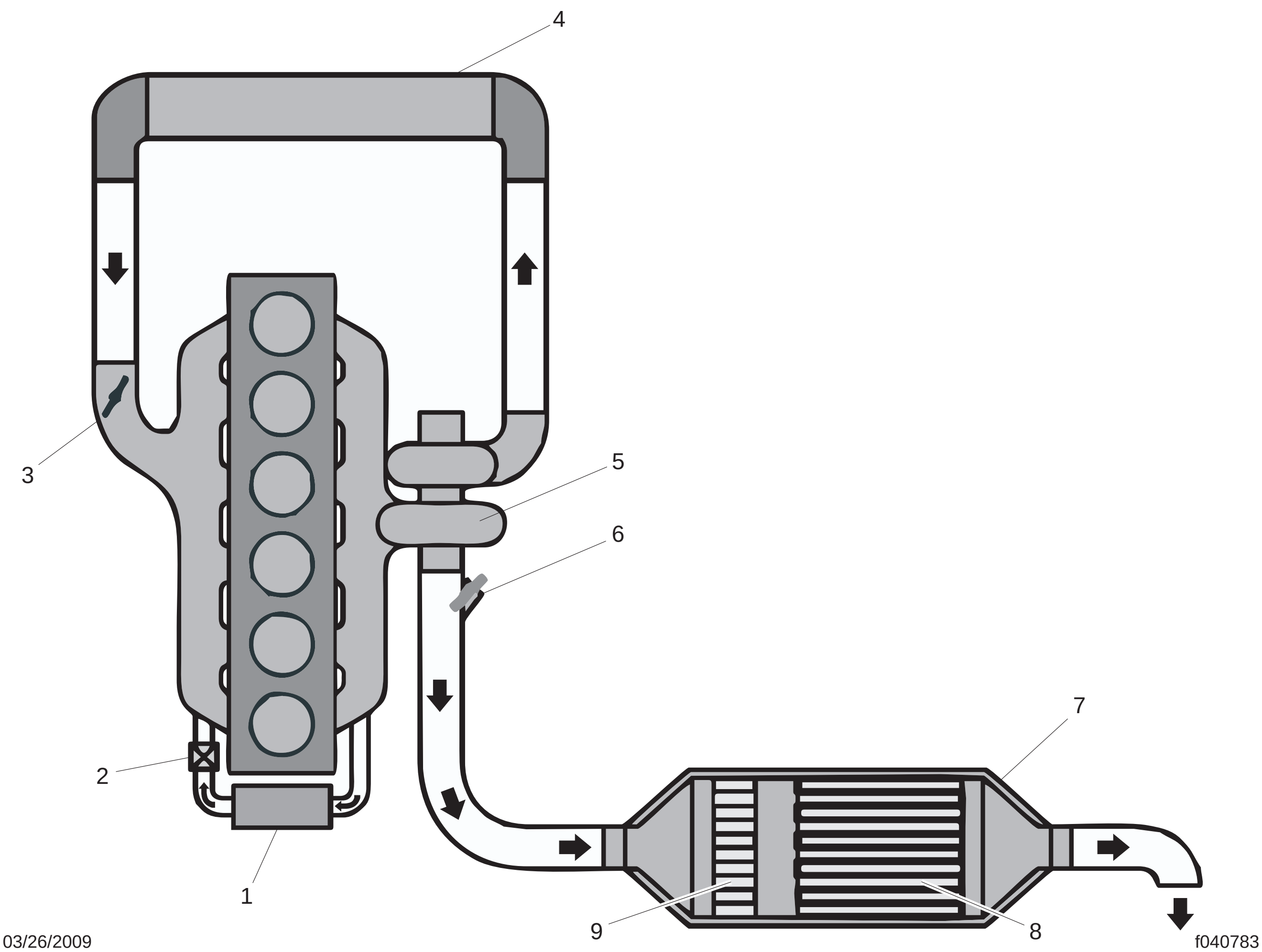
For driver pre- and post-trip inspection information, see the *Columbia Driver's Manual*.

Definition of Terms

Refer to the following terms for a better understanding of EPA07 engines.

Ash Unburnable solids that remain after regeneration in the ATD.

General Information



1. Exhaust Gas Recirculation (EGR) Cooler
2. EGR Valve
3. Intake Throttle Valve
4. Charge Air Cooler (CAC)
5. Turbocharger
6. Hydrocarbon Doser
7 Aftertreatment Device (ATD)
8. Diesel Particulate Filter (DPF)
9. Diesel Oxidation Catalyst (DOC)

Fig. 1, ATS (Detroit Diesel engine shown)

Aftertreatment Device (ATD) A device that removes pollutants from exhaust gas after the gas leaves the combustion chamber.

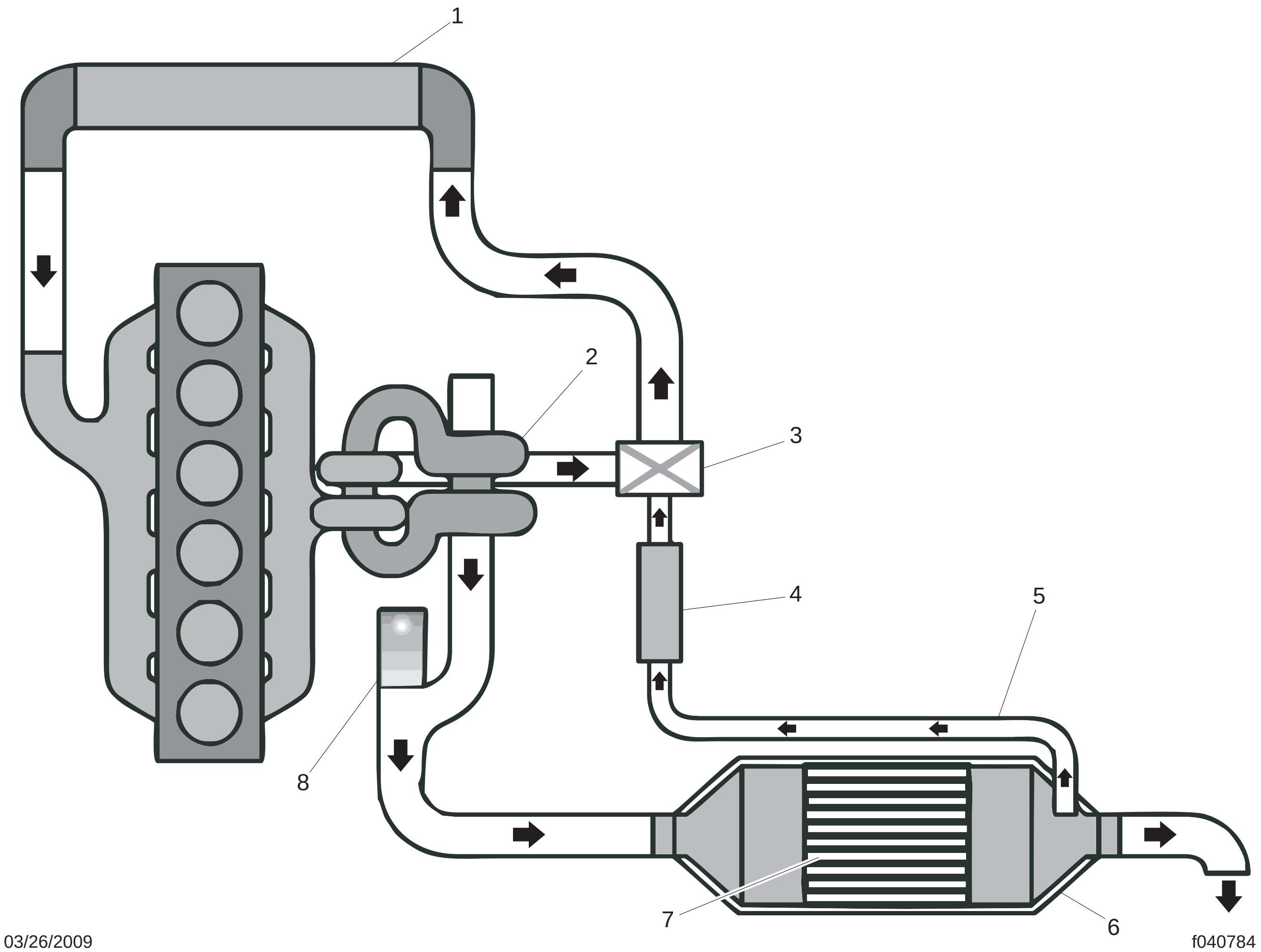
Aftertreatment System (ATS) The entire exhaust system from the turbocharger to the exhaust stack or tail pipe.

Clean Gas Induction (CGI) A process whereby small amounts of exhaust gas are drawn downstream of the DPF and recirculated into the air intake system. CGI is used in CAT engines only.

Diesel Oxidation Catalyst (DOC) A flow-through device that enhances the oxidation of hydrocarbons in the ATD on Cummins, Detroit Diesel, and Mercedes-Benz engines.

Diesel Particulate Filter (DPF) A component inthe ATD that captures particulate matter from the exhaust gas, preventing discharge from the tailpipe.

Exhaust Gas Recirculation (EGR) A process whereby exhaust is recirculated into the air intake system, creating lower cylinder temperatures. EGR is



1. Charge Air Cooler (CAC)
2. Dual-Stage Turbocharger
3. Clean Gas Induction (CGI) Mixing Valve
4. CGI Cooler
5. CGI Line
6. Aftertreatment Device (ATD)
7. Diesel Particulate Filter (DPF)
8. Regeneration Head

Fig. 2, ATS (Caterpillar engine shown)

used in Cummins, Detroit Diesel, and Mercedes-Benz engines only.

Nitrogen Oxides (NOx) Air pollutants composed of nitrogen and oxygen in various forms that contribute to the formation of smog.

Particulate Matter (PM) Soot particles formed by incomplete combustion of fuel that contribute to atmospheric pollution.

Regeneration (Regen) A process that occurs inside the ATD whereby accumulated soot is superheated and burned to ash, carbon dioxide, and water.

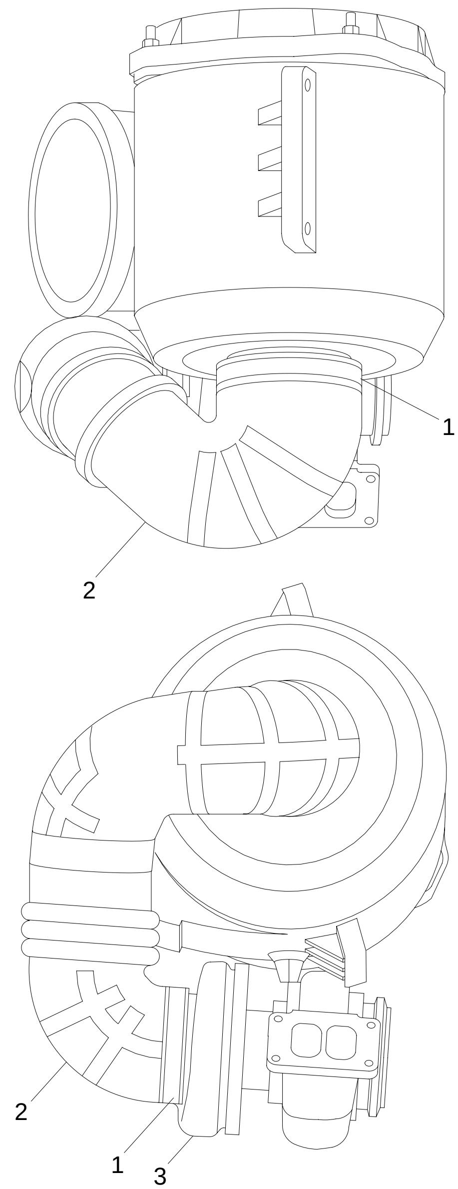
General Information

An average diesel truck engine needs over 10,000 gallons (38 000 liters) of clean air for each gallon (3.8 liters) of fuel burned. So that complete combustion occurs in each engine cylinder, more clean air than is needed is present in each cylinder. The air intake system routes this supply of outside air through an air cleaner, which filters out dust, dirt, abrasive particles, and other foreign material from the intake air, without restricting air flow.

From there, the air intake ducting routes this clean air to the engine. The air intake ducting is made up of a one-piece rubber hose and stainless steel hose clamps. See **Fig. 1**.

A lock-up (manual-reset) air restriction indicator mounts in a safety filter in the air intake ducting. See **Fig. 2**. As an option, the air restriction indicator or an air restriction (automatic-reset) gauge mounts in the dashboard. Nylon tubing connects the remote-mounted indicator or gauge to the safety filter in the ducting.

The air restriction indicator or gauge indicates when the air cleaner filter element needs to be replaced. The safety filter protects the clean-side of the air intake system in case the air restriction indicator or nylon tubing leaks or is damaged.



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1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

Fig. 1, Air Intake Ducting With Detroit Diesel Series 60 Engine

General Information

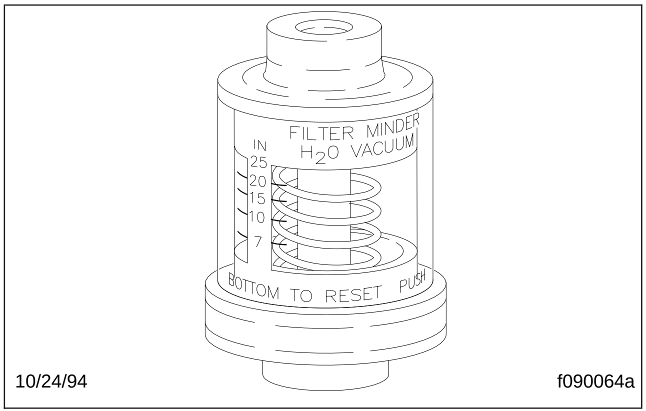


Fig. 2, Manual-Reset Air Restriction Indicator

Air Intake Ducting Removal and Installation

Removal

WARNING

Do not operate the engine with any component of the air intake system removed. Doing so could result in engine damage, and serious personal injury can occur if the turbocharger impeller is touched when it is rotating.

CAUTION

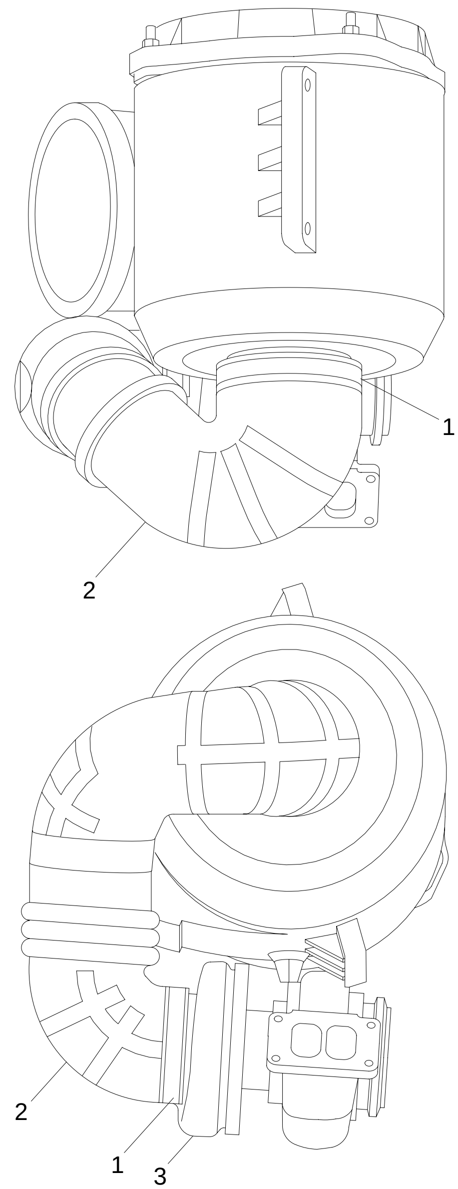
Do not operate the vehicle with the air filter element or any air intake component removed. All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood.
3. Loosen the hose clamps on the air intake ducting at the air cleaner outlet and the turbocharger inlet. See **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, and **Fig. 5**.
4. Remove the air intake ducting.
5. Replace any damaged parts with new identical parts.

IMPORTANT: Air intake ducting that has been enlarged, extended, or modified by bonding after original molding, are not acceptable for installation between the air cleaner and the engine.

Installation

1. Install the air intake ducting. Place the ducting over each connection so that it overlaps at least 1 inch (25 mm).
2. Tighten the hose clamp at the turbocharger 70 to 80 lbf·in (800 to 900 N·cm). Tighten the hose clamp at the air cleaner outlet 35 to 40 lbf·in (400 to 450 N·cm).

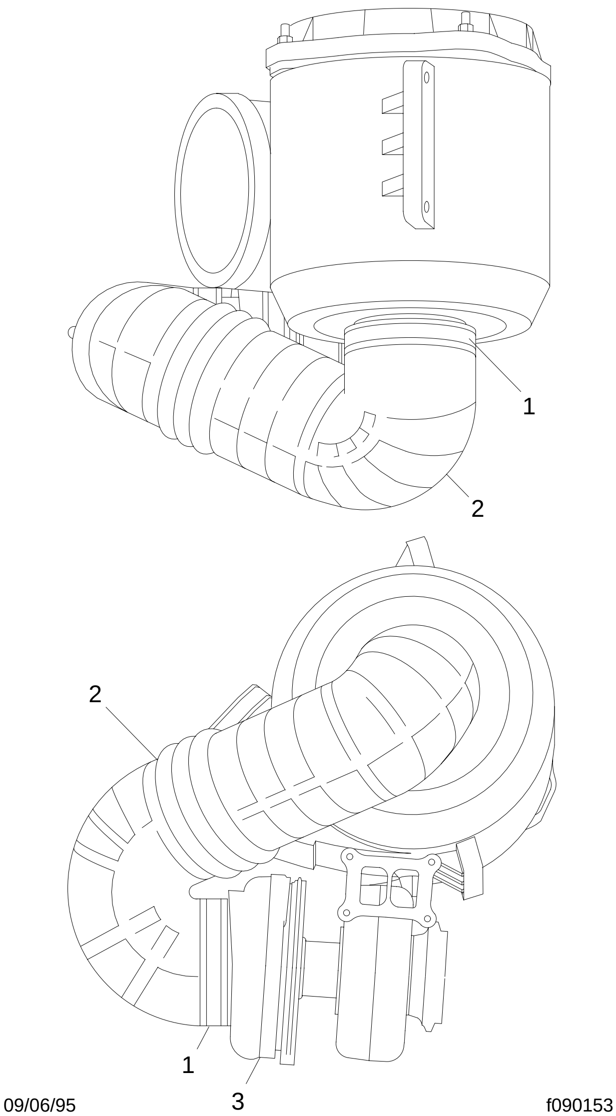


1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

Fig. 1, Air Intake Ducting (Detroit Diesel Series 60 engine)

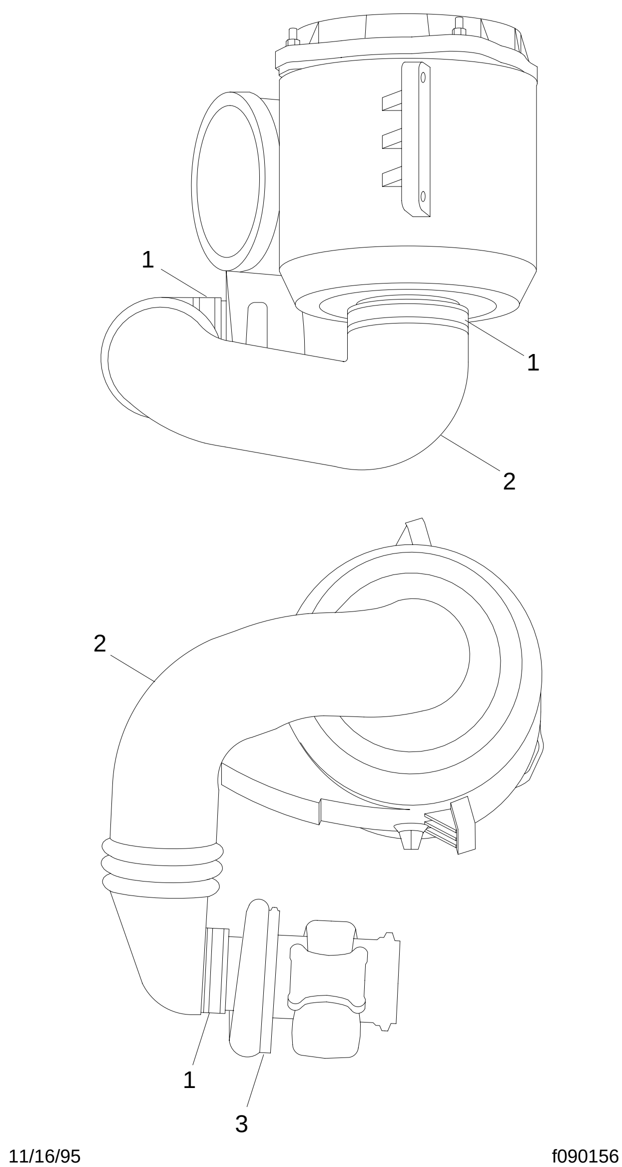
3. Lower the hood.
4. Remove the chocks from the tires.

Air Intake Ducting Removal and Installation



1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

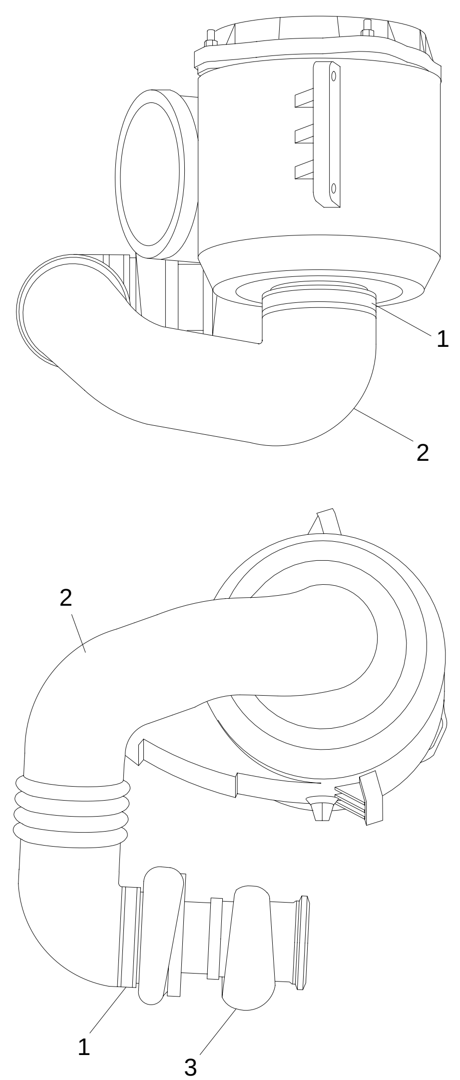
Fig. 2, Air Intake Ducting (Cummins N14 engine)



1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

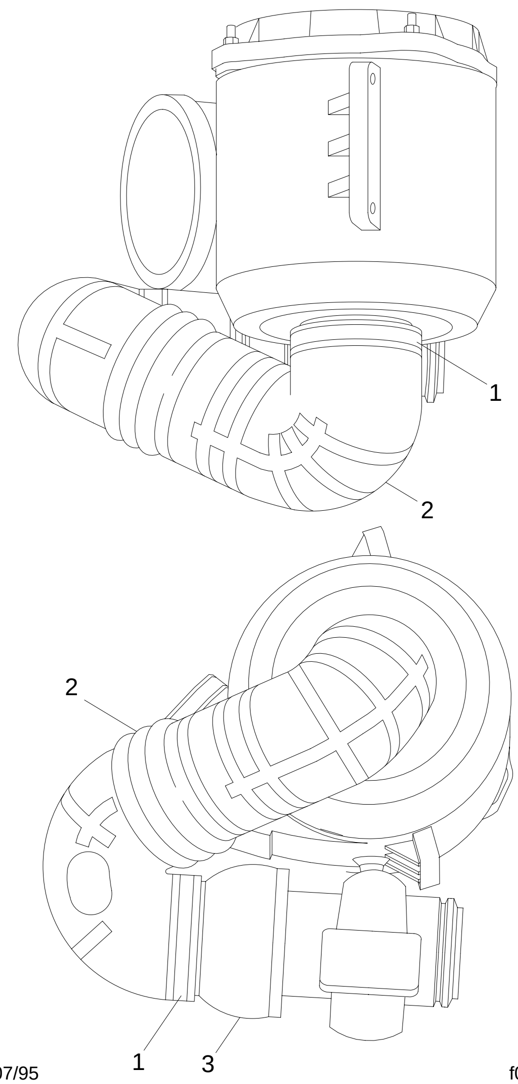
Fig. 3, Air Intake Ducting (Cummins ISM engine)

Air Intake Ducting Removal and Installation



1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

Fig. 4, Air Intake Ducting (Caterpillar C10/C12 engine)



1. Hose Clamp
2. Air Intake Ducting
3. Turbocharger

Fig. 5, Air Intake Ducting (Caterpillar C15/C16 engine)

Air Cleaner Restriction Inspection

Restriction of air flow through the air cleaner element is measured at the tap in the air cleaner outlet. Check the restriction indicator at the air cleaner or in the cab if the vehicle is equipped with a dash-mounted restriction gauge.

NOTICE

Use the air intake restriction gauge rather than visual inspection to determine if servicing the air filter element is necessary. Removal of the air filter element can cause damage to the primary seal, which may allow contaminants into the engine, potentially causing engine damage.

Vehicles may be equipped with either a manual-reset restriction indicator with graduations (**Fig. 1**), or a go/no-go restriction indicator without graduations (**Fig. 2**).

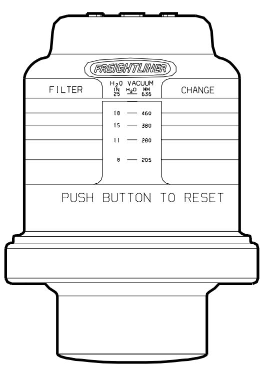


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Fig. 1, Manual-Reset Air Restriction Indicator, Graduated

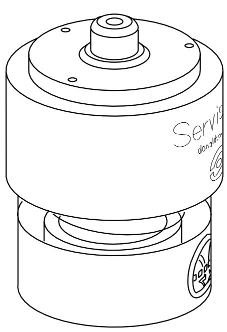

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Fig. 2, Manual-Reset Air Restriction Indicator, Go/No-Go

1. For vehicles equipped with a manual-reset indicator with graduations, check the indicator with the engine off to see if air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction.

   For vehicles equipped with a go/no-go restriction indicator without graduations, check the indicator with the engine off to see if the colored bar shows through the clear window.

Air Cleaner Element Maximum Restriction		
Engine	**Pre-EPA07 Engines**	**EPA07 Engines**
Caterpillar	25 inH_2O	25 inH_2O
Cummins	25 inH_2O	25 inH_2O
Detroit Diesel	20 inH_2O	22 inH_2O
Mercedes-Benz	22 inH_2O	22 inH_2O

Table 1, Air Cleaner Element Maximum Restriction at Full-Load and Rated rpm

2. If air restriction is below the maximum, no further work is necessary.

   If air restriction is at or above the maximum, push the reset button on the indicator.
3. Operate the engine to see if air restriction exceeds recommended values again. This can be done by running the vehicle on a dynamometer at **full-load and rated rpm**, or by driving the vehicle for one day in the vehicle's typical operating environment while not exceeding the rated rpm (typically 1800 rpm).
4. Check the indicator again. If air restriction continues to equal or exceed the maximum air restriction value in **Table 1** on an indicator with graduations, or if the colored bar shows through the clear window on a go/no-go indicator, replace the air cleaner element, then reset the indicator.

   For air cleaner element replacement instructions, see **Subject 110** for instructions.

Element Replacement

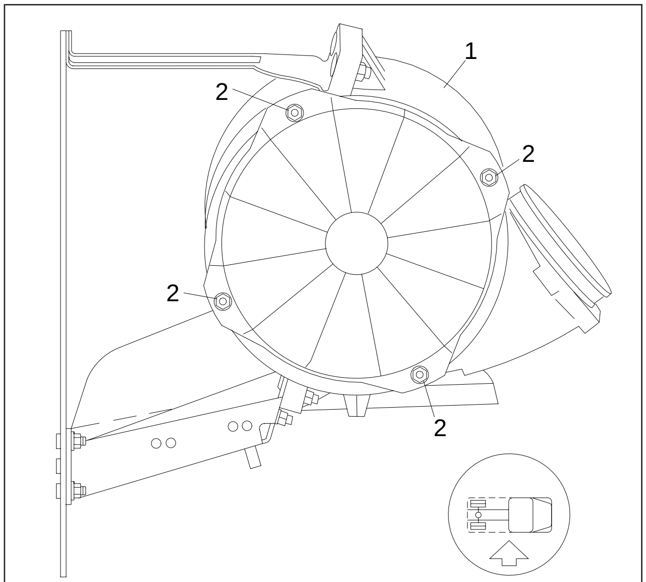
NOTICE

All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air filter element or any air intake component removed.

IMPORTANT: Do not modify, or use modified air cleaners and ducting components.

If the air cleaner housing has been damaged, immediately check all ducting and connections to the air cleaner for leakage. Adjust or replace parts as necessary. If needed, replace the air cleaner assembly, using the instructions in **Subject 120**.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Remove the four capnuts from the air cleaner cover. See **Fig. 1**.



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1. Air Cleaner Assembly
2. Capnut

Fig. 1, Air Cleaner Assembly

NOTICE

Never use impact or shock (pounding with a hammer) to release the air cleaner cover. This may distort the cover, and allow the entry of dirt and contaminants into the sealed system, causing engine damage.

4. Due to high gasket-loading pressures, removing the air cleaner cover may be difficult. After removing the capnuts, gently pry around the outside of the cover to remove it from the air cleaner housing.

NOTICE

Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.

5. Remove the air cleaner filter element. Removal may be difficult because the inboard element-gasket can stick to the cleaner housing. Push up and down on the outboard end of the element to release the gasket.

NOTICE

Do not leave any dirt on the inside of the air cleaner. If dirt gets inside the filter element, it may get into the engine and cause damage.

6. Check the housing and sealing surfaces for damage or dirt buildup that may cause sealing problems. Remove any dirt buildup.
7. Wipe the inside of the air cleaner housing with a clean damp cloth.
8. Inspect a new filter element for damaged gaskets and dented metal parts. If the gaskets are not smooth and flat, or are damaged to the extent that dust might bypass them, discard the element.

   Place a bright light inside the new element, and turn the element while looking through it from the outside. The light will reveal any hole or rupture. Holes in the element will allow dust to enter the engine. Discard the element if it is damaged.
9. Install the new filter element.

Donaldson Air Cleaner Element Replacement

10. Install the air cleaner cover, and attach the capnuts. Tighten the capnuts 95 lbf·in (1080 N·cm) evenly in a cross pattern to prevent distortion of the cover.
11. Check all connections for tightness.
12. Lower the hood.
13. Remove the chocks from the tires.

Air Cleaner Assembly Replacement

NOTICE

All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air filter element or any air intake component removed.

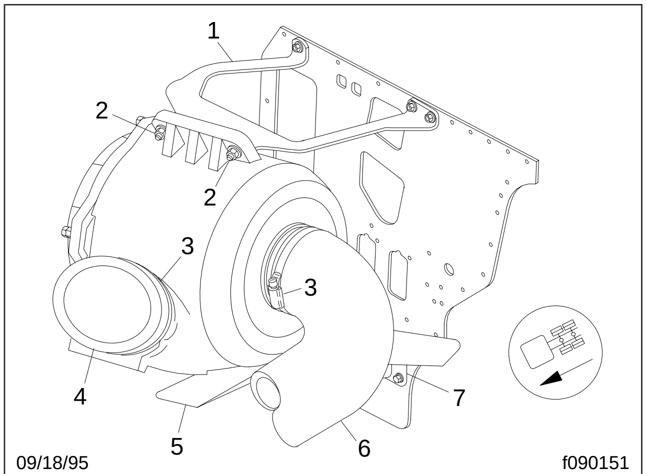
IMPORTANT: Do not modify, or use modified air cleaners and ducting components.

If the air cleaner housing has been damaged, immediately check all ducting and connections to the air cleaner for leakage. Adjust or replace parts as necessary. If needed, replace the air cleaner assembly as follows:

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Examine the hood-to-cleaner-housing seal. If the seal is in serviceable condition, remove the hose clamp and seal for installation on the new air-cleaner housing. See **Fig. 1**.
3. Loosen the hose clamp that attaches the flexible duct to the air cleaner outlet port. Pull the flexible duct off the outlet port.
4. Using a socket and a long extension, remove the two sets of locknuts, washers, and spacers from the air cleaner mounting studs extending from the lower mounting bracket, above the turbocharger heat shield.
5. Remove the two sets of locknuts and washers from the air cleaner mounting studs at the upper mounting bracket.
6. Work the air cleaner housing off the four mounting studs.
7. Install the new air cleaner housing on the mounting studs.
8. Install the two sets of locknuts and washers on the air cleaner mounting studs at the upper mounting bracket.

   Install the two sets of locknuts and washers on the air cleaner mounting studs at the lower mounting bracket. If a socket and long extension are used, removal of the turbocharger heat shield is not necessary.

   Tighten all four locknuts 26 lbf·ft (35 N·m).



1. Upper Mounting Bracket
2. Locknut and Washer
3. Hose Clamp
4. Hood-to-Cleaner-Housing Seal
5. Turbocharger Heat Shield
6. Flexible Outlet Duct
7. Lower Mounting Bracket

Fig. 1, Air Cleaner Assembly Installation

9. Remove the cover from the flexible duct. Attach the duct to the air cleaner outlet port. The hose must be installed all the way onto the port.

   Secure the connection with the hose clamp. Tighten the hose clamp 35 to 40 lbf·in (400 to 450 N·cm).

NOTICE

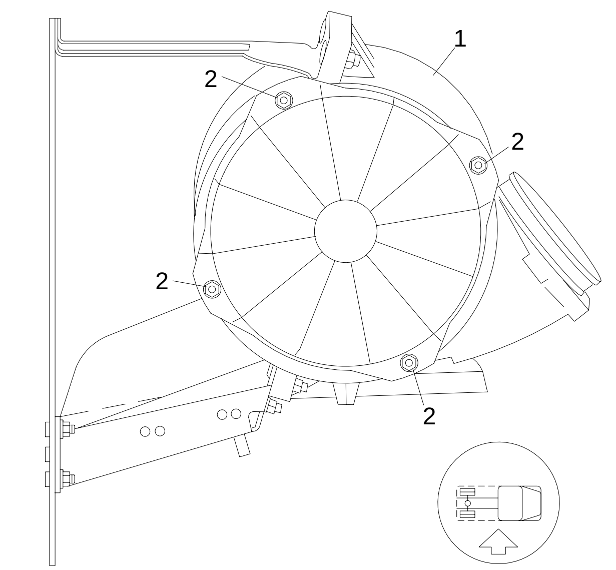
Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.

10. Inspect a new filter element for damaged gaskets and dented metal parts. If the gaskets are not smooth and flat, or are damaged to the extent that dust might bypass them, discard the element.

Donaldson Air Cleaner Assembly Replacement

Place a bright light inside the new element, and turn the element while looking through it from the outside. The light will reveal any hole or rupture. Holes in the element will allow dust to enter the engine. Discard the element if it is damaged.

11. Remove the four capnuts from the cover on the air cleaner assembly. See **Fig. 2**. Remove the cover, and install the new filter element.



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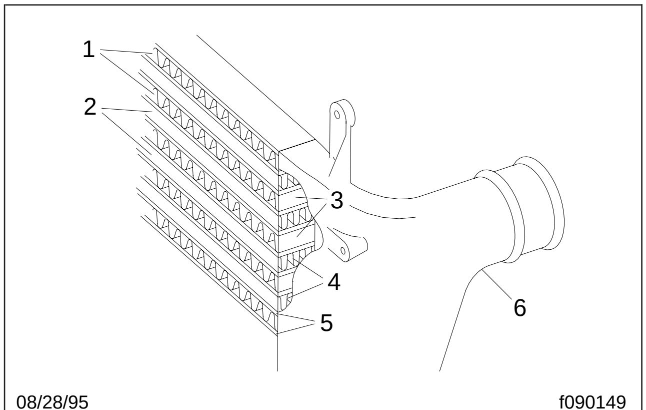
1. Air Cleaner Assembly
2. Capnut

Fig. 2, Air Cleaner Assembly Mounting

12. Attach the cover to the air cleaner assembly, and attach the capnuts. Tighten the capnuts 95 lbf·in (1070 N·cm) evenly in a cross pattern to prevent distortion of the cover.
13. Install the hose clamp and a new or serviceable hood-to-cleaner-housing seal on the new air-cleaner housing. Tighten the hose clamp 45 lbf·in (500 N·cm).
14. Check all connections for tightness.
15. Lower the hood.
16. Remove the chocks from the tires.

General Information

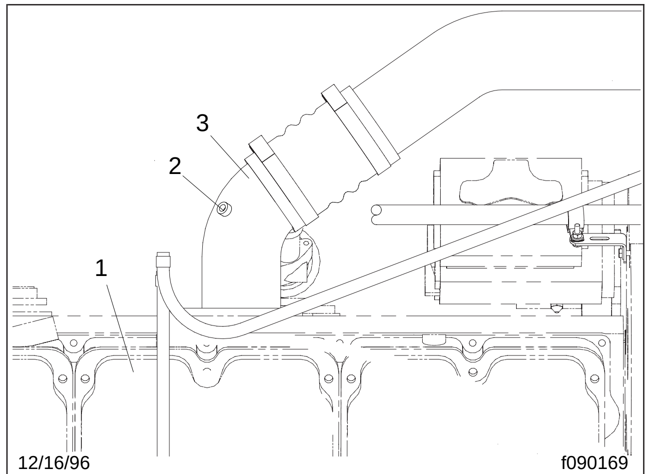
The charge air cooler (CAC) is attached to the front of the radiator and is similar to a radiator. See **Fig. 1**. Outside ambient air passing through the CAC core cools the engine's intake air charge. The air charge leaving the turbocharger is hot compressed air, about 275 to 325°F (135 to 162°C), depending on the ambient temperature. The CAC reduces the air charge temperature to about 110°F (43°C), with a 77°F (25°C) ambient temperature, before the air charge enters the engine intake manifold. This temperature decrease lowers exhaust emissions, improves fuel economy, and increases horsepower.



1. Cold Fins
2. Hot Bars
3. Cold Bars
4. Hot Fins
5. Tube Plates
6. Header Tank

Fig. 1, CAC Construction

Vehicles equipped with an ether-aided starting system have a different air intake elbow at the engine. See **Fig. 2**. See **Group 01** for information about the ether starting system.



1. Engine
2. Nozzle
3. Elbow

Fig. 2, Air Intake Elbow with Ether Starting Nozzle

Removal

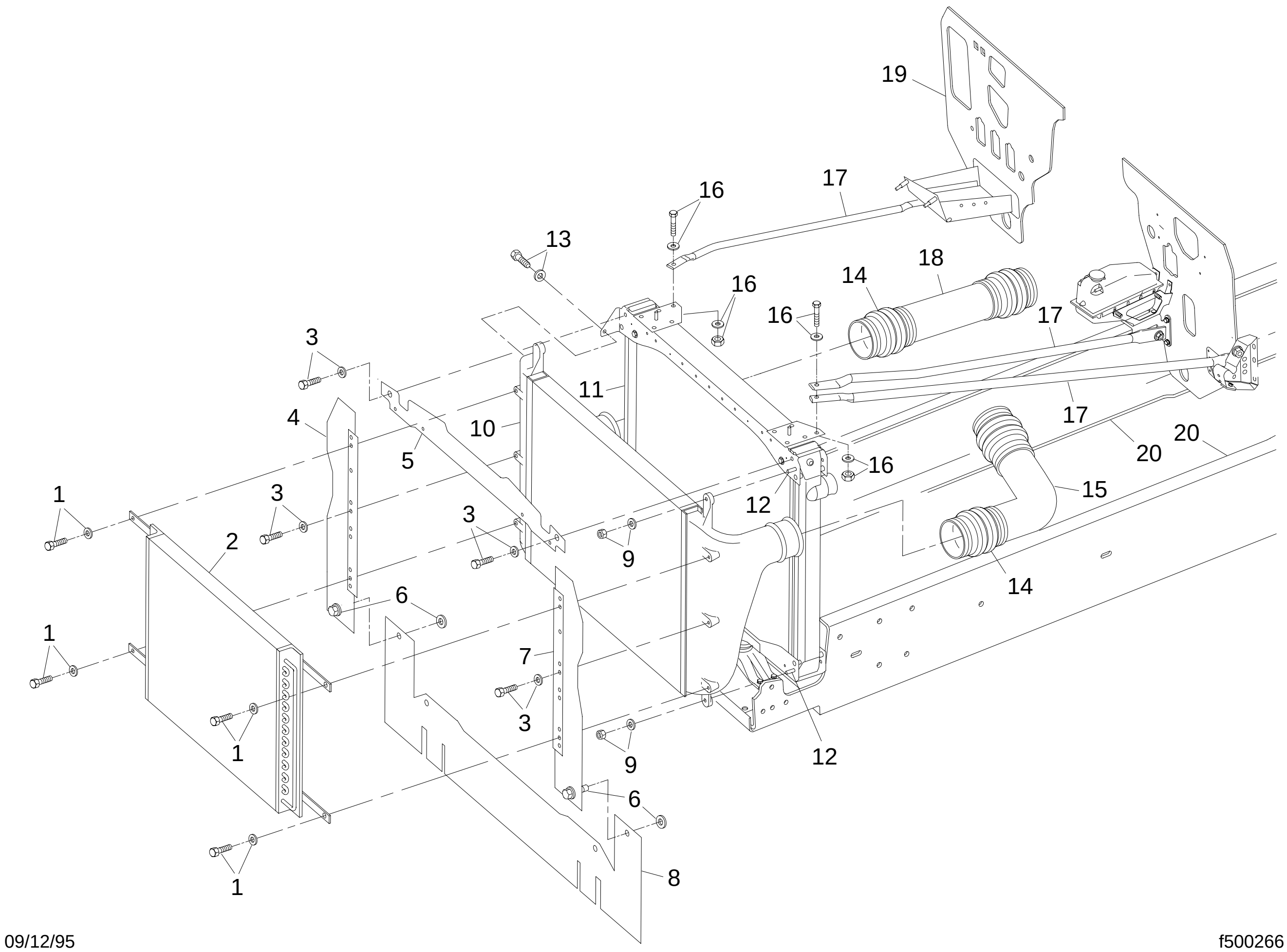
1. Apply the parking brakes and chock the tires.
2. Remove the grille from the hood.
3. Open the hood and support its front upper edge in a position that will allow the hood straps to be disconnected; place a support between the floor and the front of the hood, above the grille opening. Use cardboard, carpet, rags, or other padding on top of the support to protect the hood.
4. Disconnect both hood straps from the top of the radiator.
5. Loosen the constant tension hose clamps at both ends of the convoluted hoses that attach the inlet and outlet air piping to the charge air cooler (CAC) connections. Push the clamps and hoses back onto the piping, until they are not touching the CAC connections.
6. To allow extra slack in the A/C condenser hoses, remove the hose clamp that attaches the hoses near the right side of the radiator.
7. While standing in the grille opening, remove the lower sets of fasteners that attach the side air-recirculation baffles to the CAC. Remove the plastic panel retainers and fender washers that attach both of the side air-recirculation baffles to the lower air-recirculation baffle. See **Fig. 1**.
8. Place shop towels or rags on top of the right-side tire. Remove the fasteners that attach the condenser to the CAC; then, with the A/C hoses still connected, swing the condenser around, and carefully lay it on top of the padding on the right-side tire.
9. For a CAC that is mounted on a 1200-square-inch (see **Fig. 1**) or 1350-square-inch radiator, remove the two bolts and washers that attach the CAC to the right side of the radiator. While pressing the CAC rearward, remove the two nuts and washers that secure the CAC on the forward studs at the left side of the radiator. Hold it there after the fasteners have been removed, until someone else can support the left side of the CAC. Remove the bolts.

   For a CAC that is mounted on a 1000-square-inch radiator (see **Fig. 2**), remove the two sets of fasteners that attach the CAC to the bottom of the radiator; then, while pressing the CAC rearward, remove the two nuts and washers, but not the bolts, that attach the CAC to the top of the radiator. Hold it there after the nuts have been removed, until someone else can support the left side of the CAC. Remove the bolts.
10. While someone else supports the left side of the CAC, pull both sides of the CAC far enough forward to clear the radiator's CAC mounting tabs or forward studs, as equipped. With the CAC held forward to clear the tabs and studs, move the CAC outboard to the right, then push the right side of the CAC back and inboard until the narrowest section of the CAC air inlet connection is tight against the radiator end tank. Work the CAC air outlet connection off the radiator's left end tank. Then move the CAC to the right until the CAC air inlet connection clears the radiator's right end tank.
11. Pass the CAC out the left side of the vehicle.
12. For a CAC that is mounted on a 1350-square-inch radiator that has aluminum CAC baffles attached to the radiator support channels, remove the six Torx® fasteners that secure the baffles to the radiator. Remove and discard the aluminum CAC baffles.
13. If a new CAC is being installed, remove the side air-recirculation baffles from the old CAC.

Installation

1. With the hood supported at its full-open position, and one person standing inside the grille opening, pass the CAC in from the left side of the vehicle.
2. With someone supporting the left side of the CAC, move the CAC outboard to the right, then push the right side of the CAC back and inboard until the narrowest section of the CAC air inlet connection is tight against the radiator end tank. Work the CAC air outlet connection onto the radiator's left end tank.
3. Pull both sides of the CAC far enough forward to clear the radiator's CAC mounting tabs or forward studs, as equipped. Then push the CAC mounting tabs onto the 1200-square-inch or 1350-square-inch radiator's forward studs (see **Fig. 1**), or push the CAC mounting tabs between the mounting tabs of the 1000-square-inch radiator (see **Fig. 2**).

Pre-EPA07 CAC Removal and Installation

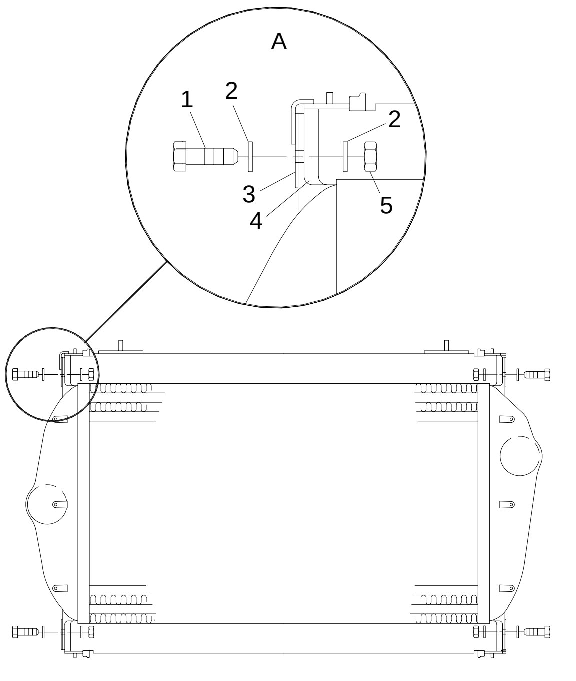


NOTE: Aluminum CAC baffles are not shown.

1. A/C Condenser Mounting Fasteners
2. A/C Condenser
3. Air-Recirculation Baffle Mounting Fasteners
4. Right-Side Air-Recirculation Baffle
5. Upper Air-Recirculation Baffle
6. Air-Recirculation-Baffle Plastic Panel Retainer and Fender Washer
7. Left-Side Air-Recirculation Baffle
8. Lower Air-Recirculation Baffle
9. CAC Mounting Nut and Washer
10. CAC
11. 1200-Square-Inch Radiator
12. Radiator Forward Stud
13. CAC Mounting Bolt and Washer
14. Convoluted Hose
15. CAC Outlet Air Piping
16. Radiator Brace-Rod Fasteners
17. Radiator Brace Rod
18. CAC Inlet Air Piping
19. Cab Frontwall
20. Frame Rail

Fig. 1, CAC Installation for 1200-Square-Inch Radiator

4. Install the fasteners that attach the CAC to the radiator. Tighten all CAC mounting fasteners 28 lbf·ft (38 N·m).
5. If the side air-recirculation baffles were removed, or a new CAC is being installed, attach both of the side air-recirculation baffles to the *center* holes of the CAC.



A. Typical, 4 places

1. 3/8–16 Hexbolt
2. Hardened Washer
3. CAC Mounting Tab of Radiator
4. Mounting Tab of CAC
5. Prevailing Torque Locknut

Fig. 2, CAC Installation for 1000-Square-Inch Radiator

6. Swing the A/C condenser around, and install it on the front of the CAC. Tighten all condenser and air-recirculation-baffle fasteners 96 lbf·in (1080 N·cm). Install the air-recirculation-baffle plastic panel retainers and fender washers that attach the lower air-recirculation baffle to the side air-recirculation baffles. See **Fig. 1**. Install any A/C condenser hose clamps that were removed.
7. Tilt the hood to an angle that will allow attachment of the hood straps to the top of the radiator. Attach the hood straps. Remove the hood support, then tilt the hood.
8. Pull the convoluted hoses and constant tension hose clamps forward until the hoses cover the CAC inlet and outlet connections up to the hose stops that are cast into the CAC connections.
9. Turn the constant tension hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

10. Lower the hood, then install the grille.

Removal

1. Apply the parking brakes and chock the tires.
2. If the vehicle has a 37-tube charge air cooler (CAC), do the following.
   - 2.1 Remove the grille from the hood.
   - 2.2 Tilt and support the hood so that the hood straps can be be disconnected. The support system must be adjustable (while loaded with the weight of the hood) and very reliable to ensure the hood is protected from damage.
   - 2.3 Disconnect both hood straps from the top of the radiator.
3. If the vehicle has a 47-tube CAC, do the following.
   - 3.1 Remove the bumper. For instructions, see **Group 31**.
   - 3.2 Remove the hood. For instructions, see **Group 88**.
   - 3.3 Remove the front closing crossmember.
4. Loosen the hose clamps at both ends of the hoses that attach the inlet and outlet air piping to the CAC, then push the clamps and hoses back onto the air piping.
5. Allow extra slack in the A/C condenser hoses by removing the hose support clamp that attaches the hoses near the right side of the radiator.
6. Place shop towels or rags on top of the right-side tire as padding for the condenser. Remove the fasteners that attach the condenser to the CAC, then, with the A/C hoses still connected, swing the condenser around, and carefully lay it on top of the padding on the right-side tire.
7. Remove the side air-recirculation baffles from the CAC.
8. Remove the bolts that hold the overflow bottle to the cooling package so that the bottle can move. The coolant does not need to be drained.
9. Loosen the two upper bolts that hold the CAC to the cooling package side rails and completely remove the two lower bolts.
10. Support the CAC, then remove the two upper bolts.
11. While someone else supports the left side of the CAC, slightly raise the right side of the CAC. See **Fig. 1**. Then, with the left side held close to the radiator, pull the right side away from the cooling package frame. See **Fig. 2**.

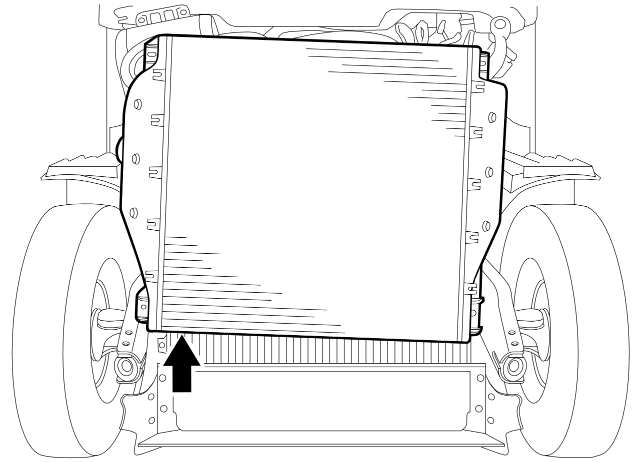


Fig. 1, 47-Tube CAC Tilted for Removal, Front View

Installation

1. With someone supporting the left side of the CAC, hook the left end tube on the cooling package, then adjust the angle of the CAC to allow the right end tube to slip past the cooling package frame.

NOTE: Installing the CAC may be more difficult than removing it, and the fit may be tight. Be sure nothing hinders the fit between the CAC and the cooling package frame.

2. Install the fasteners that attach the CAC to the radiator. Tighten all CAC mounting fasteners 28 lbf·ft (38 N·m).
3. Install the overflow bottle on the cooling package and tighten the radiator-mounting bolts and the cooling package frame-mounting bolts 18 to 24 lbf·ft (25 to 33 N·m).
4. Install the side air-recirculation baffles on the CAC, and tighten the fasteners 96 lbf·in (1080 N·cm).
5. Swing the A/C condenser around, and install it on the front of the CAC. Tighten all condenser

EPA07 CAC Removal and Installation

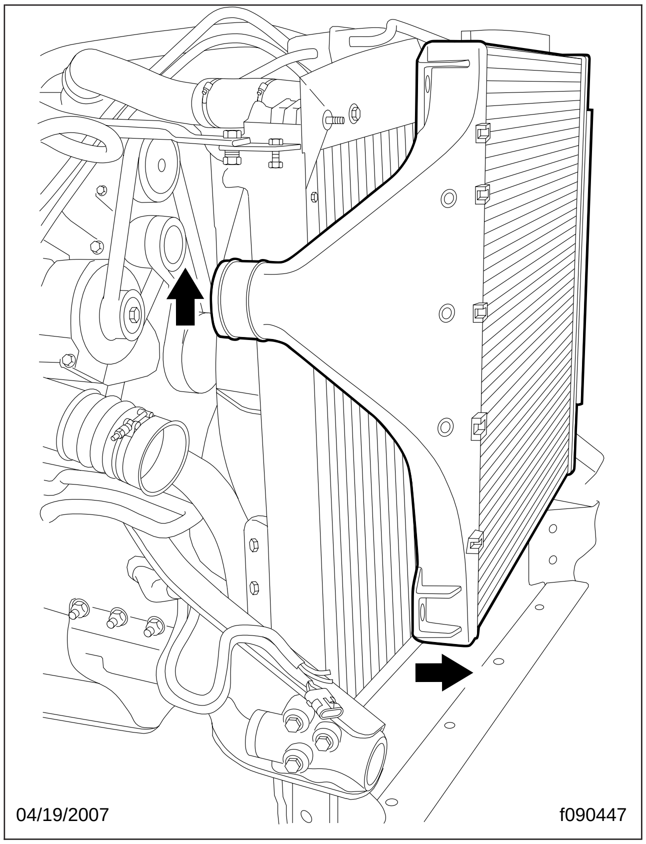


Fig. 2, 47-Tube CAC Tilted for Removal, Side View

fasteners 96 lbf·in (1080 N·cm). Install any A/C condenser hose support clamps that were removed.

6. Pull the convoluted hoses and constant tension hose clamps forward until the hoses cover the CAC tube ends up to the cast hose stops.
7. Turn the constant tension hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

8. If the vehicle has a 37-tube CAC, do the following.
   - 8.1 Tilt the hood to an angle that allows attachment of the hood straps to the top of the radiator. Attach the hood straps and remove the hood support.
   - 8.2 Return the hood to the operating position, and install the grille.
9. If the vehicle has a 47-tube CAC, do the following.
   - 9.1 Install the front closing crossmember. All capscrews should be fitted and aligned in the tow hook receivers before any are tightened.
   - 9.2 Install the hood. For instructions, see **Group 88**.
   - 9.3 Install the bumper. For instructions, see **Group 31**.
   - 9.4 Check the hood for proper alignment.

Inspection

1. Apply the parking brakes and chock the tires.
2. Check the charge air cooler (CAC) convoluted hoses and the inlet and outlet piping for holes or other damage. Also check for loose or damaged constant tension hose clamps. Replace damaged parts. If hose clamps are loose, turn them so their tightening screws are under the hoses or facing inboard. Tighten the screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

3. Check the CAC core fins. If the fins are bent, use a small pair of needlenose pliers or a small screwdriver to straighten them.
4. Check the CAC core for clogged fins. Use compressed air or water to dislodge any material restricting airflow through the core.
5. Perform the "CAC Core Leakage Test."

CAC Core Leakage Test

Charge air coolers are designed in such a way that they may bleed an insignificant amount of air. The allowable leakage mentioned in **Table 1** represents a loss of less than 0.1 percent of charge airflow. Based on this rate, there should be no measurable loss of performance.

Leakage Rate Specifications		
Engine	**Pressure Drop in 15 Seconds: psi (kPa)**	**Start Pressure: psi (kPa)**
Caterpillar	5 (34)	30 (207)
Cummins	7 (48)	30 (207)
Detroit Diesel	5 (34)	25 (172)

Table 1, Leakage Rate Specifications

The CAC core leakage test should be performed using a CAC test kit, part number 5039, which can be purchased from Kent-Moore/SPX at 1-800-328-6657.

1. Apply the parking brakes and chock the tires.
2. Connect the test equipment to the CAC core as follows. See **Fig. 1**.
   - 2.1 Remove the inlet and outlet air piping from the convoluted hoses that attach them to the CAC air inlet and air outlet.
   - 2.2 Slip a safety ring with thumbscrew over each convoluted hose and onto the CAC air inlet and air outlet. Turn the rings so the thumbscrews are facing outboard and the safety chains are inboard. Tighten the thumbscrews securely.
   - 2.3 Install an additional constant tension hose clamp on each convoluted hose.
   - 2.4 Install the test plug without an adapter in the CAC air inlet, and turn the plug so the safety chain is inboard. Tighten each constant tension hose clamp 72 lbf·in (810 N·cm).
   - 2.5 Install the test plug with adapter in the CAC air outlet and turn the plug so the safety chain is inboard. Tighten each constant tension hose clamp 72 lbf·in (810 N·cm).

WARNING

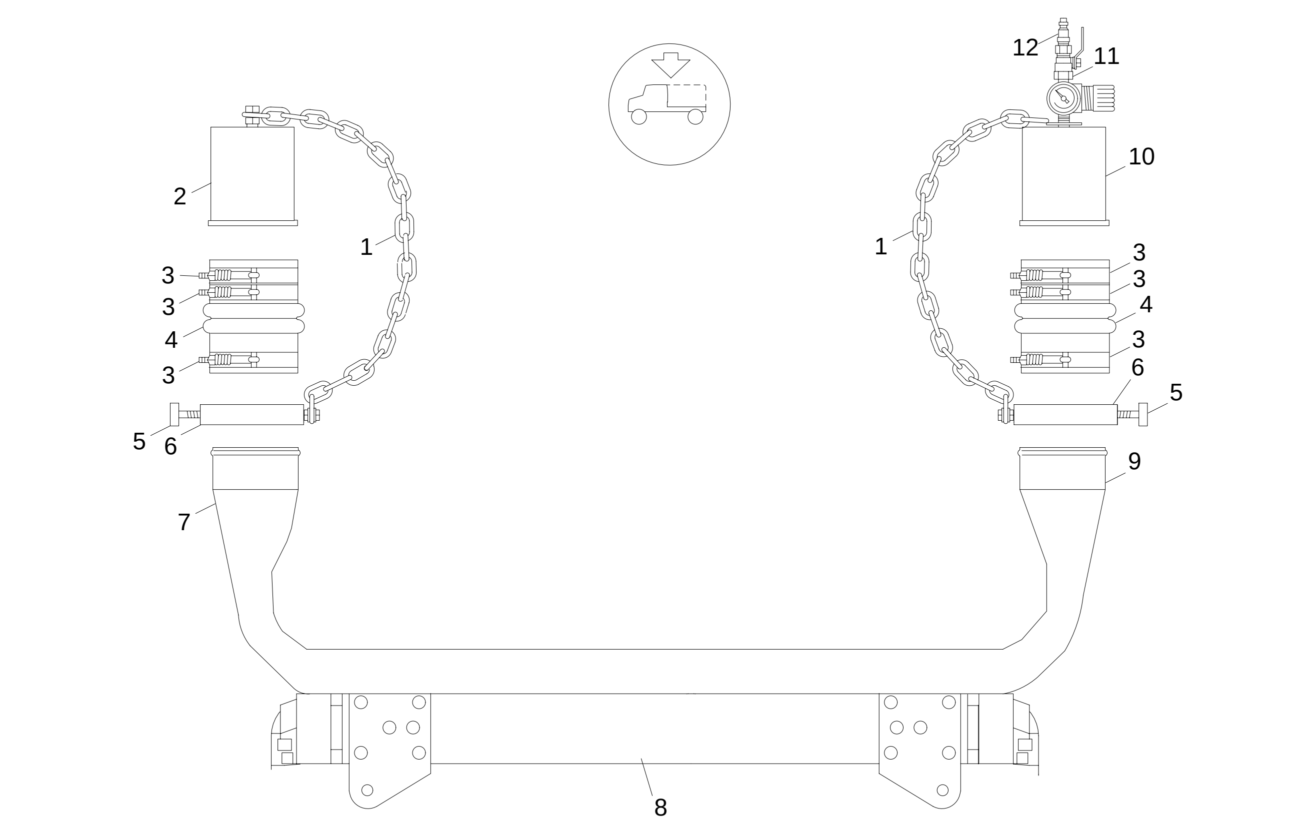
Always secure the test plugs with the safety rings. Test pressures could blow out an unsecured test plug at high speed, possibly causing eye injury or other serious personal injury.

   - 2.6 If not already installed, install a test valve/gauge assembly and air chuck in the test plug with adapter.
   - 2.7 Attach a pressurized air line to the air chuck on the pressure regulator valve.
3. Test the CAC core as follows.

WARNING

Always wear safety glasses when doing this procedure. Do not stand in front of the test plugs while the core is pressurized. A plug could sud-

CAC Inspection and Leakage Test



1. Safety Chain
2. Test Plug
3. Constant Tension Hose Clamp
4. Convoluted Hose
5. Thumbscrew
6. Safety Ring
7. CAC Air Inlet
8. Radiator
9. CAC Air Outlet
10. Test Plug with Adapter
11. Test Valve/Gauge Assembly
12. Air Chuck

Fig. 1, CAC Core Testing

denly release debris at high speed, possibly resulting in eye injury or other serious personal injury.

3.1 Open the test valve, then slowly open the pressure regulator valve and allow the CAC to gradually fill with air to the start pressure. See **Table 1**.

3.2 Close the test valve, and watch the gauge for 15 seconds. If there is more than the specified drop in the CAC pressure in 15 seconds, replace the CAC. See **Table 1**.

IMPORTANT: Do not attempt to repair the CAC.

3.3 When testing is completed, reduce the pressure on the pressure regulator valve to bleed air from the CAC.

4. Remove the test equipment (and the additional constant tension hose clamps) from the convoluted hoses.
5. Pull the convoluted hoses and constant tension hose clamps rearward until the hoses cover about 1-1/2 inches (38 mm) of the CAC air inlet and air outlet piping.
6. Turn the clamps so their tightening screws are under the hoses or facing inboard. Tighten the screws 45 lbf·in (500 N·cm).

CAC Inspection and Leakage Test

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

Flushing

If the charge air cooler (CAC) is suspected of being contaminated, flush the CAC.

1. Apply the parking brakes and chock the tires.
2. Remove the CAC. For instructions, see **Subject 100** for pre-EPA07 engines, or **Subject 110** for EPA07 engines.
3. Set the CAC in a horizontal position with the inlet and outlet ports facing up.

IMPORTANT: Use only naphtha or mineral spirits to clean the charge air cooler. Do not use caustic solutions such as those that are commonly used in radiator shops. Do not use steam or high-temperature cleaning operations. Caustic solutions, steam, and high-temperature cleaning operations will damage the RTV that seals the charge air cooler tubes to the headers, which may result in leaking.

4. Pour a filtered naphtha or mineral spirits solution into the CAC until it is 40 percent full.
5. Cap the inlet and outlet ports on the CAC.
6. Rock the CAC back and forth so that the solvent travels from one tank, through the tubes, to the other tank and back. Repeat this process ten times.

NOTE: Do not leave the solvent in the CAC for more than 10 minutes.

7. Remove the caps from the inlet and outlet ports.
8. Drain the CAC and properly dispose of the solvent.
9. Leave the caps off and allow the residual solvent to evaporate.
10. Install the CAC. For instructions, see **Subject 100** for pre-EPA07 engines, or **Subject 110** for EPA07 engines.

Restriction Test

After flushing the charge air cooler (CAC) because of turbocharger or engine damage, test the pressure drop across the CAC and air piping.

1. Remove the pipe plug (if equipped) from the tapped hole in the turbocharger air outlet elbow.

   Remove the pipe plug, or the nylon tube and atomizer for the ether start system (if equipped), or the air line to the turbocharger air-pressure gauge (if equipped), from the tapped hole in the left-hand rear of the intake manifold.

   Install an air pressure gauge in each tapped hole.
2. Operate the engine at rated speed and horsepower; there is no need to operate the engine at its peak torque rating. While operating the engine, read both air pressure gauges.

   Because of the turbulence of the air at the turbocharger outlet, subtract 0.3 inHg (1 kPa) from the pressure measurement taken at the turbocharger outlet, to make it a true reading.

   From that reading, subtract the reading taken at the intake manifold. This is the pressure drop of the CAC.

   If the pressure drop is more than 4 inHg (14 kPa), flush or replace the CAC as needed.

General Information

The Tu-Flo 550 and the Tu-Flo 750 are two cylinder, single-stage, reciprocating air compressors, which supply compressed air to the vehicle air system. The Tu-Flo 550 has a rated displacement of 13.2 cfm (374 L/min) of air at 1250 rpm.

The Tu-Flo 750 has a rated displacement of 16.5 cfm (468 L/min) of air at 1250 rpm. The compressor draws air from the air intake pipe, compresses the air, and delivers it to the air system supply reservoir. The compressor runs continuously but has "loaded" and "unloaded" modes, which are regulated by the air governor and the compressor loading assembly. When the governor sends an air signal to the unloader assembly, the unloader assembly holds the compressor air intake valve open so that no more compressed air is forced into the air system. As air in the system is used, its pressure drops, and at 90 psi (620 kPa), the air governor stops the signal to the compressor. Without the signal, the unloader assembly automatically closes the compressor air intake valve to force more air into the system.

On vehicles with air dryers, when the system reaches the cut-out pressure of 120 psi (825 kPa), the air governor also sends an air signal to open the sludge ejector in the air dryer.

Air Compressor Removal and Installation

Removal

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Drain the air system.

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

3. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
4. Drain the radiator coolant; see **Group 20** for instructions.
5. Loosen the constant-torque hose clamps at both ends of the charge air cooler outlet air piping. Remove the piping to access the air compressor.
6. Marking their locations and positions, disconnect all air, coolant, and oil lines attached to the compressor. Remove tie straps as needed to move the lines out of the way.

NOTE: On vehicles with combined air dryers and air reservoir modules, the air governor is mounted on the module not the air compressor.

7. If the air governor is mounted on the compressor, remove it and the governor mounting gasket.
8. On Cummins and Detroit Diesel engines, disconnect the wire to the fuel shutoff valve (if so equipped). Remove the fuel pump and gasket; see the engine shop manual or rebuild manual for instructions.
9. Remove the compressor support bracket, if so equipped.
10. Support the compressor, and remove the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Remove the compressor, gasket, and splined coupling.
11. Discard all mounting gaskets.

Installation

IMPORTANT: Be sure the gasket surfaces are cleaned and not damaged.

1. Install the splined coupling (if so equipped) and a new compressor gasket. Hold the compressor in place, and install the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. See the engine shop manual or rebuild manual for final torque specification.
2. Install the compressor support bracket, if so equipped.
3. On Cummins and Detroit Diesel engines, install a new gasket, install the fuel pump. Connect the wire to the fuel shutoff valve (if so equipped). See the engine shop manual or rebuild manual for instructions.
4. If applicable, use a new air governor mounting gasket, install the air governor on the compressor.
5. Identify and connect all air, coolant, and oil lines to the compressor. Secure the lines as needed with tie straps.
6. Install the charge air cooler outlet air piping. Tighten the constant-torque hose clamp screws 45 lbf·in (500 N·cm).
7. Fill the engine cooling system; see **Group 20** for instructions.
8. Operate the engine and check for leaks.
9. Remove the chocks from the tires and lower the hood.

Removal

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Remove the compressor from the vehicle, if necessary.

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

3. Remove the compressor from the vehicle. For instructions, see **Subject 100**.
4. Remove the cylinder head from the crankcase. See **Fig. 1**.

   4.1 Scribe an alignment mark across the cylinder head and the crankcase, for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   4.2 Note positions of any attached components, then remove the cylinder head capscrews.

   4.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head.

Installation

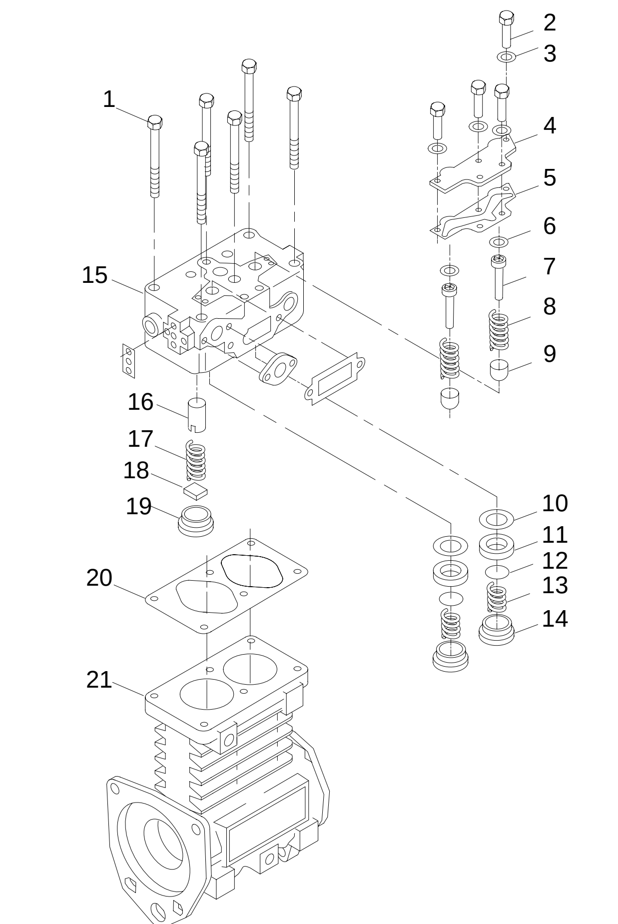
1. Scrape off any gasket material from the cylinder head and the crankcase.

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Using compressed air, blow dirt particles or gasket material from all cylinder cavities.
3. Install the cylinder head on the compressor crankcase.

   3.1 Place a new cylinder head gasket on the crankcase. If the cylinder head gasket has a bead on one side, install the gasket with the bead side up.



1. Cylinder Head Capscrew
2. Unloader Plate Capscrew
3. Unloader Plate Lockwasher
4. Unloader Plate
5. Unloader Plate Gasket
6. O-Ring
7. Unloader Piston
8. Spring
9. Unloader Bushing
10. Gasket
11. Inlet Valve Seat
12. Inlet Valve
13. Inlet Valve Spring
14. Inlet Valve Stop
15. Cylinder Head
16. Discharge Valve Stop
17. Discharge Valve Spring
18. Discharge Valve
19. Discharge Valve Seat
20. Cylinder Head Gasket
21. Crankcase

Fig. 1, Cylinder Head (exploded view)

Cylinder Head Removal and Installation

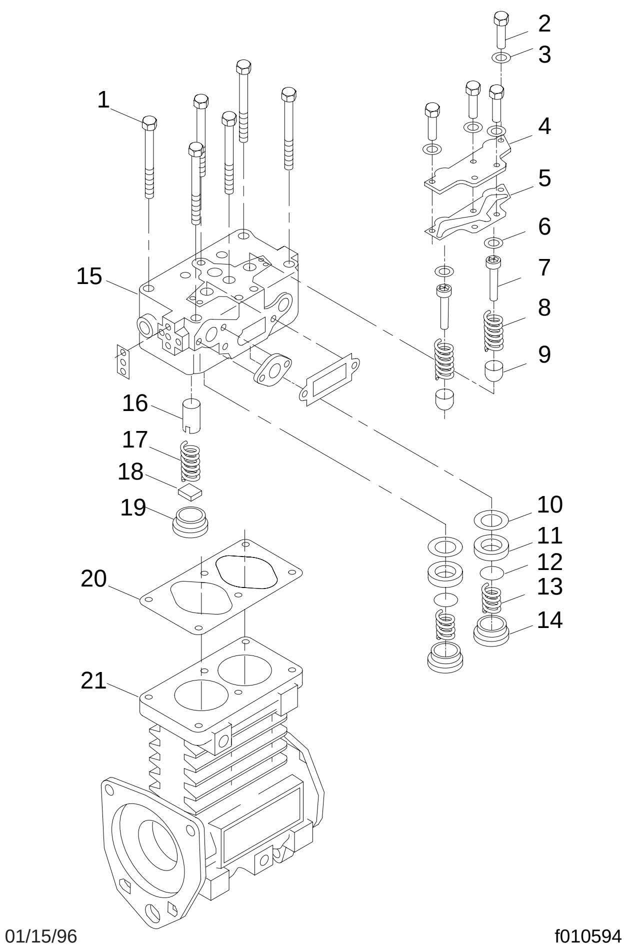
3.2 Using the previously marked alignment, position the cylinder head on the crankcase.

3.3 Position on the cylinder head any brackets, spacers, or clamps that were removed; then install the cylinder head capscrews and tighten them evenly, in a cross pattern 37 to 42 lbf·ft (50 to 57 N·m).

4. Install the compressor on the engine. For instructions, see **Subject 100**.
5. Operate the engine and make sure there are no coolant leaks.
6. Remove the chocks from the tires and lower the hood.

Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. Cylinder Head Capscrew
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11. Inlet Valve Seat
12. Inlet Valve
13. Inlet Valve Spring
14. Inlet Valve Stop
15. Cylinder Head
16. Discharge Valve Stop
17. Discharge Valve Spring
18. Discharge Valve
19. Discharge Valve Seat
20. Cylinder Head Gasket
21. Crankcase

Fig. 1, Cylinder Head (exploded view)

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Remove the compressor from the vehicle. For instructions, see **Subject 100**.
3. Place the compressor on a suitable work surface. Remove the cylinder head from the crankcase. For instructions, see **Subject 110**.
4. Remove the unloader mechanism.
   4.1 Remove the unloader plate capscrews, lockwashers, and the unloader plate. Scrape off any gasket material from the unloader plate and the cylinder head.
   4.2 Remove and discard the unloader pistons, O-rings, and springs.
5. Check the unloader piston bushings. If damaged or worn excessively, replace the compressor.

NOTE: Before disassembling the discharge valve mechanism, measure and record the discharge valve travel from closed to completely open. If the measurement exceeds 0.046 inch (1.17 mm), replace the compressor. If the measurement is within 0.046 inch, proceed to the next step.

6. Using a 9/16-inch Allen wrench, remove and discard the discharge valve seats, discharge valves, and discharge valve springs.
7. Remove and discard the inlet valve stops and springs, along with the inlet valves, inlet valve seats, and gaskets.

Cleaning and Inspection

1. Remove carbon deposits from the discharge cavity, rust and scale from the cooling cavities.
2. Clean carbon and dirt from the inlet and unloader passages.
3. Scrape all foreign material from the body surfaces.

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

4. Using solvent, thoroughly clean all metal parts removed from the cylinder head. Using shop air, blow the dirt particles from the cavities and passages.
5. Check that all cavities and passages are clear, including the inlet and unloader.
6. Check that all mating surfaces are clean of old gasket material. Remove any old material.
7. Inspect the cylinder head for cracks or damage.
8. With the cylinder head and head gasket secured to a flat surface or to the crankcase, apply shop air pressure to one of the coolant ports with all other ports plugged.
9. Check for leaks by applying a soap solution to the exterior of the body. If leakage is detected, replace the compressor.

Assembly (See Fig. 1)

1. Install the unloader mechanism.
   - 1.1 With the unloader pistons being prelubricated from the manufacturer, install the new unloader springs, and the new unloader pistons. The unloader piston O-rings are pre-installed on the unloader pistons.
   - 1.2 Install the new unloader plate gasket and the unloader plate.
   - 1.3 Install the unloader plate lockwashers and capscrews. Tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.
2. Install the inlet valve mechanism.
   - 2.1 Install the new inlet valve gaskets, new inlet valve seats, new inlet valves, and the new inlet valve springs into their bores.
   - 2.2 Install the new inlet valve stops and tighten 70 to 90 lbf·ft (95 to 122 N·m).
3. Install the new discharge valve springs, new discharge valves, and the new discharge valve seats into their bores. Tighten the seats 70 to 90 lbf·ft (95 to 122 N·m). The discharge valve travel should be 0.030 inches to 0.046 inch (0.762 mm to 1.17 mm).
4. Test for leakage at the discharge valves by applying 100 psi (690 kPa) shop air through the cylinder head discharge port and apply soap solution to the discharge valve and seat. Leakage in the form of soap bubbles is permissible.

   If there's extreme leakage, leave the air pressure applied and with a hardwood dowel and a hammer, tap the discharge valves off of their seats several times. This will improve the seal between the discharge valve and the valve seat and should reduce leakage.

   If there's still extreme leakage, replace the discharge valve seats.

   With the air pressure still applied at the discharge port of the cylinder head, check for leakage around the discharge valve stop on top of the cylinder head. No leakage is permitted.
5. Install the compressor cylinder head. For instructions, see **Subject 110**.
6. Tighten the unloader plate capscrews 15 to 18 lbf·ft (20 to 25 N·m).
7. Install the compressor on the engine. For instructions, see **Subject 100**.
8. Remove the chocks from the tires and lower the hood.

Crankcase Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Remove the compressor from the vehicle and place it on a suitable work surface. For instructions, see **Subject 100**.
3. Remove the air compressor cylinder head. For instructions, see **Subject 110**.
4. Before disassembling the compressor, use a metal scribe to mark the parts with matching numbers or lines.

IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

5. Remove the pistons and connecting rods. See **Fig. 1**.
   - 5.1 Remove the base plate capscrews.
   - 5.2 Tap the base plate with a soft mallet to break the gasket seal.
   - 5.3 Scrape off any gasket material from the crankcase and base plate.
   - 5.4 Remove the connecting rod bolts and connecting rod caps.
   - 5.5 Push the pistons and connecting rods out through the cylinder bore of the crankcase. Discard the pistons and connecting rod assemblies including the connecting rod caps and the connecting rod bolts.
6. Remove the crankshaft.
   - 6.1 Remove the key or keys from the crankshaft and any burrs from the crankshaft where the key or keys were removed.

   NOTE: Some compressors may have a crankshaft key at each end.

   - 6.2 Remove the end-cover capscrews, the end cover, end-cover seal, and the rear thrustwasher.
   - 6.3 If the compressor has sleeve bearings, remove and discard the sleeve bearings from the crankcase and the end cover.
   - 6.4 If the compressor has a ball-type main bearing, remove the rear snap ring (if so equipped). Press the crankshaft and ball bearing from the crankcase, then press the ball bearing from the crankshaft.
   - 6.5 Remove and discard the front and rear thrustwashers.

Cleaning and Inspection

1. Scrape off any gasket material from the top and bottom of the crankcase.

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

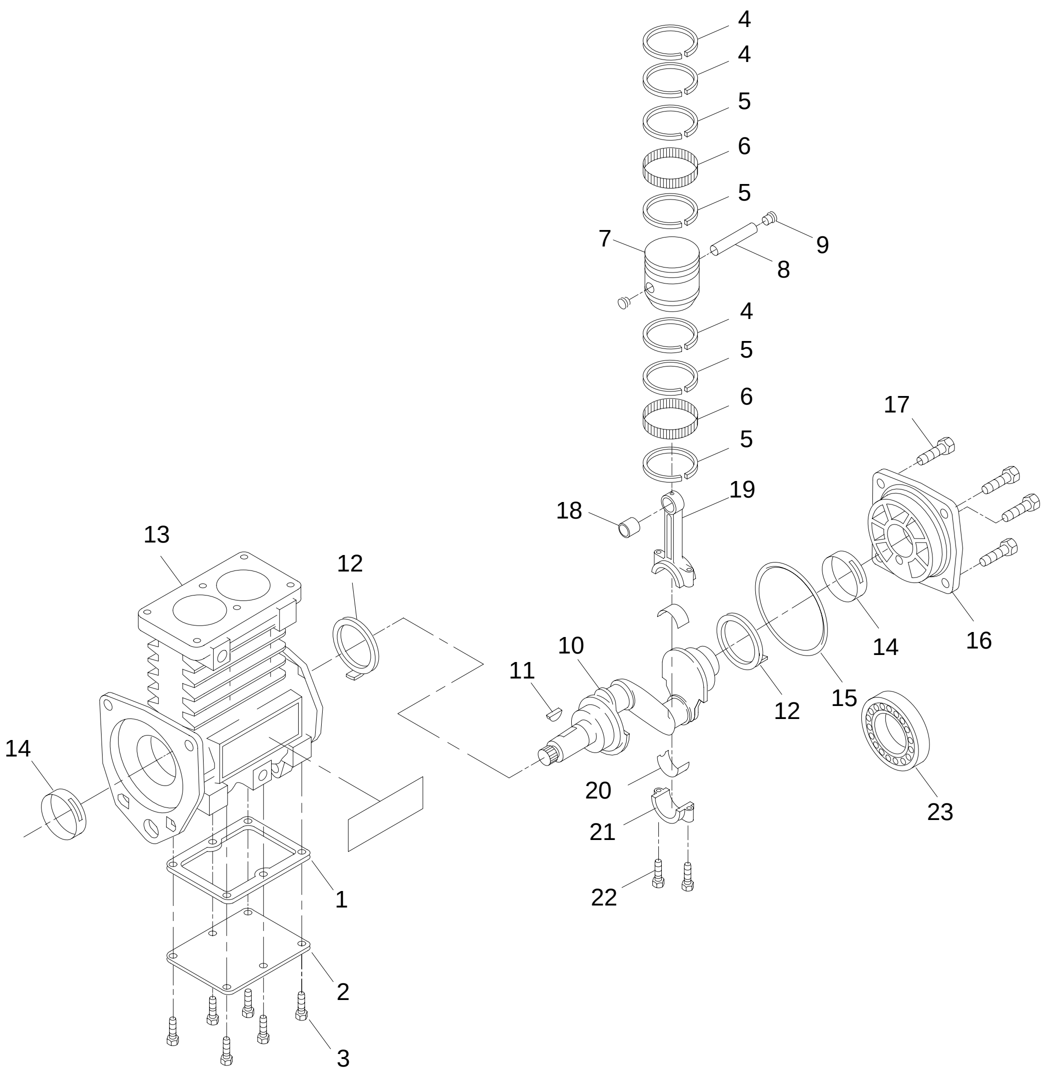
2. Clean all parts with solvent, before inspecting them, and dry the parts with compressed air.
3. Clean all oil passages through the crankshaft, crankcase, end cover, and base plate. Inspect the passages with a wire to be sure they are clear.
4. Check the fit of the new pistons, piston rings, and connecting rods.
   - 4.1 The pistons for the Tu-Flo 750 compressor are similar to the Tu-Flo 550 and may be identified by the distance from the center of the wrist pin hole to the top of the piston. See **Fig. 2**.
   - 4.2 To check the ring gap, place the ring in the top of the cylinder bore and, using a piston, push the ring to mid-point of the cylinder bore and check the ring gap. The gap for compression rings must be 0.002 to 0.013 inch (0.050 to 0.330 mm).

     The gap for oil ring and expander ring must be 0.010 to 0.040 inch (0.254 to 1.016 mm). See **Fig. 3**, and **Table 1**.

Allowable End Gap	
Ring	**End Gap in inch (mm)**
Compression	0.002–0.013 (0.050–0.330)
Oil and Expander	0.010–0.040 (0.254–1.016)

Table 1, Allowable End Gap

Crankcase Disassembly, Cleaning and Inspection, and Assembly



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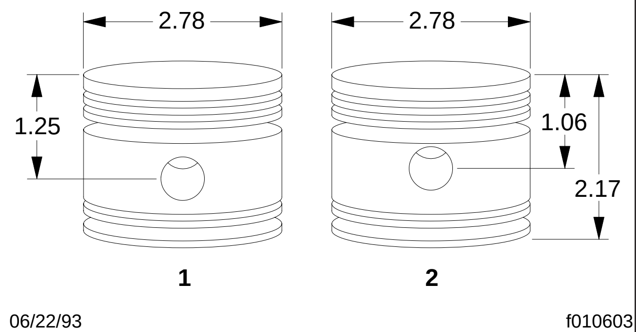
1. Base Gasket
2. Base Plate
3. Base Plate Capscrew
4. Compression Ring
5. Oil Ring
6. Expander Ring
7. Piston
8. Wrist Pin
9. Wrist Pin Button
10. Crankshaft
11. Crankshaft Key
12. Thrust Washer
13. Crankcase
14. Sleeve Bearing
15. End Cover Seal
16. End Cover
17. End Cover Capscrew
18. Wrist Pin Bushing
19. Connecting Rod
20. Connecting Rod Bearing (Sets)
21. Connecting Rod Cap
22. Connecting Rod Bolt
23. Ball Bearing

Fig. 1, Crankcase (exploded view)

4.3 Check the fit of the piston rings in the piston ring grooves. Groove clearance for the compression ring is 0.002 to 0.004 inch (0.051 to 0.101 mm). Groove clearance for the expander and oil rings is 0.000 to 0.006 inch (0.000 to 0.152 mm).

5. Inspect the crankcase.

Crankcase Disassembly, Cleaning and Inspection, and Assembly



1. Tu-Flo 550 Compressor Piston
2. Tu-Flo 750 Compressor Piston

Fig. 2, Piston Comparison

5.1 Check the crankcase surfaces for cracks and damage.

5.2 On compressors with ball-type main bearings, measure the difference between the outside diameter of the ball bearing outer race and the inside diameter of the crankcase bore. The measurement should be 0.0003 inch (0.008 mm) tight to 0.0023 inch (0.058 mm) loose. This is to maintain a correct fit. Replace the compressor if the fit is too loose.

5.3 Check the end cover for cracks and damage. Replace them as necessary.

5.4 Check the cylinder bore with an inside micrometer or with calipers. Cylinder bores which are scored, out-of-round, or tapered more than 0.0005 inch (0.013 mm) should be rebored and honed oversize. Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) oversize.

6. Inspect the crankshaft.

6.1 Check the crankshaft splines, gear teeth, tapered ends, and all machined and ground surfaces for wear, scoring, or damage. Repair the damage, or replace the crankshaft if needed.

6.2 Check the crankshaft connecting rod journals for extreme scoring, and measure them for out-of-round wear. Standard crankshaft journals are 1.1242 to 1.1250 inches (28.555 to 28.575 mm) in diameter. If the crankshaft is extremely scored or worn out-of-round, and cannot be reground, replace it.

NOTE: If the crankshaft needs to be reground or replaced, do so before proceeding to the next step. For compressors having reground crankshafts, connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) undersize.

Assembly (See Fig. 1)

1. For a compressor with sleeve bearings, install the crankshaft and end cover.

1.1 Press the new sleeve bearings into the end cover and crankcase. Make sure the slot in the bearings line up with the oil passages in the end cover and crankcase.

If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.

1.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.

1.3 Insert the crankshaft and the rear thrustwasher with the tang toward the end cover of the compressor.

1.4 Place the end-cover seal on the boss of the end cover.

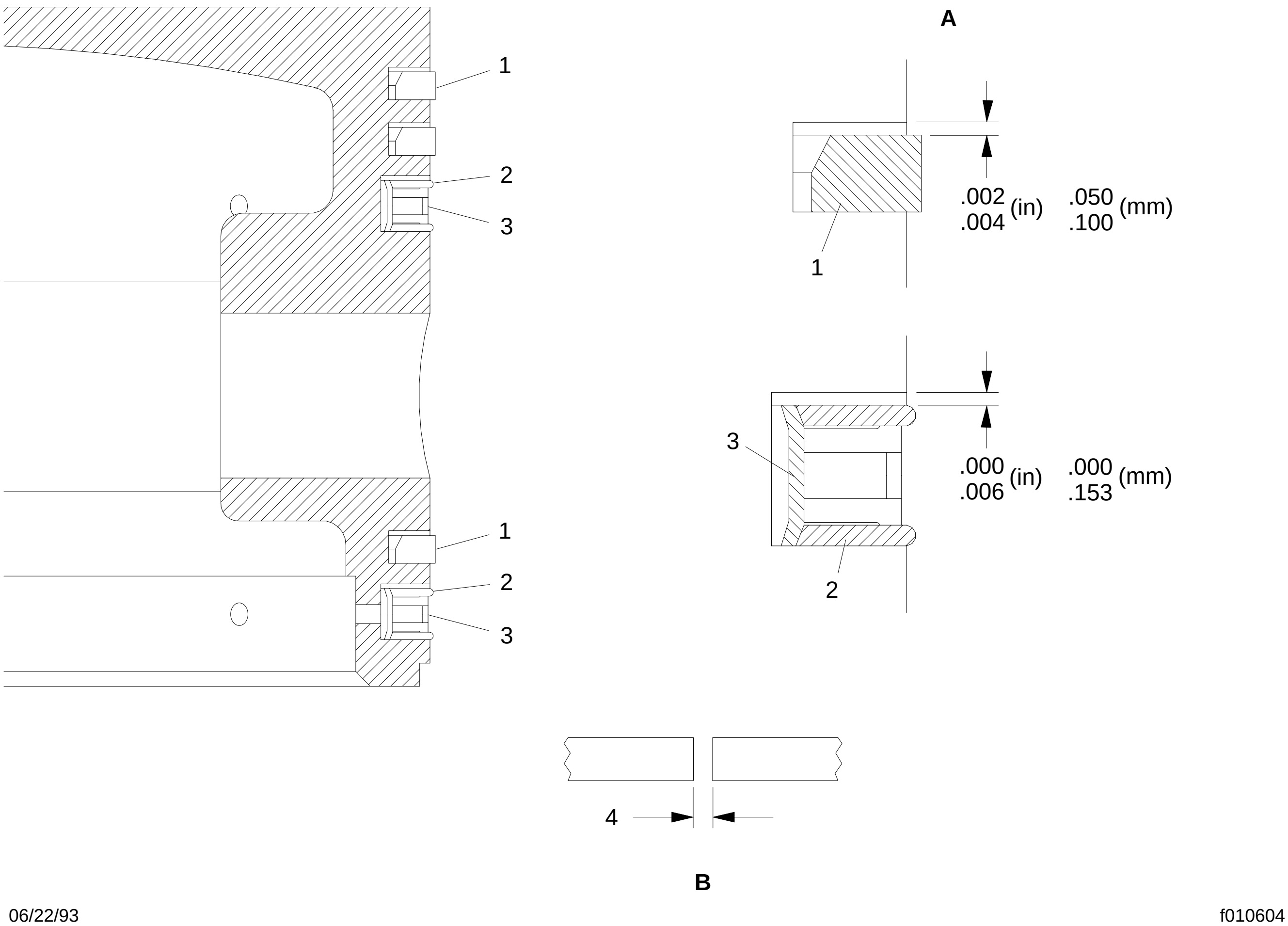
IMPORTANT: When installing the end cover, ensure that the end cover seal is not pinched and that the rear thrustwasher tang is inserted in the end cover slot.

1.5 Install the end cover. Install the capscrews and tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

2. If one end of the compressor uses a ball-type main bearing, install the crankshaft and endcovers.

2.1 Press the new sleeve bearings into the crankcase. Make sure the slots in the

Crankcase Disassembly, Cleaning and Inspection, and Assembly



A. Side Clearance
1. Compression Ring
2. Oil Ring

B. Ring End Gap With Ring in the Cylinder Bore
3. Expander Ring
4. End Gap

Fig. 3, Piston Specifications

bearings line up with the oil passage in the end cover and crankcase.

If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.

2.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.

2.3 Press the ball bearing onto the correct end of the crankshaft, so that the drive end of the crankshaft will be positioned in the crankcase as marked before disassembly. Using an arbor press, carefully press the ball bearing and the crankshaft into the crankcase. Install the retainer ring, if so equipped.

3. Install the new piston rings on the new pistons.

IMPORTANT: To properly test a compressor under operating conditions, a test rack is necessary for correct mounting, cooling, lubricating, and driving the compressor.

Crankcase Disassembly, Cleaning and Inspection, and Assembly

NOTE: Install the piston rings on the pistons starting at the center of the piston and moving outward. Rotate the piston rings in their respective grooves so that the end gap is at least 90 degrees from the previous ring's end gap.

3.1 Install the compression rings in the correct grooves, with the bevel or "pip" mark (if any) toward the top of the piston.

3.2 Install the expander rings in the oil ring grooves. The ends of the expander rings must butt and must not overlap.

3.3 Install the bottom oil ring by inserting one end below the expander ring in the ring groove, and wind the ring into position. Install the top oil ring in the same manner above the expander ring making sure the gap is staggered from the bottom oil ring and the expander ring.

4. Attach the new connecting rods to the new pistons.

4.1 Lubricate the wrist pins and the wrist pin bushings in the connecting rods with clean engine oil.

4.2 Position the connecting rods in the pistons and press in the wrist pins. Secure the wrist pins by installing the wrist pin buttons in the ends of the wrist pins.

5. Install the new pistons and new connecting rods.

5.1 Apply clean engine oil to both pistons, the piston rings, the wrist pins, the connecting rod caps and the new connecting rod bearings.

5.2 Turn the crankshaft so that the number-one rod journal (the one nearest the drive end) is down and centered.

5.3 Using a piston ring compressor, insert the number-one connecting rod and piston through the top of the number-one cylinder bore.

NOTE: The connecting rods and connecting rod caps are matched sets, therefore the caps must not be switched or rotated end for end.

5.4 Install the connecting rod bearings on the connecting rod and connecting rod cap.

5.5 Tighten the new connecting rod bolts evenly in increments of 11 to 13 lbf·ft (15 to 17 N·m).

5.6 Turn the crankshaft so that the number-two connecting rod journal is in the downward, center position.

5.7 Install the number-two connecting rod and piston in the same manner as described above.

6. Before installing the cylinder head on the crankcase, ensure that the correct pistons have been used. Turn the crankshaft one complete revolution, so that each piston moves to the uppermost position. On the upward stroke, each piston should move to the top of the crankcase. If the piston does not approach the top of the crankcase, the piston is incorrect and must be replaced or compressor damage could result.

7. Install the base plate.

7.1 Position the gasket on the crankcase. Install the base plate on the crankcase as marked before disassembly.

7.2 Tighten the six capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

8. Install the cylinder head on the crankcase. For instructions, see **Subject 110**.

9. Install the compressor on the engine. For instructions, see **Subject 100**.

10. Operate the engine and check for leaks.

11. Remove the chocks from the tires and lower the hood.

Troubleshooting

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted oil return line to engine.	Check for excessive bends, kinks, and restrictions in oil return line. Return line must descend from compressor to engine crankcase. Repair as needed.
Damaged oil seal ring or loose end cover.	Inspect oil seal ring for wear or damage. Repair as needed. Check the end cover capscrew torques and tighten as necessary.
Insufficient compressor cooling (compressor runs hot).	Remove grease, grime, or dirt from the cooling fins of the compressor. Check for damaged cooling fins. Replace components found damaged. Check for correct coolant line sizes. Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at maximum engine governed speed, and minimum allowable flow is 0.5 gallons per minute at engine idle. If low, inspect the coolant lines for rust scale, kinks, and restrictions. Repair or replace as necessary.
Compressor runs loaded an excessive amount of time.	Check air lines and connections for leakage. Repair or replace lines and connections until leakage is eliminated.
Back pressure from the engine crankcase.	Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line.
Malfunctioning compressor.	Replace or repair the compressor after making certain none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive coupling or gear (as indicated).	Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Air compressor bearing damaged or worn.	Replace the bearings.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain none of the preceding conditions exist.

Troubleshooting

Problem—Excessive Build-Up and Recovery Time

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted discharge or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Slipping drive components.	Check for faulty drive gears and coupling, and replace as necessary.
Excessive air system leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
Unloader pistons seized.	Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, repair or replace the unloading mechanism.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain none of the preceding conditions exist.

Problem—Compressor Fails to Unload

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Faulty or worn unloader pistons or bores.	Inspect for worn, dirty, or corroded unloader pistons and bores. Replace as necessary.
Malfunctioning governor.	Check the setting with an accurate test gauge. Repair or replace the air governor.
Unloader air lines from governor damaged.	Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines.

Specifications

Fastener Torque Values	
Description	**Torque: lbf·ft (N·m)**
Cylinder Head	37 to 42 (50 to 57)
Unloader Cover Plate	15 to 18 (20 to 25)
Discharge Valve Seat	70 to 90 (95 to 122)
Inlet Valve Stop	70 to 90 (95 to 122)
End Cover	15 to 18 (20 to 25)
Connecting Rod	11 to 13 (15 to 17)
Bottom Cover	15 to 18 (20 to 25)
Inlet Fitting	15 to 18 (20 to 25)
Discharge Fitting	15 to 8 (20 to 25)
Governor or Governor Adaptor	15 to 18 (20 to 25)

Table 1, Fastener Torque Values

Compressor Specifications	
Description	**inches (mm)**
Discharge Valve Travel (minimum/maximum)	0.030/0.046 (0.762/1.168)
Fit Between Crankcase Bore and Ball-Type Main Bearing (minimum/ maximum)	0.0003/0.0023 (0.008/0.058)
Clearance for Crankshaft Main Journals to I.D.. of Sleeve-Type Main Bearing (maximum)	0.005 (0.13)
Crankshaft Main Journal Standard Diameter	1.1242 to 1.1250 (28.555 to 28.575)
Clearance Between Crankshaft Rod Journals and Connecting Rod Bearing (minimum/maximum)	0.0003/0.0021 (0.008/0.053)
Crankshaft Rod Journal Standard Diameter *	1.1242 to 1.1250 (28.555 to 28.575)
Cylinder Bore Out-of-Round (maximum)	0.0005 (0.013)
Cylinder Bore Taper (maximum)	0.0005 (0.013)
Clearance Between Cylinder Bore and Cast Iron Piston (minimum/ maximum) †	0.002/0.004 (0.050 /0.101)
Clearance Between Wrist Pins and Connecting Rod Bushings (maximum)	0.0007 (0.0178)
Compression Ring Groove Clearance	0.002 to 0.004 (0.050 to 0.101)
Oil and Expander Ring Groove Clearance	0.00 to 0.006 (0.00 to 0.152)
Compression Ring Gap (installed in cylinder)	0.002 to 0.013 (0.050 to 0.330)
Oil and Expander Ring Gap (installed in cylinder)	0.010 to 0.040 (0.254 to 1.016)

* For compressors having reground crankshafts, undersize connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

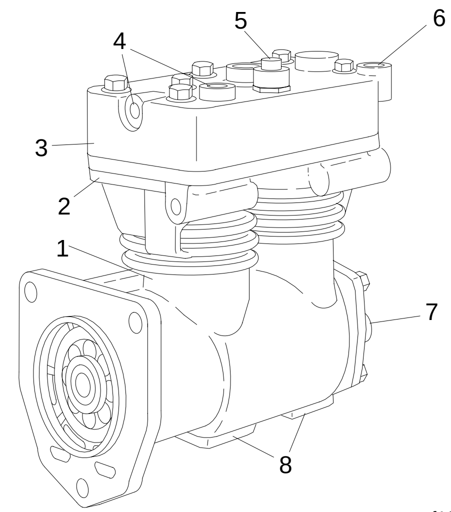
† Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

Table 2, Compressor Specifications

General Information

The DuraFlo™ 596 air compressor is a two-cylinder reciprocating compressor with a rated displacement of 27 cubic feet per minute. The compressor consists of a water-cooled cylinder head and valve body assembly and an air-cooled integral crankcase and cylinder block. See **Fig. 1**. The cylinder head is an aluminum casting that contains the required air and water ports as well as inlet check valves for each cylinder. The valve body assembly consists of steel upper and lower halves, each of which incorporates various valve openings and channels for conducting air and engine coolant in to and out of the cylinder head. The discharge valves for each cylinder are part of the valve body assembly.

The DuraFlo 596 compressor incorporates an unloader system that features and energy saving system (ESS) which reduces compressor power consumption by approximately 80 percent in the unloaded mode. The ESS also reduces compressor oil consumption (oil passing) when the compressor is in the unloaded mode.



1. Crankcase
2. Valve Body Assembly
3. Cylinder Head
4. Water Inlet Port
5. Discharge Safety Valve
6. Water Outlet Port
7. Rear Cover Oil Port
8. Crankcase Bottom Cover

Fig. 1, DuraFlo 596 Air Compressor

Operation

The compressor is driven by the vehicle engine and functions continuously while the engine is in operation. Actual compression of air is controlled by the compressor unloading mechanism operating in conjunction with a remote mounted governor and synchro valve. The governor and synchro valve combination maintains brake system air pressure between a preset maximum and minimum pressure level.

Replacement

1. Apply the parking brakes, chock the tires, shut down the engine, and open the hood.
2. Drain the air system.
3. Disconnect the batteries.

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent eye injury could result from flying debris.

4. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
5. Drain the radiator coolant. For instructions, see **Group 20**.
6. Identify and disconnect all air, water, and oil lines attached to the compressor. Remove tie straps as needed to move the lines out of the way.
7. Note the position of the discharge and inlet fittings before removing the fittings.
8. Remove the signal booster valve that is mounted on the air compressor.
9. Remove the nuts that attach the air compressor to the engine and remove the compressor.

IMPORTANT: The replacement air compressor may not have a drive gear. If the replacement air compressor does not have a drive gear, follow the instructions in the next step. If the replacement air compressor does have a drive gear, skip the next step.

10. Use a gear puller to remove the drive gear from the air compressor crankshaft and install it on the replacement air compressor. Torque the crankshaft nut 125 lbf·ft (169 N·m).
11. Install the gasket on the drive flange of the compressor. Make sure that the oil supply or return holes in the gasket are properly aligned with the compressor and engine.
12. Install the compressor on the engine using nuts.
13. Make sure the threads on the discharge and inlet fittings are clean and free of corrosion. Replace the fittings if necessary. Install the discharge and inlet fittings on the compressor in the same positions as noted earlier.
14. Inspect all air and water lines and fittings before attaching them to the compressor. Make sure the O-rings are in good condition. Replace the O-rings if necessary. Tighten all hose clamps and secure the lines with tie straps as needed.
15. Fill the engine cooling system. For instructions, see **Group 20**.
16. Connect the batteries.
17. Clean the oil supply line. Before connecting the oil line to the compressor, run the engine briefly to be sure oil is flowing freely through the supply line.
18. Install the signal booster valve on the compressor.
19. Turn on the engine and check for leaks.
20. Remove the chocks from the tires and lower the hood.

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake.	Check engine or compressor air filter and replace if necessary. Check compressor air inlet for kinks, excessive bends, and be certain inlet lines have the minimum specified inside diameter. Recommended maximum air inlet restriction is 25 inches of water.
Restricted oil return to engine.	Make certain oil drain passages in the compressor and mating engine surfaces are unobstructed and aligned. Correct gaskets must be used. Special care must be taken when sealants are used with, or instead of, gaskets.
Poorly filtered air inlet.	Check for a damaged or dirty air filter on the engine or compressor. Check for leaking or damaged compressor air intake components such as induction line, fittings, gaskets, and filter bodies. The compressor intake should not be connected to any part of the exhaust gas recirculation (E.G.R.) system on the engine.
Insufficient compressor cooling (compressor runs hot).	For air-cooled portions of the compressor: • Remove accumulated grease and dirt from the cooling fins. Replace components found damaged. • Check for damaged cooling fins. Replace compressor if found damaged. For water-cooled portions of the compressor: • Check for proper coolant line sizes. Minimum recommended line i.d. is 3/8 inch. • Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at engine governed speed. If low coolant flow is detected, inspect the coolant lines and fittings for accumulated rust scale, kinks, and restrictions. • Water temperature should not exceed 200°F (93°C). • Optimum cooling is achieved when engine coolant flows as shown in **Fig. 1**.
Contaminants not being regularly drained from system reservoirs.	Check reservoir drain valves to insure that they are functioning properly. It is recommended that the vehicle should be equipped with functioning automatic drain valves or have all reservoirs drained to zero psi daily, or optimally, to be equipped with a desiccant-type air dryer prior to the reservoir system.
Compressor runs loaded an excessive amount of time.	Vehicle system leakage should not exceed 1 psi pressure drop per minute without brakes applied and 3 psi pressure drop per minute with brakes applied. If leakage is excessive, check for system leaks and repair.
Excessive engine crankcase pressure.	Test for excessive engine crankcase pressure and repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge and compare the reading to the engine specifications. Do not restrict the compressor oil supply line. Minimum oil supply line size is 3/16-inch i.d.
Malfunctioning compressor.	Replace or repair the compressor only after making certain none of the preceding conditions exist.

Troubleshooting

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive gear or components.	Inspect the fit of the drive gear on the compressor crankshaft. The gear or coupling must be completely seated and the crankshaft nut must be tight. If the compressor crankshaft surface is damaged, it is an indication of loose drive components. If damage to the compressor crankshaft is detected, replace the compressor. When installing the drive gear or pulley, torque the crankshaft nut to the appropriate torque specifications and use care when pressing drive components on to the crankshaft. Do not back off the crankshaft nut once it is tightened to the proper torque. Do not use impact wrenches to install the crankshaft nut.
Excessively worn drive couplings or gears.	Inspect drive gear, couplings, and engine for excessive wear. Replace as necessary. NOTE: Nonmetallic gears should be replaced when the compressor is changed.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon buildup. If carbon is detected, check for proper compressor cooling. See the remedy for insufficient compressor cooling in the previous table. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Worn or burned out bearings.	Check for proper oil pressure in the compressor. Minimum required oil pressure is 15 psi when engine is idling and 15 psi maximum at governed engine rpm. Check for excessive oil temperature; oil temperature should not exceed 240°F (115°C).
Malfunctioning compressor.	Repair or replace the compressor after making certain none of the preceding conditions exist.

Problem—Compressor Does Not Unload

Problem—Compressor Does Not Unload	
Possible Cause	**Remedy**
Malfunctioning governor and synchro valve.	Test the governor and synchro valve for proper operation and inspect air lines to and from both components for kinks or restrictions. Repair or replace the governor, synchro valve, or connecting air lines.
Malfunctioning or worn unloader pistons or bores.	Inspect for worn, dirty, or corroded unloader pistons and their bores. Replace as necessary.

Problem—Compressor Leaks Oil

Problem—Compressor Leaks Oil	
Possible Cause	**Remedy**
Damaged mounting gasket.	Check the compressor mounting bolt torque. If the mounting bolt torque is low, replace the compressor mounting gasket before retorqueing the mounting bolts.

Troubleshooting

Problem—Compressor Leaks Oil	
Possible Cause	**Remedy**
Cracked crankcase or end cover.	Visually inspect the compressor exterior for cracked or broken components. Cracked or broken crankcases or mounting flanges can be caused by loose mounting bolts. The end cover can be cracked by overtorquing fittings or plugs installed in the end cover. Repair or replace the compressor as necessary.
Loose crankcase end cover or bottom cover.	Check the capscrew torques and tighten as necessary. Replace gaskets or O-rings.
Loose oil supply or return line fittings.	Check the torque of external oil line fittings and tighten as necessary.
Porous compressor casting.	Replace the compressor if porosity is found.
Mounting flange or end cover, O-ring or gasket missing, cut, or damaged.	Replace as necessary.

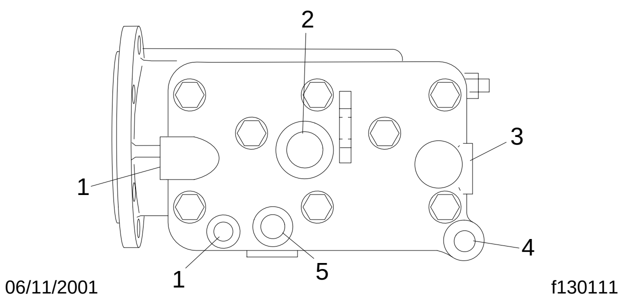
Problem—Compressor Leaks Coolant

Problem—Compressor Leaks Coolant	
Possible Cause	**Remedy**
Improperly installed plugs and coolant line fittings.	Check torque of fittings and plugs and tighten as necessary. Overtorqued fittings and plugs can crack the head or block casting.
Freeze cracks due to improper antifreeze strength.	Test antifreeze and strengthen as necessary. Check coolant flow through compressor to assure the proper antifreeze mixture reaches the compressor.
Malfunctioning compressor due to porous castings.	If casting porosity is detected, replace the compressor.

Problem—Compressor Head Gasket Malfunction

Problem—Compressor Head Gasket Malfunction	
Possible Cause	**Remedy**
Restricted discharge line.	Clear restriction or replace line.
Loose cylinder head capscrews.	Tighten evenly to a torque of 265 to 292 lbf·in (2990 to 3300 N·cm).
Malfunctioning compressor or head gasket.	Check for rough or poorly machined head or block surfaces. Replace compressor as necessary.

Troubleshooting

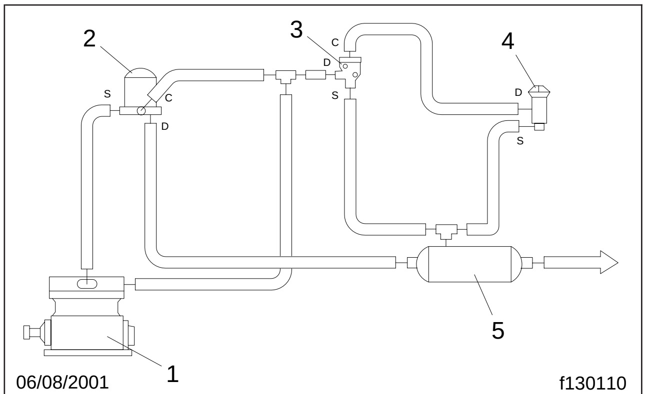


NOTE: The cylinder head connection ports are identified with the following numbers:

- Atmospheric Air In: 0
- Compressed Air Out: 2
- Coolant In: 91
- Coolant Out: 92

1. Coolant In or Out (One of the two ports is plugged.)
2. Inlet Port
3. Discharge Port
4. Coolant In or Out
5. Discharge Safety Valve

Fig. 1, Cylinder Head Port Identification



1. DuraFlo 596 Compressor
2. Air Dryer
3. Synchro Valve
4. Governor
5. Supply Reservoir

Fig. 2, Plumbing Diagram

Specifications

DuraFlo™ 596 Specifications

- Flow capacity at 1800 rpm and 120 psi: 21.4 cfm
- Operation: naturally aspirated
- Horsepower required at 1800 rpm and 120 psi: loaded 7.6, unloaded 1.1
- Swept air displacement at 1250 rpm: 27 cfm
- Maximum recommended rpm: 3000
- Minimum governor cutout pressure: 130 psi
- Maximum inlet air temperature: 250°F (121°C)
- Maximum inlet restriction: 25 inH $_2$O
- Maximum discharge air temperature: 400°F (204°C)
- Minimum oil pressure required at engine idle speed: 15 psi
- Minimum oil pressure required at maximum governed engine speed: 15 psi
- Number of cylinders: 2
- Weight: 50 pounds (23 kilograms)
- Length: 10.9 inches (28 centimeters)
- Height: 13.3 inches (34 centimeters)
- Width: 5.5 inches (14 centimeters)

Fastener Torque Values	
Description	**Torque: lbf·in (N·cm)**
13 mm Cylinder Head Capscrews	265 to 292 (2990 to 3300)
10 mm Valve Capscrews	101 to 111 (1140 to 1250)
Rear End Cover Capscrews	195 to 212 (2200 to 2400)
Bottom Cover Capscrews	97 to 115 (1100 to 1300)
Crankshaft Nut	148 to 184 lbf·ft (200 to 250 N·m)

Table 1, Fastener Torque Values

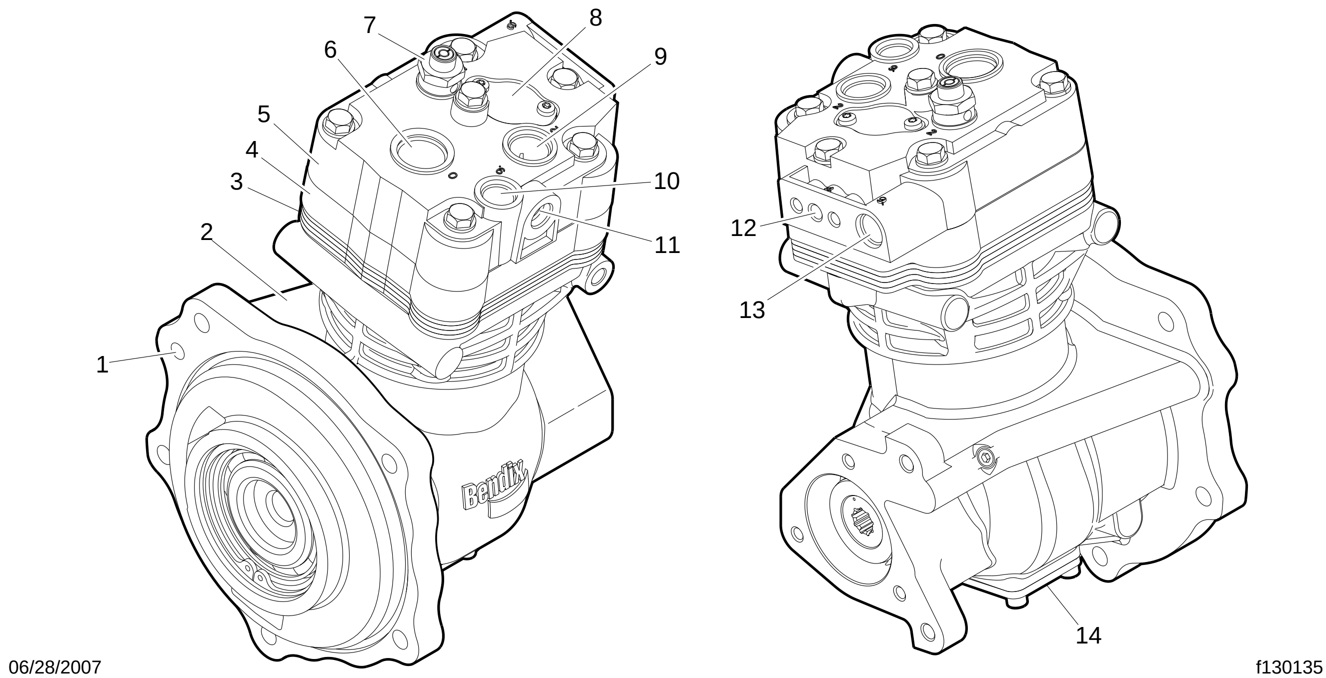
General Description

The function of the Bendix air compressors is to provide and maintain air under pressure to operate devices in the air brake system. See **Fig. 1** and **Fig. 2**. The Bendix BA-921 and 360cc air compressors are both single-cylinder reciprocating compressors with a rated displacement of 15.8 cubic feet per minute (cfm) at 1250 rpm. The Bendix BA-922 compressor is very similar to the BA-921 compressor, but has two cylinders and a rated displacement of 31.6 cfm at 1250 rpm.

The air governor operates in conjunction with the air compressor to maintain the air pressure in the air system between a maximum (cut-out) and minimum (cut-in) pressure. The air compressor turns continuously while the engine is on, but actual compression of air is controlled by the governor, which actuates the air compressor unloading mechanism. Unloading stops or starts based on the cut-in and cut-out pressure settings of the governor.

The cylinder head assembly is made up of the cylinder head, cooling plate, and a valve plate assembly. The cylinder head contains the air and coolant ports as well as an unloader piston. The cooling plate is located between the cylinder head and valve plate assemblies, and assists in cooling the cylinder head assembly. The valve plate assembly, consisting of brazed steel plates, has several valve openings and channels for conducting air and engine coolant into and out of the cylinder head. The compressor is cooled by air flowing through the engine compartment as it passes the compressor's cooling fins, and by the flow of engine coolant through the cylinder head. The vehicle's engine provides a continuous supply of oil to lubricate the compressor.

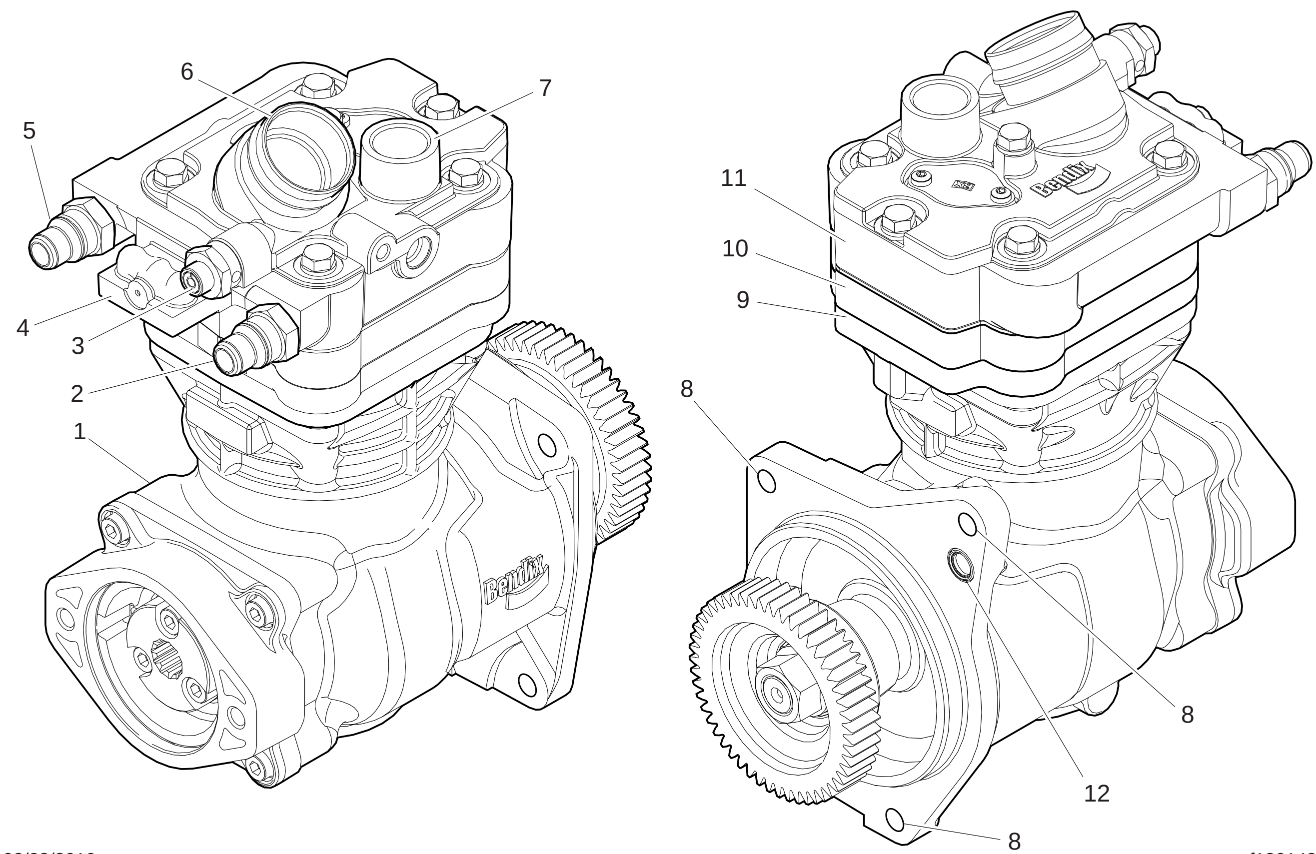
Bendix air compressors are typically equipped with a safety valve in the cylinder head safety valve port,



1. Oil Supply Bore
2. Crankcase
3. Valve Plate Assembly
4. Cooling Plate
5. Cylinder Head
6. Air Supply Port
7. Discharge Safety Valve
8. Unloader Valve Cover
9. Discharge Port
10. Coolant Supply Port
11. Freeze Plug
12. Governor Connection Port
13. Coolant Return Port
14. Crankcase Cover

Fig. 1, Bendix BA-921 Air Compressor

General Information



1. Crankcase
2. Coolant Return Port
3. Pressure Relief Valve
4. Governor Connection Port
5. Coolant Supply Port
6. Air Supply Port
7. Discharge Port
8. Mounting Fastener Holes
9. Valve Plate Assembly
10. Cooling Plate
11. Cylinder Head
12. Oil Bore

Fig. 2, Bendix 360cc Air Compressor

directly connected to the discharge port. The safety valve protects the cylinder head assembly in the event of excessively high discharge line pressure. Excessive air pressure causes the safety valve to unseat, releases air pressure, and gives an audible alert to the operator.

Replacement

1. Shut down the engine, apply the parking brakes, chock the tires, and open the hood.
2. Drain the air system.
3. Disconnect the batteries.

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent eye injury could result from flying debris.

4. Using a cleaning solvent, remove road dirt and grease from the outside of the air compressor, then dry the compressor with compressed air.
5. Depending on the vehicle's engine and chassis specifications, the air compressor may be difficult to access behind the frame rail. It may be necessary to reposition or remove components above and below the frame rail that interfere with access to the compressor, such as battery cables and transmission oil cooler lines.

   Clear any wiring harnesses out of the way, removing P-clamps as necessary.
6. Remove any components attached to the air compressor, such as the fuel pump (Series 60 engines) or power steering pump (DD13/15/16 engines).
7. Drain the coolant from the radiator and cylinder block. For instructions, see **Group 20**.
8. Remove the coolant supply and return lines from the compressor. For a Bendix BA-921/922 compressor, see **Fig. 1**. For a Bendix 360cc compressor and line connections, see **Fig. 2** and **Fig. 3**.
9. Identify and disconnect all air and oil lines attached to the air compressor.
10. Remove the air governor and the air governor mounting gasket, if equipped, or remove the air governor remote line.

NOTICE

Do not allow the air compressor drive gear to make contact with the gear train during removal. Damage to the seal surface could cause oil leakage.

11. Support the air compressor and remove the mounting fasteners that attach the compressor to the engine. Remove the air compressor.
12. Discard all gaskets.

IMPORTANT: Ensure new gaskets are clean and not damaged.

13. Install a new air compressor gasket on the compressor.

NOTICE

Ensure the correct mounting capscrews are used to install the air compressor. If the wrong length is used, the cup plugs installed in the cylinder block can be pushed out into the gear train, causing damage to the gear train.

14. Using capscrews, attach the air compressor to the gear case. See **Table 1** for torque specifications.

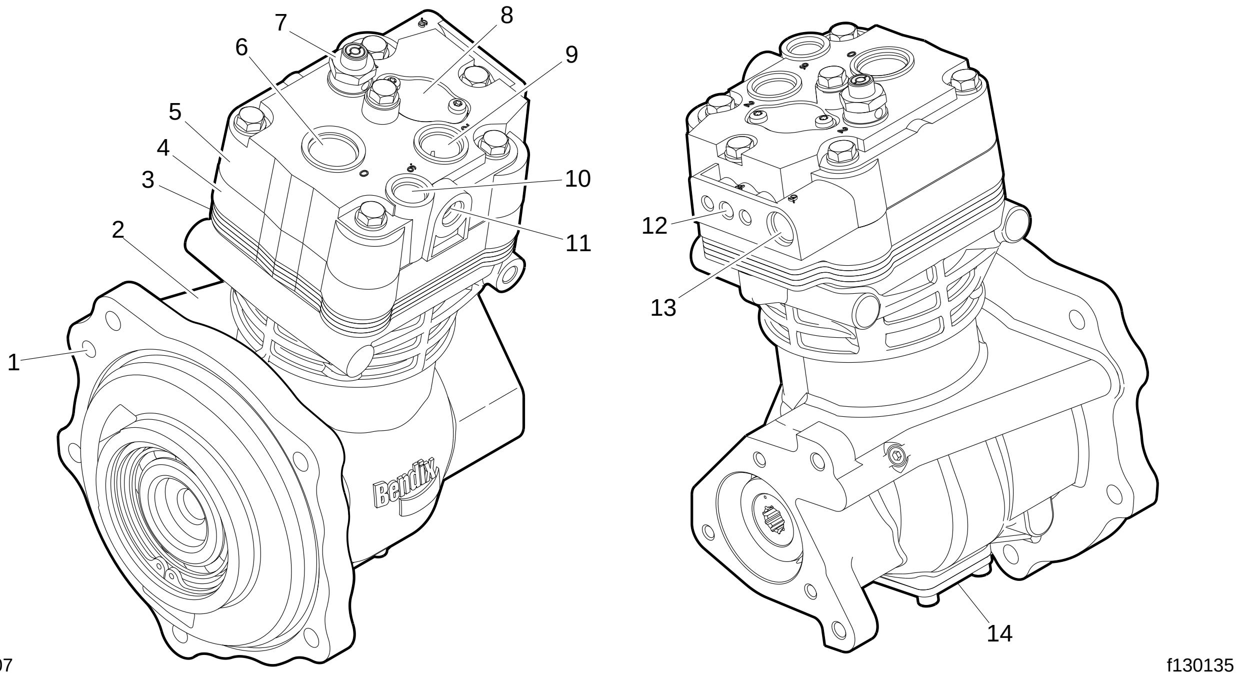
Mounting Fastener Torque Values	
Description	**Torque: lbf·ft (N·cm)**
BA-921 Mounting Capscrews M10 1.50 x 85 (4 qty) M10 1.50 x 35 (1 qty)	43–54 (58–73)
360cc Mounting Capcrews 1.37 in (35 mm) (4 qty)	44 (60)
Power Steering Pump Mounting Fasteners	27–32 (37–43)
Fuel Pump Mounting Fasteners	22–28 (30–38)
Air Governor Mounting Fasteners	11–15 (15–20)

Table 1, Mounting Fastener Torque Values

15. If equipped with a compressor-mounted air governor, install a new gasket on the air governor and install the air governor on the compressor. If the vehicle has a remote-mounted air governor, connect the air governor remote line to the compressor.

IMPORTANT: Ensure that coolant lines connected to a Bendix 360cc compressor are equipped with an O-ring and O-ring retainer on both ends. After installing the lines, ensure that

Air Compressor Replacement



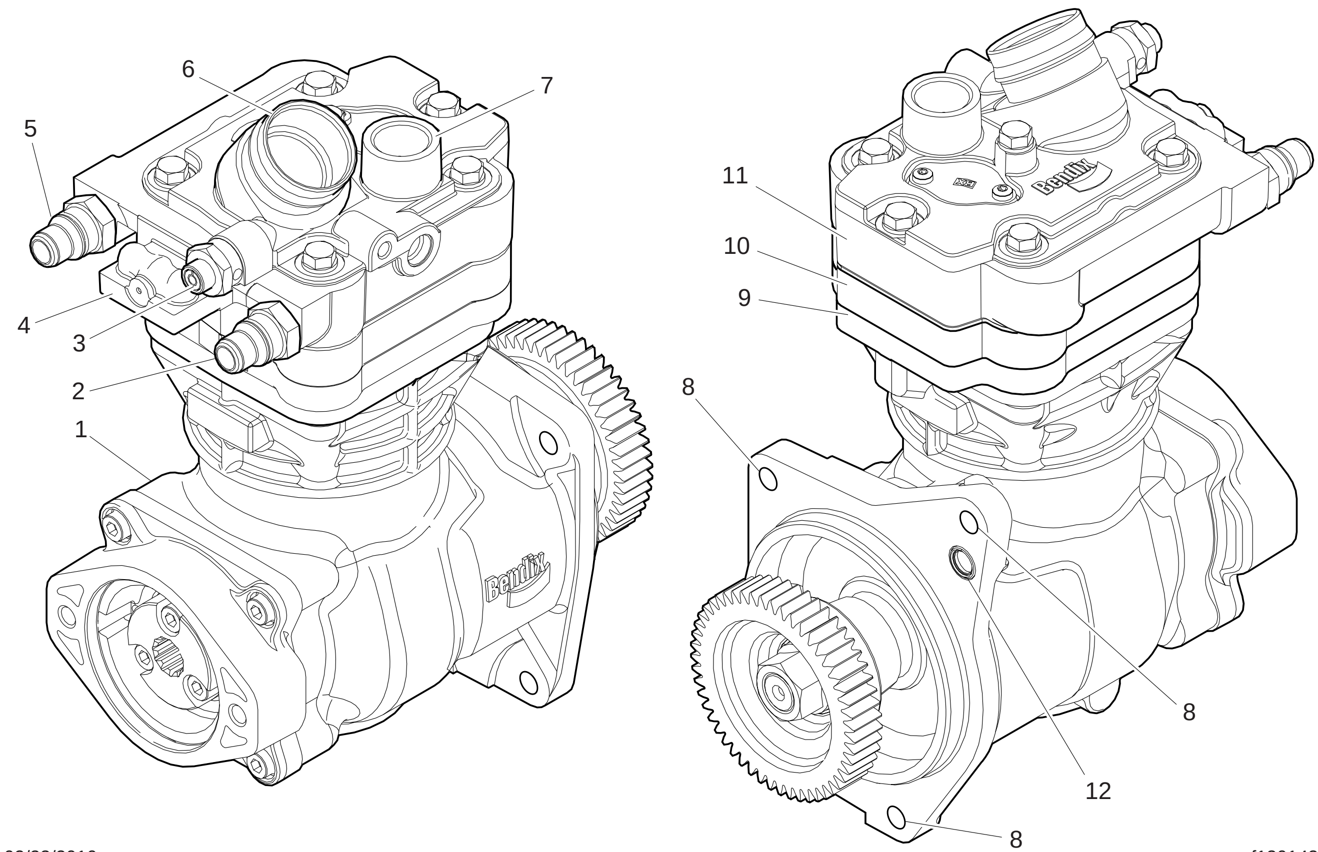
1. Oil Supply Bore
2. Crankcase
3. Valve Plate Assembly
4. Cooling Plate
5. Cylinder Head
6. Air Supply Port
7. Pressure Relief Valve
8. Unloader Valve Cover
9. Discharge Port
10. Coolant Supply Port
11. Freeze Plug
12. Governor Connection Port
13. Coolant Return Port
14. Crankcase Cover

Fig. 1, BA-921 Air Compressor

each coolant line retainer is engaged in the locked position.

16. Connect the air and coolant lines to the air compressor. Connect the oil line, if equipped, to the compressor.
17. Install any components that were removed from the air compressor, such as the fuel pump (Series 60 engines) or power steering pump (DD13/15/16 engines). See **Table 1** for torque specifications.
18. Move all wiring harnesses back into place and install any wiring harness P-clamps that were previously removed.
19. Fill the engine cooling system. For instructions, see **Group 20**.
20. Connect the batteries.
21. Start the engine and check for leaks.

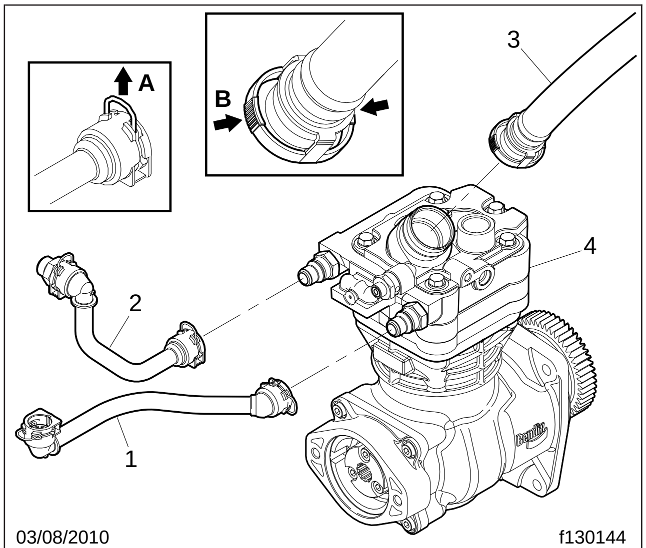
Air Compressor Replacement



1. Crankcase
2. Coolant Return Port
3. Pressure Relief Valve
4. Governor Connection Port
5. Coolant Supply Port
6. Air Supply Port
7. Discharge Port
8. Mounting Fastener Holes (4 qty)
9. Valve Plate Assembly
10. Cooling Plate
11. Cylinder Head
12. Oil Bore

Fig. 2, Bendix 360cc Air Compressor

Air Compressor Replacement



A. Pull securing clip up in order to disconnect coolant lines.
B. Squeeze the two tabs on the air supply line to disconnect it from the compressor.

1. Coolant Return Line
2. Coolant Supply Line
3. Air Supply Line
4. Air Compressor

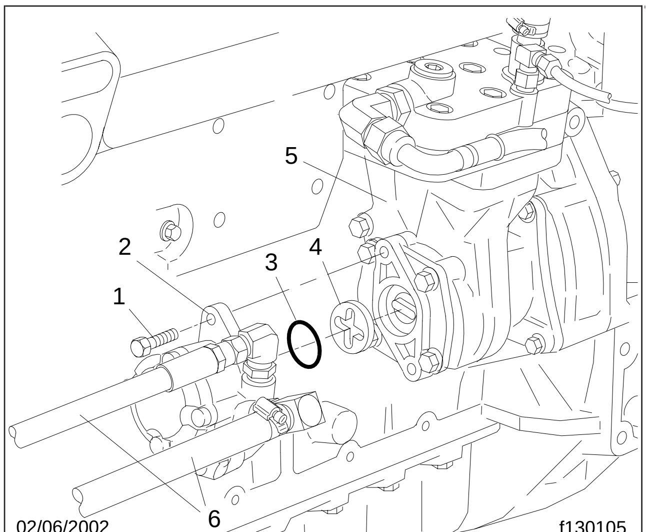
Fig. 3, Bendix 360cc Air Compressor Line Connections

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Drain the air tanks.
3. Open the hood and clean all the fittings and hose connections on the air compressor and power steering pump.
4. Drain the radiator coolant. For instructions, see **Section 20.01**, Subject 100.
5. Remove the two capscrews that attach the power steering pump to the air compressor, and move the pump away from the compressor. See **Fig. 1**.

IMPORTANT: Do not remove the power steering lines. Secure the lines and the pump so that they are out of the way.

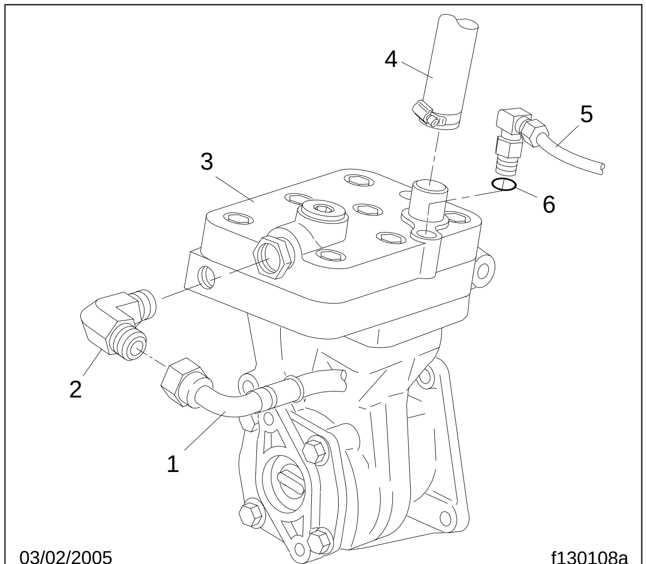
6. Remove and discard the O-ring located between the power steering pump and the cross plate.
7. Remove the cross plate located between the air compressor and the power steering pump.



1. Capscrew
2. Power Steering Pump
3. O-Ring, Power Steering Pump
4. Cross Plate
5. Air Compressor
6. Hydraulic Line

Fig. 1, Power Steering Pump Installation

8. Remove the three air lines from the air compressor.
   - 8.1 Remove the discharge line and the elbow fitting. Check inside the discharge line for carbon deposits. If deposits are found, install a new discharge line. See **Fig. 2**.
   - 8.2 Remove the unloader line. Check the fittings for damage and replace if necessary.
   - 8.3 Remove the intake air line.



NOTE: The discharge air line may be located on top of the air compressor instead of on the side.

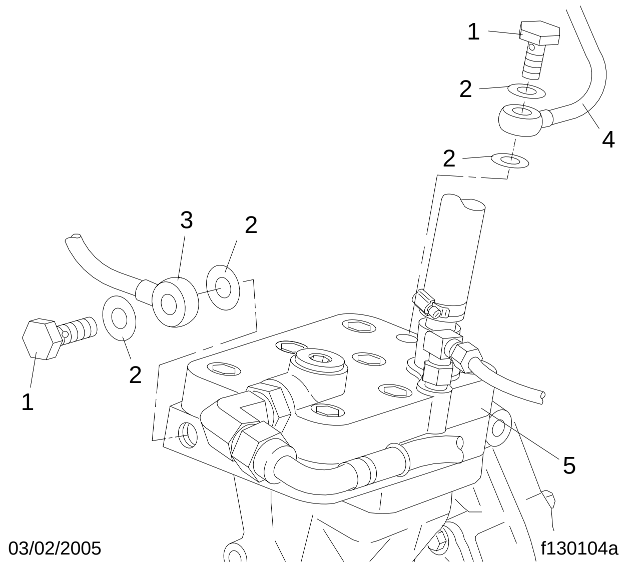
1. Discharge Air Line
2. Elbow Fitting
3. Air Compressor
4. Intake Air Line
5. Unloader Air Line
6. O-Ring

Fig. 2, Air Compressor Air Lines

9. Remove all the air fittings from the top of the compressor.
10. Remove the engine trim covers.
11. Remove the coolant delivery line and the coolant return line. Discard the seal rings. See **Fig. 3**.
12. Remove brackets and wires beneath the air compressor as necessary in order to remove the air compressor.

NOTE: The capscrews that attach the air compressor to the engine are different lengths. Be sure to note where each capscrew is located.

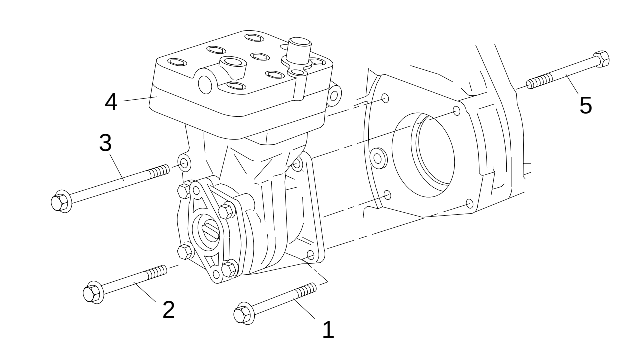
Removal, Inspection, and Installation



1. Banjo Capscrew
2. Seal Ring
3. Coolant Return Line
4. Coolant Delivery Line
5. Air Compressor

Fig. 3, Air Compressor Coolant Lines

13. Remove the four capscrews that attach the air compressor to the engine and remove the compressor. See **Fig. 4**.



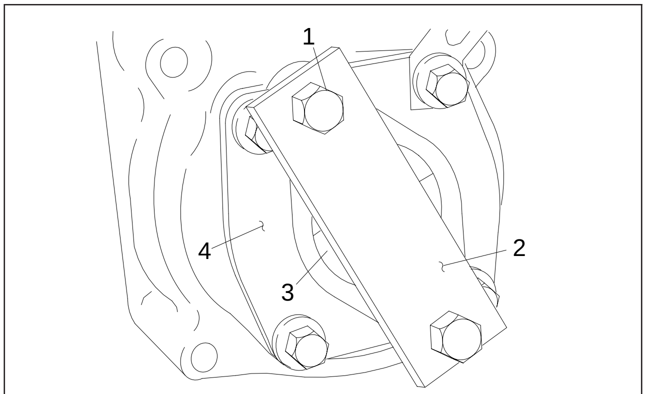
1. Outboard Lower Capscrew
2. Inboard Lower Capscrew
3. Inboard Upper Capscrew
4. Air Compressor
5. Outboard Upper Capscrew

Fig. 4, Air Compressor Installation

14. Slide the drive gear away from the flywheel. Catch any oil that runs out and dispose of it properly.

Inspection

1. If the air compressor is being replaced, attach the fittings from the compressor to the replacement compressor. If any O-rings and fittings are damaged, install new O-rings and fittings.
2. Install a new O-ring between the power steering pump and the cross plate.
3. Install an SPX Kent-Moore locking device (J 46177) on the air compressor where the power steering pump connects to the air compressor. Tighten the capscrews until the air compressor drive is locked. This device locks the driveshaft to allow removal of the drive nut. See **Fig. 5**.



1. Capscrew
2. Locking Device
3. End of Driveshaft
4. Air Compressor

Fig. 5, Locking Device Installation

4. Remove the drive gear from the air compressor.

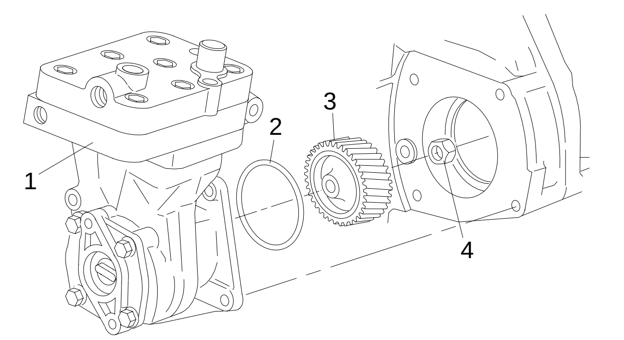
   4.1 Place the air compressor and locking device in a vise. Make sure the locking device is tightly secured and cannot slip out of the vise.

   4.2 Using an impact wrench, remove the drive nut from the drive gear. See **Fig. 6**.

   4.3 Remove the locking device from the air compressor and the vise.

   4.4 If necessary, use a gear puller to remove the drive gear from the air compressor.

   4.5 Discard the O-ring located between the air compressor and the drive gear.



1. Air Compressor
2. O-Ring
3. Drive Gear
4. Drive Nut

Fig. 6, Air Compressor Drive Gear Installation

5. Inspect the drive gear for worn or broken teeth, spalling, and corrosion. If necessary, install a new drive gear. Install the drive nut and a new O-ring. Torque the drive nut 214 lbf·ft (290 N·m).
6. Remove the air compressor from the vise.

Installation

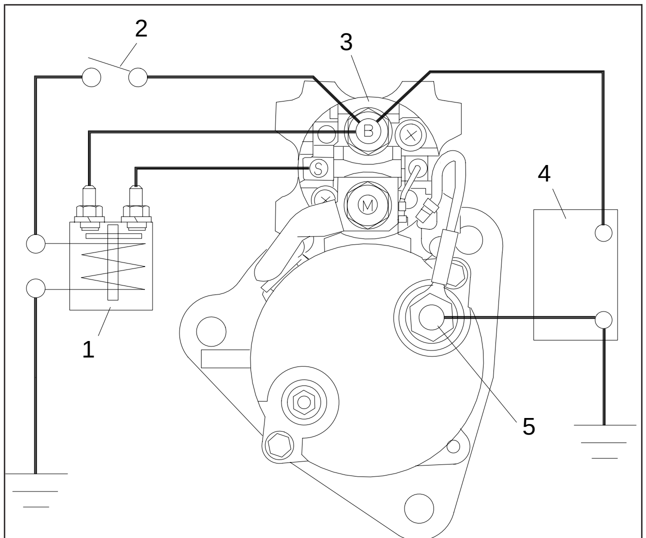
1. Using four capscrews, attach the air compressor to the engine. Torque the capscrews 44 lbf·ft (60 N·m).

NOTE: Be sure to use the correct capscrew at each mounting location.

2. Install the coolant lines on the air compressor.
   - 2.1 Install new seal rings on the coolant lines.
   - 2.2 Install the coolant delivery line at the rear of the air compressor. Torque the banjo capscrew 44 lbf·ft (60 N·m).
   - 2.3 Install the coolant return line at the front of the air compressor. Torque the banjo capscrew 44 lbf·ft (60 N·m).
3. Install any brackets that were removed in order to remove the air compressor.
4. Install the engine trim covers.
5. Install all the air fittings on top of the air compressor.
6. Install the three air lines on the air compressor.
   - 6.1 Install the discharge line and the elbow fitting. Make sure the O-ring is correctly installed on the fitting.
   - 6.2 Install the unloader line. Make sure the O-ring is correctly installed on the fitting.
   - 6.3 Torque the air intake and air discharge fittings 60 lbf·ft (80 N·m).
   - 6.4 Install the intake air line and tighten the hose clamp.
7. Install the cross plate. Use grease to hold it in place while installing the power steering pump.
8. Using two capscrews, attach the power steering pump to the air compressor. Torque the capscrews 30 lbf·ft (40 N·m).
9. Fill the cooling system. For instructions, see **Section 20.01**, Subject 100.
10. Close the hood and remove the chocks from the tires.

General Information

The Mitsubishi starter (MIB 970379FL), which weighs approximately 28 pounds (12.7 kg), uses a planetary gear reduction system. The starter attaches to the flywheel housing. In the area of the output shaft, the starter provides protection from dust, water, or oil splash for the inner starter parts. See **Fig.1**, for a circuit diagram of the Mitsubishi isolated-ground type starter.



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1. Magnetic Switch
2. Start Switch
3. Starter Solenoid
4. Battery
5. Starter Motor

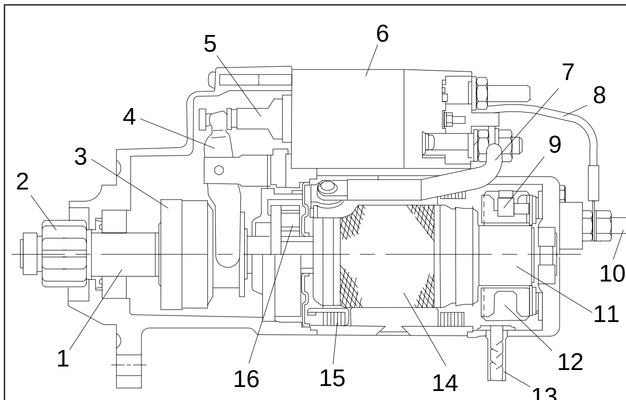
Fig. 1, Basic Starting Circuit (isolated-ground type)

Principles of Operation

When the start switch is closed (the switch is in the start position) current flows through the magnetic switch windings. The magnetic switch contacts close and current flows through the starter solenoid windings.

The starter clutch is thrust forward by movement of the plunger and the lever. See **Fig.2**. Current flowing in the starter solenoid windings causes the pinion gear to slowly rotate. The pinion engages the ring gear and, when the pinion is securely engaged, the main solenoid contacts close and the starter cranks.

When the engine starts, the starter clutch prevents excessive overrun of the armature.



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1. Output Shaft
2. Pinion
3. Clutch
4. Lever
5. Plunger
6. Solenoid
7. M-Lead
8. Ground Wire
9. Brush Spring
10. Ground Terminal
11. Commutator
12. Brush
13. Drain Tube
14. Armature
15. Field Coil
16. Planetary Gear

Fig. 2, Starter Cross-Section (isolated-ground stud type)

CAUTION

Release the start switch immediately when the engine starts, to prevent damage to the starter. Do not crank the starter for more than 30 seconds at one time or the starter may overheat. If you do crank the starter continuously for 30 seconds, wait 10 minutes to allow the starter to cool before attempting starting again.

Starter Removal and Installation

Removal

Before removing the starter from the vehicle for repair, perform the checks in **Troubleshooting 300**.

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Turn off all electrical loads such as lights, ignition, and accessories.
3. Disconnect the batteries.
4. Open the hood.
5. Disconnect the electrical leads attached to the starter, making note of the number of each and where they attach. Mark the terminals and wires for installation.

NOTE: It may be difficult to access the starter mounting bolts. Straddle the front axle with arms extended around the leaf springs and use a long socket extender or breaker bar.

6. Remove the three mounting bolts and lockwashers that attach the starter to the engine. Remove the starter.

Installation

1. Insert the starter nose housing through the mounting hole in the flywheel housing.
2. Install the three starter mounting bolts and lockwashers and tighten them securely.
3. Connect the wires to the starter as previously marked, making sure that all are accounted for. Make sure that all battery cables are routed so as to avoid contact with sharp edges and other chafe sites. Tighten the nuts 16 to 30 lbf·in (180 to 340 N·cm).
4. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.
5. Connect the batteries.
6. Lower the hood to the operating position.
7. Remove the chocks from the tires.

Approved Dielectric Red Enamel	
Protectant Material	**Approved Brands**
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at **www.glyptal.com** or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

Battery

IMPORTANT: Before troubleshooting the starting system, ensure that the batteries are fully charged and in good condition. See **Group 54** for battery safety, testing, and charging procedures.

Wiring

Inspect the starting system wiring for damage, corrosion, and loose connections at the battery, the start switch, the magnetic switch, and at the starter solenoid. Make any necessary repairs.

Magnetic Switch

For magnetic switch test procedures, see **Section 54.03**.

Ring Gear and Pinion

If the batteries, wiring, and magnetic switch are not faulty there may be damage to the ring gear and starter pinion teeth. This can cause the pinion to become locked by the ring gear and prevent pinion rotation and thrust motion. If you suspect this problem, remove the starter and inspect the pinion and ring gear end faces for damage or burrs. If necessary, replace the ring gear and the starter.

Starter

Pinion Movement/Solenoid Operation Test

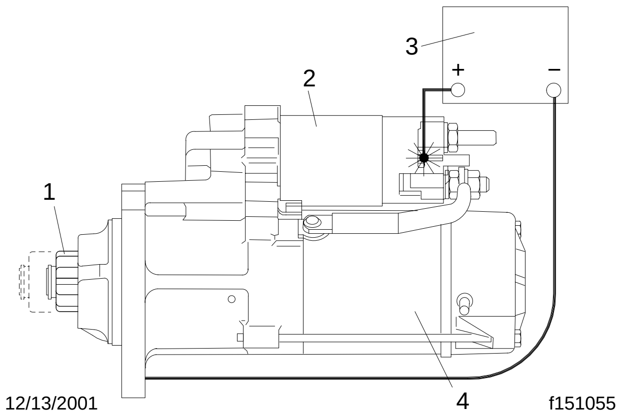
Apply 8 to 12 volts between the solenoid S-terminal and ground. Watch the pinion to see if it moves forward. See **Fig. 1**.

NOTE: The starter will slowly turn at a few hundred rpms.

CAUTION

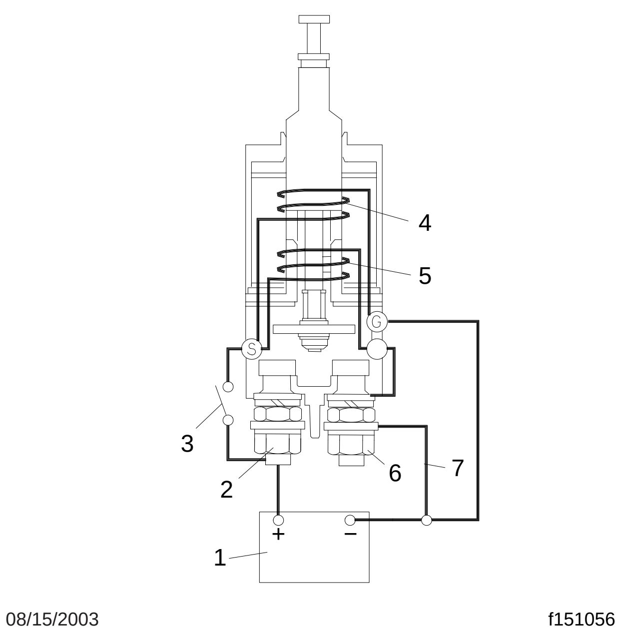
Do not apply voltage for more than 3 seconds or the solenoid may be damaged.

If the pinion does not move forward, replace the starter. The pull-in winding in the solenoid may be shorted or the pinion may be blocked and will not slide. See **Fig. 2** for switch circuit diagrams for starter switch coils.



1. Pinion
2. Starter Solenoid
3. Battery
4. Starter Motor

Fig. 1, Testing Pinion Movement



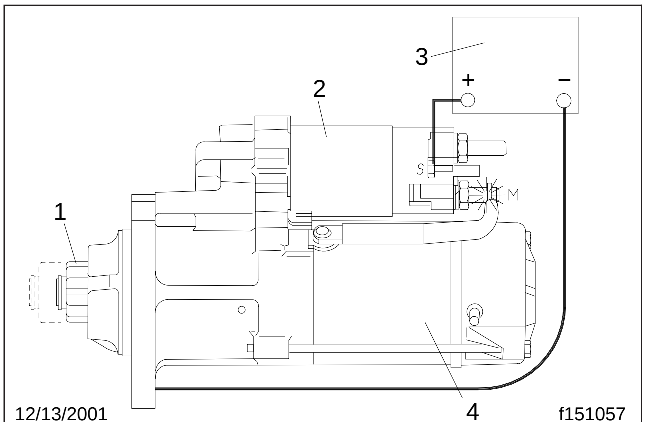
1. Battery
2. Battery Terminal
3. Start Switch
4. Hold-In Winding
5. Pull-In Winding
6. M Terminal
7. To Motor Windings

Fig. 2, Switch Circuit Diagram (starter switch coil)

Troubleshooting

If the pinion is working properly, inspect the starter solenoid hold-in coil. Remove the M-terminal nut but keep the end of the wire in contact with the terminal. See **Fig. 3**. Apply voltage between the S-terminal and the ground (voltage applied to hold-in coil only) to cause the pinion to move forward. Immediately, remove the wire from the M-terminal and watch if the pinion remains in the forward position. If the pinion returns, you may assume that the hold-in coil is shorted. Replace the starter.

See **Specifications 400** for hold-in and pull-in coil resistance values.



1. Pinion
2. Starter Solenoid
3. Battery
4. Starter Motor

Fig. 3, Testing Hold-In Windings

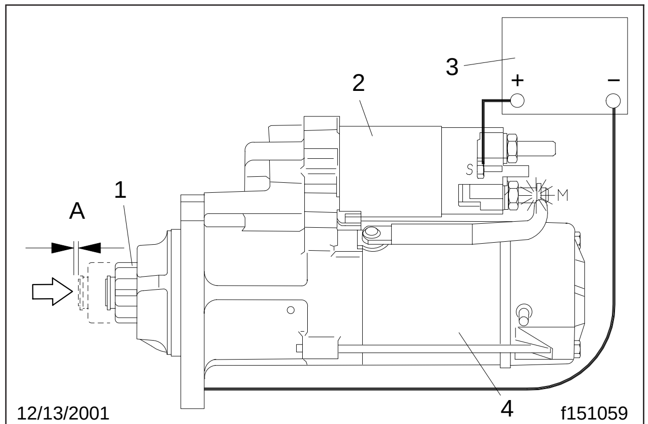
Checking Output Shaft End Play

NOTE: Check the output shaft clearance before installing the starter on the engine.

1. Remove the M-terminal nut but keep the wire in contact with the terminal.
2. Apply voltage between the S-terminal and ground so that the pinion moves forward. Then, immediately remove the wire from the M-terminal.

NOTE: The pinion will remain in the forward position until the battery is disconnected.

3. Press in and pull out on the shaft to measure the end play distance. See **Fig. 4**.



A. Press in and pull out on the pinion shaft to measure the end play distance.
1. Pinion
2. Starter Solenoid
3. Battery
4. Starter Motor

Fig. 4, Checking Output Shaft End Play

NOTE: End play should measure 0.004 to 0.118 inch (0.1 to 3.0 mm). If the measurement is not within specification, replace the starter.

Specifications

See **Table 1** for starter fastener torque values.

Fastener Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
Starter to Flywheel Housing	M12 x 1.5	53–63 (72–85)
Nut, Copper Stud	M12	15–22 (20–30)

Table 1, Fastener Torque Values

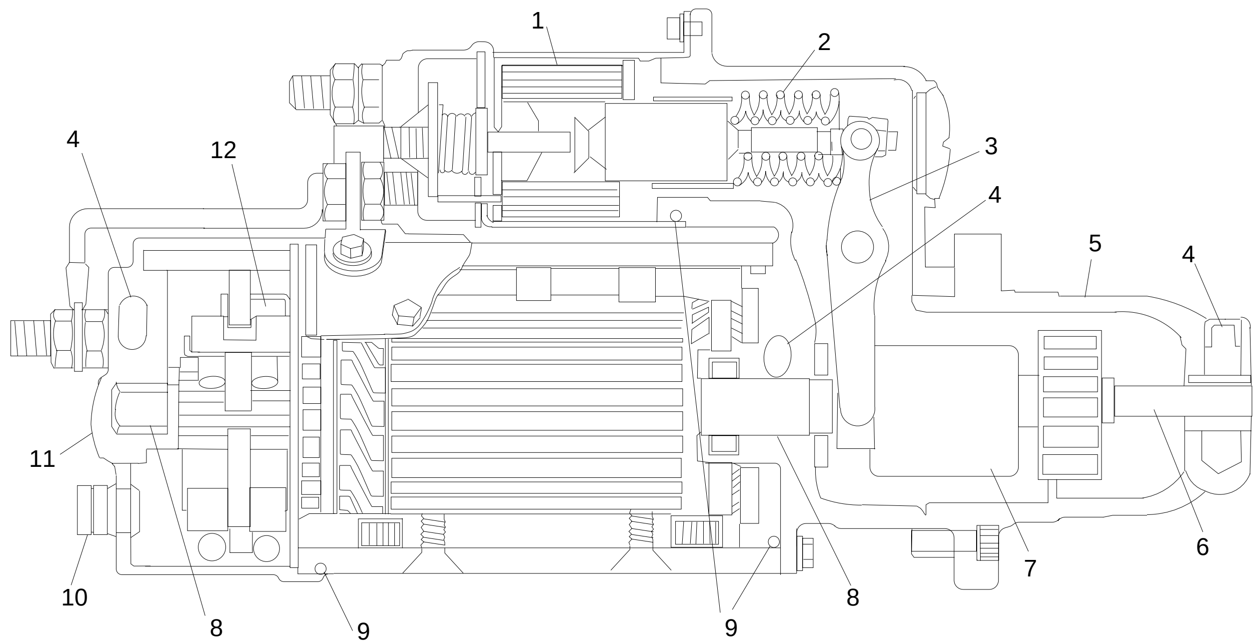
General Information

The Delco Remy starter (**Fig. 1**) is located at the forward face of the flywheel bell housing on the left-hand side of the vehicle.

NOTE: The 42–MT series starters have a drive housing that can be rotated for different mounting positions. On vehicles with the Detroit Diesel Series 55 engine, the starter is installed on the right-hand side.

The brush rigging has four one-piece brushes. The commutator end cap can be removed to inspect the brushes. The bushing lubrication is provided in each sintered bronze bushing by an oil-saturated wick. Oil can be added to each wick by removing an oil reservoir cup, which is accessible on the outside of the motor.

Under normal operating conditions, no maintenance will be required between engine overhaul periods. At the time of engine overhaul, replace the starter with a remanufactured starter.



1. Solenoid
2. Return Spring and Boot
3. Shift Mechanism
4. Oil Wick
5. Drive Housing
6. Bronze Bushing
7. Positive Engagement Drive
8. Armature Bushing
9. O-Ring
10. Thermostat (450 series only)
11. End Cap

Fig. 1, 42-MT Starter Motor Components

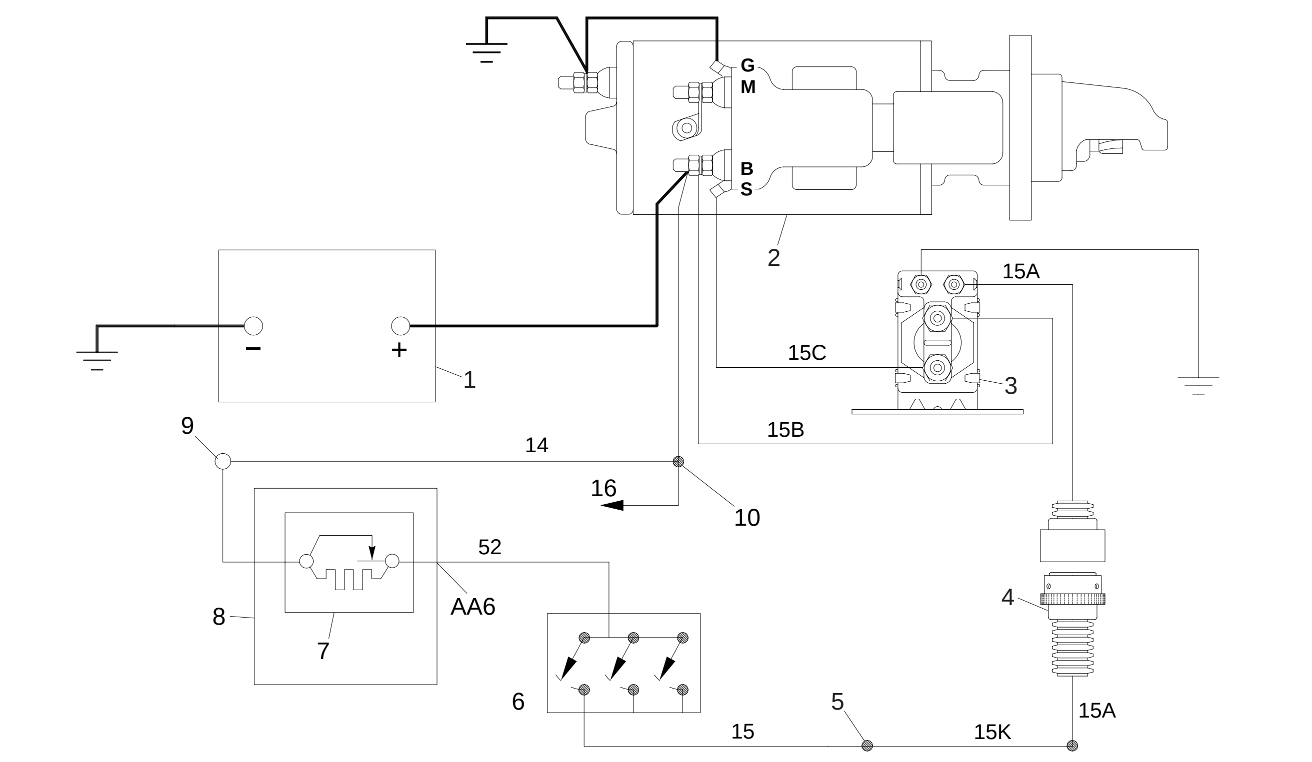
The starter has a shift lever and solenoid plunger that are totally enclosed to protect them from exposure to dirt, icing conditions, and splash. The starter is equipped with a starter drive, solenoid, and a positive-engagement mechanism that prevents the starter motor from rotating unless the pinion gear is engaged with the ring gear teeth. The pinion gear is mounted on a roller bearing one-way clutch, that allows the pinion to spin when the engine has started.

For the basic cranking circuit wiring, see **Fig. 2**.

Principles of Operation

Turning the ignition switch to the START position closes the magnetic switch contacts, connecting the battery to the starter solenoid. As a result, the plunger and the shift lever move, causing the pinion

General Information



NOTE: Wire 16 connects to the alternator.

1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Cab/Frontwall Power Stud
9. Engine Power Stud

Fig. 2, Cranking Circuit Wiring

to engage the engine flywheel ring gear. At the end of the stroke, the solenoid main contacts close and the motor cranks the engine. If the pinion fails to engage the ring gear teeth, the solenoid contacts will not close the circuit to the motor. The switch must be released and again moved to the START position to attempt another start.

When the engine starts, the pinion overruns, protecting the armature from excessive speed. When the ignition switch is returned to the normal RUN position, the solenoid spring returns the plunger and the pinion disengages from the ring gear.

Never crank the motor longer than 30 seconds at a time. Stop and allow the motor to cool for at least 2 minutes before cranking again. Weak batteries or bad connections cause slow cranking speeds that will overheat and damage the starter motor.

The 42–MT 450 series starter is equipped with a thermal overcrank protection circuit. If overheating occurs, a thermostat opens and stops the current to the magnetic switch, protecting the cranking motor. After the motor cools, usually in 1 to 6 minutes, the thermostat will close and then a new start attempt can be made.

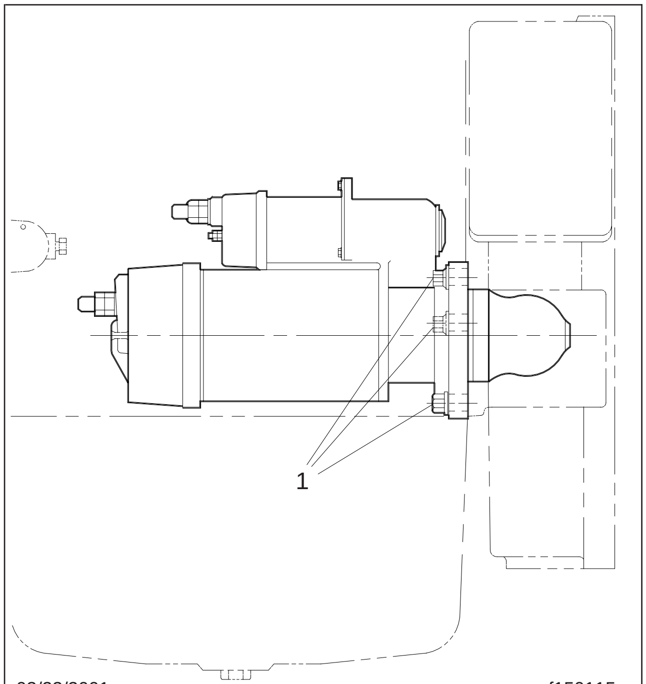
Removal

Before removing the starter from the vehicle for repair, perform the checks in **Troubleshooting, 300**.

1. Turn off all electrical loads such as lights, ignition, and accessories.
2. Disconnect the battery negative cable(s).
3. Disconnect the electrical leads attached to the starter. Mark the terminals and wires for ease of installation.

NOTE: It may be difficult to gain access to the starter mounting bolts. For ease of removal, straddle the front axle with your arms extended around the leaf springs and use a long socket extension.

4. Remove the mounting bolts and lockwashers (**Fig. 1**) that attach the starter to the engine. Remove the starter.



1. Starter Mounting Bolts (with lockwashers)

Fig. 1, Starter Installation

Installation

1. Insert the starter nose housing through the mounting hole in the flywheel housing.
2. Install the three starter mounting bolts and lockwashers. Refer to the fastener and torque values table in **Specifications, 400**.

NOTE: Torque values differ according to type of engine installed.

3. Connect the wires to the starter as previously marked. Tighten the nuts 16 to 30 lbf·in (180 to 340 N·cm).
4. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Approved Dielectric Red Enamel	
Protectant Material	**Approved Brands**
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at **www.glyptal.com** or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

5. Connect the battery negative cable(s).

Ignition Switch Removal and Installation

Removal

1. Disconnect the batteries.
2. Reach in underneath the switch housing and remove the ignition switch from the rubber grommet. It is not necessary to remove the switch housing.
3. Remove the electrical connector from the rear of the switch.

Installation

1. Connect the electrical connector to the ignition switch.
2. Install the ignition switch so that the flat side of the switch points inboard, towards the steering wheel.
3. Connect the batteries.

Troubleshooting

Problem—Starter Cranks Slowly Or Not At All

Problem—Starter Cranks Slowly Or Not At All	
Possible Cause	**Remedy**
The batteries are undercharged.	Do a load test on the batteries. See **Section 54.02**, Subject 140, for instructions. Charge or replace batteries as needed. If the batteries were discharged, check the alternator voltage and output. See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage. Go to "Available Cranking Voltage Test" for instructions.
The starter solenoid circuit is broken.	Check the starter solenoid circuit. Go to "Starter Solenoid Circuit Test" for instructions. Make repairs as needed. Start the engine to verify the repair.
The control circuit is broken.	Check the starter wiring. Go to "Starter Wiring Test" for instructions. Make repairs as needed. Start the engine to verify the repair.
The magnetic switch is broken.	Replace the magnetic switch. Go to **Section 54.03**, Subject 100, for replacement instructions.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears. Go to "Ring and Pinion Gear Test" for instructions.
The starter does not stay engaged.	Go to "Cold Weather Starting Test" for instructions.
The starter is damaged.	Replace the starter.
There is a mechanical problem in the engine.	See **Group 01** or the engine manufacturer's manuals.
The drive belt is loose.	Check the drive belt. See the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.

Troubleshooting Chart

Problem—Starter Spins, But Does Not Crank

For troubleshooting instructions, see **Fig. 1**.

Problem—Starter Makes Clicking Noise, But Does Not Crank (Or Cranks Intermittently)

For troubleshooting instructions, see **Fig. 1**.

Available Cranking Voltage Test

BATTERY CABLE TEST

1. Connect the positive lead of a carbon pile tester to the starter solenoid B (battery) terminal. Connect the negative lead of the carbon pile to the starter G (ground) terminal. See **Fig. 2**.

Troubleshooting

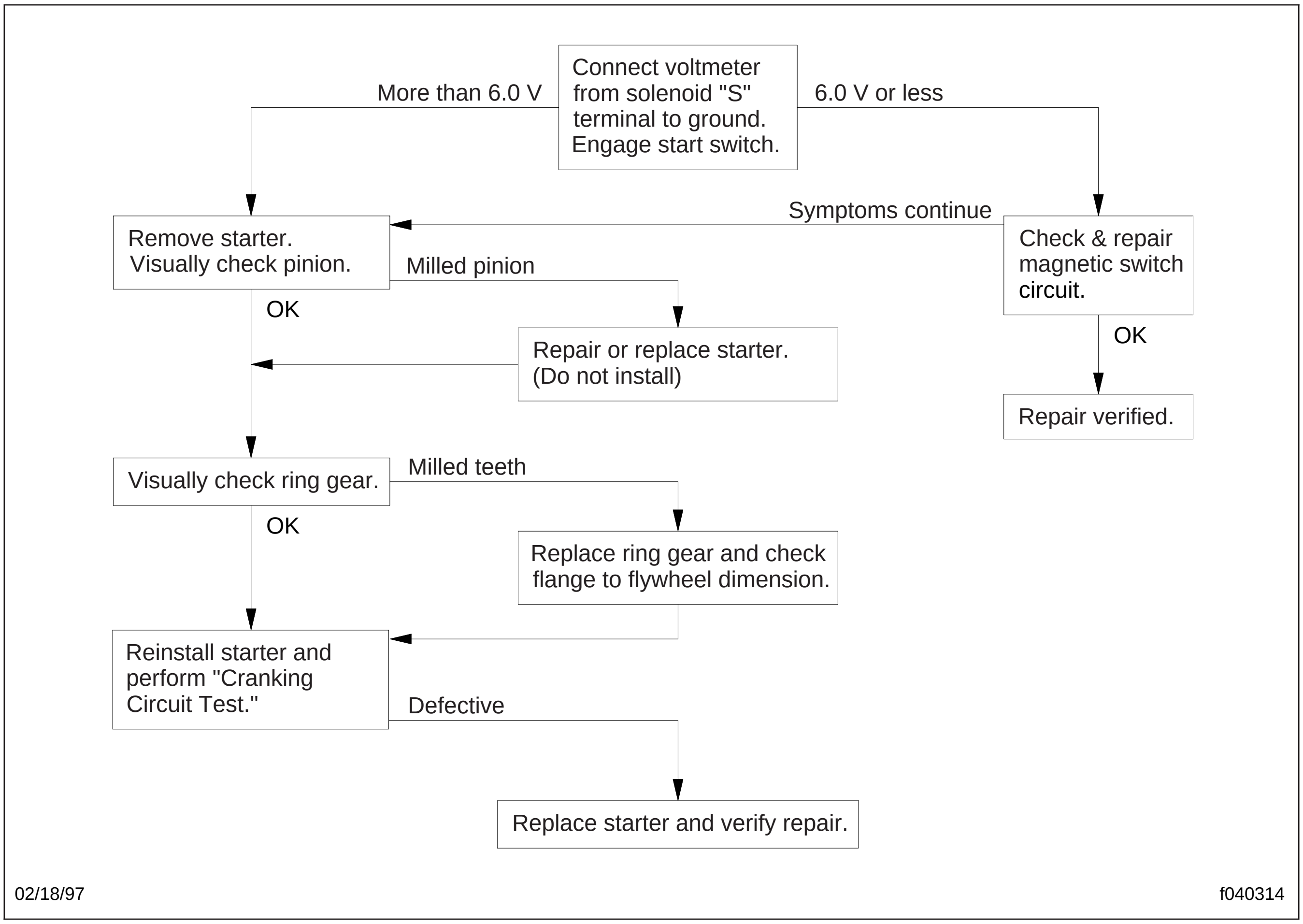


Fig. 1, Milled Pinion Symptoms

IMPORTANT: Connect the voltmeter to the starter B terminal, not to the carbon pile clamp.

2. Set a digital voltmeter on the low scale (2V, 3V, or 4V, depending on type of meter) and connect the positive lead to the battery positive (+) terminal. Connect the negative lead to the starter B terminal.
3. Turn on the carbon pile and adjust it to a 500-amp load. Read and record the voltage (V1) on the voltmeter. Turn off the carbon pile.
4. Now connect the digital voltmeter (still set on the low scale) to the battery negative (–) terminal and the starter G (ground) terminal.

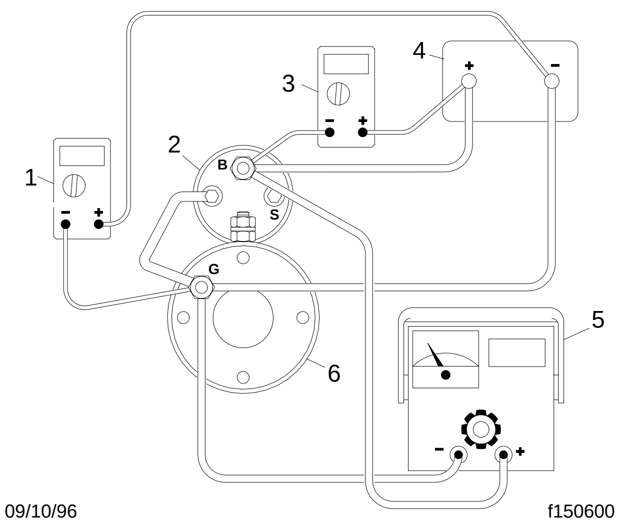
IMPORTANT: Connect the voltmeter to the starter G terminal, not to the carbon pile clamp.

5. Turn on the carbon pile again and adjust it to a 500-amp load, as before. Read and record the voltage (V2) on the voltmeter. Turn off the carbon pile.

NOTE: Ignore the minus (–) sign.

6. Add the positive (V1) and the negative (V2) voltage loss readings together. If the total voltage loss is 0.5 volt or less, the battery cables are OK.

   Add the positive (V1) and the negative (V2) voltage loss readings together. If the total voltage loss is more than 0.5 volt, repair or replace as necessary.



1. Voltmeter (recording V2, negative side voltage loss)
2. Starter Solenoid
3. Voltmeter (recording V1, positive side voltage loss)
4. Battery
5. Carbon Pile
6. Starter

Fig. 2, Battery Cable Test

7. Disconnect the carbon pile and the voltmeter. Reconnect the magnetic switch to the starter S terminal.

INTERCONNECTING CABLE TEST

1. This test requires two persons. While the first person cranks the engine, the second person uses a voltmeter to measure the voltage across the starter solenoid B (battery) and starter G (ground) terminals.
2. If the voltage is 9.0 volts or less while cranking, check the battery interconnecting cables.
   - 2.1 While cranking, measure the voltage across each battery.
   - 2.2 If the difference between any two batteries in the same battery box is more than 0.5 volt, check and replace the interconnecting cables as required.
   - 2.3 If any cable or connection feels warm to the touch, check and replace the interconnecting cables as required.

3. If the starter still does not crank, go to "Ring and Pinion Gear Test."

Starter Solenoid Circuit Test

The starter solenoid circuit includes the starter solenoid, cranking motor, magnetic switch, and ignition switch. It is part of the cranking circuit. See **Fig. 3**.

If there is excessive voltage loss in the starter solenoid circuit, the starter may not engage the flywheel at all, or it may drop out too soon when battery voltage goes down. Do the following test to check for excessive voltage loss in the starter solenoid circuit.

1. Disconnect, at the solenoid, the lead from the magnetic switch to the S terminal on the starter solenoid.
2. Use a small clamp or 8-gauge jumper wire to connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter G (ground) terminal. See **Fig. 4**.
3. Set a digital voltmeter on the 20V scale and connect the positive lead to the starter B (battery) terminal. Connect the negative lead to the magnetic switch lead to which the carbon pile is already connected.
4. Read and record (as V3) the battery voltage shown on the meter, about 12.6V.

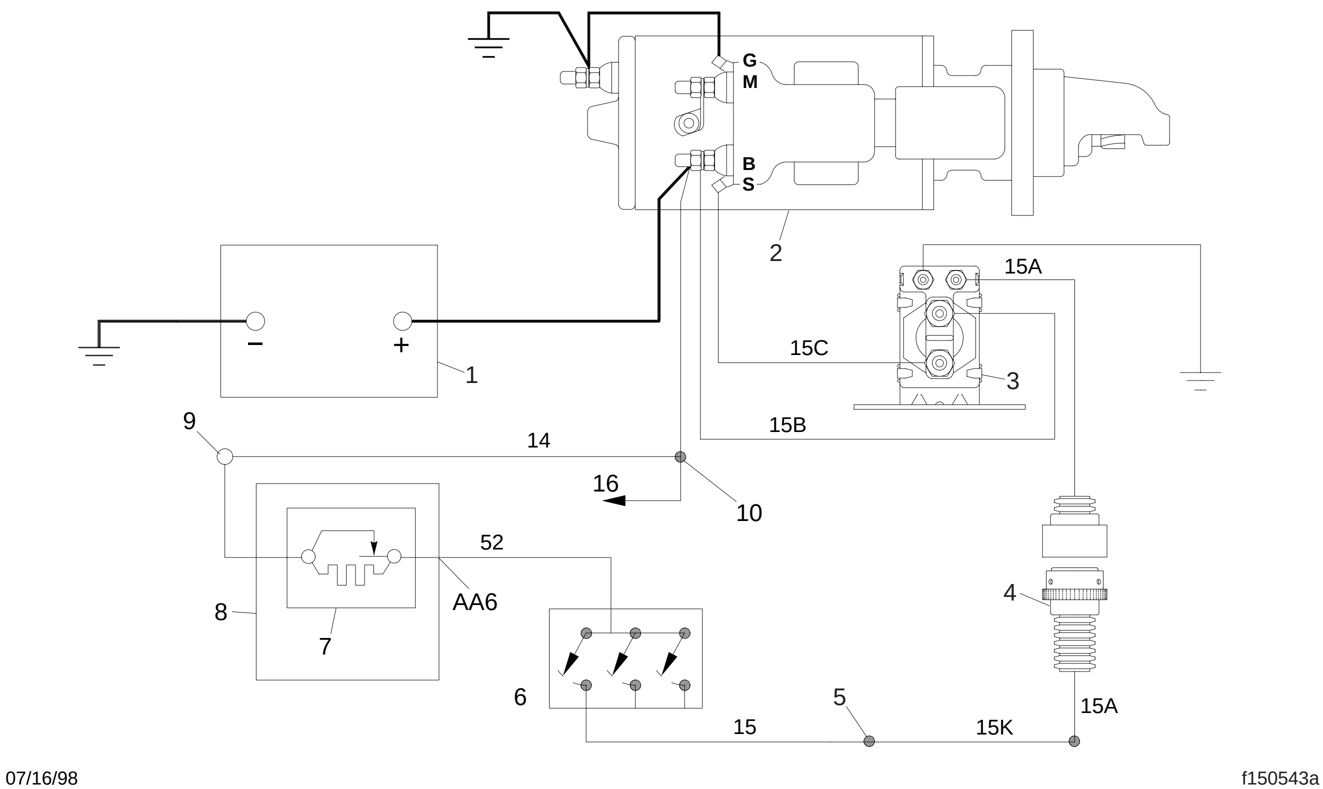
NOTE: This step requires two persons.

5. Have one person turn the ignition switch to the START position while the other person listens for the clicking sound of the magnetic switch closing. Read the voltage on the voltmeter. It should read very low voltage, less than 0.1V.

IMPORTANT: If the magnetic switch does not close, do the "Magnetic Switch Circuit Test." For instructions, see **Section 54.03**, Troubleshooting, 300.

6. Check the starter solenoid circuit voltage loss.
   - 6.1 Turn the ignition key to the START position; then turn on the carbon pile and adjust it to a 100-amp load.
   - 6.2 Now read and record (as V4) the voltage on the voltmeter. Turn off the carbon pile.

Troubleshooting



NOTE: Wire 16 connects to the alternator.

1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (Pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Cab/Frontwall Power Stud
9. Engine Power Stud

Fig. 3, Cranking Circuit Wiring

6.3 If the voltage drop (V4–V3) is 1.0V or less, the starter solenoid circuit is OK. Do the "Magnetic Switch Circuit Test." For instructions, see **Section 54.03**, Troubleshooting, 300.

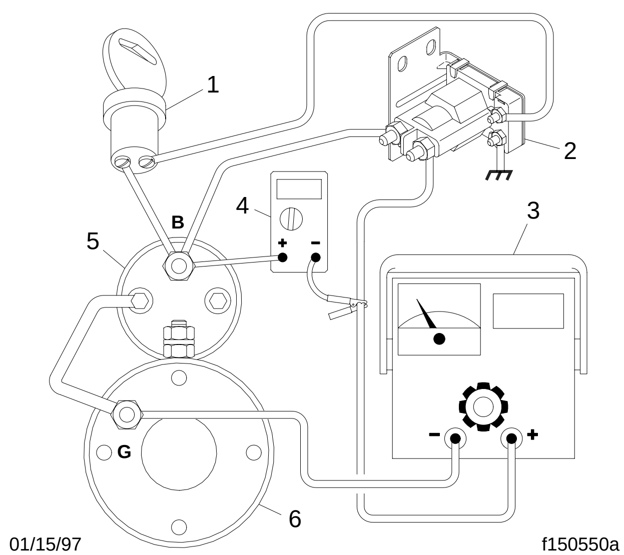
If the voltage drop (V4–V3) is more than 1.0V, the voltage loss is excessive. Go to "Starter Wiring Test."

Starter Wiring Test

1. Disconnect the lead from the magnetic switch to the S terminal on the starter solenoid (leave as in "Starter Solenoid Circuit Test").

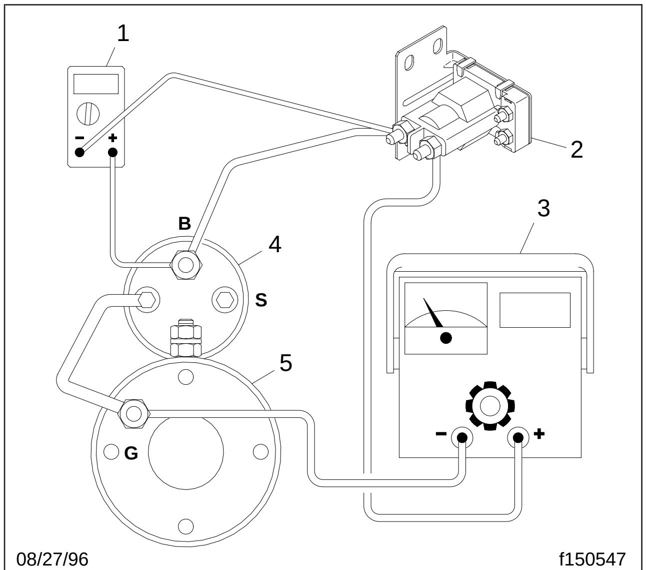
IMPORTANT: It is difficult to gain access to the starter S terminal. Avoid touching the starter B terminal at the same time as the S terminal, as this can cause an electric shock.

2. Connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter G (ground) terminal (leave as in "Starter Solenoid Circuit Test").
3. Set a digital voltmeter on the low scale and connect the positive lead of the voltmeter to the starter solenoid B (battery) terminal. Connect the negative lead of the voltmeter to the large terminal of the magnetic switch that is connected to the starter B terminal (circuit 15B). See **Fig. 5**. If any voltage shows, reconnect to the other large terminal.



1. Ignition switch
2. Magnetic Switch
3. Carbon Pile
4. Digital Voltmeter
5. Starter Solenoid
6. Cranking Motor

Fig. 4, Starter Solenoid Circuit Test



1. Digital Voltmeter
2. Magnetic Switch
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

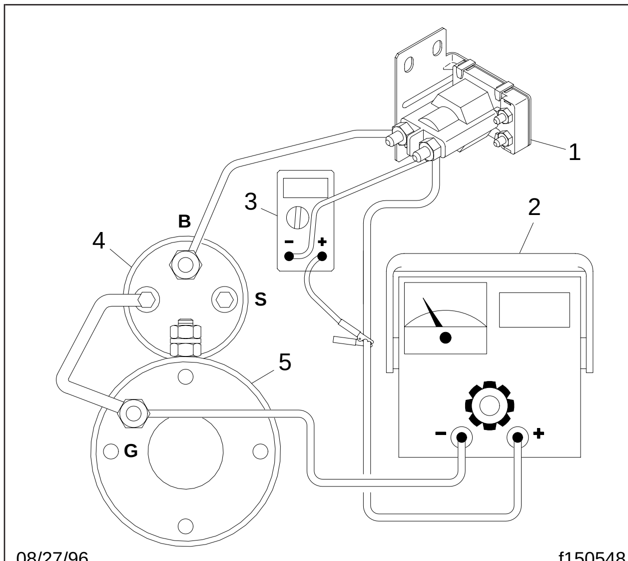
Fig. 5, Starter Wiring Test, First Wire Voltage Loss (V5)

NOTE: If desired, do a continuity check on the circuit to be sure that it is connected to the correct terminal. Low resistance indicates that the connections are correct.

4. Have a second person start the engine momentarily.

IMPORTANT: If the magnetic switch does not close, do the "Magnetic Switch Circuit Test." For instructions, see **Section 54.03**, Troubleshooting, 300.

5. Check the first wire voltage loss (V5).
   - 5.1 Turn the ignition key to the START position, then turn on the carbon pile and adjust it to a 100-amp load.
   - 5.2 Now read and record the voltage (V5) on the voltmeter. Turn off the carbon pile.
6. Now connect the positive lead of the digital voltmeter (still set on the low scale) to the magnetic switch lead which is already connected to the carbon pile (as in "Starter Solenoid Circuit Test"). Connect the negative lead of the voltmeter to the other large terminal on the magnetic switch (circuit 15C). See **Fig. 6**.



1. Magnetic Switch
2. Carbon Pile
3. Digital Voltmeter
4. Starter Solenoid
5. Cranking Motor

Fig. 6, Starter Wiring Test, Second Wire Voltage Loss (V6)

7. Have a second person start the engine momentarily.
8. Check the second wire voltage loss (V6).

   NOTE: Ignore the minus (–) sign.

   8.1 Turn the ignition key to the START position, then turn on the carbon pile and again adjust it to a 100-amp load.

   8.2 Now read and record the voltage (V6) on the voltmeter. Turn off the carbon pile.

   8.3 Add the two voltages (V5 and V6) together to get the total wire voltage loss. If the total wire voltage loss adds up to 0.8 volt or less, the wiring is OK. Replace the magnetic switch. For instructions, see **Section 54.03**, Subject 100.

   If the total wire voltage loss adds up to more than 0.8 volt, check the wire connections for tightness and the terminals for corrosion. Repair or replace as necessary.
9. Disconnect the carbon pile and the voltmeter. Reconnect the magnetic switch to the starter S terminal.
10. Check all wiring and connections and repair or replace as needed. For instructions on wire repair, see **Section 54.00**, Subject 100.

Magnetic Switch Circuit Test

For the "Magnetic Switch Circuit Test," see **Section 54.03**, Troubleshooting, 300.

Ring and Pinion Gear Test

1. This test requires two persons. While the first person bars the engine over, the second person visually checks the entire flywheel ring gear and starter pinion gear visually (check all the teeth in both gears).
2. If the pinion teeth are damaged, replace the starter. If the ring gear teeth are damaged, replace the ring gear.

NOTE: For ring gear replacement procedures, see the engine manufacturer’s manuals.

3. If the engine still does not crank properly after replacing the starter, look for a mechanical problem in the engine. For instructions, see **Group 01** or the engine manufacturer’s manuals.

Cold Weather Voltage Test

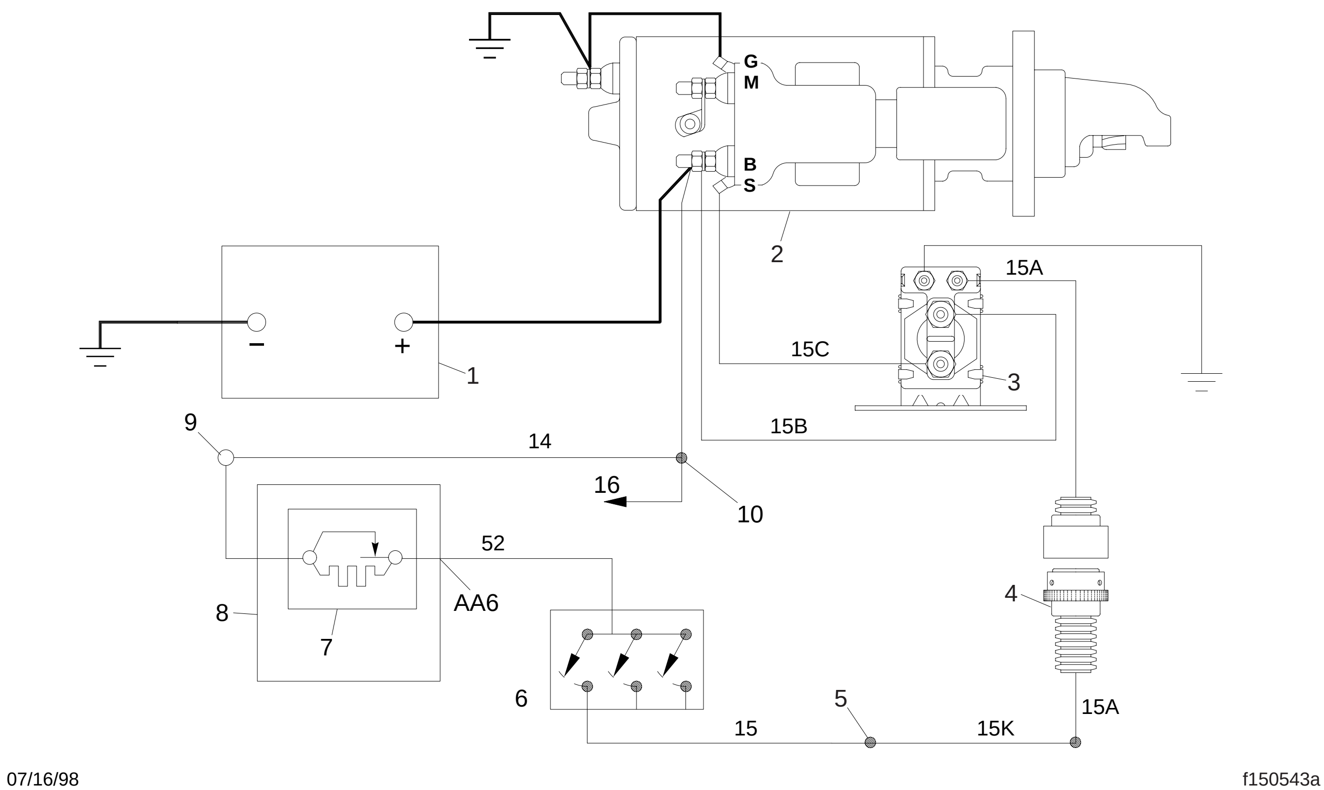
In cold weather, the starter may fail to engage, even though it performed well at higher temperatures. Do the following test to check for cold weather voltage loss in the cranking circuit.

1. With the ignition switch on, clamp a heavy battery jumper cable between the two large studs on the magnetic switch. Remove the jumper immediately to stop the engine from cranking.
2. If the engine starts with the jumper in place, do the "Starter Wiring Test." Repair/replace the wiring connections, terminals, and/or magnetic switch as necessary.
3. If the engine now starts properly, check the starter mounting bolts for tightness and do the "Alternator Wiring Test." See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
4. If the engine still does not start properly, go to "Available Cranking Voltage Test."

Specifications

For a cranking circuit wiring diagram, see **Fig. 1**.

For a schematic of the engine starting circuit wiring harness, see **Fig. 2**.

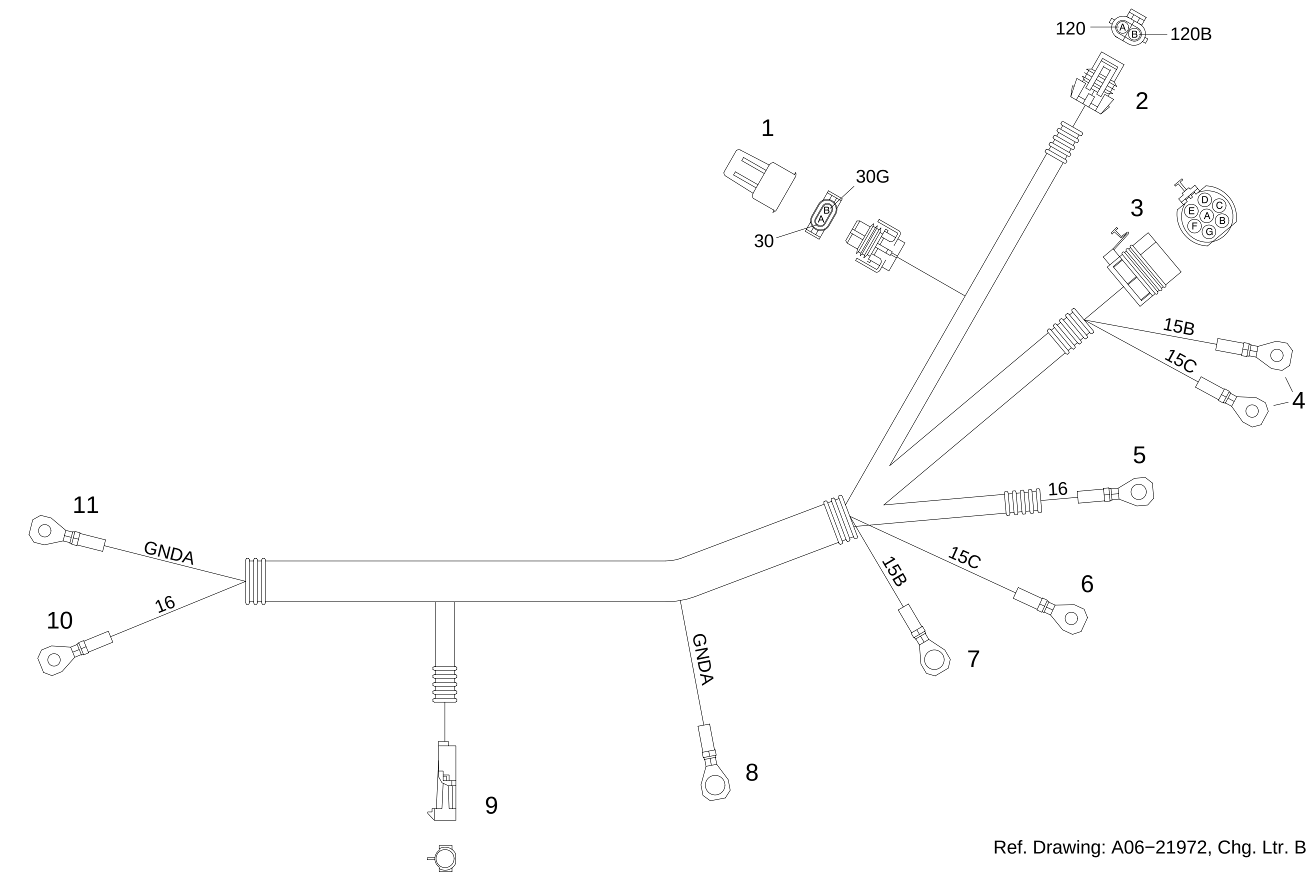


NOTE: Wire 16 connects to the alternator.

1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Cab/Frontwall Power Stud
9. Engine Power Stud

Fig. 1, Cranking Circuit Wiring

Specifications



1. Transmission Temperature Gauge Sensor Harness Connector
2. To Back-Up Light Switch
3. Frontwall Harness Connector
4. To Magnetic Switch
5. To Battery Cable Power Terminal
6. To Starter Solenoid "S" Terminal
7. To Starter Solenoid "B" Terminal
8. To Starter "G" Terminal
9. To A/C Compressor Clutch
10. To Alternator Output Terminal
11. To Alternator Ground Terminal

Fig. 2, Engine Charging Circuit Wiring Harness

Fastener Torque Values			
Fastener Description	Size	Torque Value	
		lbf·ft (N·m)	lbf·in (N·cm)
Nose Housing Bolts	5/16–18	13–17 (18–23)	—
Frame Capscrews (grade 8)	1/4–28	—	144–192 (1620–2160)
Solenoid Mounting Bolts (grade 8)	1/4–20	—	150–200 (1700–2260)
Copper Terminals	1/2–13	20–25 (27–34)	—
Solenoid Side Terminals	10–32	—	16–30 (180–340)
Brush Screw	8–32	—	18–24 (200–280)

Specifications

Fastener Torque Values			
Fastener Description	Size	Torque Value	
		lbf·ft (N·m)	lbf·in (N·cm)
Frame Plug	1-3/8–18	—	48–72 (540–820)
Starter Motor to Flywheel Housing Bolts			
Detroit Diesel (steel housing)	5/8–16	137–147 (186–199)	—
Detroit Diesel (aluminum housing)	5/8–16	85–95 (115–129)	—
Caterpillar (steel or aluminum housing)	5/8–16	130–170 (176–230)	—
Cummins (steel or aluminum housing)	5/8–16	130–170 (176–230)	—

Table 1, Fastener Torque Values

General Information

Delco Remy SI series alternators feature internally mounted integrated-circuit regulators and diode rectifiers, placed inside the end frame of the alternator. See **Fig. 1** for typical sectional and end views.

As vehicles are designed to use space more efficiently, engine compartments are more tightly packed, and operating demands are more challenging. In response to those developments and particularly the requirements of EPA07 and later vehicles, the 24-SI, 35-SI, 36-SI and later alternators are designed for high output in underhood temperatures up to 221°F (105°C).

Most alternators have a cooling fan at the front end which draws air through the housing from the back, exhausting out the front. The 24-SI (see **Fig. 2**) is a brush-type alternator with dual internal fans to draw cooling air in from both ends, exhausting out from the center of the casing.

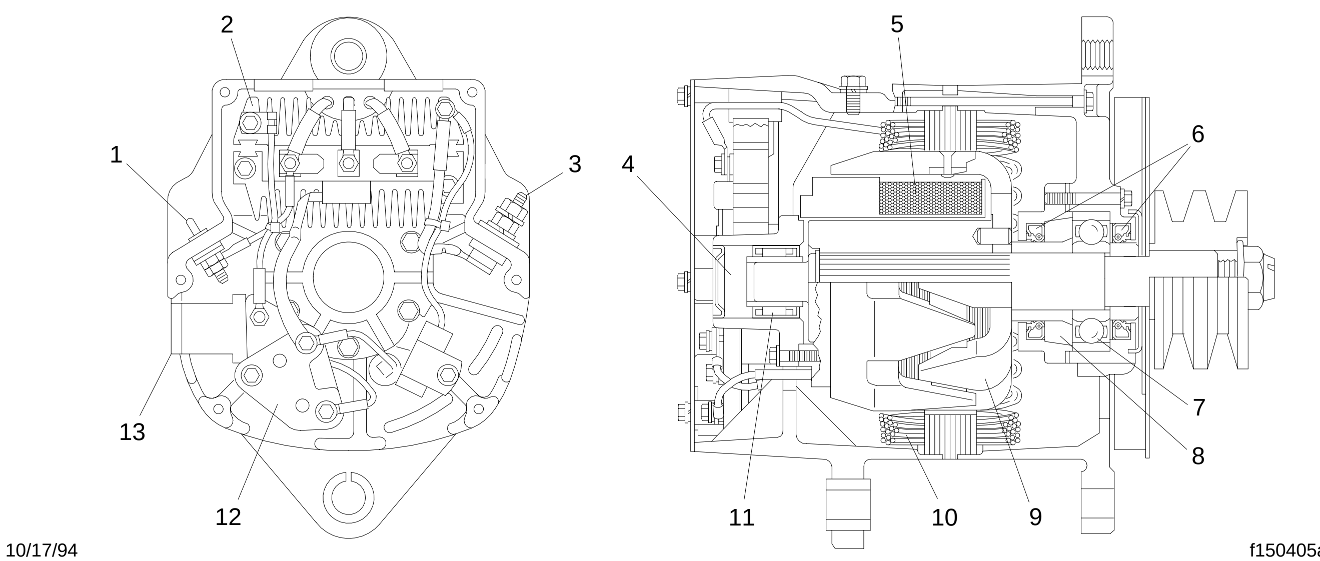
The 35- and 36-SI are physically similar brushless alternators, but the 36-SI is designed to provide 100-amp output at low engine speeds, so that the engine does not need to run fast to power auxiliary devices and keep the batteries charged.

The 35- and 36-SI alternators may be used as direct replacements for earlier models such as the 33- and 34-SI.

See **Fig. 3** for an end view of a typical 30-series alternator, in this case a 33-SI, cut away to show the regulator.

The 34-SI alternator is a specialized version of the 33-SI model, with two upper adjusting lugs for reduced susceptibility to vibration. All the field-winding stator components, which are the current-carrying conductors, are stationary. The regulator and diodes are enclosed in a sealed compartment.

The rotor is the only moving part in the assembly. It is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. See **Fig. 1** (30-SI)



1. Relay Terminal
2. Rectifier Bridge
3. Output Terminal
4. Grease Reservoir, Rectifier End
5. Stationary Field Coil (brushless construction)
6. Lip Seals
7. Ball Bearing
8. Grease Reservoir, Drive End
9. Rotor
10. Stator
11. Roller Bearing with Lip Seal
12. Integrated-Circuit Regulator
13. External Voltage Adjustment

Fig. 1, SI-Series End View and Sectional View (Typical)

General Information

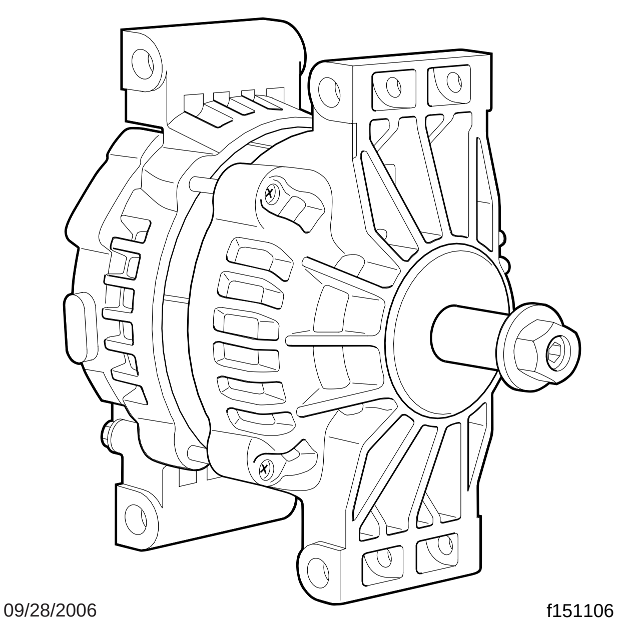
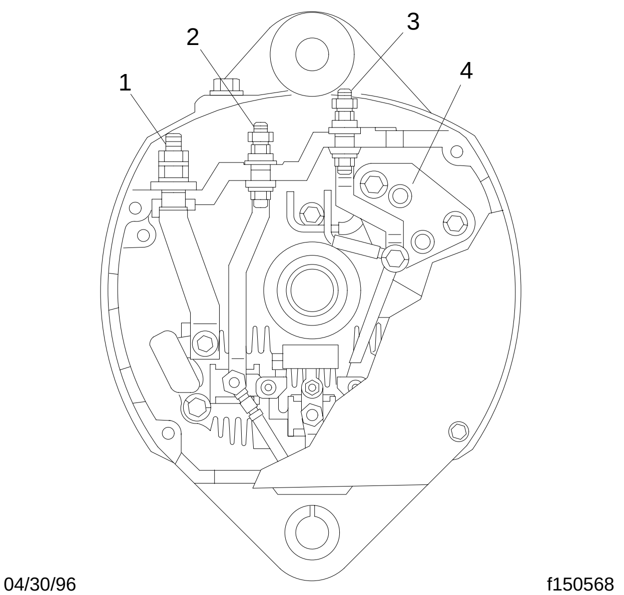


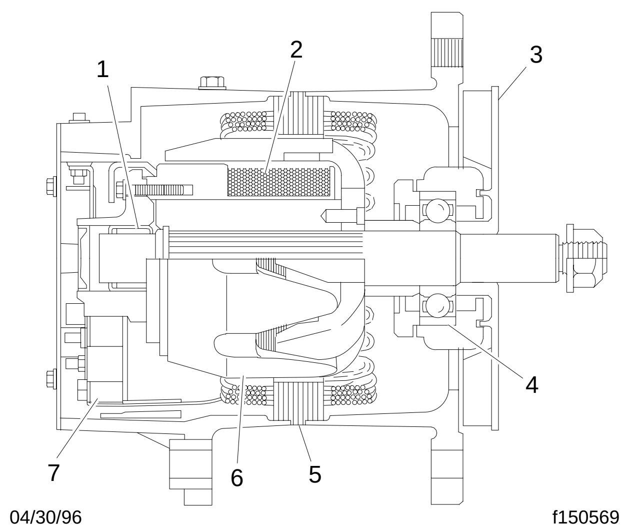
Fig. 2, 24-SI Pad Mount



1. Output Terminal
2. Relay Terminal
3. Indicator Light Terminal
4. Voltage Regulator

Fig. 3, 33-SI Terminals

and **Fig. 4** (33-SI) for representative views; other models are similar.



1. Roller Bearing
2. Stationary Field Coil (brushless construction)
3. Fan
4. Ball Bearing
5. Stator
6. Rotor
7. Rectifier Bridge

Fig. 4, 33-SI Sectional View

All 30-series bearings are sealed. No periodic maintenance is required.

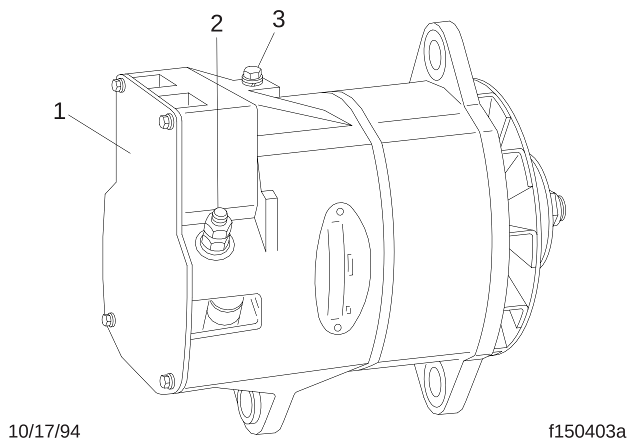
See **Fig. 5** for terminal location on the 30-SI, **Fig. 6** for terminal location on the 33– and 34-SI, and **Fig. 7** for terminals on the 35- and 36-SI.

The output terminal connects to the battery's positive terminal.

The relay terminal labeled "R" is available on some alternators, to operate auxiliary equipment.

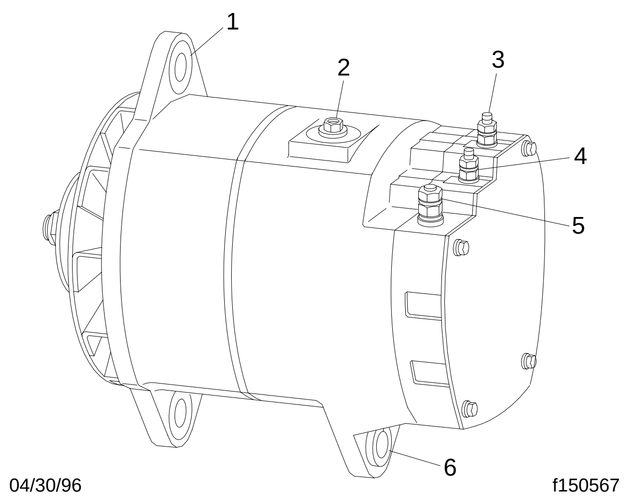
Terminal "I," when fitted, is an indicator circuit, to power an alternator warning light on the instrument panel.

The Remote Sense terminal (see **Fig. 6**) is available on some models such as the 35- and 36-SI. It connects to the batteries to monitor the state of battery charge and adjust alternator output, to keep the system at full charge.



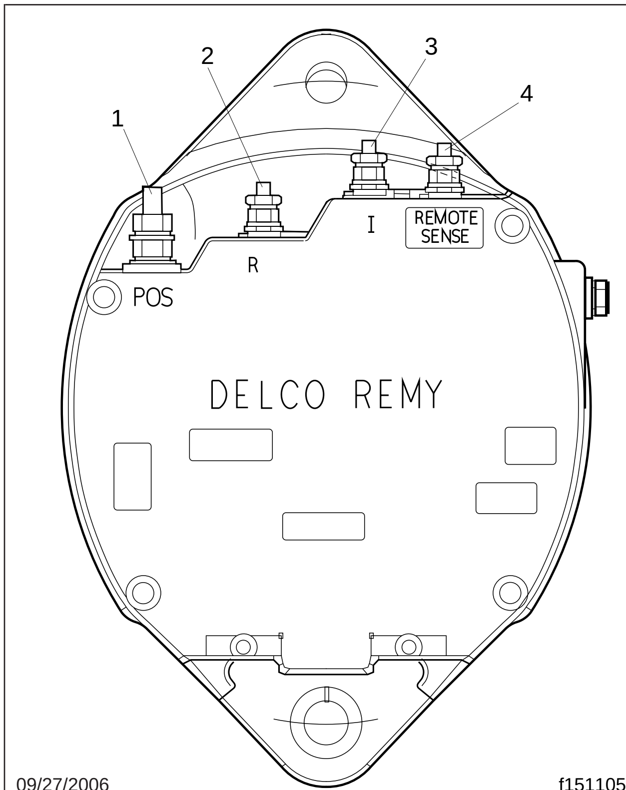
1. End Plate
2. Output Terminal
3. Ground Screw

Fig. 5, 30-SI Terminals



1. Adjusting Lug
2. Ground (G) Terminal
3. Indicator Light (I) Terminal
4. Relay (R) Terminal
5. Output (BAT) Terminal
6. Mounting Lug

Fig. 6, 33- and 34-SI Terminals



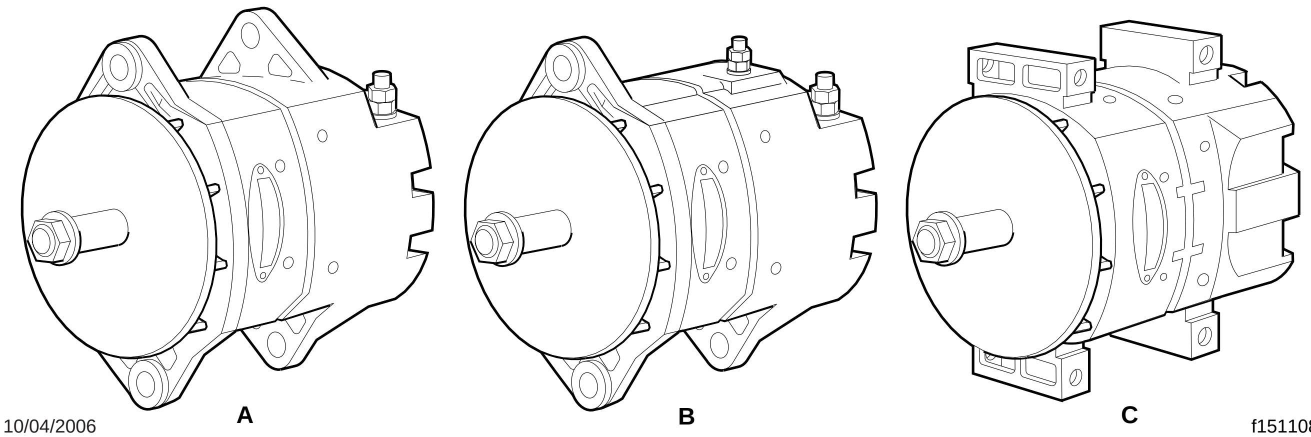
1. Output (BAT) Terminal
2. Relay (R) Terminal
3. Indicator Light (I) Terminal
4. Remote Sense Terminal (Optional)

Fig. 7, 35- and 36-SI Terminals

Mounting Configuration

There are three alternator mounting configurations available to suit particular applications; see **Fig. 8**.

General Information



A. Quad Mount
B. Hinge Mount
C. Pad Mount

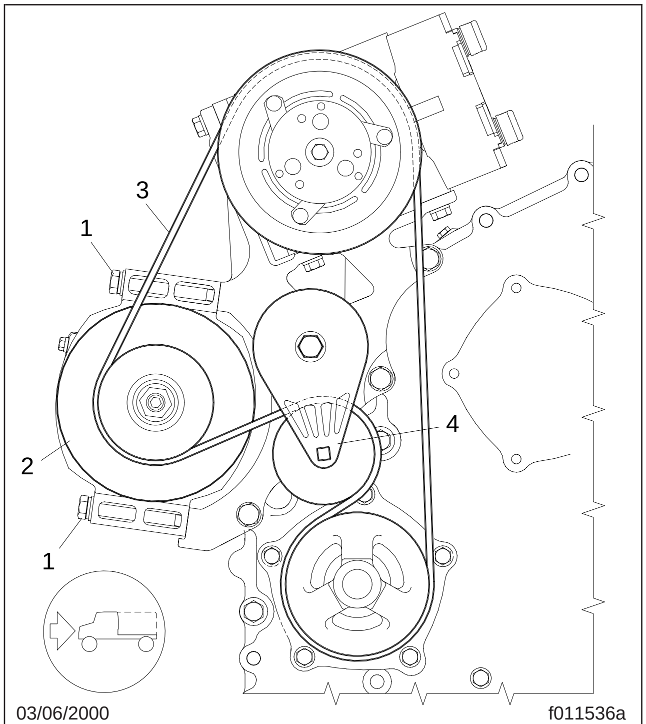
Fig. 8, Alternator Mounts (36-SI Shown)

Removal

1. Park the vehicle on a level surface, turn off all electrical loads such as lights, ignition, and accessories, set the parking brake, and chock the tires.

IMPORTANT: To be certain it is necessary to remove the alternator for service, perform the checks in **Troubleshooting 300**. Many tests and repairs can be performed with the alternator in the vehicle.

2. Turn the battery switch to the OFF position, or disconnect the batteries.
3. Tilt the hood.
4. Disconnect the electrical leads attached to the alternator. Mark the terminals and wires for correct installation.
5. Insert a 1/2-inch drive wrench in the square hole of the belt tensioner, and relieve the tension on the belt so that it can be removed from the alternator pulley. See **Fig. 1**.
6. Support the alternator, and remove the four mounting bolts and lockwashers that attach the alternator to the engine. Remove the alternator.



1. Mounting Bolt
2. Alternator
3. Belt
4. Tensioner

Fig. 1, Typical Alternator Installation

Installation

1. Place the alternator in position on its mount, and support it while you start the mounting bolts.
2. Install the four alternator mounting bolts and lockwashers. Torque the bolts 31 to 39 lbf·ft (42 to 53 N·m).
3. Insert a 1/2-inch drive wrench in the square hole of the belt tensioner, and relieve the tension on the belt tensioner, then install the belt on the alternator pulley. See **Fig. 1**.
4. Connect the wires to the alternator, as previously marked.
    - Torque the nut for the battery cable 80 to 120 lbf·in (900 to 1350 N·cm).
    - Torque the nut for the ground cable 50 to 60 lbf·in (560 to 680 N·cm).
5. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Approved Dielectric Red Enamel	
Protectant Material	**Approved Brands**
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at **www.glyptal.com** or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

6. Rotate the battery switch to the ON position, or connect the batteries.
7. Before returning the vehicle to operation, test the alternator DC output voltage or if the alternator is under 145 amp output, use the Delco Intelli-Check Alternator Analyzer. For instructions, see *Alternator Voltage Output Test* in **Troubleshooting 300**.
8. Close the hood.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

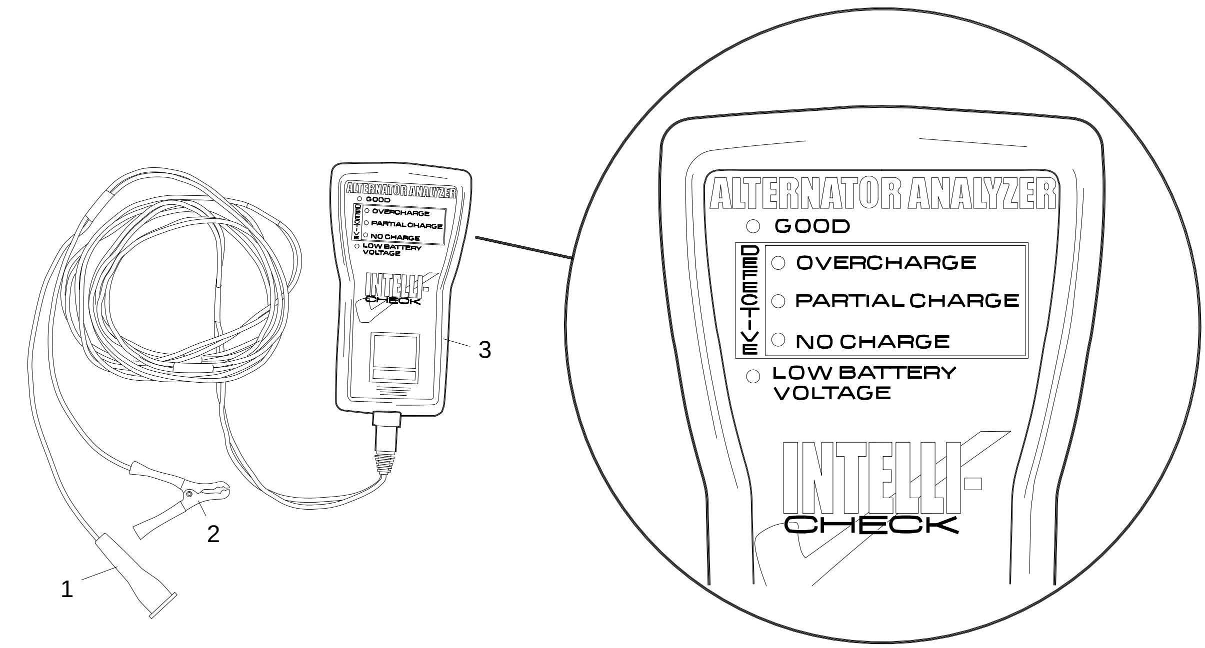
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."

Troubleshooting



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1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

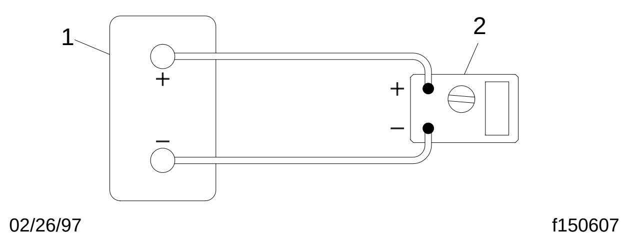
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

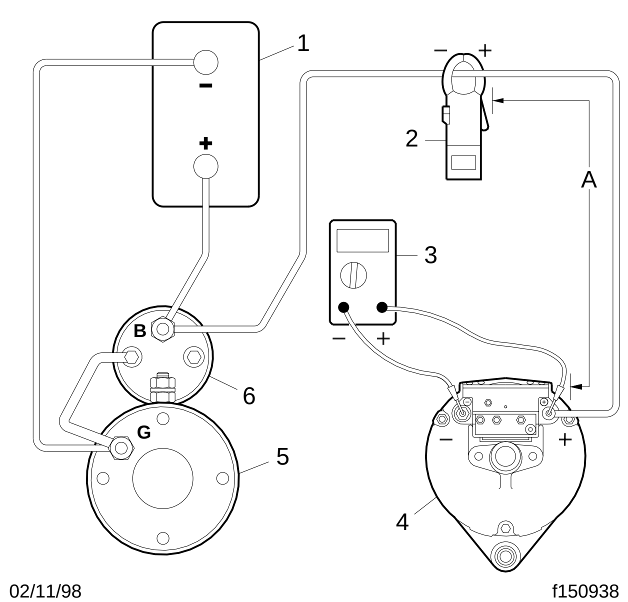
IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.



1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

Troubleshooting

4. Perform an alternator amperage output test.

   4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

   NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

   4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

   NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

   4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

   NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

   4.4 Turn off the tester and shut down the engine.

   4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

   4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

   NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

   5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

   5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

   6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

   6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

   6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

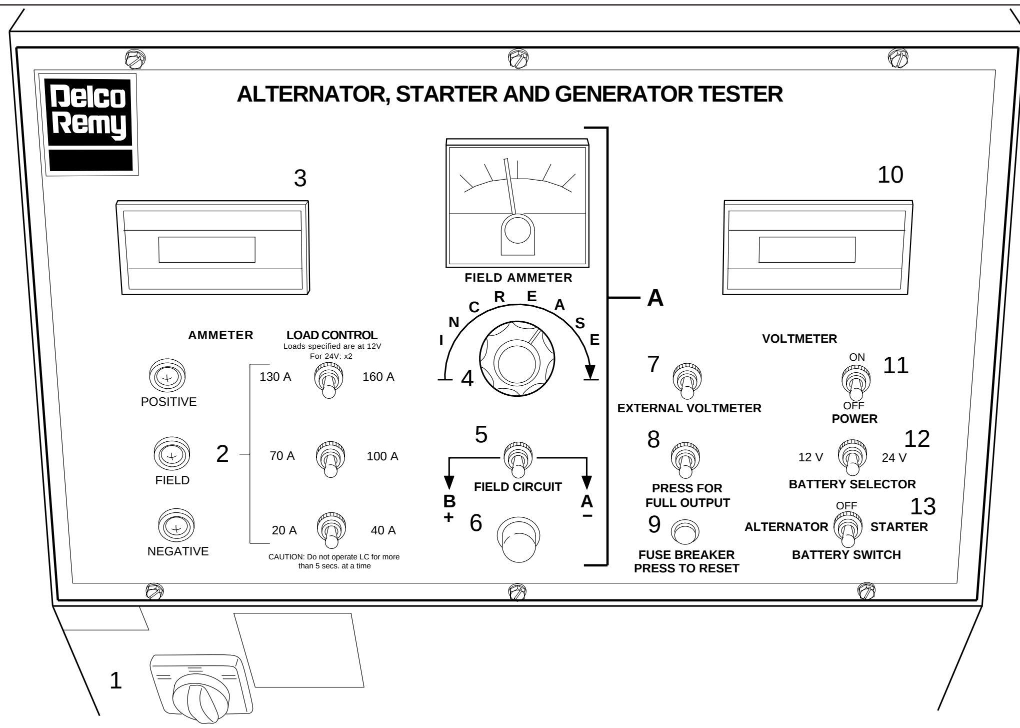
Alternator Bench Testing

Required Equipment

See **Fig. 1** for a standard Delco Remy Tester.

NOTE: This equipment and the following tests may also be used to test Leece Neville alternators.

- Delco Remy alternators require a 2-1/2 inch V-belt pulley, p/n DR 10503932 (supplied with the Delco Remy tester).
- Leece-Neville alternators require a 3-1/2 inch V-belt pulley, p/n LN 107 22, and a 5/8-inch washer, p/n LN 120 129.



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A. These controls are not used when testing alternators with internal voltage regulators.

1. Motor Switch: Forward–Off–Reverse
2. Load Control Switches
3. Ammeter
4. Variable Field Control
5. Field Selector Switch
6. DTL Lamp
7. External Voltmeter Switch
8. Full Field Switch
9. Circuit Breaker (Press to Reset)
10. Voltmeter
11. Power Switch
12. 12–24-Volt Selector
13. Alternator/Battery Test Switch

Fig. 1, Alternator Tester Control Panel (typical)

The tests in this subject require the following equipment:

- Alternator tester with the battery charged to at least 12.4 V (Delco Remy shown).
- Alternator to be tested.
- V-belt.
- Jumper lead to connect the BAT (+) alternator terminal to the remote sense terminal.
- Standard 5/8–18 hexnut, for mounting the pulley on the alternator. Use a standard hexnut, not the self-locking nut that is supplied with the alternator.

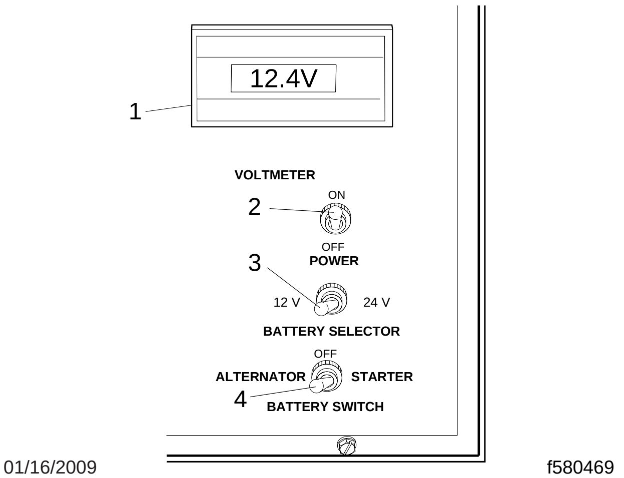
NOTICE

Repeatedly using self-locking nuts may damage the threads on the pulley shaft.

Alternator Bench Testing

Test Preparation

1. Set the battery voltage selector switch to 12V. See **Fig. 2**.



1. Voltmeter
2. Power Switch
3. Battery Voltage Selector
4. Battery Switch

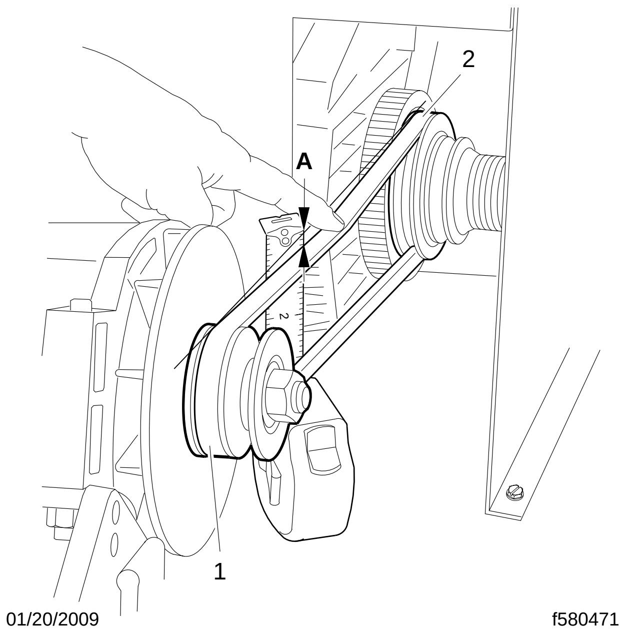
Fig. 2, Alternator Tester Power Switches

2. Set the battery switch to "Alternator." See **Fig. 2**.

NOTICE

The next step supplies battery voltage to the alternator tester power and ground cables. Ensure that they are separated and insulated from each other, and that they are not touching conductive materials. Failure to observe this precaution could cause component damage.

3. Turn the tester power switch ON. See **Fig. 2**. Check the battery voltage in the voltmeter on the tester. The tester battery voltage must be at least 12.4V; if it is below 12.4V, charge or replace the tester battery as necessary. Turn the power switch OFF.
4. Mount the appropriate manufacturer’s pulley on the alternator.
5. Mount the alternator on the tester.
   5.1 Run the belt from the largest V-groove of the bench motor drive pulley to the V-groove closest to the alternator on the alternator pulley. See **Fig. 3**. Do not use the serpentine belt groove.



A. 1/4-inch (6-mm) deflection at center of run

1. V-Groove Closest to the Alternator
2. V-Groove Closest to the Motor Pulley

Fig. 3, Belt Deflection with Alternator Mounted on Tester

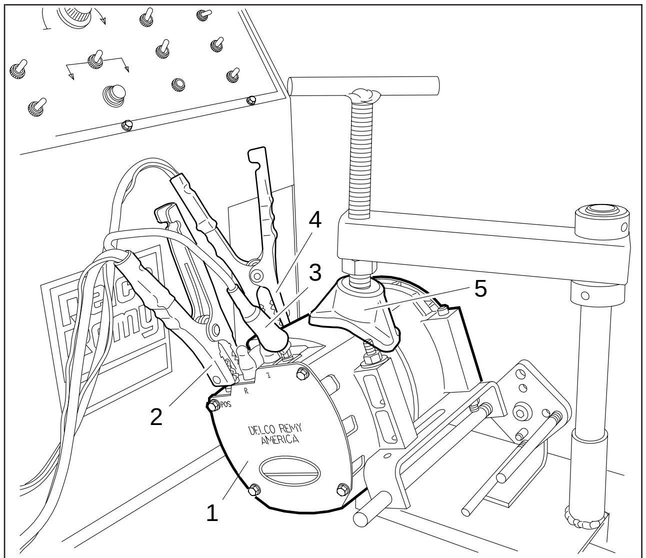
   5.2 Move the vise to align the pulleys, so that the belt runs straight between the V-groove on the motor pulley and the V-groove closest to the alternator.

   5.3 Tension the V-belt with the hand wheel, so that it deflects 1/4-inch (6 mm) under hand pressure at the center of the run, then clamp the alternator in position.

6. Connect the electrical leads from the tester to the alternator. See **Fig. 4**. Take care that the tester power and ground cables are separated and insulated from each other, and that they are not touching conductive materials.
   6.1 Connect the red positive lead from the tester to the output terminal (BAT or +) on the alternator.

6.2 Connect the black negative lead from the tester to the output ground terminal (-) or to a mounting ear of the alternator.

7. Attach a jumper lead from the output terminal (BAT or +) to the remote sense terminal. Some testers have this jumper built-in on the positive lead, as shown in **Fig. 4**, Item 3; others may require a separate jumper as shown in **Fig. 5**.



1. Alternator
2. Positive Lead
3. Remote Sense Jumper
4. Negative Lead
5. Clamp

Fig. 4, Alternator Clamped on Tester with Leads Connected

Voltage Test

NOTICE

Ensure that the alternator tester power and ground cables are separated and insulated from each other, and that they are not touching conductive materials. Failure to do so could cause damage to the tester.

1. Turn the tester power switch ON. See **Fig. 2**, Item 2.

WARNING

The following steps involve spinning the alternator with the open V-belt; be careful that all loose objects, garments, hair, and hands are well clear of the alternator and belt, and use safety shields properly, or serious personal injury may occur.

2. Turn the motor switch (located on the lower left-hand portion of the tester) to the FORWARD position, to start the alternator free-spinning. See **Fig. 1**, Item 1.

NOTE: The voltage output limit applies only to a non-loaded alternator. The purpose of this test is to ensure that the alternator produces the proper voltage with no load (free-spin).

3. Record the alternator voltage output during free-spin. See **Fig. 2**, Item 1.
   - If the alternator output is between 13.5V and 14.7V, the alternator is functioning properly; proceed to the *Load Test*.
   - If the alternator output is not between 13.5V and 14.7V, the alternator is faulty and must be replaced.

Load Test

1. Calculate the test load for the alternator being tested. The test load is 80 percent of the alternator-output rating.

   Multiply the alternator-output rating by **0.8**, to calculate the test load.

   For example, an alternator with 100-amp output rating has an 80-amp test load (100 x 0.8 = 80).

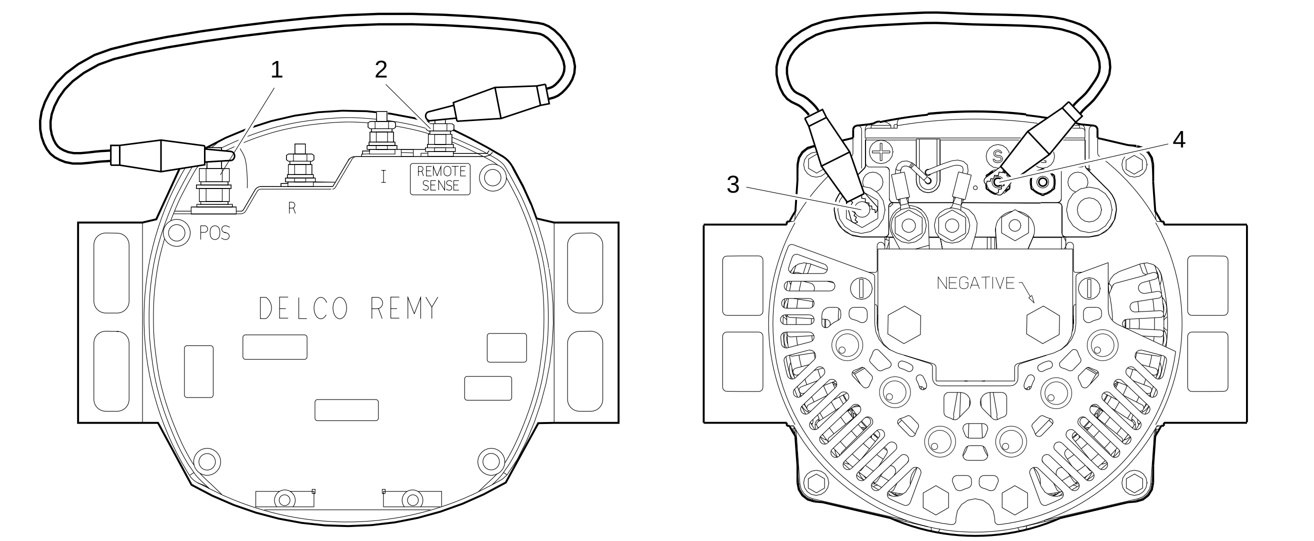
NOTE: Contact a Delco Remy or Leece-Neville representative if you are unsure of the calculation.

2. Determine the appropriate load-control-switch setting to use for the alternator being tested. See **Fig. 1**, Item 2.

   Use the load-control-switch setting **equal to, or the next level below** the test load calculation.

   For example, on this tester the available settings are 20/40, 70/100, and 130/160 amp. The load-control-switch setting for the 100-amp alternator

Alternator Bench Testing



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1. Delco Remy Positive Terminal
2. Delco Remy Remote Sense Terminal
3. Leece-Neville Positive Terminal
4. Leece-Neville Remote Sense Terminal

Fig. 5, Installed Jumper Leads (Typical)

would be 70 amp, because it is the available setting just below 80 amp.

NOTICE

Do not operate the alternator under load for more than 5 continuous seconds or damage to the alternator may occur.

3. Apply the appropriate load switch for 5 seconds then release.
4. Record the **difference** in voltage output between when the alternator is free-spinning, and under load.
   - For all alternators except Delco Remy 22SI, if the voltage difference between free-spin and loaded is more than 0.5V, the alternator is faulty and must be replaced. If the voltage difference between free-spin and loaded is less than 0.5V, the alternator is functioning properly.
   - For Delco Remy 22SI, if the voltage difference between free-spin and loaded is more than 1.0V, the alternator is faulty and must be replaced. If the voltage difference between free-spin and loaded is less than 1.0V, the alternator is functioning properly.
5. Turn the tester power switch OFF, then disconnect the electrical leads and jumper from the alternator.

General Information

Freightliner Columbia uses radiators that are 1000-square-inch and 1200-square-inch front areas. Both sizes are high-flow, single-pass radiators with plastic end-tanks. Both are two-row radiators with 14 fins per inch and are cross-flow.

In high-flow cooling systems, most coolant in a warm engine is routed through the radiator. The coolant moves relatively quickly through the radiator in a single pass.

In a typical engine and radiator system, coolant flows from the radiator outlet to the water pump, from the water pump through the oil cooler, then the engine cylinder block water jacket, then the head. For typical engine coolant plumbing, see **Fig. 1**.

If the engine is cold, the engine thermostat stays closed, and water leaving the head flows back down to the water pump and the oil cooler.

If the engine is warm, the thermostat opens and coolant is forced to flow into the upper end of the driver-side radiator end tank. The coolant flows across the core, where is is cooled by ram air entering through the vehicle grille. When the coolant reaches the bottom end of the radiator passenger-side end tank, the coolant flows back out to the water pump. For the temperature that opens the thermostat on each model of engine, see **Table 1**.

The surge tank holds extra coolant, which travels down through the fill hose to the engine as needed. The low coolant level sensor in the surge tank warns the driver when coolant is running low. The surge tank is translucent polypropylene so you can see the coolant level and compare it to the maximum and minimum levels marked on the tank. See **Fig. 2**.

To prevent gas from getting trapped in the radiator or engine, vent lines run from the highest point in the radiator and engine to the surge tank. To prevent the coolant from boiling, the coolant is pressurized 11 to 12 psi.

To add coolant, remove the large cap on the out-board end of the tank. The standard, metal SAE cap on top of the tank is used for pressure relief and vacuum-break functions only. If too much pressure builds up in the coolant system, excess coolant will vent through the SAE cap and escape through an overflow hose.

When the cab heater is activated, hoses carry some of the coolant into the cab where it flows through the heater core to warm the cab air. This coolant returns to the engine/radiator cooling system.

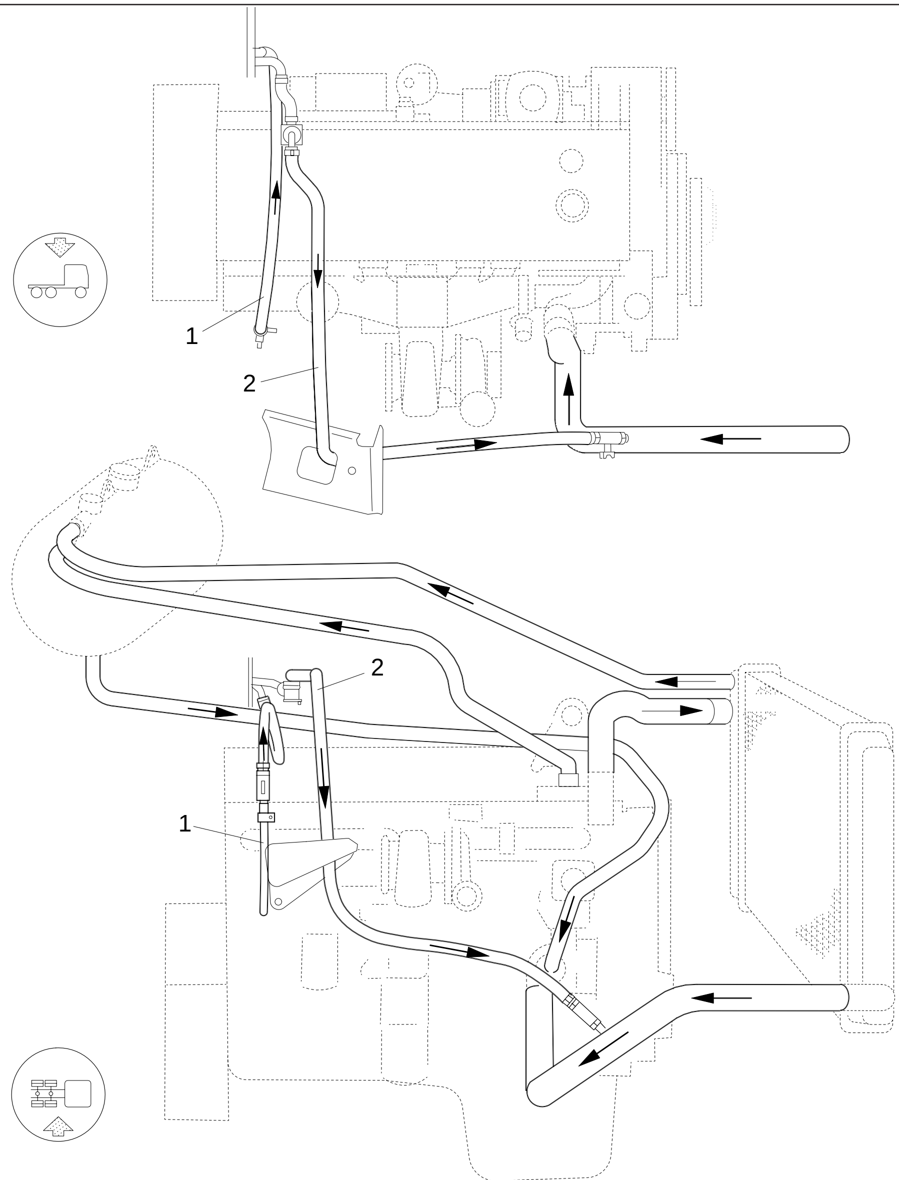
For more information about the radiator and surge tank, see **Section 20.01**.

Cooling System Control Temperatures					
Cooling Component	Detroit Diesel Series 60	Caterpillar Engines		Cummins Engines	
		C10/C12	C15/C16	N14/ISM	ISX/Signature
	Temperature °F (°C)				
Thermostat Starts to Open	190 (88)	190 (88)	190 (88)	180 (82)	180 (82)
Thermostat Fully Open	205 (96)	208 (98)	208 (98)	200 (93)	200 (93)
Engine Fan Activates	208 (98)	205 (96)	216 (101)	205 (96)	210 (99)
Engine Fan Stops	198 (92°)	198 (92)	208 (98)	195 (91)	205 (96)
High Coolant Temperature Warning Activates	221 (105)	218 (103)	226 (108)	220 (104)	225 (107)
High Coolant Temperature Engine Shutdown Activates	225 (107)	224 (106)	234 (88)	223 (106)	228 (109)
Intake Air Temperature Activates the Engine Fan	150 (66)	188 (87) *	108 (87) *	160 (71)	160 (71)

* The fan is activated at 162°F (72°C) if the turbo boost pressure is greater than 10 psi (69 kPa).

Table 1, Cooling System Control Temperatures

General Information



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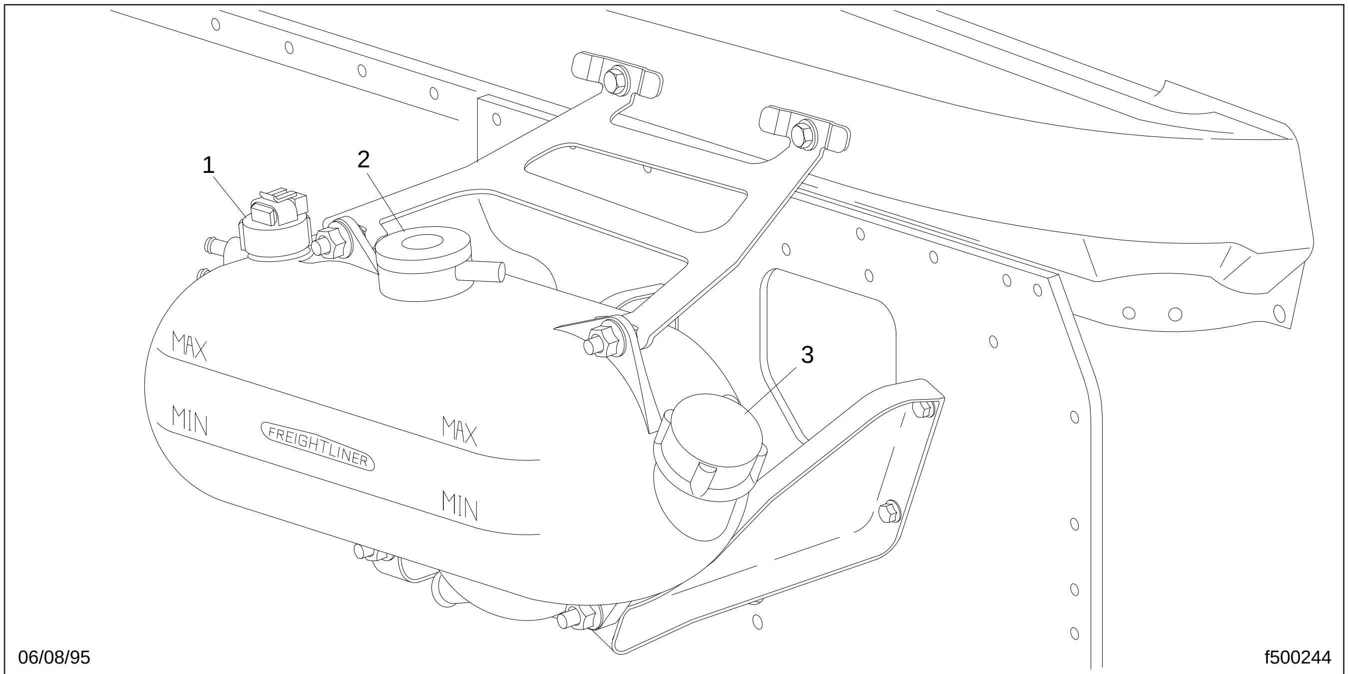
NOTE: Optional heater hose shut-off valves shown here.

1. Heater Supply Hose
2. Heater Return Hose

Fig. 1, Coolant Plumbing (typical)



1. Low Coolant Level Sensor
2. SAE Cap (for coolant overflow pressure relief only)
3. Fill Cap

Fig. 2, Surge Tank

Troubleshooting Tables

Possible causes of hot or cold engine coolant temperatures are listed below. For repairs, refer to other sections of this manual or to the engine and component manufacturers' service publications.

Problem—Coolant Temperature Above Normal

Problem—Coolant Temperature Above Normal	
Possible Cause	**Remedy**
Coolant leakage (see possible sources below) is causing a low coolant level. External Leakage: hoses and hose connections, radiator seams, core, draincock and cap, block core and drain plugs, water pump thermostat housing(s), overflow and surge tank, heater hoses and core, temperature sending unit(s), cylinder head(s) mating (gasket) surfaces, coolant filter, oil cooler(s) Internal Leakage: cylinder head gasket, warped head or block surfaces, cracked cylinder head or block, cylinder head capscrews loose, missing, or tightened unevenly; oil cooler, air compressor cylinder head and gasket cylinder liners, liner seals aftercooler	Perform the repairs necessary to stop leakage. Fill to the bottom of the radiator fill neck with the correct mixture of antifreeze and water.
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation
The radiator fins, the aftercooler, or the air conditioner condenser fins are clogged.	Clean the outside of the core, the aftercooler, and the condenser with compressed air directed from the fan side, or with water and a mild laundry soap. Straighten bent fins.
A radiator hose is collapsed or plugged.	Replace hoses.
A fan drive belt or the water pump belt is loose.	Adjust belt tension.
The cooling fan shroud is damaged.	Repair or replace the shroud.
The radiator cap is incorrect or malfunctioning.	Make sure the correct radiator cap is installed. If the cap does not hold the correct pressure, replace it.
The on-off fan clutch is not working.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
The engine oil level is incorrect.	Fill to the high (H) mark on the dipstick.
There is too much antifreeze or coolant additive in the system.	Clean and flush the cooling system. Refill the system with the correct mixture of antifreeze and water, and install the correct additive and filter, or treatment filter.

Troubleshooting

Problem—Coolant Temperature Above Normal	
Possible Cause	**Remedy**
One or both of the thermostats is incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.
The water pump is not working correctly.	Repair or replace the water pump.
The radiator core is internally plugged or damaged.	To check for blockages, warm the engine to normal operating temperature. Turn off the engine, and run your hand over the finned surface of the radiator. If there is a blockage in the radiator, it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperature is normal. If blockage is suspected, clean and flush the cooling system. Repair or replace a damaged core.
Air or combustion gases are entering the cooling system.	Check the cylinder head(s), head gasket(s), cylinder liners, aftercooler, air compressor cylinder head, and fan/shutter air control valve (if applicable) for leaks. Repair or replace parts, as necessary.
The aftercooler is plugged or damaged.	Repair or replace the aftercooler.
The oil cooler is plugged or damaged.	Repair or replace the oil cooler.
The engine is receiving too much fuel.	Refer to the engine manufacturer's fuel delivery system adjustment procedures
The wrong fan (replacement unit) is installed.	Install the correct fan.
The wrong radiator (replacement unit) is installed.	Install the correct radiator.
There is exhaust blockage.	Repair the exhaust system.
There is frozen coolant in the radiator.	Use the proper antifreeze-to-water ratio needed for winter temperatures.

Problem—Coolant Temperature Below Normal

Problem—Coolant Temperature Below Normal	
Possible Cause	**Remedy**
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation.
The on-off fan clutch operates continuously.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
One or both thermostats are incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.

General Information

The main function of a cooling system is to keep the engine at its optimum operating temperature. This results in the most efficient use of fuel and allows the engine oil to provide a good lubricating film.

The central component of the cooling system, the radiator assembly, includes the surge tank (remote mounted on the firewall), the radiator, and the surge tank pressure relief cap. See **Fig. 1**.

The surge tank provides storage space for reserve coolant, expansion space for heated coolant, and deaeration space. See **Fig. 2.** When coolant in the radiator runs low, reserve coolant stored in the surge tank flows from the tank, through the fill hose, to the water pump. As the coolant heats and expands beyond radiator capacity, excess coolant travels back through the fill hose from the water pump to the surge tank. Any air trapped in the engine block or radiator rises to the top of the engine or radiator and escapes through the vent hoses to the surge tank.

The low coolant level sensor in the surge tank warns the driver when coolant is running low. The surge tank is translucent polypropylene so you can see the coolant level and compare it to the maximum and minimum levels marked on the tank.

Columbia vehicles use full-flow (or high-flow) radiators. With full-flow radiators, the coolant flows into the radiator at the top of the left side tank and flows out of the radiator at the bottom of the right side tank. Most of the engine coolant is routed through the radiator, and it moves relatively quickly in a single pass.

There are two sizes of two-row radiators in use: one radiator has 1000 square inches of front area and the other has 1200 square inches. See **Fig. 3** and **Fig. 4**.

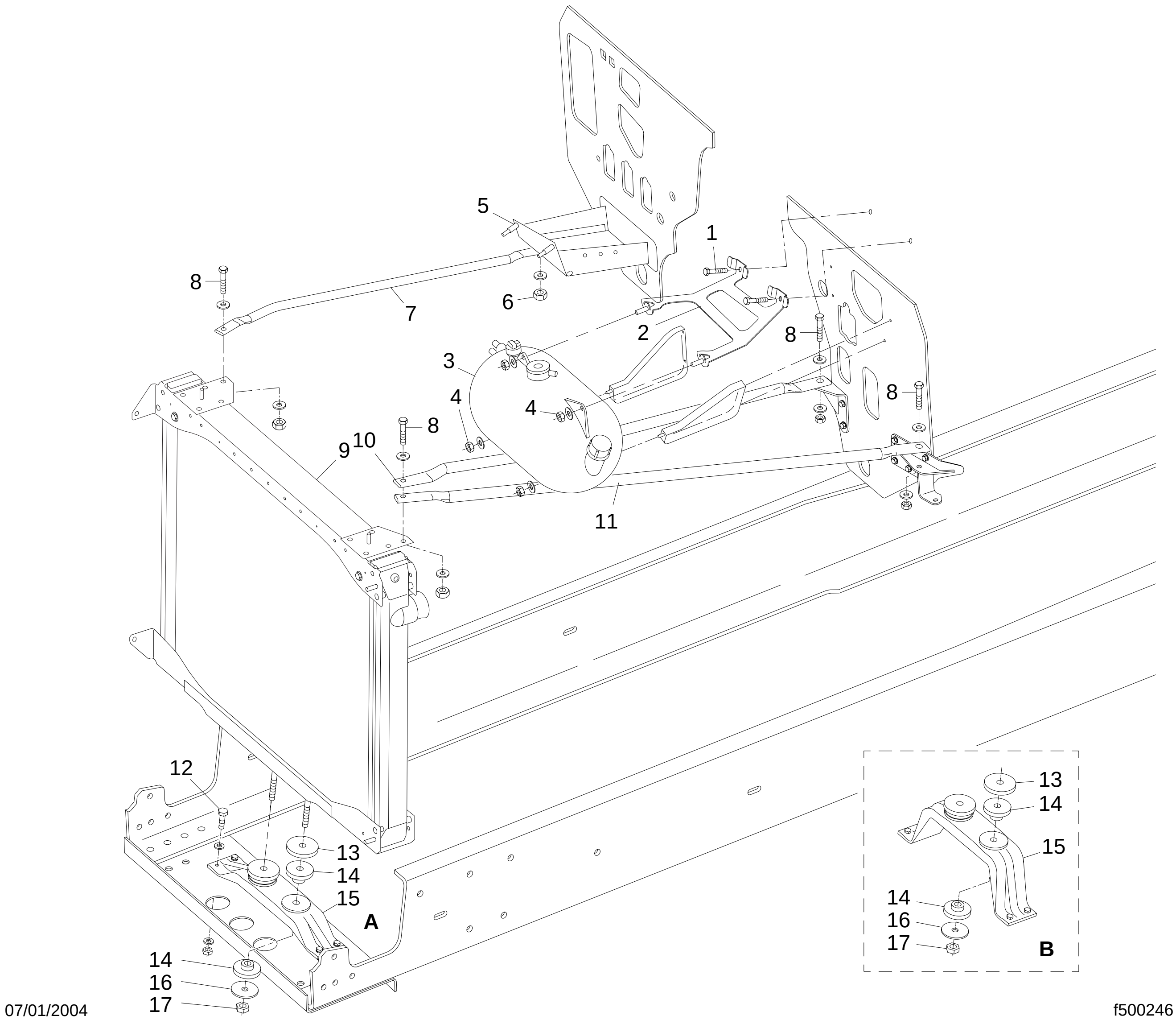
The radiators use glass-filled nylon side tanks. The edges of the radiator core header are compressed in a "dimple wave lock" crimp (see **Fig. 5**) that holds the tanks on the radiator core, and the tanks and core are held in steel channels that mount on the front closing crossmember. The radiator is also secured by brace rods that run between the top of the radiator and the firewall. The fins of the radiator core are reinforced along their forward edge to resist damage from road debris and pressure washing.

Because crimping holds the nylon side tanks tanks in place, the radiators can be disassembled and assembled.

The surge tank cap limits system pressure to about 11 to 12 psi, which raises the boiling point of the coolant. If the cooling system overheats, excess coolant is released through the overflow tube.

For more general information about the radiator and surge tank, and for cooling system troubleshooting procedures, refer to **Section 20.00** in this workshop manual.

General Information

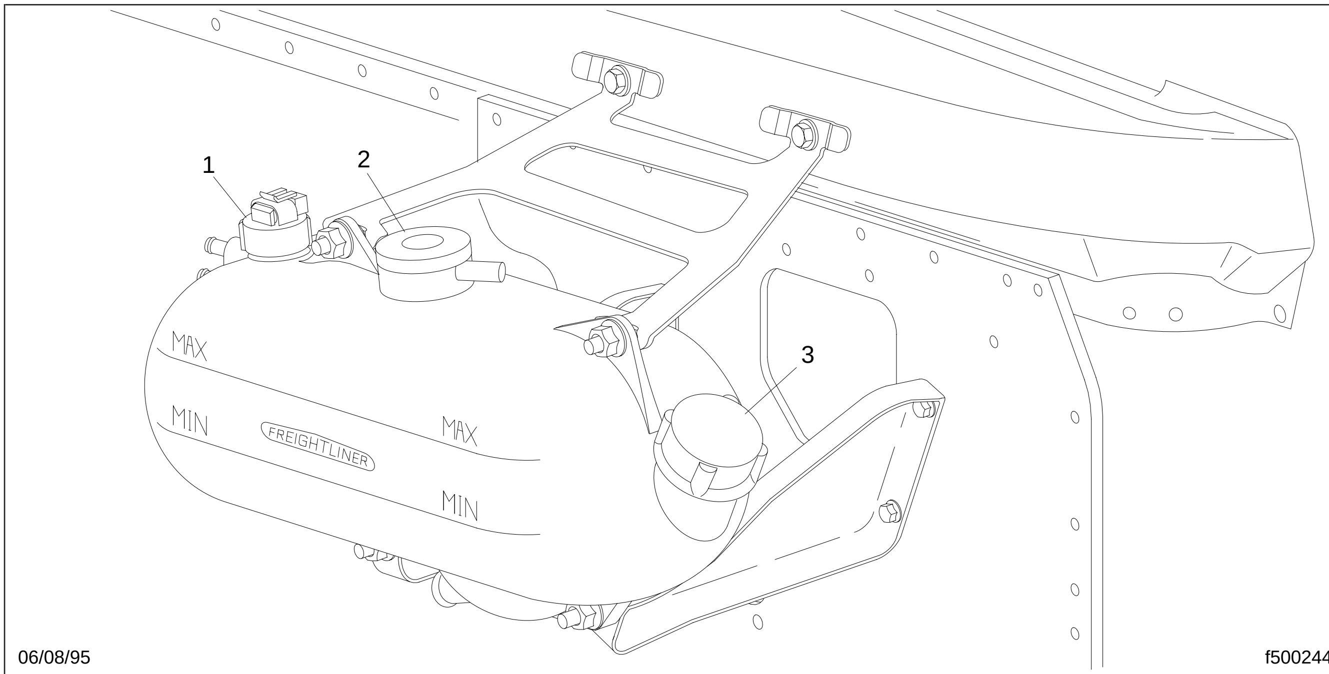


A. Support Bracket for a 1200-Square-Inch Radiator

B. Support Bracket for a 1000-Square-Inch Radiator

1. Machine Screw, 5/16-18 Stainless Steel
2. Upper Surge Tank Bracket
3. Surge Tank
4. Locknut, 3/8–16; Washer
5. Air Cleaner Mounting Bracket
6. Nut, 1/2–13, Grade 8; Washer
7. Right-Hand Radiator Strut Rod
8. Capscrew, 1/2–13x 2 Inches, Grade 8; Washer; Nut
9. Radiator
10. Left-hand Radiator Strut Rod, Inboard
11. Left-Hand Radiator Strut Rod, Outboard
12. Capscrew, 3/8–16, Grade 8; Washer; Nut
13. Spacer (used only with 11-inch frame rails)
14. Isolator
15. Radiator Support Bracket
16. Washer
17. Nut, 5/8–11, Grade 8

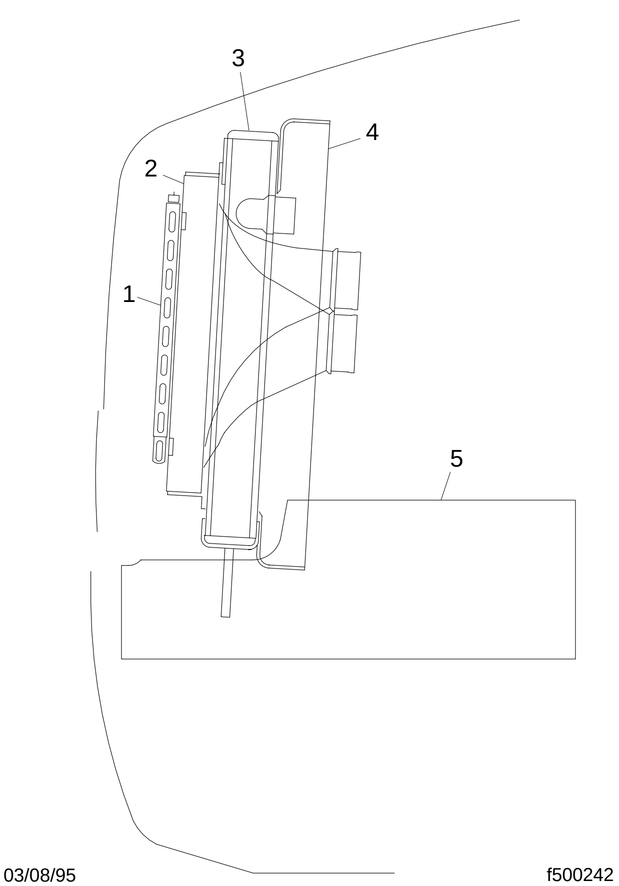
Fig. 1, Standard Radiator Installation



1. Low Coolant Level Sensor
2. SAE Cap (for coolant overflow pressure relief only)
3. Fill Cap

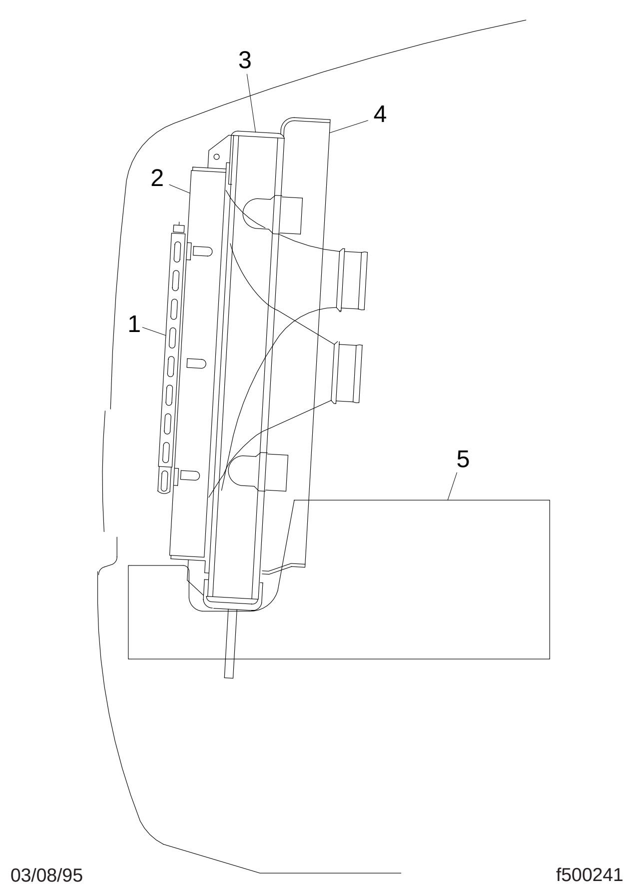
Fig. 2, Surge Tank

General Information



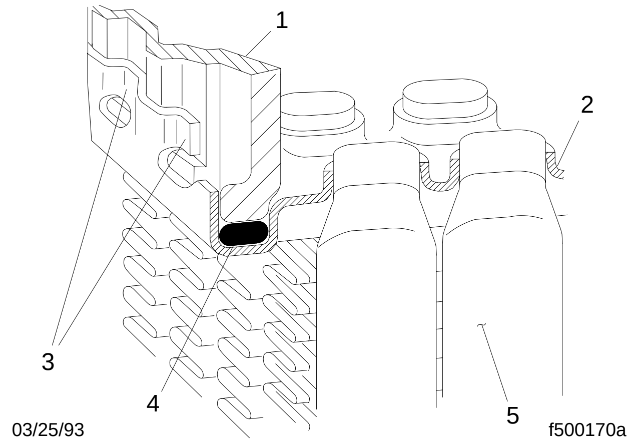
1. Condensor
2. Charge Air Cooler
3. Radiator
4. Fan Shroud
5. Frame Rail

Fig. 3, 1000-Square-Inch Radiator



1. Condensor
2. Charge Air Cooler
3. Radiator
4. Fan Shroud
5. Frame Rail

Fig. 4, 1200-Square-Inch Radiator



1. Nylon Tank
2. Radiator Header
3. Dimple Wave Lock Crimp
4. Sealing Gasket
5. Radiator Core

Fig. 5, Radiator Core and Header (cutaway view)

Coolant Draining and Filling

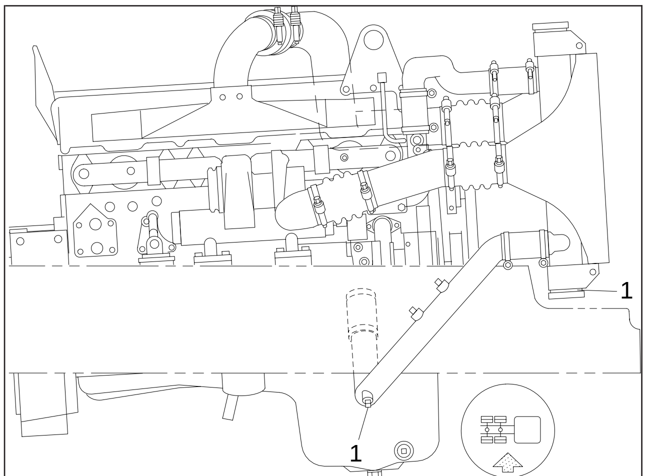
Draining

1. Park the vehicle, apply the parking brakes, and tilt the hood.

WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Place a suitable container under the elbow of the radiator outlet pipe. The container should hold at least 60 quarts (56.8 liters).
3. Remove the surge tank cap.
4. Remove the plugs from the lowest points of the coolant system. This will be a plug in the radiator side tank and a plug in the elbow of the radiator outlet pipe. See **Fig. 1**.



NOTE: Cummins ISM engine shown.
1. Coolant Drain Plug

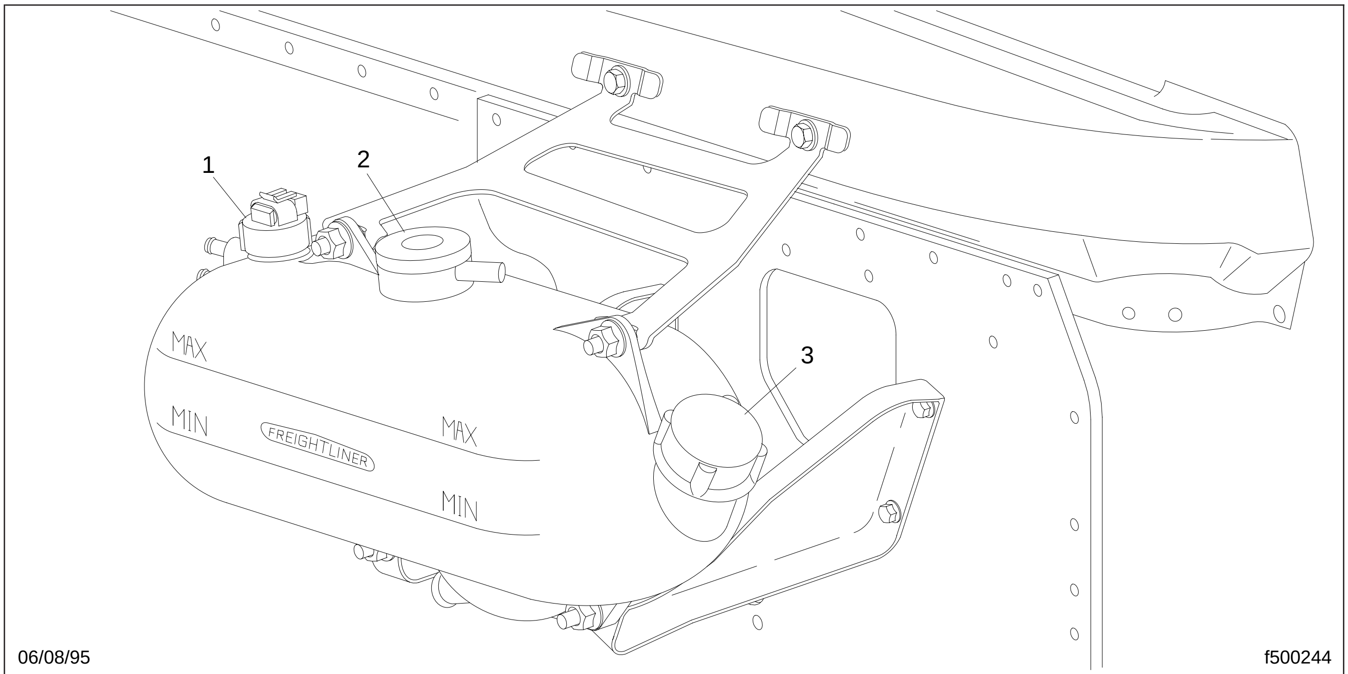
Fig. 1, Coolant Drain Plug Location

5. Allow all the coolant to drain.
6. Install the plugs in the radiator elbow and the radiator side tank.

Filling

1. Make sure the plugs are installed securely in the bottom of the radiator and the elbow of the radiator outlet pipe.
2. At the surge tank, fill the system with coolant until the level of coolant shows between the minimum and maximum coolant level lines on the surge tank. See **Fig. 2**. For approved coolant, and the coolant capacity for your engine, refer to the vehicle maintenance manual.
3. Run the engine for 10 minutes, and add coolant as needed.

Coolant Draining and Filling



1. Low Coolant Level Sensor
2. SAE Cap (for coolant overflow pressure relief only)
3. Fill Cap

Fig. 2, Surge Tank

Fan Removal and Installation

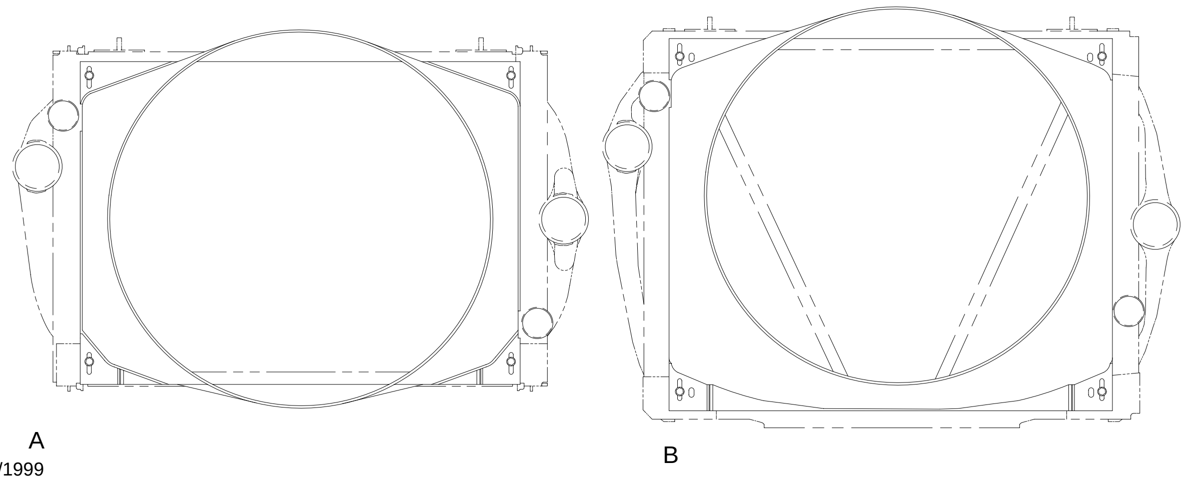
Removal

1. Partially remove the radiator. Do all the steps in **Subject 130** but *do not lift the radiator out of the vehicle*. Disconnect the radiator and charge air cooler, and have someone lean the components forward and hold them out of the way
2. Remove the fasteners that hold the fan to the fan clutch.
3. Remove the fan from the vehicle.

Installation

1. If not already done, disconnect the radiator according to the steps in **Subject 130** and have someone lean the components forward and hold them out of the way
2. Position the fan on the fan clutch, and tighten the fasteners 15 lbf·ft (20 N·m).
3. Install the radiator. For instructions, refer to **Subject 130** in this workshop manual section.
4. Remove the chocks from the tires.

Removal (See Fig. 1)



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A. Fan Shroud for a 1000-Square-Inch Radiator
B. Fan Shroud for a 1200-Square-Inch Radiator

Fig. 1, Fan Shrouds

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the four screws and washers that hold the fan shroud to the radiator.
3. Remove the radiator. For instructions, refer to **Subject 130** in this workshop manual section.

   Remove the fan shroud from the vehicle.

Installation (See Fig. 1)

1. Place the fan shroud on the engine, and move it back as far as possible around the fan.
2. Install the radiator. For instructions, refer to **Subject 130** in this workshop manual section.
3. Install the fan shroud on the radiator.
   - 3.1 Adjust the vertical clearance between the top of the fan blade and the fan shroud opening. It should be equal within 1/8 inch (3 mm) to the clearance between the bottom of the blade and the shroud opening.
   - 3.2 Tighten the screws 108 lbf·in (1220 N·cm).
4. Remove the chocks from the tires.

Removal

1. Park the vehicle and apply the parking brakes. Chock the tires.
2. Remove the grille. For instructions, refer to **Group 88**.
3. Tilt the hood, and support it in the tilted position with a padded table or bench. See **Fig. 1**.
4. Drain the coolant. For instructions, refer to **Subject 100**.
5. Disconnect the hood straps. For instructions, refer to **Group 88**.
6. If so equipped, remove the air recirculation shields along the bottom and passenger side of the radiator.
7. Disconnect the A/C condenser mounts and move the A/C condenser aside without breaking the refrigerant lines. For instructions, refer to **Group 83**.
8. Disconnect the hoses from the radiator.

   The coolant hoses connect using T-bolt clamps (see **Fig. 2**), Breeze Constant-Torque clamps, (see **Fig. 3**), or ABA Radial worm drive clamps (see **Fig. 4**). Each type and size hose clamp has specific torque requirements. See **Table 1** for hose clamp torque values.
9. Disconnect the hoses from the charge air cooler.
10. Remove the fan shroud, and move it back against the engine.
11. Attach chains and a lifting device to the hood strap attachment bolts on the top of the radiator.
12. Disconnect the struts from the radiator.
13. Remove the nuts from the radiator mounting bolts at the bottom of the radiator.

    On the 1350-square-inch radiator, remove the nuts from the radiator mounting bolts at the bottom of the module support bracket, underneath the charge air cooler.
14. Using a lifting device, remove the radiator and charge air cooler from the vehicle.

Installation

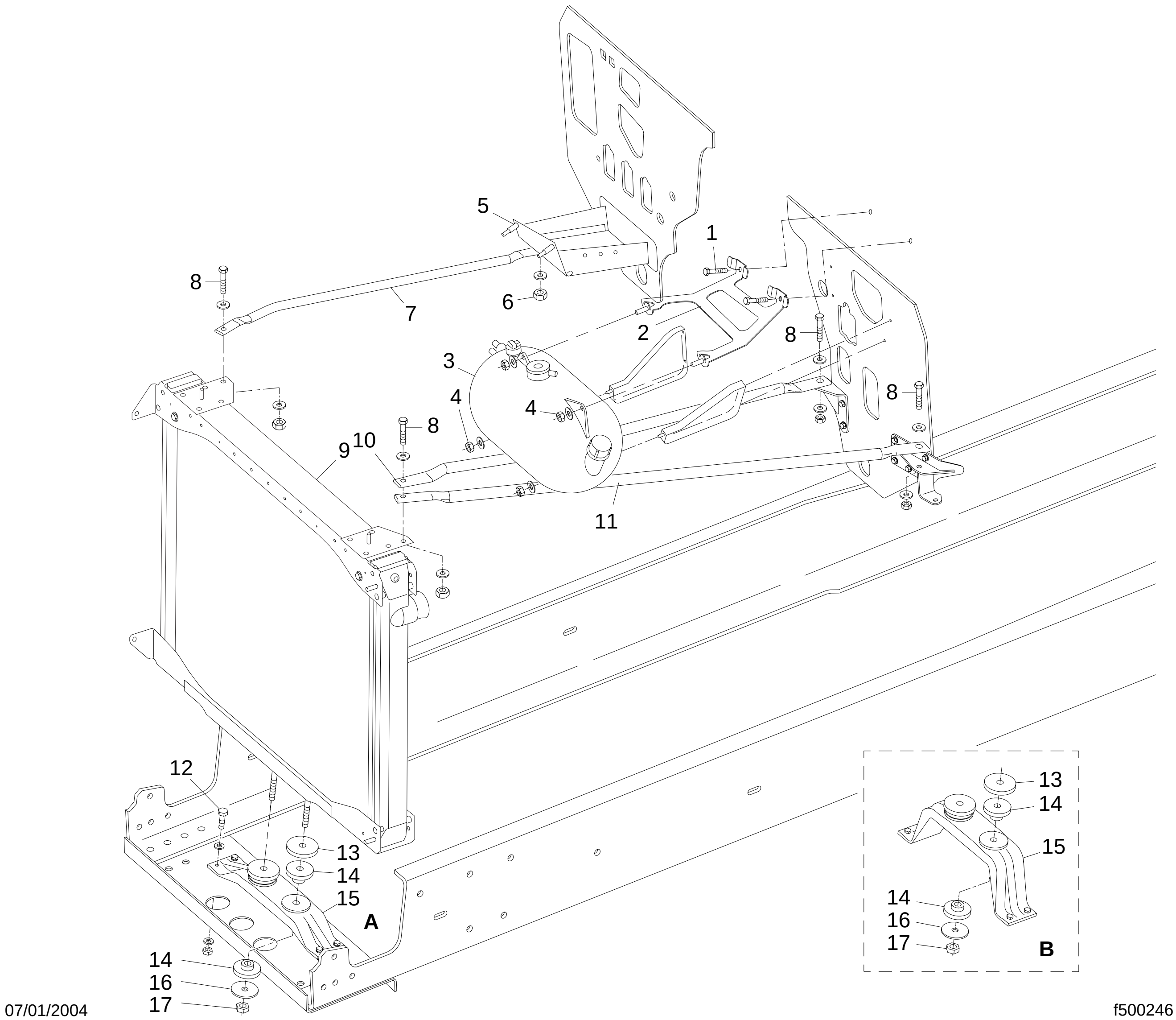
1. Using a lifting device secured to the radiator and charge air cooler with chains, lift the radiator to position it in the vehicle.
2. Install the nuts on the mounting bolts at the bottom of the radiator. Tighten the nuts 241 lbf·ft (327 N·m).
3. Remove the lifting chains from the radiator.
4. Attach the struts to the radiator.

   Tighten the strut fasteners 68 lbf·ft (92 N·m).
5. Install the fan shroud on the radiator. For instructions, refer to **Subject 120**.
6. T-bolt type hose clamps are standard on hoses with an inside diameter greater than 2 inches (51 mm). They should be tightened 55 lbf·in (620 N·cm). The screw tip of the clamp must extend about 1/4 inch (6 mm) from the clamp housing, and the Belleville washer stacks must be collapsed almost flat. Use a torque wrench to install these hose clamps correctly.

NOTE: All hose clamp adjusters lose torque after installation, due to cold-flow of the hose material from under the clamp. Breeze Constant Torque clamps typically show a 30 percent loss of torque shortly after installation; a 50 percent loss after heat-cycling, and up to 80 percent loss after time and repeated heat cycles. However, when correctly installed, Breeze Constant-Torque clamps adjust automatically, holding enough torque to keep consistent sealing pressure. During vehicle operation and shutdown, the screw tip may adjust in and out, according to temperature and pressure changes. The torque may need to be adjusted for individual applications.

ABA Radial worm-drive hose clamps may lose 30 percent of their torque at the screw adjuster, shortly after being correctly tightened. This is due to cold-flow of the hose material, not an actual loosening of the clamp. This is the way they are designed to work, they should not be tightened further. To check the torque of an ABA clamp, it must be loosened completely, then torqued to the proper value listed in **Table 1**.

Radiator Removal and Installation



A. Support Bracket for a 1200-Square-Inch Radiator
1. Machine Screw, 5/16-18 Stainless Steel
2. Upper Surge Tank Bracket
3. Surge Tank
4. Locknut, 3/8–16; Washer
5. Air Cleaner Mounting Bracket
6. Nut, 1/2–13, Grade 8; Washer
7. Right-Hand Radiator Strut Rod
8. Capscrew, 1/2–13 x 2 Inch, Grade 8; Washer; Nut
9. Radiator

B. Support Bracket for a 1000-Square-Inch Radiator
10. Left-Hand Radiator Strut Rod, Inboard
11. Left-Hand Radiator Strut Rod, Outboard
12. Capscrew, 3/8–16, Grade 8; Washer; Nut
13. Spacer (used only with 11-inch frame rails)
14. Isolator
15. Radiator Support Bracket
16. Washer
17. Nut, 5/8–11, Grade 8

Fig. 1, Standard Radiator Installation

Radiator Removal and Installation

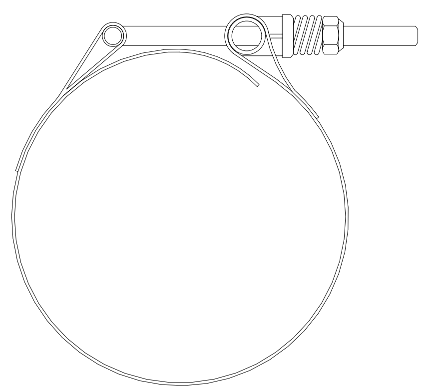
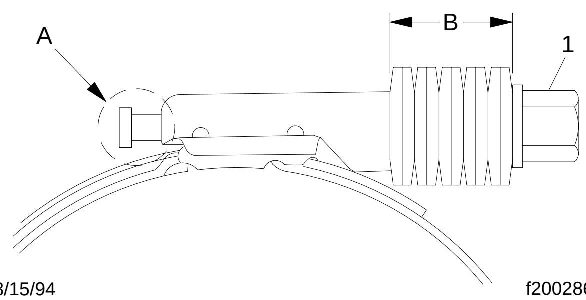


Fig. 2, T-Bolt Type Hose Clamp



A. The screw tip must extend about 1/4 inch (6 mm).
B. The Belleville washer stacks must be collapsed almost flat.
1. Tightening Screw Hex

Fig. 3, Breeze Constant-Torque Hose Clamp Installation

Over-tightening an ABA Radial worm-drive hose clamp can result in coolant leaks.

- *For Breeze Constant-Torque hose clamps with a 5/16-inch tightening screw hex:* 55 lbf·in (620 N·cm).

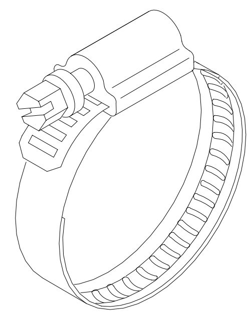


Fig. 4, ABA Radial Worm-Drive Hose Clamp (typical)

- *For Breeze Constant-Torque hose clamps with a 3/8-inch tightening screw hex:* 90 lbf·in (1020 N·cm).
- *For ABA Radial worm-drive hose clamps, see* **Table 1** *for the correct torque values.*

7. Connect the hoses to the surge tank.
8. Connect the hoses to the charge air cooler. For instructions, refer to **Group 09**.
9. Install the A/C condenser. For instructions, refer to **Group 83**.
10. Install the air recirculation shields, if so equipped.
11. Fill the coolant system. For instructions, refer to **Subject 100**.
12. Install the hood straps. For instructions, refer to **Group 88**.
13. Close the hood, then install the grille. For instructions on installing the grille, refer to **Group 88**.
14. Remove the chocks from the tires.

Hose Clamp Torque Values		
Clamp Type	**Size**	**Torque: lbf·in (N·cm)**
T-Bolt	All	55 (620)
Breeze Constant-Torque	5/16-inch tightening screw hex	90 (1020)
	3/8-inch tightening screw hex	90 (1020)

Radiator Removal and Installation

Hose Clamp Torque Values		
Clamp Type	Size	Torque: lbf·in (N·cm)
ABA	1.26-inch Diameter	31 (360)
	1.50-inch Diameter	35 (400)
	1.73-inch Diameter	35 (400)
	1.97-inch Diameter	35 (400)
	2.28-inch Diameter	35 (400)
	2.68-inch Diameter	40 (460)
	3.03-inch Diameter	40 (460)

Table 1, Hose Clamp Torque Values

Radiator Mount Removal and Installation

Removal (See Fig. 1)

1. Remove the radiator. For instructions, refer to **Subject 130** in this workshop manual section.

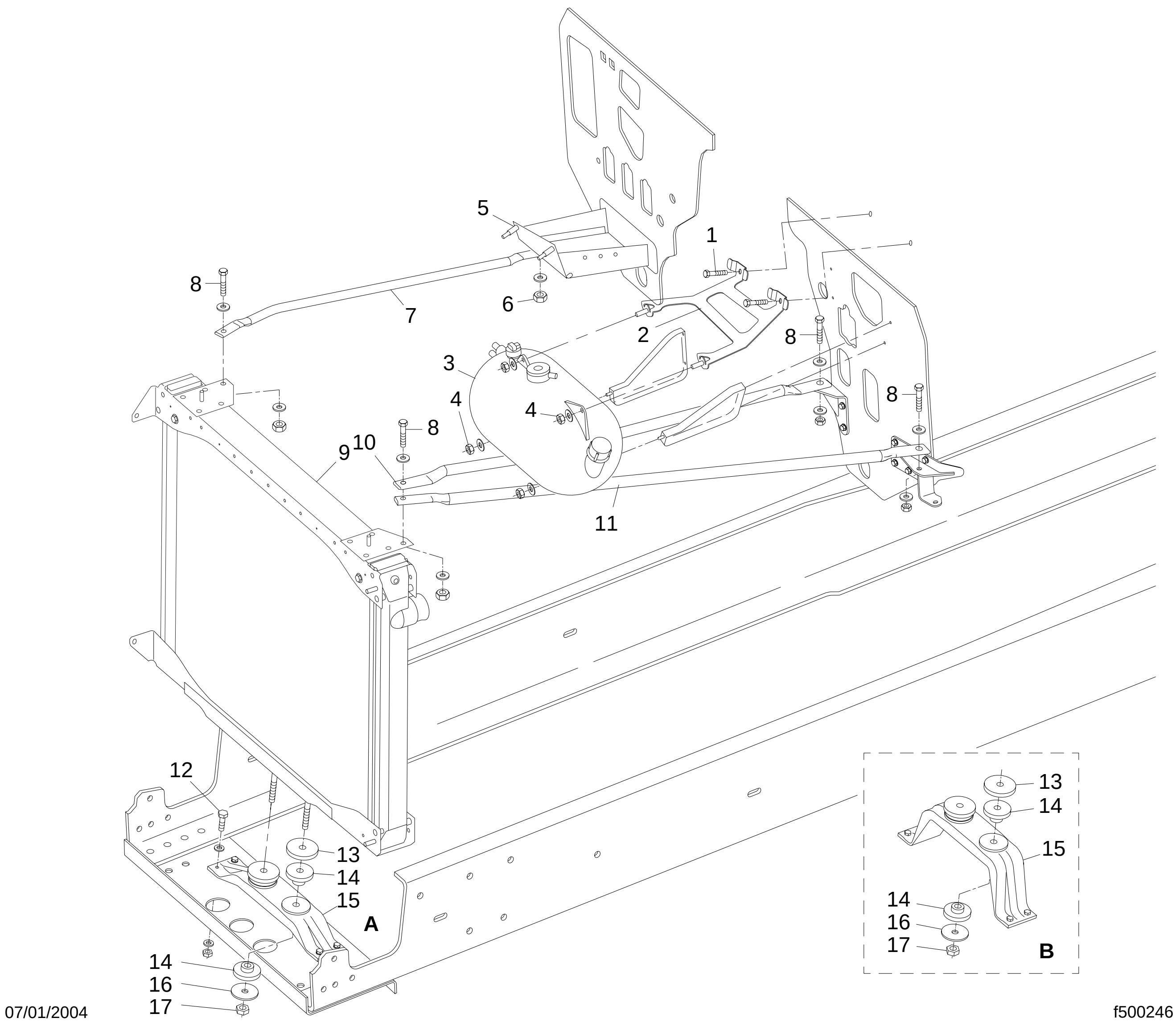
   Remove the four bolts that hold the mounting bracket to the front closing crossmember.

2. Remove the mounting bracket from the vehicle.

Installation (See Fig. 1)

1. Position the radiator mounting bracket on the front closing crossmember.
2. Install the four bolts, nuts and washers, and tighten the nuts 28 lbf·ft (38 N·m).
3. Install the radiator. For instructions, refer to **Subject 130** in this workshop manual section.
4. Remove the chocks from the tires.

Radiator Mount Removal and Installation



A. Support Bracket for a 1200-Square-Inch Radiator
B. Support Bracket for a 1000-Square-Inch Radiator

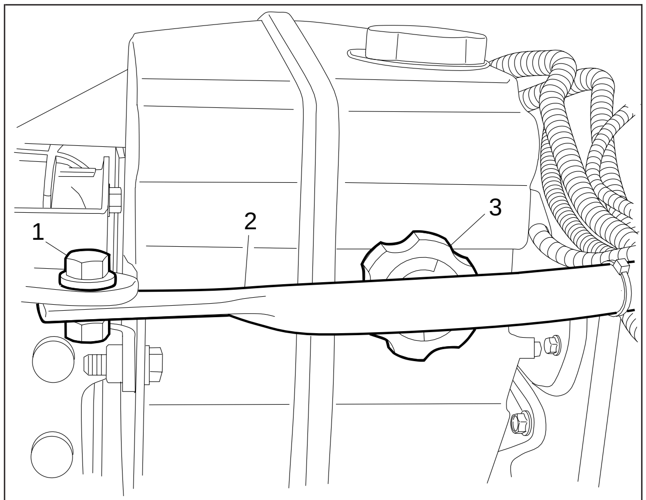
1. Machine Screw, 5/16-18 Stainless Steel
2. Upper Surge Tank Bracket
3. Surge Tank
4. Locknut, 3/8–16; Washer
5. Air Cleaner Mounting Bracket
6. Nut, 1/2–13, Grade 8; Washer
7. Right-Hand Radiator Strut Rod
8. Capscrew, 1/2–13x 2 Inches, Grade 8; Washer; Nut
9. Radiator
10. Left-hand Radiator Strut Rod, Inboard
11. Left-Hand Radiator Strut Rod, Outboard
12. Capscrew, 3/8–16, Grade 8; Washer; Nut
13. Spacer (used only with 11-inch frame rails)
14. Isolator
15. Radiator Support Bracket
16. Washer
17. Nut, 5/8–11, Grade 8

Fig. 1, Standard Radiator Installation

Engine Mounted Radiator, Cooling System Pressure Testing

NOTE: If the engine-mounted radiator strut rod blocks access to the surge tank pressure cap, remove the strut as follows.

1. Unbolt the driver's side radiator strut rod from the radiator and the engine. Set the strut rod on the engine, and do not disconnect anything that might be attached to it. See **Fig. 1**.



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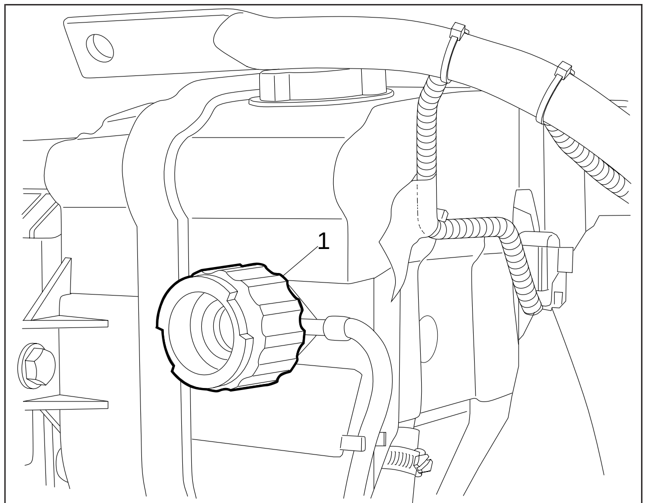
1. Strut Rod Mounting Capscrew and Nut
2. Strut Rod
3. Pressure Cap

Fig. 1, Radiator Strut Rod Installation

2. Remove the pressure cap and attach the appropriate adaptor tool (J-42401-3 or J-42401-1A) to the surge tank. See **Fig. 2**.

NOTE: These are Kent-Moore/SPX part numbers. Other companies sell these adaptors, Snap-On, Mac, Cornwell, etc. These are the same adaptors that are used on cars.

3. Attach a radiator-pressure hand pump, and apply no more than 20 psi (138 kPa) of pressure to the cooling system. See **Fig. 3**.
4. Check for leaks. Repair as needed.



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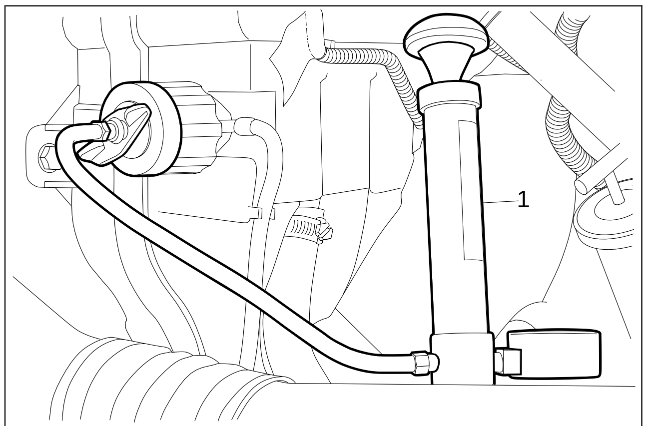
1. Adaptor

Fig. 2, Adaptor Installation



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1. Hand Pump

Fig. 3, Hand Pump Installation

5. Remove the pump and adaptor tool, and install the radiator cap.
6. Install the strut rod, and tighten the fasteners 68 lbf·ft (92 N·m).

Radiator Pressure Testing

Out of Vehicle Pressure Testing

1. Remove the radiator from the vehicle. For instructions, refer to **Subject 130** in this manual section.
2. Pressure-test the radiator.
   2.1 Plug the inlet, outlet, and all other ports on the radiator assembly.

Do not apply a higher amount of air pressure than specified below; too much pressure will damage the radiator core.

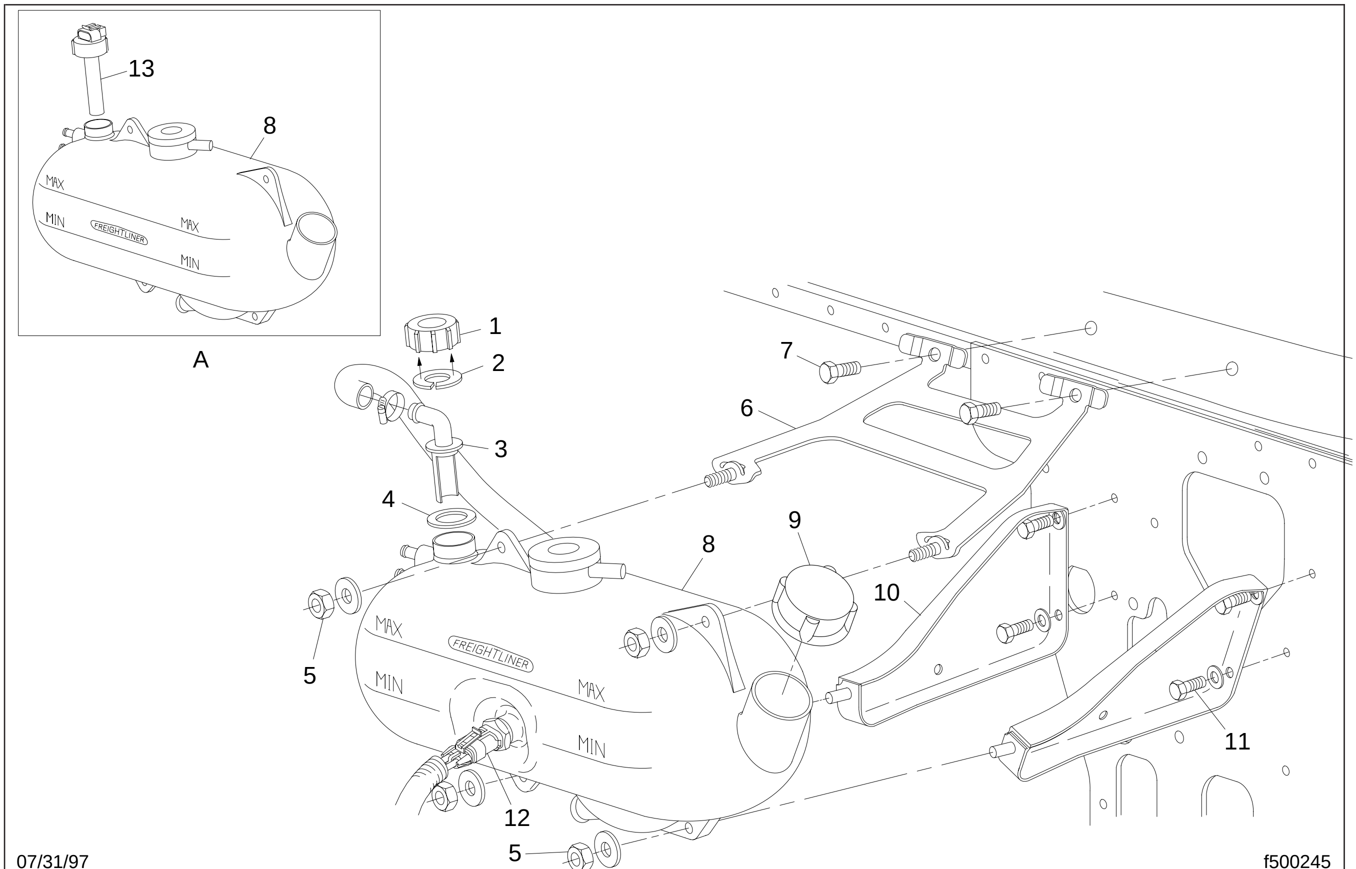
   2.2 Remove the radiator cap, and install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the filler neck.

   2.3 Submerge the radiator in a tank of water and check it for leaks. Remove the radiator from the water.

   2.4 Remove the plugs and the testing gauge, and install the radiator cap. Repair the radiator, if necessary.
3. Install the radiator in the vehicle. For instructions, refer to **Subject 130** in this manual section.

Surge Tank Removal and Installation

Removal (See Fig. 1)



A. With Low Coolant Level Sensor Installed in Top of Tank

1. Breather Cap
2. Retaining Ring
3. Breather Assembly
4. Gasket
5. Locknut, 3/8–16; Washer
6. Upper Surge Tank Bracket
7. Machine Screw, 5/16–18, Stainless Steel
8. Surge Tank
9. Surge Tank Fill Cap
10. Lower Surge Tank Bracket
11. Capscrew, 5/16–18, Grade 5; Washer
12. Low Coolant Level Sensor (installed in lower center of tank)
13. Low Coolant Level Sensor (installed in the top of tank)

Fig. 1, Standard Surge Tank Installation

1. Drain coolant from the system until no coolant shows in the surge tank. For instructions, refer to **Subject 100**.

   Disconnect the hoses from the surge tank, but be careful to avoid spilling coolant from the hoses.

2. If the low coolant level sensor is installed in the top of the surge tank, remove it.

   If the low coolant level sensor is installed in the lower center of the surge tank, disconnect the wiring from it.

3. Remove the nuts that hold the tank to the upper and lower support brackets.

Surge Tank Removal and Installation

Installation (See Fig. 1)

1. Position the surge tank on the upper and lower mounting brackets.
2. Install the four nuts and washers, and tighten the nuts 28 lbf·ft (38 N·m).
3. If the low coolant level sensor was removed from the top of the tank, install it.

   If the low coolant sensor is installed in the lower center of the tank, connect the wiring to it.
4. Connect the hoses to the tank
5. Fill the coolant system. For instructions, refer to **Subject 100** in this service manual section.

Radiator Disassembly and Assembly

IMPORTANT: Disassembling and assembling radiators with nylon tanks requires the special tools listed in **Table 1**.

Dissassembly Tools	
Description	Quantity
Plastech II® Tanking Machine With Five 2-Inch Cylinders	1
T-Bar	1
Hooked-End Bar	1
Wave Form Bar	1

Table 1, Disassembly Tools

Order these tools from:

RAD PAL
2364 17 St.
Detroit, MI 48216
313–963–3194

Disassembly (See Fig. 1)

Before disassembling the radiator, pressure flush it and check the surge tank, following the instructions in the radiator group of the vehicle maintenance manual. Clean and check the exterior of the radiator, following the instructions in the vehicle driver's manual.

1. Remove the radiator from the vehicle; for instructions, refer to **Subject 130**.

CAUTION

Use care when handling or supporting the nylon tanks. Failure to do so could damage the tanks.

2. Remove the side channels from the radiator assembly.
   2.1 Remove the four spring clips that hold the side channel mounting pins in position. See **Fig. 2**. Insert a screwdriver blade in the open end of each clip, and pry the clip open until it clears the edge of the mounting pin. Then, slip the clip off the pin.
   2.2 Use a rubber mallet and a punch to tap out the four mounting pins. See **Fig. 3**.
   2.3 Slip the side channels off the radiator core and tank assembly. See **Fig. 4**.
3. Leak test the radiator core and tank assembly.
   3.1 Securely plug all tank ports.

CAUTION

Don't apply a higher amount of pressure than specified below; too much pressure will damage the radiator core.

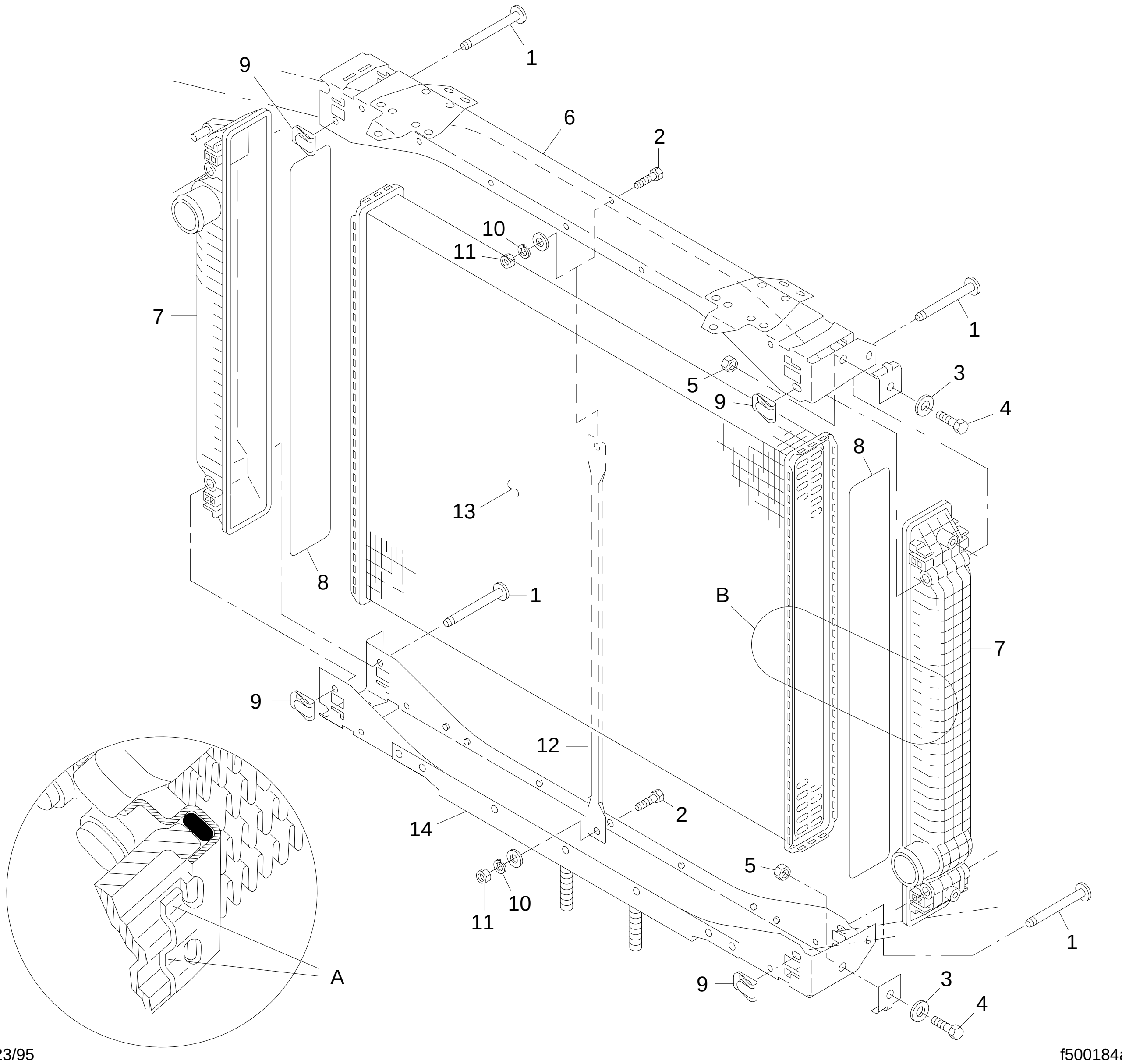
   3.2 At one tank port, install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the port.
   3.3 Submerge the radiator in a tank of water and check it for leaks. Mark any leaks for repair. If a leak is between the radiator core header and a tank, remove the tank and inspect the tank flange, the header sealing surface, and the sealing gasket. If the leak is in the core, but within 7.5 cm (3 inches) of the tank, remove the tank before repairing the leak. If the leak is in the tank, replace the tank.
4. Remove the tanks.
   4.1 Place the radiator core and tank assembly in the disassembly/assembly fixture, and clamp the assembly securely in place. See **Fig. 5**.
   4.2 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports.

CAUTION

Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

   4.3 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

Radiator Disassembly and Assembly

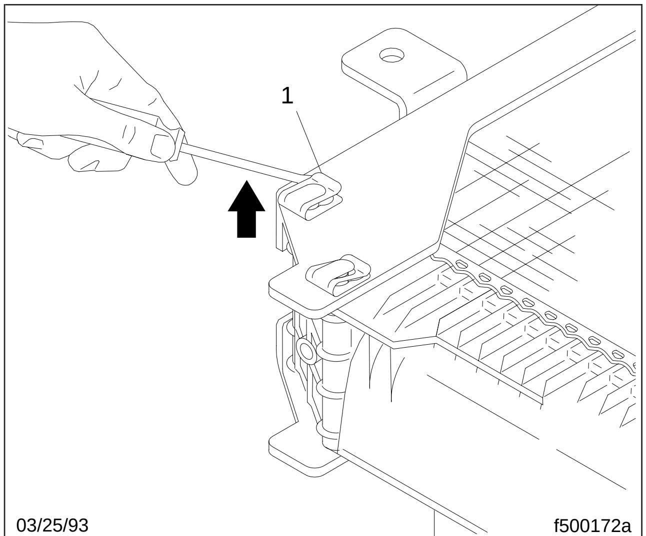


A. Dimple Wave Lock Crimp
B. See Detail

1. Channel Mounting Pin
2. Bolt
3. 3/8-Inch Flatwasher
4. 3/8-16 Bolt
5. 3/8-16 Nut
6. Side Channel (top)
7. End Tank
8. End Tank Gasket
9. Spring Clip
10. Lockwasher
11. Nut
12. Radiator Brace Rod
13. Radiator Core
14. Side Channel (bottom)

Fig. 1, Radiator With Plastic End Tanks

Radiator Disassembly and Assembly



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1. Spring Clip

Fig. 2, Remove the Spring Clip

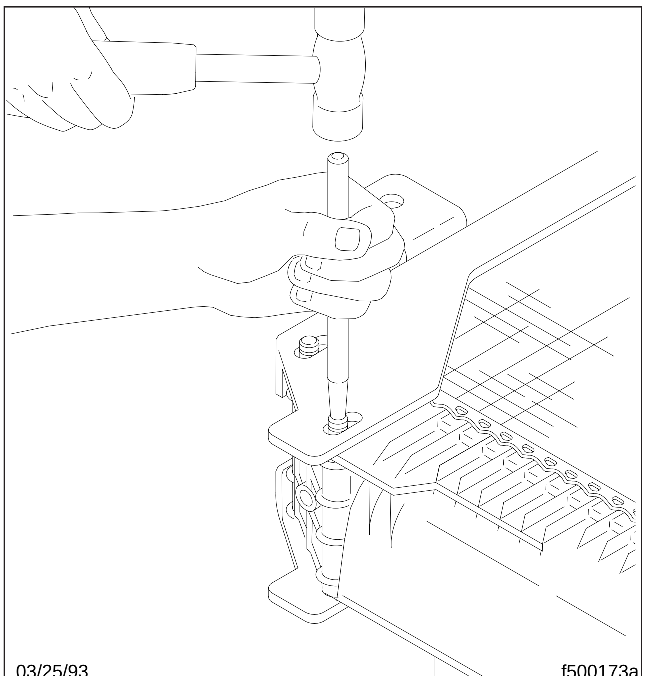

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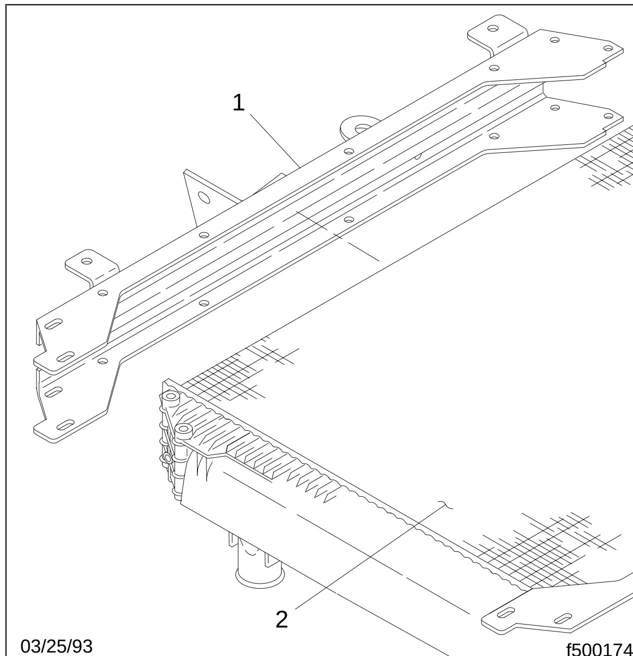
Fig. 3, Tap Out the Mounting Pins

⚠ CAUTION

In some places, especially around the tank ports, the wave lock crimps may have to be unlocked with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.



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1. Side Channel
2. Radiator Core

Fig. 4, Remove the Side Channels

4.4 Place the T-bar into the T-bar groove in the disassembly/assembly fixture. See Fig. 6.

4.5 Slide the hooked-end bar over the T-bar. Place the hook over the top of the wave crimp and pull the T-bar back to unlock the crimp. See Fig. 6.

4.6 Slide the hooked-end bar and the T-bar down the T-bar groove to the next wave crimp, and repeat the previous step until all the wave crimps are unlocked.

5. Once the wave crimps are unlocked, remove the tank.

5.1 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

Radiator Disassembly and Assembly

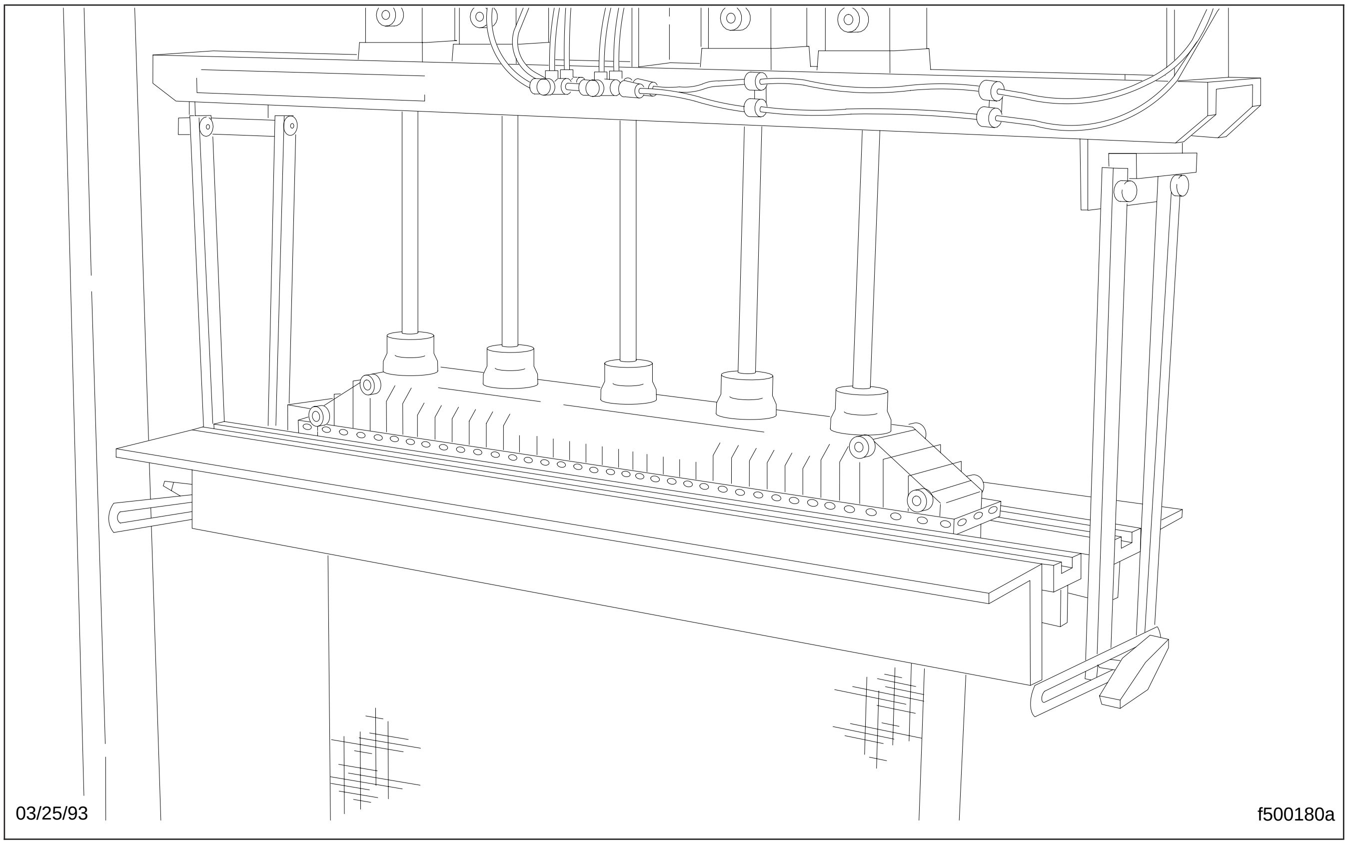


Fig. 5, Clamp the Radiator in the Disassembly/Assembly Fixture

CAUTION

If needed, use a rubber mallet or the heel of your hand and tap the side of the tank to loosen it. Do not use a screwdriver against the tank sealing flange. A screwdriver blade may damage the flange and prevent a good seal after the tank is installed.

5.2 Lift the tank from the forward side, the side opposite the tank ports. Remove the nylon tank from the radiator core. See Fig. 7.

5.3 Remove the sealing gasket from the sealing surface of the radiator core header. See Fig. 8.

5.4 Clean the sealing surface of the radiator core header.

5.5 Repair any leaks marked during leak testing.

5.6 Repeat the preceding steps to remove the opposite tank.

IMPORTANT: Check the tubes of the radiator core for scale deposits. If the radiator has been pressure-flushed, and the tubes are still clogged, the radiator should be rodded or boiled out with acid by an experienced radiator shop. Otherwise, replace the core.

Assembly

1. Install the nylon tanks on the radiator core.

   1.1 With the radiator securely clamped in the disassembly/assembly fixture, header sealing surface up, make sure the bottom of the radiator core and tank assembly is completely supported, and that the

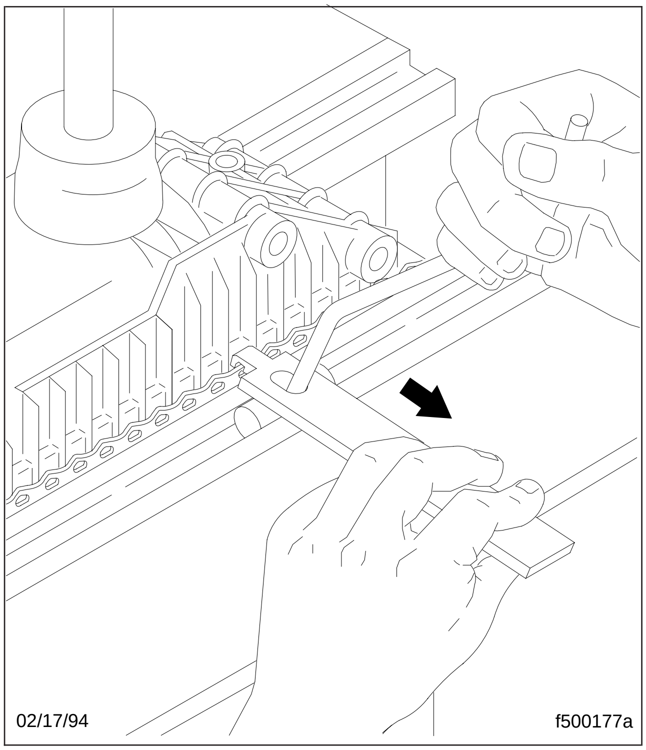


Fig. 6, Place the T-Bar

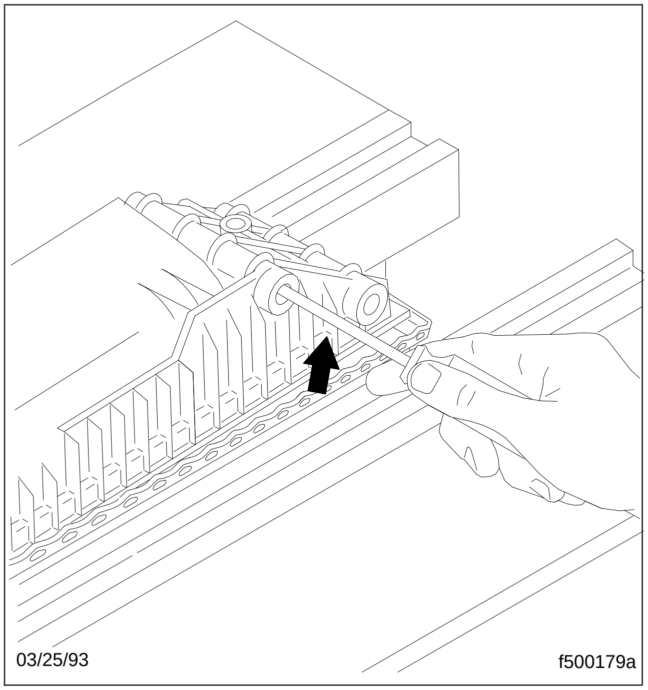
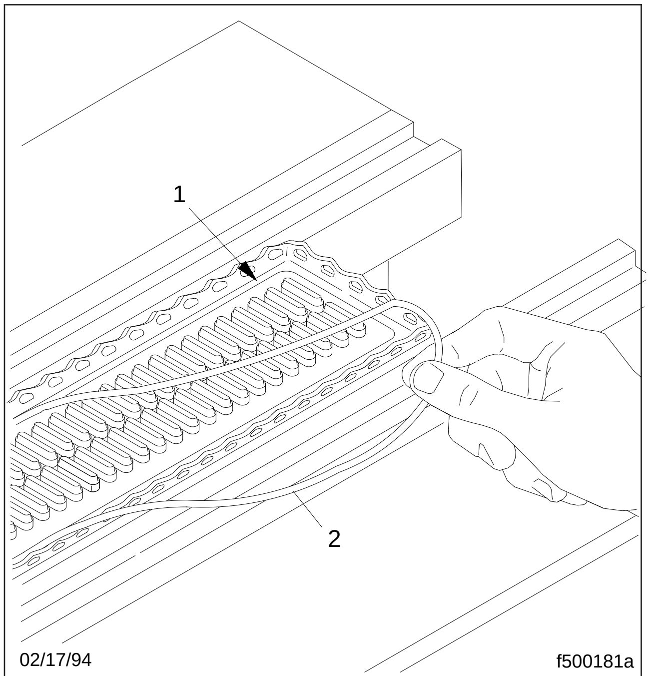


Fig. 7, Lift the Tank



1. Sealing Surface
2. Gasket

Fig. 8, Remove the Gasket

header sealing surface is free of any dents, tool marks, or foreign particles.

1.2 Lubricate a new sealing gasket with a soap and water solution, and position the gasket on the header sealing surface. See **Fig. 8** . To make sure the gasket is not twisted, run a finger along the gasket as it lies on the sealing surface. The mold lines of the gasket should be on the outside and inside diameters of the gasket; if you can feel a mold line cross over the top of the gasket, the gasket is twisted.

1.3 Inspect the tank sealing flange. The flange must be clean and free of defects. If the sealing flange is damaged, replace the tank.

1.4 Place the tank on the gasket, and tap the tank with a rubber mallet or the heel of your hand to seat the tank. Make sure the tank ports are facing the correct direction.

1.5 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will

Radiator Disassembly and Assembly

not press against breakable fittings, such as vent tube ports. See Fig. 5.

CAUTION

Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

1.6 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

1.7 Place the T-bar into the T-bar groove in the disassembly/assembly fixture.

1.8 Slide the wave form bar over the T-bar, and center the bar in front of the wave crimp slot.

CAUTION

Do not push the wave crimp until it touches the side of the nylon tank, or the tank may crack.

1.9 Push the T-bar forward to crimp the header's edge until it almost touches the tank's side. See Fig. 9.

1.10 Slide the tools down the T-bar groove to the next wave crimp slot, and repeat the previous steps until all the wave crimps are crimped.

CAUTION

In some places, especially around the tank ports, the wave crimps may have to be crimped with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.

1.11 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

1.12 Repeat the first step in this procedure to install the opposite tank.

2. Leak test the radiator core and tank assembly. For instructions, refer to "Disassembly."

3. Install the radiator side channels.

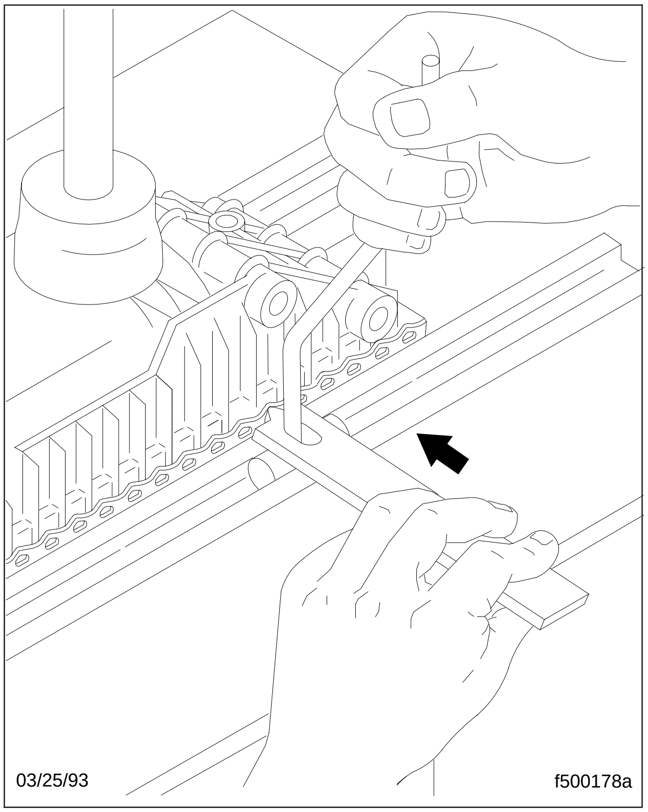


Fig. 9, Crimp the Header

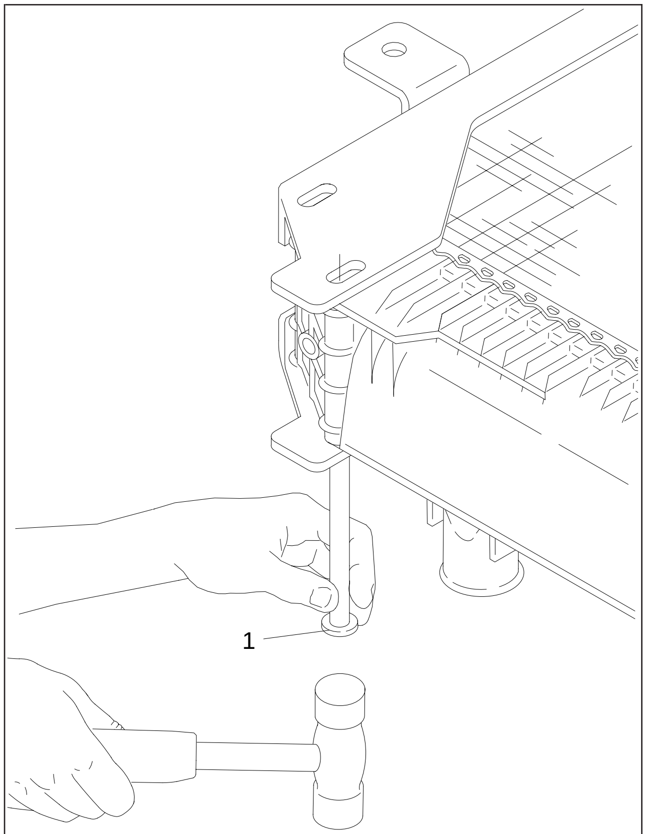
3.1 Slide the side channels onto the radiator core and tank assembly.

3.2 Using a rubber mallet and a punch, install the four mounting pins through the side channel holes and tank bosses. See Fig. 10.

3.3 Install the four spring clips to secure the mounting pins in position. See Fig. 11. To install each clip, place the clip over the end of the mounting pin, and slide the clip until it engages the groove in the pin and the open end of the clips snaps over the edge of the pin. If necessary, use a clamp to compress the side channel while installing the clips.

4. Install the radiator in the vehicle. For instructions, refer to Subject 130.

Radiator Disassembly and Assembly



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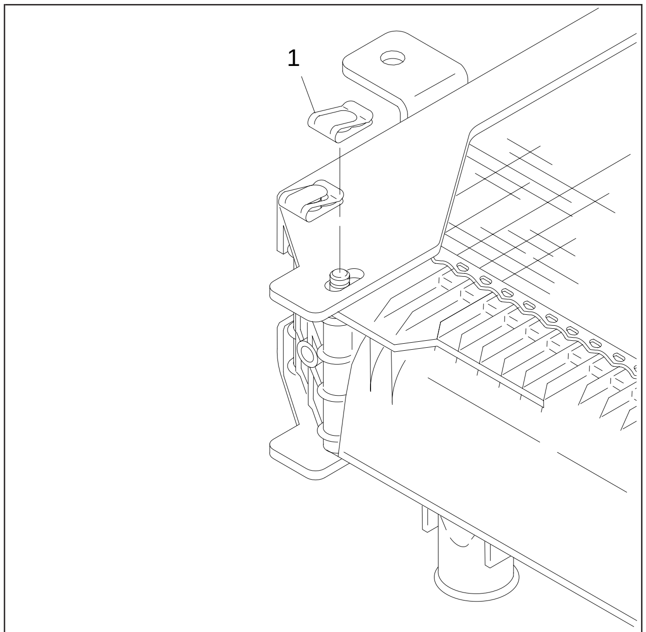
1. Pin

Fig. 10, Install the Mounting Pins



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1. Spring Clip

Fig. 11, Install the Spring Clips

Air Recirculation Shield Removal and Installation, Columbia

Removal (See Fig.1or Fig.2)

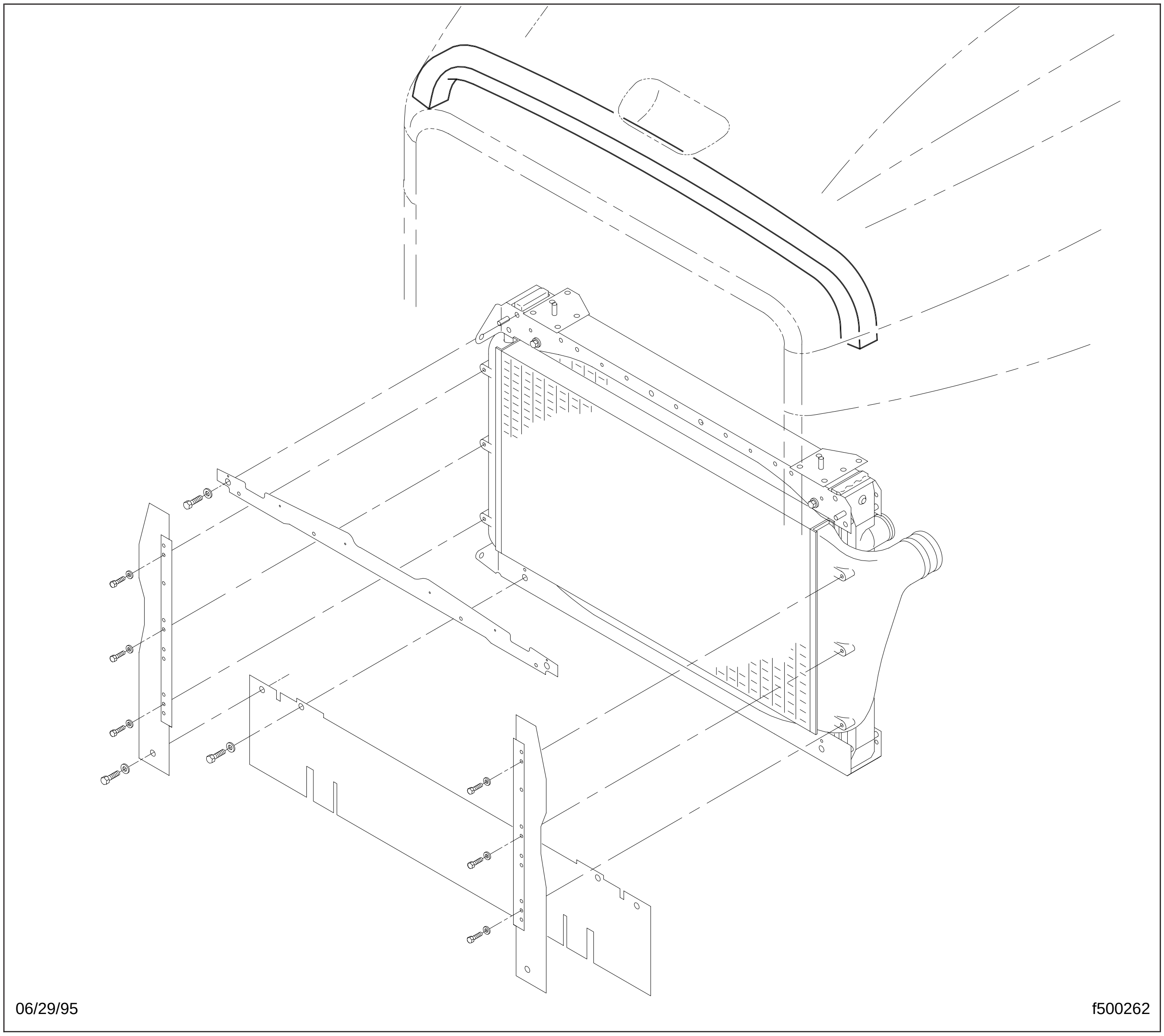


Fig. 1, Standard Air Recirculation Shield Installation (1000-square-inch radiator)

1. Park the vehicle, apply the parking brakes, and tilt the hood.
2. Remove the capscrews that hold the air recirculation shields to the charge air cooler and the radiator.
3. Remove the air recirculation shields.

Installation (See Fig.1or Fig.2)

1. Position the air recirculation shields on the engine, and secure them with capscrews.

Air Recirculation Shield Removal and Installation, Columbia

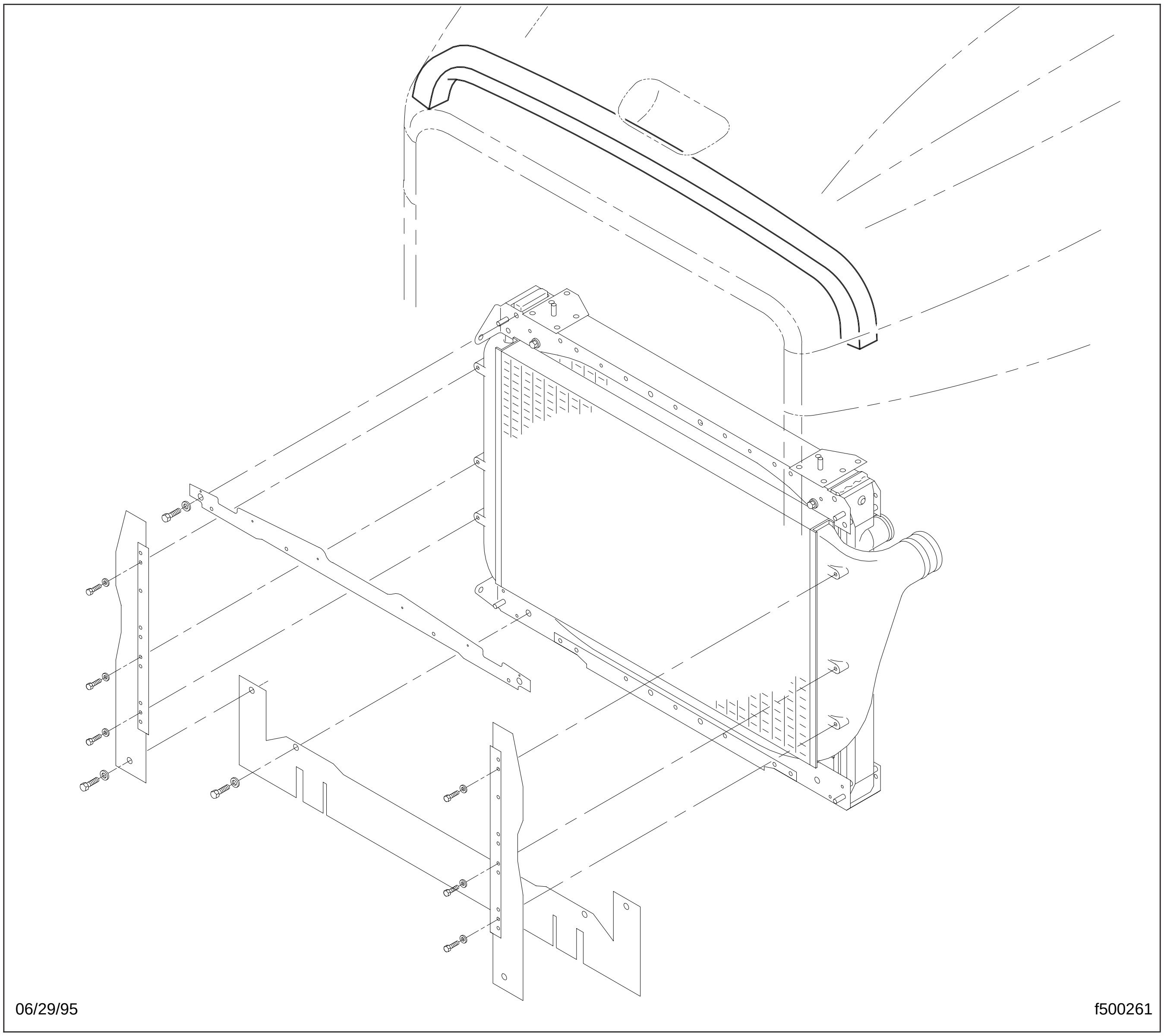


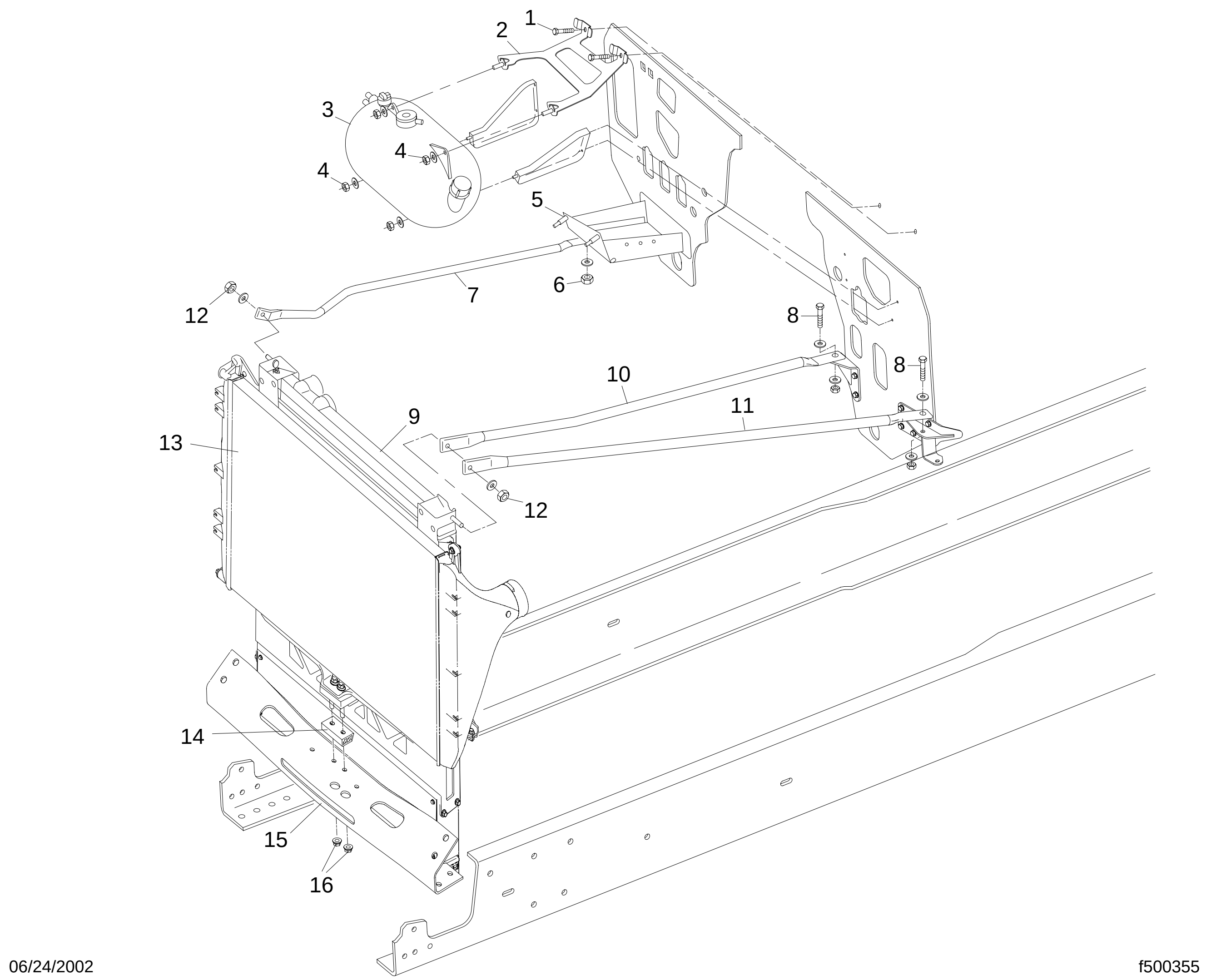
Fig. 2, Standard Air Recirculation Shield Installation (1200-square-inch radiator)

2. Tighten the capscrews firmly.
3. Close the hood.

Radiator, 1350-Square-Inch, Removal and Installation

Removal

See **Fig. 1** for removal and installation procedures.



1. Machine Screw, 5/16–18 Stainless Steel
2. Upper Surge Tank Bracket
3. Surge Tank
4. Locknut, 3/8–16; Washer
5. Air Cleaner Mounting Bracket
6. Hexnut, 1/2–13, Grade 8; Washer
7. Right-Hand Radiator Strut Rod
8. Capscrew, 1/2–13 x 2, Grade 8; Washer; Hexnut
9. Radiator Assembly
10. Left-Hand Radiator Strut Rod, Inboard
11. Left-Hand Radiator Strut Rod, Outboard
12. Hexnut, 1/2–13, Grade 8; Washer
13. Charge Air Cooler (CAC)
14. Spacer, Radiator Isolator
15. Crossmember, Frame
16. Hexnut, 1/2–13, Grade 8; Washer

Fig. 1, Radiator Installation, 1350-Square-Inch

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.

Radiator, 1350-Square-Inch, Removal and Installation

WARNING

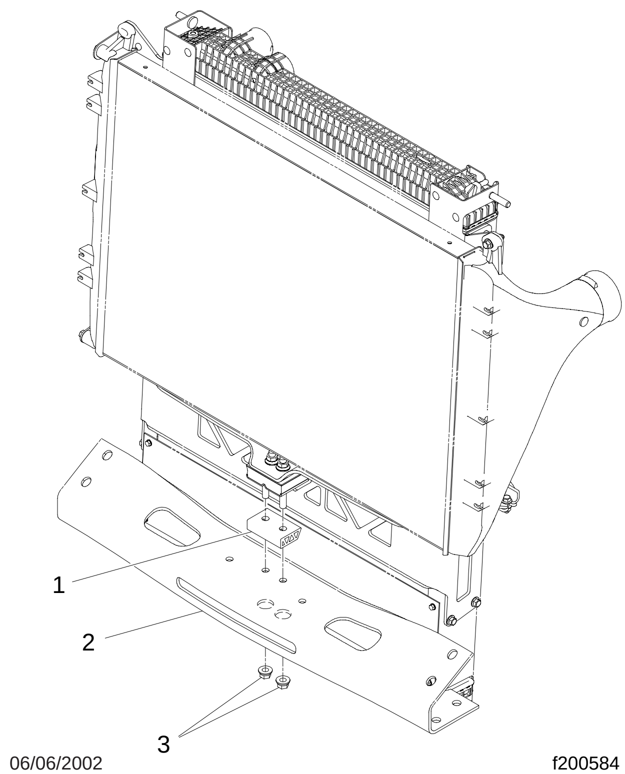
Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the radiator. See Group 20 of the *Columbia Maintenance Manual* for radiator draining procedures.
3. Open the hood.
4. Disconnect the hood support straps, and support the hood on a padded table.
5. Disconnect the hoses from the charge air cooler (CAC).
6. Without disconnecting the refrigerant lines, remove the A/C condenser from the front of the CAC. Cover the condenser with cardboard and secure it to the side and out of the way. Remove any stand-off brackets for the refrigerant hoses as needed.
7. Disconnect the upper and lower radiator hoses.
8. Remove the air recirculation shields from the radiator.
9. Disconnect the surge tank vent line from the top right side of the radiator.
10. Remove the fan.
11. Remove the fan shroud from the radiator (6 fasteners).
12. Disconnect the radiator struts from the top of the radiator (one on the right side; two on the left side).
13. Position a hoist over the radiator and attach lifting chains to the radiator strut studs on the top of the radiator. Use the same hexnuts that held the struts to the radiator.

NOTE: The studs protrude horizontally from the top of the radiator side channels.

14. Remove the 1/2–13 hexnuts holding the radiator mounting bracket to the isolator and front crossmember. See **Fig. 2**.

NOTE: The isolator has two integral studs. There are hexnuts at the top and bottom of each stud. The top studs fasten the isolator to the radiator mounting bracket; the bottom ones fasten it to the front crossmember.



1. Spacer, Radiator Isolator
2. Crossmember
3. Hexnut, 1/2–13, Grade 8; Washer

Fig. 2, Isolator, 1350-Square-Inch Radiator

15. Lift the radiator up and remove it from the vehicle.
16. If applicable, remove the CAC from the radiator. See **Group 09** for instructions.

Installation

1. If it was removed, install the CAC onto the front of the radiator. See **Group 09** for instructions.
2. Using a hoist, put the radiator and CAC in place over the front crossmember.
3. Making sure the studs on the mounting bracket are aligned with the holes in the isolator and the front crossmember, lower the radiator onto the crossmember.

Radiator, 1350-Square-Inch, Removal and Installation

4. Install the 1/2–13 hexnuts and washers. Tighten to 95 lbf·ft (129 N·m).
5. Remove the lifting chains, then connect the radiator support struts.
6. Install the fan shroud.
7. Install the fan.
8. Install the air recirculation shields.
9. Connect the vent line from the surge tank to the top right side of the radiator.
10. Carefully release the A/C condenser from its position and install it onto the front of the CAC. Be careful not to kink the refrigerant lines. Install any stand-off brackets that were removed.
11. Connect the upper and lower radiator hoses.
12. Connect the CAC hoses to the CAC.
13. Lift the hood slightly and, with an assistant holding it, attach the hood support straps.
14. Fill the radiator with approved coolant. See Group 20 of the *Columbia Maintenance Manual* for coolant capacities.
15. Start the engine and check for leaks. If any are found, tighten the applicable connections.
16. Shut down the engine.
17. Remove the chocks from the tires.

Radiator, EPA07, Removal and Installation

NOTICE

If the radiator is being replaced due to a failure of the transmission cooler, cleaning contamination from the transmission is necessary. Failure to do so can lead to a transmission failure.

Allison automatic transmissions: It is required to test the transmission fluid for contamination. The presence of water and/or any trace of ethylene glycol coolant mixtures in the transmission oil in an Allison transmission is detrimental to the internal components. Refer to the Allison service literature for more information and proper procedures, or contact an authorized Allison service facility.

Standard transmissions: The presence of water and/or ethylene glycol coolant mixtures in the lubricant in standard transmissions decreases the effectiveness of the lubricant and causes rust and wear to internal parts. If contamination is detected, refer to the transmission manufacturer's service literature for proper procedures.

Radiator Removal

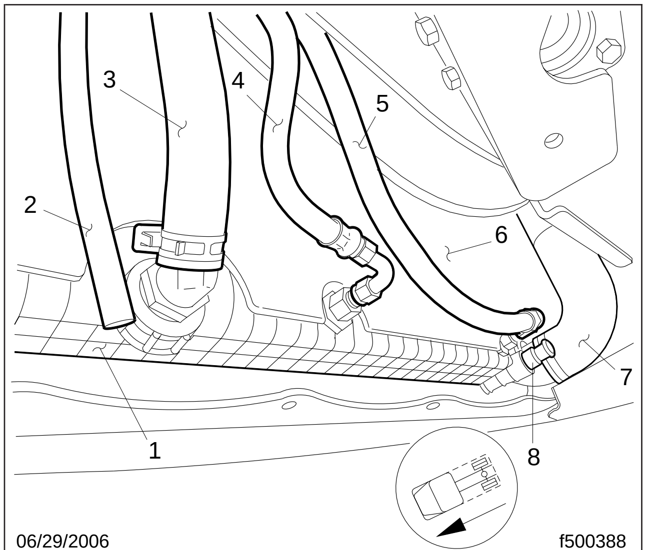
1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Remove the front bumper.

WARNING

During operation and for some time afterward, the contents of the cooling system are hot and highly pressurized. Opening the system when it is pressurized can allow scalding hot, pressurized coolant to erupt from the cooling system with considerable force, and can cause severe personal injury.

Be very careful when venting or opening the cooling system, and use appropriate protective gear.

4. Remove the surge tank cap.
5. Place a clean 14-gallon (53-liter) container near the radiator drain.
6. Connect a 1/2-inch hose to the drain fitting on the radiator (see Fig. 1) and place the other end in the container.
7. Drain the radiator into the container.



1. Radiator Bottom Tank
2. Surge Tank Vent Hose
3. Surge Tank Hose
4. Transmission Oil Cooler Hose
5. Transmission Oil Cooler Hose
6. Lower Fan Shroud
7. Lower Radiator Hose
8. 1/2-Inch Radiator Drain Fitting

Fig. 1, Bottom of Installed Radiator

NOTE: If the oil drained from the transmission in the next step is relatively fresh and kept clean, it can be reused. If you wish to reuse the oil, be sure the drain container is clean, and be sure the drain ports on the transmission are clean before disconnecting the lines.

8. Place a container of at least 2-gallon (7.5-liter) capacity under the transmission, and drain the transmission oil into it. It will probably be easier to do this by disconnecting the oil cooler lines below the drain plug.

CAUTION

Do not attempt to turn the QLD fittings; you may destroy the fitting and severely damage the radiator.

Radiator, EPA07, Removal and Installation

IMPORTANT: The transmission oil cooler lines in some early EPA07 vehicles attach to the radiator with quick-disconnect (QLD) fittings. Removal and installation of these fittings must be done correctly, to prevent damage to the fittings and the radiator.

9. Where QLD fittings are fitted, the female ports are brazed into the radiator. They are not threaded.

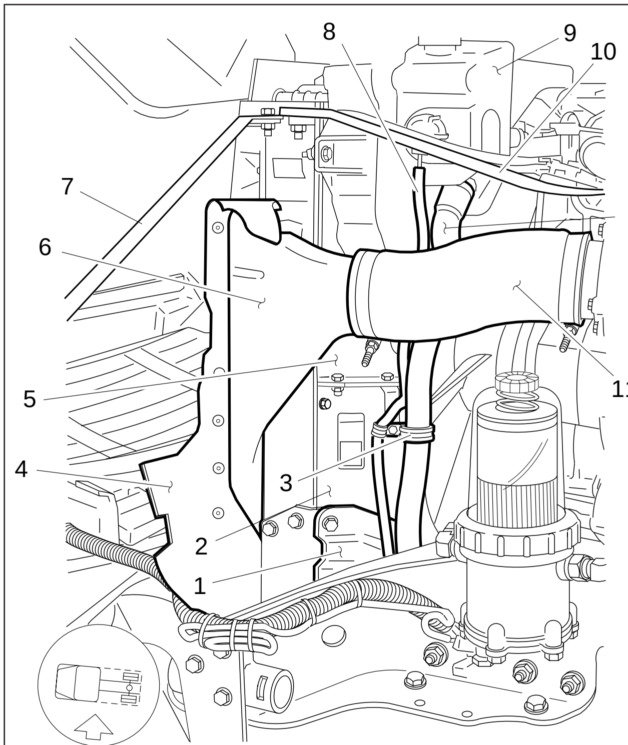
   See the heading, "Gates Quick-Disconnect QLD Fittings" below, for work procedures on QLD fittings.

10. Disconnect the transmission oil cooler lines from the radiator, and let them drain into another container; see **Fig. 1**.

NOTE: The small amount of transmission oil drained at the radiator-end of the lines, after the transmission has been drained, may be contaminated with coolant as the radiator is drained. That oil should not be reused.

11. Remove the lower elbow from the radiator end tank.
12. Put a ratchet strap in position on the passenger side of the vehicle, to support the hood when the hood supports are disconnected.

    Attach one end of the ratchet strap to the underside of the hood, or the hole in the hood above the hood latch. Attach the other end to the rear hood support, on top of the inner splash shield.
13. Remove the upper radiator struts.
14. Disconnect the hood straps from the radiator. With help from another person, adjust the length of the ratchet strap so that the hood position will allow the radiator to be hoisted up, and clear of the vehicle.
15. Disconnect the charge air cooler (CAC) hoses from the CAC; see **Fig. 2** and **Fig. 3**.
16. Remove the lower elbow from the radiator end tank.
17. Disconnect the shunt line and radiator vent line, but leave the P-clamp in place on the back of the radiator module support; see **Fig. 2**.
18. Disconnect the electrical sensors on the radiator.
19. Remove the surge tank.



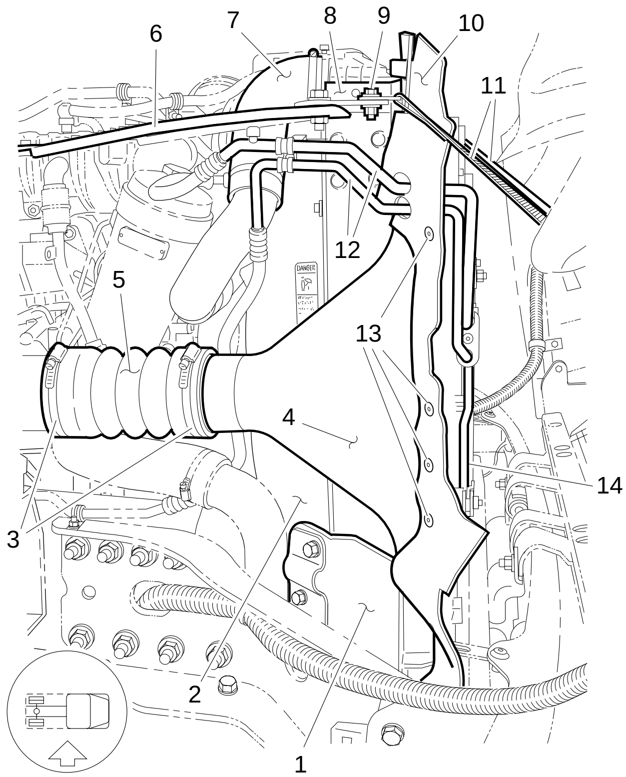
NOTE: Typical installation, others are similar.

1. Radiator Module Support
2. Lower Fan Shroud
3. Surge Tank Hose P-Clamp
4. Recirculation Baffle
5. Upper Fan Shroud
6. Charge Air Cooler (CAC)
7. Hood Support
8. Surge Tank Vent Hose
9. Surge Tank
10. Upper Radiator Support
11. CAC Hose

Fig. 2, Left Side of Radiator

20. Place alignment marks on the upper and lower fan shrouds, and mark the shroud-to-channel positions, so the shrouds can be installed in the same position on the radiator and other components.
21. Remove the four fasteners that connect the upper and lower fan shrouds.
22. Remove the fasteners that hold the fan shrouds to the radiator.
23. Remove the upper fan shroud.
24. Remove the six hexscrews that hold the fan to the fan clutch, and remove the fan.

Radiator, EPA07, Removal and Installation



NOTE: Typical installation, others are similar.

1. Radiator Module Support
2. Lower Fan Shroud
3. CAC Hose Clamps
4. Charge Air Cooler (CAC)
5. CAC Hose
6. Upper Radiator Support
7. Upper Radiator Hose
8. Upper Radiator Tank
9. Radiator Support Fastener
10. Recirculation Baffle
11. Hood Support
12. Air Conditioner (A/C) Refrigerant Tubes
13. Reusable Plastic Recirculation Baffle Rivets
14. A/C Condenser

Fig. 3, Right Side of Radiator

25. Disconnect the fasteners that hold the air-conditioner (A/C) system soft lines, to allow enough soft line flexibility so that the A/C condenser can be placed on the passenger-side tire.
26. Remove the four hexnuts that hold the A/C condenser to the radiator, and place the condenser on top of the passenger-side tire.
27. Remove the lower side recirculation baffle from the radiator. Use a screwdriver to pry the baffle off; it is held by push-on, reusable plastic rivets.
28. Attach an engine hoist to the radiator using the flanges and fasteners, where the upper radiator struts attached.
29. Remove the six hexscrews that hold the radiator to the module support.
30. Lift the radiator about 6 inches (15 cm). Remove the bottom recirculation baffle from the radiator.
31. Lift the radiator clear of the vehicle.
32. Remove the lower fan shroud from the radiator.
33. Set the radiator on a workbench, with the CAC up.
34. Remove the bolts that hold the CAC to the radiator, then remove the CAC and set it aside.
35. Use a paint pen to mark the position of the channels on the radiator.
36. Remove the fasteners that hold the channels to the radiator, and remove the channels.

Gates Quick-Disconnect QLD Fittings

As part of the changes made for EPA07 engines, the transmission oil cooler was moved into the radiator, and some early EPA07 vehicles used transmission oil cooler lines equipped with Gates Quick-Disconnect (QLD) connectors.

In July 2007, the Gates QLD connectors were superseded by JIC fittings. Only JIC-equipped radiators are available as replacements.

The Kent-Moore QLD tool (see **Fig. 4**) is the proper tool to use when disconnecting QLD connectors. One set of tools was sent to each dealer in December 2006. The tool is available from Kent-Moore in two sizes; J-48548-1 (the larger one) is used on Allison automatic transmissions, tool J-48548-2 is used for all other transmissions.

Quick-Disconnect Connectors, Removal and Installation

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the tires.

Radiator, EPA07, Removal and Installation

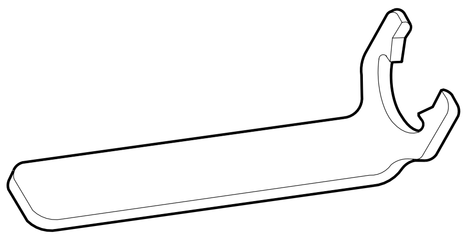


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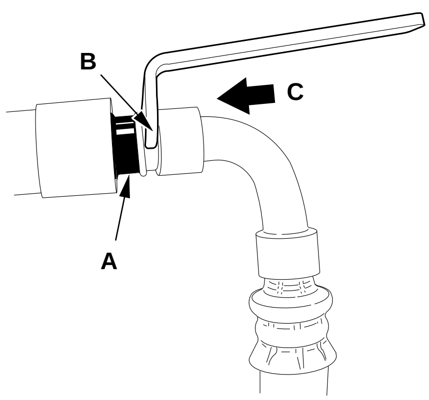
Fig. 4, Kent-Moore Tool J-48548

2. Thoroughly clean the area around the fitting.
3. Put the tool on the fitting as shown in **Fig. 5**.
4. Push the installed connector straight into the port until it stops with the rubber dust boot compressed; see **Fig. 6**.



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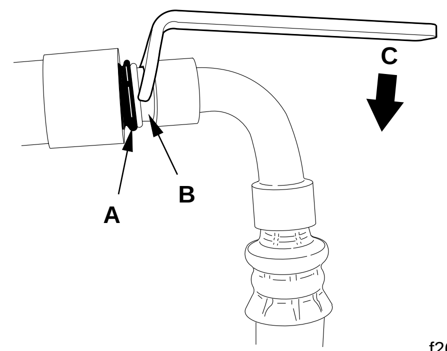
A. Dust Boot Not Compressed
B. Tool Head Inserted Perpendicular To Fitting
C. Push Male Connector Straight In, To Release

Fig. 5, QLD Fitting with Tool J-48548 in Place

NOTE: WD-40, or a similar substance, can be helpful if the quick-disconnect fitting is difficult to release. Clean the fitting, then spray it with the lubricant. Push and pull the fitting straight in and out, to distribute the lubricant so it eases disassembly, then use the tool to disconnect the fitting.

5. **While holding the male fitting compressed into the female port,** squeeze the flat face of the tool handle toward the male fitting, to release the snap connection; see **Fig. 5**. Use the tool so that pressure is equal on both ears where they



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A. Dust Boot Compressed
B. Tool Fitted Around Metal Flange, Not Rubber Dust Boot
C. Tool Levered Straight Toward Fitting

Fig. 6, QLD Fitting Removal with Tool J-48548

push against the lower male fitting. Do not twist the tool sideways, or apply unequal pressure to either ear of the tool where it forks around the fitting. The rubber dust boot should compress, releasing the fitting so that it can separate.

6. Pull the male fitting from the radiator port. Protect the openings of the connectors when they are disconnected, to keep dirt out.

Installation

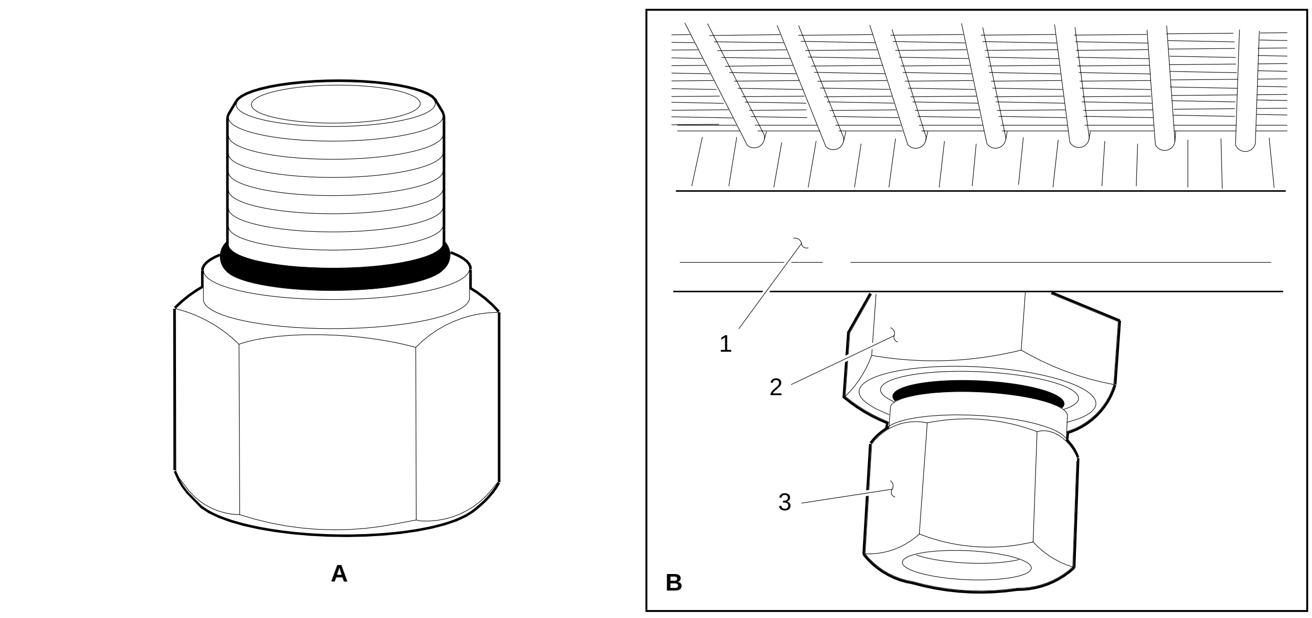
1. Apply WD-40 to the fitting, to aid assembly. Push the male connector into the port as far as possible, until the snap ring clicks into engagement.
2. Test the connection by pulling the male connector straight out, with a 10-lb (4.5-kg) force. It should hold solidly in place.
3. Remove the chocks from the tires.

Adapting QLD-Equipped Transmission Oil Cooler Lines to a JIC-Equipped Radiator

No QLD-fitted replacement radiators are available, so when a radiator must be replaced, the replacement will be JIC-equipped.

To enable using existing QLD-fitted transmission oil cooler lines with replacement JIC radiators, an adapter fitting p/n GT 7213 0003 (see **Fig. 7**) is available. It screws into the replacement radiator and allows the existing QLD-equipped lines to connect to the JIC connectors in the radiator.

2. Install the CAC onto the radiator channels, and tighten the fasteners that hold the channels and CAC to the radiator.



A. QLD-to-JIC Adapter
B. Adapter Installed in Lower Radiator

1. Lower Radiator
2. JIC Female Fitting on Transmission Oil Cooler
3. QLD-to-JIC Adapter Installed

Fig. 7, QLD-to-JIC Adapter, p/n GT 7213 0003

The adapter fittings are installed only at the radiator; the original QLD connections continue to be used at the transmission.

Thread the adapters into the transmission oil cooler; tighten them 53 lbf·ft (70 N·m).

Insert the transmission oil cooler line QLD connectors into the fitting adapters, as stated above.

Test the connection by pushing the QLD fitting straight into the adapter, then pulling straight out with 10-lb (4.5-kg) force.

Radiator Installation

1. Install the channels onto the core. Leave the channel fasteners loose, so their position can be adjusted in final installation.
2. Install the CAC onto the radiator channels, and tighten the fasteners that hold the channels and CAC to the radiator.
3. Lift the radiator with the engine hoist, and install the lower fan shroud on the radiator. Align the lower fan shroud with the alignment marks made earlier.
4. Move the radiator into position about six inches above the module support.
5. Install the bottom radiator recirculation baffle.
6. Apply sealant 48-00094-141 to the threads of the fasteners, then attach the fan. Torque the fasteners 30 lbf·ft (40 N·m).
7. Align the marks to position the upper fan shroud on the radiator, then install the fasteners that hold it to the radiator and the lower fan shroud.

NOTE: Fan tip to fan shroud clearance should be 9/32 inch (7 mm). This is closer than on pre-EPA07 models, and clearance must be carefully checked.

Radiator, EPA07, Removal and Installation

8. Install the side recirculation baffles.
9. Install the upper fan shroud.
10. Install the radiator.
11. Install the A/C condenser, and attach the P-clamps that hold the A/C soft lines.
12. Install the surge tank.
13. Connect the radiator strut rods.
14. Connect the hood support straps, and remove the temporary support straps.
15. Connect the lower radiator elbow and transmission cooler lines. If the fittings are quick-disconnect, do the following:

    15.1 If the fitting is new, remove the plastic end cap.

    15.2 Align the male connector directly with the female port.

    15.3 Push the connector into the port as far as possible, until the snap ring clicks into engagement.

    NOTE: WD-40 or a similar substance may be used to ease assembly.

    15.4 Test the connection by pulling the male connector with a 10-lb (4.5-kg) force, straight out from the female port. It should be held solidly in place.

16. Fill the cooling system with coolant.
17. Fill the transmission with transmission oil, and check the level.
18. Install the bumper.
19. Close the hood and remove the tire chocks.
20. Test drive the vehicle.
21. Check for leaks and for correct transmission oil level.

Troubleshooting Tables

Possible causes of hot or cold engine coolant temperatures are listed below. For repairs, refer to other sections of this manual or to the engine and component manufacturers' service publications.

Problem—Coolant Temperature Above Normal

Problem—Coolant Temperature Above Normal	
Possible Cause	**Remedy**
Coolant leakage (see possible sources below) is causing a low coolant level. External Leakage: hoses and hose connections, radiator seams, core, draincock and cap, block core and drain plugs, water pump thermostat housing(s), overflow and surge tank, heater hoses and core, temperature sending unit(s), cylinder head(s) mating (gasket) surfaces, coolant filter, oil cooler(s). Internal Leakage: cylinder head gasket, warped head or block surfaces, cracked cylinder head or block, cylinder head capscrews loose, missing, or tightened unevenly; oil cooler, air compressor cylinder head and gasket cylinder liners, liner seals aftercooler	Perform the repairs necessary to stop leakage. Fill to the bottom of the radiator fill neck with the correct mixture of antifreeze and water.
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation.
The radiator fins, the aftercooler, or the air conditioner condenser fins are clogged.	Clean the outside of the core, the aftercooler, and the condenser with compressed air directed from the fan side, or with water and a mild laundry soap. Straighten bent fins.
A radiator hose is collapsed or plugged.	Replace hoses.
A fan drive belt or the water pump belt is loose.	Adjust belt tension.
The cooling fan shroud is damaged.	Repair or replace the shroud.
The radiator cap is incorrect or malfunctioning.	Make sure the correct radiator cap is installed. If the cap does not hold the correct pressure, replace it.
The on-off fan clutch is not working.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
The engine oil level is incorrect.	Fill to the high (H) mark on the dipstick.
There is too much antifreeze or coolant additive in the system.	Clean and flush the cooling system. Refill the system with the correct mixture of antifreeze and water, and install the correct additive and filter, or treatment filter.

Troubleshooting

Problem—Coolant Temperature Above Normal	
Possible Cause	**Remedy**
One or both of the thermostats is incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.
The water pump is not working correctly.	Repair or replace the water pump.
The radiator core is internally plugged or damaged.	To check for blockages, warm the engine to normal operating temperature. Turn off the engine, and run your hand over the finned surface of the radiator. If there is a blockage in the radiator, it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperature is normal. If blockage is suspected, clean and flush the cooling system. Repair or replace a damaged core.
Air or combustion gases are entering the cooling system.	Check the cylinder head(s), head gasket(s), cylinder liners, aftercooler, air compressor cylinder head, and fan/shutter air control valve (if applicable) for leaks. Repair or replace parts, as necessary.
The aftercooler is plugged or damaged.	Repair or replace the aftercooler.
The oil cooler is plugged or damaged.	Repair or replace the oil cooler.
The engine is receiving too much fuel.	Refer to the engine manufacturer's fuel delivery system adjustment procedures.
The wrong fan (replacement unit) is installed.	Install the correct fan.
The wrong radiator (replacement unit) is installed.	Install the correct radiator.
There is exhaust blockage.	Repair the exhaust system.
There is frozen coolant in the radiator.	Use the proper antifreeze-to-water ratio needed for winter temperatures.

Problem—Coolant Temperature Below Normal

Problem—Coolant Temperature Below Normal	
Possible Cause	**Remedy**
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation.
The on-off fan clutch operates continuously.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
One or both thermostats are incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.

Specifications

Fastener Torques				
Description	Grade	Size	Torque lbf·ft (N·m)	lbf·in (N·cm)
Radiator Mounting Bracket Capscrews	8	3/8–16	28 (38)	—
Fan Shroud Mounting Screws	—	1/4–20 x 3/4 Inch	—	108 (1220)
Radiator Mount Nuts	8	5/8–11	241 (327)	—
Radiator Strut Nuts	8	1/2–13	68 (92)	—

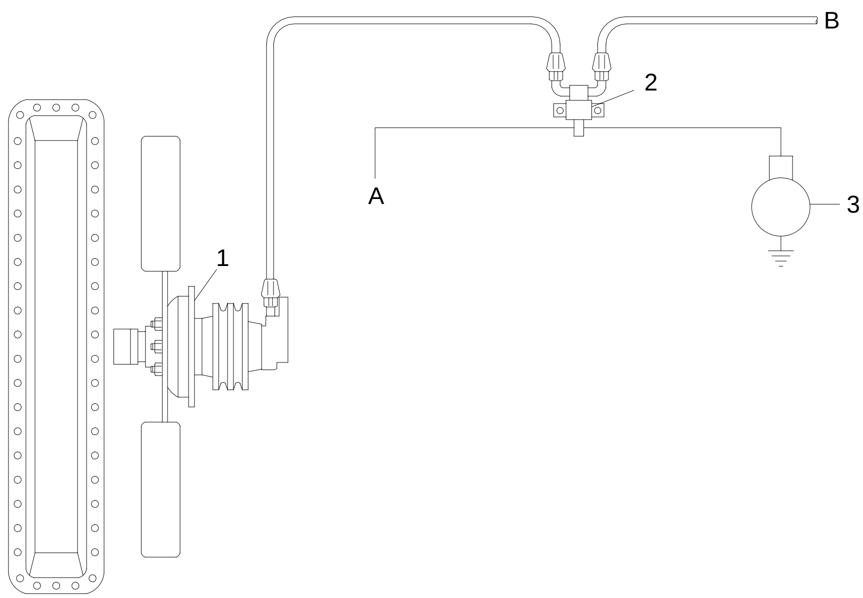
Table 1, Fastener Torques

General Information

The fan drive is a temperature-controlled, air-operated clutch for the engine cooling fan. Its purpose is to maintain engine temperature by engaging or disengaging the fan. For the specific coolant temperatures that turn the engine fan on, refer to **Section 20.00**.

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. See **Fig. 1**.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve. See **Fig. 2**.



A. To the circuit breaker.

B. From the secondary air tank.

1. Fan Clutch
2. Solenoid Valve
3. Temperature Switch

Fig. 1, Fan Clutch Piping and Wiring (vehicle without air conditioning)

Kysor K22RA

Internal spring pressure engages the Kysor fan clutch when the coolant temperature is above the specified temperature range; internal air pressure disengages the fan clutch when the coolant temperature drops below that range.

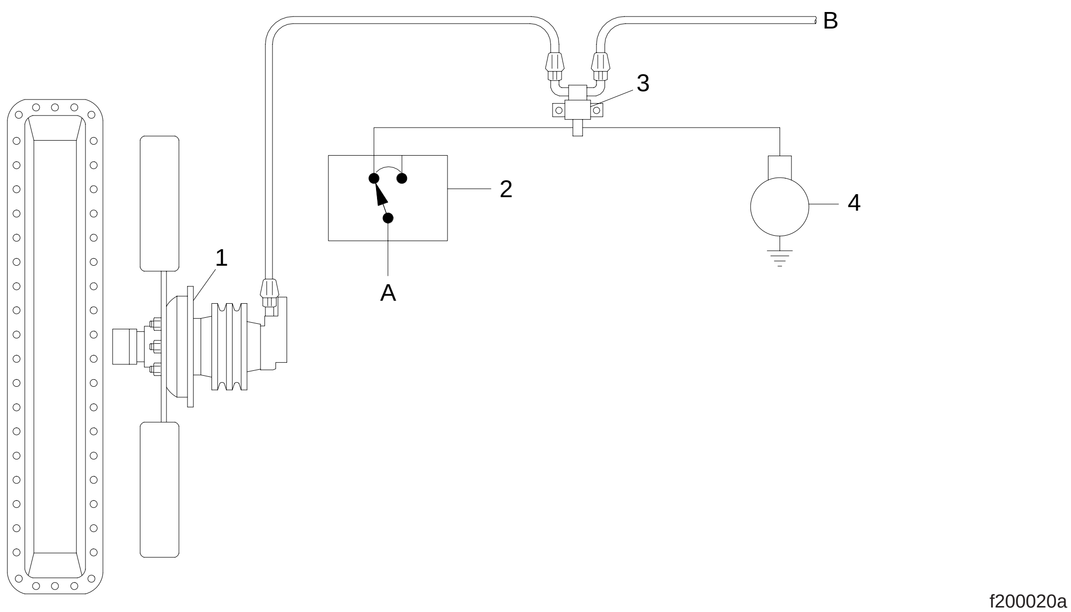
With the Kysor fan clutch, when you start a cold engine, the solenoid valve releases air pressure to the cylinder, and the fan clutch remains disengaged. The fan does not turn.

When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve stops the flow of compressed air to the fan clutch. A spring within the fan engages the clutch, and the fan turns.

When the coolant temperature drops to the temperature switch cutoff setting, the solenoid releases compressed air to the clutch, and the clutch disengages.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which stops air flow and allows the internal spring to engage the fan clutch.

General Information



A. To the circuit breaker.
B. From the secondary air tank.

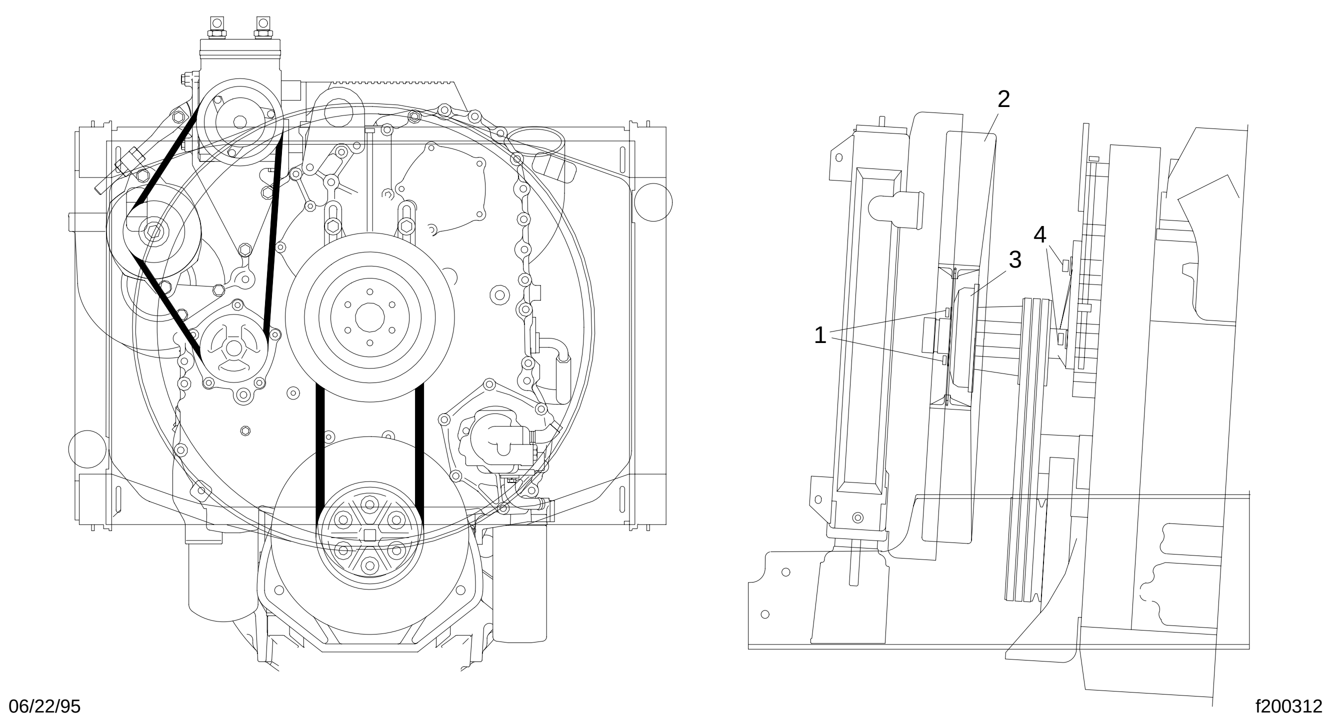
1. Fan Clutch
2. Fan Cycling Switch at the Receiver-Drier
3. Solenoid Valve
4. Temperature Switch

Fig. 2, Fan Clutch Piping and Wiring (vehicle with air conditioning)

Fan Clutch Removal and Installation, Kysor K22RA

Removal

NOTE: See **Fig. 1** for this procedure.



1. Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Flanged Bolt, M12 x 35 mm, grade 10.9; Washer

Fig. 1, Kysor Fan Clutch (Detroit Diesel Series 60 engine)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

WARNING

Always wear protective equipment such as goggles or a face shield when working with air lines that may contain pressure.

Be careful when loosening the air line fitting; the line could contain high residual air pressure. If quickly disconnected the line may whip, or it may blow out compressed air, dirt or sludge with sufficient force to damage eyes, or cause other personal injury.

3. Disconnect the air line from the fan clutch.
4. If necessary to tilt the radiator forward to gain sufficient clearance, remove the support struts from the top of the radiator.

   With one person holding each side of the radiator, tilt the top of the radiator forward.
5. With the radiator tilted forward, remove the fan. For instructions, refer to **Section 20.01** in this workshop manual.

WARNING

If the fan clutch engages during the next step, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (620 and 827 kPa) of air pressure.

Fan Clutch Removal and Installation, Kysor K22RA

6. Align the access holes in the fan clutch with the allen screws on the fan hub. See **Fig. 2**.

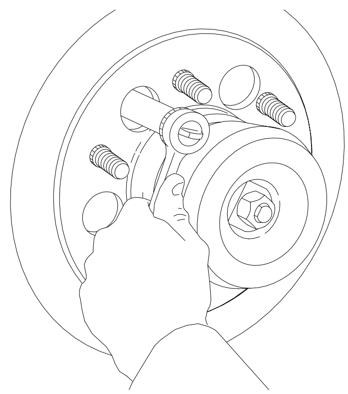


Fig. 2, Line Up the Access Holes

 6.1 Using shop air and a suitable nozzle attachment, apply between 90 and 120 psi (620 and 827 kPa) of air pressure to the fan clutch to disengage the clutch.

 6.2 Line up the access holes

7. Remove the air pressure from the fan clutch, and allow the fan to engage.
8. Remove the allen screws holding the fan clutch to the fan hub.
9. Remove the fan clutch from the fan clutch hub. It may be necessary to gently pry the clutch from the hub.

Installation

IMPORTANT: A new coupler must be used when installing the clutch onto the hub.

1. Install the fan clutch onto the fan clutch hub.

 1.1 Install a new coupler onto the fan hub.

 1.2 Position the fan clutch onto the fan hub, then push it toward the rear of the vehicle and rotate the clutch until the flats of the coupler engage the fan clutch.

 1.3 Line up the access holes in the clutch with the holes for the allen screws in the clutch hub.

 1.4 Install the allen screws, and tighten them 44 lbf·ft (60 N·m).

2. Install the fan. For instructions, refer to **Section 20.01**.
3. If the radiator was moved forward, position the radiator flat on its mounts, and connect the support struts to the top of the radiator. For instructions, refer to **Section 20.01** in this workshop manual.
4. Connect the air line to the fan clutch.
5. Lower the hood.

Fan Clutch Minor Rebuild, Kysor K22RA

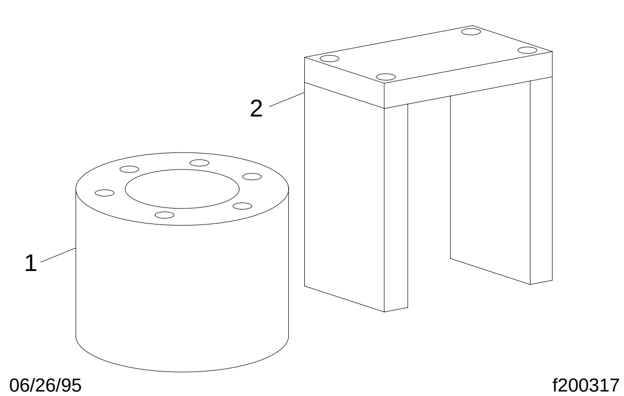
Special Tools

IMPORTANT: Special tools are are recommended, but not required for this procedure. See **Table 1** for the special tool set.

Special Tools		
Description	**Part Number**	**Order From**
Support and Compressor (see **Fig. 1**)	1090-00000-02	Wright Brothers Enterprises 8171 Hibma Marion, MI 49665 Telephone: 231-825-2939

Table 1, Special Tools

Rebuild



1. Support
2. Compressor

Fig. 1, Special Tools

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the fan clutch from the vehicle. For instructions, refer to **Subject 100**.

NOTICE

When caging and compressing the engagement spring of the fan clutch, depress the clutch shaft only enough to relieve the pressure on the retaining plates (about 1/16-inch, or 1.5 mm). Applying additional force after the clutch shaft bottoms in the housing will damage the housing and render it unserviceable.

NOTE: There are two methods of caging the engagement spring. One uses the special tools and a press. The other uses carriage bolts, washers, and wingnuts. Either method is effective.

3. Cage the engagement spring.

   If using the special support and compressor tools, place the fan clutch in a press to cage the engagement spring. See **Fig. 2**.

   If using the optional method of caging the engagement spring, do the following:

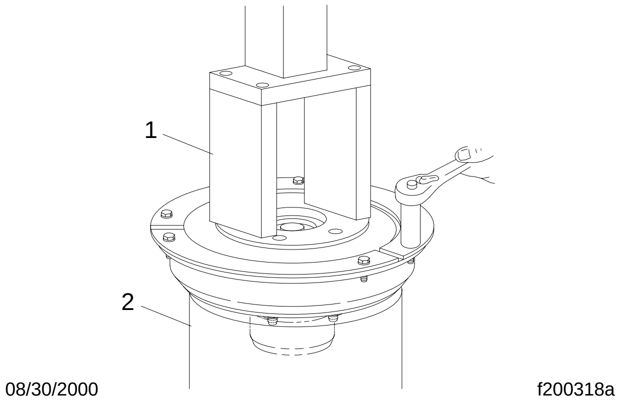
   3.1 With the access holes in the housing assembly aligned with those in the shaft assembly, install two 3-1/2-inch (89-mm) long carriage bolts and suitable washers on opposite sides of the clutch assembly.

   3.2 On the shaft assembly side, install about a 1/2-inch (13-mm) thickness of washers onto each carriage bolt.

   3.3 Install a wingnut on the end of each carriage bolt and tighten the wingnuts evenly until the engagement spring is caged.

4. Remove the lining retaining plates and the lining. See **Fig. 2** and **Fig. 3**.

Fan Clutch Minor Rebuild, Kysor K22RA



1. Compressor Tool
2. Support Tool

Fig. 2, Caging the Engagement Spring and Removing the Lining Retaining Plates

NOTICE

Do not press on the cylinder during this step, or the cylinder will be damaged. Use a 5/8-inch wrench as shown in Fig. 4 on the piston rod flats.

5. If applicable, turn the clutch over in the press, and use the special compressor tool to cage the engagement spring while removing the cylinder nut and cylinder. See **Fig. 4**.
6. Inspect the fan clutch. See **Fig. 3**
   6.1 Inspect the two surfaces where the lining rides.
   6.2 Inspect the needle bearing race on the shaft.
   6.3 Inspect the needle bearings inside the clutch housing.
   6.4 Inspect the piston bearing by rotating the piston.
7. If you find cracking or scoring on any surface, or if the bearings are rough, loose, or missing, replace the fan clutch.

NOTE: If you find metal particles in the existing grease, replace the fan clutch or contact Kysor for the training needed to perform a major fan clutch rebuild. Kysor will not provide parts for a major rebuild until the technician has completed rebuild training provided by Kysor.

IMPORTANT: Do not wash the clutch parts in solvent.

8. Using **Fig. 3** as a reference, lubricate the following rebuild parts with lubricant supplied with the rebuild kit (if the lubricant is unavailable, use one of the approved lubricants listed in **Specifications, 400)** :
   - The piston seal (pack the seal groove also)
   - The dust seal (pack the seal groove also)
   - The needle bearings inside the housing
   - The inside of the engagement spring
   - The outside of the piston rod assembly
   - The inside of the piston rod assembly
   - The inside of the cylinder assembly
   - Pack the lip of the grease seal

NOTICE

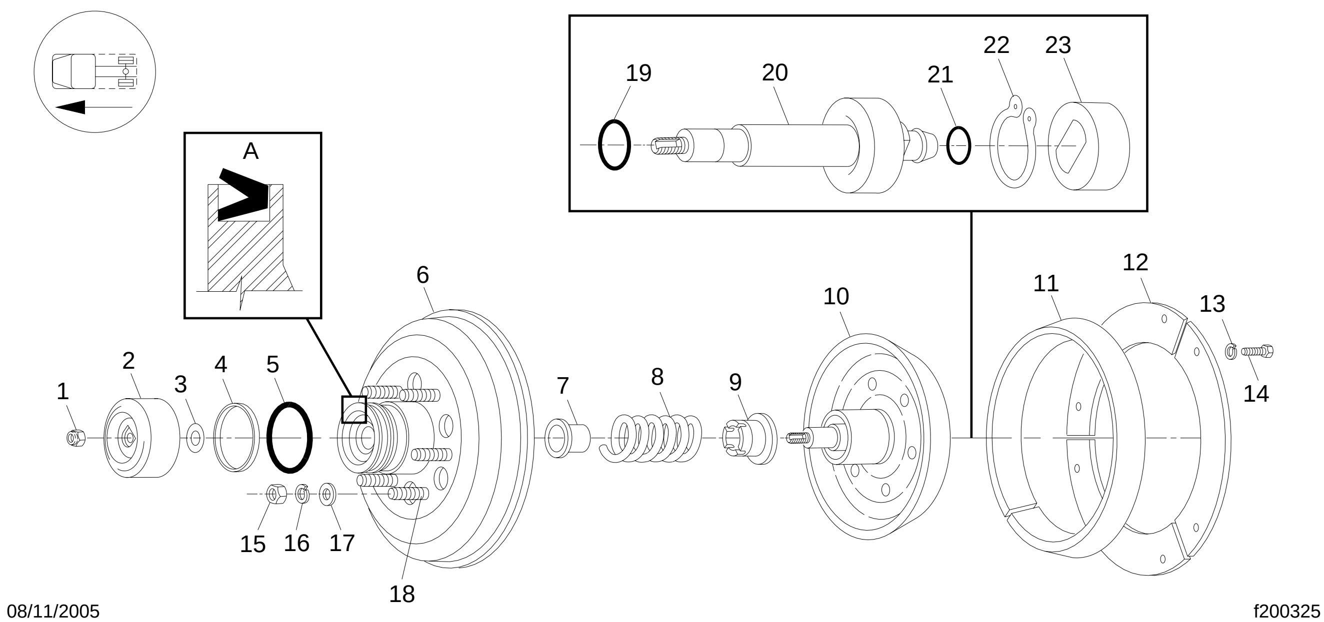
When caging the engagement spring, make sure the bottom edges of the housing assembly and the shaft assembly are flush and aligned all the way around. Failure to do so will cause the engagement spring pressure to affect the torque of the cylinder nut. This could result in the cylinder nut not being tight enough to effectively compress the piston seal washer, which could cause leakage and eventual fan clutch failure.

IMPORTANT: When caging the engagment spring, compress the clutch shaft only 1/16-inch (1.5 mm).

9. Assemble the fan clutch parts according to **Fig. 3**. Using either the special tools and a press, or carriage bolts, washers, and wingnuts, cage the engagement spring when installing the cylinder and lining. Be careful to depress the clutch shaft only 1/16-inch (1.5 mm).

   The piston rod seal washer is the last item to install before the cylinder goes on. See **Fig. 5**.
10. Tighten the cylinder nut 84 lbf·in (940 N·cm).
11. Tighten the lining screws 30 lbf·in (340 N·cm).

Fan Clutch Minor Rebuild, Kysor K22RA



A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

Fig. 3, Kysor K22RA Fan Clutch (exploded view)

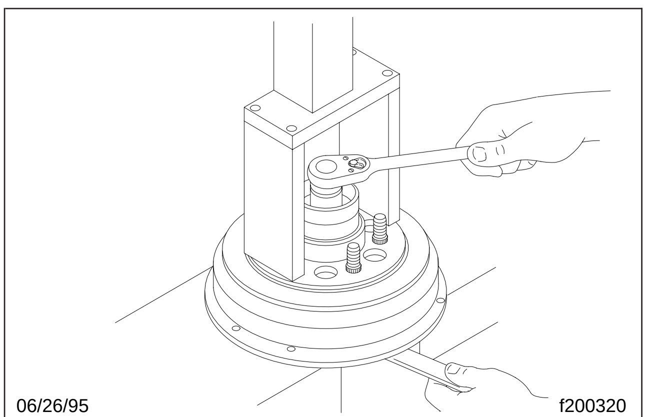


Fig. 4, Removing the Cylinder Nut and Cylinder

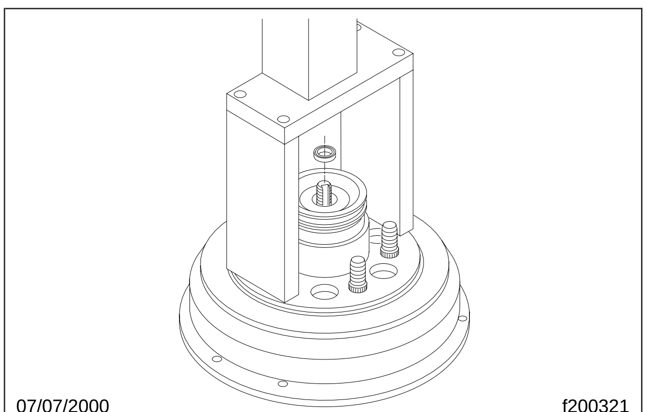


Fig. 5, Installing the Piston Rod Seal Washer

Fan Clutch Minor Rebuild, Kysor K22RA

12. As applicable, remove the fan clutch from the press or remove the carriage bolts, washers, and wing nuts.
13. Check the front-to-rear travel of the fan clutch. For instructions, refer Group 20 in the *Columbia Maintenance Manual*.
14. Install the fan clutch on the engine. For instructions, refer to **Subject 100**.
15. Close the hood and remove the chocks from the tires.

Fan Clutch Relining, Kysor K22RA

Relining

IMPORTANT: Premature wearing of the fan clutch lining is due to either insufficient air pressure necessary to fully disengage the clutch (allowing the clutch to remain partially engaged, thus increasing wear), or a problem in the control circuit for the fan. Before putting the fan clutch back in service, check the fan control and air supply systems and make any necessary repairs.

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the tires.

WARNING

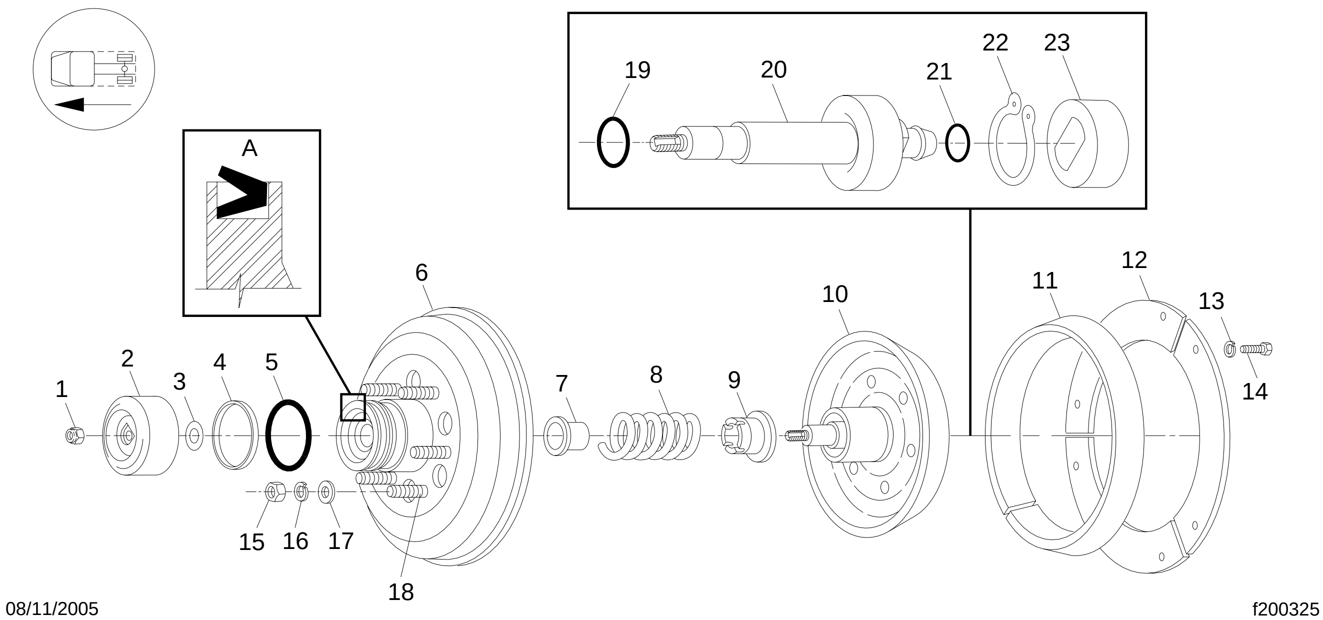
If the fan clutch engages during the next step, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (620 and 827 kPa) of air pressure.

2. Bleed all the air from the primary and secondary tanks.
3. Disconnect the air line from the fan drive, and apply 90 to 110 psi (620 to 760 kPa) shop air pressure to the fan drive.
4. Remove the six lining plate screws, and remove the three lining plates. See **Fig. 1**.
5. Remove the old lining. If the lining sticks, use a hammer and a screwdriver to free it by tapping on the dividing cut in the lining.
6. Inspect the clutch shaft. If lining residue is present, or if the surface appears glazed over (non-metallic), temporarily release the air pressure from the clutch to allow shaft to protrude, and use a ScotchBrite to break the glaze.

NOTE: Some applications may be too tight to spread the lining and slip it over the pulley. If necessary, the lining can be cut in half with a hacksaw for installation.

7. Apply air pressure to the clutch again, and install the new lining. See **Fig. 2**.
8. Install the new lining plates. Tighten the screws 30 lbf·in (340 N·cm).
9. Remove the air pressure from the fan clutch, and allow the fan to engage.
10. Disconnect the shop air, and connect the air line to the fan drive.

Fan Clutch Relining, Kysor K22RA



A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

Fig. 1, Kysor K22RA Fan Clutch (exploded view)

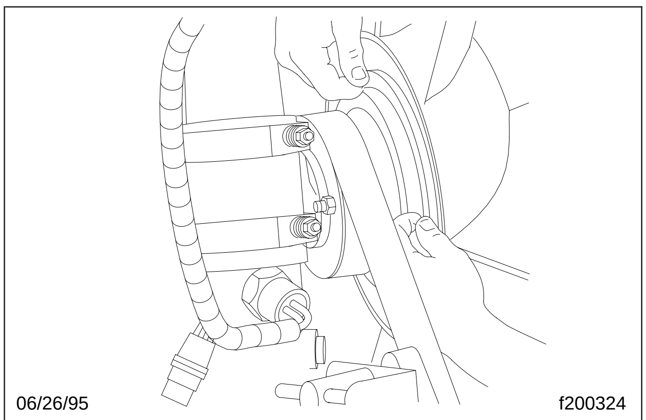


Fig. 2, Removing the Lining Plates

Troubleshooting Tables

Problem—The Fan Clutch Fails to Engage

Problem—The Fan Clutch Fails to Engage	
Possible Cause	**Remedy**
There's no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.

Problem—The Fan Clutch Does Not Disengage

Problem—The Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn't allow air to vent from the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.
The piston friction disc is seized due to contamination or worn splines.	Reline or replace the piston friction disc, and make sure the fan clutch air supply is clean.

Problem—The Fan Clutch Cycles Frequently

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed. For fan clutch control settings, refer to **Section 20.00**.
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting. Check the ACPU switch and unit.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The engine temperature is too high.	Check the programmable engine control parameters, and reprogram as needed.
The temperature switch is malfunctioning.	Replace the temperature switch.

Troubleshooting

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Problem—The Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section, **Section 20.00**.

Specifications

If the lubricant that comes with the rebuild kit for the Kysor K22RA fan clutch is unavailable, use one of the following approved lubricants:

- Aeroshell 5
- Shell Alvania R3
- Chevron SR12
- Amoco Rykon Premium #2EP
- Texaco RB Premium

Kysor K22RA Fan Clutch Torques		
Description	Torque	
	lbf·ft (N·m)	lbf·in (N·cm)
Clutch-to-Hub Fasteners	45 (61)	—
Fan-to-Clutch Fasteners	26 (35)	—
Front Piston Nut	—	84 (950)
Lining Plate Screws	—	30 (340)

Table 1, Kysor K22RA Fan Clutch Torques

General Information

An engine block heater keeps the engine coolant about 80°F (27°C) warmer than the ambient air temperature. In cold weather, the heater helps engine starting and reduces wear on the piston walls.

When starting the engine, the diesel normally ignites on the compression stroke of each piston, when the compressed air within the cylinder reaches about 725°F (385°C). However, during cold weather starts, the heat of the compressed air dissipates into the surrounding engine block so the diesel may never reach the temperature it needs to ignite. Using the engine block heater, the engine block is already warm so heat is held in the cylinder to ignite the diesel. To reduce engine wear, the block heater warms the oil film on the piston walls and reduces piston drag caused by cold oil film.

The heater consists of an element that bolts into the side of the engine water jacket. See **Fig. 1**. A cord plugs into the outside end of the element, and the cord runs to a plug below the front bumper.

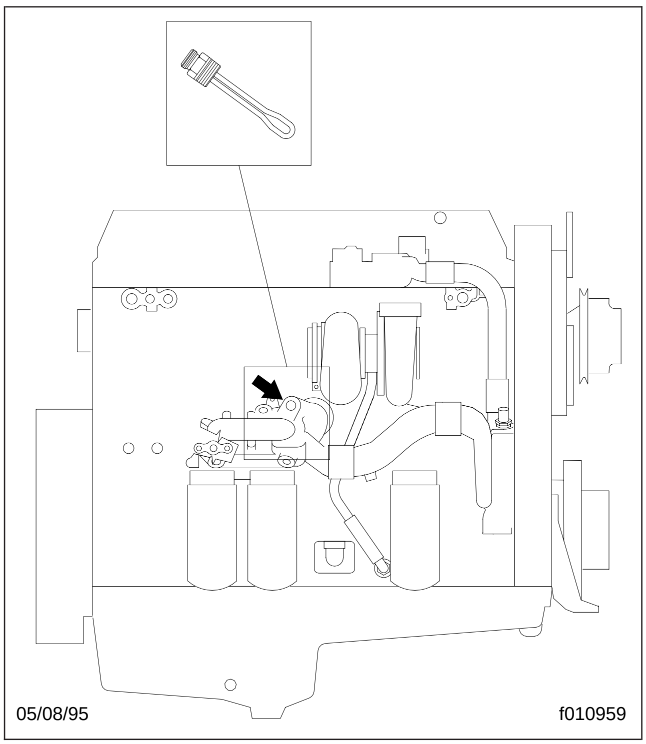


Fig. 1, Block Heater Element Installation (Detroit Diesel Series 60 engine)

To turn on the heater, connect the heater cord to a power source. The element has no thermostat. Heat dissipating from the engine block prevents coolant overheating.

Block Heater Element Replacement

Removal

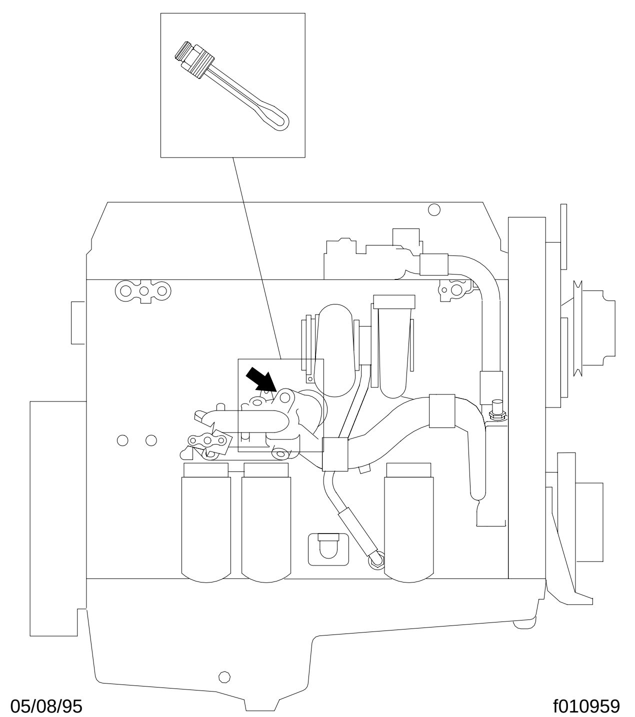


Fig. 1, Block Heater Element Installation (Detroit Diesel Series 60 engine)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the radiator. For instructions, refer to **Section 20.01**.
4. If applicable, unscrew the threaded cover that secures the cord to the element. See **Fig. 1** .
5. Pull the cord off the element.
6. Remove the element from the engine block by loosening the jam nut (if applicable) and uscrewing the element from the engine block.

Installation

1. Position the heater element in the engine block.

   Coat the threads of the element with a small amount of sealant. For the approved sealants, refer to **Specifications, 400**.
2. Secure the heater element in the engine block by screwing the element into the engine block hand tight, then use a wrench to turn the element 1-1/2 turns more.
3. Plug the cord into the element and (if applicable) secure it by screwing the threaded cord cover in place.
4. Fill the cooling system. For instructions, refer to **Section 20.01**.
5. Start the engine and check for leaks. Repair any leaks as necessary. Run the engine for half an hour to purge any air from the coolant system.
6. To test the heater, plug a wattmeter into a power source, and connect the heater cord to the meter. A reading on the meter will indicate the heater is working.

Troubleshooting

Use the following procedures to check for the most common engine block heater problems.

WIRING PROBLEMS

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Unscrew the threaded cover that secures the cord to the element. Pull the cord off the element.
4. Using an ohmmeter, check the continuity between the two poles of the element. The resistance should be very low, typically between 9 and 10 ohms. If there is no reading, the element has burned out, and if the reading is very high, the element is about to burn out.
5. If the element is good, check the cord. Plug the cord into the element and secure it by screwing the threaded cover in place.
6. Using an ohmmeter at the receptacle, check the continuity between the two power terminals. The resistance should be low, typically between 9 and 10 ohms. If there is no reading or a very high reading, the cord is damaged. Replace the cord.
7. Check the continuity between each power terminal and the ground terminal. There should be no ohmmeter reading. If there is a reading, replace the cord.
8. Check the ohmmeter reading between the ground terminal and a good vehicle ground. The reading should be zero. If not, replace the cord.

FOULED ELEMENT

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the radiator. For instructions, refer to **Section 20.01** in this manual.
4. Unscrew the threaded cover that secures the cord to the element. Pull the cord off the element.
5. Remove the element from the engine block. For instructions, refer to the **Subject 100** in this service manual section.
6. Inspect the element for residue deposits, discoloration, or damage.

   Coolant dye residue indicates the coolant solution contains too much antifreeze. Replace the element, and refer to the vehicle maintenance manual for the recommended antifreeze/water ratio.

   Gray or black residue indicates anti-leak coolant additives have been added to the system. Replace the element, and refer to the vehicle maintenance manual for the recommended coolant additives.

   Blue or black discoloration on the element indicates the coolant system needs more coolant. Replace the element, and fill the coolant system until coolant is visible in the surge tank sight glass.

   Holes in the element indicate the coolant solution contains too little antifreeze. The weak solution is boiling inside the engine block and causing pitting of the element and block. Replace the element, and refer to the vehicle maintenance manual for the recommended antifreeze to water concentrations.

   For element installation instructions, refer to **Subject 100** in this service manual section.

Specifications

APPROVED SEALANTS

- Loctite 567
- Henkel 790 Pipegrip
- Perma-Loc LH-150

General Information

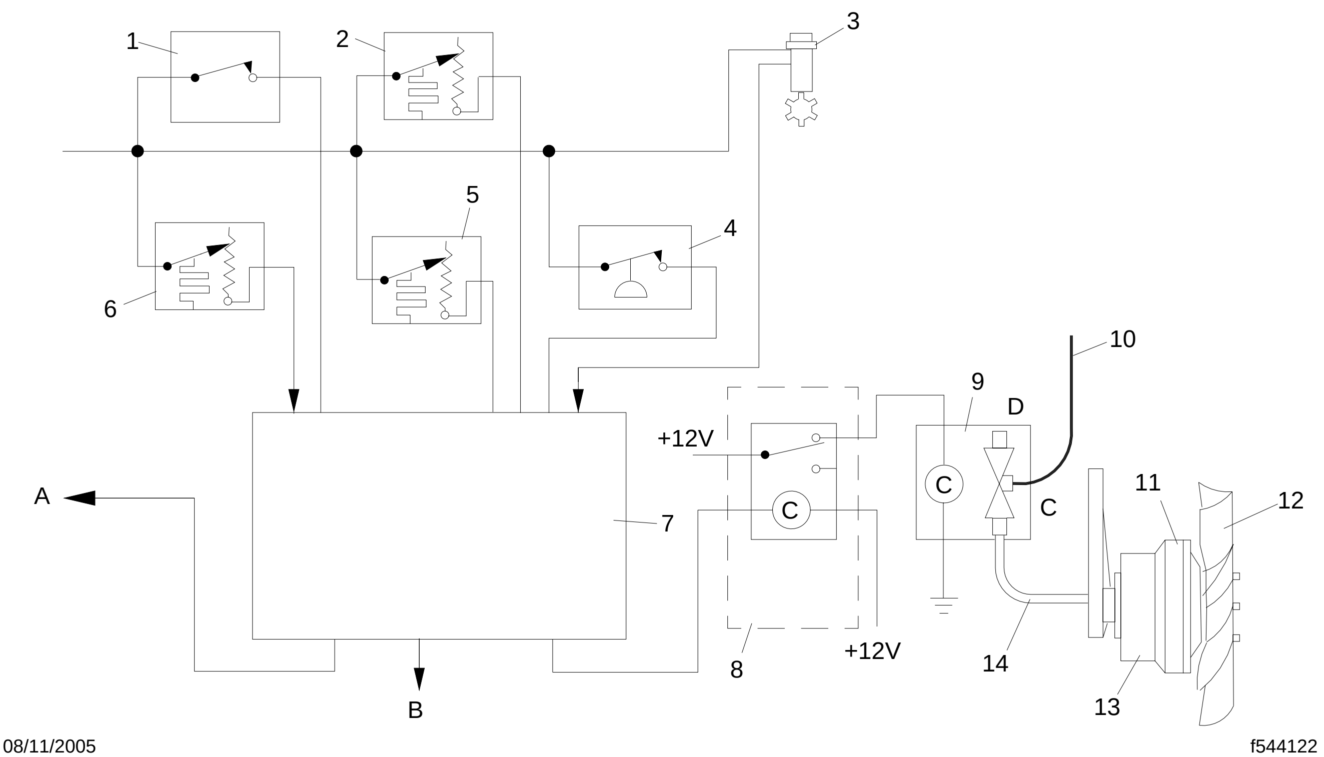
The Horton DriveMaster® fan clutch is a temperature-controlled, air-operated clutch for the engine cooling fan. It is spring engaged, and controls the engine temperature by engaging or disengaging the fan.

When the coolant temperature is below a specified range, air pressure keeps the fan disengaged to save engine power. When the coolant temperature rises above the specified range, air pressure to the fan clutch is cut off and internal spring pressure engages the fan.

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch installed in the thermostat housing. The temperature switch is connected to the engine ECM, which controls the solenoid valve. See **Fig. 1**. When you start a cold engine, the solenoid valve allows air pressure to the fan clutch and the clutch remains disengaged. When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve and the valve cuts off compressed air to engage the fan.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which cuts off air to the fan clutch, engaging the fan.

General Information



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

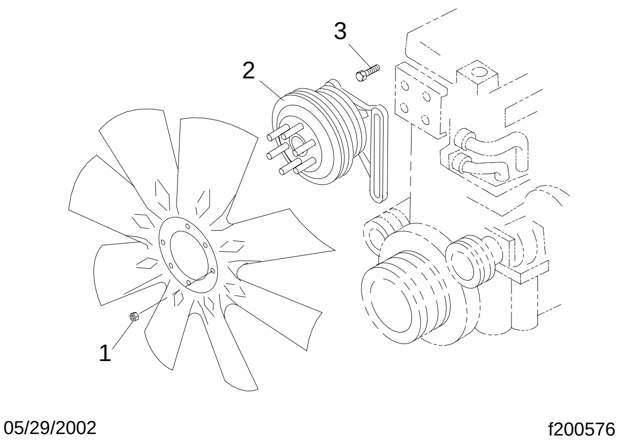
Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires.

WARNING

Wear safety goggles when draining the air system or disconnecting an air line because dirt and sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnected pressurized air lines, as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Drain the air tanks.
3. Tilt the hood.
4. Disconnect the left-side hose from the charge air cooler.
5. Remove the drive belts from the engine.
6. Disconnect the air line from the fan hub.
7. Remove the fan.
8. Remove the fan clutch assembly from the engine. See **Fig. 1**.



1. Hexnut
2. Fan Clutch Assembly
3. Hexbolt

Fig. 1, Fan Clutch Removal (typical)

8.1 If equipped with a metal fan ring, remove the two top fasteners holding the upper mounting bracket for the fan ring.

8.2 Remove the fasteners holding the fan clutch mounting bracket to the front of the engine.

WARNING

The fan clutch assembly may weigh up to 55 lbs. (25 kg). Be careful when lifting it. Use a helper or a hoist, if necessary. Failure to use care when lifting the fan clutch could cause the assembly to fall, which could result in injury or component damage.

8.3 Remove the fan clutch assembly from the vehicle. If equipped with a metal fan ring, carefully push the ring forward to allow removal of the fan clutch assembly.

Installation

1. Using either a helper or a hoist, position the fan clutch assembly in place on the front of the engine, aligning the holes in the mounting bracket with those in the front of the engine.
2. Install the fasteners.

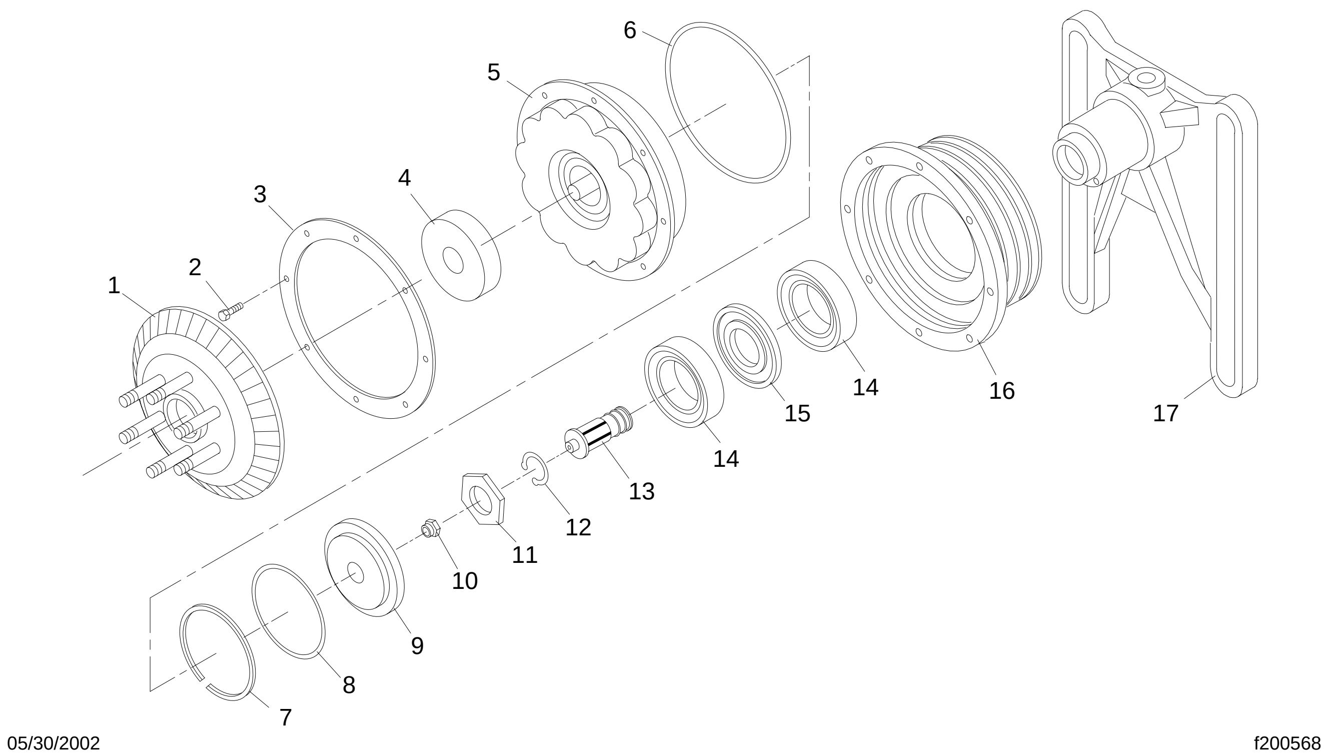
   If equipped with a metal fan ring, don't tighten the upper fan clutch fasteners completely.
3. Install the drive belts.
4. Connect the air line to the fan clutch.
5. Install the fan. Tighten the fan mounting nuts firmly.
6. Tighten the M8 fan-clutch mounting fasteners 15 lbf·ft (20 N·m).
7. Connect the left-side hose to the charge air cooler.
8. Lower the hood.
9. Remove the chocks from the tires.

Fan Clutch Major Rebuild

Disassembly

NOTE: This procedure involves a major rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Super Kit. If you are replacing just the seals or the air cartridge, see **Subject 120** for the minor rebuild procedure.

Refer to **Fig. 1** for this procedure.



1. Fan Mounting Disc
2. Torx®-Head Screw (8 qty.)
3. Friction Lining
4. Cage Nut (supplied with repair kit)
5. Spring Housing/Piston Assembly
6. Air Chamber Seal
7. Air Chamber Cap Retaining Ring
8. O-Ring
9. Air Chamber Cap
10. Face Seal
11. Bearing Nut
12. Air Cartridge Retaining Ring
13. Air Cartridge Assembly
14. Sheave Bearings
15. Bearing Spacer
16. Sheave
17. Journal Bracket

Fig. 1, Horton DriveMaster Fan Clutch

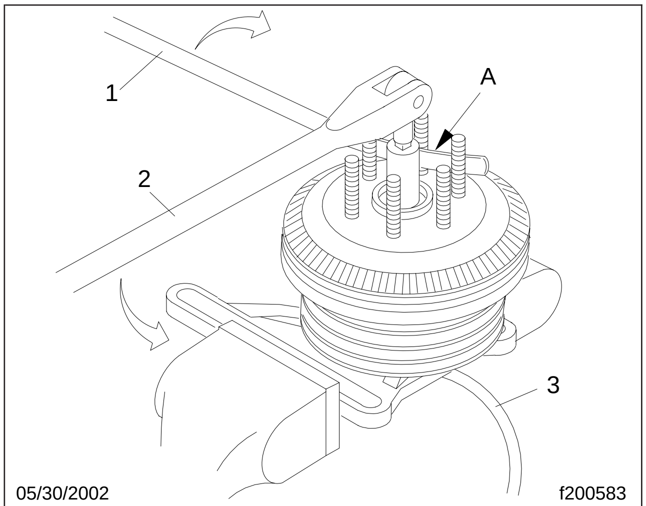
1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

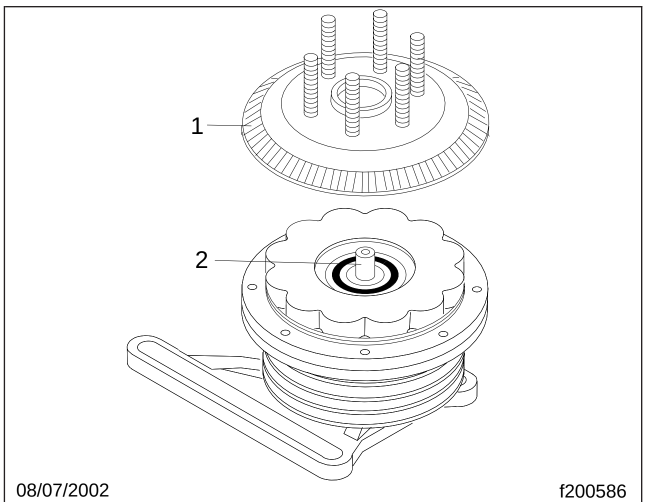
5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 2**.
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 3**

Fan Clutch Major Rebuild



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 2, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

Fig. 3, Fan Mounting Disc Removal and Installation

7. Inspect the fan mounting disc for wear or damage.

WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

8. Using a wrench and a T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

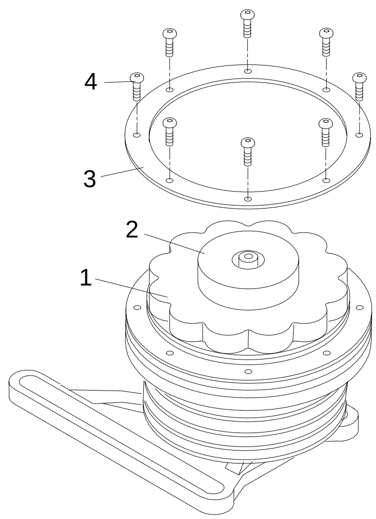
9. Release the air pressure from the fan clutch.

WARNING

Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 4**.
12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 5** .
13. Remove the air chamber seal. See **Fig. 6** .
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 6** .
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.
17. Remove the O-ring seal from the air chamber cap. See **Fig. 6** .
18. Remove the face seal. See **Fig. 6** .

Fan Clutch Major Rebuild



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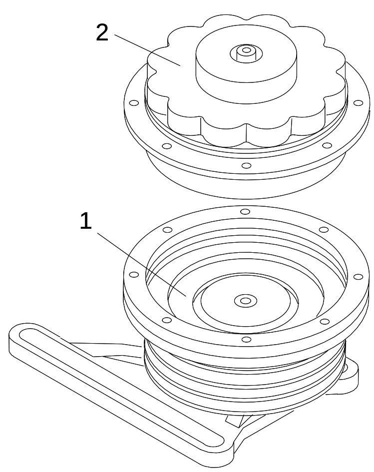
1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

Fig. 4, Friction Lining Removal and Installation



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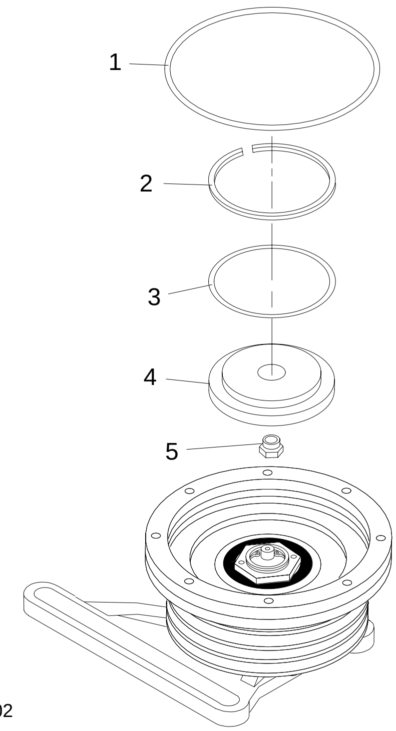
1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 5, Spring Housing/Piston Assembly Removal and Installation

19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system



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1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

Fig. 6, Air Chamber Seal Removal and Installation

20. Remove the bearing nut from the mounting bracket. See **Fig. 7** .
21. Remove the sheave from the mounting bracket. See **Fig. 8** .
22. If replacing the bearings, support the sheave and press them out.
23. Clean and remove any dirt, debris, or corrosion that may be present.
24. Remove the air cartridge.

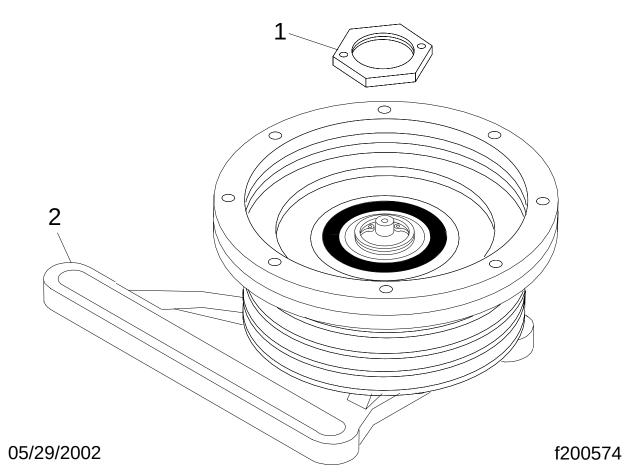
    24.1 Remove the retaining ring. See **Fig. 9**.

    24.2 Remove the air cartridge assembly. See **Fig. 10** .

Assembly

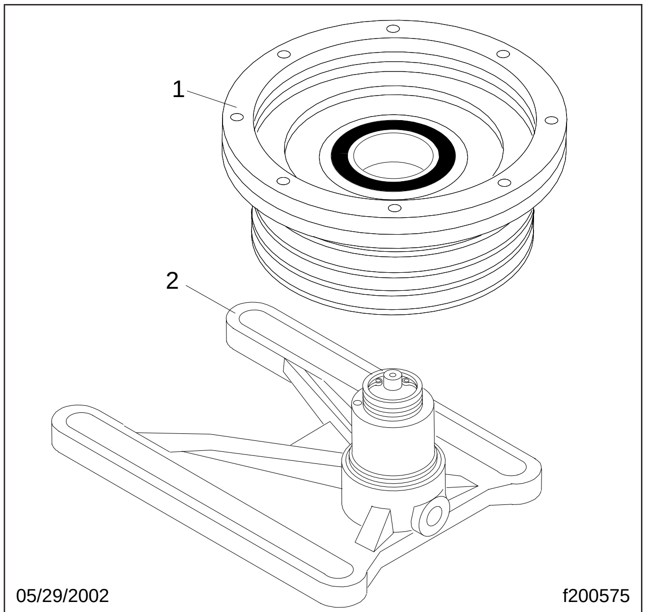
1. If necessary, clean the air cartridge bore in the mounting bracket.

Fan Clutch Major Rebuild



1. Bearing Nut
2. Mounting Bracket

Fig. 7, Bearing Nut Removal and Installation



1. Sheave
2. Mounting Bracket

Fig. 8, Removing the Sheave

NOTE: The sheave bearings do not require lubrication.

2. If replacing the sheave bearings, do the following:

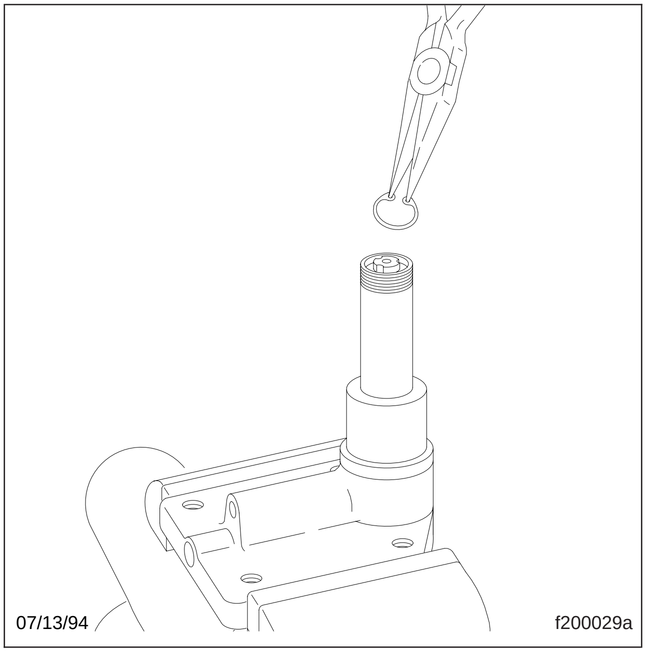
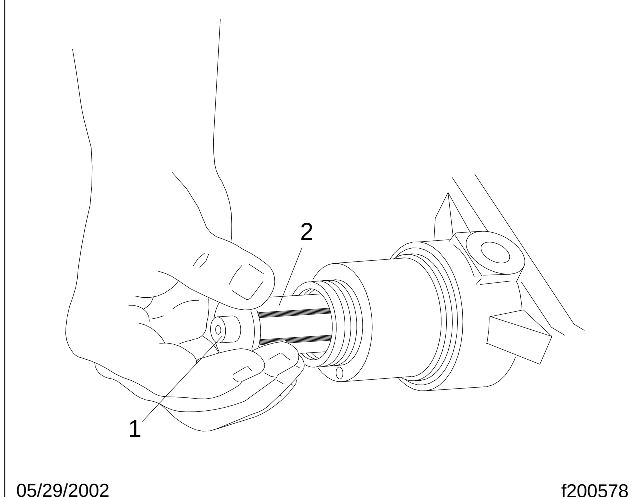


Fig. 9, Retaining Ring Removal and Installation



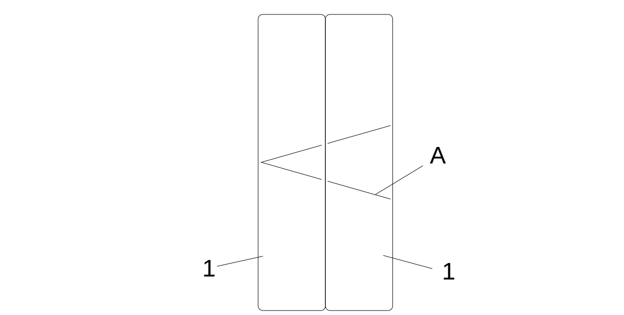
1. Float Seal Tip
2. Air Cartridge

Fig. 10, Removing the Air Cartridge

2.1 If equipped with two bearings, assemble the bearings so the markings on their edges line up to form an arrow. See

Fan Clutch Major Rebuild

Fig. 11 . It doesn't matter which way the arrow faces when the bearings are installed.



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A. Align the markings to form an arrow.
1. Sheave Bearing

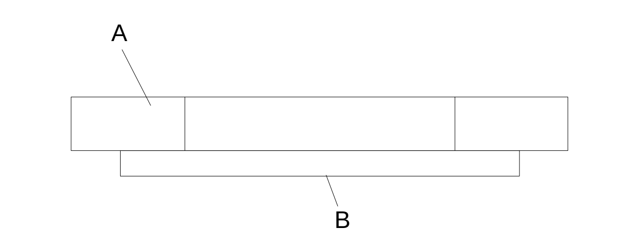
Fig. 11, Aligning the Bearings

IMPORTANT: If the fan clutch uses spacers, be sure to install them between the bearings.

2.2 Supporting the sheave, press the new sheave bearings — and spacers, if applicable — into place. Note the position of the lip inside the sheave.

2.3 Slide the sheave onto the mounting bracket. See **Fig. 8** .

2.4 Making sure that the bearing nut hex is facing up, install the bearing nut. See **Fig. 12** . Tighten 130 lbf·ft (176 N·m). See **Fig. 7** .



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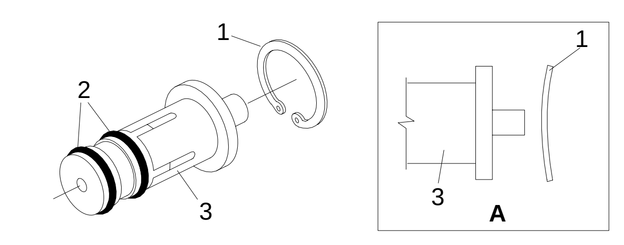
A. Hex faces up.
B. Relief faces toward mounting bracket and bearings.

Fig. 12, Correct Bearing Nut Orientation

3. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 13** .



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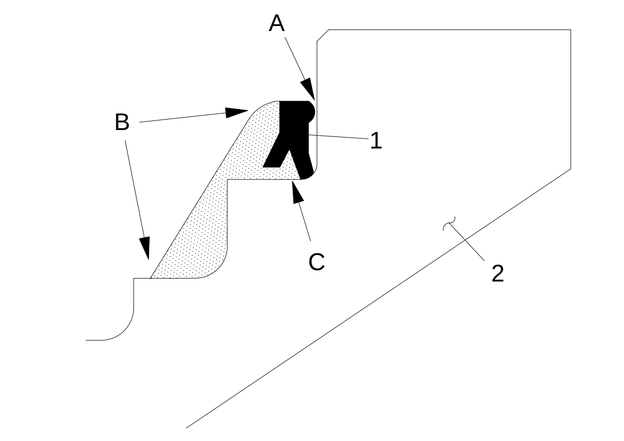
A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 13, Installing the Air Cartridge Retaining Ring

4. Install the new air cartridge assembly into the mounting bracket.
5. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 13** .
6. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
7. Assemble the air chamber cap and face seal. See **Fig. 6** .

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
8. Lubricate the O-ring seal with the fresh lubricant from the kit.
9. Install the O-ring seal on the air chamber cap. See **Fig. 6** .
10. Carefully set the air chamber cap into the sheave. See **Fig. 6** .
11. Install the retaining ring. See **Fig. 6** .
12. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 14** .
13. Lubricate contact surfaces with the fresh lubricant from the kit.

Fan Clutch Major Rebuild



A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down

1. Air Chamber Seal
2. Sheave

Fig. 14, Correct Installation of Air Chamber Seal (cross-section view)

WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.

14. Carefully set the new spring housing/piston assembly into position. See **Fig. 6** . Note that the new assembly has a cage nut installed on it.
15. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.

IMPORTANT: Handle the new friction liner by the edges to avoid contamination.

16. Set the new friction liner from the kit into place, being careful to touch only the edges.
17. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 4** . Tighten alternately 80 lbf·in (900 N·cm).
18. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
19. Remove the cage nut from the spring housing/piston assembly.
20. Install the new fan mounting disc from kit.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

21. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and push the pry bar counterclockwise.
22. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
23. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
24. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Disassembly

NOTE: This procedure involves a minor rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Seal Kit. If a major rebuild of the fan clutch is needed, see **Subject 110**.

1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 1**.
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 2**.
7. Inspect the fan mounting disc for wear or damage.

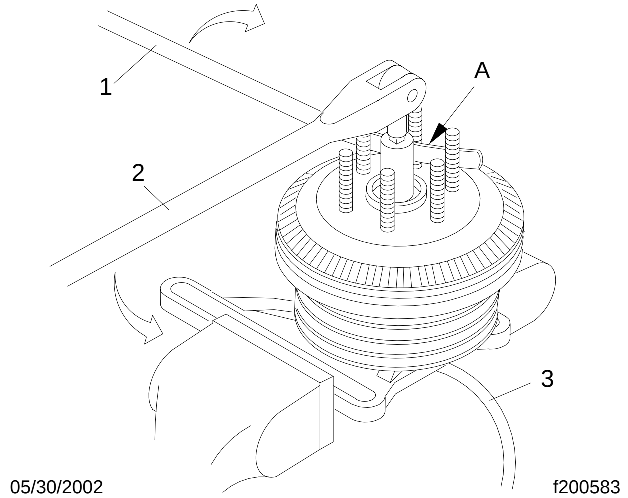
WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

8. Using a wrench and T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

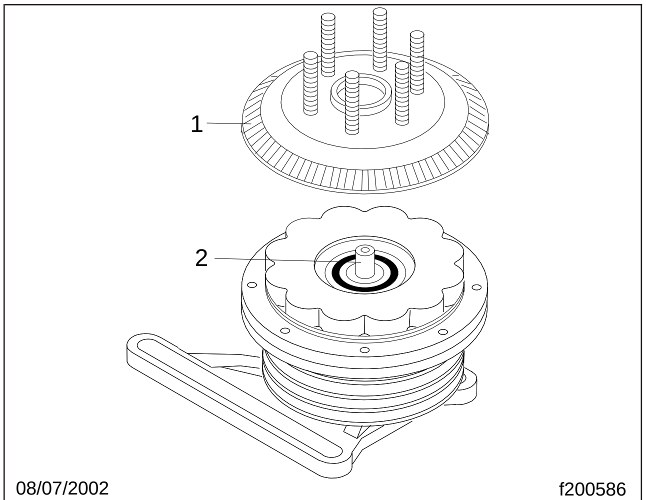
   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

9. Release the air pressure from the fan clutch.



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 1, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

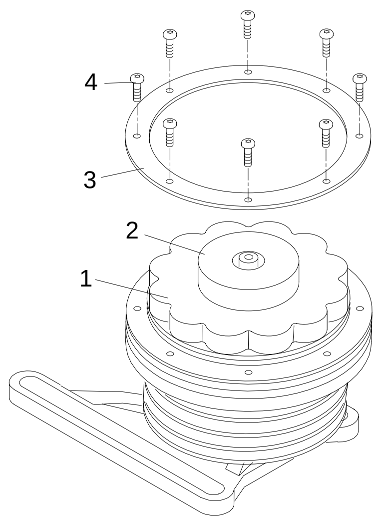
Fig. 2, Fan Mounting Disc Removal and Installation

Fan Clutch Minor Rebuild

⚠ WARNING

Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

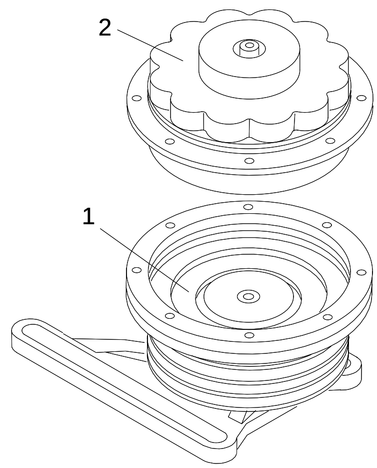
10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 3**.



1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

Fig. 3, Friction Lining Removal and Installation

12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 4** .
13. Remove the air chamber seal. See **Fig. 5** .
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 5** .
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.



1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 4, Spring Housing/Piston Assembly Removal and Installation

17. Remove the O-ring seal from the air chamber cap. See **Fig. 5** .
18. Remove the face seal. See **Fig. 5** .
19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system.
20. Remove the air cartridge.

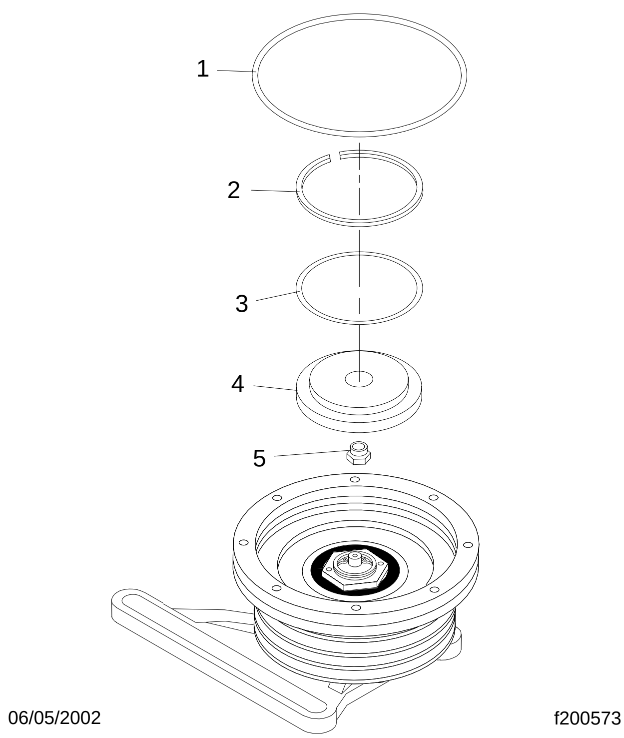
    20.1 Remove the retaining ring. See **Fig. 6**.

    20.2 Remove the air cartridge assembly. See **Fig. 7** .

Assembly

1. Clean the mounting bracket bore if necessary.
2. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 8** .
3. Install the new air cartridge assembly into the mounting bracket.
4. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 8** .

Fan Clutch Minor Rebuild



1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

Fig. 5, Air Chamber Seal Removal and Installation

5. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
6. Assemble the air chamber cap and face seal. See **Fig. 5** .

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
7. Lubricate the O-ring seal with the fresh lubricant from the kit.
8. Install the O-ring seal on the air chamber cap. See **Fig. 5** .
9. Carefully set the air chamber cap into the sheave. See **Fig. 5** .
10. Install the retaining ring. See **Fig. 5** .
11. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 9** .
12. Lubricate contact surfaces with the fresh lubricant from the kit.

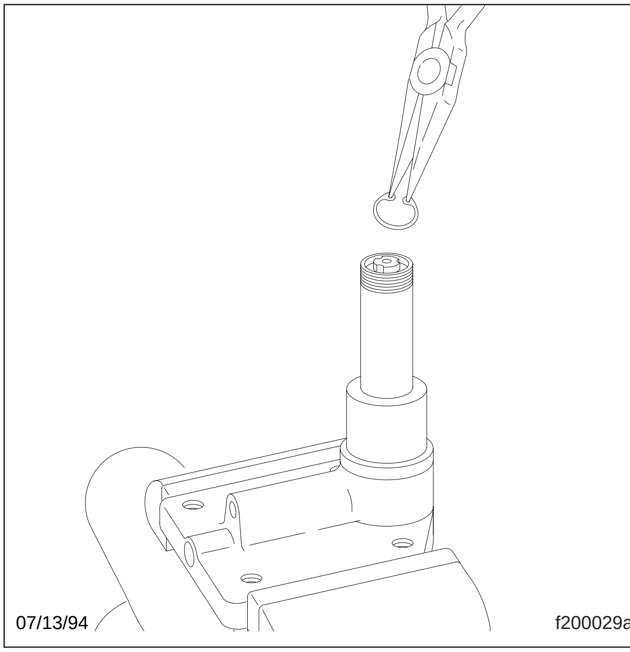
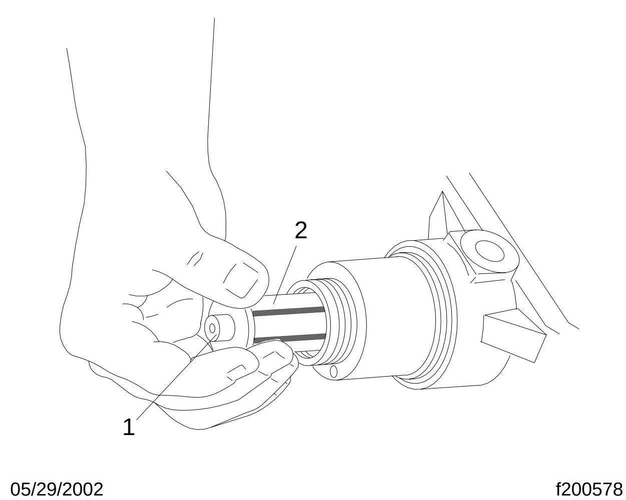


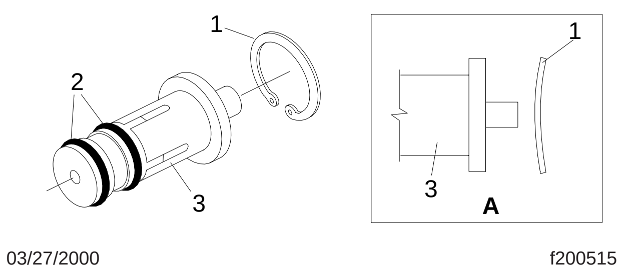
Fig. 6, Retaining Ring Removal and Installation (sheave not shown)



1. Float Seal Tip
2. Air Cartridge

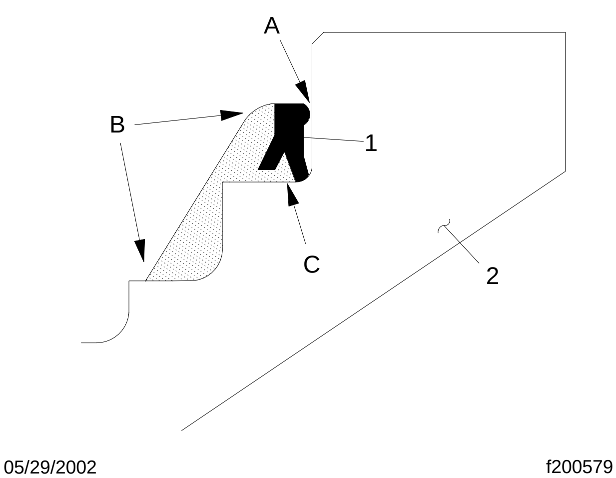
Fig. 7, Removing the Air Cartridge (sheave not shown)

Fan Clutch Minor Rebuild



A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 8, Installing the Air Cartridge Retaining Ring



A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down
1. Air Chamber Seal
2. Sheave

Fig. 9, Correct Installation of Air Chamber Seal (cross-section view)

WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.

13. Carefully set the new spring housing/piston assembly into position. See **Fig. 4** . Note that the new assembly has a cage nut installed on it.
14. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.
15. Set the friction liner from the kit into place, being careful to touch only the edges.
16. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 3** . Tighten alternately 80 lbf·in (900 N·cm).
17. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
18. Remove the cage nut from the spring housing/piston assembly.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

19. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and the pry bar counterclockwise.
20. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
21. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
22. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Troubleshooting Tables

Problem—Air Is Leaking from the Fan Clutch

Problem—Air Is Leaking from the Fan Clutch	
Possible Cause	**Remedy**
The face seal or air cartridge is damaged or worn.	Install a new seal kit.
The O-ring seals are damaged or worn.	Install a new seal kit.

Problem—The Fan Clutch Fails to Engage

Problem—The Fan Clutch Fails to Engage	
Possible Cause	**Remedy**
There’s no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.

Problem—The Fan Clutch Does Not Disengage

Problem—The Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn’t allow air supply to the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.
The piston is seized due to contamination or dry seals.	Clean the air supply. Do a major rebuild.

Problem—The Fan Clutch Cycles Frequently

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.

Troubleshooting

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting. Check the ACPU switch and unit.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The engine temperature is too high.	Check the programmable engine control parameters, and reprogram as needed.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Problem—The Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section, **Section 20.00**.

Specifications

Horton DriveMaster® Repair Kits		
Kit Description *	**Part Number**	**When Used**
Super Kit	HOR994347	Fan Clutch Major Rebuild
Seal Kit	HOR994346	Replacing Seals and Air Cartridge
Friction Disc Kit	HOR994348	Replacing Fan Mounting Disc and Friction Lining
Friction Liner Kit	HOR994349	Replacing Friction Lining Only

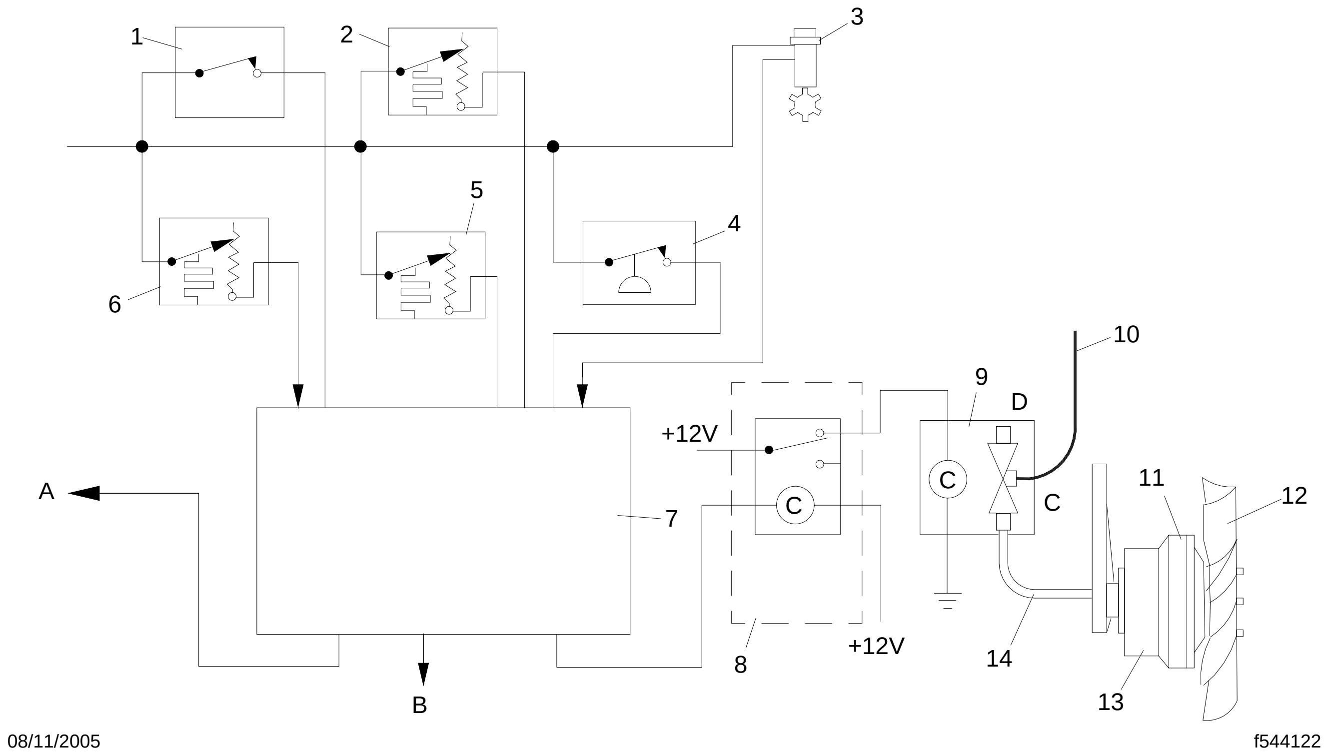
* All kits are available from the PDCs.

Table 1, Horton DriveMaster Repair Kits

Torque Values		
Description	**Torque**	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Friction Lining Screws	80 (900)	—
Face Seal	75 to 100 (850 to 1130)	—
Bearing Nut	—	130 (176)
Jack Bolt	—	100 (136)

Table 2, Torque Values

Specifications



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

General Description

Eaton® Fuller® Solo™ and Easy-Pedal™ 2000 clutches are pull-type clutches of a dry-disc design. They are both available in 15.5-inch (394-mm) dual-disc assemblies used in heavy-duty applications.

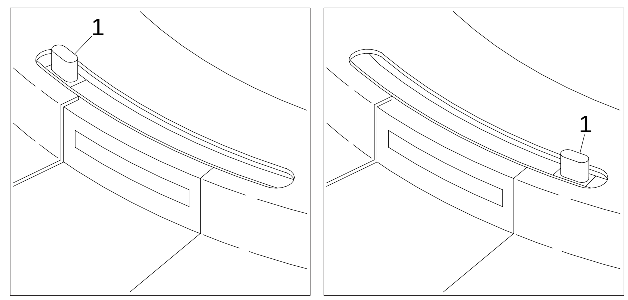
The intermediate plate separating the driven discs is carried on four lugs within the cover assembly, which is mounted on a flat flywheel. Four positive separator pins™ (roll pins) ensure an equal gap on all sides of the intermediate plate and increase the life of the clutch. Four return straps are attached to the cover assembly to retract the pressure plate when the clutch is disengaged.

Solo 15.5-Inch Clutch

Eaton Fuller Solo clutches are totally adjustment-free. See **Fig. 1**. As the clutch wears, its innovative wear-adjusting technology monitors clutch components and makes any necessary adjustments. The wear-adjusting technology comes from two sliding cams, which rotate to maintain the proper adjustment. Atop the upper cam, a wear indicating tab mirrors the cam's movement, letting you know when it's time to replace the clutch. See **Fig. 2**. This tab cannot be used as a mechanism for adjusting the clutch.

Heavy-duty Solo clutch discs are available in a standard configuration (see **Fig. 3**) and one optional configuration (see **Fig. 4**):

- Seven spring dampers with four ceramic facings are standard.
- Seven spring dampers with six ceramic facings and vibration control technology (VCT™plus) are optional.



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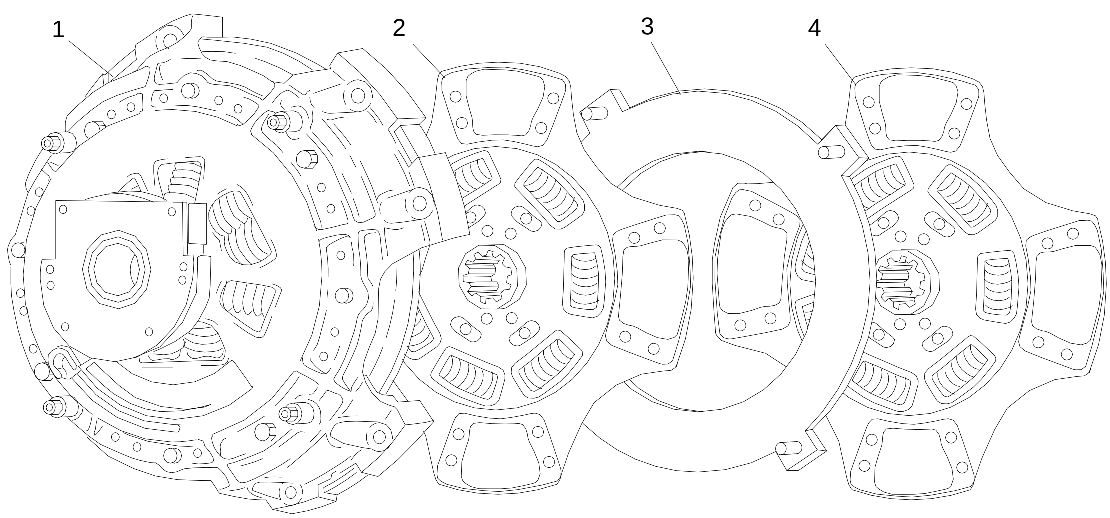
NOTE: "NEW" position on the left, "REPLACE" position on the right.

1. Wear Indicating Tab

Fig. 2, Wear Indicator



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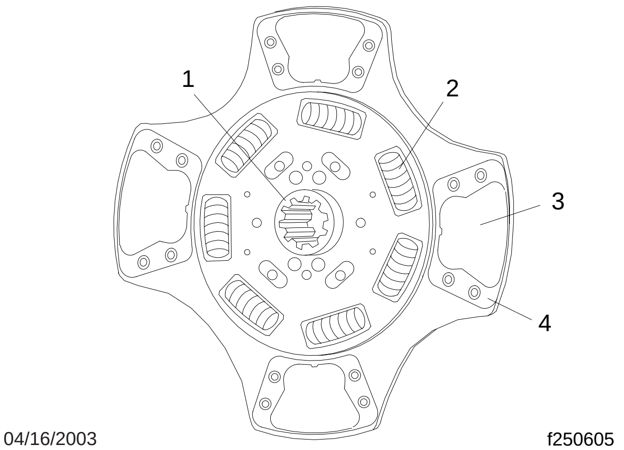
1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc

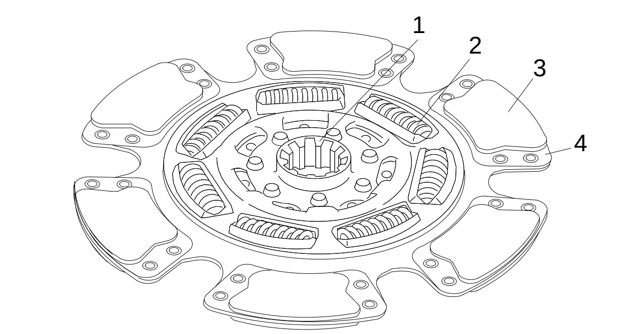
Fig. 1, Solo Heavy-Duty Clutch

General Information



1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 3, Driven Disc With Four Ceramic Facings



1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 4, Driven Disc With Six Ceramic Facings

NOTE: An earlier version of vibration control technology (VCT™) had a disc with six spring dampers and six ceramic facings. This disc has now been replaced by VCT™plus.

Modern high-torque engines require higher performance from a clutch. The extended-lube (XL-100) clutches have a special roller yoke and a ribbed release bearing housing that reduces bearing wear and extends the service interval for lubrication. XL-100 clutches are not available for Severe Service applications.

On older vehicles, clutch discs with eight, nine, or ten spring dampers may be installed. These older types of vibration dampers are not adequate for modern high-horsepower engines that operate at lower peak torques.

CAUTION

If your vehicle was originally equipped with six- or seven-spring discs, do not substitute eight- or ten-spring discs. This could cause excessive torsional vibration and component damage.

For clutch capacities, see the appropriate Solo clutch table in **Specifications, 400**.

Easy-Pedal 2000 15.5-Inch Clutch

Eaton® Fuller® Easy-Pedal 2000 clutches are easily adjustable using the Kwik-Adjust™ mechanism. See **Fig. 5**.

Easy-Pedal heavy-duty clutch discs are available in a standard configuration (see **Fig. 3**) and two optional configurations:

- Seven spring dampers with four ceramic facings. See **Fig. 3**.
- Seven spring dampers with six ceramic facings and vibration control technology (VCT™plus). See **Fig. 4**.

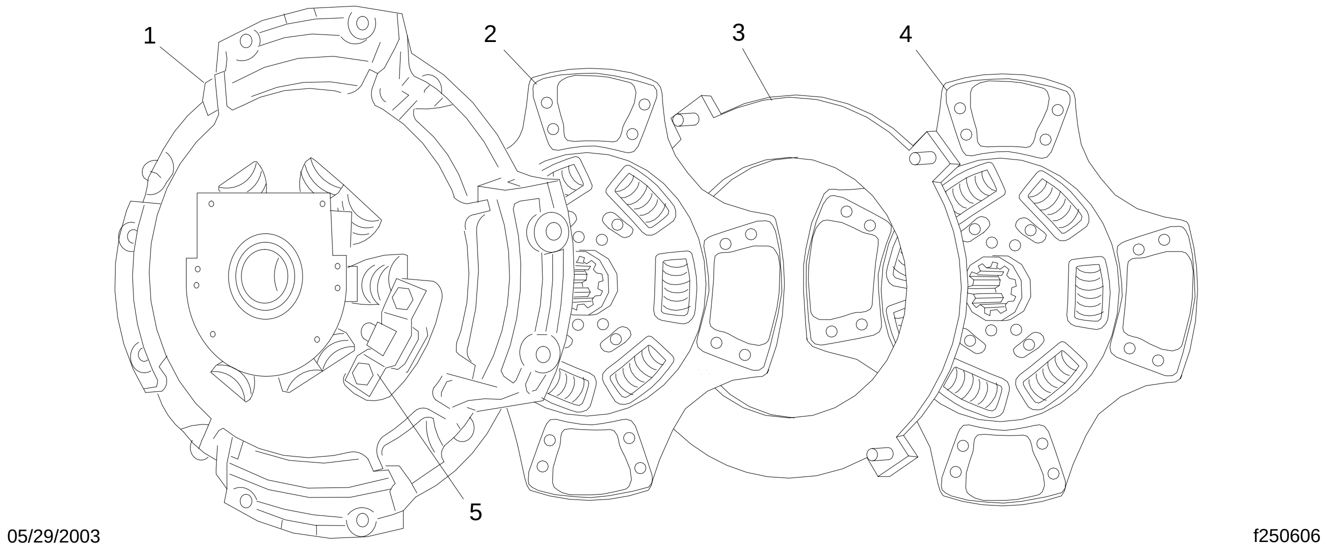
NOTE: An earlier version of vibration control technology (VCT) had a disc with six spring dampers and six ceramic facings. This disc has now been replaced by VCTplus.

On older vehicles, clutch discs with eight, nine, or ten spring dampers may be installed. These older types of vibration dampers are not adequate for modern high-horsepower engines that operate at lower peak torques.

CAUTION

If your vehicle was originally equipped with six- or seven-spring discs, do not substitute eight- or ten-spring discs. This could cause excessive torsional vibration and component damage.

Clutch capacity is indicated by the color code of the damper springs in the cover assembly. See the appropriate table for Easy-Pedal clutches in **Specifications, 400**.



1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc
5. Kwik-Adjust Mechanism

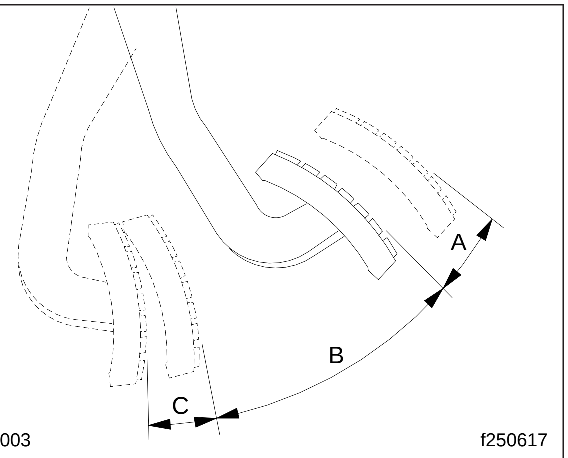
Fig. 5, Easy-Pedal Heavy-Duty Clutch

Principles of Operation

The primary purpose of the clutch is to transfer the power of the engine from the engine flywheel to the transmission. At the point where clutch engagement begins (clutch pedal partially released), the transmission input shaft may be stationary, as when the vehicle is not moving, or it may be rotating at a different speed than the flywheel, as in the case of upshifting or downshifting. Once the clutch is fully engaged (clutch pedal fully released), both the engine flywheel and the transmission input shaft will be rotating at the same speed.

The secondary purpose of the clutch is to damp unwanted vibrations that normally exist in the driveline system. The springs within each driven disc provide a flexible link between the friction surfaces and the disc hubs. Damped clutch discs are specifically designed to prolong the life of drivetrain components by reducing vibrations from the engine, non-uniform U-joint angles, and road dips and bumps.

When the clutch pedal is first pressed down, the first 1/2-inch to 1-inch (12.7 to 25.4 mm) of pedal movement (clutch free-pedal) causes the release yoke fingers to move into contact with the wear pads of the release bearing (release yoke free-travel). See Fig. 6. The release yoke pulls the release bearing away from the pressure plate inside the clutch cover. This compresses the pressure springs, allowing the driven discs to slip freely, and at a different speed from the drive discs.



A. Clutch Free-Pedal
B. Clutch Release-Pedal
C. Clutch Brake Squeeze

Fig. 6, Clutch Pedal Movement

Further downward movement of the clutch pedal (clutch release-pedal), causes the release bearing to move into contact with the clutch brake (release

General Information

bearing travel). The pressure springs force the pressure plate toward the engine flywheel, applying friction to the driven discs. Slippage occurs between the drive and driven discs because of the difference in their speeds.

In the last 1 inch to 1-1/4 inches (25 to 33 mm) of downward pedal movement, the clutch brake and the release bearing are pressed together (clutch brake squeeze). The friction between the discs increases, and the slippage and difference in speeds decreases. When the pedal is fully released, pressure and friction are sufficient to stop the discs from slipping. With no slippage, the driving and driven members turn at the same speed.

When the vehicle is stationary, the clutch brake permits shifting into first gear or reverse gear without severe gear clash. The clutch brake is between the release bearing housing and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release bearing housing and the transmission bearing cap, stopping the rotation of the main drive gear.

The clutch brake may be a disc-type or a torque-limiting type. To prevent overloads to it, the torque-limiting clutch brake is designed to slip when loads of 20 to 25 lbf·ft (27 to 34 N·m) are reached. Clutch brakes are not designed for upshifting.

NOTE: The following procedures apply only to Eaton® Fuller® Easy-Pedal® clutches. Solo™ clutches are adjustment-free.

Release yoke free-travel is the distance between the release bearing wear pads and the release yoke. At the factory, the release yoke free-travel is set to 0.105 to 0.145 inch (2.7 to 3.7 mm). This setting produces approximately two inches (51 mm) of clutch free-pedal.

IMPORTANT: When clutch free pedal is less than about 3/4 inch (19 mm), adjust the clutch internally according to the procedures in this subject. Take care to do all procedures in the proper order.

Release bearing travel is the clearance between the aft end of the release bearing housing and the forward surface of the clutch brake disc. For the clutch to release properly, the release bearing travel measurement must be between 1/2 and 9/16 inch (12.7 to 14.3 mm).

As the clutch wears, the release bearing moves towards the engine flywheel, reducing release yoke free-travel and increasing release bearing travel. If internal clutch adjustments are not made, the release yoke fingers will eventually ride against the wear pads. This could cause the following problems:

- Worn bearing wear pads and release yoke
- Damaged release bearing and housing
- Eventual clutch slippage and burn-up

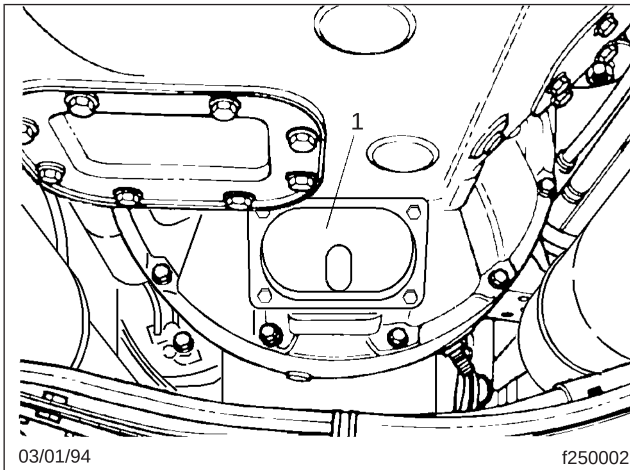
Release Bearing Travel

Measurement

CAUTION

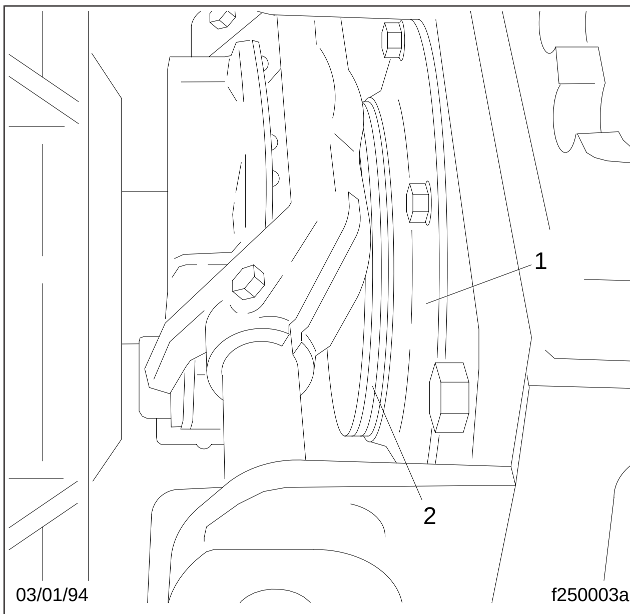
Make sure the internal adjustment is correct before making any linkage adjustments. Incorrect adjustments can cause transmission gear clash, slipping, and burning of clutch components.

1. Apply the parking brakes and chock all the tires.
2. Remove the clutch inspection cover from the bottom of the bell housing. See **Fig. 1**.
3. Slide the clutch brake (either the one-piece torque-limiting clutch brake, or the two-piece disc-type clutch brake with washer) tight against the transmission input-shaft bearing cap. See **Fig. 2**. Also, slide the release bearing as far as possible towards the transmission.



1. Clutch Inspection Cover

Fig. 1, Remove the Clutch Inspection Cover



1. Transmission Input-Shaft Bearing Cap
2. Clutch Brake

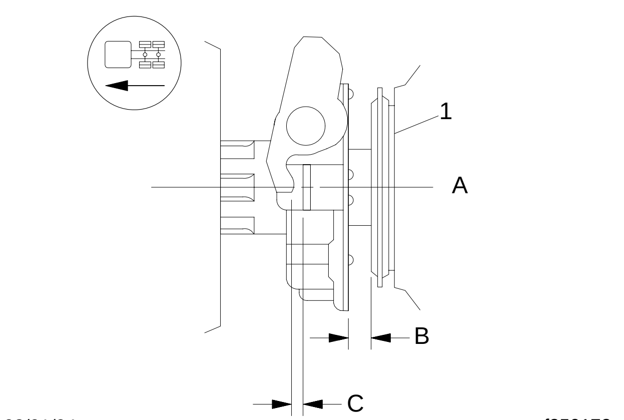
Fig. 2, Position the Clutch Brake

IMPORTANT: Release bearing travel tool A02–12419 is available through the PDCs. One end

Clutch Adjustments

of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

4. Measure the release bearing travel. See **Fig. 3** for the correct dimension to measure. Using both ends of the release bearing travel tool (**Fig. 4**), check this gap as follows:



A. Check both dimensions: release bearing travel (B) and release yoke free-travel (C).
B. Release bearing travel: 1/2 to 9/16 inch (12.7 to 14.3 mm) between release bearing housing and clutch brake.
C. Release yoke free-travel: approximately 0.105 to 0.145 inch (2.7 to 3.7 mm) between yoke and wear pads.
1. Torque-Limiting Clutch Brake

Fig. 3, Clutch Dimensions

A. 0.50 inch (12.7 mm) B. 0.56 inch (14.3 mm)

Fig. 4, Release Bearing Travel Tool A02-12419

4.1 Position the tool so that the legs straddle the transmission input shaft.

4.2 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely, the gap is too wide and adjustment is needed. See "Adjustment."

4.3 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

4.4 If the green end of the tool can't be inserted in the gap, adjustment is needed. See "Adjustment."

5. If no internal clutch adjustment is necessary, go to "Release Yoke Free-Travel."

Adjustment

To adjust Easy-Pedal clutches, use the Eaton Fuller Kwik-Adjust® mechanism (see **Fig. 5**).

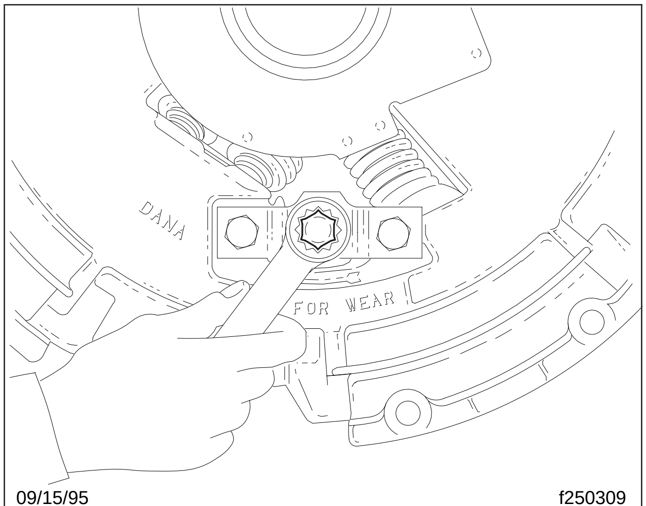


Fig. 5, Adjustment with Kwik-Adjust

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 6**.
2. Release the clutch by depressing the pedal. Block the pedal in the released position, or have someone assist you by holding the pedal down during the adjustment procedure.

NOTE: An open-end wrench is not recommended for the following step.

3. Adjust the clutch, using a 5/8-inch box-end or socket wrench on the adjustment bolt.
   3.1 Insert the 5/8-inch box-end or socket wrench through the inspection cover opening.
   3.2 To begin the adjustment, release the adjustment bolt by pressing down on the bolt head.

   NOTE: Normal wear increases the gap between the release bearing and the transmission.

   3.3 *To decrease the gap*: If clearance between the release bearing housing and the clutch brake is *more than* 9/16-inch (14.3 mm), turn the adjustment bolt clockwise (the release bearing moves toward the transmission).

   To increase the gap: If clearance between the release bearing housing and the clutch brake is *less than* 1/2-inch (12.7 mm), turn the adjustment bolt counterclockwise (the release bearing moves toward the engine).

   3.4 When the adjustment is complete, make sure the adjustment bolt is locked (pulled up flush with the mounting bolts).

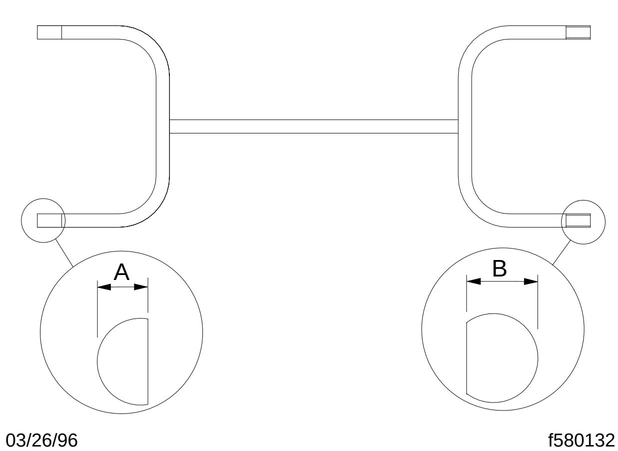
NOTE: On Easy-Pedal 2000 clutches, each complete turn of the adjustment bolt represents about 1/8-inch (3.2 mm) of release bearing movement. On earlier Easy-Pedal models, each complete turn of the adjustment bolt represents about 0.02-inch (0.5 mm) of release bearing movement.

4. After adjusting, release the pedal and check the clearance between the release bearing housing and the clutch brake. When the clearance is 1/2 to 9/16 inch (12.7 to 14.3 mm), the adjustment is complete.

Release Yoke Free-Travel

IMPORTANT: Release yoke free-travel tool A02–12254 is available through the PDCs. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

1. Measure the release yoke free-travel. See **Fig. 3** for the correct dimension to measure. Using both ends of the free-travel tool (**Fig. 6**), check the gap as follows:



A. 0.105 inch (2.7 mm) B. 0.145 inch (3.7 mm)

Fig. 6, Release Yoke Free-Travel Tool A02-12254

2. Position the tool so that the legs straddle the release yoke.
3. Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely, the gap is too wide and linkage adjustment is needed. See **Section 25.01**, Subject 100.
4. If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.
5. If the green end of the tool can't be inserted in the gap, linkage adjustment is needed. See **Section 25.01**, Subject 100.

Clutch Brake Squeeze

NOTE: This procedure requires two persons: one under the vehicle with access to the release bearing, and the other in the vehicle to depress the clutch pedal and measure the pedal travel.

Clutch Adjustments

The distance the pedal moves (from the fully depressed position) to free the feeler gauge is the clutch brake squeeze measurement.

1. Apply the parking brakes and chock all the tires.
2. Remove the clutch inspection cover from the bottom of the bell housing. See **Fig. 1**.
3. Insert a 0.010 inch (0.25 mm) feeler gauge (a business card works well if a feeler gauge is not available) between the release bearing and clutch brake.
4. Depress the clutch pedal to the end of its stroke.
5. Slowly let the pedal up. Stop when the feeler gauge can be pulled out. The pedal should be 1/2 to 1 inch (12.7 to 25.4 mm) from the end of the stroke.
6. If necessary to obtain proper clutch brake squeeze, check the linkage for worn or damaged components. Repair or replace components as necessary. Adjust the linkage according to the procedures in **Section 25.01**, Subject 100.

Removal

Solo™ Heavy-Duty Clutch

Use the following procedure if you need to temporarily remove and then reinstall an Eaton Fuller Solo Heavy-Duty 15.5" adjustment-free clutch. Failure to follow these steps could cause the Solo clutch to drag or not release upon installation.

IMPORTANT: Check the position of the wear indicating tab on the clutch cover. If the wear indicating tab is near the REPLACE position on the indicator, it is time to replace the clutch.

NOTICE

For proper installation of the Solo clutch, the wear indicating tab must be reset. Failure to reset this tab will prevent clutch release and result in possible clutch damage.

NOTE: This step requires two persons: one under the vehicle with access to the wear indicating tab, and the other in the vehicle to press the clutch pedal.

1. Reset the wear indicating tab with the clutch in the vehicle, as follows.

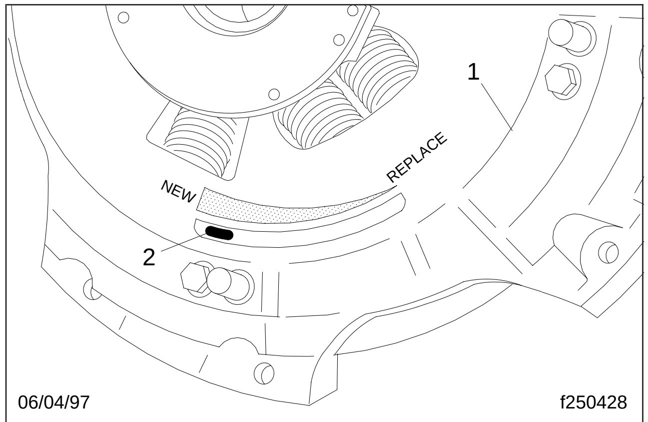
    1.1 From inside the cab, press the clutch pedal all the way down. Hold the clutch pedal down until the wear indicating tab is reset.

    1.2 Through the clutch inspection cover, slide the wear indicating tab to the left until it is at the NEW position on the indicator. See **Fig. 1**.

    1.3 From inside the cab, release the clutch pedal. Check to be sure the wear indicating tab stays at the NEW position on the indicator.

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

2. Remove the transmission. See **Section 26.00**.



With the clutch pedal down, set the tab to the NEW position on the indicator.

1. Clutch Cover
2. Wear Indicating Tab

Fig. 1, Resetting the Wear Indicating Tab

NOTICE

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

3. Remove the clutch brake from the transmission input shaft. See **Fig. 2**.

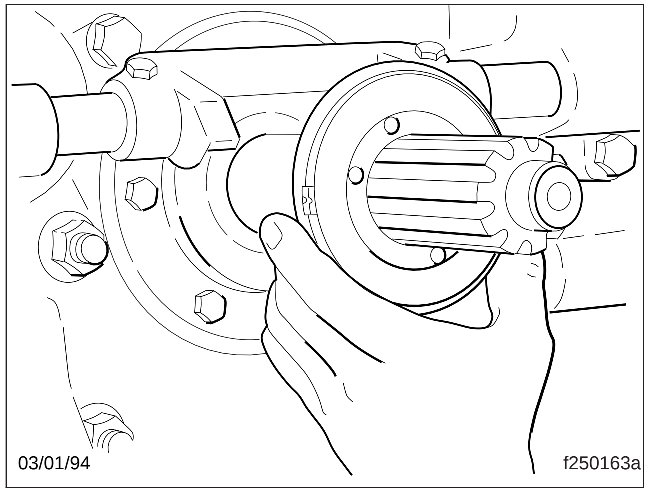


Fig. 2, Clutch Brake Removal

4. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See

Clutch Removal

Fig. 3. An old transmission input shaft may be used for this purpose.

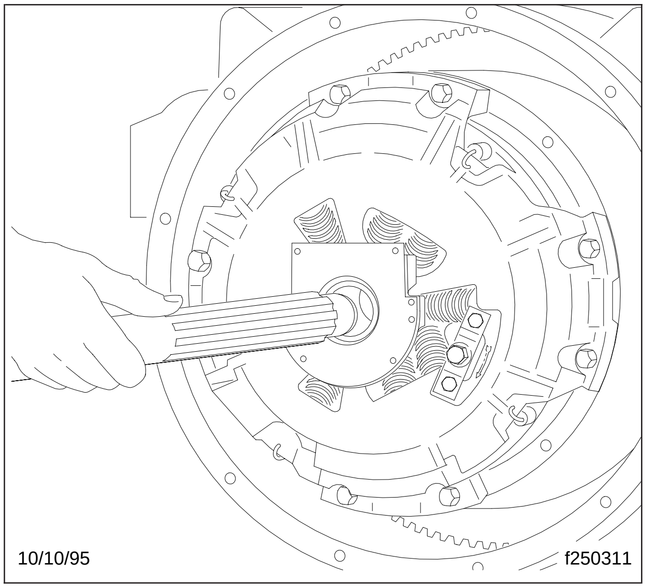


Fig. 3, Installing a Spline Aligning Tool

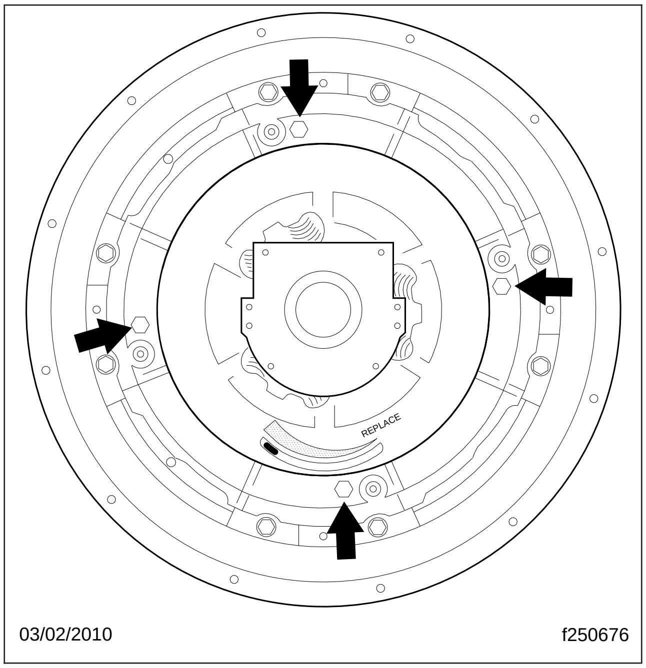


Fig. 4, Installed Shipping Bolts

NOTE: Shipping bolts are installed on the clutch cover prior to installation to prevent the clutch adjustment mechanism from unloading.

5. Install four 7/16–14 x 1-3/4 shipping bolts (if available) or hexhead machine screws into the four clutch cover holes, and tighten them finger-tight plus one full turn. See Fig. 4.

   These bolts will cage the pressure plate, preventing the four plate spacers from moving out of position when the clutch is removed from the flywheel.

6. Progressively loosen each of the mounting capscrews in the pattern shown in Fig. 5. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting capscrews.

7. Remove the two top mounting capscrews from the cover assembly. Install two 7/16–14 x 5 guide studs in the open holes to help support the clutch assembly during removal. See Fig. 6.

NOTE: Mark the positions of the clutch components so they can be properly oriented during installation.

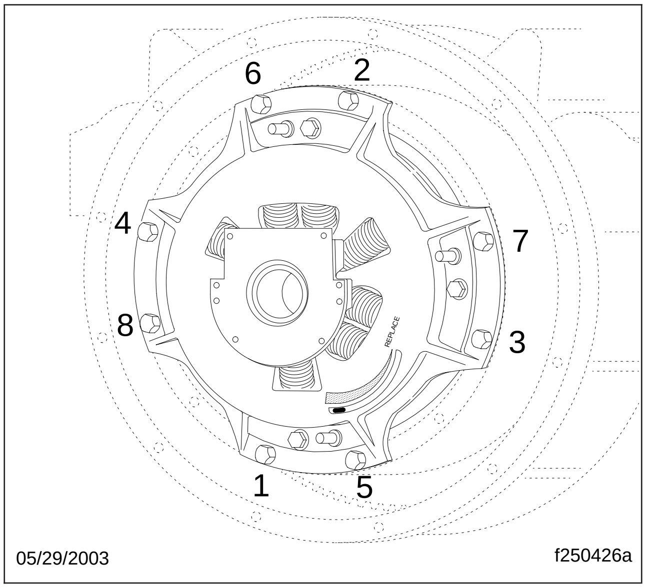


Fig. 5, Loosening Sequence

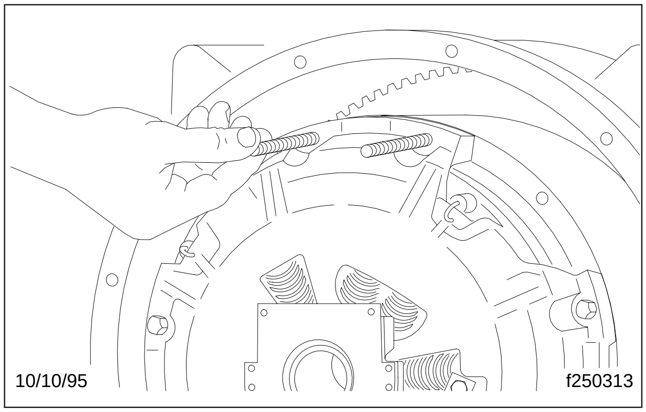


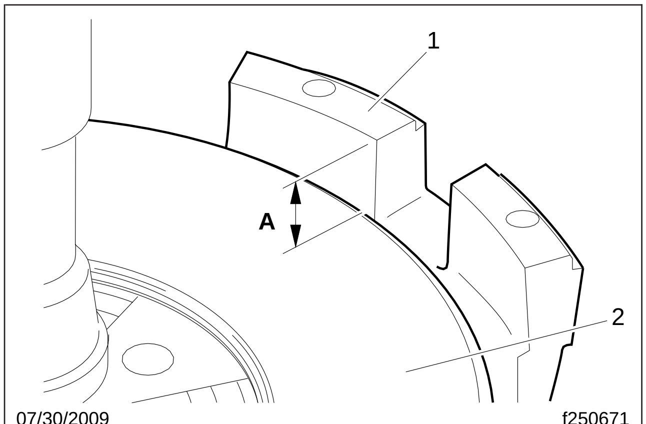
Fig. 6, Installing the Guide Studs

WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

8. Remove the mounting capscrews, and carefully remove the clutch assembly together with the spline aligning tool.

9. Reset the pressure plate, as follows. See **Fig. 7**.



NOTE: The pressure plate will be reset when it is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface of the clutch cover.

A. 1.75 to 1.78 inches (44.4 to 45.2 mm)

1. Mounting Surface
2. Pressure Plate

Fig. 7, Reset Pressure Plate

9.1 Progressively tighten the four shipping bolts in a crisscross pattern.

9.2 Measure the depth of the pressure plate. When the face of the pressure plate is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface of the clutch cover, the pressure plate is reset.

NOTE: Resetting the pressure plate will allow the clutch to release after installation.

10. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing for any unusual wear or damage. Discard the pilot bearing.

Easy-Pedal™ Clutch

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

1. Remove the transmission. See **Section 26.00**.

NOTICE

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

2. Remove the clutch brake from the transmission input shaft. See **Fig. 2**.
3. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See **Fig. 3**. An old transmission input shaft may be used for this purpose.
4. Use a release tool and two 5/8-inch (16-mm) spacer blocks to pull the bearing back. See **Fig. 8**. The spacer blocks relieve the internal spring load in the clutch assembly, and facilitate clutch removal.
5. Remove the two top mounting bolts from the cover assembly. Install 7/16–14 x 5 guide studs in the open holes to help support the clutch assembly during removal. See**Fig. 6**.
6. Progressively loosen each of the mounting bolts in the pattern shown in **Fig. 9**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting bolts.

Clutch Removal

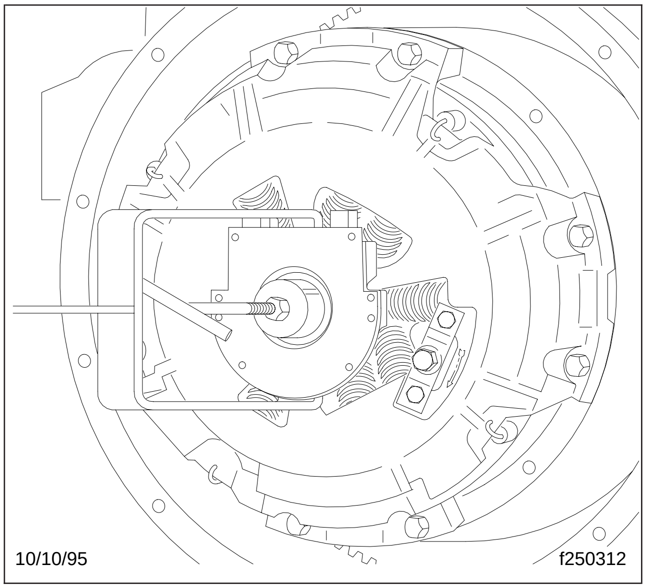


Fig. 8, Pulling the Bearing

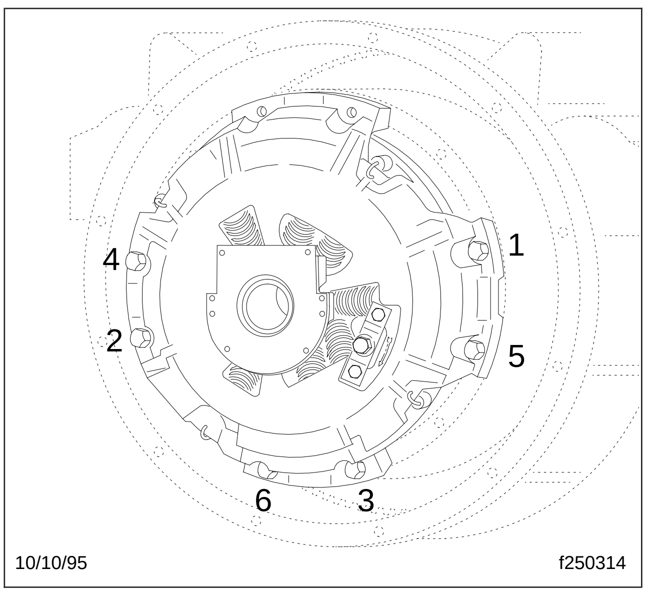


Fig. 9, Loosening Sequence, Easy-Pedal

WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

7. Remove the mounting bolts, and carefully remove the clutch assembly.

   Be careful to keep the spline aligning tool in place to retain the discs and intermediate plate. Remove the spline aligning tool, the rear driven disc, the intermediate plate, and the front driven disc.

8. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing. Correct the cause of any unusual wear or damage. Discard the bearing.

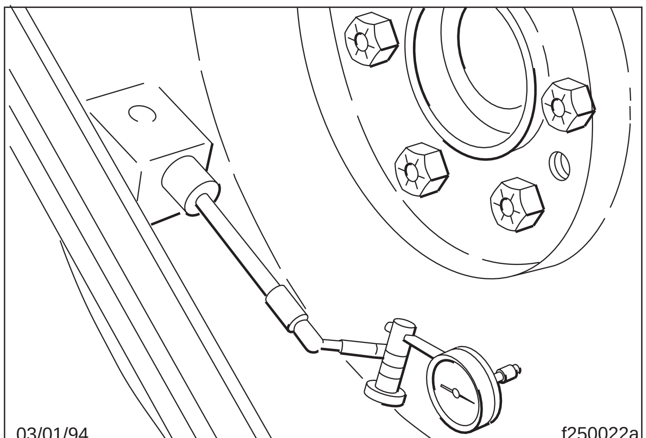
Clutch Inspection

NOTICE

Misalignment of any parts described in these procedures will cause premature wear of drivetrain components.

IMPORTANT: When taking the following readings, rotate the engine by hand; do not crank the engine with the starter. The engine may be rotated by the pulley nut at the front of the crankshaft, the flywheel mounting bolts, or the starter ring-gear on the flywheel.

1. Clean the surfaces being measured to ensure accurate measurements.
2. Measure the runout of the flywheel face (friction surface). See **Fig. 1** for the correct set-up.



Secure the dial indicator to the flywheel housing, with the gauge finger against the flywheel face, and near the outer edge.

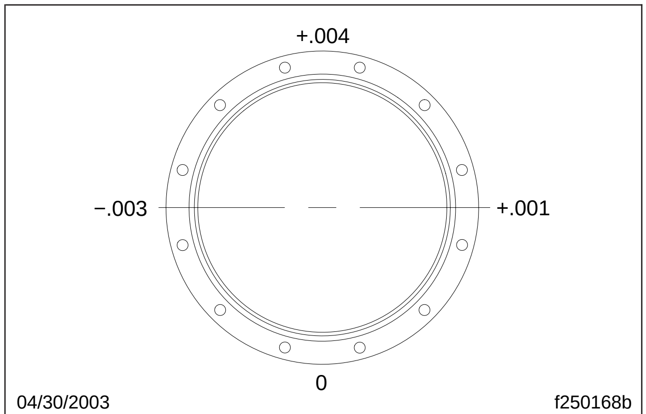
Fig. 1, Measure the Flywheel Face

2.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the face of the flywheel near the outer edge.

2.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the flywheel face.

2.3 The total runout will be the difference between the highest plus and minus readings. To calculate the runout, see **Fig. 2**.

Example: The highest reading is +0.004 at 12 o'clock. The lowest reading is –0.003 at 9 o'clock. Therefore the total runout is 0.007 inch.

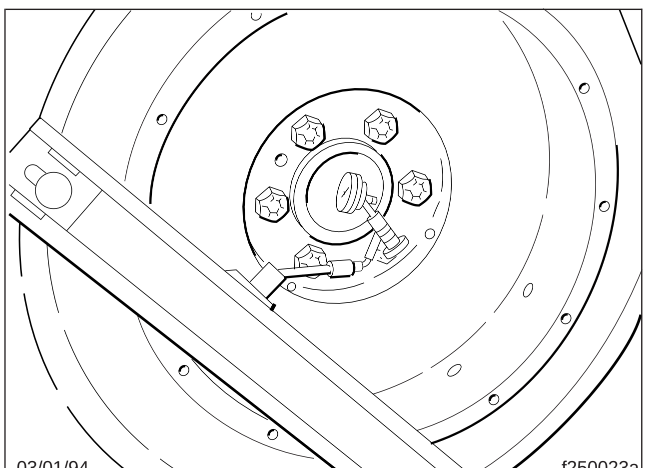


Take four readings, starting with zero at the 6 o'clock position, and going on to 9, 12, and 3 o'clock. Make sure the dial returns to zero at the original start position.

Fig. 2, Calculate the Runout

2.4 The SAE maximum total runout for the flywheel face is 0.008 inch (0.20 mm). If the readings are higher, see the engine manufacturer's manual for instructions.

3. Measure the runout of the pilot-bearing bore in the flywheel. See **Fig. 3** for the correct set-up.



Secure the dial indicator to the flywheel housing, with the gauge finger on the surface of the pilot-bearing bore.

Fig. 3, Measure the Pilot-Bearing Bore

Clutch Inspection and Pre-Installation Procedures

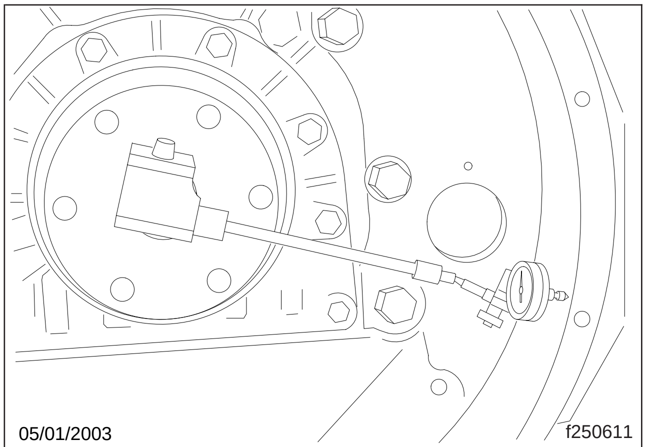
3.1 With the indicator still secured to the flywheel housing, move the gauge finger to contact the surface of the pilot-bearing bore.

3.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the bore of the pilot bearing.

3.3 Calculate the runout as before.

3.4 The SAE maximum total runout for the pilot-bearing bore is 0.005 inch (0.13 mm). If the readings are higher, see the engine manufacturer's manual for instructions.

4. Measure the runout of the flywheel housing bore. See **Fig. 4** for the correct set-up.



Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

Fig. 4, Measure the Flywheel Housing Bore

4.1 Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

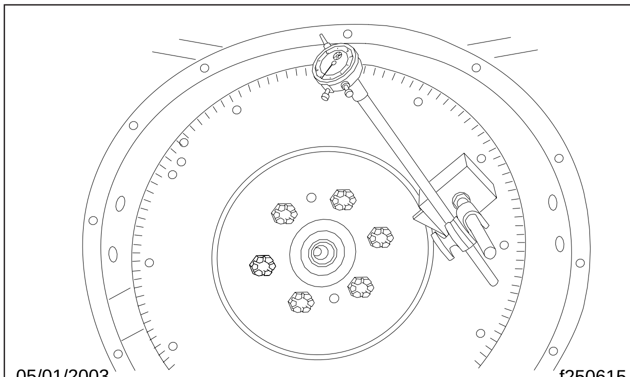
4.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the side of the flywheel housing.

4.3 Calculate the runout as before.

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

4.4 The SAE maximum total runout for the flywheel-housing bore is 0.008 inch (0.20 mm). If readings are higher, replace the flywheel housing. For instructions, see the engine manufacturer's manual.

5. Measure the runout of the face of the flywheel housing. See **Fig. 5** for the correct set-up.



Secure the dial indicator to the outer diameter of the flywheel, with the gauge finger against the face of the flywheel housing.

Fig. 5, Measure the Flywheel Housing Face

5.1 With the dial indicator secured to the outer diameter of the flywheel, move the gauge finger to contact the face of the flywheel housing.

5.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the flywheel housing.

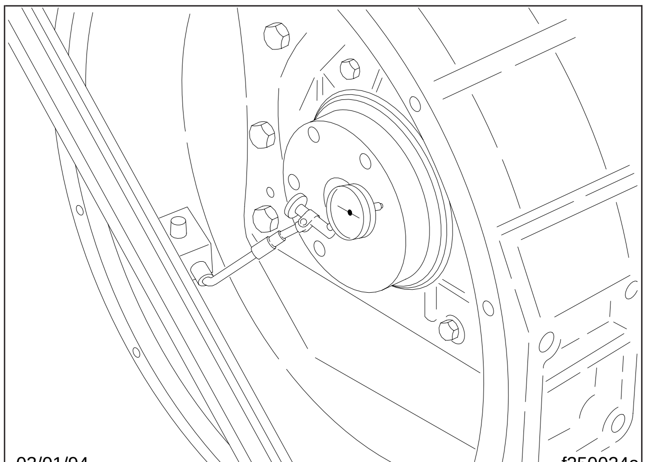
5.3 Calculate the runout as before.

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

5.4 The SAE maximum total runout for the flywheel-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the housing. For instructions, see the engine manufacturer's manual.

NOTE: Use a case-bore plug and shaft set to measure the bell-housing face and pilot. Case-bore plugs are tapped into the front and rear bores of the transmission case, and have very close tolerances. The shaft runs through the center of the plugs, and extends to the front far enough to secure a dial indicator and obtain a reading on the bell housing.

6. Measure the runout of the bell housing face and pilot.
   6.1 Secure the dial indicator to the case-bore shaft, with the gauge finger against the face of the bell housing.
   6.2 Turn the case-bore shaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the bell housing.
   6.3 Calculate the runout as before.
   6.4 The SAE maximum total runout for the bell-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the bell housing. See the transmission manufacturer's service manual for instructions.
7. Remove the flywheel (see the engine manufacturer's manual), and measure the runout of the flywheel crankshaft face. See **Fig. 6**.



Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.

Fig. 6, Measure the Crankshaft Face Runout

   7.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.
   7.2 Turn the crankshaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the crankshaft.
   7.3 Calculate the runout as before.
   7.4 See the engine manufacturer's manual for maximum runout, corrective measures, and flywheel installation instructions.

Resetting (clutch out of vehicle)

NOTICE

Use this procedure if the clutch was removed without caging the pressure plate. Resetting the pressure plate allows the clutch to release after installation and prevents possible clutch damage.

1. Remove the four shipping bolts if they have been installed. See **Fig. 7**.

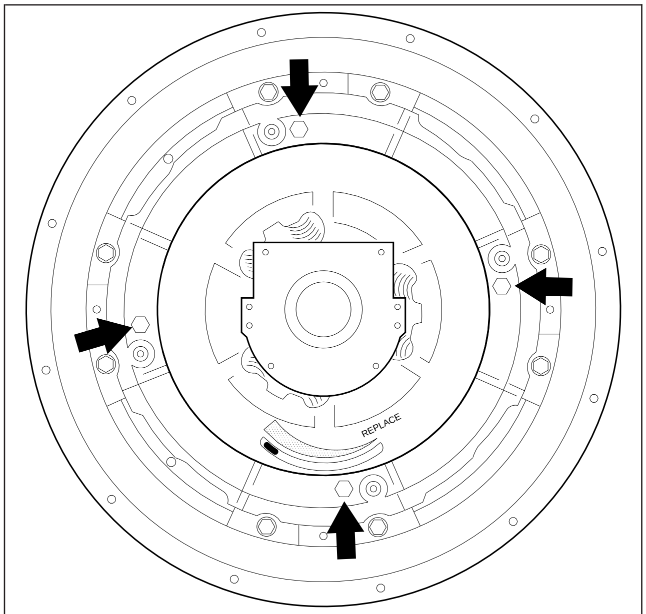


Fig. 7, Installed Shipping Bolts

2. Support the clutch cover in an arbor press with the release bearing facing down. When setting up the arbor press, allow at least 1 inch (25 mm)

Clutch Inspection and Pre-Installation Procedures

clearance for both movement of the release bearing and access to install shipping bolts. See **Fig. 8**.

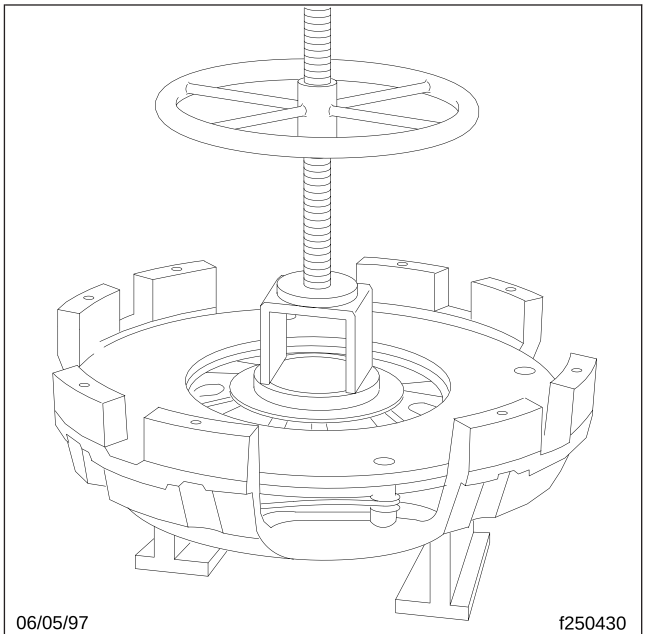


Fig. 8, Arbor Press Setup

3. Center the ram and press downward on the retainer until it comes to a stop. Lock the ram in position.
4. Slide the wear indicating tab to the left until it is at the NEW position of the indicator (**Fig. 9**) and hold it in position with a magnet.

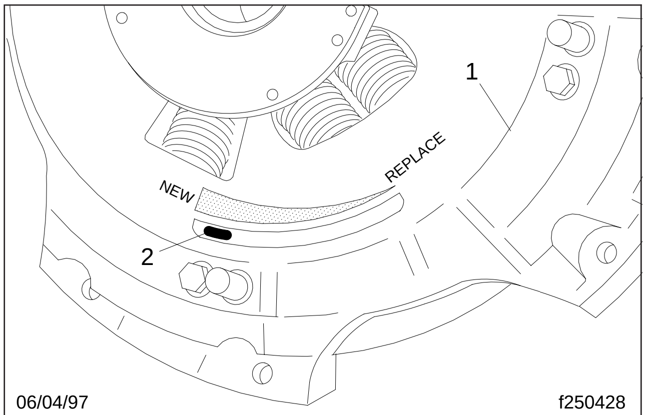
NOTE: Shipping bolts are installed on the clutch cover prior to installation to prevent the clutch adjustment mechanism from unloading.

5. Install four 7/16–14 x 1-3/4 shipping bolts (if available) or hexhead machine screws into the four clutch cover holes, and tighten them finger-tight. See **Fig. 7**.

NOTE: You may need to temporarily install slightly longer bolts to allow access of the shipping bolts.

6. Reset the pressure plate, as follows.

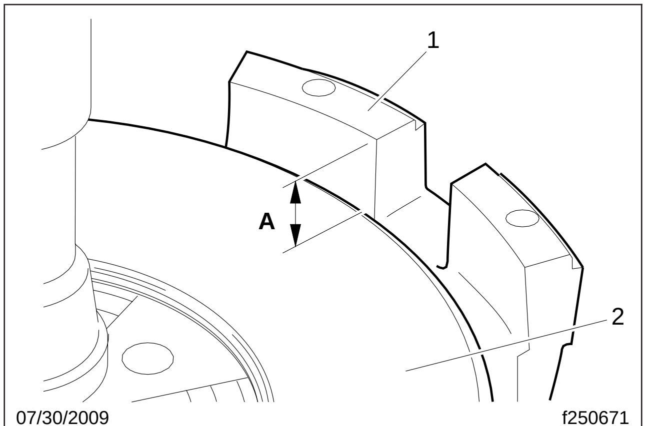
    6.1 Progressively tighten the four shipping bolts in a crisscross pattern.



1. Clutch Cover
2. Wear Indicating Tab

Fig. 9, Resetting the Wear Indicating Tab

    6.2 Measure the depth of the pressure plate. When the face of the pressure plate is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface of the clutch cover, the pressure plate is reset. See **Fig. 10**.



NOTE: The pressure plate will be reset when it is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface of the clutch cover.

A. 1.75 to 1.78 inches (44.4 to 45.2 mm)

1. Mounting Surface
2. Pressure Plate

Fig. 10, Reset Wear Pins

Pre-Installation Procedures

Before installing a new, rebuilt, or used clutch, do the following procedures:

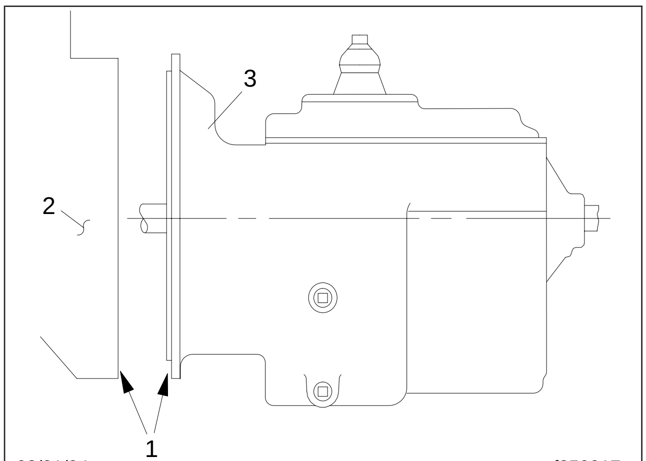
1. Install a new pilot bearing. Be sure that the pilot bearing has a press-fit in the flywheel.

NOTICE

Tap on the outer race only. Tapping on the inner race could damage the pilot bearing.

NOTE: To discourage warranty claims for drag or clutch noise, use a premium grade C3/C4 pilot bearing. Due to increased operating temperatures and longer clutch life, the standard pilot bearings and grease are no longer acceptable.

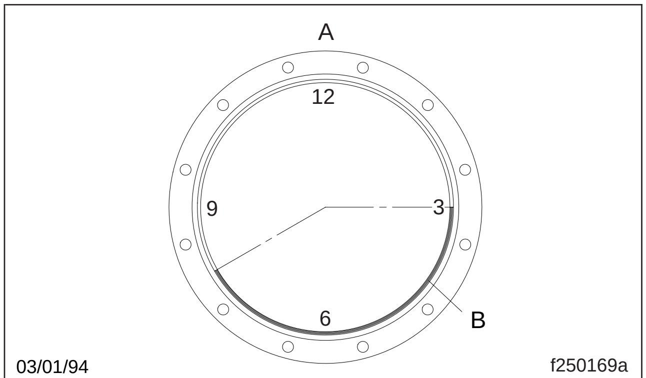
2. Check for wear on the mating surfaces of the flywheel housing and the transmission bell housing. Any noticeable wear on either part causes misalignment. If worn, replace the part. See **Fig. 11**.



1. Mating Surfaces
2. Engine Flywheel Housing
3. Transmission Bell Housing

Fig. 11, Inspect the Mating Surfaces

3. Check the flywheel for wear caused by the bell housing pilot (projecting lip of the bell housing). The correct dimension is 1/8-inch (3.2-mm). Wear is most likely to appear between the 3 o'clock and 8 o'clock positions. See **Fig. 12**.



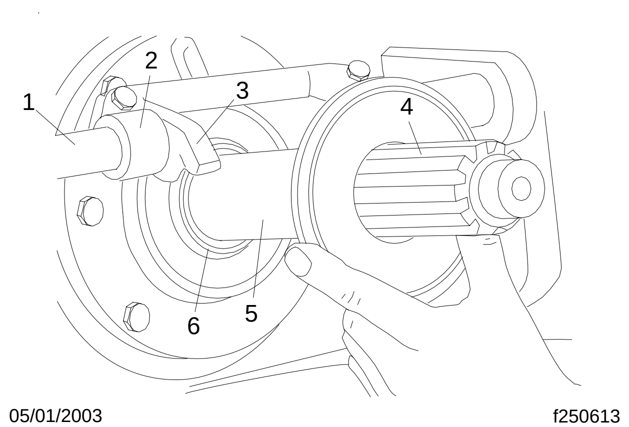
A. Top
B. The most common areas of wear are between the 3 o'clock and 8 o'clock positions.

Fig. 12, Check for Wear

NOTE: The pilot (lip) of the bell housing can wear into the flywheel housing. This can be caused by the transmission loosening up, or by road and engine vibration after high mileage.

4. Inspect the flywheel. Replace or repair the flywheel if the wear is extreme.
   - 4.1 Visually inspect the friction surface of the flywheel for heat checks and scoring.
   - 4.2 Measure the friction surface wear with a straightedge and feeler gauge. For instructions, see the engine manufacturer's manual.
5. Inspect the input shaft, both the splined and the smooth area. See **Fig. 13**.
   - 5.1 Check the fit of the splined hubs of the driven discs by sliding them along the splines of the input shaft. The hubs must slide freely so the clutch will release cleanly. If necessary, use a hand stone to dull the sharp edges of the splines.
   - 5.2 If the input shaft splines are worn or notched, or if the hubs still do not slide freely, replace the input shaft. For instructions, see the transmission manufacturer's service manual.
   - 5.3 Inspect the smooth area of the input shaft for wear and/or rough spots. Replace the input shaft if necessary.

Clutch Inspection and Pre-Installation Procedures



1. Cross-Shaft
2. Sleeve Bushing
3. Release Yoke Finger
4. Input Shaft (splined area)
5. Input Shaft (smooth area)
6. Bearing Cap

Fig. 13, Clutch Inspection Points

6. To prevent side-loading, inspect all pivot points of the clutch linkage for excessive wear and replace them if necessary. See **Fig. 13**. Pay special attention to the following points:

   6.1 Check for excessive wear at the fingers of the release yoke where they contact release bearing wear pads.

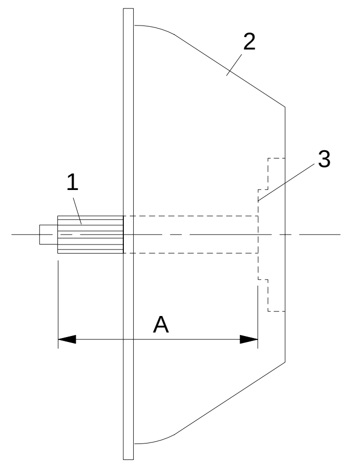
   6.2 Check the clutch cross-shaft and sleeve bushings for excessive wear. Check the sleeve bushings for walk-out.

7. To prevent clutch brake wear, check the input-shaft bearing cap and measure it as shown in **Fig. 14**.

   7.1 Visually check the bearing cap for excessive wear.

   7.2 Measure the distance between the splined end of the input shaft and the bearing cap (dimension A). If dimension A is greater than 8.71 inches (221.5 mm), replace the bearing cap.

NOTE: Torque-limiting clutch brakes are a one-piece assembly with a large and a small face. When installing a torque-limiting clutch brake on an Eaton® Fuller® or Meritor™ transmission, install the smaller face toward the transmission.



A. Length of Input Shaft, from the Splined End to the Bearing Cap

1. Input Shaft
2. Bell Housing
3. Bearing Cap

Fig. 14, Measure the Input Shaft

8. Install a new clutch brake on the transmission input shaft, as shown in **Fig. 15**. Slide it tight against the input-shaft bearing cap.

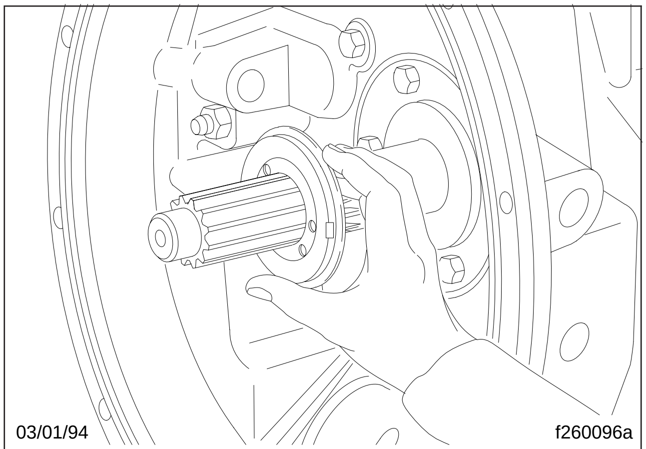


Fig. 15, Install the Clutch Brake

9. Check the diameter of the flywheel bore opening (this is the recessed area for the flywheel bolt circle). See **Table 1** for minimum flywheel bore diameters for each disc type.

Minimum Flywheel Bores	
Disc Type	**Flywheel Bore in inch (mm)**
10-Spring	8.562 (217.48)
9-Spring	9.750 (247.65)
8-Spring	7.250 (184.15)
7-Spring	9.750 (247.65)
6-Spring	9.750 (247.65)

Table 1, Minimum Flywheel Bores

Installation

Solo™ Heavy-Duty Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.

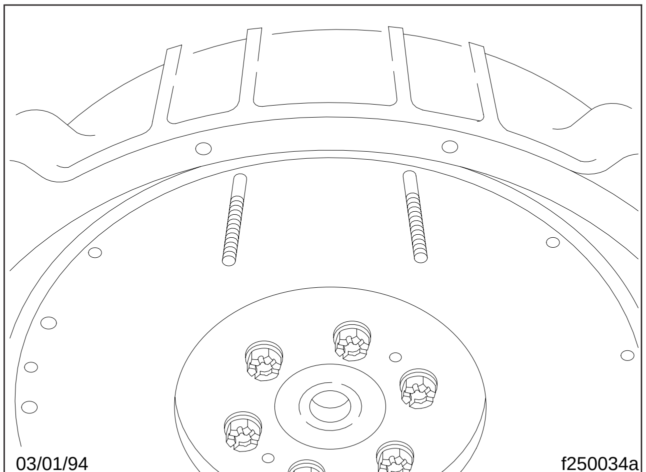


Fig. 1, Install the Guide Studs

2. If installed (on new clutches), remove the protective coating from the pressure plate and the intermediate plate.
3. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 2**.

NOTE: Six-spring driven discs are identical, front and rear. Either disc can be installed first on the aligning tool.

4. Install the rear driven disc and intermediate plate.
   - 4.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing away from the clutch cover. See **Fig. 3**.

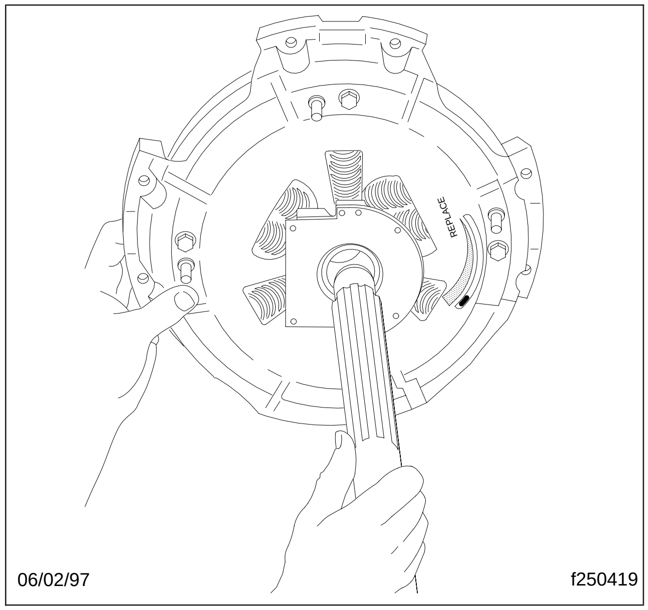


Fig. 2, Insert an Aligning Tool, Solo

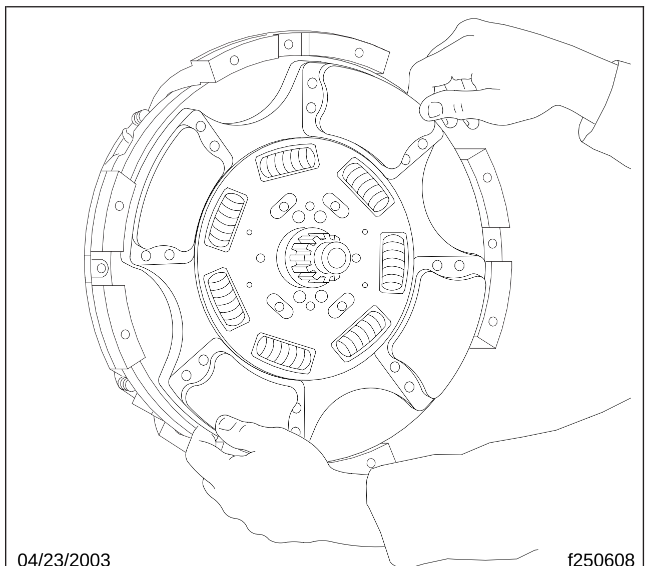
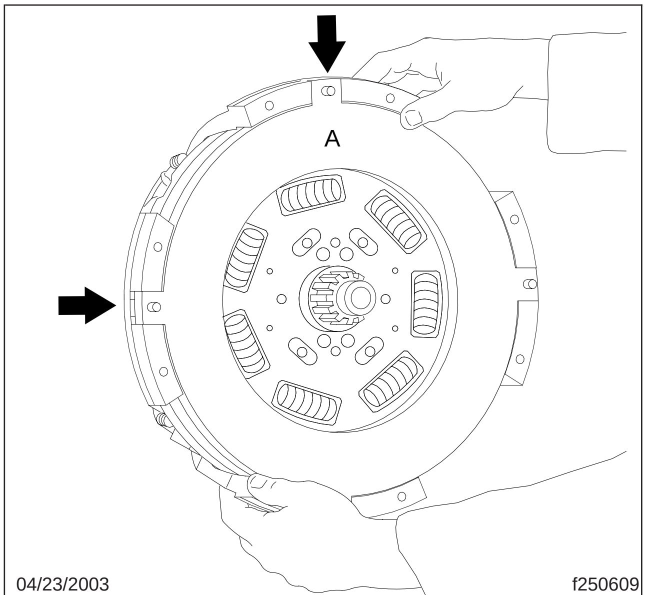


Fig. 3, Installing the Rear Driven Disc

   - 4.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.
   - 4.3 Make sure the positive separator pins™ protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.

Clutch Installation



The separator pins should protrude to the flywheel side.
A. Flywheel Side

Fig. 4, Positioning the Intermediate Plate

5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

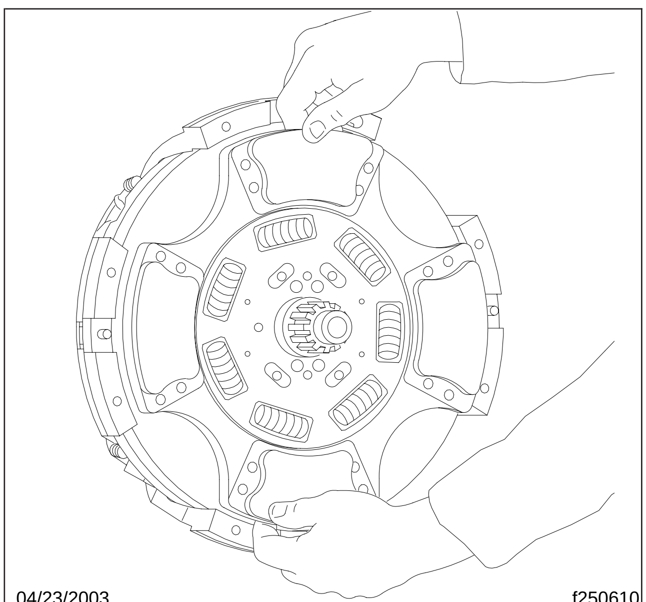


Fig. 5, Installing the Front Driven Disc

WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

6. Position the clutch over the two guide studs, and slide the assembly forward until contact is made with the flywheel surface. See **Fig. 6**.

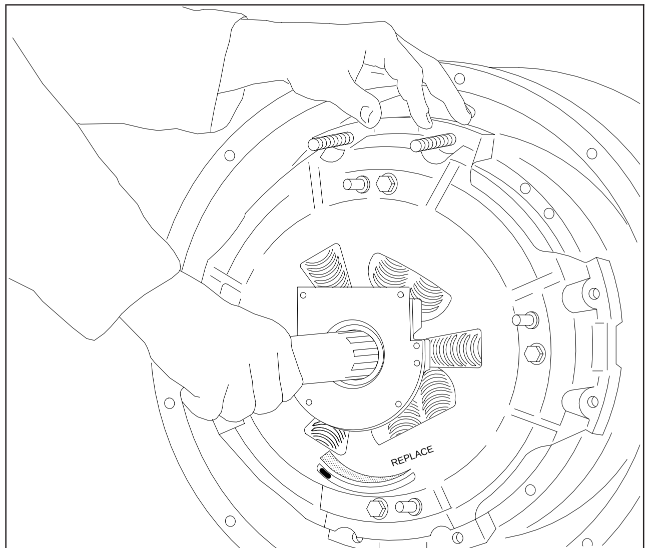


Fig. 6, Positioning the Clutch Cover, Solo

7. Install the mounting capscrews. See **Fig. 7**.
   7.1 Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting capscrews with lockwashers, and fasten them finger-tight.
   7.2 Tap the aligning tool to make sure it is centered and seated in the pilot bearing.
   7.3 Remove the two guide studs and replace them with the two remaining 7/16–14 x 2-1/4 mounting capscrews and lockwashers.
8. Tighten the eight mounting capscrews progressively, in a crisscross pattern as shown in **Fig. 8**. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

IMPORTANT: Failure to tighten the bolts according to this procedure can have the following effects:

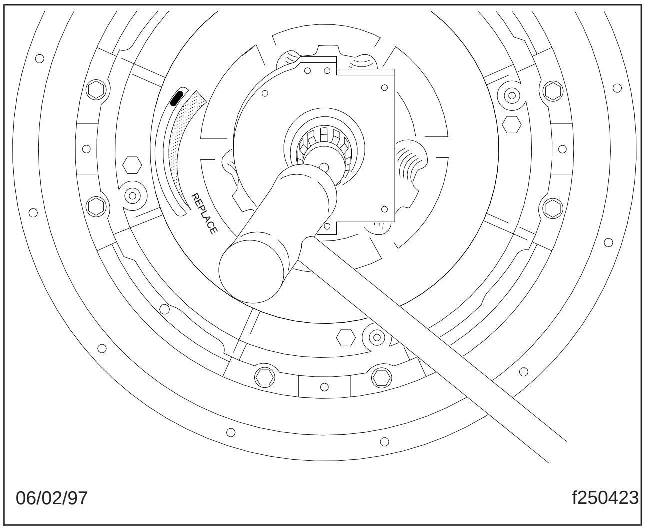


Fig. 7, Tap Aligning Tool

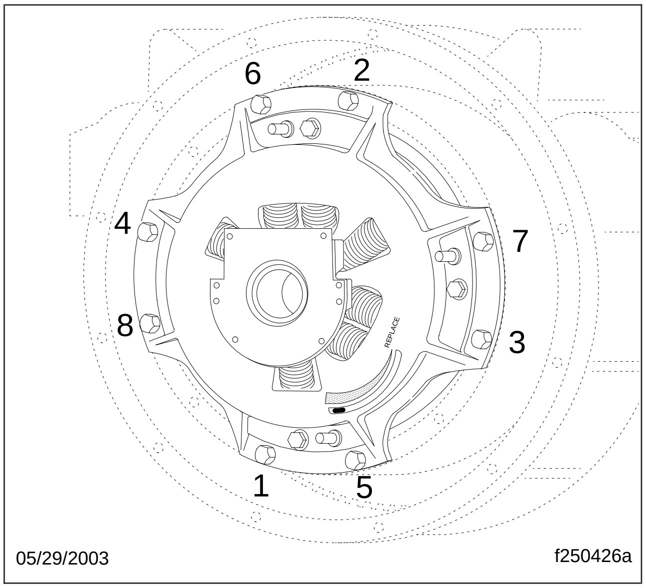


Fig. 8, Tightening Sequence, Solo

- prevent the clutch cover from centering into the pilot area of the flywheel;
- cause the clutch assembly to be out-of-balance with the flywheel;
- cause permanent damage to the clutch cover.

9. Following a crisscross pattern, remove and retain the four yellow shipping bolts from the clutch cover. See **Fig. 9**.

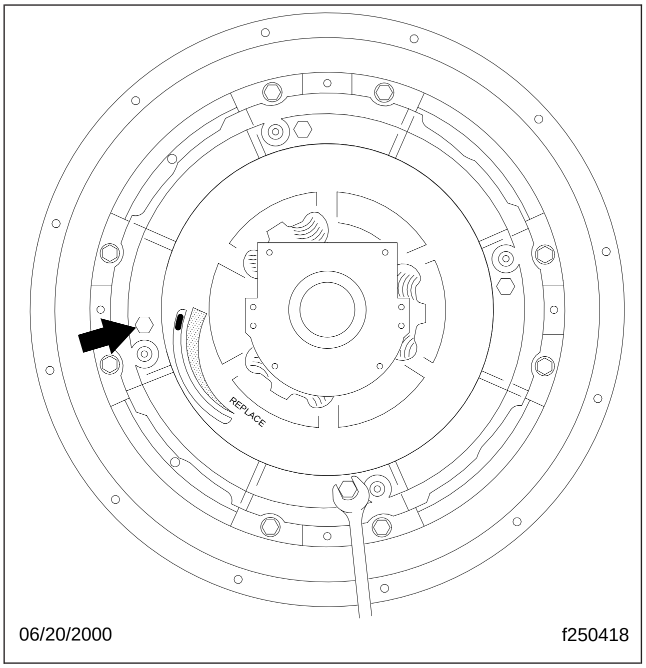


Fig. 9, Remove the Shipping Bolts

NOTE: Retain these four shipping bolts. These bolts will be needed in the future to secure the clutch assembly during removal and installation.

10. Remove the aligning tool. On maintenance-free clutches only, remove the input shaft sleeve.

NOTE: Do not be concerned if the release bearing housing touches the clutch cover.

11. Set the positive separator pins.

    11.1 Locate the pin access holes. See **Fig. 10**.

WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.

    11.2 Using a 1/4-inch (6-mm) diameter flat nose punch, *lightly* tap each of the four positive separator pins toward the flywheel through the access holes. This step verifies that all the four pins are flush against the flywheel. See **Fig. 11**.

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not re-

Clutch Installation

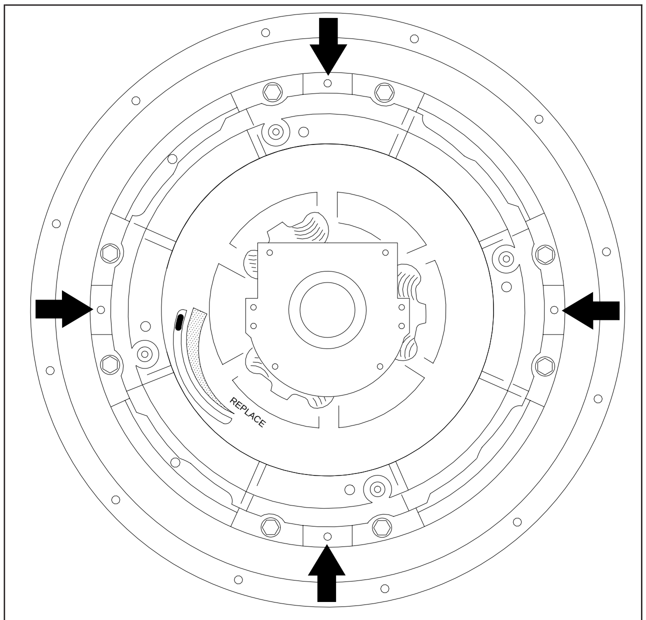
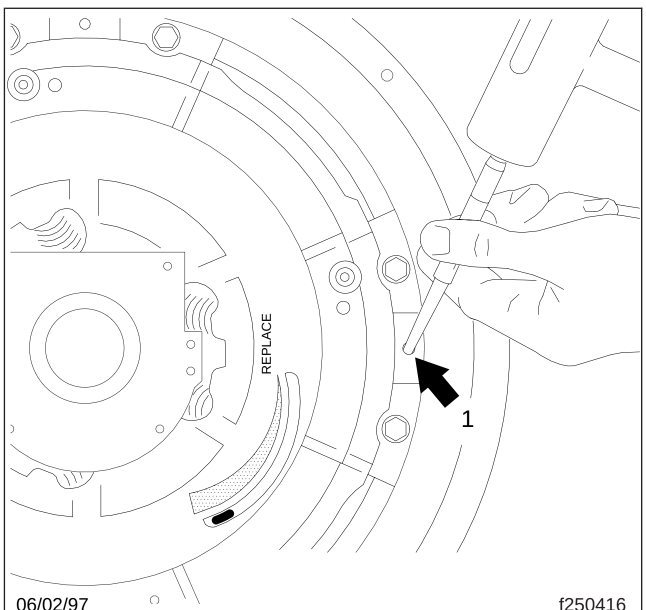


Fig. 10, Pin Access Holes, Solo



1. Pin Access Hole

Fig. 11, Tapping the Pin, Solo

lease). If necessary, after the transmission has been installed, the four pins can be set through the inspection opening of the transmission bell housing.

12. Using a clean cloth, remove all grease from the input shaft.
13. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
14. Install the transmission and attach the clutch linkage.

CAUTION

Avoid springing the driven discs when the transmission is being installed. Do not excessively force the transmission into the clutch assembly or engine housing. If it doesn't enter freely, investigate the cause of the problem and then make any necessary changes. Don't let the transmission drop or hang unsupported in the driven discs. If this should occur, the rear disc will become bent or distorted, causing the clutch to drag (not release).

IMPORTANT: Be sure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 12**. Align the splines by turning the transmission output shaft.

15. Lubricate the release bearing and cross-shaft bushings. For instructions and recommended lubricants, see Group 25 of the *Columbia™ Maintenance Manual*.

Easy-Pedal™ Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.
2. If the clutch is new, remove the protective coating from the pressure plate and the intermediate plate.

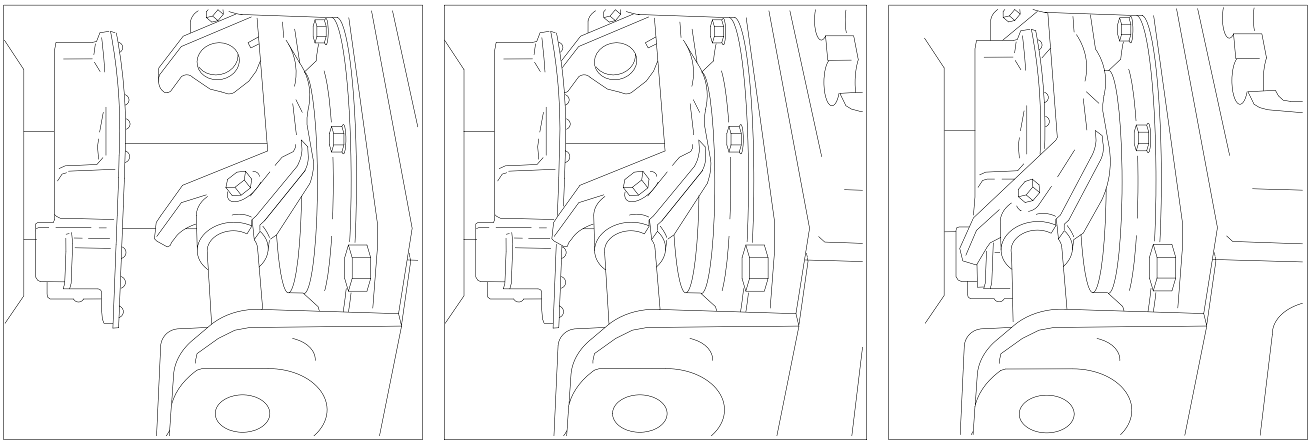


Fig. 12, Make Sure the Release Yoke Clears the Bearing

3. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 13**.

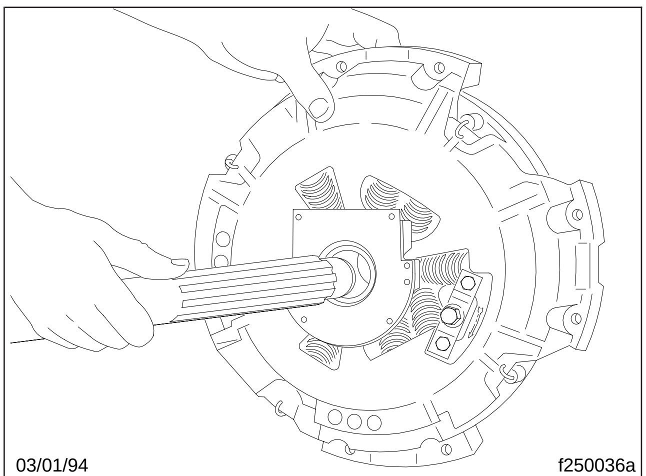


Fig. 13, Insert an Aligning Tool, Easy-Pedal

NOTE: Six-spring driven discs are identical, front and rear. Either disc can be installed first on the aligning tool.

4. Install the rear driven disc and intermediate plate.

    4.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing away from the clutch cover. See **Fig. 3**.

    NOTE: On 8-, 9-, and 10-spring discs, this side will be stamped *FLYWHEEL SIDE*.

    4.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.

    4.3 Make sure the positive separator pins™ protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.

5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

    Be sure that both driven discs are aligned as shown in **Fig. 14**.

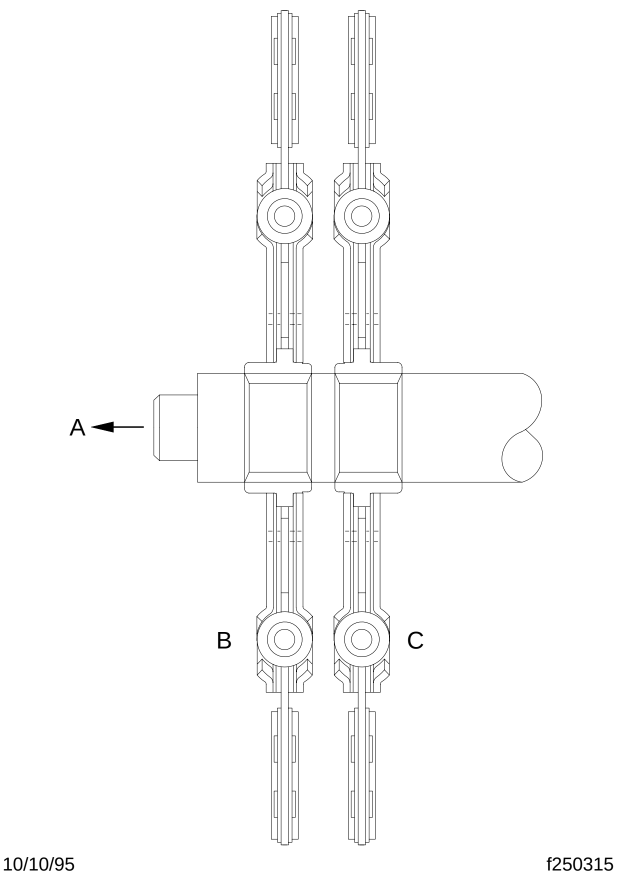
NOTE: On 8-, 9-, and 10-spring discs, this side is stamped *FLYWHEEL SIDE*.

WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

6. Position the clutch over the two guide studs, and slide the assembly forward until it starts in the flywheel pilot. See **Fig. 15**.

Clutch Installation



A. Flywheel Side
B. Front Driven Disc
C. Rear Driven Disc

Fig. 14, Checking Disc Alignment

7. Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting bolts with lockwashers, and fasten them finger-tight. Tap the aligning tool to make sure it is centered and seated in the pilot bearing, then remove the two guide studs and replace them with 7/16–14 x 2-1/4 bolts and lockwashers.

8. Tighten the eight clutch mounting bolts progressively, in the sequence shown in **Fig. 16**. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

CAUTION

If the bolts are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

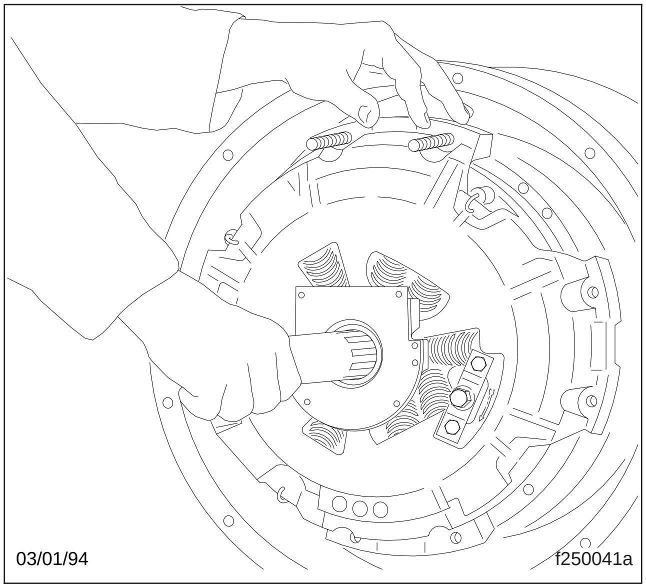


Fig. 15, Positioning the Clutch, Easy-Pedal

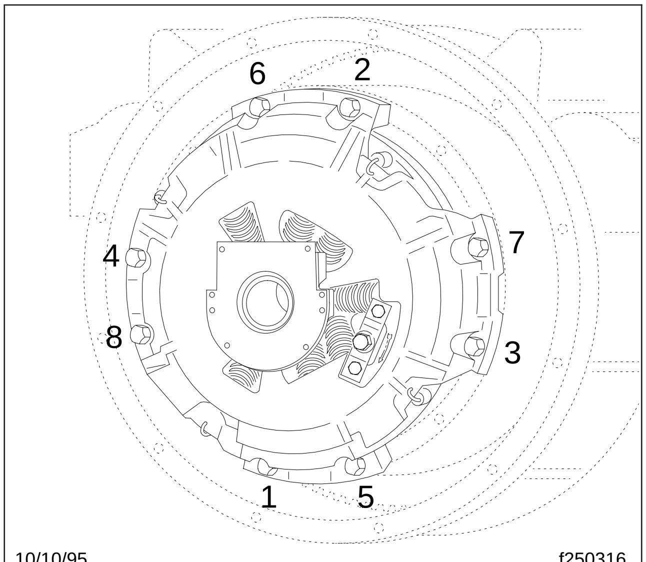


Fig. 16, Tightening Sequence, Easy-Pedal

9. As the capscrews are tightened, the release bearing spacers should fall free. If they don't, remove them. This may require light taps with a mallet on the end of the aligning tool.

10. Remove the aligning tool.

11. Set the positive separator pins.

    11.1 Locate the pin access holes. See **Fig. 17**.

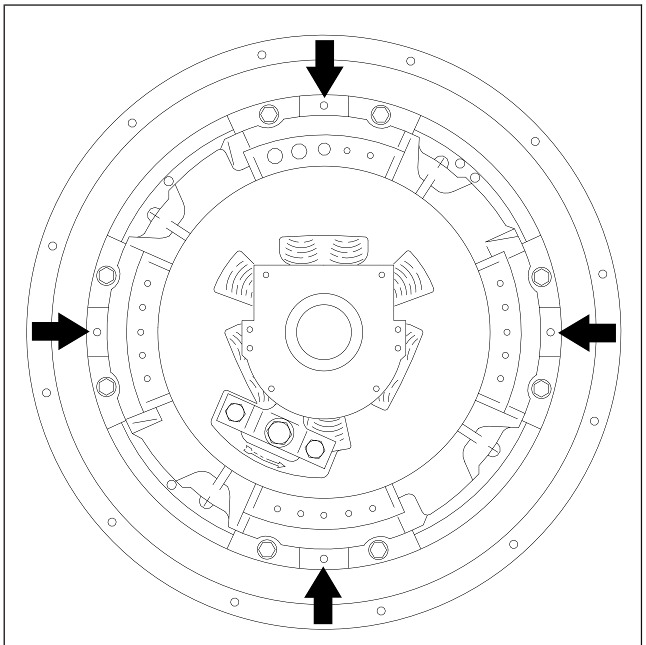


Fig. 17, Pin Access Holes, Easy-Pedal

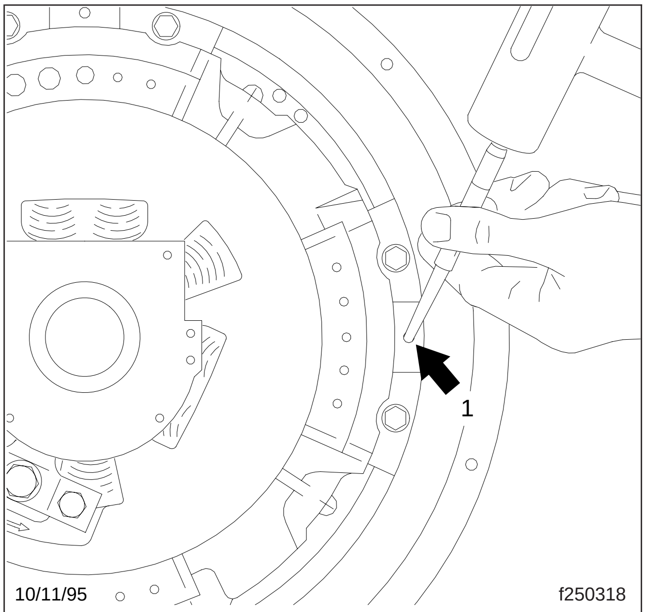
WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.

11.2 Using a 1/4-inch (6-mm) diameter flat nose punch, *lightly* tap each of the four positive separator pins toward the flywheel through the access holes. This step verifies that all the four pins are flush against the flywheel. See **Fig. 18**.

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not release). If necessary, after the transmission has been installed, the four pins can be set through the inspection opening of the transmission bell housing.

12. Using a clean cloth, remove all grease from the input shaft.
13. Shift the transmission into gear. Rotate the transmission input shaft to line up with the clutch driven-disc hub splines during assembly.



1. Pin Access Hole

Fig. 18, Tapping the Pin, Easy-Pedal

14. Install the transmission and attach the clutch linkage.

IMPORTANT: Be sure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 13**. Align the splines by turning the transmission output shaft.

CAUTION

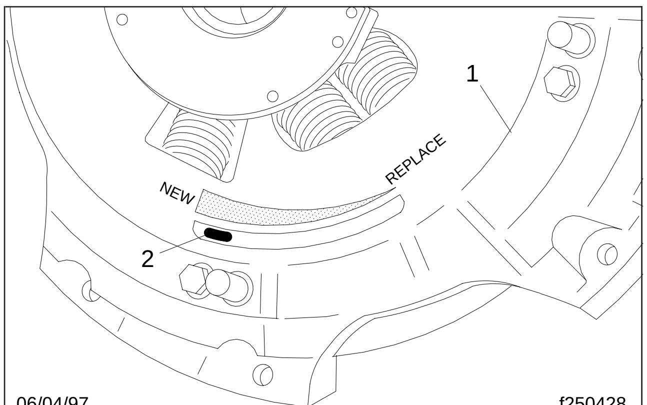
Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

15. Grease the release bearing and release shafts. For instructions and recommended lubricants, See Group 25 of the *Columbia™ Maintenance Manual*.
16. Adjust the clutch according to the procedures in **Subject 100**.

Resetting

NOTE: This procedure requires two persons; one under the vehicle with access to the wear indicating tab, and the other in the vehicle to operate the clutch pedal.

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Inside the cab, press the clutch pedal all the way down, and hold it there until instructed to release it later in this procedure.
3. Through the clutch cover, use moderate force to slide the wear indicating tab leftward until it is at the "NEW" position on the indicator. See **Fig. 1**. If the tab does not move, follow the instructions under the heading "Releasing a Seized Cam".



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With the clutch pedal down, set the tab to the "NEW" position on the indicator.

1. Clutch Cover
2. Wear Indicating Tab

Fig. 1, Resetting the Wear Indicating Tab

4. Release the clutch pedal.
5. To remove the gap between the sleeve and the pin, install four 7/16–14 x 1-3/4 bolts (shipping bolts may be used when available), and use a hand tool to tighten them until the gap is removed and the bolts are snug. See **Fig. 2**.
6. Remove the bolts.
7. Press the clutch pedal all the way down, and squeeze the clutch brake five times to reposition the bearing.

Releasing a Seized Cam

A seized cam may be caused by grease, dust, or other debris accumulated around the outer perimeter of the cam. The cam must operate freely for the clutch to work properly. The Eaton Seized Cam Adjustment Tool is designed specifically for releasing a seized cam. See **Table 1**.

1. While an assistant holds down the clutch pedal, insert the tip of the Seized Cam Adjustment Tool through the access panel and position it under the bearing. See **Fig. 3**.
2. Align the tool so that the threaded bolt extends into the slot in the cam. See **Fig. 3**.

IMPORTANT: Use the Seized Cam Adjustment Tool carefully. Do not use heavy force on it; heavy force can break the cam.

3. Using the tool, carefully try to move the cam toward the right or "Replace" position.

   If the cam moves easily, move it back to the left to verify that spring tension will pull it back to the right. If it returns to the right, then the cam has been released and you can continue with the resetting procedure. If it will not return to the right, the cam spring may be broken.

   If the cam does not move easily, continue to the next step.

IMPORTANT: Use WD-40® only. Do not substitute another penetrant for WD-40.

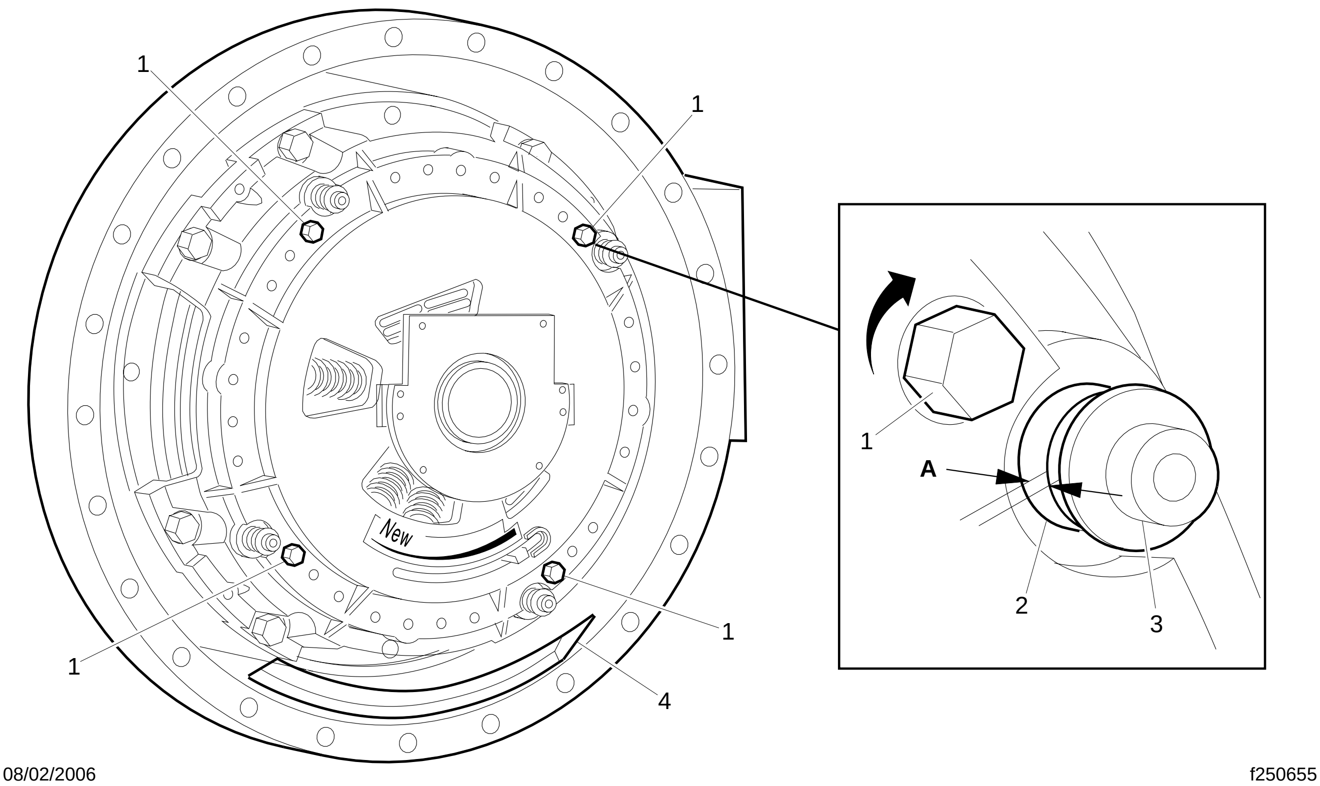
4. Use sideways pressure to the right and lightly pull the tool away from the engine to separate the top cam from the bottom cam. If the cam moves slightly to the right, let up on the clutch pedal. If the cam is still seized, spray WD-40 into the cam slot and three spring perches. To access all three perches, rotate the engine as needed.

   If the cam is still seized, do the following.

   4.1 Again spray WD-40 into the cam slot and all three spring perches.

   4.2 Inside the cab, release the clutch pedal, then press it all the way down. Next, with the clutch pedal pressed down, jiggle the tool in the cam slots to apply pressure in all directions.
5. Remove the tool.

Resetting the Clutch



A. Gap Between the Sleeve and the Pin

1. Bolt
2. Sleeve
3. Pin
4. Access Panel

Fig. 2, Removing the Gap Between the Sleeve and the Pin

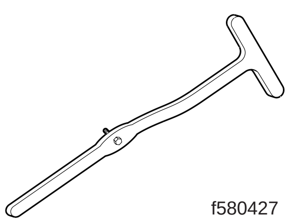
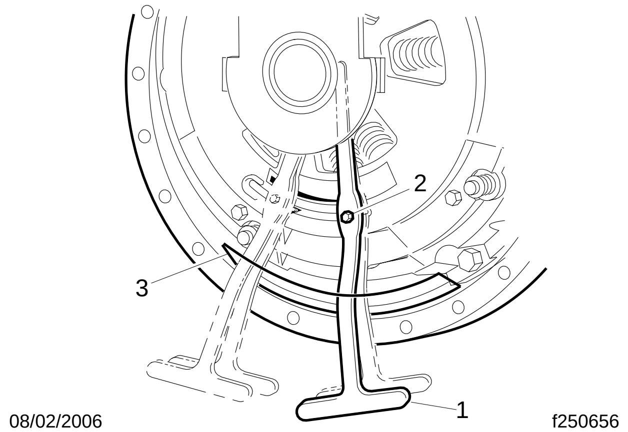
Tool	Description	Eaton Tool Part Code
 f580427	Seized Cam Adjustment Tool	CLPI-SOLOTOOL

Table 1, Special Tool for Releasing a Seized Cam



1. Seized Cam Adjustment Tool
2. Threaded Bolt
3. Access Panel

Fig. 3, Releasing a Seized Cam

Troubleshooting Tables

Problem—The Clutch Does Not Release Completely

Problem—The Clutch Does Not Release Completely	
Possible Cause	**Remedy**
The clutch pedal height is incorrect.	Adjust the clutch to obtain the following settings: • 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel; • 0.105 to 0.145 inch (2.7 to 3.7 mm) release yoke free-travel; and • 1/2 to 1 inch (12.7 to 25.4 mm) clutch brake squeeze.
The bushing in the release bearing sleeve assembly is damaged.	Replace the clutch cover.
The clutch cover assembly is not properly seated into the flywheel.	Re-seat the clutch cover assembly into the flywheel. Use a crisscross pattern when tightening the mounting bolts.
The intermediate plate and/or pressure plate is cracked or broken.	Replace any damaged parts.
The cross shafts protrude through the release yoke (a side-loading condition exists).	Check for protruding cross shafts. Repair or replace as necessary.
The release yoke fingers are bent or worn (a side-loading condition exists).	Install a new release yoke.
The engine housing and bell housing are misaligned (a side-loading condition exists).	Check for loose transmission mounting bolts. Tighten the transmission mounting bolts to the proper torque.
The clutch linkage is set up improperly (a side-loading condition exists).	Thoroughly examine the clutch linkage and adjust as necessary.
The driven discs are distorted or warped.	Replace any distorted or warped driven discs. If the transmission is allowed to hang unsupported during clutch installation, the driven discs may become distorted.
The driven discs are installed backwards, or the front and rear driven discs were switched with each other.	Install new driven discs. Also, check the clutch cover for any damage. Replace the clutch cover if damaged.
The input shaft spline is worn.	Replace the input shaft. Also, check the driven disc hubs for wear. Replace the driven discs if worn.
The input shaft spline is coated with grease, anti-seize compound, etc.	Clean and dry the input shaft spline before installation.
The input shaft splines are twisted.	Select a new driven disc and slide it along the full length of the splines. If the disc does not slide freely, replace the input shaft.
The input-shaft bearing cap is worn.	Replace the input-shaft bearing.
The flywheel pilot bearing fits either too tight or too loose in the flywheel and/or end of input shaft.	Check the pilot bearing for proper fit and replace it if worn.
The pilot bearing is dry or damaged.	Replace the pilot bearing.
The positive separator pins are bent, damaged or incorrectly set.	Be sure to use the proper tool when setting the positive separator pins. Also, take great care when handling the intermediate plate. For procedures, see **Subject 130**.

Troubleshooting

Problem—The Clutch Does Not Release Completely	
Possible Cause	**Remedy**
The clutch brake is damaged and/or not functioning.	Install a new clutch brake.
The driven disc faces are coated with oil or grease.	Replace the driven disc assemblies. Cleaning the old driven discs is not recommended.
There is foreign material (dirt, chaff, salt, etc.) inside the clutch cover.	Remove the foreign material and make sure the clutch inspection cover is installed.
The drive pins are cocked, causing the intermediate plate to stick on the drive lugs (Easy-Pedal only).	The drive pins must be ninety degrees square to the flywheel surface with a 0.006-inch (0.15-mm) minimum clearance between drive pins and intermediate plate slots. Repair or replace as necessary.
The pressure plate is not fully retracting (Easy-Pedal only).	Check the pressure plate return springs through the clutch inspection cover. If any are bent, stretched, or broken, replace them as necessary.
The release bearing travel is excessive and is causing the lever to contact the pressure plate (Easy-Pedal only).	Adjust the release bearing travel from 1/2 to 9/16 inch (12.7 to 14.3 mm).
The three anti-rattle springs were installed backwards (Easy-Pedal only).	Install the anti-rattle springs so the rounded sections are pointed toward the flywheel/engine.

Problem—The Clutch Rattles or Is Noisy

Problem—The Clutch Rattles or Is Noisy	
Possible Cause	**Remedy**
There is excessive flywheel runout.	Repair or replace the flywheel. For procedures, see the engine manufacturer's manual.
There is corrosion between the input shaft spline and the driven disc hubs.	Clean the mating parts between the input shaft and driven discs to ensure that the discs slide freely over the input shaft spline.
The engine idle is too fast.	Readjust engine idle to proper idling speed.
The clutch release bearing is dry or damaged.	Lubricate the clutch release bearing. If the noise persists, install a new clutch cover.
The flywheel pilot bearing is dry or damaged.	Replace the flywheel pilot bearing.
The bridge of the release yoke is hitting the clutch cover (an over-stroking condition exists).	Check for a worn, broken or missing clutch brake. Also, check the release yoke and input-shaft bearing cap for wear. Replace any worn parts.
The release yoke fingers are hitting the clutch cover.	Check if the release bearing, clutch cover, or release yoke fingers are worn or broken. Replace worn parts.
The clutch inspection cover is not installed.	Re-install the clutch inspection cover.
The sleeve bushings are worn.	Investigate for any side-loading conditions on the release bearing housing. If there is a side-loading condition, determine its cause. Also, before installing the new clutch, make sure that the side-loading condition has been corrected.
The clutch linkage is rattling excessively.	Clean, lubricate and reassemble or replace missing/worn parts.
An idle gear rattle is coming from the transmission.	Specify low-vibration driven discs. Check the engine for correct idle speed. For procedures, consult the engine manufacturer's manual.

Problem—The Clutch Rattles or Is Noisy	
Possible Cause	**Remedy**
The damper spring cover of the driven disc assembly is interfering with the flywheel.	Install the correct clutch assembly.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal only).	Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100**.

Problem—The Clutch Vibrates

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
The flywheel is loose.	Retighten the flywheel mounting bolts to the proper specifications.
The universal joints are worn.	Replace the worn parts.
The driveshaft is not properly phased.	Investigate and correct the phasing of the driveshaft.
The driveshaft is not balanced.	Balance and straighten the driveshaft.
The driveline angles are incorrect.	Shim the drivetrain components to equalize universal joint angles.
The flywheel is not balanced.	Balance the flywheel.
The pilot area of the clutch is not completely seated into the flywheel.	Ensure that no dirt, burrs, etc., are preventing the clutch cover from completely seating into the flywheel mounting surface.
The engine mounts are loose, damaged, or worn out.	Replace any worn or damaged parts. Retighten all bolts to proper specifications.
The engine is misfiring.	The engine is not in tune. To correct the problem, see the engine manufacturer's manual.
There is excessive flywheel runout.	Repair or replace the flywheel. For procedures, see the engine manufacturer's manual.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal only).	Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100**.

Problem—The Clutch Needs Frequent Adjustments

Problem—The Clutch Needs Frequent Adjustments	
Possible Cause	**Remedy**
The release yoke free-travel is insufficient.	After first adjusting the clutch for 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel, adjust the clutch linkage to obtain release yoke free-travel of 0.105 to 0.145 inch (2.7 to 3.7 mm).
The clutch specification is incorrect.	Check the clutch specifications in **Subject 400**. Install a new clutch with the proper specifications, if necessary.
The cross shafts and/or clutch linkage system is worn.	Investigate the entire clutch linkage system to determine if it is binding or operating sporadically and/or worn excessively.
The clutch driven discs are worn down to the rivets.	Install a new clutch. For procedures, see **Subject 130**.

Troubleshooting

Problem—The Clutch Needs Frequent Adjustments	
Possible Cause	**Remedy**
The crankshaft has excessive end play.	Repair or replace the crankshaft. Consult the engine manufacturer's manual for procedures.

Problem—The Clutch Slips

Problem—The Clutch Slips	
Possible Cause	**Remedy**
The clutch pedal has no free travel.	Readjust the clutch.
The clutch is overloaded.	Verify that the proper clutch has been specified for the particular vehicle application.
The release mechanism is binding.	Free up the release mechanism and linkage. Also, check the clutch linkage adjustment.
The driven disc faces are coated with oil or grease.	Replace the driven disc assembly.
The driver is riding the clutch pedal.	Use correct driving procedures.
The input shaft spline is worn.	Replace the input shaft.

Problem—The Clutch Grabs or Chatters

Problem—The Clutch Grabs or Chatters	
Possible Cause	**Remedy**
The clutch is worn out.	Replace the clutch and all worn components.
The linkage system is not operating freely.	Check the clutch linkage for binding or excessive wear. Replace all worn parts.
The driven disc faces are coated with oil or grease.	Replace the driven disc assembly.
The engine mounts are loose.	Retighten the engine mounts to manufacturer's specifications.
The release yoke fingers and/or the release bearing wear pads are worn excessively.	Replace all the worn parts.

All Heavy-Duty Clutches

Clutch Torque Values in lbf·ft (N·m)				
Description	Size	Grade	Easy-Pedal™ 2000	Solo™ Heavy-Duty
Mounting Bolts, Clutch Cover to Flywheel	7/16–14 x 2-1/4	5	40–50 (54–68)	40–50 (54–68)

Table 1, Clutch Torque Values

Clutch Adjustments		
Dimension	Definition	Specification in inch (mm)
Release Bearing Travel (internal adjustment)	The distance between the release bearing and the clutch brake.	1/2–9/16 (12.7–14.3)
Release Yoke Free-Travel (linkage adjustment)	The distance between the release yoke fingers and the release bearing wear pads.	0.105–0.145 (2.7–3.7)
Clutch Brake Squeeze (pedal adjustment)	The movement of the clutch pedal from the time that the clutch brake contacts the release bearing until the pedal reaches the end of its stroke.	1/2–1 (12.7–25.4)

Table 2, Clutch Adjustments

Clutch Inspection Tolerances			
Measurement	Dial Indicator at	Gauge Finger at	Maximum Runout in inch (mm)
Flywheel Face Runout	Flywheel Housing	Flywheel Face	0.008 (0.20)
Pilot Bearing Bore Runout	Flywheel Housing	Pilot Bearing Bore	0.005 (0.13)
Flywheel Housing Bore Runout	Crankshaft	Flywheel Housing Bore	0.008 (0.20)
Flywheel Housing Face Runout	Flywheel Outer Diameter	Flywheel Housing Face	0.008 (0.20)

Table 3, Clutch Inspection Tolerances

Minimum Flywheel Bores	
Disc Type	Minimum Flywheel Bore in inch (mm)
10-Spring	8.562 (217.48)
9-Spring	9.750 (247.65)
8-Spring	7.250 (184.15)
7-Spring	9.750 (247.65)
6-Spring	9.750 (247.65)

Table 4, Minimum Flywheel Bores

Solo Heavy-Duty Clutches

Solo Heavy-Duty Clutch Specifications					
Solo Part Number		Flywheel Bore in inch (mm)	Damper Style	No. of Springs	No. of Facings
Standard Yoke	Roller Yoke				
109701–81	N/A	7.0 (178)	Free Travel	8	4
109701–74	N/A	8.5 (216)	Free Travel	10	4
109701–82	109705–82Y	10.0 (254)	Low Rate	7	4
109701–20	109705–20Y	10.0 (254)	VCTplus	6	6
109701–25	109705–25Y	10.0 (254)	VCTplus	6	6
N/A	109706–32Y	10.0 (254)	VCTplus	6	6

Table 5, Solo Heavy-Duty Clutch Specifications

Solo Heavy-Duty Clutch Capacity				
Solo Part Number		Plate Load in lbf (N)	Torque in lbf·ft (N·m) *	Damper Spring Color Code
Standard Yoke	Roller Yoke			
109701–81	N/A	3600 (16 000)	1400 (2000)	White
109701–74	N/A	3600 (16 000)	1650 (2235)	Plain
109701–82	109705–82Y	4000 (18 000)	1700 (2305)	Plain
109701–20	109705–20Y	4000 (18 000)	1860 (2520)	Red
109701–25	109705–25Y	4000 (18 000)	2050 (2780)	White
N/A	109706–32Y	4000 (18 000)	2250 (3050)	Green

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 6, Solo Heavy-Duty Clutch Capacity

Easy-Pedal 2000 Clutches

Easy-Pedal 2000 Clutch Specifications				
Easy-Pedal Part Number	Flywheel Bore in inch (mm)	Damper Style	No. of Springs	No. of Facings
108391–81	7.0 (178)	Free Travel	8	4
108391–74B	8.5 (216)	Free Travel	10	4
108925–82B	10.0 (254)	Low Rate	7	4
108925–20	10.0 (254)	VCTplus	6	6
108925–25	10.0 (254)	VCTplus	6	6

Table 7, Easy-Pedal 2000 Clutch Specifications

Easy-Pedal 2000 Clutch Capacity			
Easy-Pedal Part Number	Plate Load in lbf (N)	Torque in lbf·ft (N·m) *	Damper Spring Color Code
108391–81B	3600 (16 000)	1400 (2000)	White

Specifications

Easy-Pedal 2000 Clutch Capacity			
Easy-Pedal Part Number	**Plate Load in lbf (N)**	**Torque in lbf·ft (N·m) ***	**Damper Spring Color Code**
108391–74B	3600 (16 000)	1650 (2235)	Plain
108925–82B	4000 (18 000)	1700 (2305)	Plain
108925–20	4000 (18 000)	1860 (2520)	Red
108925–25	4000 (18 000)	2050 (2780)	White

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 8, 15-1/2 Inch Easy-Pedal 2000 Clutch Capacity

Easy-Pedal 2000 Clutch Component Dimensions		
Dimension	**Standard Duty in inch (mm)**	**Super Duty in inch (mm)**
Driven Disc Thickness (new)	0.450 (11.43)	0.360 (9.43)
Intermediate Plate Thickness (new)	0.580–0.630 (14.73–16.00)	0.750–0.810 (19.05–20.57)

Table 9, Easy-Pedal 2000 Clutch Component Dimensions

General Description

The clutch linkage transfers the motion of the clutch pedal to the clutch release bearing. The clutch linkage may be adjusted to maintain clutch free pedal, but only after internal clutch adjustments are made.

Clutch free pedal is required to ensure that the release bearing does not run against the fingers of the release yoke. There should not be any play or looseness in the connections and joints of the clutch linkage.

IMPORTANT: Release bearing and release fork clearance are internal clutch adjustments, and *can not be adjusted* by adjusting the clutch linkage. Refer elsewhere in this group for internal clutch adjustments, or to the clutch manufacturer's service literature.

Adjustment

IMPORTANT: Observe the following points before beginning clutch linkage adjustment:

- Be sure internal clutch adjustments are correct before making adjustments to the clutch linkage. Refer to the appropriate section in this manual.
- Adjust clutch linkage only after repair or replacement of the clutch or clutch linkage components.
- Do not attempt to adjust the linkage to compensate for component wear.
- If equipped with cab air-suspension, be sure the air bags are properly inflated. If the air bags are not inflated, the clutch linkage can't be adjusted correctly. For instructions, see **Group 60** in this manual.

IMPORTANT: A special tool is used to adjust the clutch linkage. The special tool is a 3/4-inch (19-mm) spacer and may be ordered from the PDCs under part number 02-12282-000.

1. Tilt the hood.
2. Be sure the clutch pedal is all the way up, against the upper stop.
3. Remove the clutch inspection cover from the bottom of the bell housing.
4. Measure the distance between the release yoke and the release bearing. If this measurement is 0.105 to 0.145 inch (2.7 to 3.7 mm), no further work is needed. If the measurement is incorrect, do all of the remaining steps.
5. Loosen the rod-end jam nuts at the upper end of the threaded adjusting rod.
6. Disconnect the clutch rod from the lower end of the pedal shaft. See **Fig. 1**.
7. Place the special tool (part number 02-12282-000) between the clutch pedal stop bracket and the clutch pedal. See **Fig. 2**.
8. Without applying excessive force, pull the clutch rod forward until it stops (release fork contacts the release bearing).
9. To obtain a free travel measurement of 0.105 to 0.145 inch (2.7 to 3.7 mm) between the release fork and the release bearing, turn the clutch rod end until the center of the rod-end hole is aligned with the center of the hole in the upper clutch lever.

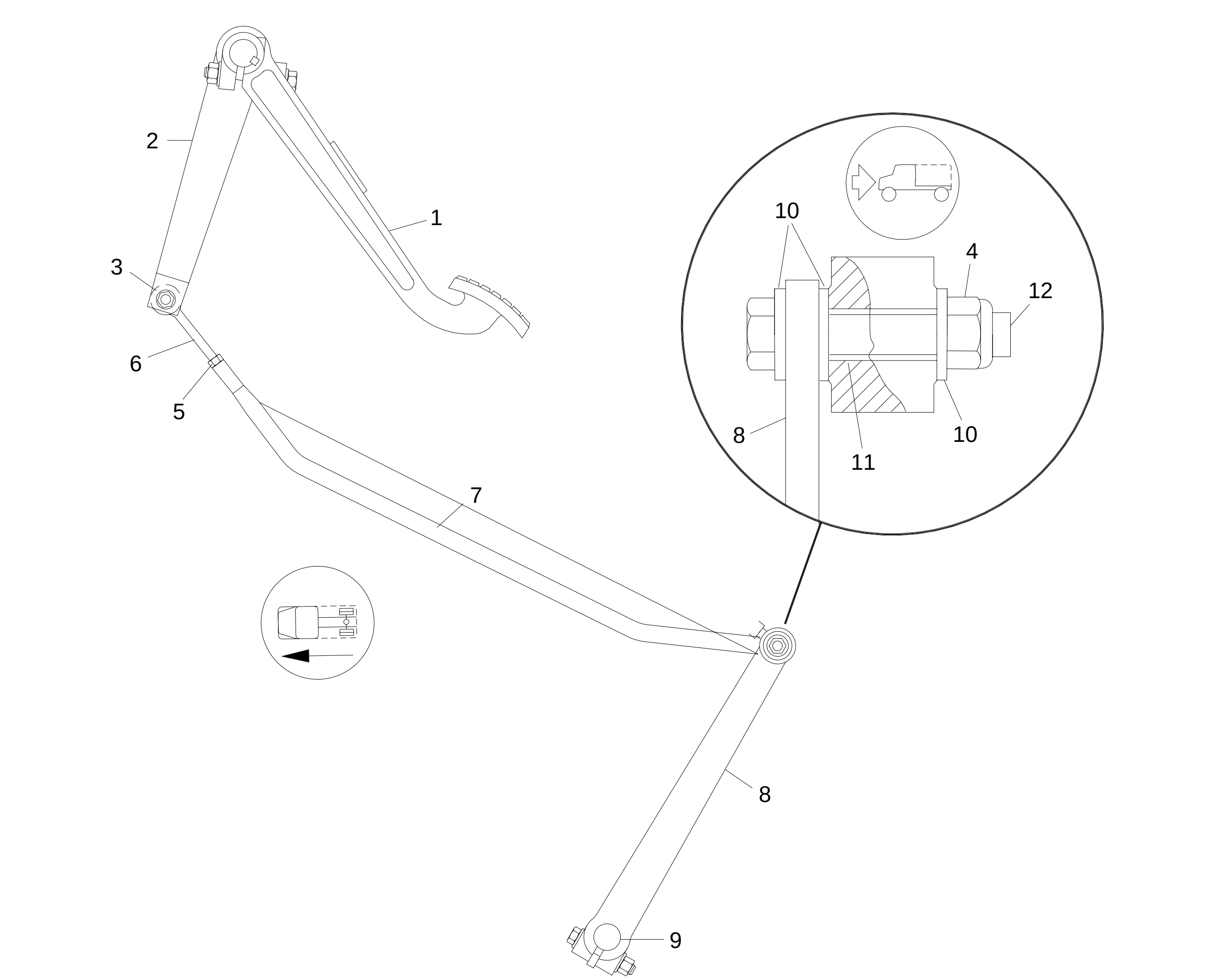
NOTE: Each complete turn of the rod end (or rod) equals about 1/32 inch (1 mm) movement. After lengthening the linkage, at least 3/8 inch (9.5 mm) of thread must remain engaged in each end of the rod.

10. After adjusting the length, connect the clutch rod to the pedal shaft. Install the rod end and nut. Tighten the nut 30 lbf·ft (41 N·m). See **Fig. 3**.

    Tighten both rod-end jam nuts 12 to 15 lbf·ft (16 to 20 N·m).

    Remove the special tool from the clutch pedal stop bracket.
11. Install the inspection cover on the bottom of the bell housing.

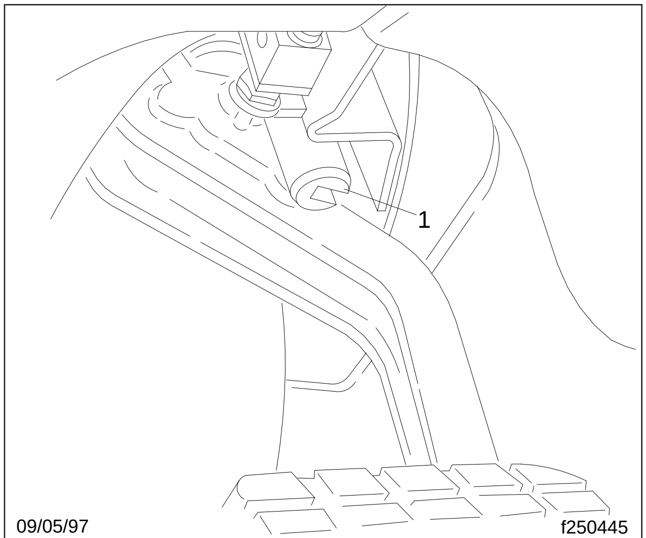
Clutch Linkage Adjustment



1. Clutch Pedal
2. Clutch Pedal Shaft
3. Rod End
4. Locknut
5. Rod-End Jam Nut
6. Threaded Adjusting Rod
7. Clutch Rod
8. Clutch Release Lever
9. Clutch Release Shaft
10. Flatwasher
11. Spacer
12. Capscrew

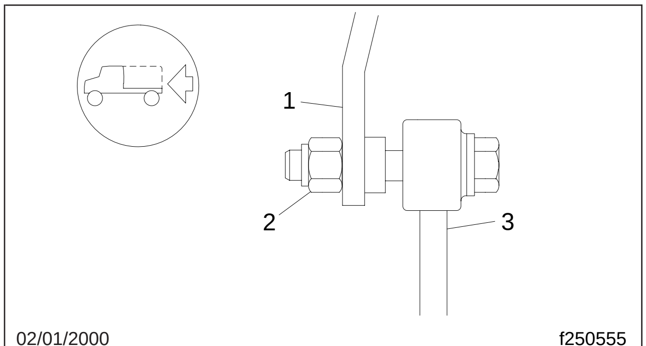
Fig. 1, Clutch Linkage

Clutch Linkage Adjustment



1. Special Tool

Fig. 2, Insert the Special Tool

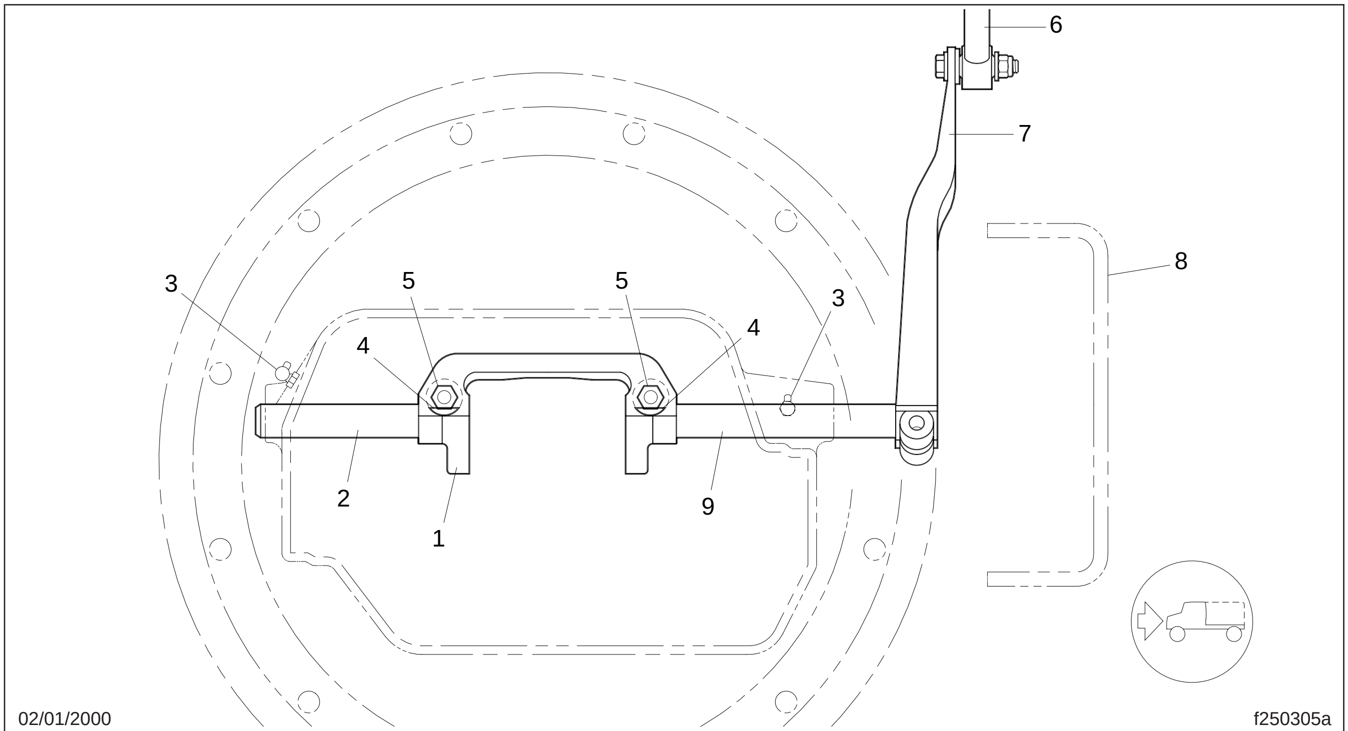


1. Clutch Pedal Shaft
2. Locknut
3. Threaded Rod End

Fig. 3, Connect the Clutch Rod to the Pedal Shaft

Clutch Release Shaft Replacement

Replacement (See Fig. 1)



1. Clutch Release Fork
2. Right Clutch Release Shaft
3. Grease Fitting
4. Shaft Key
5. Capscrew
6. Lower Clutch Rod
7. Clutch Release Lever
8. Left Frame Rail
9. Left Clutch Release Shaft

Fig. 1, Clutch Release Shaft (pull-type clutch shown)

NOTE: If the clutch release shaft assembly is damaged, use the following replacement instructions.

1. Remove the transmission from the vehicle. For instructions, refer to **Group 26** in this manual.
2. Remove the capscrew and shaft key from the right (passenger side) clutch release shaft. Remove the shaft from the mounting holes on the transmission and the clutch release fork.
3. Remove the capscrew and shaft key from the left (driver's side) clutch release shaft. Remove the shaft from the mounting holes on the transmission and the clutch release fork.
4. Insert the right (passenger side) clutch release shaft into the mounting holes on the transmission and the clutch release fork. Line up the release fork with the slot in the release shaft. Install the shaft key and the capscrew. Tighten the capscrew finger-tight.

NOTE: Make sure the release shaft does not extend through the release fork.

5. Repeat the previous step and install the left (driver's side) clutch release shaft.
6. Tighten the capscrews 35 to 45 lbf·ft (47 to 61 N·m).
7. Install the transmission. For instructions, refer to **Group 26** in this manual.
8. Wipe dirt from the grease fittings. Using a pressure gun, lubricate the clutch release shaft with multipurpose chassis grease.
9. Check for binding; the clutch release shaft assembly should rotate smoothly.

Clutch Release Shaft Replacement

10. Check that the clutch engages and disengages smoothly. If needed, adjust the clutch at the linkage. For instructions, refer to **Subject 100**.

Specifications

Description	Torque
Clutch Linkage Jam Nuts	12–15 lbf·ft (16–20 N·m)
Clutch Rod-to-Pedal Shaft	30 lbf·ft (41 N·m)

Table 1, Clutch Linkage Torque Values

General Information

General Description and Principles of Operation

Meritor clutches (**Fig. 1**) are available in 15-1/2 inch models in Freightliner trucks. An identification plate is located on the front cover. Meritor clutches feature the following design characteristics:

- Two-plate
- Diaphragm-spring
- Pull-type
- Dry-disc
- Eight-hole installation pattern

Mounted directly on the flywheel, the clutch cover assembly houses most of the components, including the pressure plate. A diaphragm-type spring provides the force necessary to push the pressure plate forward and engage the clutch. The center plate, which separates the driven discs, has tabs that fit into slots on the clutch cover assembly.

A splined transmission input shaft projects through the cover assembly and driven discs and rests in a pilot bearing in the center of the flywheel. The splined hubs of the driven discs mesh with the splined input shaft to transmit power from the engine to the transmission. The rest of the clutch assembly can spin freely around the input shaft when the clutch pedal is depressed.

A clutch brake stops the transmission gears from rotating when the truck is stopped and when shifting into first or reverse gears. This lets the gears engage quickly without gear clash.

The release bearing assembly transfers the movement of the clutch linkage to engage or disengage the clutch. The release bearing assembly is available with a grease fitting or as a "lubed for life" assembly. Ball bearings permit the release bearing to rotate freely. A coil spring is installed on the sleeve between the release bearing and the hub. The coil spring holds the sleeve on the retainer in a "ball joint" arrangement. This prevents vibration and allows for minor misalignment that may occur between the transmission and the engine due to tolerances between the mounting surface dimensions.

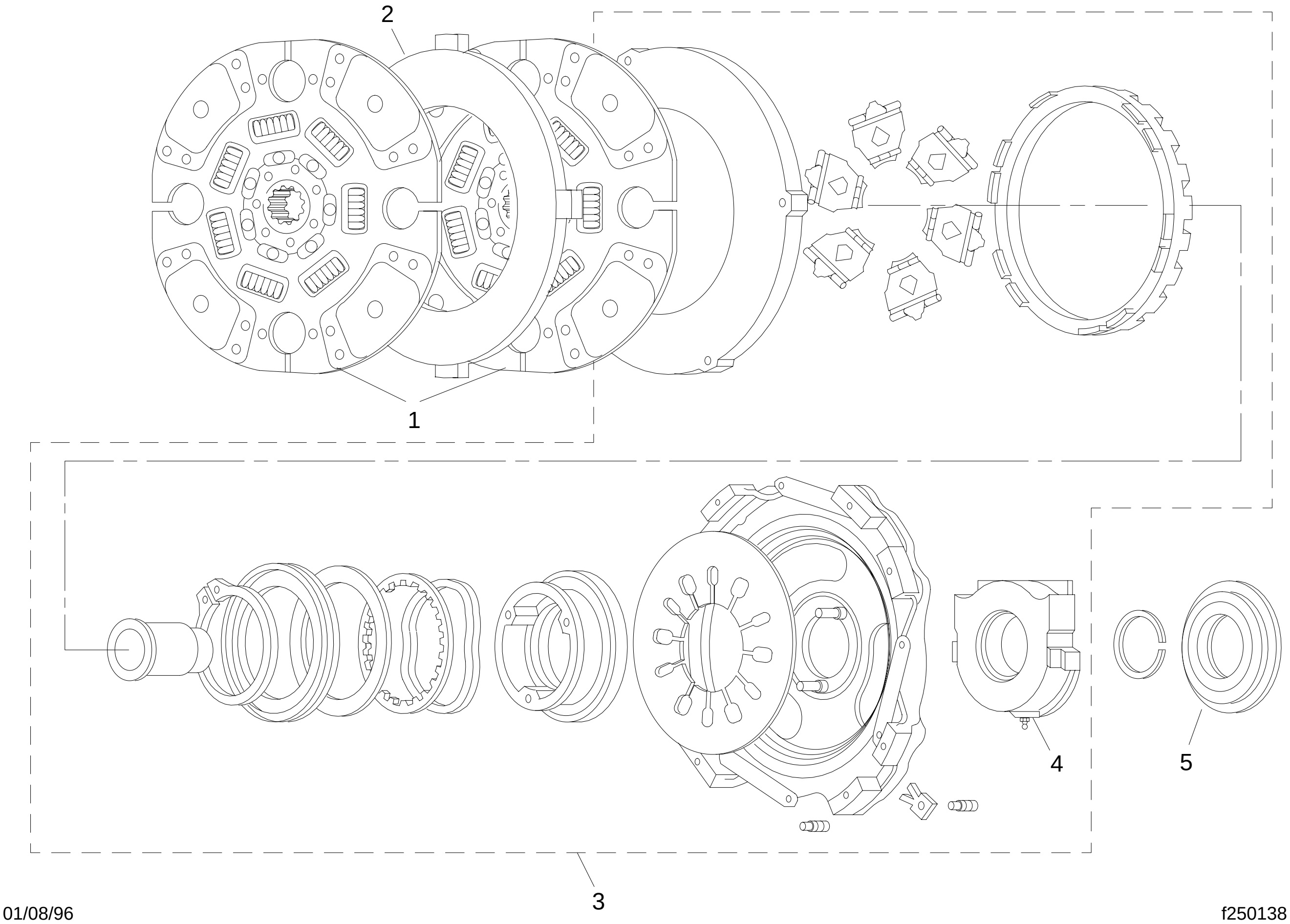
The pressure plate and cover assembly apply the force necessary to engage the clutch. The following parts are in the pressure plate and cover assembly. See **Fig. 2**.

- The *cover* is the housing for the diaphragm spring, adjusting ring, levers, retainer, and the release bearing sleeve. Three holes in the cover provide air flow to remove heat from the clutch.
- The *diaphragm spring* is a one-piece unit that produces the pressure to lock the discs between the pressure plate, the center plate, and the flywheel. The spring is located and held in the cover by the retainer.
- Six *levers* connect the cover assembly to the release bearing sleeve. The levers multiply and transfer the force of the diaphragm spring from the retainer to the pressure plate.
- The *adjusting ring*, located inside the cover and in front of the pressure plate, controls the release bearing clearance. The clearance must be adjusted periodically to compensate for clutch lining wear.
- The *pressure plate* applies the force from the diaphragm spring and locks the clutch discs between the center plate and the flywheel.

The clutch discs are splined to allow movement along the transmission input shaft. Power is transmitted from the flywheel, pressure plate, and center plate through the discs to the transmission. Dampened ceramic clutch discs absorb vibration with spring washers, friction material, and co-axial torsion springs. Ceramic disc linings (**Fig. 3**), are made from ceramic and bronze material. Rivets fasten the ceramic lining to the disc. The ceramic lining provides positive clutch engagement. The co-axial torsion springs also absorb torque shock during engagement.

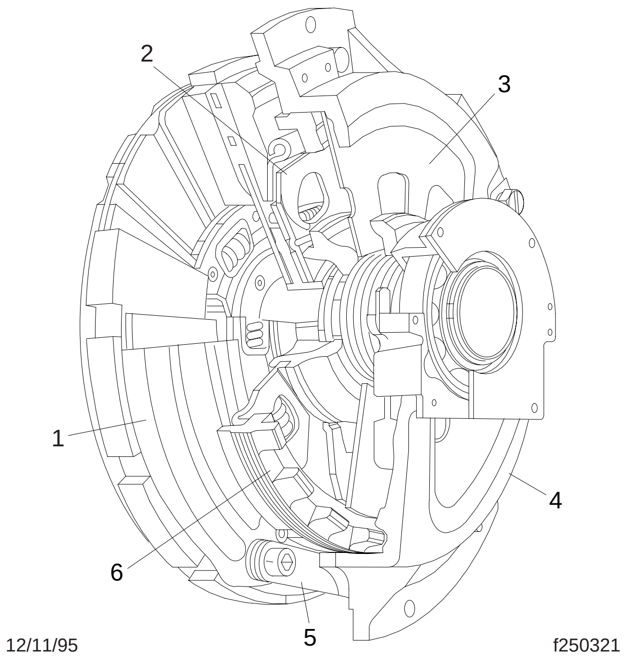
The center plate increases the service life of the clutch by increasing the surface area for power transfer. The 15-1/2 inch clutch center plate is driven by tabs on the plate which fit into slots on the clutch cover.

General Information



1. Ceramic Discs
2. Center Plate
3. Pressure Plate and Cover Assembly
4. Release Bearing
5. Clutch Brake

Fig. 1, Meritor Two-Plate Clutch



1. Pressure Plate
2. Lever
3. Diaphragm Spring
4. Cover
5. Strap
6. Adjusting Ring

Fig. 2, Clutch Components

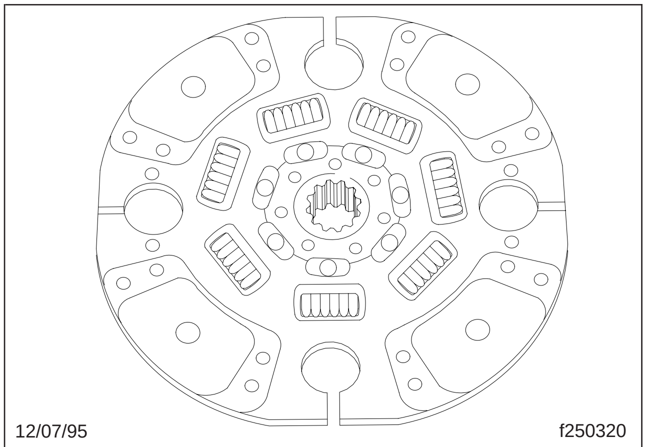


Fig. 3, Ceramic Disc

Clutch Adjustments

NOTE: Clutch linkage adjustment is required only after repair or replacement of the clutch or clutch linkage components. Refer to the clutch linkage section in this manual for procedures.

Internal clutch adjustments should be done whenever:

- the clutch is removed or installed
- any component of the clutch linkage is serviced
- the clutch free pedal is less than 1/2 inch (13 mm).

Make sure of the following before adjusting the clutch:

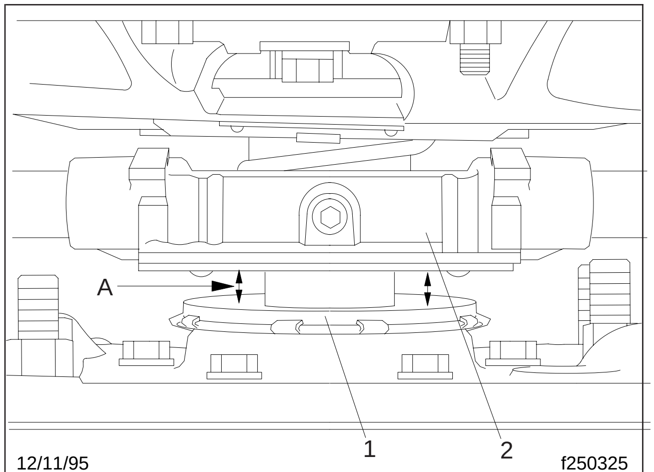
- The clutch system is in good condition.
- The linkage is tight but moves freely during operation.
- There is no "false" free pedal. Keep the clutch lever from moving and depress the clutch pedal. If the pedal moves more than 1/2 inch (13 mm), "false free pedal" is in the linkage. Inspect the linkage and all pivot points for wear or damage. Repair or replace worn or damaged parts.
- The release fork moves when the clutch pedal moves.

RELEASE-BEARING CLEARANCE CHECK

1. Remove the inspection hole cover on the clutch housing.
2. Measure the distance between the end of the release bearing and the clutch brake. See **Fig. 1**. This distance must be 1/2 to 9/16 inch (12.7 to 14.3 mm).

NOTE: While checking this dimension, pull the release bearing toward the transmission, using your hand or a screwdriver.

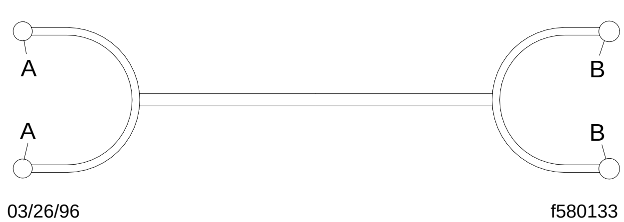
IMPORTANT: An inspection tool A02–12419 (available through the PDCs) can be used to check the distance between the release bearing and the clutch brake. See **Fig. 2**. One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.



A = 1/2 to 9/16 inch (12.7 to 14.3 mm) Clearance
1. Clutch Brake
2. Release Bearing

Fig. 1, Measuring the Release Bearing Clearance

3. If using tool A02–12419 to check the distance between the release bearing and the clutch brake, position the tool so that the legs straddle the transmission input shaft. Check the gap with both ends of the tool as follows:



A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

Fig. 2, Inspection Tool A02-12419

3.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the next step.

3.2 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the

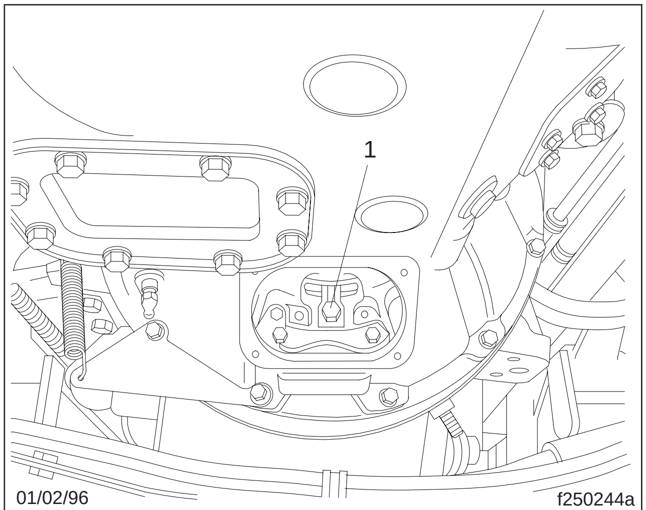
Clutch Adjustments

green end of the tool fits, snug or loose, then no adjustment is needed.

3.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the next step.

4. If the release bearing clearance is not correct, adjust the clutch.

   4.1 Turn the flywheel so that the lock plate is seen through the inspection cover. See **Fig. 3**.



1. Lock Plate

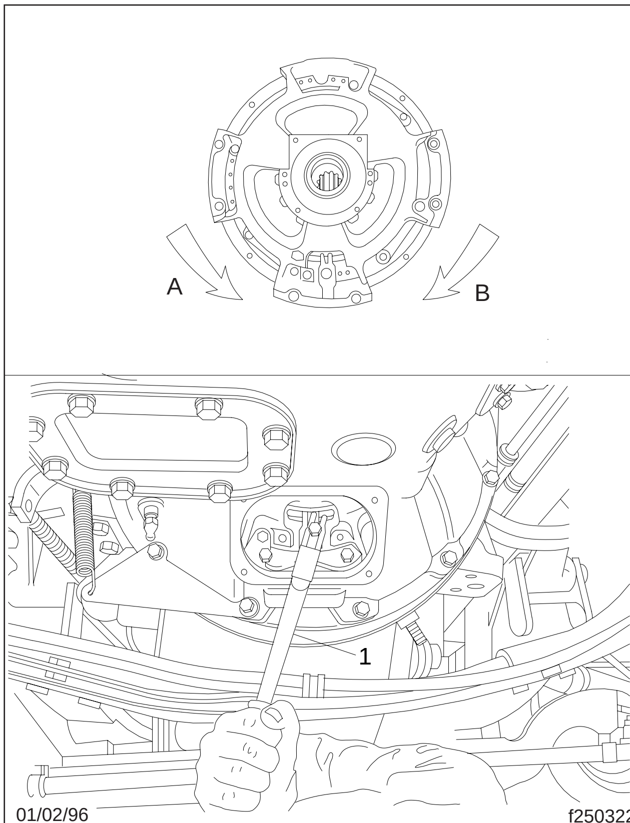
Fig. 3, Remove the Lock Plate

NOTE: Do not use the starter to move the flywheel. Turn the crankshaft with a socket wrench on the front pulley. If the front pulley is difficult to turn, use a spanner wrench on the teeth of the flywheel. See the engine manufacturer's manual for further information.

   4.2 Push the clutch pedal to the bottom of its travel. Have another person hold the pedal at the bottom of its travel (or use a block of wood to hold the pedal).

   4.3 Remove the capscrew and lockwasher that fasten the lock plate to the clutch cover. See **Fig. 3**.

   4.4 Turn the adjusting ring to obtain the specified release bearing clearance. Using a screwdriver or an adjusting tool as a lever against the notches in the ring, move the adjusting ring. See **Fig. 4**. When the adjusting ring is moved one notch, the release bearing will move 1/32 inch (about 0.5 mm).



A. Turn the adjusting ring in this direction to move the release bearing *toward* the clutch.
B. Turn the adjusting ring in this direction to move the release bearing *away from* the clutch.
1. Adjusting Ring Tool

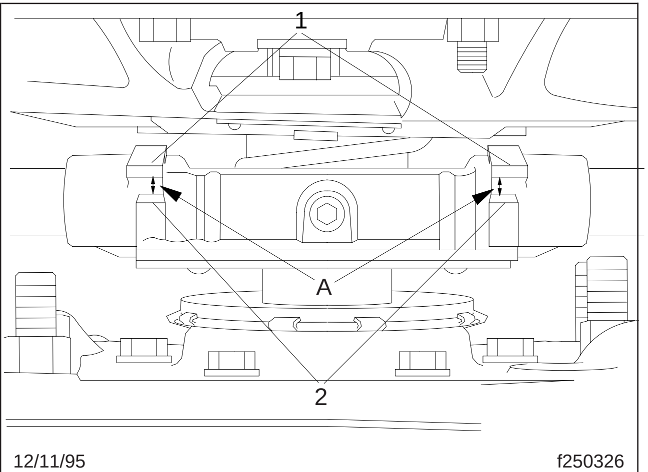
Fig. 4, Turning the Adjusting Ring

NOTE: The adjusting tool is available from: Kent-Moore Tools, part number J 36216; Owatonna Tools, part number 7028; or, Snap-on Tools, part number GA454.

   4.5 Install the lock plate. Install the capscrew that fastens the lock plate to the clutch cover. Tighten the capscrew 25 to 30 lbf·ft (34 to 40 N·m).

   4.6 Release the clutch pedal.

5. Check the clearance between the tips of the release fork and the bosses on the release bearing. The distance must be 0.105 to 0.145 inch (2.7 to 3.7 mm). See **Fig. 5**. If necessary, adjust the clutch linkage. For instructions, see **Section 25.01**.



NOTE: A = 0.105 to 0.145 inch (2.7 to 3.7 mm) Clearance
1. Release Fork
2. Boss on Release Bearing

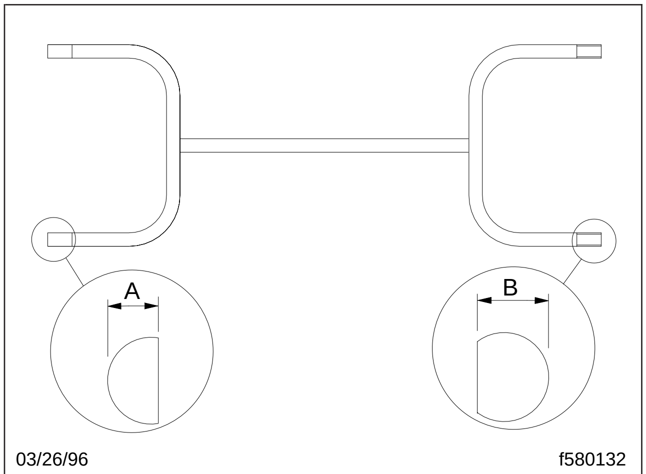
Fig. 5, Checking Clearance

NOTE: The pedal must be released to check the release bearing clearance.

IMPORTANT: An inspection tool A02–12254 (available through the PDCs) can be used to check the distance between the bosses on the release bearing and the tips of the release fork (free travel). See **Fig. 6**. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

6. If using tool A02–12254 to check the distance between the release bearing and the release fork, position the tool so it straddles the fork to ensure that there won't be any misalignment. Check the distance with both ends of the tool as follows:

   6.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the section on clutch linkage adjustment in this group.



A. 0.105 inch (2.7 mm)
B. 0.145 inch (3.7 mm)

Fig. 6, Inspection Tool A02-12254

   6.2 If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

   6.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. For instructions, see **Section 25.01**.

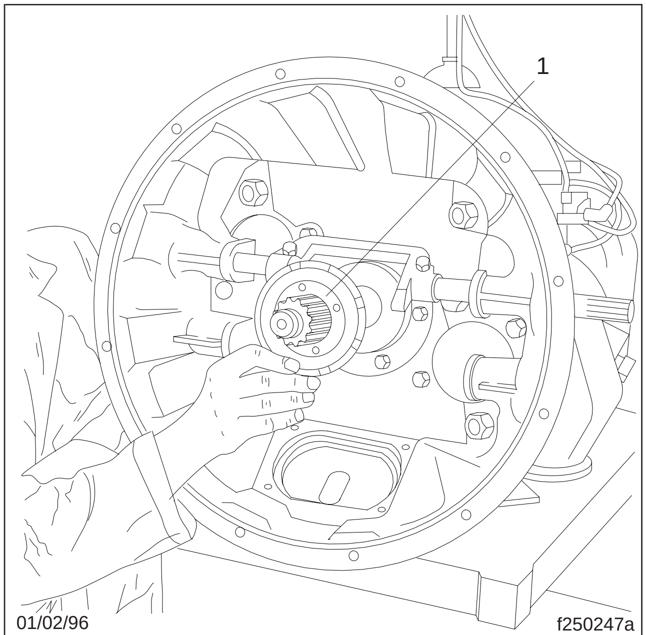
Removal

1. Remove the transmission. Follow the procedures in **Group 26** of this manual.

CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing bore in the flywheel. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing.

2. Remove the clutch brake assembly from the transmission input shaft. See **Fig. 1**.



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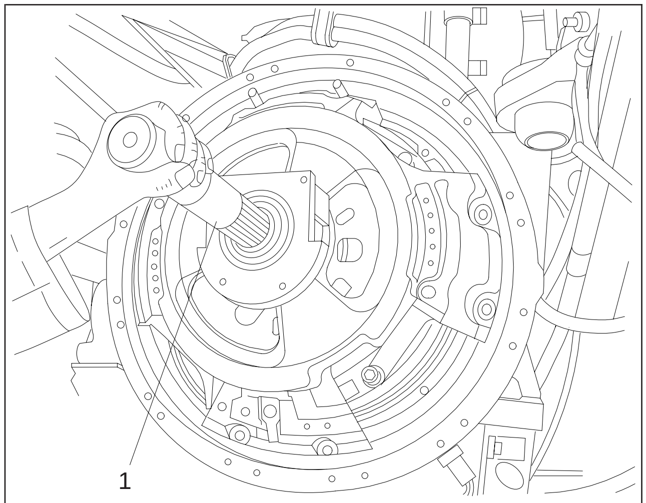
1. Clutch Brake

Fig. 1, Clutch Brake Assembly Removal

3. Install a clutch alignment tool through the clutch and into the flywheel pilot bearing to support the clutch assembly during removal. Use the correct tool so that the splines of the tool match the splines in the clutch. See **Fig. 2**.

NOTE: If an alignment tool is not available, use an input shaft from a manual transmission. Remove the gear from the end of the input shaft. See **Fig. 3**.



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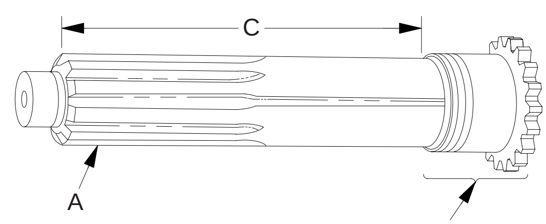
1. Alignment Tool

Fig. 2, Clutch Alignment Tool Installation

4. Remove the top two bolts that fasten the pressure plate and cover assembly to the flywheel. Install two guide studs in the holes. See **Fig. 4** . The studs can be made by removing the head from two 7/16-inch capscrews.



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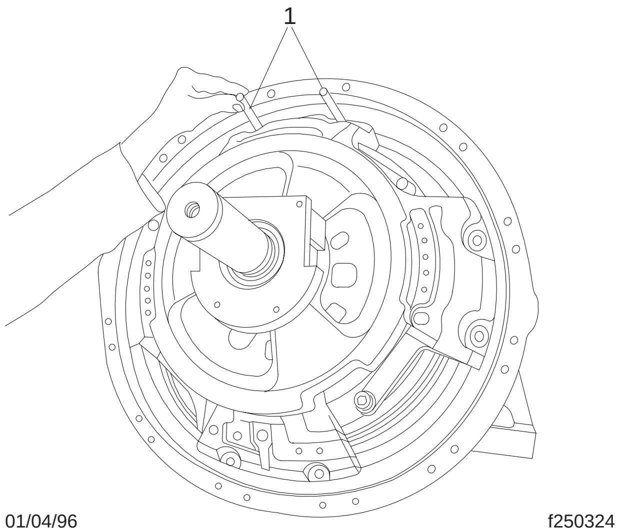
A. Make sure the splines are not damaged.
B. Remove the gear assembly from an input shaft.
C. 13 Inches (33 cm)

Fig. 3, Manual Transmission Input Shaft

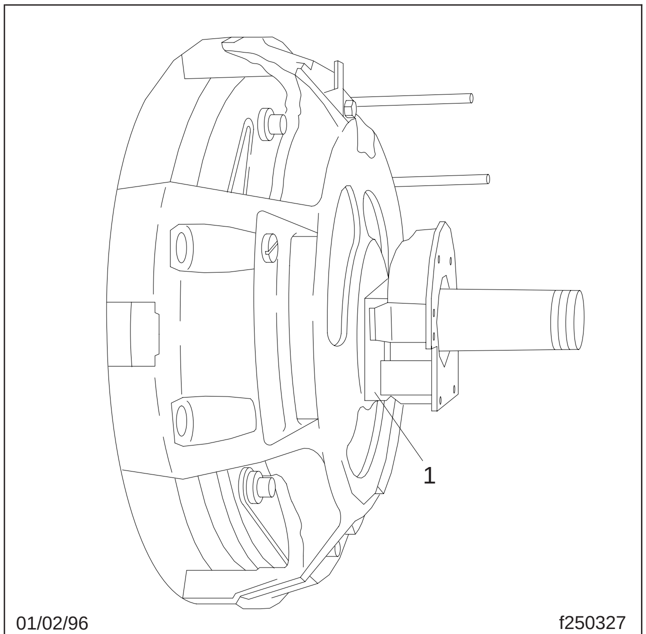
5. Make two wooden spacer blocks 1/2 to 5/8 inch (13 to 16 mm) thick. Insert them between the release bearing assembly and the clutch cover. The wooden spacer blocks ease removal and installation of the clutch. See **Fig. 5**.

Clutch Removal



1. Guide Studs

Fig. 4, Guide Stud Installation



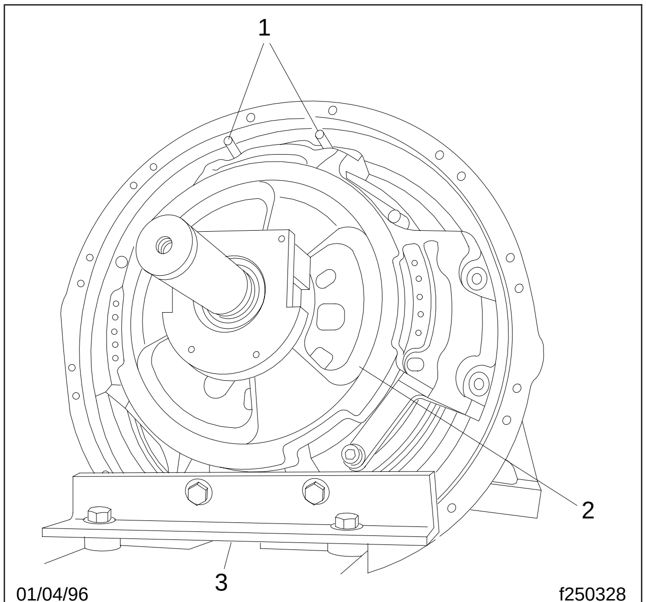
1. 1/2 to 5/8-inch (13 to 16 mm) Spacers

Fig. 5, Spacer Block Installation

WARNING

The pressure plate and cover assembly is heavy and should be removed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious personal injury.

6. Connect a lifting device to the pressure plate and cover assembly because of the weight. See **Fig. 6**.



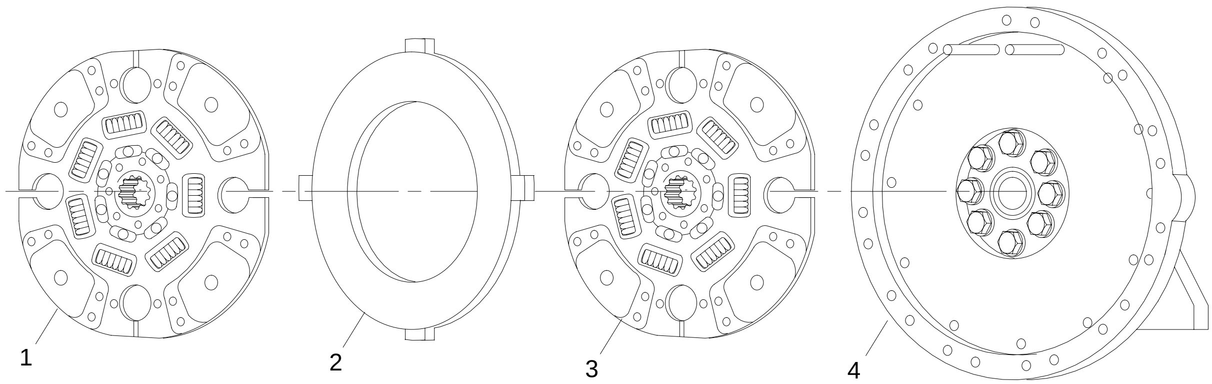
1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

Fig. 6, Connecting a Lifting Device

7. Remove the remaining bolts that fasten the pressure plate and cover assembly to the flywheel.

NOTE: When removing the clutch, the discs and the pressure plate can stay in the cover.

8. Remove the pressure plate and cover assembly over the alignment tool and off the flywheel.
9. Remove the alignment tool, the rear disc, the center plate, and the front disc. See **Fig. 7**.
10. Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced. Use an appropriate internal puller to remove the pilot bearing. Discard the pilot bearing.



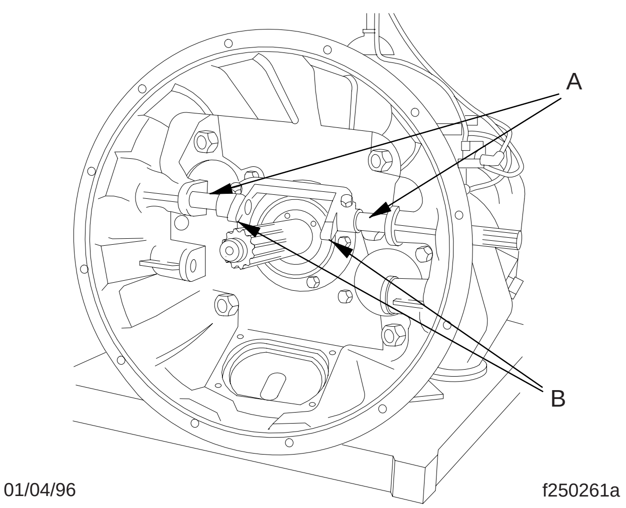
1. Front Clutch Disc
2. Center Plate
3. Rear Clutch Disc
4. Flywheel Housing

Fig. 7, Front Disc, Rear Disc, and Center Plate Removal

Inspection

1. Remove the clutch from the vehicle. For instructions, see **Subject 110**.
2. Inspect the release fork and the cross shaft. See **Fig. 1**. Make sure the release fork is straight and the tips of the fork are not worn or damaged. Replace forks that are worn or damaged.

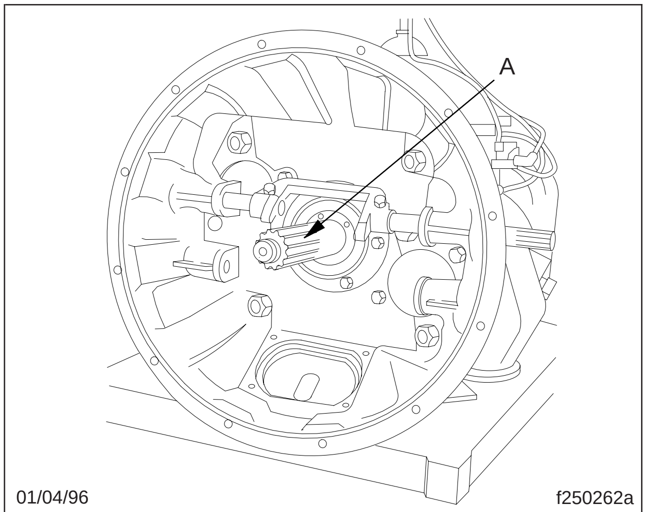
   Make sure the cross shaft rotates freely and doesn't have any side-to-side movement in the transmission housing. If used, inspect the bushings for the shaft in the housing. Replace any parts that are worn or damaged. For instructions, refer to the clutch linkage section in this group.



A. The cross shaft must rotate freely.
B. The tips on the fork must not be worn or damaged.

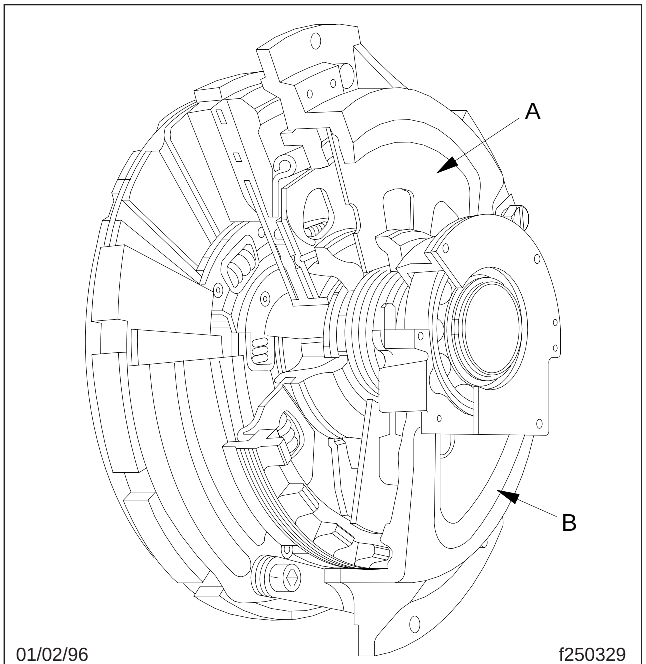
Fig. 1, Release Fork and Cross Shaft Inspection

3. Inspect the splines on the input shaft. See **Fig. 2**. Make sure the splines are not worn or damaged. Inspect the release bearing area of travel for damage. Using an emery cloth, remove small scratches from the input shaft. If the input shaft is worn or damaged, replace it. Any wear or damage on the input shaft causes the clutch to work incorrectly.
4. Remove dirt and contamination from the pressure plate and cover assembly with non-petroleum based cleaning solvents.
5. Inspect the cover for wear and damage. Make sure the diaphragm spring inside the cover is not broken. See **Fig. 3**. If the diaphragm spring is broken, the clutch cover must be disassembled to replace the spring.



A. The splines must not be worn or damaged.

Fig. 2, Input Shaft Splines Inspection

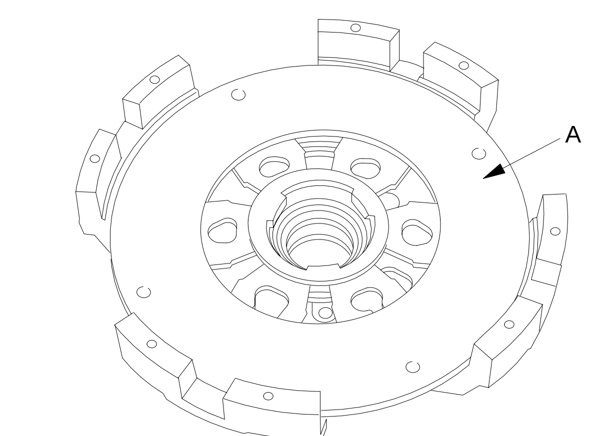


A. Make sure the diaphragm spring is not broken.
B. Make sure the cover is not worn or damaged.

Fig. 3, Diaphragm Spring and Cover Inspection

Clutch Inspection

6. Inspect the pressure plate.
   6.1 Visually check the pressure plate for wear or damage. See **Fig. 4**. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks can't be removed, replace the pressure plate.



A. Inspect the pressure plate surface for wear, cracks, or heat damage.

Fig. 4, Pressure Plate Inspection

   6.2 Put the pressure plate and cover assembly on a bench with the plate facing up.
   6.3 Using a caliper, measure any scratches or scoring on the pressure plate. See **Fig. 5**. If the damage to the surface of the plate is more than 0.015 inch (0.38 mm), replace the pressure plate.

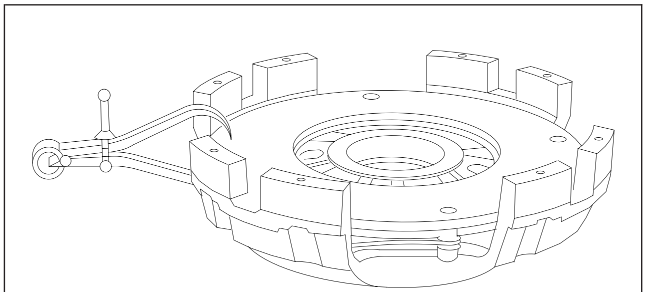
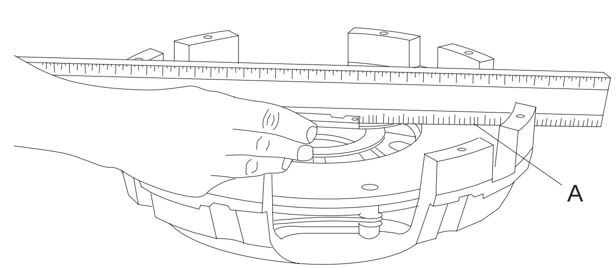


Fig. 5, Measuring Scratches or Scoring on the Pressure Plate

   6.4 Make sure the surface of the pressure plate is flat. Put a straightedge on the surface of the center plate, making sure it crosses the center of the plate. See **Fig. 6**. Using a feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.004 inch (0.10 mm), replace the pressure plate.

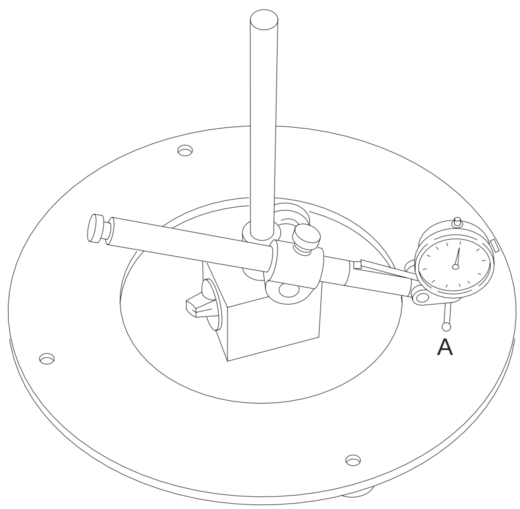


A. Pressure plate flatness gap must not be more than 0.004 inch (0.10 mm).

Fig. 6, Checking the Pressure Plate Surface

   6.5 Measure the runout of the pressure plate to make sure the surfaces are parallel to each other. Put marks on a capscrew, strap, and pressure plate location to ensure that the pressure plate is installed in the original position on the cover. Remove the capscrews that fasten the pressure plate to the strap. Put the pressure plate on a bench so that the smooth surface is up. Put the base of a dial indicator inside the center of the plate. See **Fig. 7**. Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the pressure plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), replace the pressure plate.
7. Inspect the clutch discs.
   7.1 Visually check for wear or damage. If any disc is worn, replace it.
   7.2 Make sure the co-axial springs are not loose in the hub. See **Fig. 8**. Springs that

Clutch Inspection



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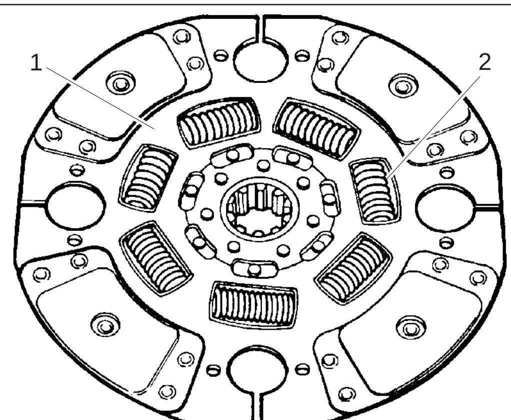
A. Pressure plate runout must not be more than 0.002 inch (0.05 mm).

Fig. 7, Dial Indicator Mounting

rattle are not necessarily loose; springs that have any movement are. If any disc has loose springs, replace it.



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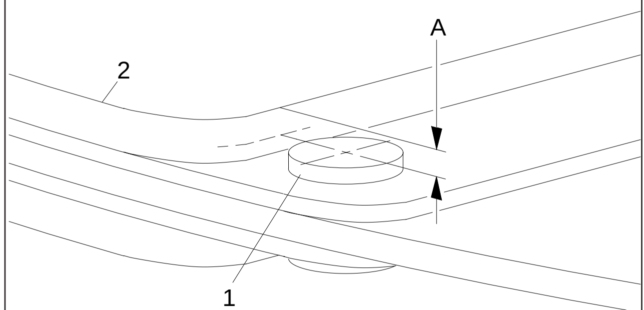
1. Hub
2. Co-Axial Spring

Fig. 8, Checking the Co-Axial Springs

7.3 Make sure the splines in the hub are not damaged. Make sure the hub is fastened to the disc. Replace any disc that is damaged.

7.4 Using a cleaning solvent with a non-petroleum base, remove grease and oil from the discs. If the grease and oil cannot be removed, replace the disc.

7.5 Ceramic linings are fastened to the disc with rivets. Replace the disc if the lining is loose, damaged, or worn to the top of the rivets. See **Fig. 9**.



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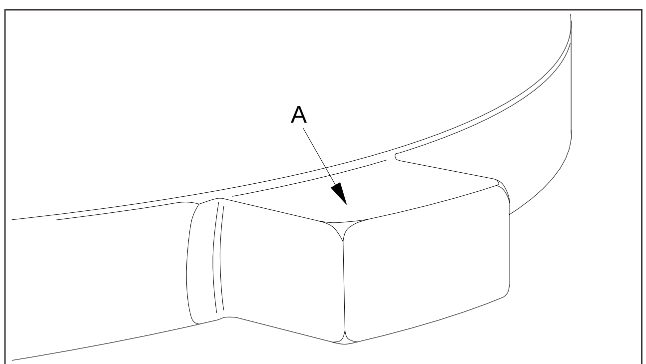
A. Replace the ceramic disc if the lining is even with or below the top of the rivet.
1. Rivet
2. Lining

Fig. 9, Checking the Ceramic Lining

8. Inspect the center plate.

8.1 Inspect the tabs on the outer edge of the center plate. See **Fig. 10**. If the tabs are worn or damaged, replace the center plate. If not, go on to the next step and inspect the center plate.



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A. Make sure the tabs are not worn or damaged.

Fig. 10, Inspecting the Tabs on 15-1/2 Inch Clutches

Clutch Inspection

8.2 Inspect the center plate for wear or damage. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks cannot be removed, replace the center plate.

8.3 Using a micrometer or a caliper, measure the thickness of the center plate. The minimum thickness should be 0.742 inch (18.84 mm). If the center plate measures less than the minimum thickness, replace it. See **Fig. 11**.

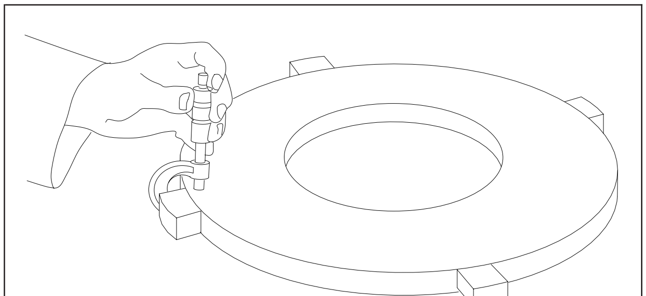
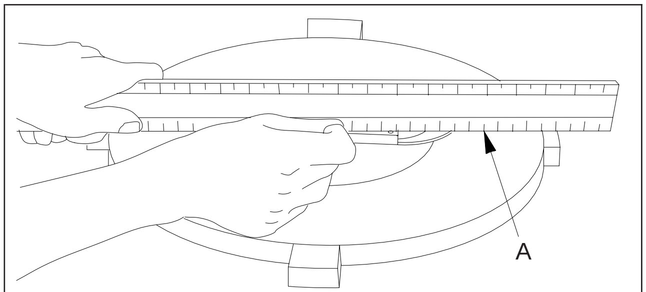


Fig. 11, Measuring Center Plate Thickness

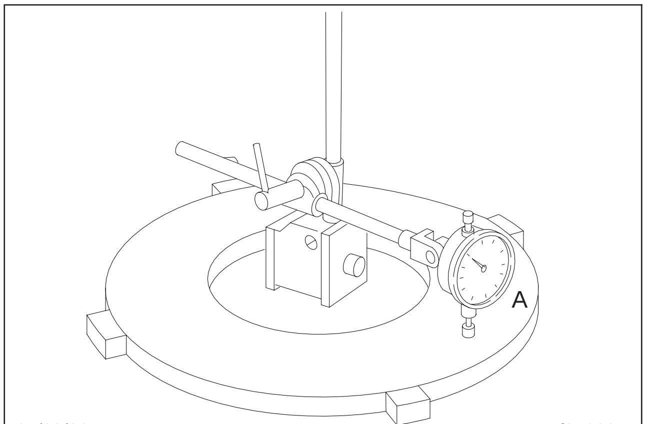
8.4 Make sure the surface of the center plate is flat. Put a straightedge on the surface of the center plate, making sure it crosses the center of the plate. See **Fig. 12**. Using a feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go on to the next step.



A. The gap must be 0.002 inch (0.05 mm) or less.

Fig. 12, Checking the Center Plate Surface

8.5 Measure the runout of the center plate to make sure the surfaces are parallel to each other. **Fig. 13**. Put the base of the dial indicator inside the center of the plate. Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the center plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go on to the next step.



A. Runout must be 0.002 inch (0.05 mm) or less.

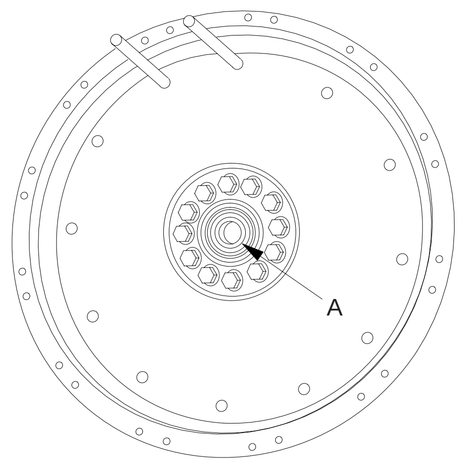
Fig. 13, Measuring Center Plate Runout

8.6 If either the runout or the flatness of the center plate is more than 0.002 inch (0.05 mm), grind enough material so that the plate is flat, but do not go below the minimum thickness. Refer to the table in **Specifications 400** for center plate minimum thickness. Re-check the flatness and runout of the center plate.

9. Although the pilot bearing must be replaced whenever the clutch is removed, inspect the old pilot bearing for wear or damage. See **Fig. 14**. If worn or damaged, correct the cause.

10. Inspect the surface of the flywheel for wear or damage. If the flywheel is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. Some wear or damage can be removed by grinding a new surface on the flywheel. If wear or damage on the surface of the flywheel cannot be removed, replace the flywheel.

Clutch Inspection



A. Make sure the pilot bearing is not worn or damaged.

Fig. 14, Inspecting the Old Pilot Bearing

Refer to the engine manufacturer's service manual for flywheel service procedures.

IMPORTANT: If the flywheel surface is reground, make sure there is still adequate thickness for the capscrews to hold the clutch to the flywheel. The threads for these capscrews are below the surface of some flywheels, requiring the use of capscrews with a shoulder. If some of the flywheel surface is removed, the capscrews may not hold. Use new capscrews that are the correct length.

11. Inspect the ring gear teeth on the outer surface of the flywheel. If the teeth are worn or damaged, replace the ring gear or the flywheel. Refer to the engine manufacturer's service manual for instructions.

    Check the tabs on the outer edge of the flywheel. Replace the flywheel if the tabs are worn or damaged.

12. The flywheel surface must be flat for correct clutch operation. Check the runout of the outer surface of the flywheel. Refer to the engine manufacturer's service manual for instructions.

NOTE: In general, maximum runout is 0.0005 inch times the flywheel diameter in inches.

13. Refer to the engine manufacturer's service manual for instructions and check the following:
    - pilot bearing bore runout
    - crankshaft end play
    - runout of the outer surface of the flywheel housing
    - runout of the inside of the flywheel housing

CAUTION

Do not clean ground or polished parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause the parts to corrode.

14. Clean the disassembled parts.

    14.1 Using a cleaning solvent or kerosene, clean all ground or polished parts or surfaces.

    14.2 Rough parts can be cleaned with the ground or polished parts. The rough parts can also be cleaned in hot solution tanks with a weak alkaline solution. The parts must remain in the tank until they are completely cleaned and heated.

    14.3 Dry the parts with clean paper, shop towels, or compressed air immediately after cleaning.

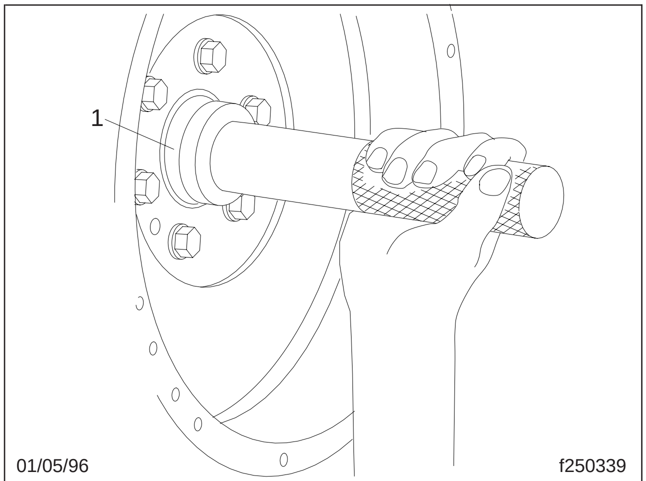
15. Apply lubricant to the cleaned and dried parts that are not damaged and are to be immediately assembled. *Do not* apply lubricant to the linings.

    If parts are to be stored, apply a special material that prevents corrosion and rust to all surfaces. *Do not* apply the material to the linings. Store the parts inside special paper or other material that prevents corrosion and rust.

Installation

NOTE: During clutch removal, spacers or wooden blocks are installed between the release bearing and the clutch cover to facilitate removal. Do not remove the spacers or wooden blocks until after the clutch is installed. The spacers or blocks make installation of the clutch easier by holding the clutch components in position.

1. Lubricate the bore in the crankshaft for the pilot bearing with the specified lubricant. Do not use too much lubricant. Excess lubricant can contaminate the discs and cause the clutch to slip.
2. Use the correct size of driver to install the pilot bearing in the crankshaft bore. See **Fig. 1**. Refer to the engine manufacturer's service manual for instructions.



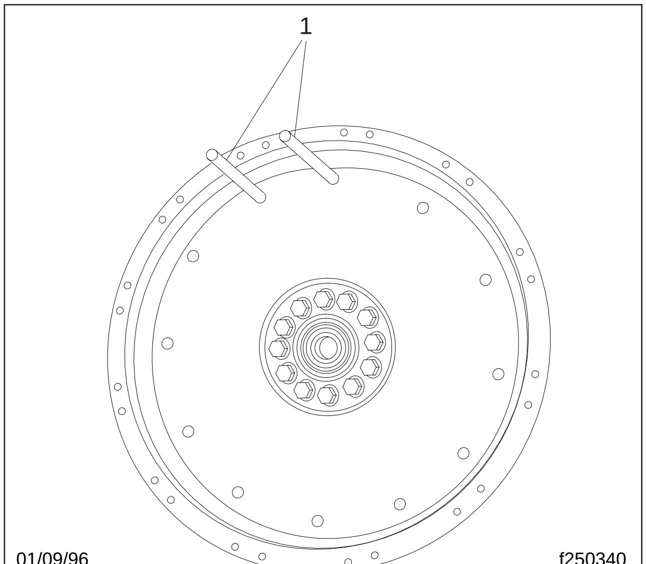
1. Pilot Bearing

Fig. 1, Pilot Bearing Installation

3. Install 3/8-inch guide studs in two of the upper mounting holes for the cover and pressure plate assembly. See **Fig. 2**.

WARNING

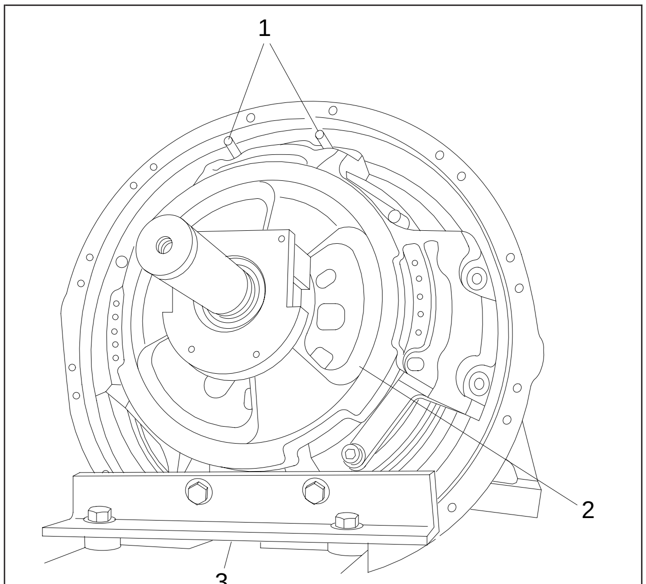
The pressure plate and cover assembly is heavy and should be installed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious personal injury.



1. Guide Studs

Fig. 2, Guide Stud Installation

4. Connect a lifting device to the pressure plate and clutch cover assembly. See **Fig. 3**.

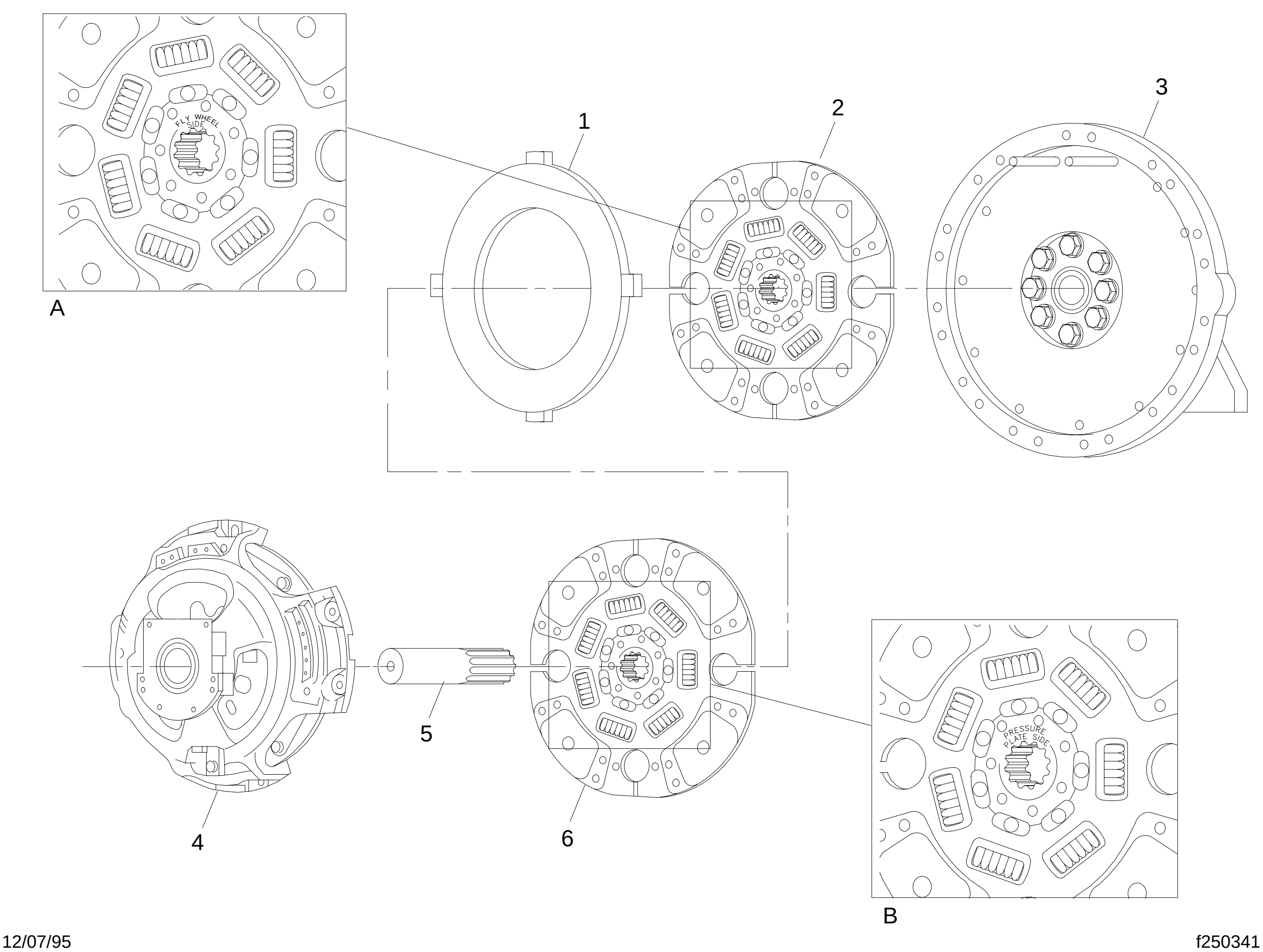


1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

Fig. 3, Lifting the Clutch Assembly

Clutch Installation

5. Install the rear disc in the pressure plate and cover assembly. Make sure the words *PRESSURE PLATE SIDE* on the disc are toward the pressure plate. See **Fig. 4**.
6. Install the center plate over the disc in the pressure plate and clutch cover assembly. Make sure the tabs on the plate are in the slots on the cover.
7. Install the front disc against the center plate. Make sure the words *FLYWHEEL SIDE* on the disc are toward the flywheel. See **Fig. 4**. Make sure the facings of ceramic clutches are aligned.
8. Install the alignment tool through the assembly. Rotate the discs so that the splines in the hub are aligned with the splines on the tool. See **Fig. 4**.



A. Markings must be toward the flywheel.
B. Markings must be toward the pressure plate.

1. Center Plate
2. Rear Clutch Disc
3. Flywheel Housing
4. Cover
5. Alignment Tool
6. Front Clutch Disc

Fig. 4, Alignment Tool Installation

Clutch Installation

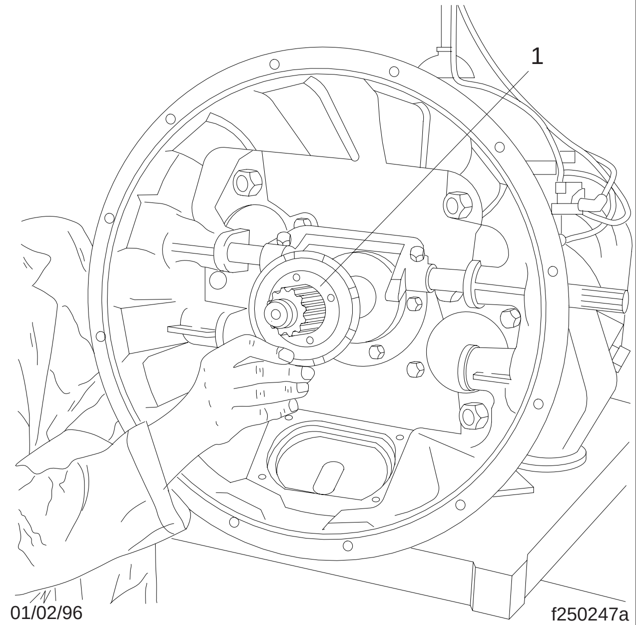
⚠ WARNING

Tilt the front of the alignment tool up when the clutch assembly is installed. If the tool is not tilted up, components will fall off the tool, causing personal injury and component damage.

9. Using a lifting device, lift the clutch assembly onto the guide studs. See **Fig. 3**. Make sure the alignment tool is installed in the flywheel pilot bearing.
10. Install the clutch assembly against the flywheel. Remove the lifting device.
11. Install and hand-tighten the capscrews that fasten the clutch to the flywheel.
12. Remove the guide studs. Install and hand-tighten the remaining capscrews.

NOTE: When the capscrews are tightened, the wooden blocks or spacers will fall from between the release bearing and the cover.

13. Tighten the capscrews to the torque values in **Specifications 400.**
14. Remove the alignment tool (or the input shaft used as an alignment tool).
15. If used, install the clutch brake on the transmission input shaft. Make sure the tabs on the clutch brake engage the slots on the input shaft. See **Fig. 5**.
16. Install the transmission. Follow the procedures in **Group 26** of this manual.



1. Clutch Brake

Fig. 5, Clutch Brake Installation

Troubleshooting Tables

Troubleshooting—Functional Problems

NOTE: Problem entries in the troubleshooting tables in this subject refer to functional or operational problems. Before troubleshooting the clutch, make sure that:

- the engine is operating correctly
- the engine mounts are in good condition
- the driveline angles of the engine, transmission, driveshaft, and rear axle are correct

Problem—The Clutch Does Not Disengage Completely

Problem—The Clutch Does Not Disengage Completely	
Possible Cause	**Remedy**
The clutch linkage and release bearing need adjustment.	Adjust the clutch linkage and release bearing.
The linkage is worn or damaged.	Lubricate the linkage. Make sure the linkage is not loose. If the condition persists, replace the linkage.
The release bearing is worn or damaged.	Lubricate (if applicable) the release bearing. If the condition persists, replace the release bearing.
The input shaft splines are worn or damaged.	Replace the input shaft.
The clutch housing is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
The pressure plate is worn or damaged.	Replace the pressure plate and cover assembly.
The center plate is worn or damaged.	Replace the center plate.
The center plate binds.	Inspect the tabs on the center plate and the slots in the cover. Service as needed.
Damaged clutch disc hub(s).	Replace the clutch discs.
The linings are worn beyond specification.	Replace the clutch discs.
The linings are damaged.	Replace the clutch.
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
A clutch with incorrect lining for the vehicle application is installed.	Install a clutch with the correct type of lining.
The pilot bearing is damaged.	Replace the pilot bearing.

Problem—Clutch Pedal Hard to Operate

Problem—Clutch Pedal Hard to Operate	
Possible Cause	**Remedy**
Damaged bosses on the release bearing assembly.	Replace the bearing assembly. Make sure the clutch is adjusted correctly.
The clutch linkage is worn or damaged.	Lubricate the linkage. If the condition still exists, replace the linkage.
The pressure plate and cover assembly components are worn or damaged.	Replace the pressure plate and cover assembly.

Troubleshooting

Problem—Clutch Pedal Hard to Operate	
Possible Cause	Remedy
The clutch cross shaft binds.	Lubricate the cross shaft. If the condition persists, replace the cross shaft and bushings as required.

Problem—The Clutch Slips

Problem—The Clutch Slips	
Possible Cause	Remedy
The driver keeps his foot on the clutch pedal.	Use correct driving procedures.
The clutch linkage or release bearing needs adjustment.	Adjust the clutch linkage or release bearing.
Pressure plate and cover assembly components are worn or damaged.	Replace the pressure plate and cover assembly.
Linings are worn or damaged.	Replace the clutch discs.
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
A clutch with incorrect lining for the vehicle application is installed.	Install a clutch with the correct type of lining.
The flywheel is worn or damaged.	Service the flywheel as needed. For instructions, refer to the engine manufacturer's service manual.

Problem—The Clutch is Noisy

Problem—The Clutch is Noisy	
Possible Cause	Remedy
The clutch linkage or release bearing needs adjustment.	Adjust the clutch linkage or release bearing.
The linkage is worn or damaged.	Lubricate the linkage. If the condition persists, replace the linkage.
The release bearing is worn or damaged.	Lubricate (if applicable) the release bearing. If the condition persists, replace the release bearing.
The clutch housing is worn or damaged.	Replace the clutch housing.
The clutch housing is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
The hub is damaged, or the co-axial spring(s) are broken in the clutch disc.	Replace the clutch discs.
Linings are worn below specified dimensions.	Replace the clutch discs.
Linings are damaged.	Replace the clutch discs.
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
The pilot bearing is damaged.	Replace the pilot bearing.

Troubleshooting

Problem—The Clutch Vibrates

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
The input shaft splines are damaged.	Replace the input shaft.
The pressure plate and cover assembly are out of balance.	Remove the pressure plate and cover assembly. Check their balance and install them. If the problem persists, replace the pressure plate and cover assembly.
The splines are damaged in the clutch disc hub(s).	Replace the clutch discs.
The flywheel is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners. Check the flywheel mounting surface for damage. If necessary, replace the flywheel.

Troubleshooting—Component Problems

NOTE: Problem entries in the troubleshooting tables in this subject refer to damage to components.

Problem—Broken Tabs on the Clutch Brake

Problem—Broken Tabs on the Clutch Brake	
Possible Cause	**Remedy**
Vibration.	Inspect the clutch disc hubs; check the installation of the clutch. Make sure dampened discs are used.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.
The driver used the clutch brake while the vehicle was moving.	Use correct driving technique.

Problem—Worn or Damaged Release Bearing Housing

Problem—Worn or Damaged Release Bearing Housing	
Possible Cause	**Remedy**
The driver keeps his foot on the pedal.	Use correct driving technique.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.

Problem—Worn Bosses on the Release Bearing Housing

Problem—Worn Bosses on the Release Bearing Housing	
Possible Cause	**Remedy**
The linkage is damaged or out of adjustment.	Lubricate and adjust the linkage. Inspect the linkage for wear or damage.

Troubleshooting

Problem—Worn Bosses on the Release Bearing Housing	
Possible Cause	**Remedy**
The release yoke is binding.	Lubricate the release yoke shaft. If the yoke does not move freely, replace the shaft and yoke assembly.
The free pedal is out of adjustment.	Adjust the free pedal to specification.

Problem—Worn or Damaged Input Shaft Splines

Problem—Worn or Damaged Input Shaft Splines	
Possible Cause	**Remedy**
The transmission is not aligned.	Make sure the flywheel housing and the clutch housing are aligned to specification.
The transmission is not installed correctly.	Install the transmission correctly.
The clutch disc hubs are damaged.	Replace the clutch discs.
The pilot bearing is worn or damaged.	Replace the pilot bearing.
Engine vibration.	Make sure dampened discs are used.

Problem—Pressure Plate Cracked or Damaged by Heat

Problem—Pressure Plate Cracked or Damaged by Heat	
Possible Cause	**Remedy**
The driver engages the clutch while coasting.	Use correct driving techniques.
The driver uses the clutch as a brake.	Use correct driving techniques.
The clutch free pedal is not adjusted correctly.	Adjust the free pedal to specifications.
There is oil or grease on the clutch linings.	Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil.
The diaphragm spring is worn or damaged.	Replace the pressure plate and the cover assembly.
The driver slips the clutch excessively during engagement.	Use correct driving techniques.

Problem—Grooves Worn in the Pressure Plate

Problem—Grooves Worn in the Pressure Plate	
Possible Cause	**Remedy**
The clutch discs are worn or damaged.	Replace the clutch discs. If damaged, replace the center plate and flywheel.

Troubleshooting

Problem—The Clutch Disc Hub is Warped

Problem—The Clutch Disc Hub is Warped	
Possible Cause	Remedy
The transmission was not installed correctly.	Replace the clutch discs. Install the transmission correctly.

Problem—The Hub Separates From the Clutch Disc

Problem—The Hub Separates From the Clutch Disc	
Possible Cause	Remedy
Excessive engine vibration.	Repair the engine.
The transmission was not installed correctly.	Install the transmission correctly.
The clutch housing is loose.	Tighten the clutch housing to the specified torque.
The driver engages the clutch while the vehicle is coasting.	Use correct driving techniques.
Shock loading.	Use correct driving techniques.

Problem—Heat Damage to the Clutch Disc

Problem—Heat Damage to the Clutch Disc	
Possible Cause	Remedy
The driver keeps his foot on the clutch pedal or slips the clutch.	Use correct driving techniques.
The clutch does not engage or disengage completely.	See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely."
The free pedal is not adjusted correctly.	Adjust the free pedal.
The diaphragm spring is worn or damaged.	Replace the pressure plate and cover assembly.
There is oil or grease on the clutch linings.	Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil.

Problem—The Linings Separate From the Disc

Problem—The Linings Separate From the Disc	
Possible Cause	Remedy
The linings are worn below the specified dimension.	Replace the clutch discs.
The driver allows the vehicle to coast downhill with the transmission in gear and the clutch engaged.	Use correct driving techniques.

Troubleshooting

Problem—Heat Damage to the Clutch Disc

Problem—Heat Damage to the Clutch Disc	
Possible Cause	**Remedy**
The driver does not start the vehicle in the correct gear.	Use correct driving techniques.
The driver engages the clutch while the vehicle is coasting.	Use correct driving techniques.
The tabs on the center plate are binding in the clutch cover.	Replace the pressure plate and cover assembly.
The clutch does not release.	See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely."

Specifications

Description	Specifications
Actuation Type	Pull
Minimum Clutch Housing Size for Mounting	SAE Number 2
Pressure Plate Actuation	Single Diaphragm Spring
Clamp Load	3600 lbf (16 013 N) 4000 lbf (17 793 N)
Adjustment	Manual
Facing Size	15.35 x 8.66 in (390 x 220 mm)
Lining Availability	Ceramic
Lining-to-Disc Fastener	Rivet

Table 1, General Specifications

Description	Clutch Diameter
Pressure Plate Runout	0.000 to 0.002 inch (0.00 to 0.05 mm)
Pressure Plate Flatness	0.002 to 0.004 inch (0.05 to 0.10 mm)
Maximum Allowable Wear	0.015 inch (0.38 mm)

Table 2, Pressure Plate Specifications

Description	Specifications
Center Plate Runout	0.000–0.002 inch (0.00–0.05 mm)
Center Plate Flatness	0.000–0.002 inch (0.00–0.05 mm)
Center Plate Minimum Thickness	0.742 inch (18.84 mm)
Center Plate Drive	Tabs on Center Plate in Clutch Cover

Table 3, Center Plate Specifications

Description	Specifications
Number of Splines on Disc	10
Spline Diameter	2.00 inch (51.0 mm)
Minimum Disc Thickness	To Top of Rivet

Table 4, Clutch Disc Specifications

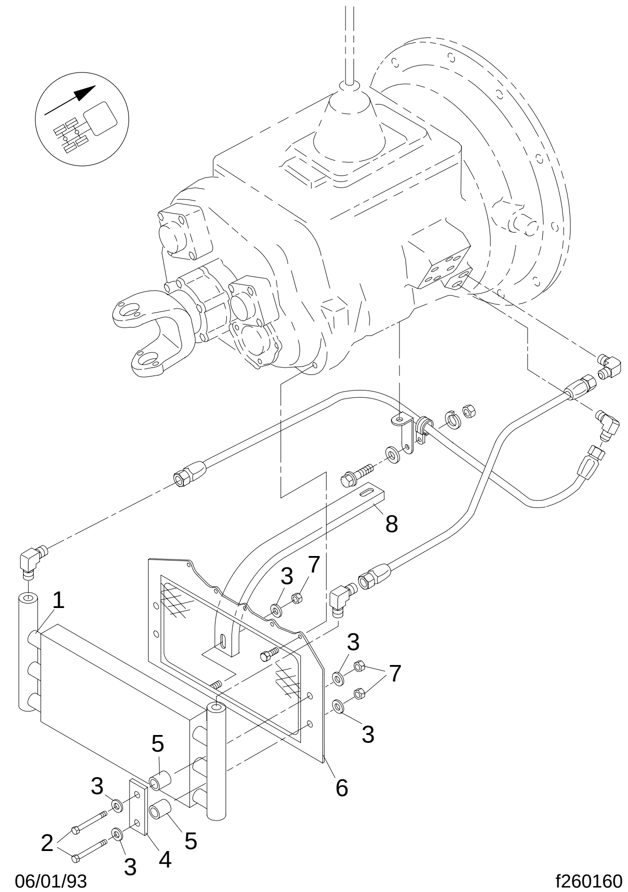
Description	Torque: lbf·ft (N·m)
Adjusting Ring Lock Capscrew	25–30 (34–40)
Capscrew Between Cover Assembly and Flywheel	45–50 (62–67)

Table 5, Torque Values

Manual Transmission Removal and Installation

Removal

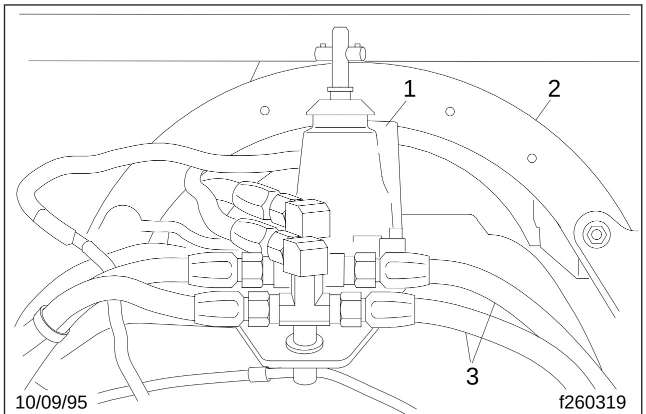
1. Apply the parking brakes, chock the tires, put the transmission into high gear, and tilt the hood.
2. Disconnect the batteries.
3. Remove the air reservoirs. For instructions, see **Section 42.06**.
4. If installed, remove the transmission fluid cooler and the plug fittings in the cooler and transmission. See **Fig. 1**.



1. Transmission Fluid Cooler
2. Capscrew, 5/16-18
3. Washer, 5/16-inch
4. Retaining Plate
5. Biscuits
6. Mounting Bracket
7. Locknut, 5/16-18
8. Support Strut

Fig. 1, Transmission Fluid Cooler Mounting

5. Disconnect the driveline from the transmission output yoke. For instructions, see **Section 41.00**.
6. Disconnect the driveline midship bearing from the midship bearing bracket, and pull the driveline off to one side, out of the way. For instructions, see **Section 41.00**.
7. Disconnect the EquiFlo bracket from the top of the transmission.
8. Remove or disconnect the shift linkage. See **Fig. 2**.



1. Shift Tower
2. Overslung Crossmember
3. Air Lines

Fig. 2, Shift Linkage Removal

8.1 Remove the shift tower boot and air lines.

8.2 Remove the shift tower from inside the cab, and cover the shift tower hole in the top of the transmission to prevent dirt from entering the transmission.

8.3 Disconnect the electrical connectors from the top of the transmission.

9. Disconnect the clutch rod from the clutch release lever. Rotate the clutch release yoke so that it will clear the clutch release bearing.
10. Disconnect all wiring at the transmission, including the speedometer sensor at the output yoke, the neutral start switch, and the back-up alarm as applicable. Mark all wires for reassembly.
11. Disconnect all air lines from the transmission, and mark those lines for reassembly. Plug all air lines, and cap all transmission air fittings.

Manual Transmission Removal and Installation

12. Position a transmission jack under the transmission, and raise its support plate against the bottom of the transmission. Adjust the support plate to the same angle as the bottom of the transmission.
13. Raise the transmission jack until it fits securely against the bottom of the transmission, then secure the transmission to the jack with a chain.
14. Remove the flywheel-housing-to-clutch-housing attachment bolts. Keep the flange of the clutch housing parallel (all the way around) to the flange of the flywheel housing, until the input shaft is clear of the clutch.

NOTICE

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent damage to the clutch discs.

15. Pull the transmission and jack straight back, until the transmission input shaft is clear of the clutch and the engine flywheel housing. Lower the transmission. See **Fig. 3**.

WARNING

After lifting the front end of the vehicle, do not get under the vehicle until it is securely supported by vehicle stands. If the vehicle is supported only by an axle jack, the vehicle can fall, resulting in personal injury or property damage.

16. Raise the front axle of the vehicle high enough that you can remove the transmission by rolling it out behind the front tire.

Installation

1. If not already done, apply the parking brakes, chock the tires, and tilt the hood.
2. If the clutch brake was removed, install the clutch brake on the transmission input shaft. See **Fig. 4**. Slide it tight against the input shaft bearing cap.

NOTE: Torque-limiting clutch brakes are a one-piece assembly with a larger and a smaller face. When installing a torque-limiting clutch brake on a Fuller® or Rockwell transmission, install the *smaller* face toward the transmission.

3. Check for wear on the fingers of the clutch release yoke, release shafts, and the release shaft bushings. Replace any worn parts as necessary.
4. Shift the transmission into gear, so that the transmission input shaft can be rotated during assembly, to line it up with the clutch driven-disc hub splines.

WARNING

After lifting the front end of the vehicle, do not get under the vehicle until it is securely supported by vehicle stands. If the vehicle is supported only by an axle jack, the vehicle can fall, resulting in personal injury or property damage.

5. If the vehicle is not already raised and supported on stands, raise the front of the vehicle high enough that you can move the transmission into position by rolling it in from behind the front tire.
6. Raise the vehicle enough to remove the vehicle stands. Remove the stands, and lower the vehicle to the ground.
7. Roll the transmission and jack into alignment behind the engine. Raise the transmission jack support plate until the flange of the clutch housing is parallel (all the way around) to the flange of the flywheel housing. Align the transmission input shaft with the hole in the release bearing sleeve. See **Fig. 5**.

NOTE: If necessary, wipe the input shaft clean with a clean, dry cloth. It is not necessary to lubricate the input shaft.

8. Push the transmission and jack straight forward, while making sure the flanges remain parallel, until the transmission input shaft begins to enter the clutch release bearing.
9. Rotate the top of the clutch release yoke rearward, and rotate the release bearing until the flat portion is at the top. Roll the transmission slowly forward. Raise or lower the transmission as required to maintain alignment.

IMPORTANT: Be sure that the release yoke clears the release bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 6**. Align the input shaft splines

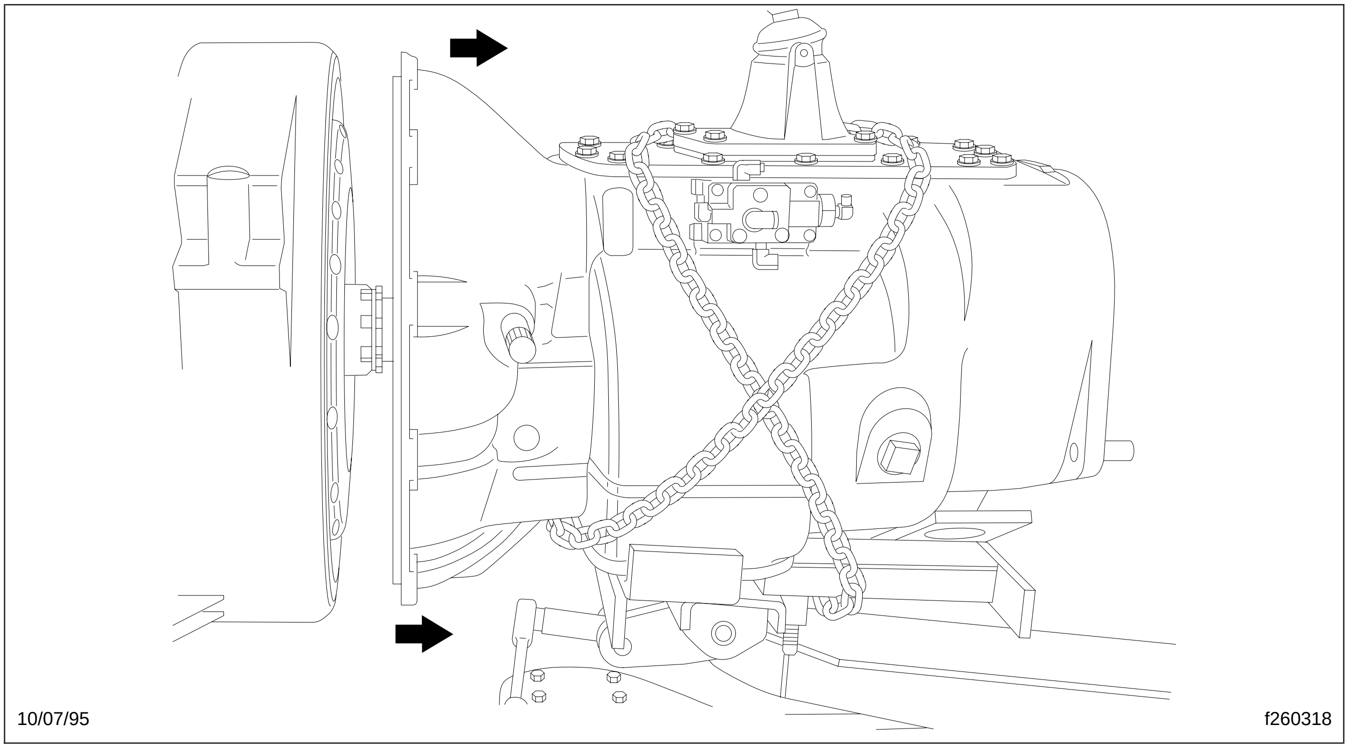


Fig. 3, Transmission Removal

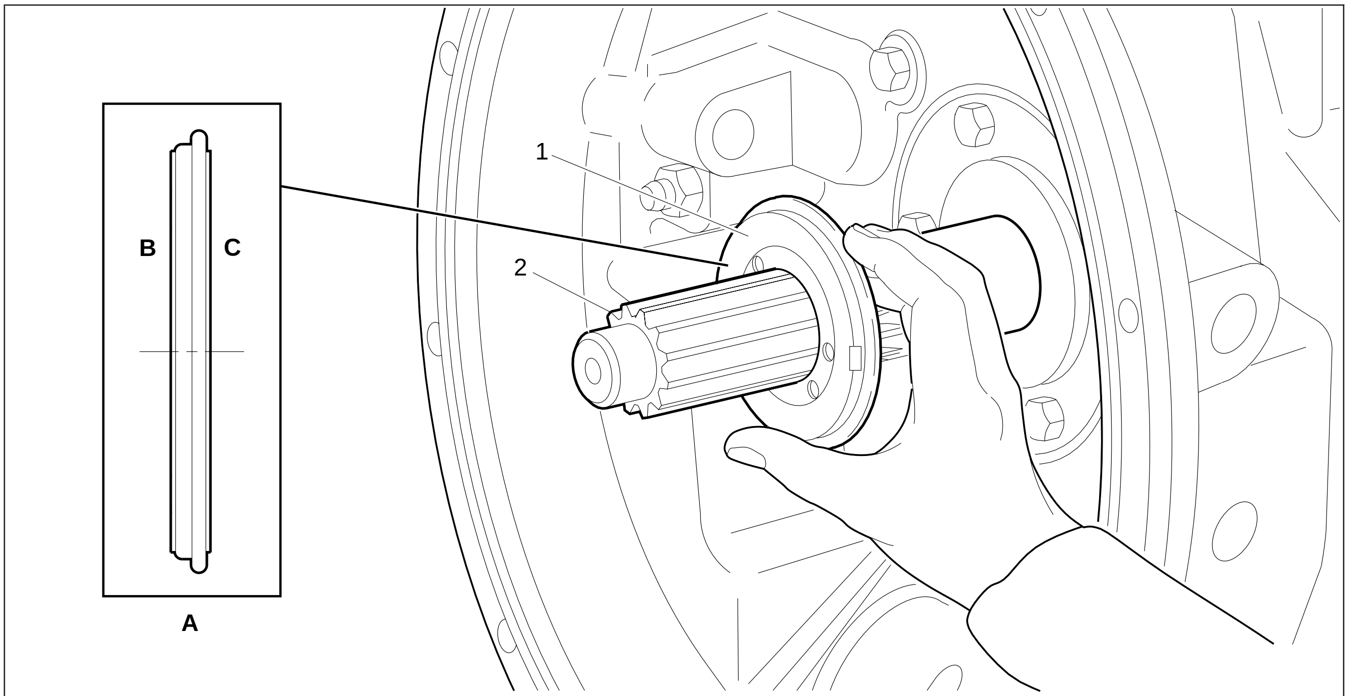
with the clutch disc splines by turning the transmission output shaft.

NOTICE

Use care to avoid springing the drive discs when the transmission is being installed. Do not force the transmission into the clutch or flywheel housing if it does not enter freely. Do not let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

10. Push the transmission forward until the clutch housing pilot flange enters the flywheel housing pilot bore. Install the flywheel-housing-to-clutch-housing attachment capscrews, and using a crisscross pattern, tighten them finger-tight. Then, using the same crisscross pattern, tighten the capscrews either 43 to 53 lbf·ft (58 to 72 N·m) for Patch-Lok capscrews, or 38 to 45 lbf·ft (52 to 61 N·m) for non-locking capscrews with lockwashers.
11. Remove the chain that secures the transmission to the jack, and remove the jack from under the vehicle.
12. Install or connect the shift linkage.
    - 12.1 Install the shift tower inside the cab.
    - 12.2 Install the air lines and shift boot.
    - 12.3 Install the electrical connectors on the top of the transmission.
13. Connect the air lines and wiring to the transmission as previously marked.
14. Connect the clutch rod to the clutch release lever. For instructions, see **Section 25.00**.
15. Connect the driveline to the transmission output yoke. For instructions, see **Section 41.00**.
16. Connect the midship bearing to the midship bearing bracket. For instructions, see **Section 41.00**.
17. Connect the EquiFlo bracket to the top of the transmission. Open the fuel shut-off valves or fill the fuel tanks as applicable.

Manual Transmission Removal and Installation



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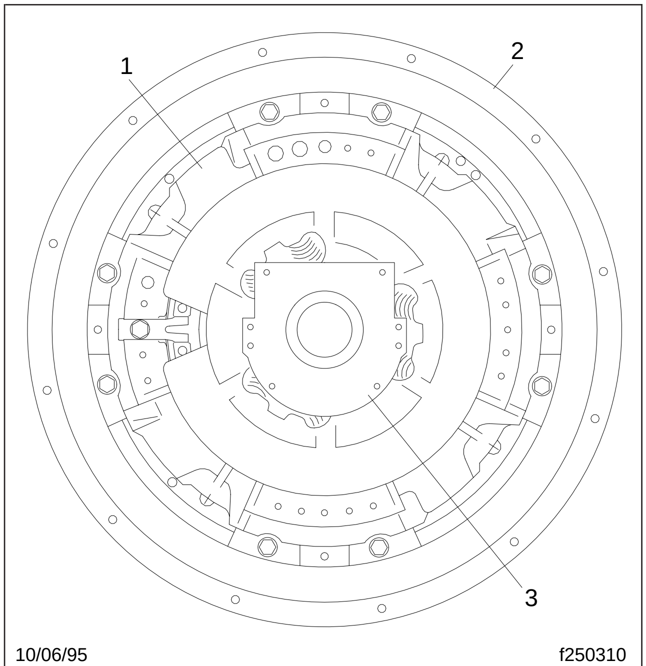
A. Cross section of clutch brake
B. Install deep side toward release bearing
C. Install shallow side toward the transmission

1. Clutch Brake
2. Input Shaft

Fig. 4, Clutch Brake Installation

18. Install the transmission fluid cooler and all the plug fittings in the cooler and transmission. See **Fig. 1**.
19. Install the air reservoirs on the vehicle. For instructions, see **Section 42.06**.
20. Connect the batteries.
21. Grease the clutch release bearing and the release shafts. For instructions, see the Group 25 of the *Columbia Maintenance Manual*.
22. Check the clutch and clutch linkage for proper clutch pedal free-travel and clutch brake operation. For instructions, refer to the vehicle driver's manual.

    To adjust the clutch, see **Section 25.00**.
23. Start the engine and run it long enough to pressurize the air system to at least 80 psi (550 kPa). Lower the hood, and remove the chocks from the tires.



1. Clutch
2. Flywheel Housing
3. Release Bearing

Fig. 5, Aligning the Transmission and Release Bearing

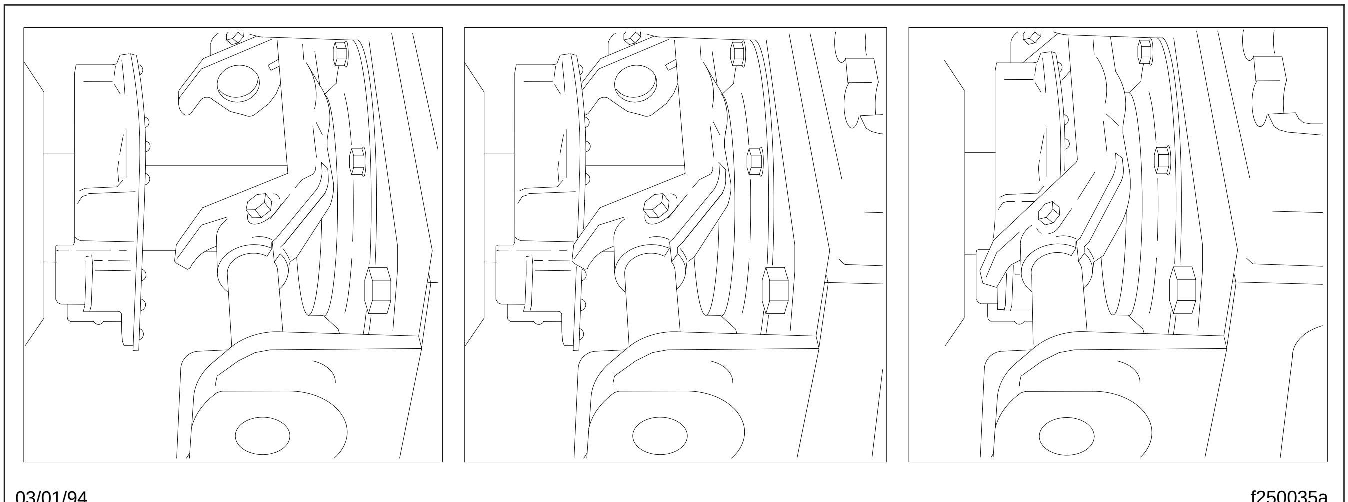


Fig. 6, Release Yoke Clearing the Release Bearing

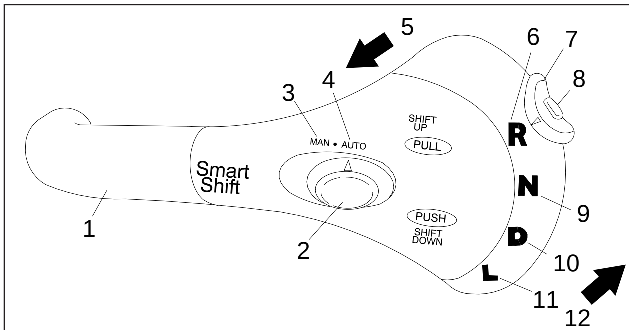
General Information

The SmartShift™ transmission shift control is an electronic transmission control device. It is required with the following automated transmissions:

- Eaton® Fuller® UltraShift™
- Eaton Fuller UltraShift™ PLUS
- Eaton Fuller AutoShift™
- ZF Meritor™ FreedomLine™
- Meritor™ SureShift™

There are three versions of the control:

- See **Fig. 1** for the UltraShift, UltraShift PLUS, and AutoShift control.
- See **Fig. 2** for the FreedomLine control.
- See **Fig. 3** for the SureShift control.



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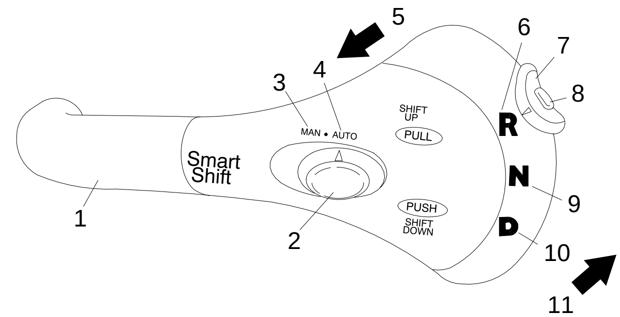
To upshift manually, pull the lever up (towards you). To downshift manually, push the lever down (away from you).

1. SmartShift Control Lever
2. Slide Switch (forward driving mode switch)
3. MAN Mode (of slide switch)
4. AUTO Mode (of slide switch)
5. Upshift Direction
6. Reverse Position (of selector switch)
7. Selector Switch
8. Neutral Lock Button
9. Neutral Position (of selector switch)
10. Drive Position (of selector switch)
11. Low Position (of selector switch)
12. Downshift Direction

Fig. 1, SmartShift Control (with Eaton Fuller UltraShift, UltraShift PLUS, and Autoshift)



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To upshift manually, pull the lever up (towards you). To downshift manually, push the lever down (away from you).

1. SmartShift Control Lever
2. Slide Switch (forward driving mode switch)
3. MAN Mode (of slide switch)
4. AUTO Mode (of slide switch)
5. Upshift Direction
6. Reverse Position (of selector switch)
7. Selector Switch
8. Neutral Lock Button
9. Neutral Position (of selector switch)
10. Drive Position (of selector switch)
11. Downshift Direction

Fig. 2, SmartShift Control (with ZF Meritor FreedomLine)

The SmartShift control replaces either the typical floor-mounted shift lever or dash-mounted pushbutton control. It mounts to the right-hand side of the steering column and is operated by the driver's right hand. SmartShift accepts driver requests for transmission functions and transmits them through hard wiring to the transmission control unit (TCU). SmartShift is a true shift-by-wire system.

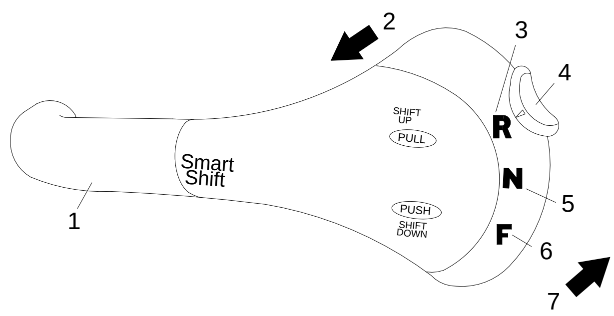
On SmartShift as designed for UltraShift, UltraShift PLUS, AutoShift, and FreedomLine, a two-position slide switch allows the driver to choose automatic (AUTO) or manual (MAN) mode.

NOTE: With SureShift, there is no slide switch.

In AUTO mode, gears shift automatically, without driver interaction. In MAN mode, the driver has direct control over gear shifts. Manual gear shifts are accomplished by a momentary pull or push on the control lever in the plane perpendicular to the steering wheel. See **Fig. 4**. All shifts into reverse (R) are done manually.

Pull upward (toward you) on the control lever to upshift and push downward (away from you) to down-

General Information

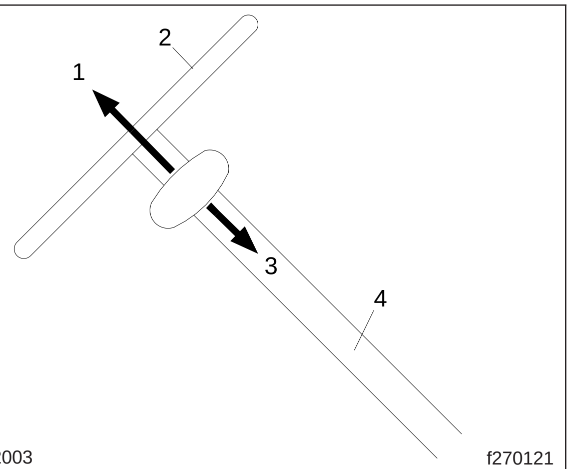


To upshift manually, pull the lever up (towards you). To downshift manually, push the lever down (away from you).

NOTE: Shown without neutral lock button. Newer SureShift models have a "D" (for drive) in place of the "F" (for forward).

1. SmartShift Control Lever
2. Upshift Direction
3. Reverse Position (of selector switch)
4. Selector Switch
5. Neutral Position (of selector switch)
6. Forward Position (of selector switch)
7. Downshift Direction

Fig. 3, SmartShift Control (with Meritor SureShift)



1. Upshift (in manual mode, pull upward)
2. Steering Wheel
3. Downshift (in manual mode, push downward)
4. Steering Column

Fig. 4, SmartShift Control Lever Operation

shift. The lever is spring-loaded and returns to mid-position when released after an upshift or downshift.

The selector switch is located at the end of the control lever. There are three different versions:

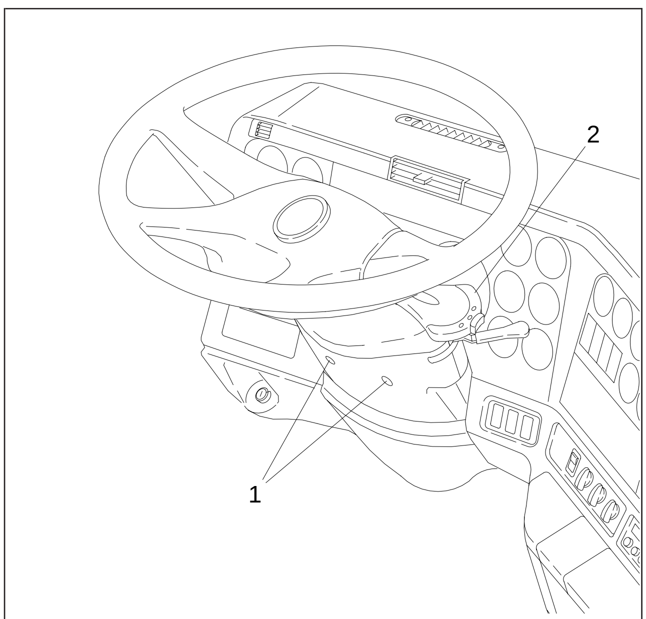
- For UltraShift, UltraShift PLUS, and AutoShift, the four-position selector switch is marked "R-N-D-L". See **Fig. 1**.
- For FreedomLine, the three-position selector switch is marked "R-N-D". See **Fig. 2**.
- For SureShift, the three-position selector switch is marked "R-N-F" (older models) or "R-N-D" (newer models). See **Fig. 3**.

For UltraShift, UltraShift PLUS, and FreedomLine, embedded in the selector switch is a small neutral lock button to prevent accidental shifts into gear from neutral. Any time you shift through N, press down on the neutral lock button to move the switch from neutral (N) to another gear. When shifting to N, it is not necessary to press the neutral lock button. For AutoShift and SureShift, all models built after November 2002 have the neutral lock button.

Shift Control Lever Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the screws that secure the steering column trim panels, and separate the forward and rear panels to access the shift control. See **Fig. 1**.
3. Disconnect the electrical connector from the plug on the shift control unit. See **Fig. 2**.
4. Remove the three bolts that secure the control lever to the bracket on the column.
5. Remove the control lever.
6. Place the new lever into position and secure it using the nuts and bolts previously removed.
7. Connect the electrical connector to the control lever.
8. Using the screws previously removed, fasten the upper and lower column panels.



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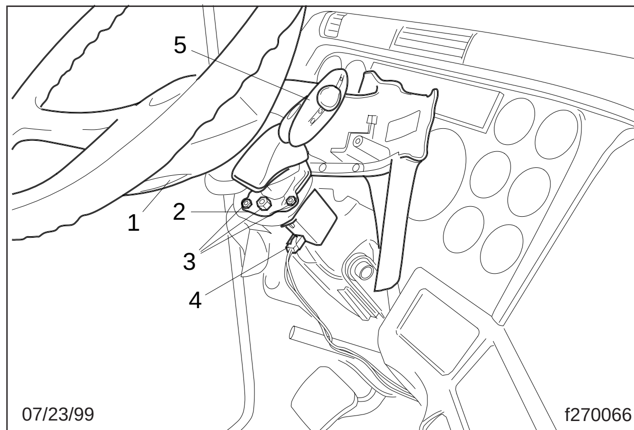
1. Steering Column Panel Capscrews
2. SmartShift Control Lever

Fig. 1, Steering Column



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1. Steering Wheel
2. Control Lever Bracket
3. Nuts and Bolts
4. Electrical Connector
5. Control Lever

Fig. 2, SmartShift Control Lever Installation

General Information

The following information is provided to help determine whether a problem is with the transmission or the SmartShift® Transmission Shift Control.

Resistance checks at the SmartShift connector can help determine connection problems.

DataLink Software can be used to test the SmartShift control. The tests require a ServiceLink computer connected to the vehicle. If the tests confirm the shift control is defective, this subject also includes connector resistance checks to rule out wiring issues.

Follow the procedures below for resistance checking and Freightliner SmartShift testing using DataLink Monitor and dash displays.

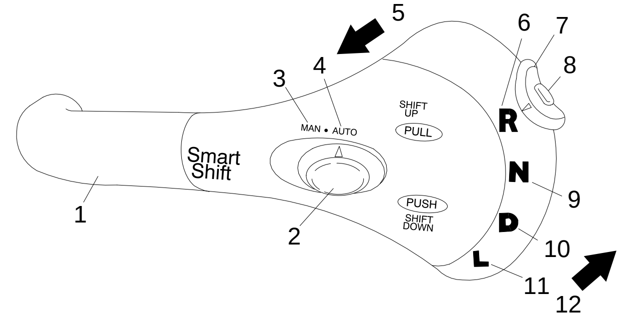
To determine which transmission is installed on the vehicle, check the shift pattern decal on the dash or visor.

NOTE: SmartShift controls designed for one transmission model should not be used with other models of transmission.

For Eaton Fuller UltraShift, UltraShift PLUS, and AutoShift, the four-position selector switch is marked "R-N-D-L". A slide switch is present. See **Fig. 1**.

For Meritor SureShift, the three-position selector switch is marked "R-N-F" (older models) or "R-N-D" (newer models). In addition, there is no slide switch. See **Fig. 2**.

For ZF Meritor FreedomLine, the three-position selector switch is marked "R-N-D". A slide switch is present. See **Fig. 3**.



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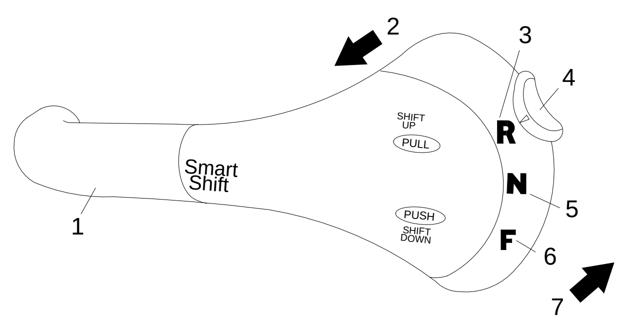
1. SmartShift Control Lever
2. Slide Switch (forward driving mode switch)
3. MAN Mode (of slide switch)
4. AUTO Mode (of slide switch)
5. Upshift Direction
6. Reverse Position (of selector switch)
7. Selector Switch
8. Neutral Lock Button
9. Neutral Position (of selector switch)
10. Drive Position (of selector switch)
11. Low Position (of selector switch)
12. Downshift Direction

Fig. 1, SmartShift Control (with Eaton Fuller UltraShift, UltraShift PLUS, and AutoShift)



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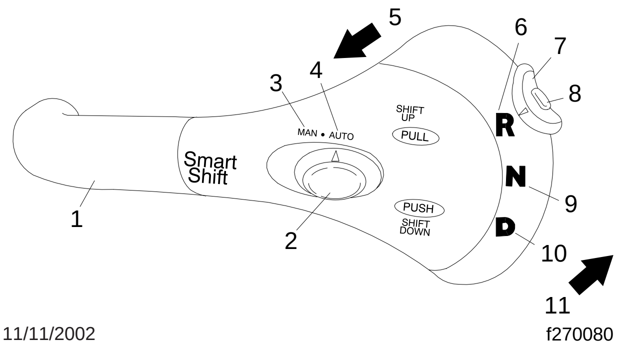
NOTE: Shown without neutral lock button. Newer SureShift models have a "D" (for drive) in place of the "F" (for forward).

1. SmartShift Control Lever
2. Upshift Direction
3. Reverse Position (of selector switch)
4. Selector Switch
5. Neutral Position (of selector switch)
6. Forward Position (of selector switch)
7. Downshift Direction

Fig. 2, SmartShift Control (with Meritor SureShift)

Troubleshooting



1. SmartShift Control Lever
2. Slide Switch (forward driving mode switch)
3. MAN Mode (of slide switch)
4. AUTO Mode (of slide switch)
5. Upshift Direction
6. Reverse Position (of selector switch)
7. Selector Switch
8. Neutral Lock Button
9. Neutral Position (of selector switch)
10. Drive Position (of selector switch)
11. Downshift Direction

Fig. 3, SmartShift Control (with ZF Meritor FreedomLine)

Shift Control Resistance Checking

Parts

See **Table 1** for parts.

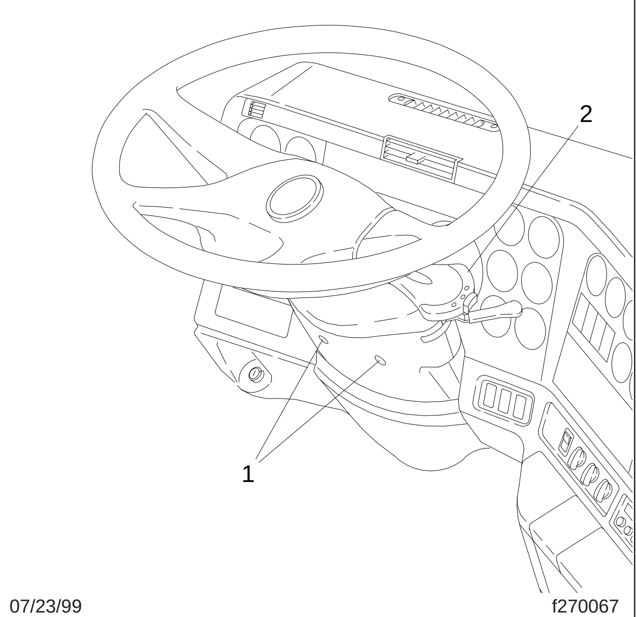
Parts for Wire Extension*		
Part Number	**Description**	**Qty.**
PAC12110847	Metri-Pack Terminal	3
PAC12047767	Connector Terminal	3
48-02493-184	18GA GTX Wire, Yellow	3 ft x 3
PAC12047781	3-Pin Connector	1
PAC12047783	Connector Lock	1

* Parts are available through the PDCs.

Table 1, Parts for Wire Extension

Procedure

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the screws that secure the steering column trim panels, and separate the forward and rear panels to access the shift control. See **Fig. 4**.
3. Disconnect the electrical connector from the plug on the shift control unit. See **Fig. 5**.



1. Steering Column Panel Capscrews
2. Shift Control

Fig. 4, Steering Column

4. Assemble the wire extension from the parts in **Table 1** to allow for easy resistance testing, as follows.

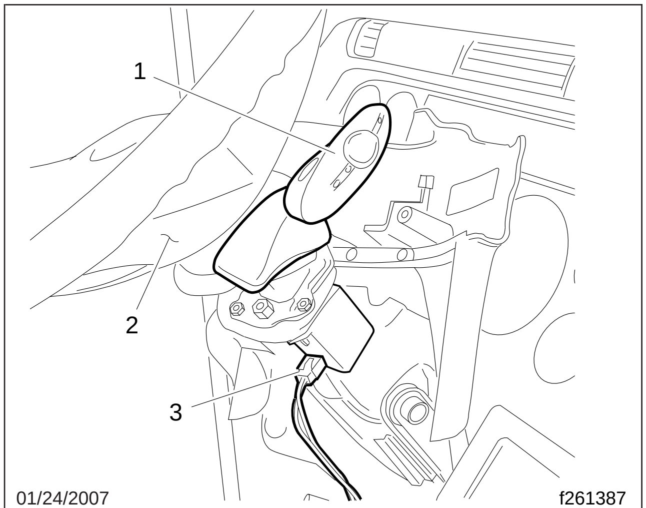
   4.1 Crimp the connector terminals at the end of each 3-foot (1-meter) wire.

   4.2 Assemble the 3-pin connector with the connector terminals and connector lock.

   4.3 Crimp the Metri-Pack terminals on the other end of the wires.

5. Plug the wire extension into the plug on the shift control unit. See **Fig. 6** for SmartShift terminal positions.

NOTE: Using this new wire extension prevents the need to remove the shift control.



1. Shift Control
2. Steering Wheel
3. Electrical Connector

Fig. 5, SmartShift Components

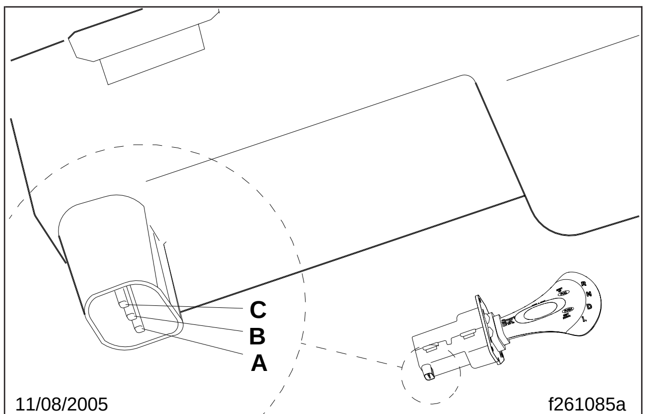
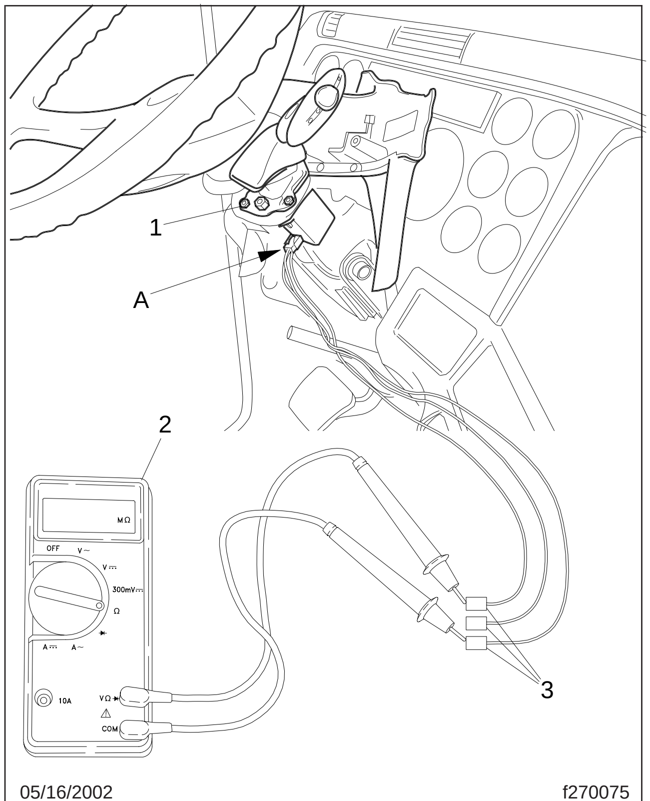


Fig. 6, SmartShift Terminal Positions

6. Check the resistance at the other end of the wires. See **Fig. 7**.

   Use **Table 2** and **Table 3** for all SmartShift applications except Meritor SureShift.

   Use **Table 4** for Meritor SureShift applications.



A. Plug the newly assembled wire extension into the plug on the shift control unit.

1. Shift Control Unit
2. Digital Multimeter (set to ohms)
3. Metri-Pack Terminals (at wire ends)

Fig. 7, Resistance Checking at Shift Control

Resistance on SmartShift Controls at B and C (Except Meritor SureShift)	
Selector Switch Position	**Reading: kOhm**
R	2.947–3.067
N	0.347–0.361
D	0.606–0.630
L*	1.65–1.72

* Applies to four-position (R-N-D-L) controls only.

Table 2, Resistance on SmartShift Controls at B and C (Except Meritor SureShift)

Troubleshooting

Resistance on SmartShift Controls at A and C (Except Meritor SureShift)	
Slide Switch + Lever Position	**Reading: kOhm**
Manual	2.865–2.981
Manual + Up	0.531–0.553
Manual + Down	1.150–1.197
Auto	11.27–11.73

Table 3, Resistance on SmartShift Controls at A and C (Except Meritor SureShift)

Resistance on the SmartShift Control, Meritor SureShift	
Selector Switch + Lever Position	**Reading: kOhm**
R	10.2–10.6
N	1.65–1.71
F or D	2.65–2.75
R + Up	4.14–4.3
R + Down	6.07–6.31

Table 4, Resistance on SmartShift Controls at A and C (Meritor SureShift)

7. After checking the resistance, unplug the wire extension, and reconnect the electrical connector.
8. Install the steering column trim panels.

SmartShift Control Checking Using DataLink Monitor (DLM)

1. With the wheels chocked, start the engine.
2. Connect the service computer to the engine and start ServiceLink.
3. Click on the **Transmission** icon on the left screen.
4. Click on the **Templates** tab. An overview of available templates will be shown.
5. If the vehicle is equipped with Eaton Fuller AutoShift, UltraShift, or UltraShift PLUS, click on **Eaton AutoShift**. If the vehicle is equipped with Meritor SureShift, click on **ZF Meritor SureShift**.

NOTE: The DLM template for the SureShift transmission will not work with the ZF Meritor FreedomLine transmission. For further diagnostic assistance on FreedomLine transmissions, use Meritor's TransSoft software.

6. Go directly to the appropriate heading in this subject, "SmartShift Control Testing for Eaton AutoShift" or "SmartShift Control Testing for Meritor SureShift and FreedomLine".

SmartShift Control Testing for Eaton AutoShift

The AutoShift DataLink Monitor template (see **Fig. 8**) will display the current vehicle status and will reflect change in status. Vehicle information is retrieved from the transmission ECU on the datalink. The monitor can also be used to verify readings on the instrument panel.

NOTE: To test the shift control using the datalink, the vehicle can be placed into a mode that allows the gears to be shifted without the engine running. The following step explains how to enter that mode.

1. Turn the ignition OFF, then turn the ignition back ON, but don't start the engine. The transmission controller will still be in the Engine ON mode, thereby allowing the gears to be shifted.
2. Test the operation of the shift control for Reverse (R) and Neutral (N), as follows.
   - 2.1 Select R on the selector switch. In the *Range Selected* field of the template an R should be displayed.
   - 2.2 Select N on the selector switch. In the *Range Selected* field of the template an N should be displayed.
3. Test the operation of the shift control for Drive (D), as follows.
   - 3.1 Select D on the selector switch and move the slide switch (reading "MAN/AUTO") to AUTO. In the *Range Selected* field of the template, a D should be displayed.
   - 3.2 With the selector switch still on D, toggle the slide switch from AUTO to MAN and back. Confirm that the *Range Selected* field shows a D while in AUTO and an H (High) while in MAN.

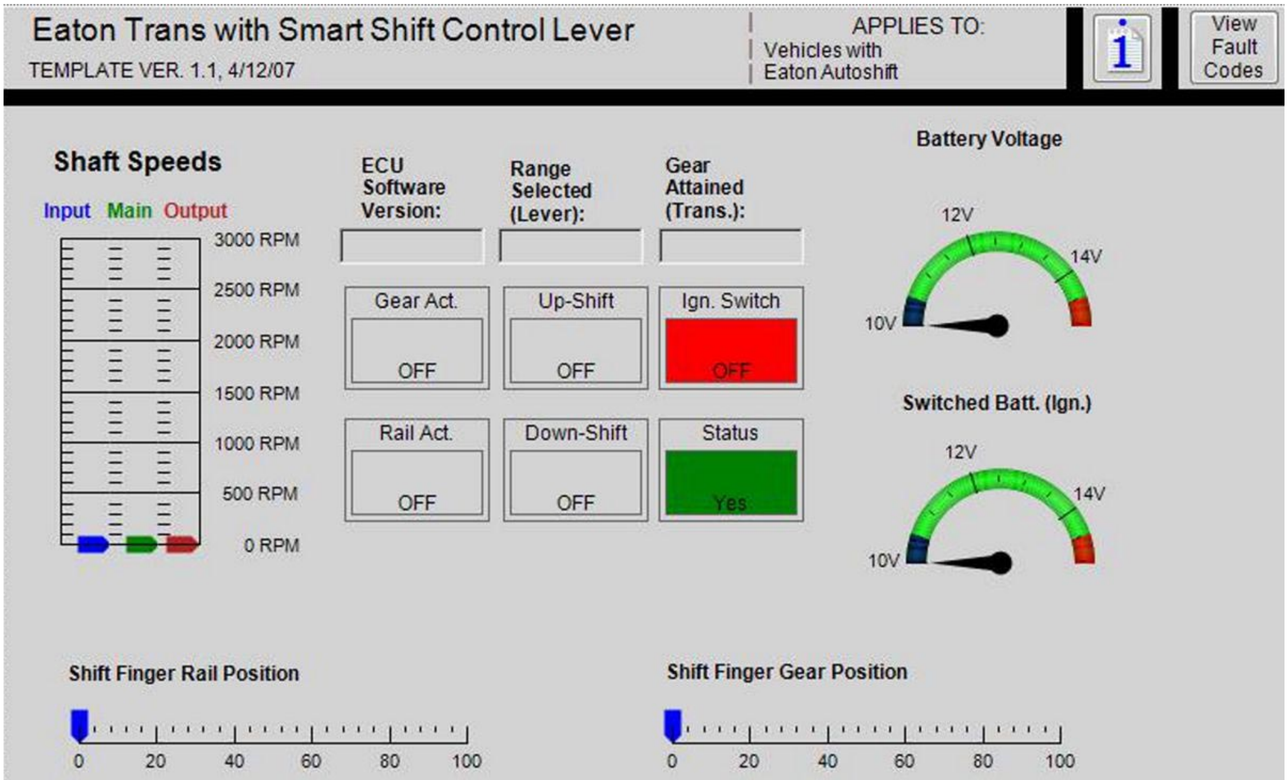


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Fig. 8, DataLink Monitor Template for Eaton AutoShift

3.3 While in Manual mode, change the selector switch to L (Low) and confirm that the *Range Selected* field changes from H to L.

4. Test upshifting and downshifting, as follows.

4.1 With the selector switch on D, pull and hold the shift control lever. The *Up-Shift* field will turn green and read ON for 3 seconds.

4.2 Push and hold the shift control lever. The *Down-Shift* field will turn green and read ON for 3 seconds.

NOTE: A blinking display indicates that the transmission is attempting to shift into the gear position. A solid display shows the current gear position attained.

5. When the selector switch is in any position but N (Neutral), the *Status* field on the Monitor template will read YES.

SmartShift Control Testing for Meritor SureShift and FreedomLine

The SmartShift control test for a Meritor SureShift system can be performed by using the dash-mounted gear display. The SureShift DataLink Monitor (DLM) template can be used if further testing of the system is necessary, for example, to confirm dash display readings or gear positions. See **Fig. 9**.

NOTE: The DLM template for the SureShift transmission will not work with the FreedomLine transmission. For further diagnostic assistance on FreedomLine transmissions, use Meritor’s TransSoft software.

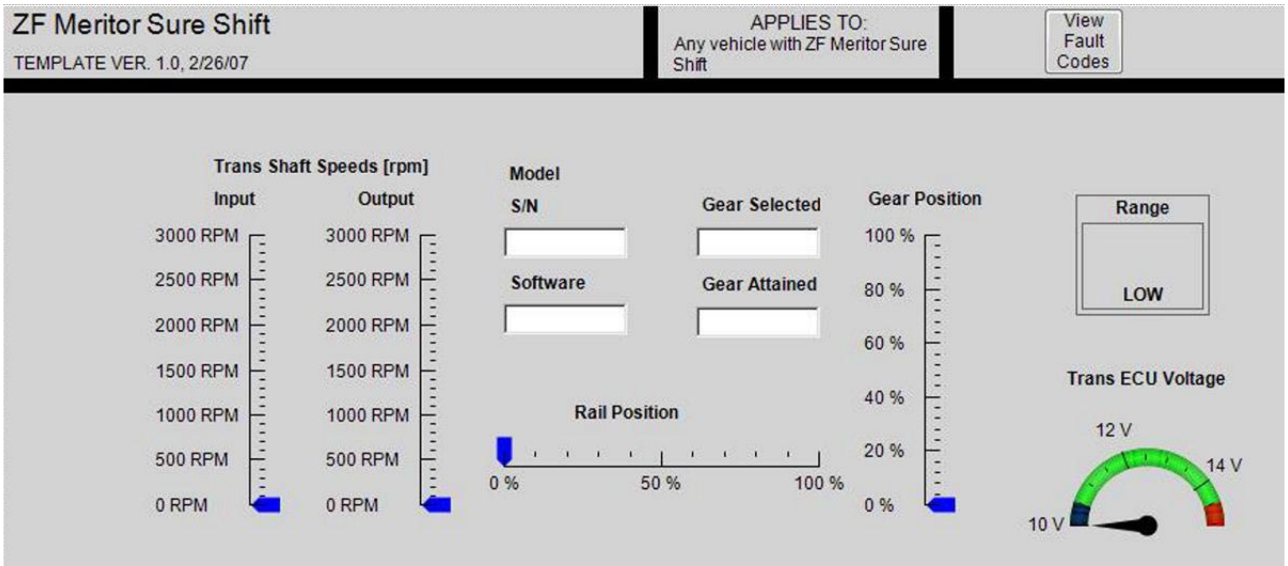

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Fig. 9, DataLink Monitor Template for ZF Meritor SureShift

⚠ WARNING

For SureShift transmissions, do not depress the clutch pedal during these tests. Doing so could result in the vehicle moving, possibly causing vehicle damage or personal injury.

Make sure all tires are chocked and the parking brake is set before performing the following tests. These tests require the vehicle to be started, and precautions need to be taken to ensure the vehicle will not move.

1. Test the operation of the shift control for Reverse (R) and Neutral (N), as follows.

   1.1 Move the selector switch to R. Confirm that the display is changing from N to RL (Reverse Low), the default reverse gear. The display will change to CL (Clutch) after one second. Repeat this step if the reading disappeared quickly.

   1.2 Pull the shift control lever once to upshift to High Reverse. Confirm the display changes to RH (Reverse High).

2. Test the operation of the shift control for F or D, as follows.

   2.1 Move the selector switch to F (Forward) or Drive (D).

   2.2 Test upshifting and downshifting. Push, then pull, the shift control lever through all the gears and verify that each gear displays correctly on the dash display.

If the display or the DLM template does not confirm the SmartShift control position, the shift control should be tested. See the shift control resistance checking procedure herein.

Accelerator Pedal Assembly

The Williams electronic suspended accelerator pedal provides an electrical signal to the engine in response to the driver's demand for more engine power. The accelerator pedal converts downward pressure into an electrical signal via the pedal position sensor.

Pedal Position Sensor

Freightliner uses various pedal position sensors, depending on the engine. The pedal position sensor is mounted to the side of the pedal assembly. The sensor and the pedal assembly are both separately replaceable.

NOTE: Vehicles manufactured on or after July 2, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed.

There are three basic technologies employed on pedal position sensors used with electronic engines:

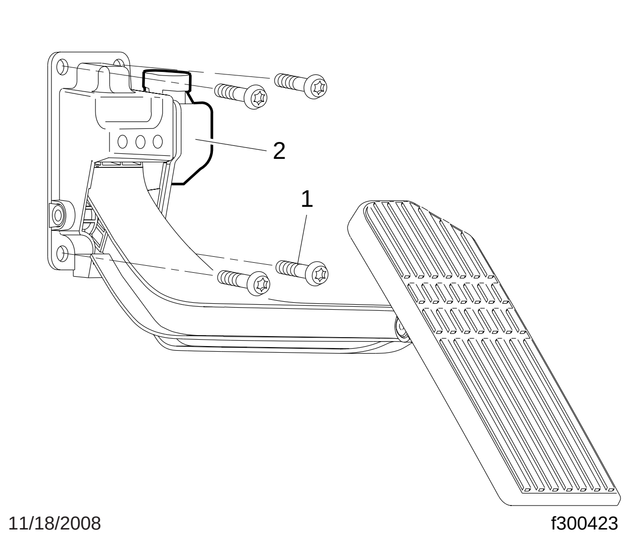
- A ratiometric sensor that generates a DC voltage output in proportion to the pedal position. The ratiometric sensor is used on Detroit Diesel, Mercedes-Benz, and pre-EPA07 Cummins engines.
- A pulse-width-modulating (PWM) sensor that generates a series of discrete voltage pulses. The width of the pulses is proportional to the pedal position. A narrower pulse width indicates a smaller accelerator pedal request and a wider pulse width indicates a larger pedal request. The PWM sensor is used on Caterpillar engines.
- A dual ratiometric sensor that uses Hall effect technology to generate two analog outputs that are proportional to the pedal position. The primary output is twice the voltage of the secondary output. The dual sensor is used on EPA07 Cummins engines.

An idle validation switch (IVS) is integrated into some ratiometric pedal position sensors. The IVS is a single-pole, double-throw switch. Some engine models monitor both switched poles, and some monitor only one pole. When the accelerator pedal returns to idle, the IVS moves to the "idle" position to signal the engine that the pedal has returned to idle. The IVS is not a serviceable part. If the IVS malfunctions, the sensor must be replaced.

Accelerator Pedal Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Disconnect the pedal position sensor wiring harness.
4. Remove the four fasteners that secure the accelerator pedal base cup to the inside of the bulkhead. See **Fig. 1**.
5. Remove the pedal assembly.



NOTE: Washers not shown
1. Fastener (4 qty.)
2. Pedal Position Sensor

Fig. 1, Accelerator Pedal Assembly

Installation

1. Align the accelerator pedal assembly with the mounting holes on the inside of the bulkhead.
2. Install the pedal assembly mounting fasteners and tighten them 7 to 12 lbf·ft (9 to 16 N·m).
3. Connect the pedal position sensor wiring harness.
4. Depress the accelerator pedal several times and ensure that the pedal does not stick or bind.

NOTE: In some vehicles, the accelerator pedal design may result in interference with floor insulation. If the pedal position sensor signal does not reach 100%, check to see if the accelerator pedal bridge is preventing full travel. If the pedal bridge prevents full travel, trim approximately 2 inches (5 cm) off the pedal bridge and round off the lower edge to prevent the bridge from catching on the floor mat.

5. Connect the batteries.
6. Test the pedal operation using the diagnostic software tool specified in **Table 1**.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

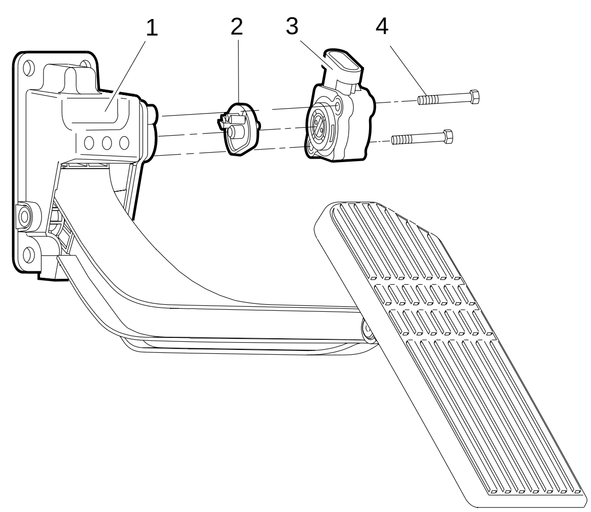
Table 1, Diagnostic Software Tools

Replacement

NOTE: Vehicles manufactured on or after July 2, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed. See **Subject 100** for instructions.

Replace the pedal position sensor as follows:

1. Apply the parking brakes and chock the tires.
2. Remove the pedal assembly. See **Subject 100** for instructions.
3. Remove the two sensor mounting screws that connect the sensor to the pedal assembly. See **Fig. 1**. Remove the pedal position sensor from the pedal assembly.



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1. Accelerator Pedal Assembly
2. Pinion Gear
3. Pedal Position Sensor
4. Mounting Screws

Fig. 1, Pedal Position Sensor Installation

4. Align the new sensor with the spline on the pinion gear, then push it into the pedal assembly. Rotate the sensor slightly so the mounting holes line up with the pedal assembly. See **Fig. 1**.
5. Install the sensor mounting fasteners and tighten them 25 to 30 lbf·in (280 to 340 N·cm).
6. Install the pedal assembly and test its operation as instructed in **Subject 100**.

Complete the following procedures to diagnose accelerator pedal assembly and pedal position sensor problems.

Common Problems and Indications

The accelerator pedal assembly was designed so that the pedal position sensor will not reach the internal stop points when it is mounted to the pedal assembly. Attempting to modify the sensor or forcing the sensor shaft beyond the internal stop points will result in severe damage to the sensor.

A number of symptoms may be reported that can indicate a problem with the accelerator pedal, pedal position sensor, or wiring to the engine, including:

- low power or poor acceleration
- slow deceleration
- vehicle does not reach top speed
- engine is stuck at idle
- engine brake does not function
- check engine light comes on
- engine fault code indicates a pedal position sensor problem

A thorough diagnosis of the entire sensor system must be performed to ensure that a pedal position sensor is faulty. Symptoms may disappear when the pedal position sensor is replaced even if the sensor is not faulty.

NOTE: In some vehicles, the accelerator pedal design may result in interference with floor insulation. If the pedal position sensor signal does not reach 100%, check to see if the accelerator pedal bridge is preventing full travel. If the pedal bridge prevents full travel, trim approximately 2 inches (5 cm) off the pedal bridge and round off the lower edge to prevent the bridge from catching on the floor mat.

Diagnostics

IMPORTANT: Vehicles manufactured on or after July 2, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed. See **Subject 100** for instructions on replacing the entire pedal assembly.

1. Connect the vehicle to the appropriate diagnostic software tool. See **Table 1** for a list of diagnostic software tools for each engine.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools

2. Make a note of the signal values at idle. See **Table 2** for the correct signal values.

NOTE: All desired signal values are approximate. Each individual vehicle and electrical system will exhibit some variation in signal values. The engine control system compensates for this variation. These diagnostic procedures are designed to identify malfunctioning components of the pedal assembly and electrical system.

3. Slowly depress the accelerator pedal and monitor the signals.

NOTE: There is a short time delay between pedal movement and display of the corresponding data.

4. Make a note of all signal values when the pedal has been pressed halfway.
5. Make a note of all signal values at full throttle.
6. Verify idle validation signal (IVS) inputs, if equipped.

NOTE: The pedal position sensor used with Caterpillar engines is a pulse-width modulated (PWM) sensor. It cannot be diagnosed using a digital multimeter set to measure voltage or re-

Troubleshooting

sistance. A multimeter capable of measuring "duty cycle" may be used to view the sensor output.

The pedal position sensor used with EPA07 Cummins engines uses Hall effect technology. Attempting to measure resistance across the sensor will not provide valid results and may damage the sensor.

7. If any signal does not change, measure the sensor voltage supply and ground circuits with a digital multimeter as follows.

   7.1 Use EZWiring™ in ServicePro to identify the circuit(s) that supply voltage to the pedal position sensor.

   IMPORTANT: The ignition key must be in the ON position.

   7.2 Disconnect the connector nearest the pedal and measure the voltage supply.

8. If a 5-volt supply is not present, look for a fault in the circuit between the pedal and the common powertrain controller (Detroit Diesel and Mercedes-Benz) or the motor control module (Caterpillar and Cummins engines).

9. Inspect and ensure that all connector pins at the pedal position sensor, frontwall, and the engine controller are free of corrosion and are not bent or damaged. Inspect and ensure that the connections between the pins and the wires are secure and also free of corrosion.

10. If the problem has not been resolved, the problem is not with the pedal position sensor. See the engine manufacturer's service literature for further guidance.

Diagnostic Software Values*

Engine	Signal	Pedal Position	Desired Value†
Caterpillar, pre-EPA07	Throttle Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Duty Cycle	Idle	15%
		Full throttle	85%
		Between idle/full throttle	Varies smoothly between 15% and 85%
Caterpillar, EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Throttle Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Duty Cycle	Idle	15%
		Full throttle	85%
		Between idle/full throttle	Varies smoothly between 15% and 85%

Diagnostic Software Values*			
Engine	**Signal**	**Pedal Position**	**Desired Value†**
Cummins, pre-EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Accelerator Pedal Sensor	Idle	0.5 volts
		Full throttle	4.5 volts
		Between idle/full throttle	Varies smoothly between 0.5 and 4.5 volts
	IVS	Idle	ON
		Full throttle	OFF
	Sensor Supply	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts
Cummins, EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Accelerator Pedal Sensor	Idle	1.0 volts
		Full throttle	4.5 volts
		Between idle/full throttle	Varies smoothly between 1.0 and 4.5 volts
	Accelerator Pedal Sensor 2	Idle	0.5 volts
		Full throttle	2.25 volts
		Between idle/full throttle	Varies smoothly between 0.5 and 2.25 volts
	Sensor Supply (both)	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts
Detroit Diesel and Mercedes-Benz, pre-EPA07	Accelerator Pedal Raw Sensor	Idle	15%
		Full throttle	75%
		Between idle/full throttle	Varies smoothly between 15% and 75%
	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	IVS	Idle	ON (grounded)
		Full throttle	OFF (open)
	Supply Analog Accelerator Pedal	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts

Troubleshooting

Diagnostic Software Values*			
Engine	**Signal**	**Pedal Position**	**Desired Value†**
Detroit Diesel and Mercedes-Benz, EPA07	Accelerator Pedal Raw Sensor	Idle	15%
		Full throttle	75%
		Between idle/full throttle	Varies smoothly between 15% and 75%
	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	IVS1	Idle	ON (grounded)
		Full throttle	OFF (open)
	IVS2	Idle	OFF (open)
		Full throttle	ON (grounded)
	Supply Analog Accelerator Pedal	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts

* All desired signal values are approximate. Each individual vehicle and electrical system will exhibit some variation in signal values.

† There is a short time delay between pedal movement and display of the corresponding data.

Table 2, Diagnostic Software Values

General Description

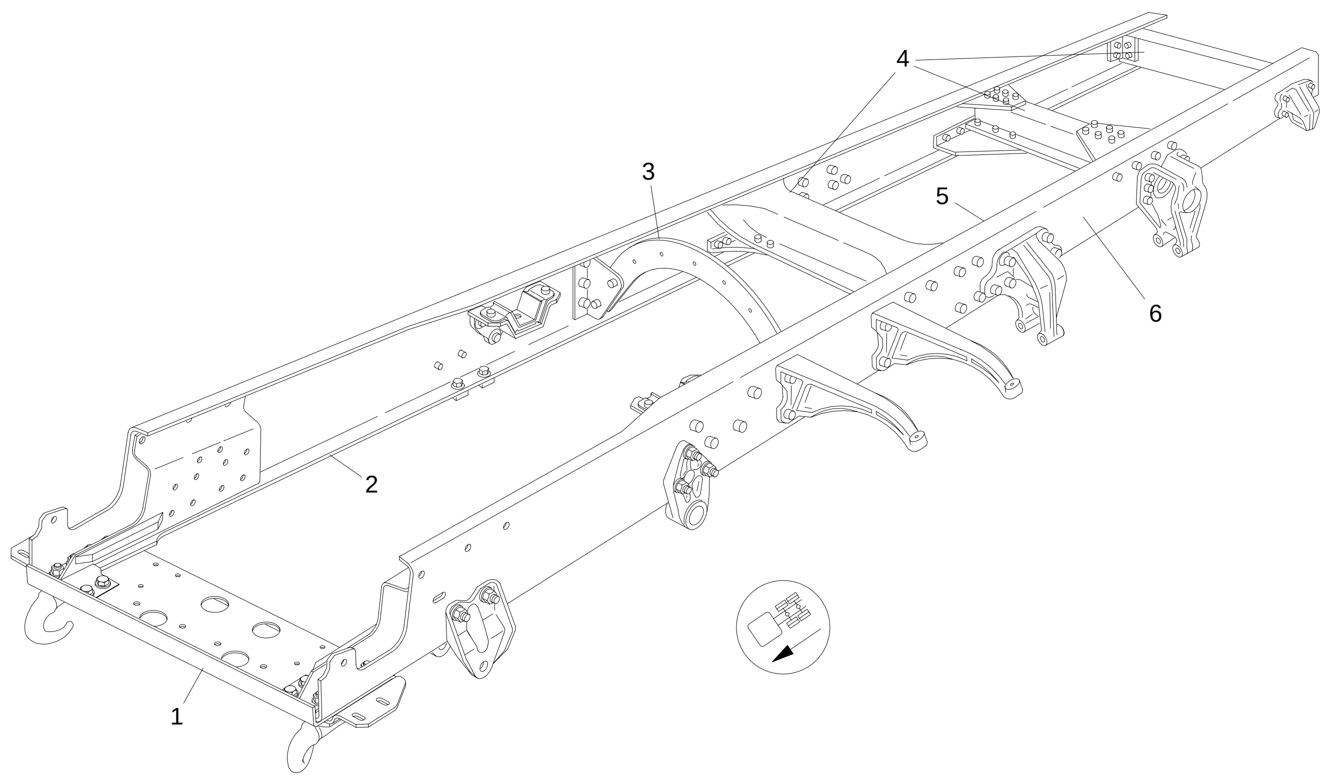
IMPORTANT: This workshop manual *does not cover* the procedures and calculations necessary to do frame modifications. Before doing any modification to the frame rails, consult with the Daimler Trucks North America Engineering Department.

The main body of the frame consists of two frame rails connected by a series of crossmembers. See **Fig. 1**. The frame supports the rest of the chassis and body.

The crossmembers control axial rotation and longitudinal motion of the rails, and reduce torsional stress transmitted from one rail to the other. Crossmembers are also used for vehicle component mounting, and protecting the wires and tubing that are routed from one side of the vehicle to the other. See **Section 01.04**, Engine Mounts, for the engine crossmember.

Frame Stations

A frame station is a reference point on the frame rail from which the location of each component mounted on the frame rail is measured. There are two frame stations on the frame rails: station zero (usually written as 0.00"); and station 1150.

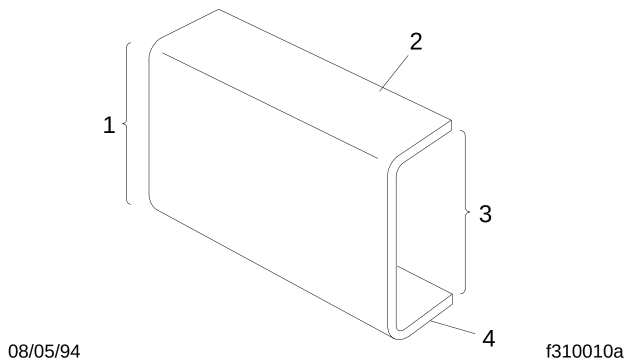


1. Front Crossmember
2. Lower Flange
3. Overslung Crossmember
4. Frame Crossmembers
5. Upper Flange
6. Frame Rail Web

Fig. 1, Frame Assembly, Columbia

The frame rails are made of steel, and both have identical specifications. Each rail has an upper flange, lower flange, and web (the surface area between the flanges). The inside area of the frame rail is called the channel. See **Fig. 2**.

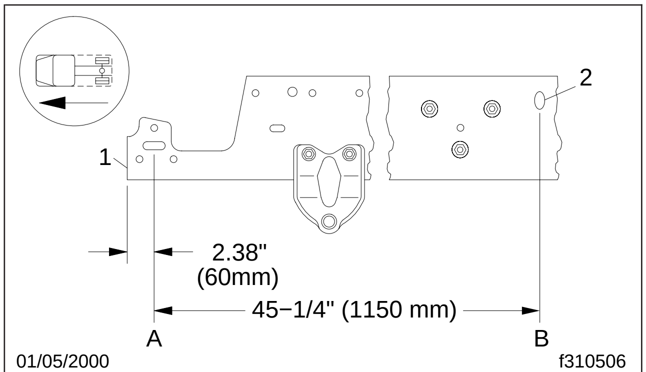
General Information



1. Web
2. Upper Flange
3. Channel
4. Lower Flange

Fig. 2, Frame Terminology

There is no identifying mark for station zero. It is located 2-3/8 inches (60 mm) to the rear of the most forward edge of the frame rail. See **Fig. 3**.



A. Station Zero (0.00)
B. Station 1150

1. Most Forward Edge of the Frame Rail
2. Station 1150 Mark

Fig. 3, Frame Rail Stations

Station 1150 is located 45-1/4 inches (1150 mm) to the rear of station zero. Station 1150 is used when station zero is not accessible because of vehicle assembly. Station 1150 is identified by a 1/2-inch (13-mm) high oval stamped near the top part of the frame rail web.

The vehicle's frame drilling chart lists the location of each frame rail component. For example, if a component is given a location of 2500, then that component is installed on the frame rail 98-7/16 inches (2500 mm) aft of station zero, or 53-3/16 inches (1350 mm) aft of station 1150.

Handling

Whenever the frame rails are lifted or moved, take care to avoid anything that may scratch, cut, or damage the exposed frame assembly. Cushion all chain hoists or cable slings with a section of heavy hose. If the frame rail is raised with a jack, place a block of wood between the jack and the frame rail.

CAUTION

Heating the frame rail for straightening purposes will reduce the strength of the rail in localized areas, which can result in structural failure of the frame rail.

Never heat the frame rails for straightening purposes. Such work should be done cold because the frame rails have been heat-treated.

Use pencil lines or soapstone for marking the frame rail. High visibility can be obtained by first chalking the surface of the frame rail, then making the pencil marks.

Repairing Frame Rail Cracks, Filling Unused Holes, and Drilling Holes

Repairing Cracks

IMPORTANT: Daimler Trucks North America LLC recommends that cracked or damaged frame rails be replaced. However, in some cases it may be necessary to repair minor damage. Before attempting any repairs, contact your regional service representative for approval.

CAUTION

Before performing any electric welding on a vehicle, read and understand the welding precautions in Subject 110. Disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

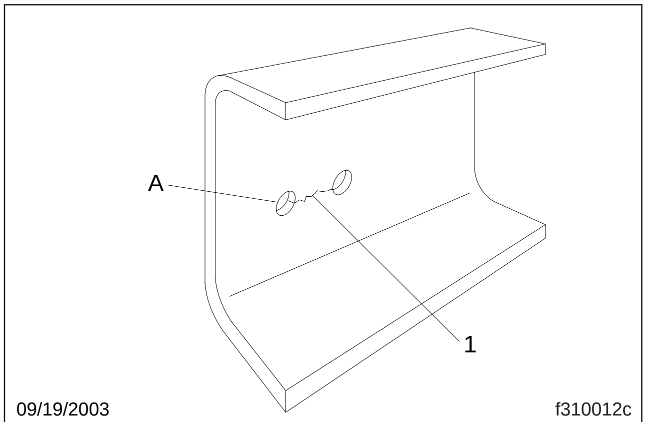
Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post, or disconnect the main connection at the ECU.

1. Drill a 1/8-inch (3-mm) diameter hole at each end of the crack to prevent further spreading of the crack. See **Fig. 1**.
2. Grind a V-shaped groove along the crack to a depth of two-thirds of the stock thickness. See **Fig. 2**.

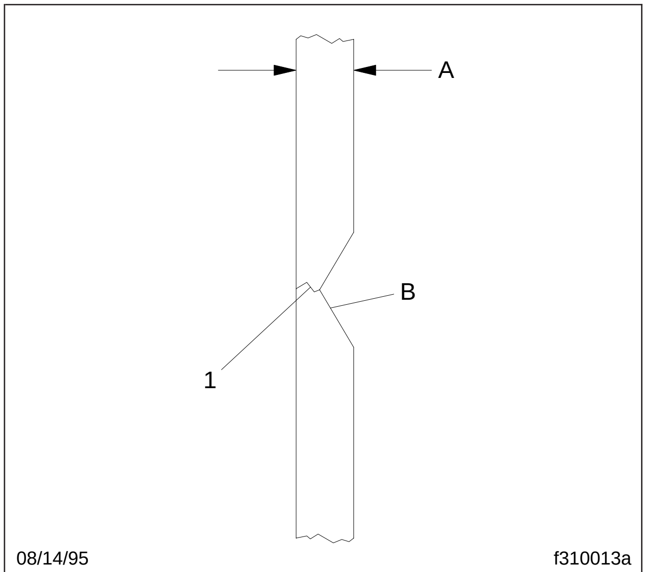
NOTE: The crack repair includes grinding a groove on each side of the frame rail. If it is not possible to grind both sides of the rail, then grind the groove on one side to the full depth of the stock thickness. See **Fig. 3**.

3. Clamp a copper or aluminum bar on the opposite side of the groove. The bar will act as a "chill" strip, keeping the heat from spreading to the surrounding area of the frame rail. See **Fig. 4**.
4. Using the applicable welding method described in **Subject 110**, deposit the weld material in the groove.



A. 1/8-inch (3-mm) Diameter Hole
1. Crack

Fig. 1, Preventing Cracks from Spreading

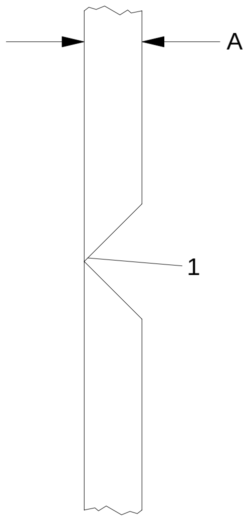


A. Frame Rail Thickness
B. Grind V-groove to 2/3 depth of stock thickness.
1. Crack

Fig. 2, Frame Rail Cross-Section

5. Grind the weld flush with the frame rail. See **Fig. 5**.
6. Cut a deep enough V-groove on the opposite side of the frame rail to reach the weld metal. See **Fig. 6**.

Repairing Frame Rail Cracks, Filling Unused Holes, and Drilling Holes



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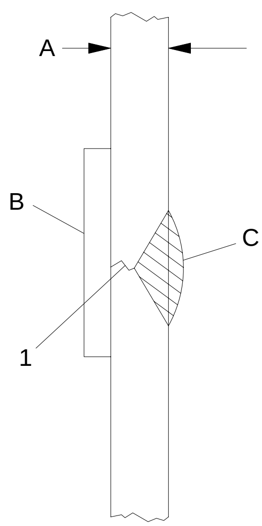
A. Frame Rail Thickness

1. V-Groove (Full Depth)

Fig. 3, Full Depth Groove



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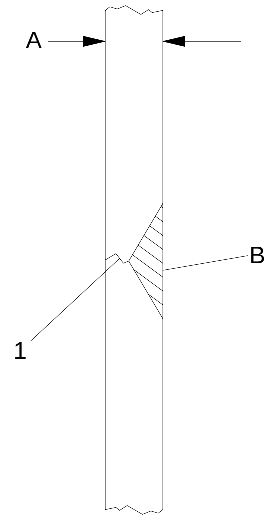
A. Frame Rail Thickness
B. Clamp the "chill" strip on opposite side of groove.
C. Deposit weld material.

1. Crack

Fig. 4, Using a Chill Strip



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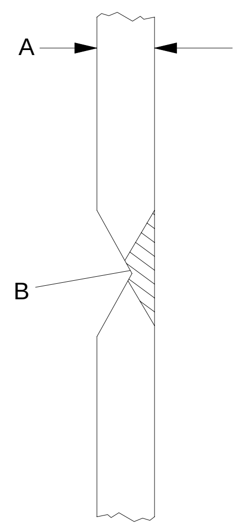
A. Frame Rail Thickness
B. Grind weld flush with frame rail.

1. Crack

Fig. 5, Weld Ground Flush



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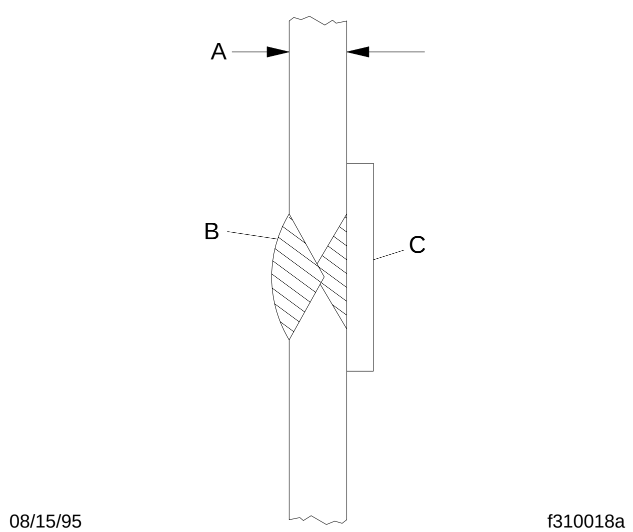
A. Frame Rail Thickness
B. Grind V-groove deep enough to reach weld.

Fig. 6, Cross-Section View

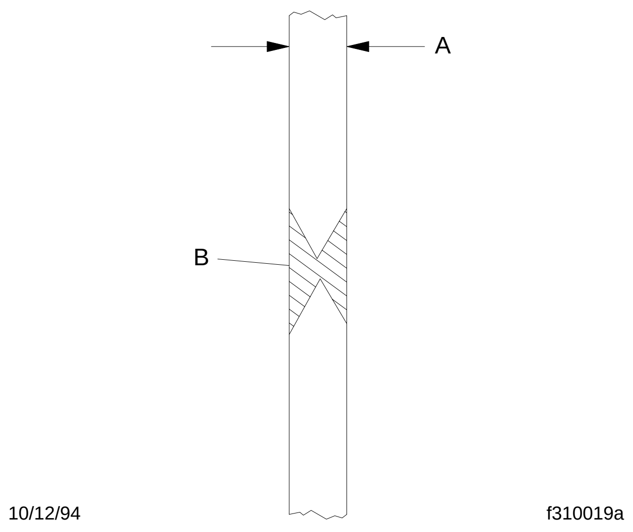
7. Clamp the "chill" strip on the opposite side of the groove. See Fig. 7. Weld the V-groove; make full penetration of the weld.



A. Frame Rail Thickness
B. Deposit weld material to penetrate opposite weld.
C. Clamp the "chill" strip on opposite side of groove.

Fig. 7, Second Weld

8. Grind the weld flush with the frame rail. See **Fig. 8**.



A. Frame Rail Thickness
B. Grind weld flush with frame rail.

Fig. 8, Second Weld Ground Flush

Filling Unused Holes

1. Fill all unused holes in the frame assembly with an applicable nut, washer, and bolt combination.
2. If the diameter of a hole is less than 3/8 inch (9.5 mm), enlarge it to 3/8 inch (9.5 mm) and fill it with an applicable nut, washer, and bolt combination.
3. Tighten the fasteners to the torque value specified for the bolt size. For proper frame fastening instructions, see **Section 31.01**, Subject 050.

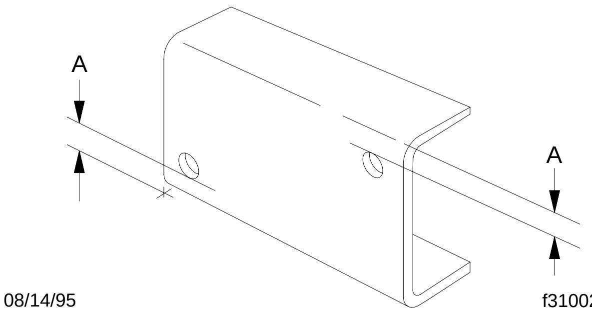
Drilling Holes

During vehicle manufacture, holes are drilled or punched in the frame rail only as specified on the vehicle frame drilling chart. If any additional holes need to be drilled, contact your regional service representative for approval.

A single exception to this rule is that holes may be drilled for tubing clips and the like through the web portion of the channel only, with the following restrictions:

- The *edge* (not the center) of the hole must be no closer than 1-11/32 inches (34 mm) from the outer face of the flange. See **Fig. 9** for the minimum distance to the flanges that holes can be placed on the web.
- Material between the centerline of the hole and the outside of the upper or lower flange must be at least 2-13/32 inches (60 mm).
- Minimum material between hole centerlines must be 2 inches (50 mm).
- All attaching fasteners must be Grade 8. Flat washers must be made with high strength steel.
- The minimum material between the rear suspension bracket and the end of the frame must be at least 2 inches (50 mm).
- Holes between the front axle centerline and the rear axle centerline cannot exceed 3/4 inches (19 mm).

Repairing Frame Rail Cracks, Filling Unused Holes, and Drilling Holes



A. 1-11/32 inches (34 mm)

Fig. 9, Minimum Distance for Drilling Holes

Safety Precautions

IMPORTANT: Only experienced, qualified persons using proper equipment should attempt welding the frame rails.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cable, and any electronic control units or similar devices installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, which could result in malfunction of the components.

1. Park the vehicle, shut down the engine, and set the parking brake. Chock the front and rear tires.
2. Open the hood.
3. Disconnect the batteries. Attach the welding ground strap as close to the work being done as safely possible.
4. Disconnect the engine electronic control unit and all other electronic devices. See Table 1 for the location of each device.

Location of Electronic Devices		
Device	**Location**	**Reference**
Engine Electronic Control Unit (ECU)	The location of the engine ECU differs with the engine manufacturer.	Fig. 1 Fig. 2 Fig. 3
Instrument Cluster Unit (ICU)	The ICU includes the driver's instrument panel, the ICU housing, and the dash message center (all installed as one unit). To disconnect the ICU, see Section 54.16 for level I, or Section 54.07 for level II.	
Data Logging Unit (DLU)	The DLU is one of several electronic modules mounted inside a compartment on the left-hand B-pillar, behind the driver's seat. The data logging unit is the top unit, and is mounted above the auxiliary power distribution module. Disconnect the electrical connector from the bottom of the unit.	Fig. 4
Air Conditioning Protection Unit (ACPU)	The ACPU connector is located near the bottom of the right-hand side of the frontwall in the engine compartment.	
Antilock Brake System (ABS)	The ABS ECU is mounted in the B-pillar compartment.	Fig. 4
Auxiliary Power Distribution Module (APD)	The APD module is mounted in the B-pillar compartment.	Fig. 4
VORAD System	The ECU for the VORAD system is mounted in a compartment on the right-hand B-pillar, behind the passenger's seat.	
Daytime Running Lights	The ECU for the daytime running lights is located in a small compartment on the right-hand B-pillar, behind the driver's seat.	
Radio	Disconnect the electrical connection to the radio.	
Alternator	Disconnect the ground strap to prevent damaging the alternator.	
Window Express Module	The Window Express module is located beneath the driver's step threshold plate. Remove the plate to disconnect the module connection.	

Welding Frame Rails

Location of Electronic Devices		
Device	**Location**	**Reference**
Vehicle Security System	The vehicle security system ECU is mounted in the right-hand B-pillar compartment.	
SPACE System	If the vehicle is equipped with a SPACE system, disconnect the ECU by unplugging the wiring attached to the SPACE device mounted behind the operator's seat.	

Table 1, Location of Electronic Devices

Welding Requirements

IMPORTANT: Before welding anything on a frame rail, contact your regional service representative for approval. There are very few cases in which welding a heat-treated frame rail is allowable. If possible, avoid direct welding of the frame rail web.

WARNING

Wear protective welding masks and gloves when welding. Failure to do so could result in personal injury, due to the intensity of heat, sparks, and flying debris.

CAUTION

Weld only as instructed in this subject; all precautions and methods must be strictly followed. Failure to do so can reduce the structural strength in the welded area of the frame rail.

Read and comply with the following requirements:

- Do not weld attachments to the frame rail. For guidelines on the attachment of equipment on the frame rails, refer elsewhere in this group.
- Use only the applicable welding method under "Welding Methods."
- Before welding, clean off any oil, grease, paint, scale, and other contaminants. Wipe dry with a clean cloth.
- Do not weld in an area that allows drafts from any source such as windows, engines, or fans, as it will affect the soft flow of gas from the welding gun.
- Do not weld into the radius of the frame rail flanges or along the edge of the flange.
- Do not weld square with the frame side rail. Make all reinforcing welds at least 30 degrees from square. This will distribute the weld stresses over a larger area.
- Do not notch, undercut, or leave craters during the welding process.
- Keep as close to the weld centerline as possible.

Welding Methods

Gas-metal arc welding is the recommended method. If gas-metal arc welding is not available, coated-electrode arc welding can be used.

For both gas-metal arc welding and coated-electrode arc welding, direct current reverse polarity is recommended; however, alternating current can be used. Use either a short arc beading technique or a narrow weave technique.

GAS-METAL ARC WELDING

For the gas-metal arc welding method:

- Use weld wire that meets American Welding Society (AWS) specification A 5.28, Class E110S.
- Use Linde M-5 gas or an equivalent argon-oxygen mixture of 5 percent oxygen.
- For machine settings, see **Specifications, 400**.

COATED-ELECTRODE ARC WELDING

For the coated-electrode arc welding method:

- Use 1/8-inch-thick AWS-E-11018 type weld rod.

- For amperage and voltage settings of each weld position, see **Specifications, 400**.

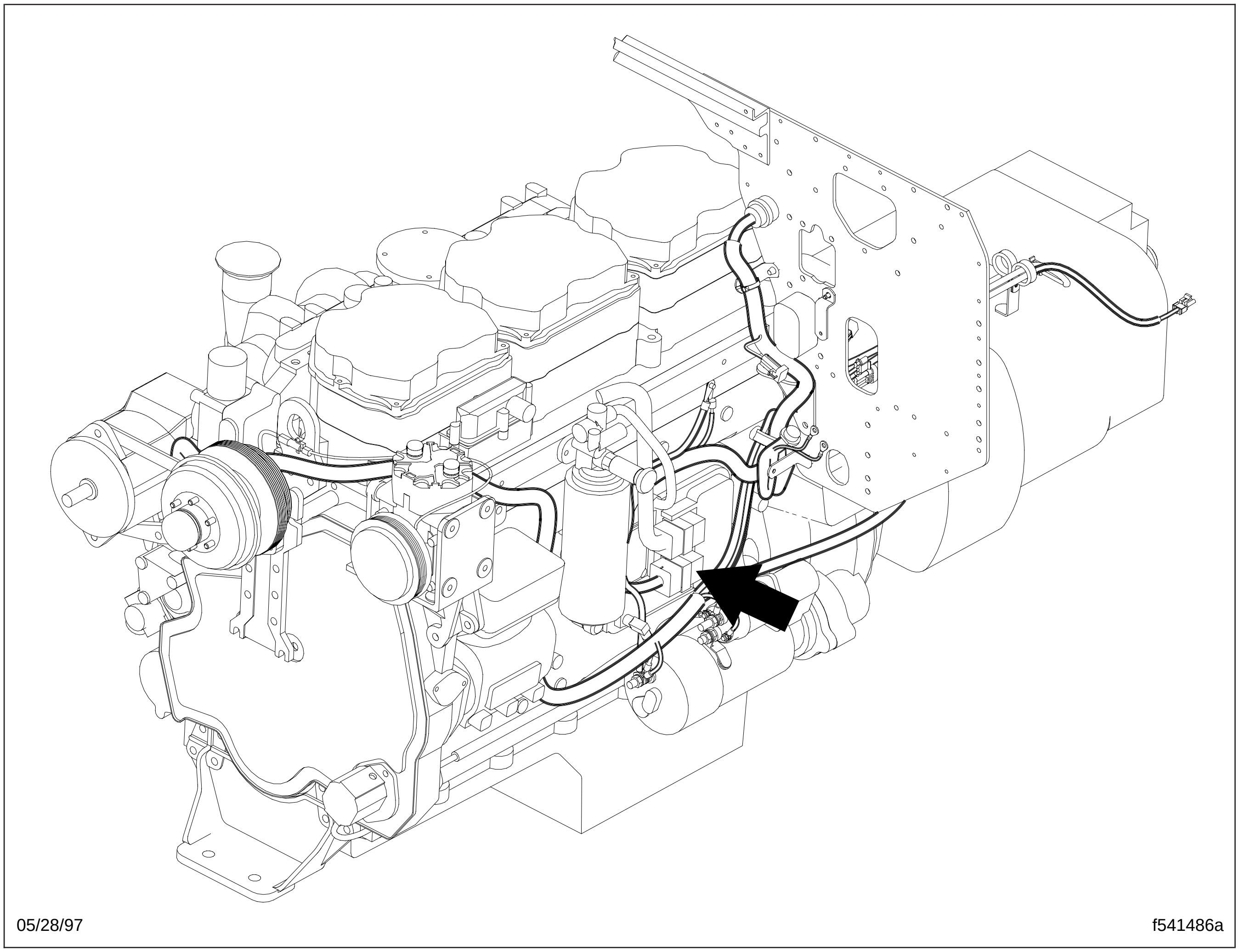


Fig. 1, Caterpillar C10 and C12 Engines, ECU Location

NOTE: On 1/4-inch-thick frame rails only, AWS-E-9018 type weld rod can be used, however, AWS-E-11018 type weld rod is recommended.

IMPORTANT: Always keep the weld rod free of moisture. The welding rod should be taken from a hermetically sealed container immediately before use, or be dried at least one hour in a 700° to 800°F (371° to 427°C) oven. Immediately after removal from a sealed container or after drying, store the welding rod in an oven at 250°F (121°C). A welding rod that has been exposed to the atmosphere longer than one-half hour must be dried before use.

Welding Frame Rails

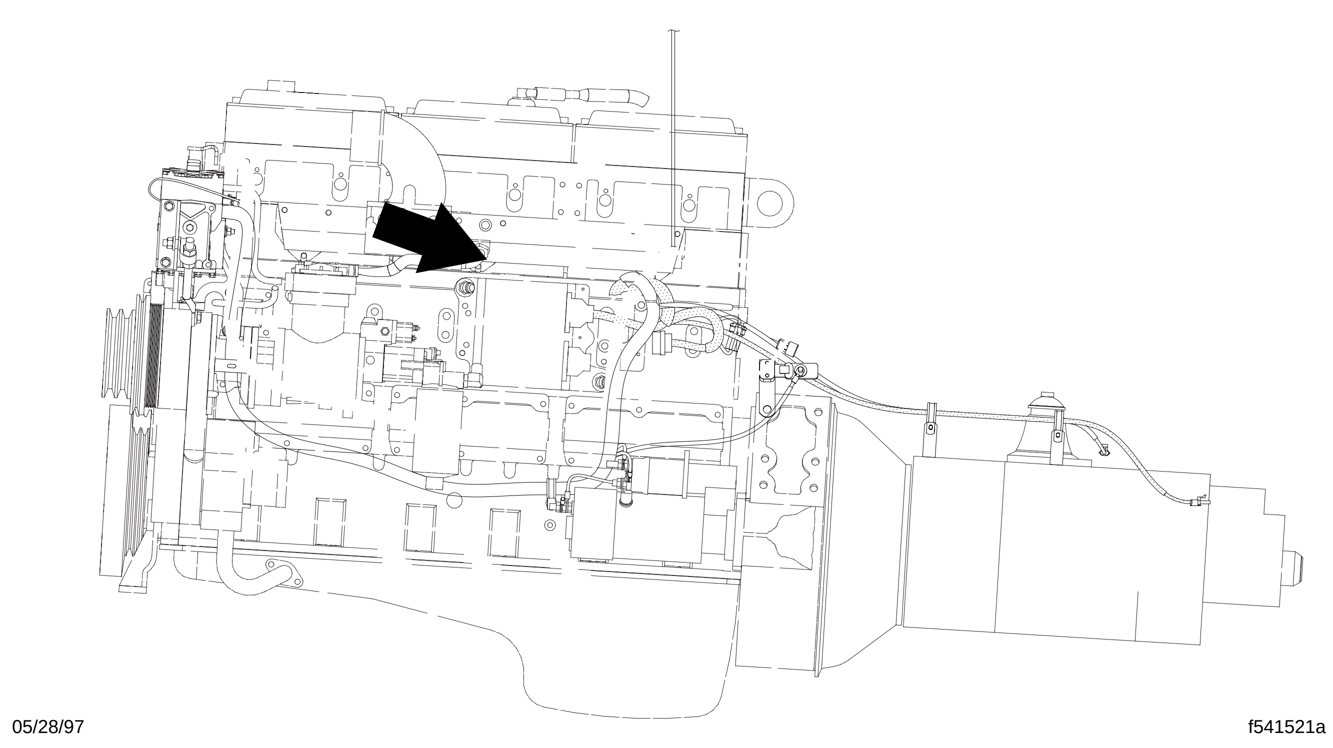


Fig. 2, Cummins N14 Engine ECU Location

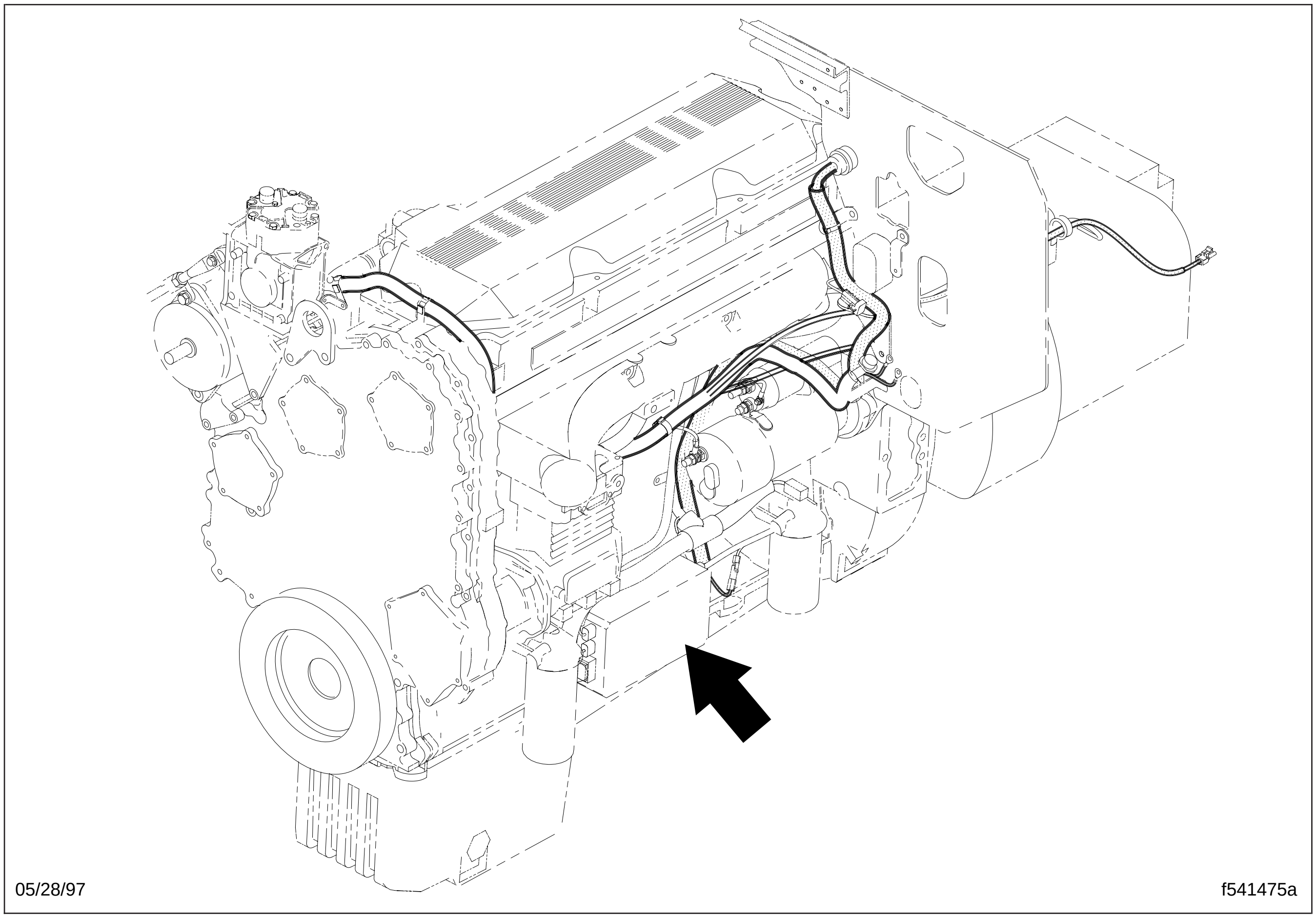
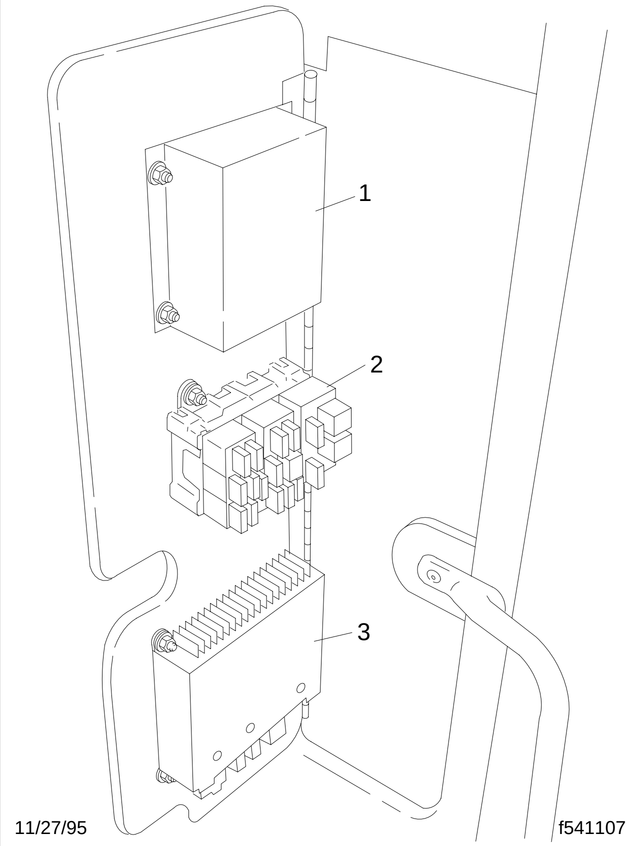


Fig. 3, Detroit Diesel Series 60 Engine ECU Location

Welding Frame Rails



1. Data Logging Unit
2. Auxiliary Power Distribution Module
3. ABS ECU

Fig. 4, Left-hand B-Pillar Electrical Compartment

Lengthening Frame Rails

Steel frame rails can be lengthened by welding an extension onto the rear of the frame rail. The end of the frame rail and the extension piece are cut so that they overlap each other. Obtain approval from your regional service representative before welding and lengthening the frame rail.

CAUTION

Before performing any electric welding on a vehicle, read and understand the welding precautions in Subject 110. Disconnect the battery power, ground cables, and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post. Or else disconnect the main connection at the ECU.

1. Cut the frame-rail end and extension to the applicable dimensions. See **Fig. 1** for truck dimensions, or **Fig. 2** for tractor dimensions. Refer only to the figure that relates to the vehicle being modified.

NOTE: If the length of the extension is to be 6 inches (152 mm) or less, then straight-cut the frame rail end and extension.

2. Grind the cut ends of the frame rail and extension to the dimensions in **Fig. 3**.

3. Align the cut ends of the extension piece with the cut ends of the frame rail so that there is a 1/16- to 1/8-inch (1.5- to 3-mm) gap between them. See **Fig. 3**. Using a torch, heat the cut ends to 70°F (21°C), if necessary, before welding.

NOTE: A 1/16-inch (1.6-mm) gap is recommended. The ends must not contact each other. Maintain the joint spacing by placing a short piece of clean, 1/16-inch (1.6-mm) diameter bare steel wire between the extension and frame rail. The wire sections must be short enough to be completely fused by the welding process.

CAUTION

Weld the web area first, making sure that the flanges do not contact each other. Residual stresses will occur in the weld if the web area is not welded first, or if the flanges contact each other when welding the web.

4. Using one of the methods in **Subject 110**, weld the extension to the frame rail, making full penetration. See **Fig. 4**. Weld the web area first, then the flange, working from the inside of the channel. When welding the web, make sure that the flanges do not contact each other.

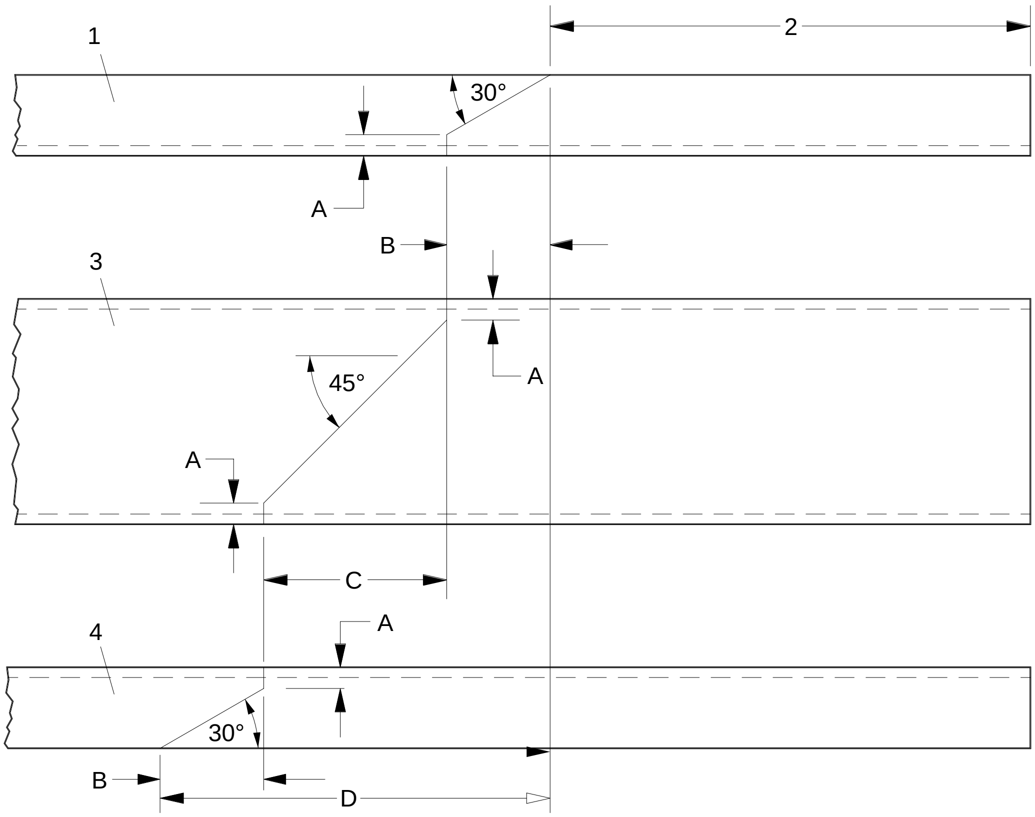
   Remove any slag between passes and back-gouge the root of the first vee before welding the other side.

CAUTION

Do not "hollow grind" the weld. Small depressions from improper grinding of the weld will reduce the strength of the frame rail.

5. When finished welding, sand the joint for appearance. Hold the sander so that the grind runs parallel with the length of the frame rail.

Lengthening Frame Rails



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

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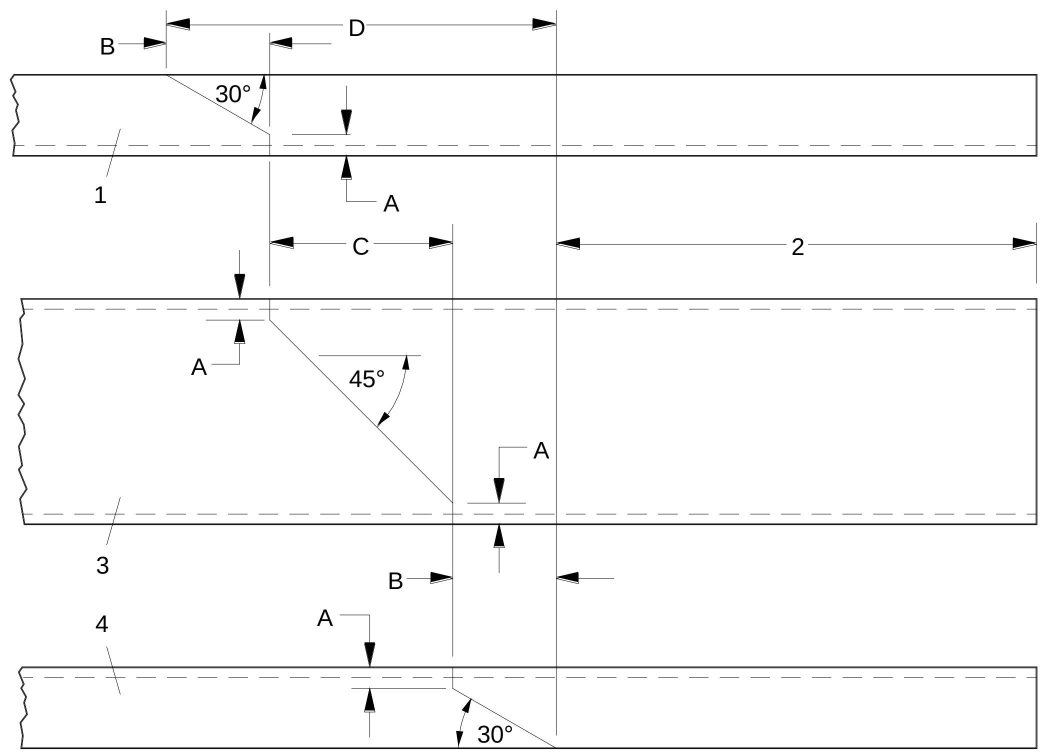
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

Fig. 1, Frame Rail and Extension Cutting Dimensions for Truck Vehicles



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
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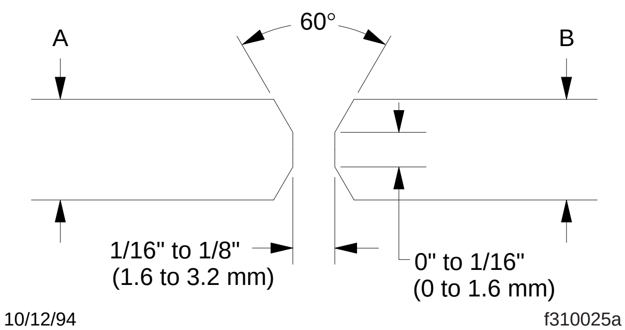
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

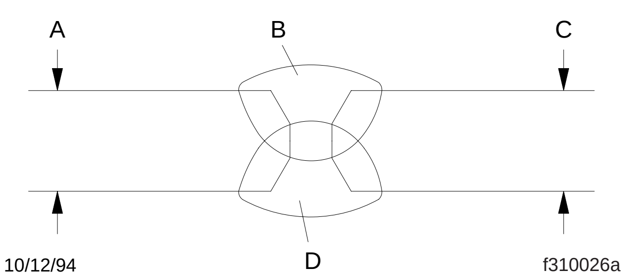
Fig. 2, Frame Rail and Extension Cutting Dimensions for Tractor Vehicles

Lengthening Frame Rails



A. Frame Rail Thickness
B. Extension Thickness

Fig. 3, Grinding Dimensions



A. Frame Rail Thickness
B. First Weld
C. Extension Thickness
D. Second weld penetrates the first weld.

Fig. 4, Correct Weld Penetration

Frame Crossmember Removal and Installation

General Information

The placement of crossmembers affects the overall stability of the frame. If a crossmember is being eliminated, added, or relocated, contact your regional service representative for instructions and approval.

1. Before working on any of the following crossmembers, park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the front and rear tires.
2. When the work is completed, remove the chocks from the tires.

Removal

Rear-Closing Crossmember

1. Remove the taillights from the rear-closing crossmember. If equipped, remove the backup alarm.
2. If the relay valve or quick-release valve is attached to the rear-closing crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.
3. Remove any clamps that attach air lines or wiring to the crossmember.
4. Remove the rear mud-flap brackets and fasteners.
5. Remove the fasteners that attach the crossmember to the angle brackets.
6. Remove the fasteners that attach the rearmost angle brackets to each frame rail, and remove the brackets. For assembly reference, note the direction that the bolts are installed.
7. Tip the top of the rear-closing crossmember to the rear and down, then slide it out the rear of the frame rails.
8. If needed, remove the forwardmost angle brackets and their fasteners. If the rear spring brackets are attached to the frame rails with the same fasteners that attach the angle brackets, before removing the fasteners, support the rear of the frame at its normal ride height, using safety stands. After removing the fasteners, remove the rear spring brackets from the springs.

Channel Crossmember

NOTE: If the vehicle is equipped with a fifth wheel, remove it if it interferes with removal of the channel crossmember. Follow the removal instructions in the applicable fifth wheel section in this manual.

1. Disconnect any suspension torque rod brackets that are attached to the crossmember. Note the number and location of any spacers.
2. If the relay valve or quick-release valve is attached to the channel crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.
3. Remove any clamps that attach air lines or wiring to the crossmember.
4. Remove all fasteners that attach the channel crossmember to the upper and lower gussets. Work the crossmember out of the gussets, then work it out of the top or bottom of the frame rails.
5. If removal of the gussets is needed, and if they attach to the frame with the same fasteners as the suspension brackets, use safety stands to support the frame at its normal unloaded ride height.

   Remove the fasteners that attach the gussets and frame brackets to the frame rails. For assembly reference, note the direction that the bolts are installed. Remove the gussets and (if equipped) frame spacers.

Five-Piece Welded Crossmember

NOTE: If the vehicle is equipped with a fifth wheel, remove it if it interferes with removal of the crossmember. Follow the removal instructions in the applicable fifth wheel section in this manual.

1. If any air brake valve is attached to the crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.

   Remove any clamps that attach air lines or wiring to the crossmember, and secure the lines or wiring away from the crossmember.
2. If rear suspension brackets are attached to the frame rails with the same fasteners that attach

Frame Crossmember Removal and Installation

the crossmember, use safety stands to support the rear of the frame at its normal ride height.

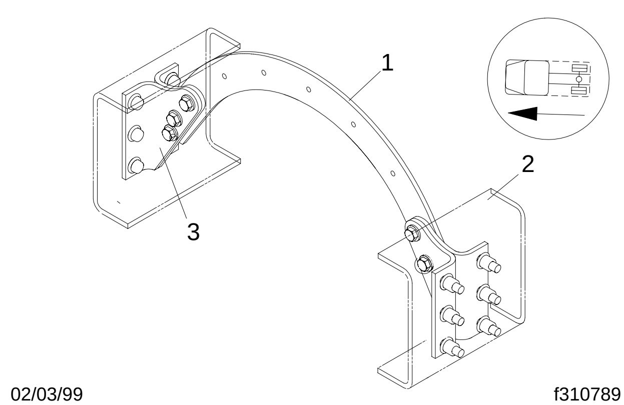
3. If removing a midship bearing crossmember, support the driveline on a safety stand, then remove the fasteners that attach the midship bearing bracket to the crossmember.
4. If removing the rear cab-mount crossmember, support the fuel tanks, then remove the fasteners from the fuel tank brackets.

   Using an overhead hoist, support the rear of the cab, then remove the cab suspension bracket from the cab and the crossmember.
5. Note whether the crossmember open channel faces the front or rear of the vehicle.
6. Using a cutting torch, cut the crossmember channel into two pieces. A slightly diagonal cut will make removal of the crossmember pieces easier.
7. Remove the fasteners that attach the crossmember halves to the frame rails, and remove the crossmember.
   - If threaded fasteners are used, save them to use with the new crossmember.
   - If Huck® fasteners are used, see **Section 31.01** for replacement instructions.

Overslung Crossmember

IMPORTANT: To improve access while removing the top crossmember bolt on the left-hand side of the vehicle, have an assistant hold the clutch pedal to the floor.

1. From underneath the chassis, remove the 5/8–11 bolts and nuts that hold each side of the crossmember to the mounting brackets. See **Fig. 1**.
2. Remove the overslung crossmember by rotating it down and outward on the right-hand side of the vehicle.



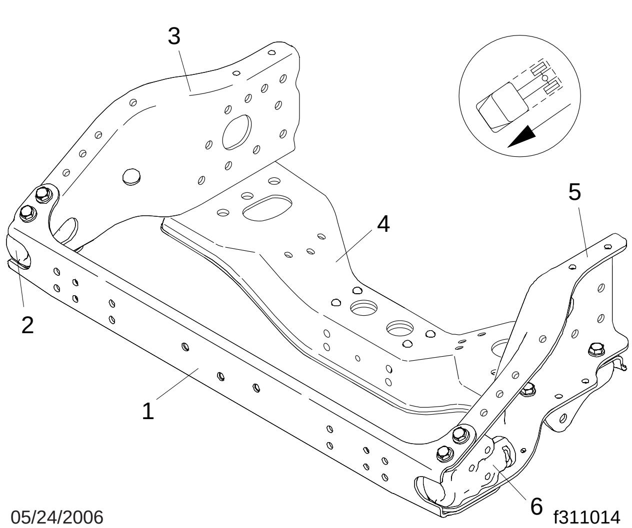
1. Overslung Crossmember
2. Frame Rail
3. Frame Rail Bracket

Fig. 1, Overslung Crossmember

3. Remove the tow device housing from each side of the vehicle. See **Fig. 2**.
4. Remove the front closing crossmember. See **Fig. 2**.

Front Closing Crossmember, Models with Bolt-On Front Frame

1. Remove the bumper. See **Section 31.03, Subject 110**.
2. Remove the hood. See **Section 88.00, Subject 100**.
3. Remove the tow device housing from each side of the vehicle. See **Fig. 2**.
4. Remove the front closing crossmember. See **Fig. 2**.



1. Front Closing Crossmember
2. Tow Device Housing, RH
3. Bolt-On Frame Bracket, RH
4. Engine Crossmember
5. Bolt-On Frame Bracket, LH
6. Tow Device Housing, LH

Fig. 2, Bolt-On Front Frame and Front Closing Crossmember

5. Drain the air system.
6. If necessary to make room for a jack stand, remove the primary air tank.
7. Place a jack under the front axle, and lift the vehicle until a jack stand can be properly situated under each frame rail.
8. Place a jack stand under each frame rail, and lift the vehicle until the front tires clear the ground and an engine stand can be conveniently installed.
9. Remove the jack from under the front axle.
10. Install an engine stand. Remove capscrews and brackets as needed.
11. Place a jack under the engine stand, and raise the jack until it's supporting the engine.
12. Cut the tie straps that attach the wiring harnesses to the bolt-on frame brackets, and pass the harnesses through the holes in the bolt-on frame brackets. See **Fig. 2**.

IMPORTANT: When removing the fuel filter/separator from the bolt-on frame bracket, do not allow it to dangle.

13. Remove the capscrews that attach the fuel filter/separator assembly to the left bolt-on frame bracket, and secure the fuel filter/separator with tie straps to the charge air cooler tube.
14. Remove the capscrews that attach the bolt-on frame brackets to the frame rails and suspension. Remove the bolt-on frame brackets.

Installation

Channel Crossmember

1. If equipped, position the correct thickness of frame spacer in each channel of the frame.

   If they were removed, install the upper and lower gussets in both sides of the frame, but do not tighten the fasteners at this time. Be sure to install each bolt in the same direction that was noted during removal.
2. Work the channel crossmember into the top or bottom of the frame, then work it into position in the gussets. Install the fasteners that attach the crossmember to the gussets, but do not tighten them at this time.
3. If it was removed from the channel crossmember, install the relay valve or quick-release valve on the crossmember. Securely tighten the fasteners.
4. Install any clamps that attach air lines or wiring to the crossmember.
5. If equipped, attach the suspension torque rod bracket(s) to the crossmember. Be sure the spacers are installed in the same location noted during removal.

   Tighten the fasteners to the applicable torque value. See **Specifications, 400**.
6. Install the fifth wheel, if it was removed. Follow the installation instructions in the applicable fifth wheel section in this manual. Tighten the fasteners that attach the channel crossmember gussets to the frame rails, then tighten the fasteners that attach the crossmember to the gussets.

   Tighten the fasteners to the applicable torque value. See **Specifications, 400**.

Rear-Closing Crossmember

1. If they were removed, install the forwardmost angle brackets, but do not tighten the fasteners at this time. If the rear spring brackets attach to the frame rails with the same fasteners that attach the angle brackets, install the rear spring brackets at this time. Then, remove the safety stands from under the frame rails. Be sure to install each bolt in the same direction that was noted during removal.
2. Slide the crossmember into the opening at the rear of the frame rails, then turn it upright to position it against the angle brackets.
3. Attach the rearmost angle brackets to the frame rails, but do not tighten the fasteners at this time.
4. Install but do not tighten the fasteners that attach the crossmember to the angle brackets.
5. Install the rear mud flap brackets. Tighten the fasteners to the applicable torque value. See **Specifications, 400**.
6. If it was removed from the rear-closing crossmember, install the relay valve or quick-release valve on the crossmember. Securely tighten the fasteners.

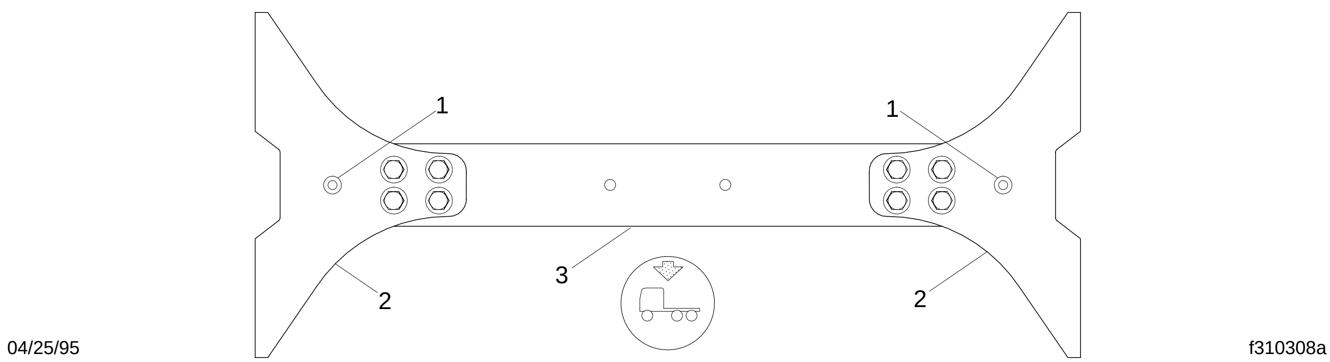
7. Install the taillights on the rear-closing crossmember. If equipped, install the backup alarm.
8. Install any clamps that attach air lines or wiring to the crossmember.
9. Tighten the fasteners that attach the angle brackets to the frame rails, then tighten the fasteners that attach the crossmember to the angle brackets.

   Tighten the fasteners to the applicable torque value. See **Specifications, 400**.

Five-Piece Bolted Crossmember

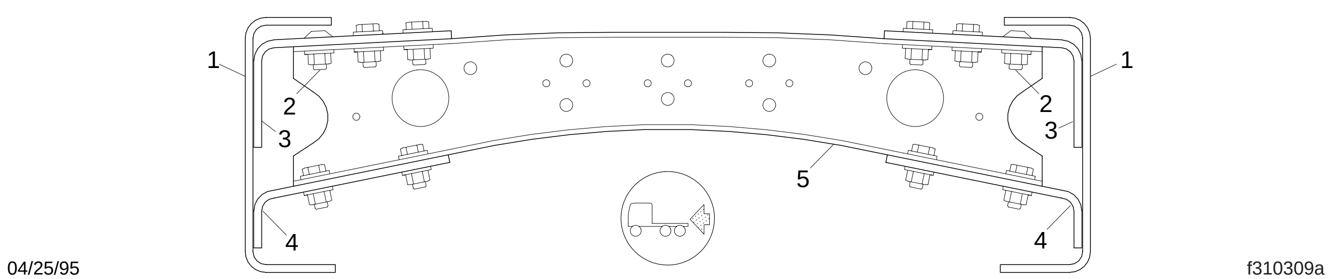
NOTE: Five-piece bolted crossmember assemblies are available as service parts to replace some five-piece welded crossmembers. See **Fig. 3** and **Fig. 4**. Always follow Parts Department information when replacing a welded crossmember with a bolted crossmember.

1. Attach one new upper gusset to the crossmember channel. Tighten the fasteners snugly, but not to their final torque value.
2. Place the crossmember channel and gusset in the frame rails with the channel opening facing the same direction as the original crossmember. Position the crossmember so its channel is resting on the lower flanges of both frame rails.
3. Slide the other upper gusset into position and attach it to the crossmember channel. Tighten the fasteners snugly, but not to their final torque value.
4. With the crossmember channel still resting on the lower flanges of both frame rails, tighten the locknuts on the button-head capscrews at the outboard end of both upper gussets 68 lbf·ft (92 N·m). See **Fig. 3**.



1. Button-Head Capscrew
2. Upper Gusset
3. Crossmember Channel

Fig. 3, Five-Piece Bolted Crossmember, Top View



1. Frame Rail
2. Button-Head Capscrew
3. Upper Gusset
4. Lower Gusset
5. Crossmember Channel

Fig. 4, Five-Piece Bolted Crossmember, Rear View

NOTE: The locknuts must be tightened now since, when the crossmember is in place, the frame upper flange blocks access to the capscrews. See **Fig. 4**.

5. Using a deadblow hammer, tap the crossmember into place. Align the mounting holes of the upper gussets with the holes in the frame rails. Install the fasteners, but do not tighten them.
6. Place the lower gussets in position against the crossmember channel and insert the fasteners that secure the gussets to the channel. Do not tighten the fasteners.
7. Install the fasteners that attach the gussets to the frame rails. If the welded crossmember was secured by Huck fasteners, see **Section 31.01** for installation instructions.
8. Tighten the fasteners that secure the gussets to the frame rails 136 lbf·ft (184 N·m). Then, tighten the fasteners that secure the gussets to the crossmember 68 lbf·ft (92 N·m).
9. If any air brake valve(s) was removed from the old crossmember, install the valve(s) on the new crossmember. Install any clamps attaching air lines or wiring to the crossmember.

Overslung Crossmember

1. Rotate the new crossmember into place from the right-hand side of the vehicle.
2. Align the holes in the crossmember with the holes in the mounting brackets. See **Fig. 1**.

IMPORTANT: To improve access, have an assistant hold the clutch pedal to the floor during the installation of the top crossmember fasteners on the left-hand side of the vehicle.

3. Install the 5/8–11 fasteners to hold the crossmember to its mounting brackets. Install the bolts so that the nuts can be tightened with a torque wrench and socket.
4. Tighten the crossmember nuts 136 lbf·ft (184 N·m).

Front Closing Crossmember, Models with Bolt-On Front Frame

1. Attach the bolt-on frame brackets to the frame rails and suspension. Hand-tighten the capscrews.

NOTE: Hand-tightening the capscrews allows for some play in the bolt-on frame brackets, which is helpful when attaching the front closing crossmember.

IMPORTANT: Each tow device housing is anchored by five capscrews — two on the top and three on the bottom. Ensure they are installed correctly and do not protrude into the tow device bore.

2. Place the tow device housing in each bolt-on frame bracket and mount the front closing crossmember.
3. Tighten the capscrews that attach the bolt-on frame brackets and front closing crossmember 136 lbf·ft (184 N·m).
4. Pass the harnesses through the holes in the bolt-on frame brackets and secure them with tie straps.
5. Remove the jacks.
6. Remove the engine stand.
7. Attach the fuel filter/separator assembly to the left bolt-on frame bracket, and tighten the capscrews 68 lbf·ft (92 N·m).
8. Install the air tank.
9. Install the hood. See **Section 88.00, Subject 100**.
10. Install the bumper. See **Section 31.03, Subject 110**.

Frame Rail Alignment

Frame rail alignment is checked by measuring the distances from two sets of points on the upper flanges of the frame rails. See **Fig. 1**. The rear set of points must be as far back as possible from the forward set of points. There must be no interference, along or between the frame rails, that would prevent measuring from any one of the four points to the other three points; the fifth wheel and deck plate (as equipped) must be removed.

There are no marks or bolt holes in the top flanges of the frame rails. Therefore, the points must be projected from the frame station marks and from the bolt holes on the frame rail webs.

IMPORTANT: Use a pencil or soapstone to make all lines, points, or other marks. Do not use any marker or tool that will scratch the surface of the frame rail. Use a machinist's square to project all points from the webs to the upper flanges, and to measure inboard from the outside face of the frame rails.

1. For each frame rail, project the exact vertical centerline of the frame station 1150 mark, from the frame web to the top flange, and mark it with a line across the top flange.

   If, because of interference, frame station 1150 cannot be used, choose and mark another matched set of points, as follows:

   1.1 Determine how far forward the upper flanges of both frame rails are clear.

   1.2 Find a matched set of bolt holes on the frame rail webs that are aligned with, or just rearward of, the front of the clear area on the flanges. The bolt holes must be in exactly the same location in each frame rail.

   1.3 Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.

2. Find the exact center of the width of each upper flange, and mark the point on each projected line. This will be the forward set of points. The forward points must be in identical locations on both frame rails.

3. As equipped, remove the fifth wheel and deck plate from the frame. Refer to the applicable fifth wheel section in this manual for instructions.

4. Measure back along each frame rail to find a set of bolt holes *at least* 72 inches (183 cm) rearward from the forward set of points. The bolt holes must be in exactly the same location in each frame rail.

IMPORTANT: If, because of interference, the distance must be less than 72 inches (183 cm), the distance must be the maximum that is possible.

5. Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.

6. Along each line, measure and mark a point 2 inches (5 cm) inboard from the outside face of its respective frame rail. The rear points must be in identical locations on both frame rails.

7. At the forward set of points, and again at the rear set of points, measure the distance across the frame, from the outside face of each frame rail. At both locations, this distance must be 33.50 inches (851 mm). See **Fig. 1**.

   If the distance at either location is incorrect, check the Freightliner *Parts Book* to determine which thickness of frame spacers, if any, belong between the crossmembers and the frame rails. Check for the correct spacers, and add or remove spacers as needed, using the procedures in **Subject 130**.

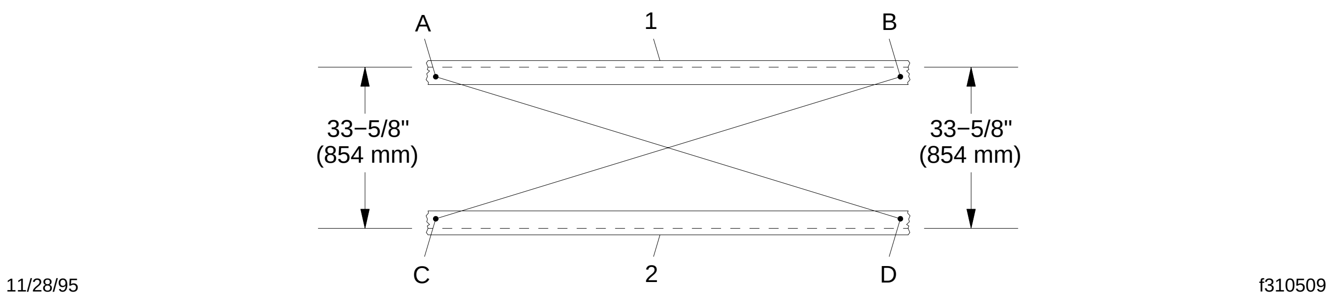
8. Measure the distance from the forward point on one frame rail to the rear point on the opposite frame rail. See **Fig. 1**. Then measure the distance from the other forward point to the rear point on its opposite frame rail.

9. Compare the two measurements. If the measurements are within 1/8 inch (3 mm) of each other, the frame rails do not need to be aligned.

   If the values differ by more than 1/8 inch (3 mm), align the frame rails.

   IMPORTANT: To align the frame rails, the frame assembly must be assembled with all of the crossmembers in place, but the attachment fasteners not tightened.

Frame Rail Alignment



A. Right Forward Point or Bolt Hole
B. Right Rear Point or Hole
1. Right Frame Rail

C. Left Forward Point or Bolt Hole
D. Left Rear Point or Bolt Hole
2. Left Frame Rail

Fig. 1, Frame Rail Squaring

9.1 Loosen all of the frame fasteners just enough to allow movement of the parts when force is applied.

9.2 Place a large wooden block against the rear end of the frame rail that has its rear point the greatest distance from the opposite rail's front point.

9.3 Using a large hammer, tap the block until the measurements are within 1/8 inch (3 mm) of each other.

10. Tighten the fasteners for the front- and rear-closing crossmembers to the applicable torque values. See **Specifications, 400**.

11. Check the frame rail alignment again, and adjust as needed.

12. When the measurements are within specifications, install the fifth wheel and deck plate (as equipped). Refer to the applicable fifth wheel section in this manual for instructions.

13. Tighten all of the frame fasteners, starting at the middle of the frame and working alternately toward both ends. Tighten the fasteners to the applicable torque values. See **Specifications, 400**.

13.1 Tighten the fasteners that attach crossmembers to the frame.

13.2 Tighten the fasteners that attach the upper and lower struts or gussets to the frame.

13.3 Tighten the fasteners that attach the lower struts or gussets to the crossmembers.

14. If the frame rails required aligning, check the axle alignment. Refer to **Section 35.00** for instructions.

Frame Shaping

IMPORTANT: Obtain approval from your regional service representative before doing any cutting or frame shaping.

WARNING

Wear protective eye and facial gear when grinding. Failure to wear this gear can result in personal injury due to flying metal debris from the grinding process.

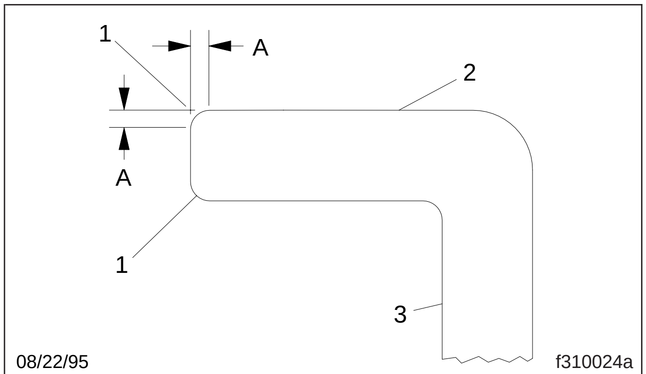
1. If the flange of a frame rail is cut (for relief cuts or notches), shape the edges of the flange to form a smooth ground radius of 0.06 to 0.12 inch (1.5 to 3.0 mm) over the entire length of the cut. **Figure 1** shows this dimension of the edge radius of the frame rail flanges.

NOTE: For information on relief cuts or notches, refer to **Subject 100**.

CAUTION

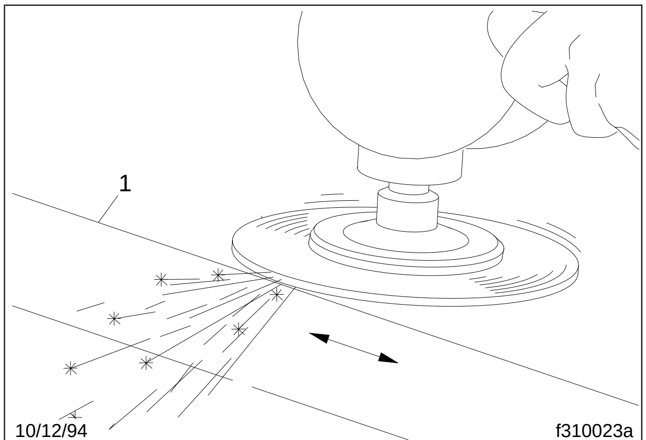
When grinding, apply light pressure only. Heavy pressure can result in harmful overheating and a loss of surface temper. Grind only in the direction of the cut. Grinding across the direction of the cut can reduce the structural strength of the frame rail.

2. Using a clean, sharp, rotary drum grinder or flapper wheel grinder, apply light pressure and grind the cut edges in the direction of the length of the frame rail, to form the radius. See **Fig. 2**. Do not grind across the edges.



A. 0.06" to 0.12" (1.5 to 3 mm)
1. Radius
2. Flange
3. Web

Fig. 1, Radius Dimensions



1. Flange

Fig. 2, Direction of Grind

Specifications

Arc welding settings are provided in **Table 1** and **Table 2**; torque specifications are listed in **Table 3**.

For frame rail and extension cutting dimensions, see **Fig. 1** for trucks and **Fig. 2** for tractors.

Gas-Metal Arc Welding Machine Settings				
Wire Diameter inch (mm)	**Current, amperes**		**Wire Extension, inch (mm)**	
	Minimum	**Maximum**	**Optimum**	**Maximum**
0.045 (1.14)	160	320	1/2 (13)	3/4 (19)
1/16 (1.6)	300	600	3/4 (19)	1-1/8 (29)
5/64 (2.0)	480	960	1 (25)	1-1/2 (38)

Table 1, Gas-Metal Arc Welding Machine Settings

Coated-Electrode Arc Welding Settings		
Weld Position	**Amperes**	**Volts**
Downhand	130–140	21–23
Overhead	130–140	21–23
Vertical Up	110–120	22–24

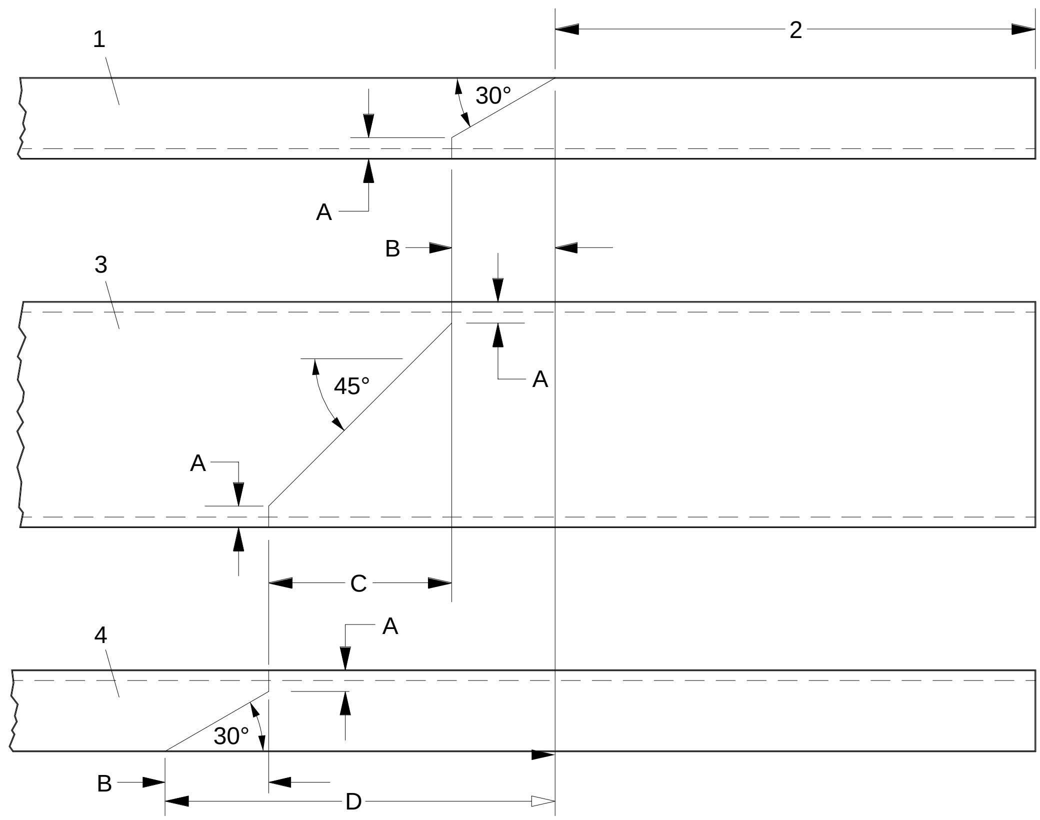
Table 2, Coated-Electrode Arc Welding Settings

Frame Fastener Torque Specifications	
Size	**Torque * lbf·ft (N·m)**
1/2–13	68 (92)
9/16–12	98 (133)
5/8–11	136 (184)
3/4–10	241 (327)
3/4–16	269 (365)
7/8–9	388 (526
7/8–14	427 (579)

* Lubricated or plated threads.

Table 3, Frame Fastener Torque Specifications

Specifications



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

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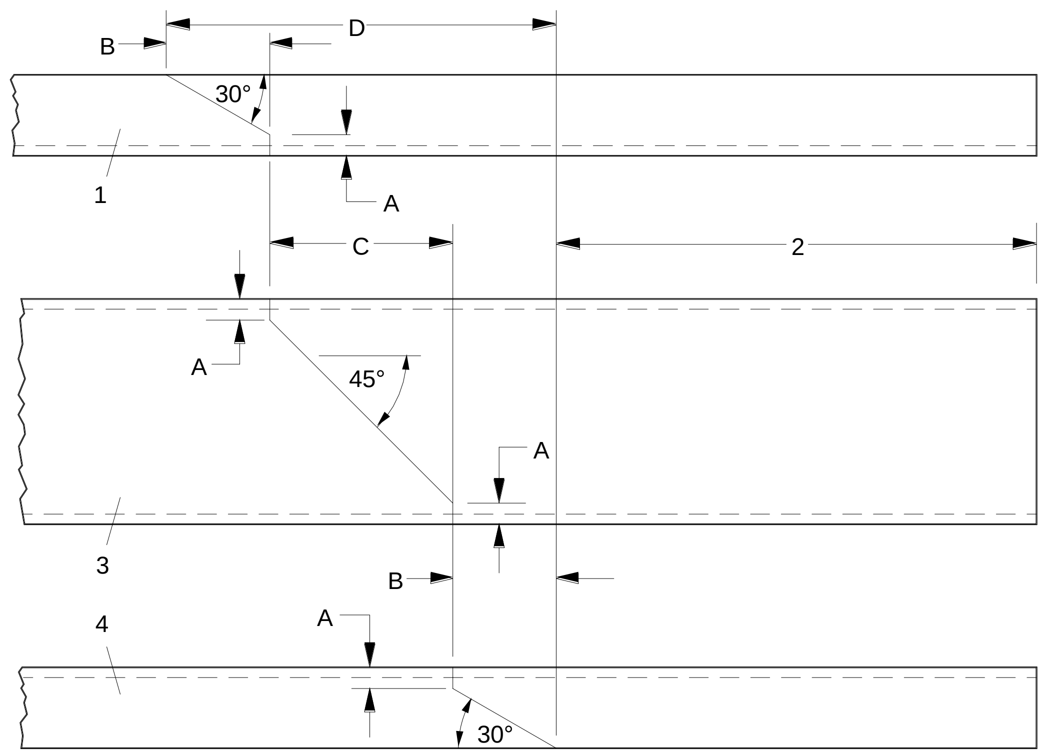
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

Fig. 1, Frame Rail and Extension Cutting Dimensions for Trucks



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

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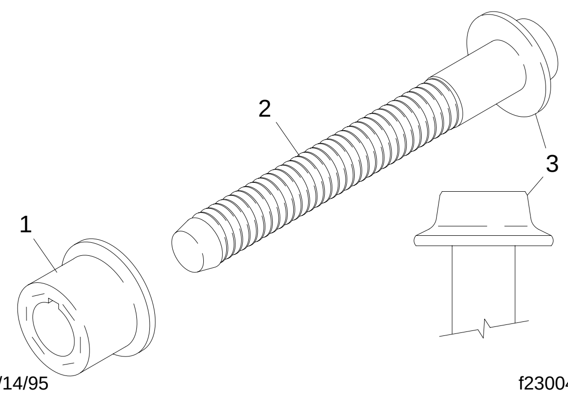
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

Fig. 2, Frame Rail and Extension Cutting Dimensions for Tractors

General Information

Either Huck® fasteners or grade 8 hexhead bolts and grade C prevailing torque locknuts are used for frame attachments. See **Fig. 1** and **Fig. 2**. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. Prevailing torque locknuts of both bolt types have distorted sections of threads to provide torque retention.



1. Spin Collar
2. Lock Pin
3. Round Head

Fig. 1, Huck Fastener

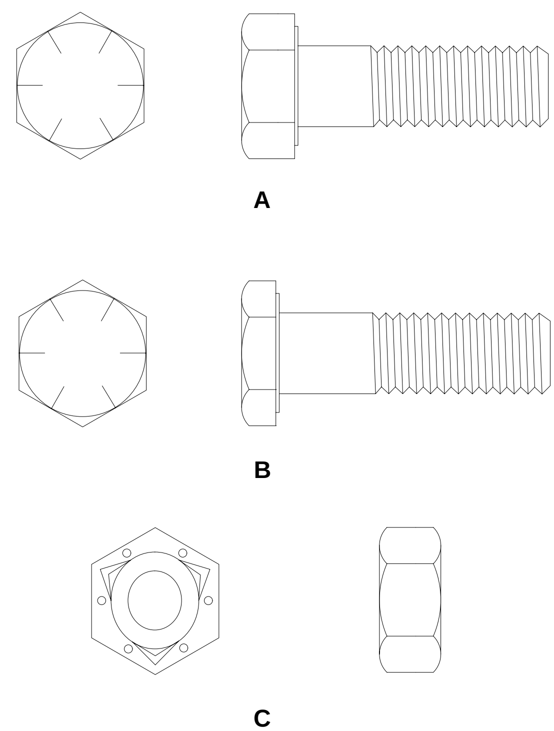
When hexhead bolts and locknuts are used on an attached part, a hardened flatwasher is required to prevent the bolt head or nut from embedding in the part.

In general, hardened washers are used to distribute the load, and to prevent localized overstressing of the frame rails, brackets, and other parts. They are placed directly against the part, under the nut or bolt head.

These special hardened washers are used on the frame rails and for the engine rear supports, rear suspension brackets, and fifth wheel mountings. They are cadmium- or zinc-plated, and have a hardness rating of 38 to 45 HRC.

HEXHEAD BOLT REPLACEMENT

Replace hexhead bolts with identical fasteners. Refer to the Freightliner Parts Book for fastener specifications.



A. Grade 8 Hexhead Bolt
B. Grade 8 Low-Profile Hexhead Bolt
C. Grade C Prevailing Torque Locknut

Fig. 2, Hexhead Fasteners

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the frame or parts.

Apply Alumilastic® compound, or an equivalent, to all surfaces where steel and aluminum parts contact each other.

Never hammer or screw bolts into place. Align the holes of the frame and the part being attached to it, so that the nut and bolt surfaces are flush against the frame and the part.

Make sure the length of the bolt threads that extend beyond the tightened locknuts are as specified in **Table 1**.

General Information

Bolt Length in (mm)	Thread Extension *	
	Minimum	Maximum
4 (102) or Less	1-1/2 Threads	5/8 in (16 mm)
Longer than 4 (102)	3 Threads	3/4 in (19 mm)

* Length of bolt thread extending beyond tightened locknut.

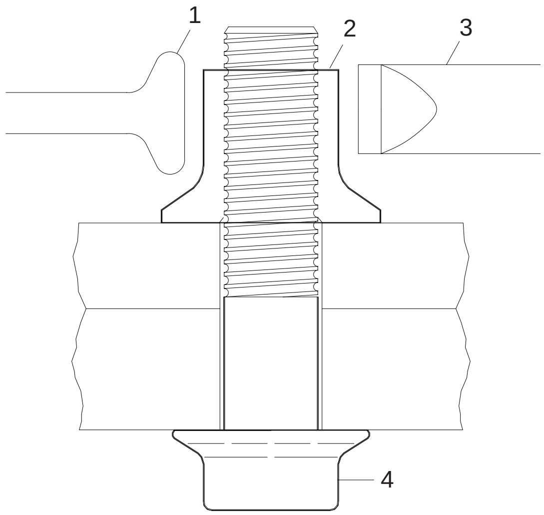
Table 1, Thread Extension Specifications

For bolts 4 inches (102 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extend through the self-locking nut after it has been tightened.

For bolts longer than 4 inches (102 mm), allow a minimum of three threads and a maximum of 3/4-inch (19-mm) bolt length.

HUCK FASTENER REMOVAL

The collar for Huck fasteners is spun on when they are installed, but it cannot be unscrewed. Use the Huck Collar Cutter to remove Huck fasteners. If the Collar Cutter isn't available, split the collar with an air chisel while supporting the opposite side of the collar with an anvil. See **Fig. 3**. Then, drive out the lock pin with a punch. Discard the fastener after removing it. Replace Huck fasteners with standard grade 8 threaded fasteners.



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1. Anvil
2. Spin Collar
3. Chisel
4. Lock Pin

Fig. 3, Huck Fastener Removal

CAUTION

Never attempt to reuse any Huck fastener that has been removed. Reusing any Huck frame fastener can result in damage to the vehicle frame or components attached to the frame.

FRAME FASTENER TIGHTENING

CAUTION

Tighten standard frame fasteners periodically. Continued vehicle operation with loose fasteners could result in component, bracket, and frame damage.

Tighten hexhead bolts and locknuts periodically to offset the effects of "bedding in" (seating). Refer to the Maintenance Schedule and the frame section in the vehicle maintenance manual for intervals.

When tightening the fasteners, tighten the nut, not the bolt head. This will give a true torque reading by eliminating bolt body friction. For torque specifications, see **Section 31.00**, Specifications, 400.

NOTE: Huck fasteners do not require periodic tightening.

General Information

The Columbia aerodynamic bumper has a steel center section with thermoplastic end caps. It is bolted to the front of the frame rail.

The standard bumper is solid dark gray; the optional painted bumper, with metallic argent silver insert, is painted the same as the fenders.

Bumper Removal and Installation

Removal

1. Park the vehicle, shut down the engine, and apply the parking brake. Chock the rear tires.
2. Open the hood.
3. Disconnect the road lights mounted on the bumper.

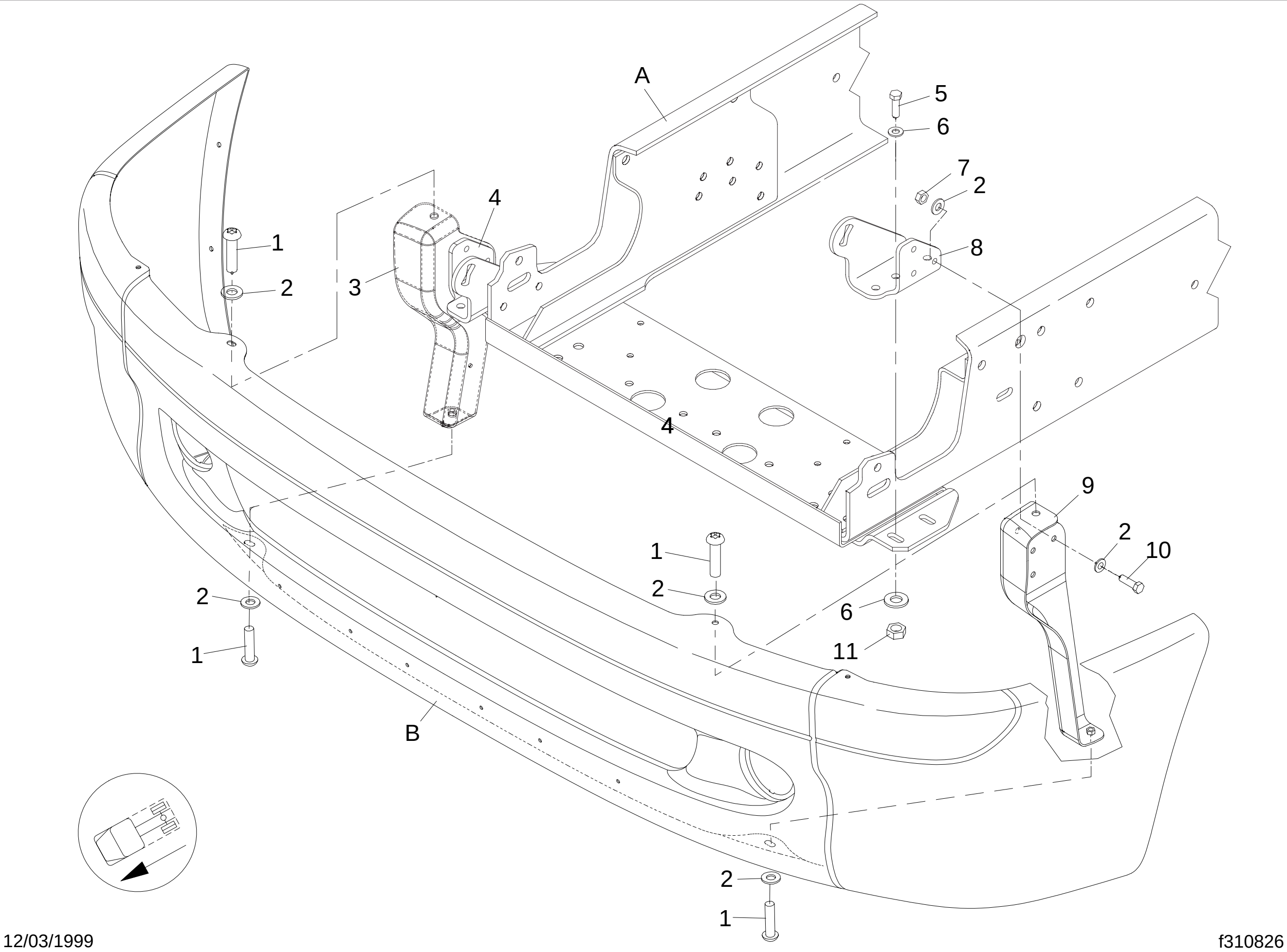
IMPORTANT: Support the bumper so it will not fall when you remove the attaching bolts.

4. Remove the two 3/8–16 capscrews and washers that attach the bumper to the bottom of the bumper assembly bracket. See **Fig. 1** for vehicles with a 1200-square-inch radiator, or **Fig. 2** for vehicles with a 1350-square-inch radiator.
5. On top of the bumper, remove the two 3/8–16 x 1-1/4 inch capscrews and washers that attach the bumper to the top of the bumper assembly bracket.
6. Using two people, remove the bumper.
7. Close the hood.

Installation

1. Open the hood.
2. Using two people, put the bumper in place on the bumper assembly bracket. See **Fig. 1**. Align the bolt holes on the bumper with the holes in the bracket.
3. Install two 3/8–16 x 1-1/4 inch capscrews and washers in the top of the bumper to secure it to the top of the bumper assembly bracket. Tighten the capscrews 40 lbf·ft (54 N·m).
4. Underneath the bumper, install the two 3/8–16 x 1-1/4 inch capscrews and washers to secure the bumper to the bottom of the bumper assembly bracket. Tighten the capscrews 40 lbf·ft (54 N·m).
5. Connect the road lights.
6. Close the hood.
7. Remove the chocks from the tires.

Bumper Removal and Installation

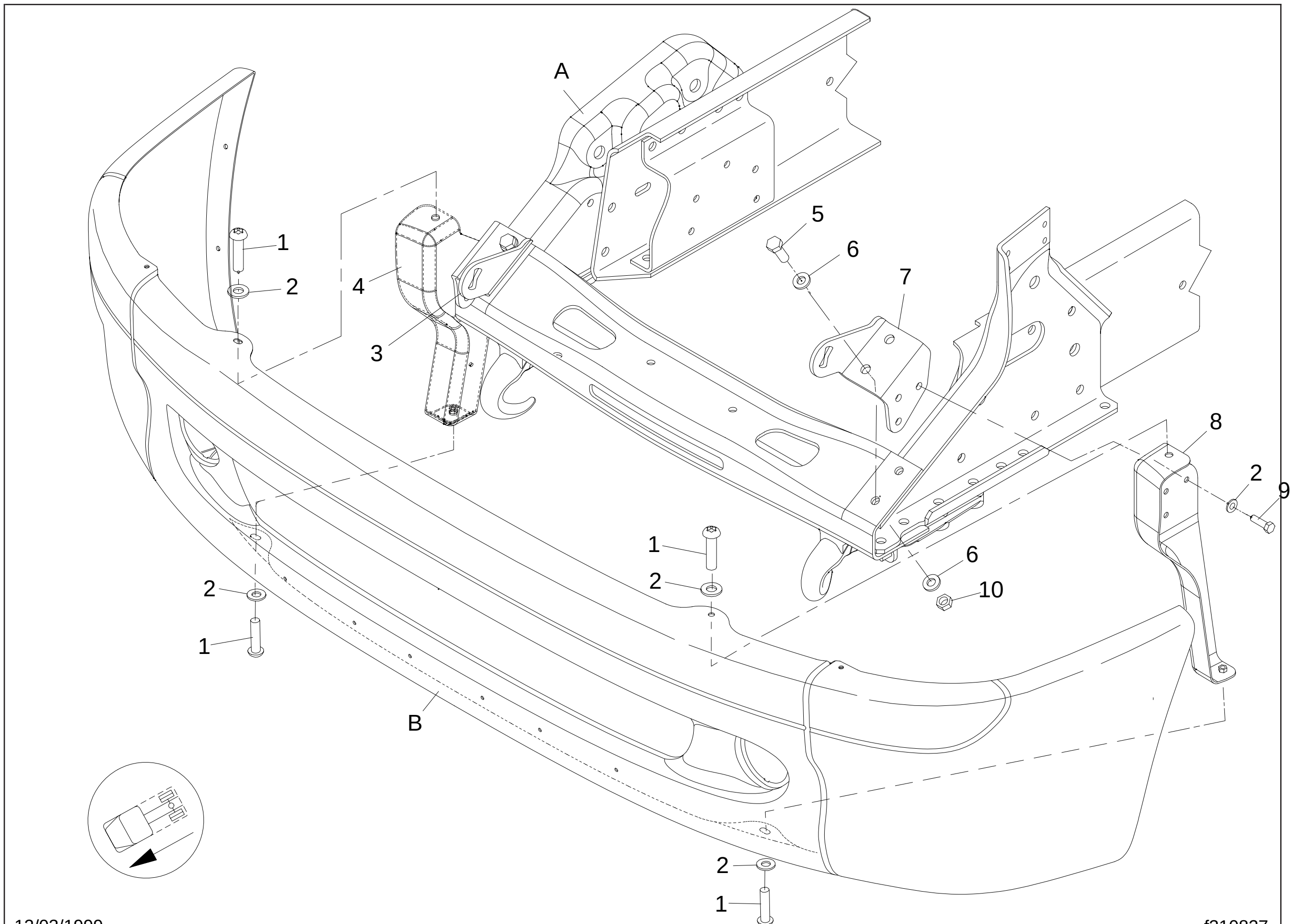


A. Frame Assembly
B. Bumper Assembly, steel center with plastic endcaps.

1. Capscrew, 3/8–16 x 1-1/4
2. Washer, 0.41 x 0.81 x 0.80
3. Bumper Assembly Bracket, RH
4. Bumper Torsion Bar Support, RH
5. Hexbolt, 1/2–13
6. Washer, 1/2 x 1.06 x 0.14
7. Locknut, 3/8–16
8. Bumper Torsion Bar Support, LH
9. Bumper Assembly Bracket, LH
10. Hexbolt, 3/8–16 x 1-1/4
11. Hexnut, 1/2–13

Fig. 1, Bumper Installation, 1200-sq-in Radiator

Bumper Removal and Installation



A. Frame Assembly
B. Bumper assembly, steel center with plastic endcaps.

1. Capscrew, 3/8–16 x 1-1/4
2. Washer, 0.41 x 0.81 x 0.80
3. Bumper Torsion Bar Support, RH
4. Bumper Assembly Bracket, RH
5. Hexbolt, 1/2–13
6. Washer, 1/2 x 1.06 x 0.14
7. Bumper Torsion Bar Support, LH
8. Bumper Assembly Bracket, LH
9. Hexbolt, 3/8–16 x 1-1/4
10. Hexnut, 1/2–13

Fig. 2, Bumper Installation, 1350-sq-in Radiator

Bumper Removal and Installation, Models with Bolt-On Front Frame Brackets

For models with bolt-on front frame brackets, there is more than one way to remove (and install) the aerodynamic bumper. When working on the engine, radiator, front closing crossmember, or other vehicle parts, it may be helpful if the bumper mounting brackets (see **Fig. 1**) are removed from the vehicle along with the bumper. To replace the bumper or work on bumper components, you can remove the bumper only (see **Fig. 2**). Instructions for both procedures are provided.

Removal

Bumper and Bumper Mounting Brackets

1. Apply the parking brakes, then chock the tires.
2. If installed, remove the bracket that fastens the headlight harness to the bumper. Retain the fasteners.
3. If the bumper is equipped with fog lights, disconnect them.
4. If an outside air temperature sensor is installed, disconnect it from the LH side support assembly on the bumper.
5. From each side of the front crossmember, remove the three capscrews and washers that attach the bumper mounting bracket to the tow device housing. See **Fig. 1**.

NOTE: The following step requires two persons.

6. While one person holds the bumper, the other one carefully separates the bumper from the front flange of the tow device housing. Together, remove the bumper from the vehicle.

Bumper Only

1. Apply the parking brakes, then chock the tires.
2. If installed, remove the bracket that fastens the headlight harness to the bumper. Retain the fasteners.
3. If the bumper is equipped with fog lights, disconnect them.
4. If an outside air temperature sensor is installed, disconnect it from the LH side support assembly on the bumper.

IMPORTANT: The following steps require two persons.

NOTE: For the four Torx capscrews, the top two are mated to weld nuts and the bottom two are mated to washers and hexnuts.

5. While one person removes the Torx capscrews, washers, and hexnuts that attach the bumper to the bumper mounting brackets, the other one holds the bumper when it is no longer attached by the fasteners. See **Fig. 2**.
6. With one person on each end of the bumper, remove the bumper from the vehicle.

Installation

Bumper and Bumper Mounting Brackets

NOTE: This step requires two persons.

1. With each person supporting a side of the bumper, align the opening for the tow device with the tow device housing and wrap the bumper over the torsion bar assembly.

NOTE: Ensure that there is an even gap between the bumper and hood. Each bumper mounting bracket has two holes with slots that allow for angle adjustments.

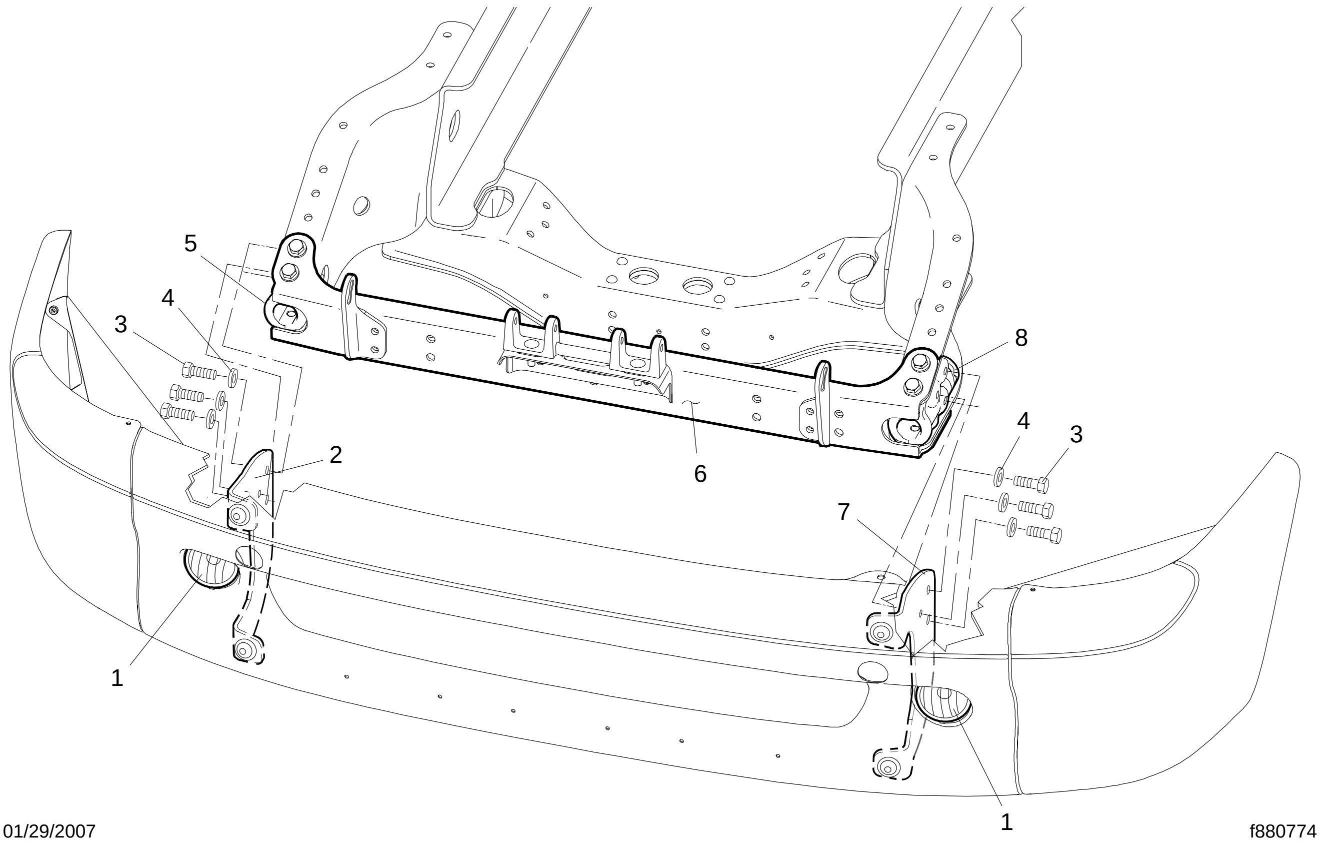
2. On each side of the front crossmember, install the three washers and capscrews that attach the bumper to the tow device housing. Tighten the capscrews 68 lbf·ft (92 N·m).
3. If removed, install the bracket that fastens the headlight harness to the bumper.
4. If an electronic outside air temperature sensor is installed, connect it.
5. If the bumper is equipped with fog lights, connect them, then use tie wraps to secure the wiring harnesses to the frame rails.
6. Remove the chocks from the tires.

Bumper Only

NOTE: This step requires two persons.

1. With each person supporting a side of the bumper, align the opening for the tow device with

Bumper Removal and Installation, Models with Bolt-On Front Frame Brackets



1. Fog Light
2. Bumper Mounting Bracket, RH
3. Capscrew
4. Washer
5. Tow Device Housing, RH
6. Front Crossmember
7. Bumper Mounting Bracket, LH
8. Tow Device Housing, LH

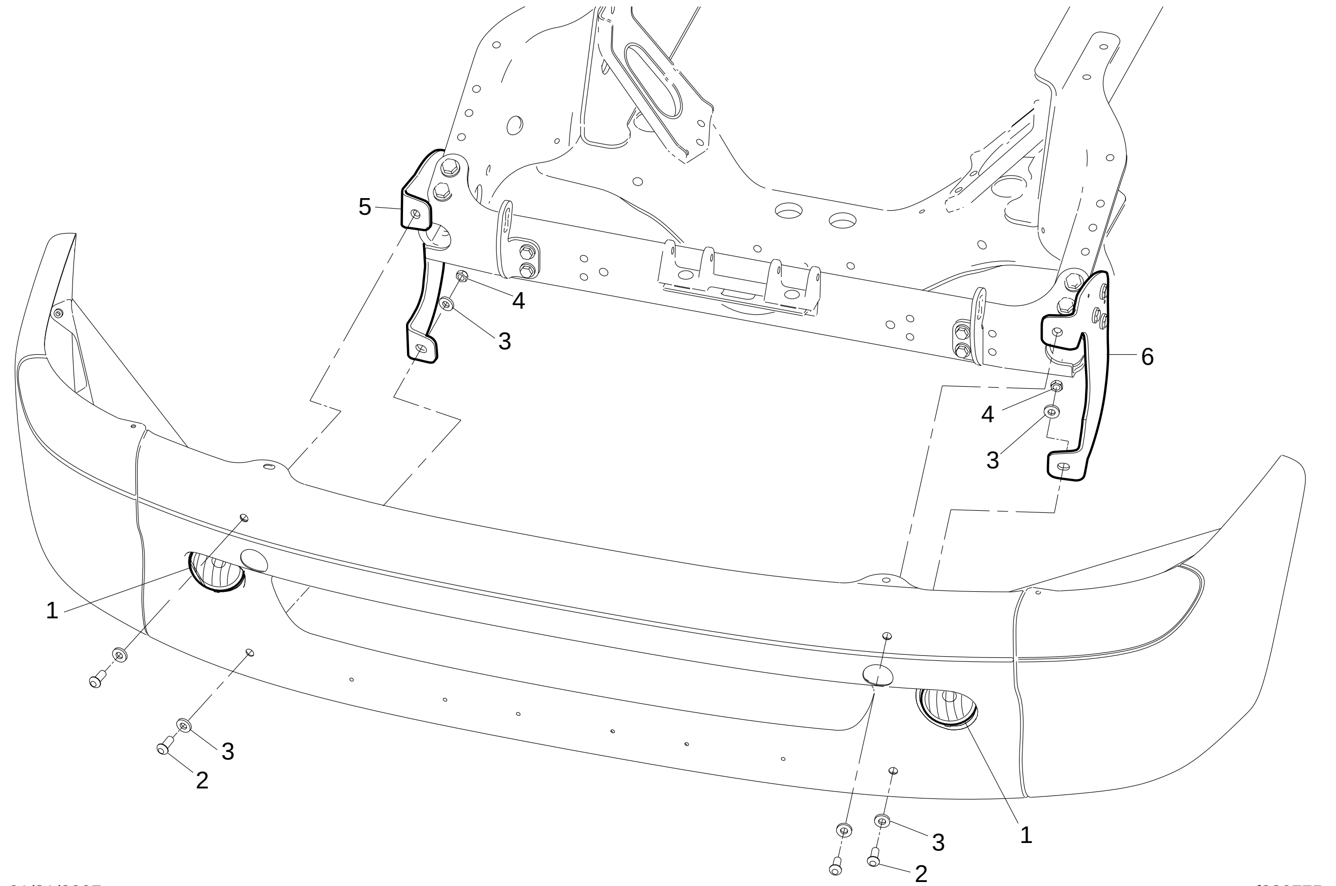
Fig. 1, Removal and Installation, Bumper and Bumper Mounting Bracket

the tow device housing and wrap the bumper over the torsion bar assembly.

NOTE: The gap between the bumper and hood must be even. Each bumper mounting bracket has two holes with slots that allow for angle adjustments.

2. Install the Torx capscrews, washers, and hexnuts that attach the bumper to the bumper mounting bracket. Tighten the capscrews 100 lbf·ft (134 N·m). Adjust the bumper as necessary to ensure that the gap between the bumper and hood is even.
3. If removed, install the bracket that fastens the headlight harness to the bumper.
4. If an electronic outside air temperature sensor is installed, connect it.
5. If the bumper is equipped with fog lights, connect them, then use tie wraps to secure the wiring harnesses to the frame rails.
6. Remove the chocks from the tires.

Bumper Removal and Installation, Models with Bolt-On Front Frame Brackets

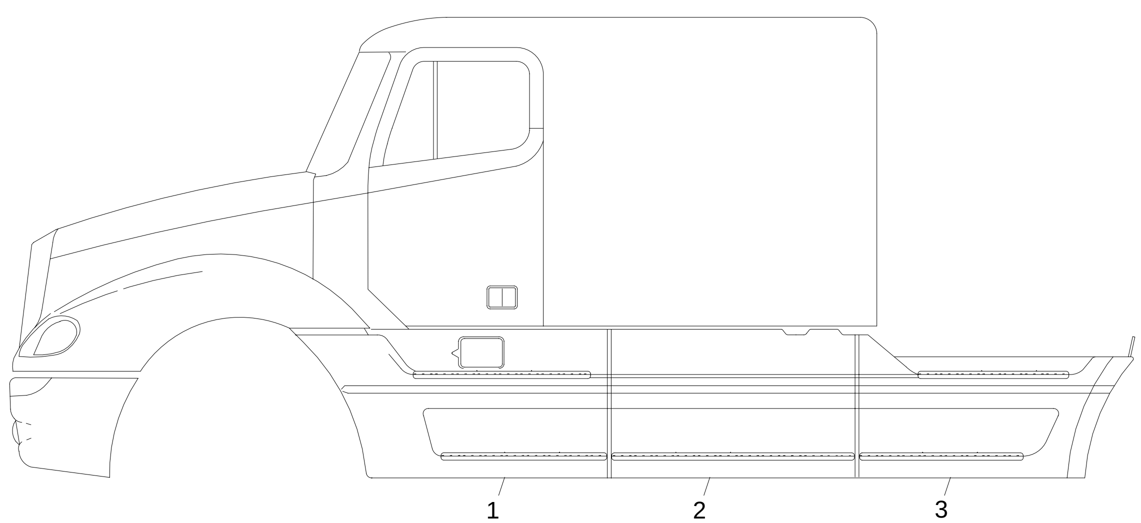


1. Fog Light
2. Capscrew
3. Washer
4. Hexnut
5. Bumper Mounting Bracket, RH
6. Bumper Mounting Bracket, LH

Fig. 2, Removal and Installation, Bumper Only

General Information

Chassis side-fairing assemblies ease air turbulence around the fuel tanks and provide access to the sleeper and back of the cab. See **Fig. 1**. The side fairings are sized to the cab or wheelbase.



1. Forward Panel 2. Intermediate Panel 3. Aft Panel

Fig. 1, Side-Fairing Panels (typical)

The side-fairing panels are made of plastic and are mounted on support rails, which run parallel to the frame rails. The support rails are mounted on brackets attached to the fuel tank mounting straps and to the frame rail itself.

There may be one, two, or three side-fairing panels on each side of the vehicle. On vehicles equipped with three fairing panels, the left aft fairing panel is available in a latched configuration that swings out to allow access to the frame rail and battery box.

The fairing panels are painted to match the color of the cab and have perforated metal plates on each step surface to prevent slipping. Machine screws inserted through these step plates hold the fairings to the support rails underneath.

Panel Removal and Installation

NOTE: The following procedure covers the removal and installation of the forward, center, and rear fairing panels. Not all vehicles are equipped with three fairing panels. Follow the applicable steps for the vehicle on which you are working.

Removal

When removing the side-fairing panels, it is easiest to remove the rear panel first, then the center, and finally the forward panel.

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the rear tires.
2. Remove the rear fairing panel.
   2.1 Remove the Torx®-head screws and washers holding the upper and lower tread plates and the panels to the support rails. See **Fig. 1**. Remove the plates.

CAUTION

Lift the panel only by the edges. Do not lift it by the oval holes that run the length of it. To do so could cause the plastic structure to break.

   2.2 Holding the panel by its edges, remove it from the support rails.
3. Using the procedure in the previous step, remove the center fairing panel, except lift the panel up and tilt the upper edge inward before removing it.
4. Remove the forward panel.
   4.1 Remove the Torx-head screws and washers from the upper and lower tread plates, and remove the plates from the panel.
   4.2 Remove the two 5/16–18 Torx-head screws, washers, locknuts, and the isolator strap from the upper forward corner of the panel. See **Fig. 1**.
   4.3 Holding the panel by its edges, remove it from the upper and lower support rails.
5. Repeat the previous steps on the other side of the vehicle, if required.

Installation

IMPORTANT: When installing the side-fairing panels, install first the forward panel, then the center panel, and finally the rear panel. This sequence allows the panels to fit together correctly.

CAUTION

Lift the panels only by the edges. Do not lift them by the oval holes that run the length of them. To do so could cause the plastic structure to break.

1. Install the forward fairing panel.
   1.1 Put the forward panel in place on the upper and lower support rails.

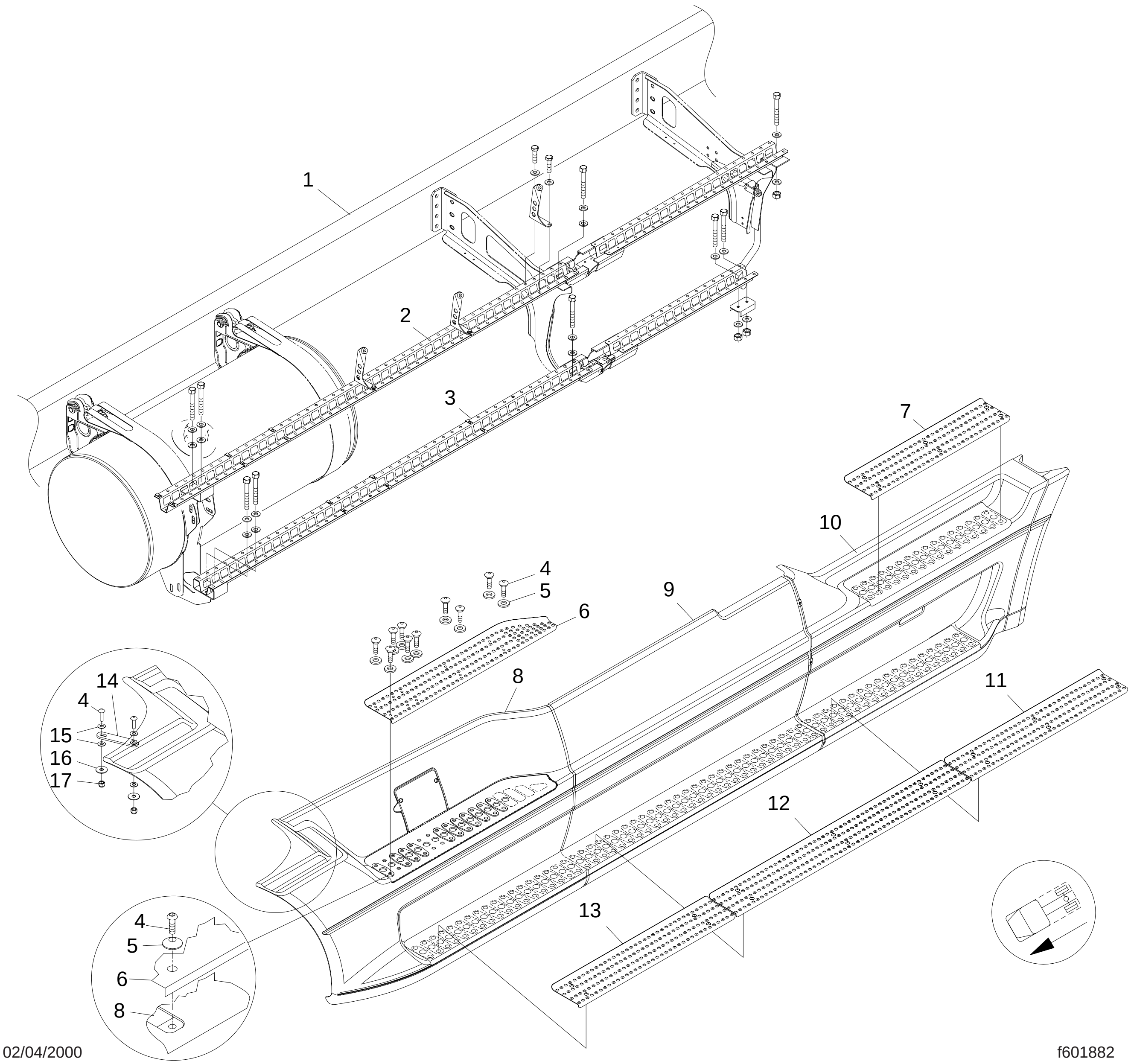
   IMPORTANT: Belleville washers are flat on the bottom, and convex (curved) on the top. Make sure they are installed correctly.

   1.2 Using Torx-head screws and Belleville washers, install the upper and lower tread plates on the forward panel steps. See **Fig. 1**.
   1.3 Hand-tighten the screws; keep them loose enough to adjust the panel.
2. Check the gap between of the upper edge of the forward panel and the lower edge of the hood. It should be 1-3/16 inches (30 mm). The edges of the panel and hood should be parallel. See **Fig. 2**.

   If necessary, adjust the position of the forward panel by loosening the brackets holding the forward ends of the upper and lower support rails to the fuel tank brackets. Move the forward ends of the support rails up or down as needed.
3. Using the procedure in the previous step, install the center panel.

   Make sure the plastic clips on the forward edge of the panel are underneath the rear edge of the forward panel, and that the plastic tabs on the back surface of the panel hook onto the edges of the upper support rail.
4. Install the rear panel.

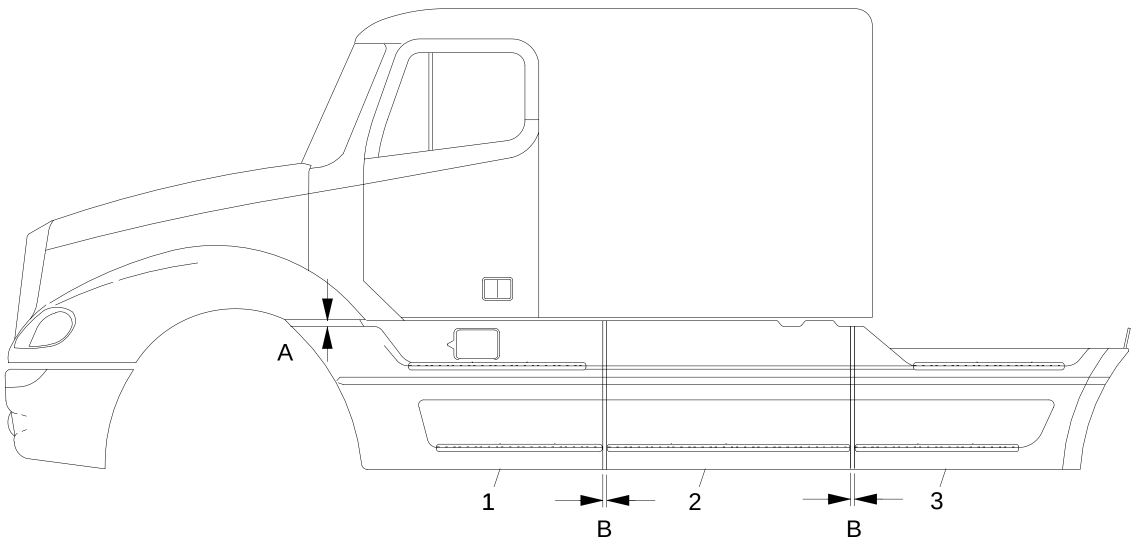
Panel Removal and Installation



NOTE: Install the Torx-head screws only where black clip nuts are located in the side-fairing panels.

1. Frame Rail
2. Upper Support Rail
3. Lower Support Rail
4. Screw, Torx-Head, 5/16–18
5. Washer, Belleville, .94 x .32 x .070 in
6. Forward Tread Plate
7. Rear Tread Plate
8. Forward Fairing Panel
9. Center Fairing Panel
10. Rear Fairing Panel
11. Rear Tread Plate, Lower
12. Center Tread Plate, Lower
13. Forward Tread Plate, Lower
14. Isolator Strap
15. Washer, Flat, 11/32 x 7/8 in
16. Washer, Plated, 5/16 x 1-1/4 in
17. Locknut, 5/16–18

Fig. 1, Side Fairing Installation (left side view)



A. These edges should be parallel and 1-3/16 in (30 mm) apart.
B. 1/2 inch (12 mm)
1. Forward Panel
2. Center Panel
3. Rear Panel

Fig. 2, Fairing Panel Alignment

5. Check the vertical gaps between the panels. They should be 1/2-inch (13-mm) wide. See **Fig. 2**. Move the panels forward or backward as needed.
6. Install two 5/16–18 Torx-head screws, washers, locknuts, and the isolator strap on the upper forward corner of the forward fairing panel. See **Fig. 1**.
7. Tighten all the Torx-head screws 16 lbf·ft (22 N·m).
8. Remove the chocks from the tires.

Support Rail Removal and Installation

Removal

This procedure includes removal of forward and rear support rails. Not all vehicles have a rear fairing section. Follow the applicable steps for the vehicle on which you are working.

On vehicles equipped with rear side fairings, the rear support rail assembly may be latched for easy removal as a unit without removing the fairing panel.

1. On vehicles with latched rear side fairings, remove the rear upper and lower support rails and fairing panel as a unit.
   1.1 Unlatch and remove the deck plate between the frame rail and upper edge of the rear fairing panel.
   1.2 Remove the retainer pins from the studs on two latch assemblies: one on the rear support bracket and the second at the joint between the forward and rear lower support rails. See **Fig. 1**.
   1.3 Unhook the two latches by bending the rubber latch in half and lifting it off the latch hook.
   1.4 Holding the panel and support rail assembly by the aft edge and the handhold in the center of the panel, pivot the aft end of the unit away from the vehicle (like opening a door) until the unit can be lifted from the vehicle.
   1.5 Repeat the removal procedure on the other side of the vehicle, if applicable.

NOTE: The remaining side-fairing panels must be removed before their support rails can be removed. This includes the right rear fairing panel on vehicles without latches on the right side.

2. Remove the remaining side-fairing panels from the vehicle. See **Subject 100** for instructions.
3. On vehicles with bolted right rear support rails (no latches), remove the rear support rails.
   3.1 Remove the fasteners from one end of the connecting bracket between the upper support rails.
   - Remove one 3/8–16 hexnut, bolt, and two washers from the base of the bracket.
   - Remove four 5/16–18 capscrews and washers from the upper flanges on the bracket.

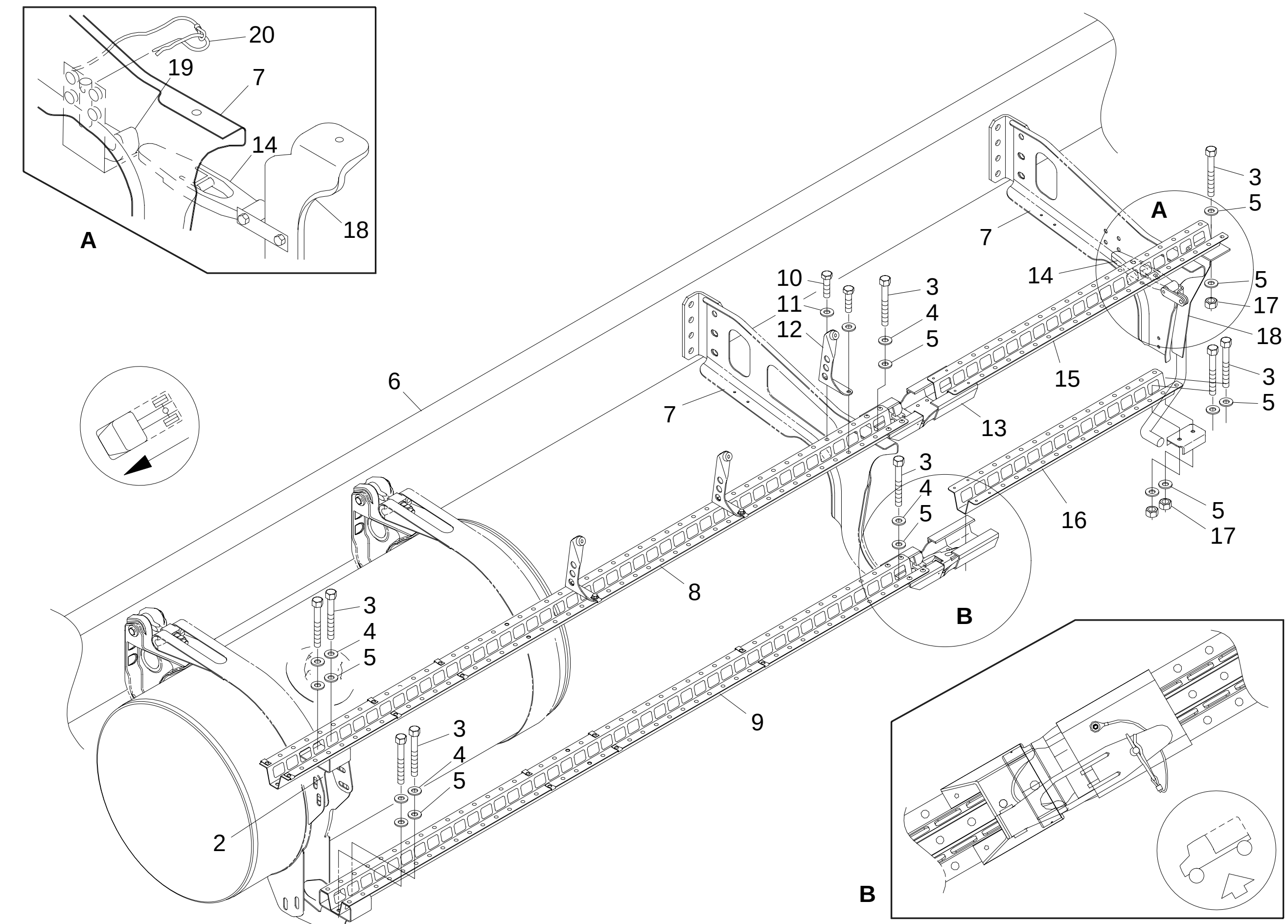
   3.2 Remove the 3/8–16 capscrew, lockwasher, and washer that hold the rear support rail on the rear support bracket.
   3.3 Slide the rear support rail out of the connecting bracket and remove the rail.
   3.4 Repeat the previous substeps to remove the lower support rail.
4. Remove the remaining support rails from the vehicle.
   4.1 Remove three 3/8–16 capscrews, lockwashers, and washers that hold the forward upper support rail on the upper U-bracket and center support bracket. See **Fig. 1**. Remove the rail.
   4.2 Remove the fasteners from the lower support rail. Remove the rail.
   4.3 Repeat the previous substeps to remove the forward support rails on the other side of the vehicle.

Installation

1. Install the forward support rails. See **Fig. 1**.
   1.1 Put the upper support rail in place on the upper U-bracket and center support bracket.
   1.2 Install three 3/8–16 capscrews, lockwashers, and washers on the upper support rail. Tighten the capscrews finger-tight.
   - Use two sets of fasteners to secure the rail to the upper U-bracket.
   - Use one set of fasteners to secure the rail to the center support bracket.

   1.3 Make sure the support rail is level and parallel with the frame rail. Clamp the fairing panel in place, then check its alignment with the hood and the bottom edge of the cab.

Support Rail Removal and Installation



NOTE: Rear fairing latch assemblies are not applicable on all vehicles.

A. Upper latch assembly.
B. Lower latch assembly.

1. Lower U-Bracket
2. Upper U-Bracket
3. Capscrew, 3/8–16
4. Lockwasher, 3/8 in
5. Washer, 0.41 x 0.81 x 0.080 in
6. Frame Rail
7. Support Bracket
8. Forward Support Rail, Upper
9. Forward Support Rail, Lower
10. Capscrew, 5/16–18 x 1 in
11. Washer, 0.34 x 0.69 x 0.080 in
12. Stiffener, Support Rail
13. Connecting Bracket (no latch)
14. Latch
15. Rear Support Rail, Upper
16. Rear Support Rail, Lower
17. Locknut, 3/8 in–16
18. Latch Bracket Assembly
19. Latch Hook
20. Retainer Pin (with tether)

Fig. 1, Support Rail Installation (left side view)

If necessary, loosen the fasteners on the upper U-bracket, then move the front end of the support rail (along with the fairing panel) up or down as needed.

1.4 Tighten the U-bracket fasteners firmly, then remove the fairing panel.

1.5 Tighten the 3/8–16 capscrews on the support rail 28 lbf·ft (38 N·m).

2. Repeat the previous substeps to install and level the forward lower support rail.

3. Repeat the previous substeps to install and level the forward support rails on the other side of the vehicle.
4. Install any rear support rails that are bolted instead of latched.
   4.1 Slide the forward end of the upper support rail into the connecting bracket on the forward support rail.
   4.2 Align the bolt holes in the rear support rail with those in the connecting bracket flanges. Install four 5/16–18 capscrews and washers, and tighten the capscrews 16 lbf·ft (22 N·m).
   4.3 Insert a 3/8–16 bolt and washer through the base of the connecting bracket and the rear frame rail. Install a washer and 3/8–16 hexnut on the bolt and tighten the hexnut 28 lbf·ft (38 N·m).
   4.4 Insert a 3/8–16 bolt and washer through the aft end of the support rail and rear support bracket. Insert a washer and hexnut on the bolt. Tighten the hexnut 28 lbf·ft (38 N·m).
   4.5 Repeat the procedure to install the lower support rail.
5. Install all latched rear support rail assemblies.
   5.1 If it was removed, install the latch bracket assembly on the rear support bracket. See **Fig. 1**.
   5.2 Install the latches if they were removed.
   5.3 Hold the rear fairing panel/support rail assembly by the edges at about a 45-degree angle to the vehicle.
   5.4 Slide the ears on the ends of the rear support rails into the ends of the forward support rails.
   5.5 Pivot the assembly into place against the vehicle.
   5.6 Hook the upper latch on the rear support bracket, then install the retainer pins in the stud.
   5.7 Hook the lower latch on the connecting bracket between the lower forward and rear support rails. Install the retainer pin in the stud.
   5.8 Place the deck plate in position above the rear fairing panel and secure the latch.
6. Install the remaining side-fairing panels. See **Subject 100** for instructions.

General Description

Fontaine 5000/6000 series fifth wheels are used for pulling trailers having a standard kingpin. When installed as a stationary fifth wheel, it is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. When used as a sliding fifth wheel, it is mounted on the Fontaine 5AWS or 5MWS model sliding mount. See **Fig. 1**.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and a sliding wedge. The kingpin is released by activating a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin lockup occurs when the kingpin is forced into the jaws and the lock control handle moves to the locked position.

The wedge reinforces the jaw and takes up slack around the kingpin.

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin. This action unlocks the fifth wheel, allowing freedom of movement underneath the trailer when the tractor is moved.

Refer to Chapter 10 in the *Columbia Driver's Manual* for complete fifth-wheel operating instructions.

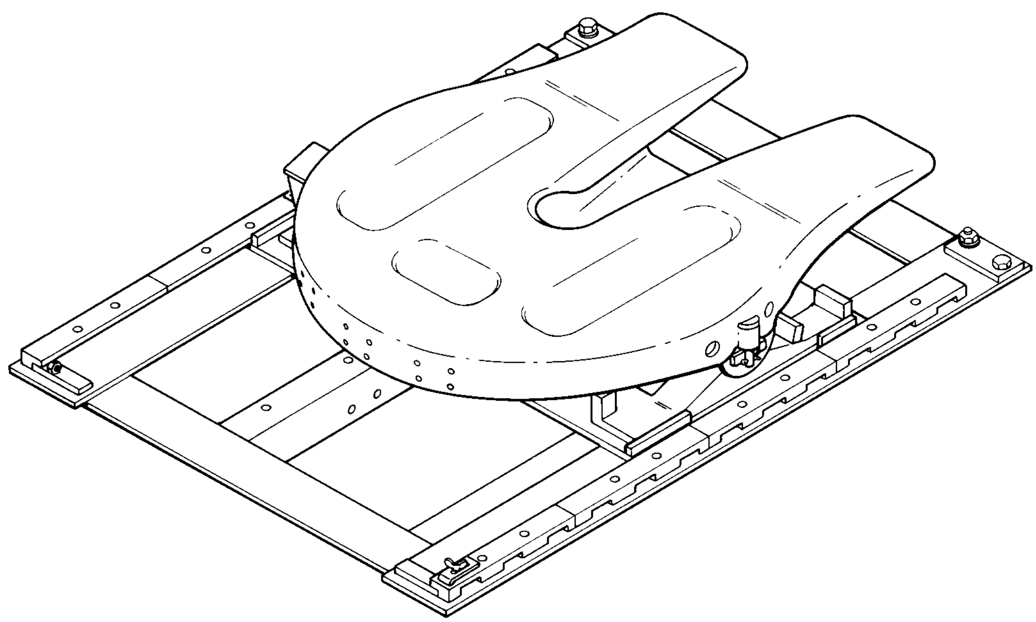


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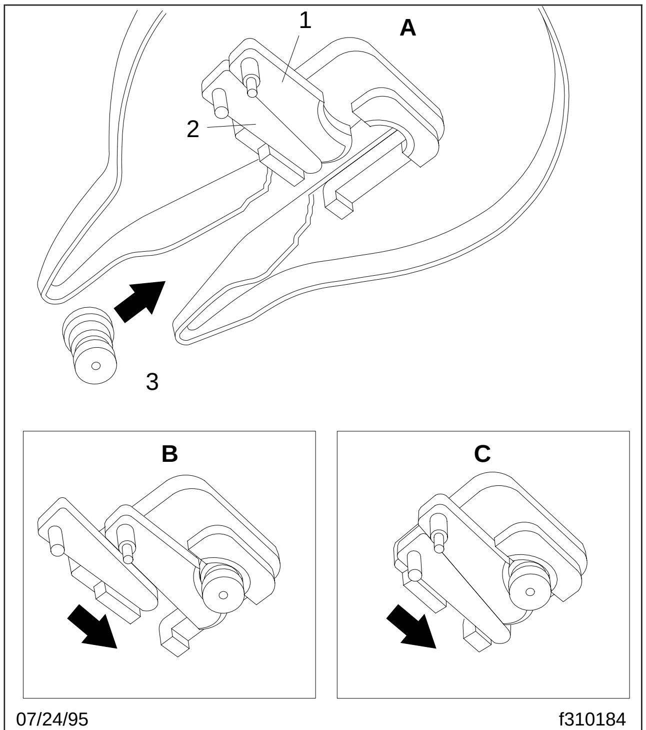
Fig. 1, Fontaine 5000/6000 Series Fifth Wheel and Sliding Mount

Principles of Operation

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. See **Fig. 2**. Then, the jaw moves behind the kingpin, followed by the wedge.

General Information



A. Unlocked Position
B. Locking
C. Locked
1. Jaw
2. Wedge
3. Trailer Kingpin

Fig. 2, Fontaine Kingpin Lock Mechanism

Removal and Disassembly

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of the trailer connection, which could cause personal injury and property damage.

WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so could result in personal injury due to parts ejecting with force.

1. Steam clean the fifth wheel. See **Fig. 1**.
2. Remove the fifth wheel from the sliding mount.
   - 2.1 Remove the cotter pins from the retaining pins.
   - 2.2 Remove the retaining pins and bushing pins from both sides of the top plate.
   - 2.3 Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
   - 2.4 Place the fifth wheel upside down on a clean flat surface.

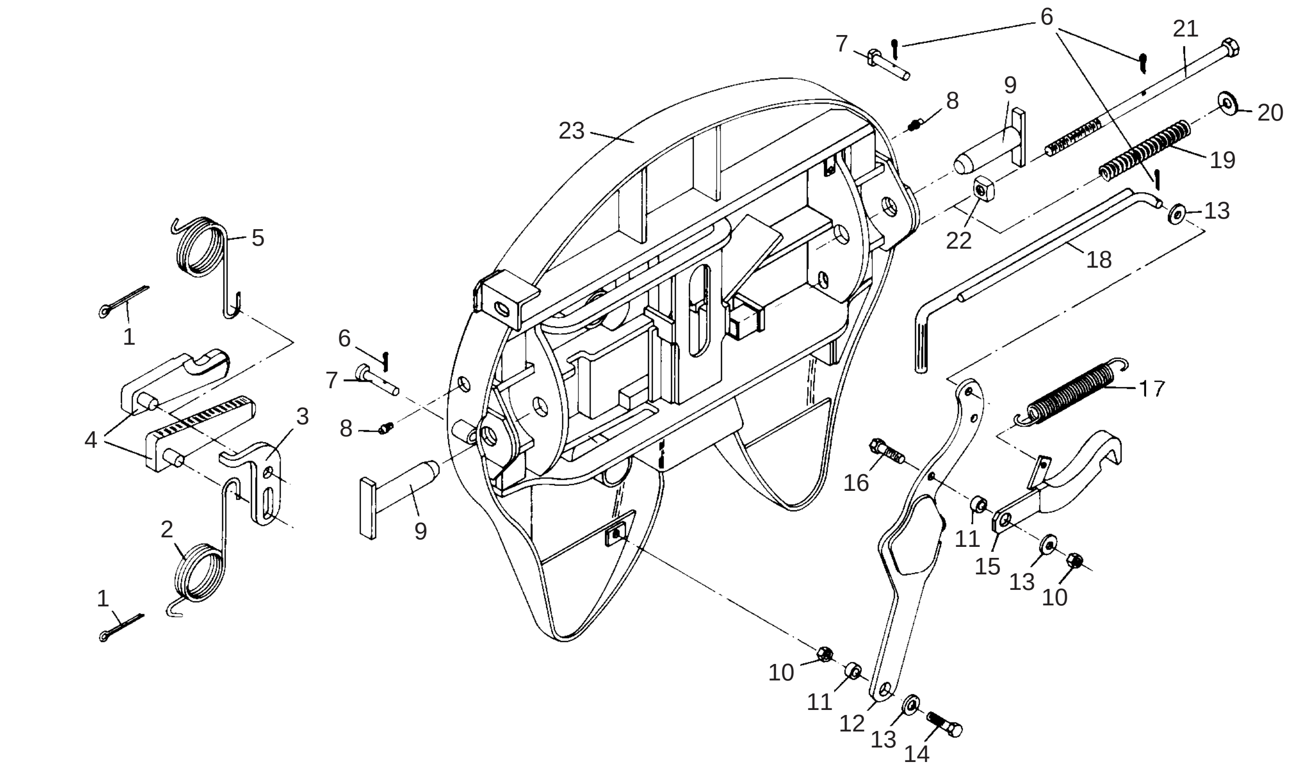
NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, which could cause personal injury and property damage.

3. Unhook the bumper spring from its clasp. See **Fig. 2**.
4. Remove the two 1/2–13 bolts from the operating handle. See **Fig. 3**.
5. Remove the bumper. See **Fig. 4**.
6. Remove the cotter pin and flatwasher that attach the release handle to the operating handle. Slide the release handle out through the side of the top plate. See **Fig. 5**.
7. Slide the operating handle over to the side of the top plate to expose the timer. See **Fig. 6**. Slide the bottom part of the operating handle first. This allows the handle to clear the studs under the handle.
8. Lift the timer off the studs. See **Fig. 7**.
9. Slide the operating handle out through the slot at the top or bottom of the fifth wheel. See **Fig. 8**.
10. Using pliers or a screwdriver, pry the jaw and wedge springs off the studs. See **Fig. 9**.
11. Remove the jaw and wedge. See **Fig. 10**.
12. Remove the jaw and wedge springs.
    - 12.1 Remove the cotter pin from each spring. See **Fig. 11**.
    - 12.2 Using a screwdriver, pry up on the spring to relieve the tension; remove the spring. See **Fig. 12**. Repeat the procedure to remove the second spring.

Removal and Disassembly



07/24/95 f310349

1. Cotter Pin, 3 inch
2. Wedge Spring
3. Timer
4. Jaw and Wedge
5. Jaw Spring
6. Cotter Pin, 1 inch
7. Retaining Pin
8. Grease Fitting
9. Bushing Pin
10. Locknut, 1/2–13
11. Pivot Bushing
12. Operating Handle
13. Flatwasher, 1/2 inch
14. Bolt, 1/2–13 x 2
15. Bumper
16. Bolt, 1/2–13 x 1-1/2
17. Bumper Spring
18. Release Handle
19. Wedge Stoprod Spring
20. Flatwasher, 5/8 inch
21. Wedge Stoprod
22. Nut, Square, 5/8–11
23. Fifth Wheel Top Plate

Fig. 1, Fontaine 5000/6000 Series Fifth Wheel (right-side release shown)

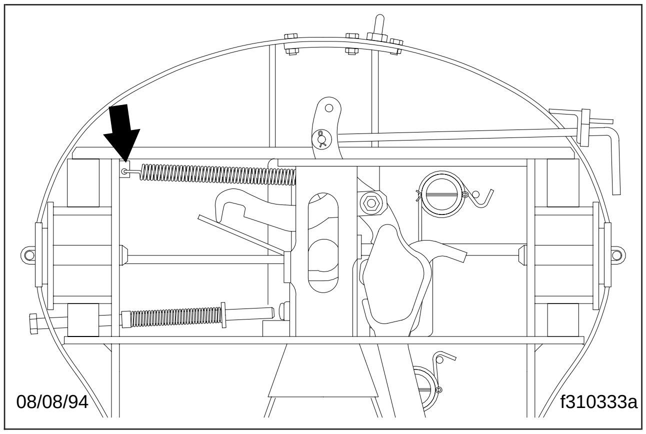


Fig. 2, Bumper Spring Removal

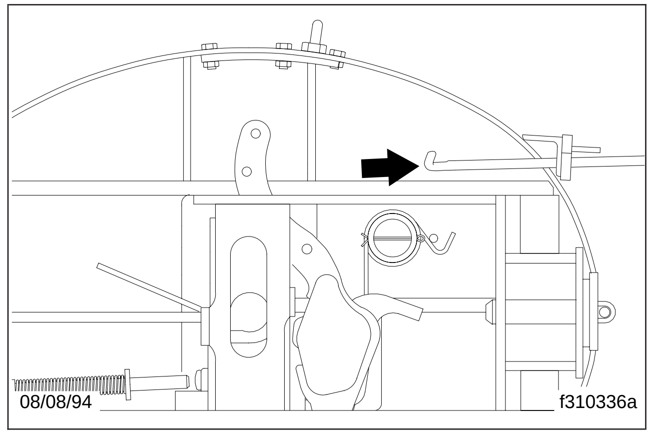


Fig. 5, Release Handle Removal

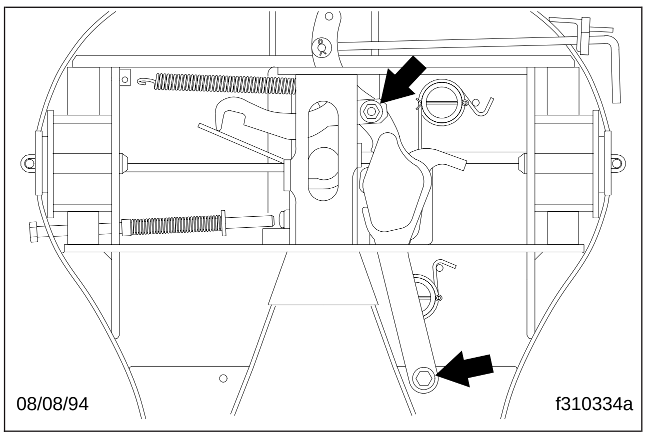


Fig. 3, Handle Bolt Removal

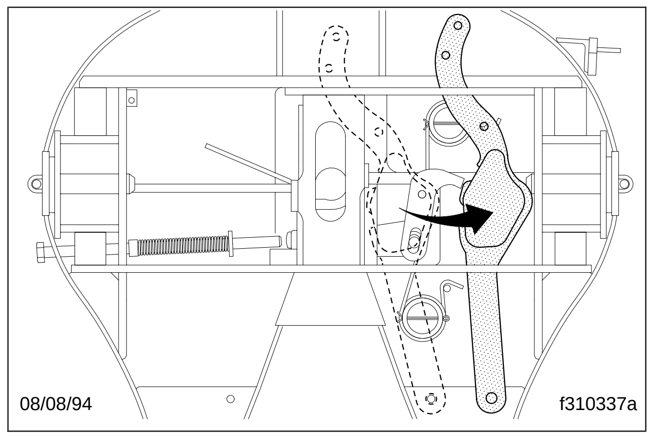


Fig. 6, Operating Handle Positioning

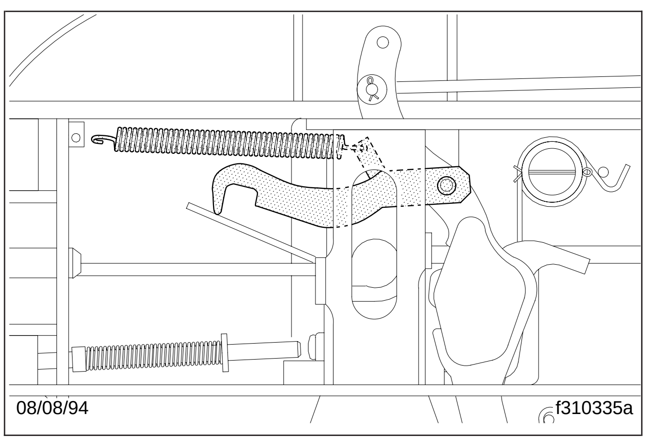


Fig. 4, Bumper Removal

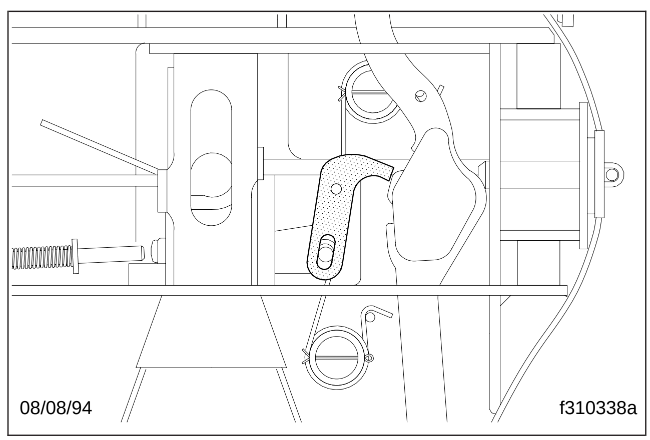


Fig. 7, Timer Removal

Removal and Disassembly

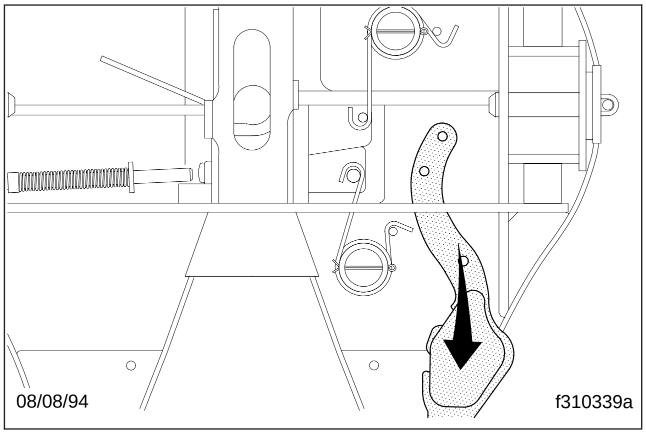


Fig. 8, Operating Handle Removal

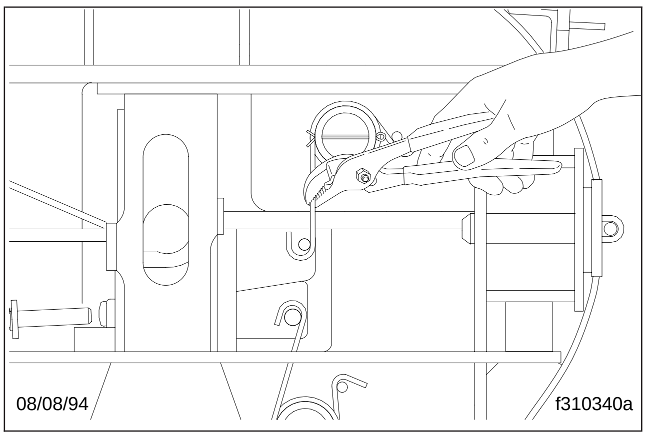


Fig. 9, Jaw- and Wedge-Spring Release

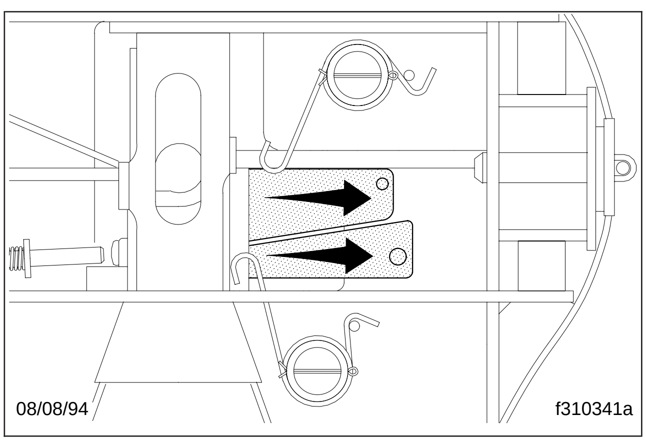


Fig. 10, Jaw and Wedge Removal

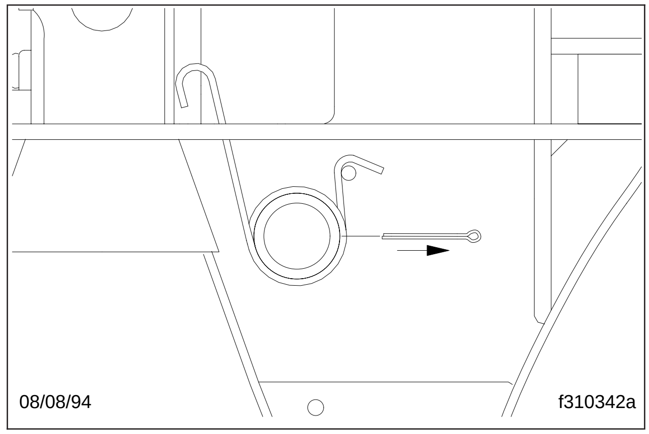


Fig. 11, Cotter Pin Removal

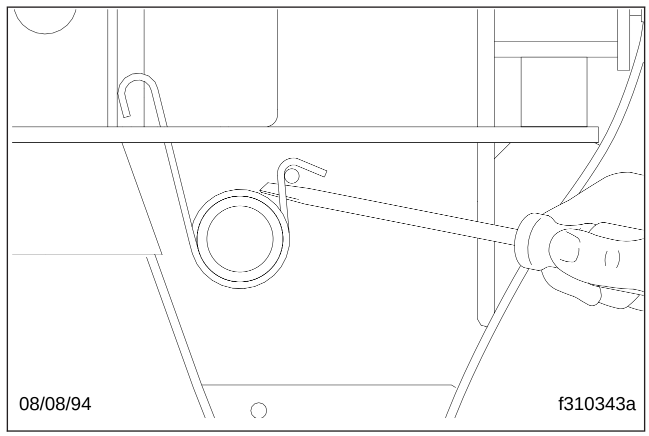


Fig. 12, Spring Removal

Assembly and Installation

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of the trailer connection, which could cause personal injury and property damage.

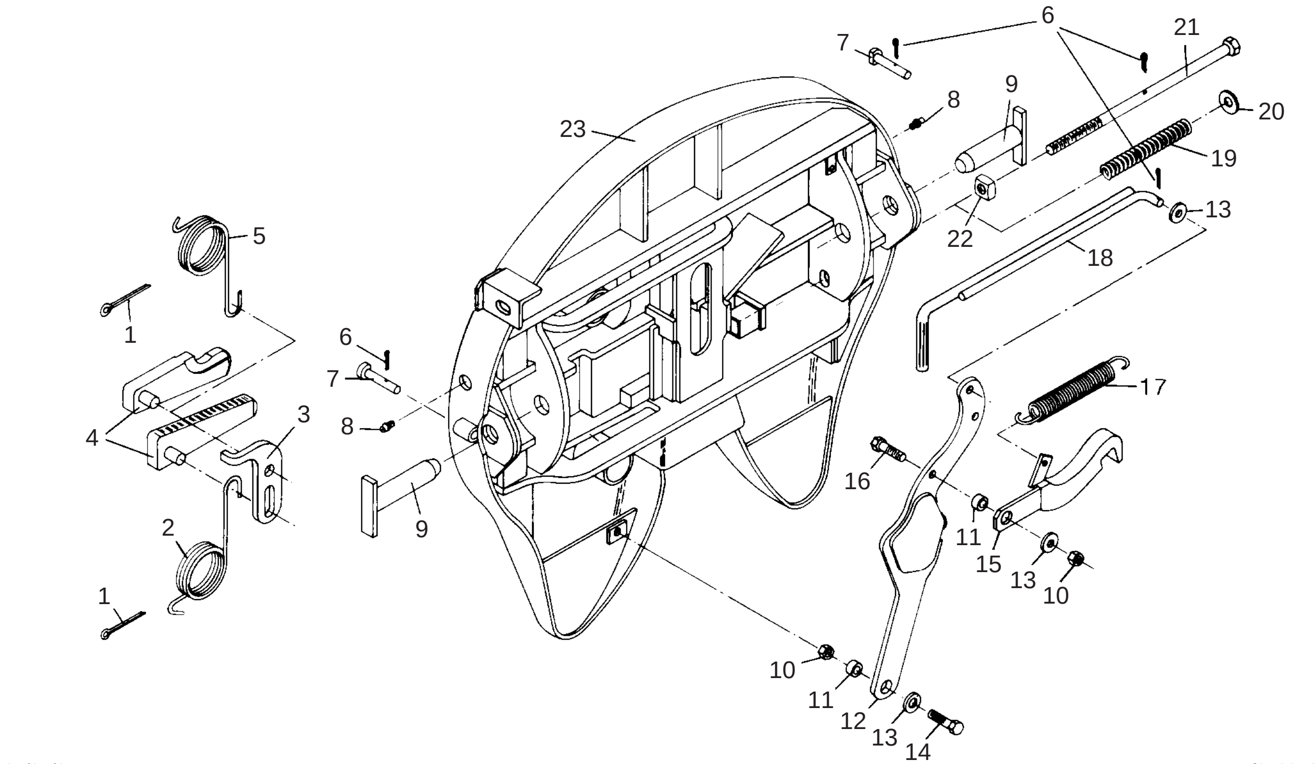
IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration. See **Fig. 1**.

WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so could result in personal injury, due to parts ejecting with force.

NOTE: Order Spring Tool 710 from the following:

Fontaine Fifth Wheel Company
125 Cleage Drive
Birmingham, Alabama 35217



1. Cotter Pin, 3 inch
2. Wedge Spring
3. Timer
4. Jaw and Wedge
5. Jaw Spring
6. Cotter Pin, 1 inch
7. Retaining Pin
8. Grease Fitting
9. Bushing Pin
10. Locknut, 1/2–13
11. Pivot Bushing
12. Operating Handle
13. Flatwasher, 1/2 inch
14. Bolt, 1/2–13 x 2
15. Bumper
16. Bolt, 1/2–13 x 1-1/2
17. Bumper Spring
18. Release Handle
19. Wedge Stoprod Spring
20. Flatwasher, 5/8 inch
21. Wedge Stoprod
22. Nut, Square, 5/8–11
23. Fifth Wheel Top Plate

Fig. 1, Fontaine 5000/6000 Series Fifth Wheel (right-side release shown)

Assembly and Installation

WARNING

When cleaning parts with no. 2 diesel fuel, do not smoke or use an open flame near the area. To do so could result in a fire, which could cause personal injury and property damage.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Insert the wedge spring through the slot in the top plate and place the spring coil on the spring bracket. See **Fig. 2**.

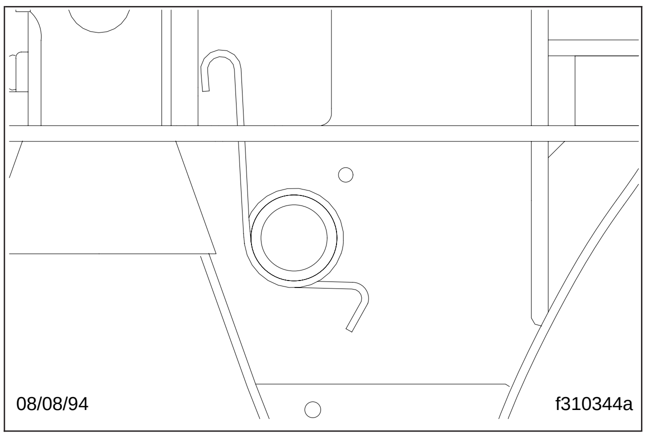


Fig. 2, Wedge Spring Installation

3. Insert spring tool 710 into the spring bracket. See **Fig. 3**. Engage the small hooked tail and wind it around until it is directly over the small stud at the back of the bracket.

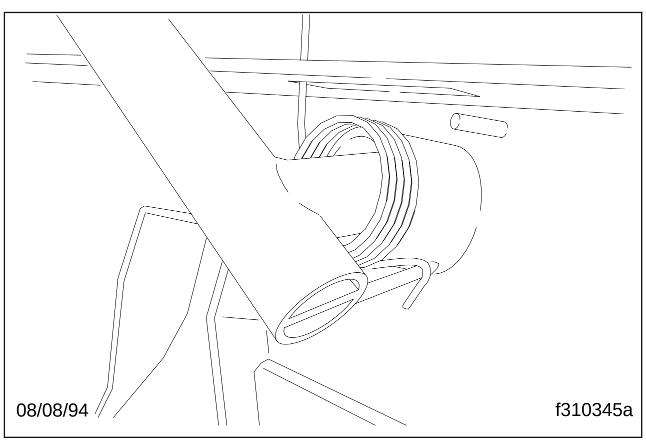


Fig. 3, Spring Winding

4. Using a hammer, tap down on the spring until it catches on the stud. Install the cotter pin. See **Fig. 4**.

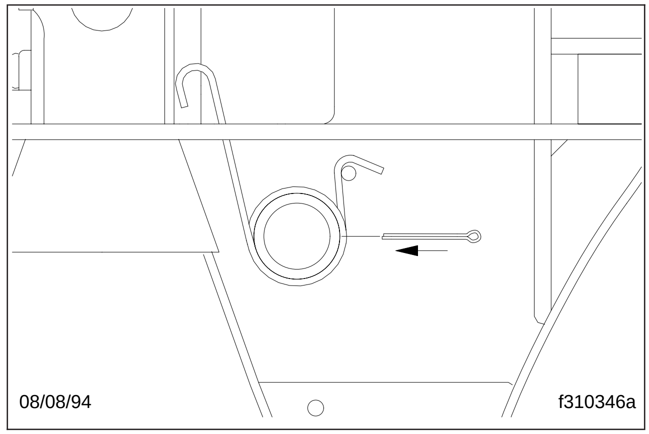


Fig. 4, Cotter Pin Installation

5. Install the jaw spring by hand; it has very little tension.
6. Install the jaw and wedge.
   - 6.1 Apply a moderate amount of a multipurpose chassis grease to the sides and serrated edges of the jaw and wedge, and the stationary jaw in the throat of the fifth wheel. See **Fig. 1**.
   - 6.2 Temporarily place a 2-inch-diameter shaft where the kingpin will engage in the fifth wheel.
   - 6.3 Place the jaw and wedge between the two springs.
   - 6.4 Using pliers or a screwdriver, pry the jaw and wedge springs over the studs on the jaw and wedge, respectively. See **Fig. 5**.
7. Insert the operating handle and move it to the side of the top plate, leaving the jaw and wedge exposed. Apply a moderate amount of multipurpose chassis grease to the grooved middle section of the operating handle.
8. Install the timer over the studs on the jaw and wedge. The small hole on the timer fits over the jaw (top) stud. Make sure the small bent arm of the timer is facing down. See **Fig. 6**.
9. Slide the operating handle (top part first) over the jaw and wedge. Make sure the handle is in a

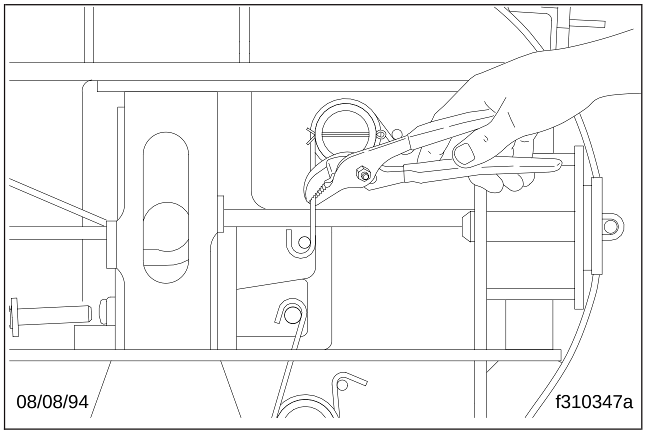


Fig. 5, Jaw and Wedge Installation

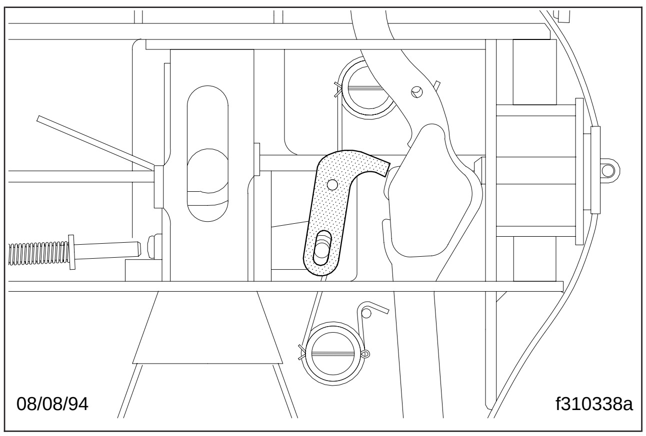


Fig. 6, Timer Installation

north/south position once it is placed over the studs. See **Fig. 7**.

10. Slide the release handle in through the safety lock. Using a flatwasher and cotter pin, attach the release handle to the second hole from the top on the operating handle.

11. Position the bumper, then attach it to the operating handle with a new 1/2–13 x 1-1/2 inch bolt, bushing, washer, and locknut. See **Fig. 8**.

12. On the other end of the operating handle, install a new 1/2–13 x 2-inch bolt, washer, bushing, and locknut.

13. Apply multipurpose chassis grease to the operating handle, and to other fifth wheel parts that may come into contact with the handle during operation.

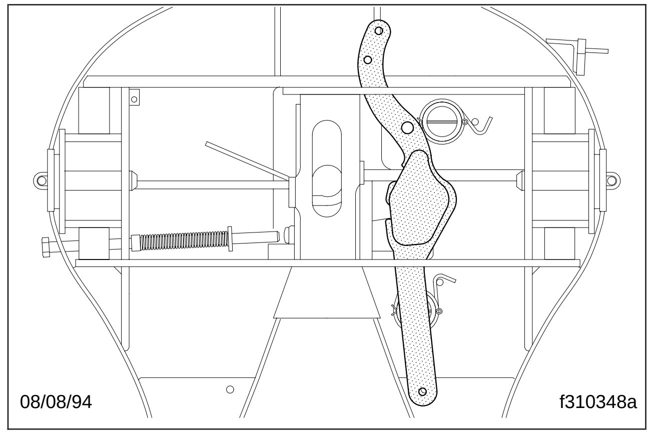


Fig. 7, Operating Handle Placement

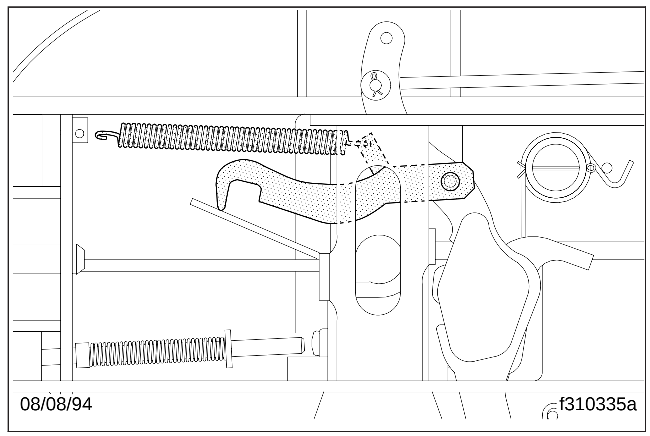


Fig. 8, Bumper Installation

14. Connect the bumper spring. See **Fig. 9**.

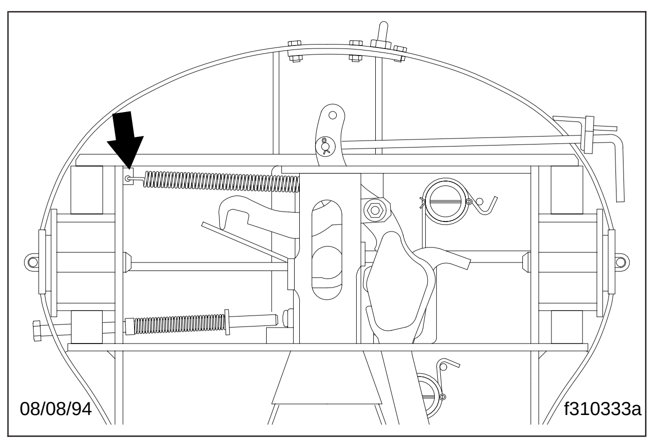


Fig. 9, Bumper Spring Installation

Assembly and Installation

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to Group 31 in the *Columbia Maintenance Manual* for complete maintenance and lubrication instructions of the fifth wheel assembly.

15. Using multipurpose chassis grease, grease the top plate and the grease (zerk) fittings on the side of the fifth wheel.

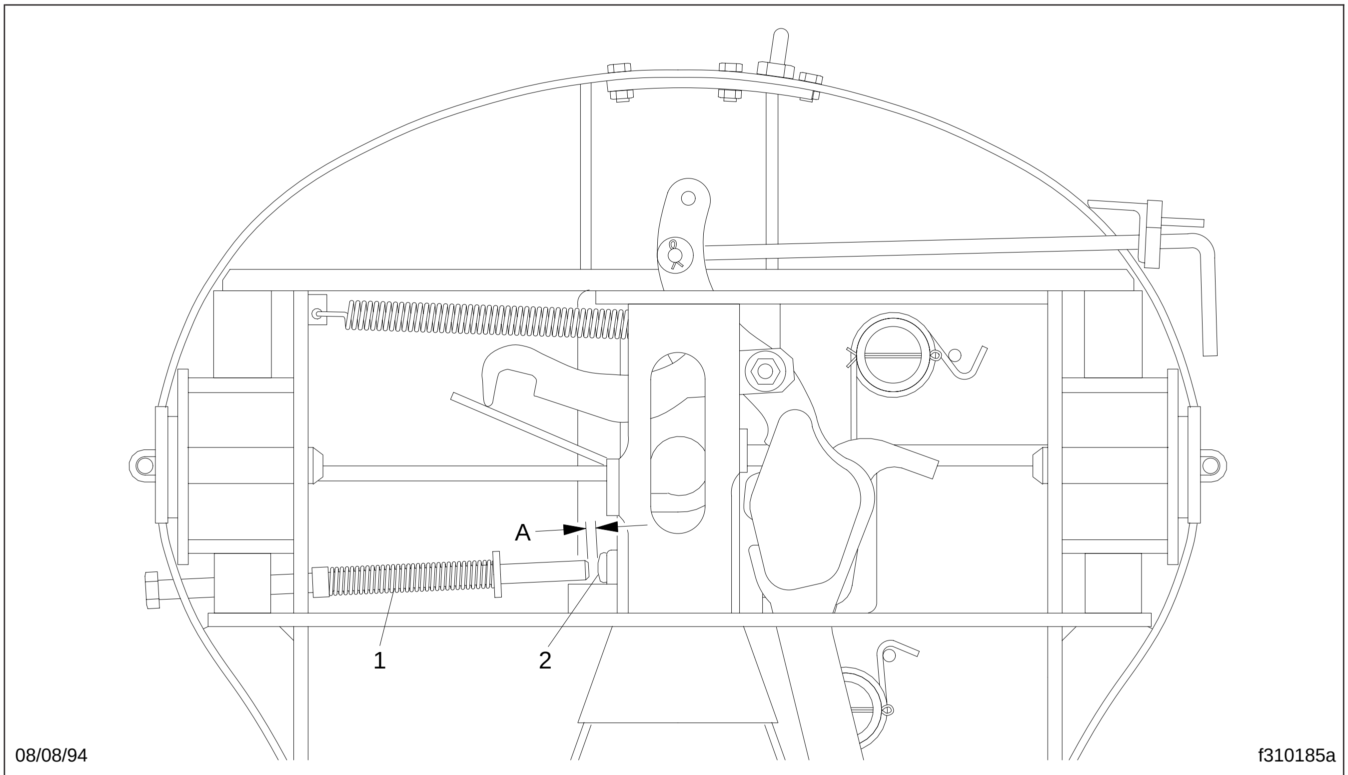
    On heavy-duty oscillating fifth wheels, grease the top of the rocker bearing bushing.

16. Measure the distance from the wedge to the end of the wedge stoprod. See **Fig. 10**. The correct measurement should be 3/8 inch (10 mm). If the measurement is more than 3/8 inch (10 mm), turn the wedge stoprod clockwise; if the measurement is less than 3/8 inch (10 mm), turn it counterclockwise.

17. Using an overhead hoist, place the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch cotter pins.

WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction due to possible disengagement of the trailer from the tractor, which could cause personal injury or property damage.



A. Measurement should be 3/8 inch (10 mm) between stoprod and wedge.
1. Stoprod
2. Wedge

Fig. 10, Stoprod-to-Wedge Gap Measurement

Troubleshooting Tables

Problem—Fifth Wheel Is Hard to Hook Up to Trailer

Problem—Fifth Wheel Is Hard to Hook Up to Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the locks correctly.	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
Bent kingpin, or damaged trailer plate is interfering with the lock movement.	Check the kingpin and trailer plate. Replace parts as needed.

Problem—Fifth Wheel Is Hard to Unhook from Trailer

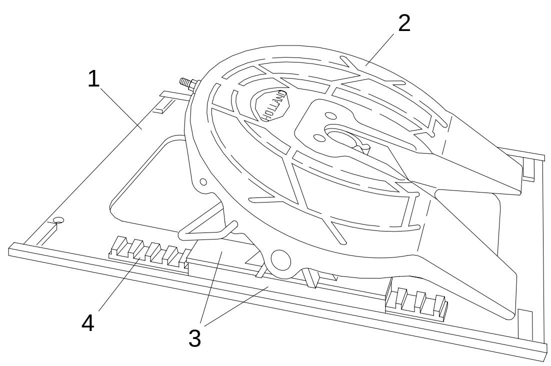
Problem—Fifth Wheel Is Hard to Unhook from Trailer	
Possible Cause	**Remedy**
The tractor is putting pressure against the locks.	Back the tractor into the trailer; set the tractor brakes. Strike the wedge stop rod to release pressure.
Too much slack in the fifth-wheel locks.	Check that the wedge stop rod is 3/8 inch (10 mm) from the end of the wedge. Adjust as needed.
	Check the kingpin diameter; it should not be worn more than 3/8 inch (10 mm). Replace if needed.
	Check the jaw and wedge for excessive wear. Replace if needed.

General Information

The Holland sliding fifth wheel mount is designed to provide maximum tractor use for different lengths and types of trailers. The FW8, FW33, and FW35 series sliding fifth wheel mounts are used with the Holland 3500 series fifth wheel, and are equipped with either a manually operated or an air-operated release slider.

Sliding fifth wheel assemblies are mounted on a baseplate with notched rails. See **Fig. 1**. Plungers are meshed into teeth on the baseplate to lock the fifth wheel.

This assembly allows forward or rearward movement of the fifth wheel along the notched rails for optimum weight distribution over the tractor axles. The mounting baseplate is bolted to the tractor frame.



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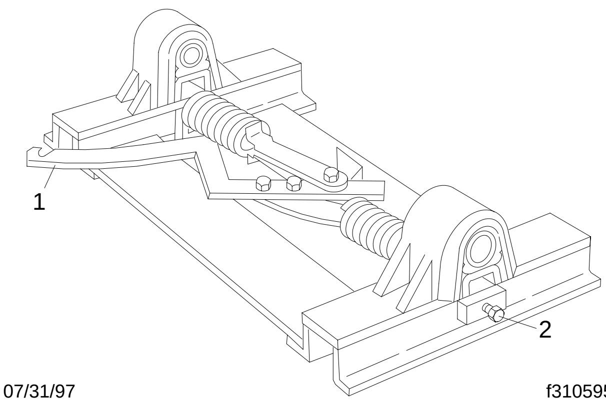
1. Baseplate
2. Fifth Wheel Top Plate (XA-3500)
3. Slide Mount
4. Baseplate Rail

Fig. 1, XA-3500 Sliding Fifth Wheel

When the fifth wheel is in the desired position, it is locked in place by wedge-shaped plungers that engage in the notched rails under the sliding mount. To release the fifth wheel, the plungers are withdrawn.

The manually operated release slider contains a release lever that unlocks or locks both sides of the sliding mount at the same time when it is manually pulled or released. See **Fig. 2**.

The air-operated release slider contains a double-ended air cylinder that locks or unlocks both sides of the sliding mount at the same time. See **Fig. 3**. The air cylinder is activated by a two-position air-control valve in the tractor cab. See **Fig. 4**.



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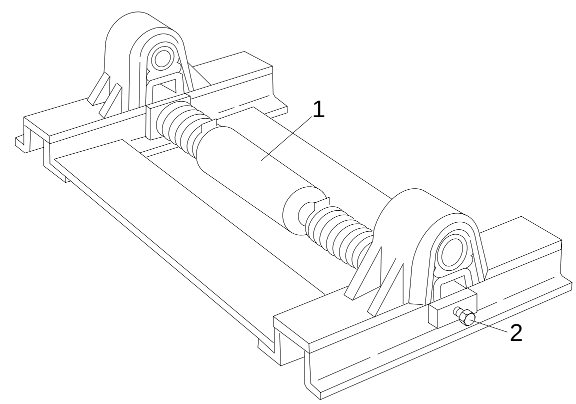
NOTE: Baseplate rails not shown.

1. Release Lever
2. Slider Plunger Release

Fig. 2, Manual Release Slider Assembly



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NOTE: Baseplate rails not shown.

1. Double-Ended Air Cylinder
2. Slider Plunger Release

Fig. 3, Air-Operated Release Slider Assembly

See Chapter 10 in the *Columbia Driver's Manual* for complete operating instructions.

General Information

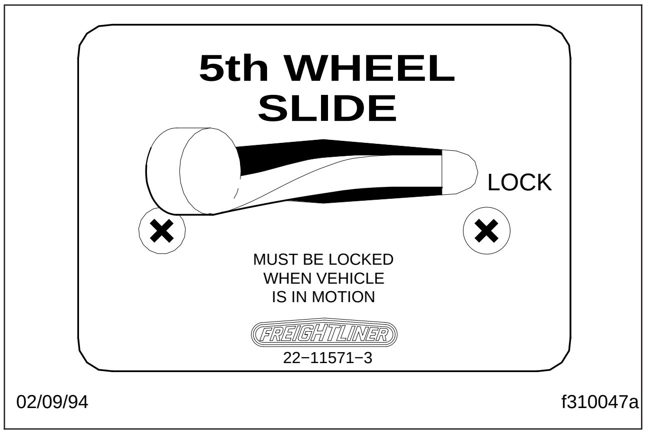


Fig. 4, Air-Control Valve in Cab

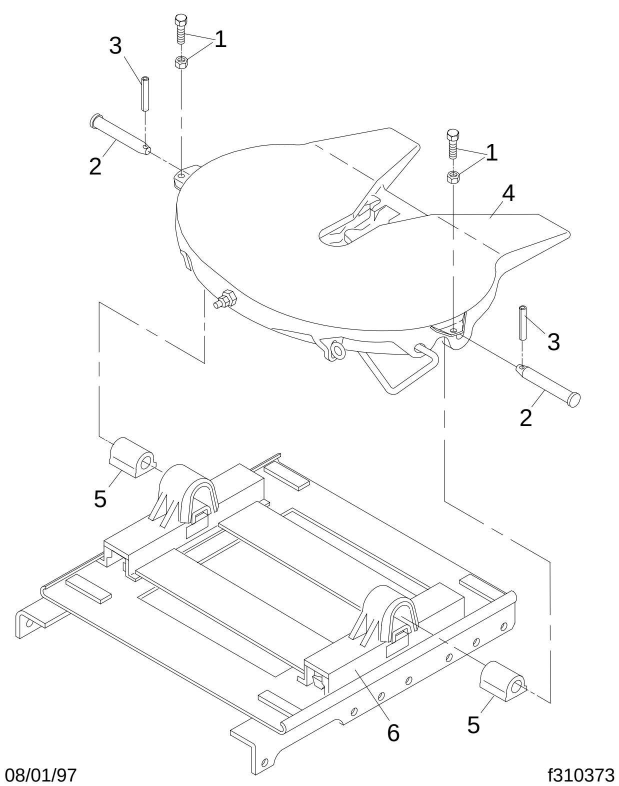
Sliding Mount Disassembly and Assembly

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of the trailer connection, which could cause personal injury and property damage.

Disassembly

1. Remove the top plate. See **Fig. 1**.



1. Bolt and Locknut (top plate XA-351 only)
2. Bushing Pin
3. Roll Pin (top plate XA-3501 only)
4. Fifth Wheel Top Plate
5. Rubber Bushing
6. Sliding Mount Assembly

Fig. 1, Sliding Mount Components

1.1 Remove the roll pins or bolts and locknuts from the bushing pins on the left and right sides of the top plate.

1.2 Remove the bushing pins.

1.3 Using an overhead hoist, lift the fifth wheel off the sliding mount assembly.

WARNING

When draining the air reservoir, do not look into the air jets, or direct them toward anyone. Dirt or sludge particles may be in the airstream, and could cause physical injury if ejected.

2. If the fifth wheel has an air-operated release sliding mount, drain the air reservoir. Disconnect and plug the air line from the air cylinder.

WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so could cause physical injury, due to parts ejecting with force.

3. Using a Holland TF-TN 2500 spring compressor (**Fig. 2**), compress one of the plunger return springs. See **Fig. 3**.

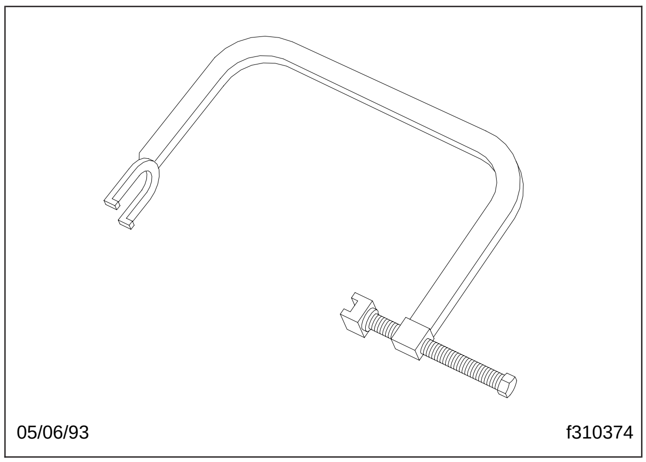
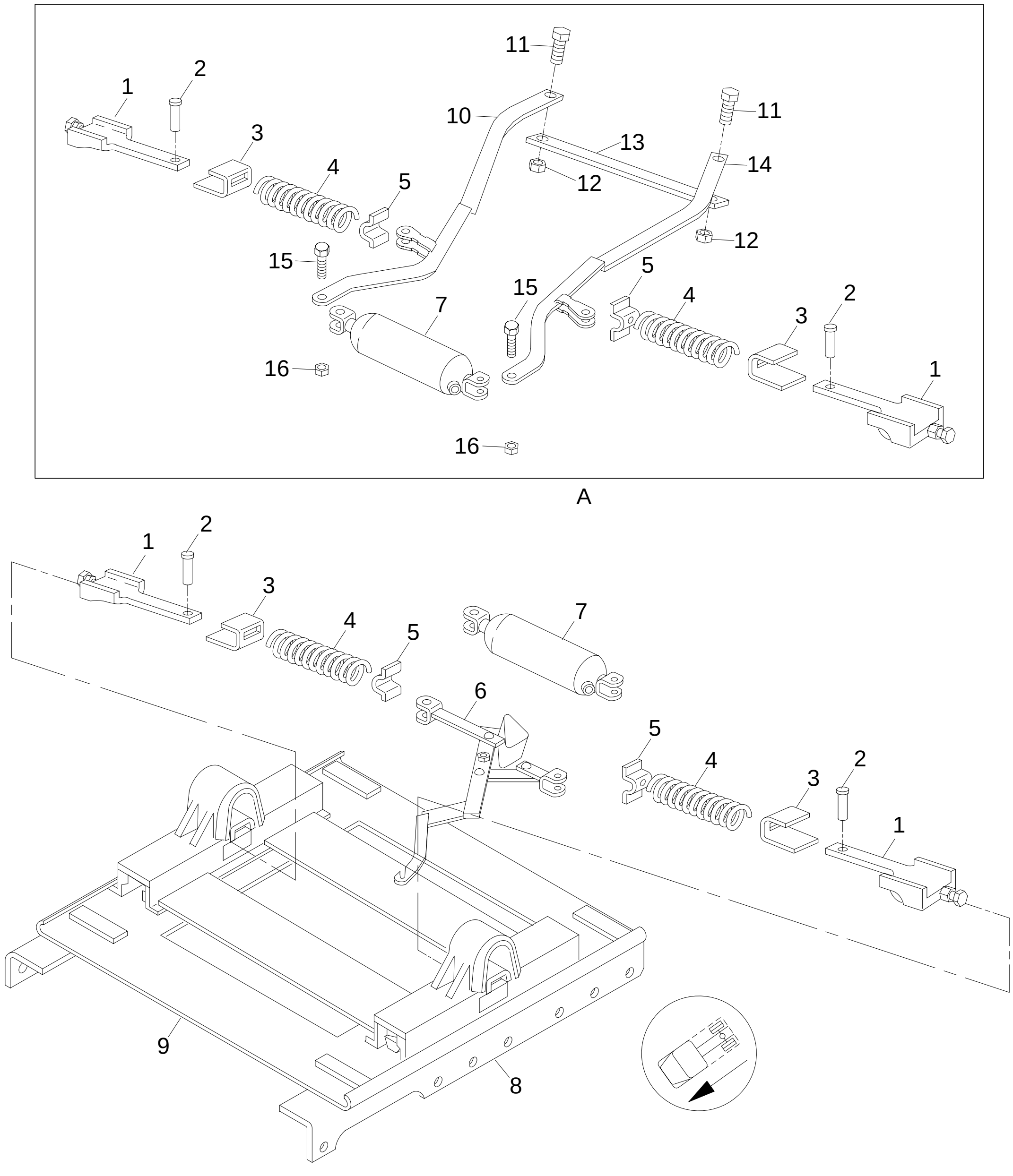


Fig. 2, Spring Compressor

4. Remove the retaining pin securing the plunger to the clevis on the air-release cylinder or manual release lever. Remove the plunger.

   If equipped with a fifth wheel height of 6-5/8 or 8-1/8 inches (168 or 206 mm), remove the re-

Sliding Mount Disassembly and Assembly



A. Spring assembly for 6-5/8 or 8-1/8 inches (168 or 206 mm) fifth wheel heights.

1. Plunger
2. Retaining Pin
3. Spring Compression Stop
4. Plunger Return Spring
5. Spring Retainer
6. Manual Release Lever
7. Air-Release Cylinder
8. Sliding Mount Assembly
9. Baseplate
10. Right Release Lever
11. Bolt, 3/8–16
12. Locknut, 3/8–16
13. Tie Bar
14. Left Release Lever
15. Bolt, 1/2–20
16. Locknut, 1/2–20

Fig. 3, Sliding Mount Spring Assemblies

Sliding Mount Disassembly and Assembly

taining pin securing the plunger to the clevis on one of the release levers, then remove the plunger.

5. Carefully remove the spring compressor. Remove the return spring, the spring compression stop, and the spring retainer.
6. Repeat the procedure to remove the second plunger.
7. Remove the air-release cylinder or the manual release lever.

   If equipped with a fifth wheel height of 6-5/8 or 8-1/8 inches (168 or 206 mm), remove the release lever assembly. See **Fig. 3**. Remove the bolts and locknuts securing the right and left release levers to the air-release cylinder or manual release lever.

WARNING

Wear protective eye and facial gear when grinding. Failure to do so could result in personal injury due to flying metal debris from the grinding.

8. If the sliding mount assembly is damaged, remove it from the baseplate.
   - 8.1 Grind the welded area on the baseplate to remove the rear stops. See **Fig. 1**.
   - 8.2 Remove the sliding mount assembly from the baseplate by sliding it off the rear of the tracks.
9. Clean the parts to remove all dirt and grease. Replace any parts that show signs of wear or damage.
10. Inspect the rubber bushings. See **Fig. 1**. If they are damaged, or if they allow movement of more than 1/8 inch (3 mm), replace them.

Assembly

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of the trailer connection, which could cause personal injury and property damage.

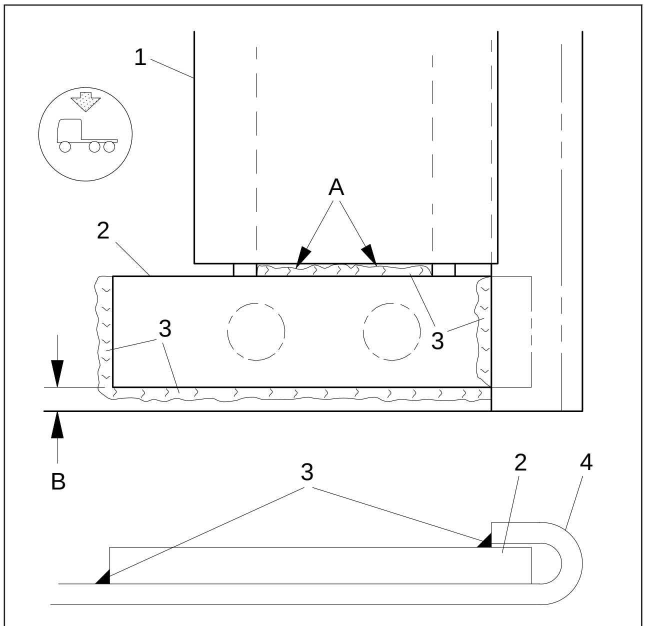
1. Using a rubber lubricant or a waterless hand cleaner, lubricate the outer surfaces of the new rubber bushings.
2. Install the rubber bushings in the sliding mount assembly until they are flush with the outboard ends of the assembly. See **Fig. 1**.
3. Using a multipurpose chassis grease, lubricate the flanges on the sliding mount assembly. Slide the assembly onto the tracks of the baseplate from the rear.
4. Move the sliding mount assembly to the rearmost position. Install the plungers in the outboard ends of the sliding mount. Engage the plungers in the rail teeth.
5. Weld the rear stops on the baseplate.
   - 5.1 Place the rear stops under the curled edge of the baseplate. See **Fig. 4**.

     Allow a clearance of about 1/8 inch (3 mm) from the rear stops to the sliding mount when it is in the full rear position.

     The stops should be about 1/4 to 1/2 inch (6 to 13 mm) from the rear edge of the baseplate.
   - 5.2 Clamp the rear stops in place, then move the sliding mount assembly forward and out of the way.
   - 5.3 Weld the stops in place with a 1/4-inch (6-mm) fillet. On the forward edge, weld only the center area. Do not weld the area where the sliding mount assembly contacts the stop.
6. Move the sliding mount assembly to the rearmost position and check for clearance. Make sure the plungers seat in the rail with all teeth engaged.
7. If equipped with a fifth wheel height of 6-5/8 or 8-1/8 inches (168 or 206 mm), and if new release levers are being installed, attach the right and left release levers to the tie bar. See **Fig. 3**. Install 3/8–16 bolts and locknuts and tighten them firmly, but make sure the parts are not binding.

   Using the 1/2–20 bolts and locknuts, attach the air-release cylinder or the manual release lever to the ends of the left and right release levers. Tighten the nuts firmly, but make sure the parts are not binding.

Sliding Mount Disassembly and Assembly



A. Weld carefully to avoid sliding mount.
B. 1/4 to 1/2 inch (6 to 13 mm)
1. Sliding Mount
2. Rear Stop
3. Weld
4. Baseplate

Fig. 4, Rear Stop Installation

8. Install the spring compression stops and the plunger return springs on the inboard ends of the plungers. Install the spring retainers.

WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

9. Using a Holland TF-TN 2500 spring compressor, compress one of the plunger return springs and its spring retainer enough to access the hole through the end of the plunger shaft.

10. If equipped with a standard fifth wheel, place the air-release cylinder or the manual release lever so that the holes in the clevis are aligned with the hole through the end of the plunger shaft. Install the retaining pin in the plunger and clevis.

    If equipped with a fifth wheel height of 6-5/8 or 8-1/8 inches (168 or 206 cm), align the holes in the clevis of one of the release levers with the hole in the end of the plunger shaft. Install the retaining pin in the plunger and clevis.

11. Carefully remove the spring compressor.

12. Repeat the procedure to install the plunger on the other side of the sliding mount assembly.

13. If the fifth wheel has an air-operated release sliding mount, connect the air lines.

    13.1 Remove the plugs from the air line.

    13.2 Connect the air line to the inlet on the air-release cylinder.

    13.3 Start the engine to build pressure in the air reservoir, then shut down the engine. Check the operation of the slide mechanism.

14. Following the procedure in **Subject 110**, adjust the plungers.

15. Install the top plate.

    15.1 Using an overhead hoist, lift the fifth wheel onto the sliding mount assembly.

    15.2 Install a bushing pin on each side of the top plate. See **Fig. 1**.

    15.3 If equipped with model XA-3501 top plate, install a roll pin in each bushing pin.

    If equipped with model XA-351 top plate, install a 1/2–20 bolt and locknut in each bushing pin. Tighten the locknuts firmly.

Sliding Mount Assembly Plunger Adjustment

Adjustment

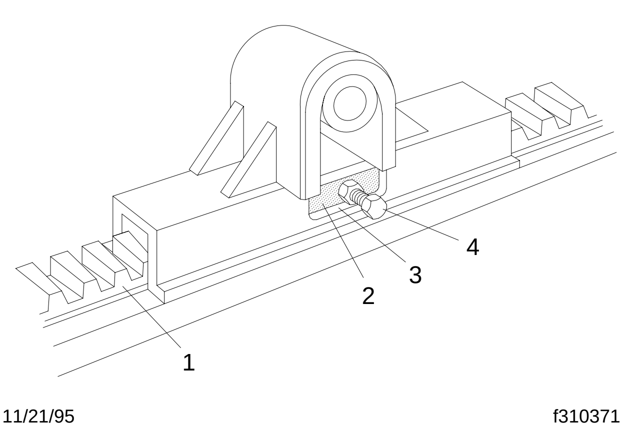
WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of the trailer connection, which could cause personal injury and property damage.

NOTE: The locking plungers are adjusted at installation and again after one month of operation. Make additional adjustments as needed.

1. The plungers should seat in the pocket with a small amount of play when locked (engaged). See **Fig. 1**. If they wedge or bind, turn the adjusting bolt clockwise or counterclockwise as needed.

   Turning the adjusting bolt clockwise moves the plunger out of the pocket; turning it counterclockwise moves the plunger further into the pocket.

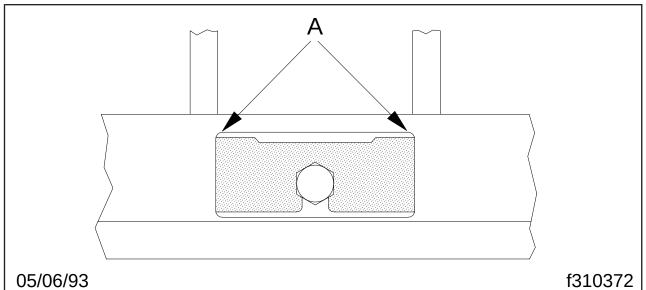


1. Rack
2. Plunger
3. Pocket
4. Plunger Adjusting Bolt

Fig. 1, Plunger Position

2. If the plungers do not unlock (release), check the air-release cylinder or the manual release lever for correct operation. Replace it if needed. See **Subject 100** for removal and installation instructions.
3. If the adjusted plunger binds on the bottom of the pocket, remove the plunger and grind the top edges 1/16 inch (2 mm). See **Fig. 2**. Install the plunger. See **Subject 100** for plunger removal and installation instructions.

   Adjust the plunger, as needed, by turning the adjusting bolt.



A. Check for interference here.

Fig. 2, Plunger Cross-Section

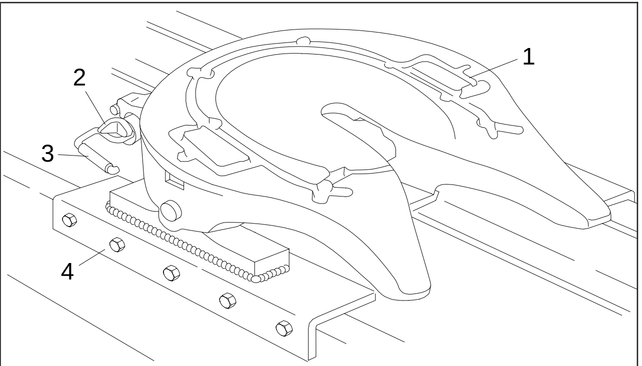
4. If the plungers are too loose, check the tension of the plunger return springs. If the springs are damaged or worn, replace them. Follow the instructions in **Subject 100**.

   If the plungers are still too loose, replace the plungers. Follow the instructions in **Subject 100**.

General Information

The ASF Simplex® series fifth wheels are used for pulling trailers having the standard 2-inch-diameter kingpin. When installed as a stationary fifth wheel, they are bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. See **Fig. 1**.

When used as a sliding fifth wheel, they are mounted on the Taperloc® sliding mount (air-operated or manual release). See **Fig. 2**.



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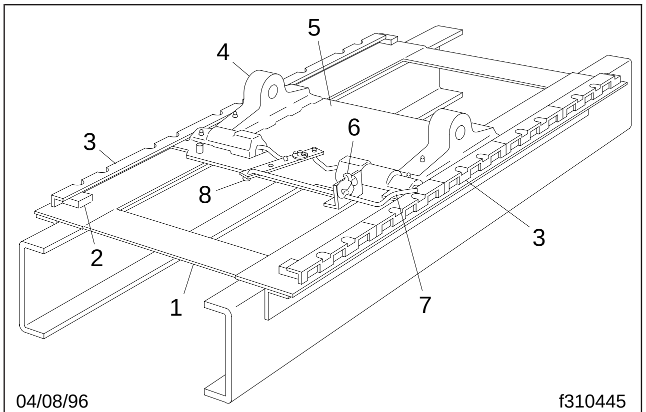
1. Lubricant Grooves
2. Safety Latch
3. Lock Control Handle
4. Mount

Fig. 1, Stationary Fifth Wheel



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1. Baseplate
2. Baseplate Rail
3. Fifth Wheel Bracket
4. Slider Saddle Plate
5. Sliding Mount
6. Safety Latch
7. Slider Handle and Rod Assembly
8. Operating Lever

Fig. 2, Taperloc Slider, Manually-Operated Release

The fifth wheel lock mechanism for the trailer kingpin consists of a rotating jaw that grips the trailer kingpin, and a spring-actuated lock. The jaw rotates on a jaw pin during coupling and uncoupling operations.

The kingpin is released by activating a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin lockup occurs when the kingpin is forced into the jaw and the operating rod handle moves to the locked position.

On air-operated sliding mounts, release or lockup of the slider saddle plate occurs when the air cylinder is activated by a two-position air-control valve in the tractor cab. See **Fig. 3**.

The manually-operated slider saddle plate has an operating rod that moves the operating lever to lock or unlock both sides of the saddle plate at the same time.

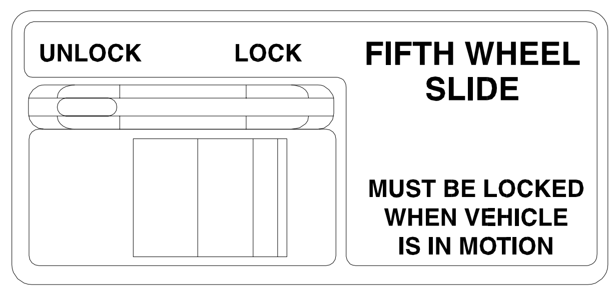

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Fig. 3, Air Control Valve in Cab

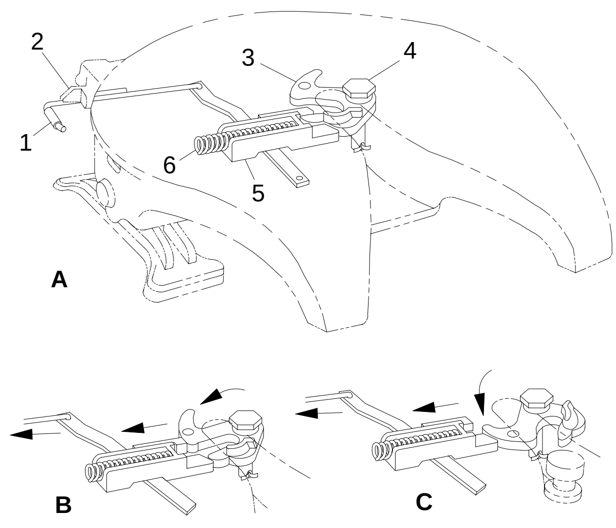
Principles of Operation

As the tractor is moved out from under the trailer, after unlocking the fifth wheel, the kingpin rotates the jaw until the jaw is in a position that allows the kingpin to disconnect. See **Fig. 4**.

During coupling, the motion of the kingpin entering the jaw rotates the jaw into the locked position, locking the jaw around the kingpin.

See Chapter 10 in the *Columbia Driver's Manual* for complete operating instructions.

General Information and Principles of Operation



A. Locked position.
B. Jaw movement compresses spring.
C. Fully open.

1. Lock Control Handle
2. Safety Latch
3. Jaw
4. Jaw Pin
5. Lock
6. Lock Spring

Fig. 4, ASF Simplex Series Kingpin Locking Mechanism

Fifth Wheel Disassembly and Assembly

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of the trailer connection, which could cause personal injury and property damage.

WARNING

Wear safety goggles during disassembly and assembly. Parts are under spring compression, and failure to wear goggles could result in personal injury, due to parts ejecting with force.

Disassembly

1. Using a bar, lock the fifth wheel.
2. Steam clean the fifth wheel.
3. Remove the fifth wheel from the sliding or stationary mount. See **Fig. 1**.
   - 3.1 Remove the clinch pins and the bracket pins. If needed, use a clamp and compress the top plate and brackets to relieve the pressure on the bracket pins.

     If cotter pins are present instead of clinch pins, discard them. Clinch pins may be reused.
   - 3.2 Using an overhead hoist, lift the fifth wheel off the mount and tractor frame.
   - 3.3 Place the fifth wheel upside down on a clean flat surface.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could cause the trailer to disconnect from the tractor, which could cause physical injury and property damage.

4. Slide the jaw away from the lock, then remove the jaw from the top plate.
5. Remove the cotter pin and the lever bar pin. Discard the cotter pin. Remove the cover plate, lever bar, lock, and lock spring.
6. Remove the cotter pin securing the lock control rod to the lever bar. Remove the lock control rod and the washer. Discard the cotter pin.
7. Check the bracket shoes and bracket rubbers for wear. For instructions, see Group 31 in the *Columbia Maintenance Manual*. If needed, remove the bracket rubbers and bracket shoes.
   - 7.1 Remove the grease fitting and drive out the bracket shoe. See **Fig. 2**.
   - 7.2 Remove the bracket rubbers.
8. With the fifth wheel in the locked position, remove the clinch pin and the jaw pin.

Assembly

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration. Brackets, bracket shoes, bracket rubbers, and bracket pins should be replaced in pairs.

WARNING

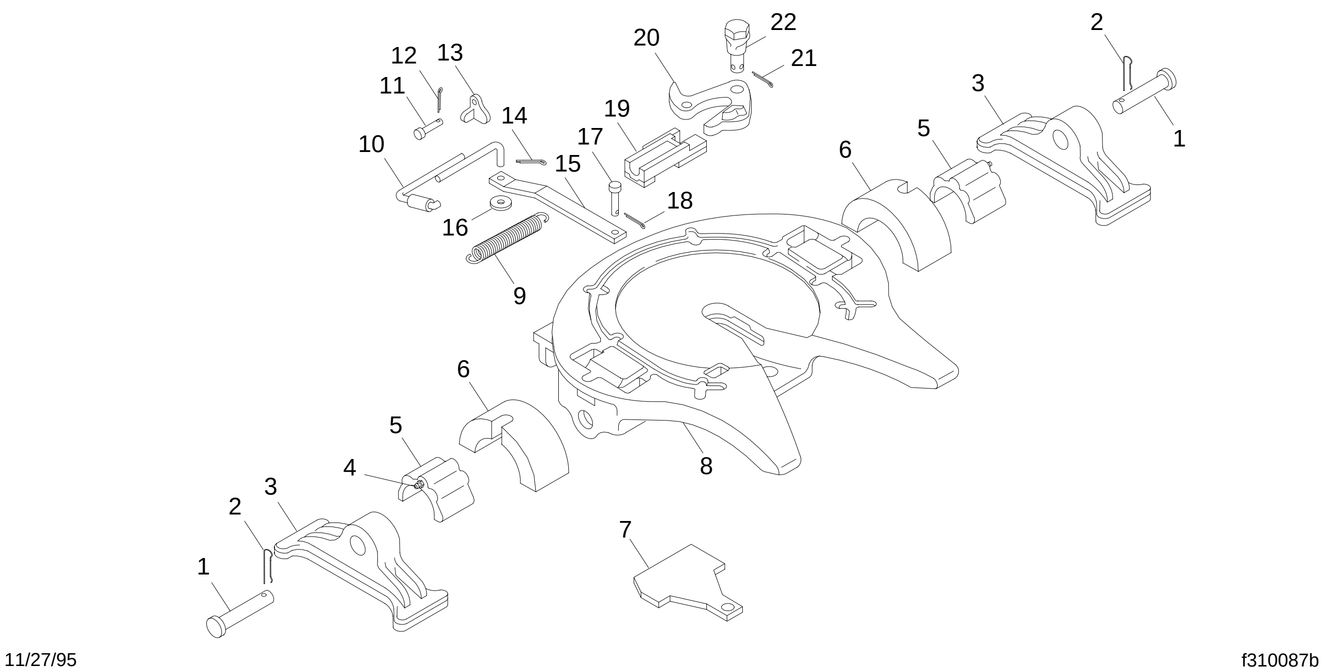
When cleaning parts with no. 2 diesel fuel, do not smoke or use an open flame near the area. To do so could result in a possible fire, which could cause personal injury and property damage.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Apply liquid soap to the bracket rubbers, and install them with the cutouts facing outboard. See **Fig. 1**.

IMPORTANT: Do not grease the bracket rubbers or pockets.

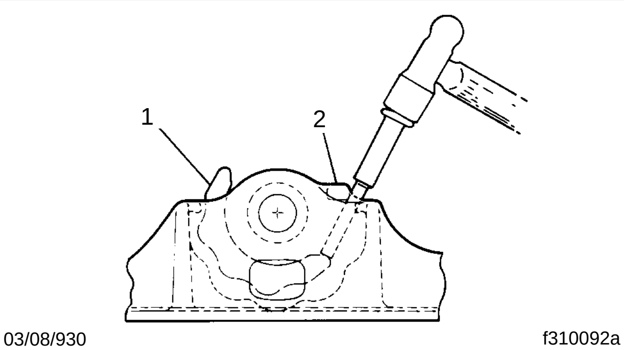
3. Grease the bracket shoe surfaces that contact the mounting brackets. Drive the bracket shoes in place against the stop and install the grease fittings in the bracket shoe. See **Fig. 2**.
4. Apply a thin film of a multipurpose chassis grease to the cover plate, lever bar pin, lever bar, jaw, jaw pin, lock, and casting lock area. The

Fifth Wheel Disassembly and Assembly



1. Bracket pin
2. Clinch Pin
3. Mounting Bracket (for stationary mounts)
4. Grease Fitting
5. Bracket Shoe
6. Bracket Rubber
7. Cover Plate
8. Top Plate
9. Lock Spring
10. Lock Control Handle
11. Latch Pin
12. Cotter Pin
13. Safety Latch
14. Cotter Pin
15. Lever Bar
16. Washer
17. Lever Bar Pin
18. Cotter Pin
19. Lock
20. Jaw
21. Clinch Pin
22. Jaw Pin

Fig. 1, Fifth Wheel Assembly (typical)



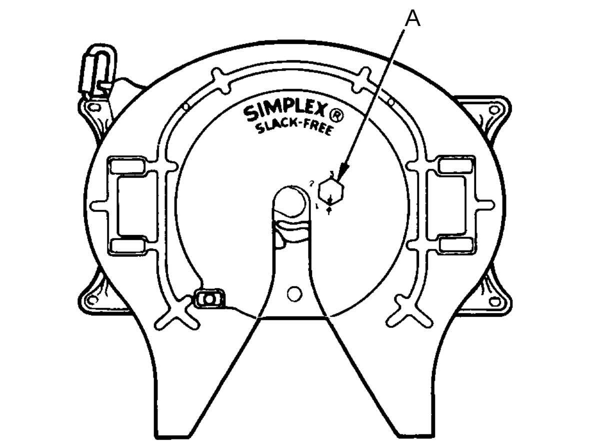
1. Bracket Shoe
2. Stop

Fig. 2, Bracket Shoe Removal

casting lock area is underneath the top plate, where the lock is located.

5. Install the lock spring in the lock, then install the lock and spring as a unit.
6. Install the lever bar and the lever bar pin.
7. Install the cover plate, then install a new cotter pin in the lever bar pin.
8. Using a new cotter pin and the existing washer, install the lock control handle on the lever bar.
9. Slide the jaw into the lock and install the jaw pin. Make sure the arrow on the jaw pin lines up with the arrow on the top plate. See **Fig. 3**. Install the clinch pin.
10. Install the fifth wheel on the sliding or stationary mount brackets.
    - 10.1 Using an overhead hoist, place the fifth wheel on the mount brackets.

Fifth Wheel Disassembly and Assembly



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A. Jaw pin positioned arrow-to-arrow.

Fig. 3, Jaw Pin Location

10.2 Clamp the fifth wheel in place to compress the bracket rubbers.

10.3 Insert the bracket pins and clinch pins.

11. Check the clearance between the jaw and kingpin.

11.1 With the jaw open, insert ASF gauge 40-2-00171 or a new kingpin in the fifth wheel. See **Fig. 4**.

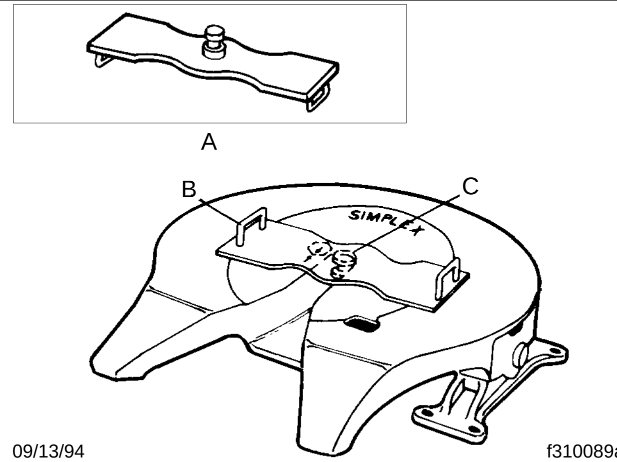
11.2 Make sure the safety latch swings freely over the lock control handle. See **Fig. 5**. This places the fifth wheel in the coupled and locked position.

11.3 Measure the distance between the kingpin (or gauge) and the front edge of the top plate slot. If using the gauge, make sure it is flat on the fifth wheel and pulled as far to the rear as possible.

11.4 Remove the gauge or kingpin.

12. The clearance between the jaw and the kingpin should be 1/8 inch (3 mm) or less. If the measurement is more than 1/8 inch (3 mm), adjust the clearance.

12.1 Using a bar, move the jaw to the locked position. This will relieve the pressure on the jaw pin.



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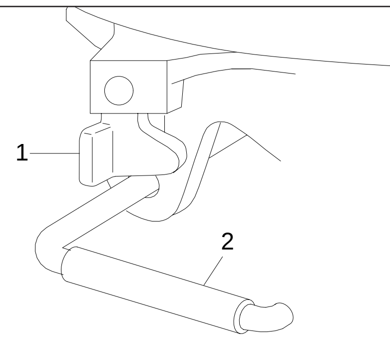
A. Bottom view of ASF gauge 40-2-00171.
B. Gauge installed.
C. Feeler shim opening.

Fig. 4, Jaw Gauge



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1. Safety Latch
2. Lock Control Handle

Fig. 5, Left-Side View

IMPORTANT: Do not turn the jaw past position 3. If more than 1/8-inch (3-mm) clearance remains at position 3, replace the jaw, jaw pin, and lock.

12.2 Remove the clinch pin from the jaw pin and lift the jaw pin just enough to clear the indexing head. Turn the jaw pin to the next higher numbered position (indicated on the casting).

NOTE: Starting from the original position, with the arrow pointing to the rear, each turn of the jaw pin (**Fig. 6**) to one of the three positions on the casting reduces the dis-

Fifth Wheel Disassembly and Assembly

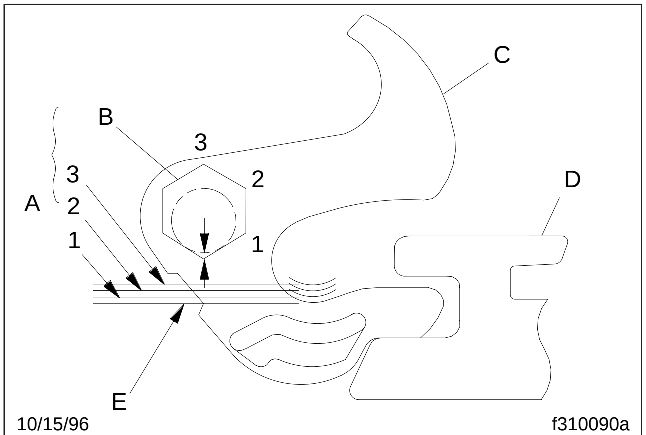
tance between the kingpin and jaw by the amount shown in **Table 1**.

12.3 Repeat the previous step to check the clearance between the jaw and the kingpin. Continue to adjust and measure the clearance until the measurement is 1/8 inch (3 mm) or less. Do not turn the jaw past postion 3.

Jaw Pin Position	Clearance Reduction inch (mm)	
	Each Turn	Total
1	1/16 (1.6)	1/16 (1.6)
2	3/32 (2.4)	5/32 (4.0)
3	1/16 (1.6)	7/32 (5.6)

Table 1, Clearance Adjustment

13. After the final adjustment, install the clinch pin in the jaw pin.



A. Jaw Pin Positions
B. Jaw Pin
C. Jaw
D. Lock
E. Original Position
1. Position 1
2. Position 2
3. Position 3

Fig. 6, Jaw Pin Positions

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to Group 31 in the *Columbia Maintenance Manual* for complete maintenance and lubrication instructions of the fifth wheel assembly.

14. Using a multipurpose chassis grease, grease the top plate and the grease fittings.
15. Check the fifth wheel operation. Refer to Chapter 10 in the *Columbia Driver's Manual* for complete fifth-wheel operating instructions.

WARNING

Do not use the fifth wheel if it does not operate correctly. The fifth wheel could malfunction due to possible disengagement of the trailer from the tractor, which could cause personal injury and property damage.

Troubleshooting

Problem—Fifth Wheel Is Hard to Hook Up to Trailer

Problem—Fifth Wheel Is Hard to Hook Up to Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the jaws correctly.	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
Bent kingpin or damaged trailer plate is interfering with the jaw movement.	Check the kingpin and trailer plate. Replace parts as needed.
The jaw pin has not been adjusted correctly.	Check the clearance between the jaw and kingpin. Adjust as needed.
The lever bar is bent.	Check the lever bar. Replace it if needed.
The lock control handle is bent.	Check the lock control handle. Replace it if needed.
The safety latch is jammed.	Check the lock control handle. Replace it if it is bent.
The cover plate is bent.	Check the cover plate. Replace it if needed.
Dirt has accumulated on the moving parts.	Clean all the parts and lubricate them lightly.

Problem—Too Much Slack at the Kingpin

Problem—Too Much Slack at the Kingpin	
Possible Cause	**Remedy**
The jaw pin has not been adjusted correctly.	Check the clearance between the jaw and kingpin. Adjust as needed.
The kingpin is worn.	Check the kingpin diameter; it should not be worn more than 1/8 inch (3.2 mm). Replace if needed.

Problem—Fifth Wheel Is Hard to Unhook from Trailer

Problem—Fifth Wheel Is Hard to Unhook from Trailer	
Possible Cause	**Remedy**
The operating rod is hard to pull out.	Back the tractor a little to relieve any kingpin load against the fifth wheel jaw.
There is pressure on the jaw from the kingpin.	Back the tractor into the trailer to reduce the pressure.
The jaw is adjusted too tightly.	Back the tractor into the trailer to relieve the pressure on the jaw. Unlock the fifth wheel. Adjust the jaw as needed.
The lever bar or the lock control handle is bent.	Check both parts. Replace if needed.
The cover plate is bent.	Check the cover plate. Replace it if it is bent.

General Information

Fontaine H5092 series fifth wheels couple to trailers having a standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels (**Fig. 1**), are mounted on the Fontaine HAWB or HMWS (previously called 5AWB and 5MWS) model slide mounts.

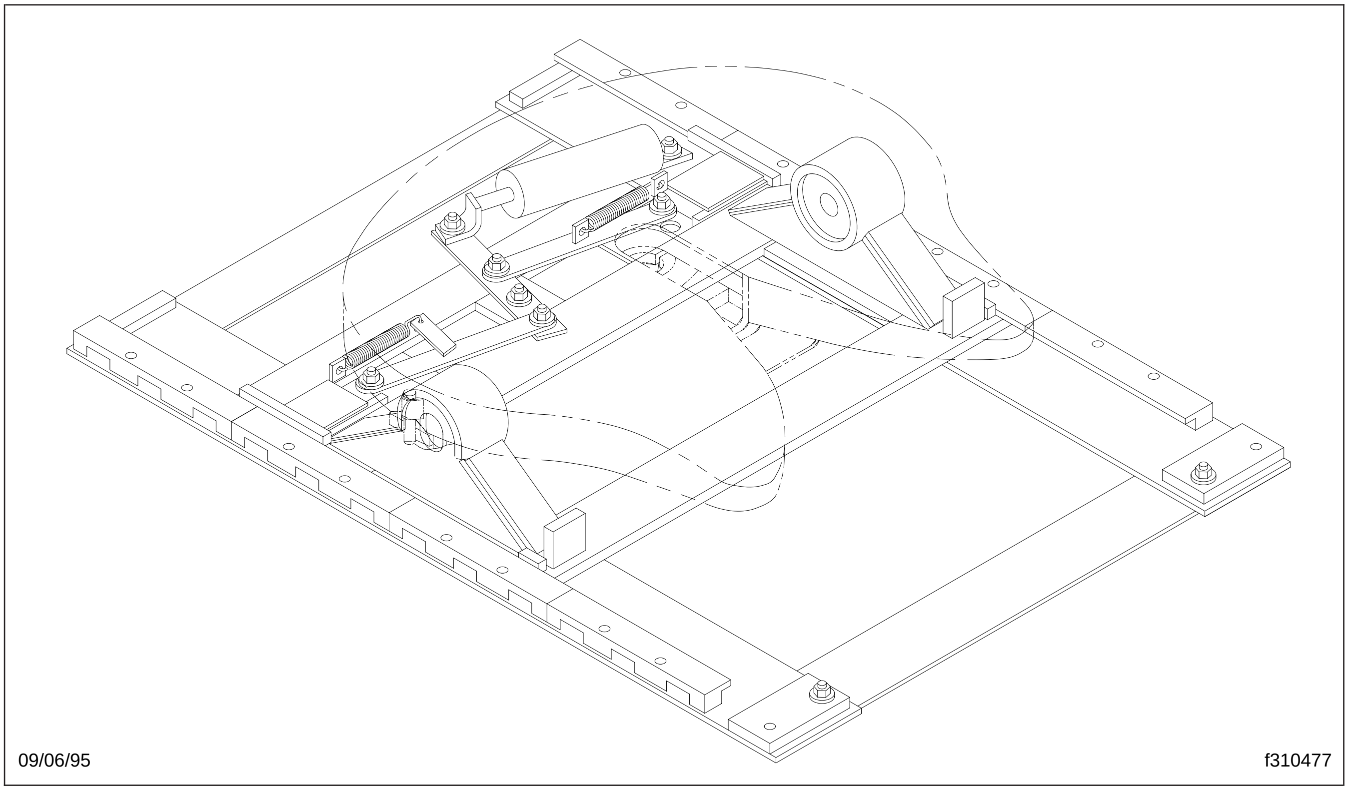


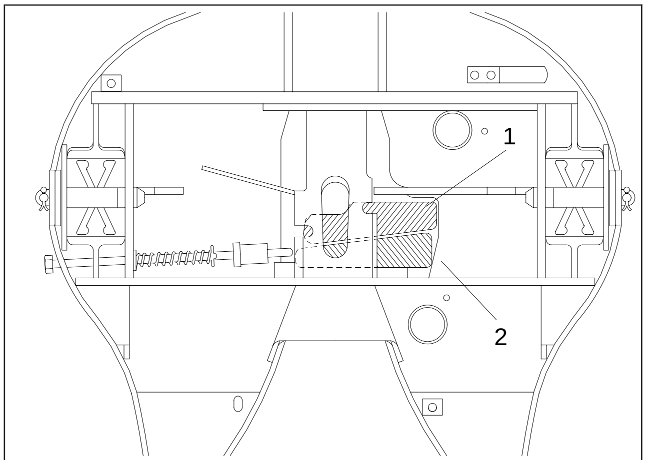
Fig. 1, Fontaine H5092 Series Air Slide Fifth Wheel

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 2** for an illustration of the jaw and wedge in the locked position.

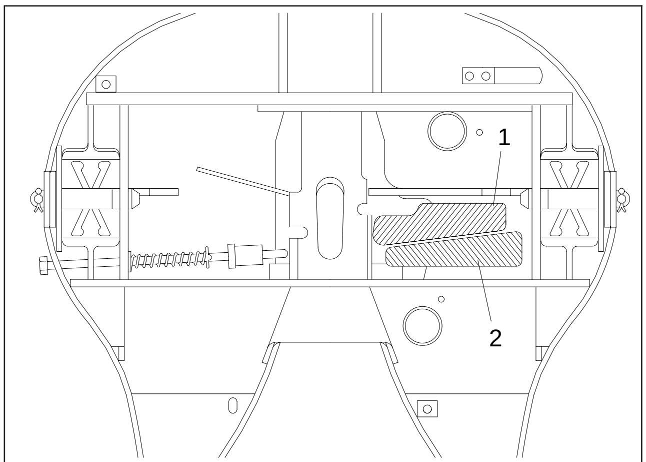
Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 3** for an illustration of the jaw and wedge in the unlocked position.

General Information



1. Jaw
2. Wedge

Fig. 2, Locked Position

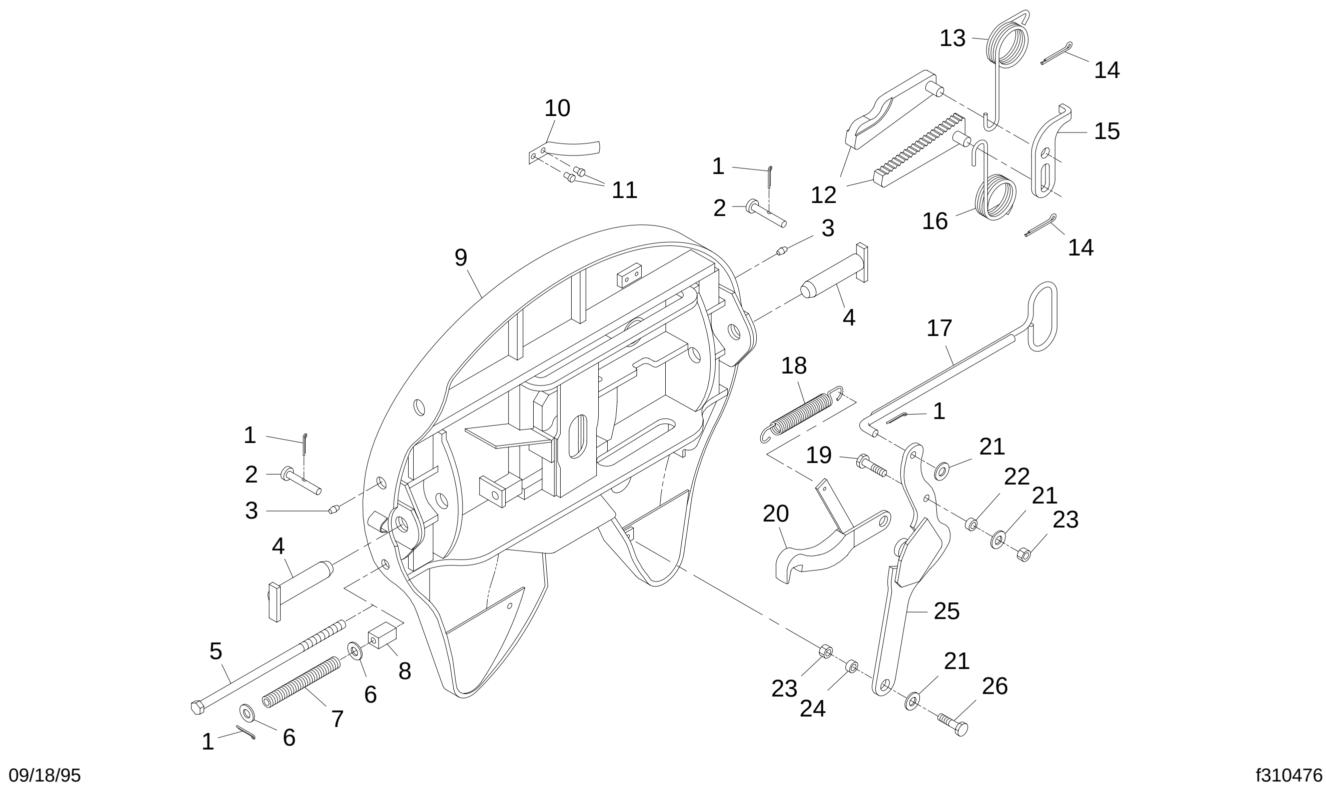


1. Jaw
2. Wedge

Fig. 3, Unlocked Position

Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of a Fontaine H5092 fifth wheel.



1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2", Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from

Removal and Disassembly

the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.

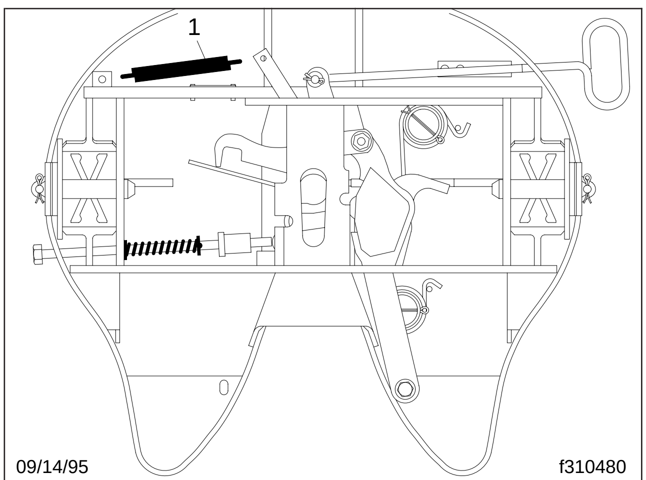
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, possibly causing personal injury and property damage.

4. Set the fifth wheel in a locked position, then unhook the bumper spring from the bumper tang and the tab on the side of the fifth wheel substructure. See **Fig. 2**. Remove the bumper spring.



1. Bumper Spring

Fig. 2, Bumper Spring Removal

5. Remove the two bolts on the operating handle. See **Fig. 3**. Each bolt has a nut, washer, and bushing. Discard the bushings.
6. Remove the cotter pin and washer that holds the pull handle to the operating handle. Slide the pull handle out through the side of the fifth wheel. See **Fig. 4**.

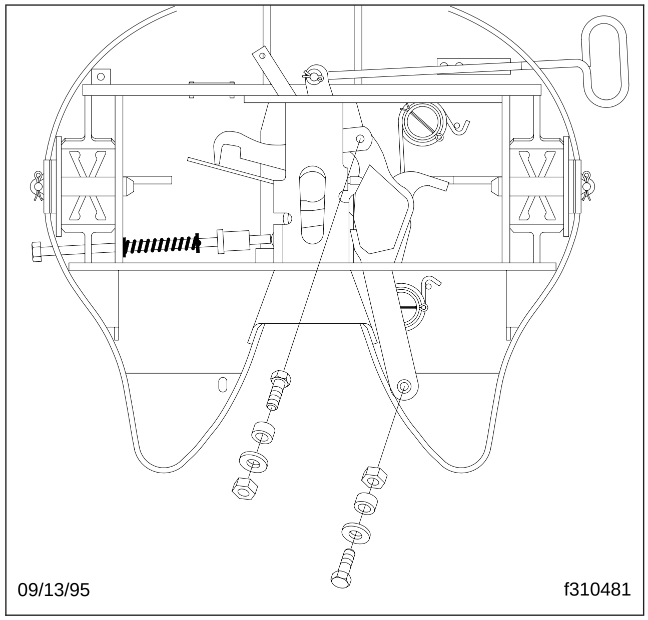


Fig. 3, Bolt Removal

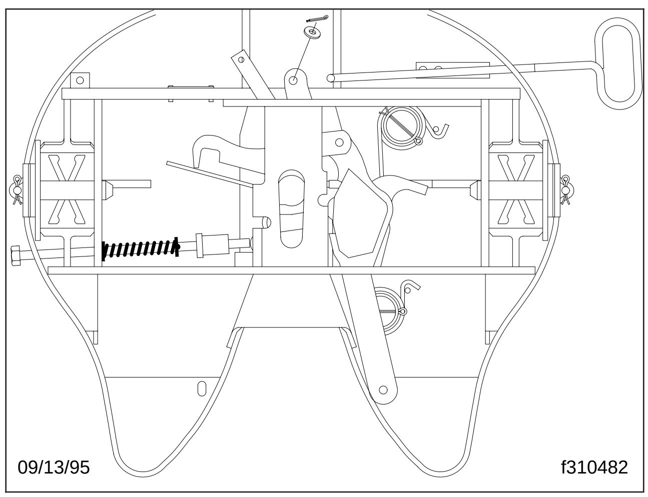
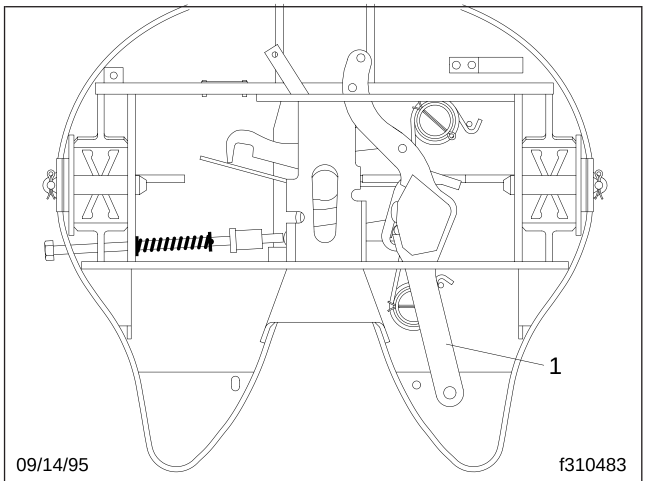


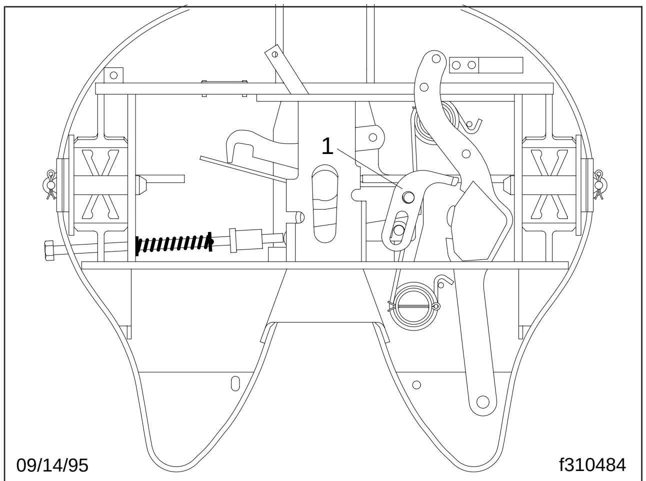
Fig. 4, Pull Handle Removal

7. Slide the operating handle over to the side of the fifth wheel. Slide the bottom part first. This will allow the handle to clear the jaw and wedge studs on the underside and clear the timer. See **Fig. 5**.
8. Remove the timer by lifting upward. See **Fig. 6**.



1. Operating Handle

Fig. 5, Operating Handle Positioning



1. Timer

Fig. 6, Timer Removal

9. Slide the operating handle out through the slot in the rear crossmember of the fifthwheel. See **Fig. 7**.
10. Slide the bumper toward the operating handle slot and to the rear of the fifth wheel until the bumper tang clears the operating handle slot. Lift upward and remove. See **Fig. 8**.

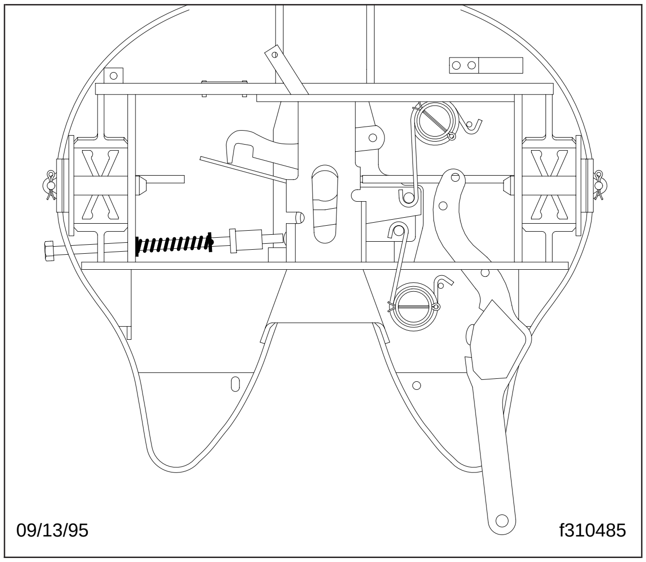
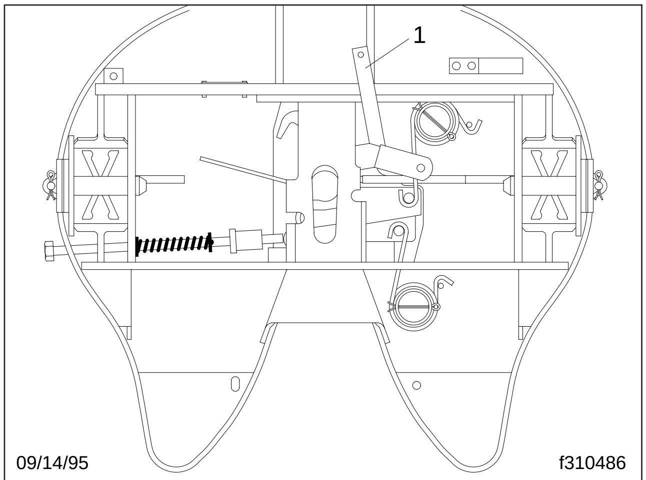


Fig. 7, Operating Handle Removal



1. Bumper

Fig. 8, Bumper Removal

WARNING

The wedge spring is under extreme tension. Always wear safety glasses. Do not stand directly over the springs. A flying spring could cause personal injury.

11. Remove the cotter pins from the jaw and wedge springs. Discard the cotter pins, and pry the small hooked tail of the jaw and wedge spring up

Removal and Disassembly

over the jaw and wedge studs. Remove and discard both springs. See Fig. 9.

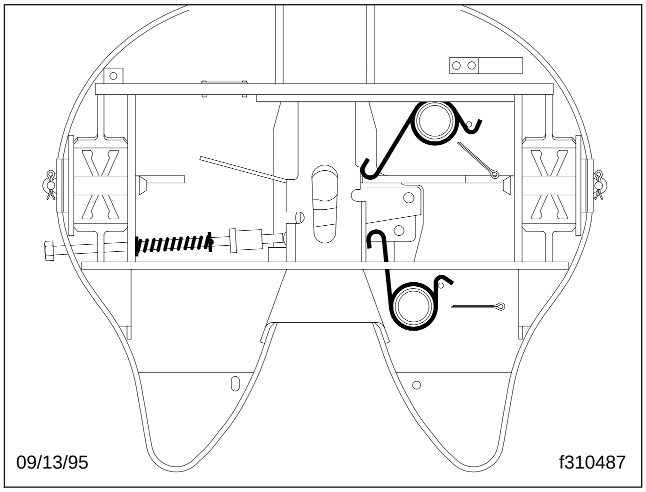


Fig. 9, Spring Removal

12. Remove the wedge first, and then the jaw. Discard the jaw and wedge. See Fig. 10.

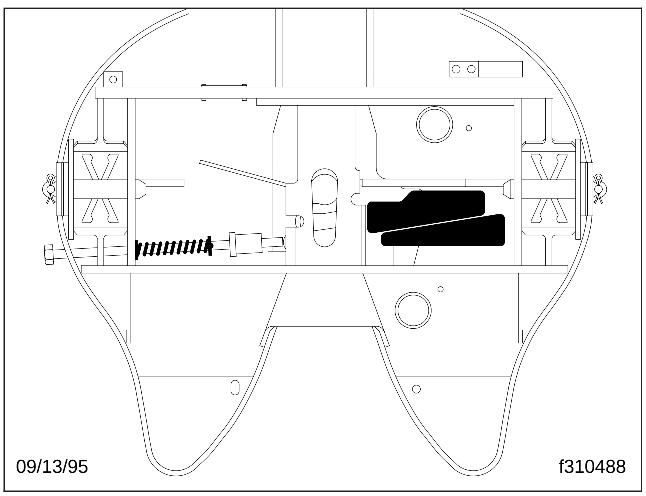
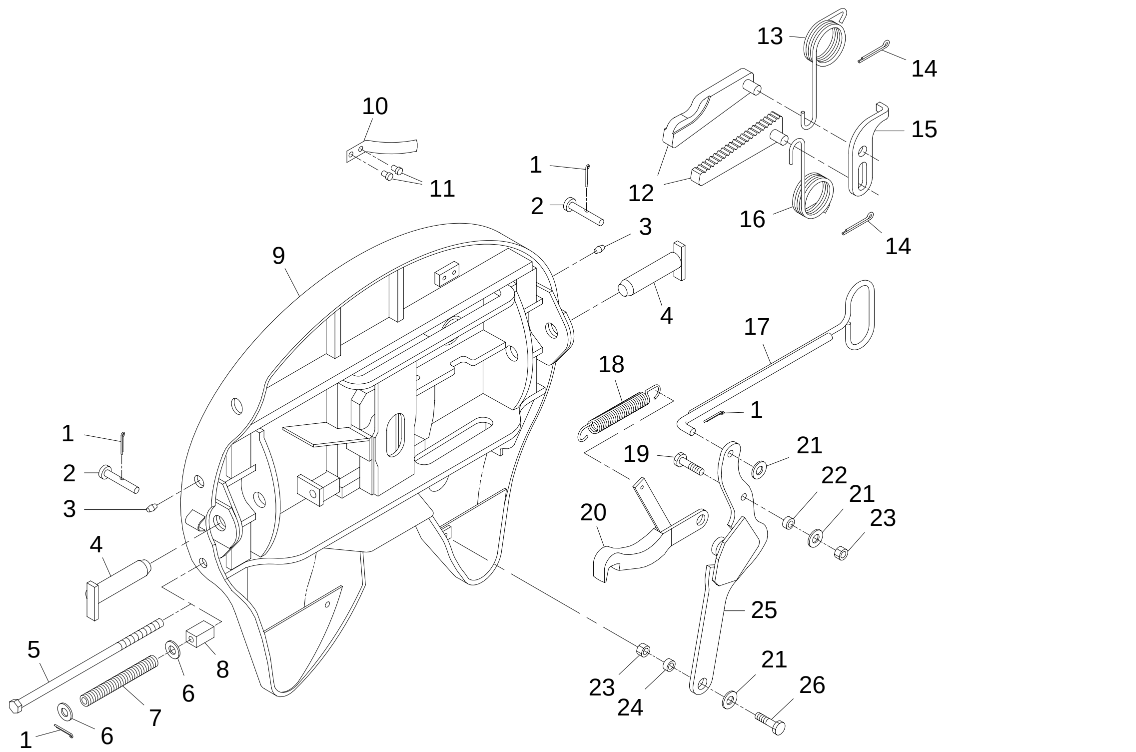


Fig. 10, Jaw and Wedge Removal

Assembly and Installation

See **Fig. 1** for an exploded view of a Fontaine H5092 fifth wheel.



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1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2", Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury and property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration.

Fifth Wheel Assembly and Installation

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Always assemble the parts around a 2 inch kingpin or a shaft with a 2 inch diameter. Insert the jaw first and then the new wedge below it. Apply a moderate amount of grease having EP (extra pressure) additives to the sides and serrated edges of the jaw and wedge. Also apply grease to the stationary jaw in the throat of the fifth wheel. See **Fig. 2**.

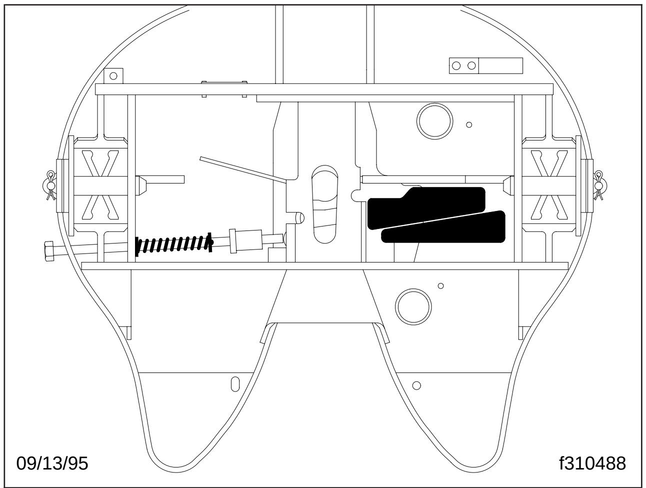


Fig. 2, Wedge and Jaw Installation

3. Insert the new wedge spring through the slot in the rear crossmember and lay the coil over the spring boss. Using a spring tool, engage the small hooked tail of the wedge spring and wind it around until it is directly over the small stud at the back of the bracket. Using a hammer, nudge the spring downward allowing it to catch on the stud. Insert a new cotter pin. See **Fig. 3**.

   Repeat these steps to replace the jaw spring.

NOTE: The jaw spring has minimal tension and can be replaced by hand.

4. Place the bumper back in position, sliding the bumper tang through the operating handle guide slot and toward the tab on the side of the fifth wheel substructure. See **Fig. 4**.
5. Apply a liberal amount of grease to the grooved middle section of the operating handle, then insert the operating handle and move it over to the side of the wheel. See **Fig. 5**.

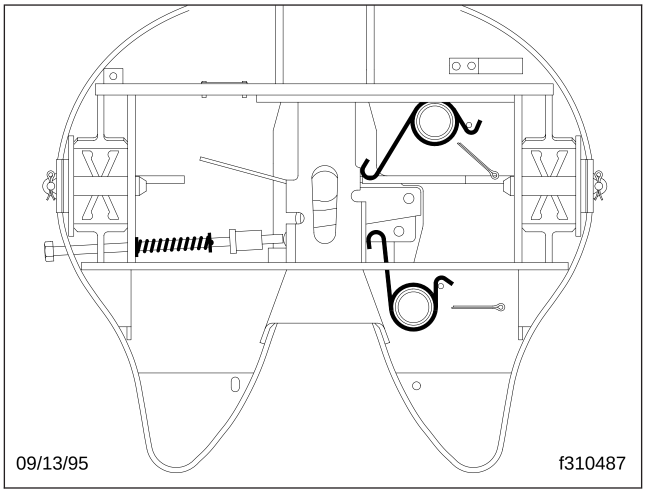
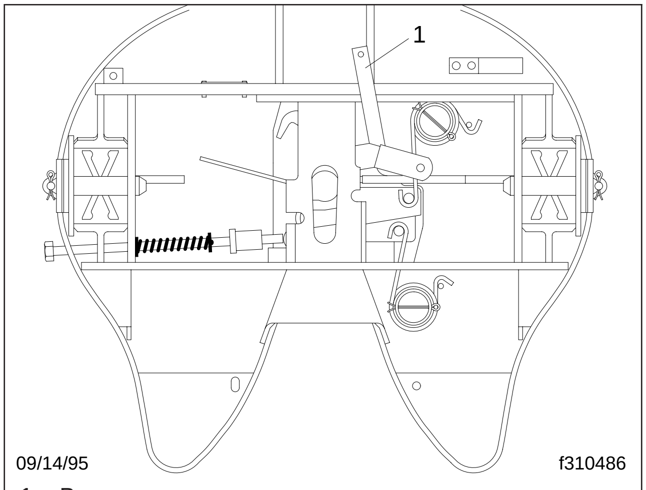


Fig. 3, Spring Installation



1. Bumper

Fig. 4, Bumper Installation

6. Insert the timer over the jaw and wedge studs. the small hole on the timer fits over the jaw stud and the slotted hole fits over the wedge stud. Be certain the small bent arm of the timer is facing downward. See **Fig. 6**.
7. Slide the operating handle toward the center of the wheel to engage the handle with the studs on the jaw and wedge. Slide the top part first. This will ensure that the grooves on the operating handle are aligned with the studs. A correctly aligned operating handle should be in a vertical position once it goes over the studs. See **Fig. 7**.

Fifth Wheel Assembly and Installation

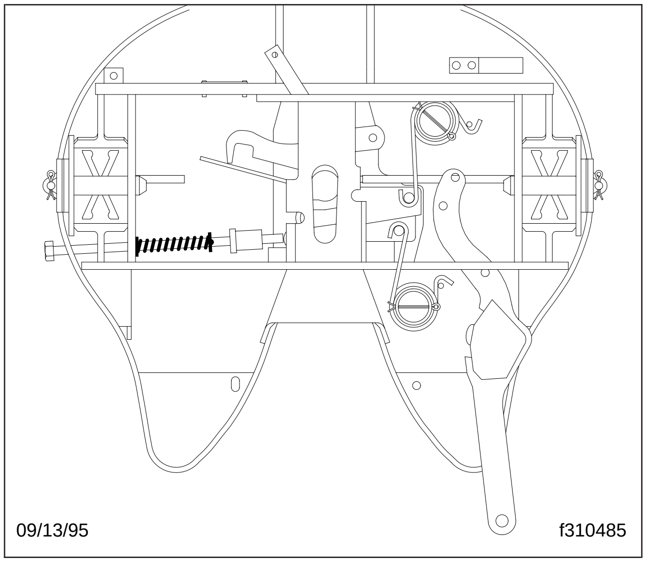
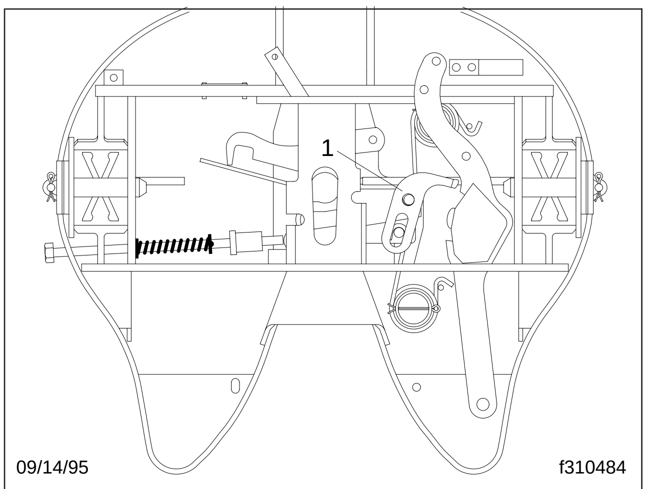


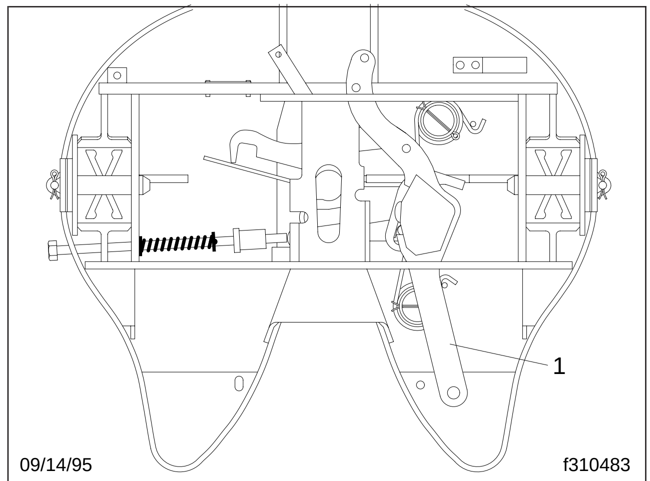
Fig. 5, Operating Handle Installation



1. Timer

Fig. 6, Timer Installation

8. Slide the pull handle in through the safety lock and using the cotter pin and washer, fasten it in the top hole of the operating handle. See **Fig. 8**.
9. Align the bumper hole with the hole in the operating handle. Replace the bolts on the operating handle. The bolt which fastens the operating handle to the bumper must be inserted with the threads facing toward you to prevent interference with the jaw springs. The other bolt should be positioned with the threads facing downward. Each bolt has a nut, washer, and new bushings.



1. Operating Handle

Fig. 7, Operating Handle Positioning

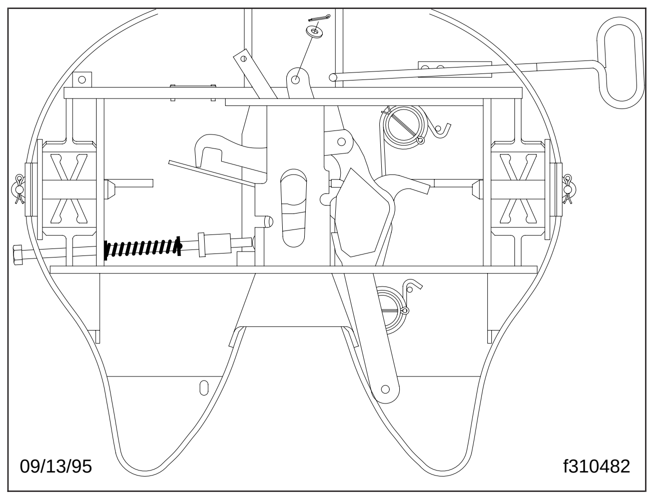


Fig. 8, Pull Handle Installation

Apply grease to the bolt parts and where there is metal to metal contact with the operating handle. See **Fig. 9**. Do not overtighten the bolts. Lubricate all pivot points.

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to Group 31 of the *Columbia™ Maintenance Manual* for complete maintenance and lubrication instructions for the fifth wheel assembly.

10. Connect the bumper spring to its clasp. See **Fig. 10**. Apply grease to the bracket pockets and to the grease fittings on the side of the fifth

Fifth Wheel Assembly and Installation

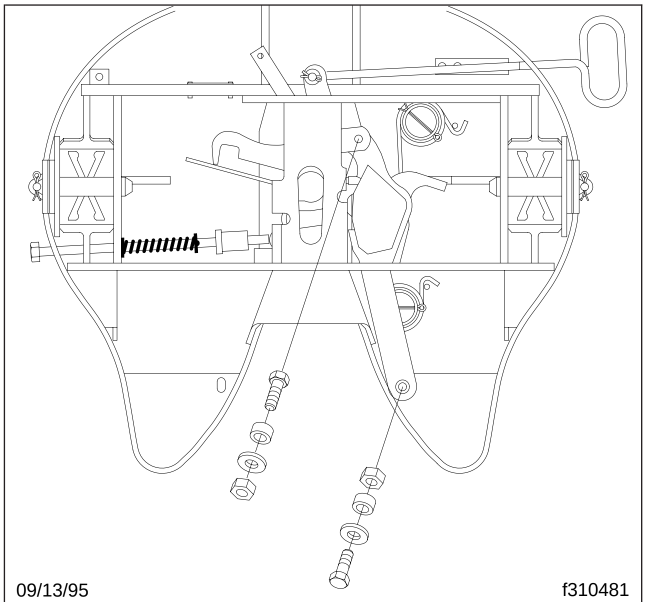
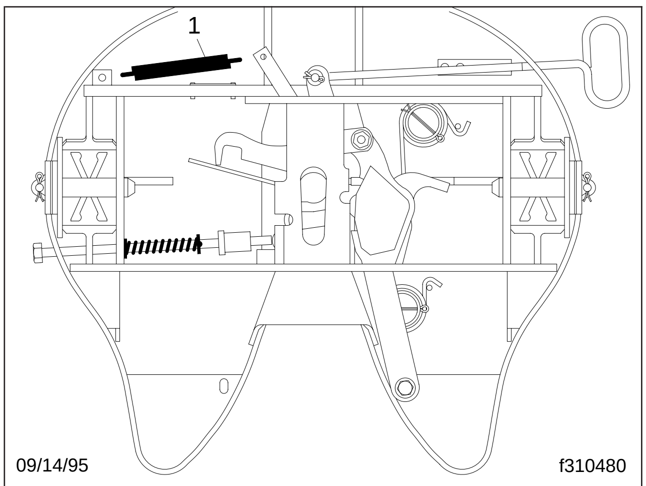


Fig. 9, Bolt Installation

wheel until grease flows into the upper brackets. Also apply a liberal amount of grease to the top plate.



1. Bumper Spring

Fig. 10, Spring Installation

> ⚠ **WARNING**
>
> **If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in personal injury or property damage due to possible disengagement of the trailer from the tractor.**

11. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

Troubleshooting Tables

Problem—Difficulty Coupling

Problem—Difficulty Coupling	
Possible Cause	**Remedy**
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Problem—Excessive Wear on the Fifth Wheel Top Plate	
Possible Cause	**Remedy**
Damaged trailer plate	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

Problem—Difficulty Uncoupling	
Possible Cause	**Remedy**
Pressure on the locking mechanism caused by the truck drifting apart from the trailer putting excess pressure on the lock	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin	Lower the landing gear.
Debris build-up in the grease	

Problem—Slack

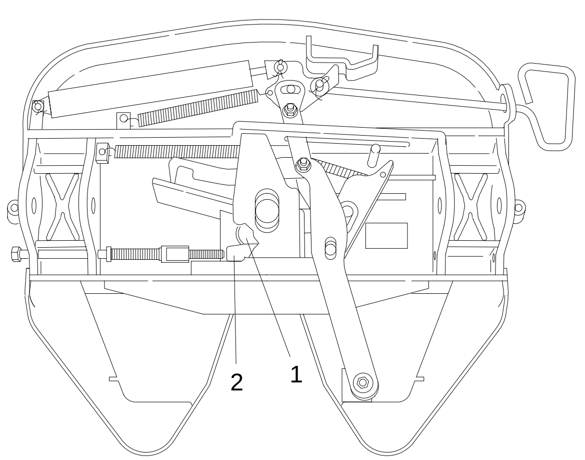
Problem—Slack	
Possible Cause	**Remedy**
Undersized kingpin	Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge	Jaw and wedge could have excessive wear. Replace them.

General Information

Fontaine 6000 and 7000 series fifth wheels couple to trailers having the standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels are mounted on the Fontaine AWB or MWS model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 1** for an illustration of the jaw and wedge in the locked position.



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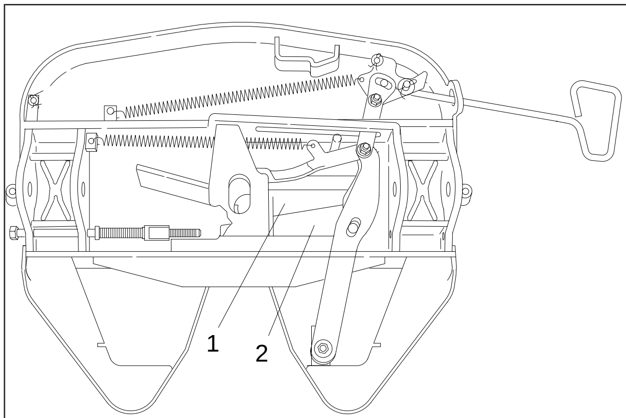
1. Jaw
2. Wedge

Fig. 1, Locked Position

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 2** for an illustration of the jaw and wedge in the unlocked postition.



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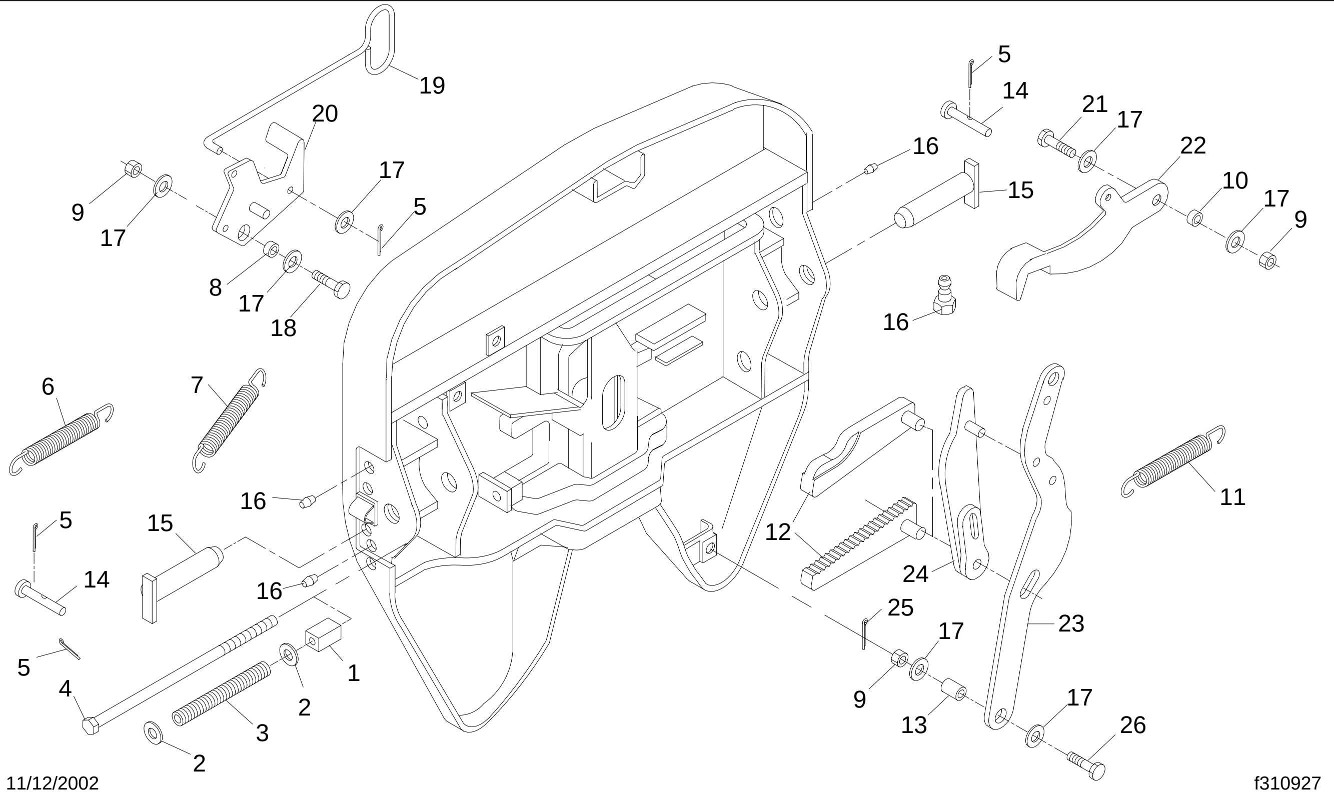
1. Jaw
2. Wedge

Fig. 2, Unlocked Position

Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.



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1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

Fig. 1, Fontaine 6000 and 7000 No-slack II Series Fifth Wheel (left side release shown)

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

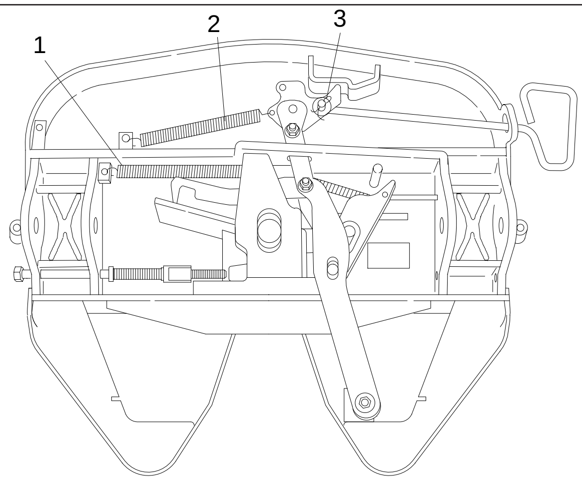
1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.

Removal and Disassembly

2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

4. Remove the secondary lock spring and bumper spring. See **Fig. 2**. Remove the pull handle cotter pin and washer, then slide out the pull handle.



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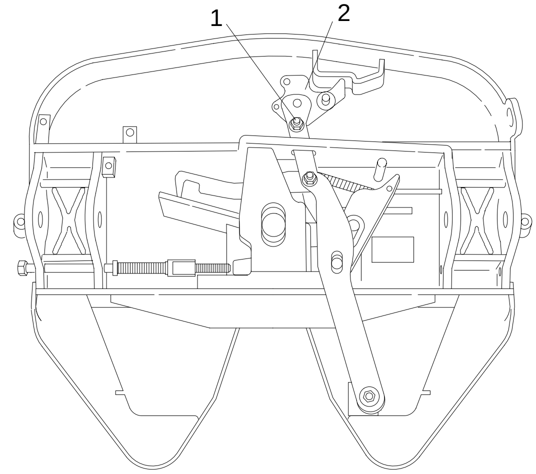
1. Bumper Spring
2. Secondary Lock Spring
3. Pull Handle Cotter Pin

Fig. 2, Pull Handle

5. Unbolt and remove the secondary lock from the operating handle. Discard the locknut and bushing. See **Fig. 3**.
6. Unbolt and remove the bumper from the operating handle. Discard the locknut and bushing. See **Fig. 4**.
7. Unbolt the operating handle from the pivot mount and remove. Discard the locknut. See **Fig. 5**.
8. Remove the timer spring and timer. See **Fig. 6**.
9. Remove the jaw and wedge. See **Fig. 7**.



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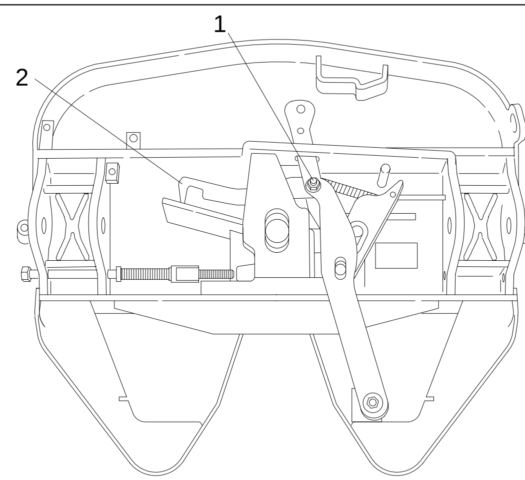
1. Bolt
2. Secondary Lock

Fig. 3, Secondary Lock



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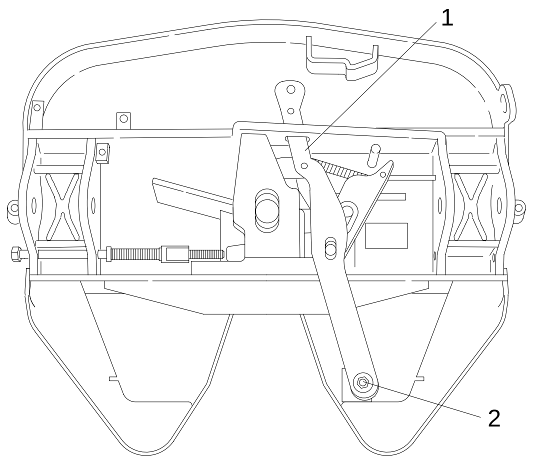
1. Bolt
2. Bumper

Fig. 4, Bumper



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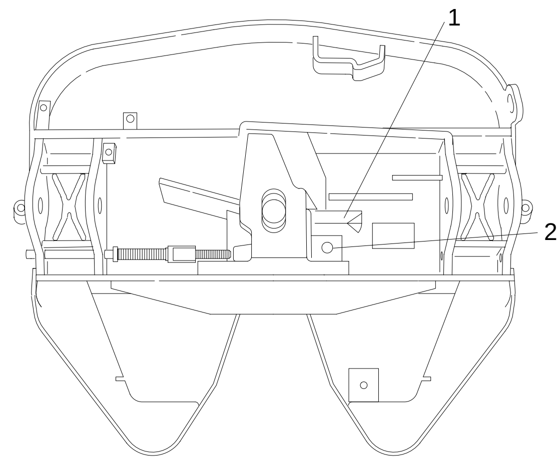
1. Operating Handle
2. Bolt

Fig. 5, Operating Handle



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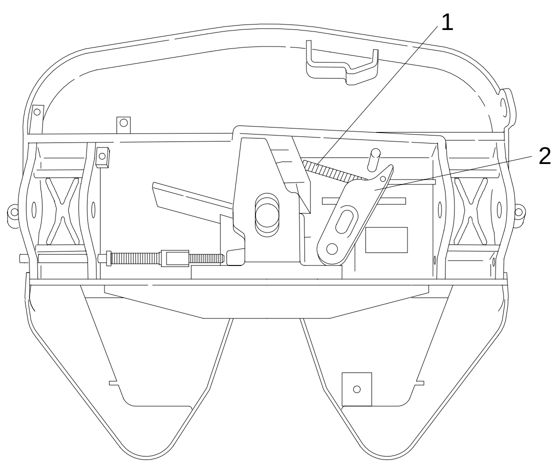
1. Jaw
2. Wedge

Fig. 7, Jaw and Wedge



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1. Timer Spring
2. Timer

Fig. 6, Timer Spring and Timer

Assembly and Installation

WARNING

Before rebuilding the assembly, check to make sure that there are no cracks in the crossmembers or other components. Also check the bracket pin holes to ensure they are not worn oversize (pins should fit snugly). Under no circumstances should a fifth wheel be repaired or used if any component (crossmember, saddle bearing, etc.) is cracked. Operating a fifth wheel with damaged components could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

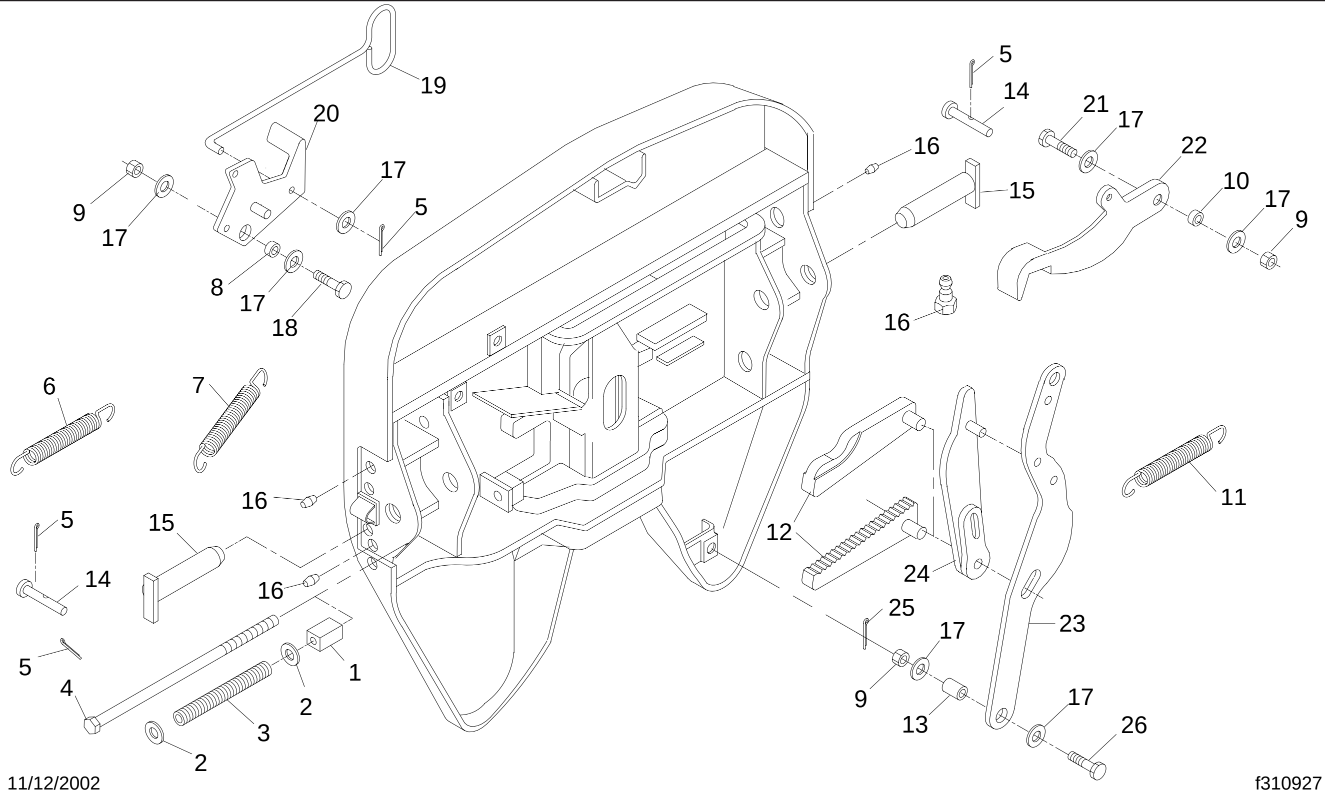
See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

1. Always assemble parts around a 2-inch kingpin or a 2-inch-diameter shaft. Insert the jaw first, then the wedge below it. See **Fig. 2**. Grease the jaw and wedge on the top and bottom.
2. Install the timer and the timer spring. See **Fig. 3**.
3. Install the operating handle and bolt to the pivot mount. See **Fig. 4**. Use the existing bolt, washer, hairpin cotter pin and bushing. Inspect the bushing for wear before using it and replace it if necessary. Use the new locknut that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
4. Install the bumper and bolt it to the operating handle. See **Fig. 5**. Use the existing bolt and washers (inspect for wear before using, and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**). After installing the bumper, check to make sure that it can pivot freely.
5. Insert the secondary lock and bolt it to the operating handle. See **Fig. 6**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
6. Install the pull handle. See **Fig. 7**. Use the existing washer and cotter pin (inspect for wear before using and replace if necessary). Attach the new secondary lock/bumper spring that is supplied in the repair kit. Open and close the fifth wheel to ensure that it works properly. The fifth wheel must be properly lubricated before opening and closing the wheel.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

7. Close the fifth wheel several times with a standard 2-inch kingpin tool. With the lock closed, adjust the wedge stop rod so that the end is 1/4 inch (6 mm) from the wedge. See **Fig. 8**.
8. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

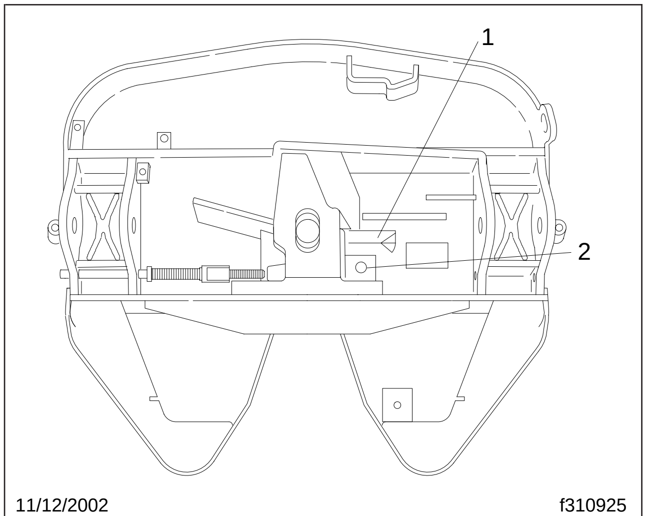
Assembly and Installation



1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

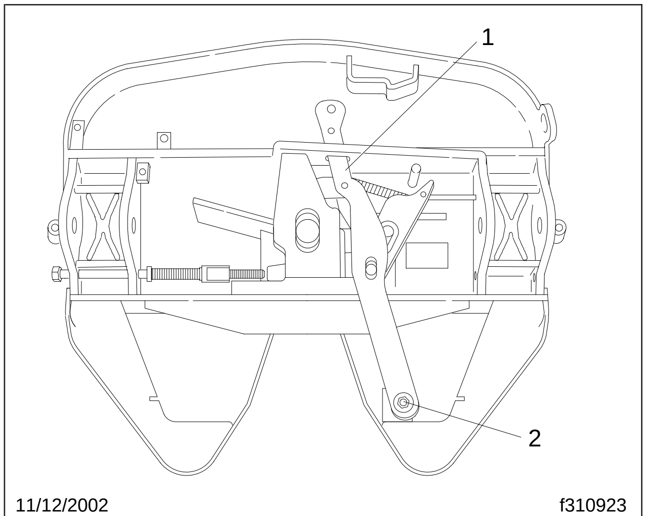
Fig. 1, Fontaine 6000 and 7000 No-slack II Series (left side release shown)

Assembly and Installation



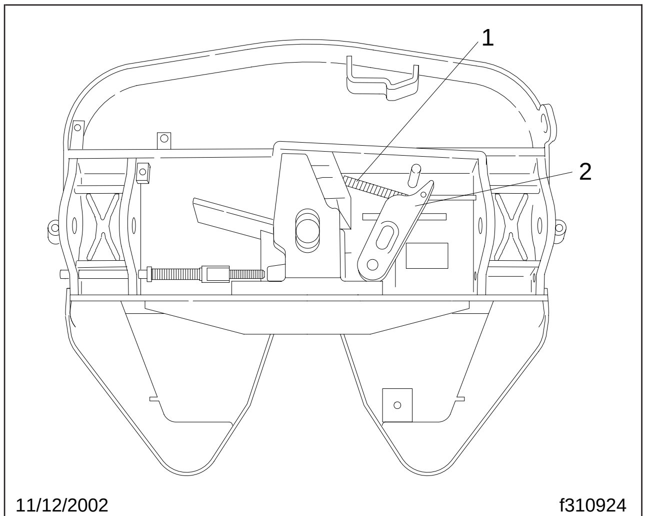
1. Jaw
2. Wedge

Fig. 2, Jaw and Wedge



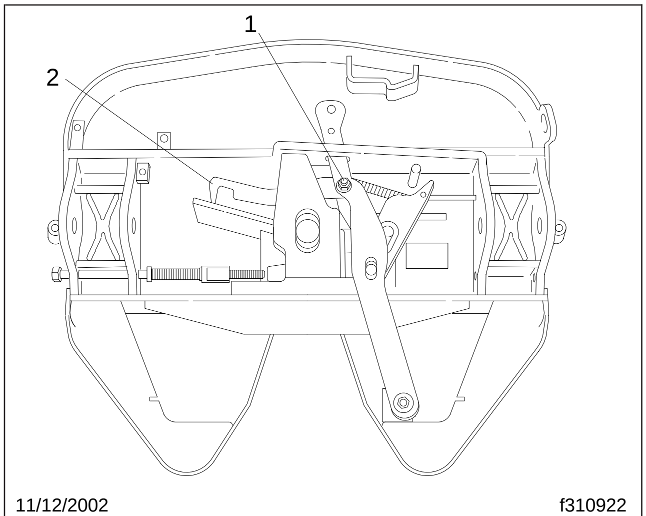
1. Operating Handle
2. Bolt

Fig. 4, Operating Handle



1. Timer Spring
2. Timer

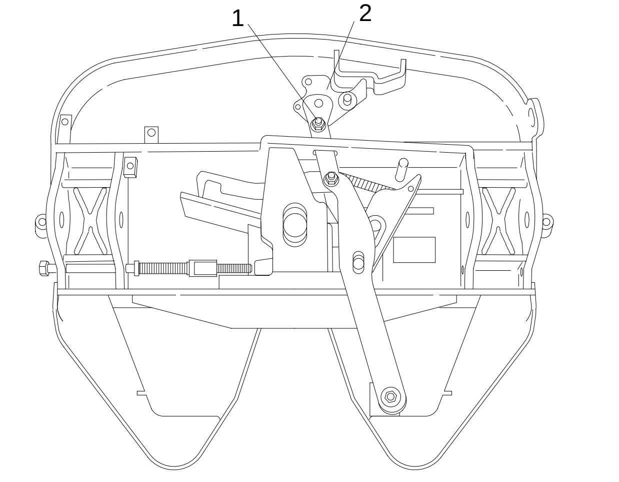
Fig. 3, Timer Spring and Timer



1. Bolt
2. Bumper

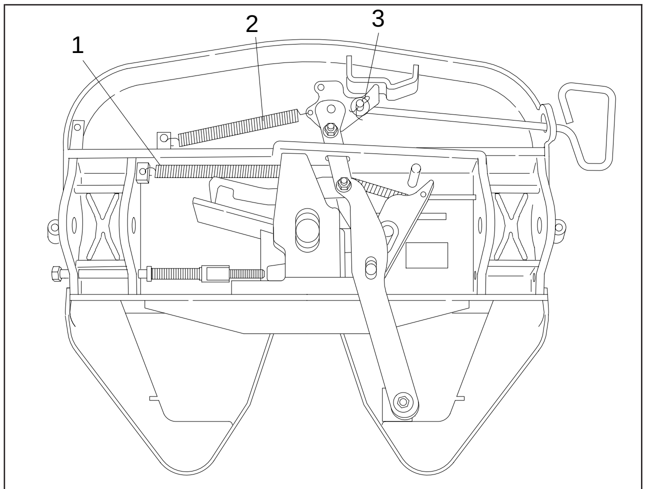
Fig. 5, Bumper

Assembly and Installation



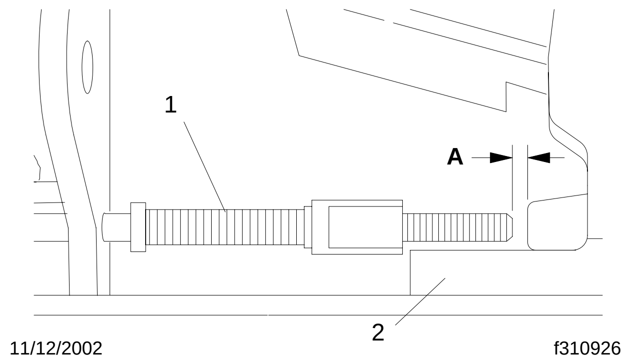
1. Bolt
2. Secondary Lock

Fig. 6, Secondary Lock



1. Bumper Spring
2. Secondary Lock Spring
3. Pull Handle Cotter Pin

Fig. 7, Pull Handle



A. 1/4 inch (6 mm)
1. Stop Rod
2. Wedge

Fig. 8, Wedge Stop Rod Adjustment

Troubleshooting Tables

Problem—Difficulty Coupling

Problem—Difficulty Coupling	
Possible Cause	**Remedy**
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Problem—Excessive Wear on the Fifth Wheel Top Plate	
Possible Cause	**Remedy**
Damaged trailer plate	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

<table>
<tr><th colspan="2">Problem—Difficulty Uncoupling</th></tr>
<tr><th>Possible Cause</th><th>Remedy</th></tr>
<tr><td>Pressure on the locking mechanism caused by the truck drifting apart from the trailer, putting excess pressure on the lock</td><td rowspan="3">Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.

Lower the landing gear.</td></tr>
<tr><td>Oval-shaped kingpin</td></tr>
<tr><td>Debris build-up in the grease</td></tr>
</table>

Problem—Slack

Problem—Slack	
Possible Cause	**Remedy**
Undersized kingpin	Replace the kingpin if it is worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge	The jaw and wedge could have excessive wear. Replace them.

General Information

The Premier model 690 trailer coupling is a non-air-adjusted, heavy-duty coupling. It is used for load capacities up to 90,000 lbs, and is available with either right- or left-hand operation. See **Fig. 1**.

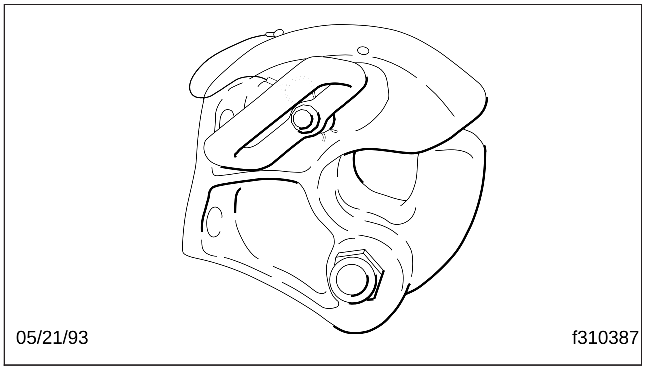
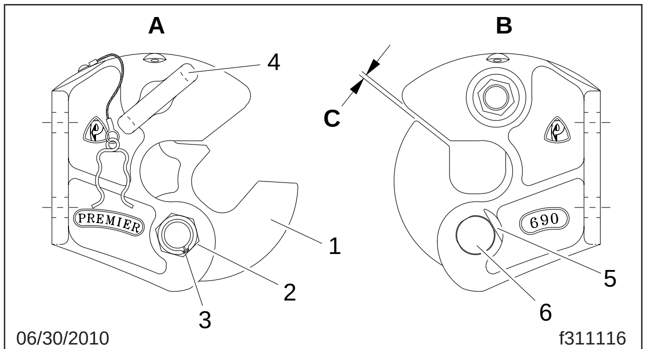


Fig. 1, Premier 690 Trailer Coupling

Inspection

With the 690 coupling in the closed position, pull outward on the 692 pintle:

- The measured gap between the top of the 692 pintle and the adjacent face of the 690 coupling body must be less than 3/8 inch (9.52 mm). See **Fig. 1**.
- A 3/8 inch (9.52 mm) or greater gap indicates that the coupling is no longer suitable for service. A repair kit will be necessary to return the coupling to service, or a new 690 coupling may be installed.



A. Left Side, Open Position
B. Right Side, Closed Position
C. 3/8 inch (9.52 mm) or less

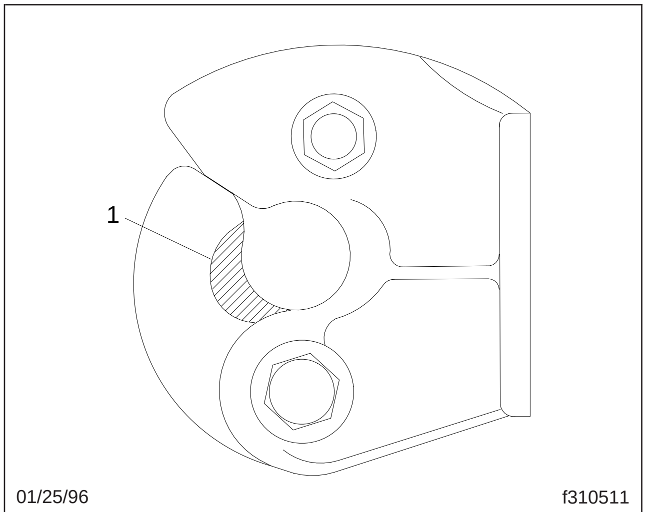
1. 692 Pintle
2. 297 Locknut
3. 295Z-87 Snap Ring
4. 691 Release Handle
5. Bolt Stop
6. 294 Bolt

Fig. 1, 690 Coupling

Using Premier wear gauge, part number 14014, check the percentage of wear on the pintle hook. See **Fig. 2** and **Fig. 3**.

WARNING

WARNING: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 20% of its original diameter, replace the entire coupling; don't repair it. Using a worn or damaged trailer coulpling could cause the trailer to disconnect from the vehicle, which could result in an accident causing serious personal injury and property damage.



1. Wear Surface

Fig. 2, Wear Checking

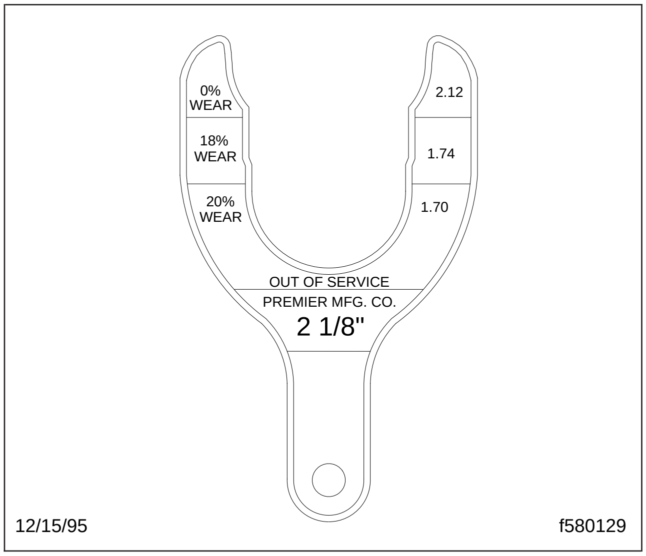
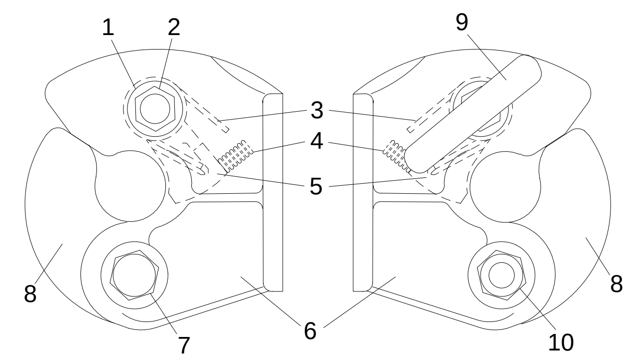


Fig. 3, Wear Gauge

Disassembly

1. Remove the coupling from the vehicle.
2. Remove the pintle-hook nut and bolt, then remove the pintle hook from the coupling body. See **Fig. 1**.
3. With the handle pushed in, remove the nut from the end of the handle.
4. Remove the bushing, then the handle from the body.
5. From the bottom of the coupling body, remove the small pawl spring, then the pawl and the large pawl spring. Discard the two springs.
6. Remove the locking pin assembly from the coupling body, and discard it. See **Fig. 2**.

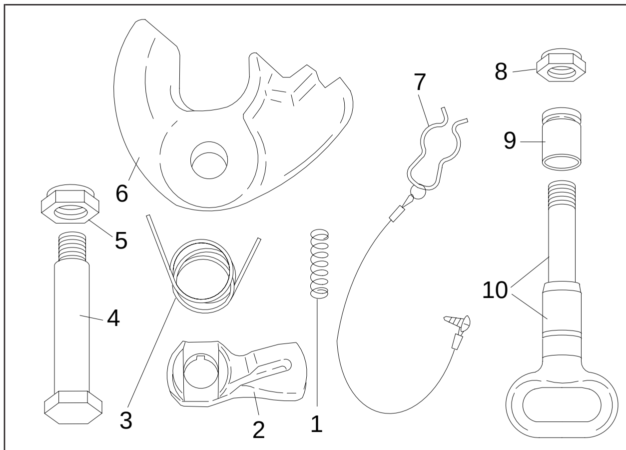


1. Bushing
2. Nut
3. Large Pawl Spring
4. Small Pawl Spring
5. Pawl
6. Coupling Body
7. Pintle-Hook Bolt
8. Pintle Hook
9. Handle
10. Pintle-Hook Nut

Fig. 1, Trailer Coupling Parts

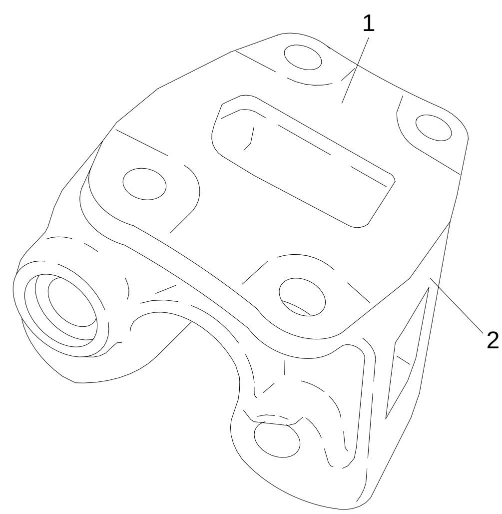
Assembly

1. Check for wear on any parts that aren't included in the new repair kit. Replace them if needed.
2. Place the coupling body on its face, with the mounting surface up and the bottom of the coupling body toward you. See **Fig. 3**.
3. Place a new large spring on the pawl, so that one leg of the spring fits into the groove in the pawl. See **Fig. 4**.



1. Small Pawl Spring
2. Pawl
3. Large Pawl Spring
4. Pintle-Hook Bolt
5. Pintle-Hook Nut
6. Pintle Hook
7. Locking-Pin Assembly
8. Nut
9. Bushing
10. Handle

Fig. 2, Repair Kit Parts

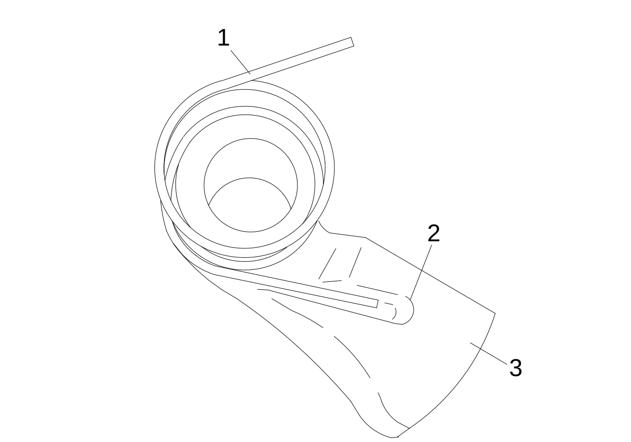


1. Mounting Surface
2. Bottom Surface

Fig. 3, View of the Mounting Surface

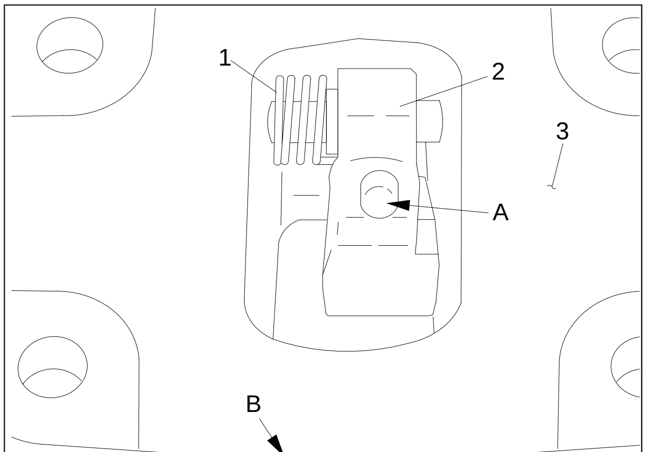
4. Install the pawl and spring in the bottom of the coupling body, with the spring to your left. See **Fig. 5**. Make sure the other leg of the spring sits in the slot inside the body.

Disassembly and Assembly



1. Large Pawl Spring
2. Groove
3. Pawl

Fig. 4, Pawl and Pawl Spring



A. Install small pawl spring in here.
B. Bottom of Coupling Body

1. Large Pawl Spring
2. Pawl
3. Mounting Surface

Fig. 5, Pawl Spring Installation

5. Install the new handle into the coupling body and the pawl. Make sure the taper of the handle matches the taper of the hole in the pawl, and that the handle locks into place. See **Fig. 2**.
6. Install the bushing over the threaded end of the handle, then install the nut.
7. Turn the handle toward yourself, then—from the bottom of the coupling body—install the small pawl spring in the depression on the pawl. See **Fig. 5**. Make sure the other end of the spring fits into the depression inside the coupling body.
8. Rotate the pawl up and lock it into position by turning the handle away from you, then pushing it in.

NOTICE

Do not overtighten the nuts for the pintle hook and the handle or it may cause the parts to bind, which could result in unnecessary wear on the coupling.

9. Set the coupling body on its mounting surface, then install the new pintle hook, bolt, and nut. Tighten the nuts on the pintle hook bolt and the handle snugly.
10. Install the new locking pin assembly on the top of the coupling body. See **Fig. 2**.
11. Lubricate all the moving parts with light penetrating oil. Don't lubricate the wear surface of the pintle hook. Open and close the pintle hook several times to distribute the oil.
12. Install the coupling on the vehicle. Tighten the mounting bolts 320 lbf·ft (434 N·m).

NOTE: Before performing the 294 bolt replacement procedure, first verify that the 690 coupling is not in need of a complete repair kit. Perform the inspection procedure in **Subject 100**.

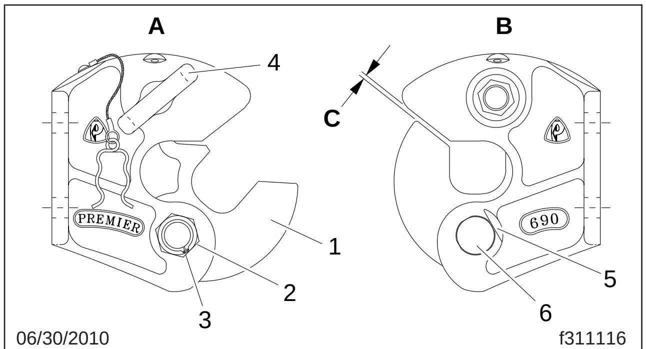
Bolt Replacement

See **Table 1** for new parts required. Parts can be ordered from Premier Manufacturing Company at: (800) 255-5387 or (503) 234-9202.

Parts Required		
Description	Part Number	Qty.
Bolt	294	1
Locknut	297	1

Table 1, Parts Required

1. Place the 690 coupling into the OPEN position as shown in **Fig. 1**.



A. Left Side, Open Position
B. Right Side, Closed Position
C. 3/8 inch (9.52 mm) or less

1. 692 Pintle
2. 297 Locknut
3. 295Z-87 Snap Ring
4. 691 Release Handle
5. Bolt Stop
6. 294 Bolt

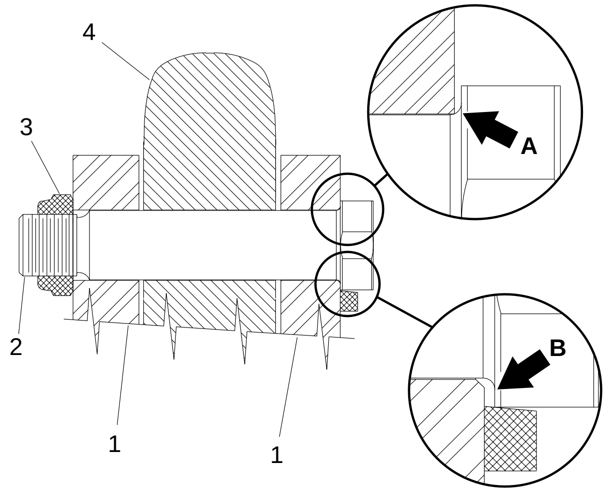
Fig. 1, 690 Coupling

2. If the bolt is an old style with a snap ring, remove the 295Z-87 snap ring from the end of the 294 bolt, then discard it.
3. Remove the 297 locknut and discard it.
4. Firmly gripping the 692 pintle, slide the 294 bolt out of the 690 coupling body.
5. Using a hammer or file, destroy the threaded end of the 294 bolt and discard it.
6. Thoroughly clean the 690 coupling body holes where the 294 bolt was inserted, as well as the interior surfaces of the 690 coupling body. Clean the hole and all surfaces of the 692 pintle.
7. On each side of the coupling body, measure the hole diameters where the 294 bolt was inserted. If a hole diameter exceeds 1.156 inches (29.36 mm) the coupling body is considered out-of-service and must be replaced.
8. Inspect the holes around the 691 release handle for wear. If there is a gap of 1/32-inch (0.79 mm) or greater between the 691 handle shaft and hole circumference, remove the handle assembly, then measure the hole diameters. If a hole diameter exceeds 1.30 inches (33.02 mm), the coupling is to be considered out-of-service and must be replaced.
9. Test fit the 294 bolt by inserting it from the right side through the holes of the 690 coupling body, without the 692 pintle in place. Make certain that the new 294 bolt head is flush with the outer 690 coupling body side wall.

   If the new 294 bolt head and the 690 coupling body are not flush, two possible causes are shown in **Fig. 2**.

   - Arrow A indicates a gap between the new 294 bolt head and the 690 coupling body caused by the hole in the 690 coupling body not being chamfered. This can be resolved by grinding a 45 degree chamfer, no larger than 1/16 inch (1.59 mm), around the entire circumference of the 690 coupling body hole.
   - Arrow B indicates a gap because the bolt stop is preventing the bolt from sitting flush to the coupling body. This can be corrected by grinding or filing the bolt stop until the bolt head clears it.
10. For final assembly, remove the 294 bolt and apply heavy grease to the the 692 pintle hole, the 690 coupling body holes, and the shank of the new 294 bolt (do not lubricate the threads).
11. Place the 692 pintle into the 690 coupling body, aligning the pintle hole with the body holes. From the right side, insert the new 294 bolt through the aligned holes. Clean all signs of lubrication from

294 Bolt Replacement



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A. Gap caused by 690 body hole not chamfered. Correct by chamfering hole.
B. Gap caused by bolt stop preventing the bolt head from seating flush to the coupling body. Correct by grinding or filing the bolt stop until the bolt head clears it.

1. 690 Body
2. 294 Bolt
3. 297 Locknut
4. 692 Pintle

Fig. 2, Bottom Section View

the threads of the 294 bolt. Align one of the four flatheads adjacent to the bolt stop as shown in **Fig. 1**.

12. Securing the 294 bolt head with a wrench, thread a new 297 locknut onto the bolt. Ensure that no lubricant is present on the bolt threads, then torque to 50 lbf·ft (68 N·m).
13. Open and close the 690 coupling several times, making sure it operates smoothly and correctly.

General Information

Standard Freightliner front suspensions use tapered leaf spring assemblies, with shock absorbers as standard equipment. See Fig. 1.

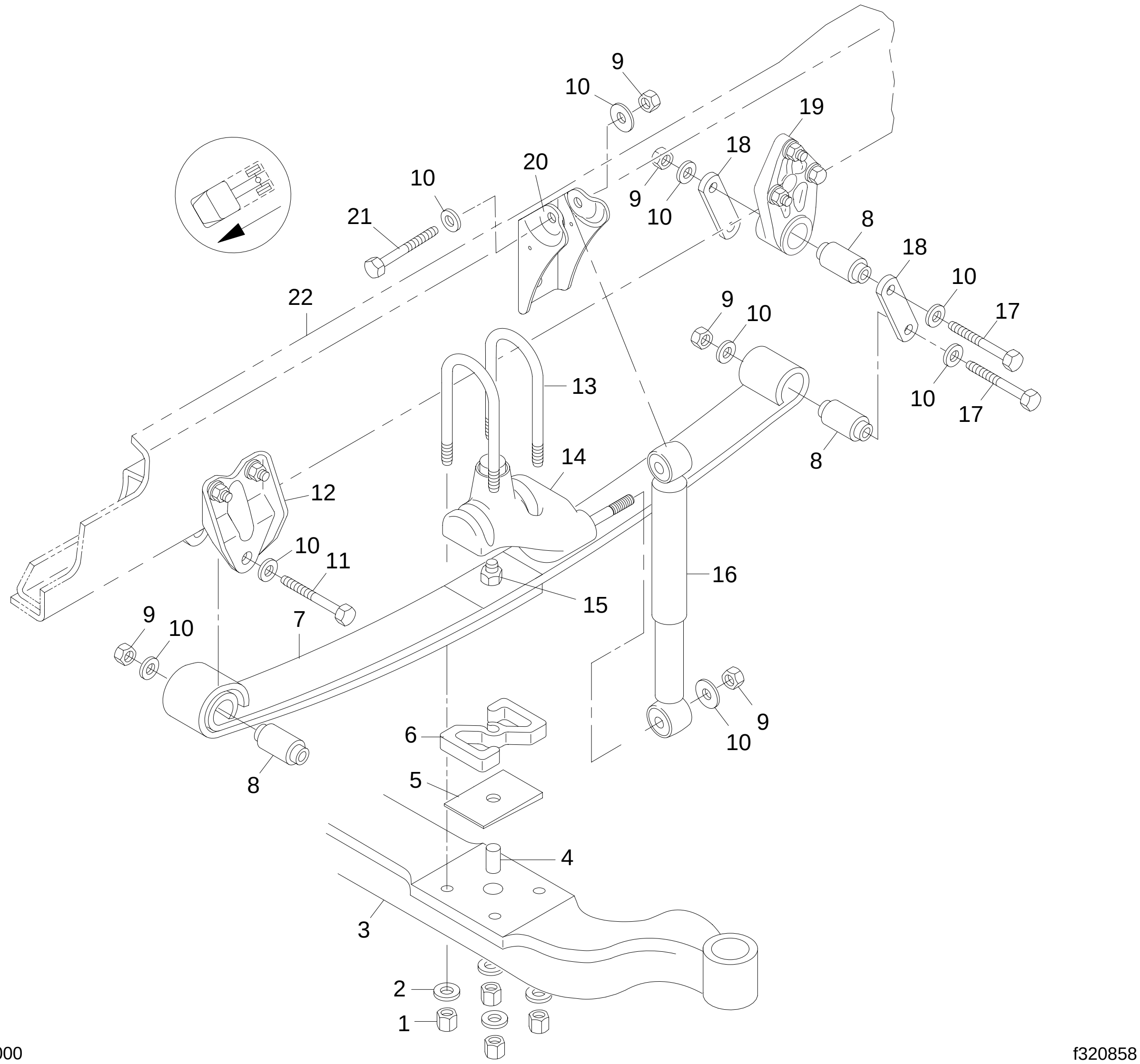
The spring assemblies are attached to the axle with U-bolts, hardened washers, and high nuts. The forward end of each spring contains a rubber bushing and a through-bolt that mounts to a stationary front suspension bracket. The rear of each spring mounts to a pair of spring shackles that are suspended from a frame-mounted bracket. The rear spring eye and shackle bracket each contain a rubber bushing and a through-bolt to allow the spring shackles to pivot. The spring shackles allow for variations in spring length during spring flexing.

The leaf spring assembly absorbs and stores energy, then releases it. The individual leaves are held together by a center bolt, with the center bolt nut used as a locating dowel for the axle stop and shock-absorber lower bracket installation on the vehicle.

Steel spring pins with bronze bushings are available as an option. See Fig. 2. These pins have a longitudinal lubrication groove in them. Bronze bushings are used with 12,000-pound or 14,000-pound leaf springs, and are graphite impregnated with a grease seal at each end.

Threaded spring pins with threaded steel bushings are also available with 12,000-pound or 14,000-pound front leaf suspensions.

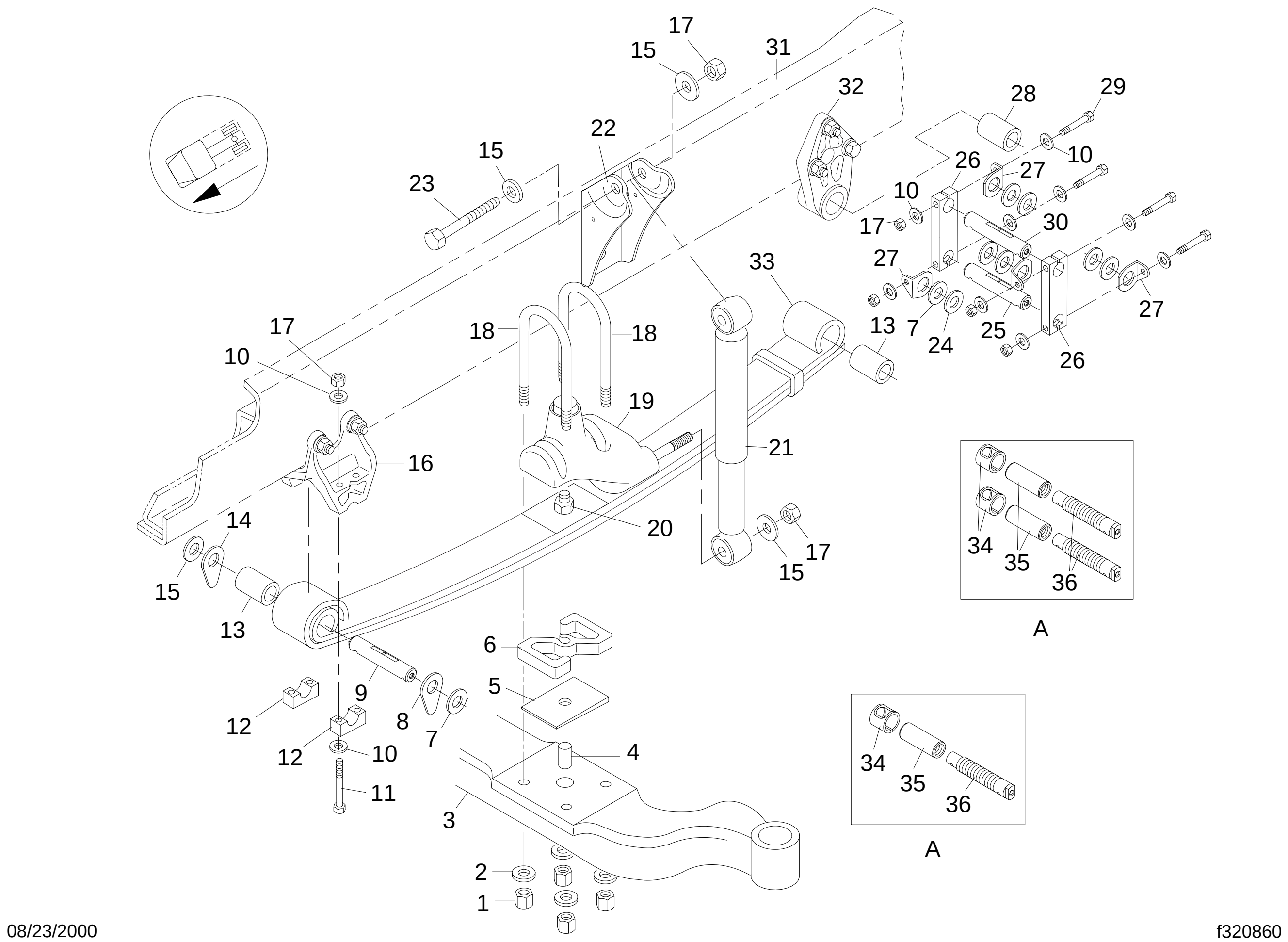
General Information



1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Spring Assembly
8. Spring Pin and Rubber Bushing Assembly
9. Locknut, 3/4–10
10. Hardened Washer
11. Spring-Eye Bolt
12. Forward Spring Bracket
13. U-Bolt
14. Axle Stop and Shock Absorber Lower Mounting Bracket
15. Spring Center-Bolt and Nut
16. Shock Absorber
17. Shackle Bolt, 3/4–10
18. Spring Shackle
19. Shackle Bracket
20. Shock Absorber Upper Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

Fig. 1, Front Suspension with Rubber Bushings

General Information



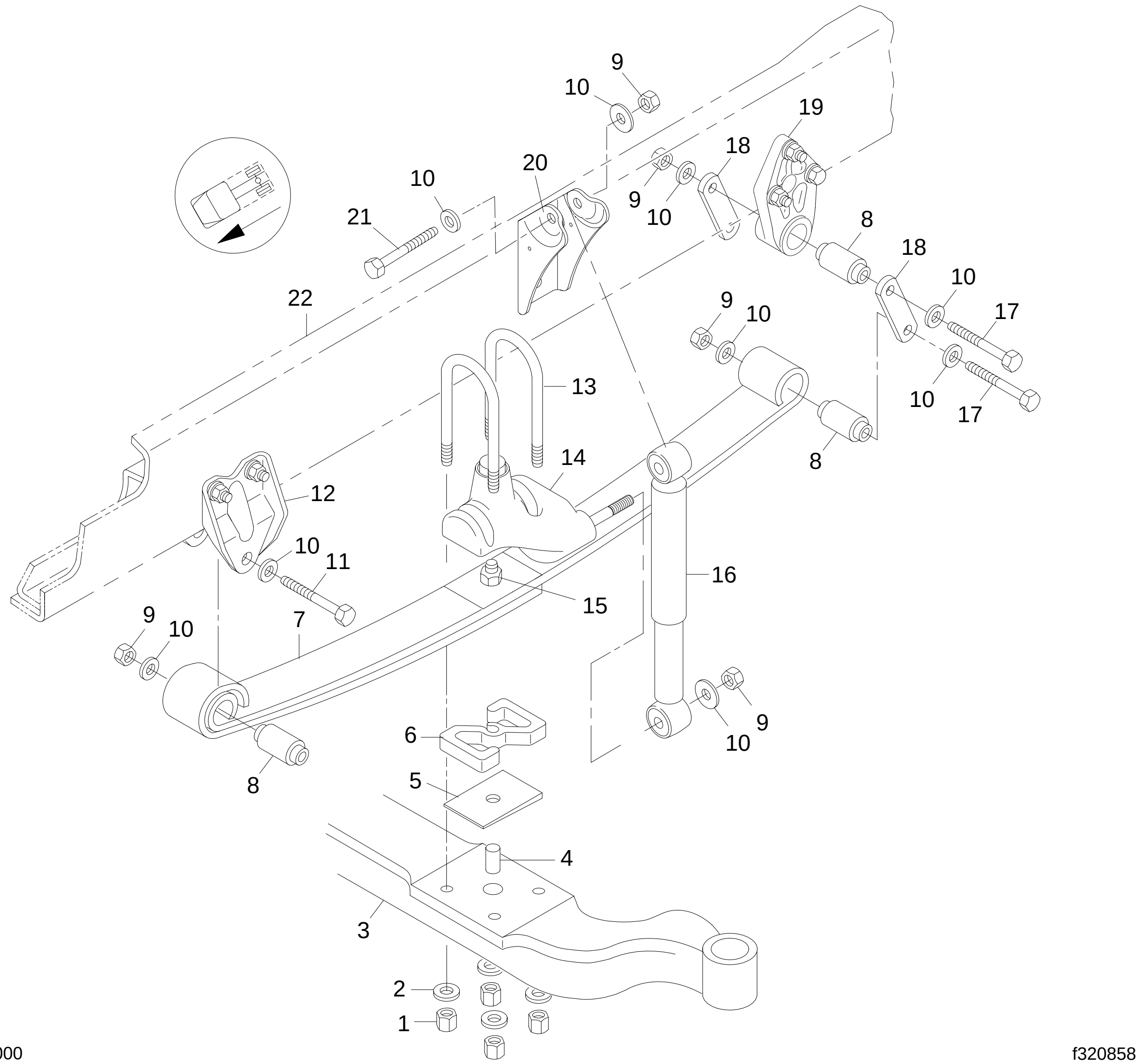
A. Equipped with Threaded Spring Pins

1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Outboard Spacing Washer(s)
8. Outboard Spring Spacer
9. Spring Pin, Forward Spring Eye
10. Hardened Washer, 1/2–13
11. Hexbolt, 1/2–13 x 5"
12. Spring Pin Retainer
13. Spring-Eye Bushing
14. Inboard Spring Spacer
15. Hardened Washer
16. Front Suspension Bracket
17. Locknut, 3/4–10
18. U-Bolt
19. Axle Stop and Lower Shock Absorber Lower Mounting Bracket
20. Spring Center-Bolt and Nut
21. Shock Absorber
22. Shock Absorber Upper Mounting Bracket
23. Hexbolt, 3/4–10 Hardened Washer
24. Hardened Washer, 2-1/4" o.d.
25. Spring Pin, Rear Spring Eye
26. Shackle
27. Wear Plate
28. Shackle Bracket Bushing
29. Pinch Bolt, 1/2–13 x 4"
30. Spring Pin, Shackle Bracket
31. Frame Rail
32. Shackle Bracket
33. Leaf Spring
34. Split Ring
35. Threaded Bushing
36. Threaded Spring Pin

Fig. 2, Front Suspension with Bronze Bushings or Threaded Spring Pins

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

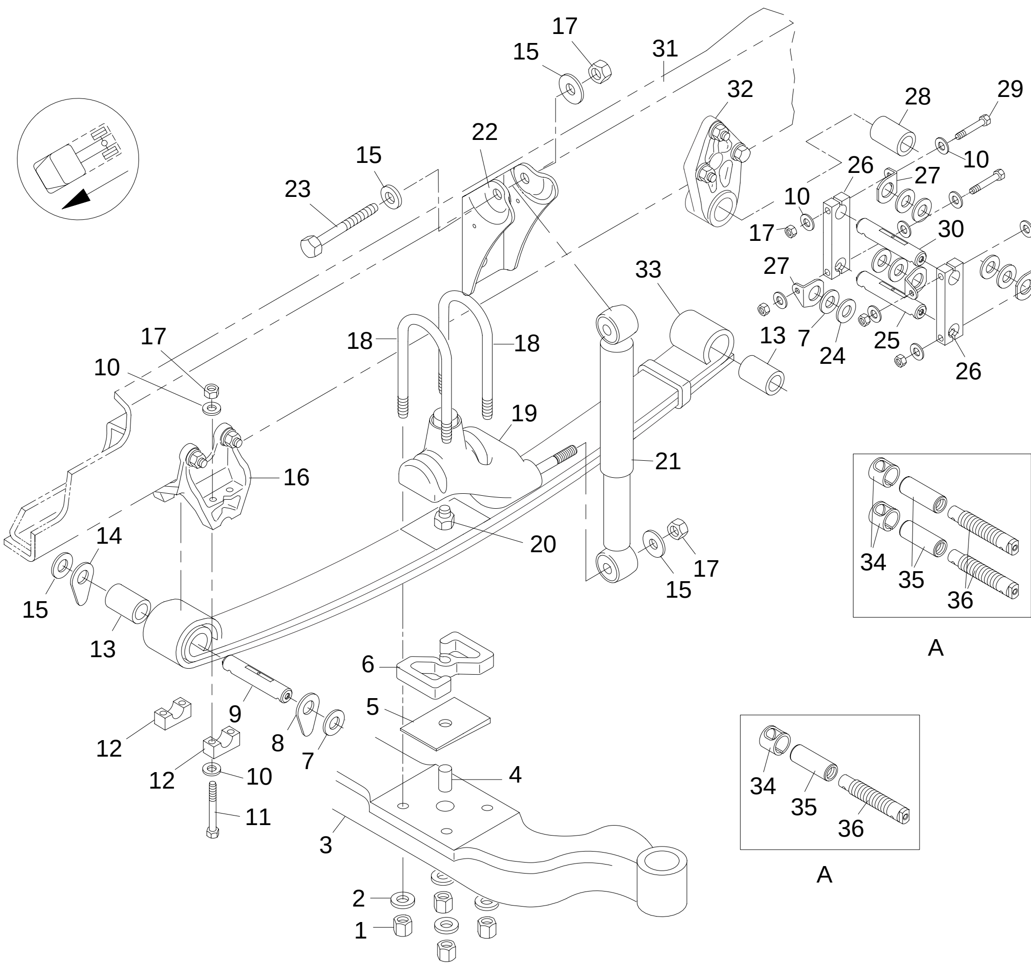
Removal (See Fig.1 orFig.2)



1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Spring Assembly
8. Spring Pin and Rubber Bushing Assembly
9. Locknut, 3/4–10
10. Hardened Washer
11. Spring-Eye Bolt
12. Forward Spring Bracket
13. U-Bolt
14. Axle Stop and Shock Absorber Lower Mounting Bracket
15. Spring Center-Bolt and Nut
16. Shock Absorber
17. Shackle Bolt, 3/4–10
18. Spring Shackle
19. Shackle Bracket
20. Shock Absorber Upper Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

Fig. 1, Front Suspension with Rubber Bushings

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



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A. Equipped with Threaded Spring Pins

1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Outboard Spacing Washer(s)
8. Outboard Spring Spacer
9. Spring Pin, Forward Spring Eye
10. Hardened Washer, 1/2–13
11. Hexbolt, 1/2–13 x 5"
12. Spring Pin Retainer
13. Spring-Eye Bushing
14. Inboard Spring Spacer
15. Hardened Washer
16. Front Suspension Bracket
17. Locknut, 3/4–10
18. U-Bolt
19. Axle Stop and Lower Shock Absorber Lower Mounting Bracket
20. Spring Center-Bolt and Nut
21. Shock Absorber
22. Shock Absorber Upper Mounting Bracket
23. Hexbolt, 3/4–10 Hardened Washer
24. Hardened Washer, 2-1/4" o.d.
25. Spring Pin, Rear Spring Eye
26. Shackle
27. Wear Plate
28. Shackle Bracket Bushing
29. Pinch Bolt, 1/2–13 x 4"
30. Spring Pin, Shackle Bracket
31. Frame Rail
32. Shackle Bracket
33. Leaf Spring
34. Split Ring
35. Threaded Bushing
36. Threaded Spring Pin

Fig. 2, Front Suspension with Bronze Bushings or Threaded Spring Pins

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

1. Apply the parking brakes and chock the rear tires. Raise the vehicle until both wheels are off the ground and the frame is supported with safety stands. The axle and leaf springs can then be manipulated with the floor jack.

IMPORTANT: Make sure the frame rails are level and an equal distance off the ground.

2. On vehicles with tapered leaf spring assemblies, unplug the road-light wires behind the front bumper. Remove the bumper mounting bolts; reference the location of the mounting bolt spacers for later assembly. Remove the bumper from the vehicle.

   On vehicles with flat leaf spring assemblies, remove the wheel and tire. For instructions, refer to **Group 40** in this manual.

3. Remove the U-bolts, stop assembly, and spring liner (if equipped) from the spring.
4. On vehicles equipped with shock absorbers, compress the shock absorber to prevent it from interfering with further work.

NOTE: if necessary, remove the mud guards to access the shackles.

5. Starting at the aft end of the spring, remove the flanged pinch bolts and flanged nuts securing the shackle spring pin.
6. If the spring pin is threaded, unscrew it from the bushing.

   If the spring pin is nonthreaded, drive it outboard with a suitable drift and remove it.

   Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

7. Remove the flanged pinch bolts and flanged nuts from the forward frame bracket.
8. If the spring pin is threaded, unscrew it from the bushing.

   If the spring pin is nonthreaded, drive it inboard with a suitable drift to remove it.

   Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

9. Remove the spring assembly by lifting it up off the axle and out the front of the truck. Note the taper direction of the caster shim so that it will not be reversed during installation
10. If the shackle pin or shackle bracket bushings are to be inspected or replaced, remove the pin.

    10.1 Remove the flanged pinch bolts and flanged nuts.

    10.2 Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

    10.3 If the shackle pin is threaded, unscrew it from the shackle pin bushing.

    10.4 If the shackle pin is nonthreaded, drive the pin outboard using a suitable drift to remove it.

11. Remove the shackle bracket for inspection; replace its bushing if necessary. See the applicable steps under "Cleaning and Inspection" in this subject.

Cleaning and Inspection

1. Using a wire brush and solvent or steam cleaning equipment, wash all parts to remove dirt, grease, and scale.
2. Inspect the shackle bracket and the spring shackles for cracks, wear, or other damage. Replace damaged parts.
3. Inspect the spring for cracks and corrosion. If any leaves are cracked or broken, replace the entire spring assembly.

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. On front spring assemblies, if cracks or breaks exist in the two top leaves, a loss of vehicle control could occur. Failure to replace a damaged spring assembly could cause an acci-

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

dent resulting in serious personal injury or property damage.

4. If the protective coating is gone from some areas of the spring, paint the cleaned areas with a rust-inhibiting paint. If rusting or corrosion is severe, replace the spring.
5. Using a micrometer, check nonthreaded spring pins and shackle pin for wear.

   On leaf spring assemblies, replace a pin if the diameter at any point on the pin is less than 1.242 inches (31.54 mm).
6. Inspect threaded spring and shackle pins for cracked or broken threads. Replace any pin that has damaged threads.
7. Inspect the spring and bracket bushings. Replace the bushings if gouged, cracked, pitted, or otherwise damaged. For instructions, see **Subject 110**.
8. If nonthreaded bushings are not damaged, inspect them for wear. Using a micrometer, check the inside diameter of each bushing. The inside diameter of any bushing should not exceed the diameter of its pin by more than 0.010 inch (0.25 mm). Replace any bushing that exceeds this limit.

Installation (See Fig.1or Fig.2)

WARNING

Failure to install identical spring assemblies could affect the balance of the front suspension and cause difficult handling of the vehicle, resulting in injury or property damage.

1. Install the shackle bracket if previously removed. Tighten the mounting fastener locknuts 190 lbf·ft (260 N·m).

NOTE: All suspension bracket (frame) fasteners require periodic retorquing. Refer to the suspension section in the vehicle maintenance manual for instructions.

2. Using multipurpose chassis grease, lubricate both spring pins, the shackle pin, and the inside surfaces of the bushings.
3. If the shackle was disconnected from the shackle bracket, attach it to the bracket.

   3.1 Apply Alumilastic® or similar compound to all areas of the shackle that contact metal. This includes all capscrews, washers, and locknuts that contact the aluminum shackle. Do not apply the compound to the inner (bearing) surface of the bushing or on fastener threads.

CAUTION

Failure to apply Alumilastic or similar compound will result in electrolytic corrosion of dissimilar metal components, and will damage the suspension system.

   3.2 Install the shackles.

NOTE: When nonthreaded shackle pins are used, make sure the correct spacing washers are inserted between bracket ends and shackles. Be sure the hardened wear washers are in direct contact with the spring eye.

   3.3 Insert the nonthreaded pin or screw in the threaded pin with its grease fitting end toward the outboard side. Install the split ring on the inboard end of the threaded pin. Align the grooves of the pin with the flanged pinch-bolt bores.

   3.4 Install the flanged pinch bolts and flanged nuts to hold the shackle pin and spacing washers in place. Torque the nuts 95 lbf·ft (130 N·m).

CAUTION

Do not overtighten the shackle pinch-bolt nuts. Overtightening these nuts could distort and weaken the aluminum shackles.

4. Place the caster shim on the front axle in the position referenced earlier.
5. Install the spring assembly on the caster shim; make sure the spring bolt head fits into the bore in the axle.
6. Place the axle stop assembly and spring liner (if equipped) on top of the spring assembly.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

7. Place the U-bolts over the axle stop and spring assembly and through the holes in the axle. It may be necessary to slightly compress the sides of the U-bolts in order to get the U-bolt ends to align with the axle holes. A C-clamp attached above the U-bolt threads can be used for this purpose.
8. Attach the hardened washers and the high nuts finger-tight.
9. Attach the spring assembly to the frame bracket.
   9.1 With nonthreaded spring pins, hold the correct number of spacing washers, as referenced during removal, between the outboard end of the bracket and the spring; insert the grease fitting end of the pin far enough into the bushing to hold the spacers in place. Hold the remaining spacers in place and push the spring pin in until its grooves align with the frame bracket's flanged pinch-bolt bores.

   With threaded pins, screw the pin all the way into the bushing with the grease fitting end toward the outboard side until the spring pin grooves align with the frame bracket's flanged pinch-bolt bores. Install the split ring on the inboard end of the pin.

   9.2 With nonthreaded spring pins, check for play between the spring and the bracket ends. If needed, install additional 1/32-inch spacing washers (1-1/8 inch i.d., 1-7/8 inch o.d.) so that there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the difference between the two sides should be no more than one spacing washer.

   9.3 Install the flanged pinch bolts and flanged nuts. Tighten the nuts 95 lbf·ft (130 N·m).
10. Attach the spring assembly to the shackle bracket.
   10.1 With nonthreaded spring pins, hold the correct number of spacing washers, as referenced during removal, between the outboard shackle and the spring. With the grease fitting pointed to the outboard side, insert the spring pin far enough into the bushing to hold the spacers in place. Hold the remaining spacers in place and push the pin until its grooves align with the shackle pinch-bolt bores.

   With threaded spring pins, screw the pin all the way into the bushing with the grease fitting end toward the outboard side until the spring pin grooves align with the shackle pinchbolt bores. Install the split ring on the inboard end of the pin.

   10.2 With nonthreaded spring pins, check for play between the spring and the shackle ends. If needed, install additional 1/32-inch spacing washers (1-1/8 inch i.d., 1-7/8 inch o.d.) so that there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the difference between the two sides should be no more than one spacing washer.

   10.3 With both threaded and nonthreaded spring pins, install the flanged pinch bolts and flanged nuts. Tighten the nuts 95 lbf·ft (130 N·m).

CAUTION

Do not overtighten the shackle pinch-bolt nuts. Overtightening these nuts could distort and weaken the shackles.

11. Attach the hardened washers and high nuts to the U-bolts. For U-bolt tightening instructions and torque values, see the applicable table in **Specifications, 400**.

CAUTION

Failure to retorque the fasteners as instructed could result in spring breakage and abnormal tire wear.

12. Wipe all dirt from the grease fittings on the spring pins and the shackle pin. Apply multipurpose chassis grease with a pressure gun until grease appears at the opposite end of the pin.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

13. On vehicles with flat leaf spring assemblies, install the tire and wheel. For instructions, refer to **Group 40** in this manual.
14. Remove the jack stands from the chassis, and lower the truck.
15. On vehicles with tapered leaf spring assemblies, install the bumper and attach the road-light wires. Make sure the spacers are in the locations referenced earlier.

Shackle Bracket Bushing Replacement

1. With the shackle bracket removed from the vehicle, press out the worn or damaged bushing.
2. With an inside micrometer or bore gauge, check the bracket bore for damage or wear. Replace the bracket if the bushing bore is damaged or worn.
3. *If installing rubber bushings,* check the shackle bracket bolt for ease of fit in the bushing. It should have an easy slip fit without wobble between it and the bushing.

CAUTION

Do not press in rubber bushings by the center sleeve. To do so could damage the bushings.

4. Press the new bushing into the bracket until the bushing is centered in the bracket.
5. Check the shackle bracket bolt again for ease of fit in the bushing. It should still have an easy slip fit without wobble between it and the bushing. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.
6. *If installing bronze bushings,* check the shackle pin for ease of fit in the bushing. It should have an easy slip fit without wobble between it and the bushing.
7. Press the new bushing into the bracket until the bushing is centered in the bracket. The bushing ends must be flush or inside the vertical edges of the bracket bore, and the split in the bushing must be within 1/4 inch (6 mm) of the bottom of the bracket bore.

   Check the shackle pin again for ease of fit in the bushing. It should still have an easy slip fit without wobble between it and the bushing. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.
8. *If installing threaded shackle pins,* check the fit of the threaded pin in the bushing. It should screw in easily by hand without binding. Press the new bushing into the bracket until the bushing is centered in the bracket. Check the threaded pin again for ease of fit in the bushing. It should still screw in easily by hand without binding. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.

Spring Bushing Replacement

1. Remove the leaf spring. See **Subject 100** for instructions
2. Press out the worn or damaged bushing.

CAUTION

Do not press in the bushing by the center sleeve. To do so could damage the bushing.

3. *If installing rubber bushings,* apply a coating of Perma-Bond® HM–160 or Loctite® RC–609 adhesive to the inside of the spring eye, and to the outside of the bushing. Press the new bushing into the spring eye until the bushing is flush with the edges of the spring eye.

   If installing bronze bushings, press the new bushing into the spring eye until the bushing and the spring edges are flush. The split in the bushing must be within 3/16 inch (5 mm) of the top of the spring eye.

   If installing bushings for threaded spring pins, press the new bushing into the spring eye until the bushing is flush with the edges of the spring eye.
4. Install the leaf spring. See **Subject 100** for instructions.

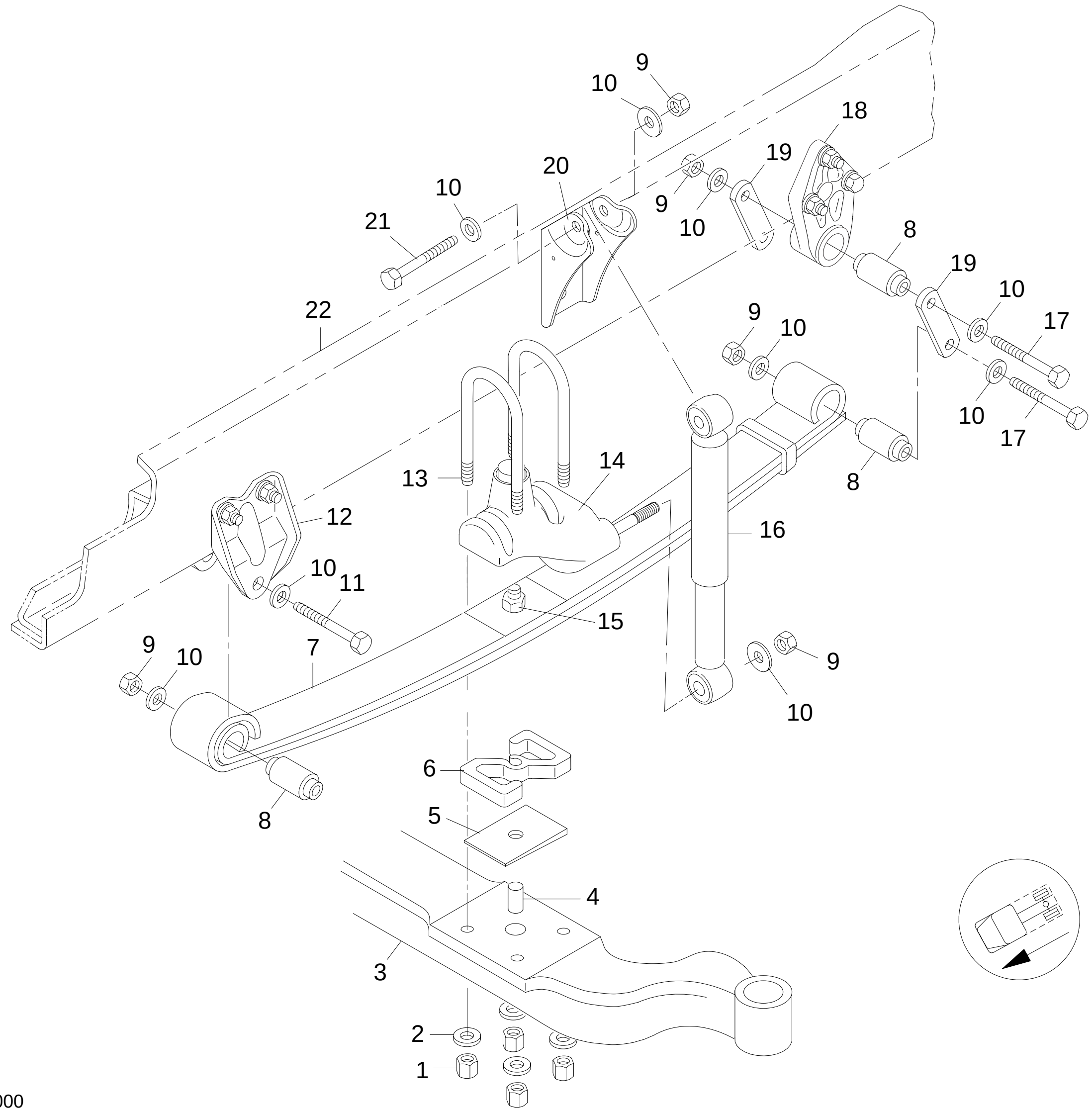
Removal (See Fig. 1)

1. Remove the 3/4–10 hexbolt, hardened washers, and locknut from the shock shcok absorber and the upper mounting bracket.
2. Swing the shock absorber out away from the upper mounting bracket.
3. Remove the 3/4–10 locknut and hardened washer from the stud of the lower mounting bracket.
4. Pull straight out on the lower part of the shock absorber to remove it.

Installation (See Fig. 1)

1. Apply a suitable antiseize compound to the threads of the lower mounting bracket stud, then slide the shock absorber onto the stud.
2. Install the washer and a new locknut on the bracket studs. Tighten the locknut just enough to hold the shock aborber in place.
3. Swing the shock absorber up and align the upper eye of the shock absorber with the holes of the upper mounting bracket.
4. Install a hardened washer and the 3/4–10 hexbolt through the mounting holes and the eye of the shock absorber. Make sure the hexbolt head is facing toward the front of the vehicle.
5. Install a washer and 3/4–10 locknut onto the hexbolt. Tighten 150 lbf·ft (203 N·m).
6. Tighten the nut on the lower mount 140 lbf·ft (190 N·m).

Shock Absorber Removal and Installation



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1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Spring Assembly
8. Spring Pin and Rubber Bushing Assembly
9. Self-Locking Nut, 1/2–13
10. Hardened Washer
11. Spring-Eye Bolt
12. Forward Spring Bracket
13. U-Bolt
14. Shock Absorber Lower Mounting Bracket
15. Spring Center-Bolt and Nut
16. Shock Absorber
17. Shackle Bolt
18. Shackle Bracket
19. Spring Shackle
20. Shock Absorber Upper Mounting Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

Fig. 1, Front Suspension with Rubber Bushings

Vehicle Lean Inspection

IMPORTANT: Chassis lean can be caused by several factors such as uneven vehicle weight distribution, mismatched springs, or improper spacer installation. The following instructions detail inspecting for and correcting chassis lean due to improper spring or spacer installation. Additional troubleshooting procedures may also be found at the Hendrickson website

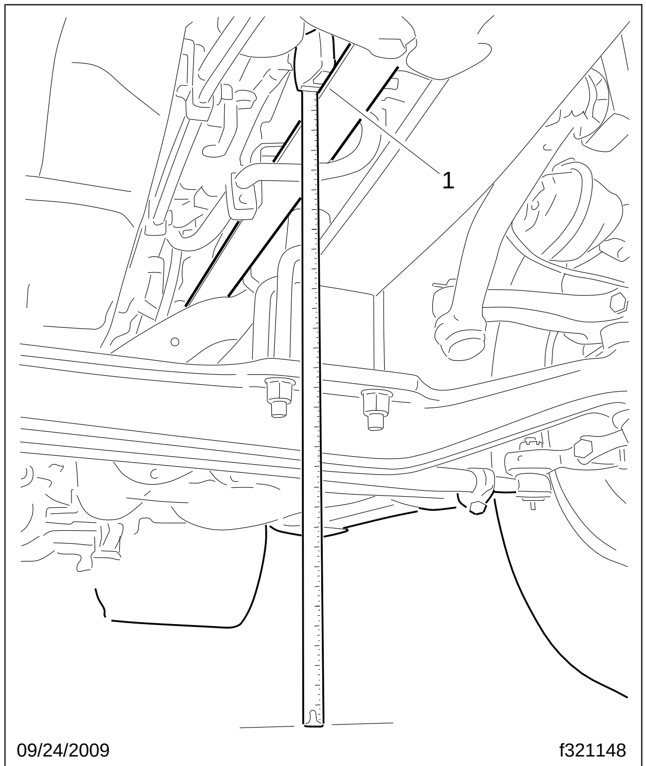
(www.hendrickson-intl.com/literature/pdfs_tech_airtek_freightliner.asp).

1. Park the vehicle on a level surface with the wheels pointing straight ahead. Set the parking brake, turn off the engine, and chock the tires. When exiting the vehicle, try not to rock the vehicle.

NOTE: The vehicle should be unloaded when performing the following inspection.

2. Check tire pressure and tire size. Pressures should be within 2 psi of each other. Tire size should be the same on each axle.
3. Check that the rear axle alignment and rear suspension ride height are within specification. Refer to the applicable sections in **Group 32** or **Group 35** in this manual.
4. Check the springs, bushings and spring mounting hardware for damage. Replace damaged components before checking for chassis lean.
5. Measure the weight of the vehicle at each wheel position. Weight imbalance will cause the vehicle to lean. If the vehicle weight differs from side to side, check the cab alignment and the fuel tank levels, and correct if necessary.
6. Measure the distance from the bottom of the lower frame flange to the ground, forward of the front axle center line. This is frame height. See **Fig. 1**.
7. If the frame height differs from side to side by 3/8 inch (9.53 mm) or more, inspect the spring part numbers, and (if present) markings on the top side of the springs with a label marking plus (+) or minus (–). Verify that both spring labels match.

   If the labels or part numbers do not match, replace one or both springs so the vehicle has matching springs. See **Fig. 2**.



1. Lower Frame Flange

Fig. 1, Measuring Frame Height

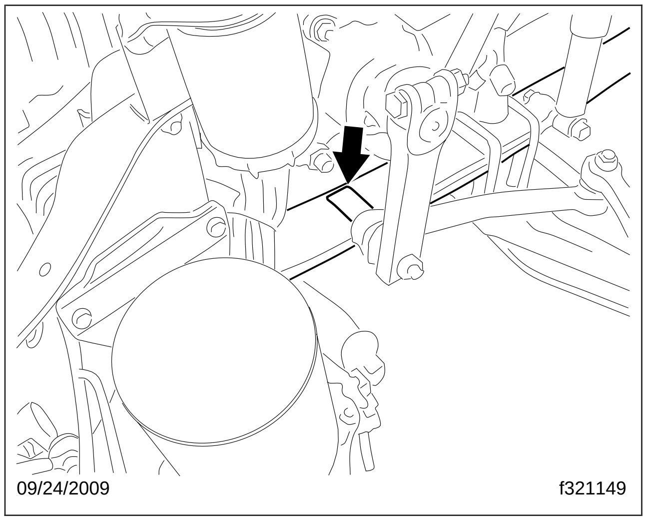


Fig. 2, Spring Label Location

8. Measure the height difference at the end of the frame rails to ground. If this measurement is greater than 3/8 inch (9.53 mm), the front axle

Troubleshooting

spacer adjustments will have minimal effect on lean and other actions are required. If the end of frame to ground measurements are less than 3/8 inch (9.53 mm) difference, correct the lean by increasing the low side front axle spacer thickness by no more than 1/2 inch (13 mm). Use a 45, 55, or 65-mm spacer in place of the existing spacer.

See **Table 1** for parts information.

9. Check the frame height again. If the difference between measurements is still equal to or greater than 3/8 inch (9.53 mm), swap springs from side to side and check the measurements again.

   If the chassis lean is still the same, the problem is with the vehicle. If the lean has changed sides, replace both springs.

10. **Figure 3** represents a checklist for weak or sagging springs.

    Use this checklist as the information may be requested when filing a warranty claim.

Part Description	Part Number	Quantity
Axle Spacer, 45 mm	16-15105-040	As Required
Axle Spacer, 55 mm	16-15105-055	As Required
Axle Spacer, 65 mm	16-15105-065	As Required

Table 1, Parts Information

Troubleshooting Tables

Problem—Vehicle Wanders

Problem—Vehicle Wanders	
Possible Cause	**Remedy**
One or more spring leaves are broken.	Replace the spring assembly.
The wheels are out of alignment.	Adjust the wheel alignment using the instructions in **Group 33** of this manual.
Caster is incorrect.	Install correct caster shims. Refer to **Group 33** of this manual for specifications.
Steering gear is not centered.	Adjust steering using the instructions in **Group 46** of this manual.
Drive axles are out of alignment.	Align the drive axles using the instructions in **Group 35** of this manual.

Problem—Vehicle Bottoms Out

Problem—Vehicle Bottoms Out	
Possible Cause	**Remedy**
Excessive weight on the vehicle is causing an overload.	Reduce the loaded vehicle weight to the maximum spring capacities.
One or more spring leaves are broken.	Replace the spring assembly.
The spring assembly is weak or fatigued.	Replace the spring assembly.

Problem—Frequent Spring Breakage

Problem—Frequent Spring Breakage	
Possible Cause	**Remedy**
The vehicle is overloaded or operated under severe conditions.	Reduce the loaded vehicle weight to the maximum spring capacities. Caution the driver on improper vehicle handling.
There is insufficient torque on the U-bolt high nuts.	Torque the U-bolt high nuts to the value listed in the torque table in **Specifications, 400**.

Problem—Frequent Spring Breakage	
Possible Cause	**Remedy**
A loose center bolt is allowing the spring leaves to slip.	Check the spring leaves for damage. If damaged, replace the spring assembly. If not, tighten the center-bolt nut to the value listed in torque table in **Specifications, 400**.
Worn or damaged spring pin bushings are allowing spring end-play.	Replace the spring pin and bushing.

Problem—Noisy Spring

Problem—Noisy Spring	
Possible Cause	**Remedy**
A loose U-bolt nut or center bolt is allowing spring leaf slippage.	Inspect the components for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table in **Specifications, 400**.
A loose, bent, or broken spring shackle or front suspension bracket is impairing the spring flex.	Inspect the shackles and brackets for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table in **Specifications, 400**.
Worn or damaged spring pins are allowing spring end-play.	Replace any worn or damaged spring pins.

Problem—Rough Ride

Problem—Rough Ride	
Possible Cause	**Remedy**
Refer to the applicable suspension section in this manual.	

Troubleshooting

The following is a checklist for weak or sagging springs. This information may be requested when filing for warranty.

Conditions

☐ Is the ground level?

(If ground is not level move the truck to a level location)

☐ Is the vehicle loaded?

(Vehicle should be measured unloaded)

☐ Are the spring part numbers the same?

(Part numbers should be the same)

☐ Is there any visible damage to the spring or bushings?

(Any damage to the springs, bushings, shocks, or suspension brackets should be repaired)

Tires

☐ Are the tire pressures and sizes the same?

(Tire pressure should be within 2 psi from side to side)

☐ Do the tires have the same amount of wear?

☐ Are the tires the same size?

Measurements

☐ Measure the distance from the floor to the bottom of the frame rail on each side of the truck as close to the front axle as possible.

Passenger Side __________

Driver Side __________

(Measurements should be within 3/8” from side to side)

Weight

☐ Measure the weight of the vehicle at each forward axle position.

Passenger Side __________

Driver Side __________

(Weight should be equal from side to side. If weight is more on one side, check that the cab is centered on the frame rails, and if equipped with dual tanks, that the fuel level is equal on both sides. Due to the many options available for mounting components, the vehicle may have a weight bias to one side. If the vehicle does have a weight bias to one side, the spring can be shimmed to level the vehicle.)

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Fig. 3, Checklist for Weak or Sagging Springs

Front Suspension Fastener Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
Shackle Bracket-to-Frame Locknut	3/4–10	240 (325)
Forward Spring-Eye Bolt	3/4–10	240 (325)
Upper and Lower Shackle Bolt	3/4–10	240 (325)
Axle U-bolt High Nuts (Tighten in a diagonal pattern as shown in **Fig. 1**.)	5/8–18	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 180–230 (245–313)
	3/4–16	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 270–330 (367–449)
	7/8–14	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420–500 (571–680)
	1–14	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520–600 (707–816)
Spring Assembly Center-Bolt Nut	1/2–20	65 (88)
Shock Absorber Upper and Lower Mounting Locknut	3/4–10	140 (190)

Table 1, Front Suspension Fastener Torque Values

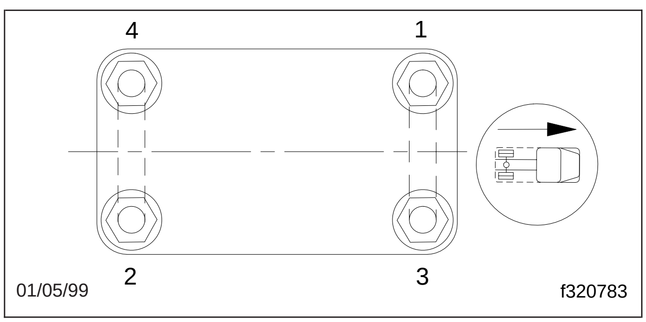
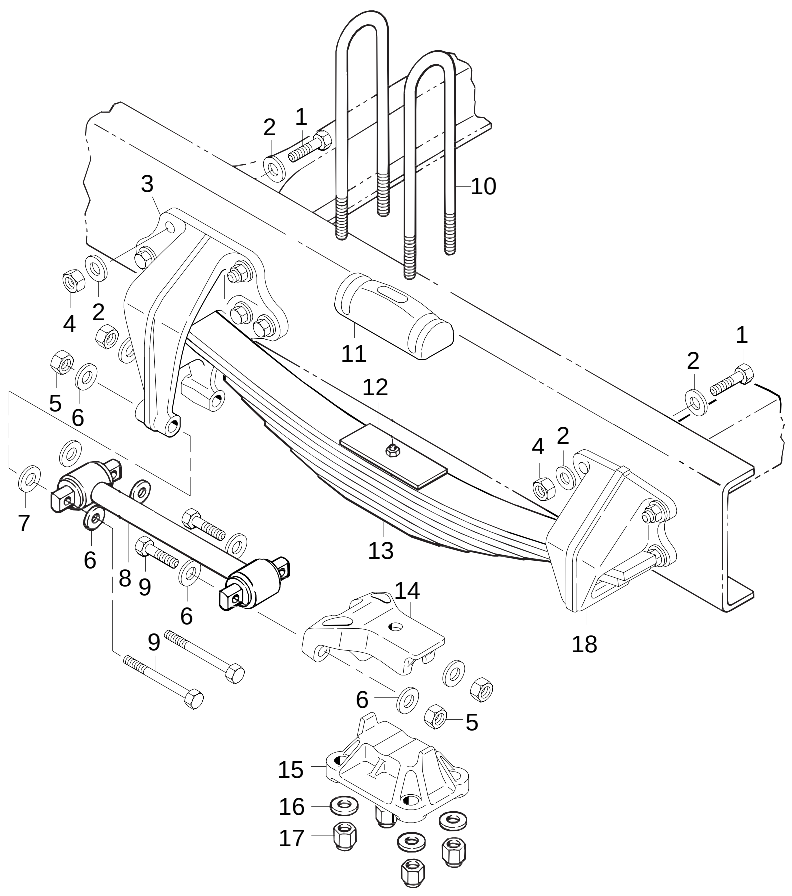


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Information

General Description

The single-axle rear spring suspension (**Fig. 1**) uses a full-floating spring design. Semi-elliptical spring assemblies are attached to the axles with U-bolt assemblies. The spring ends ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket. Radius rods attached to the axle seats and the forward spring brackets hold the axle in alignment.

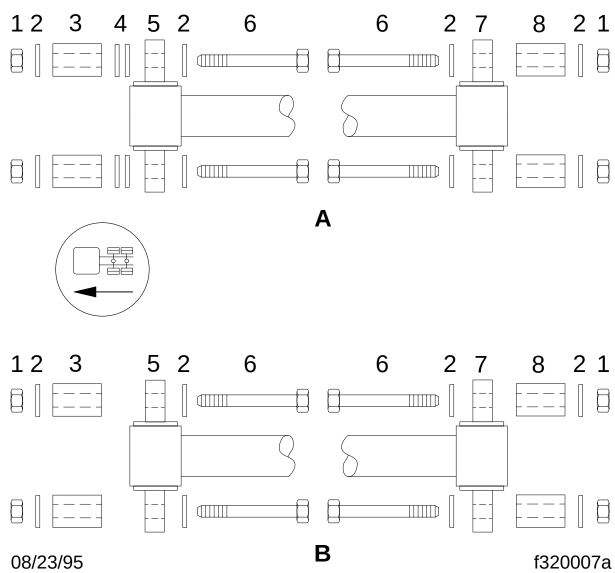


1. Huckbolt HP 8® Frame Fasteners
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Radius Rod
9. Radius Rod Hexhead Bolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Rear Spring Bracket

Fig. 1, Single-Axle Spring Suspension

Radius Rod Removal and Installation

Removal (See Fig. 1)



A. Right-Side Radius Rod
B. Left-Side Radius Rod
1. Hex Locknut
2. Hardened Washer
3. Forward Spring Bracket
4. Alignment Washers (install only on one side; right-side installation shown.)
5. Radius Rod Front Pin
6. Hexbolt
7. Radius Rod Rear Pin
8. Axle Seat

Fig. 1, Radius Rod Attachment (top view)

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (Ref. 4) at the forward end of the radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket and to the axle seat.
4. Remove the radius rod and any axle alignment washers.

Installation (See Fig. 1)

IMPORTANT: At all points where steel parts contact the aluminum forward spring bracket, apply Alumilastic® compound, or an equivalent, on the mating surfaces.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Place the radius rod pins between the rear side of the forward spring bracket, and the front side of the axle seat.
2. Install the hexhead bolts, hardened washers, and locknuts in the axle seat and the radius rod rear pin.
3. Install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket.
4. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
5. Check the axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Spring Assembly Replacement

Replacement (See Fig. 1)

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes, then block the axle. Make sure the stands will securely support the weight of the axles and frame. To gain easy access to the suspension system, remove the wheel assembly; see **Group 40** in this manual for instructions.
3. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
4. Lift the spring assembly off the axle seat, then move it to the rear, out of the forward spring bracket. Lift the front of the spring, then move it forward, out of the rear spring bracket.
5. Using chassis grease, lubricate the ends of the new spring where they contact the stationary wear shoes in the spring brackets.
6. Work the new spring assembly into the spring brackets, and place it on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
7. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
8. Install the U-bolt retainer, hardened washers, and new U-bolt high nuts. Tighten the high nuts until snug.
9. Tighten the axle U-bolt high nuts and torque to the specifications listed in **Subject 400**.

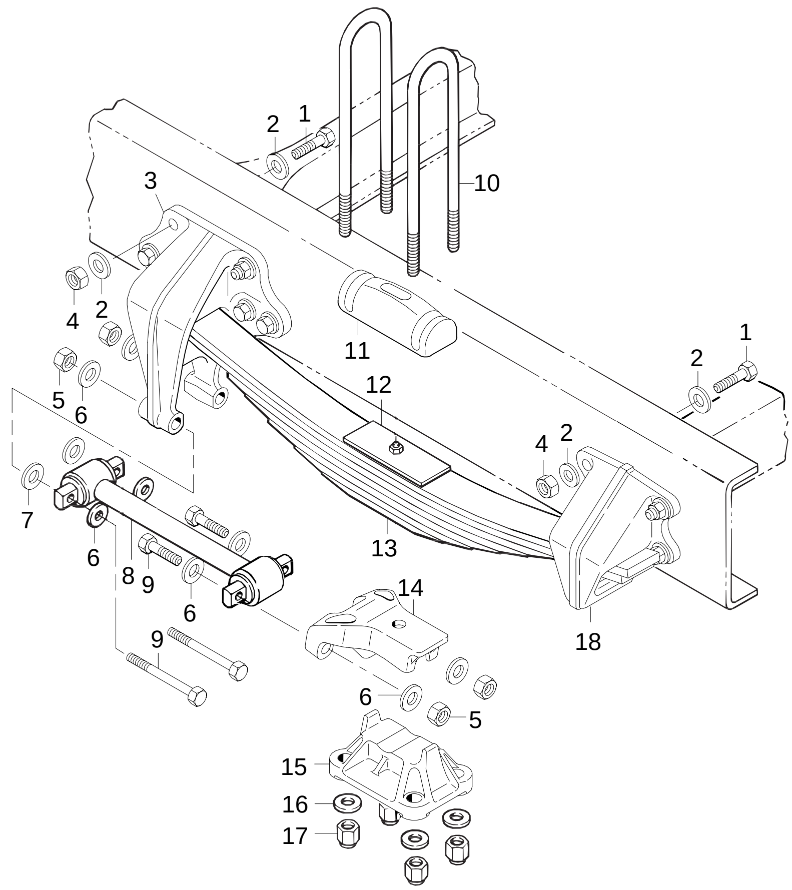
CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Columbia Maintenance Manual*.

10. Install the wheel assembly. For instructions, see **Group 40** in this manual. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the rear axle alignment. For instructions, see **Subject 130**.

Spring Assembly Replacement



1. Huckbolt HP 8® Frame Fastener
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Radius Rod
9. Radius Rod Hexhead Bolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Rear Spring Bracket

Fig. 1, Single-Axle Spring Suspension

Replacement

WARNING

Replace worn, cracked, or damaged spring brackets. Failure to do so could result in bracket breakage, possibly leading to loss of vehicle control and resulting in personal injury or property damage.

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact the aluminum spring brackets, apply Alumilastic® compound, or an equivalent, on the mating surfaces.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the rear axle with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axle and frame.

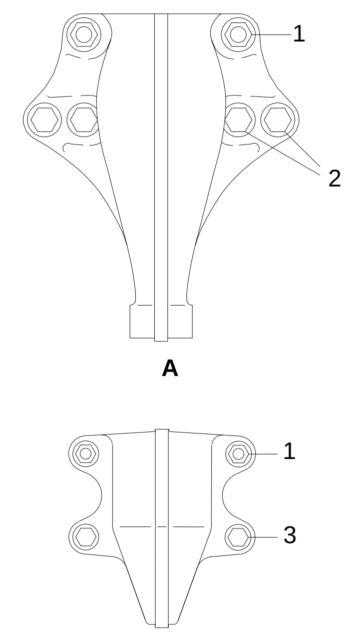
IMPORTANT: See **Section 31.01** of this manual for correct removal and installation of Huckbolt HP 8® frame fasteners. See **Fig. 1**.

3. If removing the forward spring bracket, note the number of axle alignment washers, if any, between the bracket and the radius rod front pin. Remove the fasteners that attach the radius rod to the bracket, and remove any axle alignment washers.
4. Remove the fasteners that attach the spring bracket to the frame rail, and remove the spring bracket.
5. Place the new spring bracket on the frame rail. Align the mounting holes, and install the spring bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. See **Fig. 1**.

If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. See **Fig. 1**.

6. Tighten the locknuts to the applicable torque value in **Specifications, 400**.



A. Forward Spring Bracket
B. Rear Spring Bracket
1. Huckbolt HP 8® Frame Fasteners
2. Bolt Heads (outboard)
3. Bolt Head (outboard)

Fig. 1, Frame Brackets

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

Spring Bracket Replacement

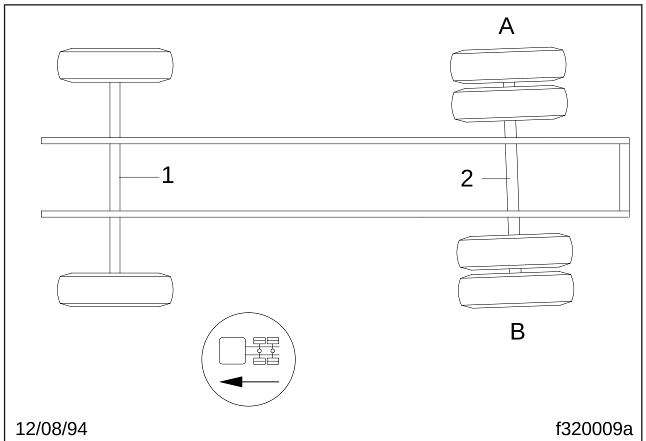
IMPORTANT: While Huck fasteners do not require periodic tightening, all standard suspension fasteners do. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the *Columbia Maintenance Manual*.

7. If replacing the forward spring bracket, position any previously removed axle alignment washers between the bracket and the radius rod front pin. Install the bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket. Tighten the locknuts to the torque value in **Specifications, 400**.
8. Remove the safety stands from under the frame and axle, and lower the vehicle.
9. Check the axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Rear Axle Alignment Adjustment

Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the axle at a right angle to the frame. For instructions, see **Group 35** in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 1**.



A. Leading End
B. Trailing End
1. Front Axle
2. Rear Axle

Fig. 1, Single Axle, Shown Out of Alignment

NOTE: To adjust the axle alignment, add washers between the radius rod front pin and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

2. On both sides of the axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the radius rod to the forward spring bracket. Remove any axle alignment washers.
4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will support the weight of the frame.
5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.
6. Insert the correct thickness of axle alignment washers between the radius rod front pin and the forward spring bracket.
7. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.
8. Tighten the locknuts to the applicable torque value in **Specifications, 400**.
9. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
10. Check the axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications, 400**.

    If not in alignment, repeat the procedure above.

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All standard suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the *Columbia Maintenance Manual*.

Specifications

Torque Values			
Description	Size	IFI Grade	Torque lbf·ft (N·m)
Forward Spring Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Axle U-bolt High Nuts Tighten in a diagonal pattern as shown in Fig. 1.	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420–500 (571–680)
	1–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520–600 (707–816)
Rear Spring Bracket-to-Frame Rail Locknut *	5/8–11	C	135 (184)
Radius Rod Locknut *	5/8–18	C	135 (184)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.

Table 1, Torque Values

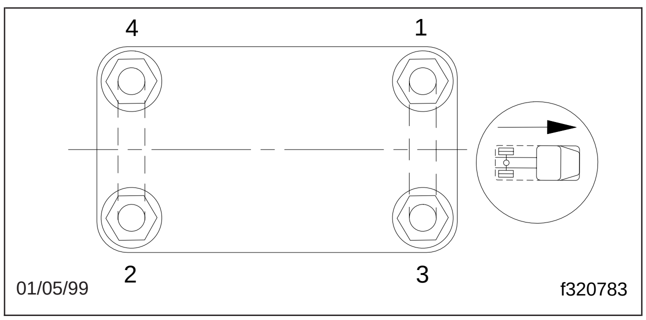


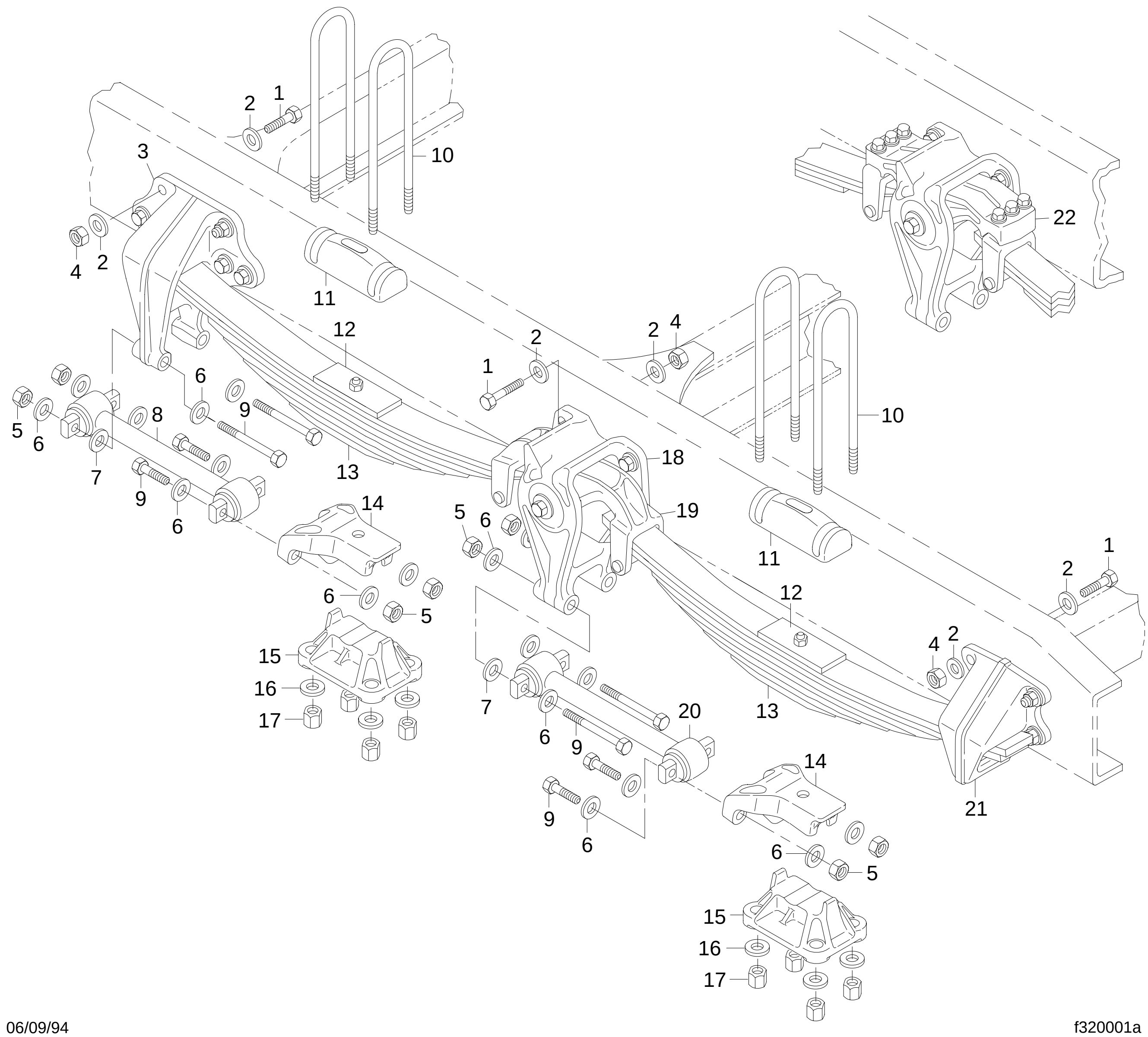
Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

The tandem-axle rear spring suspension (**Fig. 1**) uses a six-point equalizing leaf spring design, which compensates for axle articulation, from side to side, and front to rear. Four semi-elliptical spring assemblies are attached to the axles with U-bolts. On both sides of the vehicle, the forward end of the forward spring and the rear end of the rear spring ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket.

At the center, between the forward and rear springs, the springs ride on an equalizer, which pivots on a sleeve in the equalizer bracket. Equalizer travel is stopped when the top of the equalizer and equalizer bracket make contact. Each axle is held in alignment by a pair of radius rods that extend forward from the axle seats to the forward spring brackets for the forward-rear axle, and to the equalizer brackets for the rearmost axle.

General Information

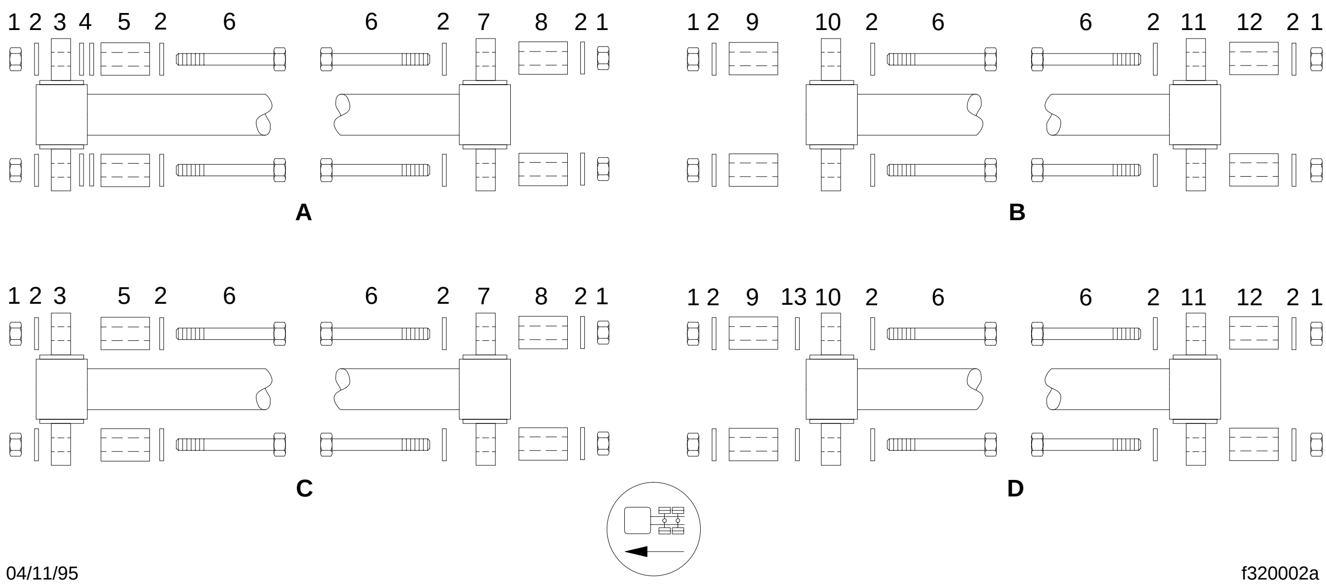


1. Huckbolt HP 8® Frame Fasteners
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

Radius Rod Removal and Installation

Removal (See Fig. 1)



A. Forward Right-Side Radius Rod
B. Rear Right-Side Radius Rod
C. Forward Left-Side Radius Rod
D. Rear Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Radius-Rod Front Pin
4. Alignment Washers (Install only on one side of front axle; right-side installation shown.)
5. Forward Spring Bracket
6. Hexbolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius-Rod Front Pin
11. Rear Radius-Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washers (Install only on one side of rear axle; left-side installation shown.)

Fig. 1, Radius Rod Attachment (top view)

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (Ref. 4) at the forward end of each radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket, and to the axle seat.
4. Remove the radius rod and any axle alignment washers.

Installation (See Fig. 1)

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact aluminum brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

If installing forward and rear radius rods, install the forward radius rod before installing the rear radius rod.

1. If installing a forward radius rod, place the radius rod front pin on the front side of the forward spring bracket, and place the radius rod rear pin in front of the axle seat.

   If installing a rear radius rod, place the radius rod pins between the rear side of the equalizer bracket and the front side of the axle seat.

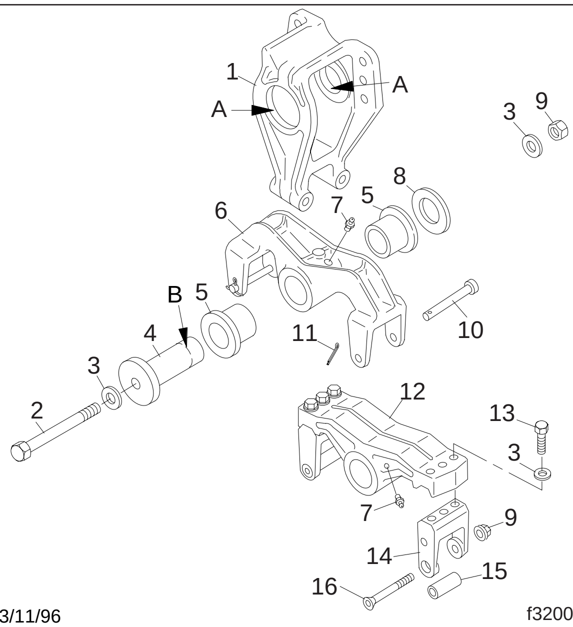
Radius Rod Removal and Installation

2. Install a hexhead bolt with a hardened washer through each end of the radius rod rear pin and the axle seat ears. Install the hardened washers and locknuts.
3. If installing a forward radius rod, install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts.

   If installing a rear radius rod, install any previously removed axle alignment washers between the radius rod front pin and the equalizer bracket. Install the hexhead bolts, hardened washers, and locknuts.
4. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
5. After all of the radius rods are installed, check the rear axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

Equalizer Removal, Inspection, and Installation

Removal (See Fig. 1)



A. Apply Loctite here.
B. No grease.
1. Equalizer Bracket
2. Hexhead Bolt
3. Bearing Washer
4. Cap and Tube Assembly
5. Equalizer Assembly Bushing
6. Equalizer (used on vehicles with two drive axles)
7. Grease Fitting
8. Wear Washer(s)
9. Locknut
10. Spring Retainer Pin
11. Cotter Pin
12. Equalizer (used on vehicles with a tag or pusher axle)
13. Capscrew
14. Wear-Shoe Side-Restraint
15. Side-Restraint Sleeve
16. Flathead Bolt

Fig. 1, Equalizer Assembly

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame. To allow access to the equalizer, remove the wheel assemblies on that side, using the instructions in **Group 40** in this manual.
3. If removing an equalizer from a vehicle with two drive axles, remove the cotter pin from the outboard end of each spring retainer pin, then remove the retainer pins.

   If removing an equalizer from a vehicle with a pusher or tag axle, remove the nuts from the flathead bolts in the wear-shoe side-restraints, on each end of the equalizer. Remove the flathead bolts and side-restraint sleeves. Remove the six capscrews and washers, and remove both wear-shoe side-restraints from the equalizer.
4. Remove the cap and tube assembly locknut, inboard bearing washer, bolt, and outboard bearing washer.
5. Insert a bar between the bottom of the equalizer and the equalizer bracket. Gently lever the weight of the equalizer off the cap and tube assembly. Insert a piece of barstock through the inboard cap and tube assembly bolt hole, and lightly tap the cap and tube assembly out of the equalizer.
6. Remove the equalizer from the equalizer bracket. Remove the wear washer(s) and equalizer bushings from the equalizer.

Inspection

1. Thoroughly clean the equalizer with steam or a hot soap solution. Inspect it for wear, cracks,or other damage. Replace the equalizer if any of these conditions are present.

CAUTION

Failure to replace the equalizer if it is cracked or otherwise damaged could result in progressive damage to, and eventual breakage of the equalizer. Breakage of the equalizer could cause a loss of vehicle control, resulting in personal injury or property damage.

2. Inspect the equalizer bushings, cap and tube assembly, and the equalizer bracket for wear, cracks, or other damage. If any of these conditions are present, replace the bushings or the cap and tube assembly.

Equalizer Removal, Inspection, and Installation

Installation (See Fig. 1)

1. Apply a thin film of multipurpose chassis grease to the outside of the equalizer bushings, then install the bushings in the equalizer.
2. Install the equalizer in the equalizer bracket.

NOTE: The next four steps must be completed before the Loctite begins to cure (approximately 5 to 10 minutes).

3. Apply Loctite 680 to both interior surfaces of the equalizer bracket, where the cap and tube assembly is inserted. Apply multipurpose chassis grease to the cap and tube assembly, except the last inch which connects to the equalizer bracket. Start the cap and tube assembly into the equalizer, through the equalizer bracket.
4. Push the cap and tube assembly part way through the equalizer, then place the wear washer(s) between the inboard equalizer bushing and the equalizer bracket. Push the cap and tube assembly the rest of the way into the equalizer bracket.
5. Place the outboard bearing washer on the equalizer cap and tube assembly bolt, and install the bolt in the cap and tube assembly.
6. Install the inboard bearing washer and locknut on the cap and tube assembly bolt. Tighten the locknut to the torque value in **Specifications, 400**.
7. Lubricate the equalizer assembly by applying multipurpose chassis grease at the grease fitting. Lubricate with a hand gun or pressure gun until grease is forced past the bushing seals, or if equipped with a pressure-relief grease fitting, until grease is forced out from the base of the pressure relief fitting.
8. If installing an equalizer on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

   If installing an equalizer on a vehicle with a pusher or tag axle, apply Alumilastic compound, or an equivalent, to the surfaces where the wear-shoe side-restraints contact the equalizer. Attach the side-restraints to the equalizer, offsetting them toward the inboard side of the equalizer. Tighten the equalizer wear-shoe capscrews to the torque value in **Specifications, 400**. Install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

9. Install the wheel assemblies. For instructions, see **Group 40** in this manual. Remove the safety stands from under the frame and axle, and lower the vehicle.
10. If the radius rods have been loosened, or the equalizer bracket has been removed, check the rear axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the axle alignment using the instructions in **Subject 140**.

Spring Assembly Replacement

Replacement (See Fig. 1)

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs; then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes and the spring retainer pin (or side-restraint sleeve); then block the axle. Make sure the stands will securely support the weight of the axles and frame. To access the spring assembly, remove the wheel assembly. For instructions, see **Group 40** in this manual.
3. If equipped with two drive axles, remove the cotter pin from the spring retainer pin on the end of the equalizer where the spring is being replaced. Drive the spring retainer pin out of the equalizer.

   If equipped with a pusher or tag axle, remove the nut from the flathead bolt on the end of the equalizer where the spring is being replaced. Remove the bolt and the side-restraint sleeve from the wear-shoe side-restraint.
4. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
5. Remove the spring assembly by lifting it off the axle spring seat, then moving it toward the equalizer, out of the forward or rear spring bracket.
6. Using chassis grease, lubricate the new spring assembly where the ends will contact the stationary wear shoes in the spring bracket and equalizer.
7. Place the new spring assembly in the spring bracket and on the axle seat. Make sure the spring center-bolt head seats in the axle spring seat hole.
8. If the upper U-bolt pad is aluminum, apply Alumilastic compound, or an equivalent, to those areas of the pad that will come in contact with the U-bolts and with the upper spring leaf.

CAUTION

Failure to apply Alumilastic® compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

IMPORTANT: Do not re-use old high nuts.

9. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
10. Install the U-bolt retainer, hardened washers, and U-bolt high nuts. Tighten the high nuts until snug.
11. If installing a spring assembly on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

    If installing a spring assembly on a vehicle with a pusher or tag axle, install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.
12. Tighten and torque the U-bolts as shown in **Specifications, 400**.

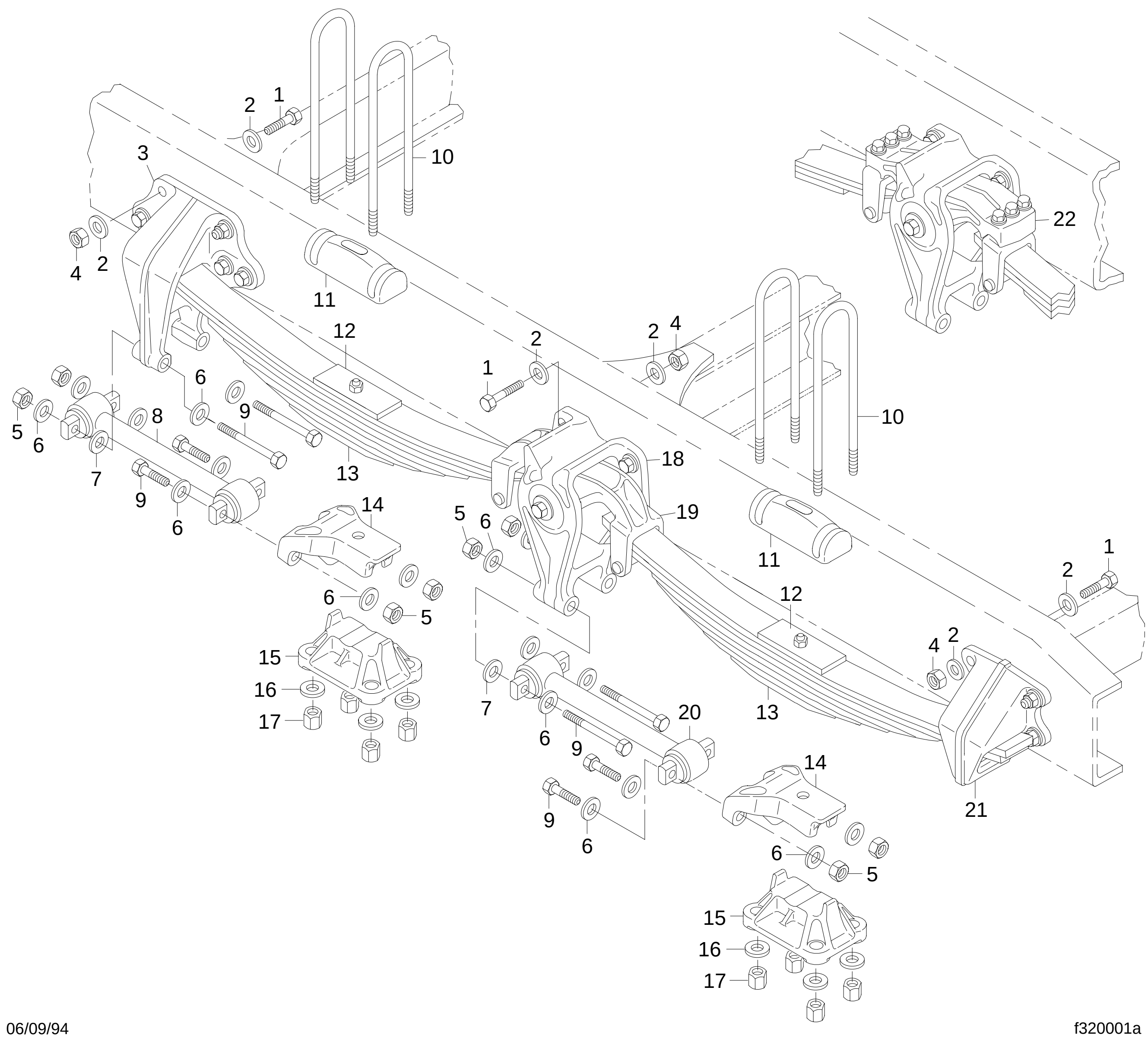
CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Columbia Maintenance Manual*.

13. Install the wheel assembly, using the instructions in **Group 40** in this manual. Remove the safety

Spring Assembly Replacement



1. Huckbolt HP 8® Frame Fasteners
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

Spring Assembly Replacement

stands from under the frame and axle, and lower the vehicle.

14. Check the rear axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the axle alignment using the instructions in **Subject 140**.

Spring Bracket and Equalizer Bracket Replacement

Replacement (See Fig. 1)

WARNING

Replace worn, cracked, or damaged spring brackets or equalizer brackets. Failure to do so could result in breakage of the bracket, possibly leading to loss of vehicle control and resulting in personal injury or property damage.

IMPORTANT: At all points where steel parts contact the aluminum spring brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame.
3. If removing the forward spring bracket or the equalizer bracket, note the number of any axle alignment washers, then remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket. Remove any axle alignment washers.
4. If removing an equalizer bracket, remove the equalizer. For instructions, see **Subject 110**.

IMPORTANT: See **Section 31.01** of this manual for correct removal and installation of Huckbolt HP 8® Frame Fasteners.

5. Remove the fasteners that attach the forward or rear spring bracket, or equalizer bracket, to the frame rail. Remove the bracket.
6. Place the new spring bracket or equalizer bracket on the frame rail. Align the mounting holes, and install the bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. See **Fig. 2**.

If installing the equalizer bracket, for clearance, install all of the nuts on the inboard side of the frame rail. See **Fig. 2**.

If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. See **Fig. 2**.

7. Tighten the bracket mounting locknuts to the applicable torque value in **Specifications, 400.**

CAUTION

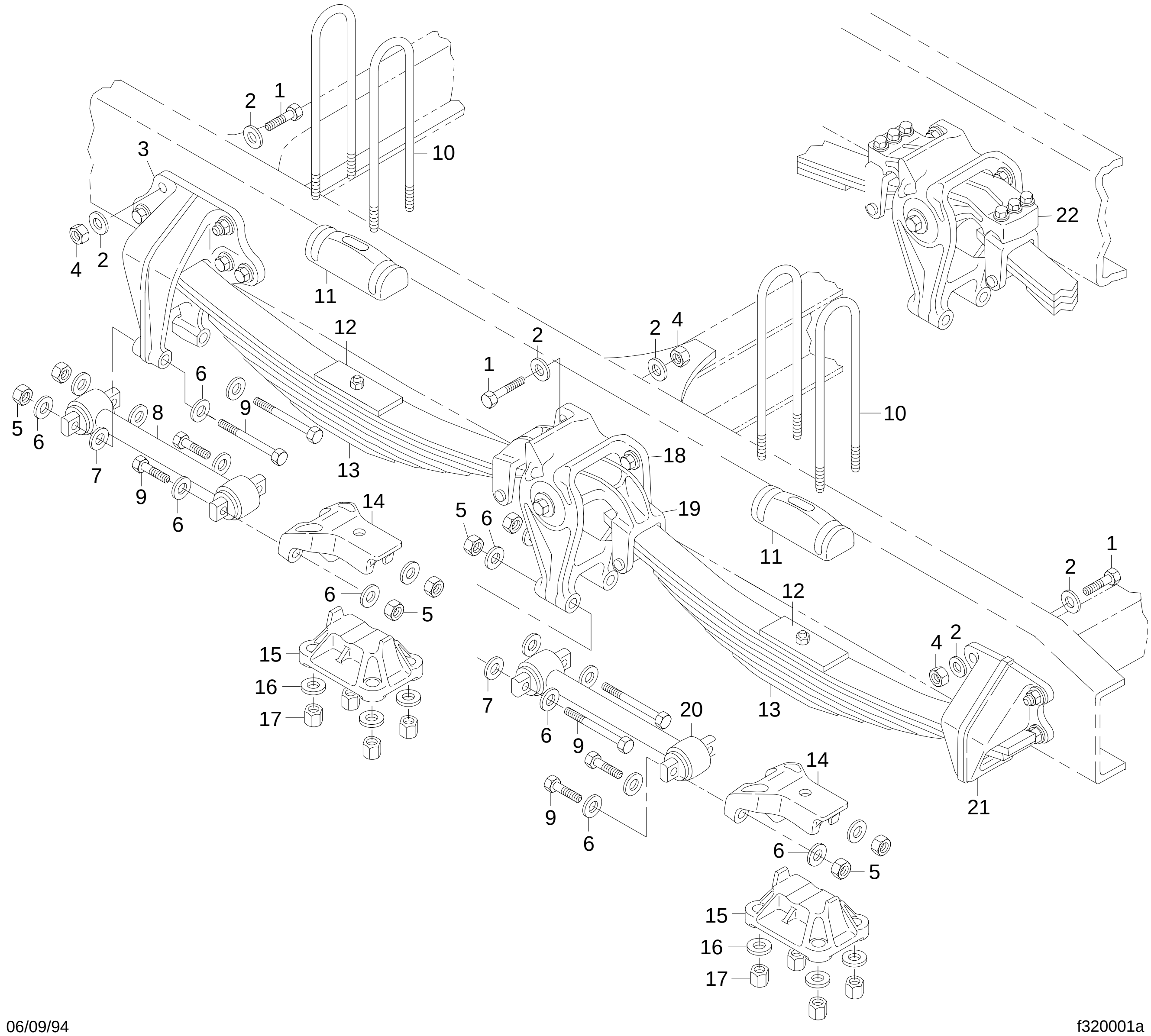
Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the *Columbia Maintenance Manual*.

8. When replacing the forward spring bracket or equalizer bracket, install any previously removed axle alignment washers between the forward radius rod front pin and the forward spring bracket, or between the rear radius rod front pin and the equalizer bracket, as applicable. See **Fig. 3**.

   Install bolts with hardened washers in the radius rod front pin, and the forward spring bracket or equalizer bracket. Install the hardened washers and locknuts, and tighten the locknuts to the torque value in **Specifications, 400**.
9. If replacing an equalizer bracket, install the equalizer. For instructions, see **Subject 110**.
10. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the rear axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the axle alignment using the instructions in **Subject 140**.

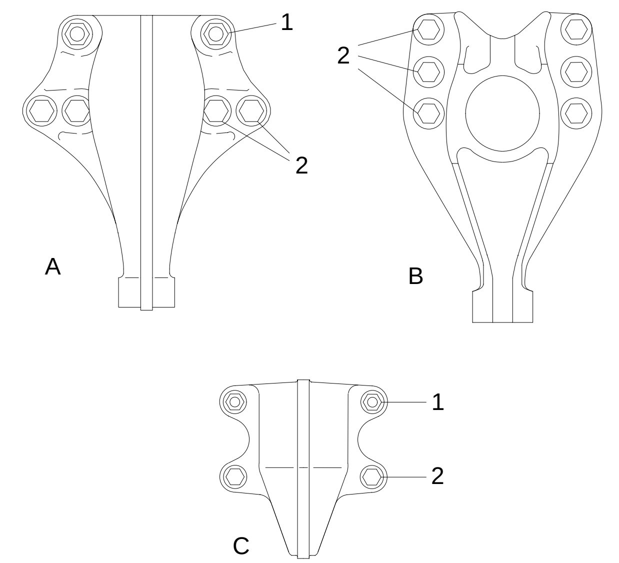
Spring Bracket and Equalizer Bracket Replacement



1. Huckbolt HP 8® Frame Fasteners
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

Spring Bracket and Equalizer Bracket Replacement



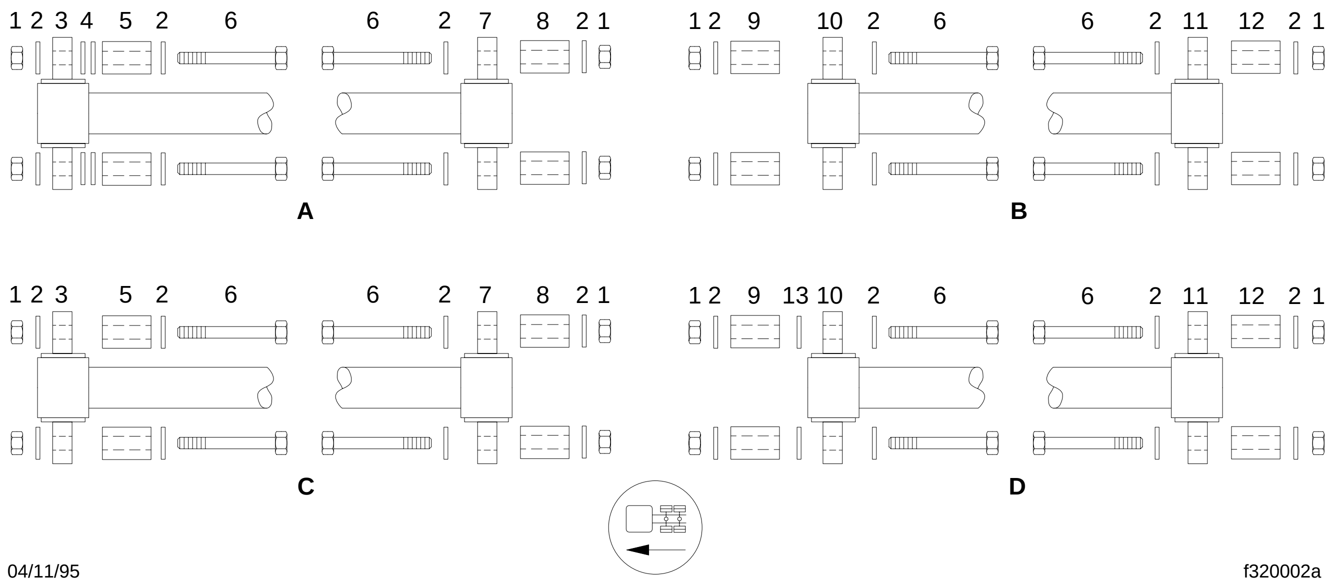
NOTE: All bolts are Huck bolts except those represented by callout "2" in Item C, which are standard bolts.

A. Forward Spring Bracket
B. Equalizer Bracket
C. Rear Spring Bracket

1. Nut (outboard)
2. Bolt Head(s) (outboard)

Fig. 2, Frame Brackets

Spring Bracket and Equalizer Bracket Replacement



A. Forward Right-Side Radius Rod
B. Rear Right-Side Radius Rod
C. Forward Left-Side Radius Rod
D. Rear Left-Side Radius Rod

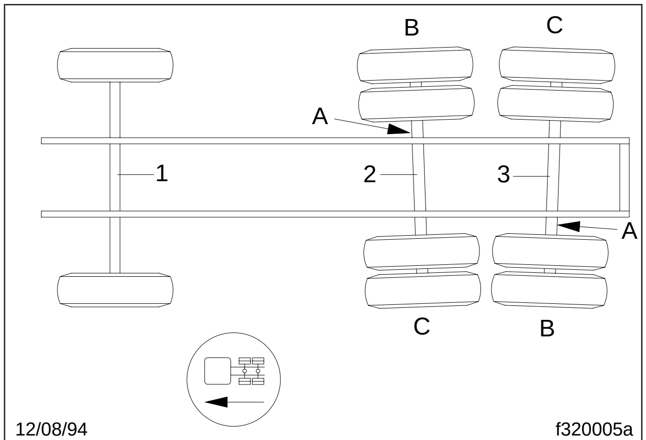
1. Hex Locknut
2. Hardened Washer
3. Forward Radius-Rod Front Pin
4. Alignment Washers (Install only on one side of front axle; right-side installation shown.)
5. Forward Spring Bracket
6. Hexbolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius-Rod Front Pin
11. Rear Radius-Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washers (Install only on one side of rear axle; left-side installation shown.)

Fig. 3, Radius Rod Attachment (top view)

Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at a right angle to the frame. For instructions, see **Group 35** in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 1**.

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".



A. Adjust here.
B. Leading End
C. Trailing End
1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

Fig. 1, Tandem Axle (shown out of alignment)

2. Chock the front tires. On both sides of the forward-rear axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the forward radius rod to the forward spring bracket. Remove any axle alignment washers.

NOTE: To adjust the forward-rear axle alignment, add alignment washers between the radius rod and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove alignment washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.
5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.
6. Between one end of the radius rod front pin and the forward spring bracket, insert the correct thickness of axle alignment washers needed to bring the forward-rear axle into alignment. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket.
7. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.
8. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
9. Remove the safety stands, and lower the vehicle.
10. Check the forward-rear axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications, 400**.

    If not in alignment, repeat all of the steps above.

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All standard suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the *Columbia Maintenance Manual*.

11. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, see **Group 35** in this manual. This difference is the

Rear Axle Alignment Adjustment

approximate distance that the leading end of the rearmost axle will have to be adjusted rearward, or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. See **Fig. 1.**

12. On both sides of the rearmost axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
13. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the rear radius rod to the equalizer bracket. Remove any axle alignment washers.
14. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.
15. Move the loosened end of the axle forward or backward, by rolling the wheels. Move the axle just enough to provide space to allow installation of alignment washers between the equalizer bracket and the radius rod pin.
16. Between one end of the radius rod pin and the equalizer bracket, insert the additional thickness of alignment washers needed to make up for the difference in center-point bar measurements.

    For example, if one end of the axle was equipped with a 3/16-inch (4.5-mm) thickness of washers, and the difference in the center-point bar measurements is 1/4 inch (6 mm) less on that side, add an additional 1/4 inch (6 mm) of washers (for a total of 7/16 inch [10.5 mm]) to correct the alignment.

    Or, if one end of the axle was equipped with a 1/4-inch thickness of washers, and the difference in center-point bar measurements is 3/16 inch (4.5 mm) more on that side, install a 1/16-inch (1.6-mm) thickness of washers in place of the 1/4-inch (6-mm) thickness.
17. Install the bolt, hardened washers, and locknut in the equalizer bracket and the radius rod pin. Place an equal thickness of alignment washers on the other end of the radius rod pin, and install the fasteners at that end.
18. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
19. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
20. Using the center-point bar, check the rearmost axle alignment. If alignment is within specifications, center the spring in the rear spring bracket, if needed, then tighten the axle U-bolt nuts to the applicable torque value in **Specifications, 400**.

    If not in alignment, repeat the applicable steps above.

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All standard suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the *Columbia Maintenance Manual*.

Specifications

Torque Values			
Description	**Size**	**IFI Grade**	**Torque lbf·ft (N·m)**
Equalizer Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Forward Spring Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Rear Spring Bracket-to-Frame Rail Locknut *	5/8–11	C	135 (184)
Axle U-bolt High Nuts Tighten in a diagonal pattern as shown in **Fig. 1**.	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420–500 (571–680)
	1–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520–600 (707–816)
Radius Rod Locknut *	5/8–18	C	135 (184)
Equalizer Cap and Tube Assembly Locknut *	3/4–16	C	270 (365)
Equalizer Wear Shoe Capscrew	5/8–11	8	135 (184)
Side-Restraint Sleeve Locknut	1/2–13	C	68 (93)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.

Table 1, Torque Values

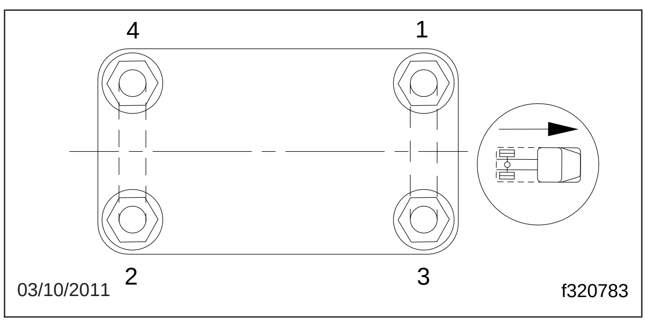


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

There are two terms used to describe rough ride conditions: harmonic and harsh. Harmonic ride problems are those in which the once-per-revolution energy input from such things as bent or imbalanced wheels match the natural frequency of the frame flexing. This produces a fore-and-aft motion in the cab, which continues as long as the critical road speed is maintained. Harmonic ride problems can occur on smooth roads.

Harsh ride problems are those in which the suspension transfers, rather than absorbs, the momentary energy inputs produced when the tires hit bumps or holes in the road. Wavy asphalt, or a series of bumps, may cause repetition of the harsh, jarring motion in the cab, but the motion stops after the tires pass over the bumps. Harsh ride problems occur on rough roads.

This section is designed for use as an aid in locating and correcting rough ride problems. It is not intended for use as a replacement for the detailed service information located in the applicable subjects in this manual, or in the component manufacturer's service manuals.

Harmonic Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions in the applicable sections in this manual.
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

WARNING

Use safety stands to securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing serious personal injury and component damage.

3. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the corrections under "Harmonic Ride, Tires Off the Ground" in **Troubleshooting, 300**.
4. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the corrections under "Harmonic Ride, Tires On the Ground" in **Troubleshooting, 300**.

Harsh Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions in the applicable sections in this manual.
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

WARNING

Use safety stands to securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing serious personal injury and component damage.

3. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the corrections under "Harsh Ride, Tires Off the Ground" in **Troubleshooting, 300**.
4. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the corrections under "Harsh Ride, Tires On the Ground" in **Troubleshooting, 300**.
5. If the problem persists, perform the harmonic ride checks in this subject. Occasionally, ride problems associated with rough roads are harmonic ride problems masked by the road conditions.

Troubleshooting Tables

Problem—Harmonic Ride, Tires Off the Ground

Problem—Harmonic Ride, Tires Off the Ground	
Possible Cause	**Remedy**
Bent, distorted, or out-of-round wheels or rims are causing a rough ride.	Inspect and repair the assemblies using the instructions in **Group 40** in this manual.
Bent, distorted, or out-of-round brake drums or hubs are causing a rough ride.	Replace damaged components using the instructions in **Group 33** or **Group 35** in this manual.
An improperly seated tire-to-rim bead is causing an out-of-round assembly.	Inspect the tires and rims for proper bead seating. Correct the problem using the instructions in **Group 40** in this manual.
A tire and rim assembly on spoke wheels is improperly installed, causing an out-of-round assembly.	Remove and install the tire and rim assembly using the instructions in **Group 40** in this manual.
Worn or distorted rim spacers are causing an out-of-round assembly.	Replace damaged spacers using the instructions in **Group 40** in this manual.
The wheels, brake drums, or hub assemblies are out of balance.	Inspect the components for missing balance weights. Balance, as necessary.
Radial force variations in the tires are causing a rough ride.	Exchange the tires and wheels with a set that is known to cause no ride problems. If this corrects the problem, discard the old tires. For instructions, see **Group 40** in this manual.

Problem—Harmonic Ride, Tires On the Ground

Problem—Harmonic Ride, Tires On the Ground	
Possible Cause	**Remedy**
Worn or loose cab mounts allow the cab to bounce.	With a long bar, lever the cab legs up and down. If there is looseness, replace or tighten the mounts, as necessary.
Forces from the trailer suspension are pushing on the tractor fifth wheel.	Review the ride problems that apply to the trailer suspension. Contact the trailer manufacturer for instructions. Perform the corrections, as necessary.

Problem—Harsh Ride, Tires Off the Ground

Problem—Harsh Ride, Tires Off the Ground	
Possible Cause	**Remedy**
Seized front spring shackle pins are not allowing the springs to flex.	Replace seized shackle pins. For instructions, refer to the applicable suspension section in this group.

Troubleshooting

Problem—Harsh Ride, Tires On the Ground

Problem—Harsh Ride, Tires On the Ground Possible Cause	Remedy
The tires are improperly inflated.	Adjust the tire pressure using the instructions in Group 40 in the *Columbia Trucks Maintenance Manual*.
The frame is bottoming out against the suspension.	Check the suspension for weak or damaged springs or components. Inspect the springs for "gull-winging" when the vehicle is loaded. Replace the spring assembly, as necessary, using the instructions in the applicable suspension section in this group.
	Reduce the overall loaded weight on each axle to conform with the maximum spring load capacities on the vehicle specification sheet. Do not exceed the maximum spring load capacities.
	Adjust the air spring height using the instructions in the applicable suspension section in this group.
The vehicle normal loaded weight is markedly below the spring load capacity.	Contact the Freightliner Service Operations Regional Office for the correct application of a lower rated spring. Replace the spring assembly using the instructions in the applicable suspension section in this group.
When the vehicle is loaded, the front axle spring shackle angle is not within the rearward 3- to 18-degree angle.	Contact the Freightliner Service Operations Regional Office for shackle angle corrective measures. Refer to the applicable suspension section in this group for service instructions.
The weight on the tractor fifth wheel is causing overloading on the front axle springs.	If possible, move the fifth wheel toward the rear of the vehicle; otherwise, change the loading pattern on the trailer.
There is a loaded weight differential between the rear axles greater than 800 pounds (363 kg).	Contact the Freightliner Service Operations Regional Office for corrective measures.
Forces from the trailer suspension are pushing on the tractor fifth wheel causing a rough ride condition.	Review the ride problems that apply to the trailer suspension. Contact the trailer manufacturer for instructions. Perform the corrections, as necessary.

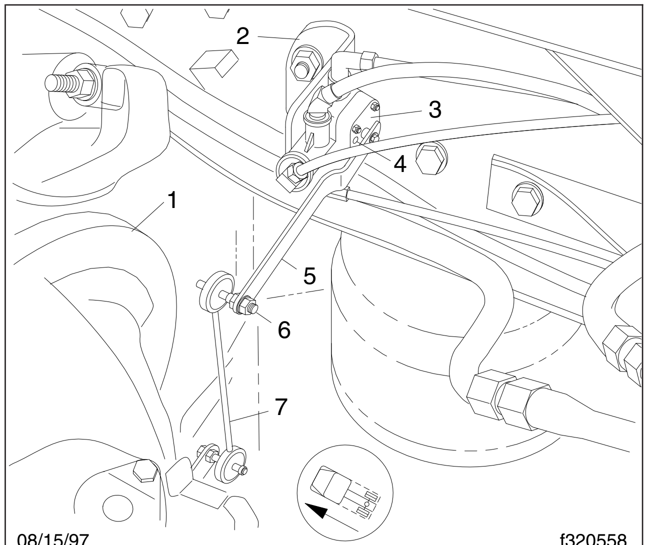
General Information

The Freightliner AirLiner Suspension is a single axle or tandem axle suspension that uses a combination of air and leaf springs. The suspension is manufactured at numerous weight ratings up to 46,000 pounds (20 865 kg). The top of the air spring is bolted to a bracket on the frame rail, or through the bottom flange of the frame rail; the bottom is bolted to the rear end of the tapered leaf spring assembly or, for the 23,000-pound (10 433 kg) and 46,000-pound suspensions, to a cross bar. The axle housing is fastened to the leaf spring assembly by U-bolts. A control rod, mounted between the axle housing and the frame rail, can be used to help locate the assembly laterally.

The air springs compensate for changes in road conditions and vehicle load, maintaining vehicle height. The air springs also absorb road shock.

A height-control valve (**Fig. 1**) regulates the air flow into or out of all the air springs. As the air spring compresses or expands, changes in the clearance between the vehicle frame and the differential housing activate the height-control valve.

A pressure holding valve, located in the air line to the height-control valve, is preset to maintain a minimum pressure of 65 psi (448 kPa) in the vehicle secondary air system if a leak should occur in the air suspension system.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Pilot Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

Fig. 1, Barksdale Height-Control Valve Assembly

Ride Height Adjustment

IMPORTANT: Before checking the suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty.

Vehicles with dual ride height control valves follow the same procedure as single valves, but with two height gauge blocks, and both height control valves adjusted simultaneously. Both linkages should be disconnected when adjusting, and both valves should be repositioned once the correct ride height has been reached on both sides.

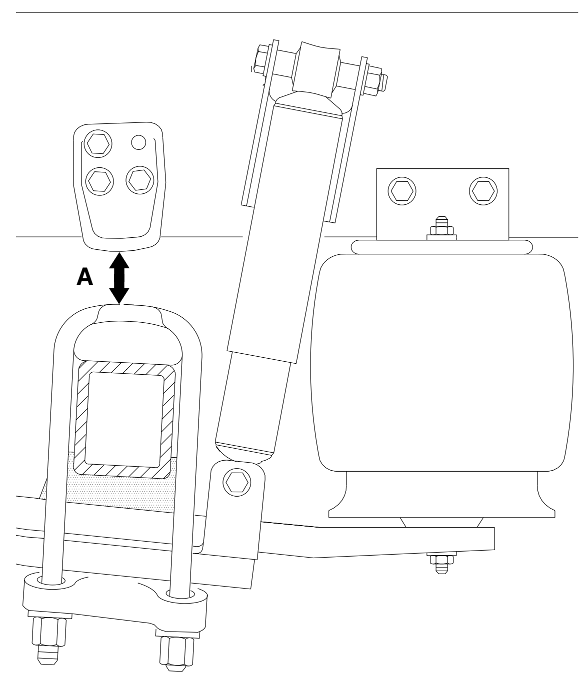
1. Park the vehicle on a level surface, using a light application of the brakes. Set the parking brake and chock the tires. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Space the tire chocks 2 inches (5 cm) ahead and behind the tire so the vehicle can roll 2 inches in either direction.
3. Release the parking brake and verify by hand that the vehicle can roll forward and aft. This should remove any load from the suspension.
4. Determine the correct ride height for the suspension:
    - Some common suspensions and ride height dimensions are shown in **Table 1**, **Table 2**, **Table 3**, **Table 4**, and **Table 5**.
    - In PartsPro, enter the VIN and Module "622" (Rear Suspension), and retrieve the Parts List. The installation drawing will be listed as a part with a D16 prefix. Use the EZ Wiring icon to view this drawing, which will specify where to measure the ride height and the target ride height distance for that suspension. This dimension is usually labelled the "E" dimension; the target ride height should be in a table on the same page of the drawing.

IMPORTANT: **Suspensions with Dual-Leaf Springs, and all Vehicles built before August 24, 2001:** Measure between the top of the U-bolt and the bottom of the axle stop (distance A).

Suspensions with Single-Leaf Springs, built after August 24, 2001: Measure between the top of the U-bolt **pad** and the bottom of the axle stop (distance B).

5. Measure the distance between either forwardmost axle stop and the suspension using the dimension indicated in the drawing or figure for the suspension.
6. If the distance is within the acceptable range, no adjustment is needed. Apply the parking brakes.

   If the measurement is not within the acceptable range, go to the next step.

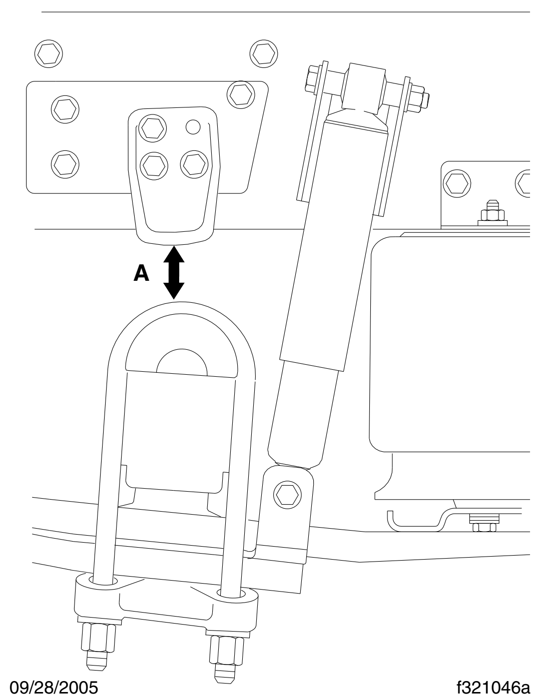


Measure Point	Suspension Height Measurement (A)		
	Min	Target	Max
A = Measure Here	2-3/8 inch (60 mm)	2-5/8 inch (67 mm)	2-7/8 inch (73 mm)

Table 1, Suspension Ride Height Measurement, Dual-Leaf Spring, 20k/40k High Ride

7. Disconnect the height-control valve linkage at the lever stud. (For dual valves, disconnect both.)

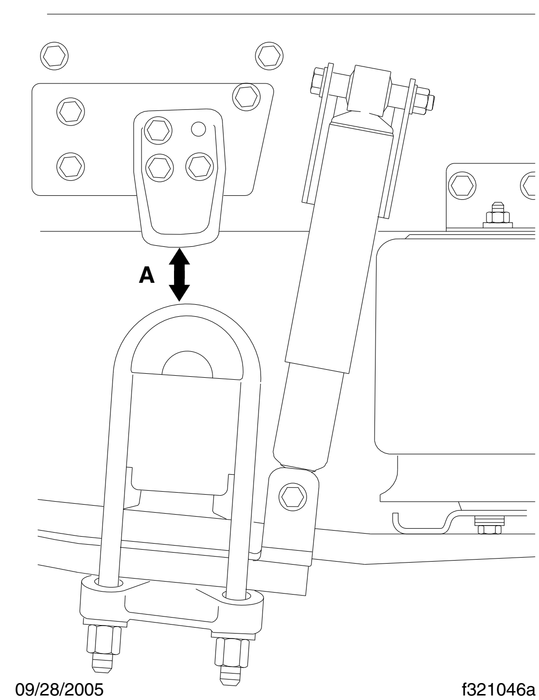
Suspension Ride Height Adjustment



Measure Point	Suspension Height Measurement (A)		
	Min	Target	Max
A = Measure Here	2-3/4 inch (70 mm)	3 inch (76 mm)	3-1/4 inch (83 mm)

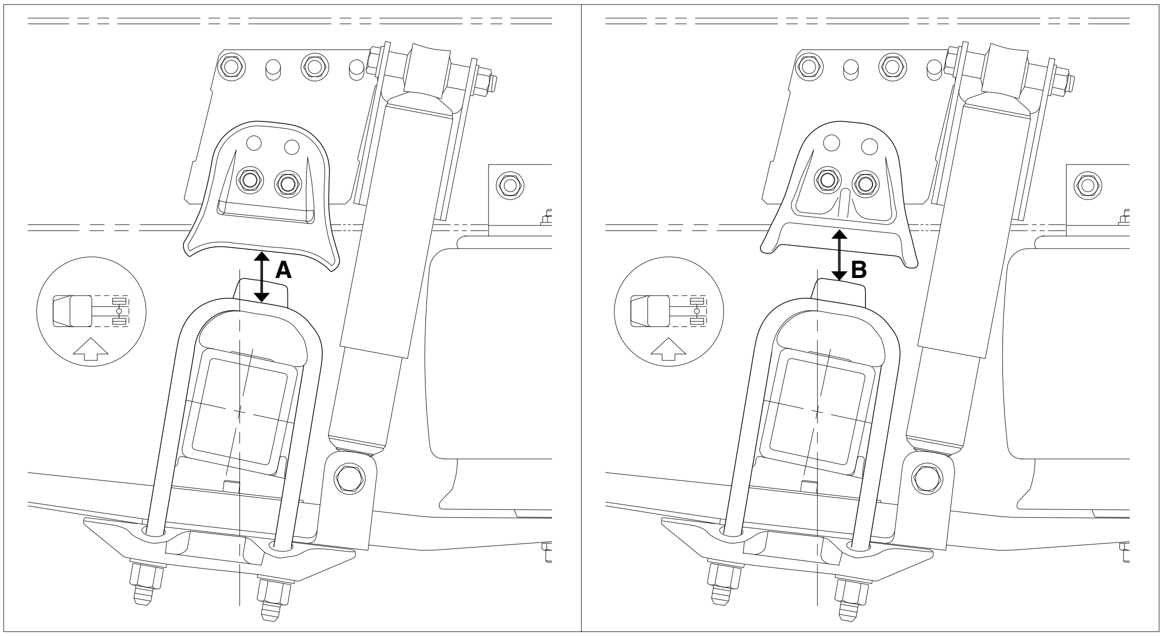
Table 2, Suspension Ride Height Measurement, Dual-Leaf Spring, 23k/46k/69k High Ride

8. If there is not enough room for the block between the axle stop and the top pad, lift the valve lever to inflate the airbags enough to fit the block. (For dual valves, lift both levers.) Do not install the block yet.
9. Pin the lever in neutral position with a 5/32-inch drill bit or nylon rod to lock the lever in neutral position. See **Figure 1**.
10. Install the height gauge block. (For dual valves, install a block on both sides.)
11. Unpin the valve lever and use it to lower the suspension until the axle stop rests on the block. (For dual valves, unpin and lower with both valves.)
12. Move the lever to neutral and pin. (For dual valves, pin both.) The vehicle should now be at the target ride height.



Measure Point	Suspension Height Measurement (A)		
	Min	Target	Max
A = Measure Here	2-3/4 inch (70 mm)	3 inch (76 mm)	3-1/4 inch (83 mm)

Table 3, Suspension Ride Height Measurement, Dual-Leaf Spring, 23k/46k/69k High Ride



Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-5/8 inch (67 mm)	2-7/8 inch (73 mm)

Table 4, Suspension Ride Height Measurement, Single-Leaf Spring, 20k/40k, High Ride Height

13. While holding the height-control valve mounting studs in place with an Allen wrench, loosen the nuts that attach the valve to the mounting bracket. See **Figure 2**.

NOTICE

When loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

14. Adjust the position of the valve body until the lever—still pinned in neutral position—can connect to the linkage. Attach the linkage. The linkage rod should be vertical, and the valve body should now be in the correct position for the vehicle's ride height. (For dual valves, adjust and connect both.)

    If the linkage cannot reach the stud, check the surrounding components for bent or damaged parts and remedy as needed.
15. While holding the height-control valve mounting studs in place with an Allen wrench, tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten, as that could damage the valve.
16. Disconnect the linkage from the valve lever stud. (For dual valves, disconnect both.)
17. Raise the valve lever to raise the suspension enough to remove the block, then pin the valve

Suspension Ride Height Adjustment

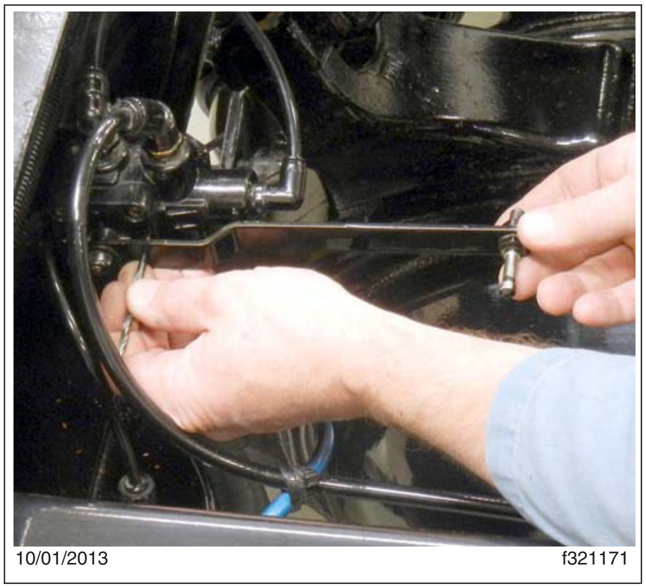


Fig. 1, Inserting a 5/32-inch drill bit or nylon rod to lock the arm in neutral position.

lever in neutral position. (For dual valves, raise and pin both valves.)

18. Remove the block. (For dual valves, remove both blocks.)
19. Remove the pin or drill bit holding the height-control lever in neutral position, then connect the valve lever to the linkage. (For dual valve, unpin and connect both valve levers.)
20. Drive the vehicle unloaded for about 1/4 mile (1/2 km), then park the vehicle on a level surface using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.

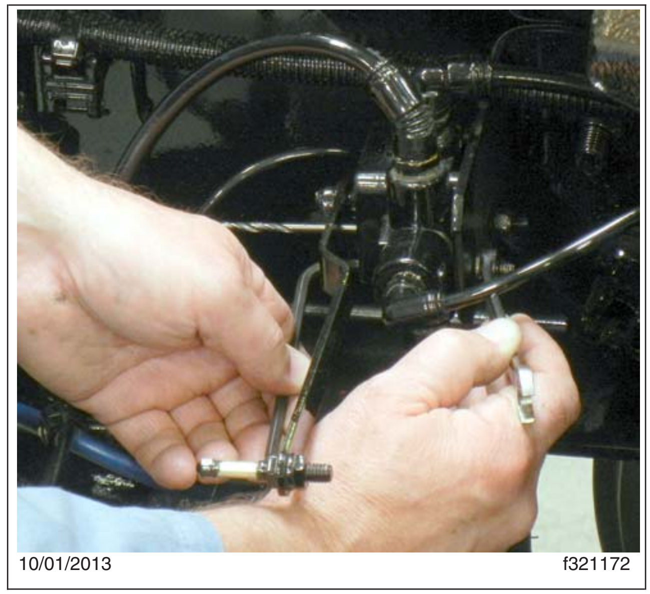
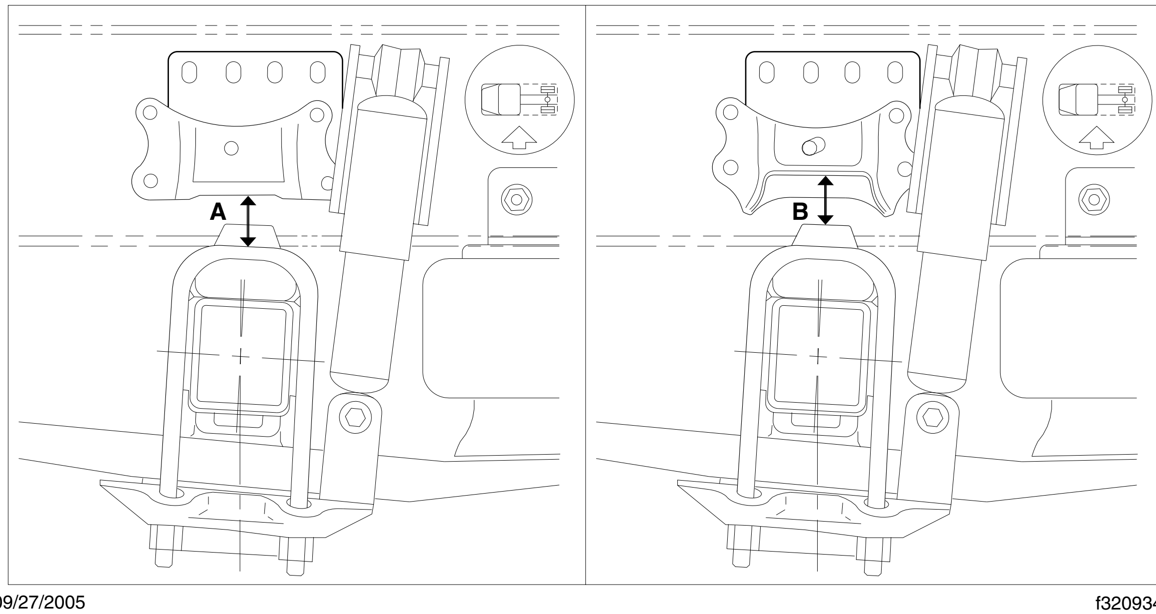


Fig. 2, Holding the height control valve mounting stud in place with an Allen wrench when loosening the nut.

21. Check the ride height of the vehicle again, measuring where indicated in the drawing or figure for the suspension.

    If the distance is within the acceptable range, the ride height is correctly set. Apply the parking brakes.

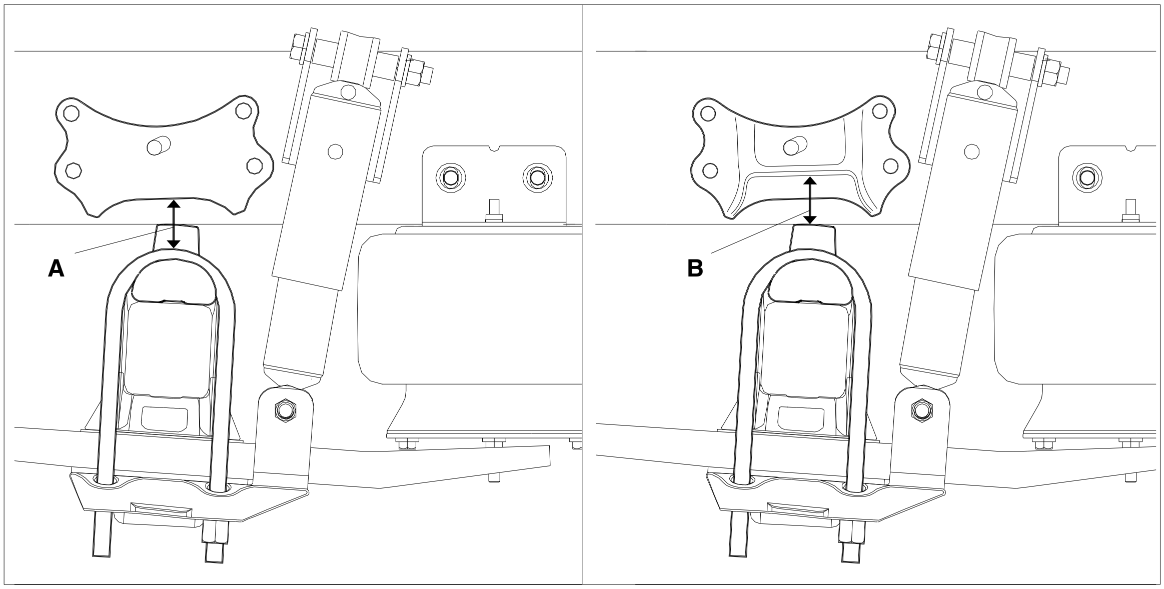
    If the distance is not within the acceptable range, repeat the adjustment procedure.



Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-1/2 inch (64 mm)	2-7/8 inch (73 mm)

Table 5, Suspension Ride Height Measurement, Single-Leaf Spring, 10k/12k/15k/18k Mid Ride Height and 40k Low and Mid Ride Height

Suspension Ride Height Adjustment



Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-1/8 inch (54 mm)	2-9/32 inch (58 mm)	2-5/8 inch (67 mm)

Table 6, Suspension Ride Height Measurement, Single-Leaf Spring, 10k/12k/15k Low or Extra Low Ride Height

Height-Control Valve Checking

It is normal to hear air escaping from the height-control valve for as much as 10 minutes after getting out of the vehicle when it is in an unladen condition. This air "leaking" is just the height-control valve exhausting air from the suspension air springs in order to return to the neutral mode.

The height-control valves used on the Columbia are Barksdale valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

CAUTION

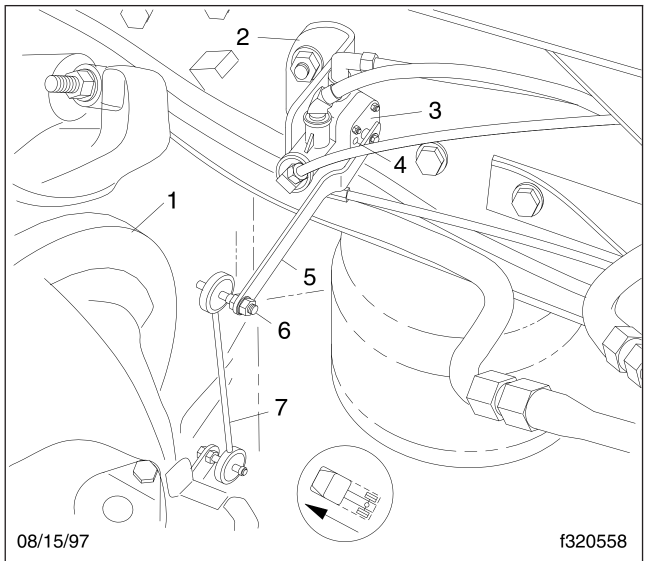
When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Checking the Height-Control Valve Without Using a Test Kit

1. Apply the parking brakes and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Disconnect the vertical linkage from the control lever; see **Fig. 1**.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Pilot Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

Fig. 1, Barksdale Height-Control Valve Assembly

5. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is working.

Height Control Valve Checking

6. Return the control lever to the neutral position. Air should stop flowing. If so, that section of the valve is working.
7. Push the control lever down about 45 degrees for 6 to 8 seconds. If air exhausts from the valve, that section of the valve is working.
8. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
9. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the vertical linkage to the control lever, then tighten the linkage nut.

   If needed, adjust the ride height or replace the height-control valve. For adjustment of the ride height, see **Subject 100**. For replacement of the height-control valve, see **Subject 130**.

NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking the Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. For valves without an integral dump port, go to the next step.

   For valves with an integral dump port, check the rubber exhaust flapper at the back of the valve housing for leaks; see **Fig. 2**. Use a soapy solution.

   If a leak is found, there may be contaminants blocking the piston. Cycle the height-control valve switch inside the cab for two-second bursts, four or five times, to clear away any contaminants.

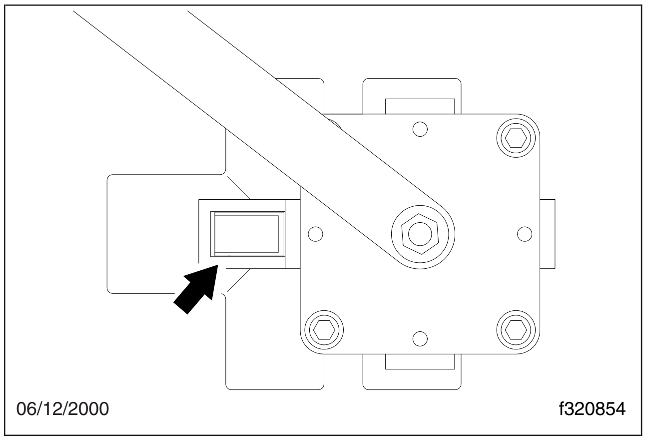
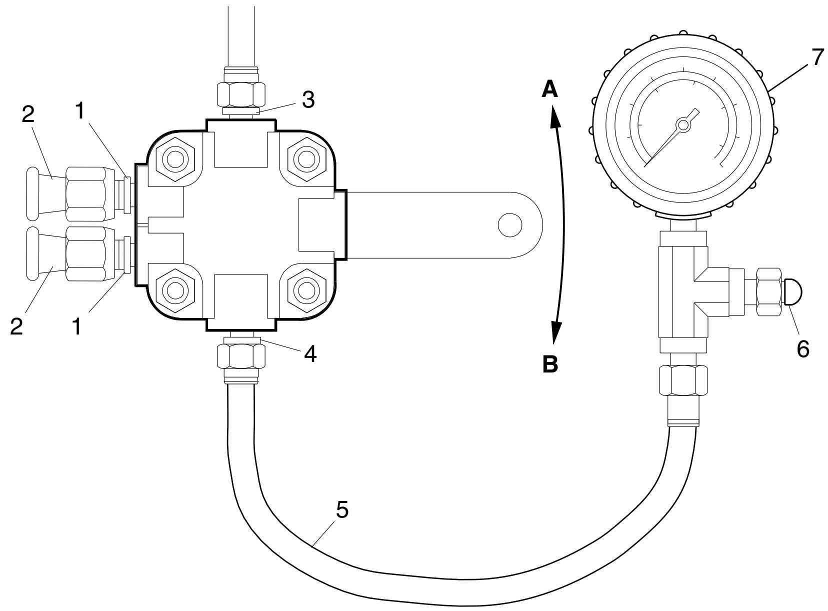


Fig. 2, Exhaust Flap Location (height-control valve with integral dump port)

5. Disconnect the vertical linkage from the horizontal control lever.
6. Rotate and hold the horizontal control lever down at about 45 degrees to exhaust air from the air springs.
7. *If equipped with an integral dump port,* turn on the quick dump switch on the dash. Leave the switch on until testing is complete.

   If not equipped with an integral dump port, disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 3**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.



A. Fill
B. Exhaust

1. Air Spring Port
2. Parker Plug
3. Air Intake Port
4. Exhaust Port Test Fitting
5. Air Line
6. Reset Button
7. Test Gauge Assembly

Fig. 3, Test Connections

9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 3**.

NOTE: It may be necessary to cut the tie straps that hold the chassis wiring running below the height-control valve, in order to access the exhaust port.

10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.
    11.1 Rotate the valve control lever up 45 degrees from the horizontal to the fill position.
    11.2 Press the reset button on the test gauge.
    11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.
    12.1 Rotate the valve control lever down 45 degrees from the horizontal to the exhaust position.
    12.2 Press the reset button on the test gauge.
    12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable

Height Control Valve Checking

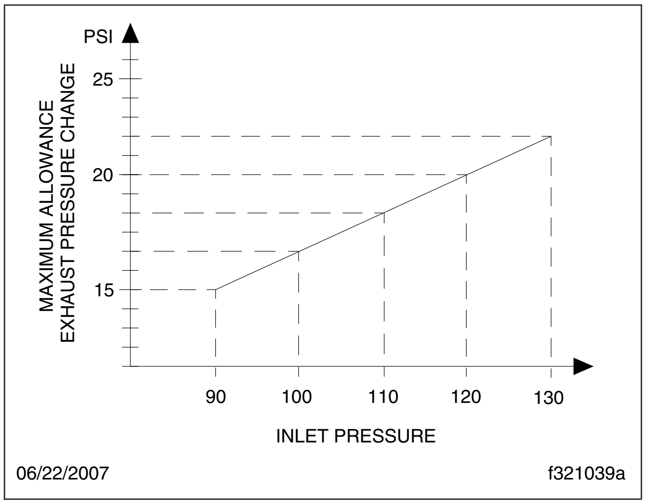


Fig. 4, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

exhaust pressure change versus inlet pressure.

The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see **Subject 130**.
15. Install the flapper on the exhaust port by pressing it into place.
16. *For height-control valves with an integral dump port,* connect the vertical linkage to the height-control valve control lever. Turn off the quick dump switch on the dash. The ride height will automatically return to the correct position.

    For height-control valves without an integral dump port, remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

Barksdale Height-Control Valve Replacement

The Barksdale valve does not use an adjustable linkage rod. To adjust the Barksdale valve, see **Subject 110**.

1. Apply the parking brakes and chock the tires.

WARNING

Keep your hands and all objects away from the area under and around the slack adjusters and suspension components when removing the pressure from the air system. These parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

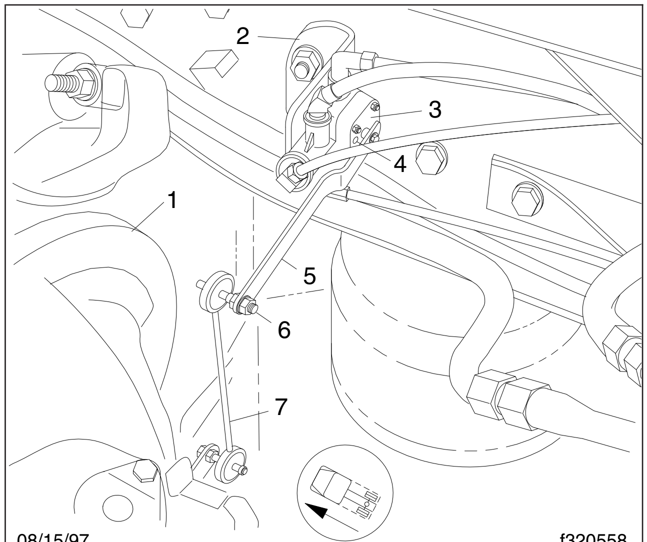
2. Drain all air from the air tanks.

WARNING

Air lines under pressure can whip dangerously if disconnected. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

3. Remove the nut and washer that attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
4. Rotate and hold the horizontal control lever down until all air is exhausted from the air springs.
5. Disconnect the air lines at the height-control valve, and mark the lines for later reference. Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.

IMPORTANT: For quick-connect tube fittings, do not remove the tube by cutting it close to the fitting. If the remaining part of the tube cannot be pulled from the fitting, the fitting will not be reusable and the warranty on that unit will be void.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Pilot Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

Fig. 1, Barksdale Height-Control Valve

CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

6. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
7. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and

Height Control Valve Replacement

tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.

8. Remove the tape from the air lines and fittings, and connect the air lines to the height-control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
9. Close the drain cocks on all reservoirs.
10. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
11. Adjust the height-control valve; see **Subject 110**.

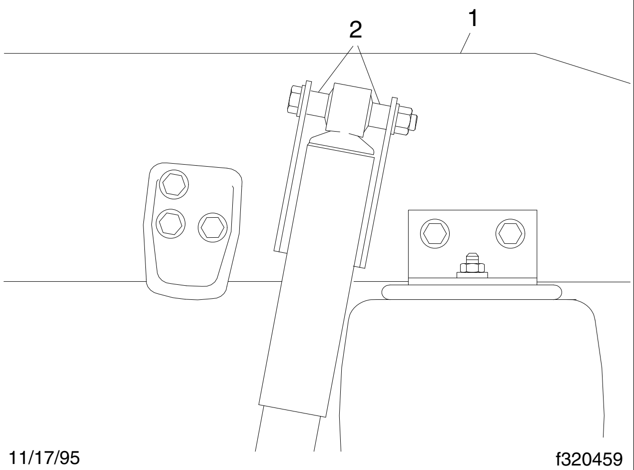
Shock Absorber Replacement

1. Chock the tires.
2. Remove the locknut, bolt, and spacer from the shock absorber lower mounting bracket. See **Fig. 1**.
3. Remove the nut, upper retainer, and upper bushing from the top of the shock absorber.
4. Pull the shock absorber out of the upper mounting bracket, and remove the retainer and bushing.
5. Install the replacement shock absorber, making sure the new bushings and retainers are correctly positioned. See **Fig. 1**.

WARNING

Use only the retainers included with the replacement shock absorber. Do not use washers. They can be extruded over the nut and be ejected violently, possibly causing personal injury and property damage.

6. Tighten the shock absorber lower mounting locknut 170 lbf·ft (230 N·m).
7. Tighten the shock absorber upper mounting nut to compress the bushings to the dimension as shown in **Fig. 1**.



1. Frame Rail
2. Bushings

Fig. 1, Shock Absorber Installation

Air Spring Replacement

IMPORTANT: Effective March 2011, the steel bead on the inside of the air bag where it attaches to the piston, changed to a square bead to increase the pull-off force between the air bag and piston. The new air bag is stamped "BD8" and "Do Not Re-Assemble Rubber Bellow to Piston." See **Fig. 1**. With this design change it is not possible to reseat the air bag to the piston. In the event of an air bag failure, or separation from the piston, the complete air-spring assembly must be replaced. For service it is acceptable to have a replacement air-spring assembly on one side of the vehicle, and an older style on the other side.

NOTE: The air-spring-to-frame-rail mounting bracket is not supplied with the air-spring assembly. If it needs to be replaced it must be ordered separately.

Follow these steps to replace the air-spring and piston assembly.

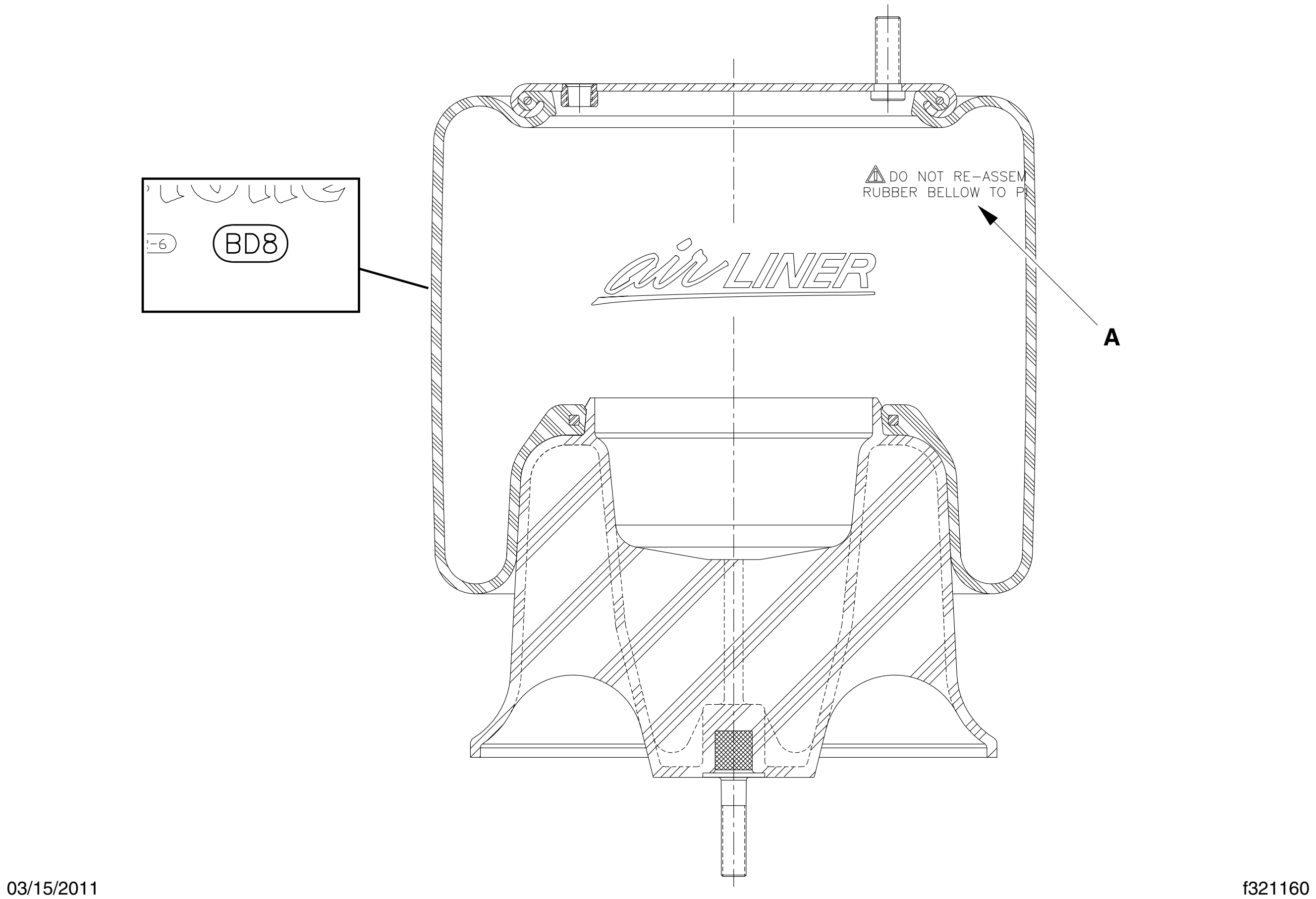
1. Chock the front tires. Raise the vehicle frame and support it with safety stands to remove all weight from the air springs. The leveling valve automatically releases air from the air springs when all weight is removed from the suspension.
2. Disconnect the air supply line,including the brass tee, from the air spring. Using tape, cover the ends of the air supply line and the fitting to prevent dirt or foreign material from entering.
3. Remove the locknuts and washers that connect the air spring to the upper mounting bracket, or to the frame rail flange. See **Fig. 2** and **Fig. 3**.
4. Remove the capscrews and lockwashers that connect the air spring to the rear of the leaf spring. Remove the air spring. See **Fig. 4**.

NOTE: Suspensions manufactured to a 46,000-pound (20 865 kg) or 23,000-pound (10 433 kg) weight rating have a different leaf spring, and an additional cross bar attached between the air spring and rear of the leaf spring. See **Fig. 5**.

5. Place the new air spring on the rear of the leaf spring (or the cross bar on the 23,000- and 46,000-pound suspensions), and install the washer and locknut that hold the air spring (and cross bar) in place. See **Fig. 4**. Tighten the locknut 55 lbf·ft (75 N·m).
6. *For bracket-mounted air springs:* Attach the air spring to the upper mounting bracket, using the 1/2–13 locknut on the outside of the frame rail and the 3/4–16 locknut on the inside. See **Fig. 2** . Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).

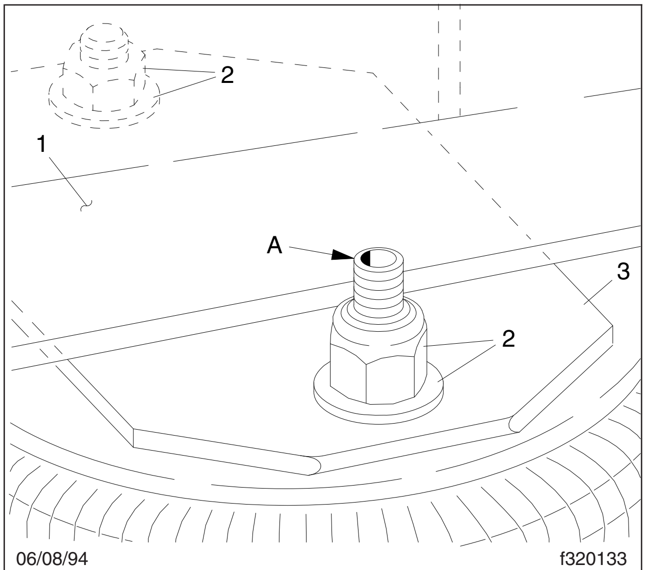
   For flange-mounted air springs: Attach the air spring to the frame rail flange, using the 3/4–16 locknut on the forward stud of the air spring, and the 1/2–13 locknut on the rear stud. See **Fig. 3**. Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).
7. Remove the tape from the ends of the air supply line, the fitting, and the brass tee. Connect the air supply line to the air spring. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
8. Remove the safety stands, and lower the vehicle. Remove the chocks from the tires.

Air Spring Replacement



A. Caution: Do Not Re-Assemble Rubber Bellow to Piston

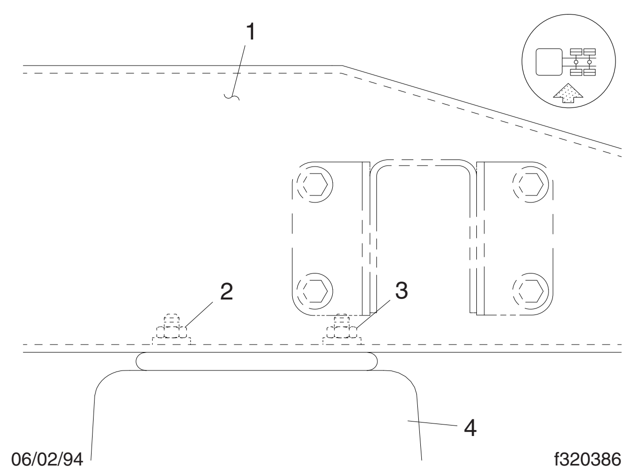
Fig. 1, Air-Spring and Piston Assembly



A. Air line connects here.

1. Right Frame Rail Flange
2. Locknut and Washer
3. Upper Mounting Bracket

Fig. 2, Bracket-Mounted Air Spring



1. Frame Rail (left)
2. 3/4–16 Locknut and Washer
3. 1/2–13 Locknut and Washer
4. Air Spring

Fig. 3, Flange-Mounted Air Spring

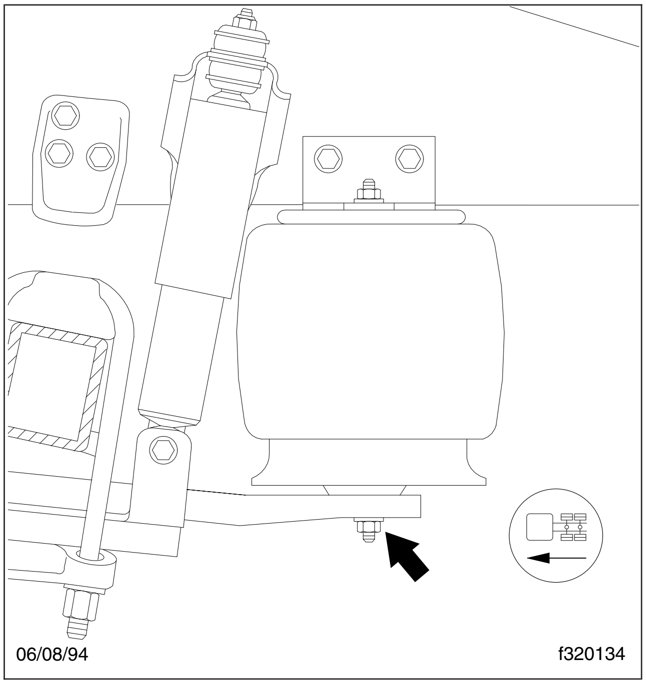
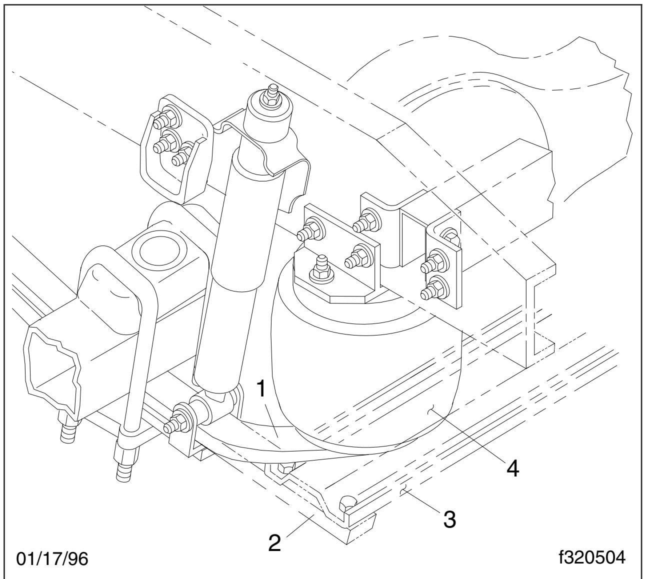


Fig. 4, Capscrew Connecting Leaf Spring and Air Spring



1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

Fig. 5, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)

Leaf Spring Replacement

(See Fig. 1)

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands. Remove the wheel and tire assembly to easily access the suspension. See **Group 40** in this manual for instructions.
3. Remove the nut, bolt, and washers from the shock absorber lower mounting bracket. Remove the high nuts, flatwashers, and axle clamp from each U-bolt. Support the leaf spring assembly with a jack.
4. If the air spring mounts to the leaf spring, disconnect the bottom of the air spring from the leaf spring.

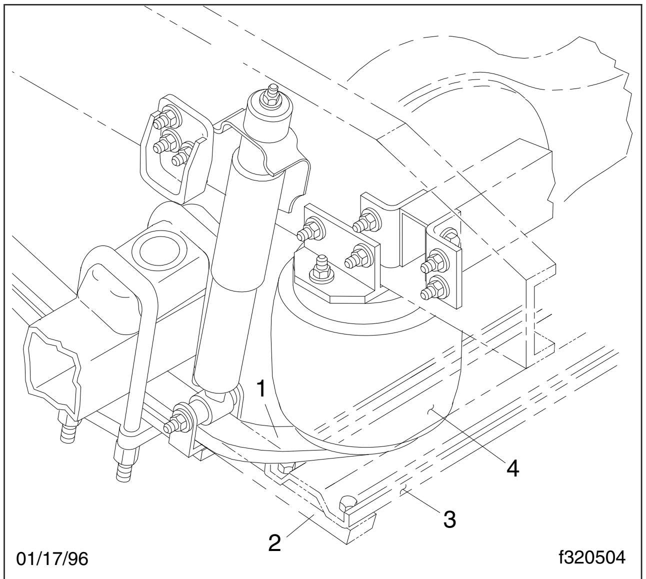
   If the air spring mounts to a cross bar, disconnect the cross bar from the leaf spring by removing the capscrews, nuts, and washers. See **Fig. 1**.
5. Note the number and position of the alignment shims on the spring mounting bolt. See **Fig. 2**.
6. Remove the hexnut, washers, alignment shim(s), spring mounting bolt, and wear shoe clip from the spring hanger. See **Fig. 2**.

WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

7. Remove and discard the leaf spring assembly.
8. While supporting a new leaf spring assembly with a jack, position the assembly on the spring hanger. Install the bolts, wear shoe clips, washers, alignment shims, and hexnuts. Tighten the bolts just enough to hold the leaf spring assembly in place.
9. If the air spring mounts to the leaf spring, attach the air spring to the leaf spring assembly. Install the washer and locknut. Tighten the locknut 55 lbf·ft (75 N·m).

   If the air spring mounts to a cross bar, attach the cross bar to the leaf spring assembly. The longer capscrews attach in the forwardmost holes; the shorter capscrews attach in the aft holes.
10. Making sure that the U-bolt pads are in place on the top of the axle, fasten the leaf spring assembly to the axle using the U-bolts, axle clamp, washers, and high nuts making sure the U-bolt pads and axle clamps are positioned correctly.

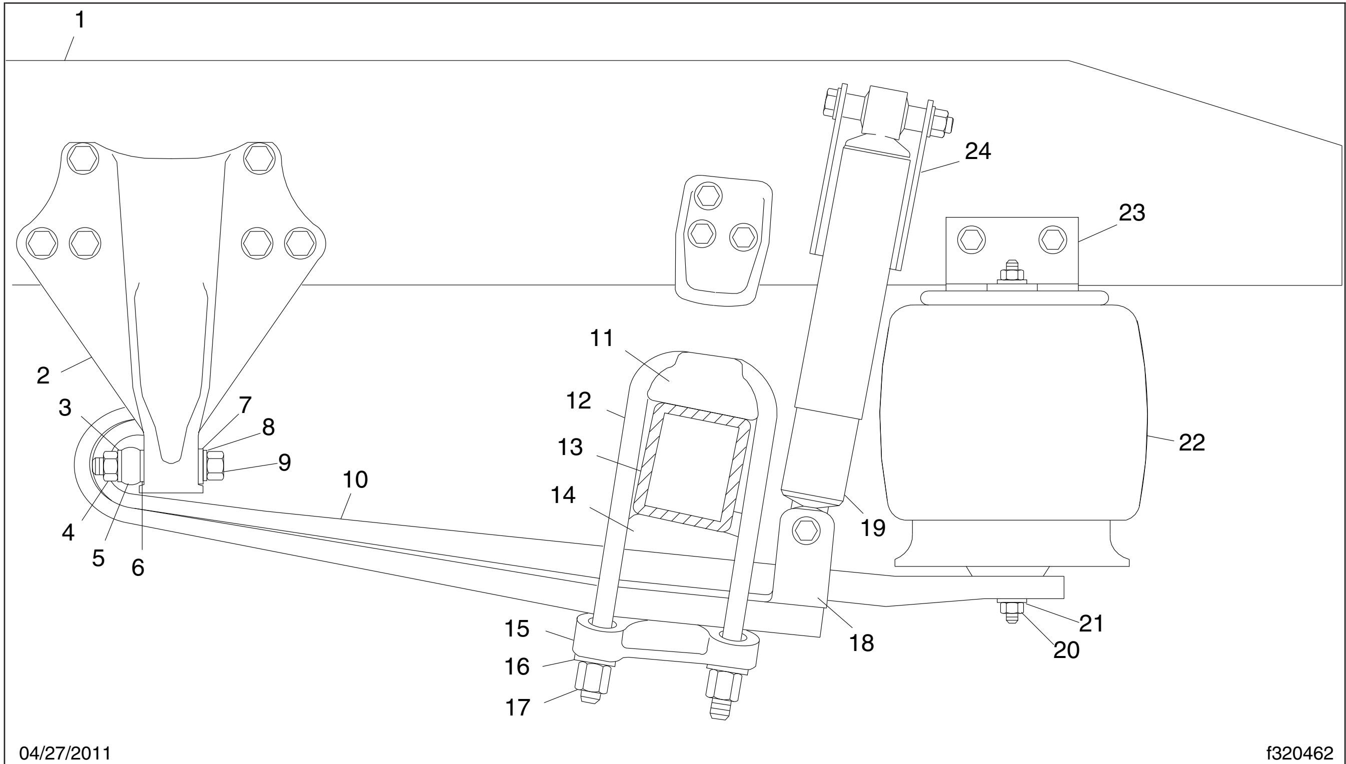


1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

Fig. 1, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)

NOTE: On single-drive axles angled 5 degrees, the arrow on the U-bolt pads must point to the front of the axle housing. See **Fig. 3**. On single-drive axles angled 3 degrees, there is no arrow. Make sure that the axle bump stop on the U-bolt pad is positioned toward the vehicle centerline. See **Fig. 4**.

Leaf Spring Replacement



1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Mounting Eye Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Mounting Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 2, AirLiner Leaf Spring Assembly

With both 5- and 3-degree single-drive axle angles, the arrow on the bottom of the axle clamp must point toward the rear of the vehicle. See **Fig. 2**.

On tandem axle suspensions, refer to **Table 1** for U-bolt pad orientation. The arrow on the bottom of the axle clamp must point toward the rear of the vehicle on the forward rear axle and toward the front of the vehicle on the rearmost axle.

11. Hand tighten the high nuts. In a diagonal pattern, tighten the axle U-bolt high nuts 60 lbf·ft (81 N·m). Then, in the same pattern, tighten them 200 lbf·ft (271 N·m); then, torque to the final value of 400 to 460 lbf·ft (542 to 624 N·m).

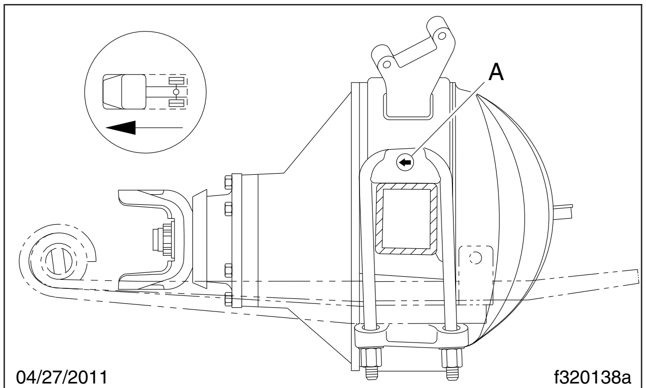
    For the 23,000-pound and 46,000-pound suspensions, tighten the high nuts in a diagonal pattern to a final torque value of 520 to 600 lbf·ft (705 to 813 N·m).
12. Install the bolt, washers, and hexnut to connect the shock absorber to its lower mounting bracket. Tighten the hexnut 170 lbf·ft (230 N·m).
13. Tighten the locknut on the bottom of the air spring 55 lbf·ft (75 N·m).

On 23,000-pound and 46,000-pound suspensions, tighten the locknuts on the bottom of the cross bar 241 lbf·ft (327 N·m).

14. Tighten the hexnuts at the front of the leaf spring 170 lbf·ft (230 N·m).
15. Install the wheel and tire assembly. For instructions, refer to **Group 40** in this manual. Remove the safety stands, and lower the vehicle.
16. Check the rear axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the rear axle alignment using the instructions in **Subject 180**.

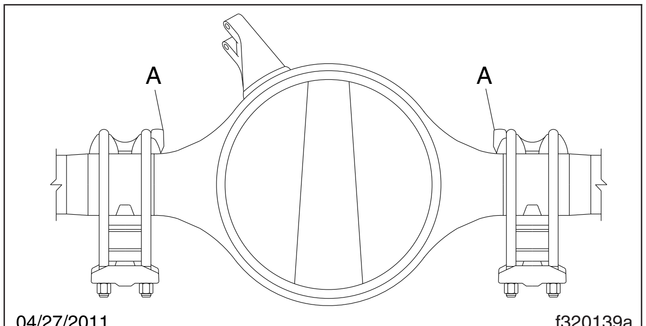
U-Bolt Pad Orientation for Axles		
Axle Designation		**U-Bolt Pad Orientation**
Meritor SQ 100, SSHD	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.
Meritor RT40-145, RT44-145, RT46-160	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	Arrow toward front of vehicle.
Eaton 402, 461	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.

Table 1, U-Bolt Pad Orientation for Axles



A. Arrow on U-Bolt Pad

Fig. 3, U-bolt Pad Arrow Positioning



A. Axle Bump Stop

Fig. 4, Axle Bump Stop Positioning

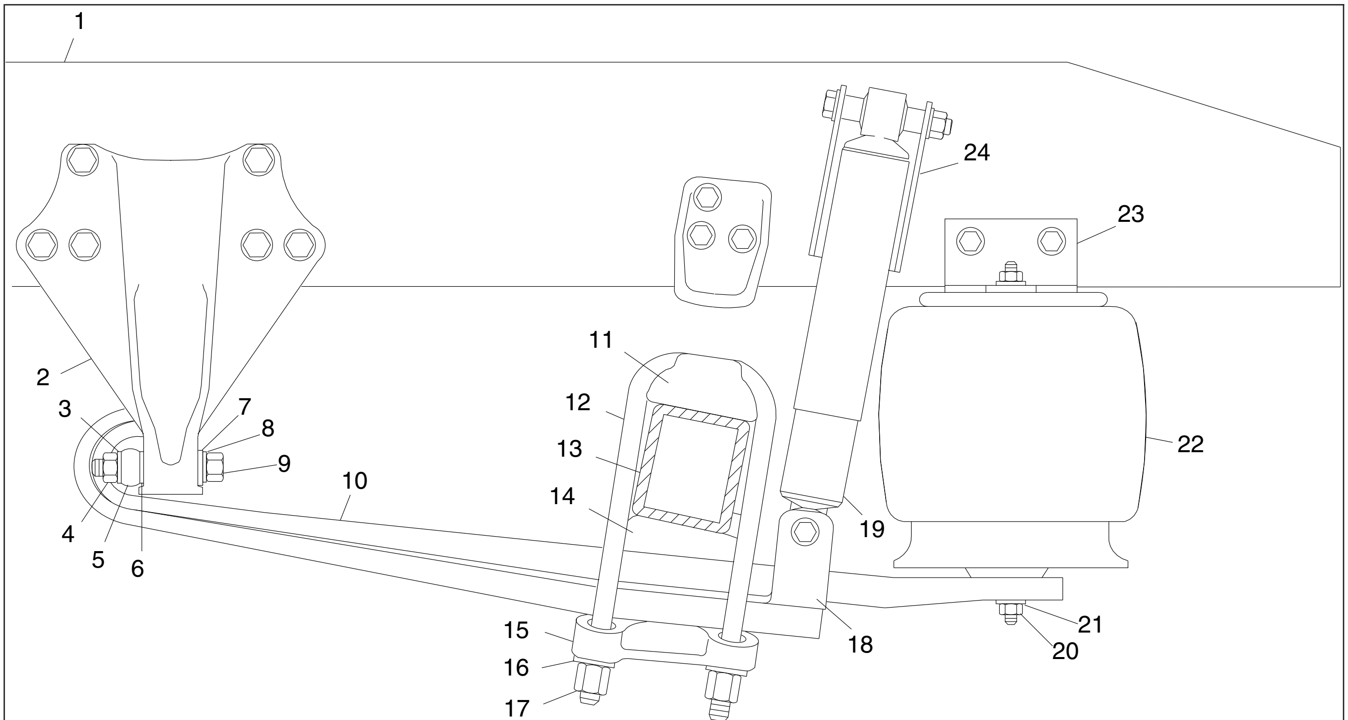
Rear Axle Alignment Adjusting

See **Fig. 1**.

Follow the instructions in the rear axle section in this manual to see if rear axle alignment adjustment is needed. If adjustment is needed, proceed as follows:

3. When the axle is in alignment, install alignment shim(s) to take up the slack between the spring hanger and the spring pin.

IMPORTANT: Make sure the same number of shims is installed on both ends of the spring pin.



1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Pinch Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 1, Rear Axle Suspension

1. Loosen the spring pinch bolts so that the forward end of the leaf spring can slide fore and aft in the spring hanger.
2. Move the axle forward or backward until it is aligned within the tolerances in **Group 35** of this manual.
4. Tighten the spring pinch bolts 170 lbf·ft (230 N·m).
5. Check the axle alignment again. If necessary, repeat the above procedure until the alignment is within tolerances.

Rear Axle Tracking Adjustment

Single Axle

1. At the forward edge of the right rear tire, measure the distance from the inner side of the tire to the outer side of the right frame rail. See **Fig. 2**.

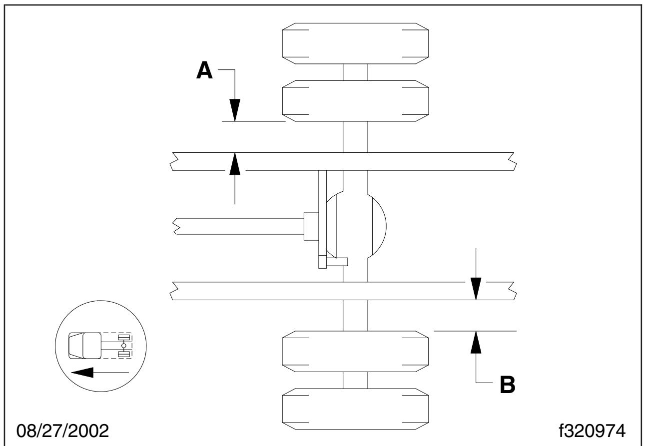
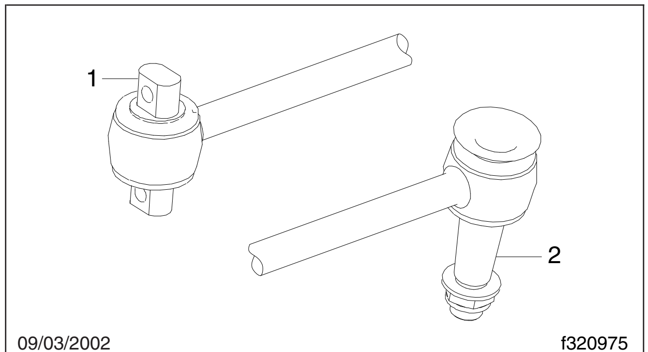


Fig. 2, Rear Axle Tracking Measurements (single axle)

2. At the rear edge of the left rear tire, measure the distance from the inner side of the tire to the outer side of the left frame rail. See **Fig. 2**.

   Measurement "A" should not vary by more than 1/4-inch (6 mm) from measurement "B."
3. If measurements "A" and "B" vary by more than 1/4-inch (6 mm), loosen the fasteners holding the lateral torque rod to the frame rail. Add or remove torque-rod shims as needed.
4. For bar-pin style torque rods, tighten the fasteners 136 lbf·ft.

   For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3**.



1. Bar Pin
2. Taper Pin

Fig. 3, Torque Rod Types

Tandem Axles

1. Check the tracking of the forward-rear axle. For instructions, see "Single Axle" in this subject. Adjust the tracking if needed.
2. At the forward-rear drive axle, measure the distance from the inner side of the right rear tire to the outer side of the right frame rail. Measure at the forward edge of the tire. See **Fig. 4**.

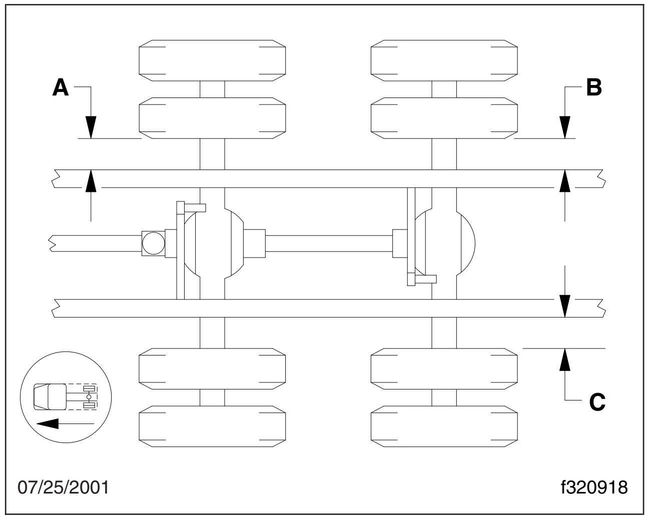


Fig. 4, Rear Axle Tracking Measurements (tandem axles)

3. At both sides of the rear-rear drive axle, measure the distance from the inner side of the rear tires to the outer side of each frame rail. Measure at the rear edge of each tire. See **Fig. 4**.

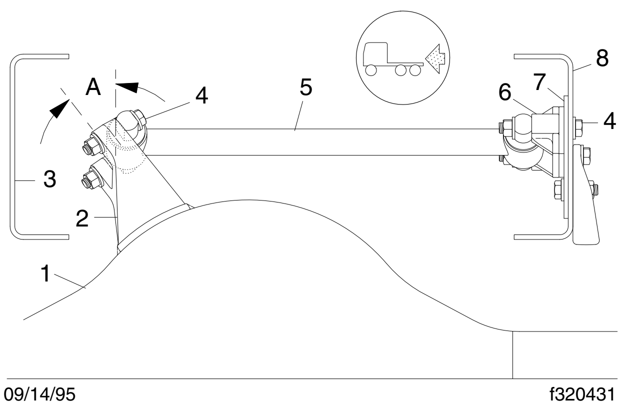
IMPORTANT: Measurements "B" and "C" should not vary by more than 1/4-inch (6 mm) from measurement "A."

4. If measurements "B" and "C" vary by more than 1/4-inch (6 mm) from measurement "A," loosen the fasteners holding the axle lateral torque rod at the rear-rear drive axle to the frame rail. Add or remove torque-rod shims as needed.

5. For bar-pin style torque rods, tighten the fasteners 136 lbf·ft. For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See Fig. 3.

Replacement

1. Park the vehicle. Shut down the engine, and apply the parking brakes.
2. Chock the tires. Raise the vehicle. Support the frame rails with jack stands.
3. Remove the fasteners holding the control rod to the frame rail bracket. Remove the shims, and set the shims aside.
4. Remove the control rod.
5. Position the new control rod so that the end with the fasteners angled up at 35 degrees is installed in the axle housing bracket. See **Fig. 1**.

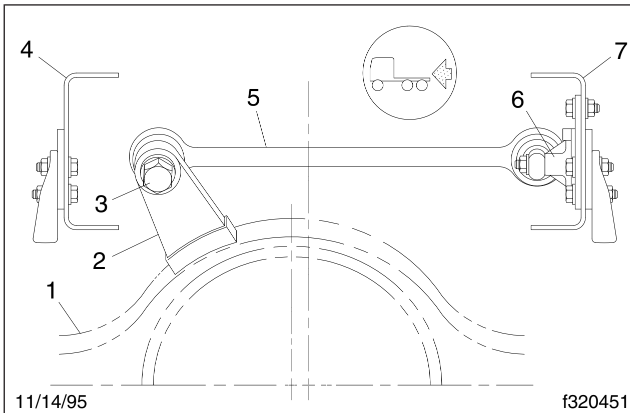


A. Angle: 35 degrees

1. Axle Housing
2. Control Rod Axle Bracket
3. Left Frame Rail
4. Bolt
5. Control Rod
6. Control Rod Frame Bracket
7. Shim
8. Right Frame Rail

Fig. 1, AirLiner Control Rod Installation

6. Install the fasteners with the bolt heads facing up. Tighten the fasteners enough to hold the control rod in place.
7. Install the shims that were previously removed.
8. Install the other end of the control rod in the frame rail bracket; then, install the fasteners. Tighten the fasteners enough to hold the control rod in place.
9. Tighten all the fasteners 136 lbf·ft (184 N·m).
10. Remove the jack stands. Lower the vehicle. Remove chocks.



1. Axle Housing
2. Control Rod Axle Bracket
3. Bolt
4. Left Frame Rail
5. Control Rod
6. Control Rod Frame Bracket
7. Right Frame Rail

Fig. 2, Control Rod Installation on 23,000- and 46,000-pound AirLiner Suspensions

NOTE: Control rods on suspensions manufactured to a 23,000-pound (10 433 kg) or 46,000-pound (20 865 kg) weight rating are larger and are attached to the axle bracket with a single bolt. Tighten the fasteners attaching the control rod frame bracket to the frame rail 160 to 170 lbf·ft (217 to 230 N·m), and the bolt connecting the control rod to the axle housing 175 to 225 lbf·ft (237 to 305 N·m). See **Fig. 2**.

Replacement

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands.
3. Remove the wheel and tire assembly to easily access the suspension. For instructions, see the information in **Group 40** in this manual.
4. Remove the leaf spring assembly. See removal information in **Subject 170**.

WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

5. Remove the bushing from the leaf spring eye.

WARNING

Do not use a cutting torch to remove the outer metal of the bushing from the spring eye. Welding, torching, or cutting the leaf spring assembly can damage the leaf spring material, which may result in the failure of the components and cause serious personal injury, death, or property damage.

5.1 Using a shop press with a capacity of at least 10 tons (9 072 kg), place the spring assembly in the shop press with the spring assembly squarely supported on the press bed for safety and to avoid bending the spring assembly.

5.2 Center the bushing tool on the outer metal of the bushing and push the bushing from the spring eye.

5.3 Remove any burrs or material left behind by the old bushing.

6. Install the new bushing in the leaf spring eye.

6.1 Position the bushing on the shop press.

6.2 Apply a bonding agent, either Perma-bond HM–160 or Loctite RC–609 or 680, liberally around the outside surface of the bushing.

6.3 Press the bushing into place.

6.4 Allow the bonding agent to cure for 24 hours.

NOTE: After the curing time, the bushing must resist a minimum 7,700 lb (3 490 kg) pushout force.

7. Install the leaf spring assembly. See the information in **Subject 170**.
8. Install the wheel and tire assembly. For instructions, see **Group 40** in this manual. Remove the safety stands, and lower the vehicle.
9. Check the rear axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the rear axle alignment using the instructions in **Group 35** in this manual.
10. Remove the chocks from the tires.

Torque Specifications

For fastener torque values, see **Table 1**.

Torque Values for AirLiner Suspension			
Description	Size	Torque lbf·ft (N·m)	Torque lbf·in (N·cm)
Height-Control Valve Housing Bolts*	1/4–20	—	45 (500)
Height-Control Valve Mounting Locknuts*	1/4–20	—	95 (1100)
Shock Absorber Mounting Locknuts	3/4–10	165 (220)	—
Air Spring Upper Mounting Locknuts	3/4–16	45 (61)	—
	1/2–13	23 (31)	—
Air Spring Lower Mounting Locknuts	1/2–13	55 (75)	—
Leaf Spring Mounting Eye Bolt Locknuts	3/4–10	241 (327)	—
Control Rod Mounting Bolt Locknuts	5/8–11	136 (184)	—
Axle U-Bolt High Nuts Tighten in a diagonal pattern as shown in **Fig. 1**.	3/4–16	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 270 to 330 (367 to 449)	—
	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420 to 500 (571 to 680)	—
	1–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520 to 600 (707 to 816)	—
Air Spring Upper Mounting Bracket	5/8–11	136 (184)	—
Spring Hanger Mounting Locknuts	3/4–10	240 (325)	—

* See the cautionary statements below.

Table 1, Torque Values for AirLiner Suspension

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

Specifications

⚠ CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

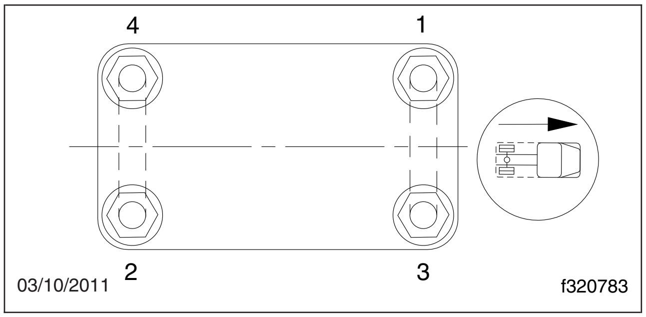
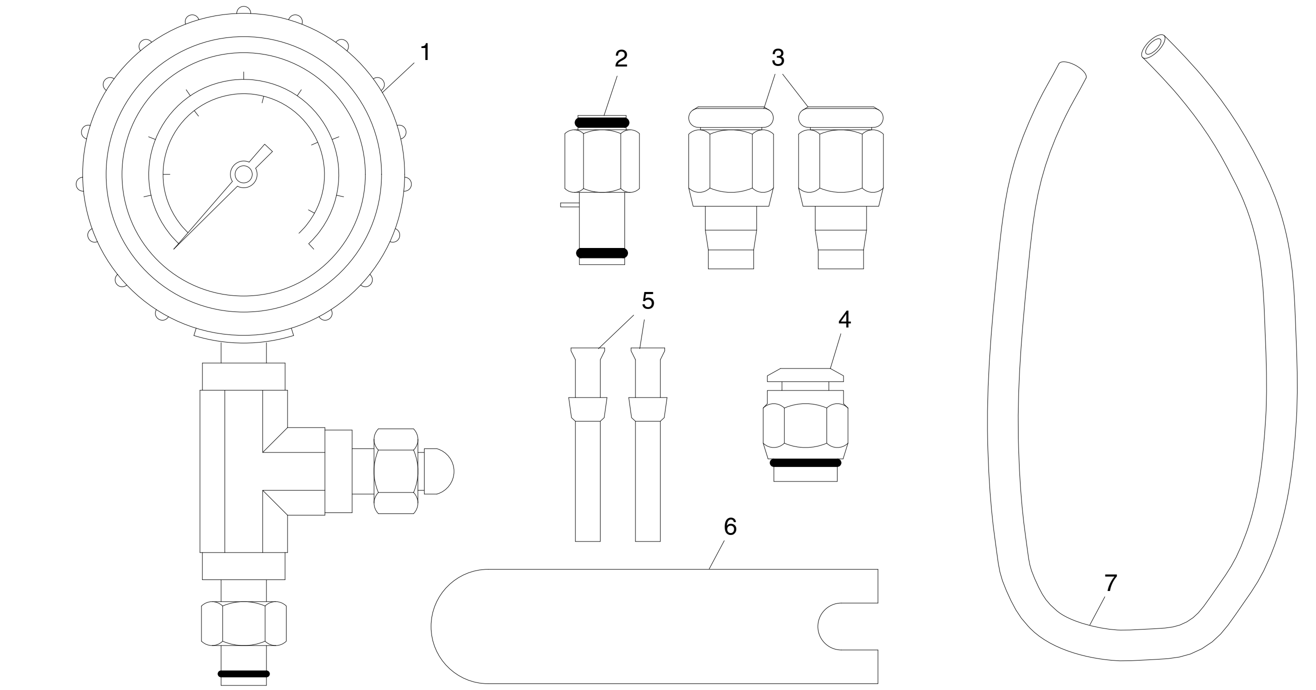


Fig. 1, Tightening Pattern for U-Bolt High Nuts

Special Tools

Use the kit shown in **Fig. 2** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in paragon.



NOTE: Parts for cab suspension valve testing included.

1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve (used for cab suspension valve testing)
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve (used for cab suspension valve testing)
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 2, Barksdale Height-Control Valve Test Kit BKS KD2264

General Information

The AirLiner Plus suspension is used on vehicles with pusher or tag axles to improve traction performance. The system maintains an accurate leveling of frame height through the use of the Meritor WABCO ECAS (Electronically Controlled Air Suspension) system with sensors and an electronic control unit. A height sensor mounted between the frame and the drive axle housing provides the ECAS control unit with frame height information. Other sensors provide additional information, which the control unit uses to quickly lower or raise the frame height as necessary. The operation occurs while the vehicle is in motion or while parked.

The vehicle must be equipped with a rear axle air suspension, and requires ABS with Automatic Traction Control to trigger the optional load transfer function automatically.

AirLiner Plus components include:

- A cab-mounted electronic control unit that uses information about the vehicle’s rear frame height to adjust the air pressure of the air spring bags;
- A frame rail-mounted solenoid valve that adjusts the air pressure;
- An axle- and frame-mounted height sensor that provides the control unit with frame-height information;
- A brake light switch that informs the control unit when the brakes are applied;
- A dash-mounted warning light that indicates a system fault;
- A load transfer light that displays automatic load transfer status;
- A three-position dash switch that allows automatic load transfer, driver-activated load transfer, or no load transfer;
- An optional hand-held remote control unit that is used to alter the chassis height for loading and unloading.

ECU Removal and Installation

Removal

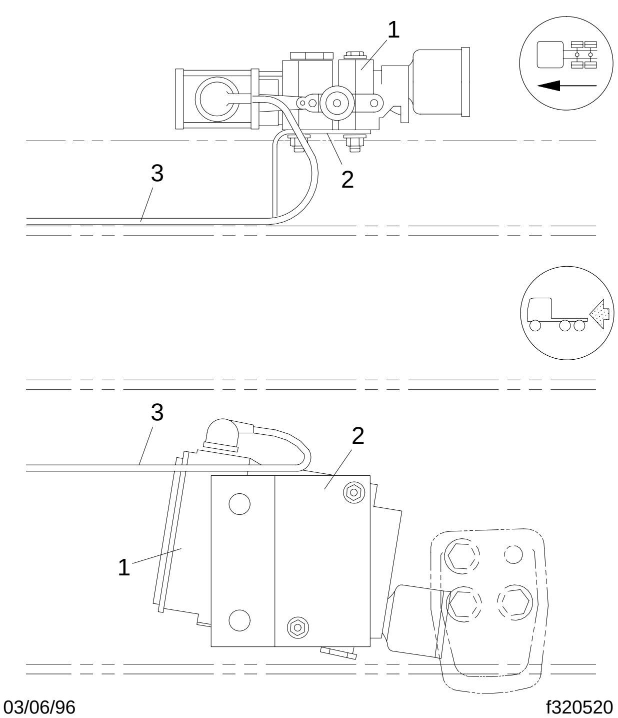
1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Remove the lower cover at the base of the left B-pillar.
4. Disconnect the electrical connections at the base of the B-pillar.
5. Remove the grab handle.
6. Remove the shoulder harness adjustable D-loop mechanism mounted to the B-pillar.
7. Detach the plastic channel that attaches the upholstery to the door frame. This will provide slack in the upholstery to allow access to the ECU mounted inside the B-pillar.
8. Remove the fasteners that attach the B-pillar upholstery to the cab wall.
9. Reach inside the B-pillar and remove the fasteners that attach the ECU.
10. Disconnect the electrical connections on the unit, and remove the ECU from the B-pillar.

Installation

1. Install the ECU inside the B-pillar. Connect the electrical connections.
2. Install the B-pillar upholstery.
3. Attach the plastic channel around the door frame and upholstery.
4. Install the shoulder harness adjustable D-loop mechanism.
5. Install the grab handle.
6. Connect the electrical connections at the base of the B-pillar.
7. Install the lower panel at the base of the B-pillar.
8. Remove the chocks from the tires.

Replacement

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Drain air from the suspension system.
4. At the ECAS solenoid valve (see **Fig. 1**), which is mounted to the frame rail, disconnect the electrical connector.



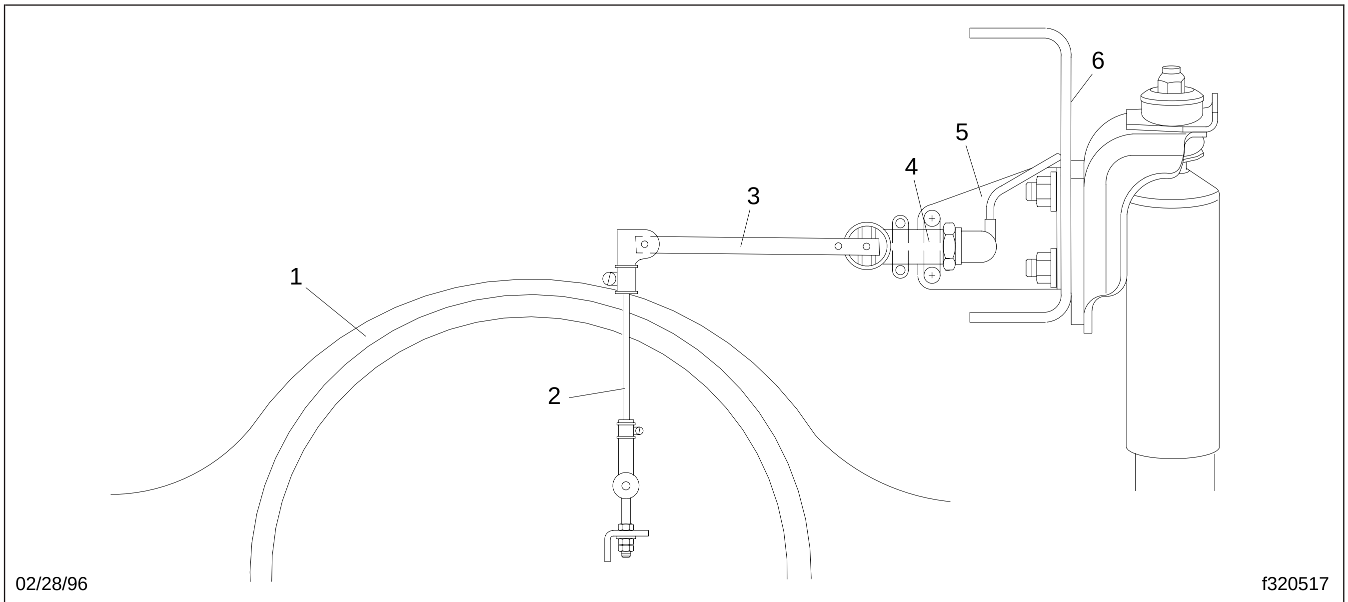
1. Solenoid Valve
2. Bracket
3. Wire

Fig. 1, Solenoid Valve Assembly

5. Mark the air lines for later reference.
6. Disconnect the air lines from the solenoid valve.
7. Remove the two bolts attaching the solenoid valve to the valve bracket.
8. Remove the valve from the bracket.
9. Attach the new valve to the bracket. Install the bolts.
10. Connect the air lines to the valve as marked earlier.
11. Connect the electrical connector to the valve.
12. Remove chocks from tires.

Replacement

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. At the ECAS height sensor (see **Fig. 1**), which is mounted between the frame rail and the drive axle housing, disconnect the electrical plug on the back of the sensor.



1. Axle
2. Linkage Rod
3. Overtravel Lever
4. Sensor
5. Bracket
6. Frame Rail

Fig. 1, Height Sensor Assembly

4. Remove the bolts attaching the sensor to the frame rail bracket.
5. Disconnect the linkage rod from the axle housing.
6. Remove the overtravel lever from the height sensor.
7. Remove the sensor.
8. To install the sensor, attach the overtravel lever to the height sensor.
9. Attach the linkage rod to the axle housing.
10. Fasten the sensor to the frame rail bracket.
11. Connect the electrical plug to the back of the height sensor.
12. Remove the chocks from the tires.

Troubleshooting Information

1. Indicator Lights:
   - ECAS FAIL lights up if there is a failure in the ECAS system.
   - Load XFER lights up whenever there is a manual or automatic load transfer.
2. Frame Height Control: ECAS will maintain the vehicle frame height to a preset value within 3/16-inch (4.7 mm) by adjusting the pressure in the rear suspension air bags. With the remote-control unit, the operator can adjust the frame height within the operating limits if the vehicle is parked or traveling less than 7 mph (15 km/h).
3. Load Transfer Activation: The weight is transferred from the tag axle to the drive axle by adjusting the pressure in the air bags. The load is shifted for 20 seconds, then is slowly equalized back to the normal condition. The complete load transfer cycle takes approximately 45 seconds. The load transfer occurs under the following conditions.
   - Automatic activation: The drive wheels slipping (usually when starting out on a slick surface) will activate the load transfer. If the vehicle is equipped with Automatic Traction Control, the load transfer will activate just after the ATC.
   - Manual activation: Pressing the MOM ON (Momentary On) side of the ECAS XFER dash switch will activate the load transfer. Manual activation works only at vehicle speeds less than 30 mph (50 km/h).
4. Load Transfer Termination: The load transfer cycle will terminate under the following conditions.
   - Applying the service brakes with a vehicle speed of more than 30 mph (50 km/h).
   - Vehicle speed exceeds 75 mph (120 km/h).
   - Pressing the STOP button on the remote control or disconnecting the remote control. This will terminate the load transfer at any speed.

Troubleshooting Tables

Before performing any diagnostics, make sure there are no ABS faults. Because of the interaction of the ABS and the ECAS systems, a fault in one system may cause a malfunction in the other system.

The following types of failures cause the "ECAS FAIL" indicator light to remain on:

- Grounded "ECAS FAIL" light wire;
- No power at ECAS electronic control unit (ECU) pin 1;
- Electrical fault in ECAS height sensor;
- Electrical fault in ECAS valve;
- Failure of J1587 data bus;
- Internal ECU fault;
- Faulty calibration of ECAS height control;
- Frame height cannot be adjusted within five minutes after ignition or within 30 seconds during normal service.

See **Table 1** for troubleshooting problems when the "ECAS FAIL" light remains on. This would include problems where the wrong action occurs, such as the air bags inflating rather than deflating, or the drive axle air bags deflating rather than the tag axle air bags. The causes may be crossed electrical wiring or air supply plumbing.

See **Table 2** for frame height problems.

See **Table 3** for incorrect ECAS functionality.

See **Table 4** for indicator lamp problems.

See **Table 5** for manual load transfer problems.

NOTE: All lamps are activated by the ECU for approximately two seconds after the ignition is switched on. The ignition must be switched off for at least 6.4 seconds before restarting to determine lamp condition.

Troubleshooting

Electrical Systems Testing				
System Tested	**Ignition**	**Test these pins on ECAS ECU harness 35-pin connector (disconnected unless otherwise noted)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS FAIL light	On	—	Light is out	Find short to ground in wire between ECAS FAIL light and ECU.
Ground	Off	27 and Battery Ground	0 ohms	Trace wire between pin 27 and ground to find cause of high resistance.
Ground	Off	1 and 27	System voltage	Find open circuit or cause of high resistance in wiring.
Ignition and constant power	On	1 and 27 9 and 27	System voltage	Find open circuit or cause of high resistance in wiring.
Height sensor	Off	25 and 27	100 to 140 ohms	If resistance is infinite (open circuit), find open circuit in wires to height sensor and repair. If there is continuity but resistance is out of specification, check resistance at height sensor. If sensor is not within specification, replace sensor.
ECAS valve electrical checks	Off	13 and 27 15 and 27 30 and 27	15 to 25 ohms	If resistance is infinite (open circuit), find open circuit in wires to ECAS valve and repair. If there is continuity but resistance is out of specification, check resistance at ECAS valve. If valve is not within specification, replace valve.
Data bus connectivity (ECAS reads vehicle speed and other data from J1587 data bus)	On	Connect harness to ECU, and run Service Link to see if ECU is connected to data bus.	—	If other ECUs are identified with Service Link, check data bus wires to ECU for open, grounded, or crossed wires (pins 4 and 2). If no other ECUs are identified with Service Link, there is a main data bus problem, not a specific ECAS problem.
Internal ECU fault	—	There is no test for ECU. If all other tests are within specifications, ECU is probably bad.	—	Replace ECU.

Table 1, Electrical Systems Testing

Frame Height Systems Testing		
System Tested	**Test Procedure**	**Remedy (if not within specification)**
ECAS height calibration	Using the remote control unit, raise or lower the vehicle frame. Press the Normal key, and the frame should return to normal height.	Install the height sensor arm in the correct position relative to the height sensor rotating spool.

Frame Height Systems Testing		
System Tested	**Test Procedure**	**Remedy (if not within specification)**
Frame height adjust time	Check air suspension system for leaks or restrictions in lines or valve ports. Check air supply system for proper charge time.	Repair as required.

Table 2, Frame Height Systems Testing

ECAS Functionality Testing				
System Tested	**Ignition**	**Test these pins on ECAS ECU harness 35-pin connector (disconnected)**	**Acceptable Value**	**Remedy (if not within specification)**
Inflate function	On	Connect 9 to 15. Alternately connect 13 to 9 and to 15.	All rear suspension air bags inflate when (and only when) 13 is connected.	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags. **CAUTION** **Do not over-inflate air bags. This may extend the shock absorbers to their limits and cause damage.**
Deflate function	On	Connect 9 to 13.	All rear suspension air bags deflate.	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.
Load transfer function	On	Connect 9 to 30.	Tag axle air bags deflate.	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.
		Disconnect 9 from 30. Connect 9 to 15.	Pressure will equalize between drive and tag axle air bags.	Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.

Table 3, ECAS Functionality Testing

Indicator Light Testing				
System Tested	**Ignition**	**Test these pins on ECU harness 35-pin connector (disconnected)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS FAIL light	On	Connect 33 and 27.	Light on	Replace bulb. If bulb still does not light, check the wiring between the bulb and the 35-pin connector.
ECAS XFER light	On	Connect 18 and 27.	Light on	Replace bulb. If bulb still does not light, check the wiring between the bulb and the 35-pin connector.

Table 4, Indicator Light Testing

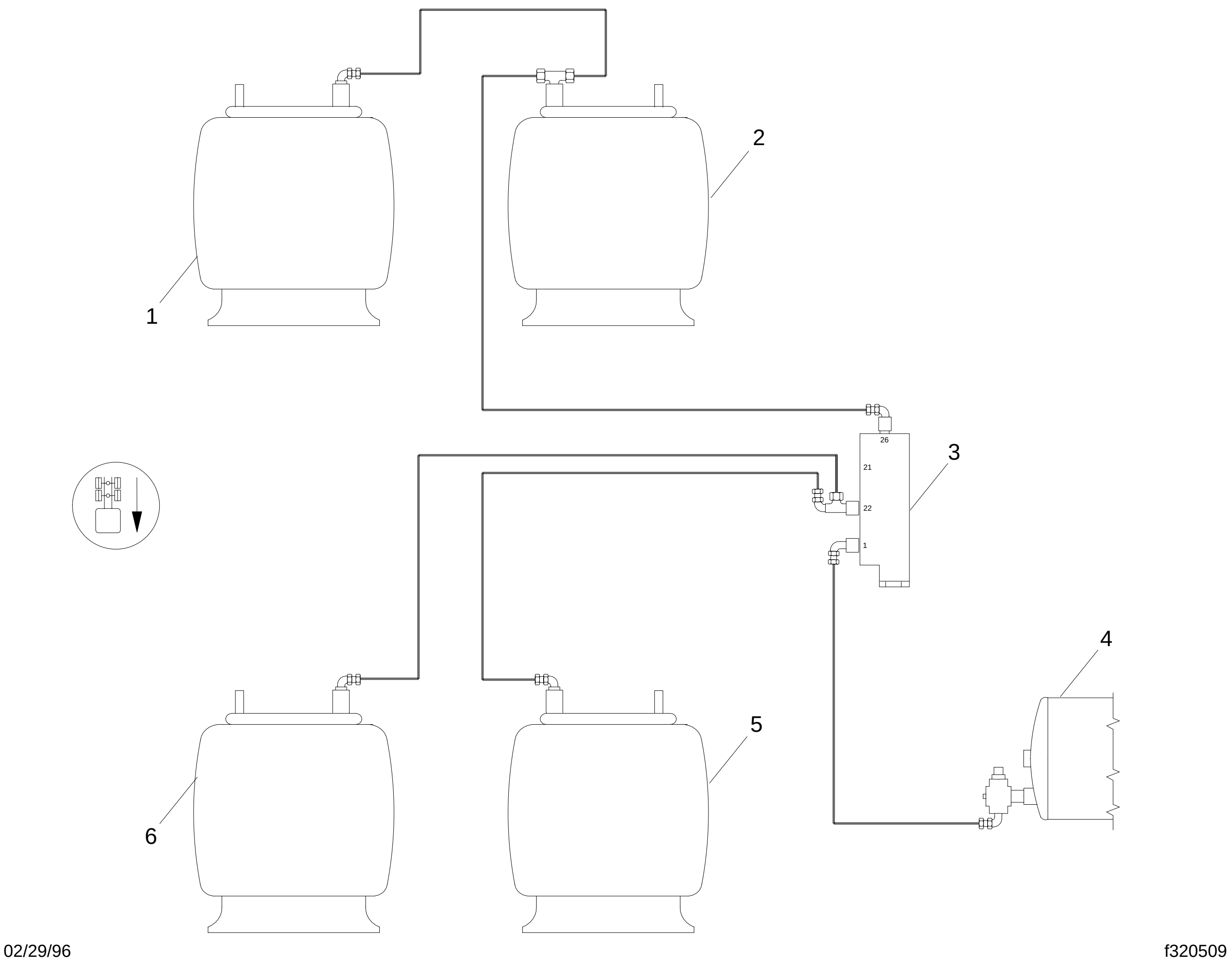
Troubleshooting

Manual Load Transfer Testing				
System Tested	**Ignition**	**Test These Pins On ECAS ECU harness 35-pin connector**	**Acceptable Value**	**Remedy (if not within specification)**
Manual load transfer switch	Off	17 and 27, MOM ON switch released (with harness disconnected)	>30k ohms	Locate and repair ground (wire pin to pin 17).
		17 and 27, MOM ON switch pressed (with harness disconnected)	0 to 2 ohms	Locate and repair high resistance in switch circuit.
	On	ECAS ECU harness; Jump pin 17 to ground (with harness connected to ECU	Load transfer cycle will occur	Perform air bag functionality tests. If air bags function correctly as described, manual load transfer function of ECU is malfunctioning. Replacement of ECU is probably necessary.

Table 5, Manual Load Transfer Testing

Specifications

See **Fig. 1** for the AirLiner Plus air system plumbing diagram, and see **Fig. 2**, **Fig. 3** and **Fig. 4** for diagrams of the AirLiner Plus electrical system.



1. Right Rear Air Bag
2. Left Rear Air Bag
3. Solenoid Valve
4. Secondary Air Reservoir
5. Left Forward Air Bag
6. Right Forward Air Bag

Fig. 1, AirLiner Plus ECAS Air System Plumbing Diagram

Specifications

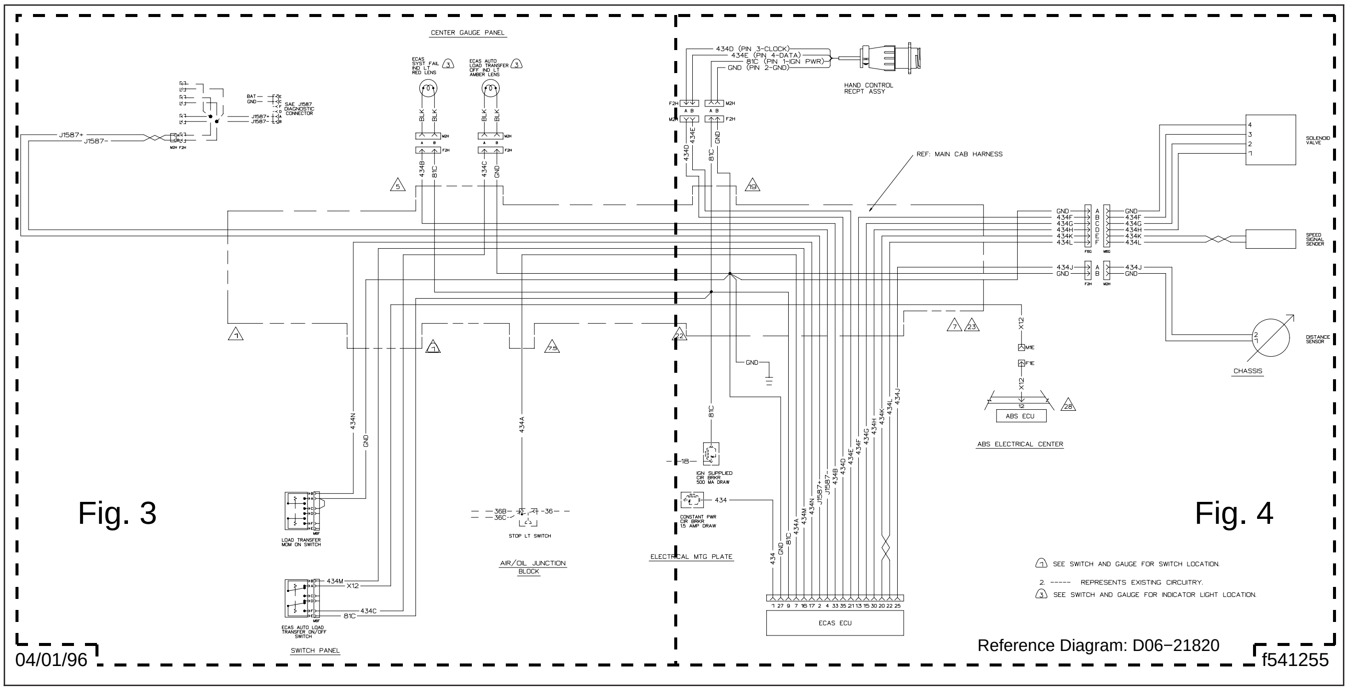


Fig. 2, AirLiner Plus ECAS Electrical Diagram (complete view)

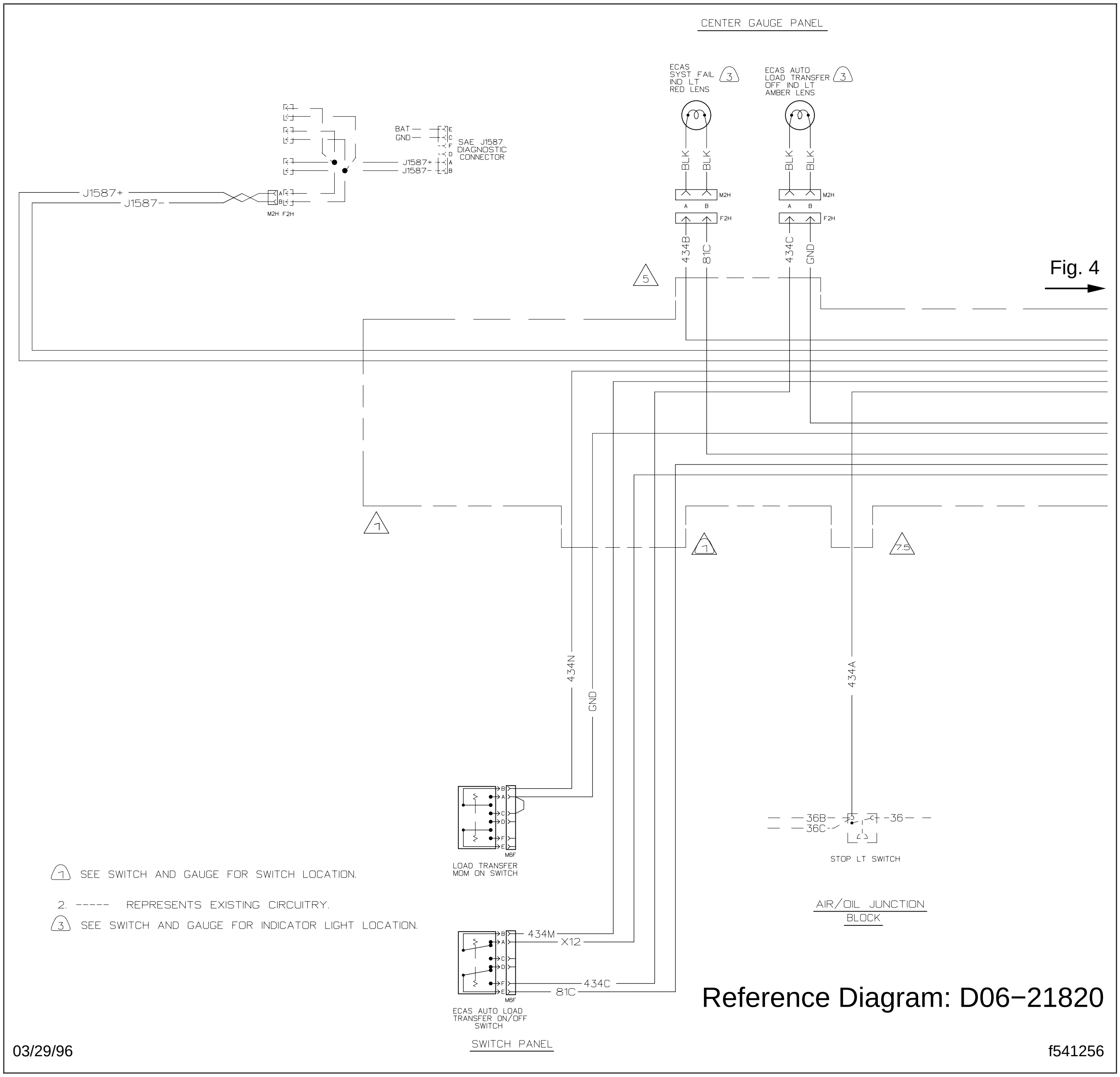


Fig. 3, AirLiner Plus ECAS Electrical Diagram (partial view)

Specifications

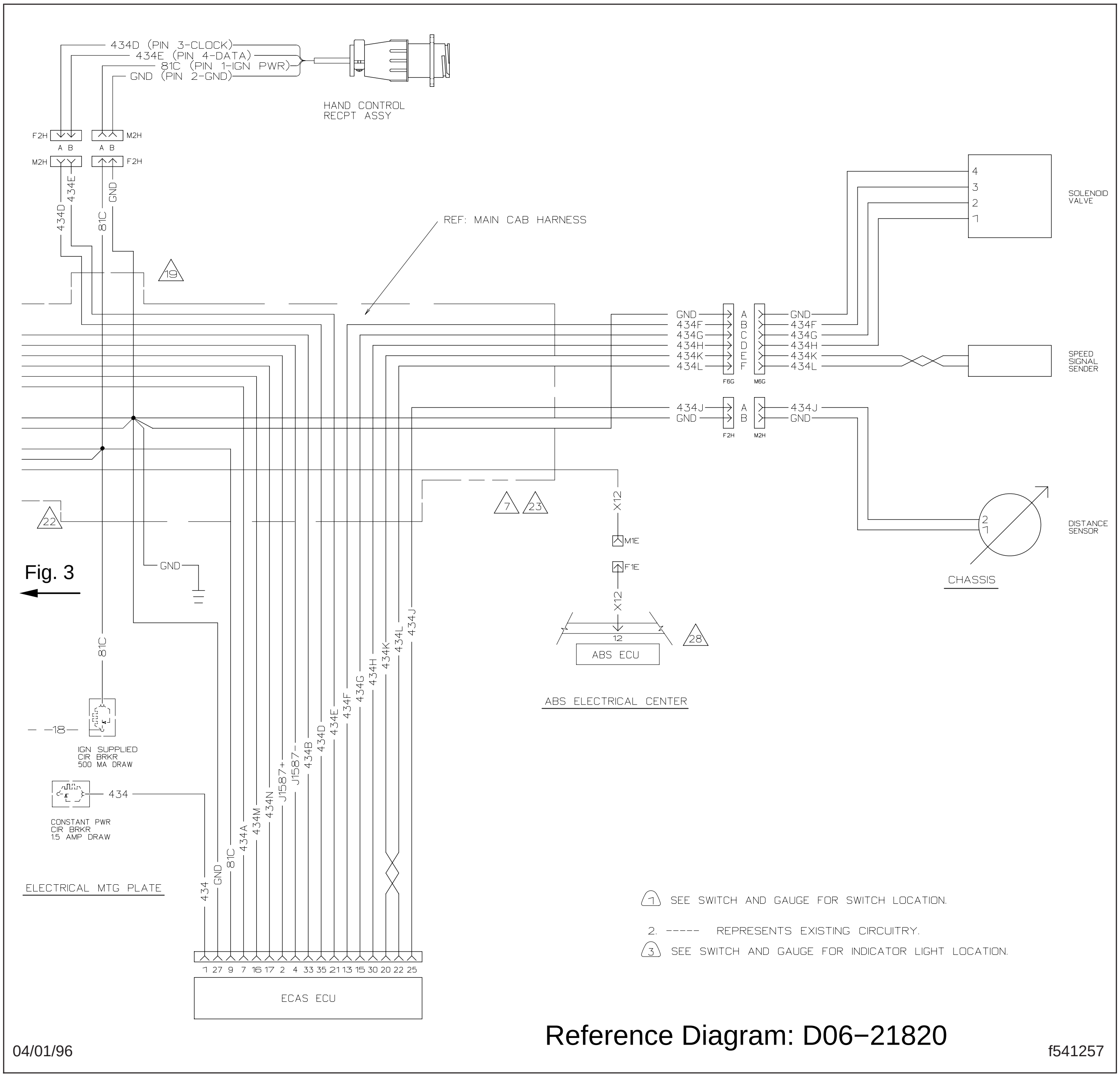


Fig. 4, AirLiner Plus ECAS Electrical Diagram (partial view)

General Description

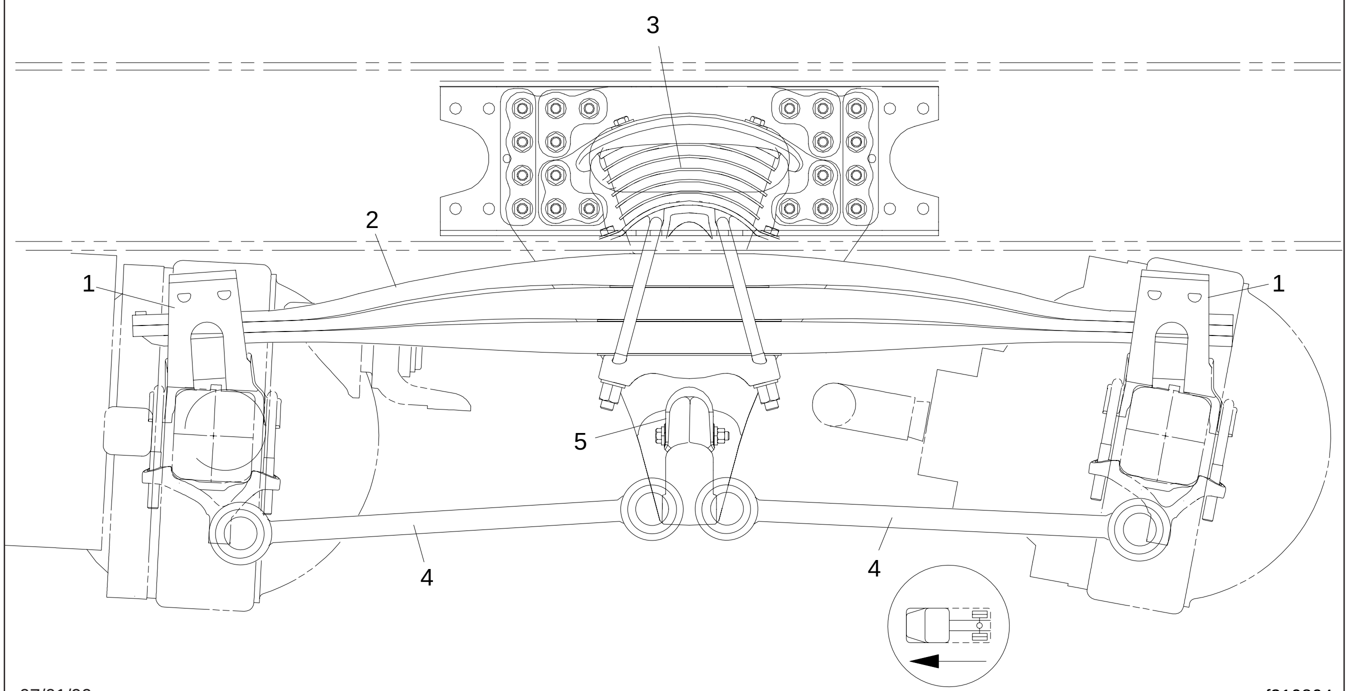
The TufTrac Suspension is heavy-duty "six rod" tandem-axle suspension option for trucks built for severe on/off highway work. See **Fig. 1**. The TufTrac design allows a truck to maneuver over bumps, ridges and washboard roads that typically generate high rates of axle articulation, without bottoming out the suspension or losing traction.

The TufTrac suspension is available in three weight ratings – 40,000-, 46,000- and 52,000-pound (18 144-, 20 865-, 23 586-kilogram) capacities. The 40,000-pound (18 144-kilogram) capacity suspension uses two taper leaf springs and has an axle spacing of 54 inches. The 46,000-pound (20 865-kilogram) capacity suspension has three leaf springs (shown in this section), while the 52,000-pound (23 586-kilogram) suspension features four leaf springs. Both the 46,000-pound (20 865-kilogram) and the 52,000-pound (23 586-kilogram) suspensions have a standard axle spacing of 56 inches.

Principles of Operation

Six functional links in the TufTrac suspension maintain the positions of the axles. Side-to-side axle movement is controlled by two v-rods from the frame to the axles at the top of the differentials. Four control rods from the frame to the axles at the bottom control the forces of driving and braking as well as fore-and-aft road shocks. Vertical loads are carried by the rubber-isolated parabolic taper leaf spring packs.

General Information

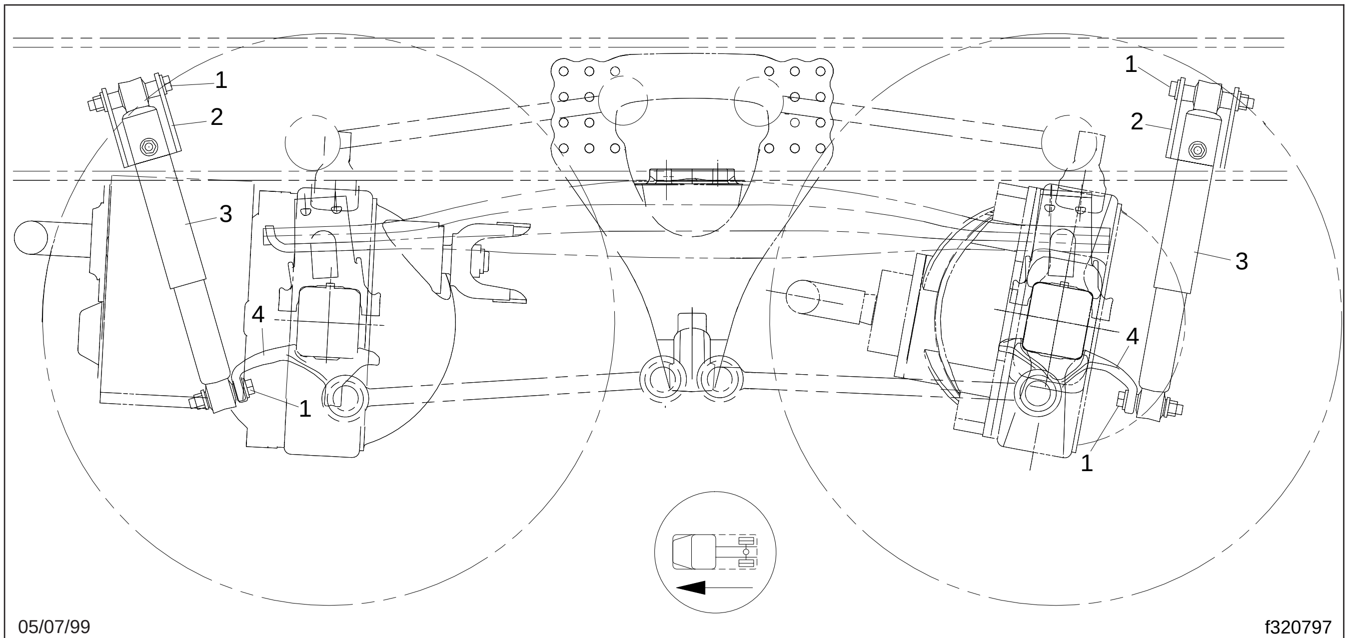


1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

Replacement (See Fig. 1)

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the lower shock mounting nut and washer.
3. Remove the upper shock mounting nut and washer.
4. Remove the upper and lower mounting bolts and remove the shock absorber.
5. Position the new shock absorber in place and install the mounting bolts.
6. Loosely fasten the bolts with the nuts and washers removed from the old shock absorber.
7. Torque each mounting nut 241 lbf·ft (327 N·m).
8. Remove the chocks from the tires.

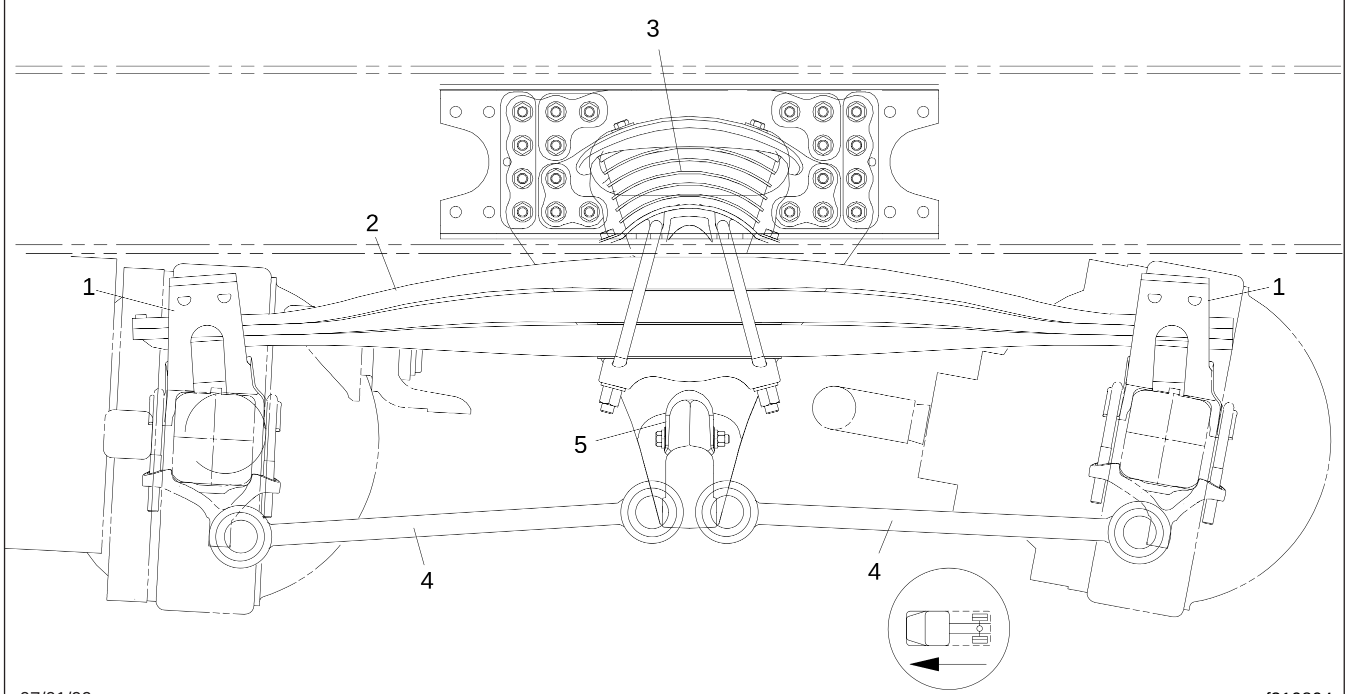


1. Mounting Bolt
2. Upper Mounting Bracket
3. Shock Absorber
4. Lower Mounting Bracket

Fig. 1, Shock Absorber Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the rebound stop from the suspension. See **Fig. 1**.
   - 2.1 Remove the nut and bolt securing the rebound stop to the mounting bracket.
   - 2.2 Slide the rebound stop from the mounting bracket.
3. Remove the upper two fasteners on the center bearing.
4. Jack up the vehicle under the rear axle.
5. Support the rear frame rails with jack stands, then lower the jack. This will clear the center bearing from the top of the mounting bracket. See **Fig. 2**.
6. Remove the lower center bearing bolts attached to the spring assembly casting. Discard the bolts.
7. Remove the center bearing. See **Fig. 3**.
8. Position the new center bearing in the mounting bracket.
9. Install the upper mounting bolts and tighten 68 lbf·ft (92 N·m).



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1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

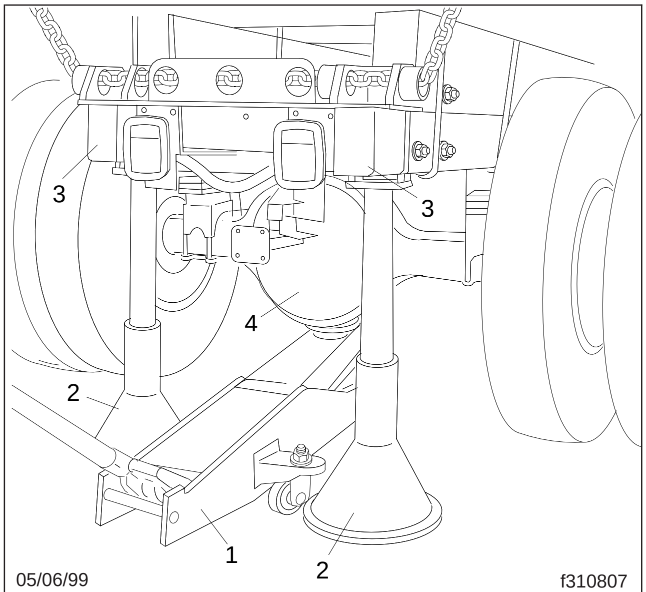
Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

10. With the jack, raise the rear axle until bottom of the center bearing meets the mounting bracket on the leaf springs.

IMPORTANT: Be sure to use new bolts with Loctite (p/n 23-12576-125) when attaching the center bearing to the leaf spring casting.

11. Install new lower mounting bracket bolts (p/n 23-12576-125). Tighten the bolts 155 lbf·ft (210 N·m).

Center Bearing Replacement



1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement

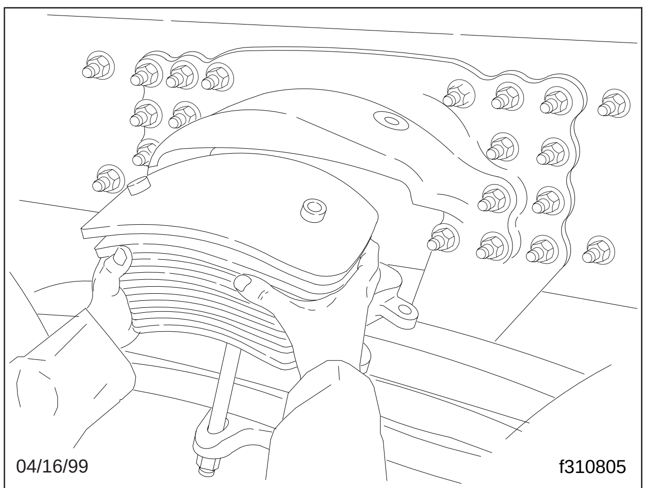


Fig. 3, Center Bearing Removal

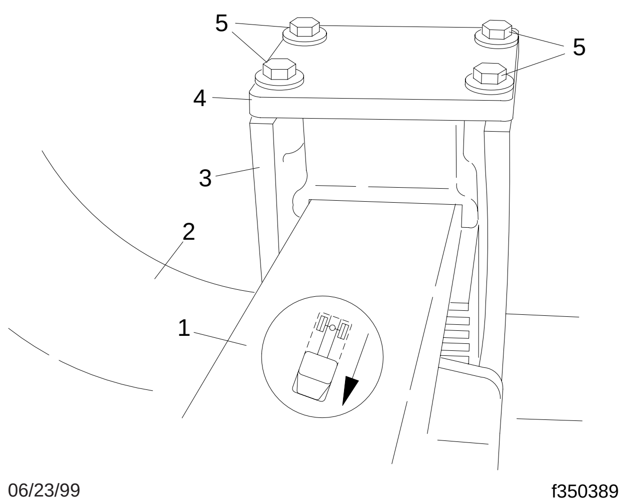
12. Return the vehicle to its normal operating position.
13. Install the rebound stop.
14. Remove the chocks from the tires.

Spring Assembly Removal, Assembly and Installation

IMPORTANT: The spring pack assembly is not available as an assembled unit in the aftermarket. If the spring pack assembly is to be replaced with a new assembly, the springs, center bearing seat and retainer bracket must be assembled before installation on the vehicle.

Removal

1. Park the vehicle on a level surface. Shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the tip pad bolts above each axle on the axle clamp. There are four bolts on each pad. See **Fig. 1**.



1. Leaf Springs
2. Axle
3. Axle Pad
4. Tip Pad
5. Tip Pad Bolts

Fig. 1, Tip Pad Installation

3. Remove the center bearing. See **Subject 110**.
4. With the vehicle still raised, remove the wheels on both rear axles on the side the spring assembly will be replaced. For instructions, see **Group 40**.

WARNING

Do not attempt to remove the spring assembly by hand. The assembly is very heavy and attempting to lift it could result in bodily injury.

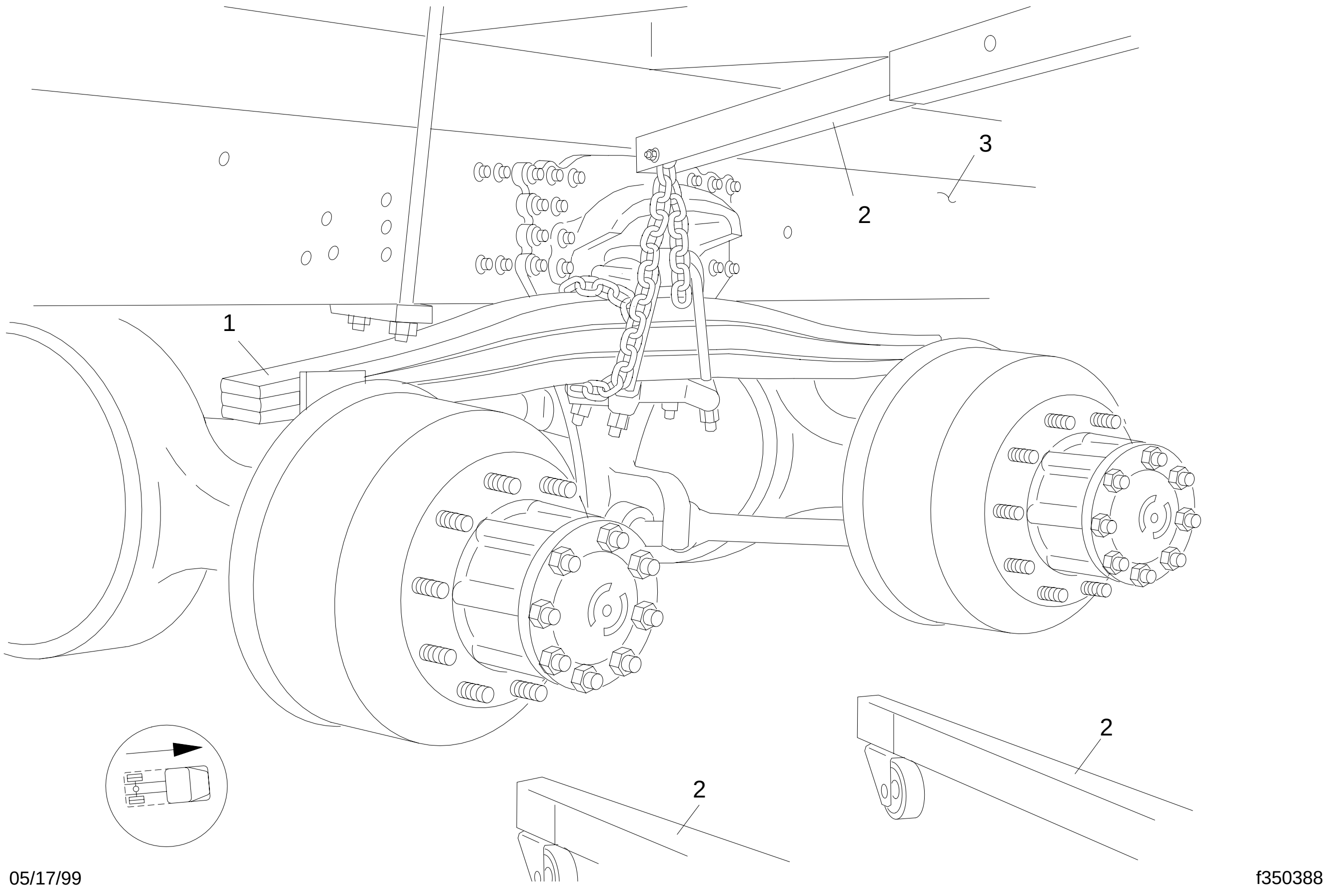
5. Using a lift (i.e. engine hoist), remove the leaf spring assembly from the vehicle. See **Fig. 2**.

Assembly

IMPORTANT: Leaf springs in a spring pack assembly cannot be replaced individually. The entire spring pack assembly must be replaced.

1. Support both sides of the new spring pack assembly on jack stands. Make sure all the leaf springs are interlocking with the studs and dimples at the centers of the leaf springs.
2. If the assembly contains a spacer, place it on the center of the top leaf spring. Make sure the dimple in the spacer is aligned with the stud in the center of the top leaf spring.
3. Place the center bearing seat on the top of the spacer or leaf spring, as applicable. Make sure the dimple in the middle of the center bearing seat aligns with the stud in the middle of the leaf spring or the spacer.
4. Install the two 3/4-inch U-bolts over the center bearing seat. Make sure the U-bolts rest in the grooves of the center bearing seat.
5. At the bottom of the spring pack, install the U-bolt retainer bracket over the threaded ends of the U-bolts.
6. Holding the retainer bracket in place, install a hardened washer and hexnut over the threaded end of each U-bolt.
7. Tighten the U-bolts in a diagonal sequence as follows:
   - Stage 1: 60 lbf·ft (81 N·m)
   - Stage 2: 200 lbf·ft (271 N·m)
   - Stage 3: 300 lbf·ft (407 N·m)

Spring Assembly Removal, Assembly and Installation



1. Springs
2. Lift (hoist)
3. Frame Rail

Fig. 2, Leaf Spring Replacement

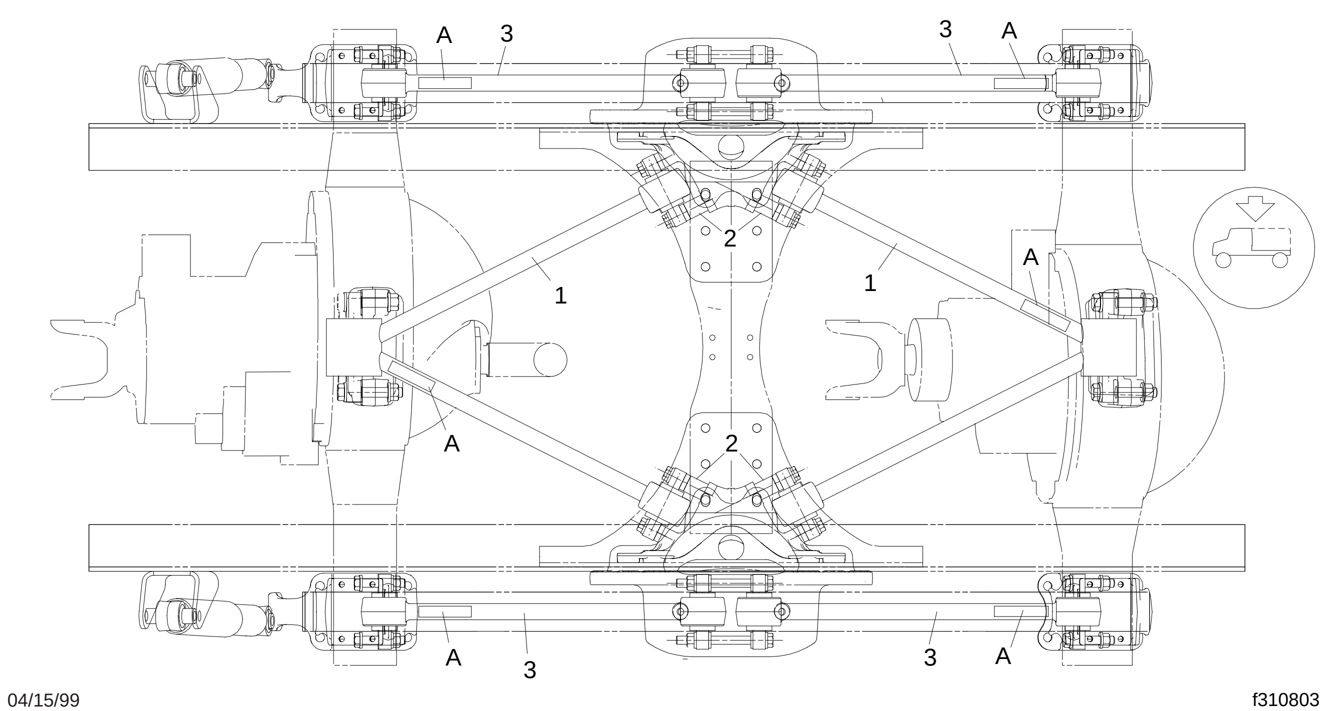
Installation

WARNING

Do not attempt to install the spring assembly by hand. The assembly is very heavy and attempting to lift it could result in bodily injury.

1. Place the new spring assembly on the vehicle.
   1.1 Attach the new assembly to the lift.
   1.2 Using the lift (hoist), lift the assembly into place on the axle clamps.
2. Install the center bearing. For instructions, see **Subject 110**.
3. Install the tip pad and bolts on each axle clamp. Tighten the bolts 37 lbf·ft (50 N·m). See **Fig. 1**.
4. If not already installed, install the rebound stop and mounting bolt. Tighten the nut 68 lbf·ft (92 N·m).
5. Install the wheels. For instructions, see **Group 40**.
6. Return the vehicle to its normal operating position.
7. Remove the chocks from the tires.

Lower Control Rod Replacement (See Fig. 1)



A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control and V-Rod Assembly

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the front tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.
4. Remove the bolts holding both rods between the rear axles, below the rebound stop. See **Fig. 3**.
5. Remove the nut and bolt from the axle clamp.
6. Remove the control rod from the vehicle.

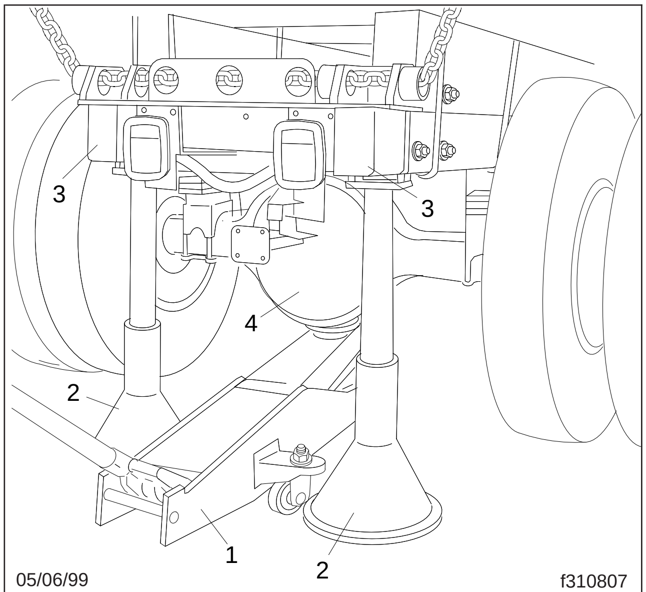
IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle rods "RDA."

7. Fasten the new control rod to the axle clamp. Tighten the nut 136 lbf·ft (184 N·m).
8. Fasten the other end of the rod to the bracket below the rebound stop. Tighten the nut 136 lbf·ft (184 N·m).
9. Remove the chocks from the tires.

V-Rod Replacement

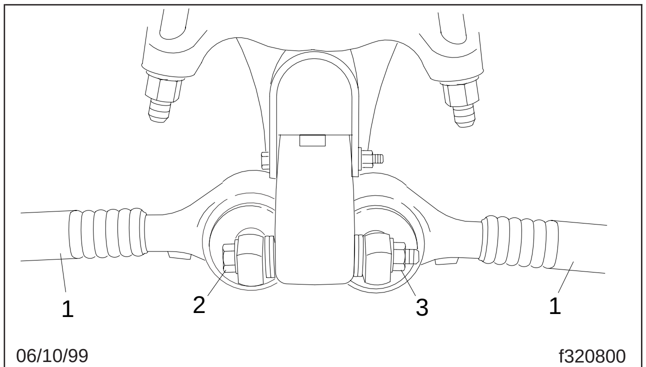
1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.

Lower Control Rod and V-Rod Replacement



1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement



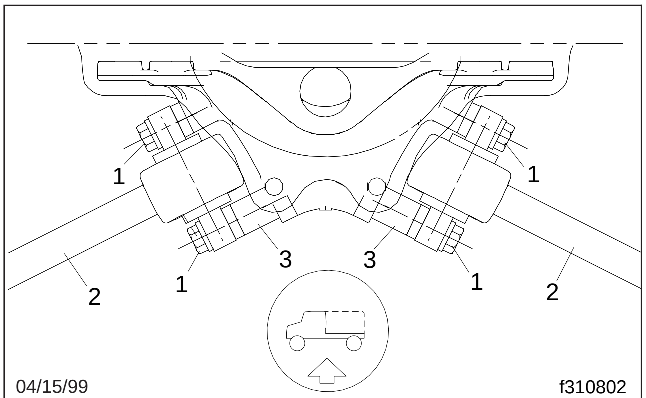
1. Lower Control Rod
2. Mounting Bolt
3. Mounting Nut

Fig. 3, Lower Control Rods

4. Remove all six mounting bolts securing the v-rod to the chassis and axle.
5. Remove the v-rod from the chassis.

IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle "RDA."

6. Install the v-rod. See **Fig. 4**.



1. Mounting Bolt
2. V-Rod
3. Spacer

Fig. 4, V-Rod Installation

6.1 Place the new rod in position between the frame rails.

6.2 Install the bolts and spacers and loosely tighten all connections.

6.3 After all fasteners and spacers are installed, torque as follows:

- Tighten the bolts at the frame bracket 136 lbf·ft (184 N·m).
- Tighten the bolts at the axle bracket 427 lbf·ft (579 N·m).

7. Remove the chocks from the tires.

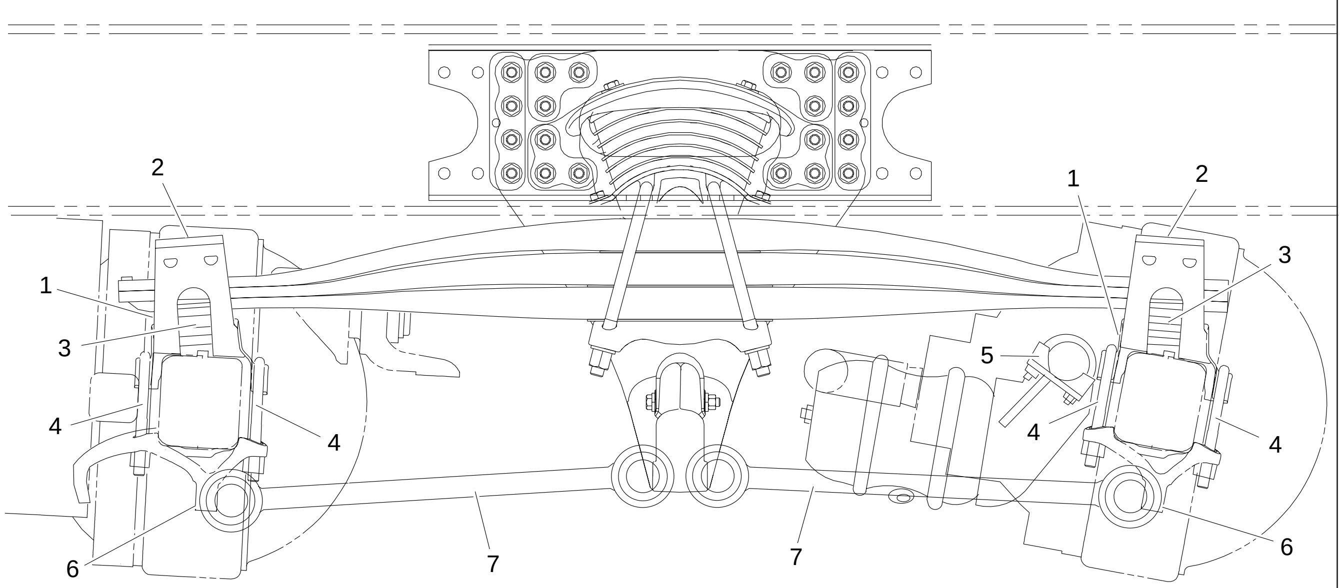
Replacement

1. With the vehicle parked on a level surface, shut down the engine, and chock the tires.

NOTE: All of the following steps should be performed on the left side of the vehicle, first; then the right side of the vehicle.

2. Remove the two upper spring-tip pads and bolts from the suspension spring. See **Fig. 1**.
3. Disconnect the shock absorbers from the lower axle retainer on the suspension spring.
4. Disconnect the two lower torque-control rods from the lower axle retainers.
5. Remove and discard the U-bolt nuts and washers.
6. Remove the brake cam tube-support bracket.
7. Remove and discard the lower axle retainers.
8. Remove and discard the axle U-bolts from both rear axles.
9. Jack up the center of the suspension spring (at the center bearing, between the tandem) and support with jack stands at the frame. See **Fig. 2**. Make sure that all weight has been relieved from the axle clamp group and that there is sufficient clearance to remove the upper axle clamp.
10. Remove the lower spring-tip pads from both rear axles.
11. Remove and discard the upper axle clamps from both rear axles.
12. On both rear axles, install new upper axle clamps. Locate the dowel pin through the hole in the bottom of each axle clamp to confirm proper alignment.

NOTE: Confirm that you are installing the correct upper axle clamps before continuing. You can visually identify the new upper axle clamp because the step has been removed from the area directly above the U-bolt saddles. See **Fig. 3**.



1. Upper Axle Clamp
2. Upper Spring-Tip Pad
3. Lower Spring-Tip Pad
4. U-Bolt
5. Brake Cam Tube-Support Bracket
6. Lower Axle Retainer
7. Lower Torque-Control Rods

Fig. 1, TufTrac Suspension (left-side view)

Axle Clamp and Retainer Replacement

13. Install the lower spring-tip pads into the front and rear axle clamps.
14. Jack up the left-side suspension spring, remove the jack stands, and lower the spring. While the spring is being lowered, ensure that it is seated correctly onto the lower spring-tip pads.
15. Install new lower axle retainers onto both rear axles.
16. Install the brake cam tube-support bracket onto the rear axle.

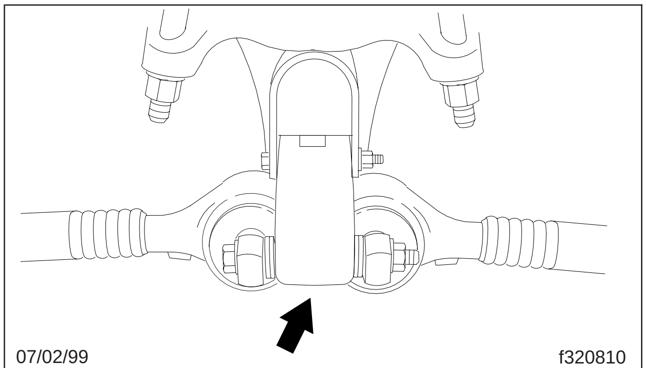
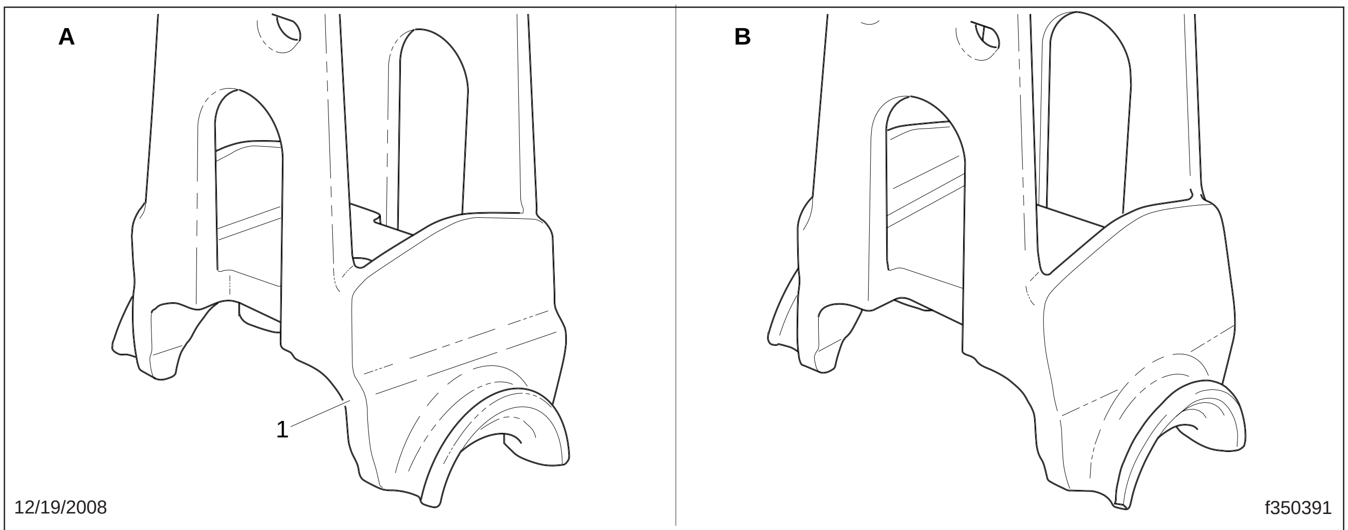


Fig. 2, Vehicle Jacking Point



A. Original Axle Clamp
1. Step in U-Bolt Saddle

B. New Axle Clamp

Fig. 3, Upper Axle Clamps

17. Install new U-bolts as follows.

IMPORTANT: Install two new washers for each U-bolt nut.

17.1 Install each U-bolt over the U-bolt saddle in the upper axle clamp and through the holes in the lower axle retainer.

17.2 Install the washers and finger-tighten the nuts in the order shown in **Fig. 4**.

Make sure all brackets are snug against the axle housing before proceeding.

IMPORTANT: U-bolt nuts must be tightened in the order shown in **Fig. 4**.

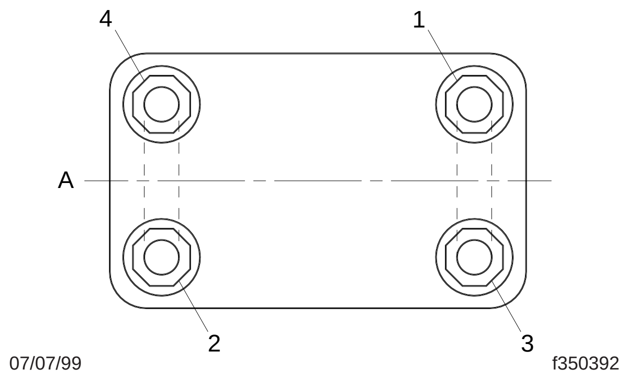
17.3 Tighten the nuts 60 lbf·ft (81 N·m), then 200 lbf·ft (271 N·m), in two separate rotations, following the order shown in **Fig. 4**.

18. Attach the lower torque-control rods to the lower axle retainers, then tighten 136 lbf·ft (184 N·m).
19. Install the shock absorbers as follows.

19.1 Install the lower shock mounting bolts.

19.2 Install the lower shock absorber mounting washers and nuts, then hand-tighten the nuts.

19.3 Tighten the nuts to 241 lbf·ft (327 N·m).



A. Centerline of Spring

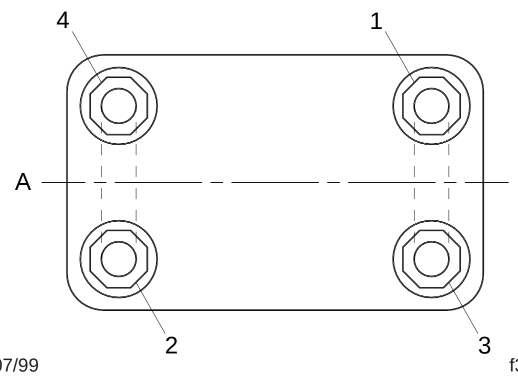
1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 4, U-Bolt Nut Tightening Sequence

20. Install the spring-tip pads on the suspension spring, then install the bolts, and tighten 37 lbf·ft (50 N·m).
21. Repeat the steps for the right-side spring.

Torque Specifications	
Description	**Torque Value lbf·ft (N·m)**
Shock Absorber Mounting Bolt	241 (327)
Center Bearing Upper Mounting Bolts	68 (92)
Center Bearing Lower Mounting Bolts	155 (210)
Tip Pad Bolts	37 (50)
Rebound Stop Mounting Bolt	68 (92)
Lower Control Rod Mounting Bolts	136 (184)
V-Rod Frame Bracket Mounting Bolts	136 (184)
V-Rod Axle Bracket Mounting Bolts	427 (579)
5/8–18 Axle Clamp U-Bolt Nuts (Tighten as shown in Fig. 1.)	Stage 1: Hand-Tighten Stage 2: 60 (81) Stage 3: 200 (271)
3/4-Inch Spring Pack U-Bolt Nuts	Stage 1: 60 (81) Stage 2: 200 (271) Stage 3: 300 (407)

Table 1, Torque Specifications



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A. Centerline of Spring

1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 1, U-Bolt Nut Tightening Sequence

General Description

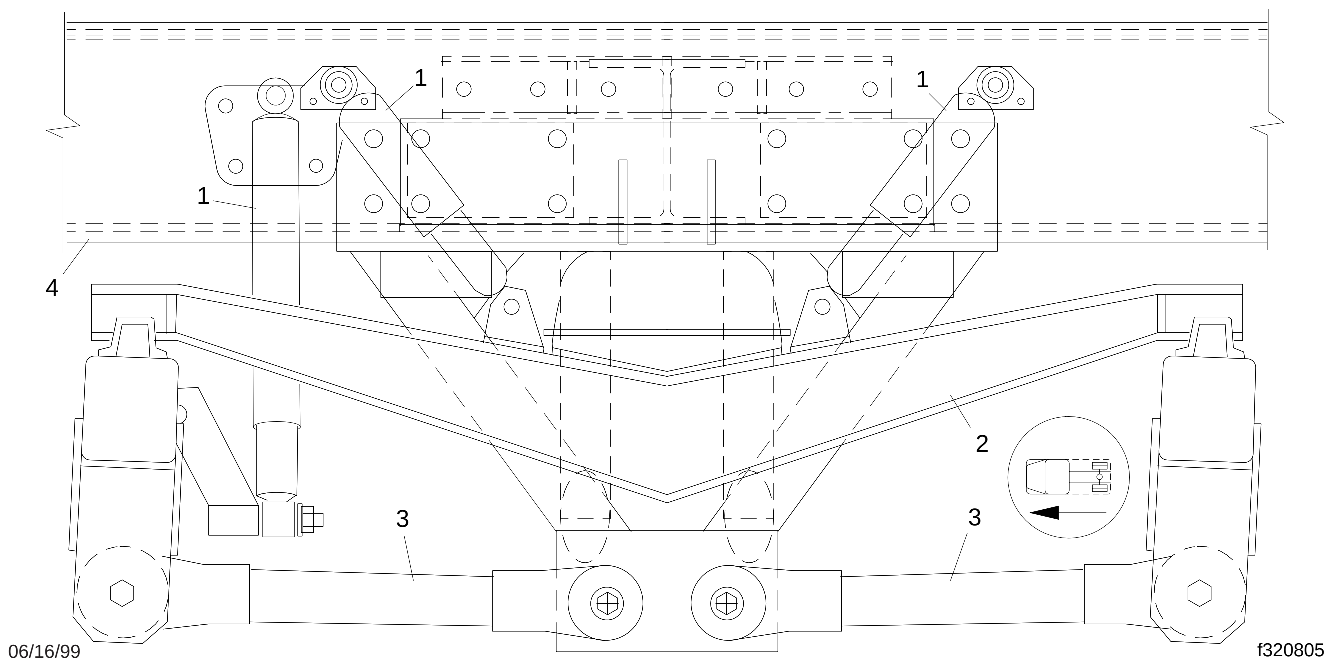
The Chalmers 854 Rear Suspension (Fig. 1 and Fig. 2) is a walking beam-type tandem axle suspension that uses hollow rubber springs instead of leaf springs or air bags. Each hollow rubber spring is mounted between a frame-rail plate and the center (front-to-rear) of the steel walking beam. A sawhorse bracket assembly is attached to the frame and provides mounting points for the lower torque rods that tie the axles to the frame. The upper torque rods are fastened to brackets that bolt to the frame side rails and to tower assemblies that are welded to the top of the differential housings.

The 854 Rear Suspension allows a high degree of both parallel and diagonal articulation, while maintaining wheel load equalization to within 3 percent.

The Chalmers suspension design separates the rear suspension's responsibility for supporting/cushioning the load from that of locating/guiding the axles. The suspension is very light, relative to its load carrying capacity, but requires very little maintenance. In fact, there are no lubrication fittings since grease and oil are never needed.

The 854 Rear Suspension is available in three different maximum load capacities: 40,000 lb. (18 000 kg), 46,000 lb. (21 000 kg), and 52,000 lb. (23 600 kg). The 40,000 lb. (18 000 kg) version is easily distinguished from the other two versions since the upper torque rods do not cross over one another on the 40,000 lb. (18 000 kg) version.

The 854 suspension is available in a 54-inch axle spacing. The axle-to-axle spacing dimension is often included as part of the suspension name, such as "Chalmers 852 Rear Suspension" or "Chalmers 854 Suspension."



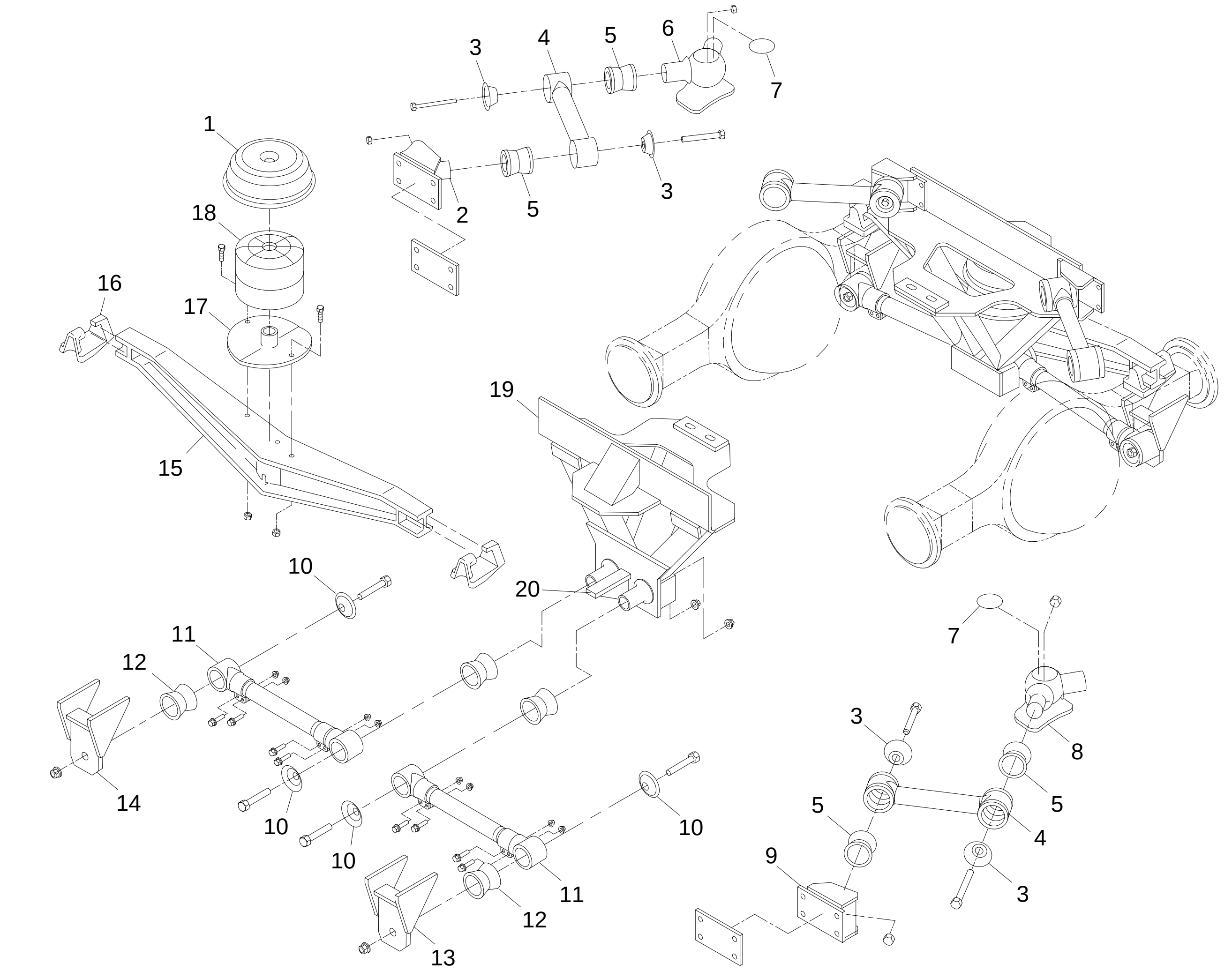
1. Shock Absorber
2. Beam
3. Lower Torque Rod
4. Frame Rail

Fig. 1, Chalmers 854 Tandem Axle Suspension

Shock absorbers are included on all versions of the suspension, and are beam-mounted.

The rear suspension may be precision-aligned by adjusting the length of the lower torque rods. These rods have both left- and right-hand threads cut on the same tube so rotating the tube changes the effective length of the tube.

General Information

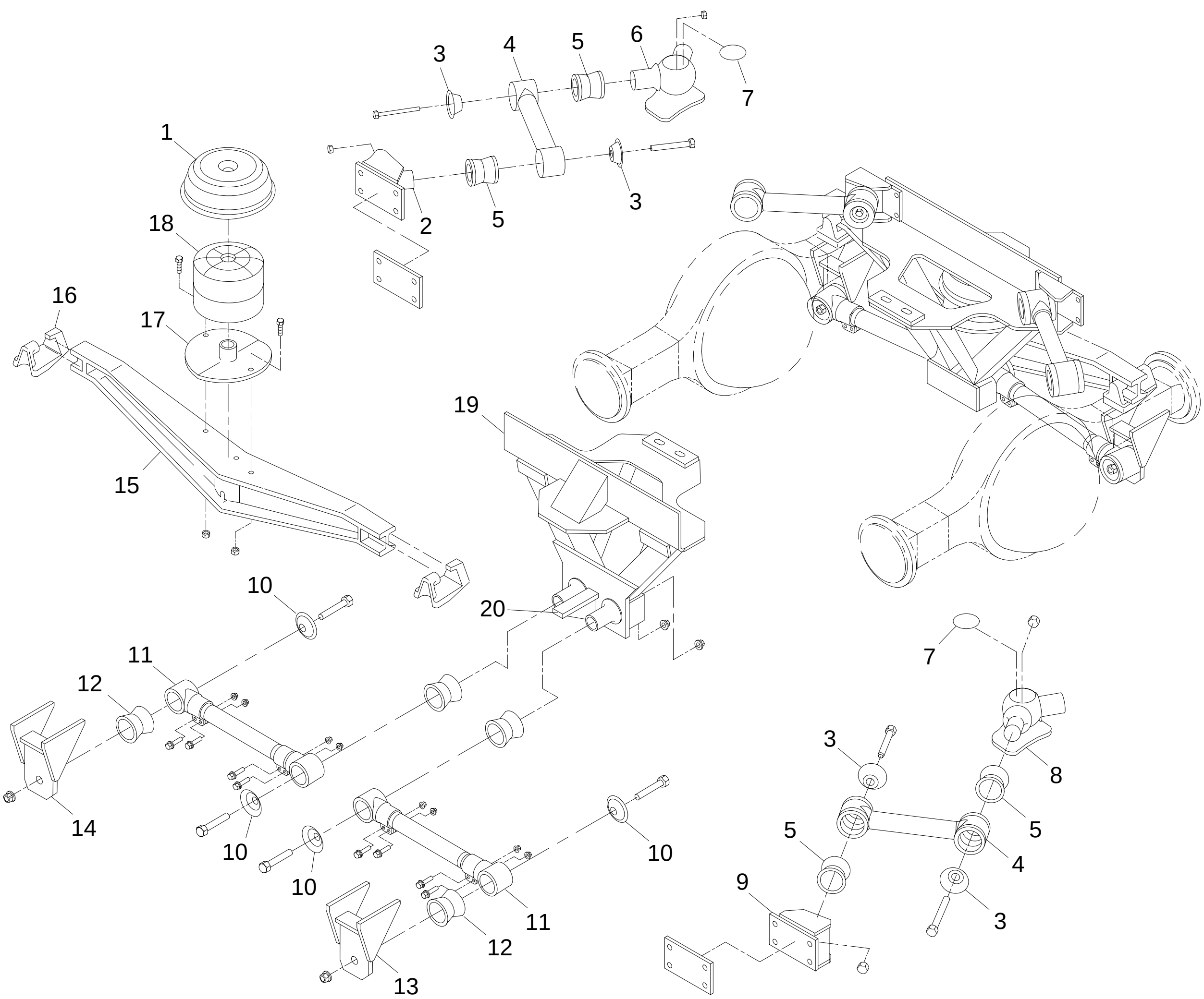


1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 2, Chalmers 854 Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)

Rubber Spring Replacement

Removal (See Fig. 1)



1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

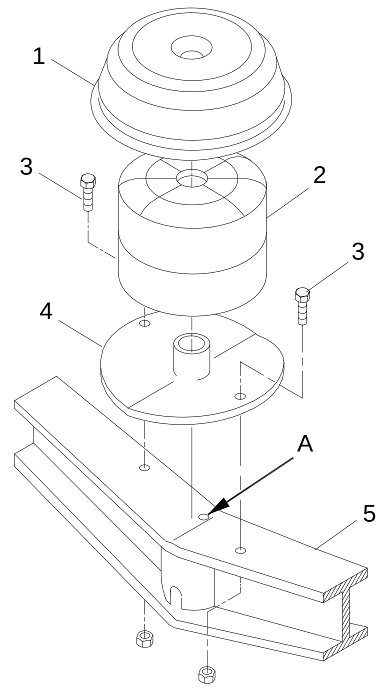
Fig. 1, Chalmers 854 Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)

Rubber Spring Replacement

1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (**Fig. 1**) to the walking beam assembly. Discard the fasteners.
5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. See **Fig. 1**.
6. Separate the restrictor can, spring, and spring plate; discard the spring.
7. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. See **Fig. 2**.
8. Inspect the spring plate for cracks; replace if it any are present.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

9. Position the new rubber spring on the spring plate, making sure that the vent hole is centered on the spring plate tube. Place the restrictor can over the spring; make sure the can is centered on the spring.
10. Slide, as one assembly, the spring plate, spring and restrictor cap, into position on the walking beam.
11. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).
12. Remove the safety stands from under the vehicle, then lower the vehicle.
13. Remove the chocks from the tires.



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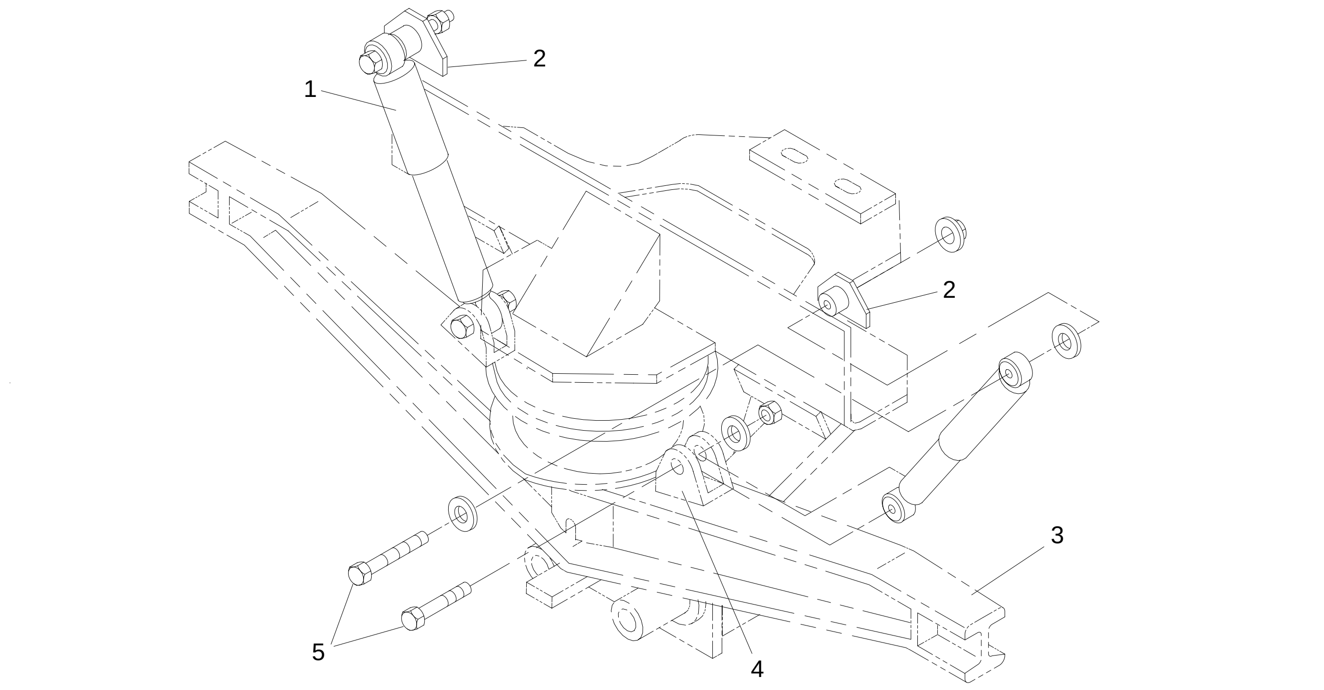
A. Make sure that the vent hole in the walking beam is free of rust and debris.
1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

Fig. 2, Spring Assembly Components

Replacement

The Chalmers 854 rear suspension is fitted with beam-mounted shock absorbers. See **Fig. 1**.



1. Shock Absorber
2. Frame-Mounted Bracket
3. Walking Beam
4. Beam-Mounted Bracket
5. 3/4" Mounting Bolts

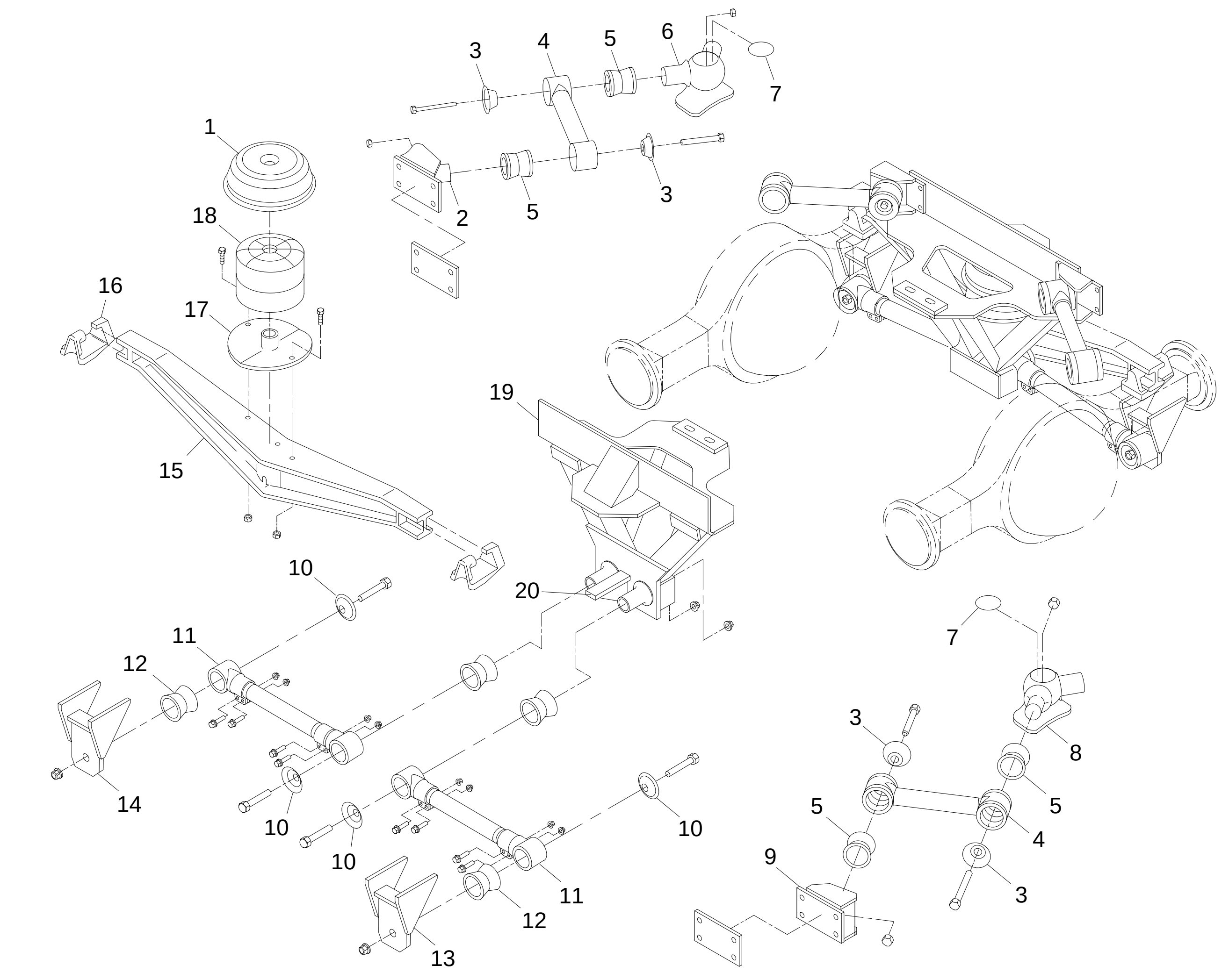
Fig. 1, Shock Absorbers, Beam-Mounted

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Remove the shock absorber mounting fasteners.
   3.1 Remove the upper and lower bolts. See **Fig. 1**.
   3.2 Discard the fasteners.
4. Remove and discard the shock absorber.
5. Install the new shock absorbers.

   Extend or compress the shock absorber as necessary to install the mounting bolts. Install the locknuts and tighten the fasteners 170 lbf·ft (230 N·m).
6. Remove the chocks from the tires.

Walking Beam Removal, Inspection, and Installation

Removal (See Fig. 1)



1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 854 Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)

Walking Beam Removal, Inspection, and Installation

1. If necessary, power wash the walking beams and axle housing ends to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. If equipped, disconnect beam-mounted shock absorbers from the walking beam being replaced. See **Subject 120**, if necessary.
6. Remove the two bolts and nuts that secure the walking beam spring plate (**Fig. 1**) to the walking beam assembly. Discard the fasteners.
7. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. See **Fig. 1**.

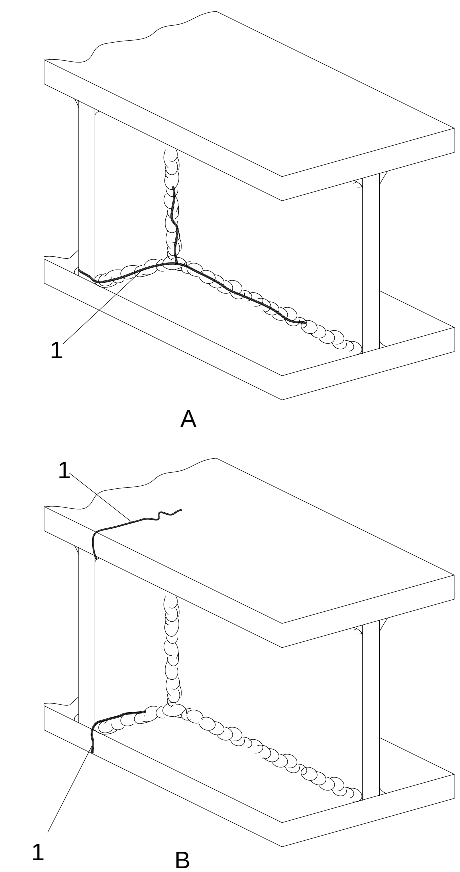
NOTE: Tag or otherwise mark each torque rod to ensure that it can be re-installed in the same position and orientation.

8. Disconnect the rearmost axle's upper torque rods from the rear axle tower and the lower torque rods from the rear axle housing brackets. See **Fig. 1**.
9. Roll the rear axle rearward just enough to disengage the axle saddles from the walking beam ends.
10. Lift up the free end of the walking beam and slide the beam rearward to disengage it from the front axle saddle; remove the walking beam.

Inspection

1. Inspect the beam ends carefully, looking for cracks. Cracks along weld lines may be repairable, while cracks in or across the beam flanges require walking beam replacement. See **Fig. 2**.

NOTE: Take flange thickness measurements at least 1/2" (12 mm) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/replacement.

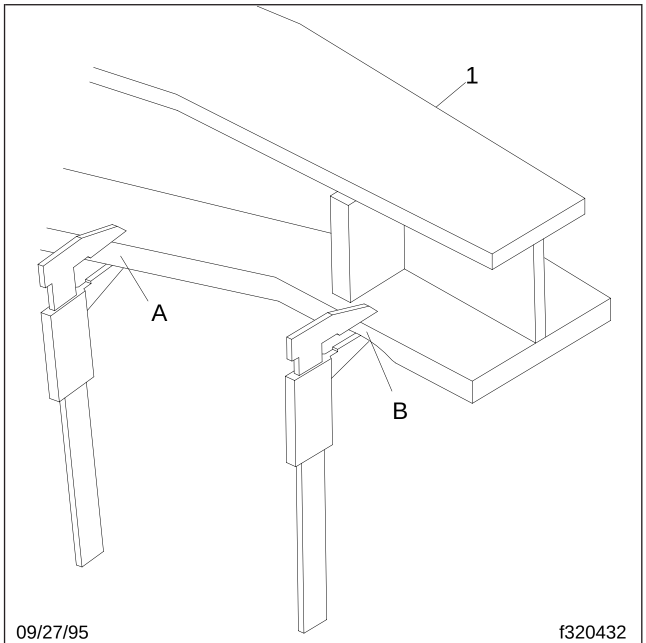


A. Repairable Walking Beam
B. Non-repairable Walking Beam
1. Cracks

Fig. 2, Repairable/Non-repairable Beam Cracks

2. Check for excessive wear on the beam flanges, where they contact the axle housing saddle brackets.

   If flange wear is significant, use a micrometer or vernier calipers to take measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 0.062 inch (1.5 mm). See **Fig. 3**.



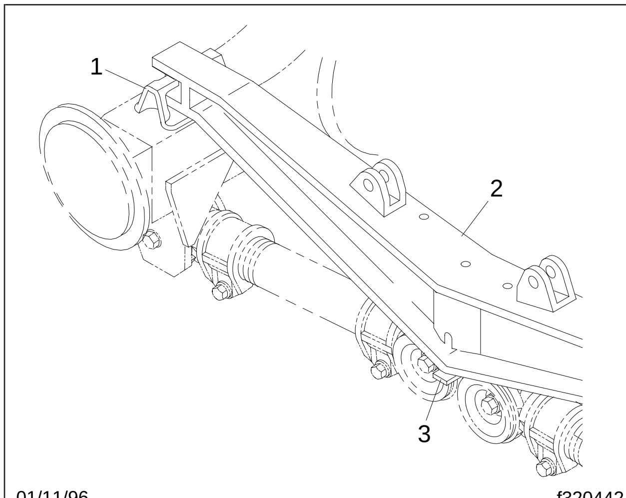
A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.
1. Walking Beam

Fig. 3, Beam Wear Measurement

3. Beams showing excessive wear must be repaired or replaced. See **Subject 140** for beam repair information.

Installation

1. Position the new or repaired walking beam over the rearmost rear axle, with the front end of the beam tilted downward.
2. Slide the beam forward and downward so the front end of the beam enters the axle housing saddle bracket. See **Fig. 4**. Let the middle of the beam rest on the sawhorse bracket beam stop.
3. Carefully roll the rearmost rear axle forward, while lifting the rear end of the walking beam enough so the beam end enters the axle housing saddle bracket.
4. Connect the rearmost axle's upper and lower torque rods to the axle housing brackets. Install and tighten the torque rod bushing through-bolts 135 lbf·ft (183 N·m).



1. Front Axle Housing, Beam Saddle Bracket
2. Walking Beam
3. Beam Stop

Fig. 4, Beam/Saddle Bracket Alignment

5. Slide, as one assembly, the spring plate, rubber spring, and restrictor cap, into position on the walking beam.
6. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).
7. If so equipped, connect the beam-mounted shock absorbers to the beam brackets and tighten the fasteners 170 lbf·ft (230 N·m).
8. Remove the safety stands from under the vehicle, then lower the vehicle.
9. Remove the chocks from the tires.

Repair

NOTE: This subject addresses only instances where excessive beam flange wear occurs, but cracks in the web or flange are not present.

Cracked webs and/or flanges require walking beam replacement.

Walking beams with excessive flange wear, however, can be repaired by welding a Chalmers Wear Plate over the worn areas as described below.

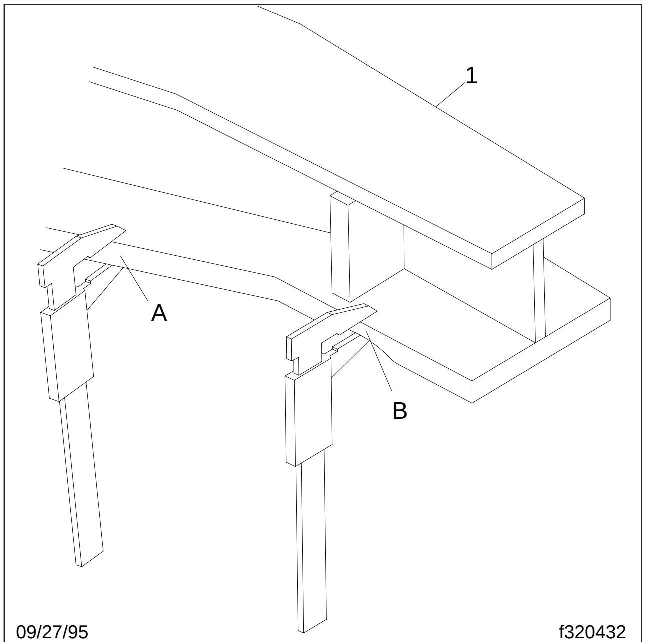
1. Remove the walking beam assembly. See **Subject 130** for information.

NOTE: Take flange thickness measurements at least 1/2 inch (12 mm) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/ replacement.

2. Confirm that flange wear is severe enough to warrant repairs. Use a micrometer or vernier calipers to take flange thickness measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 0.062 inch (1.5 mm). See **Fig. 1**.
3. If repair is required, clean the worn area of the beam thoroughly. Make sure that any oil or grease is removed, as well as rust or road dirt accumulation. If necessary, slight grinding of the beam is allowed to smooth raised areas.
4. Clamp Chalmers Wear Plate #700313 to the bottom flange of the beam. Make sure the plate is centered and has good surface-to-surface contact with the beam. Slight grinding is allowable to obtain good plate-to-beam contact.
5. Tack weld the plate to the beam, welding on the sides of the plate only.

CAUTION

Weld at the sides of the wear plate and beam only. Never weld at the ends of the wear plate. Welding the ends of the wear plate does not allow the wear plate to properly slightly expand nor contract, an action which, if the ends are welded, can cause cracks in the welds.

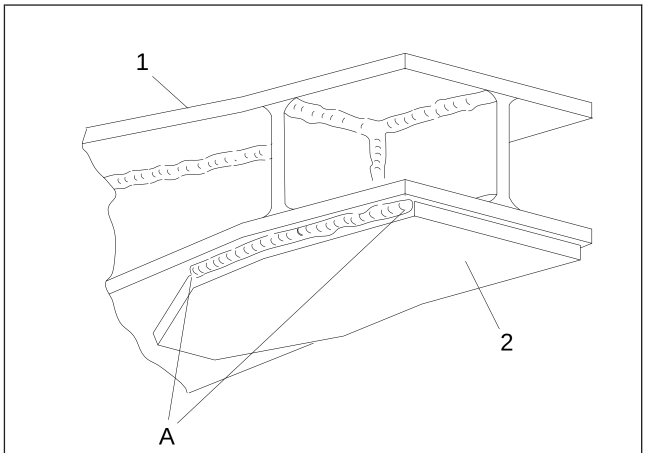


A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.
1. Walking Beam

Fig. 1, Beam Wear Measurement

6. Remove the clamps and weld the plate to the beam, again, welding on the sides of the plate only. See **Fig. 2**.
7. Prime and paint the repaired area.
8. Install the repaired walking beam assembly. See **Subject 130** for information.

Walking Beam Repair



A. Limit weld to this area only.
1. Walking Beam
2. Wear Plate

Fig. 2, Chalmers Wear Plate Welding

Torque Rod Removal and Installation

The torque rods hold the rear axles in place, maintaining both axle alignment and pinion nose angle. When servicing the torque rods, it is good practice to remove and install them one at a time to avoid the possibility of mixing them up and affecting the alignment or pinion nose angle.

Several different styles of torque rods and bushing spigots exist. On the 40,000-pound version of the 852 suspension, the torque rods have tubular steel bodies and the upper rods do not cross over one another. On the 46,000- and 52,000-pound versions, the lower torque rods have tubular steel bodies, but the upper torque rods are made of "I-beam" shaped ductile iron. These upper torque rods do cross over one another. See **Fig. 1** and **Fig. 2**.

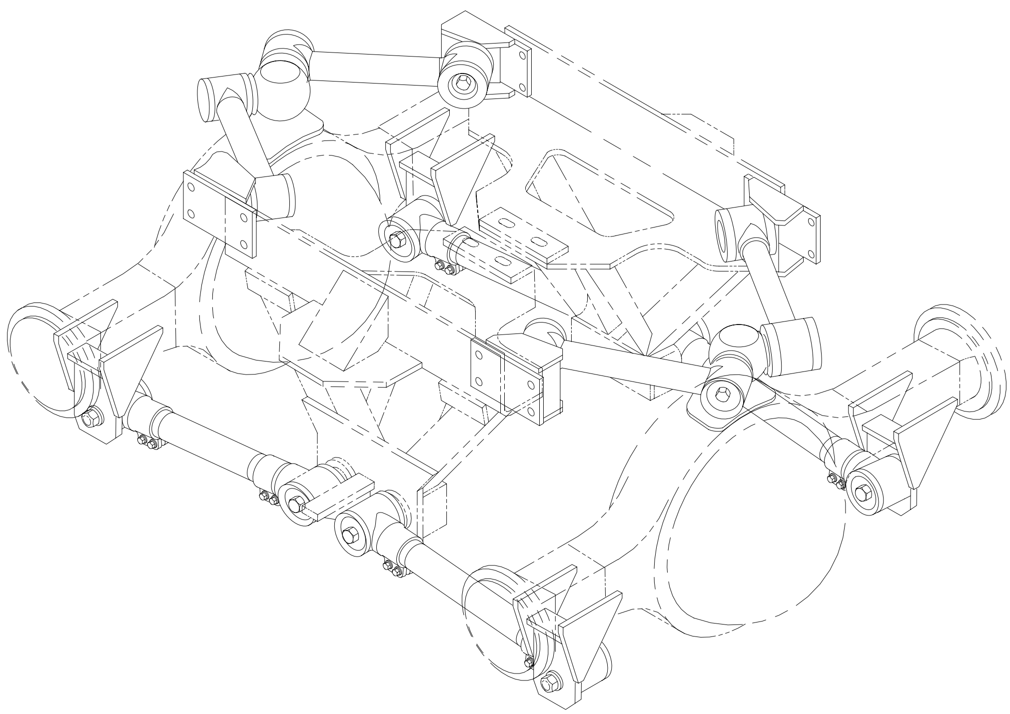


Fig. 1, Torque Rod Arrangement, 40,000-Pound Capacity Suspension

Removal

NOTE: Inspect torque rod bushings for free play before removing the torque rods. See **Subject 160** for torque rod bushing inspection information.

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. Working on one torque rod at a time, remove the torque rod bolts and spigot caps. Discard th bolts. Set the spigot caps aside for cleaning and inspection.

   Remove the torque rods by prying between the torque rod eye and the spigot base or frame bracket.

NOTE: At the axle housing towers, pry off the tower cap to access the torque rod fasteners.

Torque Rod Removal and Installation

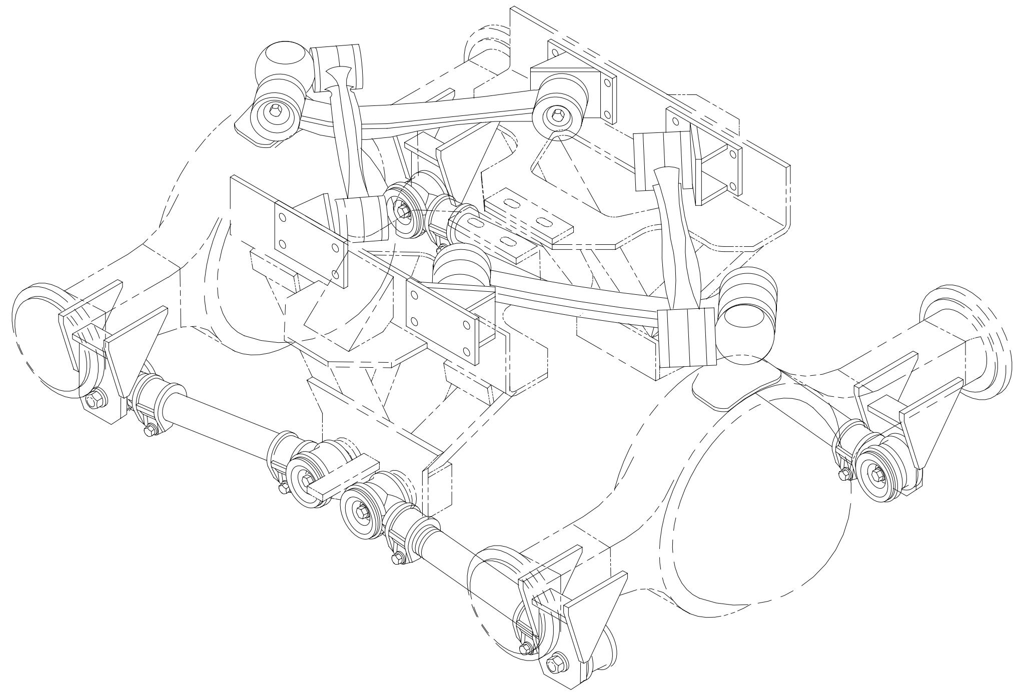
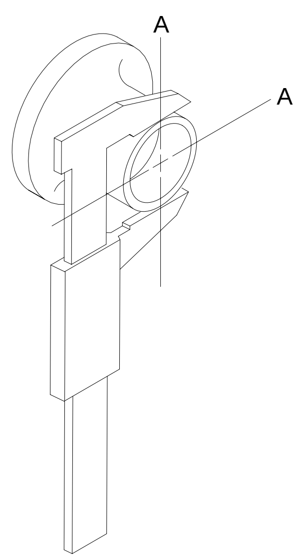


Fig. 2, Torque Rod Arrangement, 46,000- and 52,000-Pound Capacity Suspensions

6. Replace worn or damaged bushings following the instructions in **Subject 160**.
7. Inspect the spigots for damage, severe corrosion, or extensive wear. Replace damaged or severely corroded spigots. To determine whether or not a spigot is worn enough to warrant replacement, see **Fig. 3** and **Table 1**.

   The smaller of the two measurements should be used as the spigot diameter.



A. Measure outside diameter at two locations, 90 degrees apart.

Fig. 3, Spigot Measurement Points

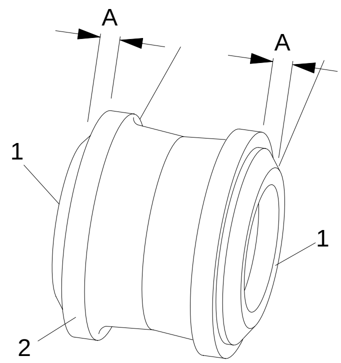
Installation

1. Check the torque rod bushings to make sure they are properly installed. They must be centered within the torque rod eye. See **Fig. 4**.

IMPORTANT: Never use any mineral-based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

2. Lubricate the outside of the spigots and the inside of the rubber bushings with a generous

Torque Rod Removal and Installation



A. The amount of rubber protruding from each side of the torque rod eye must be equal.
1. Torque Rod Bushing 2. Torque Rod Eye

Fig. 4, Torque Rod Bushing Protrusion

amount of rubber lubricant such as Rimslip® or equivalent.

3. Push the torque rod into position on its spigots. After the torque rod is partially installed, use a heavy soft-faced mallet to drive the torque rod into position until the bushing contacts the spigot bottom face.

NOTE: For easier installation, alternate mallet blows between ends of the torque rod to drive it onto the spigots evenly.

4. Install the spigot caps.
5. Install and tighten the torque rod bushing through-bolts 135 lbf·ft (183 N·m).
6. Remove the safety stands from under the vehicle, then lower the vehicle. Remove the chocks.

Spigot Size	Spigot Part #	Usage	Minimum Spigot Diameter With Standard Bushing: inch (mm)	Minimum Spigot Diameter With Oversize Bushing: inch (mm)
1	800200	40,000 lb. capacity—all	2.350 (60)	2.320 (59)
2	800021	46,000 & 52,000 lb. capacity—all	2.530 (64)	2.500 (63)

Table 1, Spigot Wear Limits

Torque Rod Bushing Inspection and Replacement

Inspection

1. If necessary, power wash the upper and lower torque rods to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Using your hands only, attempt to move the torque rod ends, checking for free play. Some movement as the bushings "give" is normal, but only free play is cause for bushing replacement.

NOTE: Never use a lever or pry bar to check for torque rod bushing free play. To do so may result in unnecessary bushing replacement.

5. If free play is detected, replace the bushing as described below.

Replacement

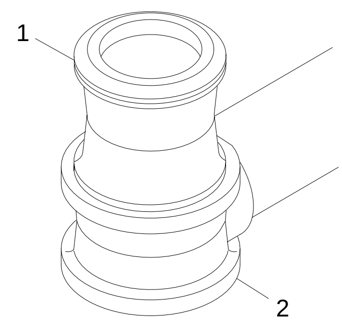
1. Remove the torque rod containing the worn out bushing. If necessary, see **Subject 150**.

NOTE: Remove only one torque rod at a time to avoid mixing-up torque rod positions.

2. Place the torque rod on the floor or a workbench with a bushing open end facing upward. Push the tip of a large screwdriver down between the torque rod eye and the bushing and pry out the bushing. Discard removed bushings.
3. Use a wire brush and/or scraper to clean the torque rod eyes, removing all rust, scale, and rubber accumulations.
4. Inspect the torque rod eyes looking for cracks, distortion, or severe corrosion. Replace torque rods with damaged bushing eyes.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

5. Lubricate both the inside of the torque rod eye and the outside of the new bushing with a generous amount of rubber lubricant, such as Rimslip® or equivalent.
6. Place the torque rod on a solid level floor with an open end of the eye facing upward. Position a lubricated bushing on the eye, making sure that the tapered shoulder of the bushing is centered on the eye. See **Fig. 1**.



1. Torque Rod Bushing
2. Torque Rod Eye

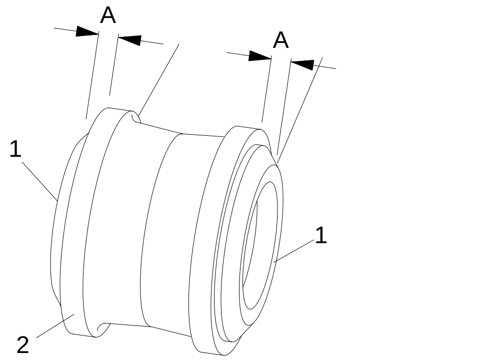
Fig. 1, Torque Rod Bushing Installation

7. Using a heavy, soft-faced mallet, strike the bushing squarely to drive it into the torque rod eye. Then, flip the torque rod over 180 degrees and tap on the torque rod shaft with the mallet while the bushing rests on the floor.

NOTE: If available, a small press may be used instead of a mallet for bushing installation.

8. The bushing is completely installed when it is centered within the torque rod eye. See **Fig. 2**.
9. Install the re-bushed torque rod. See **Subject 150**, if necessary.

Torque Rod Bushing Inspection and Replacement



A. The amount of rubber protruding from each side of the torque rod eye must be equal .
1. Torque Rod Bushing
2. Torque Rod Eye

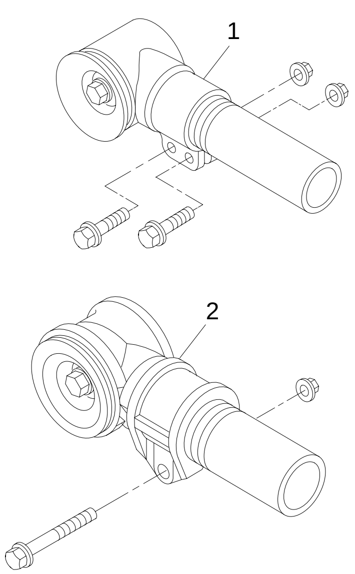
Fig. 2, Torque Rod Bushing Protrusion

Adjustment

On the Chalmers 854 Rear Suspension, the lower torque rods provide the only means for adjusting rear axle alignment. The upper torque rods play no part in the axle alignment process.

The lower torque rod bodies consist of steel tubes, with fine threads cut into the ends of the tube. Left-hand threads are cut into one end of the tube, right-hand threads into the other end. Therefore, by simply twisting the tube body while restraining the ends, the effective length of the tube is changed.

Two types of torque rod ends are used. On the #1 size, two 1/2-inch clamp bolts, secure the rod end to the tube. On the #2 size, a single 5/8-inch bolt is used. See **Fig. 1**.



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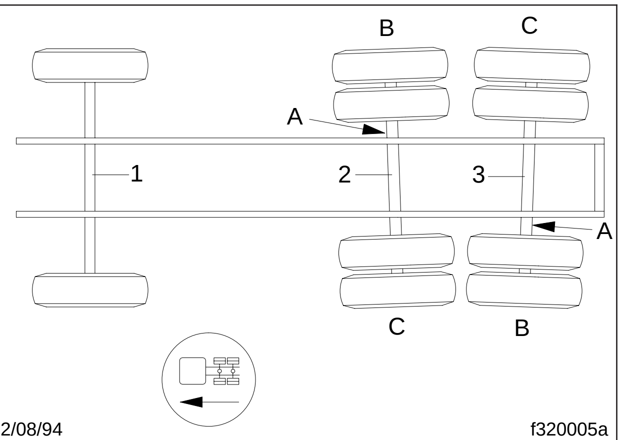
1. #1 Joint
2. #2 Joint

Fig. 1, Adjustable Torque Rod Ends

1. Ensure that the torque rod bushings are in a fully relaxed, neutral state by slowly moving the vehicle back and forth a few times. Apply the service brakes, *not the parking brakes*.
2. Chock the front tires to prevent vehicle movement.
3. Relieve drive axle brake or wind-up loads by placing the transmission in neutral and releasing the brakes.
4. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at right angles to the frame. For instructions, see **Group 35** in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 2**.

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".



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A. Axle Out of Alignment
B. Leading End
C. Trailing End

1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

Fig. 2, Tandem Axle, Shown Out of Alignment

5. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

6. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or

Rear Axle Alignment Adjustment

lengthen the torque rod. Continue to rotate the tube until the forward-rear axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

7. When the forward-rear axle is square with the frame, tighten the pinch bolts.

   7.1 Tighten 1/2-inch UNC bolts on #1 joints 65 lbf·ft (88 N·m).

   7.2 Tighten 5/8-inch UNC bolts on #2 joints 135 lbf·ft (183 N·m).

8. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, see **Group 35** in this manual. This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted rearward, or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. See **Fig. 2**.

9. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

10. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or lengthen the torque rod. Continue to rotate the tube until the rearmost axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

11. When the rearmost axle is square with the frame, tighten the pinch bolts.

    11.1 Tighten 1/2-inch UNC bolts on #1 joints 65 lbf·ft (88 N·m).

    11.2 Tighten 5/8-inch UNC bolts on #2 joints 135 lbf·ft (183 N·m).

12. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.

13. Using the center-point bar, check the rearmost axle alignment. If alignment is not within specifications, repeat the applicable steps above.

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the suspension.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the *Columbia Maintenance Manual*.

Specifications

Description	Bolt Size	IFI Grade	Torque lbf·ft (N·m)
Beam Spring Plate Bolt	3/8 UNC	8	35 (47)
Torque Rod End Through Bolts	5/8 UNC	8	135 (183)
Shock Absorber Bolt	3/4	8	170 (230)
#1 Torque Rod End Pinch Bolts	1/2 UNC	8	65 (88)
#2 Torque Rod End Pinch Bolts	5/8 UNC	8	135 (183)

Table 1, Fastener Torques, 854 Suspension

General Information

The Front Airliner Suspension (also referred to as the Hendrickson AIRTEK suspension) is comprised of a front air suspension, and a welded steering axle (Hendrickson STEERTEK), that work together to form an integrated torsion system. See **Fig. 1**. See **Group 33** for Hendrickson STEERTEK front axle information.

Axle Clamp Group

The clamp group provides four-sided clamping pressure. The clamp group consists of the following:

- top axle wrap
- bottom axle wrap
- top axle wrap liner
- bottom axle wrap liner
- top pad
- 3/4-inch bolts, washers, nylon locknuts

Air Springs

The air springs are engineered to support 50 percent of the vertical load while providing very low spring rate. The "push-to-connect" air supply design also provides fast and easy installation and removal.

Leaf Spring Assembly

The leaf springs share loads equally with the air springs. Front and rear bushings are greaseless, and only require periodic inspections.

Shock Absorbers

The shock absorbers are tuned specifically for the AIRTEK system.

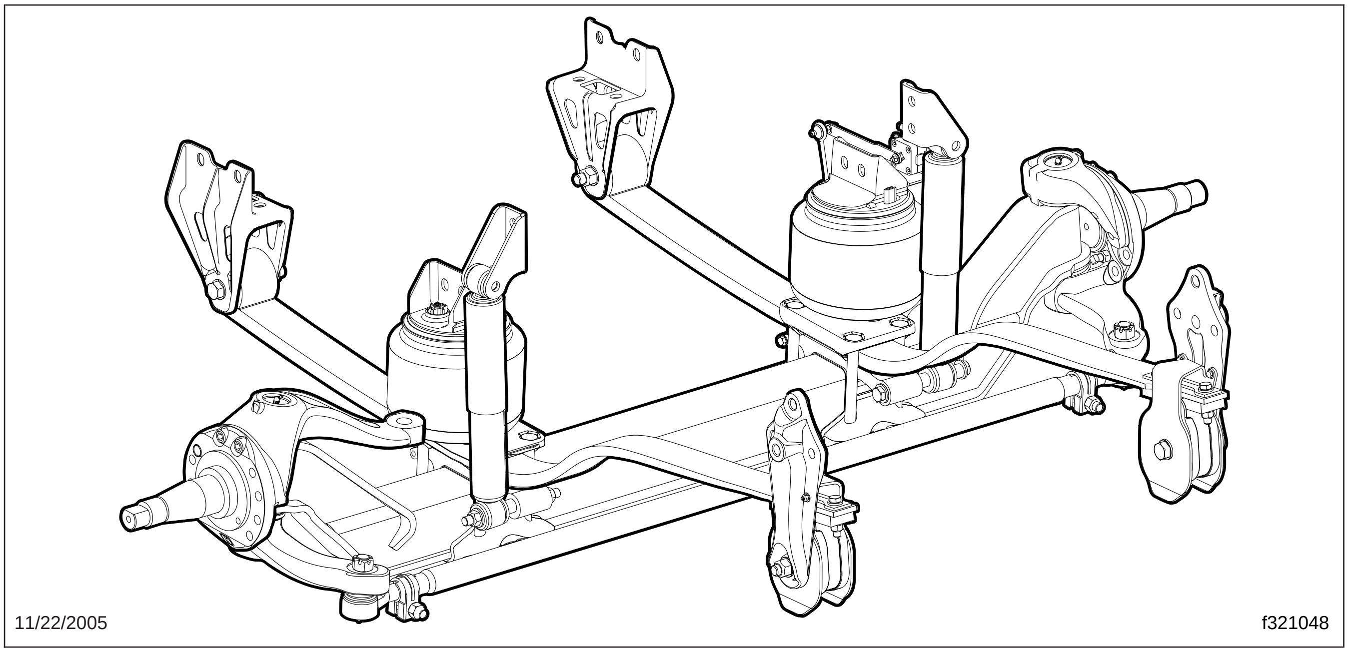


Fig. 1, Front AirLiner (Hendrickson AIRTEK) Suspension

Ride Height Adjustment

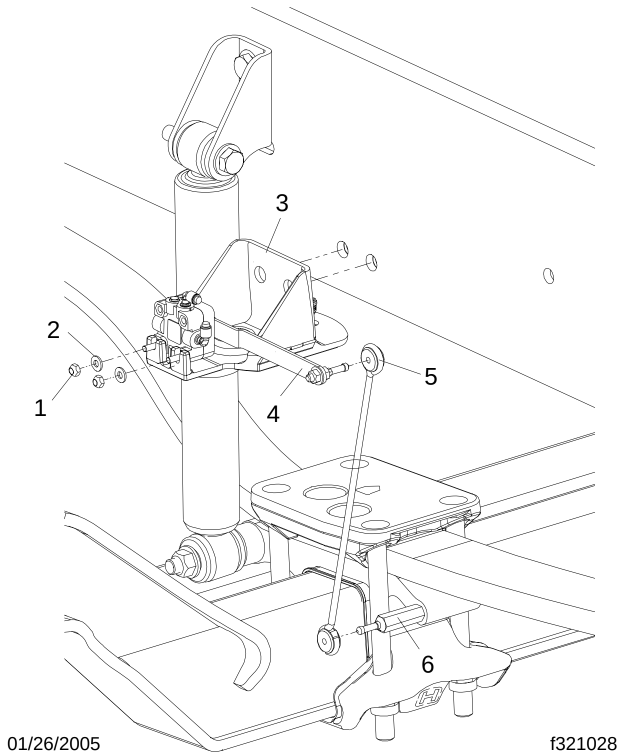
NOTE: As of August 2007, the Front AirLiner Suspension is equipped with dual height-control valves, one on each side of the vehicle. For vehicles with dual valves, inspect and adjust the ride height on both sides of the vehicle.

1. Use a work bay with a level floor. Drive the vehicle slowly, straight ahead. Try to slacken or loosen the suspension as the vehicle is positioned. End with all the wheels positioned straight ahead. Try to roll to a stop without the brakes being used.
2. Shut down the engine, then chock the tires. Do not set the parking brakes.
3. To ensure that the vehicle is level, check the tire pressure. The air pressure in both front tires should match.
4. Disconnect the vertical linkage from the stud on the horizontal control lever, and exhaust the suspension air by lowering the lever; see **Fig. 1**. If equipped with dual height-control valves, repeat for the other side of the vehicle.

NOTE: It is very important that the height-control valve be cycled completely before and after any ride height adjustments. This cycling of the height-control valve will help to make the adjustment as accurate as possible.

5. Attach the linkage to the stud on the horizontal control lever, and allow the suspension system to fill with air. If equipped with dual height-control valves, repeat for the other side of the vehicle. Wait until the airflow to the front air springs has stopped.
6. Measure the suspension ride height of the front axle. If equipped with dual height-control valves, measure the ride height on both sides of the vehicle.

   Using a Hendrickson AIRTEK height gauge, literature no. 45745-159, hold the gauge vertically and place it so the upper notch feature is between the height-control-valve mounting bolts, and sits flush against the bottom of the air-spring bracket; see **Fig. 2**. The piston-flange edge should contact the lower region marked "ACCEPTABLE."



1. 1/4-Inch Locknut
2. 1/4-Inch Washer
3. Air Spring Hanger
4. Horizontal Control Lever
5. Vertical Linkage
6. Link Mount

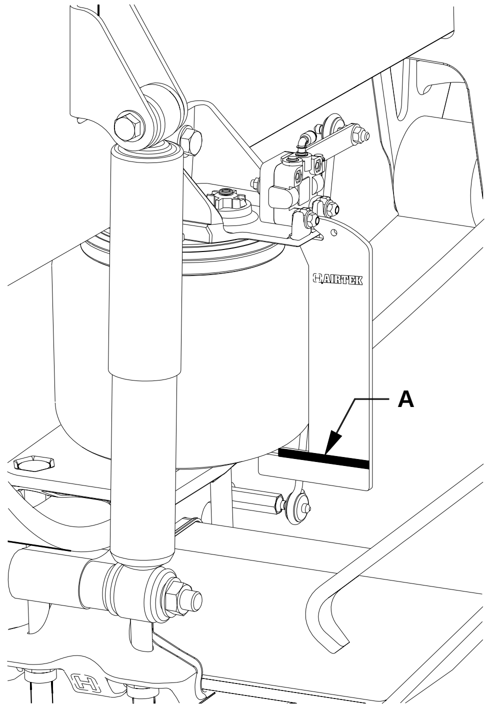
Fig. 1, Height-Control Valve Linkage

   If the flange edge contacts at the "BELOW SPEC" region, the ride height is set too low. If the flange contacts at the "ABOVE SPEC" region, the ride height is set too high.

   If a gauge is not available, measure the vertical distance from the bottom of the upper air-spring bracket to the bottom of the air-spring piston flange. This distance should be between 7-3/4 and 8 inches (197 and 203 mm).

7. If the suspension ride height is not within specification, disconnect the vertical linkage from the horizontal control lever, fill and exhaust the suspension system, then fill the system until the suspension is at the proper ride height.
8. Move the control lever to the neutral position, then hold it in position by inserting a 5/32-inch

Ride Height Adjustment



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A. Acceptable Range

Fig. 2, Using the Ride Height Gauge

(4-mm) pin or drill bit into the holes in the control lever and valve body.

CAUTION

When loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

9. While holding the height-control valve mounting studs in place with an Allen wrench, loosen the valve mounting just enough to allow movement of the height-control valve.
10. Adjust the height-control valve by rotating the valve body until the rubber grommet at the upper end of the vertical linkage lines up with the stud on the horizontal control lever.
11. Make sure the height-control valve stays in position. If necessary, hold the height-control valve mounting studs in place with an Allen wrench, and tighten the nuts slightly. Do not tighten the locknuts to the specified torque until after the proper ride height is verified.
12. Remove the pin or drill bit from the holes in the control lever and valve body.
13. Detach the linkage from the stud on the horizontal control lever, and exhaust the suspension system air, then attach the linkage to the stud on the horizontal control lever, and fill the suspension system with air. Wait until the airflow to the front air springs has stopped.
14. Measure the suspension ride height again. If necessary, repeat 6 through 14.
15. Once the proper ride height is attained, tighten the valve mounting locknuts 95 lbf·in (1100 N·cm), while holding the height-control valve mounting studs in place with an Allen wrench. Do not overtighten.

Height-Control Valve Test

It is normal to hear air escaping from the height-control valve for as much as 10 minutes after getting out of the vehicle when it is in an unladen condition. This air "leaking" is just the height-control valve exhausting air from the suspension air springs in order to return to the neutral mode.

The height-control valves used on the Columbia are Barksdale valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Checking the Height-Control Valve Without Using a Test Kit

1. Apply the parking brakes and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

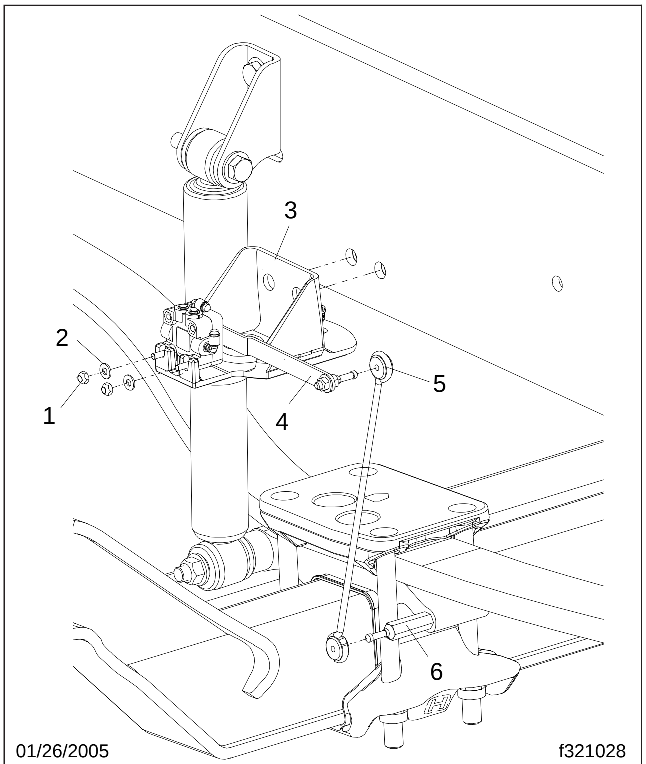
NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is working.
6. Return the control lever to the neutral position. Air should stop flowing. If so, that section of the valve is working.
7. Push the control lever down about 45 degrees for 6 to 8 seconds. If air exhausts from the valve, that section of the valve is working.
8. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
9. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the vertical linkage to the control lever, then tighten the linkage nut.

   If needed, adjust the ride height or replace the height-control valve. For adjustment of the ride height, see **Subject 100**. For replacement of the height-control valve, see "Height-Control Valve Replacement" below.

NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking a Barksdale Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can

Height-Control Valve Test and Replacement



1. 1/4-Inch Locknuts
2. 1/4-Inch Washers
3. Air Spring Hanger
4. Horizontal Control Lever
5. Vertical Linkage
6. Link Mount

Fig. 1, Height-Control Valve Linkage

determine if a leak is acceptable only by using the Barksdale test kit.

Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. For valves without an integral dump port, go to the next step.

   For valves with an integral dump port, check the rubber exhaust flapper at the back of the valve housing for leaks; see **Fig. 2**. Use a soapy solution.

   If a leak is found, there may be contaminants blocking the piston. Cycle the height-control valve switch inside the cab for two-second bursts, four or five times, to clear away any contaminants.

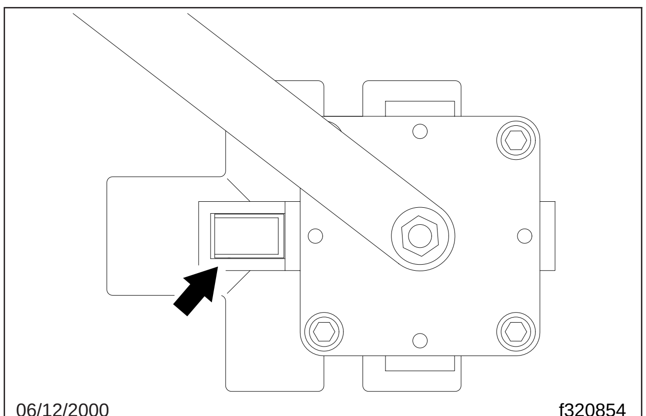


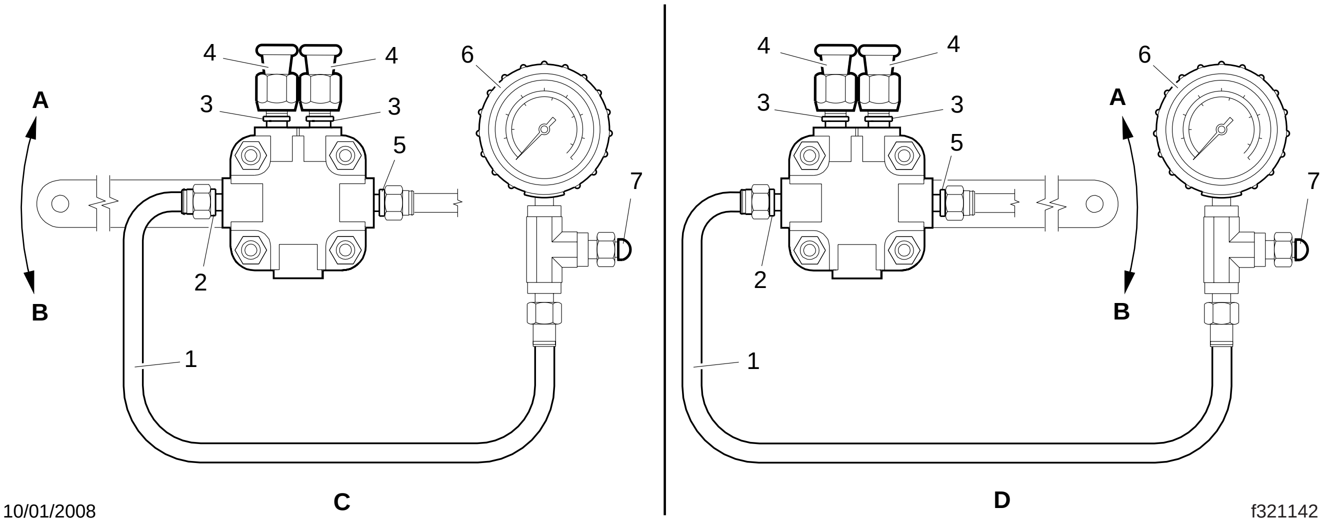
Fig. 2, Exhaust Flap Location (height-control valve with integral dump port)

5. Disconnect the vertical linkage from the horizontal control lever.
6. Rotate and hold the horizontal control lever down at about 45 degrees to exhaust air from the air springs.
7. *If equipped with an integral dump port,* turn on the quick dump switch on the dash. Leave the switch on until testing is complete.

If not equipped with an integral dump port, disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 3**.

11.1 Rotate the valve control lever up 45 degrees from the horizontal to the fill position.

11.2 Press the reset button on the test gauge.



A. Fill
B. Exhaust
C. Left-Hand Valve
D. Right-Hand Valve

1. Air Line
2. Exhaust Port Test Fitting
3. Air Spring Port
4. Parker Plug
5. Air Intake Port
6. Test Gauge Assembly
7. Reset Button

Fig. 3, Test Connections

8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 3**.

NOTE: It may be necessary to cut the tie straps that hold the chassis wiring running below the height-control valve, in order to access the exhaust port.

10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.

11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.

12.1 Rotate the valve control lever down 45 degrees from the horizontal to the exhaust position.

Height-Control Valve Test and Replacement

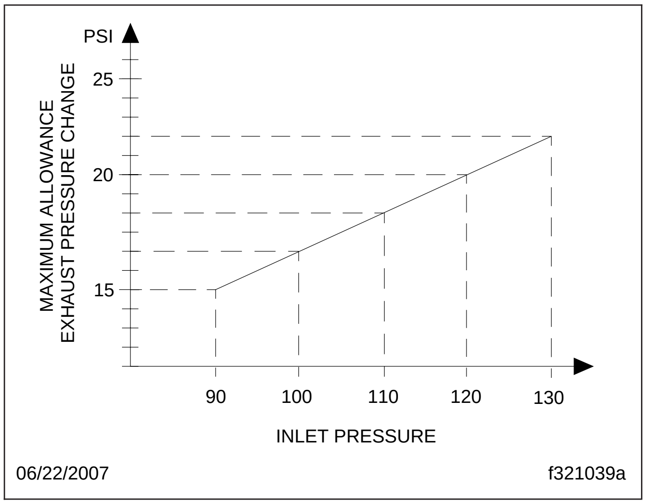


Fig. 4, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

12.2 Press the reset button on the test gauge.

12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see "Height-Control Valve Replacement" below.
15. Install the flapper on the exhaust port by pressing it into place.
16. *For height-control valves with an integral dump port,* connect the vertical linkage to the height-control valve control lever. Turn off the quick dump switch on the dash. The ride height will automatically return to the correct position.

    For height-control valves without an integral dump port, remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

Height-Control Valve Replacement

1. Apply the parking brakes and chock the tires.

WARNING

Keep your hands and all objects away from the area under and around the slack adjusters and suspension components when removing the pressure from the air system. These parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

2. Drain the air from the secondary air tank.

WARNING

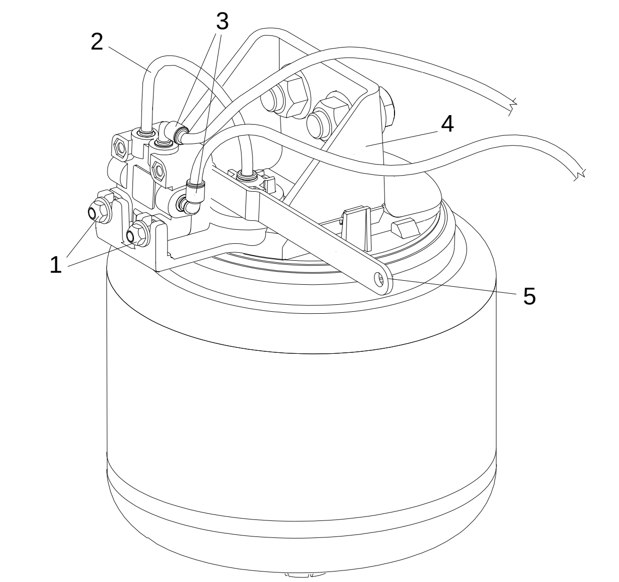
Air lines can whip dangerously if disconnected under pressure. Drain all air from the secondary air tank before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

3. Disconnect the vertical linkage, then lower the control lever to exhaust the air.
4. Remove the air lines from the height-control valve; see **Fig. 5**. Push in on the air line to release the tension, then push down on the collar and pull out the air line.

CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Height-Control Valve Test and Replacement



1. 1/4-Inch Locknuts
2. 1/4-Inch Nylon Air Line
3. Quick-Connect Fittings
4. Air-Spring Hanger Bracket
5. Horizontal Control Lever

Fig. 5, Height-Control-Valve Components

5. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the air-spring hanger bracket. Remove the height-control valve.
6. Position the new height-control valve on the hanger bracket, parallel to the flange. While holding the height-control mounting studs in place with an Allen wrench, install the nuts and washers. Do not tighten the locknuts to the specified torque until after the proper ride height is attained.

IMPORTANT: When replacing or installing nylon air lines on quick-connect fittings, it is critical that the end of the air line is cut square. An improper cut can cause the air line to seat improperly in the quick-connect fitting, allowing air leakage.

7. Install the air lines on the height-control valve.
8. Attach the vertical linkage to the horizontal control lever and the linkage mount.
9. Adjust the height-control valve to the proper specifications; see **Subject 100**.
10. While holding the height-control mounting studs in place with an Allen wrench, tighten the height-control valve mounting locknuts 95 lbf·in (1100 N·cm). Do not overtighten.

Shock Absorber Removal and Installation

Removal

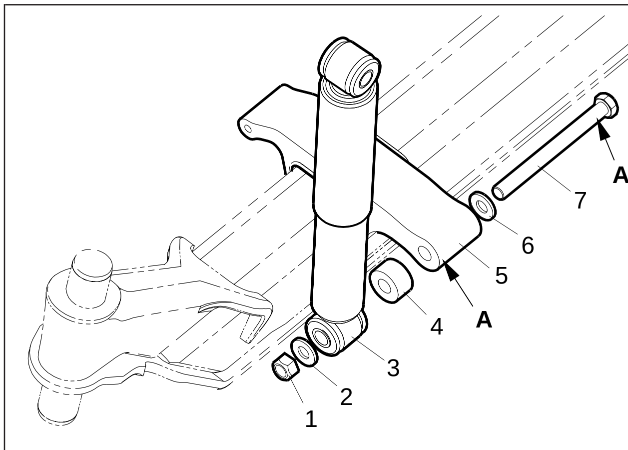
CAUTION

Anytime the front axle on an AIRTEK suspension is suspended, it is mandatory that the shock absorbers remain connected. The shock absorbers are the rebound travel stops for the springs. Failure to do so could cause the air springs to exceed their maximum length, causing the air springs to separate from the piston, or reverse arch the steel leaf springs. This could result in premature steel leaf spring failure.

1. Set the parking brake, and shut down the engine. Chock the tires.

NOTE: It is not necessary to replace the shock absorbers in pairs if only one shock absorber requires replacement.

2. Remove the shock absorber lower mounting bolt, spacer, washers, and locknut.
3. Remove the shock absorber upper mounting bolt, washers, and locknut, then remove the shock absorber.
4. Inspect the shock absorber mounting brackets and hardware for damage or wear. Replace as necessary.



A, Apply a thin coating of antisieze compound to the shock absorber lower mounting bolt shank, the mating face of the axle wrap, the spacer, and to the inside bore of the aluminum top axle wrap.

1. 3/4-Inch Locknut
2. 3/4-Inch Washer
3. Shock Absorber
4. Spacer
5. Top Axle Wrap
6. 3/4-Inch Washer
7. 3/4–10 Bolt

Fig. 1, Shock Absorber Installation

Installation

1. Place the shock absorber into the upper mounting bracket.
2. Install the shock absorber upper mounting bolt, washers, and locknut.
3. Apply a thin coating of antiseize compound to the shank of the shock absorber lower mounting bolt, the mating surfaces of the axle wrap and spacer, and the inside bore of the aluminum axle wrap. This is necessary to help prevent the bolt from seizing to the aluminum axle wrap. See **Fig. 1**.
4. Install the lower bolt from the inboard side of the axle wrap to the outboard side, then install the spacer, washers, and locknut.
5. Tighten both of the shock absorber mounting locknuts 225 to 255 lbf·ft (305 to 345 N·m).

Air Spring Removal and Installation

Removal

1. Set the parking brake, and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with stands.
4. Separate the air spring from the upper air-spring bracket by applying downward pressure on the air spring, pushing outward on the lock tabs outside the bracket, and inward on the inlet lock tabs to dislodge the air spring from the upper air-spring bracket. See **Fig. 1**. See **Fig. 2** for lock tab locations.

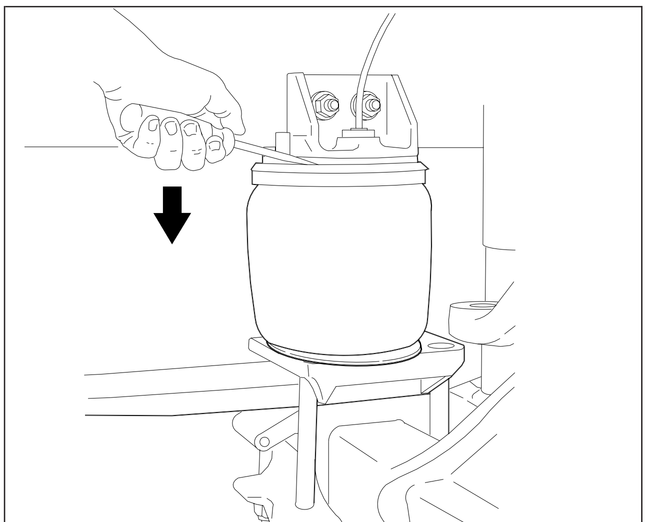
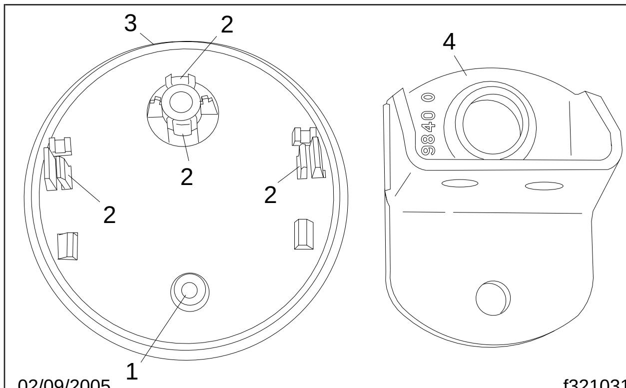


Fig. 1, Upper Air Spring Bracket

5. Apply upward pressure between the base of the air spring and the top-pad casting. This will dislodge the air spring from the top-pad casting. See **Fig. 3**.



1. Locating Nodule
2. Four Lock Tabs
3. Top of Air Spring
4. Top of Air-Spring Bracket

Fig. 2, Air Spring Mounting

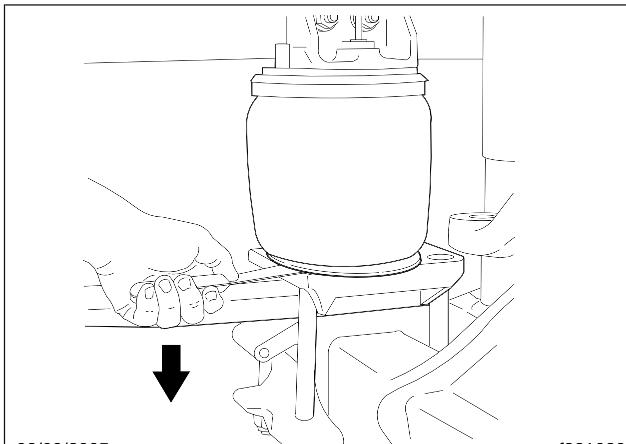


Fig. 3, Base of the Air Spring

6. Pull the air spring out from between the upper bracket and the top pad casting.

Installation

CAUTION

If the air spring will be re-installed, inspect the lock tabs for damage or cracks prior to installation. Damaged lock tabs may allow the air spring to become dislodged during operation, resulting in loss of vehicle control.

Air Spring Removal and Installation

1. Insert the air spring into the top-pad casting. Make sure the lock tabs click in place.
2. Compress the air spring and slide it into position. Using the locating nodule, index the air spring position to the upper air-spring bracket.
3. Pull the air spring up into the upper air-spring bracket until the air spring snaps into place. Verify that all four lock tabs are engaged. See **Fig. 2**.

NOTE: When replacing or installing nylon air line tubing into quick-connect fittings, it is critical that the end of the air line is cut square. An improper cut can cause the air line to seat improperly in the quick-connect fitting, allowing air leakage.

4. Install the air lines on the air spring.
5. Inflate the air springs and check for leaks.
6. Lower the frame.
7. Charge the suspension system with air.

WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

8. Check the ride height and adjust it if necessary. See **Subject 100** for instructions.
9. Remove the chocks.

Spring-Eye Bushing Replacement and Spring-Eye Retorque

The spring-eye bushing for the front AirLiner suspension is designed for the life of the spring. If a premature failure occurs, careful consideration must be given to the contributing factor that made the bushing fail. This must be corrected in order to prevent the new bushing from failing in the same manner. It is recommended that in the event of a high-mileage bushing failure that the front leaf spring be replaced.

Spring-Eye Bushing Replacement

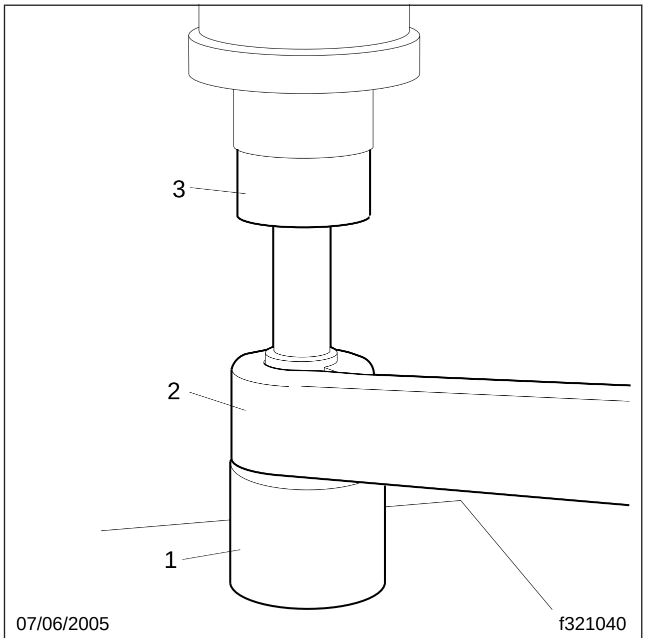
Remove the front spring, following the procedure in **Subject 150**. Once the leaf spring is removed from the chassis, it will be necessary to use:

- A hydraulic press with an operating capacity of a minimum of 10,000 lb (4500 kg).
- A receiving tool.
- A removal and installation driver.

WARNING

Do not use heat or a cutting torch to remove the bushing from the steel spring. The use of heat can adversely affect the strength of the spring. A component damaged in this manner can result in a loss of vehicle control, and possible personal injury or property damage.

1. Support the spring, and center the spring-end hub on the receiving tool. The leaf spring must be level to distribute the vertical-pushing load equally on the bushing.
2. Place the center of the bushing driver on the spring-eye bushing. See **Fig. 1**.
3. Pushing directly on the driver, press out the spring-eye bushing until it clears the spring-eye bore.
4. Inspect the spring eye for any cracks or burrs. If cracks are present, install a new leaf spring.
5. Remove any nicks or burrs with an emery cloth or a rotary sander.
6. Lubricate the inner diameter of the spring bore, and the new rubber bushing, with a vegetable-based oil (cooking oil). Do not use petroleum- or soap-based lubricant. They can cause an adverse reaction with the spring-eye material.



1. Receiving Tool
2. Spring Eye
3. Bushing Driver

Fig. 1, Removing the Spring-Eye Bushing

7. Cut a strip of 3M Scotch® 890T black-fiber tape (duct tape or equivalent) 1-inch (25-mm) wide by 6-inches (150-mm) long.
8. Feed the tape into the spring eye, with the adhesive side facing the gap in the eye, to cover the sharp edge. Center the tape equally around each end.
9. Support the spring, and center it on the receiving tool.
10. Center the new bushing on the spring-eye bore, and line up the hydraulic press.
11. Press the bushing into the spring-eye bore, overshooting the desired final position by approximately 3/16 inch (5 mm). Press the bushing again from the opposite side, to center it in the spring-eye bore.
12. Once the bushing is installed, follow the instructions for the front leaf-spring installation in **Subject 150**.

Spring-Eye Bushing Replacement and Spring-Eye Retorque

Spring-Eye Retorque

NOTE: This procedure is also necessary when replacing the front or rear hanger brackets, or the steel leaf spring.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.

WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

3. Disconnect the air lines at the air springs.
4. Raise the vehicle and support the frame with stands.

WARNING

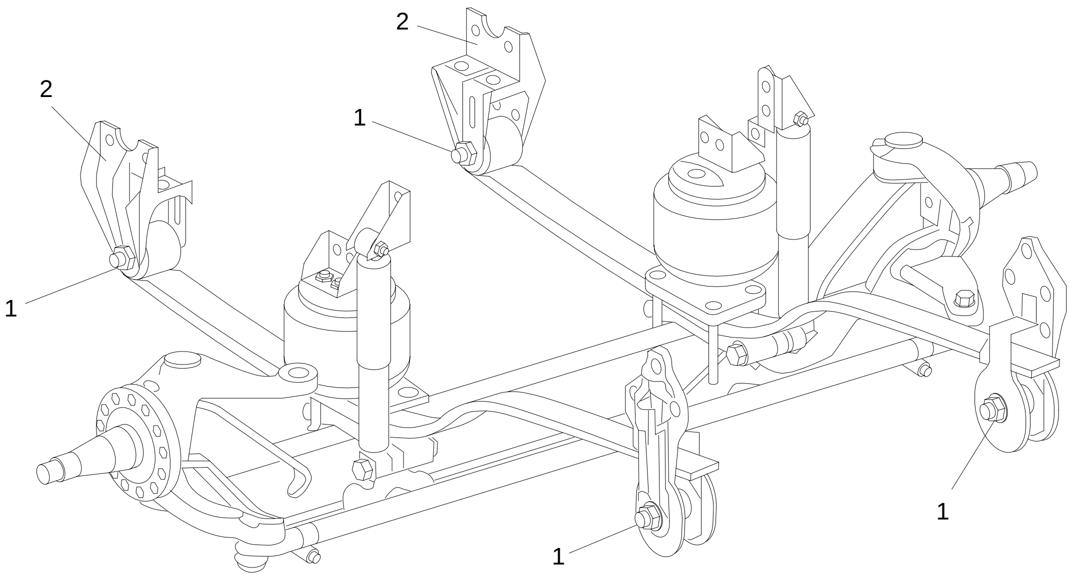
The shock absorbers must remain connected when the front axle is suspended. The shock absorbers are the rebound travel stops for the springs. Disconnecting the shock absorbers could cause the air springs to exceed their maximum length, causing the air springs to separate from the piston, or reverse arch the steel leaf springs, which may result in premature steel leaf spring failure.

5. Lower the front axle. Allow at least 3 inches (76 mm) of wheel clearance to the ground. The shock absorbers must be connected. DO NOT reverse arch the springs.
6. Loosen all four front and rear spring-eye bolts. See **Fig. 2**. The suspension may drop down slightly.

IMPORTANT: DO NOT remove the spring-eye bolts. The tires must not contact the ground.

7. Allow the suspension to settle.
8. Tighten the 3/4-inch locknuts on the front and rear spring-eye bolts 285 to 305 lbf·ft (385 to 415 N·m).
9. Raise the front axle and remove the frame stands.
10. Lower the vehicle.
11. Check the air springs to verify that they are seated properly, and install the air lines into the air springs.
12. Connect the height-control valve and charge the air system.
13. Affix a long straightedge to the bottom of the frame rails, in front of the air springs.
14. With the vehicle on a level surface, measure the distance from the top of the straightedge to the ground on both sides of the vehicle. Record the measurements.
15. Determine the difference from one side to the other. Remove the straightedge.
16. Perform a road test and repeat the previous three steps.
17. If the the difference in measurements is more than 3/8 inch (9.5 mm), contact Hendrickson Tech Services.

Spring-Eye Bushing Replacement and Spring-Eye Retorque



1. Bolt
2. Front Leaf-Spring Hanger

Fig. 2, Front Spring Mounting

Removal

NOTE: When replacing both steel springs, use springs with the same camber designation. The camber designation of the new spring is located at the front of the top leaf and will be defined with a (+), (0), or a (–).

1. Park the vehicle on a level surface and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.
3. Position a floor jack with a 4-inch lifting plate, below the axle, and raise the vehicle.
4. Remove the tires.
5. Position frame stands behind the rear spring mounts. It may be necessary to remove peripheral components for installation of the frame stands.
6. Lower the jack, allowing the axle to hang, but do not remove the jack from the axle.
7. Loosen both front spring-eye bolts, but do not remove the bolts.
8. Remove both rear spring-eye centerbolts.
9. Remove both lower shock absorber mounting bolts.

NOTE: To ease removal of the spring-eye bolts it may be necessary to raise or lower the axle.

10. Disconnect both air springs from the top pads of the clamp groups.
11. On the spring that is not being replaced, loosen the clamp group nylon locknuts.

WARNING

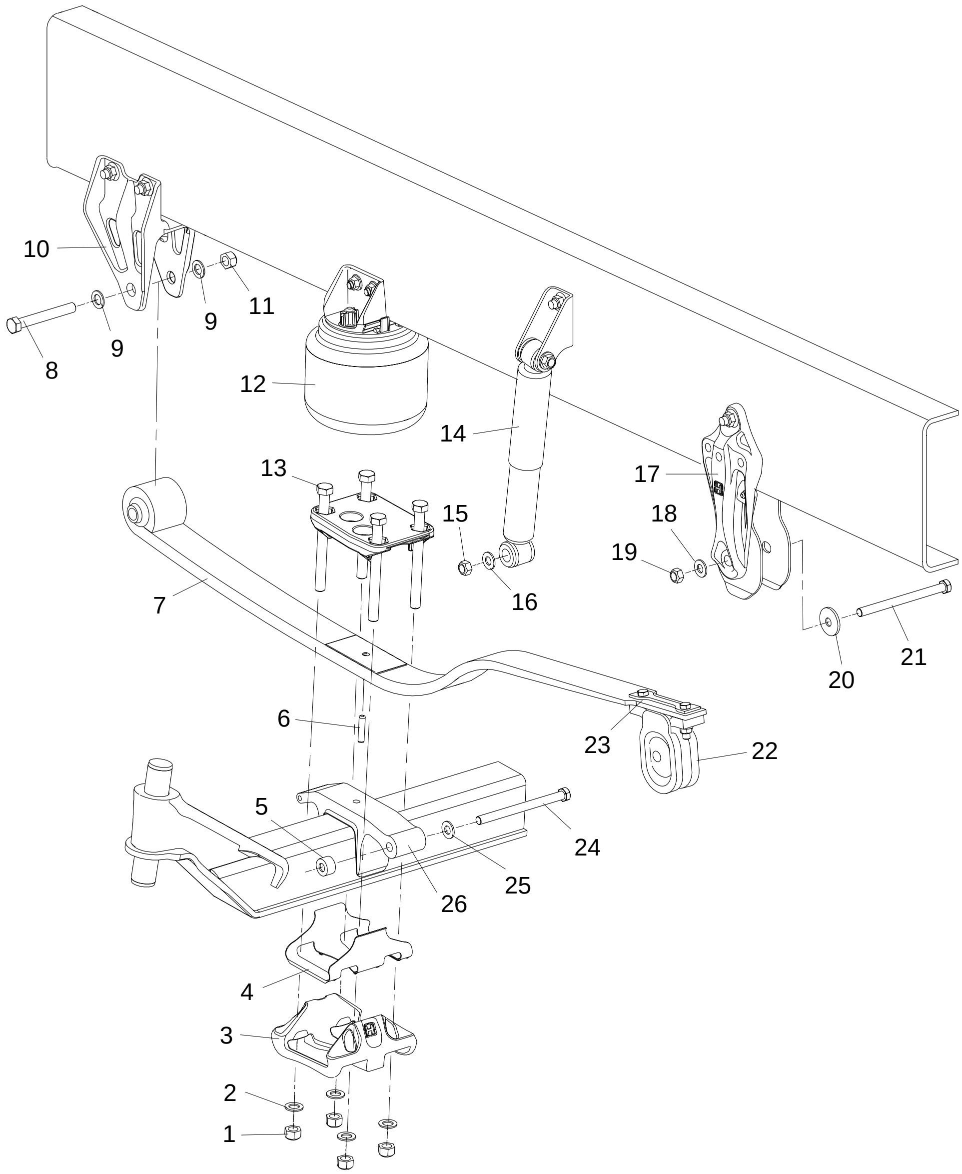
Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.

12. Remove the 3/4-inch clamp group bolts, nuts, washers, top pad, galvanized liner, and the bottom axle wrap, from the spring that is going to be removed. See **Fig. 1**.
13. Lower the jack, allowing the suspension to pivot down and out of the rear hanger clamps.
14. Remove the front spring-eye bolt from the spring that is being removed, then remove the spring assembly.
15. Remove the thrustwashers from the rear spring-mount assembly. See **Fig. 1**.
16. Remove the 1/2-inch bolts, then remove the rear spring-mount assembly.
17. Inspect the thrustwashers, rear spring-mount bushing, rear-hanger clamp, top axle wrap, and the front and rear spring hangers. Replace them if worn, cracked, or damaged.

Installation

1. Lubricate the front spring-eye bushing and the front hanger with a vegetable-based oil (cooking oil). **DO NOT** use petroleum- or soap-based lubricants; they can cause an adverse reaction with the spring-eye-bushing material.
2. Install the spring over the axle, and into the front spring hanger.
3. Install the 5 1/2-inch long front spring-eye bolt, washers, and nut, but do not tighten.
4. Using the dowel pin located on the top axle wrap, engage the spring to the axle. It may be necessary to loosen the other clamp group to allow the axle to pivot when installing the spring on the dowel pin.
5. Install the top pad on top of the spring.
6. Install a new bottom axle wrap liner in the bottom axle wrap.
7. Install the bottom axle wrap.
8. Install new clamp group bolts, washers, and new nylon locknuts.
9. Snug the clamp group, but DO NOT torque at this time.
10. Raise the axle and the rear spring assemblies into the rear spring hangers.
11. Install the 5-inch long centerbolts in the rear hangers. The bolt must be installed from the in-

Leaf Spring Removal and Installation



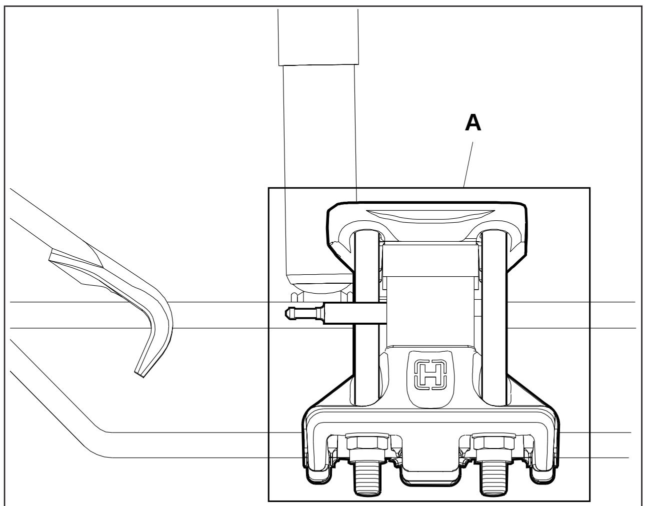
1. 3/4–10 Nylon Locknut
2. 3/4-Inch Flatwasher
3. Bottom Axle Wrap
4. Bottom Axle Wrap Liner
5. Shock Spacer
6. Dowel Pin
7. Leaf Spring
8. 3/4–10 x 5-1/2 Hexbolt
9. 3/4-Inch Flatwasher
10. Front Hanger
11. 3/4–10 Locknut
12. Air Spring
13. 3/4–10 Hexbolt
14. Shock Absorber
15. 3/4–10 Locknut
16. 3/4-Inch Hardened Washer
17. Rear Hanger
18. 3/4-Inch Flatwasher
19. 3/4–10 Locknut
20. 3/4-Inch Wide Washer
21. 3/4–10 x 5 Hexbolt
22. Thrustwasher
23. Rear Spring Mount
24. 3/4–10 x 7 Lower Shock Bolt
25. 3/4-Inch Hardened Washer
26. Top Axle Wrap

Fig. 1, Front AirLiner Spring Assembly

board side, to the outboard side. The 2-inch o.d. washer should be against the aluminum wrap on the inboard side. See **Fig. 1**.

IMPORTANT: Only the weight of the axle should be on the spring at the time of the spring eye tightening torque.

12. Tighten the lower shock mounting bolts to 225 to 255 lbf·ft (305 to 345 N·m).
13. Tighten the front and rear spring-eye 3/4-inch locknuts to 285 to 305 lbf·ft (385 to 415 N·m).
14. Install the tires.
15. Install the air springs into the top pads. Make sure the piston is correctly seated in the top pad.
16. Remove the frame supports and load the front axle with the vehicle weight.
17. Ensure that the clamp group is properly aligned, and the bottom axle wrap is centered on the top axle wrap. See **Fig. 2**. Ensure that the hexbolts are seated in the top-pad casting. See **Fig. 3**.



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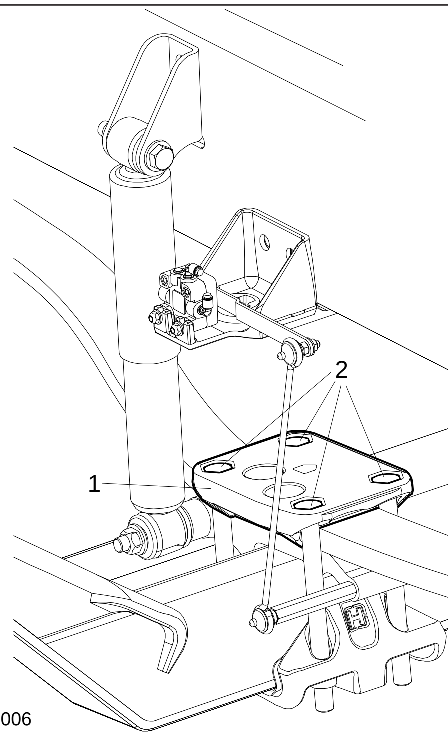
A Ensure the axle clamp group is properly aligned as shown.

Fig. 2, Axle Clamp Group

18. Tighten the clamp-group locknuts in sequence. See **Fig. 4**.
    18.1 Tighten the first diagonal to 100 lbf·ft (135 N·m).



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1. Top Pad
2. 3/4-Inch Bolts

Fig. 3, Top Pad Installation

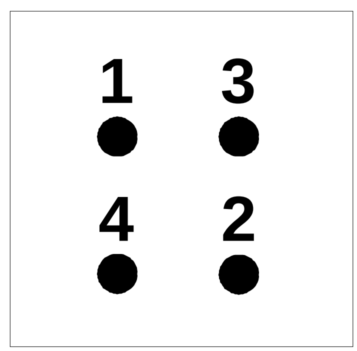

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Fig. 4, Clamp Group Locknut Tightening Sequence

    18.2 Tighten the second diagonal to 100 lbf·ft (135 N·m).
    18.3 Tighten the first diagonal to 270 to 330 lbf·ft (365 to 445 N·m).
    18.4 Tighten the second diagonal to 270 to 330 lbf·ft (365 to 445 N·m).

Leaf Spring Removal and Installation

19. Raise the frame and remove the frame stands.
20. Lower the vehicle.
21. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

22. Remove the chocks from the tires.

Front and Rear Spring Hanger Replacement

Front Spring Hanger Replacement

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.

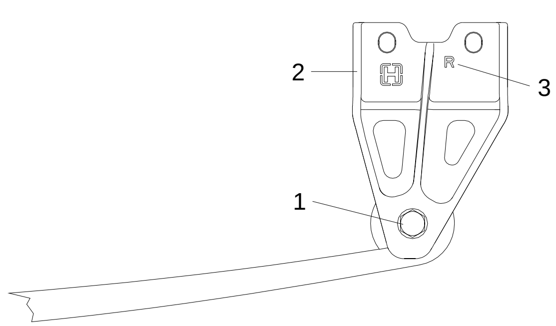
IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle from the shock absorbers.
5. Remove the front spring-eye bolt. See **Fig. 1**.



1. Spring-Eye Bolt
2. Front Spring Hanger
3. Right or Left Hanger Designation

Fig. 1, Front Leaf Spring Hanger

NOTE: A bottle jack may be required to raise the axle slightly in order to remove the mounting bolt, then lower it until the spring eye is clear of the hanger.

6. Remove the frame fasteners, then remove the spring hanger.
7. Inspect the mounting surfaces on the frame for cracks or fretting.
8. Inspect the spring-eye bushing for damage or excessive wear. If damaged or worn excessively, replaceme the bushing. See **Subject 140** for replacement instructions.
9. Install the new hanger, flush with the bottom of the frame. Left or right hanger designation is stamped on the outboard surface of the hanger. See **Fig. 1**.
10. Install the 3/4 x 5-1/2 spring-eye bolt. Tighten the locknut 285 to 305 lbf·ft (385 to 415 N·m).

NOTE: A bottle jack may be required to raise the axle slightly to facilitate installation of the front spring-eye bolt.

11. Raise the vehicle and remove the jack stands or frame support, then lower the vehicle.
12. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

13. Remove the chocks.

Rear Spring Hanger Replacement

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.

Front and Rear Spring Hanger Replacement

IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

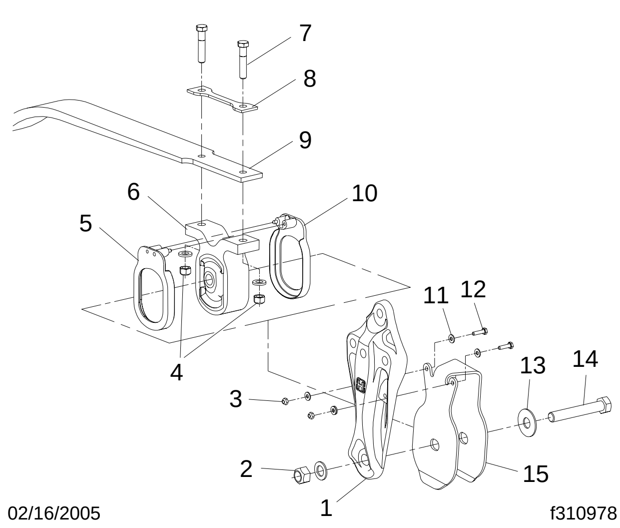
WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle from the shock absorbers.
5. Remove the rear hanger centerbolt.

NOTE: A bottle jack may be required to raise the axle slightly to facilitate removal of the rear hanger centerbolt.

6. Remove the two 1/4 x 1-1/4 hexbolts, washers, and the locknut, that attach the rear hanger to the hanger clamp.
7. Remove the frame fasteners, then remove the spring hanger. See **Fig. 2**.
8. Remove the clamp from the rear spring mount.
9. Remove the two thrustwashers.
10. Inspect the rear spring mount, rear hanger clamp, and both thrustwashers for excessive wear or damage. Replace if necessary.
11. Install the thrustwashers on the rear spring mount.
12. Slide the rear hanger clamp over the rear spring mount.
13. Using new fasteners, install the rear spring hanger on the frame.



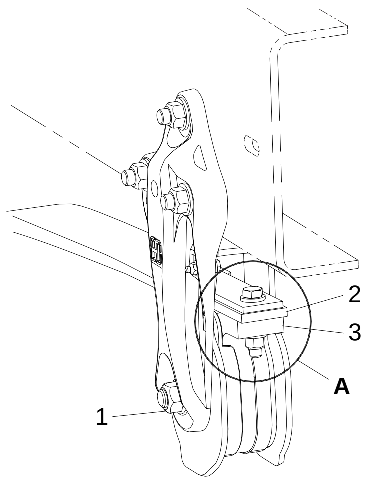
1. Rear Spring Hanger
2. 3/4-Inch Locknut
3. 1/4-Inch Locknut
4. 1/2-Inch Locknut
5. Thrustwasher
6. Rear Spring Mount
7. 1/2-Inch Hexbolt
8. Spring End Plate
9. Leaf Spring Taper
10. Thrustwasher
11. 1/4-Inch Washer
12. 1/4-Inch Bolt
13. 2-Inch o.d. Washer
14. 3/4-Inch Hexbolt (installed from the inboard side)
15. Rear Hanger Clamp

Fig. 2, Rear Spring Mount Assembly

14. Install the two 1/4 x 1-1/4 bolts, washers, and nuts, through the rear hanger, and rear hanger clamp assembly. Tighten the locknuts 84 to 120 lbf·in (950 to 1350 N·cm).
15. Place the 2-inch o.d. washer against the inboard side of the rear hanger clamp. Install the 3/4 x 5 centerbolt, through the center of the spring hanger from the inboard side towards the outboard side.

NOTE: A bottle jack may be required to raise the axle slightly to facilitate installation of the rear hanger centerbolt.

16. Install the washer and locknut. Tighten the locknut to 285 to 305 lbf·ft (385 to 415 N·m). See **Fig. 3**.
17. Raise the vehicle and remove the jack stands or frame support.
18. Lower the vehicle.



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A. Verify that the rear spring mount is centered on the leaf spring taper.

1. 3/4-Inch Locknut
2. Leaf Spring Taper
3. Rear Spring Mount

Fig. 3, Rear Spring Hanger Installation

19. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

20. Remove the chocks.

Thrustwasher and Rear Hanger Clamp Removal and Installation

Removal

1. Set the parking brake, and shut down the engine. Chock the tires.

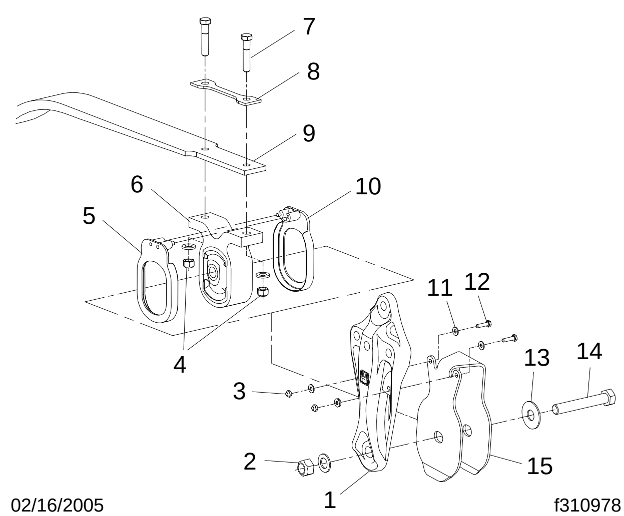
IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle, ensuring there is enough clearance to allow the rear spring mount to clear the bottom of the spring hanger.
5. Loosen, but do not remove the front spring-eye bolt.
6. Support the axle with a floor jack.
7. Remove the rear hanger centerbolt.
8. Remove the lower shock bolt.
9. Lower the jack until the rear spring mount is below the spring hanger.
10. Remove the 1/4 x 1-1/4 rear hanger clamp bolt, and remove the rear hanger clamp.
11. Remove the two thrustwashers from the rear spring mount. See **Fig. 1**.
12. Inspect the spring mount for torn rubber, a worn metal sleeve, or a cracked housing. If any of these conditions exist, replace the spring mount.



1. Rear Spring Hanger
2. 3/4-Inch Locknut
3. 1/4-Inch Locknut
4. 1/2-Inch Locknut
5. Thrustwasher
6. Rear Spring Mount
7. 1/2-Inch Hexbolt
8. Spring-End Plate
9. Leaf-Spring Taper
10. Thrustwasher
11. 1/4-Inch Washer
12. 1/4-Inch Bolt
13. 2-Inch o.d. Washer
14. 3/4-Inch Hexbolt (Centerbolt installed from inboard side)
15. Rear-Hanger Clamp

Fig. 1, Rear Spring Mount Assembly

Installation

1. Install the two 1/4 x 1 bolts, washers, and nuts, through the rear hanger, and rear hanger clamp assembly. Tighten the 1/4-inch locknuts84 to 120 lbf·in (950 to1350 N·cm).
2. Install two new thrustwashers onto the rear spring mount.
3. Raise the axle to install the rear spring mounts into the rear hanger clamps.
4. Install the 3/4 x 5 rear centerbolt, from the inboard side towards the outboard side. Place the 2-inch o.d. washer against the inboard side of the rear-hanger clamp.
5. Apply a thin coat of antiseize to the lower shock bolt.
6. Install the lower shock bolt, from the inboard side towards the outboard side. Tighten the shock bolt 225 to 255 lbf·ft (305 to 345 N·m).

Thrustwasher and Rear Hanger Clamp Removal and Installation

7. Remove the jack and let the suspension hang.
8. Tighten the front spring-eye bolt and rear center-bolt to 285 to 305 lbf·ft (385 to 415 N·m).
9. Raise the frame and remove the frame stands.
10. Lower the vehicle.
11. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

12. Remove the chocks from the tires.

Axle Wrap Removal and Installation

Bottom Axle Wrap

Removal

1. Park the vehicle and chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.

WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with frame stands.
4. Remove the air spring from the side that is being worked on. For instructions, see **Subject 130**.
5. Remove the 3/4-inch hexbolts and the nylon locknuts that fasten the axle wrap to the axle. See **Fig. 1**.

WARNING

Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.

6. Remove the bottom axle wrap. It may be necessary to use a deadblow mallet to dislodge the axle wrap.
7. Inspect the axle wrap, and replace if necessary.
8. Discard the used bottom axle wrap liner.

Installation

1. Install a new liner into the bottom axle wrap.
2. Using new 3/4-inch hexbolts and grade 8 nylon locknuts, install the bottom axle wrap on the axle. Ensure that the clamp group is aligned, the bottom axle wrap is centered on the top axle wrap, and the hexbolts are seated in the top-pad casting.
3. Tighten the clamp-group locknuts in sequence. See **Fig. 2**.
   - 3.1 Tighten the first diagonal to 100 lbf·ft (135 N·m).
   - 3.2 Tighten the second diagonal to 100 lbf·ft (135 N·m).
   - 3.3 Tighten the first diagonal to 270 to 330 lbf·ft (365 to 445 N·m).
   - 3.4 Tighten the second diagonal to 270 to 330 lbf·ft (365 to 445 N·m).
4. Following the instructions in **Subject 130**, install the air spring that was removed.

Top Axle Wrap

Removal

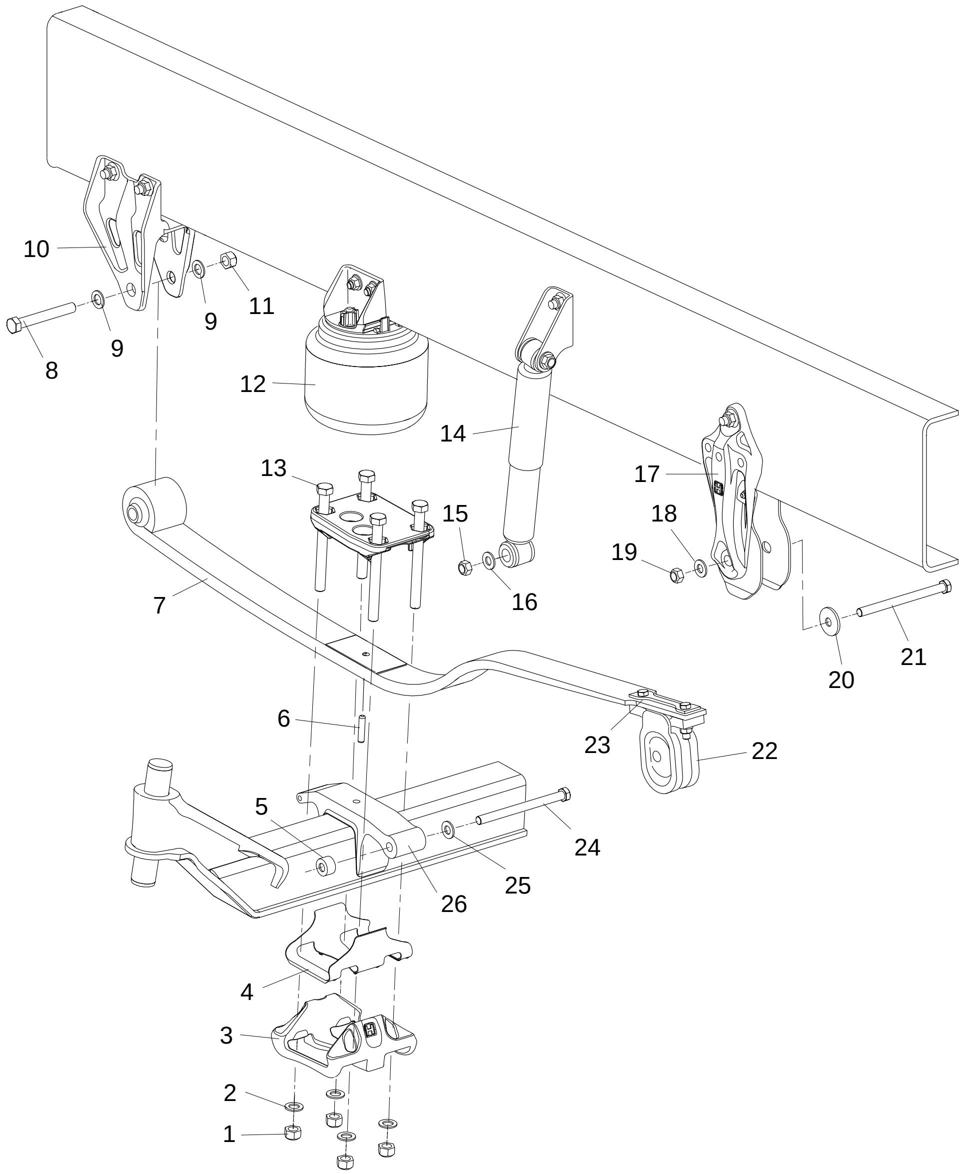
1. Park the vehicle and chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with frame stands.
4. Remove the front tires.
5. Lower the floor jack and suspend the front axle to remove the load from the leaf springs.
6. Remove the air spring from the side that is being worked on. For instructions, see **Subject 130**.
7. Position a floor jack, that has a four-inch lifting plate, under the center of the axle.
8. Secure the axle on the jack to prevent the axle from rolling off the floor jack.
9. Remove the 3/4-inch hexbolts and the nylon locknuts that fasten the axle wrap to the axle.

Axle Wrap Removal and Installation



1. 3/4–10 Nylon Locknut
2. 3/4-Inch Flatwasher
3. Bottom Axle Wrap
4. Bottom Axle Wrap Liner
5. Shock Spacer
6. Dowel Pin
7. Leaf Spring
8. 3/4–10 x 5-1/2 Hexbolt
9. 3/4-Inch Flatwasher
10. Front Hanger
11. 3/4–10 Locknut
12. Air Spring
13. 3/4–10 Hexbolt
14. Shock Absorber
15. 3/4–10 Locknut
16. 3/4-Inch Hardened Washer
17. Rear Hanger
18. 3/4-Inch Flatwasher
19. 3/4–10 Locknut
20. 3/4-Inch Wide Washer
21. 3/4–10 x 5 Hexbolt
22. Thrustwasher
23. Rear Spring Mount
24. 3/4–10 x 7 Lower Shock Bolt
25. 3/4-Inch Hardened Washer
26. Top Axle Wrap

Fig. 1, Front AirLiner Spring Assembly

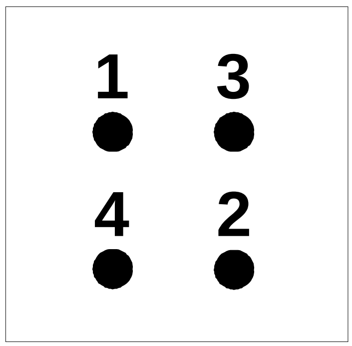


Fig. 2, Clamp Group Locknut Tightening Sequence

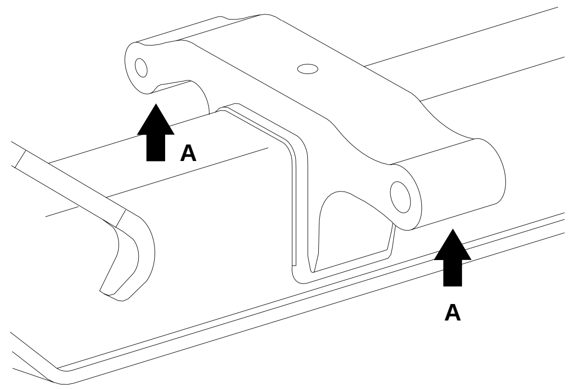
WARNING

Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.

10. Remove the top spring pad casting, the bottom axle wrap, and the liner.
11. Remove the lower shock-mounting bolts.
12. Using the floor jack, lower the axle away from the leaf springs.
13. Remove the dowel pin, alignment shim, and spacer (if equipped).
14. Strike the axle wrap with a plastic deadblow mallet at the front and rear on the underside of the axle wrap, to dislodge it from the axle. See Fig. 3.
15. Clean the axle wrap and axle, then inspect for cracks or damage. Replace if cracks or damage are visible.

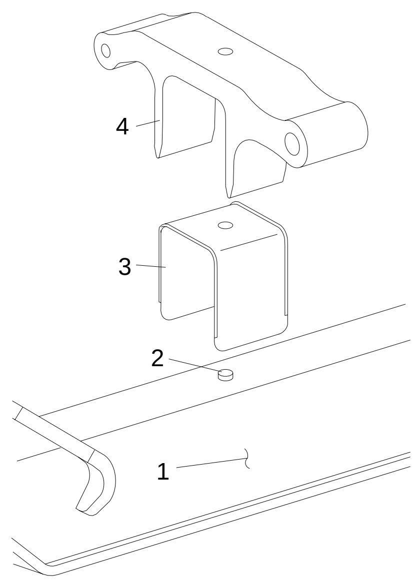
Installation

1. Install a new axle wrap liner on the axle. See Fig. 4.
2. Spray the axle wrap liner and the axle wrap with a silicon lubricant.



A. Carefully strike upward with a plastic deadblow mallet.

Fig. 3, Top Axle Wrap Removal



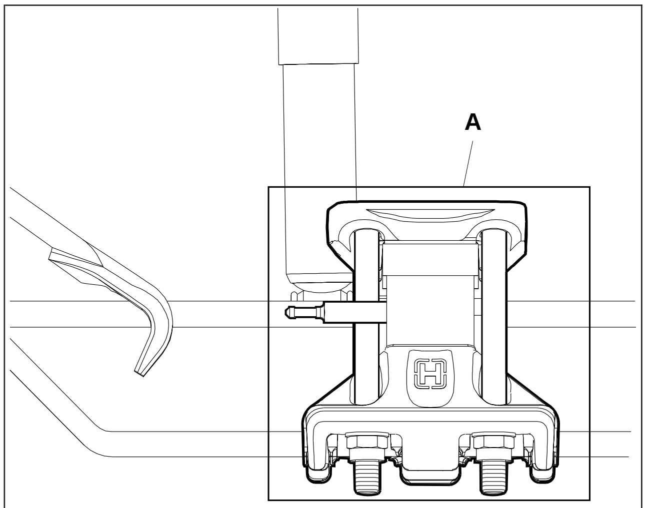
1. Axle
2. Locating Bushing
3. Top Axle Wrap Liner
4. Top Axle Wrap

Fig. 4, Top Axle Wrap Installation

3. Position the axle wrap on the axle.
4. Protect the top surface of the axle wrap with a block of wood, cardboard, or shop towels.
5. Using a deadblow mallet, drive the axle wrap onto the axle, indexing the locating bushing until the axle wrap is firmly seated on the axle.

Axle Wrap Removal and Installation

6. Install the dowel pin(s) into the axle wrap.
7. Install the alignment shims and spacer (if equipped).
8. Raise the axle assembly with a jack, and engage the dowel pins in the leaf spring bore.
9. Install the top pad with the arrows facing inboard on the leaf spring.
10. Install new clamp group hexbolts into the top pad.
11. Remove the old bottom axle-wrap liner, and install a new one.
12. Install the bottom axle wrap.
13. Install new clamp group washers and nylon locknuts (Grade 8).
14. Ensure that the clamp group is properly aligned and the hexbolts are seated in the top pad, and the bottom axle wrap is centered on the top axle wrap. See **Fig. 5** and **Fig. 6**.



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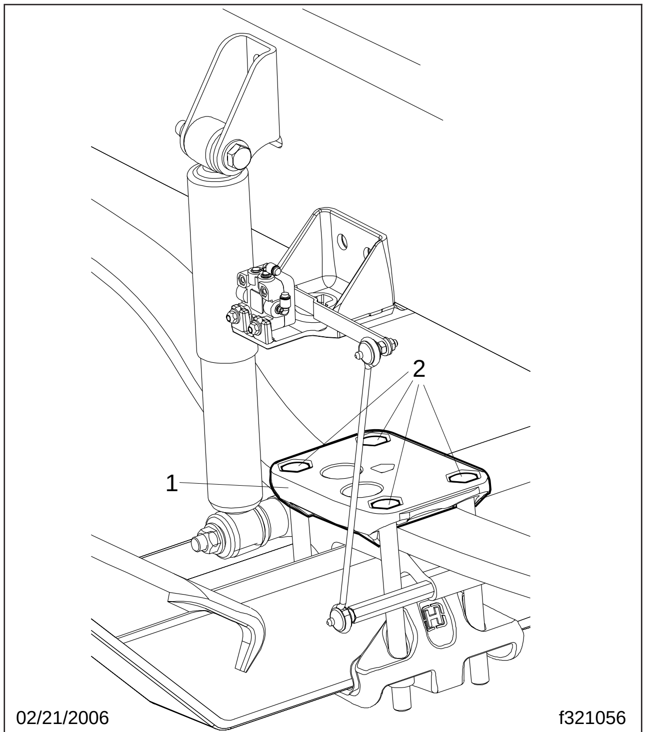
A Ensure the axle clamp group is properly aligned as shown.

Fig. 5, Axle Clamp Group

15. Tighten the clamp-group locknuts in sequence. See **Fig. 2**.
    15.1 Tighten the first diagonal 100 lbf·ft (135 N·m).



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1. Top Pad
2. 3/4-Inch Bolts

Fig. 6, Top Pad Installation

    15.2 Tighten the second diagonal 100 lbf·ft (135 N·m).
    15.3 Tighten the first diagonal 270 to 330 lbf·ft (365 to 445 N·m).
    15.4 Tighten the second diagonal 270 to 330 lbf·ft (365 to 445 N·m).

16. Apply a thin coating of antiseize to the lower shock mounting bolt.
17. Install the lower shock bolt from the inboard side to the outboard side of the top axle wrap and attach the spacer, washer, and locknut.
18. Tighten the shock eye locknuts 225 to 255 lbf·ft (305 to 345 N·m).
19. Install the tires.
20. Install the air springs, following the instructions in **Subject 130**.

Torque Specifications

For fastener torque values, see **Table 1**.

Fastener Application	Torque	
	lbf·ft (N·m)	lbf·in (N·cm)
Front Frame Hanger to Frame	160–180 (215–245)	—
Front Spring Eye	285–305 (385–415)	—
Rear Hanger to Rear Hanger Clamp	—	84–120 (950–1350)
Rear Spring Hanger to Rear Spring Mount	285–305 (385–415)	—
Rear Spring Mount to Leaf Spring	80–110 (110–150)	—
Upper Air-Spring Bracket	160–180 (215–245)	—
Height-Control Valve to Air-Spring Bracket Locknuts*	—	95 (1100)
Barksdale Height-Control Valve Housing Capscrews*	—	45 (500)
Clamp-Group Hardware	285–305 (385–415)	—
Shock-Absorber Eye Bolt	225–255 (305–345)	—
Shock Bracket to Frame	160–180 (215–245)	—

* See the cautionary statements below.

Table 1, Front AirLiner (AIRTEK) Suspension Fastener Torque Values

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

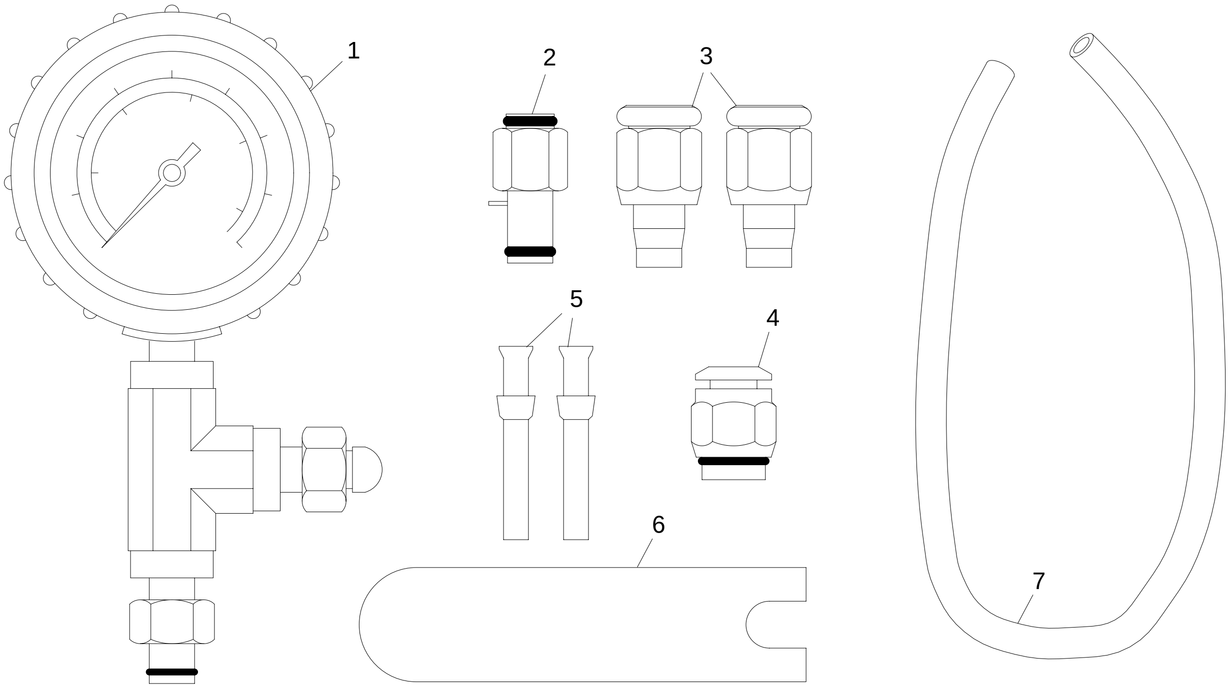
CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Special Tools

Use the kit shown in **Fig. 1** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in paragon.

Specifications



NOTE: Parts for cab suspension valve testing included.

1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve (used for cab suspension valve testing)
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve (used for cab suspension valve testing)
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 1, Barksdale Height-Control Valve Test Kit BKS KD2264

General Description

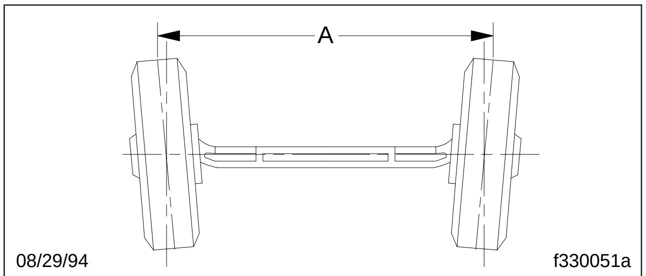
NOTE: For front axle troubleshooting procedures, refer to **Section 33.01**.

The front axle requires periodic servicing to maintain accurate wheel alignment. If the front axle is damaged enough to affect the camber angle it must be replaced. For axle removal and installation instructions, see **Subject 160**.

Correct front axle wheel alignment is needed to ensure long tire life, ease of handling, and steering stability.

Three factors are involved in wheel alignment: camber angle, caster angle, and wheel toe-in.

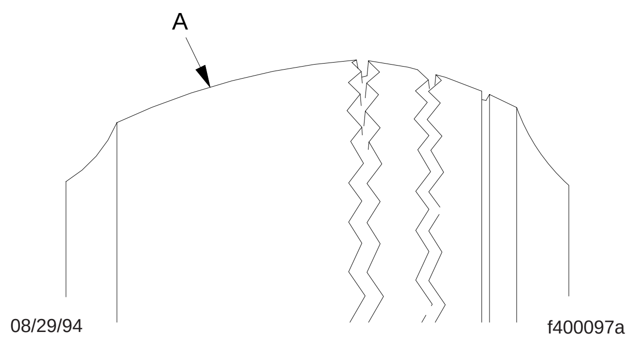
Camber angle (**Fig. 1**) is the vertical tilt of the wheel as viewed from the front of the vehicle. Camber angle is measured in degrees, and is not adjustable. Positive camber is the outward tilt of the wheel at the top. Excessive positive camber in one wheel causes the vehicle to pull in the opposite direction, rapidly wearing the outboard side of the tire tread. Negative camber is the inward tilt of the wheel at the top. Excessive negative camber in one wheel causes the vehicle to pull in the same direction that the negative-camber wheel is on, wearing the inboard side of the tire tread. If camber angles are not correct, the tires will wear smooth around the edge on one side. See **Fig. 2**.



A. Camber (Positive)

Fig. 1, Camber Angle (front view)

Caster angle (**Fig. 3**) is the tilt of the knuckle pin (or kingpin) as viewed from the side. Caster angle is measured in degrees and it is adjustable. A positive caster angle is the tilt of the top of the knuckle pin toward the rear of the vehicle. A negative caster angle is the tilt of the top of the knuckle pin toward the front of the vehicle. Caster angles are based on the design load of the vehicle. An incorrect caster angle does not cause tire wear. However, a positive caster angle that exceeds specifications could cause vehicle shimmy, road shock, and an increased steering effort. A negative caster angle that does not meet specifications could cause unstable steering. The vehicle may wander and weave, and extra steering effort may be necessary. After leaving a turn, the tendency to return to and maintain a straight-ahead position is reduced. Too much or too little caster in one wheel can cause erratic steering when the service brakes are applied to stop the vehicle.



A. One side of the tread is worn excessively.

Fig. 2, Tire Damage Due to Excessive Camber

Wheel toe-in (**Fig. 4**) is the distance in inches that the front of the wheels are closer together than the rear of the wheels, as viewed from the top. Wheel toe-in is adjustable. If it is not adjusted correctly, the vehicle could pull to one side while driving. Wheel shimmy and cupped tire treads (indentations on the road contact surface of the treads) could occur. Also, rapid or severe tire wear on the steering axle could occur, usually in a feather-edged pattern. See **Fig. 5**.

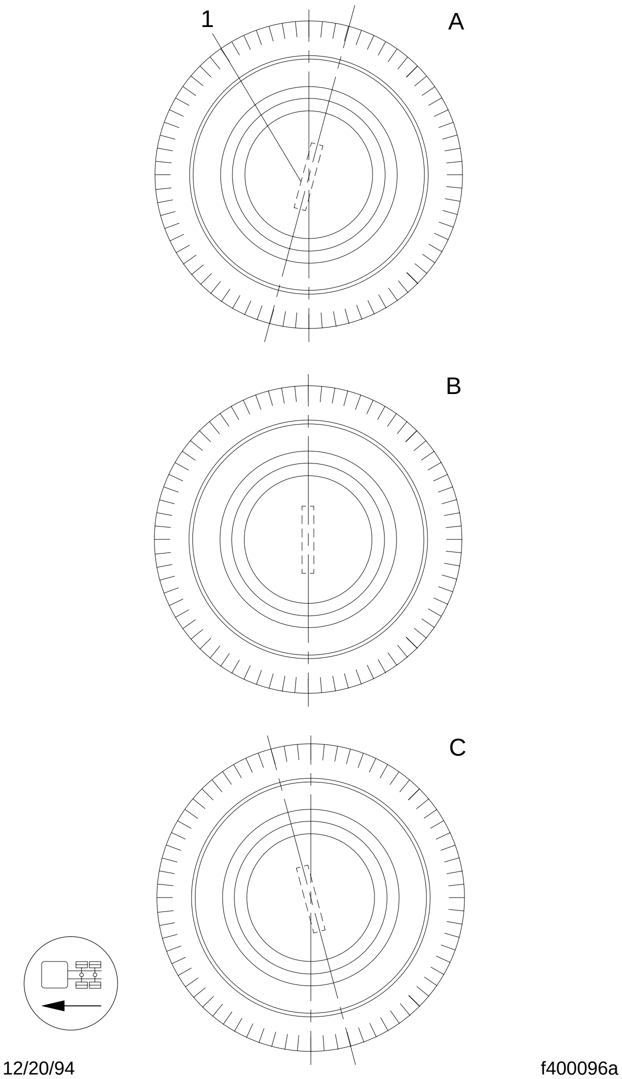
Advanced wear patterns can be seen, but less severe wear patterns are detected only by rubbing the palm of your hand flat across the tire tread.

Feather-edging more often affects the front tire on the passenger's side of the vehicle, and is usually more apparent on the outside grooves of the tire.

If any of the conditions listed above occur, the vehicle could need a front end wheel alignment, and possibly, drive axle alignment. However, in some cases these conditions are not wheel alignment related; refer to **Section 33.01** for other possible causes.

If excessive tire tread wear has resulted from incorrect wheel alignment, replace the damaged tires. For

General Description

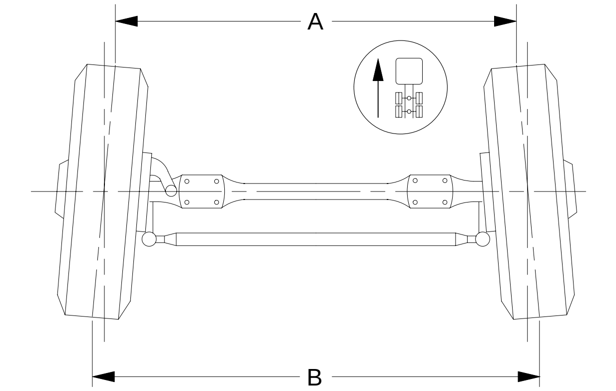


1. Knuckle Pin (King Pin)

A. Positive Caster
B. Zero Caster
C. Negative Caster

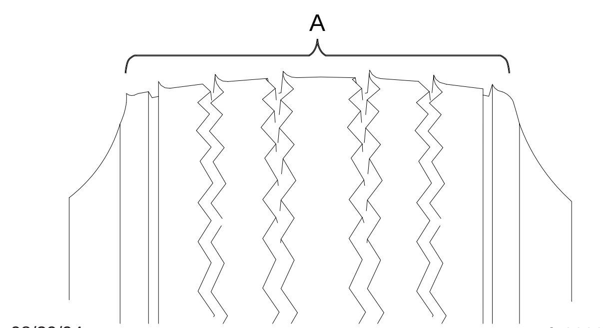
Fig. 3, Caster Angle

minimum tread wear specifications, refer to the wheels and tires section in the vehicle maintenance manual.



NOTE: B minus A equals toe-in.

Fig. 4, Wheel Toe-In (overhead view)

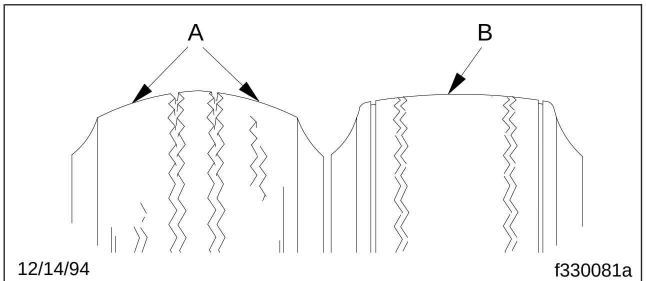


A. Feathered Edges

Fig. 5, Tire Damage Due to Excessive Toe-In or Incorrect Drive Axle Alignment

Preliminary Checks

1. Steering axle wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 50 mph (80 km/h). Off-balance wheel assemblies cause vibrations that result in severely shortened life for tires, and steering suspension parts.
2. Do not mix tires of different size, type, or weight. Tire wear should be even and not worn to limits exceeding government specifications. Refer to **Group 40** in this manual and the vehicle maintenance manual for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. Refer to the wheels and tires section in this manual for recommended pressures. An underinflated tire causes tread wear completely around both tire shoulders. An overinflated tire causes tread wear in the center of the tire. See **Fig. 1.**



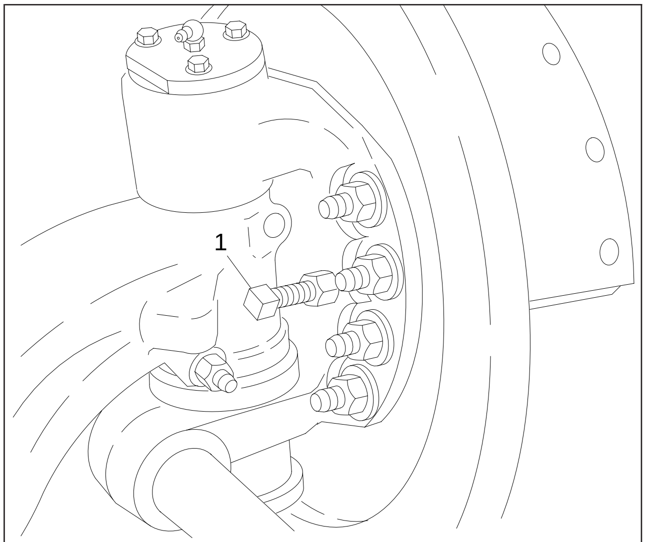
A. Underinflation Wear B. Overinflation Wear

Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires

4. Check for out-of-round wheels, rims, or wheel stud holes. Replace the wheel if any of these conditions exist.
5. On each side of the vehicle, check the height of the chassis above the ground. Sagging, fatigued, or broken suspension springs create a lopsided vehicle appearance. This causes an unbalanced weight distribution. Anything that changes the ratio of weight on the springs affects the alignment angles and also the tire tread contact area. Replace damaged springs as instructed in the suspension section in this manual.
6. Inspect the front axle beam (also called the axle center) for bends or twists. If the axle beam is bent or twisted over 1/2 degree, replace it before aligning the front axle wheels.
7. Check for damaged, worn, or bent steering gear or linkage parts. Make sure the steering gear is centered. Replace damaged components, and adjust the steering gear, using the instructions in the steering section in this manual.
8. Check the steering angle, and adjust the axle steering stops, as needed. Refer to **Subject 110**.

Checking and Adjusting

Steering (or turning) angle is the degree of front wheel movement from a straight-ahead position to either an extreme right or left position. Although front wheel movement can be limited by the amount of internal travel in the steering gear, it generally depends on how much clearance there is between chassis components and the tire and wheel assemblies. All axles have adjustable stopscrew-and locknut-type axle stops (**Fig. 1**), which are located on the rear side of each front axle spindle.



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1. Stopscrew and Locknut

Fig. 1, Axle Stop

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Make sure the steering gear is in the center of travel when the wheels are in a straight-ahead position. Center the gear, using the instructions in the steering section in this manual. Bottoming of the steering gear must not occur when making an extreme right or left turn.
2. If using stationary turn-plates or turntables (**Fig. 2**), drive the vehicle on the plates; the tires must be exactly straight ahead. Apply the parking brakes.

   If using portable gauges, apply the parking brakes, chock the rear tires, and raise the front of the vehicle. Place a turn-plate or turntable under each tire. With the tires exactly straight ahead, lower the vehicle so that the tires rest on the center of the gauges.

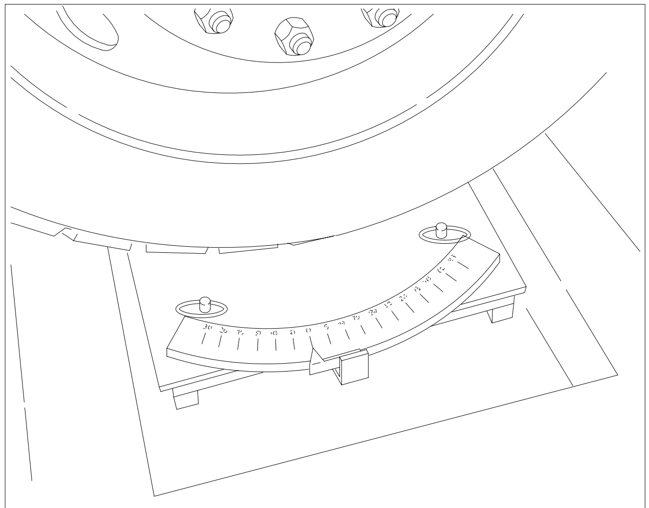

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Fig. 2, Turn-Plate (Turntable), Stationary Type

3. Remove the lockpins from the gauges, and adjust the dials so that the pointers on both gauges read zero.
4. With the brakes fully applied, turn the steering wheel clockwise to the end of travel. Have someone check both sides of the vehicle for interference at the tires and wheels. There must be at least 0.50 inch (13 mm) clearance from any fixed object, and 0.75 inch (19 mm) from any moving object.

   If necessary, loosen the stopscrew locknut; adjust the stopscrew to contact the axle when the maximum turning angle of the wheels is determined.

   Tighten the locknut to the value in the torque table under **Specifications 400**.

Steering Angle Checking and Adjusting

5. Repeat the step above with the steering wheel turned counterclockwise. Adjust the axle stop, as needed.
6. If equipped with power steering, adjust the steering gear so that pressure is released ahead of the axle stop. This will prevent possible damage to the steering or axle components. For poppet valve adjustment instructions, refer to **Group 46** in this manual.
7. Drive the vehicle off the turn-plates or turntables, or remove them from under the tires and lower the vehicle.

Measuring and Adjusting Front Axle Wheel Alignment Angles

Measuring and Adjusting

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

Precision instruments and equipment are needed for accurately measuring and adjusting wheel alignment. Refer to the operating instructions provided by the wheel alignment equipment manufacturer.

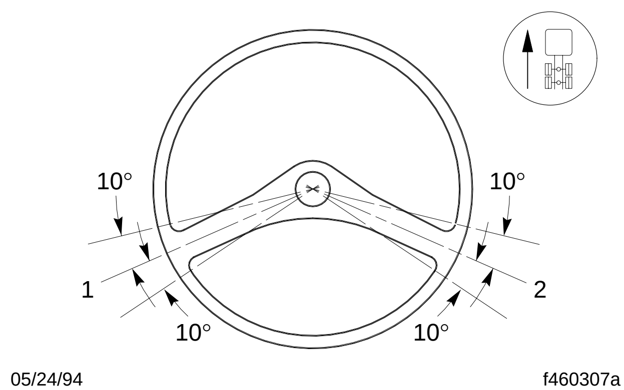
Before checking or correcting wheel alignment, make sure the vehicle is at curb weight. Curb weight is the weight of the unloaded vehicle complete with accessories and full fuel tanks.

If a road test is necessary, the route should be one that allows full left and right turns and full stops. It should also include a length of straight, level road to check the steering wheel position during straight-ahead driving.

During the road test, note any steering effort and possible roughness. Check for looseness, too much wheel play, any tendency for the vehicle to lead in one direction, and for pull during stopping.

Note the position of the steering wheel while driving on a straight, level road. When the steering gear is centered, the steering wheel spokes should be at the 4 and 8 o'clock positions, or within 10 degrees of that position. See **Fig. 1.**

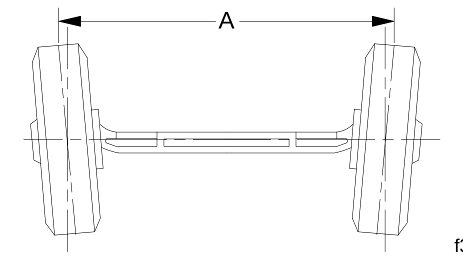
If there are any problems, refer to **Section 33.01**.



1. 8 o'Clock
2. 4 o'Clock

Fig. 1, Steering Wheel Position

Checking (See Fig. 1)



A. Camber (Positive)

Fig. 1, Camber Angle

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle; make sure the stands will support the weight of the cab, frame, and front axle.
3. Before measuring camber, check the front wheel bearings for wear and incorrect adjustment. Try moving the wheel on the axle spindle (steering knuckle) either by grasping the front tire on the top and bottom, or by using a bar for leverage. If movement between the brake drum and the backing plate or other axle-mounted reference point is 0.05 inch (1 mm) or more, the bearings may be worn or incorrectly adjusted. Inspect the wheel bearings for damage using the instructions in **Section 33.01**. If needed, replace or adjust the bearings.
4. Remove the safety stands, and lower the vehicle to the ground.
5. Using the alignment equipment manufacturer's instructions, measure the front wheel camber.
6. Compare the camber angles with those shown in the appropriate table in **Specifications, 400**. Differences between the measurements taken in the step above and the angles in the table are caused by damaged (bent) axle components.

   Incorrect camber angles could be caused by damage in one or more of the following front axle components: the knuckle pin, the knuckle pin bushings, the axle spindle, or the axle beam. Replace twisted or otherwise damaged components. Don't try to straighten twisted or bent components; replace them with new components. If a bent or twisted front axle knuckle pin, axle spindle, or axle beam has been straightened, the axle warranty will be voided.

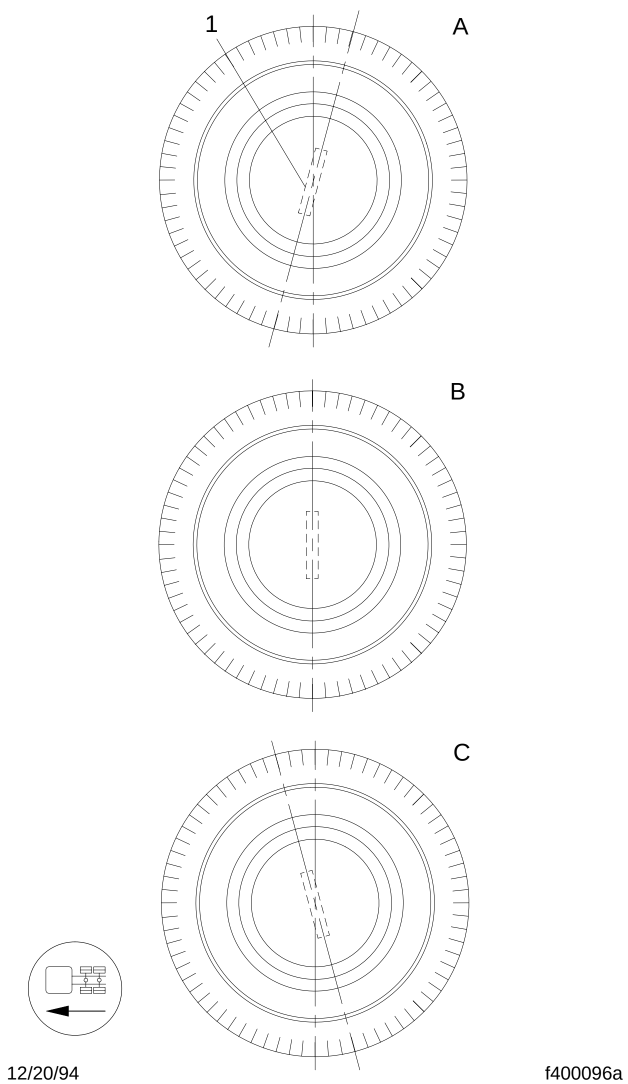
WARNING

WARNING: Do not attempt to straighten any twisted or bent front axle component. This could crack or weaken the component, possibly resulting in a collapsed front axle, loss of a wheel, and serious personal injury.

7. Remove the chocks from the tires.

Checking and Adjusting

(See Fig. 1)



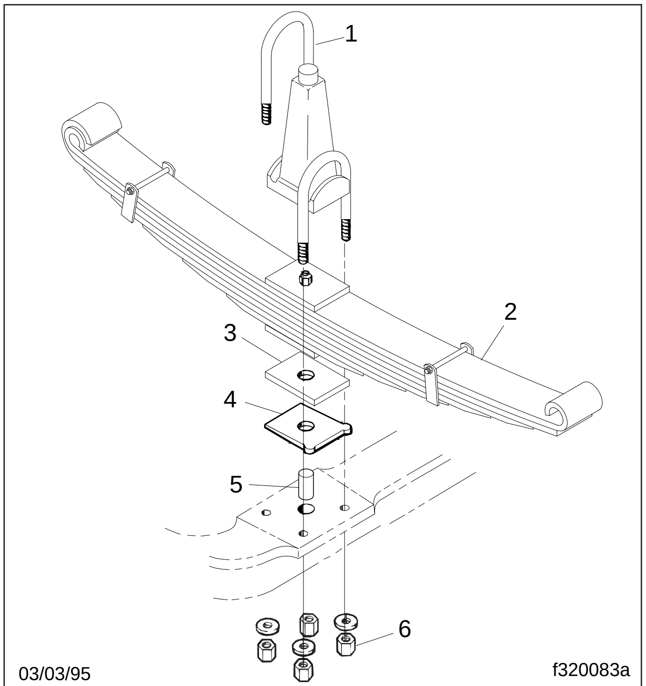
A. Positive Caster
B. Zero Caster
C. Negative Caster
1. Knuckle Pin (Kingpin)

Fig. 1, Caster Angle

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

Using the alignment equipment manufacturer's operating instructions, measure the front wheel caster.

Compare the caster angles with those shown the appropriate table in **Specifications 400**. If needed, adjust the caster angle by placing wedge-shaped shims between the axle spacer and the axle beam, as follows (see **Fig. 2**):



1. Axle Spring U-Bolt
2. Leaf Spring Assembly
3. Spacer
4. Front Caster Shim
5. Dowel Pin
6. U-Bolt High Nut

Fig. 2, Axle Spring Installation

IMPORTANT: Extreme angle shims cannot be used to correct caster angles that vary by more than 2 degrees from the values in the table. Weak or broken leaf springs, or worn shackle bushings, can cause extreme deviations to caster angles. Replace damaged parts before doing caster adjustments.

Caster Angle Checking and Adjusting

1. Apply the parking brakes, and chock the front and rear tires.
2. Back off the U-bolt nuts from the U-bolts on one side of the front axle. See **Fig. 2**.
3. Raise the spring away from the axle enough to allow removal of the front caster shim.
4. Remove the shim, and install one that will provide the correct caster angle, as specified in the table in **Specifications 400**. Install the dowel pin and check penetration.

IMPORTANT: Place front caster shims between the axle beam and the axle spacer, or between the axle beam and the shock absorber bracket. See **Fig. 2.**

5. Lower the vehicle onto the axle.
6. Coat the threaded ends of the U-bolts with chassis lube or an antiseize compound, such as Loctite® 242. Tighten the U-bolt nuts to the value in the appropriate table in **Specifications 400**.

   U-bolt nuts need periodic retightening. Refer to the suspension section in the vehicle maintenance manual for recommended intervals.

CAUTION

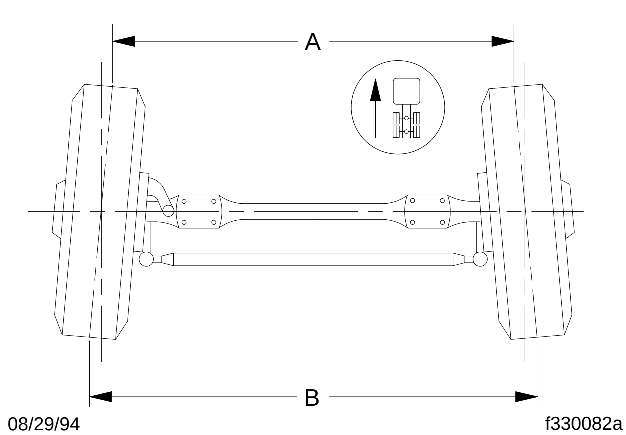
Failure to periodically retighten the U-bolt nuts could result in spring breakage and abnormal tire wear.

7. Using the steps above, replace the shim on the other side of the axle.
8. Remove the chocks from the tires. Do a final caster angle check.

Checking and Adjusting

(See Fig. 1)

Using the alignment equipment manufacturer's operating instructions, measure the wheel toe-in. Compare the measurement with that shown in the appropriate table in **Specifications 400**. If corrections are needed, go to the applicable (tie rod adjustment) step below.



NOTE: B minus A equals toe-in.

Fig. 1, Wheel Toe-In (Overhead View)

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle. Make sure the stands will support the weight of the cab, axle, and frame.
3. Using spray paint or a piece of chalk, mark the entire center rib of each front tire.
4. Place a scribe or pointed instrument against the marked center rib of each tire, and turn the tires. The scribes must be held firmly in place so that a single straight line is scribed all the way around each tire.
5. Place a turn-plate or turntable under each tire. Remove the safety stands from under the axle, then lower the vehicle. Remove the lockpins from the gauges; make sure the tires are exactly straight ahead.

NOTE: If turn-plates or turntables are not available, lower the vehicle. Remove the chocks from the rear tires and release the parking brakes. Move the vehicle backward and then forward about six feet (2 meters).

6. Place the trammel bar at the rear of the front tires; locate the trammel pointers at spindle height, and adjust the pointers to line up with the scribe lines. Lock in place. Make sure that the scale is set on zero.
7. Place the trammel bar at the front of the tires as shown in **Fig. 2**. Adjust the scale end so that the pointers line up with the scribe lines. See **Fig. 3.**

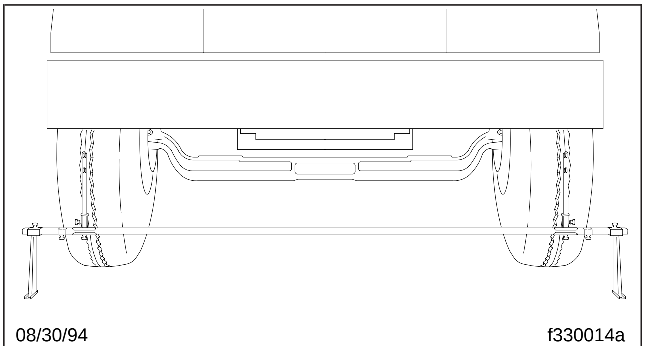


Fig. 2, Trammel Bar Positioning

8. Read the toe-in from the scale. Compare the toe-in with the value in the appropriate table in **Specifications 400**. If corrections are needed, go to the next step.
9. Loosen the tie rod (cross tube) clamp nuts, and turn the tie rod as needed.

   If the vehicle is not on turn-plates or turntables, move the vehicle backward and then forward about six feet (two meters). This is important when setting the toe-in on vehicles equipped with radial tires.

   Do a final wheel toe-in check to make sure that it is correct.

Wheel Toe-In Checking and Adjusting

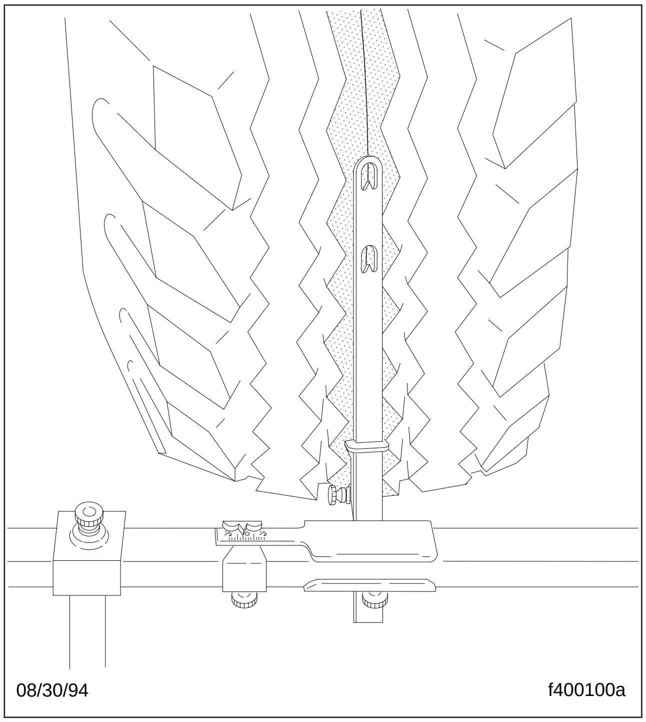


Fig. 3, Calculating Wheel Toe-In

Tighten the clamp nuts to the values in the appropriate table in **Specifications 400**.

10. If not already done, remove the chocks from the rear tires. Road test the vehicle.

Front Axle Removal and Installation

Removal

NOTE: This procedure involves removing the axle from underneath the front of the vehicle. If you cannot support the vehicle high enough for the axle to clear the bumper, then you will need to remove the bumper.

1. Park the vehicle on a level surface, set the parking brakes, then chock the rear tires.
2. Tilt the hood or cab. For cab tilt instructions, see **Group 60**.
3. Raise the vehicle, then support the frame rails with safety stands.
4. Remove the front tires.
5. If so equipped, disconnect the ABS sensors from the axle knuckles. Pull the sensors straight out.

WARNING

When draining the air system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions while working on the air brake system can cause personal injury.

6. Drain the air tanks.
7. Disconnect the air lines from the front brake chambers.
8. Remove the brake drums. See **Group 42** for instructions.
9. Remove the hubs. Refer to the applicable subject in **Section 33.01** for instructions.
10. Disconnect the steering drag link from the axle steering arm. See **Group 46** for instructions.
11. If needed, remove the front bumper. See **Group 31** for instructions.
12. Remove the U-bolts and nuts holding the axle to the leaf springs.
    - 12.1 Take the weight off the leaf springs by raising the axle.
    - 12.2 On one side of the axle, remove all the U-bolt nuts and washers, then remove the two U-bolts.
    - 12.3 Repeat the procedure on the other side of the axle.
13. Remove the axle stops from the top of the leaf springs.
14. Remove the axle spacers from the top of the axle beam.
15. Using a suitable axle jack, remove the axle by sliding it out from the front of the vehicle.
16. Remove the brake shoes, cam, and spider. See **Group 42** for instructions.

Installation

1. From the front of the vehicle, and using a suitable axle jack, roll the axle into place under the leaf springs.
2. Install the axle spacers.
3. Slowly raise the axle up to the bottom of the leaf springs, making sure the dowels on top of the axle beam line up with the holes in the axle spacers.
4. Install the axle stops onto the tops of the leaf springs.
5. Install the U-bolts.
    - 5.1 Using a suitable clamp (such as a large C-clamp) compress one of the U-bolts, then install it on one side of the axle. Do the same for the second U-bolt.
    - 5.2 Install the U-bolt nuts and washers. Tighten the nuts finger-tight.
    - 5.3 Repeat the procedure on the other side of the axle.
6. Tighten the U-bolt nuts.

   For 3/4–16 U-bolt nuts: In a diagonal pattern, tighten the U-bolt nuts successively 80 lbf·ft (108 N·m), 200 lbf·ft (270 N·m), then 300 lbf·ft (406 N·m).

   For 7/8–16 U-bolt nuts: In a diagonal pattern, tighten the U-bolt nuts successively 60 lbf·ft (81 N·m), 200 lbf·ft (270 N·m), then 460 lbf·ft (624 N·m).

Front Axle Removal and Installation

7. Install the brake spider, cam, and brake shoes. See **Group 42** for instructions.
8. If so equipped, install the ABS sensors in the axle knuckles.
9. Connect the air lines to the brake chambers.
10. Connect the drag link to the steering arm. See **Group 46** for instructions.
11. Install the tires.
12. If it was removed, install the bumper. See **Group 31** for instructions.
13. Raise the vehicle, then remove the safety stands.
14. Lower the vehicle.
15. Lower the hood or return the cab to the operating position. For cab tilt instructions, see **Group 60**.
16. Remove the chocks from the rear tires.

IMPORTANT: When aligning the front axle, it is essential that the rear axle(s) be checked for correct alignment at the same time. Alignment of the rear axle(s) has a direct impact on how the vehicle tracks. Refer to **Section 35.00**.

NOTE: The alignment specifications below are for unloaded vehicles. These specifications will vary as weight is added to the vehicle and transferred to the front axle.

Alignment Specifications

Caster

IMPORTANT: Caster settings for the left and right sides *must* be within ½ degree of each other. It is necessary for only one side to be within the specifications given in **Table 1**, **Table 2**, and **Table 3**.

Caster Target and Limits, Hunter Equipment	
Target: degrees	**Limits: degrees**
+3-1/2	+2 to +5

Table 1, Caster Target and Limits, Hunter Equipment

Caster Target and Limits, Bee Line Equipment (except LC4000)	
Target: degrees	**Limits: degrees**
+3-1/2	+3 to +6-1/2

Table 2, Caster Target and Limits, Bee Line Equipment (except LC4000)

Caster Target and Limits, Bee Line LC4000	
Target: degrees	**Limits: degrees**
+3-1/2	+2-1/4 to +4-3/4

Table 3, Caster Target and Limits, Bee Line LC4000

Toe-In

Toe-In Target and Limits, Hunter Equipment	
Target: degrees	**Limits: degrees**
+0.09	0.00 to +0.18

Table 4, Toe-In Target and Limits, Hunter Equipment

Toe-In Target and Limits, Bee Line Equipment	
Target: in (mm)	**Limits: in (mm)**
+1/16 (+1.6)	0 to +1/8* (0 to +3.2)

* If adjustment is required, set the toe-in as close as possible to +1/16 inch (+1.6 mm).

Table 5, Toe-In Target and Limits, Bee Line Equipment

Camber

Camber, Detroit and Meritor Axles		
Axle Model	**Left Camber: degrees**	**Right Camber: degrees**
All	–1/4 ± 7/16	–1/4 ± 7/16

Table 6, Camber, Detroit and Meritor Axles

Camber, Dana/Eaton Axles		
Axle Model	**Left Camber: degrees**	**Right Camber: degrees**
All E Series	+1/4 ± 7/16	0 ± 7/16

Table 7, Camber, Dana/Eaton Axles

Camber, Hendrickson Axles		
Axle Model	**Left Camber: degrees**	**Right Camber: degrees**
STEERTEK	0 ± 1	0 ± 1

Table 8, Camber, Hendrickson Axles

Specifications

Torque Values

Tie Rod Clamp Nut Torque Values				
Axle Manufacturer	Axle Model	Tie Rod Clamp Nut Size	Plain Nut Torque*: lbf·ft (N·m)	Locknut Torque*: lbf·ft (N·m)
Detroit	All	5/8–11	60–80 (81–108)	60–80 (81–108)
Meritor	All	5/8–11	50–60 (68–81)	50–60 (68–81)
Hendrickson	STEERTEK			
Dana/Eaton	All	5/8–18	—	40–60 (55–81)

* All torque values in this table apply to parts lightly coated with rust-preventive type oil.

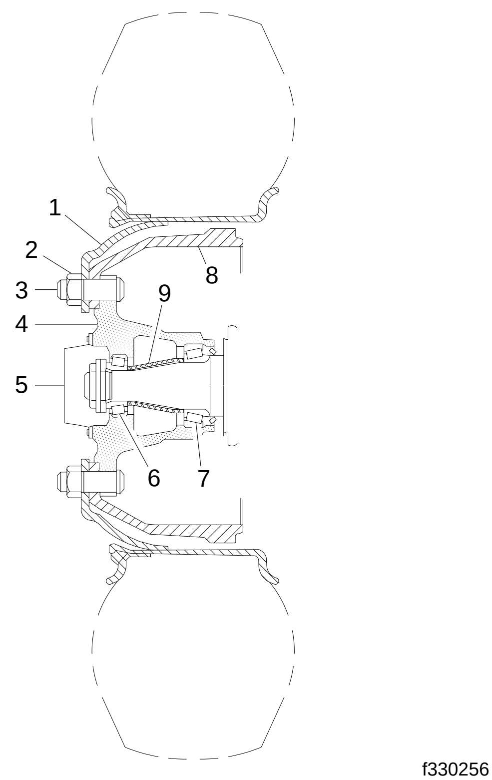
Table 9, Tie Rod Clamp Nut Torque Values

Miscellaneous Torque Values	
Description	Torque: lbf·ft (N·m)
U-Bolt Nuts 7/8–14	400 (542)
U-Bolt Nuts 7/8–16	460 (624)
U-Bolt Nuts 3/4–16	300 (406)
Meritor Stopscrew Locknut	50–65 (68–88)
Dana/Eaton Stopscrew Locknut	90–120 (122–163)

Table 10, Miscellaneous Torque Values

General Information

Wheel end assemblies include the wheel hub, wheel bearings, brake drum (or rotor), wheel studs, and spindle nut. See **Fig. 1**.



1. Disc Wheel
2. Wheel Nut
3. Wheel Stud
4. Hub
5. Hub Cap
6. Outer Wheel Bearing
7. Inner Wheel Bearing
8. Brake Drum
9. Bearing Spacer

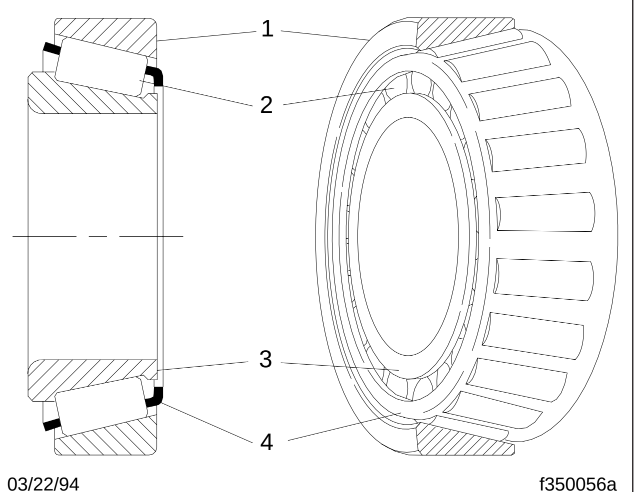
Fig. 1, Wheel End Assembly with Drum Brakes

Wheel Hub

ConMet PreSet hubs have a spacer between the inner and outer bearings that adjusts the bearings to the correct end-play and preload when the retaining nut is tightened. For more information about PreSet hubs, and removal and installation procedures, see **Subject 100**.

Tapered Wheel Bearings

Each hub has a set of inner and outer tapered wheel bearing assemblies. A typical tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. See **Fig. 2**. All components carry the load, with the exception of the cage, which spaces the rollers around the cone.



1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 2, Tapered Wheel Bearing Assembly

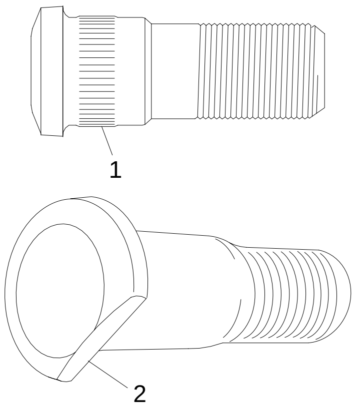
Brake Drum

The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

Wheel Studs

A headed wheel stud (**Fig. 3**) is used on front axle disc wheel hub assemblies and has either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub. For replacement procedures, see **Subject 180**.

General Information



1. Serrations
2. Clipped Head

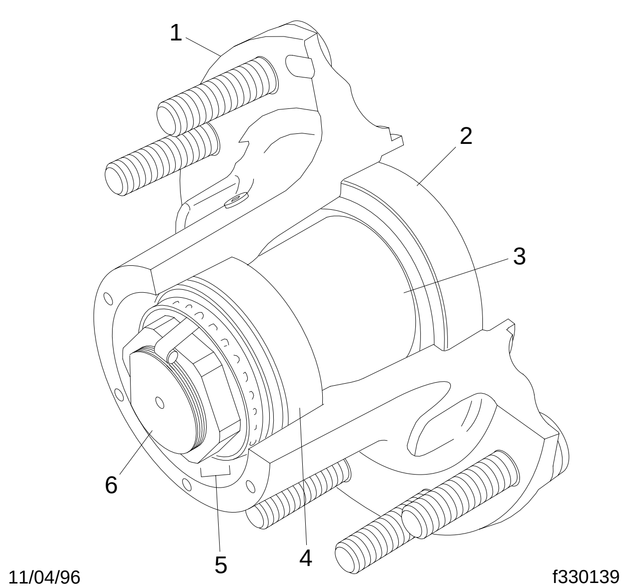
Fig. 3, Typical Wheel Studs

Meritor FF-981 Easy Steer Plus Axle

Vehicles may be equipped with the Meritor FF-981 Easy Steer Plus Axle. This axle has the hubs, bearings, and oil seals factory-installed on the axle spindles. The hubs can be removed and installed on the axle, and the studs can be replaced, but the wheel bearings and oil seal are not serviceable in the field. To install a new hub, mount it on the axle spindle, and secure it. For installation and adjustment instructions, see **Subject 140**.

General Information

ConMet PreSet® steer axle hubs are equipped with a special tubular spacer inside the hub, between the inner and outer bearings. See **Fig. 1**.



1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Retaining Nut
6. Axle Spindle

Fig. 1, ConMet PreSet Hub, Cut-Away View

When installing a PreSet hub with the spacer and special PreSet bearings, the correct end play is set automatically and wheel bearing adjustment is unnecessary.

For vehicles equipped with ConMet PreSet hubs, it is highly recommended to **stay with the PreSet system** to optimize bearing and seal life. However, if you are replacing the bearings for a PreSet hub, and the special PreSet bearings are not available, standard wheel bearings can be used. In this case, the bearing spacer must be removed and the bearings adjusted manually. See the installation instructions for more information.

NOTE: On some axles, the hub, wheel bearings, studs, and oil seal are installed as a unitized wheel-end assembly. These wheel ends must be replaced as a unit. For Meritor unitized wheel end installation and adjustment procedures, see **Subject 140**.

Removal

For a typical wheel and axle assembly, see **Fig. 2**.

1. Chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. For drum brakes, back off the slack adjuster to release the front axle brake shoes.

WARNING

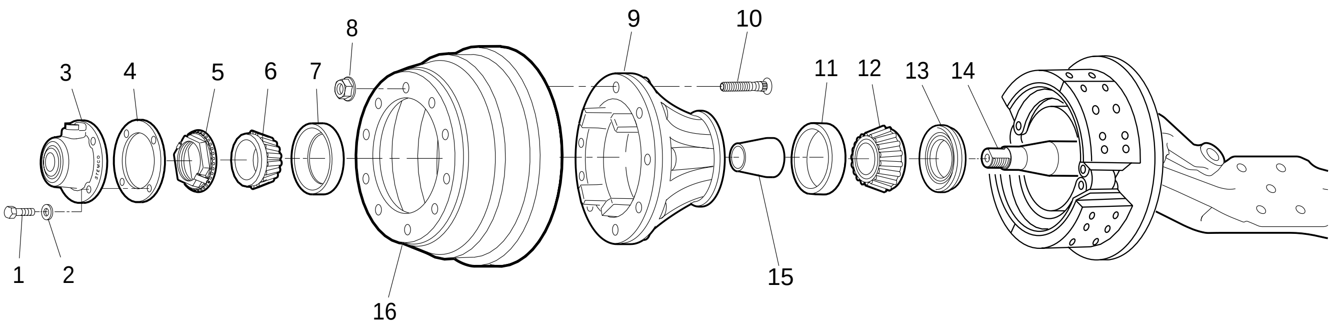
Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

4. Remove the wheel and tire assembly. See **Group 40** for instructions.
5. For drum brakes, remove the brake drum. For instructions, see **Subject 160**.

NOTE: Oil will spill as the hub cap and wheel hub are removed. Place a suitable container under the axle spindle to catch any spilled oil, and avoid contaminating the brake shoes with oil. Dispose of the oil properly.

6. Remove the capscrews, washers, and hub cap. Remove and discard the hub cap gasket.
7. Remove the wheel bearing locking device:
   - For an Axilok spindle nut, see **Subject 190**; then go to the next step.
   - For a Pro-Torq spindle nut, see **Subject 150**; then go to the next step.
   - If the axle is equipped with a four-piece bearing-lock system, see **Subject 130**; then go to the next step.

Hub Assembly Removal and Installation



NOTE: On some axles, the hub, wheel bearings, studs, and oil seal are installed as a unitized wheel-end assembly. These wheel ends must be replaced as a unit.

1. Hub Cap Capscrew
2. Washer
3. Hub Cap
4. Gasket
5. Axilok Nut
6. Outer Wheel Bearing
7. Outer Wheel Bearing Cup
8. Wheel Nut
9. Hub
10. Wheel Stud
11. Inner Wheel Bearing Cup
12. Inner Wheel Bearing
13. Oil Seal
14. Axle Spindle
15. Bearing Spacer
16. Brake Drum

Fig. 2, Typical Wheel End Assembly, Front Axle with Drum Brakes

NOTICE

Be careful not to let the outer wheel bearing drop from the axle spindle. Dropping the bearing can warp the cage or damage the rollers, ruining the bearing. On vehicles equipped with WABCO ABS, use care when working with the hubs. To prevent damage to the tone wheel, do not drop the hub, or lay it down in a way that would damage the tone wheel.

NOTE: If working with Meritor Easy Steer Plus® hubs, remove the wheel end (hub, bearings, and oil seal) as a unit.

8. Move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads). Then, carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

NOTICE

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

9. Remove the hub from the axle spindle. Be careful not to damage the axle spindle threads as the assembly is removed.
10. Remove the inner wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in clean, oil-proof paper or lint-free rags. If the inner wheel bearing remains in the hub after the hub is removed, place a protective cushion where it will catch the bearings, and use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.
11. Remove the oil seal from the axle spindle, if not already removed. See **Section 33.02** for additional information.

Installation

For a typical wheel and axle assembly, see **Fig. 2**.

Hub Assembly Removal and Installation

NOTE: For Meritor unitized wheel end installation and adjustment procedures, see **Subject 140**.

1. Using cleaning solvent, remove the old oil from the axle spindle (steering knuckle) and the disassembled parts. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.
2. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.

NOTICE

Make sure that both bearing assemblies are coated with fresh oil. Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.

3. Coat both bearing assemblies with fresh oil. Install the inner wheel bearings and oil seal. Handle the bearings with clean, dry hands. See **Section 33.02** for oil seal installation instructions.
4. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
5. If present, remove the temporary plastic bearing cover from the front of the hub.

NOTICE

Do not use the bearing spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.

6. If using PreSet bearings, ensure the tubular spacer is in the PreSet hub.

   If replacing PreSet bearings with non-PreSet bearings, remove the tubular spacer from inside the hub. Save it for future use to convert the hub back to the PreSet system.

NOTE: For Meritor unitized wheel end installation and adjustment procedures, see **Subject 140**.

NOTICE

- **On vehicles equipped with WABCO ABS, use care when installing the hubs. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.**
- **Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.**

7. Mount the hub assembly on the axle spindle.
8. Remove the friction tape, then adjust (if needed) and secure the bearings:
   - For an Axilok spindle nut, see **Subject 190**; then go to the next step.
   - For a Pro-Torq spindle nut, see **Subject 150**; then go to the next step.
   - If the axle is equipped with a four-piece bearing-lock system, see **Subject 130**; then go to the next step.
9. Place the hub cap and a new gasket in position, then install the washers and capscrews. In a star pattern, tighten the capscrews 15 lbf·ft (20 N·m).
10. If applicable, add fresh oil to the wheel hub to the level indicated on the hub cap. For recommended axle lubricants, see **Specifications, 400**.

WARNING

Failure to add oil to the wheel hub after the hub has been serviced will cause the wheel bearings to overheat and seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury and property damage.

11. Rotate the hub to distribute the oil, then check the level at the hub cap. Add lubricant as needed.
12. For drum brakes, install the brake drum on the wheel hub. For instructions, see **Subject 160**.

Hub Assembly Removal and Installation

WARNING

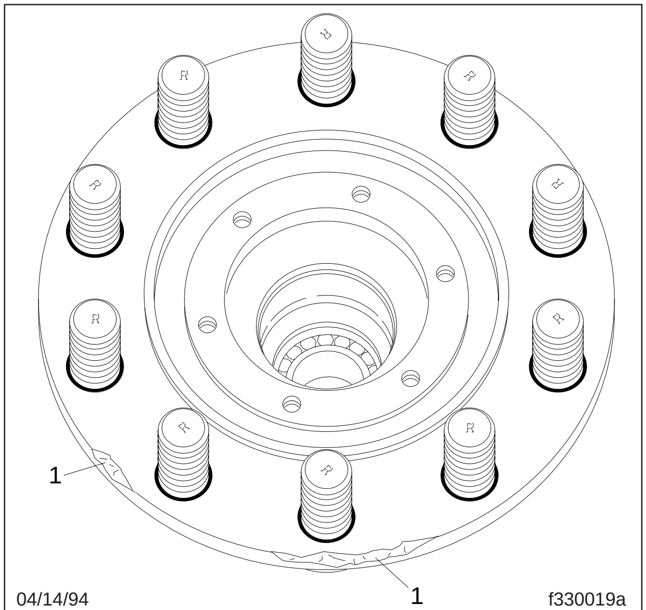
If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the wheel hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

13. Install the wheel and tire assembly. See **Group 40** for instructions.
14. Adjust the front axle brakes. For instructions, see **Group 42**.
15. Remove the safety stands from under the axle and lower the vehicle.

Wheel Hub Assembly Inspection

1. Inspect the wheel hub mounting flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. See **Fig. 1**. Replace the wheel hub if any of these conditions exist.

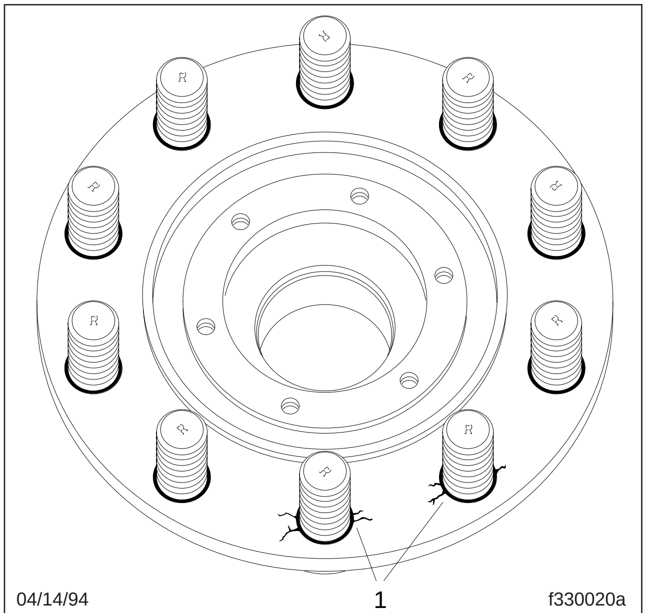
   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. See **Fig. 2**. If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.



1. Wear Spots

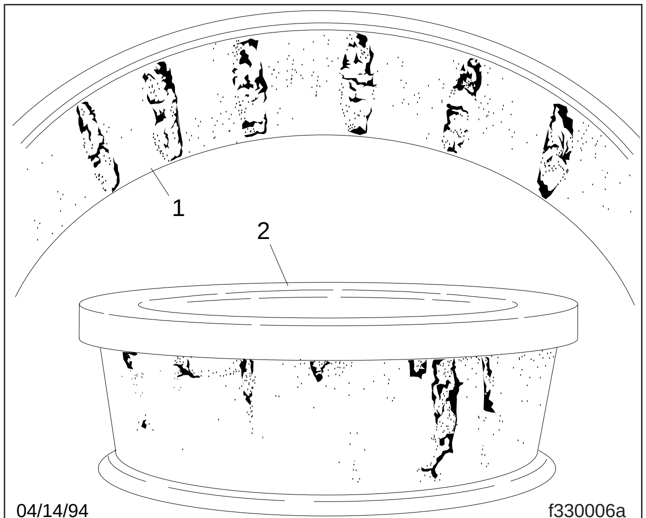
Fig. 1, Damaged Front Axle Wheel Hub

2. Remove all the old oil from the wheel hub cavity. Inspect the inner surface of the hub for cracks, dents, wear, or other damage. Replace the wheel hub if damage exists.
3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the wheel bearing cups for cracks, wear, spalling, or flaking. See **Fig. 3**. Replace the cups if damaged in any way. For instructions, see **Subject 120**.
4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.



1. Cracked Stud Grooves

Fig. 2, Damaged Front Axle Wheel Hub



1. Cup
2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

Axle Components Cleaning and Inspection

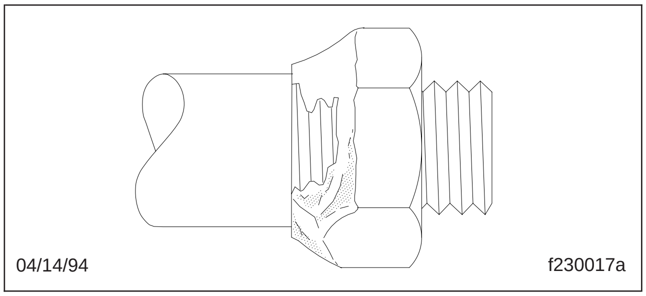


Fig. 4, Damaged Wheel Stud Nut

5. Inspect the wheel or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. For instructions, see **Subject 180**.

Wheel Bearing Inspection

Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush. Before inspecting, clean the bearings.

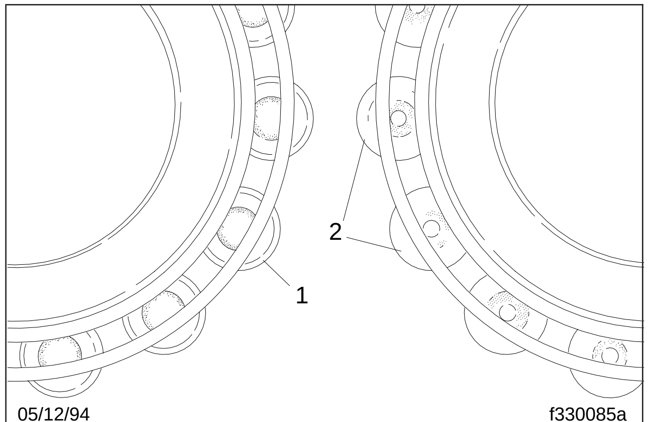
1. Remove the wheel hub and bearing cones. For instructions, see **Subject 100**.
2. Clean all old oil from the bearings and hub cavity with kerosene or diesel fuel and a stiff brush. Don't use gasoline or heated solvent.
3. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface which is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

CAUTION

Do not spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.

4. After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

   4.1 Large ends of rollers worn flush to the recess, or radii at the large ends of the rollers worn sharp. These are indications of advanced wear. See **Fig. 5**.



1. New Bearing
2. Worn Bearing Rollers

Fig. 5, Wheel Bearing Roller Wear

   4.2 Visible step wear, particularly at the small end of the roller track. Deep indentations, cracks, or breaks in the cone surfaces. See **Fig. 6**.

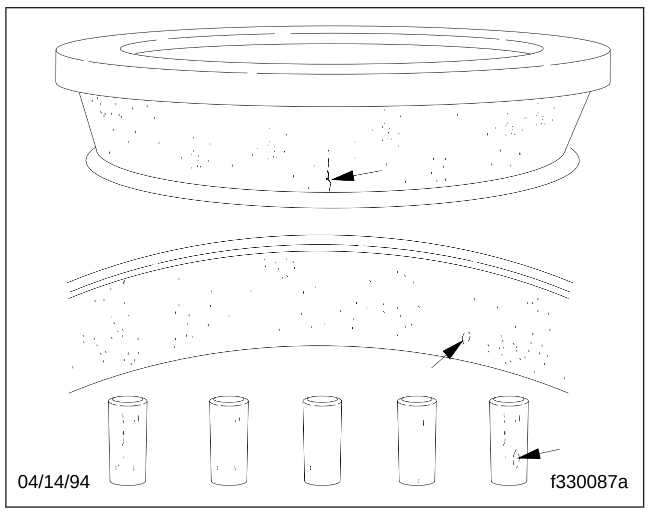


Fig. 6, Indentations, Cracks, or Breaks in Bearing Surfaces

   4.3 Bright rubbing marks on the dark phosphate surfaces of the bearing cage. See **Fig. 7**.

   4.4 Water etch on any bearing surface. Water etch appears as gray or black stains on

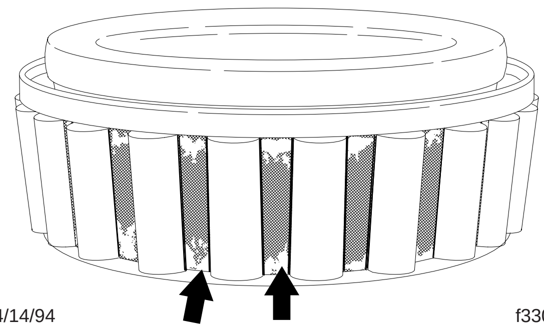


Fig. 7, Rubbing Marks on Bearing Cage

the steel surface, and it greatly weakens the affected area. If water etch is present, replace the bearing seals.

4.5 Etching or pitting on functioning surfaces. See Fig. 8.

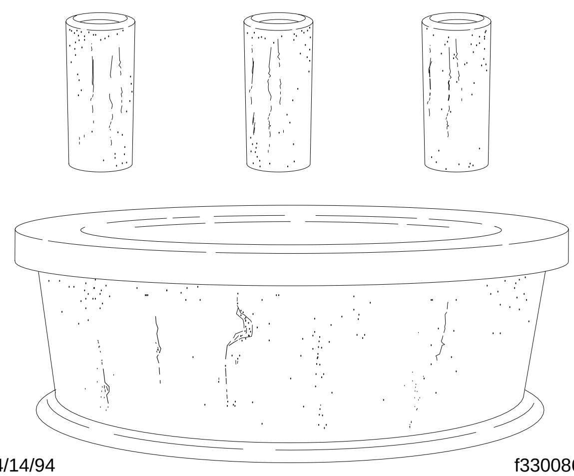


Fig. 8, Etching (Pitting) on Bearing Surfaces

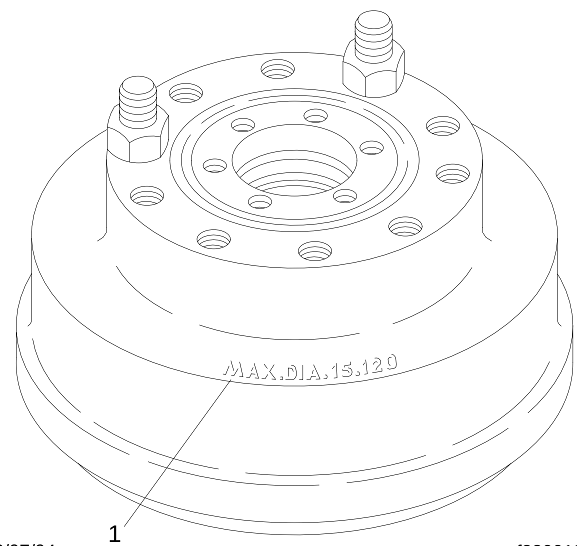
4.6 Spalling (flaking) of the bearing cup, roller, or cone surfaces. See Fig. 3.

After inspection, brush the bearings with fresh axle lubricant.

Brake Drum Inspection

New brake drums are purposely undersized to allow for turning (remachining), since in mounting drums on the hub, there can be some eccentricity. If a new drum is installed, the protective coating on the inner friction surface must be removed with a solvent, prior to drum installation, then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside surface of the drum. See Fig. 9 for a typical location of this stamp.



1. Maximum Diameter Stamp

Fig. 9, Outboard Mounted Hub and Drum Assembly

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be followed with a hot water wash.

CAUTION

Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will cause drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimate drum breakage.

If the drums are turned or replaced, replace the brake linings. See Group 42 in this manual for instructions.

Axle Components Cleaning and Inspection

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80–grit emery cloth or by turning the drums.
2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not impair performance and lining life if the network of fine hairline cracks remains small. Examine heat checks of drums frequently to be certain the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum). Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

NOTE: If normal heat checking as described above is present, inspect the drums at least every 12,000 miles (19 300 km) thereafter. Inspect the drums (using a flashlight from the inboard side of the wheels) every 6000 miles (9700 km). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove the contaminants. Locate and correct the source of the contamination. If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil or grease saturated linings cannot be salvaged, they must be replaced. For brake lining replacement procedures, see **Group 42** in this manual.

WARNING

If the brake drums are contaminated with fluids, replace the brake linings. Failure to replace fluid contaminated brake linings could result in a partial loss of braking capacity, which could lead to personal injury or property damage.

4. Measure the inside diameter of the drum. If the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
5. Check for a variation in gauge readings at different points on the radius of the drum's working surface. If the variation is more than 0.010 inch (0.25 mm) at any point, the drum is out-of-round to unacceptable limits. Remachine or replace the same-axle drums.
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised dark-colored spots on the inner friction surface or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs.

Wheel Bearing Cup Removal and Installation, Ferrous Hubs

Removal

Wheel bearing cups on ferrous hubs are removed and installed by driving them out and pressing them in without heating the hub.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild-steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

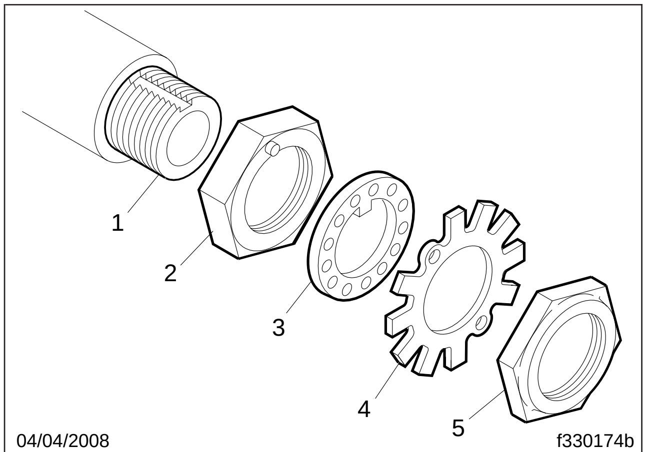
Installation

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the replacement bearing cup hub contact surface with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable driving tool. Cups must seat against the shoulder in the hub.
5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Four-Piece Wheel Bearing Lock System Removal, Installation, and Adjustment

General Information

ConMet PreSet hubs may use a four-piece wheel bearing lock system. See **Fig. 1**.



1. Axle Spindle
2. Adjusting Nut
3. Lockring
4. Bend-Type Locking Washer
5. Jam Nut

Fig. 1, Typical Four-Piece Wheel Bearing Lock Set

NOTE: For Meritor unitized wheel end installation and adjustment procedures, see **Subject 140**.

Removal

Once a four-piece wheel bearing lock set is removed, discard the bend-type locking washer, if installed. Inspect the adjusting nut, lockring, and jam nut for visible damage prior to reuse.

Installation

Instructions for installing a four-piece wheel bearing lock set for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

Using PreSet Bearings

1. Install the adjusting nut onto the axle spindle, and tighten it 300 lbf·ft (407 N·m). See **Fig. 1**.

NOTE: The gaps between holes in the lockring are spaced unevenly, so to fit the tab on the adjusting nut into one of the holes with minimal turning of the adjusting nut, gauge the distance on one side of the lockring, then the other, and choose the side that requires the adjusting nut to be advanced the least. Do not back off the nut.

2. Install the lockring (as described in the note above) and bend-type locking washer.
3. Install the jam nut, and tighten it 200 lbf·ft (271 N·m).
4. Bend the tabs on the locking washer at 6 o'clock and 12 o'clock to lock the jam nut in place. See **Fig. 2**.

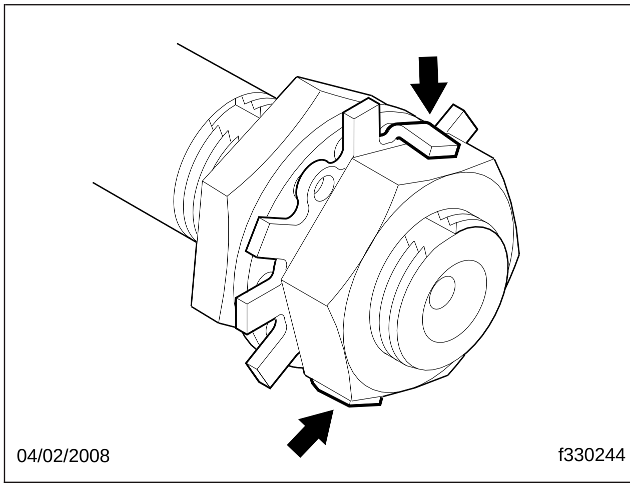


Fig. 2, Tabs Bent to Lock the Jam Nut

5. Rotate the hub in both directions. It should turn freely with no dragging or binding.

Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

1. Install the adjusting nut, as follows. See **Fig. 1**.
   1.1 Install the adjusting nut on the spindle, and tighten it finger-tight.
   1.2 While rotating the wheel hub assembly, tighten the adjusting nut 200 lbf·ft (271 N·m).

Four-Piece Wheel Bearing Lock System Removal, Installation, and Adjustment

1.3 Back off the adjusting nut one full turn.

1.4 Tighten the adjusting nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.

1.5 Back off the adjusting nut one-quarter turn.

NOTE: The gaps between holes in the lockring are spaced unevenly, so to fit the tab on the adjusting nut into one of the holes with minimal turning of the adjusting nut, gauge the distance on one side of the lockring, then the other, and choose the side that requires the adjusting nut to be advanced the least. Do not back off the nut.

2. Install the lockring (as described in the note above) and bend-type locking washer.
3. Install the jam nut, and tighten it 200 to 300 lbf·ft (270 to 405 N·m).
4. Using a dial indicator, measure the end play as follows.

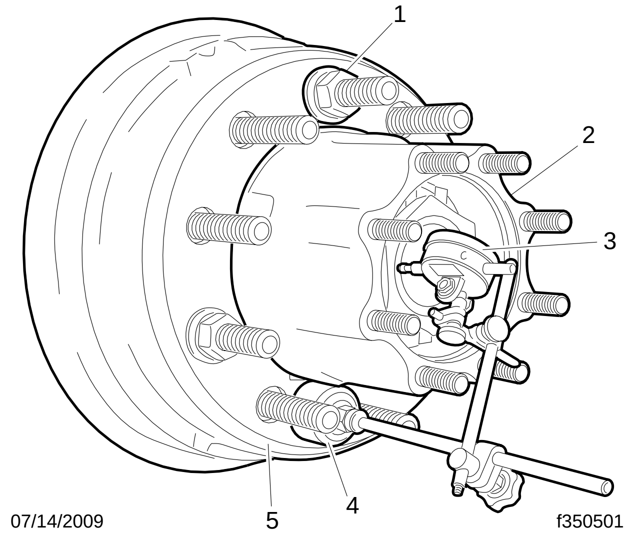
IMPORTANT: Do not measure the wheel bearing end play with the wheel mounted on the hub; you cannot accurately measure or adjust bearing end play with the wheel mounted on the hub. Also, ensure that the brakes are not applied so that that drum and hub can move freely.

4.1 On vehicles equipped with aluminum hubs, install an iron brake drum onto the hub to provide a ferrous surface for the magnetic base of the dial indicator. With flange nuts, secure the drum to the hub using the stud at the 12 o'clock position, followed by the studs at about the 4 o'clock and 8 o'clock positions. Ensure the nuts hold the drum securely; use washers if needed.

4.2 Clean the spindle end; ensure it is free of debris and provides the smooth surface needed for the dial indicator to take an accurate measurement.

4.3 Attach the magnetic base of a dial indicator to the drum (or, on vehicles equipped with iron hubs, the hub). See **Fig. 3**.

4.4 Set the measuring end of the indicator against the spindle end as shown in **Fig. 4**. The indicator should be square with the end of the spindle.



NOTE: Assembly for rear axle shown.

1. Flange Nut
2. Aluminum Hub
3. Dial Indicator
4. Magnetic Base
5. Iron Brake Drum

Fig. 3, Dial Indicator Setup, Aluminum Hub with Iron Brake Drum

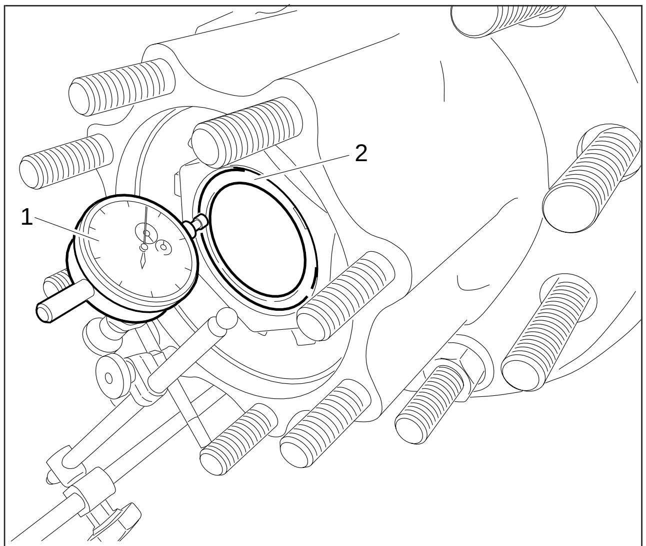
IMPORTANT: Maintain continual pressure on the hub until you have taken both the inboard and outboard measurements. If you release the hub, an accurate measurement is not possible.

4.5 To seat the bearings, grip the hub at the three o'clock and nine o'clock positions, and push inward while oscillating it approximately 45 degrees. Maintain pressure on the hub and note the measurement.

NOTE: The end play measurements must be taken at the same point to prevent an uneven spindle end from skewing the results. As needed, mark the spot on the spindle where the inboard measurement was taken.

4.6 Pull the hub and drum outward while oscillating it as before. Maintain pressure on the hub, and note the outboard extent of the end play. See **Fig. 5**.

Four-Piece Wheel Bearing Lock System Removal, Installation, and Adjustment

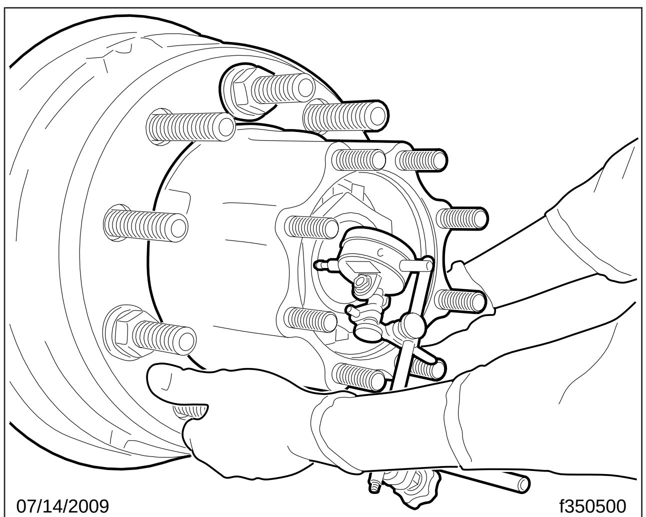


The indicator should be square with the end of the spindle.

NOTE: Assembly for rear axle shown.

1. Dial Indicator 2. Spindle End

Fig. 4, Indicator Square with the Spindle



NOTE: Assembly for rear axle shown.

Fig. 5, Pulling the Hub Outward to Measure End Play

4.7 Find the end play by noting the difference between the two readings.

⚠ WARNING

The wheel-bearing end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). Correct end play is crucial: if the wheel-bearing end play is not correct, the wheel bearings could fail. This could cause the loss of the wheel and hub assembly, resulting in an accident causing serious injury or property damage. Use a dial indicator to measure the end play.

5. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm).** If the end play is not within this range, adjust the end play as follows.

   5.1 Remove the jam nut and locking device, and back off or tighten the inner adjusting nut.

   5.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the adjusting nut again.

   5.3 Measure the end play.

   If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), repeat the adjustment procedure until the correct end play is achieved.

   IMPORTANT: The correct end play **must** be achieved before completing the hub assembly installation procedure.

6. Once the end play is between 0.001 and 0.005 inch (0.03 and 0.13 mm), bend two tabs on the locking washer at 6 o'clock and 12 o'clock to lock the jam nut in place. See **Fig. 2**.

7. Rotate the hub in both directions. It should turn freely with no dragging or binding.

Meritor Unitized Wheel-End Installation and Adjustment

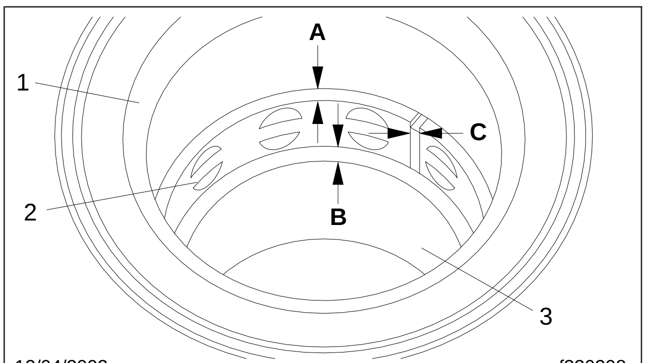
IMPORTANT: The following information is based on a Meritor technical bulletin for unitized wheel ends, and has been formatted for this Freightliner workshop manual. Contact Meritor if you wish to refer to the original technical bulletin.

Installation

WARNING

Do not service the bearings on Meritor unitized wheel ends. Disassembling the wheel end (hub) and bearings could contaminate the bearing lubricant, possibly damaging the bearings. This could result in the eventual loss of the wheel end (hub), which could cause an accident resulting in serious personal injury and property damage.

1. If not already done, clean the axle spindle and inner surfaces of the wheel bearings with a clean, lint-free cloth.
2. If installing a new wheel end (hub), inspect it as follows:
   - The inner clip ring is present and is aligned correctly between the inner and outer bearings. See **Fig. 1**.



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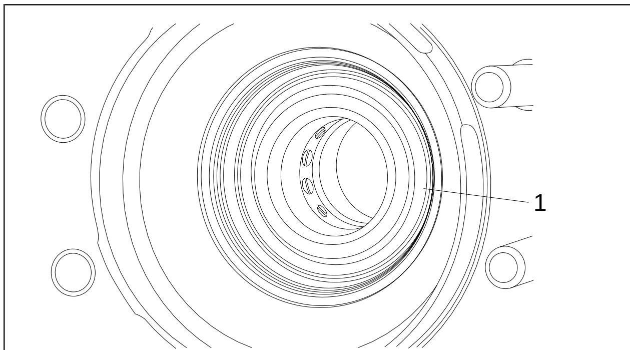
A. This gap must be equal to the "B" gap.
B. This gap must be equal to the "A" gap.
C. This gap must not exceed 1/4-inch (6 mm).

1. Inner Bearing
2. Clip Ring
3. Outer Bearing

Fig. 1, Checking the Inner Clip Ring

   - The gaps between the inner and outer bearings and the clip ring are equal. See **Fig. 1**. If necessary, adjust by hand.
   - The bearing face is clean, with no seal coating, dirt, or rust
   - The inboard or outboard seals are undamaged and the bearings are seated correctly. See **Fig. 2** and **Fig. 3**.
   - The tone wheel teeth are all present and undamaged. See **Fig. 3**.



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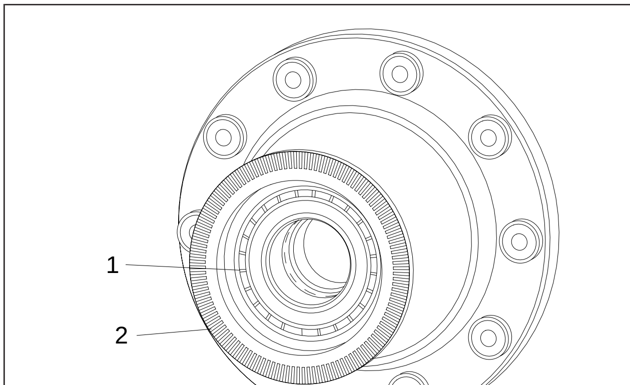
1. Outer Oil Seal

Fig. 2, Outboard Side of Wheel End (hub)



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1. Inner Oil Seal
2. Tone Ring

Fig. 3, Inboard Side of Wheel End (hub)

WARNING

Do not apply anti-seize compound to the axle spindle threads. This could result in the axle nuts losing their clamping ability, which could cause the loss of the hub and wheel assembly, which could cause an accident resulting in serious personal injury and property damage.

Meritor Unitized Wheel-End Installation and Adjustment

3. Apply anti-seize compound to the new O-ring, spindle, and inner surfaces of the wheel bearings.

   Use Meritor compound part number 2297-C-8297 or Dow Corning Molykote® D.

   If any of the compound gets on the axle spindle threads, wipe it off.
4. Install the O-ring onto the axle spindle.
5. Install the wheel end (hub) straight onto the axle spindle, being careful not to damage the spindle threads.
6. With the wheel end (hub) mounted on the axle spindle, install the inner D-ring, then the inner locknut. Tighten 600 lbf·ft (813 N·m) while rotating the wheel end (hub) at least five times.

NOTE: The inner and outer locknuts are identical, but their torque values are different.

7. Install the tabbed washer.
8. Bend one of the tabs over the flat of the inner locknut.
9. Install the outer locknut and tighten it 250 lbf·ft (339 N·m).
10. Bend an opposing tab of the tabbed washer over a flat of the outer locknut.
11. Install the brake drum. If necessary, adjust the slack adjuster. For instructions, see **Group 42** of this workshop manual.
12. Install the wheel and tire assembly. Hand tighten the wheel nuts.
13. Raise the vehicle, remove the jackstands, then lower the vehicle.
14. Tighten the wheel nuts 500 lbf·ft (678 N·m).

NOTE: Plastic and metal hub caps are interchangeable; however, the installation procedure is different for each type.

15. If installing a metal hub cap, go to the next step.

    If installing a plastic hub cap, do the following:

    15.1 Using a wire brush, remove any grease or mud from the inner threads of the hub. Wipe the threads with a clean shop cloth.

    15.2 Apply a continuous 1/8-inch (3 mm) bead of RTV silicone sealant to the outside first thread of the hub cap. Apply the sealant around the entire circumference.

    IMPORTANT: Use only the following RTV sealants on the hub cap:

    - Meritor part number 2297-Z-7098
    - Three Bond®
    - Loctite® Ultra Grey Adhesive Sealant 18581

    15.3 Install the hub cap by hand until it is seated.

    IMPORTANT: Disregard the torque value embossed on the hub cap.

    15.4 Using a torque wrench, tighten the hub cap 75 lbf·ft (102 N·m).

    If you cannot tighten the hub cap to the correct torque value, or if it makes a popping sound while being tightened, replace it with a new one.
16. If installing a metal hub cap, do the following:

    16.1 Using a wire brush, clean the inner threads of the hub and the hub cap threads. Wipe the inner threads of the hub with a clean shop cloth.

    16.2 Apply Loctite® 17430 (Meritor part number 2297-D-7076) gasket sealant to the hub cap threads.

    16.3 Install the hub cap by hand until it is seated.

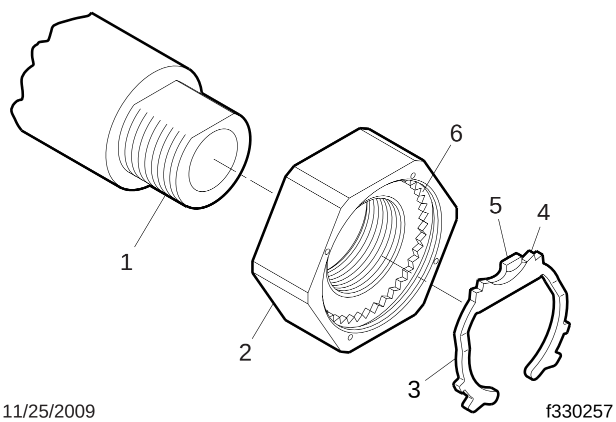
    16.4 Using a torque wrench, tighten the hub cap 350 lbf·ft (475 N·m).

    IMPORTANT: If you cannot tighten the hub cap to the correct torque value, or if it makes a popping sound while being tightened, replace it with a new one.
17. Remove the chocks from the tires.

Pro-Torq Spindle Nut Removal, Installation, and Adjustment

General Information

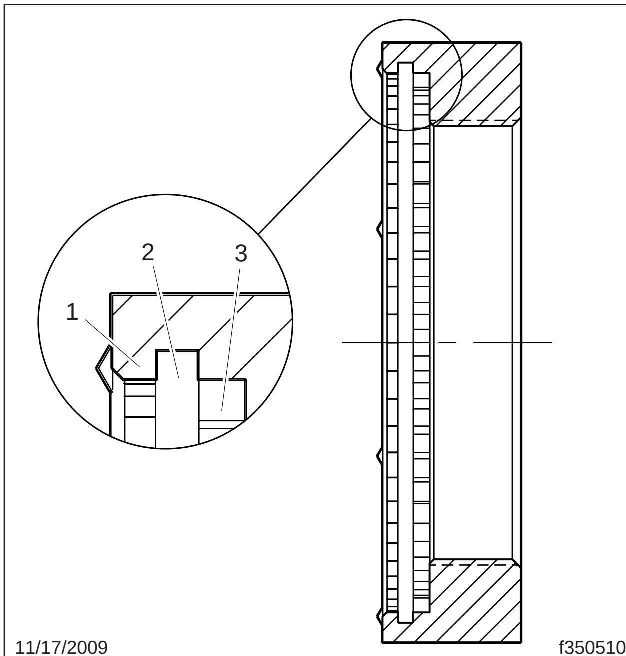
Pro-Torq® spindle nuts may be used on ConMet Pre-Set hubs. See **Fig. 1** and **Fig. 2**.



1. Axle Spindle
2. Pro-Torq Nut
3. Keeper Arm
4. Mating Teeth, Keeper
5. Keeper Tab
6. Mating Teeth, Nut

Fig. 1, Pro-Torq Spindle Nut and Keeper

Each time the Pro-Torq nut assembly is removed for maintenance purposes, replacing the "keeper" is recommended.



1. Lip
2. Undercut Groove
3. Mating Teeth

Fig. 2, Pro-Torq Spindle Nut, Cross Section

Removal

WARNING

Do not place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may damage the spindle threads and deform the keeper, and allow the nut to unthread during operation. Failure to follow this instruction could cause the hub to separate from the axle, resulting in severe personal injury or death.

1. Insert the blade of a flathead screwdriver (or similar tool) in the slot of one of the keeper arms; see **Fig. 3**. Ensuring that the tool contacts the keeper and not the teeth of the nut, turn the tool slightly and carefully pry the arm from the undercut groove of the nut.

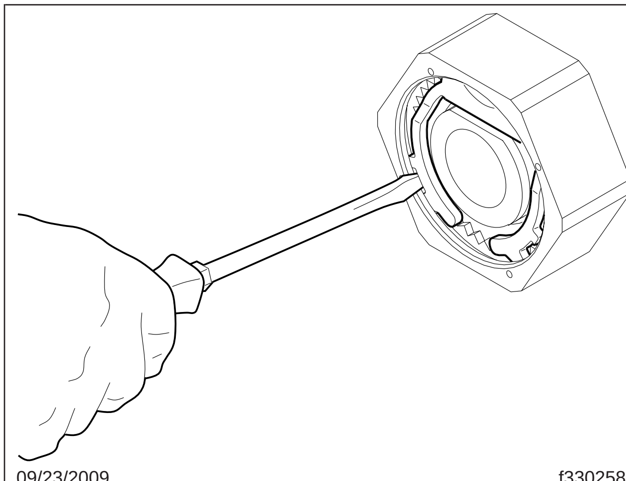


Fig. 3, Removing the Keeper

2. Repeat at the other arm, and remove the keeper from the nut.
3. Remove the Pro-Torq nut.

Pro-Torq Spindle Nut Removal, Installation, and Adjustment

Installation

The following procedure applies to Pro-Torq steer axle nut 448-4836. The part number is stamped on the nut.

WARNING

Do not place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may damage the spindle threads and deform the keeper, and allow the nut to unthread during operation. Failure to follow this instruction could cause the hub to separate from the axle, resulting in severe personal injury or death.

Instructions for installing a Pro-Torq spindle nut for both PreSet and non-PreSet type bearings are provided in this subject. See the instructions pertaining to the bearing type used with the hub you are securing.

Using PreSet Bearings

1. Ensure the keeper is removed from the nut.
2. Install the Pro-Torq spindle nut, and tighten it 250 lbf·ft (339 N·m). **Do not back it off**.
3. Install the keeper.

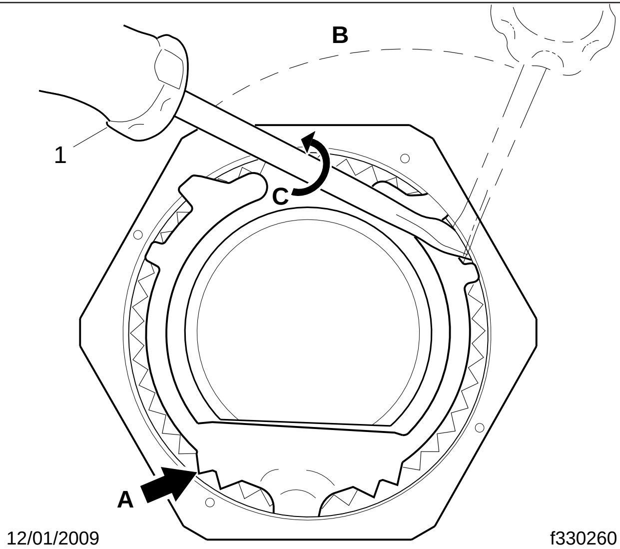
   3.1 With the correct side of the keeper facing out, insert the keeper tab in the undercut groove of the Pro-Torq nut, and engage the mating teeth.

   IMPORTANT: If the keeper cannot be engaged, advance the nut until it can be. Do not back off the nut.

   3.2 Use a flathead screwdriver to carefully compress and guide each arm past the lip and into the undercut groove of the nut as shown in **Fig. 4**. To secure the keeper it may be necessary to nudge the arms into the groove.

WARNING

Failure to secure the keeper and lock the Pro-Torq nut could cause the wheel assembly to come off the vehicle, resulting in severe personal injury or death.



A. Engage the mating teeth.
B. Compress the arm.
C. Turn the screwdriver to seat the keeper in the groove.

1. Flathead Screwdriver

Fig. 4, Installing the Keeper

4. Inspect the installation; ensure the keeper is locked in the undercut groove of the nut.

Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

1. Ensure the keeper is removed from the nut.
2. Seat the bearings.

   2.1 Using a torque wrench, tighten the nut 200 lbf·ft (270 N·m). Spin the hub at least one full rotation.

   NOTE: Torque is lost when the hub is spun.

   2.2 Tighten the nut 200 lbf·ft (270 N·m). Spin the hub at least one full rotation.

   2.3 Tighten the nut 200 lbf·ft (270 N·m), but *do not spin the hub*.

3. Loosen the nut to zero torque. *Do not spin the hub*.

Pro-Torq Spindle Nut Removal, Installation, and Adjustment

4. Adjust the bearing.
   4.1 Using a torque wrench, tighten the nut 100 lbf·ft (136 N·m). Spin the hub at least one full rotation.

   NOTE: Torque is lost when the hub is spun.

   4.2 Tighten the nut 100 lbf·ft (136 N·m). Spin the hub at least one full rotation.

   4.3 Tighten the nut 100 lbf·ft (136 N·m).

   4.4 Back off the nut one-quarter turn.

IMPORTANT: If the keeper cannot be engaged, advance the nut until it can be. Do not back off the nut.

5. Install the keeper.
   5.1 With the correct side of the keeper facing out, insert the keeper tab in the undercut groove of the Pro-Torq nut, and engage the mating teeth.

   5.2 Use a flathead screwdriver to carefully compress and guide each arm past the lip and into the undercut groove of the nut as shown in **Fig. 4**. To secure the keeper it may be necessary to nudge the arms into the groove.

WARNING

Failure to secure the keeper and lock the Pro-Torq nut could cause the wheel assembly to come off the vehicle, resulting in severe personal injury or death.

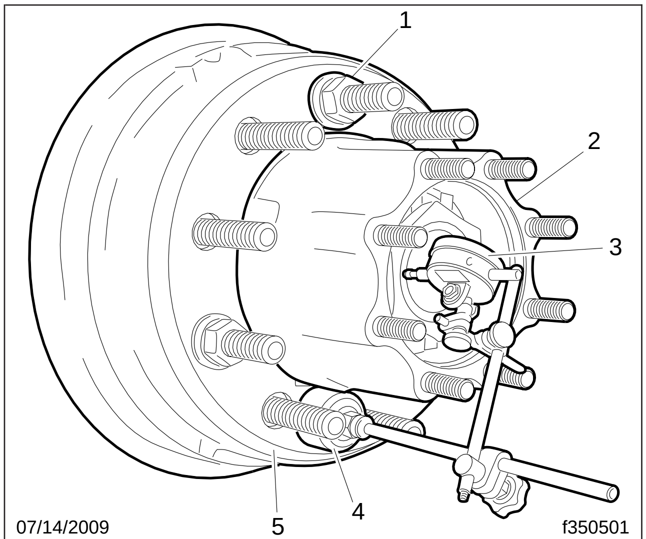
6. Inspect the installation; ensure the keeper is locked in the undercut groove of the nut.
7. Using a dial indicator, measure the end play as follows.

   IMPORTANT: Do not measure the wheel bearing end play with the wheel mounted on the hub; you cannot accurately measure or adjust bearing end play with the wheel mounted on the hub. Also, ensure that the brakes are not applied so that that drum and hub can move freely.

   7.1 On vehicles equipped with aluminum hubs, install an iron brake drum onto the hub to provide a ferrous surface for the magnetic base of the dial indicator. With flange nuts, secure the drum to the hub using the stud at the 12 o'clock position, followed by the studs at about the 4 o'clock and 8 o'clock positions. Ensure the nuts hold the drum securely; use washers if needed.

   7.2 Clean the spindle end; ensure it is free of debris and provides the smooth surface needed for the dial indicator to take an accurate measurement.

   7.3 Attach the magnetic base of a dial indicator to the drum (or, on vehicles equipped with iron hubs, the hub). See **Fig. 5**.



NOTE: Assembly for rear axle shown.

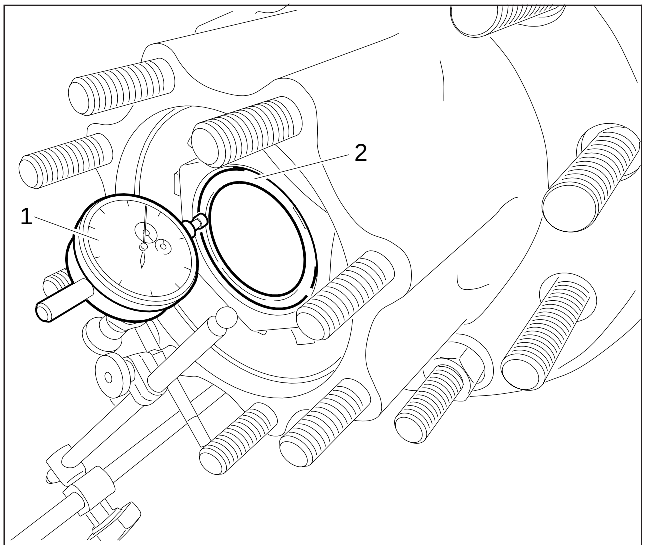
1. Flange Nut
2. Aluminum Hub
3. Dial Indicator
4. Magnetic Base
5. Iron Brake Drum

Fig. 5, Dial Indicator Setup, Aluminum Hub with Iron Brake Drum

   7.4 Set the measuring end of the indicator against the spindle end as shown in **Fig. 6**. The indicator should be square with the end of the spindle.

IMPORTANT: Maintain continual pressure on the hub until you have taken both the inboard and outboard measurements. If you release the hub, an accurate measurement is not possible.

Pro-Torq Spindle Nut Removal, Installation, and Adjustment



The indicator should be square with the end of the spindle.

NOTE: Assembly for rear axle shown.

1. Dial Indicator
2. Spindle End

Fig. 6, Indicator Square with the Spindle

7.5 To seat the bearings, grip the hub at the three o'clock and nine o'clock positions, and push inward while oscillating it approximately 45 degrees. Maintain pressure on the hub and note the measurement.

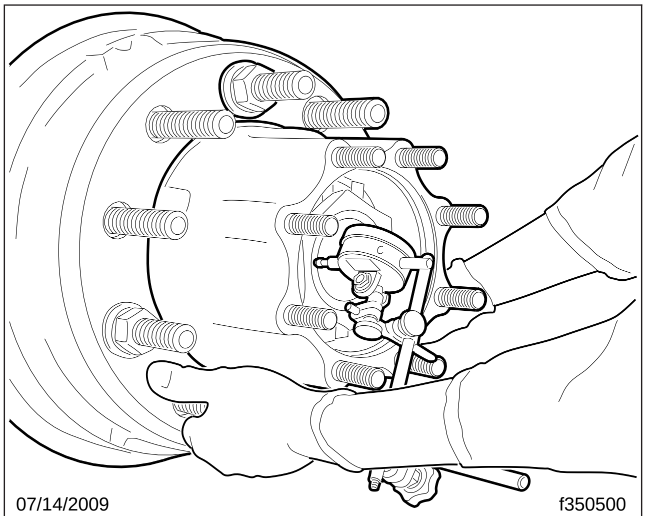
NOTE: The end play measurements must be taken at the same point to prevent an uneven spindle end from skewing the results. As needed, mark the spot on the spindle where the inboard measurement was taken.

7.6 Pull the hub and drum outward while oscillating it as before. Maintain pressure on the hub, and note the outboard extent of the end play. See **Fig. 7**.

7.7 Find the end play by noting the difference between the two readings.

WARNING

The wheel-bearing end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). Correct end play is crucial: if the wheel-bearing end play is not correct, bearing life will diminish and the wheel bearings could fail. This could cause the loss of the wheel and hub assembly, resulting in an accident causing serious injury or property damage. Use a dial indicator to measure the end play.



NOTE: Assembly for rear axle shown.

Fig. 7, Pulling the Hub Outward to Measure End Play

8. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Pro-Torq nut, and repeat the tightening sequence as described in previous steps. Once the end play is correct, remove the iron brake drum if installed, and continue your service procedure.

Outboard-Mounted Drum Removal and Installation

WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

For an exploded view of a typical wheel and axle assembly, including the brake drum, see **Fig. 1**.

Removal

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the front axle brake shoes.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

4. Remove the wheel and tire assembly. See **Group 40** for instructions.

   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
5. Remove the brake drum.
6. Inspect the drum. See **Subject 110** for instructions.

Installation

1. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.
2. Install the brake drum on the wheel hub.

   2.1 On hub-piloted drums, position the brake drum on the top step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock (top center) position. See **Fig. 2**.

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

   2.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

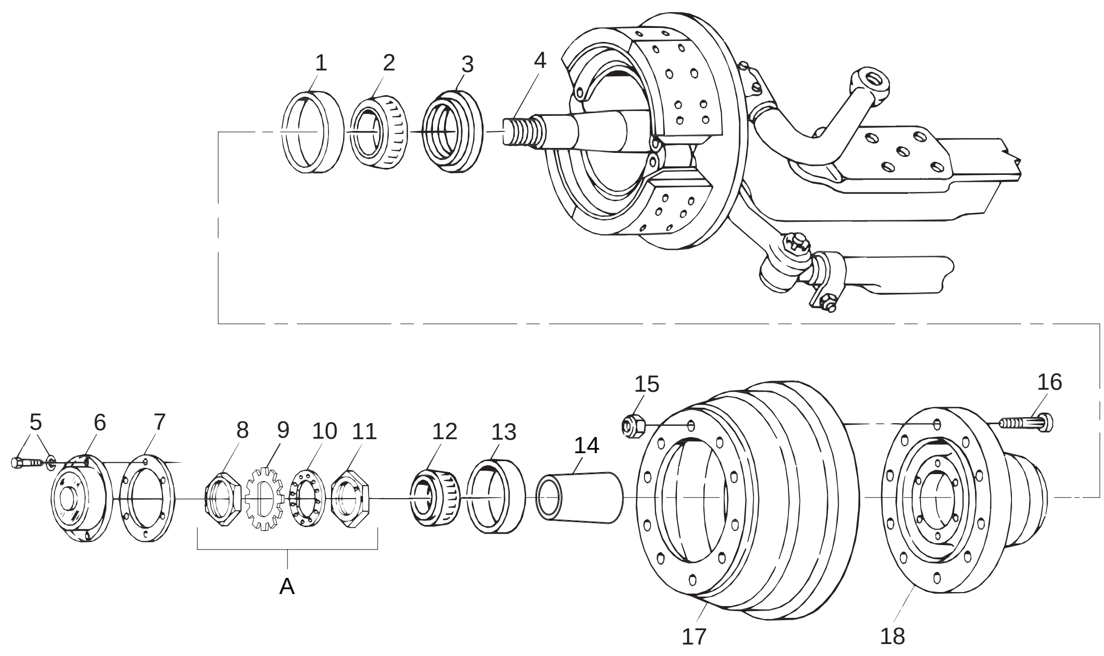
   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary to hold the drum in position, adjust the brakes before installing the wheels.
3. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the proper nut tightening sequence. For instructions, see **Group 40** in this manual.

WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury and property damage.

Outboard-Mounted Drum Removal and Installation

4. Adjust the front axle brakes. Refer to the brake section in the vehicle maintenance manual.
5. Remove the safety stands from under the axle; lower the vehicle.
6. Remove the chocks from the rear tires.

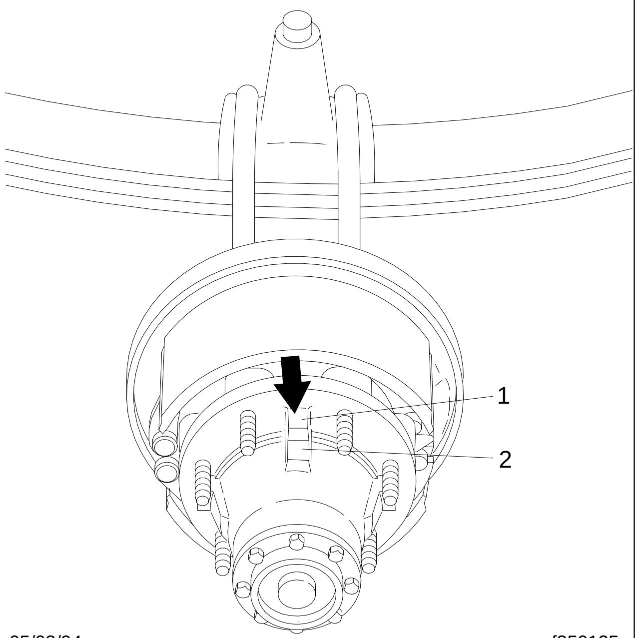


NOTE: On Meritor FF-981 Easy Steer Plus axles, the hub, wheel bearings, studs, and oil seal are assembled at Meritor and installed as an assembly.

A. Four-piece bearing system shown, Pro-Torq or Axi-Lok locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Hub Cap Capscrew
6. Hub Cap
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Outer Bearing Cup
14. Bearing Spacer (used only with Con-Met integral wheel bearing packs)
15. Wheel Nut
16. Wheel Stud
17. Brake Drum
18. Hub

Fig. 1, Typical Wheel and Axle Assembly



NOTE: Pilot pad at 12 o’clock position

1. Drum Pilot
2. Wheel Pilot

Fig. 2, Hub Pilot Pads

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

Removal (See Fig. 1)

To insure a tight fit, wheel bearing cups are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

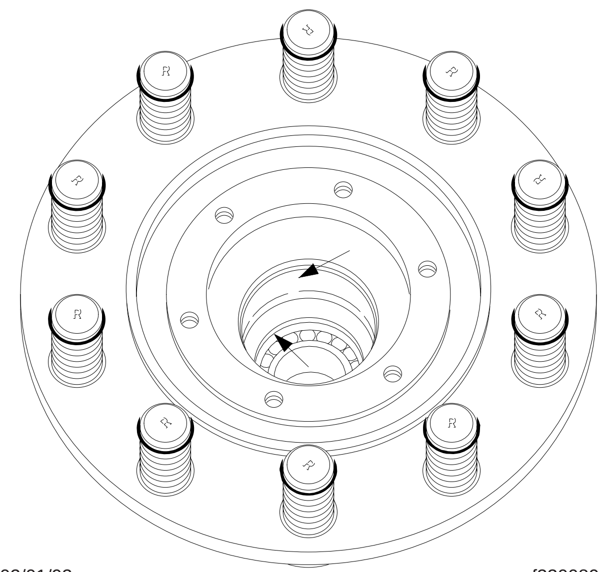


Fig. 1, Wheel Bearing Cup Locations

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

   If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

WARNING

Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

Installation

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

WARNING

Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

4. Coat the replacement bearing cup hub contact surface with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

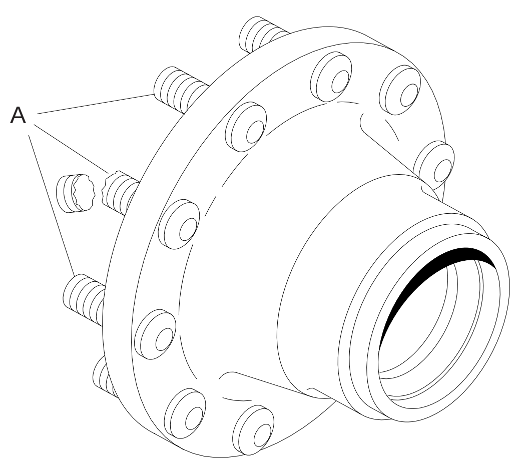
will also cause permanent damage to the wheel hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.

7. Allow the wheel hub to cool before handling. Then, using a 0.0015–inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.
8. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean, lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Replacement

WARNING

If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it. See Fig. 1. If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.



A. Replace

Fig. 1, Wheel Stud Replacement

1. Remove the wheel hub from the axle. For instructions, see **Subject 100**.
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is supported evenly around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

CAUTION

Do not use a drift and hammer or concentrated heat for removing and installing the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.

4. Apply a coating of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is supported evenly around and next to the stud being installed.
6. Position the stud in its hole. *Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.*

CAUTION

If headed studs with serrations are being installed, position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.

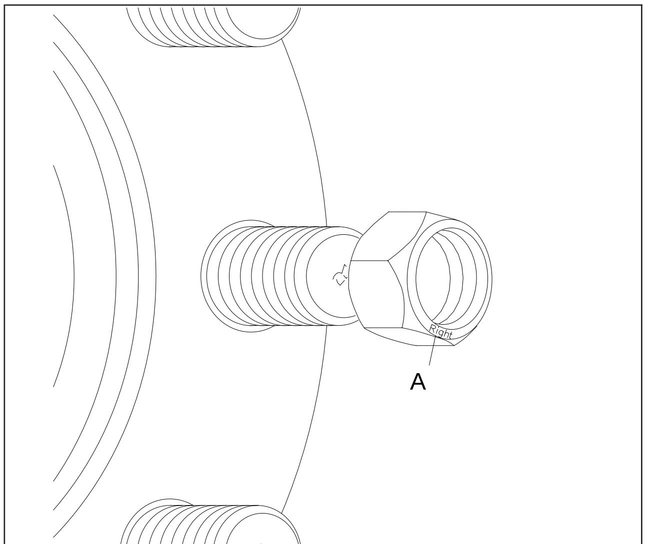
NOTE: If the left side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left" If the right side of the vehicle is being serviced, the replacement stud must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right" (Fig. 2).

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded into the hub. If the head of the stud is embedded into the hub, replace the hub.

WARNING

Don't embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss

Wheel Stud Replacement



A. "Right"

Fig. 2, Thread Stamp Location

of a wheel or loss of steering control, possibly resulting in personal injury.

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.

10. Install the wheel hub on the axle. For instructions, see **Subject 100**.

Axilok Spindle Nut Removal, Installation, and Adjustment

General Information

Axilok® spindle nuts are used on ConMet PreSet hubs. See Fig. 1 and Fig. 2. These nuts can be damaged if they are not removed or installed correctly. Use the following guidelines when removing and installing Axilok retaining nuts.

- Use only the correct size, *six-point* socket to remove or install Axilok spindle nuts. Do not use a worn or loose-fitting socket. **Do not use a 12-point socket.**
- Do not use hammers, chisels, pliers, wrenches, or power tools to remove or install Axilok nuts.
- Do not use an Axilok nut if the locking clips are damaged or missing, or if the retainer cage tab or D-flat is damaged or missing.
- Never try to repair a damaged Axilok nut; always replace it with a new one.
- Always start an Axilok installation by hand. A good-fitting six-point socket will completely disengage the nut's locking clips, allowing it to spin freely by hand. See Fig. 3. Use an accurately calibrated torque wrench to tighten the nut to its final torque value.

Installation

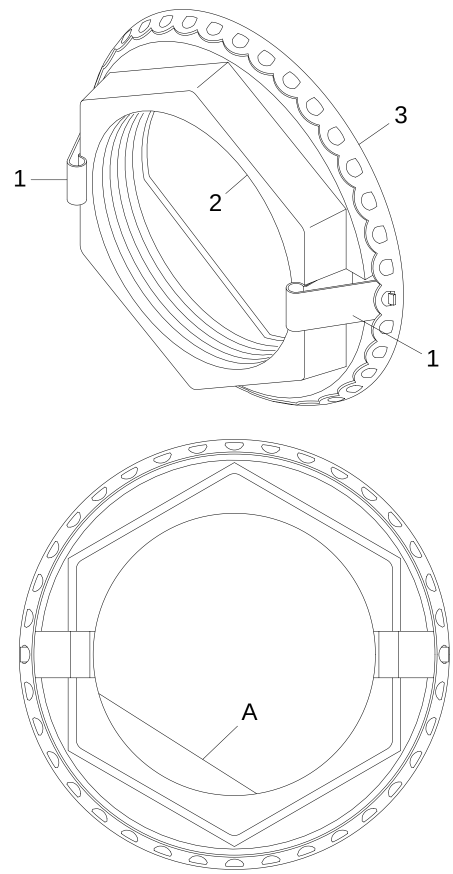
Instructions for installing an Axilok nut for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

Using PreSet Bearings

WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

1. Apply a few drops of oil through one of the holes in the Axilok retainer cage to reduce friction between the retainer cage and nut.
2. By hand, install the Axilok nut onto the axle spindle. See Fig. 1 and Fig. 2.



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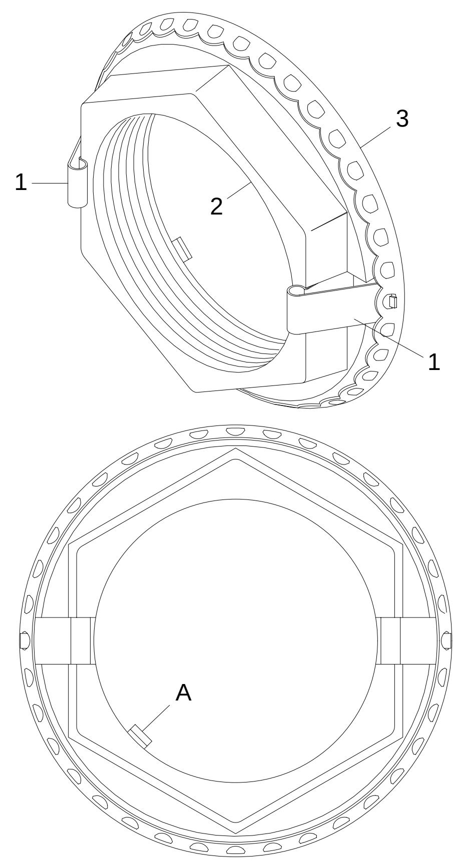
A. The flat side of the retainer must engage the flat side of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer Cage

Fig. 1, Axilok Retaining Nut, Meritor Front Axle

3. Tighten the retaining nut 250 lbf·ft (339 N·m). The nut should lock in place when you remove the wrench. If it does not, advance the nut until it does. **Do not back it off**.
4. Ensure that both locking clips are present and engaged in the retainer cage. See Fig. 3. If the locking clips are not engaged, the nut is not locked in position and can rotate freely.

Axilok Spindle Nut Removal, Installation, and Adjustment



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A. This retainer tab must engage the keyway of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer Cage

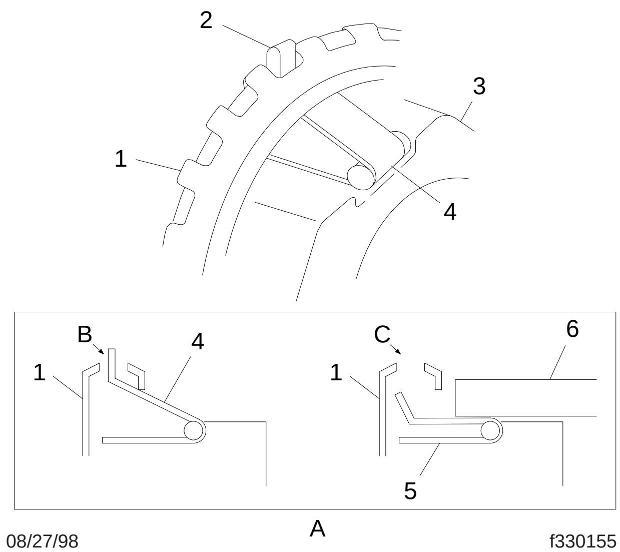
Fig. 2, Axilok Retaining Nut, Eaton Front Axle

Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.



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A. Cross-Section View
B. The tab is engaged.
C. The tab is disengaged.

1. Retainer Cage
2. Locking Clip Tab
3. Nut
4. Locking Clip
5. Locking Clip (compressed)
6. Six-Point Socket

Fig. 3, Axilok Nut, Checking the Position of the Locking Clip

1. Apply a few drops of oil through one of the holes in the Axilok retainer cage to reduce friction between the retainer cage and nut. See Fig. 1 and Fig. 2.
2. Install the Axilok nut and adjust the wheel bearings, as follows.

   2.1 By hand, install the Axilok nut onto the axle spindle and turn it against the bearing while spinning the hub.

   2.2 Tighten the nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the hub in both directions.

   2.3 Loosen the nut to zero torque, and spin the hub a few turns.

   2.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the hub in both directions. Back off the nut one-eighth to one-sixth turn.

Axilok Spindle Nut Removal, Installation, and Adjustment

2.5 Remove the wrench from the nut, and verify whether both locking clips are present and engaged in the retainer cage. See **Fig. 3**. If the locking clips are not engaged, advance the Axilok until they are.

3. Using a dial indicator, measure the end play as follows.

IMPORTANT: Do not measure the wheel bearing end play with the wheel mounted on the hub; you cannot accurately measure or adjust bearing end play with the wheel mounted on the hub. Also, ensure that the brakes are not applied so that that drum and hub can move freely.

3.1 On vehicles equipped with aluminum hubs, install an iron brake drum onto the hub to provide a ferrous surface for the magnetic base of the dial indicator. With flange nuts, secure the drum to the hub using the stud at the 12 o'clock position, followed by the studs at about the 4 o'clock and 8 o'clock positions. Ensure the nuts hold the drum securely; use washers if needed.

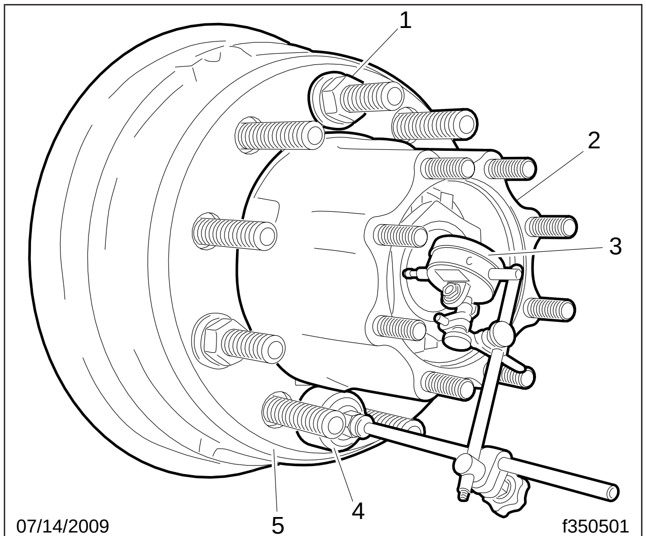
3.2 Clean the spindle end; ensure it is free of debris and provides the smooth surface needed for the dial indicator to take an accurate measurement.

3.3 Attach the magnetic base of a dial indicator to the drum (or, on vehicles equipped with iron hubs, the hub). See **Fig. 4**.

3.4 Set the measuring end of the indicator against the spindle end as shown in **Fig. 5**. The indicator should be square with the end of the spindle.

IMPORTANT: Maintain continual pressure on the hub until you have taken both the inboard and outboard measurements. If you release the hub, an accurate measurement is not possible.

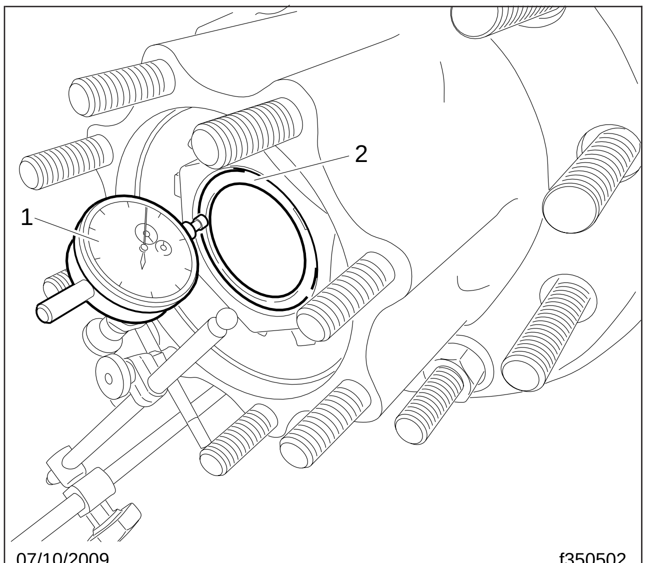
3.5 To seat the bearings, grip the hub at the three o'clock and nine o'clock positions, and push inward while oscillating it approximately 45 degrees. Maintain pressure on the hub and note the measurement.



NOTE: Assembly for rear axle shown.

1. Flange Nut
2. Aluminum Hub
3. Dial Indicator
4. Magnetic Base
5. Iron Brake Drum

Fig. 4, Dial Indicator Setup, Aluminum Hub with Iron Brake Drum



The indicator should be square with the end of the spindle.

NOTE: Assembly for rear axle shown.

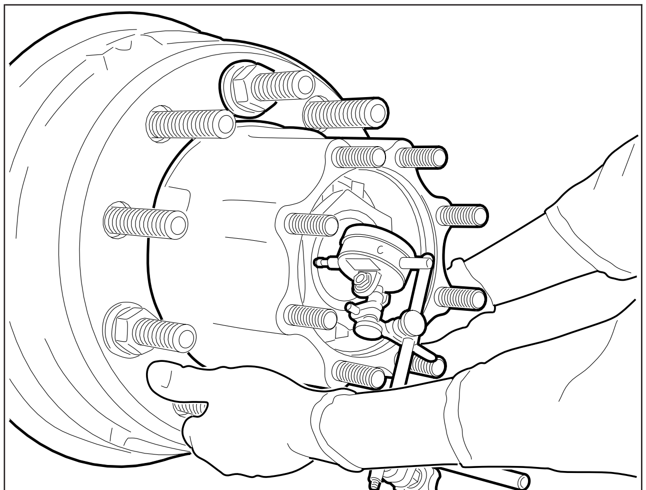
1. Dial Indicator
2. Spindle End

Fig. 5, Indicator Square with the Spindle

Axilok Spindle Nut Removal, Installation, and Adjustment

NOTE: The end play measurements must be taken at the same point to prevent an uneven spindle end from skewing the results. As needed, mark the spot on the spindle where the inboard measurement was taken.

3.6 Pull the hub and drum outward while oscillating it as before. Maintain pressure on the hub, and note the outboard extent of the end play. See **Fig. 6**.



NOTE: Assembly for rear axle shown.

Fig. 6, Pulling the Hub Outward to Measure End Play

3.7 Find the end play by noting the difference between the two readings.

WARNING

The wheel-bearing end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). Correct end play is crucial: if the wheel-bearing end play is not correct, the wheel bearings could fail. This could cause the loss of the wheel and hub assembly, resulting in an accident causing serious injury or property damage. Use a dial indicator to measure the end play.

4. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Axilok nut, and repeat the tightening sequence as described earlier in this procedure. Once the end play is correct, continue with your service procedure.

Meritor Unitized Wheel-End End Play Checking

End Play Checking

IMPORTANT: The following information is based on a Meritor technical bulletin for unitized wheel ends, and has been formatted for this Freightliner workshop manual. Contact Meritor if you wish to refer to the original technical bulletin.

WARNING

Do not service the bearings on Meritor unitized wheel ends. Disassembling the wheel end and bearings could contaminate the bearing lubricant, possibly damaging the bearings. This could result in the eventual loss of the wheel end (hub), which could cause an accident resulting in serious personal injury and property damage.

1. Park the vehicle on a level surface, set the parking brakes, shut down the engine, and chock the rear tires.
2. Raise the vehicle until the front tires are clear of the ground. Support the vehicle with safety stands.

WARNING

Never work under a vehicle that is supported only by a jack. Jacks can slip, causing the vehicle to fall. This could result in serious injury or death.

3. Rotate the tire and wheel assembly. It should rotate smoothly and without any noise.
4. Remove the tire and wheel assembly.
5. Remove the brake drum. If needed, back off the slack adjuster.
6. Remove the hub cap.
7. Attach the magnetic base of a dial indicator to the end of the axle spindle.
8. Touch the dial indicator stem to the surface of the wheel end (hub), making sure the stem is perpendicular to the surface of the wheel end.
9. Set the dial indicator to zero.
10. Without rotating the wheel end, grasp it at the 3 and 9 o'clock positions, and push it straight in. Note the reading on the dial indicator.

    Pull the wheel end straight out. Note the reading on the dial indicator.

    The difference between the two readings is the end play.
11. If the end play is less than 0.003-inch (0.08 mm), go to the step for installing the hub cap.

    If the end play is 0.003-inch (0.08 mm) or greater, go to the next step.
12. Remove the outer locknut and tabbed washer from the axle spindle.
13. Loosen, but don't remove, the inner locknut.
14. While rotating the wheel end a minimum of five rotations, tighten the inner locknut 600 lbf·ft (813 N·m).
15. Install the tabbed washer and the outer locknut. Tighten 250 lbf·ft (339 N·m).
16. Repeat the procedure for checking the end play.
17. If the end play is greater than 0.003-inch (0.08 mm) but less than 0.006-inch (0.15 mm), the end play is correct. Go to the next step.

    If the end play is 0.006-inch (0.15 mm) or greater, replace the entire wheel end assembly. For instructions, see **Subject 140**.
18. Check the rotation of the wheel end. If it doesn't rotate smoothly and without noise, replace it. For instructions, see **Subject 140**.

    If the wheel end rotates smoothly and without noise, go to the next step.
19. Bend an opposing tab of the tabbed washer over a flat of the inner locknut. Do the same for the outer locknut. Make sure that a tab of the washer is bent over a flat of both the inner and outer locknuts.
20. Install the wheel and tire assembly. Hand tighten the wheel nuts.
21. Raise the vehicle, remove the jackstands, then lower the vehicle.
22. Tighten the wheel nuts 500 lbf·ft (678 N·m).
23. Install the hub cap.

    If installing a metal hub cap, go to the next step.

    If installing a plastic hub cap, do the following:

Meritor Unitized Wheel-End End Play Checking

23.1 Using a wire brush, remove any grease or mud from the inner threads of the hub. Wipe the threads with a clean shop cloth.

23.2 Apply a continuous 1/8-inch (3 mm) bead of RTV silicone sealant to the outside first thread of the hub cap. Apply the sealant around the entire circumference.

IMPORTANT: Use only the following RTV sealants on the hub cap:

- Meritor part number 2297-Z-7098
- Three Bond®
- Loctite® Ultra Grey Adhesive Sealant 18581

23.3 Install the hub cap by hand until it is seated.

IMPORTANT: Disregard the torque value embossed on the hub cap.

23.4 Using a torque wrench, tighten the hub cap 75 lbf·ft (102 N·m).

If you cannot tighten the hub cap to the correct torque value, or if it makes a popping sound while being tightened, replace it with a new one.

24. If installing a metal hub cap, do the following:

24.1 Using a wire brush, clean the inner threads of the hub and the hub cap threads

24.2 Apply Loctite® 17430 (Meritor part number 2297-D-7076) gasket sealant to the hub cap threads.

24.3 Install the hub cap by hand until it is seated.

24.4 Using a torque wrench, tighten the hub cap 350 lbf·ft (475 N·m).

IMPORTANT: If you cannot tighten the hub cap to the correct torque value, or if it makes a popping sound while being tightened, replace it with a new one.

25. Remove the chocks from the tires.

If either the lateral or radial runout of the hub is beyond acceptable limits, replace the hub. For instructions, see **Subject 100** in this section.

Measurements

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

2. Remove the wheel and tire assembly. See **Group 40** for instructions.
3. For drum brakes, remove the brake drum. See **Subject 160** for instructions.
4. Clean the hub surfaces where the measurements will be taken—see **Fig. 1** and **Fig. 2**.
5. To measure lateral runout, set up a dial indicator as shown in **Fig. 1**, then turn the hub one revolution and note the highest and lowest measurements.

   For ConMet hubs, the acceptable lateral runout is 0.008 inch (0.2 mm); for other hubs, see the hub OEM for the acceptable lateral runout specification.
6. To measure radial runout, set up a dial indicator as shown in **Fig. 2**, then turn the hub one revolution and note the highest and lowest measurements.

   For ConMet hubs, the acceptable radial runout is 0.008 inch (0.2 mm); for other hubs, see the hub OEM for the acceptable radial runout specification.

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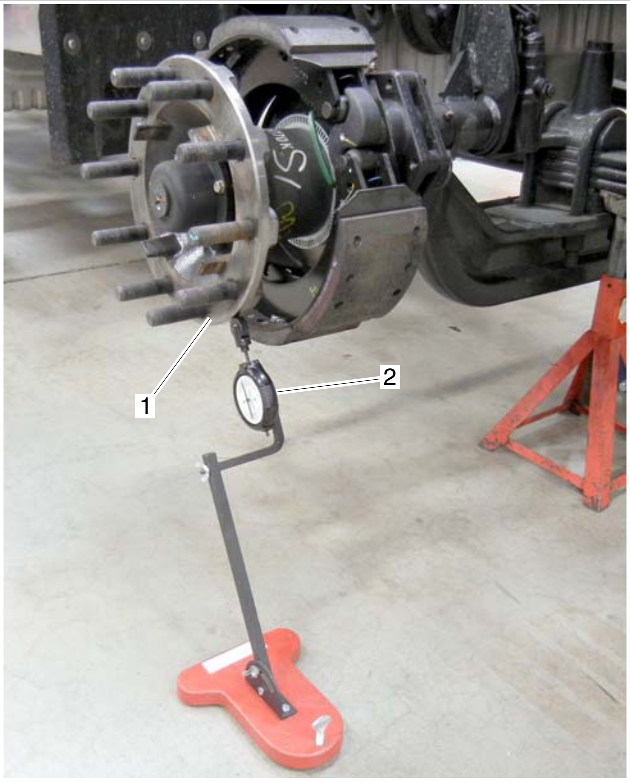
1. Hub
2. Dial Indicator (with roller point)

Fig. 1, Setup to Measure Lateral Runout

Hub Runout Measurements



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1. Hub
2. Dial Indicator (with roller point)

Fig. 2, Setup to Measure Radial Runout

Troubleshooting Tables

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Possible Cause	Remedy
Not enough oil was used on the bearings, or the wrong type of oil was used.	Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil.
Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed.	Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant.
An incorrect adjustment of the wheel bearings is causing noise and wear.	Adjust the wheel bearings following the applicable instructions in this section.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, see **Specifications, 400**.

Problem—Broken Wheel or Rim Studs

Problem—Broken Wheel or Rim Studs	
Possible Cause	**Remedy**
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. See **Group 40** of this manual for the wheel or rim nut tightening sequence.
An incorrect nut tightening sequence was used.	
The wrong brake drums were installed.	Install new brake drums.
Wheels are mismatched (hub-piloted wheels are mixed with stud-piloted wheels).	Install properly matched wheels.
The vehicle is being overloaded.	Do not exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Problem—Damaged Hub	
Possible Cause	**Remedy**
(Cracked hub) Local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal.	Replace the hub assembly. When removing the bearing cup, oven-heat the hub.
(Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement.	Replace the hub assembly. Replace the wheel studs.
The wrong brake drums were installed.	Install new brake drums.
Insufficient tightening of the wheel nuts to the wheel hub.	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **Specifications, 400**.

Troubleshooting

Problem—Loss of Lubricant from the Wheel Hubs

Problem—Loss of Lubricant from the Wheel Hubs	
Possible Cause	**Remedy**
The seals or gaskets are worn or damaged.	Replace worn or damaged parts.

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied	
Possible Cause	**Remedy**
Dirt or grease has built up on the brake linings (glazing), or the brake linings have worn excessively.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake drums are worn, heat-checked or cracked.	Install new brake drums.

Problem—Service Brakes Grab or Pull

Problem—Service Brakes Grab or Pull	
Possible Cause	**Remedy**
For detailed information, see **Group 42** of this manual.	

Problem—Poor Lining-to-Drum Contact

Problem—Poor Lining-to-Drum Contact	
Possible Cause	**Remedy**
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Install new brake drums or turn the drums.
The brake shoes are stretched or bent.	Replace the brake shoes.
Undersized linings were installed.	Install new brake linings on both sets of axle brake shoes.
An incorrect grind was used on the brake linings.	
The wrong brake drums were installed.	Install new brake drums.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the applicable instructions in this section.

Problem—Brake Linings Are Tapered Across the Width

Problem—Brake Linings Are Tapered Across the Width	
Possible Cause	**Remedy**
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the drums.
The brake shoes are bent.	Replace the brake shoes.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the applicable instructions in this section

Troubleshooting

Problem—Brake Shoes on the Same Brake Are Wearing Unequally

Problem—Brake Shoes on the Same Brake Are Wearing Unequally	
Possible Cause	**Remedy**
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake shoes are stretched.	Replace the brake shoes.

Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) Are Wearing Unequally

Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) Are Wearing Unequally	
Possible Cause	**Remedy**
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The inside surface of the brake drum is in poor condition.	Turn or replace the drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the applicable instructions in this section.

Problem—Edge of the Lining Is Showing Wear

Problem—Edge of the Lining Is Showing Wear	
Possible Cause	**Remedy**
The brake lining is too wide.	Install new brake linings on both sets of axle brake shoes.
The brake linings are misaligned because of incorrectly drilled brake lining holes.	
Undersized brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the applicable instructions in this section.
There is an incorrect fit of the wheel onto the spindle due to the wrong wheel bearings.	Install new wheel bearings and adjust them following the applicable instructions in this section.
The brake shoes are bent.	Replace the brake shoes.

Problem—Brake Linings Are Scored or Grooved

Problem—Brake Linings Are Scored or Grooved	
Possible Cause	**Remedy**
Worn or scored brake drums have been causing poor contact with the brake linings.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
There is abrasive material between the lining and the drum.	

Troubleshooting

Problem—Brake Linings Are Loose

Problem—Brake Linings Are Loose	
Possible Cause	**Remedy**
The rivet holes in the brake shoes are too large.	Replace the brake shoes.
Incorrectly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Brake Lining Is Cracked at the Rivet Holes or Bolt Holes

Problem—Brake Lining Is Cracked at the Rivet Holes or Bolt Holes	
Possible Cause	**Remedy**
Overtightening of the lining bolts is causing cracks.	Install new brake linings. Replace the rivets or bolts with the correct size.
The wrong size counter bore for the rivet holes was made.	
The wrong rivets or bolts were used.	Replace the rivets or bolts with the correct size.
Incorrectly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Out-of-Round Rivet Holes or Bolt Holes

Problem—Out-of-Round Rivet Holes or Bolt Holes	
Possible Cause	**Remedy**
The rivets or bolts are loose.	Replace the brake shoes or linings.

Problem—Brake Drums Are Heat-Checked

Problem—Brake Drums Are Heat-Checked	
Possible Cause	**Remedy**
The brake drums are out-of-round.	Turn or replace the brake drums.
The wrong brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the applicable instructions in this section.
The brake linings are glazed (dirt or grease build-up) or are worn unevenly.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The lining friction material for the operation of the vehicle is incorrect.	
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Problem—Brake Drums Are Heavily Scored

Problem—Brake Drums Are Heavily Scored	
Possible Cause	**Remedy**
The brake linings are damaged.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
There is excessive wear on the linings.	
On the last brake reline, the drums were not turned.	Turn the brake drums.

Problem—Excessive Brake Lining Wear

Problem—Excessive Brake Lining Wear	
Possible Cause	**Remedy**
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Problem—Hard Steering

Problem—Hard Steering	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate tires to the correct pressure.
Binding in the steering gear due to a lack of lubrication.	Test the steering system for binding with the front tires off the ground. For instructions, see **Group 46** of this manual.
Too much caster angle in the front wheels.	Check the caster angle and adjust as needed.
The front suspension is sagging due to a damaged spring.	Repair or replace the spring as needed. For instructions, see **Group 32** of this manual.
The axle spindle is bent.	Replace the spindle.
The frame is misaligned.	Check the frame alignment; correct, as needed.

Problem—Erratic Steering When the Brakes are Applied

Problem—Erratic Steering When the Brakes are Applied	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more front axle spring U-bolt nuts are loose.	Check the U-bolt nuts for looseness. If loose, check the U-bolt for damage. Replace damaged parts; tighten loose nuts.
The brakes are not adjusted evenly.	Adjust the brakes on all axles. Also, check operation of the slack adjusters.
Grease or oil contamination of the brake linings is reducing brake effectiveness.	Replace the brake linings and clean the drums. Find and correct the cause of grease or oil contamination.
The caster angle is wrong.	Check, and adjust as needed.
An axle spindle is bent.	Replace the axle spindle.
The front axle wheel bearings are worn or were incorrectly adjusted.	Check the bearings for wear or damage; replace as needed.

Troubleshooting

Problem—Vehicle Pulls to One Side During Operation

Problem—Vehicle Pulls to One Side During Operation	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more of the alignment measurements are incorrect.	Check all the alignment measurements. Correct as needed.
The wheels or tires are out-of-round.	Inspect the wheels and tires. Replace out-of-round parts.
The front axle wheel bearings are too tightly adjusted.	Check the bearings for wear or other damage. Replace the bearings if needed.
The front suspension is sagging due to a damaged spring.	Repair or replace the spring as needed. For instructions, see **Group 32** of this manual.
The axle spindle is bent.	Replace the spindle.
The frame is misaligned.	Check the frame alignment; correct as needed.
The rear axle(s) is out of alignment.	Check, and if needed, adjust the rear axle alignment.

Problem—Front Wheel Wander

Problem—Front Wheel Wander	
Possible Cause	**Remedy**
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for out-of-round brake drums; correct as needed.
One of the front springs is weak or broken.	Repair or replace the spring as needed. For instructions, see **Group 32** of this manual.

Problem—Front Wheel Shimmy

Problem—Front Wheel Shimmy	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for out-of-round brake drums, correct or replace as needed.
One or more tires are out-of-round or bulged.	Replace the tire.
The front axle wheel bearings are worn or were incorrectly adjusted.	Check the bearings for wear or other damage. Replace the bearings if needed.
Parts of the steering gear or linkage are worn.	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
The axle spindle is bent.	Replace the spindle.
One or more of the alignment measurements are incorrect.	Check all alignment measurements and correct as needed.
The knuckle pin is loose due to worn bushings.	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts as needed.

Troubleshooting

Problem—Front Wheel Shimmy	
Possible Cause	**Remedy**
Shock absorbers are worn or damaged.	Check the shock absorbers and replace if needed.

Problem—Vehicle Wanders

Problem—Vehicle Wanders	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more of the alignment measurements are incorrect.	Check all of the alignment measurements; correct as needed.
The rear axle(s) is out of alignment.	Check the rear axle alignment and adjust as needed.
Parts of the steering gear or linkage are worn.	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
A knuckle pin is loose due to worn bushings.	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts.
The axle spindle is bent.	Replace the spindle.

Problem—Cupped Tires

Problem—Cupped Tires	
Possible Cause	**Remedy**
Tire pressure is too low or too high in one or both front tires.	Inflate or deflate the tires to the correct pressure.
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for eccentric brake drums; correct or replace as needed.
The wheel toe-in in not correct.	Adjust the wheel toe-in.
The brakes are not adjusted evenly.	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
The front axle wheel bearings are worn or were not adjusted correctly.	Check the bearings for wear or other damage; replace them if needed.
The camber angle is not within specifications.	Check the front wheel camber angle. If not correct, find and replace the damaged axle component.

Problem—Steering Wheel Spokes Do Not Point at the 4 and 8 O’clock Positions

Problem—Steering Wheel Spokes Do Not Point at the 4 and 8 O’clock Positions	
Possible Cause	**Remedy**
The steering gear is not centered.	Center the steering gear.
If adjustable, the drag link is out of adjustment.	Adjust the drag link.
The steering wheel was not installed (positioned) correctly on the steering column.	Reposition the steering wheel on the steering column.

Troubleshooting

Problem—Steering Wheel Spokes Do Not Point at the 4 and 8 O’clock Positions	
Possible Cause	**Remedy**
The pitman arm is not correctly aligned with the timing mark on the steering gear output shaft.	Reposition the pitman arm on the steering gear output shaft. For instructions, see **Group 46** of this manual.

Specifications

Dana Spicer® Axle Recommended Lubricant		
Lubricant Type	**Condition**	**SAE Viscosity Grade**
Eaton Roadranger® Synthetic Axle Lubricants, or Equivalent with Military Specification MIL–L–2105D	Over-the-Road Service	75W–90
	Off-Highway Equipment, or Under Extra Heavy Loads	80W–140

Table 1, Dana Spicer Axle Recommended Lubricant

Meritor Axle Recommended Lubricant			
Lubricant Type	**Ambient Temperature**	**SAE Viscosity Grade**	**Meritor Specification**
Hypoid Gear Oil API Service Classification GL–5	+10°F (–12.2°C) and up*	85W–140	0–76–A
	–15°F (–26.1°C) and up*	80W–140	0–76–B
	–15°F (–26.1°C) and up*	80W–90	0–76–D
	–40°F (–40°C) and up*	75W–90	0–76–E
	–40°F (–40°C) to +35°F (+2°C)	75W	0–76–J
	–40°F (–40°C) and up*	75W–140	0–76–L
Synthetic Gear Oil	–40°F (–40°C) and up*	75W–90	0–76–N
	–40°F (–40°C) and up*	75W–140	0–76–M

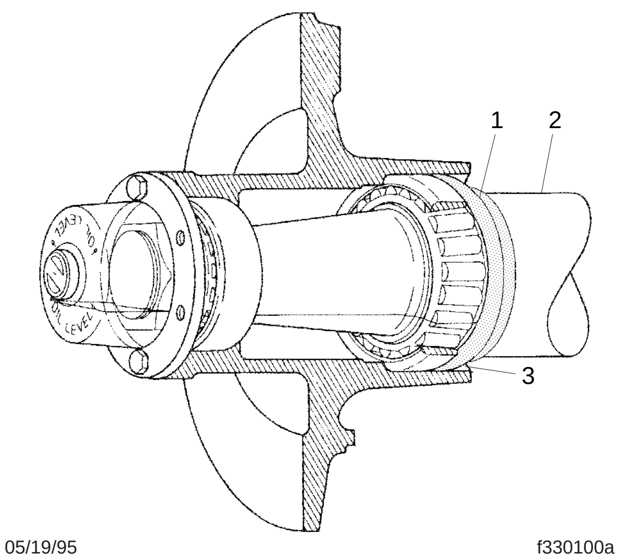
* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

Table 2, Meritor Axle Recommended Lubricant

General Information

Wheel oil seals (also called "oil bath seals" or "hub seals") work as a dam to keep oil in the hub cavity so that it constantly "bathes" the wheel bearings. The seals also protect the wheel bearings by keeping dirt, dust, and water out of the hub.

The oil seal fits between the hub bore and the axle spindle (see **Fig. 1**), and the sealing element either turns with the wheel (*hub-mounted seals*) and seals against the axle spindle, or the sealing element stays stationary with the axle spindle (*spindle-mounted seals*) and seals against the turning hub.

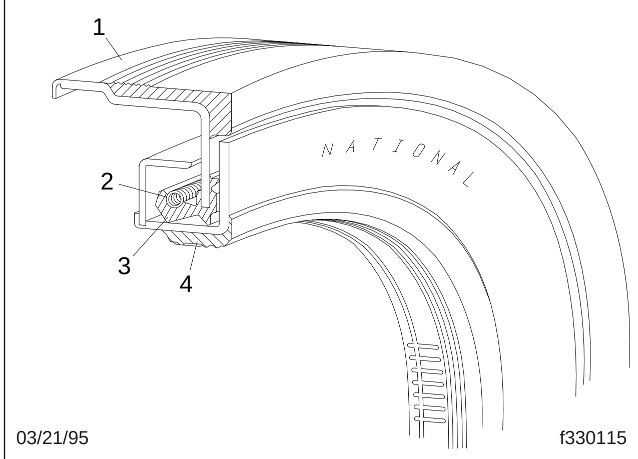


1. Wheel Oil Seal
2. Axle Spindle
3. Wheel Hub Bore

Fig. 1, Spindle-Mounted Wheel Oil Seal, Stemco Seal Shown

Most wheel oil seals consist of four basic parts (**Fig. 2**):

- The outside edge (also called the outer "cup" or "case")
- The inside edge (also called the inner "cup" or "case")
- The sealing element
- The garter spring



1. Outside Edge
2. Garter Spring
3. Sealing Element
4. Inside Edge

Fig. 2, Wheel Oil Seal Parts, National Oil Seal, Advanced Design

The outside edge is usually metal coated with rubber or another sealing agent so that it grips the hub bore tightly enough to prevent oil escaping between the outer edge of the seal and the hub bore.

The inside edge is usually metal or rubber with a metal ring within it to prevent the sealing element from wearing a groove in the axle spindle.

The sealing element is usually molded rubber, leather, or a synthetic such as nitrile or silicone. The element is molded into lips which will seal against the axle spindle or against the outside or inside edge described above. The innermost lip, called the "primary lip," keeps the oil inside the hub cavity. The outermost lip, called the "secondary lip," keeps dirt out of the hub cavity.

The garter spring is a coiled wire spring with its ends connected to make a loop. On hub-mounted seals, the spring runs around the outside of the sealing element to press the element inwards against the sealing surface. On spindle-mounted seals, the spring runs around the inside of the sealing element to press the element outward against the sealing surface.

Freightliner uses four brands of axle oil seals:

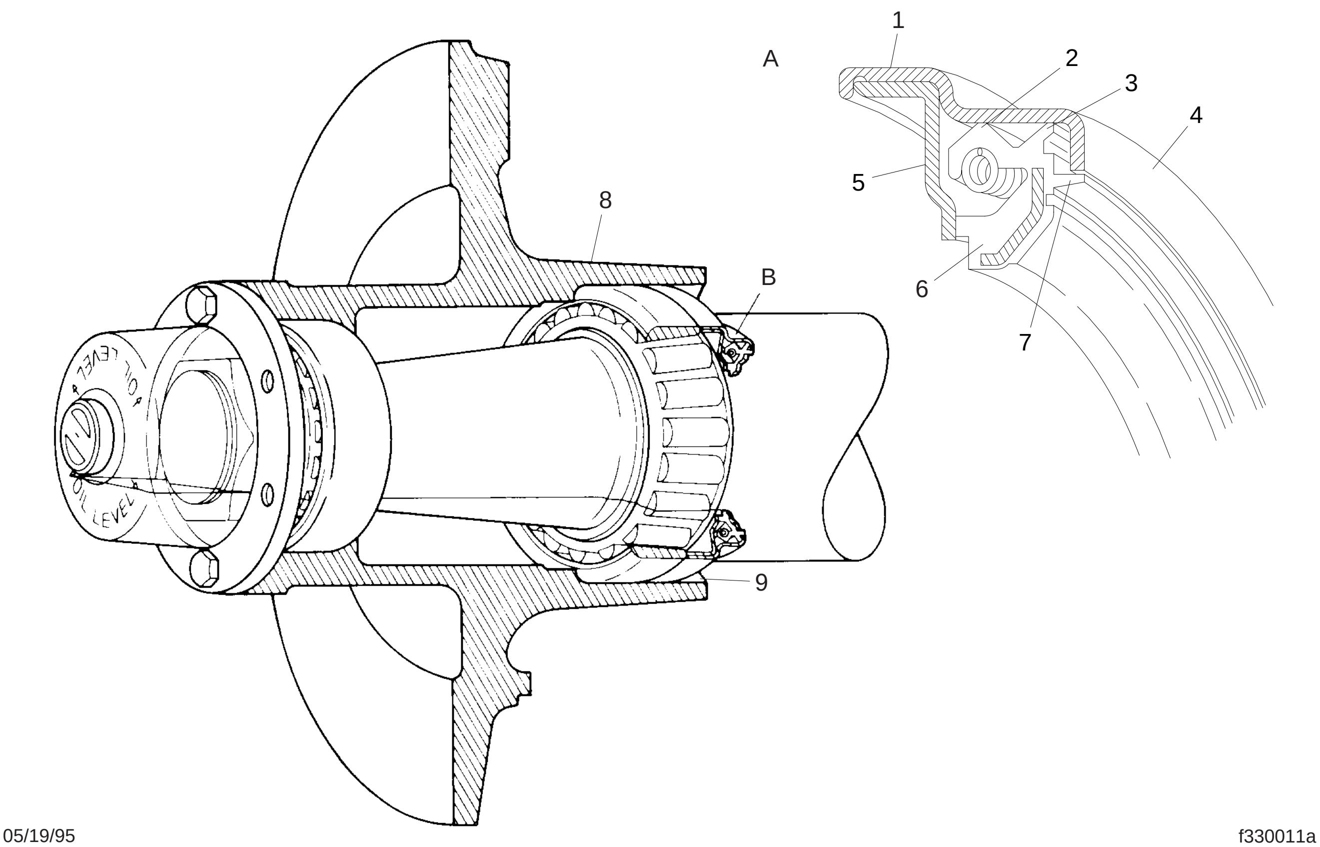
- Chicago Rawhide (Scotseal® and Scotseal Plus®)
- Eaton (Outrunner™)

General Information

- National (5-Star Gold® and Advanced Design®)
- Stemco (Guardian® and SS4®)

Chicago Rawhide (See Fig. 3)

Although you install the Scotseal into the hub bore, the seal's element grips the axle spindle tightly enough that the sealing element stays stationary with the spindle and seals against the outer cup which



A. Detail A
B. Oil Seal (See detail A)

1. Bore-Tite® Coating
2 Primary Sealing Lip
3. Dirt Lip
4. Outer Cup
5. Inner Cup
6. Sealing Element (Packing)
7. Bumper Lip
8. Hub
9. Hub Bore

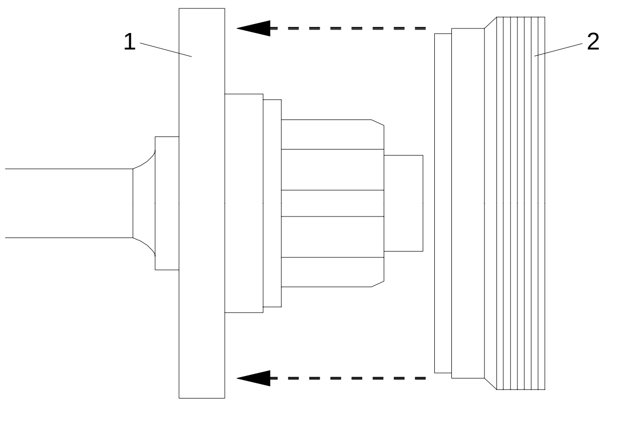
Fig. 3, Chicago Rawhide Scotseal

The Chicago Rawhide Scotseal is a unitized, one-piece design consisting of a sealing element (packing) that is assembled between metal outer and inner cups. The sealing element consists of three sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed and two dirt exclusion lips. The seal is press fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal directly onto the axle spindle.*

turns with the hub.

The Chicago Rawhide Scotseal maintains a metal-to-metal contact between the outer cup and the hub bore surface as well as a metal-to-metal contact between the sealing element inside edge and the axle spindle.

Eaton (See Fig. 4)



1. Eaton Outrunner Installation Tool
2. Eaton Outrunner Seal

Fig. 4, Eaton Outrunner Seal

The Eaton Outrunner has a rubber-coated outside edge and is installed in the hub bore using Eaton installation tools.

National (See Fig. 2 and Fig. 5)

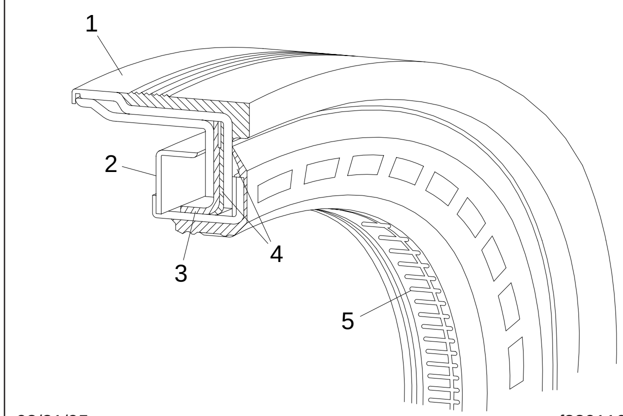
National wheel oil seals are hub-mounted, with a rubber-coated outside edge that grips inside the hub bore and also holds the sealing element. The element turns with the hub and seals against the inside edge of the seal which grips the axle spindle and acts as a wear sleeve. The shield protects the sealing element, and holds the two parts (the outside and inside edges) together.

The 5-Star Gold seal features a Teflon® lay-down sealing lip compatible with any combination of mineral and/or synthetic gear lubricants and/or greases.

Stemco (See Fig. 6 and Fig. 7)

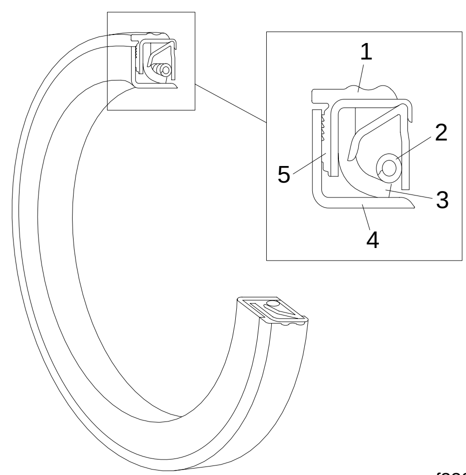
The Stemco wheel oil seals are spindle-mounted, with a rubber-coated outside edge that grips inside the hub bore and also holds the sealing element.

Although you install the Stemco seal onto the axle spindle, the outside edge grips the hub bore tight enough that the sealing element turns with the hub and seals against the inside edge which grips the axle spindle and acts as a wear sleeve.



1. Metal and Rubber Outside Edge
2. Shield
3. Teflon Lay-Down Primary Sealing Lip
4. Dual Secondary Sealing Lips
5. Rubber Inside Edge

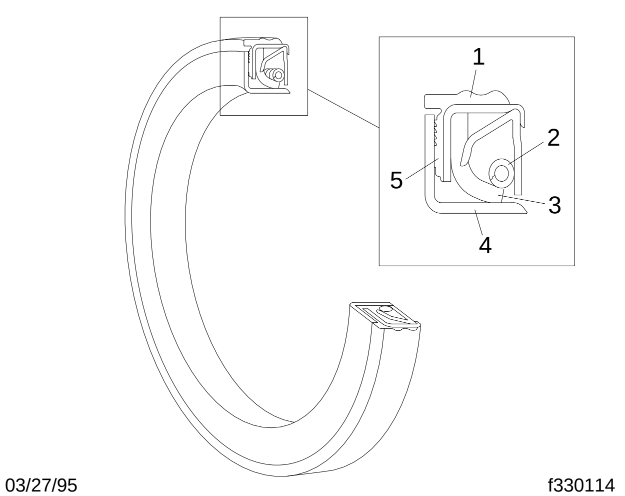
Fig. 5, National 5-Star Gold Axle Oil Seal



1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Elasto-Leather, Primary Lip)
4. Inside Edge
5. Secondary Lips

Fig. 6, Stemco Guardian Wheel Oil Seal

General Information



1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Teflon, Primary Lip)
4. Inside Edge
5. Secondary Lips

Fig. 7, Stemco SS4 Wheel Oil Seal

Seal Replacement, Chicago Rawhide

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Chicago Rawhide Scotseal®.

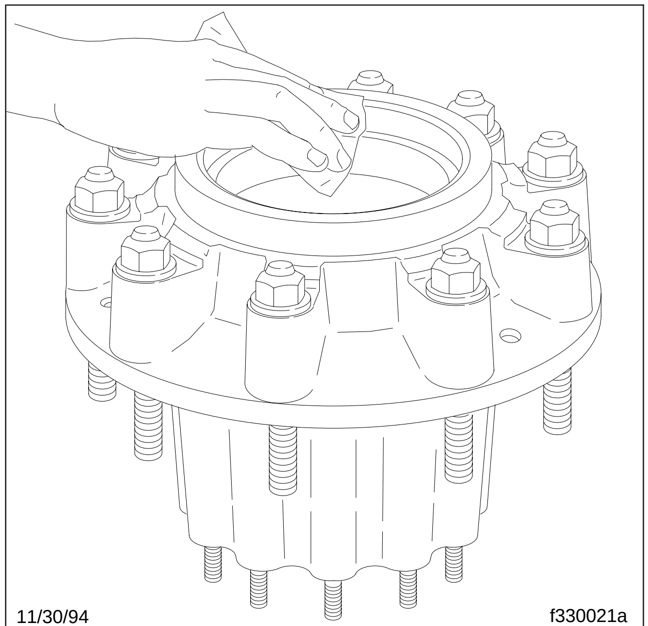
1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 1** and **Fig. 2**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.



NOTE: Rear hub shown.

Fig. 1, Clean the Hub

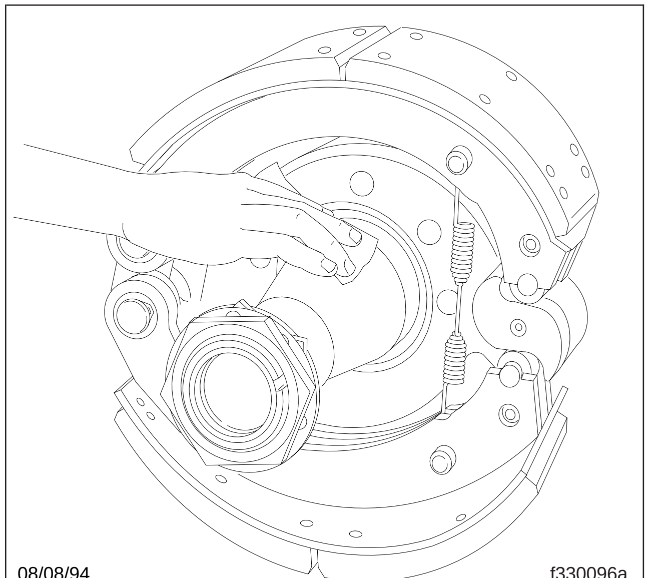
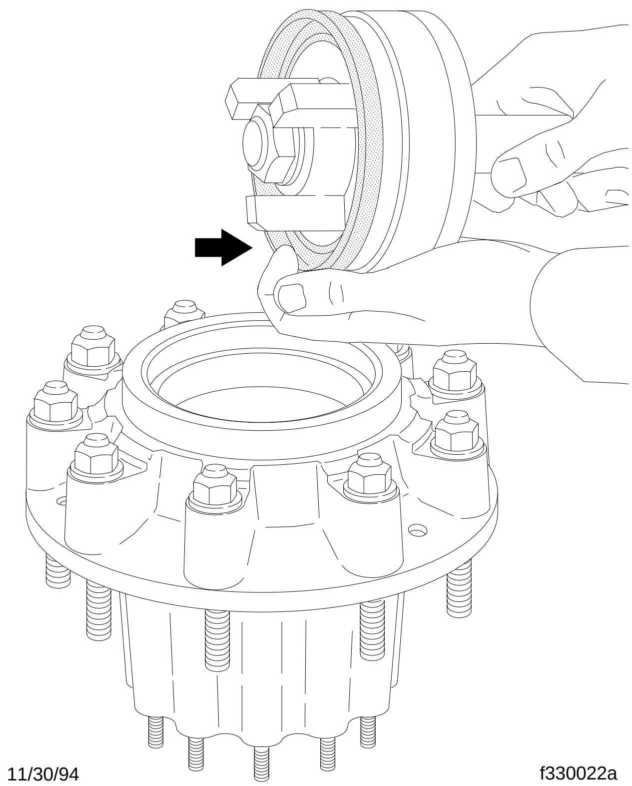


Fig. 2, Clean the Spindle

8. Seat the small outside edge of the seal in the recess of the tool adapter. See **Fig. 3**. The correct adapter is identified on the box.

Seal Replacement, Chicago Rawhide

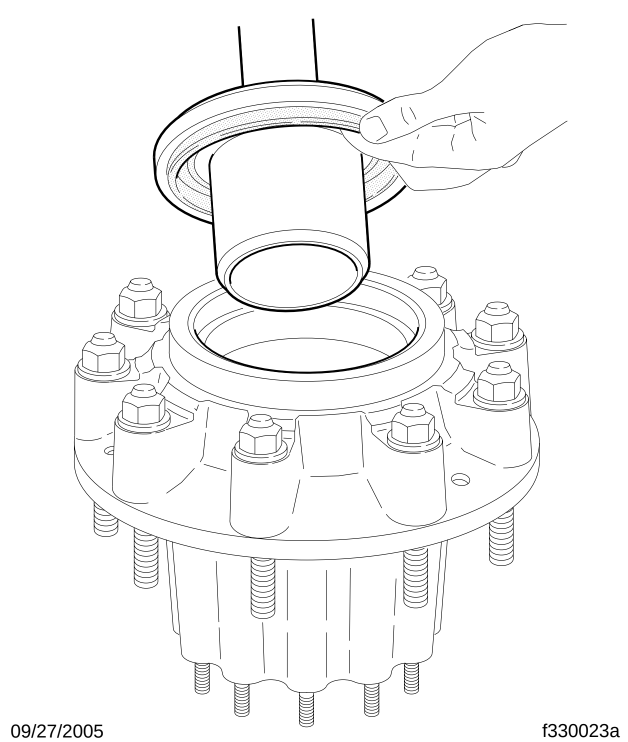


NOTE: Rear hub shown.

Fig. 3, Place the Seal on the Installation Tool

9. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4**. The plug prevents cocking of the seal in the bore.
10. Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 5**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
11. After the seal is bottomed in the bore, check for freedom of movement by manually moving the interior rubber part of the seal back and forth. A slight movement indicates a damage-free installation.
12. Install the wheel hub on the axle, and adjust the wheel bearings. For instructions, see **Section 33.01**.

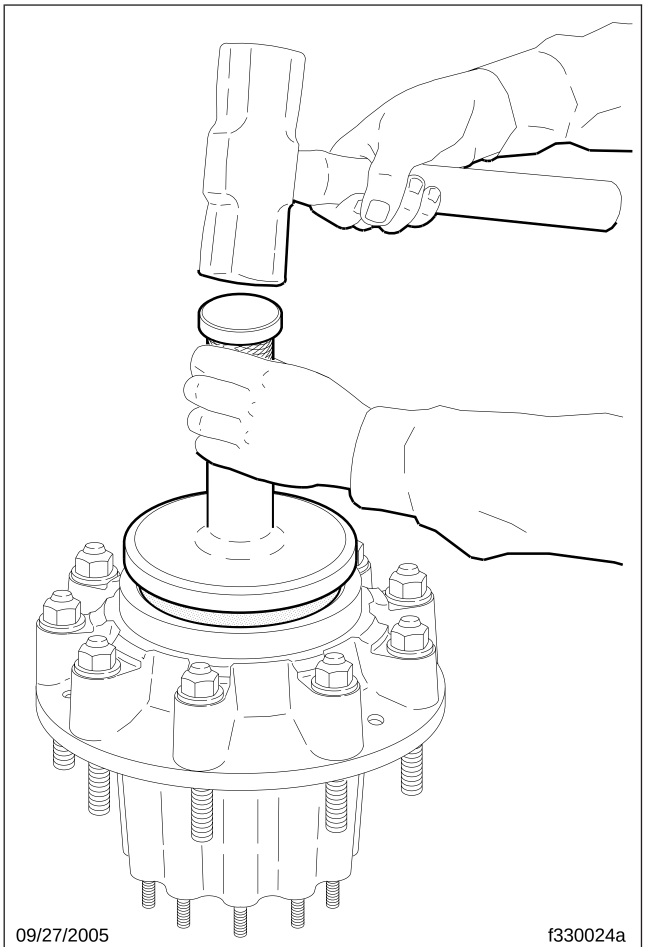
IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.



NOTE: Rear hub shown.

Fig. 4, Insert the Tool in the Hub Bore

13. Place the hubcap and a new gasket in position. Install the capscrews. Tighten the capscrews 15 lbf·in (20 N·m).
14. Fill the hub with oil to the level shown on the hubcap. See **Fig. 6**. Do not overfill.
15. Spin the wheel and check the oil level.
16. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.



NOTE: Rear hub shown.

Fig. 5, Strike the Tool

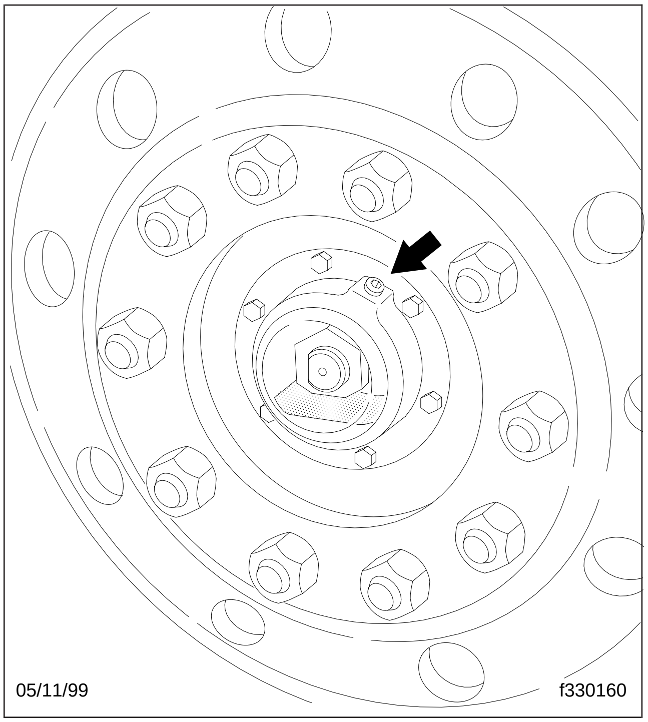


Fig. 6, Hub Filler Plug

Seal Replacement, Dana Spicer®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Dana Spicer Outrunner™ seal.

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.

CAUTION

Never use a sharp chisel to cut through an axle ring (wear sleeve). A sharp chisel could damage the spindle or shoulder.

3. Remove the steel axle ring (wear sleeve) by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.
4. Clean and inspect the bearings, the spindle, spindle threads, seal bore, and the hub cavity.

   IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

   4.1 Inspect the inner hub bore. Remove dirt and contaminants from all recesses and corners. Smooth any sharp edges with emery cloth, and fill in any grooves with filler. See **Fig. 2**.

   4.2 Wipe the hub area with a clean shop cloth.

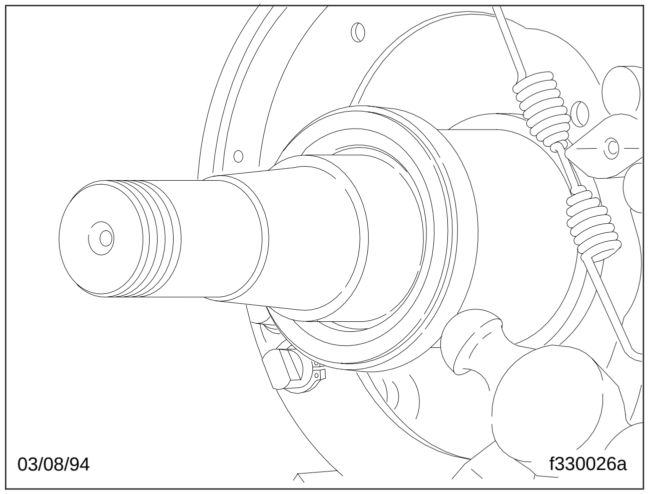
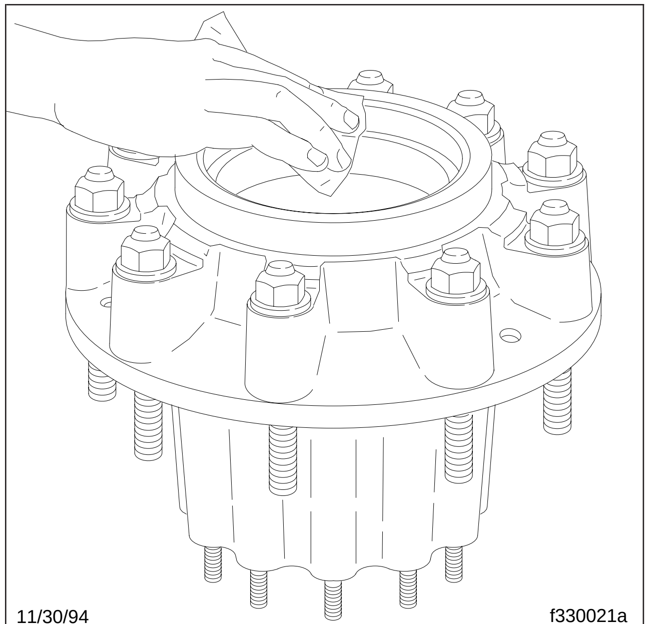


Fig. 1, Removing the Axle Ring



NOTE: Rear hub shown.

Fig. 2, Clean and Inspect the Hub Bore

   4.3 After removing the wear sleeve, inspect the spindle. Remove any sharp edges and burrs from the leading edges and the shoulder area. Repair deep gouges with filler and smooth with an emery cloth. See **Fig. 3**.

   4.4 Wipe the seal and shoulder area with a clean shop cloth.

Seal Replacement, Dana Spicer®

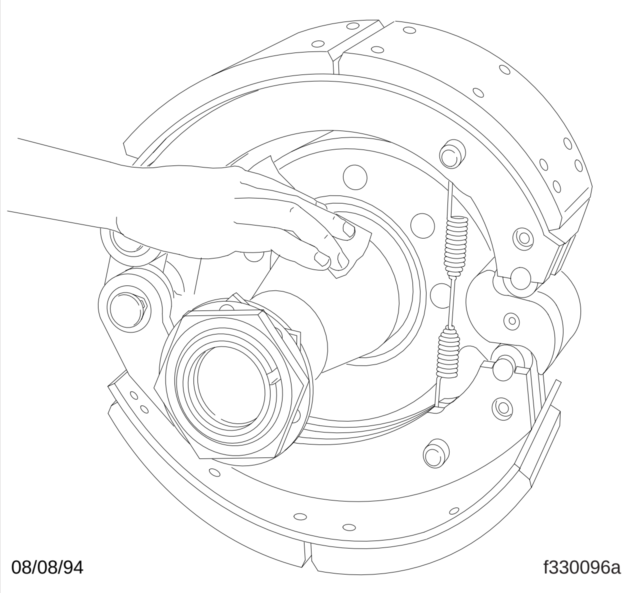


Fig. 3, Clean and Inspect the Axle Spindle

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

4.5 Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.

4.6 Coat the wheel bearing cones with oil.

5. Install the inner wheel bearing cone in the inner wheel bearing cup.

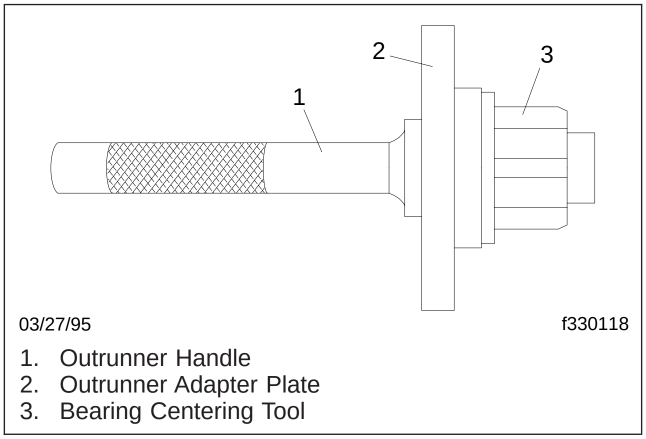
IMPORTANT: Use the Dana Spicer Outrunner installation tool *with the centering tool* when installing the seal. See Fig. 4.

6. Install the oil seal in the hub bore.

CAUTION

Do not use any silicone or permatex type bore sealant with this seal. The Dana Spicer Corporation recommends a light coating of bearing oil on the outer circumference of the seal.

Do not mix lubricants of different grades. Do not mix mineral and synthetic lubricants. Do not pack the bearings with grease when using an oil bath system. Failure to follow these installation guidelines will result in less than desired performance of the Outrunner seal, and installation-related failures are not covered under warranty.



1. Outrunner Handle
2. Outrunner Adapter Plate
3. Bearing Centering Tool

Fig. 4, Outrunner Installation Tool

6.1 Place the Outrunner seal tool with the words "air side" facing the adapter plate of the installation tool. See Fig. 5. Lubricate the seal outer circumference with wheel bearing oil.

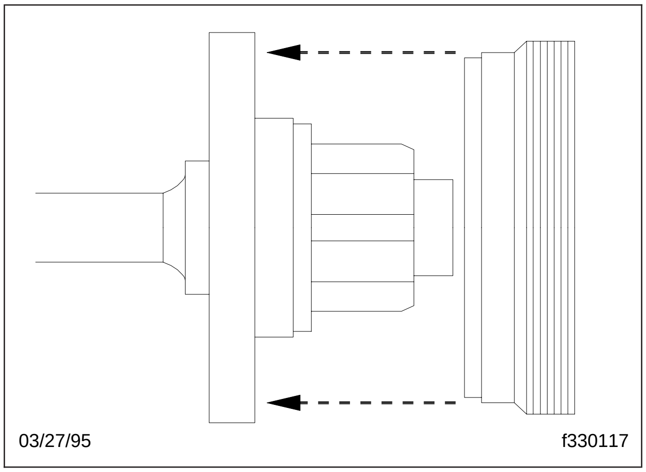


Fig. 5, Seal Placement on Tool

IMPORTANT: Install the seal in the hub bore with the hub lying flat. Do not install the seal with the hub in the vertical (upright) position.

6.2 With the hub and the wheel assembly lying flat on the floor, place the inner bearing cone in the cup.

Seal Replacement, Dana Spicer®

6.3 Position the oil seal in the hub bore. Before striking the handle of the installation tool, tap the adapter plate around the outer edge to position the seal. See **Fig. 6**.

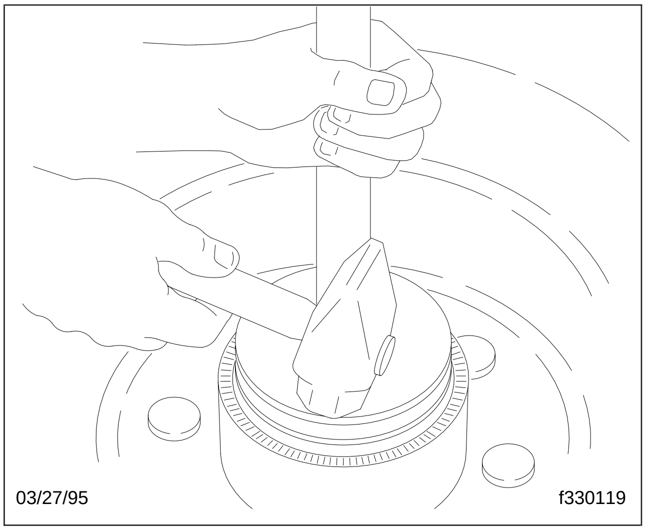


Fig. 6, Position the Seal

6.4 Hit the handle of the installation tool *gently*. See **Fig. 7**.

Because of the rubber outer circumference, the Outrunner seal is easier to install than seals with metal outer circumferences. When the adapter plate bottoms out on the hub surface, the seal is installed correctly. You will hear a metal-to-metal sound.

6.5 Check that the seal is not cocked, and that the unitized seal inner circumference and inner bearing turn freely.

6.6 Lubricate the inner circumference of the seal with a light film of clean bearing oil.

7. Install the wheel hub on the axle, and adjust the wheel bearings. For instructions, see **Section 33.01**.

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

8. Place the hubcap and a new gasket in position. Install the capscrews. Tighten the capscrews 15 lbf·ft (20 N·m).

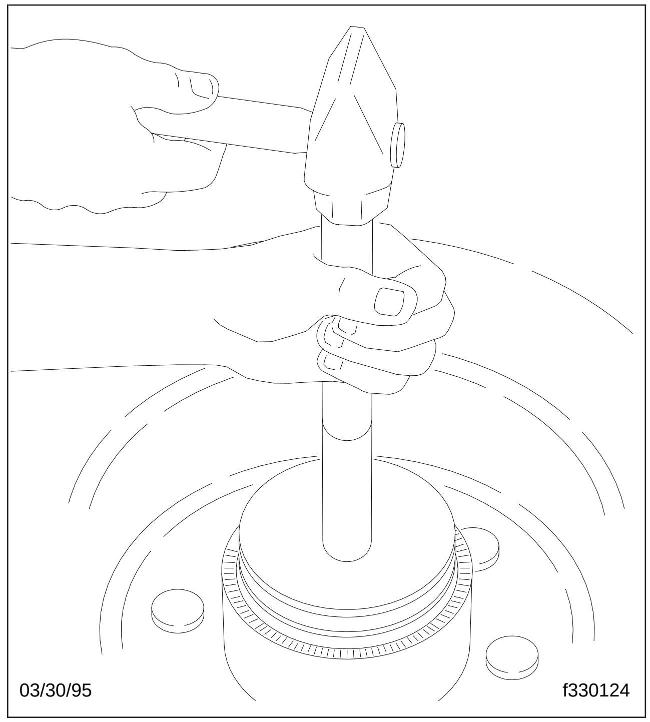


Fig. 7, Install the Seal

9. Fill the hub with oil to the level shown on the hubcap. See **Fig. 8**. Do not overfill.
10. Spin the wheel and check the oil level.
11. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

Seal Replacement, Dana Spicer®

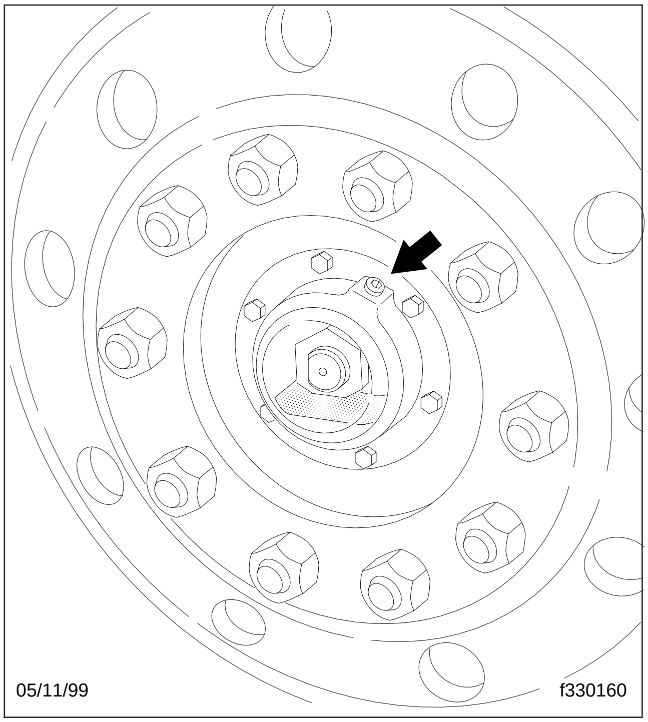


Fig. 8, Hub Filler Plug

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

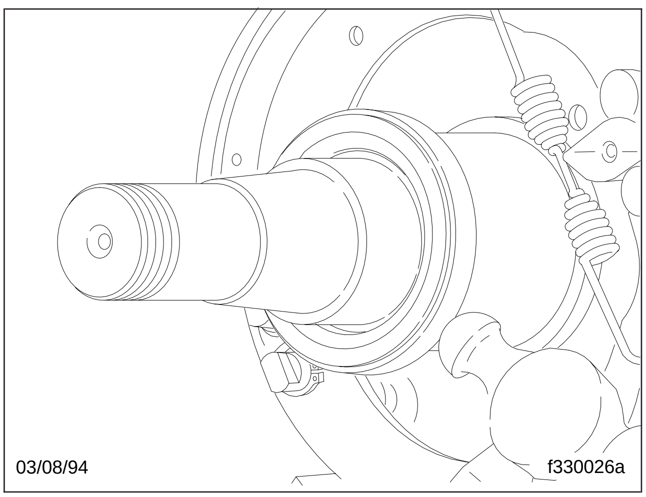


Fig. 1, Remove the Axle Ring

5. Inspect the spindle shoulder and hub bore.
   - 5.1 If necessary, use a file to remove burrs from the leading edges and shoulder area.
   - 5.2 Fill any deep scratches with a hardening compound and smooth it with an emery cloth. See **Fig. 2**.

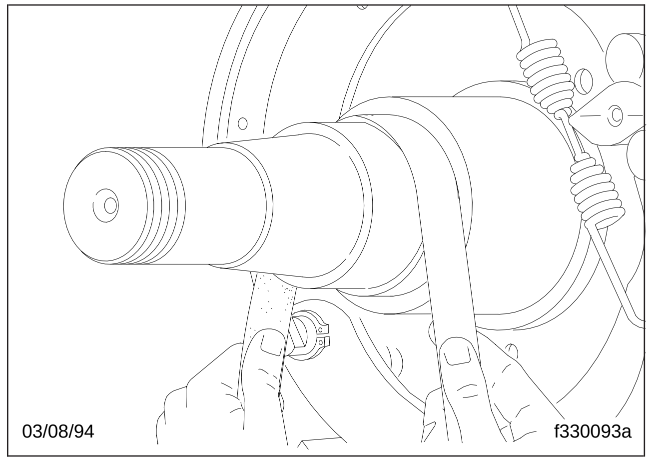


Fig. 2, Clean the Axle Spindle

   - 5.3 Use a clean cloth to remove all dirt, grit, and metal filings.
   - 5.4 Check the seal for a correct fit by placing the seal on the axle spindle, up to the first rubber rib. The correct seal will not go any farther.

   IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

   - 5.5 Inspect the hub bore, and remove any burrs from the leading edge with an emery cloth.
6. Select the seal installation tools designed for use with National oil bath seals. These should include a universal handle, an adapter plate, and a bearing pilot. See **Fig. 3**.
7. Install the seal in the hub.

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

Seal Replacement, National®

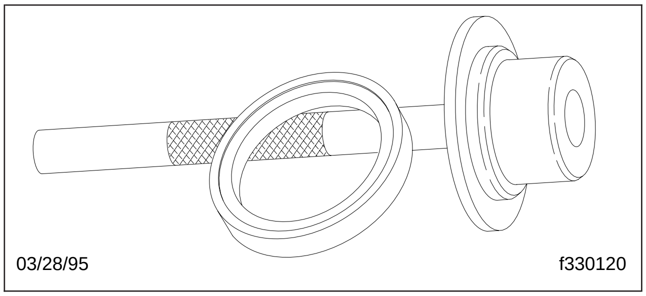


Fig. 3, Installation Tools

7.1 Prelube the inner bearing cone with clean oil and place it in the hub. See **Fig. 4**.

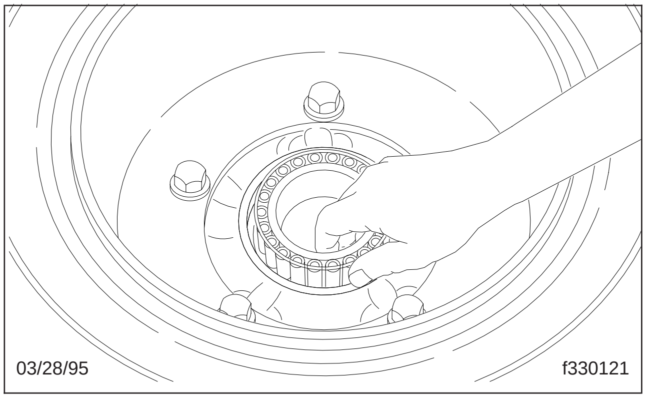


Fig. 4, Place the Bearings in the Hub

7.2 Place the oil bath seal on the installation tool with the words "air side" facing the adapter plate. Lubricate the outside diameter of the seal with clean oil to ease the installation. See **Fig. 5**.

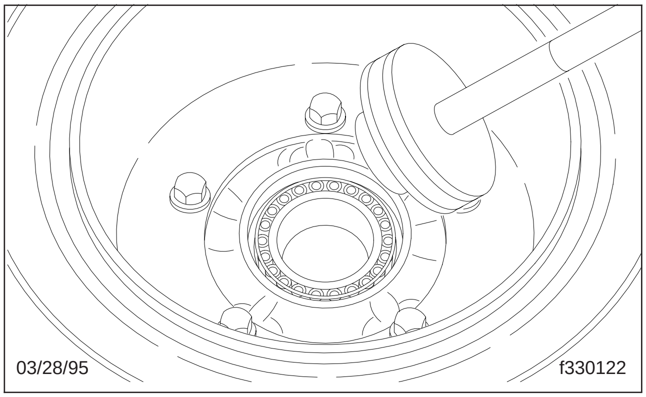


Fig. 5, Place the Seal on the Tool

7.3 Hold the tool straight, and drive the seal with a firm hit until the sound of the impact changes. See **Fig. 6**. Make sure the seal is squarely in position and the inner wheel bearing rotates freely.

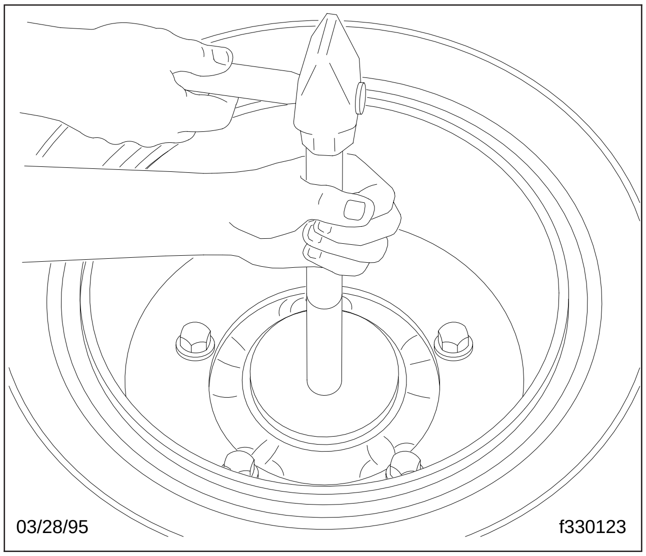


Fig. 6, Drive the Seal Into the Hub

7.4 Lubricate the inside diameter of the seal with clean oil.

8. Install the hub, and adjust the wheel bearings. For instructions, see **Section 33.01**. Fill the hub cavity with clean oil.
9. Install the hub cap with a new gasket. Tighten the hub cap nuts 15 lbf·ft (20 N·m). Add oil to the level shown on the window. See **Fig. 7**. Turn the hub and allow the oil to settle. Recheck the hub and fill to a level between the oil line and about 1/4 inch (6 mm) above the oil line. Do not overfill the hub. Install the vent plug or threaded filler plug.
10. Spin the wheel and check the oil level.
11. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

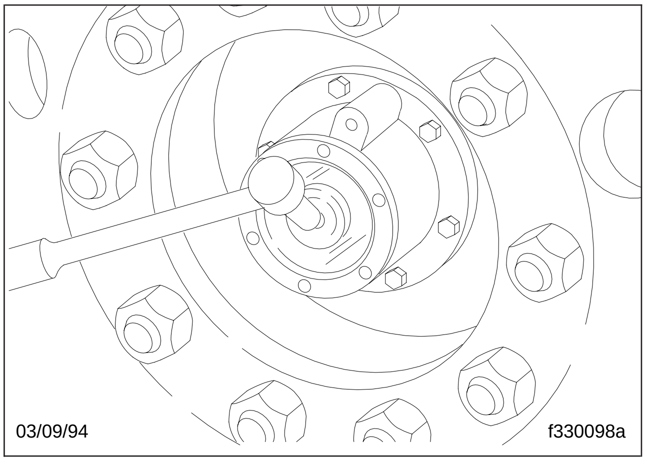


Fig. 7, Fill the Hub With Oil

Seal Replacement, Stemco®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

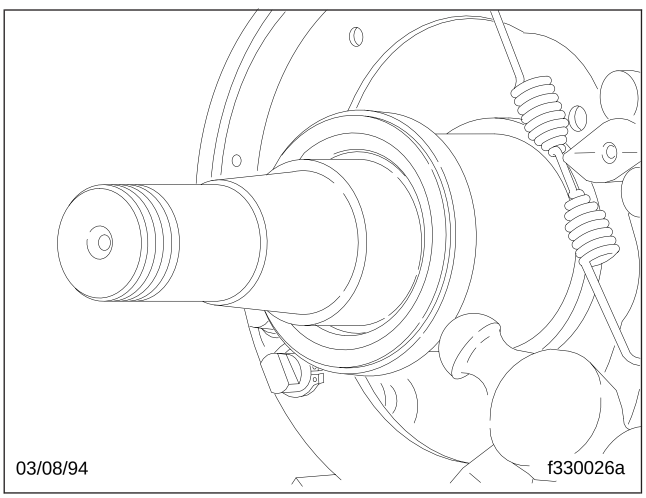


Fig. 1, Remove the Axle Ring

5. Using a wire brush, remove any old sealant and corrosion from the axle spindle and shoulder. Remove any burrs with an emery cloth. See **Fig. 2**. Wipe the spindle and shoulder clean with safety solvent.

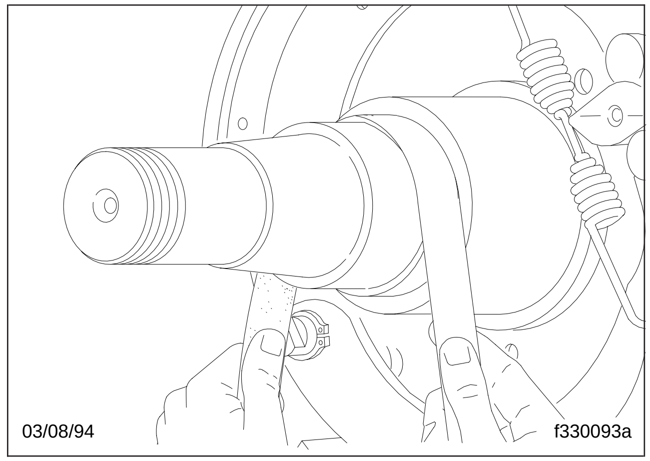
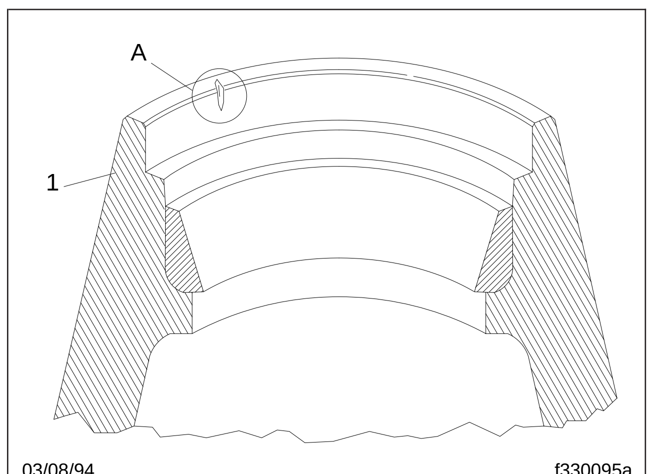


Fig. 2, Clean the Axle Spindle

6. Remove any burrs from the inside of the hub bore. See **Fig. 3**. The hub bore must be free of burrs that will scratch the outer surface of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.



A. Check for burrs.
1. Hub

Fig. 3, Inspect the Hub Bore

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

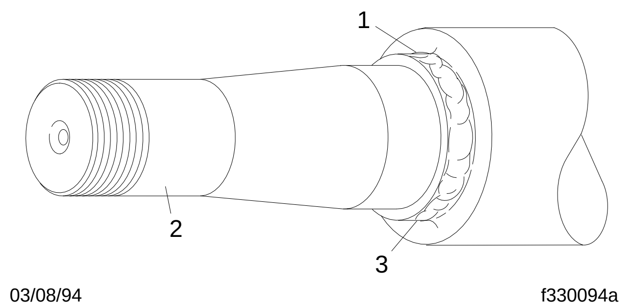
Seal Replacement, Stemco®

7. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged parts as necessary.

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

8. If burrs were removed from the spindle shoulder, apply a thin layer of non-hardening sealant to the spindle shoulder. See **Fig. 4**.



1. Sealant
2. Spindle
3. Shoulder

Fig. 4, Apply Sealant to the Spindle Shoulder

NOTE: Use a non-hardening sealant such as Permatex® Number-2 or Loctite® 515.

9. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside circumference of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. See **Fig. 5**.

CAUTION

Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.

10. Position the Stemco installation tool over the spindle. See **Fig. 6**. Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After the tool bottoms, turn it while applying several light taps

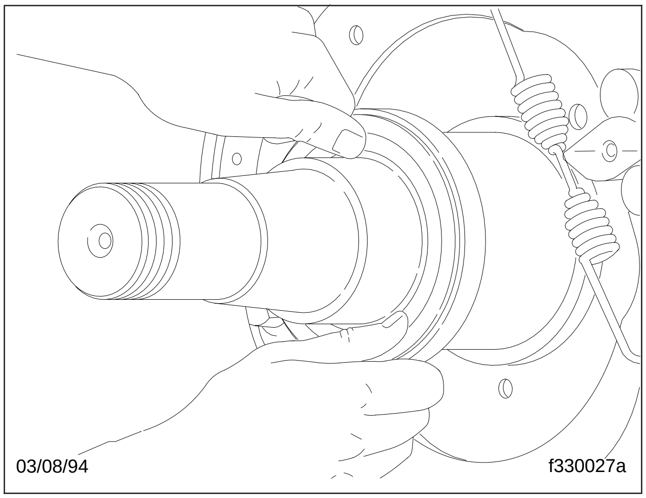


Fig. 5, Place the Seal on the Spindle

with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.

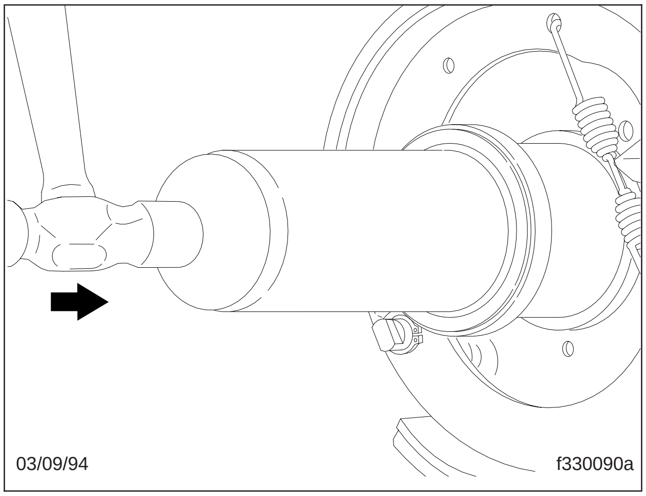


Fig. 6, Drive the Seal onto the Spindle

IMPORTANT: Use only the tool specified by Stemco for the vehicle's axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

11. Make sure there are no gaps between the ring and shoulder. See **Fig. 7**.

12. Coat the inner wheel bearing with oil and install it on the spindle. See **Fig. 8**. No additional oil is

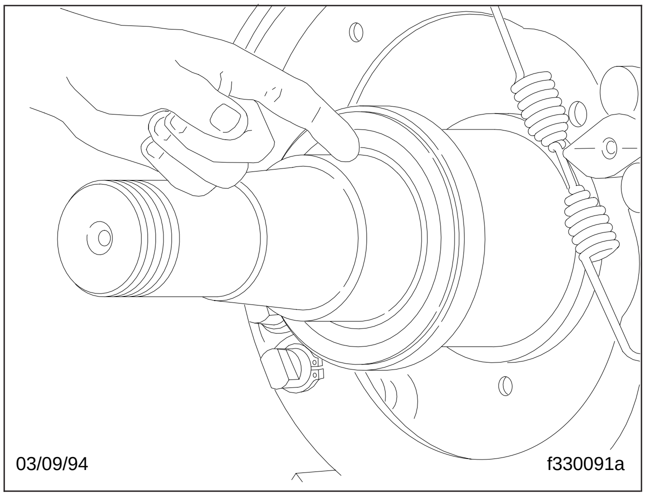


Fig. 7, Check the Ring for Gaps

needed on the outside of the seal. The seals are lubed at the factory.

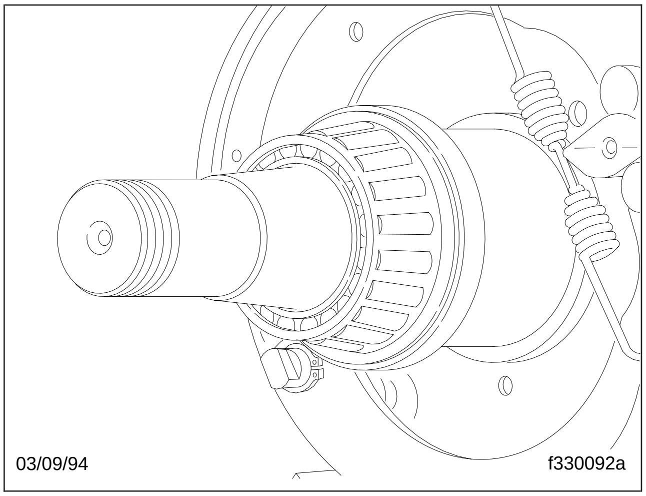


Fig. 8, Install the Inner Bearings

13. Install the hub and wheel bearings. For instructions, see **Section 33.01**.

IMPORTANT: Do not force the wheel onto the seal. The wheel will seat on the seal when the adjustment nut is tightened.

14. Adjust the wheel bearings. For instructions, see **Section 33.01**.

15. Install the hub cap with a new gasket. Tighten the hub cap nuts 15 lbf·ft (20 N·m). Add oil to the level shown on the window. See **Fig. 9**. Turn the hub and allow the oil to settle. Recheck the hub and fill to a level between the oil line and about 1/4 inch (6 mm) above the oil line. Do not overfill the hub. Install the vent plug or threaded filler plug.

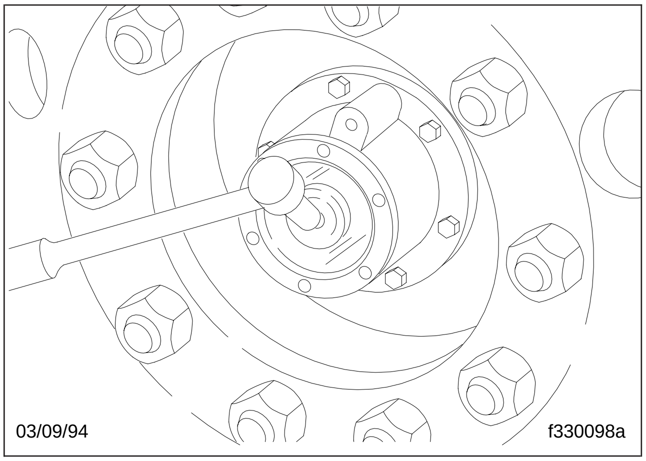


Fig. 9, Fill the Hub with Oil

16. Spin the wheel and check the oil level.

17. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

Specifications

Bearing Centering Tool Interchange				
Spindle Type	Bearing Cone	Centering Tool Number		
		Dana Spicer® Outrunner™	Chicago Rawhide	National®
—	641	BCT-6	706	RD-406
—	39581	BCT-2	702	RD-402
—	557A	BCT-3	703	RD-403
FL	6461A	BCT-8	708	RD-418
—	H715345	BCT-16	716	RD-407
—	HM212044	BCT-3	703	RD-403
—	HM212047	BCT-4	704	RD-404
FF	HM212049	BCT-6	706	RD-406

Table 1, Bearing Centering Tool Interchange

Adapter Plates		
Seal	Adapter Plate	Color
847	847-T	Blue
855	855-T	
857	857-T	
863	863-T	

Table 2, Adapter Plates

General Information

Detroit front axles have a unique steering knuckle design that reduces vibration and wear. Low-friction, high-strength needle bearings roll on a large-diameter kingpin, replacing the conventional bushings.

They are compatible with all standard industry model brakes, hubs, and wheel bearings.

There are three basic models for the Detroit front axle: Model 2, Model 3, and Model 5. The basic model is indicated by the numbers on the axle identification tag.

The following explains a typical model number.

Typical Model Number: AF-12-3.

- *AF* = front axle
- *12* = Weight Rating (times 1000 lbs.)
- *3* = Model Number

NOTE: Detroit axles are a proprietary product, though in some applications they may be referred to as "Freightliner" or "Axle Alliance" axles or "MB components."

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the rear tires. Put the transmission in neutral.
2. At both ends of the front axle, loosen all the wheel nuts.

WARNING

Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, causing the vehicle to fall, which could result in serious injury or death.

3. Raise the front of the vehicle and support it with safety stands.
4. Drain the air system.
5. Remove the front wheel and tire assemblies. For instructions, see **Group 40**.
6. Remove the brake drums and front hubs from the axle. See **Section 33.01, Subject 100** for instructions.
7. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
8. Remove the ABS sensors and wiring from the brake spiders (anchor plates) and secure them and their wiring out of the way.
9. Remove the brake air chambers and the slack adjusters. For instructions, see the applicable sections in **Group 42**.
10. Remove the brake spiders from the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
11. Disconnect the drag link from the axle steering arm.
12. If so equipped, disconnect the sway bar from the axle brackets.
13. Using a suitable jack, support the front axle.
14. Remove the U-bolt nuts or remove the nuts holding the axle beam to the leaf springs and the air bag brackets, as applicable.
15. Remove the U-bolts, if applicable.
16. Remove the axle from the vehicle.
17. If you are replacing the steering knuckles, put the axle on a suitable stand and secure it to prevent it from moving.

Installation

1. With the axle on a suitable jack, position it under the vehicle.
2. For vehicles with front air suspension, raise the axle so that the holes in the axle beam line up with the bolts holding the air bags to the leaf springs. Install the nuts and washers and tighten the nuts 220 lbf·ft (298 N·m).

   For vehicles with a leaf-spring front suspension, install the U-bolts and nuts. For instructions on tightening U-bolt nuts, see the applicable section in **Group 32**.
3. If so equipped, connect the sway bar to the axle brackets. Tighten the sway bar fasteners 100 lbf·ft (136 N·m).
4. Connect the drag link to the steering arm. For instructions, see the applicable section in **Group 46**.
5. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
6. Install the brake air chambers and slack adjusters onto the axle. For instructions, see the applicable sections in **Group 42**.
7. Install the ABS sensors.
8. Install the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
9. Install the hubs and adjust the wheel bearings. For instructions, see **Section 33.01, Subject 100**.
10. Install the brake drums.
11. Adjust the slack adjusters. For instructions, see the applicable section in **Group 42**.
12. Install the tire and wheel assemblies. For instructions, see **Group 40**.
13. Raise the vehicle, remove the safety stands, and lower the vehicle.
14. Start the engine and build the air pressure.

Axle Removal and Installation

15. If equipped with a front air suspension, check that the suspension air bags are inflating correctly.
16. Remove the chocks from the rear tires.

Disassembly

NOTE: The following procedures can be done with the axle installed on the vehicle or with the axle removed from the vehicle.

1. If the axle has been removed, make sure it is securely mounted on a suitable stand. Go to the step for removing the tie rod from the tie-rod arm.

   If the axle is on the vehicle, park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the rear tires. Drain the air system.

2. If the axle is on the vehicle, do the following substeps to gain access to the steering knuckle.

   2.1 Remove the wheel and tire assembly from the applicable side of the vehicle.

   2.2 Remove the brake drum and hub. For instructions, see **Section 33.01, Subject 100**.

   2.3 Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.

   2.4 If so equipped, remove the ABS sensor and wiring from the brake spider (anchor plate) and secure the sensor and the wiring out of the way.

   2.5 Disconnect the air line from the brake air chamber, then remove the air chamber and the slack adjusters. For instructions, see the applicable sections in **Group 42**.

   2.6 Remove the brake spider from the axle flange. For instructions, see the applicable service brake section in **Group 42**.

   2.7 Disconnect the drag link from the steering arm, if present.

   NOTE: On the driver's side of the vehicle, the steering arm connects to the steering knuckle. On the passenger's side, no steering arm is present.

3. If not already done, disconnect the tie rod from the tie-rod arm.

4. Remove the tie-rod arm from the steering knuckle. See **Fig. 1**.

5. If applicable, remove the steering arm. See **Fig. 1**.

6. Remove the steering knuckle and spindle assembly from the axle beam. See **Fig. 1**.

   6.1 Remove the upper and lower snap rings that hold the cover plates in place.

   6.2 Remove the upper and lower cover plates from the steering knuckle.

   6.3 Remove and discard the O-ring from the edges of each cover plate.

   6.4 Note the orientation of the draw keys and the kingpin, then remove the draw keys and nuts that hold the kingpin in place.

   6.5 Using a brass drift, remove the kingpin by driving it downward. Make a note of where the needle bearings were installed.

   6.6 Remove the spacer(s) and shim(s) from the upper surface of the axle beam bore.

   6.7 Push down on the steering knuckle and spindle assembly to clear the lip on the thrust friction bearing and remove the assembly from the axle beam bore.

NOTE: The steering knuckle on the passenger's side (side without a steering arm) has a thrust roller bearing instead of a thrust friction bearing. Unlike the thrust friction bearing, the thrust roller bearing has no protruding lip at the top. When removing the thrust roller bearing from the axle beam bore, it is not necessary to push down on the steering knuckle.

7. Remove the grease seal from the upper steering-knuckle bore.

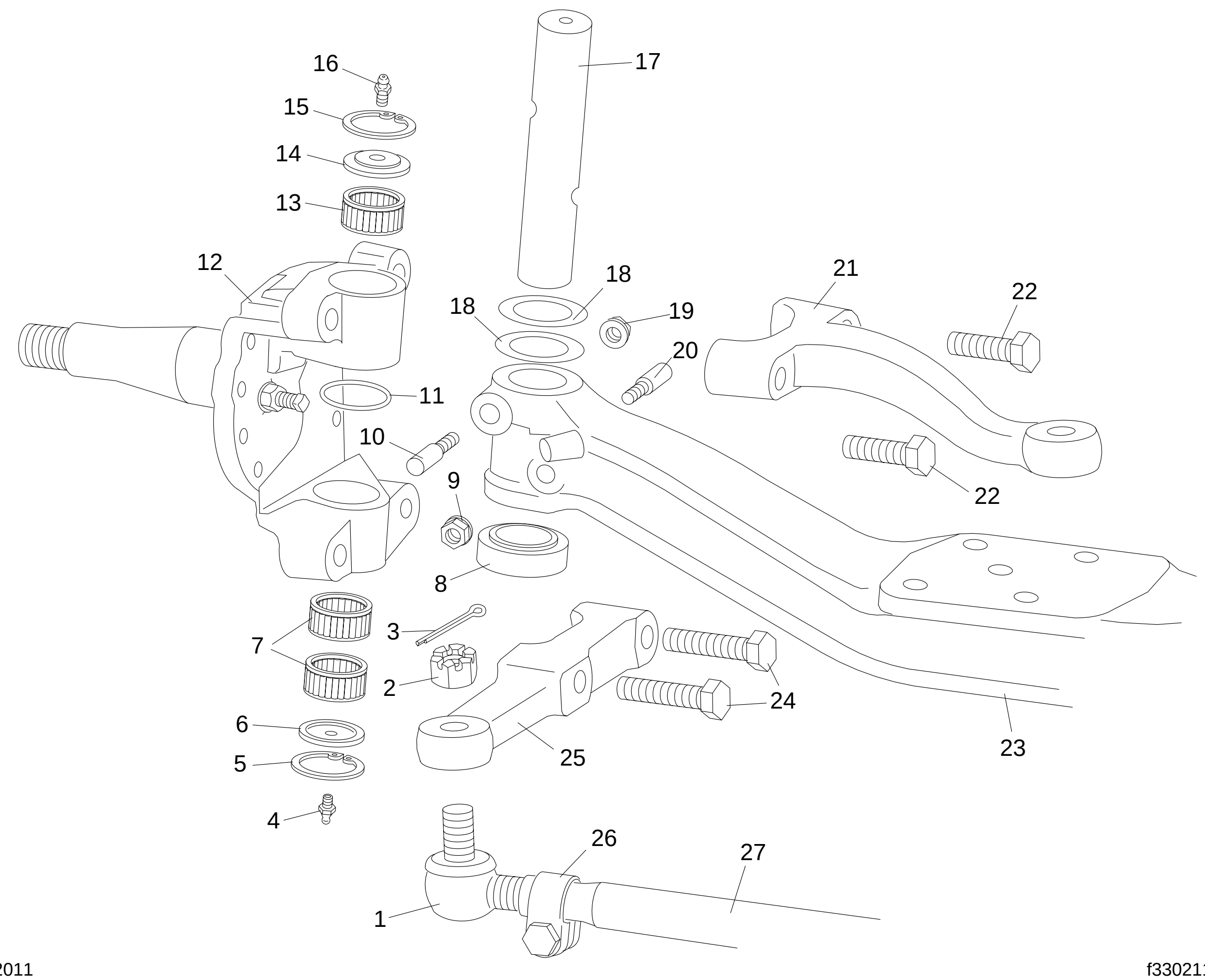
8. Remove the thrust friction bearing (driver's side) or the thrust roller bearing (passenger's side) from the top of the lower steering knuckle bore.

NOTE: If removing the thrust friction bearing (driver's side), note the orientation of the bearing for future reference.

9. Using a brass drift, drive out the needle bearings from the steering knuckle bores.

10. If needed, repeat the entire procedure for the other side of the axle assembly.

Steering Knuckle Disassembly and Assembly



NOTE: The number of upper and lower needle bearing sets may vary, depending on the axle model.

1. Tie-Rod Ball Joint
2. Castle Nut
3. Cotter Pin
4. Lower Grease Fitting
5. Lower Snap Ring
6. Lower Cover Plate
7. Lower Needle Bearings (may be one or two sets)
8. Thrust Friction Bearing (thrust roller bearing on the passenger side)
9. Lower Draw Key Nut
10. Upper Draw Key
11. Grease Seal
12. Steering Knuckle
13. Upper Needle Bearing (may be one or two sets)
14. Upper Cover Plate
15. Upper Snap Ring
16. Upper Grease Fitting
17. Kingpin
18. Shim
19. Upper Draw Key Nut
20. Lower Draw Key
21. Steering Arm
22. Steering Arm Capscrew
23. Axle Beam
24. Tie-Rod Arm Capscrews
25. Tie-Rod Arm
26. Tie-Rod Clamp
27. Tie-Rod Tube

Fig. 1, Front Axle Components (driver side shown)

Assembly

IMPORTANT: If replacing the kingpin, use a complete rebuild kit with all new components.

1. Clean the steering knuckle bores and the axle beam bores. Check for damage such as grooves, scratches, and pitting.

   If any bores show significant damage, replace the component.
2. Install the grease seal — with the grooved side down (toward the road) — into the top of the upper steering knuckle bore. Carefully drive the seal down into the bore until the outer edge of the seal is flush with the bottom edge of the bore. Make sure the seal is not cocked.
3. Install new needle bearings into the bores of one of the steering knuckles. Install the same number of bearings as was removed.

NOTE: Install the needle bearings just far enough into the bores so that the cover plates can be installed.

4. Install a new thrust friction bearing (driver's side) or thrust roller bearing (passenger's side) into the top of the lower steering knuckle bore. Install the thrust friction bearing (or thrust roller bearing) with the sealed side up.

NOTE: The thrust friction bearing has a protruding lip at the top. The thrust roller bearing has no such protruding lip.

5. Partially install the steering knuckle onto the axle beam.

   5.1 Making sure the flats on the kingpin are aligned with the draw-key holes in the axle beam, put the new kingpin into the top bore of the steering knuckle. Note that the top of the new kingpin is clearly marked. Push the kingpin through the axle beam bore until the upper end of the kingpin is flush with the upper surface of the axle beam bore.

   5.2 Align the steering knuckle with the axle beam, then check the clearance between the axle beam bore and the upper steering knuckle bore. Clearance is to be a maximum of 0.003 inch (0.08 mm).

   IMPORTANT: To correctly check the clearance, the thrust friction or thrust roller bearing must be installed correctly, and upward pressure must be applied to the steering knuckle.

   5.3 If needed, install sufficient spacers to reduce the clearance to 0.002 to 0.003 inch (0.05 to 0.08 mm).
6. Install the kingpin fully into the steering knuckle bores, making sure the flats on the kingpin are still aligned with the draw-key holes in the axle beam.
7. Install new upper and lower draw keys and nuts. See **Fig. 1**.

   7.1 Install the upper draw key from the back of the axle, and the lower one from the front of the axle.

   IMPORTANT: Make sure the new draw keys are the same length as those removed. On some axle models the lower draw key is longer than the upper one.

   7.2 Tighten the draw-key nuts 30 to 55 lbf·ft (40 to 75 N·m).
8. Install new grease fittings and cover plates.

   8.1 Install the new upper cover plate (with a new O-ring) and the snap ring. Install the new grease fitting into the cover plate.

   8.2 Install the new lower cover plate (with a new O-ring) and the snap ring. Install the new grease fitting into the cover plate.
9. Install the steering arm. Apply Loctite® 277 to the threads and tighten the steering arm capscrews: if M20 capscrews are used, tighten them 425 lbf·ft (575 N·m); if M24 capscrews are used, tighten them 664 lbf·ft (900 N·m).
10. Attach the tie-rod arm to the steering knuckle. Apply Loctite® 277 to the threads and tighten the tie-rod arm capscrews: if M20 capscrews are used, tighten them 425 lbf·ft (575 N·m); if M24 capscrews are used, tighten them 664 lbf·ft (900 N·m).
11. Attach the tie-rod arm to the tie rod. Tighten the castle nut 120 to 170 lbf·ft (163 to 230 N·m) plus a maximum of one-sixth of a turn to align a slot in the castle nut with the cotter pin hole in the tie

Steering Knuckle Disassembly and Assembly

rod stud. Insert the cotter pin and bend the tangs to secure it.

12. If removed, install the axle.
13. If removed, connect the drag link to the steering arm.
14. Install the brake spider on the axle flange. For instructions, see the applicable service brake section in **Group 42**.
15. Install the brake air chambers and slack adjusters on the axle. For instructions, see the applicable sections in **Group 42**.
16. Install the ABS sensor.
17. Install the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
18. Install the hub and adjust the wheel bearings. For instructions, see **Section 33.01**.
19. Install the brake drum.
20. Install the tire and wheel assembly. For instructions, see **Group 40**.
21. If necessary, repeat the entire procedure for the other side of the vehicle.
22. Raise the vehicle, remove the safety stands, then lower the vehicle.
23. Remove the chocks from the tires.

Torque Values			
Application	**Size**	**Class**	**Torque: lbf·ft (N·m)**
Air Bag-to-Leaf Spring Nuts	—	—	220 (298)
Draw-Key Nuts	—	—	30–55 (40–75)
Sway Bar Fasteners	—	—	100 (136)

Table 1, Torque Values

General Information

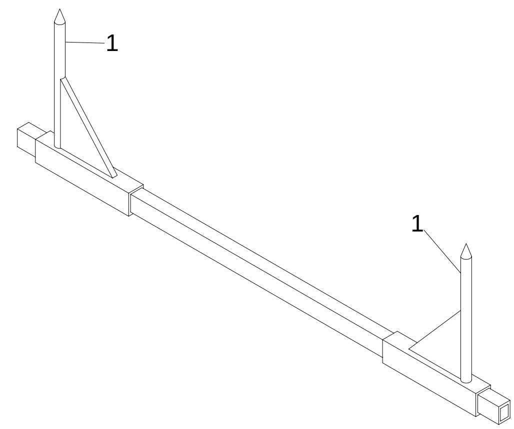
Rear axle alignment should be checked whenever rear axle or suspension components are replaced. It should also be checked when there is excessive front and rear tire wear, or hard or erratic steering.

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. If this type of equipment is not available, the basic tools needed for checking rear axle alignment on tandem or single axles are a straightedge (that is nonflexible and at least as long as the axle), steel tape rule, and trammel bar or center point bar.

The straightedge is used to see if a single axle, or a forward-rear axle of a tandem axle installation, is in alignment with the frame. The distance from the straightedge to the center of the wheel hub is measured on each side of the vehicle; any difference in the measurements means that the axle is out of alignment.

A center point bar (**Fig. 1**) is used to see if the forward-rear axle and rearmost axle of a tandem installation are aligned with each other (parallel). It has adjustable pointers at each end, which are inserted into the axle cap holes of each axle. By comparing the distance between the two axles on one side to the distance on the other side, it can be determined if the axles are parallel.

Instructions and a list of materials for making a center point bar are in **Subject 130**.



1. Adjustable Pointer

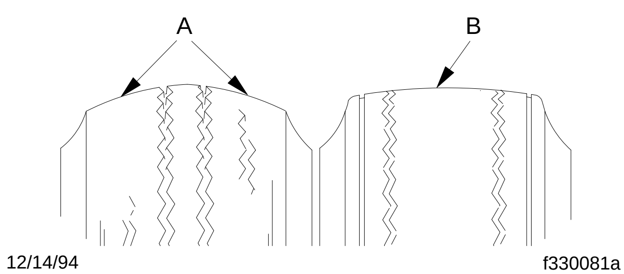
Fig. 1, Center Point Bar

The following preliminary checks should be completed before checking any alignment measurements.

Preliminary Checks

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. Relieve internal stresses in the suspension by driving the vehicle back and forth in a straight line.

1. Wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 50 mph (80 km/h). Off-balance wheel assemblies cause vibrations that result in severely shortened life for tires and suspension parts.
2. Do not mix tires of different size, type, or weight. Tire wear should be even and not worn to limits exceeding government specifications. Refer to **Group 40** in this manual and **Group 40** in the *Columbia Maintenance Manual* for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. Refer to **Group 40** in this manual for recommended pressures. An underinflated tire causes tread wear completely around both tire shoulders. An overinflated tire causes tread wear in the center of the tire. See **Fig. 1.**



A. Underinflation Wear
B. Overinflation Wear

Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires

4. Check for out-of-round wheels and wheel stud holes. Replace the wheel if any of these conditions exist.
5. On each side of the vehicle, check the height of the chassis above the ground; for instructions, see **Group 32** in this manual or the suspension manufacturer's service literature. Sagging, fatigued, or broken suspension springs create a lopsided vehicle appearance and an unbalanced weight distribution. Anything that changes the ratio of weight on the springs affects the alignment angles and also the tire tread contact area. Replace damaged springs as instructed in the applicable suspension section.
6. Check and, if necessary, correct frame rail alignment as instructed in **Group 31** in this manual.
7. Check and, if necessary, adjust rear axle tracking. For instructions, see **Group 32** in this manual or the suspension manufacturer's service literature.
8. Check the rear axle wheel bearings for wear and incorrect adjustment. Refer to **Section 35.01** for instructions.

Checking Using Computerized Alignment Systems

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

Follow the manufacturer's instructions for use of the alignment equipment, and use the alignment measurements given in **Fig. 1** and the applicable tables in **Specifications 400**.

Checking Using the Manual Method

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction.

1. Park the vehicle on a level surface. Relieve internal stresses in the suspension by driving the vehicle back and forth in a straight line, or by jacking the axle up and letting it down.
2. Chock the front tires and place the transmission in neutral. Release the parking brakes.

NOTICE

Do not use scribe lines for marking on frame rails. Scribe lines, which cut or scratch the metal, can develop into starting points for structural damage to the frame.

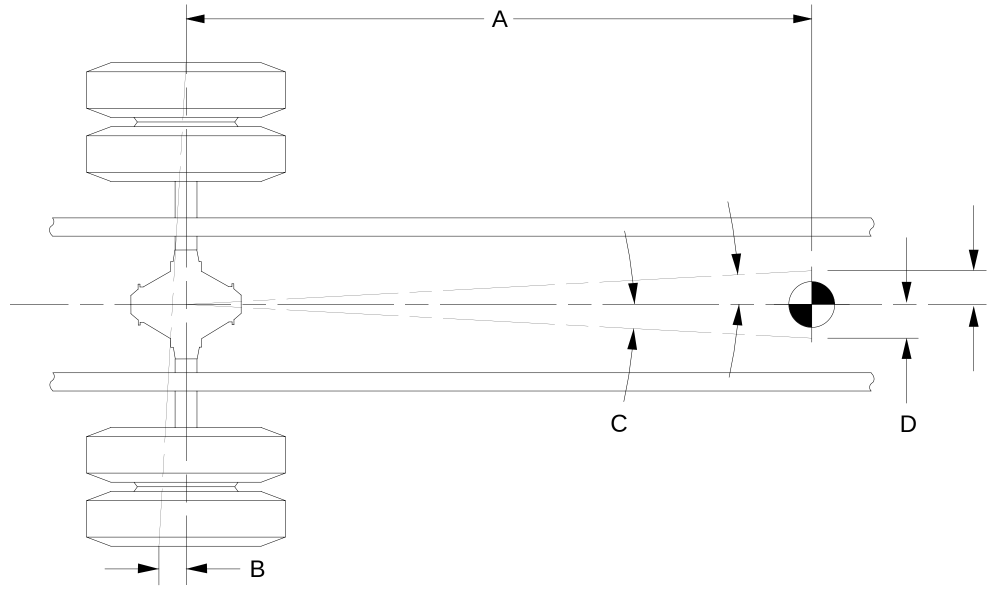
3. Select a point on the frame rail forward of the rear axle, and mark it using a pencil or soapstone. Then mark two other points, exactly 4 inches (102 mm) forward and to the rear of the original point. Make sure that all three marks are aligned and of equal distance from the outside edge of the frame rail. Using a center point or trammel bar, place one pointer on the forward-most point, and make an arc with a pencil or soapstone on the opposite frame rail. Then place the pointer on the rearmost point and make an arc on the opposite frame rail intersecting the first arc. See **Fig. 2**. The point where the two arcs intersect and the original (or middle) point on the opposite frame rail have matching locations.
4. Line up the straightedge with the two matching points. Check that the straightedge extends out about the same distance on each side of the frame rail. Using C-clamps, clamp the straightedge to the frame; see **Fig. 3**. The straightedge must line up exactly with the points.
5. Measuring from the outside edge of each frame rail, mark the straightedge on both sides of the frame. The marks (**Fig. 3**, Ref. A) must be of equal distance from the frame and as far from the frame rail as the tires are at their farthest point from the frame.

IMPORTANT: The distance between the mark on the straightedge and the frame rail must be equal on both sides of the vehicle.

6. On each side of the vehicle, measure the distance from the mark on the straightedge to the center of the wheel hub. See **Fig. 3**.

   The difference between these measurements should be 1/4 inch (6 mm) or less. See **Fig. 1**. If the difference is more than 1/4 inch (6 mm), adjust the axle alignment. For instructions, see **Group 32** in this manual, or the suspension manufacturer's service literature.

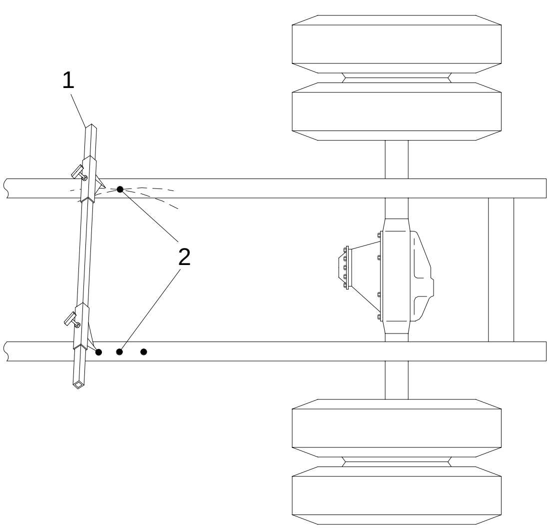
Alignment Checking, Single Axle



For items A and D, see Specifications 400.

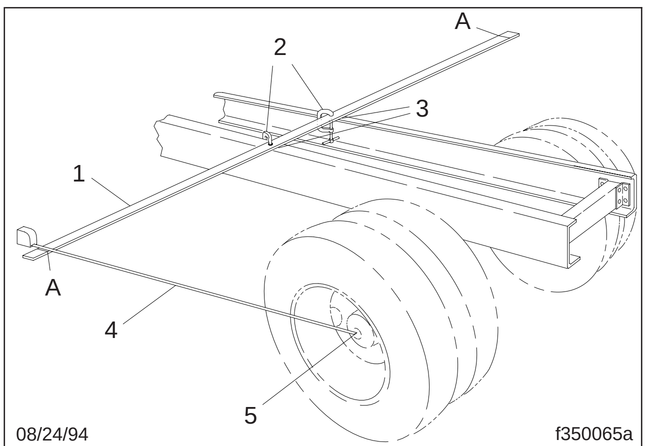
A. Distance from Rear Axle to Target (using Bee Line Alignment Tools)
B. Maximum Allowable Difference if Aligned Manually = ±1/4 inch (6 mm)
C. Maximum Allowable Tolerance if Aligned with Hunter Tools = ±0.18 degree
D. Maximum Allowable Tolerance if Aligned with Bee Line Tools

Fig. 1, Alignment Measurements



1. Center Point/Trammel Bar
2. Matching Points

Fig. 2, Marking an Arc



A. Marks

1. Straightedge
2. C-Clamps
3. Matching Points
4. Tape Measure
5. Wheel Hub

Fig. 3, Straightedge to Wheel Hub Measurement

Alignment Checking, Tandem Axle

To align a tandem axle, first, check and (if needed) align the rearmost axle; then, check and (if needed) align the forward-rear axle.

Checking Using Computerized Alignment Systems

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

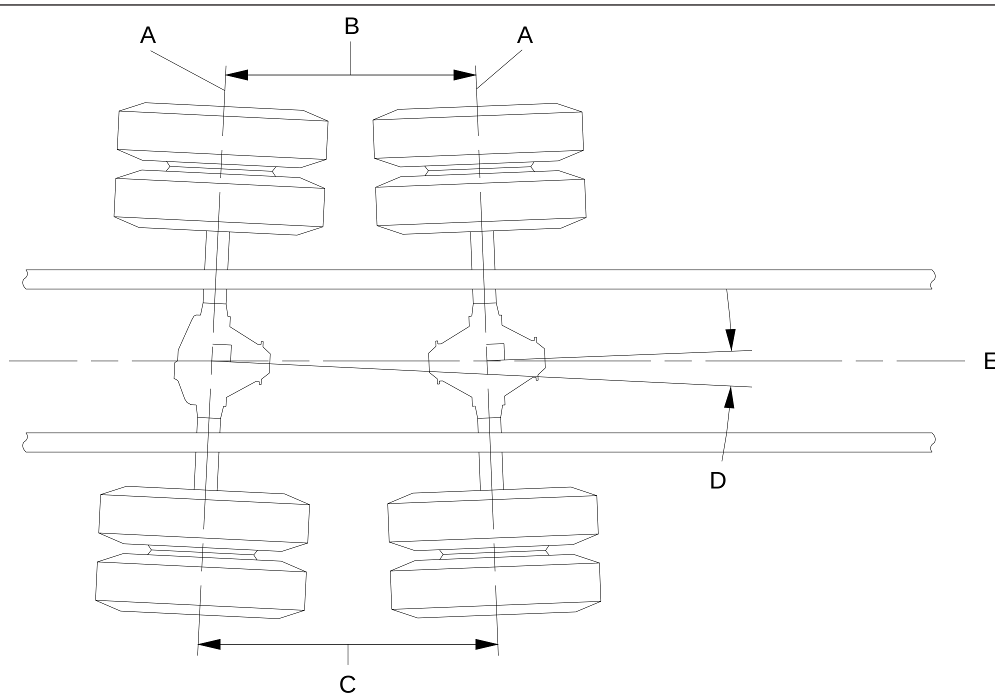
Follow the manufacturer's instructions for use of the alignment equipment, and use the alignment measurements given in **Fig. 1** and the applicable tables in **Specifications 400**.

Checking Using the Manual Method

A straightedge and a center point bar are needed to manually align a tandem axle. For instructions for making a center point bar, see **Subject 130**.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction.

1. Using the instructions in **Subject 110**, check and align the rearmost axle.
2. Using a center point bar, set the two points into the axle cap holes as shown in **Fig. 2**. Lock them in place by tightening the setscrews.
3. With the points still locked in place, move the center point bar to the other side of the vehicle, set the two points into the axle cap holes, and compare the axle spacing. If there is a difference



A. Axle Centerline
B. Left-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
C. Right-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
D. Maximum Tolerance as Measured with Hunter Alignment Tools = ±0.08 degree
E. Vehicle Centerline

Fig. 1, Tandem Axle Measurements

Alignment Checking, Tandem Axle

of 1/8 inch (3 mm) or less between the spacing on one side of the vehicle compared to the other, no further action is necessary. If the difference is more than 1/8 inch (3 mm), adjust the forward-rear axle alignment. See **Fig. 1**. For instructions, see **Group 32** in this manual, or the suspension manufacturer's service literature.

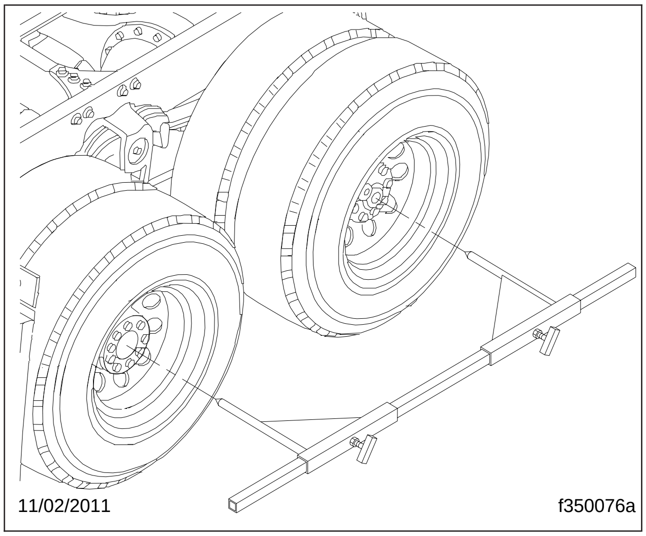


Fig. 2, Center Point Bar Placement

Materials Required

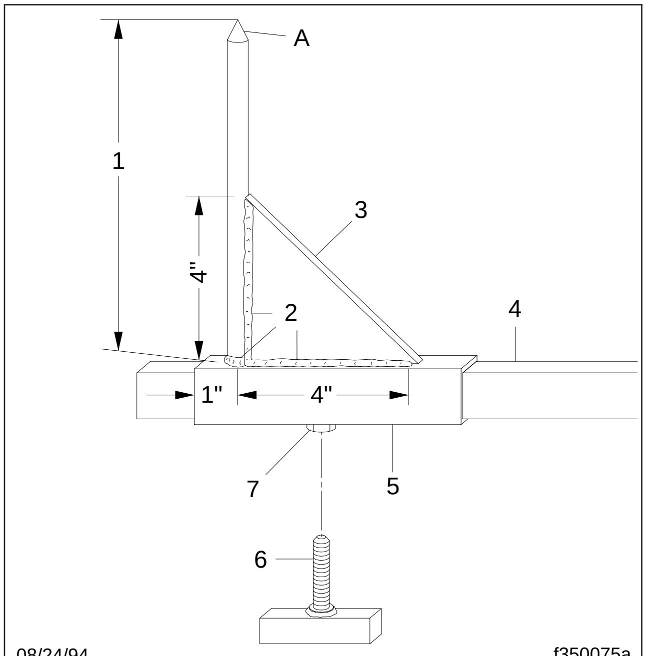
NOTE: To obtain metric conversions (millimeters), multiply the number of inches by 25.4.

The following materials are required:

- 62" of square steel tube (1" x 1", measured outside)
- 12" of square steel tube (1-1/8" x 1-1/8", measured inside)
- 20" of 3/8" steel rod
- two 1/2" x 3" pieces of steel square-bar stock
- one 4" x 4" steel plate, 1/8" thick
- two 3/8–16 capscrews (grade 5), 2" long
- two 3/8–16 hexnuts (equivalent to grade 5)

Construction

1. Cut the 1-1/8 x 1-1/8 inch (inside measurement) square steel tube in half to obtain two pieces 6 inches long. These will be the sliding members (slides) of the center point bar.
2. Cut the 4-inch by 4-inch steel plate diagonally into two pieces (gussets). Weld one gusset to each slide, as shown in **Fig. 1**.
3. Cut the steel rod in half to obtain two 10-inch rods. Grind one end of each to form a point.
4. Weld the pointed steel rods to the slides and gussets, as shown in **Fig. 1**.
5. Drill a 1/2-inch hole in the center of each slide, on the side opposite where the pointer was welded. Drill through only one side of the tube.
6. Directly over each hole drilled in the step above, weld a 3/8–16 nut (equivalent to grade 5).
7. Weld a piece of steel stock, about 1/2-inch wide by 3-inches long, over the head of each of two 3/8–16 by 2-inch long capscrews.
8. Place a slide over each end of the 60-inch piece of steel tube, with the pointed rods to the outside. Screw the handscrews (made in the step above) into the slides until they are clamped tightly to the cross tube.



A. Grind to a point.

1. 3/8-Inch Diameter Rod
2. Weld
3. Gusset
4. 1-Inch Square Steel Tube
5. 1–1/8 Inch Square Steel Tube
6. 3/8–16 Bolt
7. 3/8–16 Nut

Fig. 1, Center Point Bar Construction

Specifications

Maximum Tolerance from Perpendicular, Manual Method	
Method	**Maximum Tolerance ± from Perpendicular**
Manual	1/4-inch (6 mm)

Table 1, Maximum Tolerance from Perpendicular, Manual Method

Maximum Tolerance from Perpendicular, Hunter Equipment	
Method	**Maximum Tolerance ± from Perpendicular**
Hunter *	±0.18 degree

* To use Hunter alignment equipment, refer to the applicable Hunter service literature.

Table 2, Maximum Tolerance from Perpendicular, Hunter Equipment

Maximum Tolerance from Perpendicular at Target, Bee Line Equipment	
Distance from the Forward or Rear Drive Axle to Target inches (mm)	**Maximum Tolerance± from Perpendicular inches (mm)**
100 (2540)	5/16 (8)
120 (3048)	3/8 (10)
140 (3556)	7/16 (11)
160 (4064)	1/2 (13)
180 (4572)	9/16 (14)
200 (5080)	5/8 (16)
220 (5588)	11/16 (17)
240 (6096)	3/4 (19)
260 (6604)	13/16 (21)

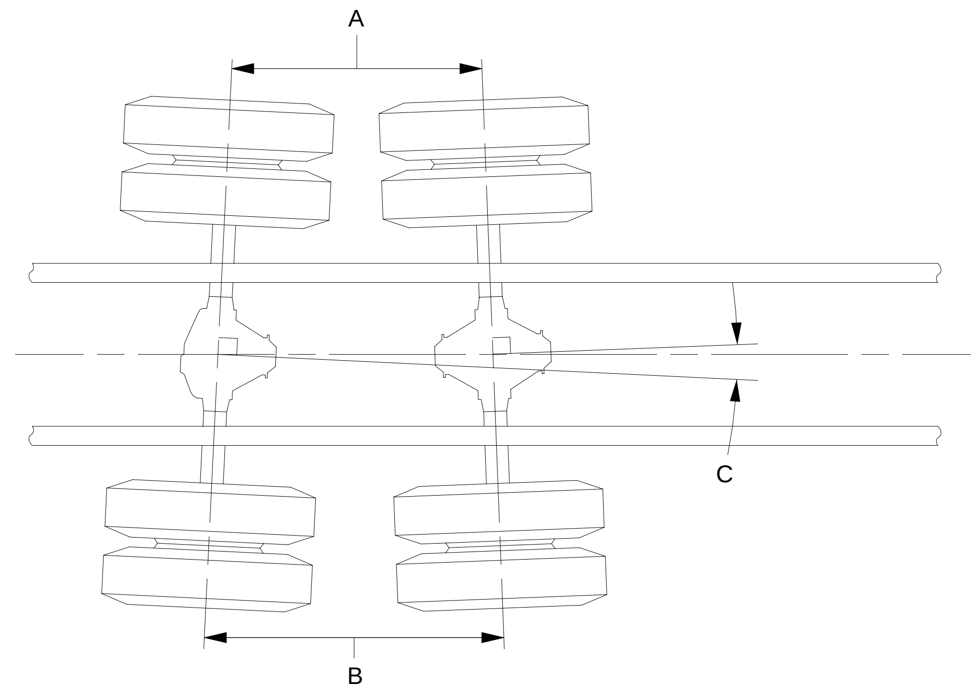
Table 3, Maximum Tolerance from Perpendicular at Target, Bee Line Equipment

Rear Axle Parallelism Specifications	
Method	**Maximum Tolerance**
Hunter	±0.08 degree maximum axle-to-axle difference; reference "C" in Fig. 1.

Rear Axle Parallelism Specifications	
Method	**Maximum Tolerance**
Bee Line or Manual	±1/8-inch max. difference in axle end-spacing; reference "B" minus "A" in Fig. 1.

Table 4, Rear Axle Parallelism Specifications

Specifications

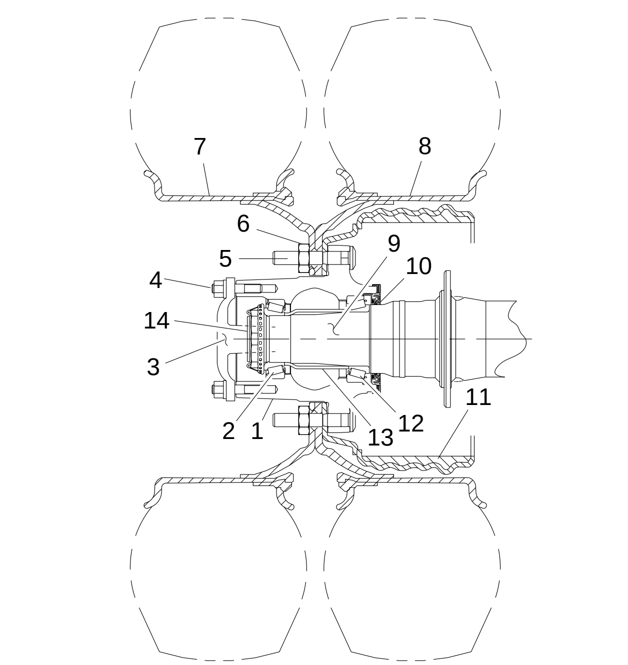


NOTE: See **Table 4** for values corresponding to callouts A, B, and C.

Fig. 1, Tandem Axle Measurements

General Information

Wheel end assemblies include the wheel hub, wheel bearings, axle spindle, brake drum (or rotor), wheel studs, and spindle nut. See **Fig. 1**.



1. Hub
2. Outer Wheel Bearing
3. Drive Axle Shaft
4. Drive Axle Stud
5. Wheel Stud
6. Wheel Nut
7. Outer Wheel
8. Inner Wheel
9. Spindle
10. Oil Seal
11. Brake Drum
12. Inner Wheel Bearing
13. Bearing Spacer
14. Spindle Nut

Fig. 1, Typical Wheel End Assembly with Drum Brakes

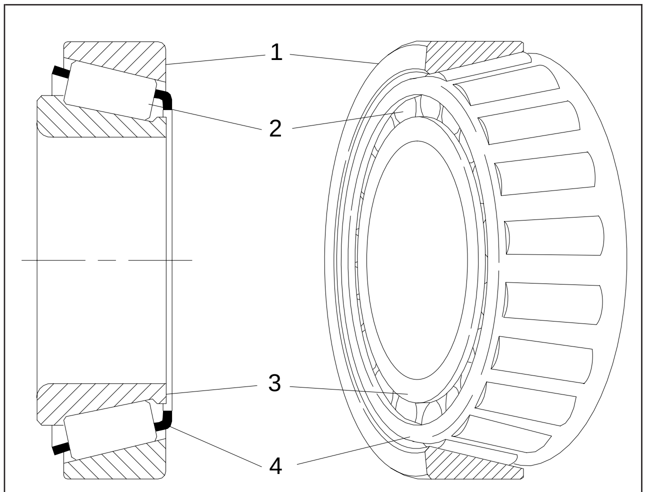
Wheel Hub

Some Colombia vehicles are equipped with ConMet PreSet® hubs. These hubs have a spacer between the inner and outer bearings that adjusts the bearings to the correct end play and preload when the retaining nut is tightened.

For more information about PreSet hubs, and hub removal and installation procedures, see **Subject 100**.

Tapered Wheel Bearings

Each hub has a set of inner and outer tapered wheel bearing assemblies. A typical tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. See **Fig. 2**. All components carry the load, with the exception of the cage, which spaces the rollers around the cone.



1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 2, Tapered Wheel Bearing Assembly

Drive Axle Spindle Assembly

The drive axle spindle assembly is made up of a drive axle flange and shaft, drive axle studs and stud nuts, a flange gasket, an axle spindle, an oil seal, and the locking assembly described above.

The surfaces of the spindle and the nut threads are machined. When these surfaces become damaged, repairs are necessary. There are standard methods for performing those repairs that preserve the proper alignment of the axle spindle assembly. Refer to the axle manufacturer for instructions.

NOTICE

The National Highway Traffic Safety Administration (NHTSA) has warned against repairs that involve cutting off a portion of a damaged spindle and welding on a replacement part. The heat of

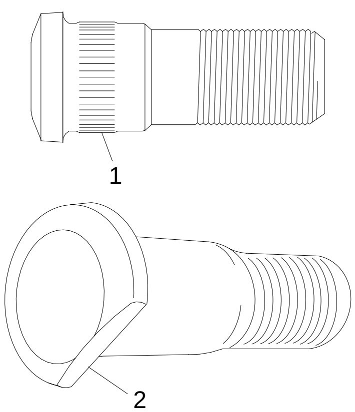
welding can reduce the strength of spindles made with heat-treated materials and lead to spindle failure. After the cutting and welding operations, the replacement part may not be correctly aligned on the spindle. This can cause damage to the spindle nut.

Brake Drum

The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

Wheel Studs

A headed wheel stud is used on rear axle disc wheel hub assemblies. Each of these studs has either serrations on the stud body or a flat area on the stud head to prevent the stud from turning in the wheel hub. See **Fig. 3**. Wheel studs are press-fit in the hub. For replacement procedures, see **Subject 180**.



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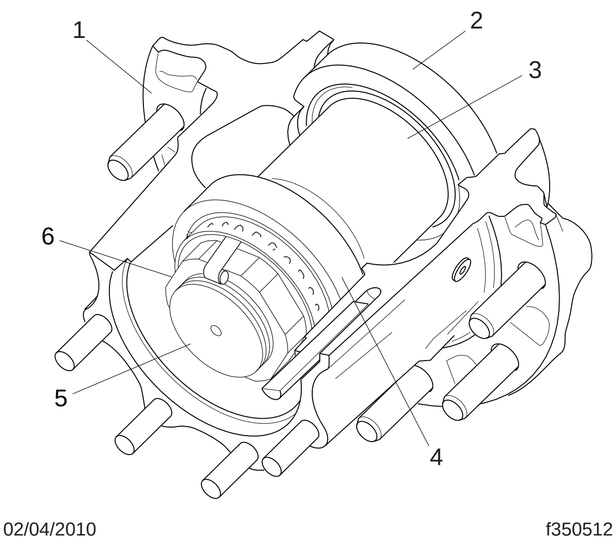
1. Serrations
2. Clipped Head

Fig. 3, Typical Wheel Studs

General Information

Some Columbia vehicles use ConMet PreSet® hubs, which are equipped with a unique bearing spacer between special inner and outer bearings. See **Fig. 1.**



1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Axle Spindle
6. Retaining Nut

Fig. 1, ConMet PreSet Hub, Cut-Away View

When installing a PreSet hub with the spacer and special PreSet bearings, the correct end play is set automatically and wheel bearing adjustment is unnecessary.

For vehicles equipped with ConMet PreSet hubs, it is highly recommended to **stay with the PreSet system** to optimize bearing and seal life. However, if you are replacing the bearings for a PreSet hub, and the special PreSet bearings are not available, standard wheel bearings can be used. In this case, the bearing spacer must be removed and the bearings adjusted manually. See the installation instructions for more information.

Removal

For a typical wheel end and axle assembly, see **Fig. 2**.

1. Shut down the engine and chock the front tires. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. For drum brakes, back off the slack adjuster to release the rear axle brake shoes.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

4. Remove both wheel and tire assemblies. For instructions, see **Group 40**.
5. For drum brakes, remove the brake drum. See **Subject 160** for instructions.

NOTE: Oil will spill as the drive axle shaft (or hub cap) and the wheel hub are removed. Place a suitable container under the drive axle flange or hub cap to catch any spilled oil. Dispose of the oil properly.

6. Remove the drive axle stud nuts and washers. See **Fig. 3**.

NOTICE

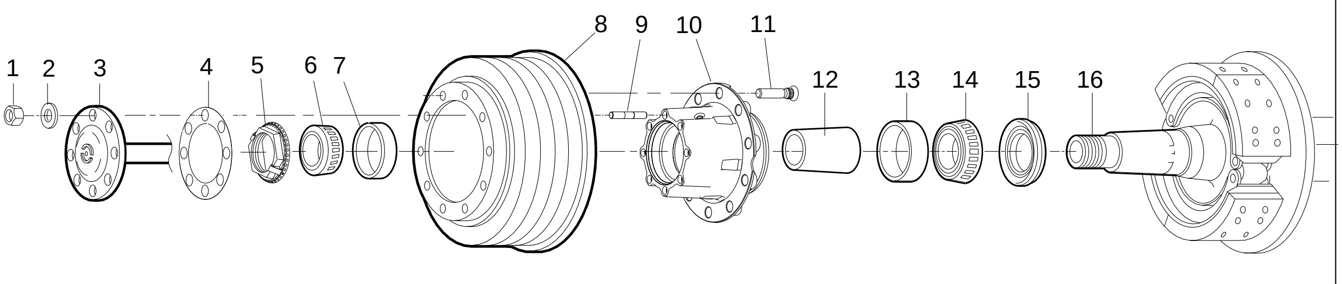
When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.

7. Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange. The shaft will usually spring slightly outward after the seal has broken.

NOTE: Even if the drive axle shaft doesn't spring outward, the seal may have loosened enough to allow the shaft to be pulled from the axle housing. If the seal has not broken, repeat the step above.

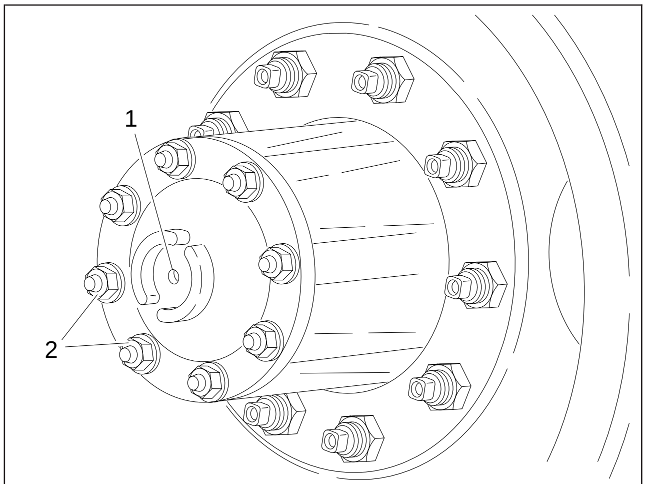
8. If so equipped, remove the tapered dowels and washers from the drive axle flange.

Hub Assembly Removal and Installation



1. Drive Axle Stud Nut
2. Washer
3. Drive Axle Shaft
4. Gasket
5. Axilok Nut
6. Outer Wheel Bearing
7. Outer Wheel Bearing Cup
8. Brake Drum
9. Drive Axle Stud
10. Hub
11. Wheel Stud
12. Bearing Spacer
13. Inner Wheel Bearing Cup
14. Inner Wheel Bearing
15. Oil Seal
16. Axle Spindle

Fig. 2, Typical Wheel End Assembly, Drive Axle with Drum Brakes



1. Center Portion of Drive Axle Flange
2. Drive Axle Studs and Nuts

Fig. 3, Wheel Assembly and Hub

9. Remove the drive axle shaft.
10. Remove and discard the gasket.
11. Remove the wheel bearing locking device:
    - For a Pro-Torq spindle nut, see **Subject 150**; then go to the next step.
    - For an Axilok spindle nut, see **Subject 190**; then go to the next step.

NOTICE

Be careful not to let the outer wheel bearing drop from the axle spindle. Dropping the bearing can warp the cage or damage the rollers, ruining the bearing. On vehicles equipped with WABCO ABS, use care when working with the hubs. To prevent damage to the tone wheel, do not drop the hub, or lay it down in a way that would damage the tone wheel.

12. Move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads).
13. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

NOTICE

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

14. Remove the hub. Be careful not to damage the axle spindle threads as the assembly is removed.

15. Remove the inner wheel bearing. Handle the bearings with clean, dry hands, then wrap the bearings in either clean oil-proof paper or lint-free rags. If the inner wheel bearing remains in the hub after the hub is removed from the axle, place a protective cushion where it will catch the bearings, then use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.
16. Remove the oil seal from the axle spindle, if not already removed. See **Section 35.02** for oil seal removal instructions.

Installation

For a typical wheel end and axle assembly, see **Fig. 2**.

1. Using cleaning solvent, remove the old oil from the axle spindle and the disassembled parts. Allow the parts to dry, or dry them with clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.
2. On brake drum assemblies with an aluminum hub, coat the hub-to-drum contact surfaces with Alumilastic compound or an equivalent.
3. Coat both bearing assemblies with fresh oil. Then install the inner wheel bearing and oil seal. Handle the bearings with clean, dry hands. See **Section 35.02** for oil seal installation instructions.

NOTICE

Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.

4. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.

NOTICE

Do not use a bearing spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.

5. If using PreSet bearings, ensure the tubular bearing spacer is in the PreSet hub.

   If replacing PreSet bearings with non-PreSet bearings, remove the tubular bearing spacer from inside the hub. Save it for future use to convert the hub back to the PreSet system.

NOTICE

- **On vehicles equipped with WABCO ABS, use care when installing the hubs. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.**
- **Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.**

NOTE: A temporary plastic alignment sleeve may be installed in the center of a new ConMet PreSet hub. It will be pushed out when the hub is installed on the axle spindle. If it is present, remove and discard this sleeve.

6. Mount the bearings and hub on the spindle.
7. Remove the friction tape, then adjust and secure the bearings:
   - If the axle is equipped with a four-piece bearing-lock system, see **Subject 140**; then go to the next step.
   - For a Pro-Torq spindle nut, see **Subject 150**; then go to the next step.
   - For an Axilok spindle nut, see **Subject 190**; then go to the next step.
8. Install a new gasket, and the drive axle shaft or, on non-drive axles, the hub cap. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.
9. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle stud nuts. Using the sequence shown in **Fig. 4**, tighten the nuts to the torque values given in the table in **Specifications, 400**.
10. For drum brakes, install the brake drum on the wheel hub. See **Subject 160** for instructions.

Hub Assembly Removal and Installation

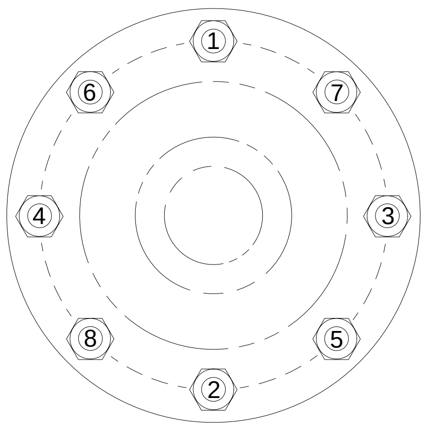


Fig. 4, Tightening Sequence, Drive Axle Stud Nuts

WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the wheel hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

11. Install the inner and outer wheel and tire assemblies. For instructions, see **Group 40**.

WARNING

Add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced. Failure to add oil will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

12. For drive axles, pour the recommended drive axle lubricant through the axle housing filler hole.

    On Freightliner axles, tighten the oil filler plug 37 lbf·ft (50 N·m).

    On Meritor axles, tighten the oil filler plug 35 lbf·ft (47 N·m).

    On Dana Spicer axles, tighten the oil filler plug 40 to 60 lbf·ft (54 to 81 N·m).

13. To lubricate the wheel ends, tilt the axle to the left and right by jacking the opposite side 8 inches (20 cm). Hold the tilted position for two minutes on each side to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two extra pints (1 liter) of lubricant will be needed to bring the oil level even with the base of the filler hole.

NOTE: Drive axle wheel bearings are lubricated by oil drawn from the axle housing bowl section. This method ensures good exchange of heat, prevents stagnation, and minimizes the maintenance required on bearings and hub assemblies.

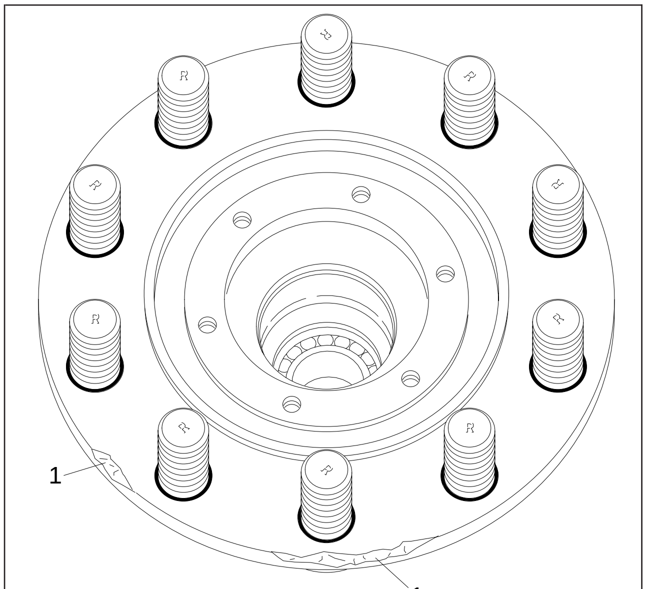
14. For non-drive axles, add about 1 to 1-1/2 pints (0.5 to 0.7 liter) of oil to the level shown on the hub cap. Do not overfill. Install the vent plug or threaded filler plug.
15. Turn the wheels, wait one minute, and check the lubricant level.
16. Adjust the rear axle brakes. For instructions, see **Group 42**.
17. Remove the safety stands from under the axle, then lower the vehicle.

Axle Components Cleaning and Inspection

Wheel Hub Assembly Inspection

1. Inspect the wheel hub mounting flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. See **Fig. 1**. Replace the wheel hub if any of these conditions exist.

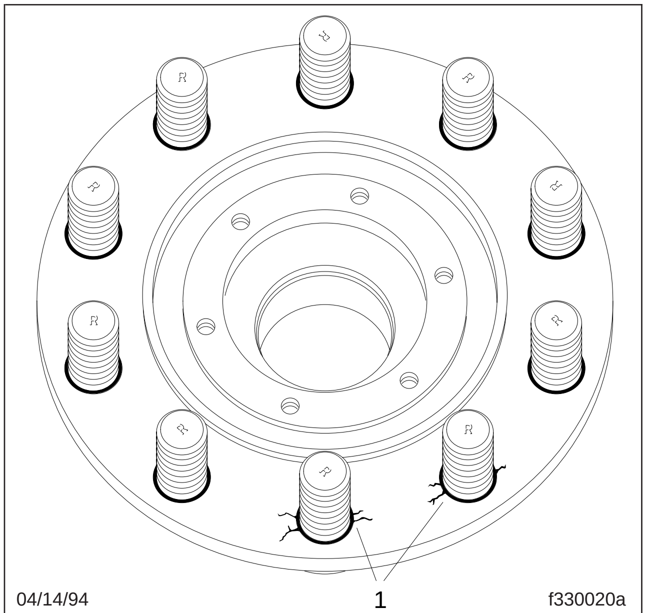
   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. See **Fig. 2**. If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.



1. Wear Spots

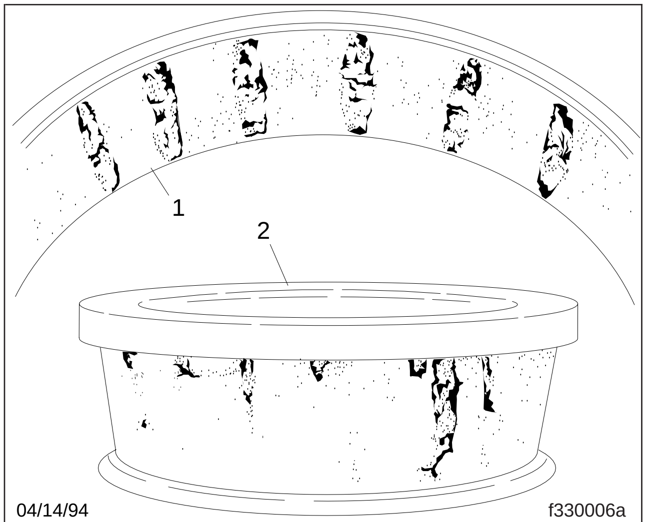
Fig. 1, Damaged Front Axle Wheel Hub

2. Remove all the old oil from the wheel hub cavity. Inspect the inner surface of the hub for cracks, dents, wear, or other damage. Replace the wheel hub if damage exists.
3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the wheel bearing cups for cracks, wear, spalling, or flaking. See **Fig. 3**. Replace the cups if damaged in any way. See **Subject 120** or **Subject 170**.
4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts are usually caused by inadequate tightening and must be replaced with new ones. See **Fig. 4**.



1. Cracked Stud Grooves

Fig. 2, Damaged Front Axle Wheel Hub



1. Cup
2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

Axle Components Cleaning and Inspection

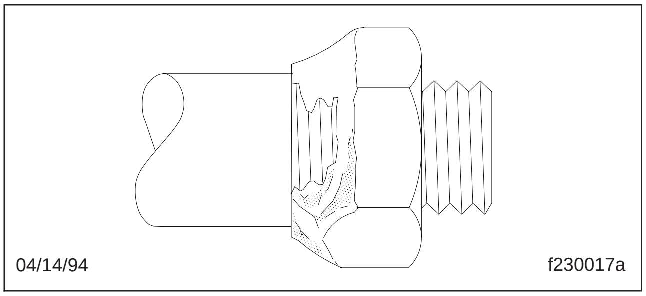


Fig. 4, Damaged Wheel Stud Nut

5. Inspect the wheel or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. See **Subject 180**.

Wheel Bearing Inspection

Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush. Before inspecting, clean the bearings.

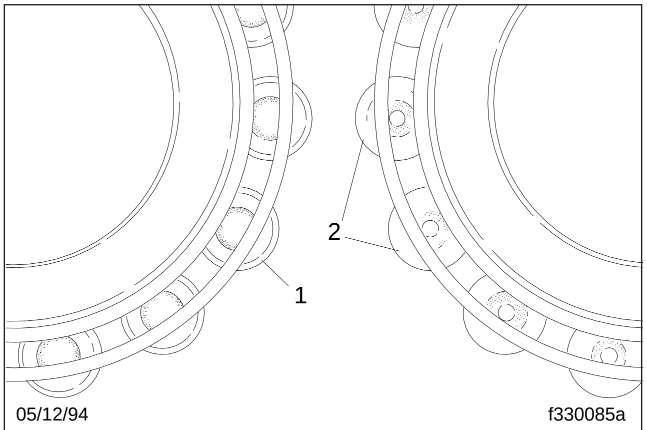
1. Remove the wheel hub and bearing cones. See **Subject 100**.
2. Clean all old oil from the bearings and hub cavity with kerosene or diesel fuel and a stiff brush. Don't use gasoline or heated solvent.
3. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface which is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

CAUTION

Do not spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.

4. After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

   4.1 Large ends of rollers worn flush to the recess, or radii at the large ends of the rollers worn sharp. These are indications of advanced wear. See **Fig. 5**.



1. New Bearing
2. Worn Bearing Rollers

Fig. 5, Wheel Bearing Roller Wear

   4.2 Visible step wear, particularly at the small end of the roller track. Deep indentations, cracks, or breaks in the cone surfaces. See **Fig. 6**.

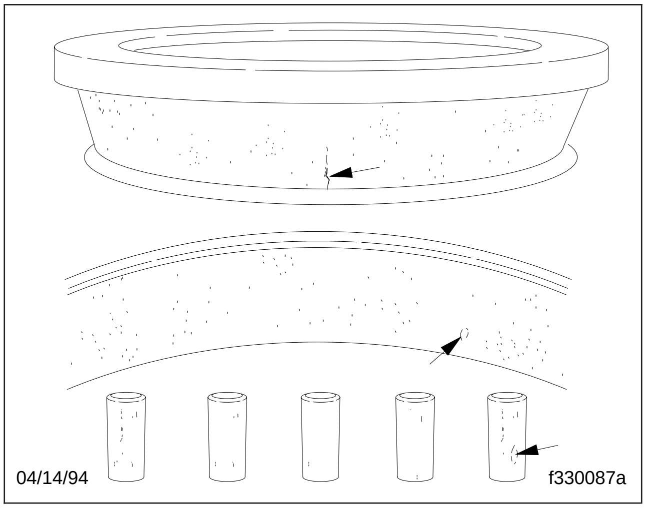


Fig. 6, Indentations, Cracks, or Breaks in Bearing Surfaces

   4.3 Bright rubbing marks on the dark phosphate surfaces of the bearing cage. See **Fig. 7**.

   4.4 Water etch on any bearing surface. Water etch appears as gray or black stains on

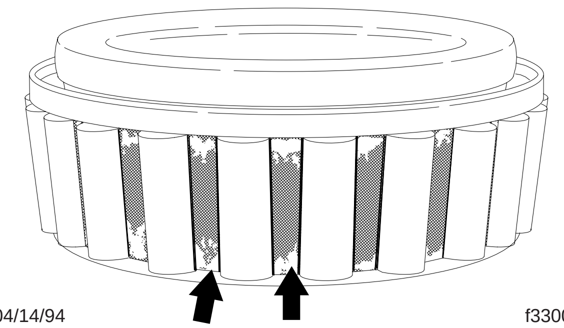


Fig. 7, Rubbing Marks on Bearing Cage

the steel surface, and it greatly weakens the affected area. If water etch is present, replace the bearing seals.

4.5 Etching or pitting on functioning surfaces. See **Fig. 8**.

4.6 Spalling (flaking) of the bearing cup, roller, or cone surfaces. See **Fig. 3**.

After inspection, brush the bearings with fresh axle lubricant.

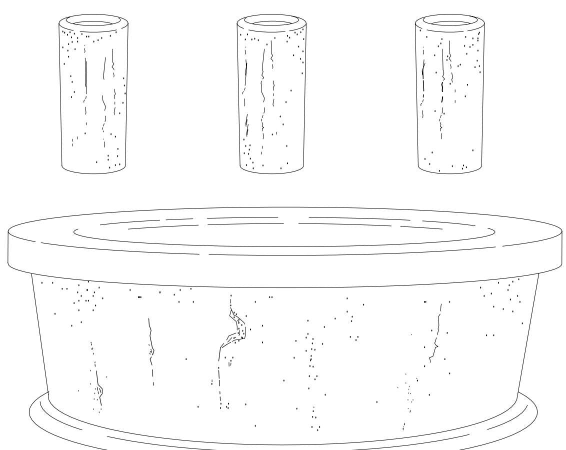
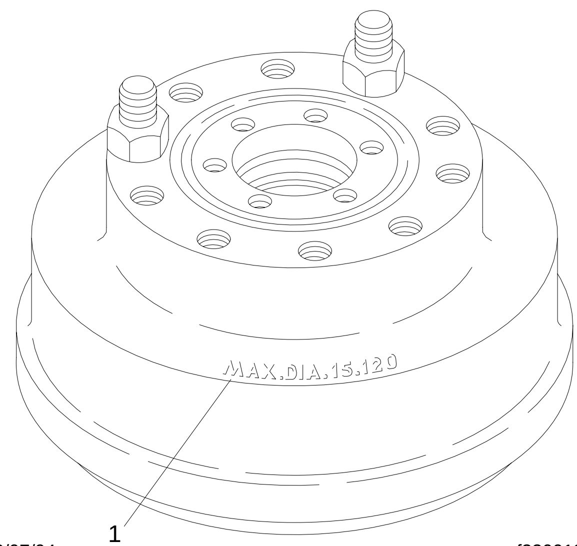


Fig. 8, Etching (Pitting) on Bearing Surfaces

Brake Drum Inspection

New brake drums are purposely undersized to allow for turning (remachining), since in mounting drums on the hub, there can be some eccentricity. If a new drum is installed, the protective coating on the inner friction surface must be removed with a solvent, prior to drum installation, then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside surface of the drum. See **Fig. 9** for a typical location of this stamp.



1. Maximum Diameter Stamp

Fig. 9, Outboard Mounted Hub and Drum Assembly

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be followed with a hot water wash.

CAUTION

Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will cause drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimate drum breakage.

If the drums are turned or replaced, replace the brake linings. See **Group 42** in this manual for instructions.

Axle Components Cleaning and Inspection

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80–grit emery cloth or by turning the drums.
2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not impair performance and lining life if the network of fine hairline cracks remains small. Examine heat checks of drums frequently to be certain the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum). Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

NOTE: If normal heat checking as described above is present, inspect the drums at least every 12,000 miles (19 300 km) thereafter. Inspect the drums (using a flashlight from the inboard side of the wheels) every 6000 miles (9700 km). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove the contaminants. Locate and correct the source of the contamination. If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil or grease saturated linings cannot be salvaged, they must be replaced. For brake lining replacement procedures, see **Group 42** in this manual.

WARNING

If the brake drums are contaminated with fluids, replace the brake linings. Failure to replace fluid contaminated brake linings could result in a partial loss of braking capacity, which could lead to personal injury or property damage.

4. Measure the inside diameter of the drum. If the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
5. Check for a variation in gauge readings at different points on the radius of the drum's working surface. If the variation is more than 0.010 inch (0.25 mm) at any point, the drum is out-of-round to unacceptable limits. Remachine or replace the same-axle drums.
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised dark-colored spots on the inner friction surface or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs.

Wheel Bearing Cup Removal and Installation, Ferrous Hubs

Removal

Wheel bearing cups on ferrous hubs are removed and installed by driving them out and pressing them in without heating the hub.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild-steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

Installation

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the replacement bearing cup hub contact surface with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable driving tool. Cups must seat against the shoulder in the hub.
5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Drive Axle Stud Replacement

Replacement

1. Remove the wheel hub from the axle. For instructions, refer to **Subject 100**.
2. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, proceed to the next step.

   If the drive axle stud is broken near the surface of the hub, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then center-punch the surface as a starting point for drilling. Follow these recommendations:

   2.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel hub are damaged, replace the hub.

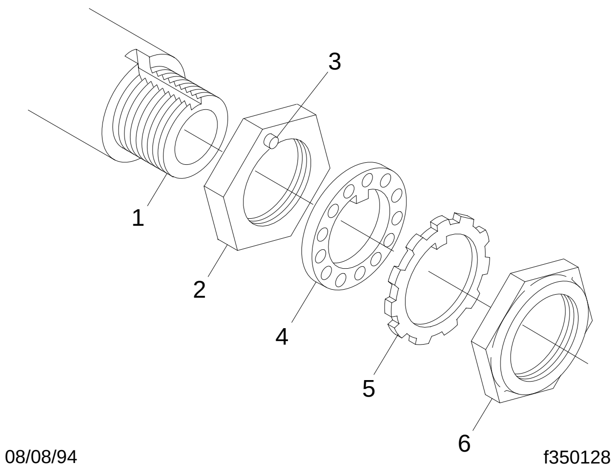
   2.2 Do not drill more than 1.25 inches (32 mm) into the broken stud, as measured at the stud's entrance into the wheel hub. Drilling through the bottom of the drive axle stud could damage the hub. If the wheel hub is drilled into, replace it.

   2.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
3. After the damaged stud is removed, tap out the drive axle stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original drive axle stud installation size.
4. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the drive axle stud (the coarse threads) with an anaerobic thread-lock compound.
5. Using double nuts on the fine-thread portion of the stud, install the new stud. Seat the drive axle stud using the torque values in the torque table in **Specifications, 400**.
6. Allow sufficient time for the thread-lock compound to set, as suggested by the manufacturer.
7. If the hub was removed from the axle, refer to **Subject 100** for installation instructions.

Four-Piece Wheel Bearing Lock System Installation and Adjustment

General Information

A four-piece wheel bearing lock system is used on some Columbia vehicles. See **Fig. 1**.



1. Axle Spindle
2. Adjusting Nut
3. Dowel
4. Lockring
5. Tanged Nut-Lock
6. Jam Nut

Fig. 1, Four-Piece Wheel Bearing Lock Set

Installation

Instructions for installing a four-piece wheel bearing lock set for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

Using PreSet Bearings

1. Install the adjusting nut onto the axle spindle, and tighten it 300 lbf·ft (407 N·m). See **Fig. 1**.

NOTE: The gaps between holes in the lockring are spaced unevenly, so to fit the tab on the adjusting nut into one of the holes with minimal turning of the adjusting nut, gauge the distance on one side of the lockring, then the other, and choose the side that requires the adjusting nut to be advanced the least. **Do not back off the nut**.

2. Install the lockring (as described in the note above) and nut locking device.
3. Install the jam nut, and tighten it 200 lbf·ft (271 N·m).
4. Rotate the hub in both directions. It should turn freely with no dragging or binding.

Using Non-PreSet Bearings

For non ConMet PreSet hubs and ConMet PreSet hubs without the bearing spacer and PreSet bearings, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

1. Install the adjusting nut, as follows. See **Fig. 1**.
   - 1.1 Install the adjusting nut on the spindle, and tighten it finger-tight.
   - 1.2 While rotating the wheel hub assembly, tighten the adjusting nut 200 lbf·ft (271 N·m).
   - 1.3 Back off the adjusting nut one full turn.
   - 1.4 Tighten the adjusting nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.
   - 1.5 Back off the adjusting nut one-quarter turn.

NOTE: The gaps between holes in the lockring are spaced unevenly, so to fit the tab on the adjusting nut into one of the holes with minimal turning of the adjusting nut, gauge the distance on one side of the lockring, then the other, and choose the side that requires the adjusting nut to be turned the least.

2. Install the lockring (as described in the note above) and nut locking device.
3. Install the jam nut, and tighten it 300 to 400 lbf·ft (410 to 540 N·m).
4. Using a dial indicator, measure the end play as follows.

   IMPORTANT: Do not measure the wheel bearing end play with the wheel mounted on the hub; you cannot accurately measure or adjust bearing end play with the wheel mounted on the hub. Also, ensure that the brakes are not applied so that that drum and hub can move freely.

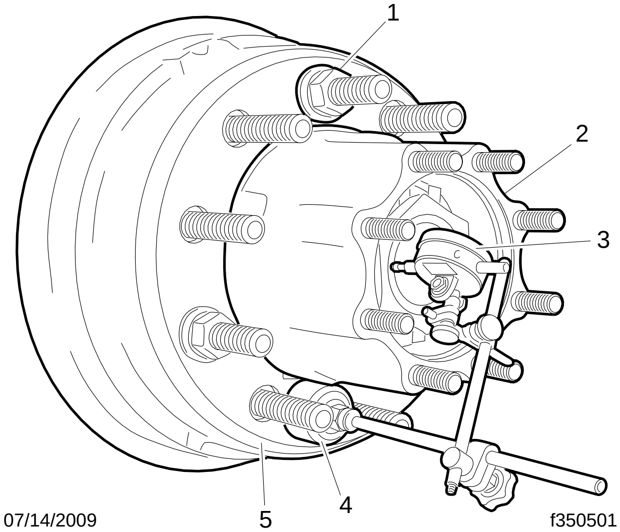
   - 4.1 On vehicles equipped with aluminum hubs, install an iron brake drum onto the hub to provide a ferrous surface for the magnetic base of the dial indicator. With

Four-Piece Wheel Bearing Lock System Installation and Adjustment

flange nuts, secure the drum to the hub using the stud at the 12 o'clock position, followed by the studs at about the 4 o'clock and 8 o'clock positions. Ensure the nuts hold the drum securely; use washers if needed.

4.2 Clean the spindle end; ensure it is free of debris and provides the smooth surface needed for the dial indicator to take an accurate measurement.

4.3 Attach the magnetic base of a dial indicator to the drum (or, on vehicles equipped with iron hubs, the hub). See **Fig. 2**.



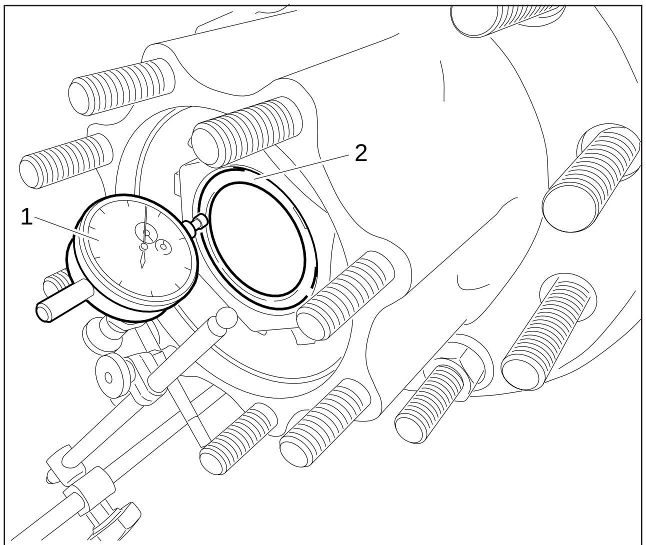
1. Flange Nut
2. Aluminum Hub
3. Dial Indicator
4. Magnetic Base
5. Iron Brake Drum

Fig. 2, Dial Indicator Setup, Aluminum Hub with Iron Brake Drum

4.4 Set the measuring end of the indicator against the spindle end as shown in **Fig. 3**. The indicator should be square with the end of the spindle.

IMPORTANT: Maintain continual pressure on the hub until you have taken both the inboard and outboard measurements. If you release the hub, an accurate measurement is not possible.

4.5 To seat the bearings, grip the hub at the three o'clock and nine o'clock positions,



The indicator should be square with the end of the spindle.

1. Dial Indicator
2. Spindle End

Fig. 3, Indicator Square with the Spindle

and push inward while oscillating it approximately 45 degrees. Maintain pressure on the hub and note the measurement.

NOTE: The end play measurements must be taken at the same point to prevent an uneven spindle end from skewing the results. As needed, mark the spot on the spindle where the inboard measurement was taken.

4.6 Pull the hub and drum outward while oscillating it as before. Maintain pressure on the hub, and note the outboard extent of the end play. See **Fig. 4**.

4.7 Find the end play by noting the difference between the two readings.

WARNING

The wheel-bearing end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). Correct end play is crucial: if the wheel-bearing end play is not correct, the wheel bearings could fail. This could cause the loss of the wheel and hub assembly, resulting in an accident causing serious injury or property damage. Use a dial indicator to measure the end play.

Four-Piece Wheel Bearing Lock System Installation and Adjustment

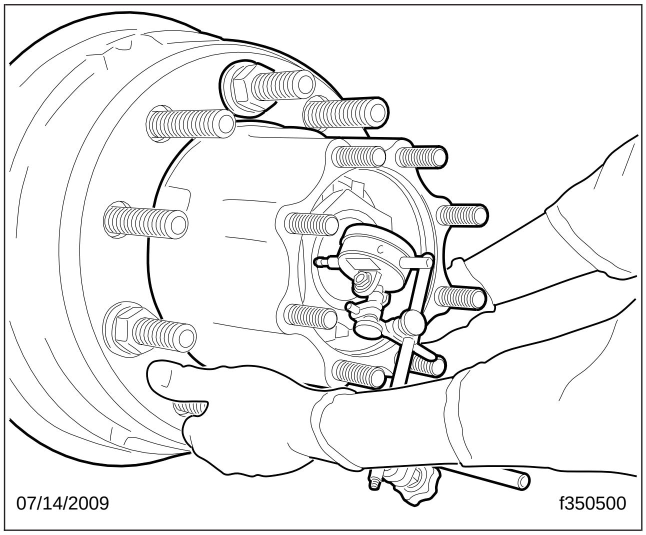


Fig. 4, Pulling the Hub Outward to Measure End Play

5. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm).** If the end play is not within this range, adjust the end play as follows.

   5.1 Remove the jam nut and locking device, and back off or tighten the inner adjusting nut.

   5.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the adjusting nut again.

   5.3 Measure the end play.

   If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), repeat the adjustment procedure until the correct end play is achieved.

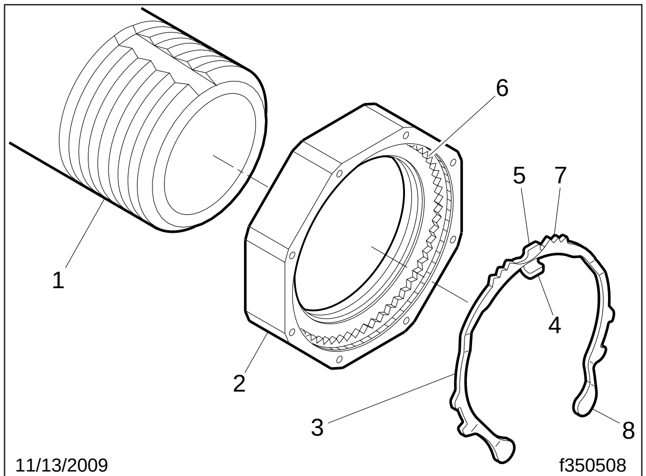
   IMPORTANT: The correct end play **must** be achieved before completing the hub assembly installation procedure.

6. Once the end play is between 0.001 and 0.005 inch (0.03 and 0.13 mm), rotate the hub in both directions. It should turn freely with no dragging or binding.

Pro-Torq Spindle Nut Removal, Installation, and Adjustment

General Information

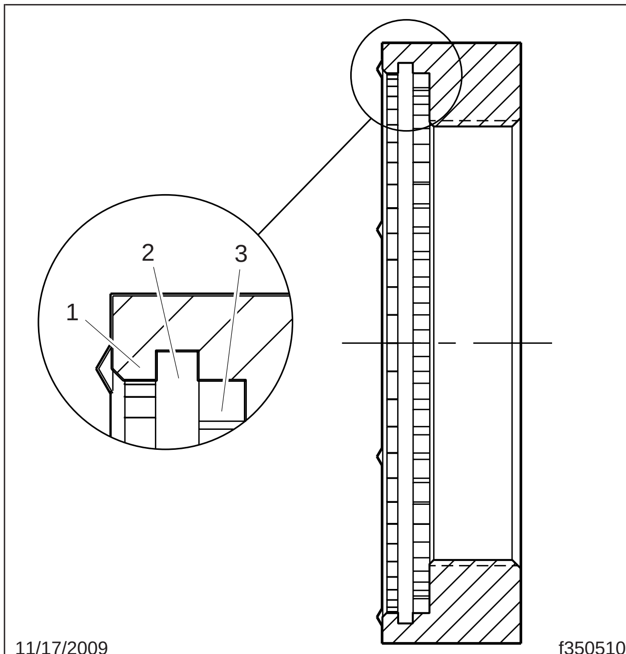
Pro-Torq® spindle nuts may be used on Columbia vehicles. See **Fig. 1** and **Fig. 2**.



1. Axle Spindle
2. Pro-Torq Nut
3. Keeper Arm
4. Keyway Tab
5. Keeper Tab
6. Mating Teeth, Nut
7. Mating Teeth, Keeper
8. Keeper Protrusion

Fig. 1, Pro-Torq Spindle Nut and Keeper

Each time the Pro-Torq nut assembly is removed for maintenance purposes, replacing the "keeper" is recommended.



1. Lip
2. Undercut Groove
3. Mating Teeth

Fig. 2, Pro-Torq Spindle Nut, Cross Section

Removal

WARNING

Do not place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may damage the spindle threads and deform the keeper, and allow the nut to unthread during operation. Failure to follow this instruction could cause the hub to separate from the axle, resulting in severe personal injury or death.

1. Insert the blade of a flathead screwdriver (or similar tool) in the slot of one of the keeper arms; see **Fig. 3**. Ensuring that the tool contacts the keeper and not the teeth of the nut, turn the tool slightly and carefully pry the arm from the undercut groove of the nut.

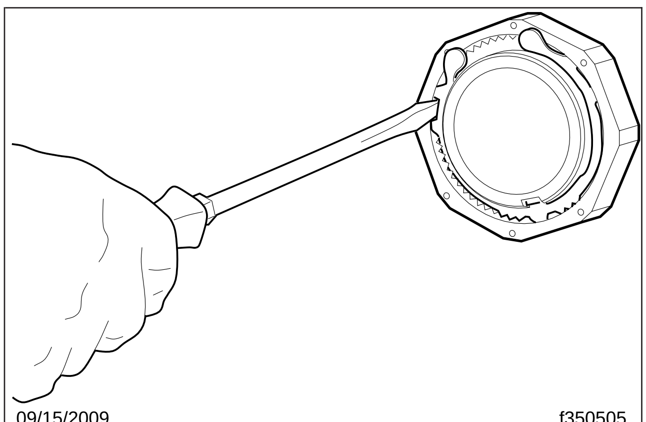


Fig. 3, Removing the Keeper

2. Repeat at the other arm, and remove the keeper from the nut.
3. Remove the Pro-Torq nut.

Pro-Torq Spindle Nut Removal, Installation, and Adjustment

Installation

The following procedure applies to Pro-Torq drive axle nut 449-4973. The part number is stamped on the nut.

WARNING

Do not place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may damage the spindle threads and deform the keeper, and allow the nut to unthread during operation. Failure to follow this instruction could cause the hub to separate from the axle, resulting in severe personal injury or death.

Instructions for installing a Pro-Torq spindle nut for both PreSet and non-PreSet type bearings are provided in this subject. See the instructions pertaining to the bearing type used with the hub you are securing.

Using PreSet Bearings

1. Ensure the keeper is removed from the nut.
2. Install the Pro-Torq spindle nut, and tighten it 250 lbf·ft (339 N·m). **Do not back it off**.

WARNING

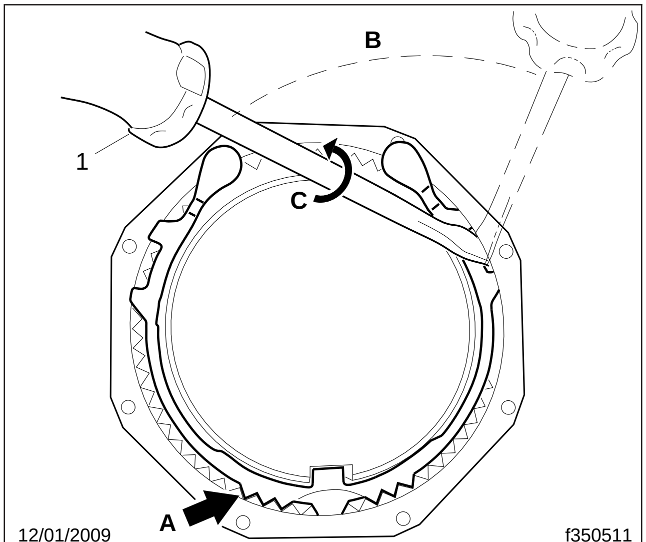
Do not bend or manipulate the keyway tab in any way. Doing so may cause it to break off in service, which could lead to the hub separating from the axle and result in severe personal injury or death.

3. Install the keeper.
   3.1 With the protrusions facing outboard, insert the keeper tab in the undercut groove of the Pro-Torq nut and the keyway tab in the spindle keyway.

   IMPORTANT: If the keeper cannot be engaged, advance the nut until it can be. Do not back off the nut.

   3.2 Engage the mating teeth.

   3.3 Use a flathead screwdriver to carefully compress and guide each arm past the lip and into the undercut groove of the nut as shown in **Fig. 4**. To secure the keeper it may be necessary to nudge the arms into the groove.



A. Engage the mating teeth.
B. Compress the arm.
C. Turn the screwdriver to seat the keeper in the groove.

1. Flathead Screwdriver

Fig. 4, Installing the Keeper

WARNING

Failure to secure the keeper and lock the Pro-Torq nut could cause the wheel assembly to come off the vehicle, resulting in severe personal injury or death.

4. Inspect the installation; ensure the keeper is locked in the undercut groove and that the keyway tab does not contact the bottom of the keyway.

Using Non-PreSet Bearings

For non ConMet PreSet hubs and ConMet PreSet hubs without the bearing spacer and PreSet bearings, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

1. Ensure the keeper is removed from the nut.
2. Seat the bearings.

Pro-Torq Spindle Nut Removal, Installation, and Adjustment

2.1 Using a torque wrench, tighten the nut 200 lbf·ft (270 N·m). Spin the hub at least one full rotation.

NOTE: Torque is lost when the hub is spun.

2.2 Tighten the nut 200 lbf·ft (270 N·m). Spin the hub at least one full rotation.

2.3 Tighten the nut 200 lbf·ft (270 N·m), but *do not spin the hub*.

3. Loosen the nut to zero torque. *Do not spin the hub*.
4. Adjust the bearing.

4.1 Using a torque wrench, tighten the nut 100 lbf·ft (136 N·m). Spin the hub at least one full rotation.

NOTE: Torque is lost when the hub is spun.

4.2 Tighten the nut 100 lbf·ft (136 N·m). Spin the hub at least one full rotation.

4.3 Tighten the nut 100 lbf·ft (136 N·m).

4.4 Back off the nut one-eighth turn.

WARNING

Do not bend or manipulate the keyway tab in any way. Doing so may cause it to break off in service, which could lead to the hub separating from the axle and result in severe personal injury or death.

IMPORTANT: If the keeper cannot be engaged, advance the nut until it can be. Do not back off the nut.

5. Install the keeper.

5.1 With the protrusions facing outboard, insert the keeper tab in the undercut groove of the Pro-Torq nut and the keyway tab in the spindle keyway.

5.2 Engage the mating teeth.

5.3 Use a flathead screwdriver to carefully compress and guide each arm past the lip and into the undercut groove of the nut as shown in **Fig. 4**. To secure the keeper it may be necessary to nudge the arms into the groove.

WARNING

Failure to secure the keeper and lock the Pro-Torq nut could cause the wheel assembly to come off the vehicle, resulting in severe personal injury or death.

6. Inspect the installation; ensure the keeper is locked in the undercut groove and that the keyway tab does not contact the bottom of the keyway.
7. Using a dial indicator, measure the end play as follows.

IMPORTANT: Do not measure the wheel bearing end play with the wheel mounted on the hub; you cannot accurately measure or adjust bearing end play with the wheel mounted on the hub. Also, ensure that the brakes are not applied so that that drum and hub can move freely.

7.1 On vehicles equipped with aluminum hubs, install an iron brake drum onto the hub to provide a ferrous surface for the magnetic base of the dial indicator. With flange nuts, secure the drum to the hub using the stud at the 12 o'clock position, followed by the studs at about the 4 o'clock and 8 o'clock positions. Ensure the nuts hold the drum securely; use washers if needed.

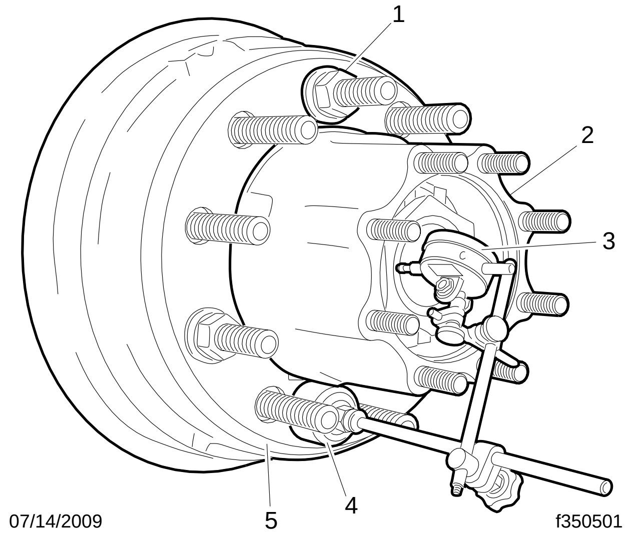
7.2 Clean the spindle end; ensure it is free of debris and provides the smooth surface needed for the dial indicator to take an accurate measurement.

7.3 Attach the magnetic base of a dial indicator to the drum (or, on vehicles equipped with iron hubs, the hub). See **Fig. 5**.

7.4 Set the measuring end of the indicator against the spindle end as shown in **Fig. 6**. The indicator should be square with the end of the spindle.

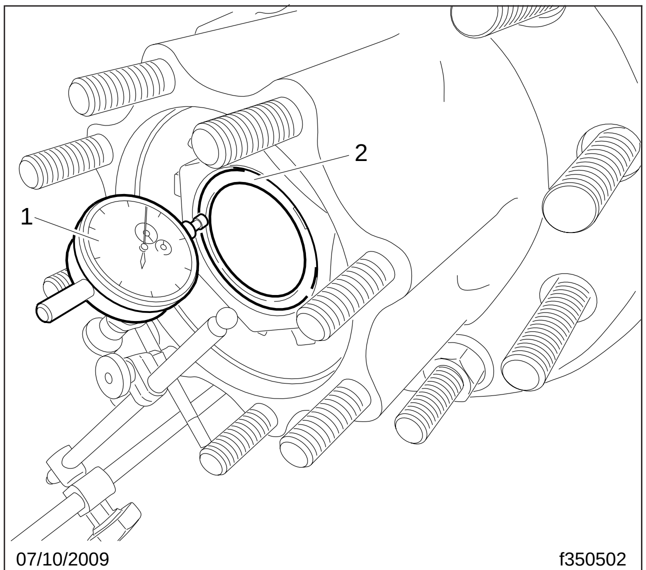
IMPORTANT: Maintain continual pressure on the hub until you have taken both the inboard and outboard measurements. If you release the hub, an accurate measurement is not possible.

Pro-Torq Spindle Nut Removal, Installation, and Adjustment



1. Flange Nut
2. Aluminum Hub
3. Dial Indicator
4. Magnetic Base
5. Iron Brake Drum

Fig. 5, Dial Indicator Setup, Aluminum Hub with Iron Brake Drum



The indicator should be square with the end of the spindle.

1. Dial Indicator
2. Spindle End

Fig. 6, Indicator Square with the Spindle

7.5 To seat the bearings, grip the hub at the three o'clock and nine o'clock positions, and push inward while oscillating it approximately 45 degrees. Maintain pressure on the hub and note the measurement.

NOTE: The end play measurements must be taken at the same point to prevent an uneven spindle end from skewing the results. As needed, mark the spot on the spindle where the inboard measurement was taken.

7.6 Pull the hub and drum outward while oscillating it as before. Maintain pressure on the hub, and note the outboard extent of the end play. See **Fig. 7**.

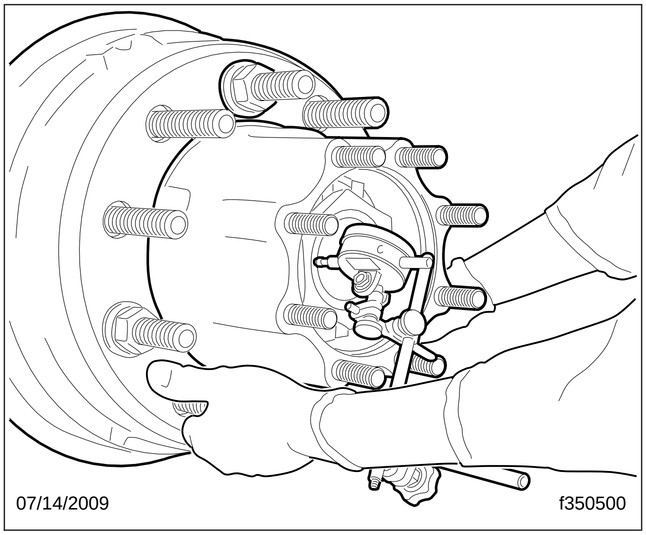


Fig. 7, Pulling the Hub Outward to Measure End Play

7.7 Find the end play by noting the difference between the two readings.

WARNING

The wheel-bearing end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). Correct end play is crucial: if the wheel-bearing end play is not correct, bearing life will diminish and the wheel bearings could fail. This could cause the loss of the wheel and hub assembly, resulting in an accident causing serious injury or property damage. Use a dial indicator to measure the end play.

8. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Pro-Torq nut, and repeat

the tightening sequence as described in previous steps. Once the end play is correct, remove the iron brake drum if installed, and continue your service procedure.

Outboard-Mounted Drum Removal and Installation

⚠ WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

For an exploded view of a typical wheel and axle assembly, including the brake drum, see **Fig. 1**.

Removal

1. Park the vehicle, shut down the engine, release the parking brakes and chock the front tires.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

4. Remove the wheel and tire assembly. See **Group 40** in this manual for instructions.

   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
5. Remove the brake drum.

Installation

1. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.
2. Install the brake drum on the wheel hub.

   2.1 On hub-piloted drums, position the brake drum on the top step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock (top center) position. See **Fig. 2**.

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

   2.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary to hold the drum in position, adjust the brakes before installing the wheels.
3. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the correct nut tightening sequence. For instructions, see **Group 40** in this manual.

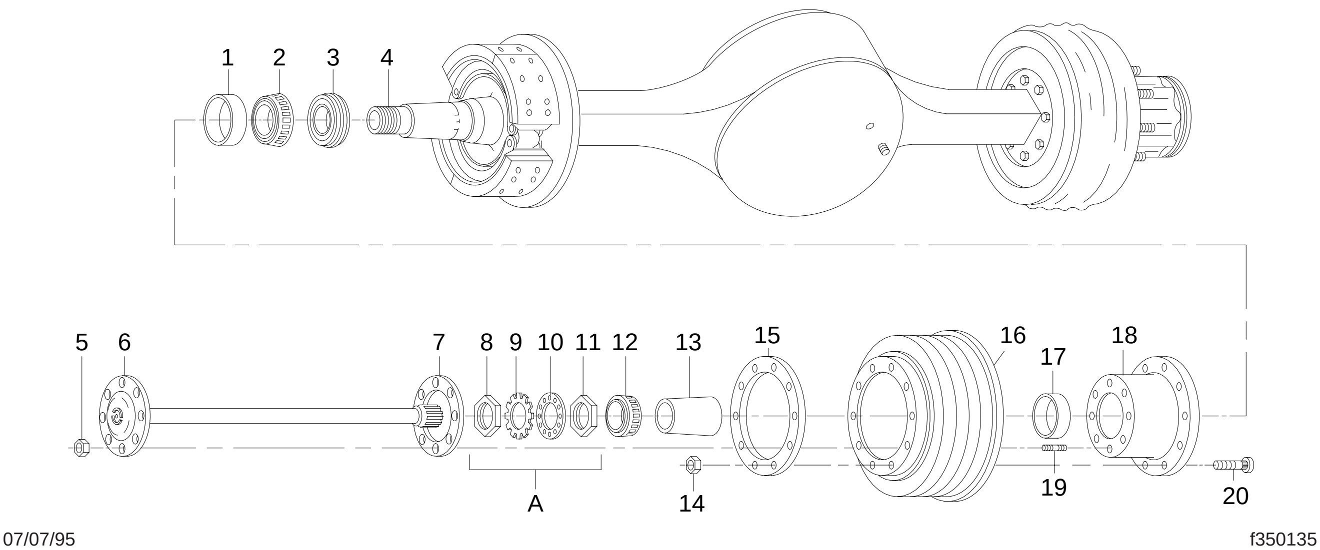
⚠ WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury and property damage.

4. Adjust the rear axle brakes. See **Group 42** in the *Columbia Maintenance Manual*.

Outboard-Mounted Drum Removal and Installation

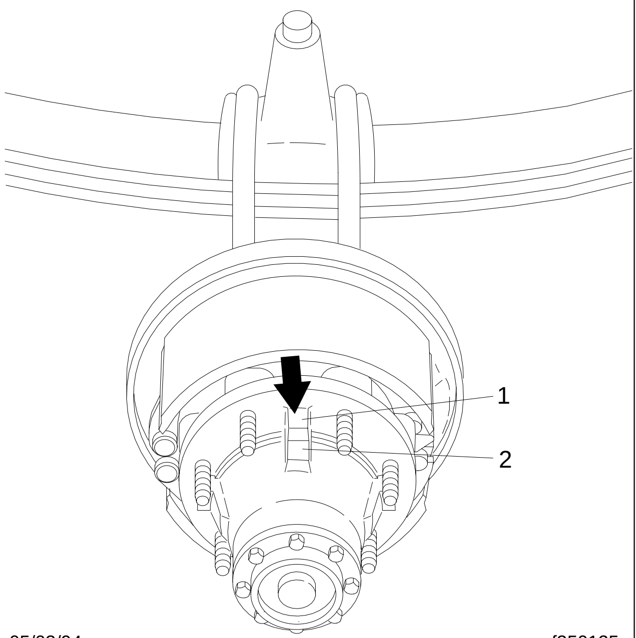
5. Remove the safety stands from under the axle; lower the vehicle.
6. Remove the chocks from the tires.



A. Four-piece bearing system shown, Pro-Torq or Axi-Lok locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Bearing Spacer (used only with Con-Met integral wheel bearing packs)
14. Brake Drum Nut
15. Hub Spacer
16. Brake Drum
17. Outer Wheel Bearing Cup
18. Hub
19. Drive Axle Stud
20. Wheel Stud

Fig. 1, Typical Drive Axle and Hub Assembly (exploded view)



NOTE: Pilot pad at 12 o’clock position

1. Drum Pilot
2. Wheel Pilot

Fig. 2, Hub Pilot Pads

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

Removal

To ensure a tight fit, wheel bearing cups are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

   If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

WARNING

Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

Installation

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

WARNING

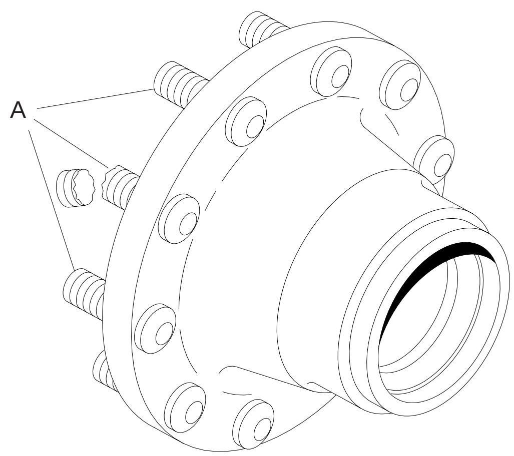
Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

4. Coat the replacement bearing cup hub contact surface with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and will also cause permanent damage to the wheel hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.
7. Allow the wheel hub to cool before handling. Then, using a 0.0015–inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.
8. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean, lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Replacement

WARNING

If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it. See Fig. 1. If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.



NOTE: Front hub shown.

A. Replace

Fig. 1, Wheel Stud Replacement

1. Remove the wheel hub from the axle. For instructions, see **Subject 100**.
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is supported evenly around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

CAUTION

Do not use a drift and hammer or concentrated heat for removing and installing the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.

4. Apply a coating of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is supported evenly around and next to the stud being installed.
6. Position the stud in its hole. *Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.*

CAUTION

If headed studs with serrations are being installed, position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.

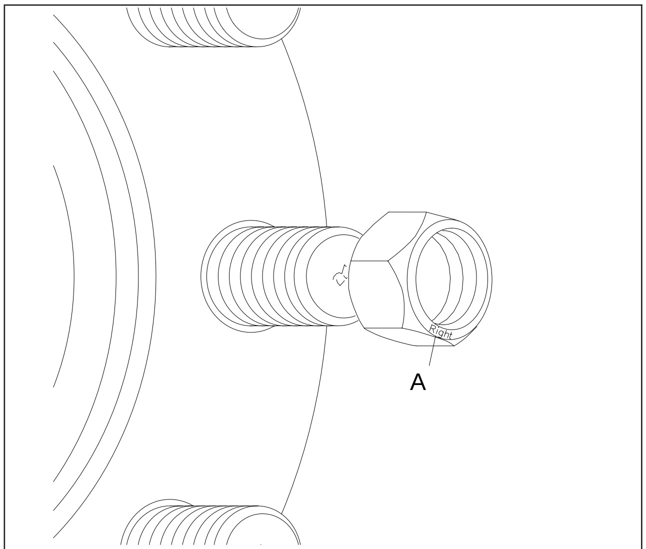
NOTE: If the left side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left" If the right side of the vehicle is being serviced, the replacement stud must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right." See **Fig. 2**.

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded into the hub. If the head of the stud is embedded into the hub, replace the hub.

WARNING

Don't embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange.

Wheel Stud Replacement



A. "Right"

Fig. 2, Thread Stamp Location

Weakness in the wheel hub can result in the loss of a wheel or loss of steering control, possibly resulting in personal injury.

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.

10. Install the wheel hub on the axle. For instructions, see **Subject 100**.

Axilok Spindle Nut Removal, Installation, and Adjustment

General Information

Axilok® spindle nuts are used on ConMet PreSet hubs. See **Fig. 1**. These nuts can be damaged if they are not removed or installed correctly. Use the following guidelines when removing and installing Axilok retaining nuts.

- Use only the correct size, *six-point* socket to remove or install Axilok spindle nuts. Do not use a worn or loose-fitting socket. **Do not use a 12-point socket.**
- Do not use hammers, chisels, pliers, wrenches, or power tools to remove or install Axilok nuts.
- Do not use an Axilok nut if the locking clips are damaged or missing, or if the retainer cage tab or D-flat is damaged or missing.
- Never try to repair a damaged Axilok nut; always replace it with a new one.
- Always start an Axilok installation by hand. A good-fitting six-point socket will completely disengage the nut's locking clips, allowing it to spin freely by hand. See **Fig. 2**. Use an accurately calibrated torque wrench to tighten the nut to its final torque value.

Installation

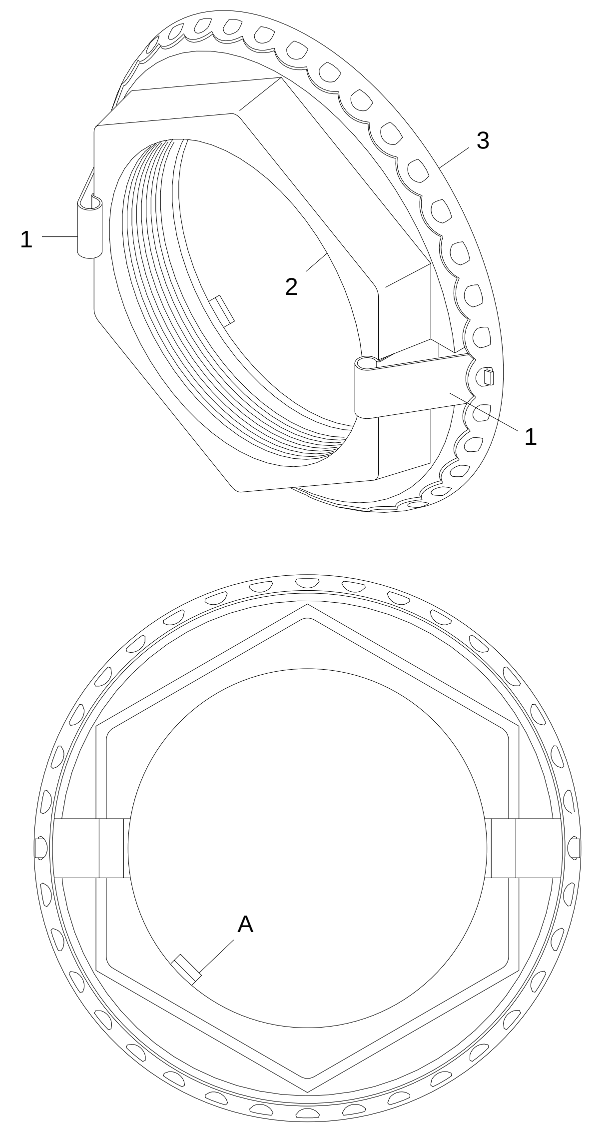
Instructions for installing an Axilok nut for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

Using PreSet Bearings

WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

1. Apply a few drops of oil through one of the holes in the Axilok retainer cage to reduce friction between the retainer cage and nut.
2. By hand, install the Axilok nut onto the axle spindle. See **Fig. 1**.



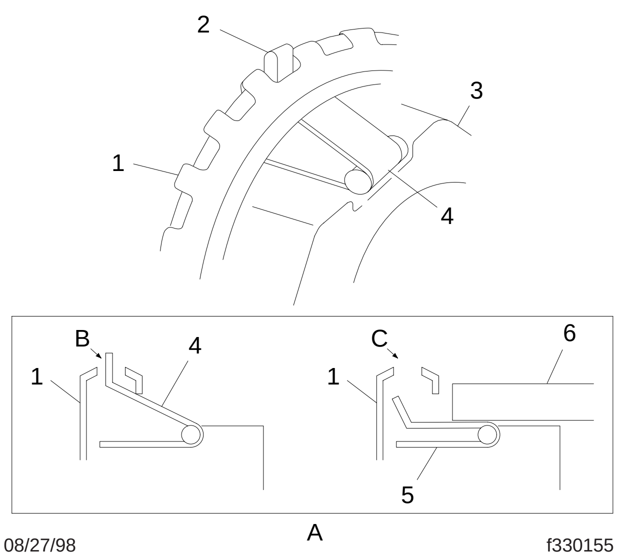
A. The retainer tab must engage the keyway of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer Cage

Fig. 1, Rear Axle Axilok Nut

3. Tighten the retaining nut 250 lbf·ft (339 N·m). The nut should lock in place when you remove the wrench. If it does not, advance the nut until it does. **Do not back it off**.

Axilok Spindle Nut Removal, Installation, and Adjustment



A. Cross-Section View
B. The tab is engaged.
C. The tab is disengaged.

1. Retainer Cage
2. Locking Clip Tab
3. Nut
4. Locking Clip
5. Locking Clip (compressed)
6. Six-Point Socket

Fig. 2, Axilok Nut, Checking the Position of the Locking Clip

4. Ensure that both locking clips are present and engaged in the retainer cage. See **Fig. 2**. If the locking clips are not engaged, the nut is not locked in position and can rotate freely.

Using Non-PreSet Bearings

For non ConMet PreSet hubs and ConMet PreSet hubs without the bearing spacer and PreSet bearings, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

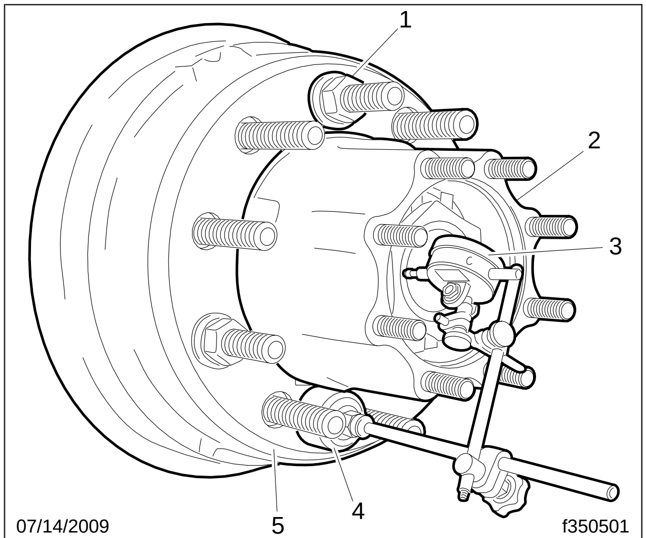
1. Apply a few drops of oil through one of the holes in the Axilok retainer cage to reduce friction between the retainer cage and nut.
2. Install the Axilok nut and adjust the wheel bearings, as follows.
   2.1 By hand, install the Axilok nut onto the axle spindle. Then turn it against the bearing while spinning the hub. See **Fig. 1**.
   2.2 Tighten the nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the hub in both directions.
   2.3 Loosen the nut to zero torque, and spin the hub a few turns.
   2.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the hub in both directions. Back off the nut one-eighth to one-sixth turn.
   2.5 Remove the wrench from the nut, and verify whether both locking clips are present and engaged in the retainer cage. See **Fig. 2**. If the locking clips are not engaged, advance the Axilok until they are.
3. Using a dial indicator, measure the end play as follows.

   IMPORTANT: Do not measure the wheel bearing end play with the wheel mounted on the hub; you cannot accurately measure or adjust bearing end play with the wheel mounted on the hub. Also, ensure that the brakes are not applied so that that drum and hub can move freely.

   3.1 On vehicles equipped with aluminum hubs, install an iron brake drum onto the hub to provide a ferrous surface for the magnetic base of the dial indicator. With flange nuts, secure the drum to the hub using the stud at the 12 o'clock position, followed by the studs at about the 4 o'clock and 8 o'clock positions. Ensure the nuts hold the drum securely; use washers if needed.
   3.2 Clean the spindle end; ensure it is free of debris and provides the smooth surface needed for the dial indicator to take an accurate measurement.

Axilok Spindle Nut Removal, Installation, and Adjustment

3.3 Attach the magnetic base of a dial indicator to the drum (or, on vehicles equipped with iron hubs, the hub). See **Fig. 3**.



1. Flange Nut
2. Aluminum Hub
3. Dial Indicator
4. Magnetic Base
5. Iron Brake Drum

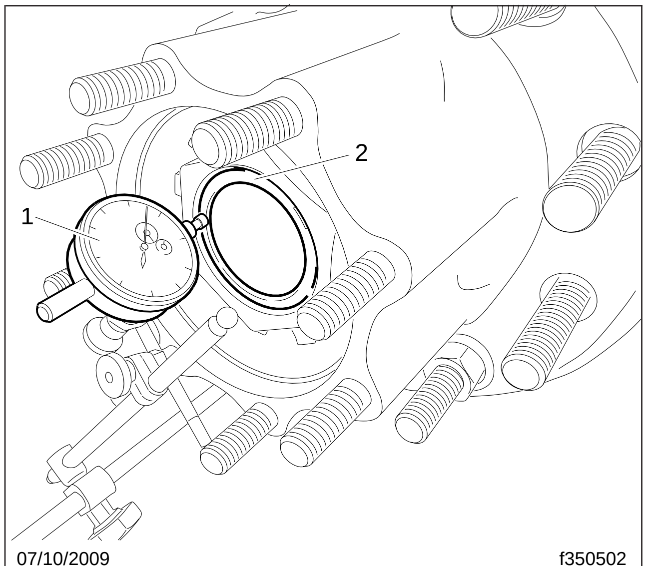
Fig. 3, Dial Indicator Setup, Aluminum Hub with Iron Brake Drum

3.4 Set the measuring end of the indicator against the spindle end as shown in **Fig. 4**. The indicator should be square with the end of the spindle.

IMPORTANT: Maintain continual pressure on the hub until you have taken both the inboard and outboard measurements. If you release the hub, an accurate measurement is not possible.

3.5 To seat the bearings, grip the hub at the three o'clock and nine o'clock positions, and push inward while oscillating it approximately 45 degrees. Maintain pressure on the hub and note the measurement.

NOTE: The end play measurements must be taken at the same point to prevent an uneven spindle end from skewing the results. As needed, mark the spot on the spindle where the inboard measurement was taken.



The indicator should be square with the end of the spindle.

1. Dial Indicator
2. Spindle End

Fig. 4, Indicator Square with the Spindle

3.6 Pull the hub and drum outward while oscillating it as before. Maintain pressure on the hub, and note the outboard extent of the end play. See **Fig. 5**.

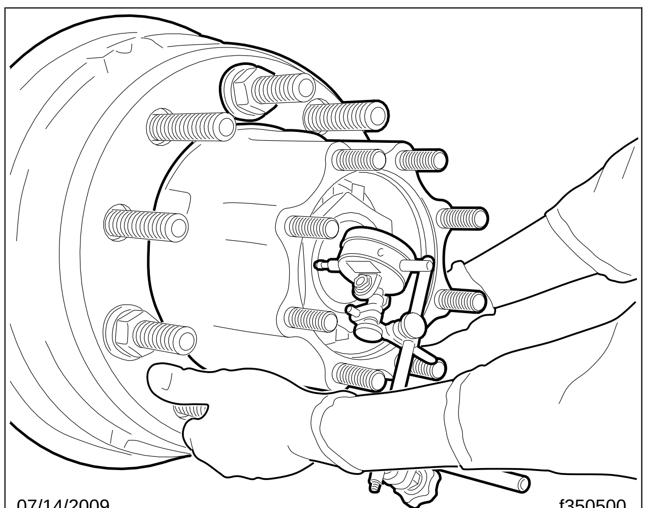


Fig. 5, Pulling the Hub Outward to Measure End Play

3.7 Find the end play by noting the difference between the two readings.

Axilok Spindle Nut Removal, Installation, and Adjustment

WARNING

The wheel-bearing end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). Correct end play is crucial: if the wheel-bearing end play is not correct, the wheel bearings could fail. This could cause the loss of the wheel and hub assembly, resulting in an accident causing serious injury or property damage. Use a dial indicator to measure the end play.

4. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Axilok nut, and repeat the tightening sequence as described earlier in this procedure. Once the end play is correct, continue with your service procedure.

If either the lateral or radial runout of the hub is beyond acceptable limits, replace the hub. For instructions, see **Subject 100** in this section.

Measurements

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

2. Remove the wheel and tire assembly. See **Group 40** for instructions.
3. For drum brakes, remove the brake drum. See **Subject 160** for instructions.
4. Clean the hub surfaces where the measurements will be taken—see **Fig. 1** and **Fig. 2**.
5. To measure lateral runout, set up a dial indicator as shown in **Fig. 1**, then turn the hub one revolution and note the highest and lowest measurements.

   For ConMet hubs, the acceptable lateral runout is 0.008 inch (0.2 mm); for other hubs, see the hub OEM for the acceptable lateral runout specification.
6. To measure radial runout, set up a dial indicator as shown in **Fig. 2**, then turn the hub one revolution and note the highest and lowest

   For ConMet hubs, the acceptable radial runout is 0.008 inch (0.2 mm); for other hubs, see the hub OEM for the acceptable radial runout specification.

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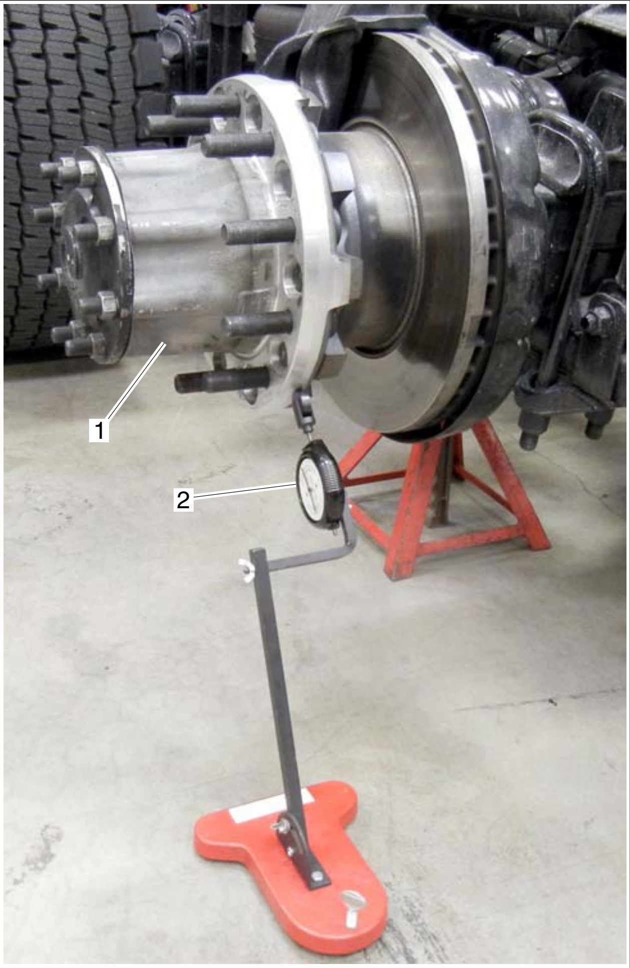
1. Hub
2. Dial Indicator (with roller point)

Fig. 1, Setup to Measure Lateral Runout

Hub Runout Measurements



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1. Hub
2. Dial Indicator (with roller point)

Fig. 2, Setup to Measure Radial Runout

Troubleshooting Tables

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals	
Possible Cause	**Remedy**
Not enough oil was used on the bearings, or the wrong type of oil was used.	Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil. For lubricant specifications, see Group 35 of the *Columbia Maintenance Manual*.
Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed.	Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant.
An incorrect adjustment of the wheel bearings is causing noise and wear.	Adjust the wheel bearings following the instructions in **Subject 140** or **Subject 150**.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, see Group 35 of the *Columbia Maintenance Manual*.

Problem—Broken Wheel or Rim Studs

Problem—Broken Wheel or Rim Studs	
Possible Cause	**Remedy**
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. See Group 40 of the *Columbia Maintenance Manual* for the wheel or rim nut tightening sequence.
An incorrect nut tightening sequence was used.	
The wrong brake drums were installed.	Install new brake drums.
Wheels are mismatched (hub-piloted wheels are mixed with stud-piloted wheels).	Install properly matched wheels.
The vehicle is being overloaded.	Do not exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Problem—Damaged Hub	
Possible Cause	**Remedy**
(Cracked hub) Local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal.	Replace the hub assembly. When removing the bearing cup, oven-heat the hub.
(Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement.	Replace the hub assembly. Replace the wheel studs as instructed in **Subject 180**.
The wrong brake drums were installed.	Install new brake drums.
Insufficient tightening of the wheel nuts to the wheel hub.	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **Specifications, 400**.

Troubleshooting

Problem—Loss of Lubricant From the Wheel Hubs

Problem—Loss of Lubricant From the Wheel Hubs	
Possible Cause	**Remedy**
The drive axle studs are loose.	Tighten the nuts to the torque values in the torque table in **Specifications, 400**. Add lubricant to the axle housing or to the wheel hub.
The seals or gaskets are worn or damaged.	Replace worn or damaged parts.
Minor burrs or rough spots are on the inboard portion of the drive axle flange.	Use fine-grit emery cloth to remove the burrs or rough spots. If they cannot be removed, replace the drive axle shaft.

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied	
Possible Cause	**Remedy**
The brake linings are glazed (dirt or grease build-up) or are worn unevenly.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake drums are worn, heat-checked, or cracked.	Install new brake drums.

Problem—Service Brakes Grab or Pull

Problem—Service Brakes Grab or Pull	
Possible Cause	**Remedy**
The drum could be out of round if it was not correctly positioned on the drum pilot tabs before the wheel was installed.	Position one of the hub-piloted tabs in the top position before placing the drum on the hub. When doing so, be sure the drum is located flat against the hub and on the largest-diameter portion of the pilot tabs. After placing the wheel(s) on the studs, firmly hand-tighten the nut on the stud closest to the top position. Proceed with the other nuts.
See the air brake system troubleshooting section in **Group 42** of this manual.	

Problem—Poor Lining-to-Drum Contact

Problem—Poor Lining-to-Drum Contact	
Possible Cause	**Remedy**
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
The brake shoes are stretched or bent.	Replace the brake shoes.
Undersized linings were installed.	Install new brake linings on both sets of axle brake shoes.
An incorrect grind was used on the brake linings.	
The wrong brake drums were installed.	Install new brake drums.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the instructions in **Subject 140** or **Subject 150**.

Problem—Brake Linings Are Tapered Across the Width

Problem—Brake Linings Are Tapered Across the Width	
Possible Cause	**Remedy**
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
The brake shoes are bent.	Replace the brake shoes.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the instructions in **Subject 140** or **Subject 150**.

Problem—Brake Shoes on the Same Brake Are Wearing Unequally

Problem—Brake Shoes on the Same Brake Are Wearing Unequally	
Possible Cause	**Remedy**
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The inside surface of the brake drum is in poor condition.	Turn or replace the brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 140** or **Subject 150**.

Problem—Edge of the Lining Is Showing Wear

Problem—Edge of the Lining Is Showing Wear	
Possible Cause	**Remedy**
The brake lining is too wide.	Install new brake linings on both sets of axle brake shoes.
The brake linings are misaligned because their holes were incorrectly drilled.	
Undersized brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 140** or **Subject 150**.
There is an improper fit of the wheel onto the spindle due to the wrong wheel bearings or cone.	Install and adjust the new wheel bearings and cone.
The brake shoes are bent.	Replace the brake shoes.

Problem—Brake Linings Are Scored or Grooved

Problem—Brake Linings Are Scored or Grooved	
Possible Cause	**Remedy**
Worn or scored brake drums have been causing poor contact with the brake linings.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
There is abrasive material between the lining and the drum.	

Troubleshooting

Problem—Brake Linings Are Loose

Problem—Brake Linings Are Loose	
Possible Cause	**Remedy**
The rivet holes in the brake shoes are too large.	Replace the brake shoes.
Improperly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Brake Lining is Cracked at the Rivet Holes or Bolt Holes

Problem—Brake Lining is Cracked at the Rivet Holes or Bolt Holes	
Possible Cause	**Remedy**
Overtightening of the lining bolts is causing cracks.	Replace the brake linings. Replace the rivets or bolts with the correct size.
The wrong size counter bore for the rivet holes was made.	
The wrong rivets or bolts were used.	Replace the rivets or bolts with the correct size.
Improperly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Out-of-Round Rivet Holes or Bolt Holes

Problem—Out-of-Round Rivet Holes or Bolt Holes	
Possible Cause	**Remedy**
The rivets or bolts are loose.	Replace the brake shoes or linings.

Problem—Brake Drums Are Heat-Checked

Problem—Brake Drums Are Heat-Checked	
Possible Cause	**Remedy**
The brake drums are out-of-round.	Turn or replace the brake drums.
The wrong brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 140** or **Subject 150**.
The brake linings are glazed (dirt or grease build-up) or are worn unevenly.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The lining friction material for the operation of the vehicle is incorrect.	
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Troubleshooting

Problem—Brake Drums Are Heavily Scored

Problem—Brake Drums Are Heavily Scored	
Possible Cause	**Remedy**
The brake linings are damaged.	Install new brake linings on both sets of axle brake shoes. Turn or replace the drums.
There is excessive wear on the linings.	
On the last brake reline, the drums were not turned.	Turn the brake drums.

Problem—Excessive Brake Lining Wear

Problem—Excessive Brake Lining Wear	
Possible Cause	**Remedy**
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Specifications

Torque Values			
Description		**Size (grade 8)**	**Torque: lbf·ft (N·m)**
Drive Axle Studs (to Hub)		1/2–13	70 (95)
		5/8–11	135 (185)
Hub Cap Capscrews		5/16–18	15 (20)
Drive Axle Stud Nuts	With Dowels	5/8–18	130 to 140 (175 to 190)
	Without Dowels	5/8–18	150 to 170 (203 to 230)
Oil Filler Plug	Dana Spicer axles	—	40–60 (54–81)
	Meritor axles	—	35 (47)
	Freightliner axles	—	37 (50)

Table 1, Torque Values

General Information

Wheel oil seals (also called "oil bath seals" or "hub seals") work as a dam to keep oil in the hub cavity so that it constantly "bathes" the wheel bearings. The seals also protect the wheel bearings by keeping dirt, dust, and water out of the hub.

The oil seal fits between the hub bore and the axle spindle, and the sealing element either turns with the wheel (*hub-mounted seals*) and seals against the axle spindle, or the sealing element stays stationary with the axle spindle (*spindle-mounted seals*) and seals against the turning hub.

Most wheel oil seals consist of four basic parts:

- The outside edge (also called the outer "cup" or "case")
- The inside edge (also called the inner "cup" or "case")
- The sealing element
- The garter spring

The outside edge is usually metal coated with rubber or another sealing agent so that it grips the hub bore tight enough to prevent oil escaping between the outer edge of the seal and the hub bore.

The inside edge is usually metal or rubber with a metal ring within it to prevent the sealing element from wearing a groove in the axle spindle.

The sealing element is usually molded rubber, leather, or a synthetic such as nitrile or silicone. The element is molded into lips which will seal against the axle spindle or against the outside or inside edge described above. The innermost lip, called the "primary lip," keeps the oil inside the hub cavity. The outermost lip, called the "secondary lip," keeps dirt out of the hub cavity.

The garter spring is a coiled wire spring with its ends connected to make a loop. On hub-mounted seals, the spring runs around the outside of the sealing element to press the element inwards against the sealing surface. On spindle-mounted seals, the spring runs around the inside of the sealing element to press the element outward against the sealing surface.

Freightliner uses two brands of axle oil seals:

- Chicago Rawhide (Scotseal® and Scotseal Plus®)
- Dana Spicer (Outrunner™)

Chicago Rawhide (See Fig. 1)

The Chicago Rawhide Scotseal is a unitized, one-piece design consisting of a sealing element (packing) that is assembled between metal outer and inner cups. The sealing element consists of three sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed and two dirt exclusion lips. The seal is press fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal directly onto the axle spindle.*

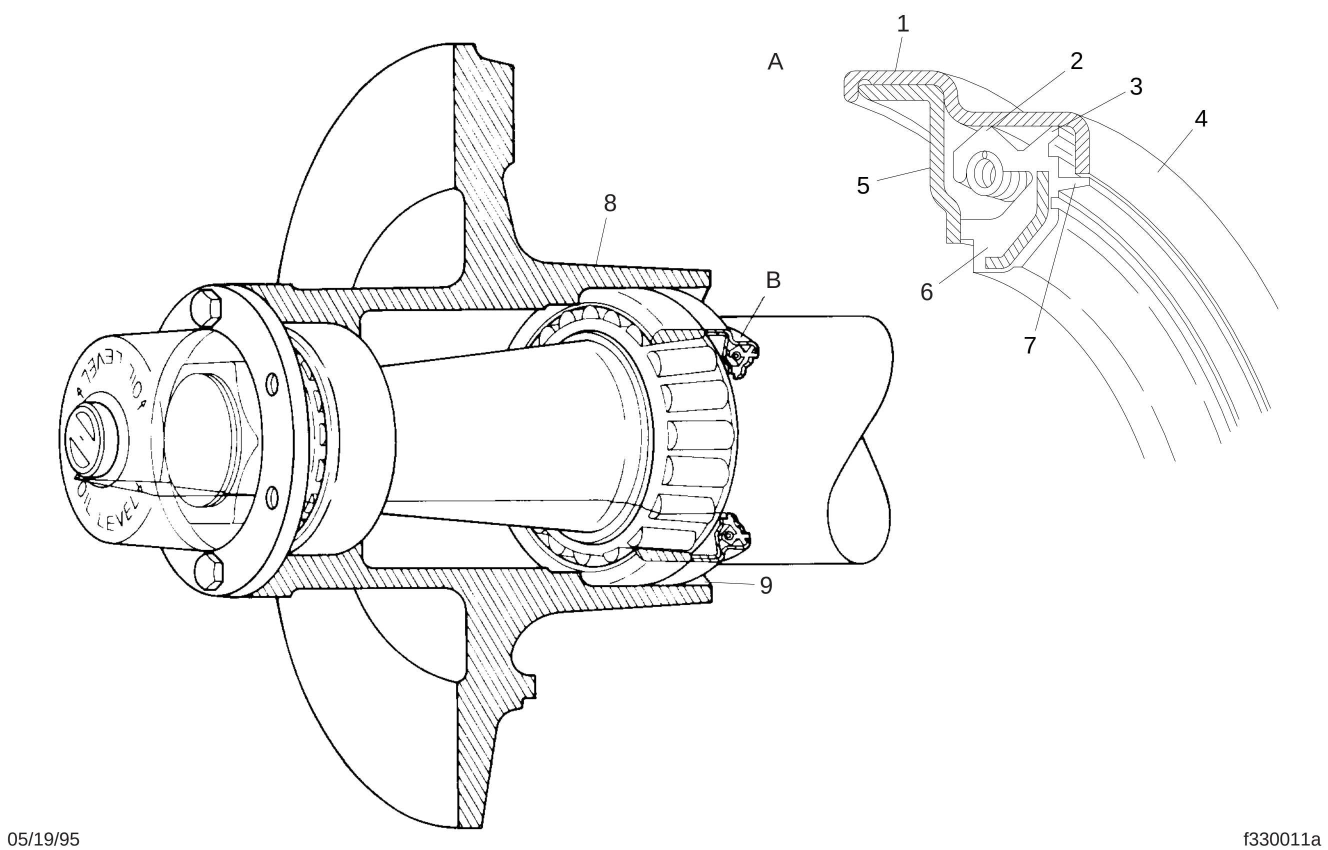
Although you install the Scotseal into the hub bore, the seal's element grips the axle spindle tightly enough that the sealing element stays stationary with the spindle and seals against the outer cup which turns with the hub.

The Chicago Rawhide Scotseal maintains a metal-to-metal contact between the outer cup and the hub bore surface as well as a metal-to-metal contact between the sealing element inside edge and the axle spindle.

Dana Spicer (See Fig. 2)

The Dana Spicer Outrunner has a rubber-coated outside edge and is installed in the hub bore using Dana Spicer installation tools.

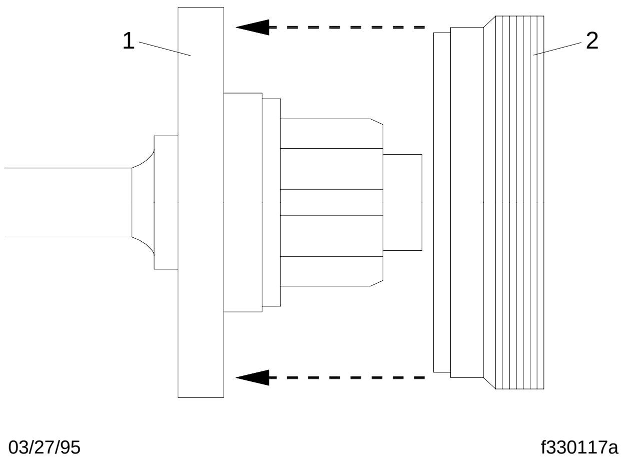
General Information



A. Detail A
B. Oil Seal (See detail A)

1. Bore-Tite® Coating
2 Primary Sealing Lip
3. Dirt Lip
4. Outer Cup
5. Inner Cup
6. Sealing Element (Packing)
7. Bumper Lip
8. Hub
9. Hub Bore

Fig. 1, Chicago Rawhide Scotseal



1. Dana Spicer Outrunner Installation Tool
2. Dana Spicer Outrunner Seal

Fig. 2, Dana Spicer Outrunner Seal

Seal Replacement, Chicago Rawhide

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Chicago Rawhide Scotseal®.

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 1** and **Fig. 2**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.

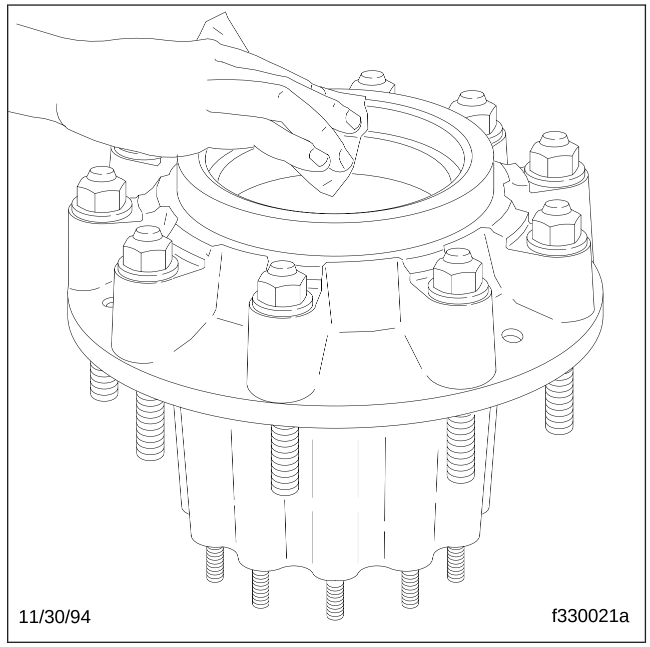


Fig. 1, Clean the Hub

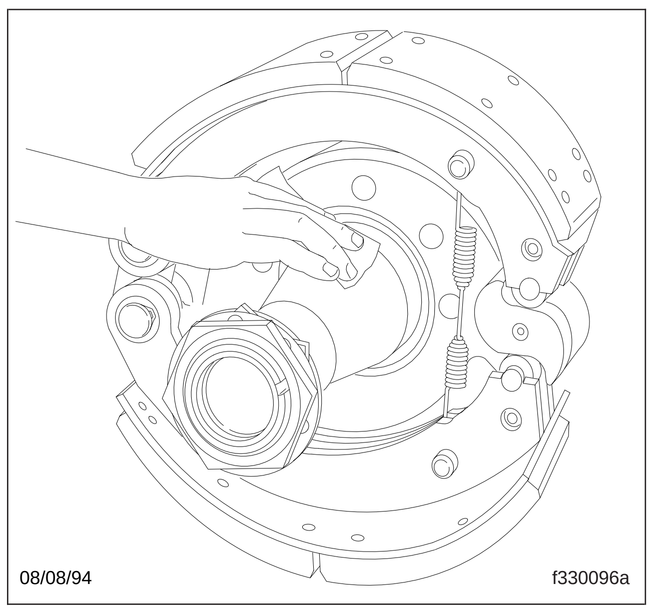


Fig. 2, Clean the Spindle

8. Seat the small outside edge of the seal in the recess of the tool adapter. See **Fig. 3**. The correct adapter is identified on the box.

Seal Replacement, Chicago Rawhide

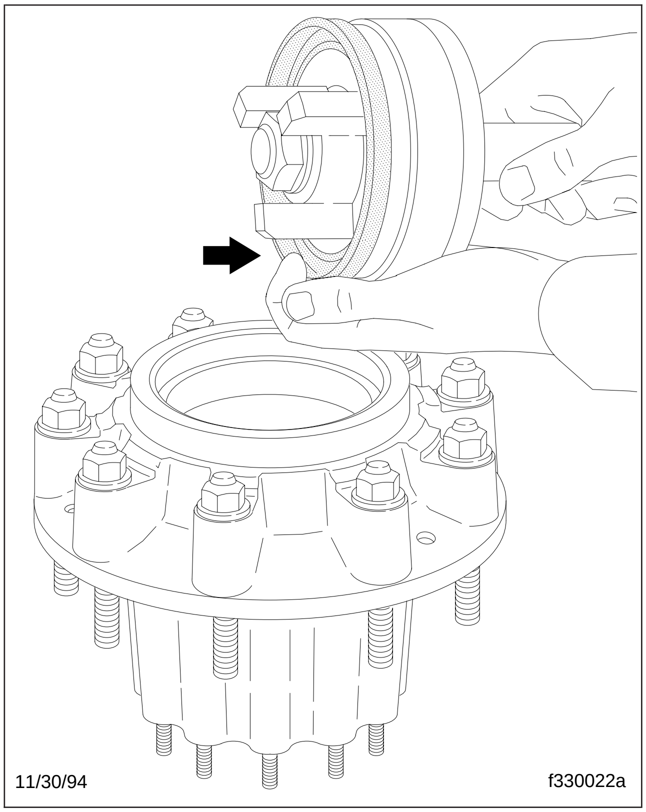


Fig. 3, Place the Seal on the Installation Tool

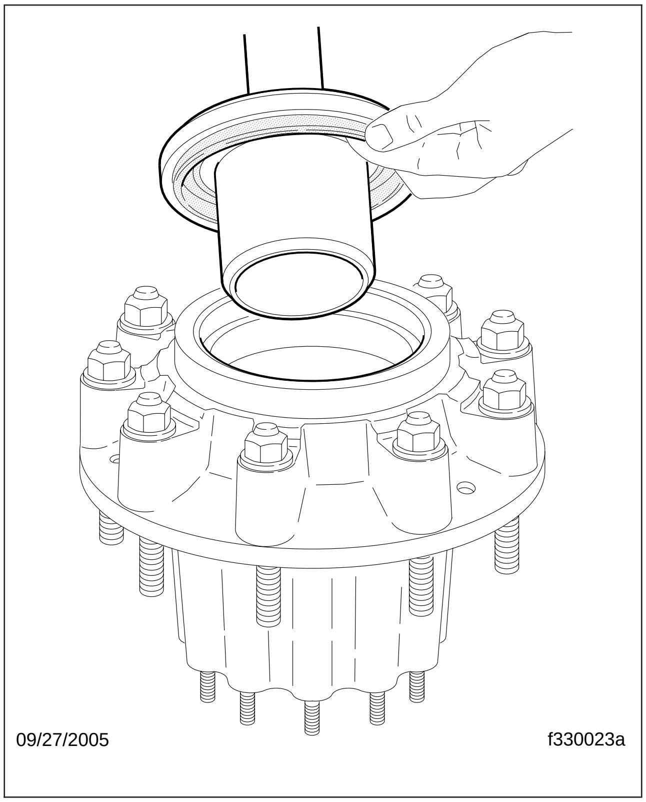


Fig. 4, Insert the Tool in the Hub Bore

9. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4**. The plug prevents cocking of the seal in the bore.
10. Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 5**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
11. After the seal is bottomed in the bore, check for freedom of movement by manually moving the interior rubber part of the seal back and forth. A slight movement indicates a damage-free installation.
12. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

Seal Replacement, Chicago Rawhide

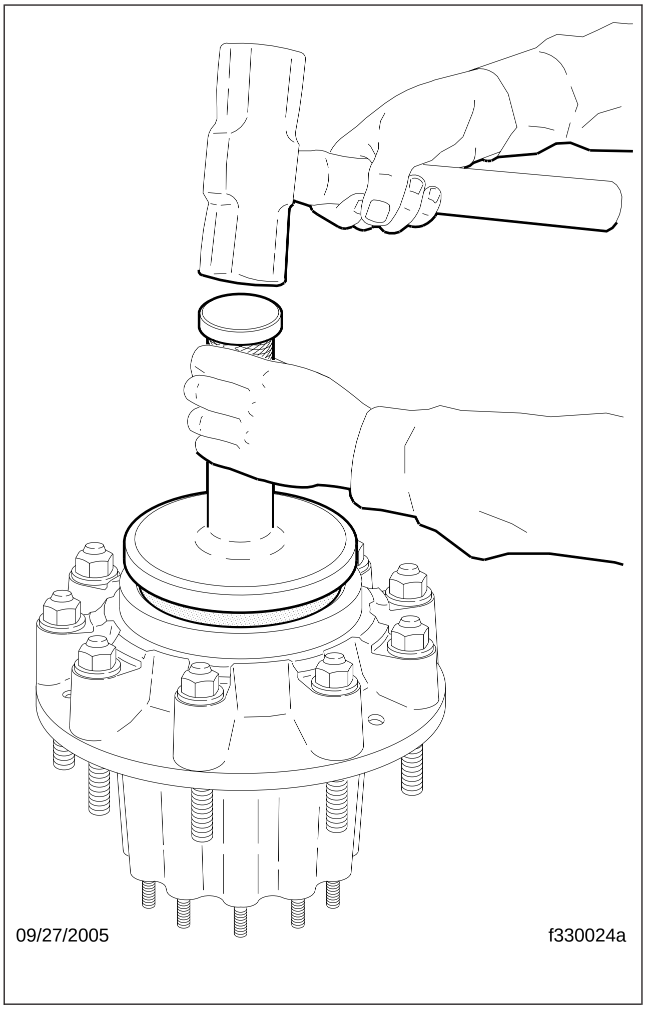


Fig. 5, Strike the Tool

Seal Replacement, Dana Spicer®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Dana Spicer Outrunner™ seal.

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.

CAUTION

Never use a sharp chisel to cut through an axle ring (wear sleeve). A sharp chisel could damage the spindle or shoulder.

3. Remove the steel axle ring (wear sleeve) by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.
4. Clean and inspect the bearings, the spindle, spindle threads, seal bore, and the hub cavity.

   IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

   4.1 Inspect the inner hub bore. Remove dirt and contaminants from all recesses and corners. Smooth any sharp edges with emery cloth, and fill in any grooves with filler. See **Fig. 2**.

   4.2 Wipe the hub area with a clean shop cloth.

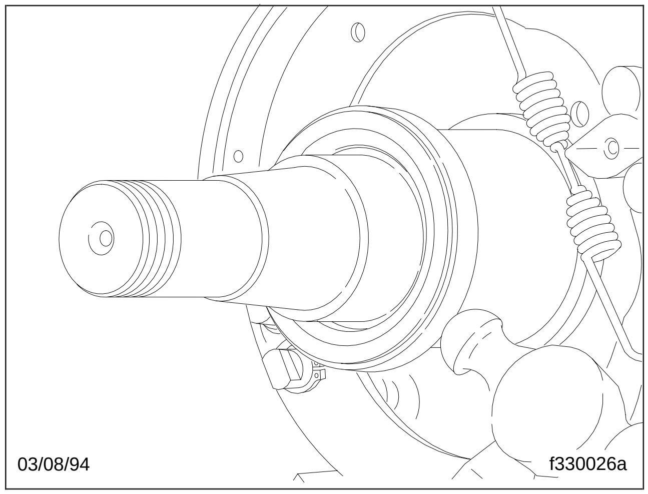


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Fig. 1, Removing the Axle Ring

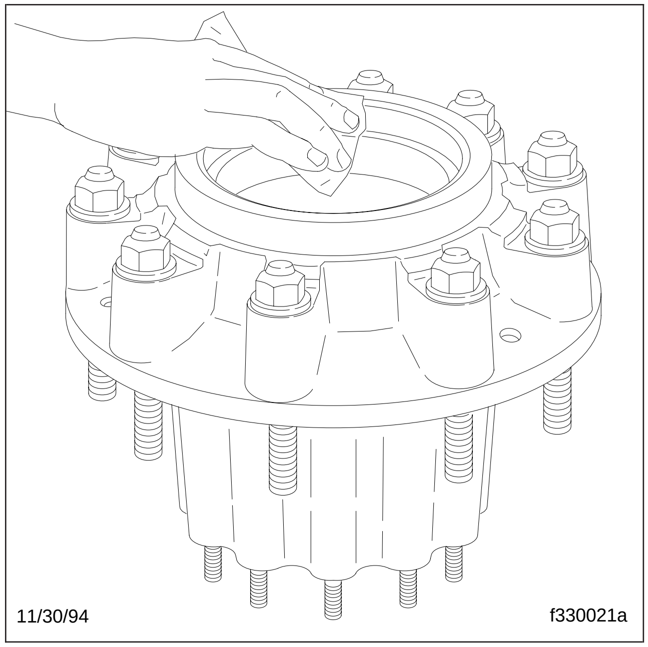

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Fig. 2, Clean and Inspect the Hub Bore

   4.3 After removing the wear sleeve, inspect the spindle. Remove any sharp edges and burrs from the leading edges and the shoulder area. Repair deep gouges with filler and smooth with an emery cloth. See **Fig. 3**.

   4.4 Wipe the seal and shoulder area with a clean shop cloth.

Seal Replacement, Dana Spicer®

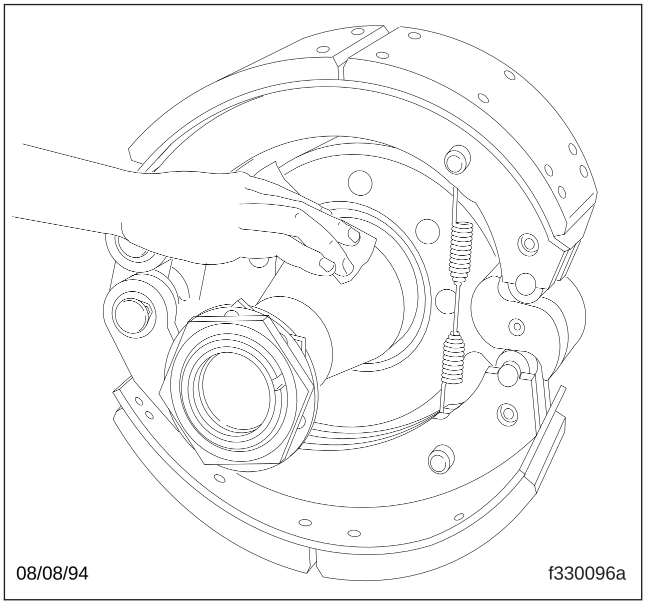


Fig. 3, Clean and Inspect the Axle Spindle

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

4.5 Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.

4.6 Coat the wheel bearing cones with oil.

5. Install the inner wheel bearing cone in the inner wheel bearing cup.

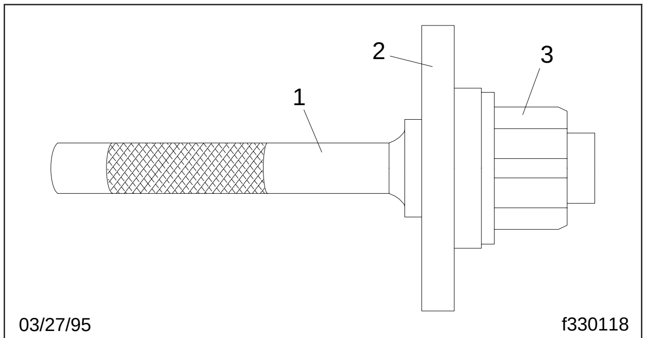
IMPORTANT: Use the Dana Spicer Outrunner installation tool *with the centering tool* when installing the seal. See **Fig. 4**.

6. Install the oil seal in the hub bore.

CAUTION

Do not use any silicone or permatex type bore sealant with this seal. The Dana Spicer Corporation recommends a light coating of bearing oil on the outer circumference of the seal.

Do not mix lubricants of different grades. Do not mix mineral and synthetic lubricants. Do not pack the bearings with grease when using an oil bath system. Failure to follow these installation guidelines will result in less than desired performance of the Outrunner seal, and installation-related failures are not covered under warranty.



1. Outrunner Handle
2. Outrunner Adapter Plate
3. Bearing Centering Tool

Fig. 4, Outrunner Installation Tool

6.1 Place the Outrunner seal tool with the words "air side" facing the adapter plate of the installation tool. See **Fig. 5**. Lubricate the seal outer circumference with wheel bearing oil.

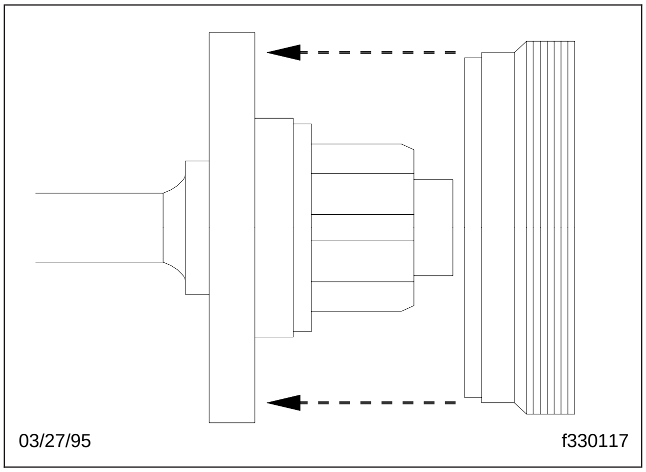


Fig. 5, Seal Placement on Tool

IMPORTANT: Install the seal in the hub bore with the hub lying flat. Do not install the seal with the hub in the vertical (upright) position.

6.2 With the hub and the wheel assembly lying flat on the floor, place the inner bearing cone in the cup.

6.3 Position the oil seal in the hub bore. Before striking the handle of the installation tool, tap the adapter plate around the outer edge to position the seal. See **Fig. 6**.

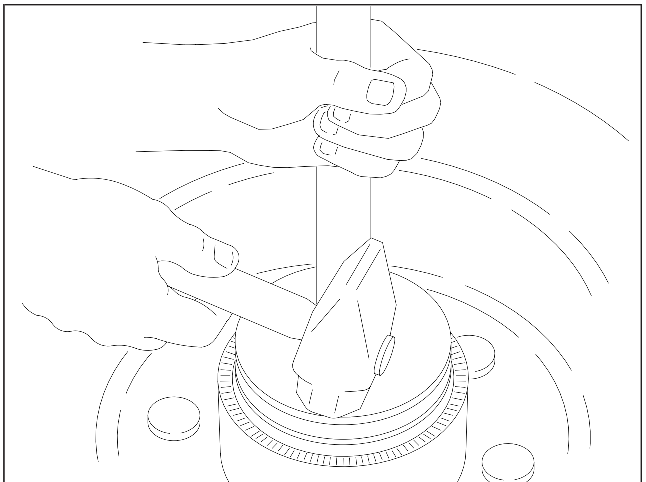


Fig. 6, Position the Seal

6.4 Hit the handle of the installation tool *gently*. See **Fig. 7**.

Because of the rubber outer circumference, the Outrunner seal is easier to install than seals with metal outer circumferences. When the adapter plate bottoms out on the hub surface, the seal is installed correctly. You will hear a metal-to-metal sound.

6.5 Check that the seal is not cocked, and that the unitized seal inner circumference and inner bearing turn freely.

6.6 Lubricate the inner circumference of the seal with a light film of clean bearing oil.

7. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

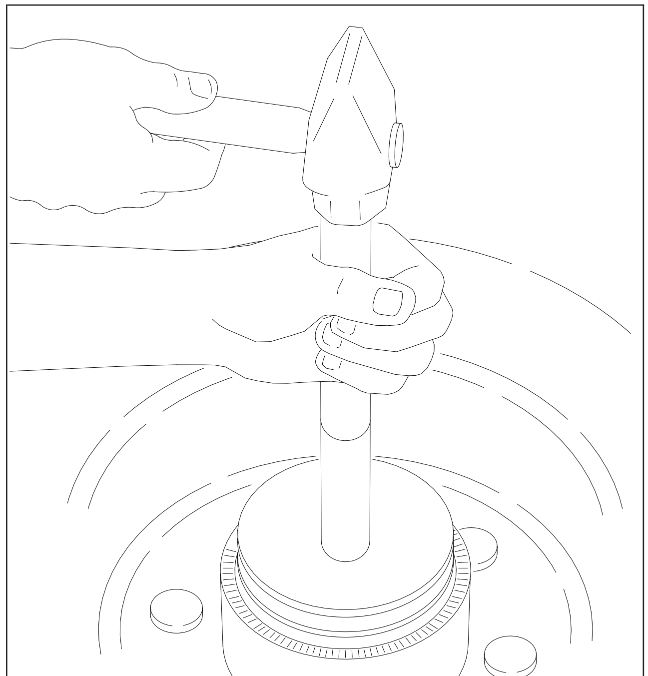


Fig. 7, Install the Seal

Seal Replacement, National®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

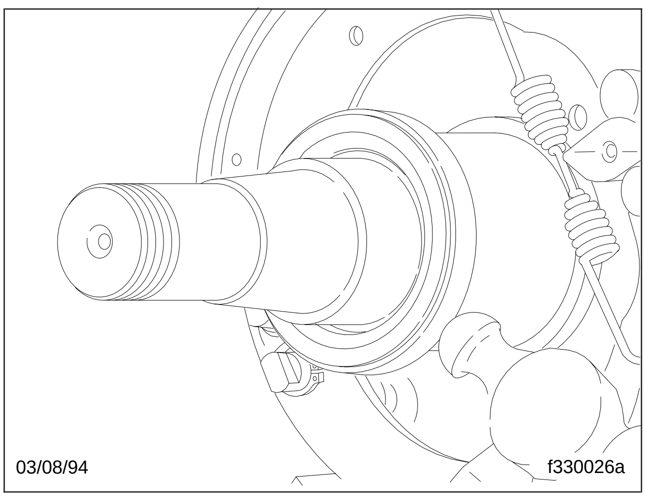


Fig. 1, Remove the Axle Ring

5. Inspect the spindle shoulder and hub bore.

   5.1 If necessary, use a file to remove burrs from the leading edges and shoulder area.

   5.2 Fill any deep scratches with a hardening compound and smooth it with an emery cloth. See **Fig. 2**.

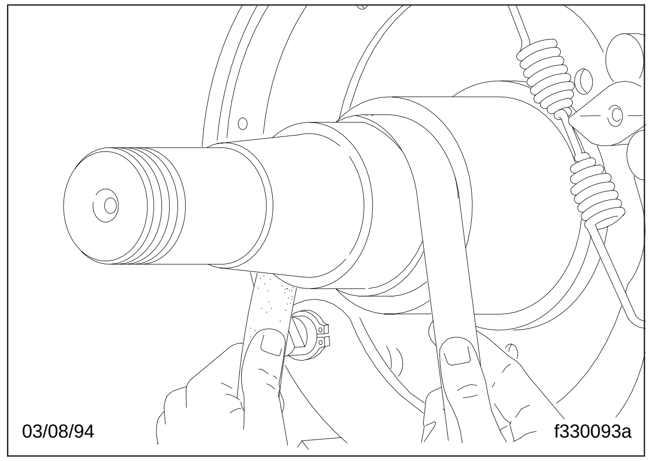


Fig. 2, Clean the Axle Spindle

   5.3 Use a clean cloth to remove all dirt, grit, and metal filings.

   5.4 Check the seal for a correct fit by placing the seal on the axle spindle, up to the first rubber rib. The correct seal will not go any farther.

   IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

   5.5 Inspect the hub bore, and remove any burrs from the leading edge with an emery cloth.

6. Select the seal installation tools designed for use with National oil bath seals. These should include a universal handle, an adapter plate, and a bearing pilot. See **Fig. 3**.
7. Install the seal in the hub.

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

Seal Replacement, National®

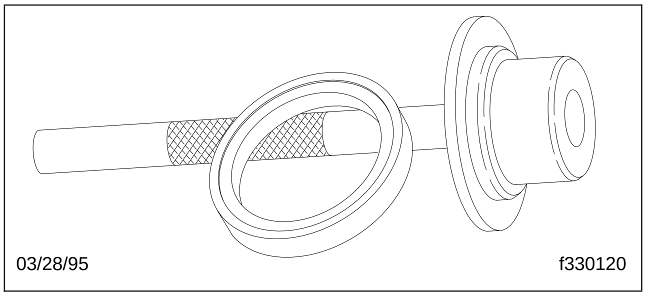


Fig. 3, Installation Tools

7.1 Prelube the inner bearing cone with clean oil and place it in the hub. See **Fig. 4**.

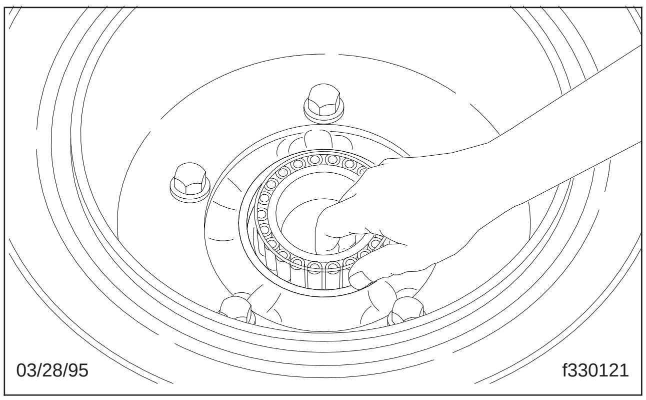


Fig. 4, Place the Bearings in the Hub

7.2 Place the oil bath seal on the installation tool with the words "air side" facing the adapter plate. Lubricate the outside edge of the seal with clean oil to ease the installation. See **Fig. 5**.

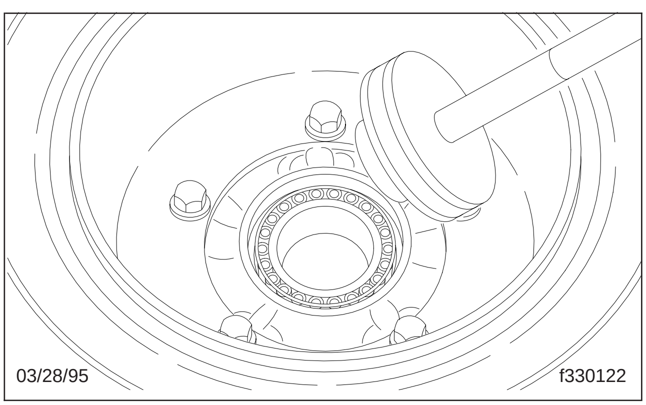


Fig. 5, Place the Seal on the Tool

7.3 Hold the tool straight, and drive the seal with a firm hit until the sound of the impact changes. See **Fig. 6**. Check to see the seal is squarely in position and that the inner wheel bearing rotates freely.

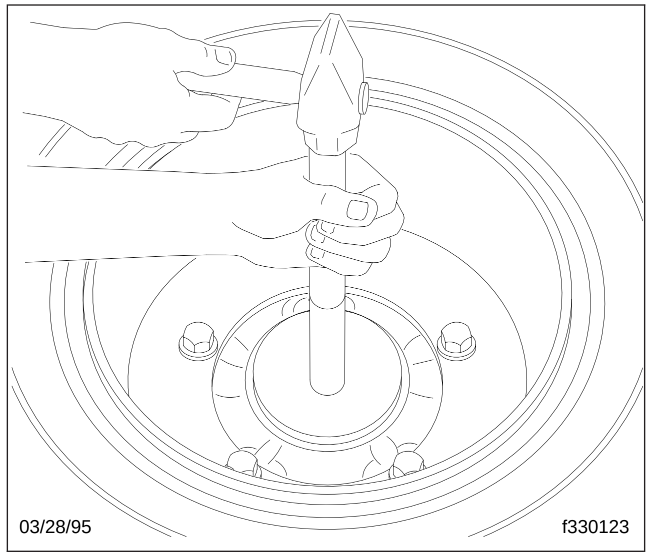


Fig. 6, Drive the Seal Into the Hub

7.4 Lubricate the inside edge of the seal with clean oil.

8. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

Seal Replacement, Stemco®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

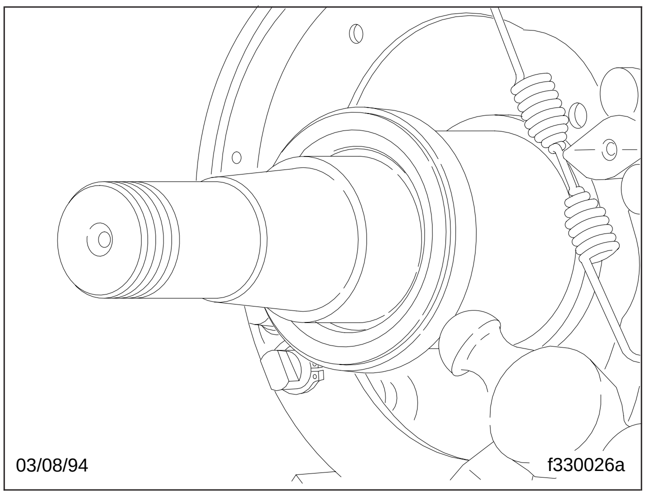


Fig. 1, Remove the Axle Ring

5. Using a wire brush, remove any old sealant and corrosion from the axle spindle and shoulder. Remove any burrs with an emery cloth. See **Fig. 2**. Wipe the spindle and shoulder clean with safety solvent.

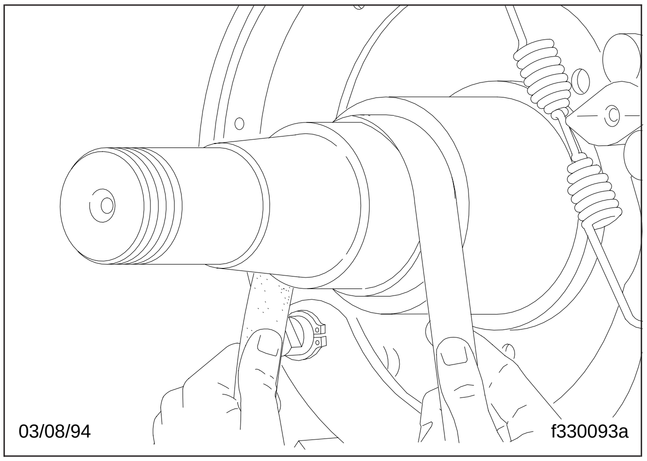
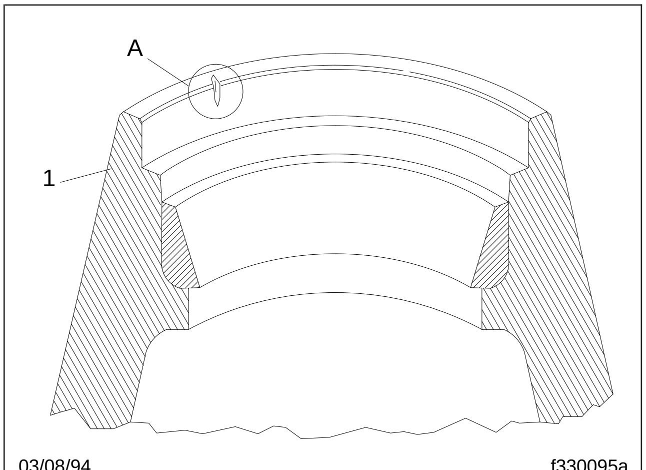


Fig. 2, Clean the Axle Spindle

6. Remove any burrs from the inside of the hub bore. See **Fig. 3**. The hub bore must be free of burrs that will scratch the outer surface of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.



A. Check for burrs.
1. Hub

Fig. 3, Inspect the Hub Bore

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

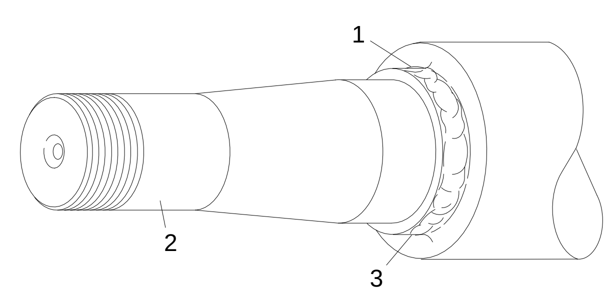
Seal Replacement, Stemco®

7. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged parts as necessary.

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

8. If burrs were removed from the spindle shoulder, apply a thin layer of non-hardening sealant to the spindle shoulder. See **Fig. 4**.



1. Sealant
2. Spindle
3. Shoulder

Fig. 4, Apply Sealant to the Spindle Shoulder

NOTE: Use a non-hardening sealant such as Permatex® Number-2 or Loctite® 515.

9. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside circumference of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. See **Fig. 5**.

CAUTION

Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.

10. Position the Stemco installation tool over the spindle. See **Fig. 6**. Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After the tool bottoms, turn it while applying several light taps

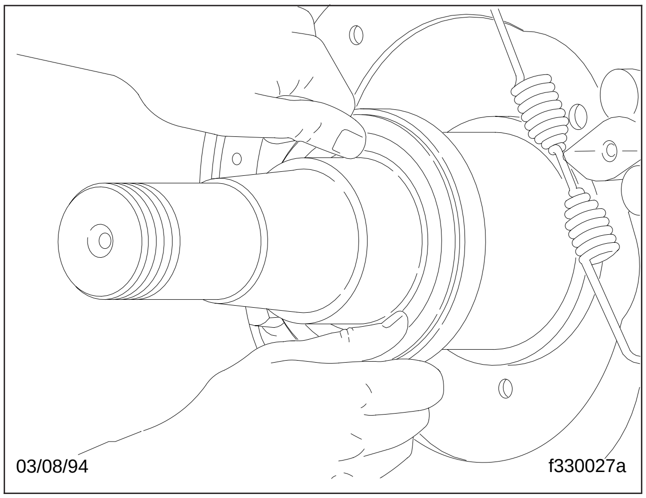


Fig. 5, Place the Seal on the Spindle

with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.

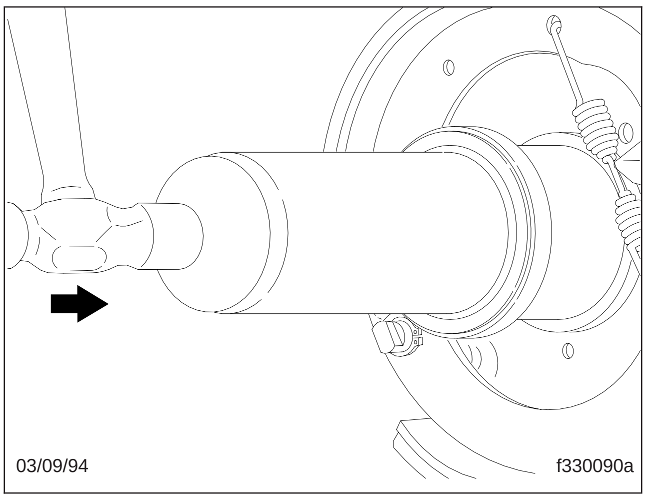


Fig. 6, Drive the Seal onto the Spindle

IMPORTANT: Use only the tool specified by Stemco for the vehicle's axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

11. Make sure there are no gaps between the ring and shoulder. See **Fig. 7**.

12. Coat the inner wheel bearing with oil and install it on the spindle. See **Fig. 8**. No additional oil is

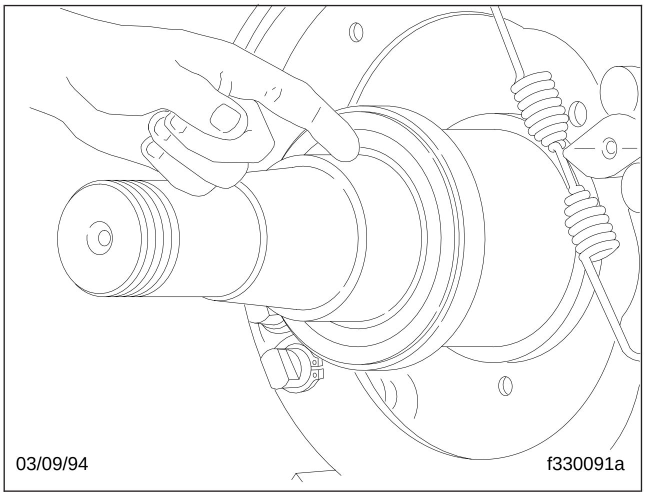


Fig. 7, Check the Ring for Gaps

needed on the outside of the seal. The seals are lubed at the factory.

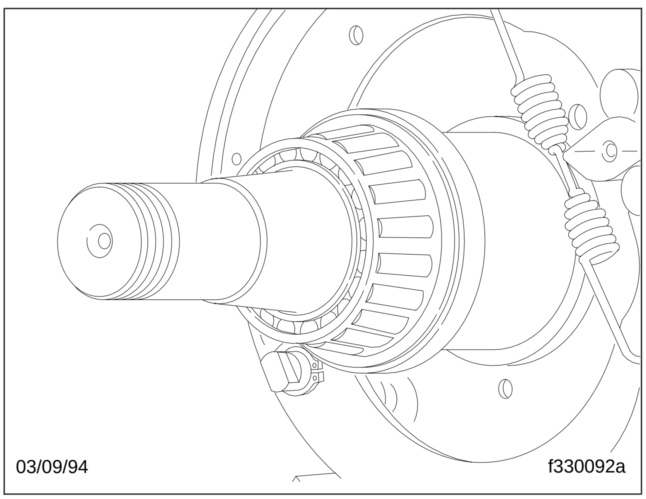


Fig. 8, Install the Inner Bearings

13. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

Bearing Centering Tool Interchange				
Spindle Type	Bearing Cone	Centering Tool Number		
		Dana Spicer® Outrunner™	Chicago Rawhide	National®
—	580	BCT-10	710	RD-410
—	582	BCT-10	710	RD-410
—	594	BCT-15	715	RD-416
—	595	BCT-10	710	RD-410
—	598	BCT-14	714	RD-415
—	663	BCT-10	710	RD-410
—	665	BCT-11	711	RD-411
—	759	BCT-12	712	RD-412
—	5760	BCT-8	708	RD-418
15K	33287	BCT-7	707	RD-408
—	47678	BCT-8	708	RD-418
L	47686	BCT-10	710	RD-410
—	495AX	BCT-8	708	RD-418
R	594A	BCT-15	715	RD-416
—	598A	BCT-14	714	RD-415
—	HM516449	BCT-10	710	RD-410

Table 1, Bearing Centering Tool Interchange

Adapter Plates		
Seal	Adapter Plate	Color
848	848-T	Gold
849	849-T	
852	852-T	
854	854-T	
856	856-T	
858	858-T	
860	860-T	
861	861-T	

Table 2, Adapter Plates

General Information

Detroit rear axles are compatible with industry-standard brakes, hubs, and wheel bearings.

The following explains an example of the number found on a Detroit rear axle identification tag, which is located on the carrier. See **Fig. 1**.

Typical Model Number: ART-40.0-4

- *ART* = tandem rear axle
- *40.0* = weight rating (times 1000 lb)
- *4* = basic model number

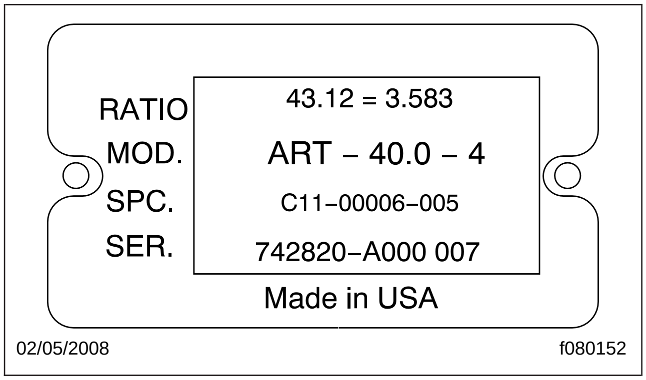


Fig. 1, Rear Axle ID Tag

Detroit rear axles may have a main differential lock, which is commonly known as the "DCDL" (Driver-Controlled Differential Lock). The DCDL is an optional feature that can lock the differential assembly to improve traction on icy road conditions. When the differential lock is engaged, the clutch collar completely locks the differential case, gearing, and axle shafts together to maximize traction of both wheels and protect against spinout. Each part of the DCDL is replaceable; see **Subject 180**.

On tandem axles there are three possible differential lock options: forward-rear carrier only, rear-rear carrier only, or both rear carriers.

NOTE: Detroit axles are a proprietary product, though in some applications they may be referred to as "Freightliner" or "Axle Alliance" axles or "MB components."

Warranty

To assist in the determination of warrantable and non-warrantable failures for these axles, warranty evaluation guides are available through WarrantyLit on **www.accessfreightliner.com**. These guides help determine whether or not pre-approval is needed for a repair. The following evaluation guides are available:

- **Warranty Evaluation Guide**
- **Submission Guidelines - Differential Cross Failure**
- **Submission Guidelines - Pinion Bearing Cage Damage**
- **Submission Guidelines - Pinion Nut Failure**
- **Submission Guidelines - Thrust Bearing Failure**
- **Submission Guidelines - Yoke (Pinion) End Play**

Removal

For rear axle components, see **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the axle, loosen all the wheel nuts.
4. Continue to raise the vehicle evenly until there is room to fit a stand underneath the axle housing.

WARNING

Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, allowing the vehicle to fall, which could result in serious injury or death.

5. Support the vehicle with safety stands.
6. Remove the tire and wheel assemblies.
7. Drain the oil from the differential housing. Install the drain plug.
8. Disconnect the driveshaft from the differential carrier. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
9. Release the parking brakes.
10. Cage the parking brake springs to prevent the parking brakes from engaging. For instructions, see **Group 42**.
11. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
12. Place a basin under the axle shaft flanges to catch any oil, then remove the axle shafts. For instructions, see **Subject 120**.
13. Drain the air system.
14. Disconnect the DCDL air line from the carrier housing.
15. If necessary, back off the slack adjusters, then remove the brake drums.
16. Remove the hubs from the axle spindles. For instructions, see **Section 35.01, Subject 100**.
17. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
18. If applicable, disconnect the leveling valve rod(s) from the suspension.
19. At the frame rail or crossmember, disconnect the wiring for the ABS sensors. Remove any tie straps that hold the wires to the frame rails.
20. Disconnect the air lines from the rear brake chambers.
21. Remove the brake air chambers and the slack adjusters from the axle housing. For instructions, see **Group 42**.
22. Remove the ABS sensors and wiring, and the fasteners that hold the brake spiders to the axle flanges. Remove the spiders from the axle.
23. Using a suitable jack, support the axle housing.
24. If applicable, remove the hexnuts that hold the bottom of each suspension air bag to its suspension bracket.
25. Remove the suspension components that attach the axle to the vehicle. If applicable, remove the U-bolt nuts from the U-bolts. Discard the U-bolt nuts and U-bolts.
26. Lower the axle enough to clear the suspension components.
27. Remove the axle from the vehicle.
28. If you are going to replace the differential carrier, place the axle on a secure axle stand.

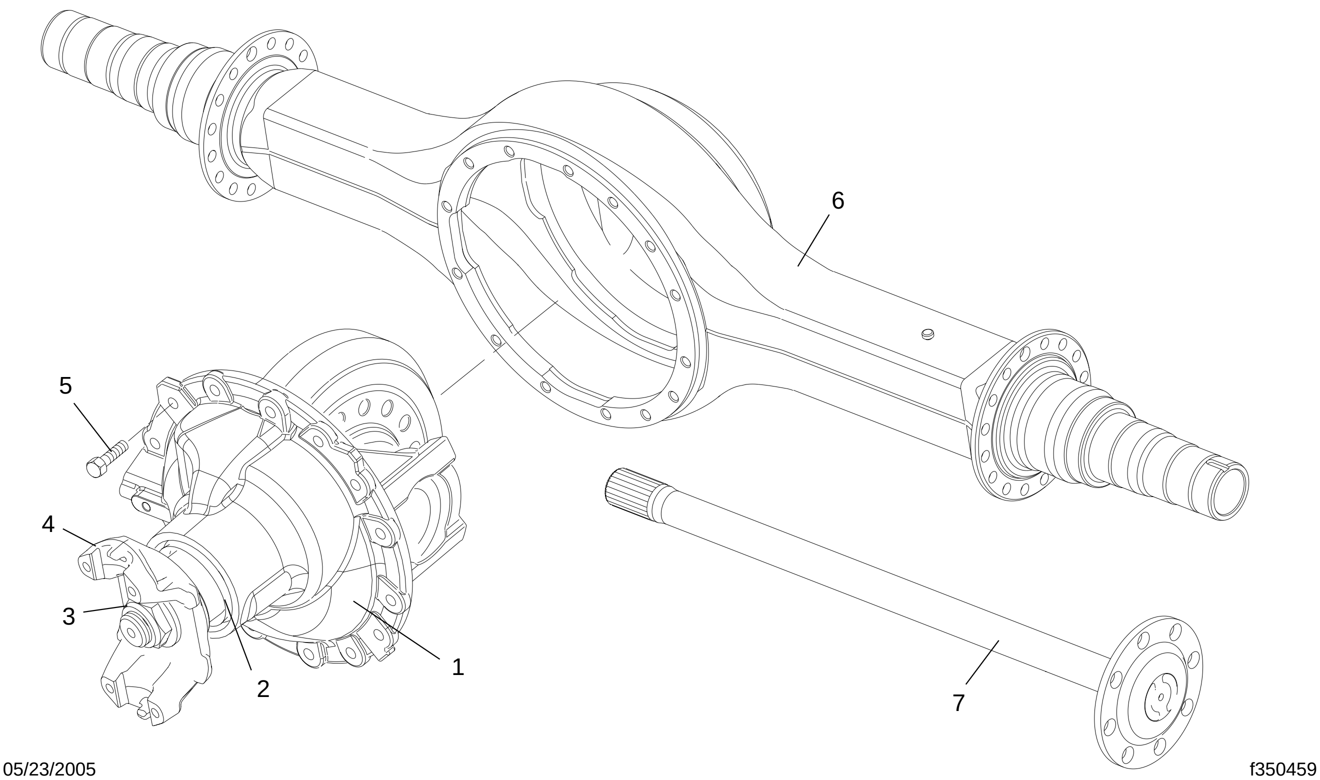
Installation

1. Position the axle underneath the vehicle.
2. Install the suspension components that attach the axle to the vehicle, as follows.

   NOTE: U-bolts and U-bolt nuts cannot be reused.

   2.1 On vehicles with conventional suspensions, install the upper U-bolt brackets,

Single or Rearmost Axle Removal and Installation



1. Differential Carrier
2. Radial Shaft Seal
3. Yoke Nut
4. Carrier Yoke
5. Carrier Capscrew
6. Rear Axle Housing
7. Axle Shaft

Fig. 1, Single or Rearmost Axle Components

new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

On vehicles with air suspensions, in addition to the U-bolts, install the hexnuts that attach the air springs to the suspension brackets. For torque values, see **Group 32**.

On vehicles without U-bolts, install the walking beams.

2.2 If applicable, tighten the new U-bolt nuts in a diagonal pattern. For torque values, see **Group 32**.

3. Connect the driveshaft to the differential carrier yoke. For instructions, see **Section 41.00, Subject 120**.
4. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
5. Install the ABS sensors and connect the wiring at the frame rail. Secure the wiring with tie straps as needed.
6. Install the brake air chambers and slack adjusters on the axle housing brackets. For instructions, see **Group 42**.
7. Connect the air lines to the brake air chambers.
8. Install the brake shoes, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. Fill each hub with approved axle oil until you can see a little amount of oil trickling out of the back of the hub (use about 0.8 quart, or 0.75 liter). Install the hubs on the axle spindles, and adjust

the wheel bearings. For instructions, see the applicable subject in **Section 35.01**.

NOTE: See **Table 1** for approved axle oils.

10. If DCDL is installed on the vehicle, connect the DCDL air line, fill the air system, and use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged.
11. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.

Single Rear Axle Oil Type and Capacity		
Approved Oil Type	Capacity: quarts (liters)	
	Hubs Full	Hubs Dry
80W-90 Gear Oil	10.6 (10.0)	12.2 (11.5)
75W-90 Synthetic Gear Oil		

Table 1, Single Rear Axle Oil Type and Capacity

12. Install the brake drums on the hubs.
13. Install the wheels and tires. For instructions, see **Group 40**.
14. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
15. Uncage the parking brake springs.
16. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.
17. If the hubs are dry, raise one side of the vehicle about 4 inches (10 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

18. Turn the wheels, wait one minute, and check the lubricant level.
19. Raise the vehicle, remove the safety stands, then lower the vehicle.
20. If applicable, connect the suspension leveling valve(s). Start the engine, build the air pressure, and make sure the suspension air bags inflate correctly. Make sure the ride height is correct. For instructions, see **Group 32**.
21. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
22. Set the parking brake.
23. Remove the chocks from the tires.

Single or Rearmost Axle Differential Carrier Removal and Installation

When the wheel lock is removed, inspect the carrier for damage and replace it if damage is found. If no damage is found, install the carrier again.

Removal

NOTE: The differential carrier can be removed either with the rear axle installed on the vehicle or with the rear axle removed from the vehicle.

Axle Installed on Vehicle

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires. Put the transmission in neutral.
2. If applicable, release the suspension air pressure.
3. Using suitable jacks, raise the vehicle evenly until there is room to fit a jack underneath the axle housing.
4. Remove the tires and wheels. For instructions, see **Group 40**.
5. Drain the oil from the axle housing.
6. Disconnect the driveshaft from the carrier yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
7. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
8. Place a basin under the axle shaft flanges, then remove the axle shafts. For instructions, see **Subject 120**.
9. Do the steps under the heading, "Axle Removed from Vehicle."

Axle Removed from Vehicle

1. Using a suitable jack, support the differential carrier. Chain the differential carrier to the jack.
2. If DCDL is installed on the vehicle, ensure the lock is engaged. Turn the appropriate wheels to verify it is fully engaged.

WARNING

The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.

3. Remove the carrier capscrews that hold the differential carrier to the axle housing. See **Fig. 1**.
4. With the differential carrier securely supported, remove it from the axle housing.

Installation

IMPORTANT: If you replace the yoke on the differential carrier, use a **new** nut when installing the new yoke.

NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

1. Remove any old sealant material from the mating surfaces of the axle housing. Clean the inside of the rear axle housing and the forward carrier mating surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing as necessary.
3. Apply a thin bead of Loctite® 5900 sealant all the way around the mating surface of the axle housing, and around each bolt hole.

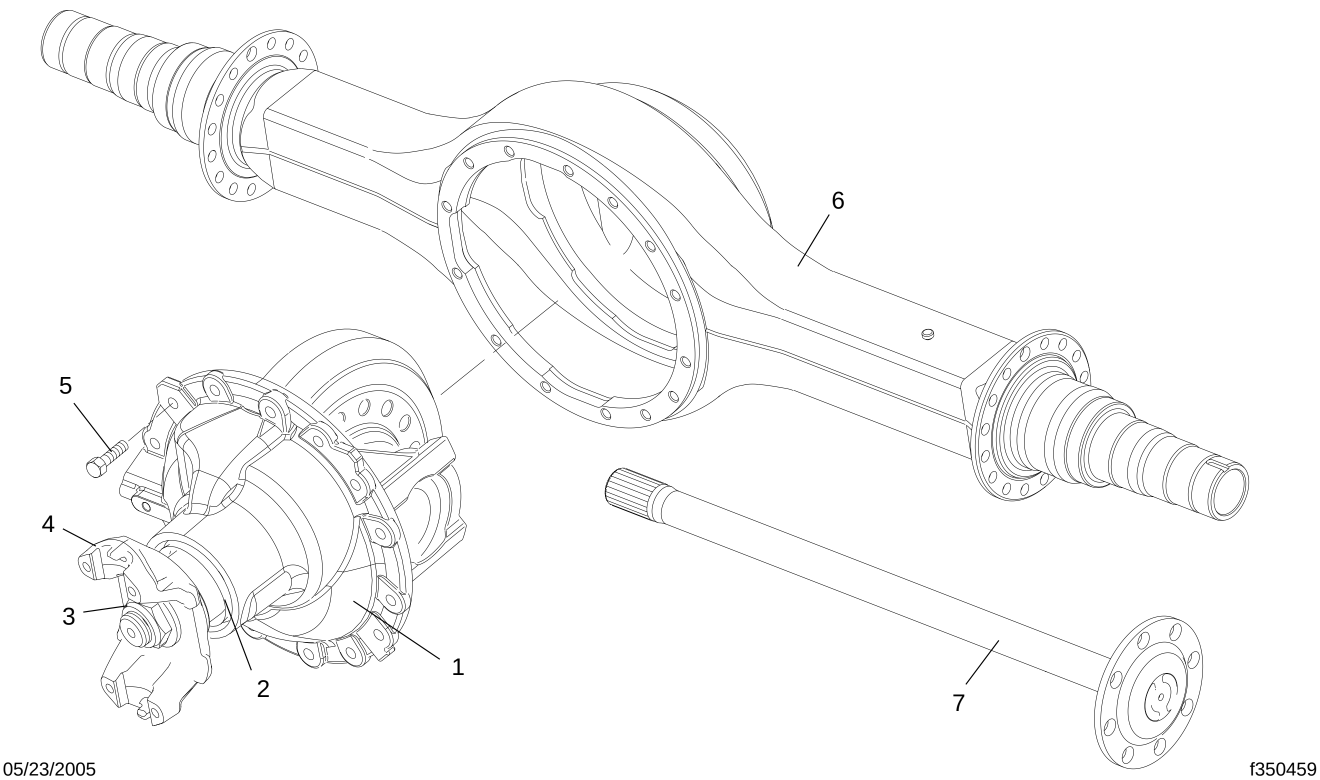
NOTE: Alignment dowels for installing the differential carrier can be made by sawing off the heads of two M16 x 1.5 x 100 mm bolts.

4. Install alignment dowels 180 degrees apart at the 3 o’clock and 9 o’clock positions on the axle housing flange.
5. If DCDL is installed on the vehicle, ensure it is engaged.

NOTICE

Make sure the differential carrier is centered and straight on the axle housing before you install the mounting capscrews. Attempting to install the carrier when it is not centered or straight may cause damage to the carrier.

Single or Rearmost Axle Differential Carrier Removal and Installation



1. Differential Carrier
2. Radial Shaft Seal
3. Yoke Nut
4. Carrier Yoke
5. Carrier Capscrew
6. Rear Axle Housing
7. Axle Shaft

Fig. 1, Single or Rearmost Axle Components

6. Using a hoist (if the axle is removed from the vehicle) or a suitable transmission jack, install the differential carrier into the axle housing. Use the alignment dowels to center the carrier on the axle housing.
7. Install the end caps on the sides of the carrier into the corresponding slots in the axle housing. See **Fig. 2**.

   7.1 For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

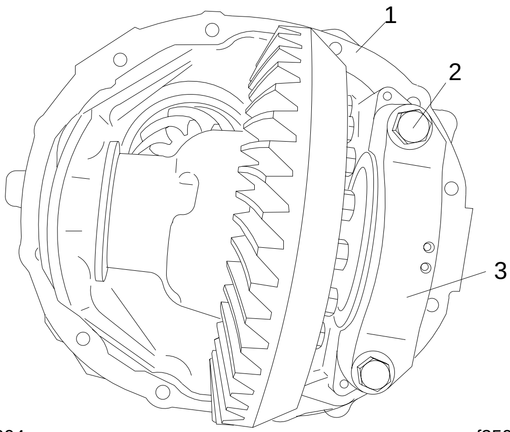
   IMPORTANT: The end caps fit tightly into the axle housing. Be very careful not to cock the carrier.

   7.2 Install the carrier capscrews finger-tight. Make sure the carrier capscrews turn easily in the axle housing.

   7.3 In a star pattern, gradually tighten the M16 carrier capscrews: 200 lbf·ft (270 N·m).
8. If removed, install the axle on the vehicle. For instructions, see **Subject 100**.

   If the axle is already on the vehicle, go to the next step.
9. Connect the driveshaft to the carrier yoke. For instructions, see **Section 41.00, Subject 120**.
10. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
11. Install the wheels and tires. For instructions, see **Group 40**.
12. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

Single or Rearmost Axle Differential Carrier Removal and Installation



1. Differential Carrier
2. End Cap Bolt
3. End Cap

Fig. 2, Carrier End Caps

Single Rear Axle Oil Type and Capacity		
Approved Oil Type	Capacity: quarts (liters)	
	Hubs Full	Hubs Dry
80W-90 Gear Oil	10.6 (10.0)	12.2 (11.5)
75W-90 Synthetic Gear Oil		

Table 1, Single Rear Axle Oil Type and Capacity

13. If the hubs are dry, raise one side of the vehicle about 4 inches (10 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage

14. Turn the wheels, wait one minute, and check the lubricant level.
15. Raise the vehicle, remove the safety stands, then lower the vehicle.
16. Start the engine, build the air pressure, and check that the suspension air bags inflate evenly and correctly. Make sure the ride height is correct.
17. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
18. Remove the chocks from the tires.

Removal

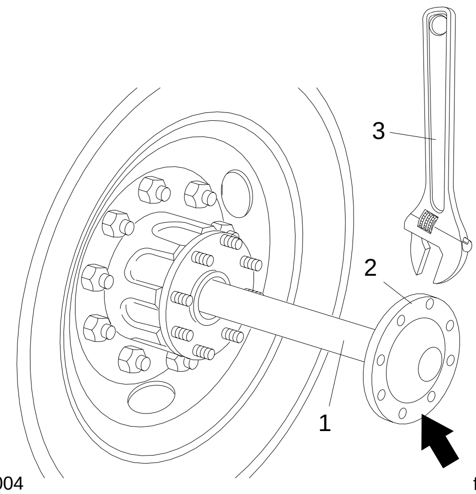
1. Chock the front tires.
2. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
3. Raise the rear of the vehicle with a suitable jack high enough to clear the axle. Support the axle with jack stands.
4. Place a basin under the axle shaft flanges to catch any oil. Dispose of used oil properly.
5. If necessary, remove the tires. For procedures, see **Group 40**.

NOTE: This procedure can be done with the wheels and tires installed or with the wheels and tires removed.

6. Remove the drive axle stud nuts that attach the axle shaft to the wheel hub.
7. Tap the axle shaft flange if necessary to loosen it and slide the axle shaft out of the axle. Remove and discard the gasket.

Installation

1. Position a new gasket on the axle shaft flange.
2. If DCDL is installed on the vehicle, ensure it is engaged.
3. Install the axle shaft, as follows. See **Fig. 1**.
   - 3.1 Carefully raise the axle with a floor jack, and support the axle with jack stands. Slide the axle shaft into the axle.
   - 3.2 Apply light pressure with the hand or knee to the axle flange.
   - 3.3 Use an adjustable wrench to center the shaft. Turn the shaft with a slight rotating motion.
   - 3.4 Install the drive axle stud nuts and tighten them to the values given.
     - 1/2–20 nuts: 75 to 115 lbf·ft (102 to 156 N·m)
     - 5/8–18 nuts: 150 to 170 lbf·ft (203 to 230 N·m)



Apply light pressure with the hand or knee at the arrow. Use the adjustable wrench to center the shaft.

1. Axle Shaft
2. Axle Flange
3. Adjustable Wrench

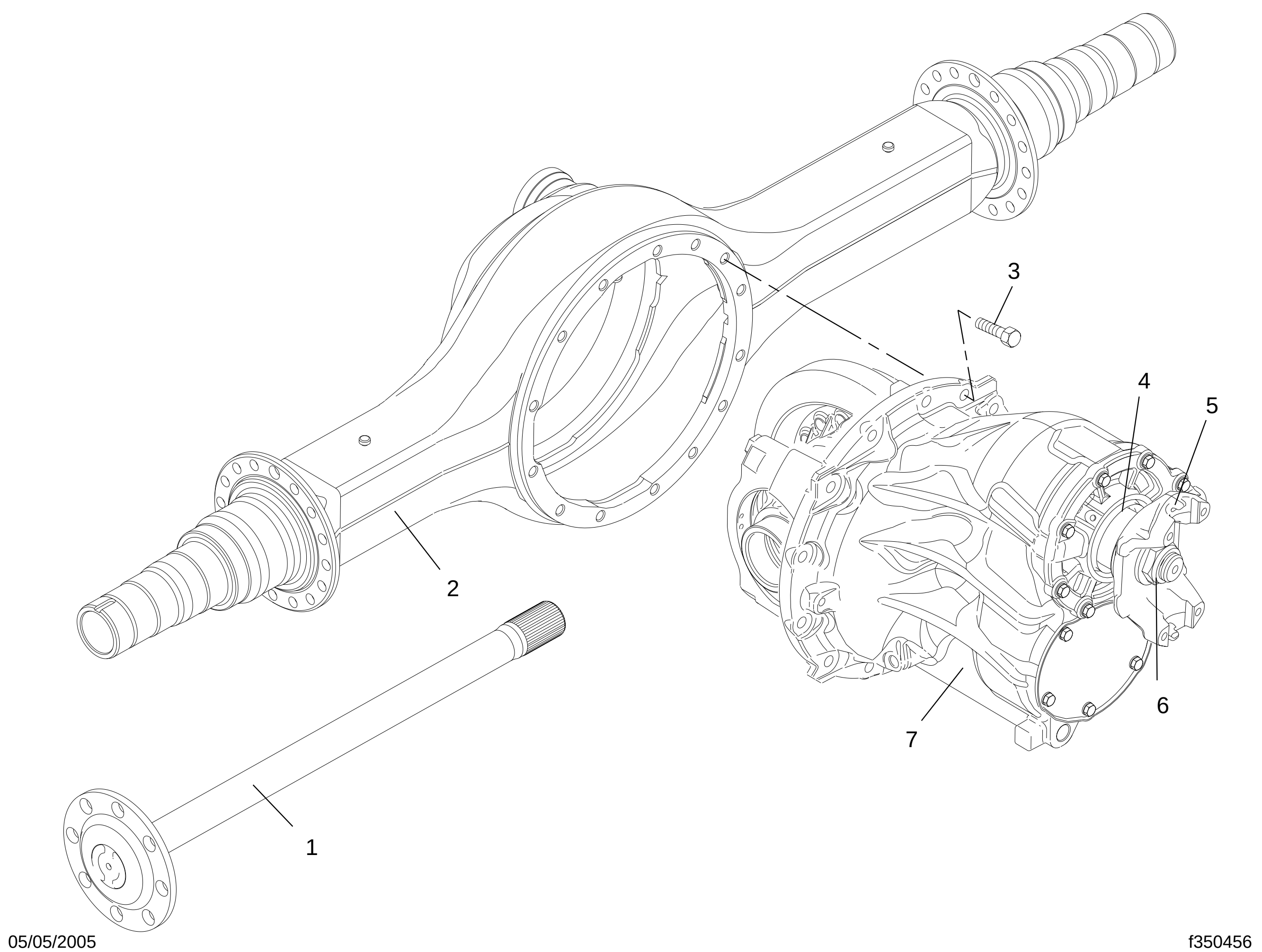
Fig. 1, Installing the Axle Shaft

4. If removed, install the tires and tighten the wheel nuts according to the procedures in **Group 40**.
5. Remove the supports and lower the vehicle.
6. As needed, replace any oil that was drained from the hub when the axle shaft was removed.
7. Remove the chocks from the front tires.

Removal

For forward-rear axle components of a tandem installation, see **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the axle, loosen all the wheel nuts.
4. Using a suitable jack, continue to raise the vehicle evenly until there is room to fit a stand underneath the axle housing.



1. Axle Shaft
2. Forward-Rear Axle Housing
3. Carrier Capscrew
4. Input Seal
5. Carrier Yoke
6. Input Yoke Nut
7. Forward Differential Carrier

Fig. 1, Forward-Rear Axle Components

Forward-Rear Axle Removal and Installation

WARNING

Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, allowing the vehicle to fall, which could result in serious injury or death.

5. Support the vehicle with safety stands.
6. Remove the oil drain plug from the bottom of the axle housing and drain the oil from the axle housing. Install the drain plug after emptying.
7. Remove the wheels and tires. For instructions, see **Group 40**.
8. Release the parking brakes.
9. If necessary, back off the slack adjusters, then remove the brake drums.
10. If installed, make sure the optional DCDL (main differential lock) has been shifted into the engaged (locked) position.
11. If not done previously, disconnect the air lines at the interaxle lock and (if installed) the wheel lock.
12. Disconnect the main driveshaft from the forward differential carrier. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
13. Disconnect the interaxle driveshaft from the output yoke of the forward-rear axle and the input yoke of the rearmost axle. For instructions, see **Section 41.00, Subject 120**.
14. Cage the parking brake springs to prevent the parking brakes from engaging. For instructions, see **Group 42**.
15. Drain the air system.
16. Place a basin under the axle shaft flanges to catch any oil; then remove the axle shafts. For instructions, see **Subject 120**.
17. Remove the hubs from the axle spindles. For instructions, see **Section 35.01, Subject 100**.
18. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
19. Remove the ABS sensors and wiring, and the fasteners that hold the brake spiders to the axle flanges. Remove the spiders from the axle.
20. If applicable, disconnect the leveling valve rod(s) from the suspension.
21. At the frame rail or crossmember, disconnect the wiring for the ABS sensors. Remove any tie straps that hold the wires to the frame rails.
22. Disconnect the air lines from the rear brake chambers.
23. Remove the brake air chambers and the slack adjusters from the axle housing. For instructions, see **Group 42**.
24. Using a suitable jack, support the axle housing.
25. If applicable, remove the hexnuts that hold the bottom of each suspension air bag to its suspension bracket.
26. Remove the suspension components that attach the axle to the vehicle. If applicable, remove the U-bolt nuts from the U-bolts. Discard the U-bolt nuts and U-bolts.
27. Lower the axle enough to clear the suspension components.
28. Remove the axle from the vehicle.
29. If you are going to replace the differential carrier, place the axle on a secure axle stand.

Installation

1. Position the axle underneath the vehicle.
2. Install the suspension components that attach the axle to the vehicle, as follows.

   NOTE: U-bolts and U-bolt nuts cannot be reused.

   2.1 On vehicles with conventional suspensions, install the upper U-bolt brackets, new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

   On vehicles with air suspensions, in addition to the U-bolts, install the hexnuts that attach the air springs to the suspension brackets. For torque values, see **Group 32**.

   On vehicles without U-bolts, install the walking beams.

Forward-Rear Axle Removal and Installation

2.2 If applicable, tighten the new U-bolt nuts in a diagonal pattern. For torque values, see **Group 32**.

3. Connect the interaxle driveshaft to the output yoke of the forward carrier and the input yoke of the rear carrier. For instructions, see **Section 41.00, Subject 120**.
4. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
5. Install the ABS sensors and connect the wiring at the frame rail. Secure the wiring with tie straps as needed.
6. Install the brake air chambers and slack adjusters on the axle housing brackets. For instructions, see **Group 42**.
7. Connect the air lines to the brake air chambers.
8. Install the brake shoes, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
10. Connect the main driveshaft to the forward input yoke. For instructions, see **Section 41.00, Subject 120**.
11. Connect the air hoses to the air cylinder for the interaxle lock and (if installed) the wheel lock.
12. Connect the electrical connector of the sensor unit for axles equipped with a wheel lock.
13. Fill each hub with approved axle oil until you can see a little amount of oil trickling out of the back of the hub (use about 0.8 quart, or 0.75 liter). Install the hubs on the axle spindles, and adjust the wheel bearings. For instructions, see the applicable subject in **Section 35.01**. See **Table 1** for approved axle oils.

Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	**Capacity: quarts (liters)**	
	Hubs Full	**Hubs Dry**
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

Table 1, Forward-Rear Axle Oil Type and Capacity

14. Install the brake drums on the hubs.
15. Install the wheels and tires. For instructions, see **Group 40**.
16. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
17. Uncage the parking brake springs.
18. Using approved axle oil, fill the forward-rear axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.
19. Raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

20. Turn the wheels, wait one minute, and check the lubricant level.
21. Raise the vehicle, remove the safety stands, then lower the vehicle.
22. If applicable, connect the suspension leveling valve(s). Start the engine, build the air pressure, and make sure the suspension air bags inflate correctly. Make sure the ride height is correct. For instructions, see **Group 32**.
23. Check the operation of the wheel lock, if installed.
24. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
25. Set the parking brake.
26. Remove the chocks.

Forward-Rear Axle Differential Carrier Removal and Installation

For forward-rear axle components of a tandem installation, see **Fig. 1**.

Forward-Rear Axle Differential Carrier

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. If applicable, release the suspension air pressure.
3. Using suitable jacks, raise the vehicle evenly until there is room to fit a jack underneath the axle housing.
4. Remove the tires and wheels. For instructions, see **Group 40**.
5. Remove the oil drain plug from the bottom of the axle housing and drain the oil from the axle housing. Install the drain plug after emptying.
6. Disconnect the driveshaft from the carrier yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
7. Place a basin under the axle shaft flanges to catch any oil; then remove the axle shafts. For instructions, see **Subject 120**.
8. Using a suitable jack, support the differential carrier. Chain the differential carrier to the jack.

NOTICE

When using a pry bar, be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

9. Remove the differential carrier from the axle housing, as follows.

   9.1 Remove all but the top two forward carrier capscrews.

   9.2 Loosen and back off, but do not remove, the top two carrier capscrews. The capscrews will hold the carrier in the housing.

   NOTE: Use a pry bar that has a round end to help separate the carrier from the housing.

   9.3 Using a pry bar, separate the mating surfaces of the differential carrier and axle housing.

   9.4 When the surfaces are separated, finish removing the top two capscrews.

   9.5 With the carrier on the jack, slide the carrier away from the rear axle housing.

WARNING

The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.

   9.6 Lift the carrier assembly onto a suitable stand.

Installation

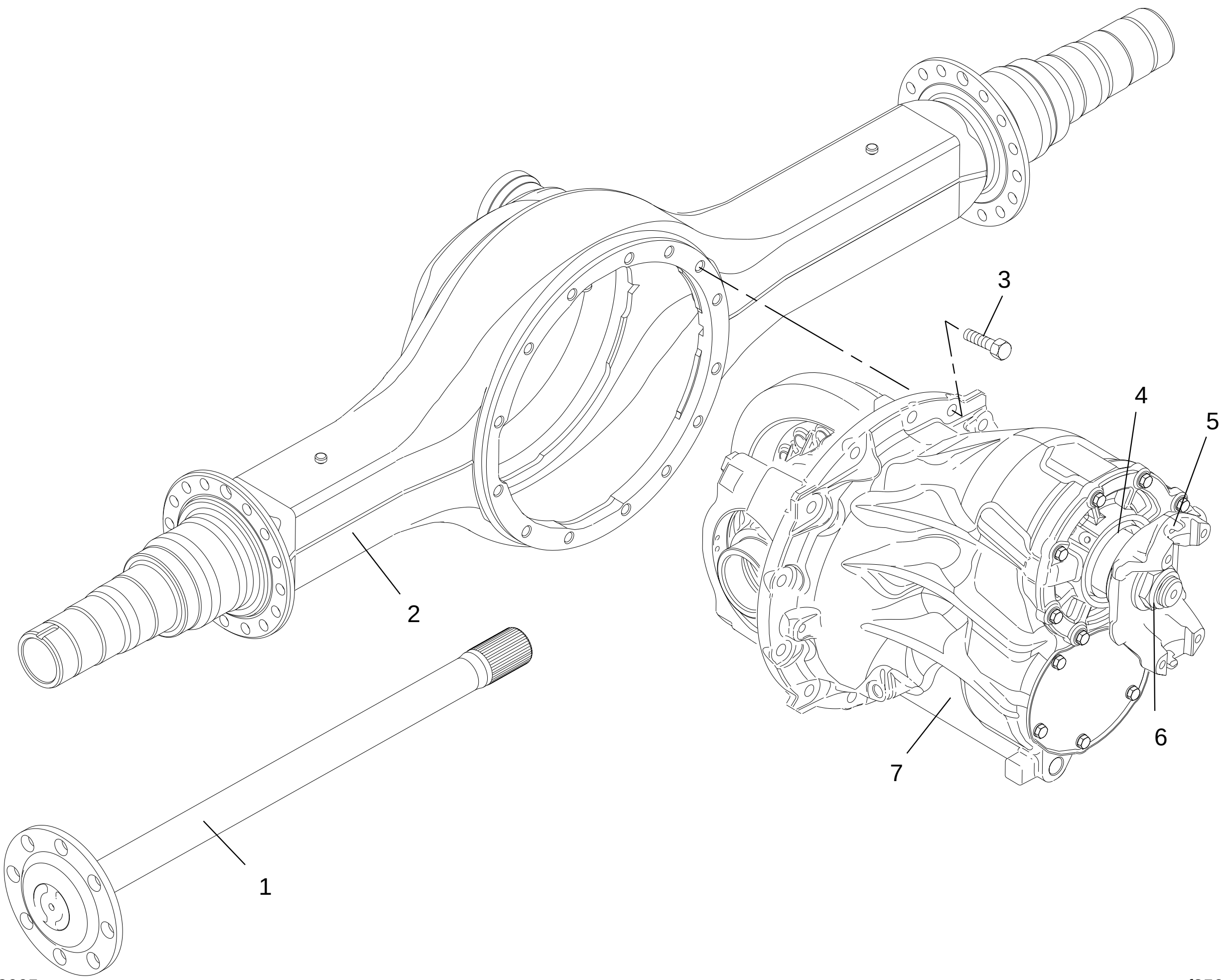
NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

1. Remove any old sealant material from the mating surfaces of the axle housing. Clean the inside of the axle housing and the carrier mating surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing as necessary.
3. Apply a thin bead of Loctite® 5900 sealant all the way around the mating surface of the axle housing, and around each bolt hole.

NOTE: Alignment dowels for installing the differential carrier can be made by sawing off the heads of two M16 x 1.5 x 100 mm bolts.

4. Install alignment dowels 180 degrees apart at the 3 o'clock and 9 o'clock positions on the axle housing flange.
5. Position the forward differential carrier in front of the axle housing, using an axle jack or other suitable lifting tool.

Forward-Rear Axle Differential Carrier Removal and Installation



1. Axle Shaft
2. Forward-Rear Axle Housing
3. Carrier Capscrew
4. Input Seal
5. Carrier Yoke
6. Input Yoke Nut
7. Forward Differential Carrier

Fig. 1, Forward-Rear Axle Components

NOTICE

Do not use a hammer or a mallet to install the differential carrier. A hammer or a mallet will damage the mounting flange of the carrier and cause oil leaks.

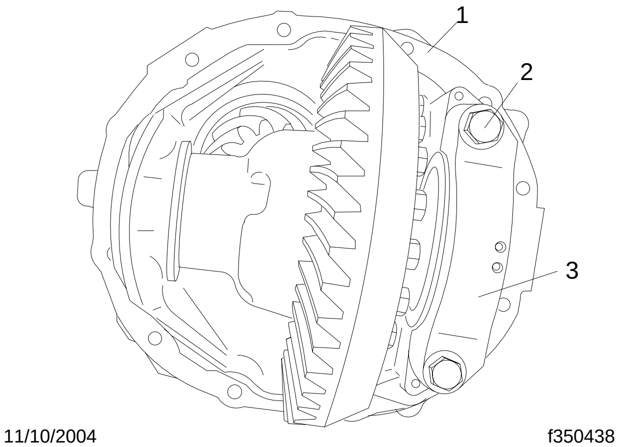
6. Install the end caps on the sides of the forward differential carrier into the corresponding slots in the axle housing. See **Fig. 2**.

6.1 For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

IMPORTANT: The end caps fit tightly into the axle housing. Be very careful not to cock the carrier.

6.2 Install the forward carrier capscrews finger-tight. Make sure the carrier capscrews turn easily in the axle housing.

Forward-Rear Axle Differential Carrier Removal and Installation



1. Differential Carrier
2. End Cap Bolt
3. End Cap

Fig. 2, Carrier End Caps

6.3 In a star pattern, gradually tighten the M16 forward carrier capscrews 200 lbf·ft (270 N·m).

7. Connect the driveshaft to the carrier yoke. For instructions, see **Section 41.00, Subject 120**.
8. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
9. Install the wheels and tires. For instructions, see **Group 40**.
10. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	**Capacity: quarts (liters)**	
	Hubs Full	**Hubs Dry**
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

Table 1, Forward-Rear Axle Oil Type and Capacity

11. If the hubs are dry, raise one side of the vehicle about 4 inches (10 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

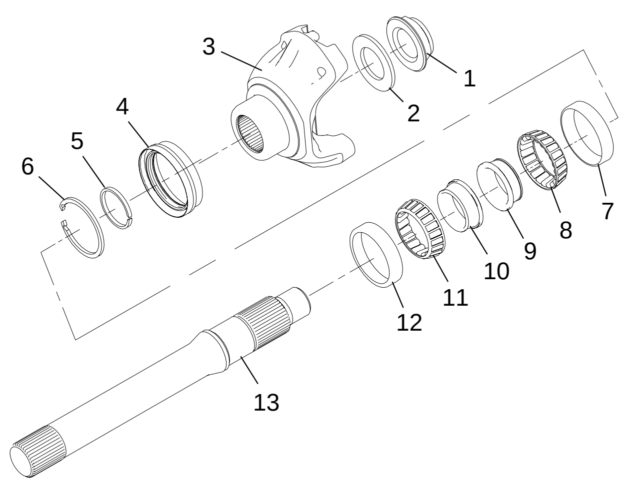
NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

12. Turn the wheels, wait one minute, and check the lubricant level.
13. Raise the vehicle, remove the safety stands, then lower the vehicle.
14. Start the engine, build the air pressure, and check that the suspension air bags inflate evenly and correctly. Make sure the ride height is correct.
15. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
16. Remove the chocks from the front tires.

Repair

1. Remove the output yoke nut, washer, and output yoke. See **Subject 170**.
2. Remove the output oil seal from the thru-shaft bore. See **Subject 170**.
3. Remove the snap ring and spacer from the thru-shaft. See **Fig. 1**.



1. Output Yoke Nut
2. Washer
3. Output Yoke
4. Output Oil Seal
5. Spacer
6. Snap Ring
7. Outer Bearing Race
8. Outer Bearing
9. Outer Bearing Cup
10. Inner Bearing Cup
11. Inner Bearing
12. Inner Bearing Race
13. Thru-Shaft

Fig. 1, Thru-Shaft Components

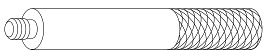
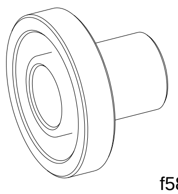
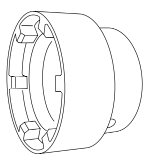
4. Using a suitable shaft puller, draw the thru-shaft out of the bore.
5. Using a suitable bearing puller on the outer races, remove both the inner and outer bearings from the thru-shaft.
6. Inspect the bearings for wear and damage. Replace both bearings if any damage is found.
7. Install the inner bearing race in the thru-shaft bore.
8. Using an arbor press or other suitable pressing tool, press the bearings and bearing cups onto the thru-shaft.
9. Insert the thru-shaft into its bore.
10. Install the outer bearing race onto the thru-shaft and into the bore.
11. Install the snap ring and spacer. Use the next thicker snap ring from the snap ring pack supplied with the bearings.
12. Install the output oil seal. See **Subject 170**.
13. Install the output yoke, nut, and washer. See **Subject 170**. Make sure the output yoke nut is firmly tightened, but do not tighten the nut to specifications at this time.
14. Attach a dial indicator to the flat surface of the output yoke.
15. Using a pry bar or other lever, apply force to the base of the output yoke. If the dial indicator shows a deflection of 0.0012 to 0.0024 inches (0.03 to 0.06 mm), the end play is correct.

    If the deflection is too large, use a thicker snap ring. If the deflection is too small, use a thinner snap ring.
16. Coat the threads of the nut with Loctite® 577. Tighten the output yoke nut 516 lbf·ft (700 N·m).

Single or Rearmost Axle Yoke and Seal Replacement

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools			
Tool	Description	Manufacturer	Part Number
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580406	Rear Pinion Seal Installer*	Kent-Moore	J-47354
 f580450	Yoke Nut Socket†	Daimler	MBA 742589020700

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

Table 1, Special Tools

Replacement

1. Disconnect the driveshaft from the differential carrier. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
2. Remove the yoke nut from the center of the carrier yoke. If the yoke nut is round and slotted, use the yoke nut socket shown in **Table 1**. See **Fig. 1**. Be careful not to damage the seal bore.
3. Remove the old carrier yoke from the input shaft.
4. Pry up the seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or shaft bearings. See **Fig. 2**.
5. Install the rear pinion seal on the rear input shaft, as follows. See **Fig. 3**.

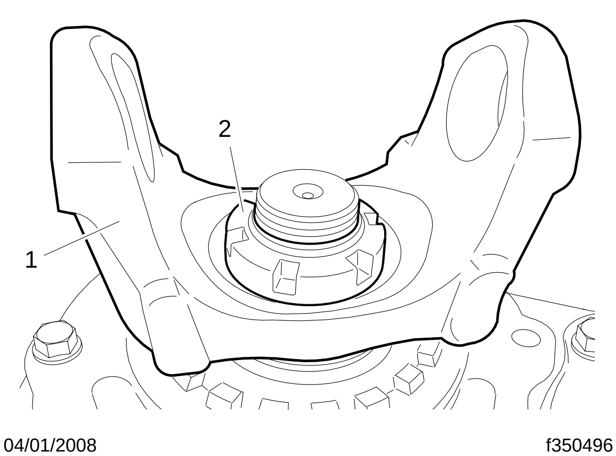
    5.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

    5.2 Assemble the rear pinion seal installer onto the threaded end of the universal handle. See **Table 1**.

    IMPORTANT: Be careful not to cock the seal during installation.

    5.3 Using the rear pinion seal installer assembly, press the seal into the bore until the seal surface is flush with the bottom surface of the counterbore. When the sound changes in pitch, the seal is in far enough.

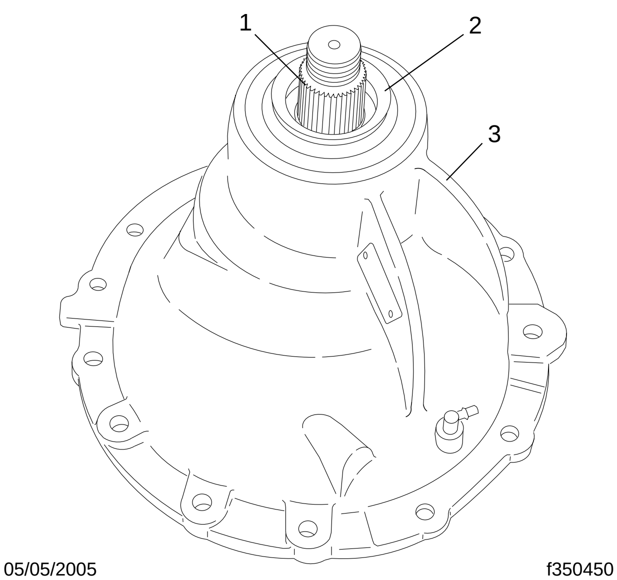
Single or Rearmost Axle Yoke and Seal Replacement



NOTE: The yoke nut may be a hexnut rather than the round, slotted nut shown here.

1. Yoke
2. Yoke Nut

Fig. 1, Yoke Nut on the Carrier

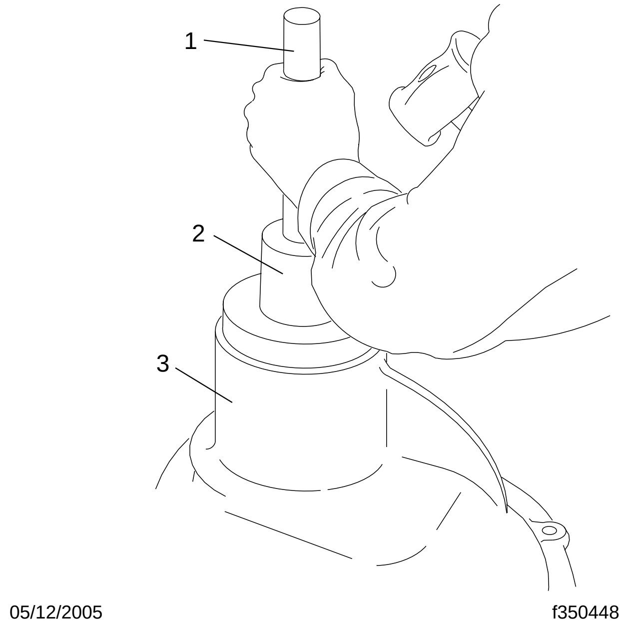


1. Input Shaft
2. Rear Pinion Seal
3. Carrier Housing

Fig. 2, Rear Pinion Seal

6. Install the carrier yoke on the input shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.



1. Universal Handle
2. Rear Pinion Seal Installer
3. Carrier Housing

Fig. 3, Installing the Rear Pinion Seal

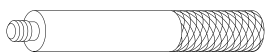
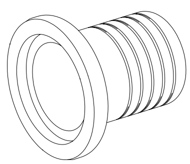
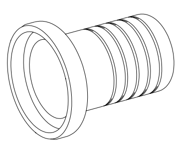
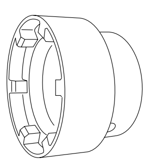
7. Install a new M45 x 1.5 pinion nut on the carrier yoke and tighten 627 lbf·ft (850 N·m).
8. Punch in the cylindrical area at the pinion groove to lock the nut in place.

IMPORTANT: The bent area has to reach the bottom of the pinion groove.

9. Connect the driveshaft. For instructions, see **Section 41.00, Subject 120**.

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools for Forward-Rear Axle Yoke and Seal Replacement			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580410	Input Seal Installer*	Kent-Moore	J-47369
 f580408	Output Seal Installer*	Kent-Moore	J-47368
 f580450	Yoke Nut Socket†	Daimler	MBA 742589020700

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

Table 1, Special Tools for Forward-Rear Axle Yoke and Seal Replacement

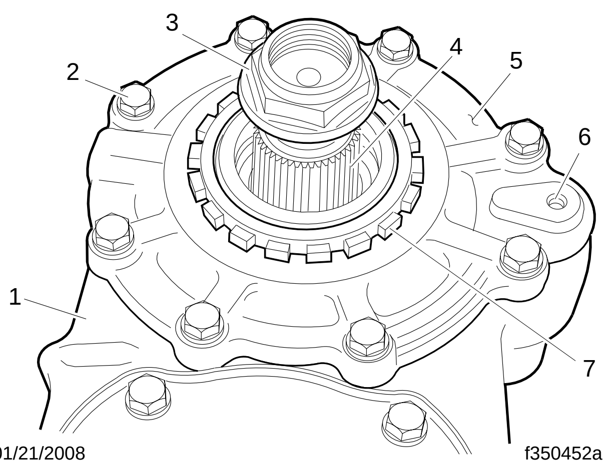
Replacement

Forward Carrier Input Yoke and Seal

1. Disconnect the main driveshaft from the forward carrier input yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
2. Remove the input yoke nut and washer from the center of the forward carrier input yoke.
3. Remove the old forward carrier input yoke from the forward input shaft.
4. If there is an oil leak at the threaded ring, repair it; for instructions, see **Subject 200**.

Forward-Rear Axle Yoke and Seal Replacement

5. If there is a leak between the bearing cage and the carrier housing, remove the bearing cage, as follows. See **Fig. 1**.



1. Forward Carrier Housing
2. Bearing Cage Mounting Capscrew
3. Input Yoke Nut
4. Input Shaft
5. Bearing Cage
6. Interaxle Lock Bore
7. Threaded Ring

Fig. 1, Bearing Cage

   5.1 Remove the bearing cage capscrews from the bearing cage.

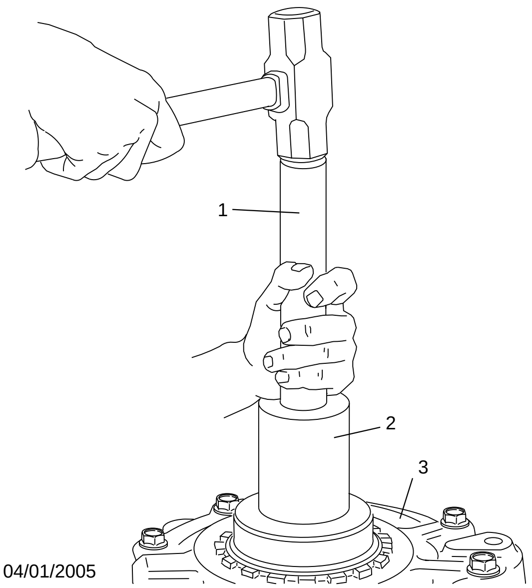
   5.2 Pry the bearing cage from the forward carrier housing. Clean any remnants of sealant clinging to the mating surfaces of the carrier housing and the bearing cage.

6. Pry up the input seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or shaft bearings.

7. Install the seal in the input shaft bore, as follows. See **Fig. 2**.

   7.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

   7.2 Assemble the input seal installer onto the threaded end of the universal handle. See **Table 1**.



1. Universal Handle
2. Input Seal Installer
3. Carrier Housing

Fig. 2, Installing the Forward Carrier Input Seal

   7.3 Using the input seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

8. On the mating surface of the bearing cage, lay down a bead of Loctite® 5900 sealant, or equivalent. Go around all of the bolt holes and other openings in the inside cover of the bearing cage. See **Fig. 3**.

IMPORTANT: Do not allow sealant to get into the interaxle lock bore. See **Fig. 4**. Do not attempt to repair the interaxle differential lock (IAD). No repairs to this component are possible.

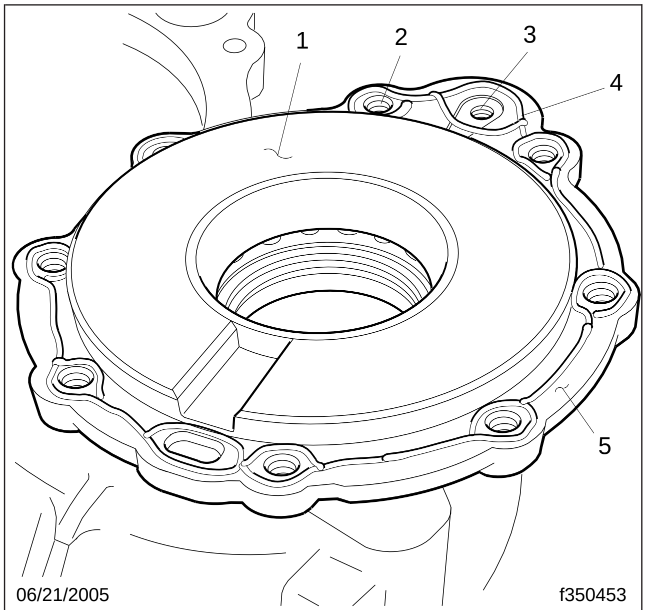
9. Install the bearing cage onto the forward carrier housing. Tighten the M12 bearing cage capscrews 107 lbf·ft (145 N·m).

10. Install the forward carrier input yoke on the forward input shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

11. Coat the threads of a new M45 x 1.5 input yoke nut with Loctite® 277. Install the new washer and

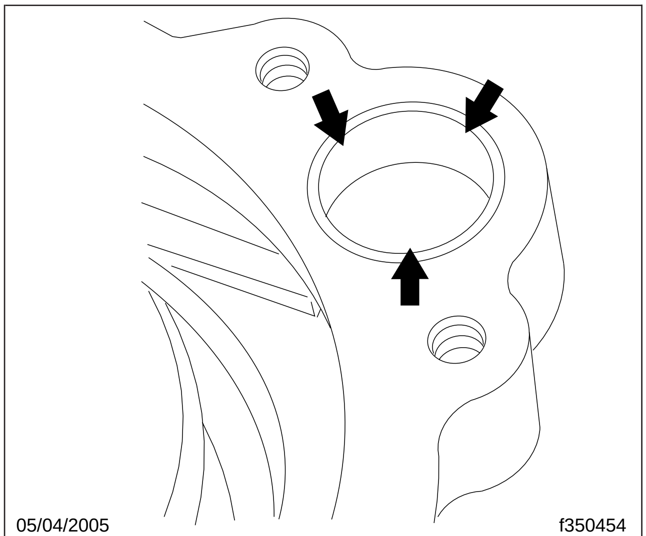
input yoke nut on the forward carrier input yoke. Tighten the nut 627 lbf·ft (850 N·m).



Apply a bead of sealant to the inner mating surface as shown.

1. Inside Cover
2. Mounting Capscrew Hole
3. Interaxle Lock Bore
4. Sealant
5. Mating Surface

Fig. 3, Sealant Application



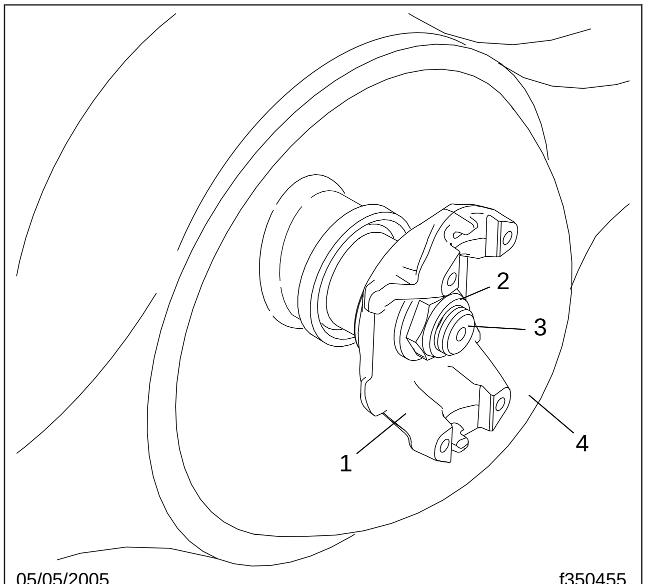
Keep sealant away from this bore.

Fig. 4, Interaxle Lock Bore

12. Connect the main driveshaft. For instructions, see **Section 41.00, Subject 120**.

Output Yoke and Seal

1. Disconnect the interaxle driveshaft from the output yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
2. Remove the output yoke nut and washer from the center of the output yoke.
3. Remove the output yoke from the thru-shaft. See **Fig. 5**.



1. Output Yoke
2. Output Yoke Nut
3. Thru-Shaft
4. Axle Housing

Fig. 5, Output Yoke

4. Pry up the output oil seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or thru-shaft bearings.
5. Install the seal on the thru-shaft, as follows.

   5.1 Inspect the area around the output oil seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

Forward-Rear Axle Yoke and Seal Replacement

5.2 Assemble the output seal installer onto the threaded end of the universal handle. See **Table 1**.

5.3 Using the output seal installer assembly, press the seal into the bore until the seal surface is flush with the thru-shaft receptacle.

6. Install the output yoke on the thru-shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

7. Coat the threads of a new M39 x 1.5 output yoke nut with Loctite® 577. Install the new washer and output yoke nut on the forward carrier output yoke. Tighten the nut 516 lbf·ft (700 N·m).
8. Connect the interaxle driveshaft. For instructions, see **Section 41.00, Subject 120**.

Main Differential Lock Disassembly and Assembly

Special Tool

A special tool is required for this procedure. See **Table 1**.

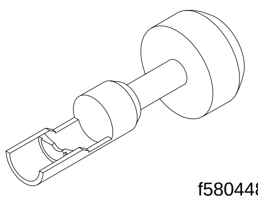
Special Tool for Main Differential Lock Disassembly and Assembly			
Tool	Description	Manufacturer	Part Number
 f580448	Spring Compression Tool	Axle Alliance Special Tool	W742 589 00 16 00

Table 1, Special Tool for Main Differential Lock Disassembly and Assembly

General Information

Commonly known as DCDL (Driver-Controlled Differential Lock), a main differential lock is available on single and tandem rear axles. On tandem rear axles DCDL is available for the forward, rear, or both axles. The following procedures only apply to Model 4 rear axles with optional DCDL.

Each part of the main differential lock is replaceable. See **Fig. 1**.

Disassembly

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires.
2. Remove the differential carrier, and place it on a work stand.

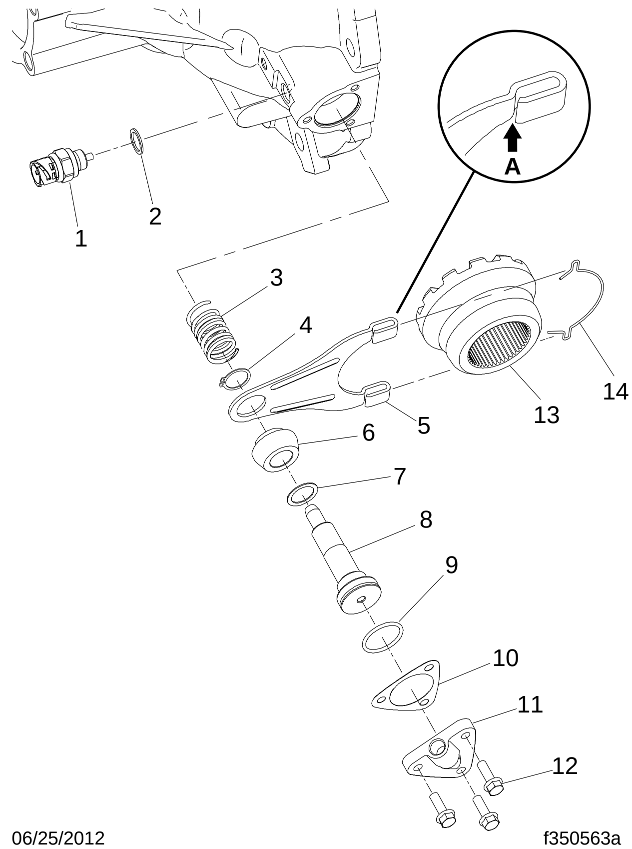
   To remove a single or rearmost axle differential carrier, see **Subject 110**.

   To remove a forward-rear differential carrier, see **Subject 140**.
3. Unlatch the retaining clip, and remove it. See **Fig. 1**.
4. Remove the clutch collar.
5. Remove the DCDL sending unit from the carrier housing.
6. Remove the three bolts that attach the air interface to the carrier housing.
7. Remove the air interface and gasket.
8. Remove the shift shaft piston from the bore in the carrier housing, and note the number of shims found on the piston. There should be at least one shim, and a maximum of three.
9. Using the spring compression tool (see **Table 1**), compress the spring and pull the shift fork from the carrier housing.
10. Remove the spring from the carrier housing.

Assembly

1. Install the spring in the carrier housing, and, using the spring compression tool, compress it to install the shift fork in the housing. Ensure that the spring is centered in the bore.
2. Ensure the O-ring on the shift shaft piston is properly installed and lubricated. Then install the piston, being careful to properly align it in the bore. Do not force the piston into the bore.
3. Place the air interface and gasket over the air interface bore, and insert the three capscrews that attach the air interface to the carrier housing. Tighten the capscrews in a regular sequence that ensures it seats evenly. Tighten the capscrews 19 lbf·ft (25 N·m).
4. Install the clutch collar.

Main Differential Lock Disassembly and Assembly



A. Opening in fork loop faces away from the clutch collar as shown.

1. Sending Unit
2. Sending Unit Seal
3. Spring
4. Snap Ring
5. Shift Fork
6. Alignment Boss
7. Shim(s)
8. Shift Shaft Piston
9. O-Ring
10. Air Interface Gasket
11. Air Interface
12. Capscrew
13. Clutch Collar
14. Retaining Clip

Fig. 1, DCDL Components

5. Install the retaining clip on the shift fork.
6. Install the DCDL sending unit in the carrier housing, as removed.
7. Connect the DCDL air line, and engage the DCDL. Ensure the teeth of the lock fully engage the teeth of the gear inside the carrier housing.
8. The clearance between the clutch collar and ring gear must be between 0.4 and 1.4 mm. Engage the DCDL, and use a feeler gauge to measure the gap.

   If the gap between the clutch collar and ring gear measured between 0.4 and 1.4 mm, ensure the same number of shims are on the shift shaft piston (as when it was removed).

   If the gap between the clutch collar and ring gear was not between 0.4 and 1.4 mm, add or remove shims to vary the gap until it measures within the acceptable range. The acceptable maximum number of shims is three, and the minimum is one.
9. Install the differential carrier.

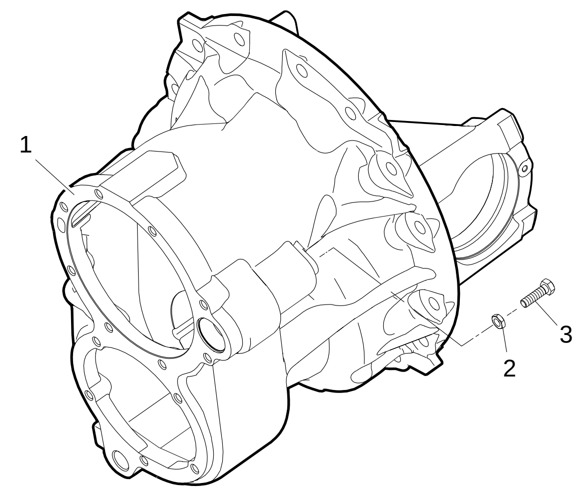
   For instructions on installing a single or rearmost axle differential carrier, see **Subject 110**.

   For instructions on installing a forward-rear axle differential carrier, see **Subject 140**.
10. Remove the chocks.

Adjustment

The Interaxle Differential (IAD) has an adjustment screw that can become loose or even fall out, causing an oil leak, and malfunction of the IAD. To ensure the adjustment screw is properly tightened and secured, follow the steps below. The IAD is sometimes called the power divider. See **Fig. 1**.

1. Chock the front tires.
2. Use the IAD switch in the cab to engage the lock.
3. At the forward-rear axle, rotate one of the wheels to ensure the teeth of the lock fully engage the teeth of the gear inside the carrier housing.
4. Remove the adjustment screw, and using a suitable solvent (such as brake cleaner), clean the threads of the screw and bore. Dry the surfaces completely, making sure no cleaning solvent remains.
5. Coat the threads of the adjustment screw with Loctite® 577, install it, and hand-tighten it until it hits the shaft.
6. Disengage the IAD to relieve the air pressure exerted on the adjustment screw.
7. Hand-tighten the adjustment screw one quarter turn, then tighten the locknut 30 lbf·ft (41 N·m).
8. Remove the chocks.



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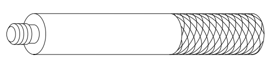
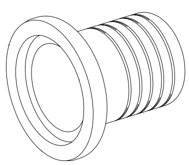
1. Carrier Housing
2. Lock Nut
3. Adjustment Screw

Fig. 1, Interaxle Differential and Adjustment Screw

Special Tools

Special tools are required for this procedure. See **Table 1**.

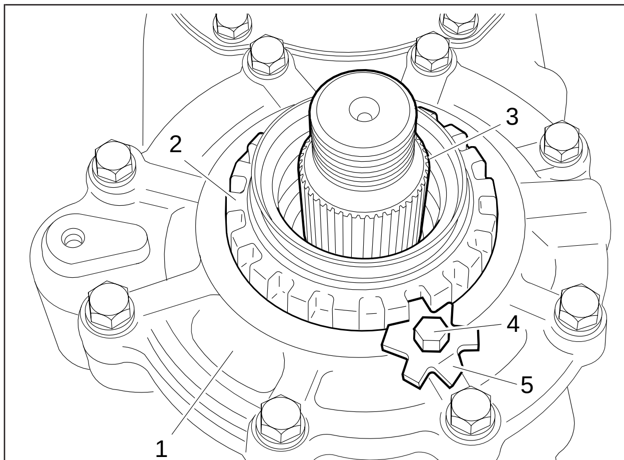
Special Tools for Threaded Ring Repair			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580410	Input Seal Installer*	Kent-Moore	J-47369

* To order Kent-Moore tools call 1-800-328-6657.

Table 1, Special Tools for Threaded Ring Repair

Repair

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Disconnect the main driveshaft from the forward carrier input yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the yoke nut and washer from the input shaft of the forward differential carrier, then remove the yoke.
4. Remove the capscrew and the locking plate from the bearing cage on the front of the differential carrier. See **Fig. 1**.
5. Using a spanner wrench, remove the threaded ring to expose the bearing cavity. See **Fig. 2**.
6. Using a suitable solvent, such as brake cleaner, clean the surface of the bearing cavity. See **Fig. 2**. Dry the surface, making sure no cleaning solvent remains.
7. Coat the threads of the threaded ring with Loctite® 577 sealant. Apply a 1/8-inch (3-mm) diameter bead all the way around the bottom thread, then spread the sealant evenly over the threads, so that all threads are thoroughly covered with the sealant.

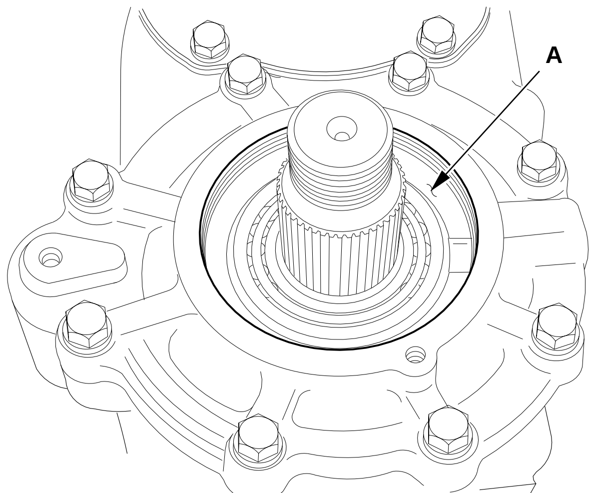


09/15/2006 f350472

1. Bearing Cage
2. Threaded Ring
3. Input Shaft (yoke removed)
4. Capscrew
5. Locking Plate

Fig. 1, Forward-Rear Axle Differential Housing

Threaded Ring Repair



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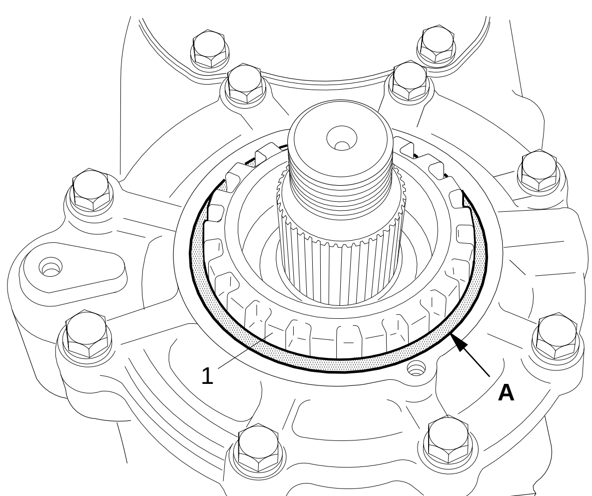
A. Clean and dry this entire surface.

Fig. 2, Bearing Cavity Exposed

8. Install the threaded ring (without the new input-shaft seal) and turn it clockwise (tighten it) enough to form a uniform bead of sealant all the way around the threaded ring. See **Fig. 3**.



09/14/2006 f350470

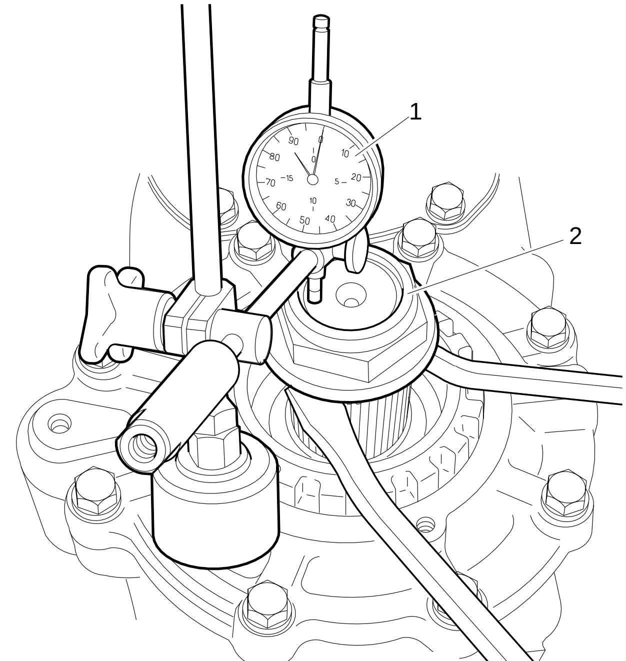
A. Loctite Bead from the Threads

1. Threaded Ring

Fig. 3, Preliminary Installation of the New Threaded Ring

9. Install the old yoke nut on the input shaft to protect the threads, then strike the nut sharply with a brass mallet to unseat the bearing.
10. Adjust the initial bearing preload to 0.002 inch (0.05 mm), as follows:

    10.1 Install a dial indicator on the bearing cage, and using two pry bars, pry up evenly on the yoke nut (and the input shaft) to determine the bearing preload. See **Fig. 4**.



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1. Dial Indicator
2. Old Yoke Nut

Fig. 4, Measuring Bearing Preload

    10.2 Tighten the threaded ring until the dial indicator reads 0.002 inch (0.05 mm).

11. Using a suitable marker or paint, mark the center of one of the teeth on the threaded ring and the surface of the bearing cage. See **Fig. 5**.

IMPORTANT: The next step is critical. Tightening the threaded ring by advancing it one tooth will set the bearing preload to 0.00 to 0.0012 inch (0.00 to 0.03 mm). If you tighten the threaded ring beyond this tolerance, you cannot back it off; you will need to remove the threaded ring and repeat the entire installation procedure.

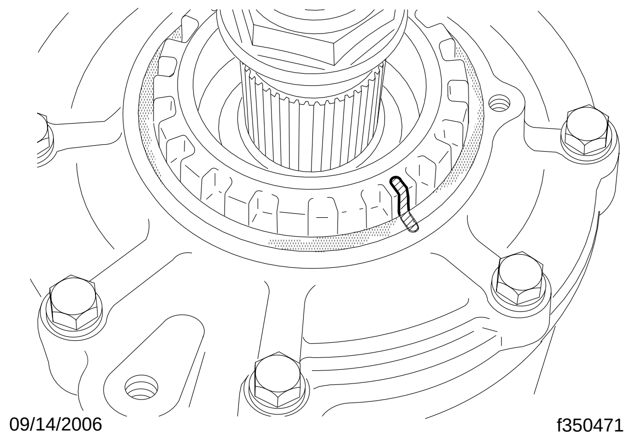


Fig. 5, Marking the Tooth and Bearing Cage

12. Very carefully advance the threaded ring one tooth while checking the paint mark. Stay close to a one-tooth advancement when making the final adjustment. Bear in mind that the new locking plate must fit into place once the correct tightness is achieved. The locking tab should fit in place either slightly before or slightly past a one-tooth advancement of the threaded ring. *You cannot back off the threaded ring once it is tightened.*

    Try fitting the new locking plate in place by turning and flipping it over as you slowly tighten the threaded ring. Tighten the threaded ring so the bearing preload is 0.00 to 0.0012 inch (0.00 to 0.03 mm). When the correct tolerance is reached, the mark on the surface of the bearing cage should line up with the center of the next tooth. See **Fig. 6**. Do not tighten the threaded ring any further.

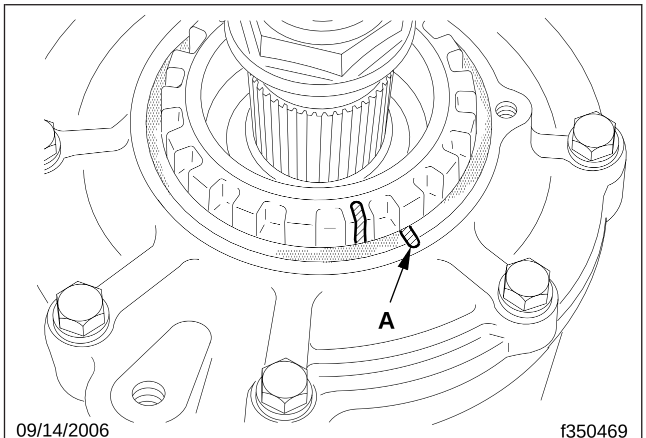
13. When the bearing preload is correct, install the new locking plate and capscrew. Tighten the capscrew 18 lbf·ft (24 N·m).

14. Install the new input-shaft seal as follows (see **Fig. 7**):

    14.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

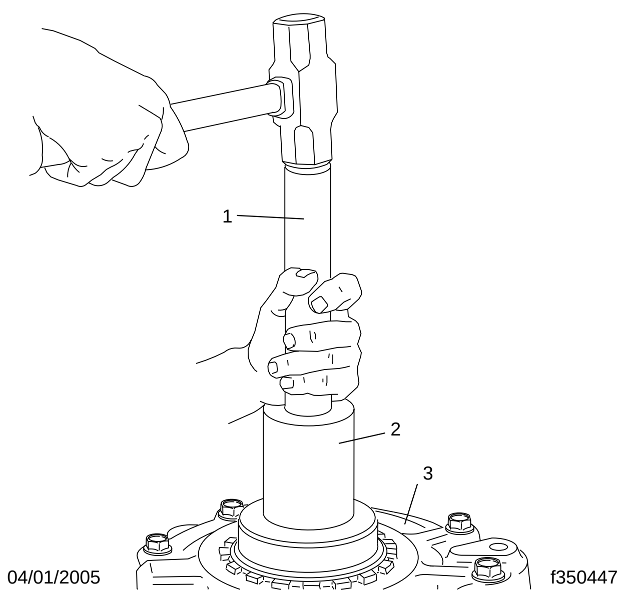
    14.2 Apply a light coating of axle oil to the seal bore.

    14.3 Coat the mating surfaces of the new seal with Loctite® 5900 sealant, or equivalent.



A. Measure preload at this point. At final tightening, this mark should be opposite the center of the next tooth, but no further.

Fig. 6, Advancing the Threaded Ring



1. Universal Handle (Kent-Moore tool, J-8092)
2. Input Seal Installer (Kent-Moore tool, J-47369)
3. Carrier Housing

Fig. 7, Installing the Forward Carrier Input Seal

    14.4 Assemble the input shaft seal installer onto the threaded end of the universal handle. See **Fig. 7**.

Threaded Ring Repair

14.5 Using the input shaft seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

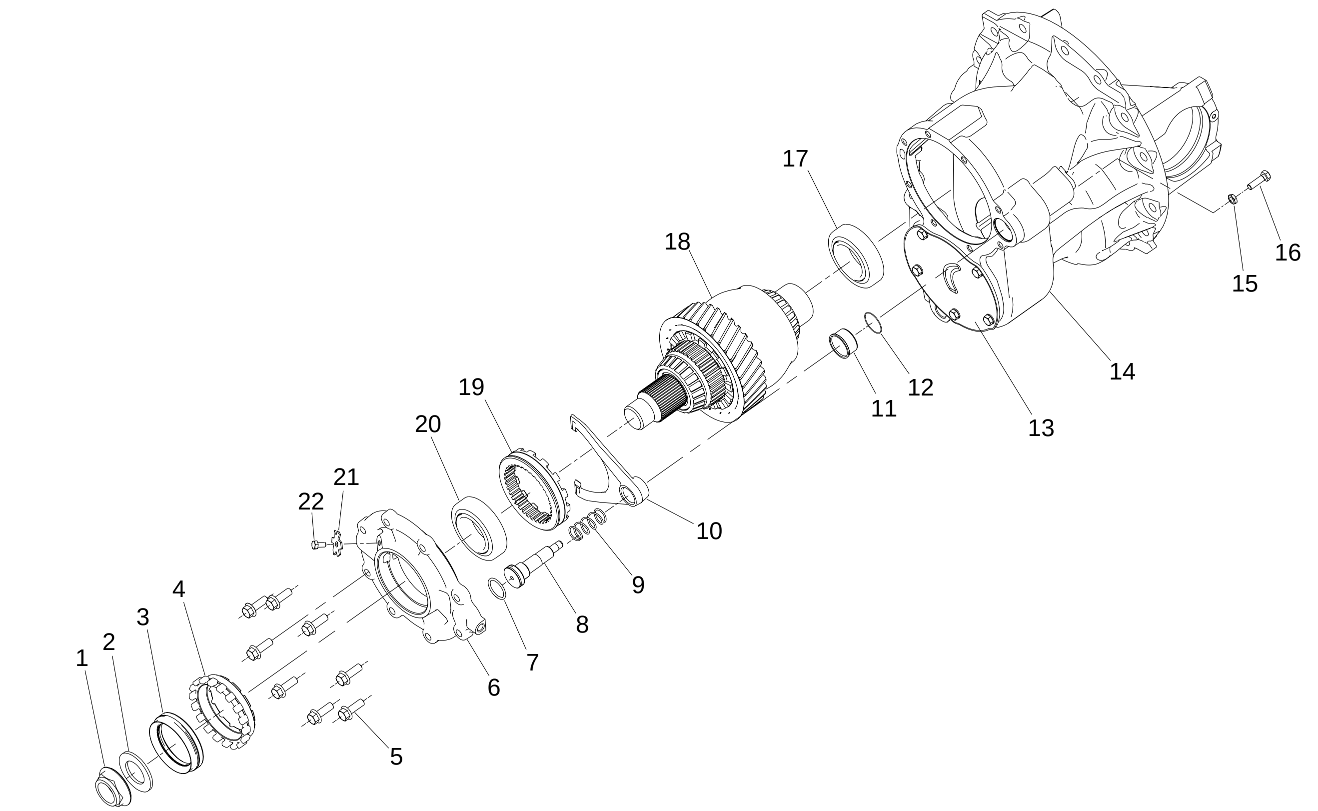
15. Apply Loctite 242 to the threads of the new yoke nut, then using it and a new washer, install the existing yoke on the input shaft. Tighten the yoke nut 627 lbf·ft (850 N·m).
16. Connect the main driveshaft to the input shaft. For instructions, see **Section 41.00, Subject 120**.
17. Remove the chocks.

Interaxle Differential Replacement

The following on-vehicle procedure replaces the interaxle differential (IAD) assembly and accomplishes a minor carrier rebuild by replacing the bearing races and, as needed, the shift shaft bushing. The front cover is resealed and the input shaft seal is replaced. See **Fig 1**.

Special Tools

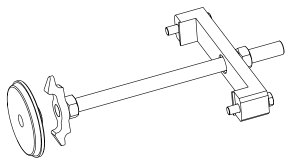
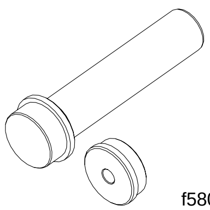
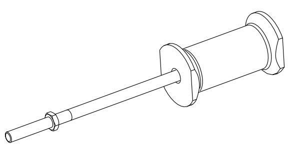
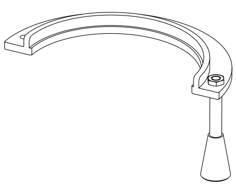
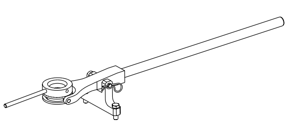
Special tools are required for this procedure. See **Table 1**.



1. Yoke Nut
2. Washer
3. Input Shaft Seal
4. Threaded Ring
5. Bearing Cage Capscrews
6. Bearing Cage
7. Shift Shaft Piston O-ring
8. Shift Shaft Piston
9. Piston Spring
10. Shift Fork
11. Shift Shaft Bushing
12. Shift Shaft Bushing O-ring
13. Cover Plate
14. Carrier Housing
15. Locknut
16. IAD Adjustment Screw
17. Output Bearing Race
18. IAD Assembly
19. Clutch Collar
20. Input Bearing Race
21. Locking Plate
22. Locking Plate Capscrew

Fig. 1, The Interaxle Differential and Carrier Housing Components

Interaxle Differential Replacement

Special Tools for Interaxle Differential Replacement			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580478	Output Bearing Remover and Installer	Detroit	MBA 420589003300
 f580480	Shift Shaft Bushing Remover and Installer	Detroit	MBA 420589013300
 f580476	Slide Hammer	Detroit	MBA 060589003300
 f580479	Half-Moon Device	Detroit	MBA 420589006300
 f580477	Push-Pull Device	Detroit	MBA 420589001600

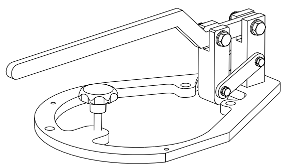
Special Tools for Interaxle Differential Replacement			
Tool	Description	Manufacturer	Part Number
 f580481	Shift Shaft Piston Installer	Detroit	MBA 420589023300

Table 1, Special Tools for Interaxle Differential Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires.
2. Ensure the interaxle differential is disengaged and the system is charged with air. The rear wheels will need to turn near the end of this procedure.
3. Place a suitable strap around the driveshaft and frame to hold the driveshaft out of the way after it is disconnected.
4. Disconnect the main driveshaft from the forward carrier input yoke (for instructions, see **Section 41.00, Subject 120**), and support it with the strap.
5. Clean the carrier housing and surrounding area as needed to remove any debris that could enter the housing.
6. Drain the oil from the carrier housing.
7. Disconnect the air line connected to the bearing cage.
8. Remove the yoke nut and washer from the input shaft of the forward differential carrier, then remove the yoke.
9. Remove the capscrew and the locking plate. See **Fig 1**.
10. Using a spanner wrench, remove the threaded ring by turning it counterclockwise.
11. Remove the bearing cage capscrews from the bearing cage, and pry the bearing cage from the carrier housing. It may help to tap the bearing cage loose with a chisel; see **Fig. 2**.

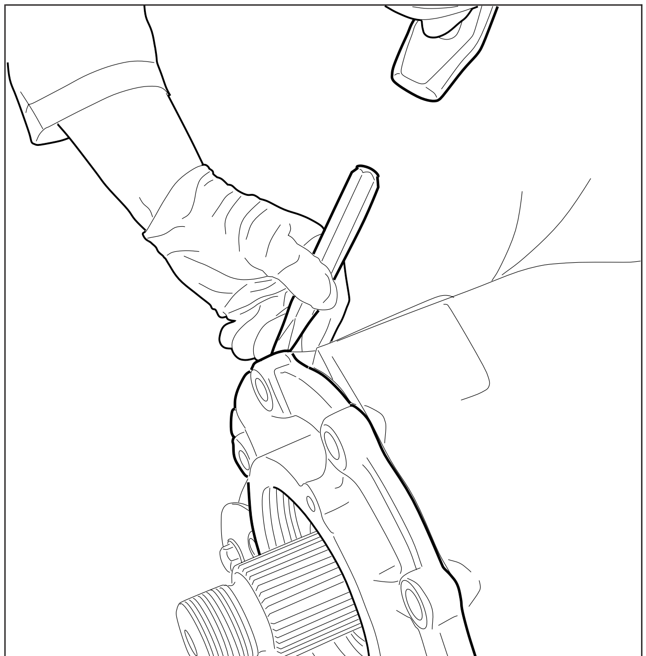


Fig. 2, Tapping the Bearing Cage Loose

12. Remove the IAD adjustment screw and locknut.

NOTICE

When unseating the shift shaft piston, multiple taps may be needed, but use moderate force only and be careful to hit the piston only (not the housing). Stop tapping it once it protrudes from the housing. The use of excessive force, or tapping it while it protrudes from the housing can damage the piston and the housing.

Interaxle Differential Replacement

13. Using a brass or plastic mallet, squarely tap the shift shaft piston to unseat it, and then remove it from the carrier housing.
14. Remove the piston spring, clutch collar, and shift fork.

NOTICE

The IAD assembly is heavy. Use appropriate support while removing and transporting it to prevent dropping and damaging it. Do not allow it to rest on the oil slinger; see Fig. 3. Resting the IAD assembly on the oil slinger could damage the oil slinger.

15. Remove the IAD assembly.

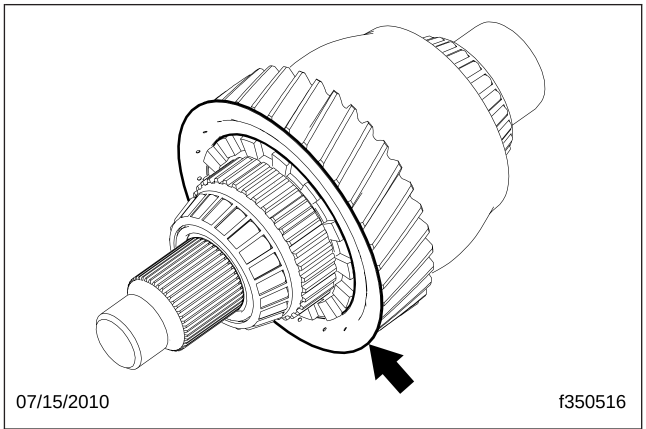


Fig. 3, Oil Slinger

16. Align the output bearing remover (see **Table 1**) with the notches in the rear of the carrier housing, then attach it to the housing with bearing cage capscrews, and use it to remove the output bearing race. See **Fig. 4**.
17. If the brass shift shaft bushing is damaged or worn, assemble the slide hammer and shift shaft bushing remover (see **Table 1**), and slide the hammer handle to remove the bushing. See **Fig. 5**.
18. Using a suitable solvent (such as brake cleaner), clean any remaining sealant from the threaded ring and mating surfaces of the carrier housing and the bearing cage. Dry the surfaces with compressed air, ensuring no cleaning solvent remains.

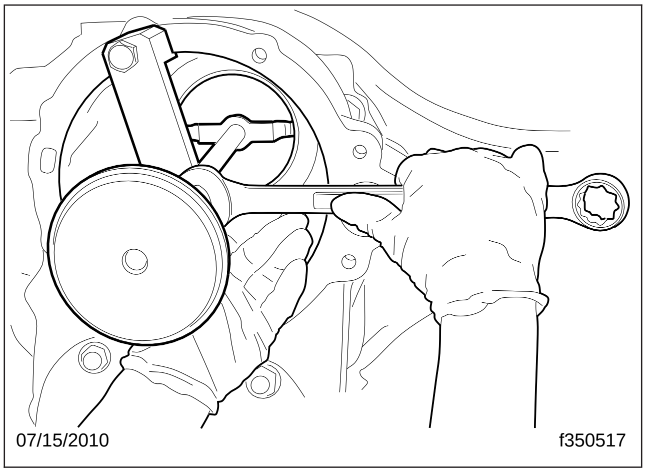
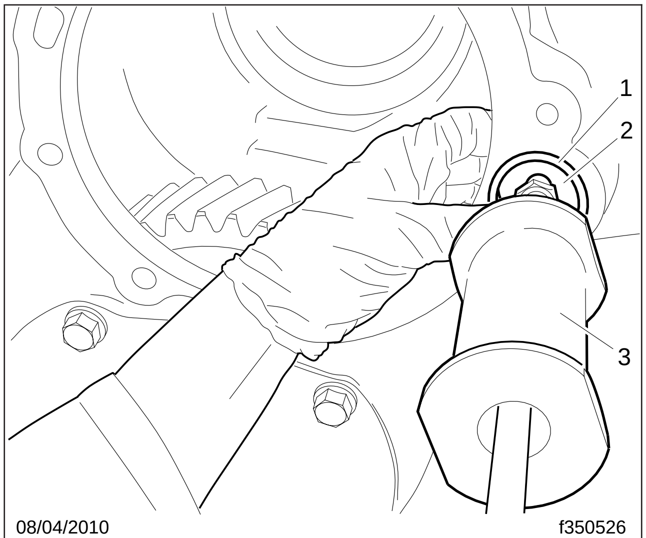


Fig. 4, Removing the Output Bearing Race



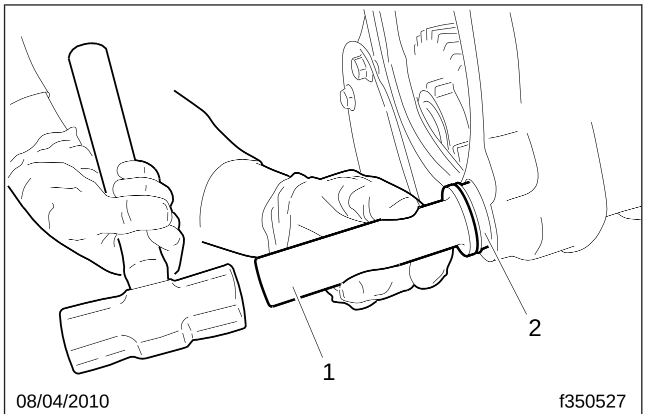
1. Shift Shaft Bushing
2. Shift Shaft Bushing Remover
3. Slide Hammer

Fig. 5, Installing the Bushing Remover

19. As in the previous step, clean the groove at the piston bushing bore.
20. If the brass shift shaft bushing was removed, install a new one using a mallet and the Shift Shaft Bushing Installer. See **Fig. 6**.
21. A new output bearing race is included with the new IAD. Install it as follows.

    21.1 To get it started, lightly tap the race into place with a hammer handle or wood block. The race must be square in the housing or damage will occur when it is pressed. See **Fig. 7**.

21.2 Fasten the output bearing installer to the carrier housing, and use it to press the race into the housing. As the race is installed, slight jerks can be felt and heard. See **Fig. 8**.



1. Shift Shaft Bushing Installer
2. Shift Shaft Bushing

Fig. 6, Installing the Bushing

22. Lubricate the output gear and bearing of the new IAD assembly with white grease.
23. Install the IAD assembly and output gear. Do not allow the assembly to rest on the oil slinger.
24. Install the clutch collar and shift fork.
25. Apply a thin film of white grease to the shift shaft piston, and insert it with the piston spring into the housing until about 1 inch (2.5 cm) of the piston protrudes from the bore.
26. The half-moon device (see **Table 1**) helps align the shift fork and shift shaft piston. To install it, slide it between the oil slinger and the shift fork. See **Fig. 9**.
27. Install the shift shaft piston as follows.

27.1 The shift shaft piston installer (see **Table 1**) is designed to install the piston without damaging it or the carrier housing. Use two bearing cage capscrews to mount it to the carrier housing. See **Fig. 10**.

27.2 Adjust the hex screw until the shift fork is snug but not bound.

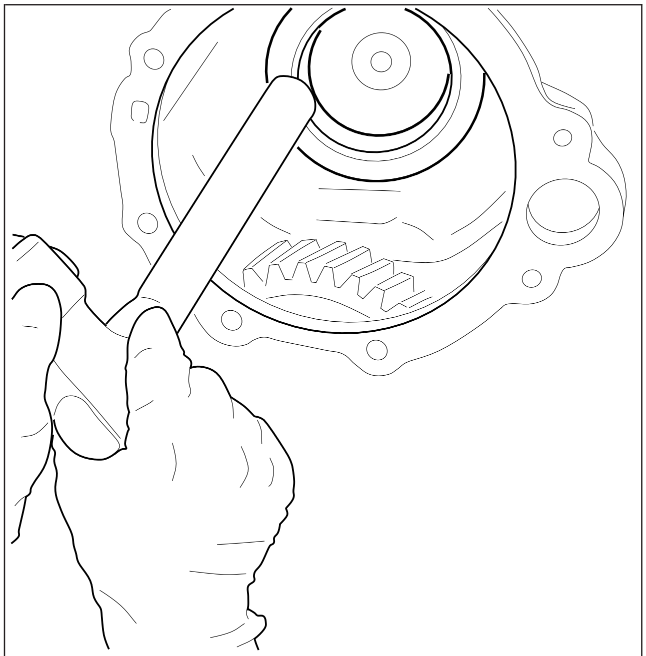


Fig. 7, Setting the Race

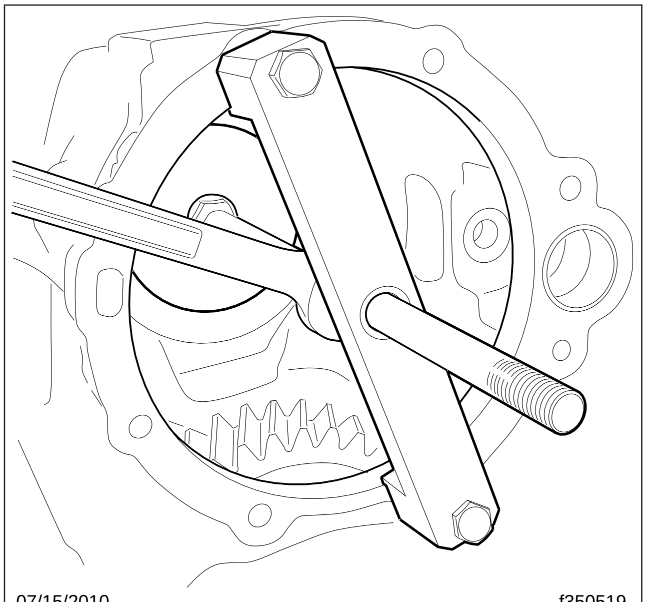


Fig. 8, Pressing a New Race into the Housing

27.3 In a single movement of moderate force, use the lever of the installer to press the piston into the bore until only about 1/8 to

Interaxle Differential Replacement

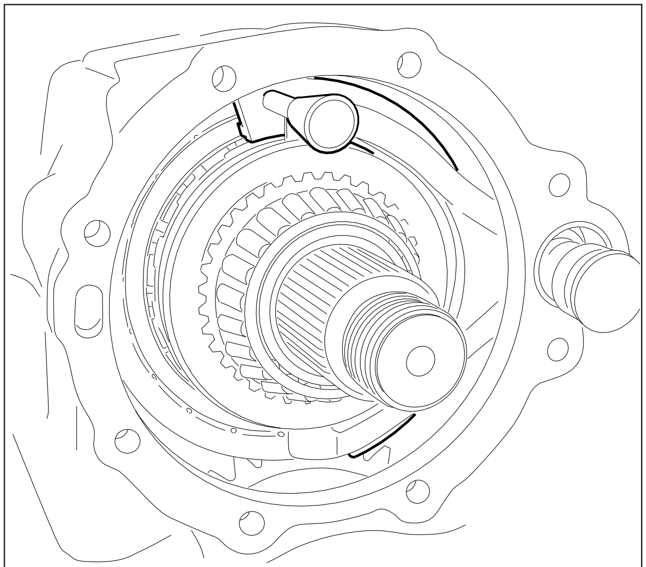
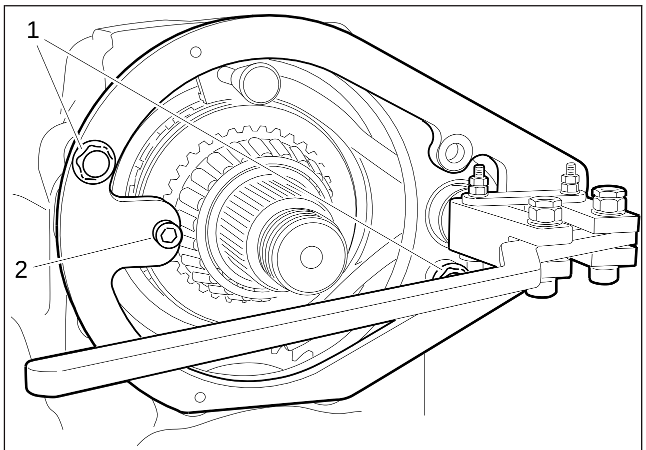


Fig. 9, The Half-Moon Device, Installed



1. Capscrews
2. Hex Screw

Fig. 10, Shift Shaft Piston Installer, Mounted

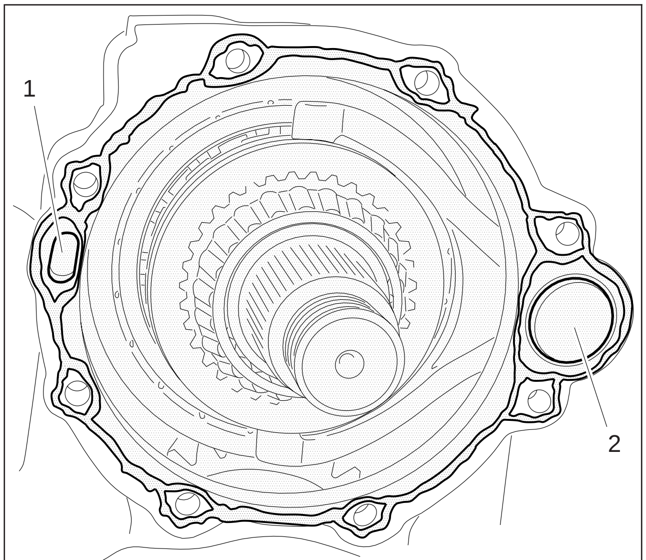
1/16 inch (2 to 3 mm) of the piston protrudes from the carrier housing. When the piston seats, a "click" sound may be audible. If the piston does not seat readily, adjust the hex screw, and try again.

27.4 Once the piston is seated, remove the shift shaft piston installer and the half-moon device.

28. Remove the input bearing race from the bearing cage. Place the new race into the cage so that it is more forward than in the final position. As the preload is adjusted, the race will seat to its final position.
29. Apply Loctite® 577 sealant to the threads of the threaded ring and tighten it until it is snug against the race.

IMPORTANT: Do not overapply sealant. Do not allow sealant to enter the oil return or touch the shift shaft piston.

30. Apply a small bead of Loctite 5900 to the carrier housing. See **Fig. 11**. To help ensure a good seal, spread it uniformly over the surface area.



1. Oil Return
2. Shift Shaft Piston

Fig. 11, Sealant Applied to Carrier Housing

31. Install the bearing cage, and using a star pattern tighten the capscrews to 103 lbf·ft (140 N·m).
32. The push-pull device (see **Table 1**) is used to set pre-load on the input bearing. Remove the two upper capscrews from the cover plate and install the device as shown in **Fig. 12**.
33. Set the correct end play as follows.

33.1 Set up a dial indicator as shown in **Fig. 13**.

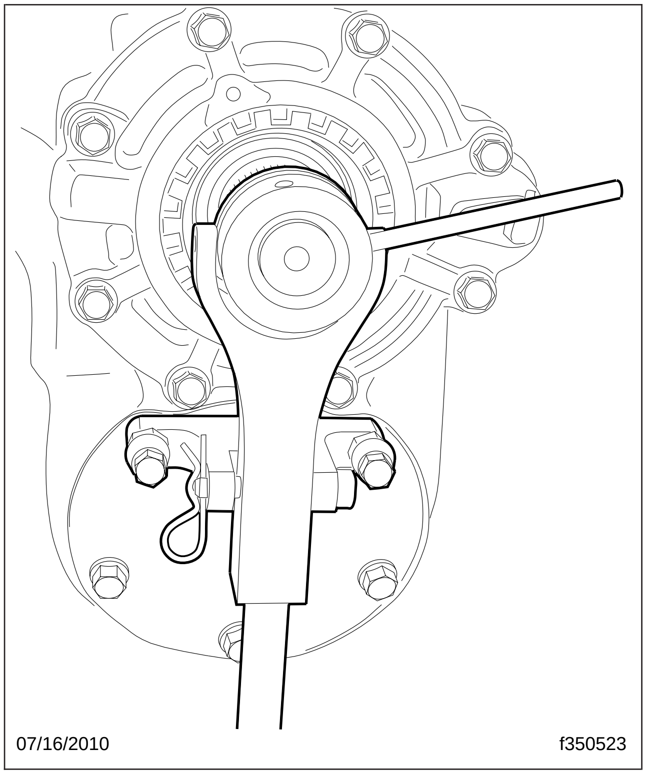


Fig. 12, Push-Pull Device, Installed

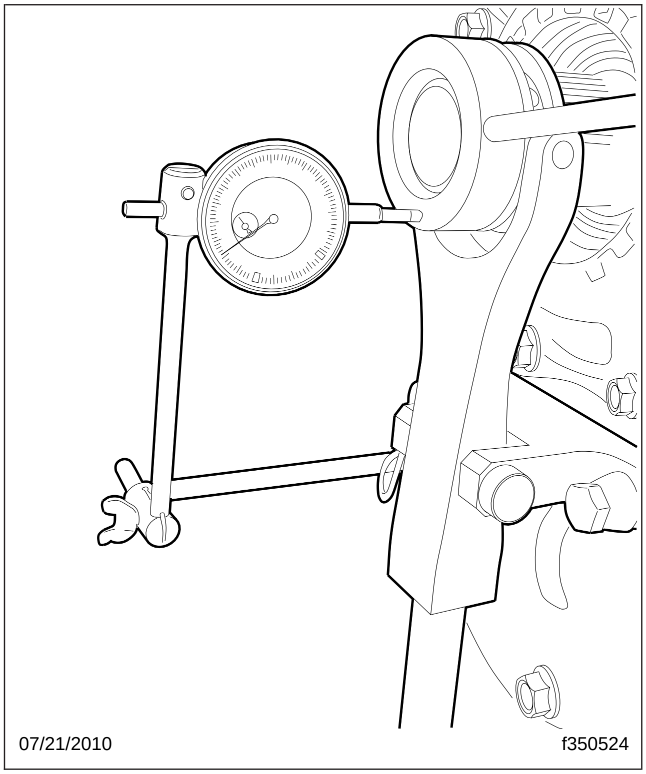


Fig. 13, Dial Indicator and Push-Pull Device

33.2 Turn the input shaft three revolutions and tighten the threaded ring until there is between 0.002 and 0.003 inch (0.05 and 0.08 mm) of end play. Turn the input shaft three more revolutions and verify the measurement.

33.3 When there is between 0.002 and 0.003 inch (0.05 and 0.08 mm) of end play, align a mark on the threaded ring with one on the bearing cage. See **Fig. 14**.

33.4 Tighten the threaded ring almost one notch.

IMPORTANT: Do not loosen the threaded ring. If the threaded ring is loosened, the bearing cage must be removed and the race re-installed.

33.5 The locking plate has six positions that can lock the threaded ring. Find the position that fits best, install it, and tighten the capscrew 18 lbf·ft (24 N·m).

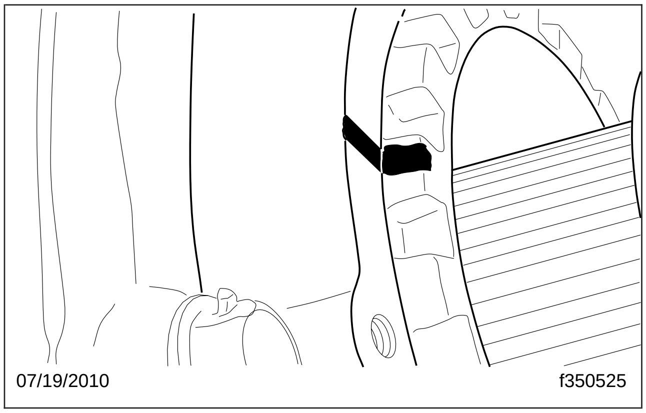


Fig. 14, Threaded Ring and Bearing Cage, Marked

33.6 Remove the push-pull device and dial indicator, and install the the two upper capscrews on the cover plate. Tighten the capscrews 63 lbf·ft (85 N·m).

34. Install a new input shaft seal and the yoke, nut, and washer; see **Subject 170** for instructions.

Interaxle Differential Replacement

35. Clean, install, and adjust the IAD adjustment screw and locknut as follows.

    35.1 Clean the IAD adjustment screw and locknut with a suitable solvent (such as brake cleaner). Dry the cleaned surfaces, ensuring no solvent remains.

    35.2 Connect an air line at the interaxle lock.

    35.3 Apply air, and by hand, turn the input shaft to ensure the gear cogs fully engage.

    35.4 Coat the threads of the adjustment screw with Loctite® 577.

    35.5 Install the adjustment screw, with the locknut, into the carrier housing, and handtighten the screw until it touches the engaged shift shaft piston.

    35.6 Disengage the IAD to relieve the air pressure exerted on the adjustment screw.

    35.7 Hand-tighten the adjustment screw one quarter turn, then tighten the locknut 30 lbf·ft (41 N·m).

36. Connect the main driveshaft; for instructions, see **Section 41.00, Subject 120**.
37. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 2**.

Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	**Capacity: quarts (liters)**	
	Hubs Full	**Hubs Dry**
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

Table 2, Forward-Rear Axle Oil Type and Capacity

38. To lubricate the wheel ends, tilt the axle to the left and right by jacking the opposite side 8 inches (20 cm). Hold the tilted position for two minutes on each side to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two more pints (1 liter) of lubricant will be needed to bring the oil level even with the base of the filler hole.

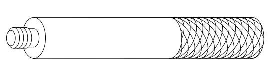
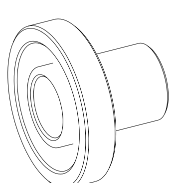
Specifications

Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
All Model 4 Axles		
Carrier Capscrews	M16	200 (270)
Drive Axle Stud Nuts	1/2–20	75–115 (102–156)
	5/8–18	150–170 (203–230)
Yoke Nut (model 4 axles)	M45 x 1.5	627 (850)
Forward-Rear Axles		
Bearing Cage Capscrews	M12	107 (145)
Input Yoke Nut	M45 x 1.5	627 (850)
Output Yoke Nut	M39 x 1.5	516 (700)

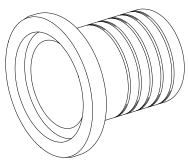
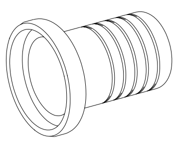
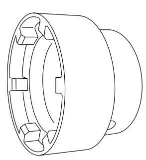
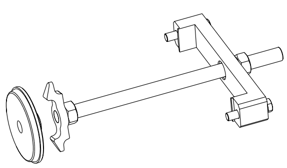
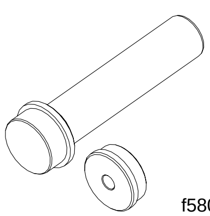
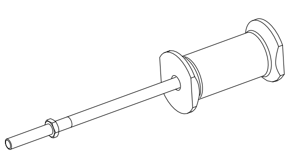
Table 1, Torque Values

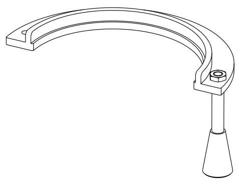
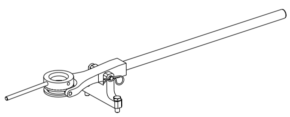
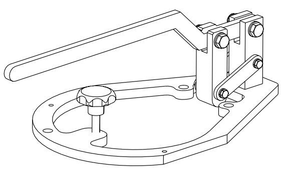
Rear Axle Lubricant Type and Capacity			
Approved Lubricant Type	**Axle**	**Oil Capacity: quarts (liters)**	
		Hubs Full	**Hubs Dry**
80W/90 Gear Oil	Forward-Rear	14.3 (13.5)	15.9 (15.0)
75W/90 Synthetic Gear Oil			
80W/90 Gear Oil	Single and Rearmost Tandem	10.6 (10.0)	12.2 (11.5)
75W/90 Synthetic Gear Oil			

Table 2, Rear Axle Lubricant Type and Capacity

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580406	Rear Pinion Seal Installer*	Kent-Moore	J-47354

Specifications

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580410	Input Seal Installer*	Kent-Moore	J-47369
 f580408	Output Seal Installer*	Kent-Moore	J-47368
 f580450	Yoke Nut Socket†	Detroit	MBA 742589020700
 f580478	Output Bearing Remover and Installer	Detroit	MBA 420589003300
 f580480	Shift Shaft Bushing Remover and Installer	Detroit	MBA 420589013300
 f580476	Slide Hammer	Detroit	MBA 060589003300

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580479	Half-Moon Device	Detroit	MBA 420589006300
 f580477	Push-Pull Device	Detroit	MBA 420589001600
 f580481	Shift Shaft Piston Installer	Detroit	MBA 420589023300

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

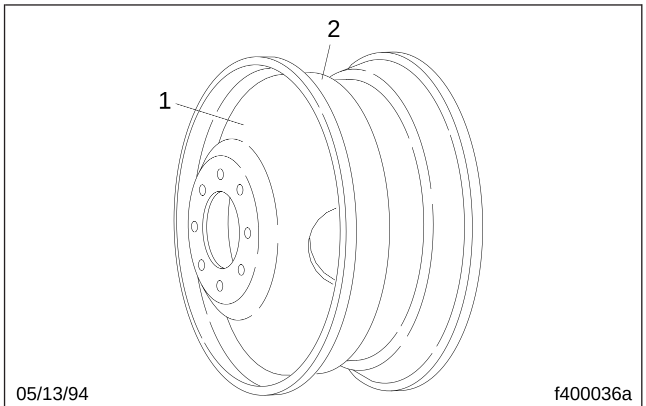
Table 3, Special Tools for Detroit Rear Axles

General Information

WHEELS AND TIRES

The tires support the weight of the vehicle, and are integral parts of the transmission and braking systems. The wheels serve as load carrying members between the tires and the axle.

Disc wheels consist of a rim and disc. The rim, the portion of the wheel on which the tire is mounted and supported, is welded to the disc. See **Fig. 1**. After the tire is mounted on the wheel, the assembly is held in place on the hub with wheel studs and nuts.



1. Disc
2. Rim

Fig. 1, Disc wheel

Standard ten-hole dual disc wheels are held in place on the hub by self-centering inner and outer wheel nuts. Eight-hole and optional ten-hole (single and dual) disc wheels are centered by pilot pads and are held in place on the hub with cone locknuts.

The radial tires have ply cords that run from bead to bead, and at a right angle to the belt plies and tire tread. See **Fig. 2**. The belt plies constrict the radial ply cords and give rigidity to the tread.

Tire body plies, breakers, and belts are made of polyester, rayon, nylon, fiberglass, steel, or aramids (fibrous reinforcements). In radial ply tires, these materials are used in various combinations, including steel body/steel belt, polyester body/fiberglass belt, or nylon body/steel belt.

Wheels and tires operate either with or without tubes. Tube-type tires require a tube and flap for correct assembly on a two-or three-piece rim. Tubeless tires require only the tire, and a one-piece drop-center wheel or rim. See **Fig. 1**.

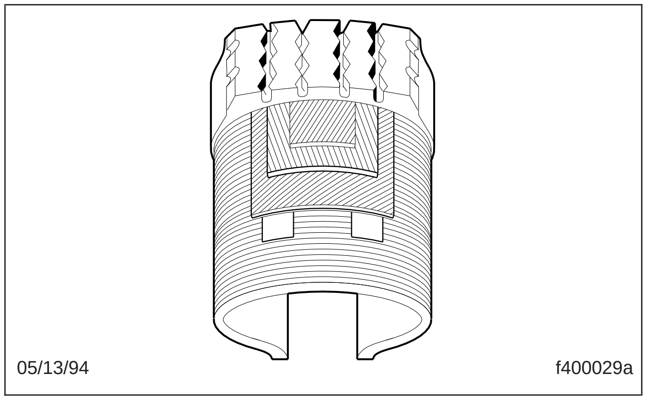


Fig. 2, Radial Ply Tire Construction

TIRE MATCHING AND MIXING

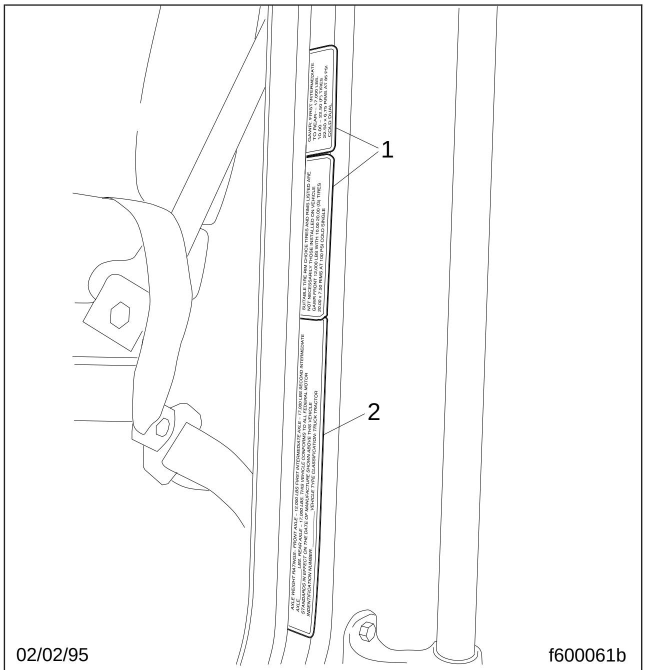
IMPORTANT: Review and follow these requirements for matching and mixing tires, before installing any tire and wheel or rim assembly on a vehicle.

Before changing wheels and tires, consider the effect that the change may have on the Gross Vehicle Weight Rating (GVWR) of the vehicle. At the time of vehicle certification, the GVWR is calculated by adding the vehicle's Gross Axle Weight Ratings (GAWR). The GVWR and each of the GAWRs are shown on a certification label (U.S.-purchased tractors) or "Statement of Compliance" label (Canadian-purchased tractors) attached to the left rear door post. See **Fig. 3**.

Tire and rim labels certify the minimum tire and rim combinations that can be installed on the vehicle for the given GAWRs. See **Fig. 3** and **Fig. 4**. Each GAWR is determined by considering each component of the axle system, including suspension, axle, wheels, and tires. The lowest component's capacity is the value used for the system. Therefore, the tires and rims installed on the vehicle at the time of vehicle manufacture may have a higher load capacity than that certified by the tire and rim label.

Tires and rims of the minimum capacity can be installed without changing the load limitations. If tires and rims are installed that have a lower load capacity than that shown on the tire and rim label, then the tires and rims determine the load limitations (the GAWRs and GVWR will be lower).

General Information



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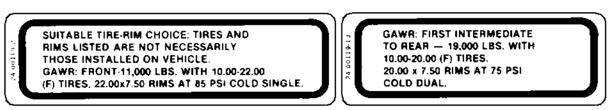
1. Tire and Rim Labels
2. Certification Label

Fig. 3, Certification Label, U.S.



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NOTE: Examples only. Actual specifications may vary from vehicle to vehicle.

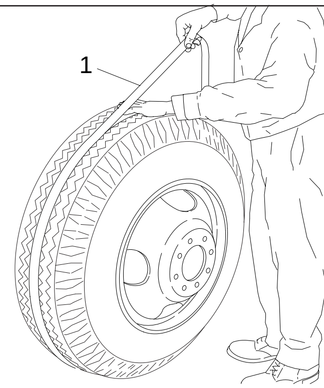
Fig. 4, Tire and Rim Labels

When pairing tires in a dual assembly, the tire diameters must not differ by more than 1/4 inch (6.4 mm), or the tire circumference by more than 3/4 inch (19 mm). The total tire circumference of one driving rear axle must match, as nearly as possible, the total tire circumference of the other driving rear axle.

CAUTION

Mismatching dual tires overloads the larger diameter tire, causing it to overdeflect and overheat. The smaller diameter tire, lacking proper road contact, wears faster and unevenly. Tread or ply separation, tire body breaks, and blowouts can occur from mismatched duals.

With an endless pi tape (Fig. 5) or square (Fig. 6), measure the diameter of the tires 24 hours after inflation. A matching stick (Fig. 7), string gauge (Fig. 8), or tire straight edge (Fig. 9) can also be used to determine the difference in tire radius, which is then doubled to calculate the diameter difference.



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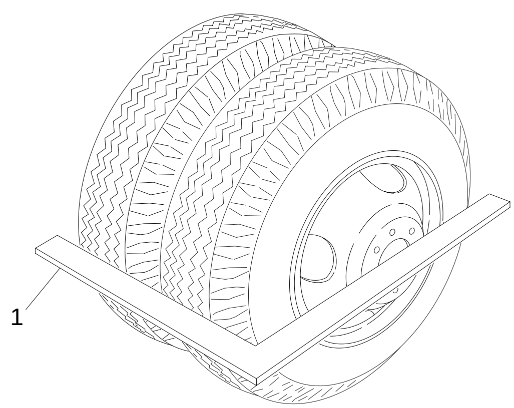
1. Endless Pi Tape

Fig. 5, Endless Pi Tape



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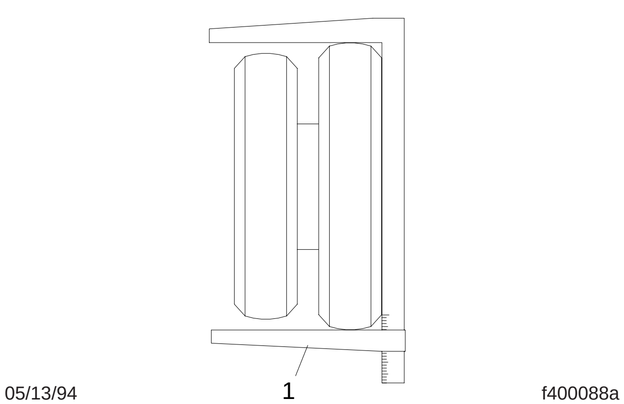
1. Square

Fig. 6, Square

When pairing tires of unequal diameters (but within the above limits), mount the larger tire on the outside.

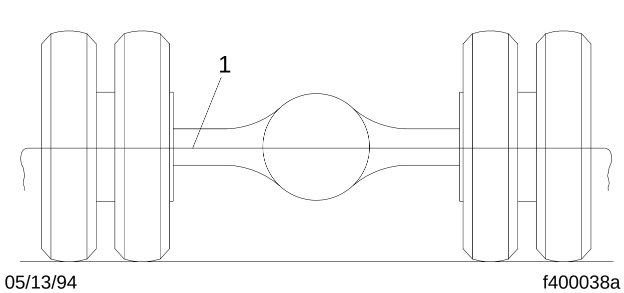
CAUTION

Driving a vehicle on one tire of a dual assembly dangerously exceeds the carrying capacity of the single tire and wheel. Operating in this manner can cause damage to the wheel and tire.



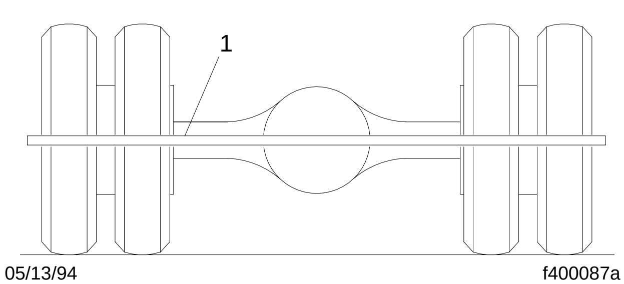
1. Matching Stick

Fig. 7, Matching Stick



1. String Gauge

Fig. 8, String Gauge



1. Tire Straight Edge

Fig. 9, Tire Straight Edge

Inflate all tires on an axle, or on both axles of a tandem unit, to within 5 psi (35 kPa) of one another. For tire inflation specifications, see **Specifications, 400.**

There must be sufficient space between dual tires for air to flow and cool the tires, and to prevent them from rubbing against one another. Rims and wheels of the same size, but of different makes and types, can have different offsets, which would affect dual spacing. If there is sidewall contact between tires, or between the inside tire and the chassis, refer to the tire manufacturer's catalog to determine the minimum dual spacing. Refer to the rim or wheel manufacturer's catalog to determine the correct offset.

Federal Motor Carrier Safety regulations require the removal of all tires with less than 4/32 inch (3 mm) remaining groove depth on a front axle, and tires with less than 2/32 inch (1.5 mm) remaining groove depth on a rear axle. However, tires with the word "Regroovable" on the sidewall, may be regrooved.

Better tire and vehicle performance is usually obtained by using tires of the same size and construction. Using tires of different construction is permitted if the following rules are observed:

- Do not mix radial and bias ply tires on the same axle.
- If both radial and bias ply tires are used, better handling is usually obtained by using the bias ply tires on the front axle.
- Use either all radial or all bias ply tires on the non-driving rear axles of a vehicle. However, all radial or all bias ply tires must be used on vehicles with tandem drive-axles.

CAUTION

Mixing radial and bias ply tires should be done as an emergency measure only. Some loss of steering control and premature tire wear could occur when driving under such conditions.

Disc Wheel Removal and Installation

Removal

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock all tires that will not be serviced.
2. If removing wheels and tires from the front axle wheels, raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.

   If removing wheels and tires from the rear axle wheels, raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
3. If any of the following conditions apply, deflate the tire being serviced by removing the valve core. On a dual assembly, deflate both tires.
   - the wheel or tire is damaged
   - there is suspected damage
   - the tire has been run at 80 percent or less of its recommended operating pressure
4. Turn the wheel until one hub-pilot pad is in the top-center position.
5. Place a jack or wheel-and-tire dolly under the wheel assembly being serviced.

CAUTION

Keep the wheel square to the hub during removal. The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads.

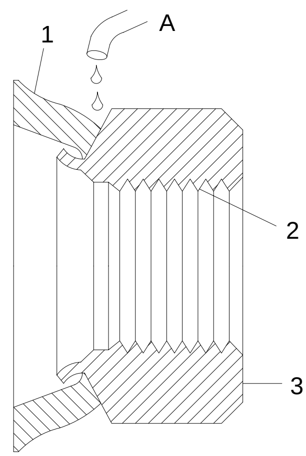
IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand threads.

6. Leaving one top and one bottom nut to keep the wheel straight, remove the other eight two-piece flange nuts from the wheel. Then, remove the top and bottom nuts.
7. Remove the wheel. Do not let it drop on, or drag across, the stud threads.

Installation

1. Inspect the wheel and tire assembly using the instructions in **Subject 130** and **Subject 140**.

   Replace any damaged wheels and tires. Follow the tire matching and mixing requirements in **Subject 050**.
2. Clean the hub and wheel mounting surfaces, the fasteners, and between the rims of dual wheels.
3. Make sure the tire is correctly inflated. For instructions, see **Subject 150**.
4. Apply a few drops of light engine oil to the wheel studs, the area between the body and the flange of each nut, and the hub pilot. Wipe off any excess oil.
   - See **Fig. 1** for lubrication of the cone locknuts on 8-hole disc wheels.
   - See **Fig. 2** for lubrication of the two-piece flange nuts on 10-hole disc wheels.



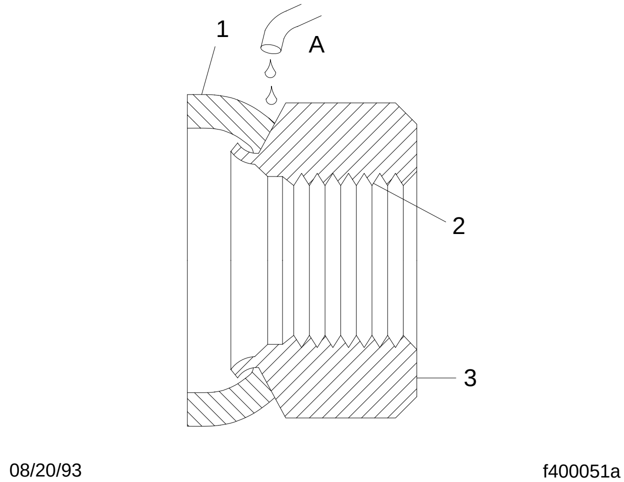
A. Apply oil here.
1. Cone
2. Locknut Threads
3. Locknut Body

Fig. 1, Cone Locknut Lubrication (8-hole disc wheels)

IMPORTANT: Freightliner "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 3**.

IMPORTANT: Before installing the wheels, make sure the drum is in position on the raised step of the pilot pad. One of the hub's pilot pads must be centered at the top. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

Disc Wheel Removal and Installation



A. Apply oil here.
1. Flange
2. Nut Threads
3. Nut Body

Fig. 2, Two-Piece Flange Nut (10-hole disc wheels)

5. Turn the hub until one hub-pilot pad is in the top-center position.

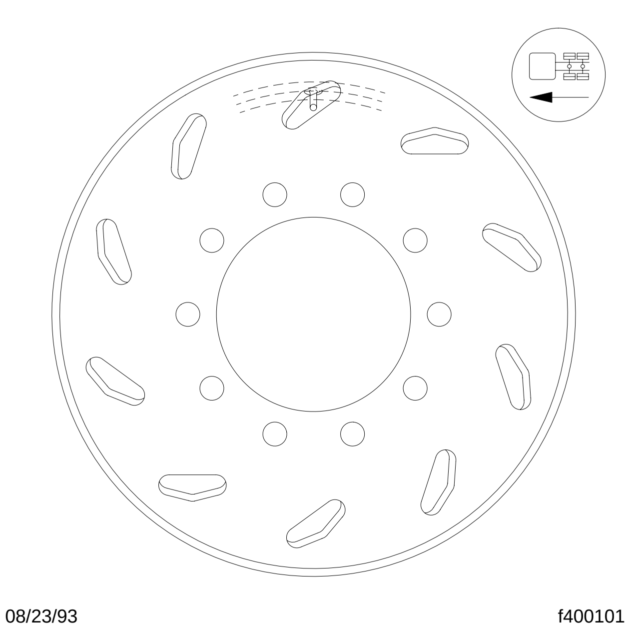


Fig. 3, Directional Freightliner "Turbo" Wheel

CAUTION

Keep the wheel square to the hub during installation. The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or hub-pilot pads.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheel are opposite the balance weight(s) on the brake drum.

6. Using a jack or wheel-and-tire dolly, install the wheel assembly (inner wheel on a dual wheel assembly) on the hub. Make sure the wheel is square to the hub. Be careful not to damage the threads or hub-pilot pads.
   - 6.1 Before placing the wheel assembly on the hub, rotate the wheel as needed until the balance weight(s) on the wheel are 180 degrees from the weight(s) on the brake drum.
   - 6.2 Make sure the hub-pilot pad is still centered at the top after the wheel is installed.
7. On a dual wheel assembly, repeat the previous step to mount the outer wheel against the inner wheel.
   - 7.1 Before placing the outer wheel assembly on the hub, rotate the wheel as needed until the balance weight(s) on the wheel are 180 degrees from the weight(s) on the brake drum.
   - 7.2 If this causes the valve stems to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side as the brake drum balance weight(s).

CAUTION

The wheel nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.

8. Install the wheel nuts on the studs.
   - On 8-hole disc wheels, install and hand-tighten cone locknuts on a top and opposing bottom stud.

- On 10-hole disc wheels, install and hand-tighten two-piece flange nuts on the top and bottom studs.

9. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
10. Install and hand-tighten the remaining nuts.

CAUTION

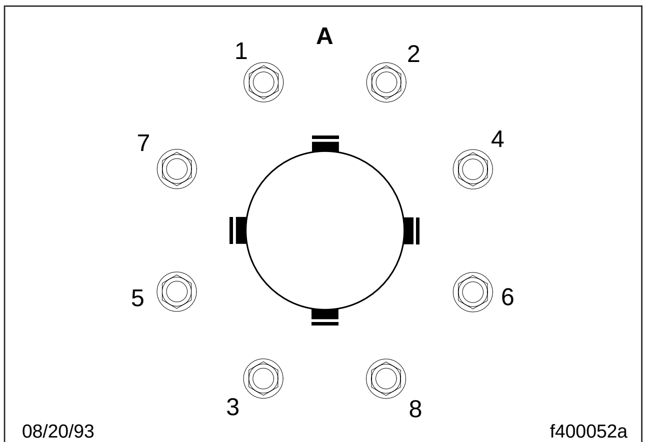
Use the specified torque values and follow the correct tightening sequence. Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area.

11. Tighten the nuts in two stages. Follow the sequence in **Fig. 4** for 8-hole disc wheels or **Fig. 5** for 10-hole disc wheels.

    11.1 On all disc wheels, tighten the nuts initially to 50 to 100 lbf·ft (68 to 136 N·m).

    11.2 On 8-hole disc wheels, tighten the cone locknuts 450 to 550 lbf·ft (610 to 745 N·m).

    On 10-hole disc wheels, tighten the two-piece flange nuts 450 to 500 lb·ft (610 to 678 N·m).



A. Top

Fig. 4, 8-Hole Disc Wheel Tightening Sequence

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts.

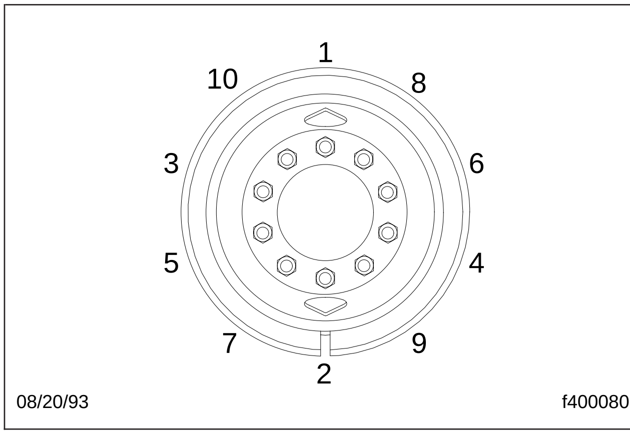


Fig. 5, 10-Hole Disc Wheel Tightening Sequence

NOTE: Nuts on double-threaded wheel studs should be tightened 390 to 450 lbf·ft (529 to 610 N·m).

WARNING

Always replace damaged parts with new parts. Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, which could cause personal injury or property damage.

12. Replace any damaged parts. Follow the instructions in **Section 33.01** to replace front-axle parts, or **Section 35.01** for rear-axle parts.
13. Remove the safety stands, lower the vehicle, and remove the chocks.

IMPORTANT: The wheel nuts seat during vehicle operation. As a result, it is necessary to periodically tighten the nuts to the specified torque.

14. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts.
    - 8-Hole Disc Wheels—following the tightening sequence in **Fig. 4**, tighten the cone locknuts 450 to 550 lbf·ft (610 to 745 N·m).

Disc Wheel Removal and Installation

- 10-Hole Disc Wheels—following the tightening sequence in **Fig. 5**, tighten the two-piece flange nuts to the original specification.

15. Tighten the wheel nuts every 50,000 miles (80 000 km) thereafter.

Tire Demounting and Mounting Service Precautions

Service Precautions

WARNING

Read the following information. Failure to follow the safety precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst, which could result in personal injury or equipment damage.

IMPORTANT: Do not mount or demount tires without proper training, as required in Occupational Safety and Health Administration (OSHA) Rules and Regulations 1910.177, *Servicing Multi-Piece and Single Piece Rim Wheels*.

Service information containing demounting and mounting instructions are available through your rim supplier. Charts detailing service procedures are available through OSHA area offices.

The address and telephone number of the nearest OSHA area office can be obtained by looking in the local telephone directory under U.S. Government, Labor Department of Occupational Safety and Health Administration.

Use the information from the above sources with the following precautions before and during tire demounting and mounting.

SAFETY

- The air pressure contained in a tire is dangerous. When servicing a tire, stay out of any potential path or route that a rim wheel component may travel during an explosive separation.
- Examine all wheel and tire parts as explained in **Subject 130** and **Subject 140**. Replace damaged, rusted, or worn parts.
- Be sure all parts of an assembly match in size, manufacturer, and classification within a manufacturer's line. Wheels and rims are under stress, and are dangerous if improperly assembled.
- Before assembling the wheel or rim, check the catalog issued by the wheel or rim manufacturer for the correct part numbers and sizes of approved parts.
- Never use a part that does not bear clear, legible, and correct numbers and manufacturer's identification, even if that part appears to fit.
- Do not reinflate a tire that has been driven flat, or has been driven at 80 percent or less of its recommended operating pressure. Use your spare.
- Before removing a low tire from the vehicle, make sure it is completely deflated. Later, have the assembly taken apart and all the parts checked for damage, including the side ring or lockring.

TOOLS

- Use special tools, as recommended by tire suppliers, for demounting and mounting tires. These tools must be smooth and used with care to avoid gouging the rim.
- Loosening tire beads may be difficult, since considerable force may be needed. The use of a machine designed for loosening tire beads is recommended.
- Do not use a duck-bill hammer or any steel hammer on wheel or rim parts. Use rubber, leather-faced, or plastic mallets to tap parts together, if necessary.

HANDLING

- Handle the wheels and rims on a wooden floor or rubber mat to prevent nicking or gouging the wheel or rim.
- Make sure that tires are stored indoors, or outdoors under cover, to prevent water collecting inside the tire.

LUBRICATION

- Lubricate the tire with an approved tire-mounting lubricant. Never use antifreeze, silicones, petroleum-based lubricants, or any flammable material, such as ether or some other starting aid.
- When lubricating a tire prior to mounting, make sure excess lubricant does not run into the tire.
- Michelin Tire Corporation recommends applying lubricant to the valley of the tire, formed by the tire and rim, before using tools to break the bead.
- Michelin also recommends applying a sufficient but sparing amount of lubricant to the entire

Tire Demounting and Mounting Service Precautions

rim face when mounting a tire on a rim, to ensure correct bead seating and ease of mounting.

Five-Degree Full Drop Center

WARNING

Read the information in Subject 110. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst, which could cause personal injury and equipment damage.

To demount or mount tubeless tires on 5-degree full drop center rims, regular or safety type, follow the same procedures used to demount or mount tubeless automobile tires.

Fifteen-Degree Tapered Drop Center

WARNING

Read the information in Subject 110. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen both beads from the rim.
   - 2.1 Place the rim on a wooden floor or rubber mat with the wide side up.
   - 2.2 Drive the flat end of the tire tool between the tire bead and the rim flange.
   - 2.3 Holding the tool upright, hammer on the neck to free the tire bead from the rim. See **Fig. 1**.
   - 2.4 Repeat at 8-inch (20-cm) intervals around the flange, until the bead is free from the rim.
   - 2.5 Turn the rim over and repeat the previous substeps to loosen the second bead from the rim.

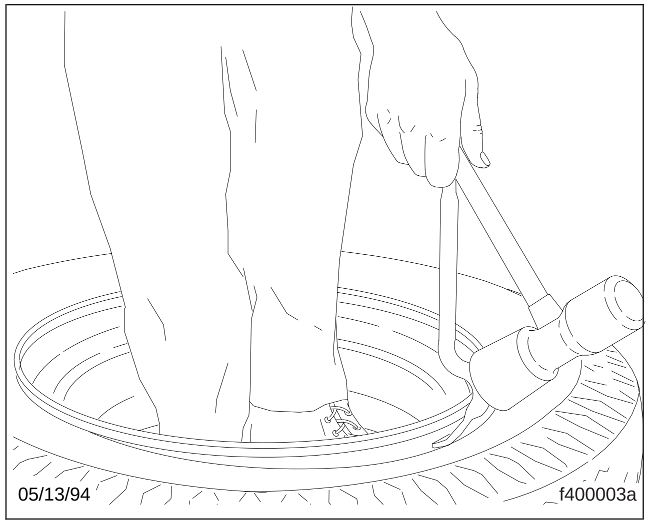


Fig. 1, Loosening the Beads

3. Remove one bead from the rim.
   - 3.1 Make sure the wide side of the rim is down.
   - 3.2 Lubricate the tire bead and the rim.
   - 3.3 Insert the curved end of two tire tools between the bead and the rim, just to one side of the tire valve. See **Fig. 2**.
   - 3.4 Step on the side of the tire opposite the valve to force the first bead into the rim well.
   - 3.5 Hold one of the tools in place with your foot and pry with the second tool, to force the bead up over the rim flange.
   - 3.6 Continue prying around the tire to work the first bead off of the rim. Leave the second bead in the rim well.
4. Remove the rim from the tire.
   - 4.1 Stand the rim and tire assembly upright, with the valve stem near the top.
   - 4.2 Lubricate the second bead and rim.
   - 4.3 Insert the straight end of the tool between the tire bead and the back rim flange,

Demounting and Mounting Tubeless Tires

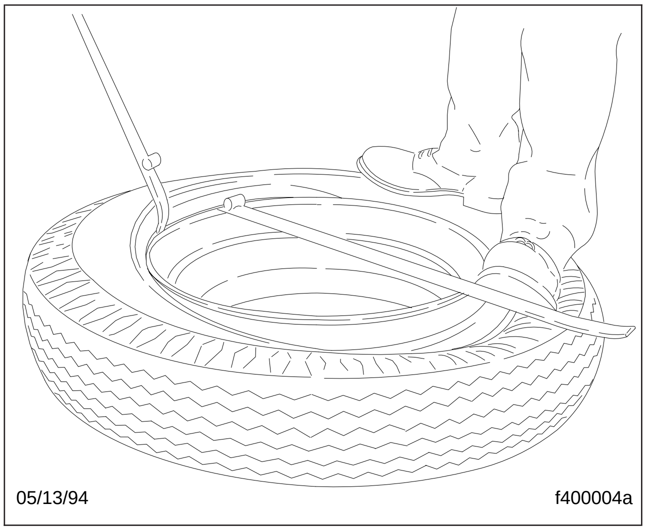


Fig. 2, Forcing First Bead From Rim

hooking the tool over the second flange. See **Fig. 3**.

4.4 Lean the tire assembly toward the tool and use a rocking or bouncing action to pry the rim out of the tire.

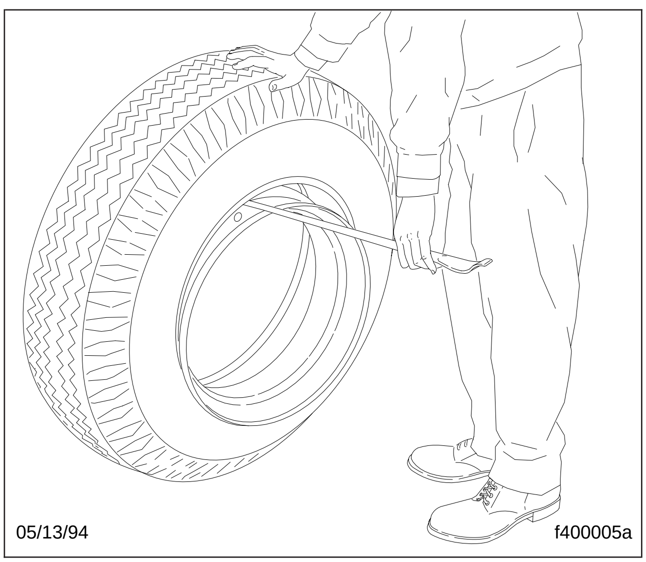


Fig. 3, Prying the Rim Out of the Tire

5. Clean and inspect all parts. Follow the instructions in **Subject 130** and **Subject 140**.

MOUNTING

1. Install the valve stem in the tire.

   1.1 Place the valve stem, with a rubber washer, through the valve hole from the tire side of the rim.

   1.2 Screw the valve nut on the stem from the opposite side. Make sure the rubber bushing and metal collar or nut are centered and fit snugly in the valve hole. See **Fig. 4**.

   1.3 Tighten the nut securely.

Fig. 4, Valve Stem Installation

2. Lubricate the bead seats on the rim and both tire beads.

   2.1 Place the rim on a wooden floor or rubber mat with the wide side down.

   2.2 Using a brush or swab, lubricate both bead seats (flanges) of the rim and both tire beads with an approved lubricant. Do not let excess lubricant run inside the tire.

   Apply enough lubricant to enable correct bead seating and to make mounting easier.

3. Work the lower tire bead into the rim well.

   3.1 Lay the tire on the rim. If there is a balance mark on the tire, align the mark with the valve stem.

Demounting and Mounting Tubeless Tires

3.2 Push one area of the lower bead over the flange and into the rim well.

3.3 Using the straight end of the tire tool, with the stop resting on the rim flange, take small bites to work the remaining section of the bead into the rim. See **Fig. 5**.

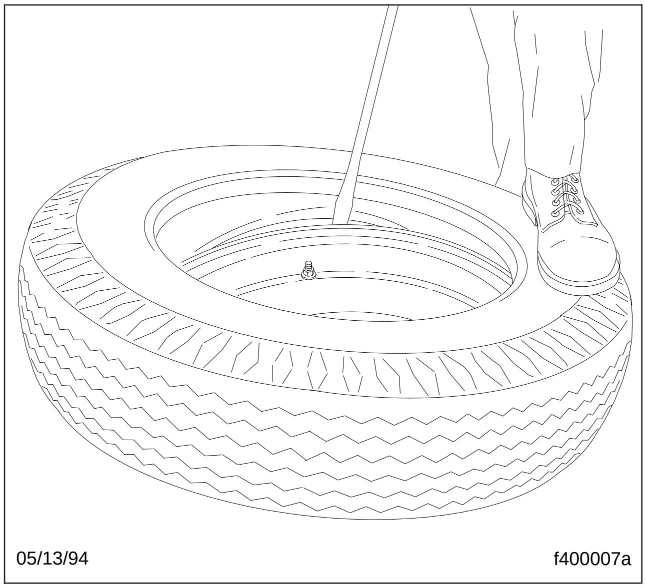


Fig. 5, Working the Lower Bead into the Rim

4. Work the upper tire bead into the rim well.

4.1 Start the upper tire bead over the rim flange and into the rim well by standing on the tire. If necessary, push a section of the bead into the rim well and anchor it by attaching Vise-Grip® pliers to the rim flange with the snub side toward the tire.

4.2 Using the spoon end of the tire iron, with the stop toward the rim, work around the bead. See **Fig. 6**. Use small bites until the bead slips over the flange and into the rim well.

4.3 If necessary, insert a second tire iron and relubricate the last 8 inches (20 cm) of the bead.

IMPORTANT: Inflate tires immediately after mounting, before the tire lubricant dries. Once the lubricant dries, bead positioning is not possible, even with increased inflation pressure.

Fig. 6, Working the Upper Bead into the Rim

5. Inflate the tire. Follow the instructions in **Subject 150**.

Inspection

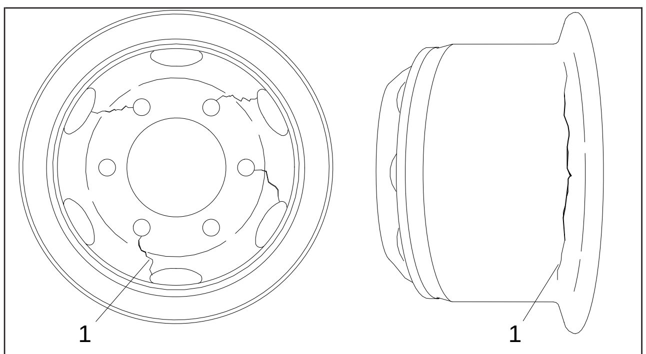
WARNING

Inspect the tires and wheels, and correct any problems. Failure to do so could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst, which could cause personal injury or property damage.

Examine the wheel or rim, and all parts. Remove any grease, dirt, or rust. Using a wire brush, remove any rubber from the bead seat. Use special care when cleaning the rim gutter. Rust or other foreign matter can prevent the correct fitting of side rings. Replace corroded parts. Paint the rim to prevent corrosion.

NOTE: Do not paint Alcoa aluminum disc wheels. If the wheels are corroded, contact the manufacturer for instructions.

Sprung or broken side rings, a cracked rim, wheel (Fig. 1), or brake drum, damaged inner or outer wheel nuts, or an out-of-round wheel or rim, requires the replacement of the damaged part. Replace the wheel if it has out-of-round stud holes.



1. Crack

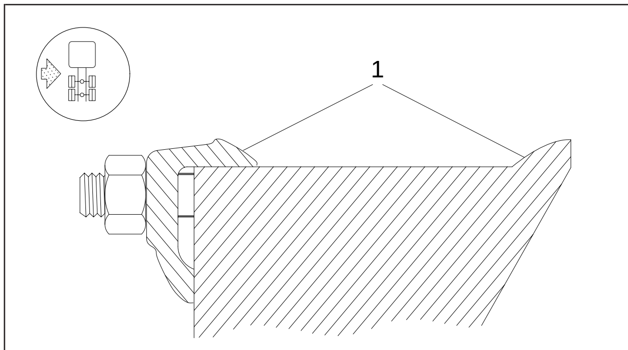
Fig. 1, Cracked Wheel and Rim

NOTE: For inspection and service procedures for the hub, wheel studs, wheel, and brake drum assemblies, see Section 33.01 for front-axle parts, or Section 35.01 for rear-axle parts. When replacing the spoke wheel or the brake drum, contact the wheel manufacturer for the correct torque value for the brake drum nut that attaches the spoke wheel to the brake drum.

Inspect valve cores for cracks, bends, and air retention. Replace damaged or leaky cores.

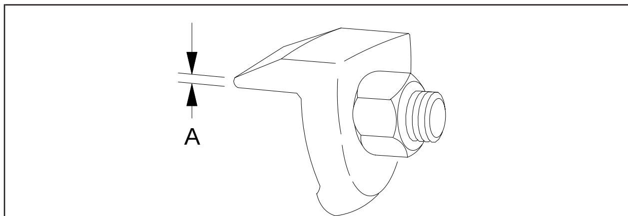
The most critical area of a spoke wheel is the 28-degree tapered rim mounting surface See Fig. 2. Clean the surface and examine it for damage or excessive wear. Replace the wheel if the mounting surface is damaged or worn below the 28-degree taper.

Check the clamps, rim spacer, rim studs, and spoke-wheel nuts for damage or wear. The clamps must not be excessively worn. The end of the wedge portion must be at least 1/16-inch (1.5-mm) thick. See Fig. 3. The rim spacer must not be bent, distorted, or crushed. Replace all damaged or broken parts.



1. 28-Degree Tapered Rim Mounting Surfaces

Fig. 2, Spoke Wheel Tapered Mounting Surface



A. End of wedge must be at least 1/16" (1.5 mm) thick.

Fig. 3, Rim Clamp

Do not attempt to rework, weld, heat, or braze any rim or wheel parts that are cracked, broken, or damaged. Use new parts or parts that are not cracked, broken, or otherwise damaged, and that are of the same size and type.

Remove all foreign matter, such as grease and dirt, from the wheel mounting surface. Smooth any pro-

Wheel and Components Inspection

jections on the mounting surface to ensure even pressure when tightening the wheel nuts.

Tire and Components Inspection

Inspection

⚠ WARNING

Inspect the tires and wheels, and correct any problems. Failure to do so could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst, which could cause personal injury and equipment damage.

Inspect the inside and outside of the tire for out-of-roundness, loose cords, cuts, foreign objects, and other damage. Repair as needed. Contact the tire manufacturer for repair procedures.

Do not repair tires with the following problems:

- Cuts in the tread that are wire or breaker fiber deep.
- Tread worn to the wire or breaker fibers.
- Tread that is scalloped or otherwise worn unevenly.
- Visible, broken, deformed, or otherwise damaged bead wires.
- Deteriorated rubber.
- Rubber cracked to the wire or cord.
- Separations in the casing.
- Exposed cord (for example, due to weather checking or sidewall scuffing).

Inspect the tread for abnormal or excessive wear. See **Troubleshooting, 300** for possible causes of abnormal wear. Rotate the tires if they are wearing irregularly. If the front axle tires become irregularly worn, move them to the drive axle(s) or trailer axles.

Check the front-end alignment. In a dual assembly, if one tire wears faster than its mate, the position of the two tires should be reversed.

Government regulations require the removal of any tire with less than 2/32-inch (1.5-mm) tread remaining. Retread the tire, if possible. Regroove it only if it is marked "Regroovable" on the sidewall. Discard the tire if it cannot be retreaded or regrooved.

Clean and inspect the tube and flap of tube-type tires. Discard tubes or flaps that are buckled or creased. Do not use an old tube in a new tire, and always mount a used flap in the same size tire and on the same size rim as the one from which it was removed.

Michelin Tire Corporation recommends using only new tubes, flaps, valve cores, caps, and O-rings in a new mounting.

Tire Inflation

IMPORTANT: Inflate tires immediately after mounting, before the tire lubricant dries. Once the lubricant dries, bead positioning is not possible, even with increased inflation pressure.

1. Check all parts to make sure they are correctly seated prior to inflation.

WARNING

During initial tire inflation, there is the possibility of an explosion of the assembly. Observe the following safety rules to reduce the possibility of serious physical injury in the event of an explosion.

- Inflate tires in a safety cage or an approved portable restraining device.
- Always use a clip-on chuck with an inline valve and gauge.
- Make sure the inflation hose is long enough to permit standing to the side of the tire during inflation.
- Never sit on, or stand in front of, an assembly that is being inflated.

2. Place the tire in a safety cage, or an approved portable restraining device. See **Fig. 1**.

IMPORTANT: Water in the tire can cause ply separation. During tire inflation, air tank reservoirs and lines must be dry. Use well-maintained air line moisture traps, and service them regularly.

3. Inflate the tire 10 psi (69 kPa).
4. Check the parts for correct seating. If the seating is not correct, completely deflate the tire and correct the problem. Never attempt to seat rings or other parts by hammering on an inflated or partially inflated tire.

IMPORTANT: Due to the different flex characteristics of radial sidewalls, it may be necessary to use an inflation aid, such as the following, to help seat tubeless tire beads:

- Metal rings, which use a blast of compressed air to seat the beads.

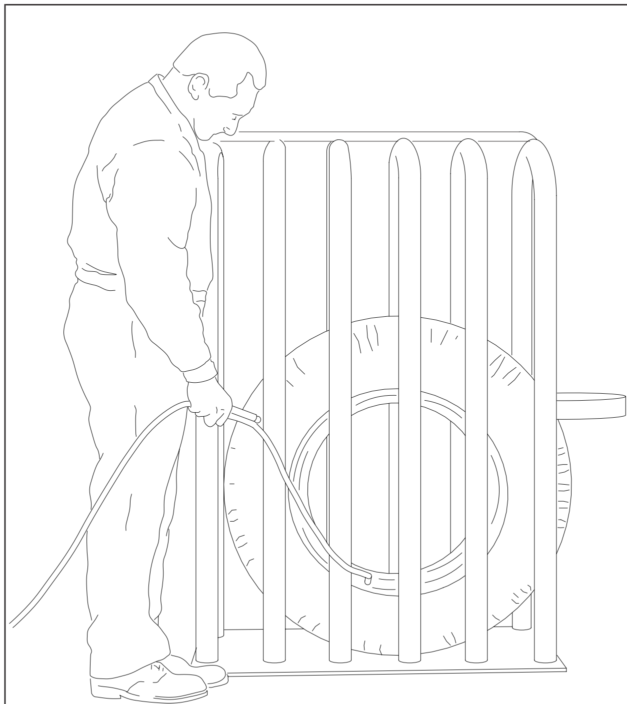
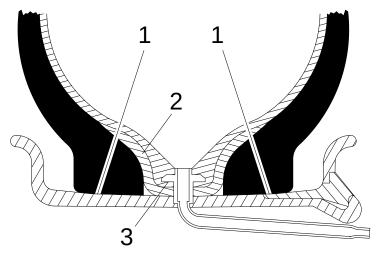


Fig. 1, Safety Cage for Tire Inflation

- Rubber rings, which seal between the tire bead and rim, allowing the bead to move out and seat correctly. A well-lubricated, heavy-duty bicycle tube can be used to help seal between the tire bead and rim.

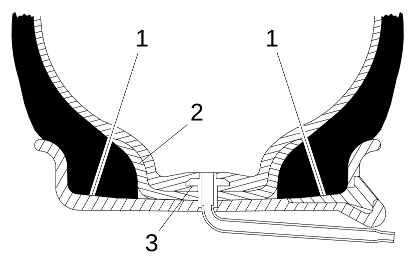
5. Continue to inflate the tire to the recommended pressure. See **Specifications, 400** for correct cold-inflation pressures.
   - Michelin Tire Corporation recommends an initial pressure of 90 to 100 psi (620 to 690 kPa) for this step to correctly seat the tire beads.
   - The position of the beads, flap, and tube with 4 to 5 psi (28 to 35 kPa) pressure is shown in **Fig. 2**. The tube is fully rounded-out within the tire, but there isn't enough pressure to move the beads on wide-base rims.
   - Depending on the tire size and rim condition, from 20 to 40 psi (140 to 275 kPa) pressure is needed to push the beads onto the bead seat. See **Fig. 3**.

Tire Inflation



1. Tapered Bead Seat
2. Flap
3. Valve Base

Fig. 2, Position of Beads, Flap, and Tube at 4 to 5 psi (28 to 35 kPa)



1. Tapered Bead Seat
2. Flap
3. Valve Base

Fig. 3, Beads Pressured Onto the Bead Seat

CAUTION

Inflating tube-type tires incorrectly can crack or tear the edge or inside of the valve base. Once seated, the tube can stretch only in the rim area. Because resistance to stretch is greatest at the valve base, there is often enough tension to break the tube at the edge of the valve base or in the valve base.

6. After the initial inflation, completely deflate the tire by removing the valve core. This ensures correct bead seating, and prevents buckling or overstretching the tube in tube-type tires.

WARNING

Inflate tires to the specified pressure. Tire underinflation or overinflation will damage wheels and tires, and could result in a blowout, which could cause personal injury and property damage.

- Driving on overinflated tires weakens the cords by reducing their ability to absorb road shocks, and increases the danger of cuts, snags, and punctures.
- Overinflation overstresses and damages the rims.
- Driving on underinflated tires generates excessive heat, which weakens the tire body and reduces tire strength.

CAUTION

Use tires of the same size, type, and capacity to carry the load at the recommended cold pressure. Attempting to increase the load capacity of a tire by overinflation will damage the tire assembly.

7. Inflate the tire to the recommended cold inflation pressure listed in **Specifications, 400**.
8. Install the valve cap and tighten finger-tight.
9. Check the inflation pressure 24 hours after mounting new tires.

NOTE: Testing a vehicle on a dynamometer can cause severe tire damage. Because manufacturers differ in their recommendations for preventing tire damage, refer to the manufacturer's instructions for testing a vehicle on a dynamometer.

General Information

Runout is side-to-side (lateral) or up-and-down (radial) movement when the tire/wheel assembly is rotated. Runout can be measured with a dial indicator, a tire runout gauge, or another instrument capable of measuring small movements of the tire/wheel assembly.

Lateral runout, shown in **Fig. 1**, is side-to-side movement of the rotating tire/wheel assembly. This may cause a perceived "shimmy" or "wobble".

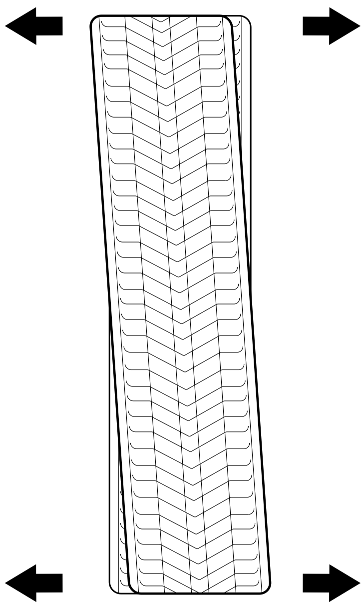


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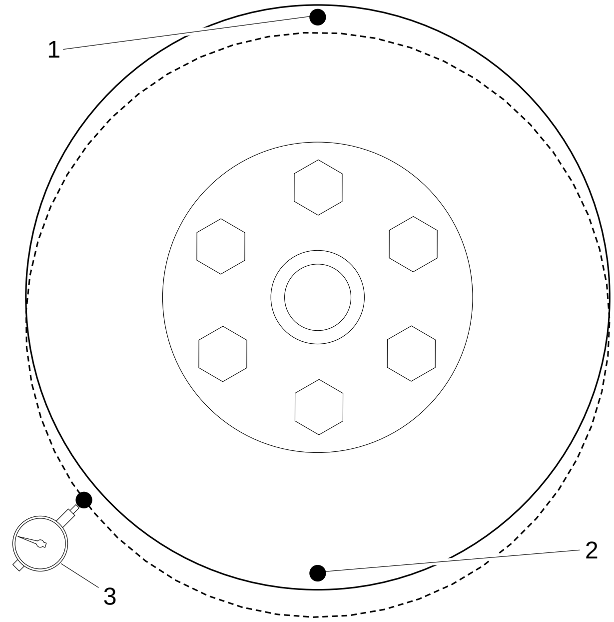
Fig. 1, Lateral Runout

Radial runout, shown in **Fig. 2**, is a changing radius of the rotating tire/wheel assembly. For a tire or wheel, its effect is to raise and lower the vehicle as it rolls along, giving the perception of a vertical "hop" or "bounce".

If a tire and wheel assembly shows visible up-and-down or side-to-side movement, it may have excessive runout. Use the inspection procedure that follows to measure runout.

Inspection

IMPORTANT: Before checking wheel runout, check the tires for proper:



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1. High Spot
2. Low Spot
3. Dial Indicator

Fig. 2, Radial Runout

- inflation;
- wheel nut torque;
- bead seating on the rim.

Use a tire runout gauge, as shown in **Fig. 3**, to check lateral and radial runouts of the entire wheel end assembly.

Check radial runout on a smooth rib in the center of the tread. Check lateral runout on a smooth surface along the tire's mid-sidewall. If the wheel end assembly radial runout exceeds 0.060 inch (0.2 cm), or the lateral runout exceeds 0.150 inch (0.4 cm), the tire/wheel assembly should be removed to check the brake drum and hub runouts. Brake drum and hub runout tolerances are as follows:

- brake drum lateral runout—0.045 inch (0.11 cm)
- brake drum radial runout measured inside of the drum—0.020 inch (0.050 cm)
- hub lateral runout measured at the face of the hub—0.015 inch (0.38 cm)

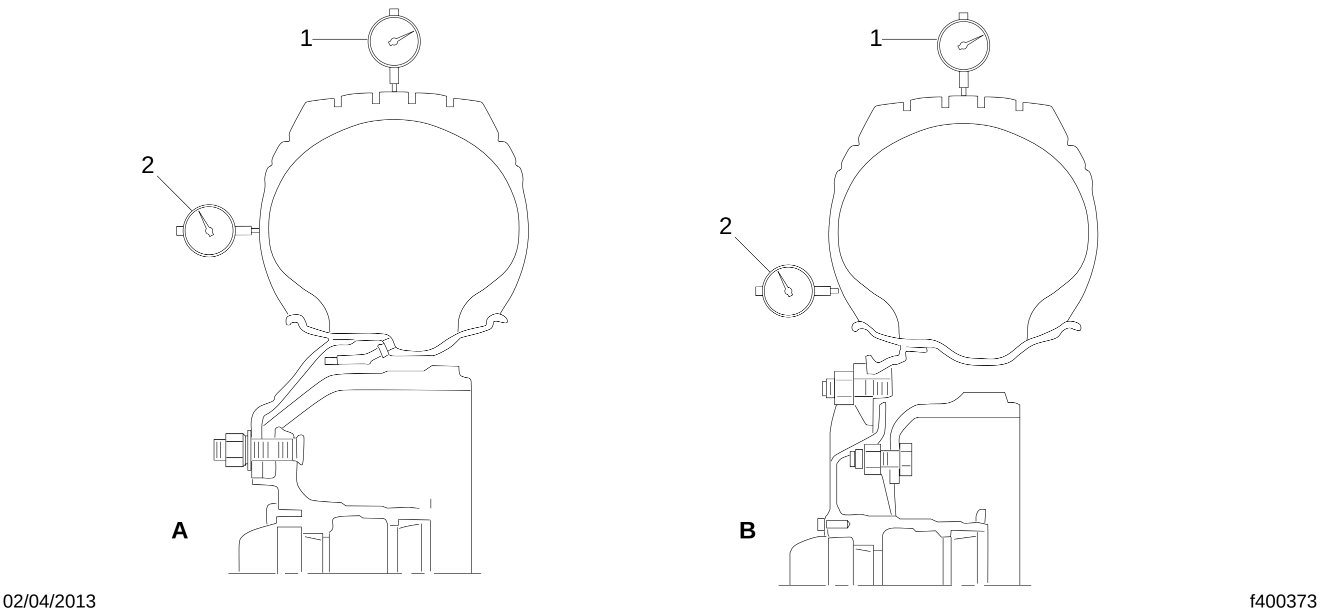
Wheel and Tire Runout Measurements

- hub radial runout measured near the hub pilots—0.015 inch (0.38 cm)

If hub and brake drum runouts are within specification, then the wheel runout will need to be checked. Demount the tire from the wheel and check lateral and radial runouts for the wheel as shown in **Fig. 4**. For tire demounting instructions, see **Section 40.00, Subject 120**. Make certain the wheel is properly fixed in a wheel balancer or remounted on the hub. See **Table 1** for wheel runout specifications.

Wheel Runout Specifications		
Wheel Type	**Lateral Runout: inches (cm)**	**Radial Runout: inches (cm)**
Aluminum	0.030 (0.08)	0.030 (0.08)
Steel	0.060 (0.15)	0.060 (0.15)

Table 1, Wheel Runout Specifications

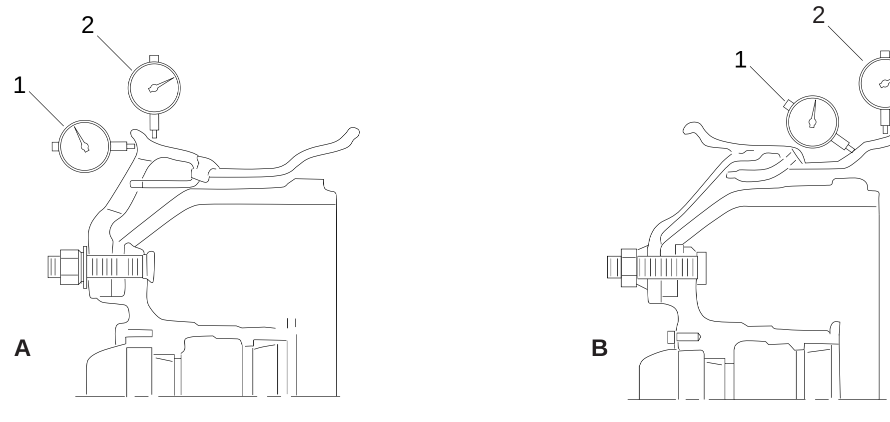


A. Tubeless Steel Disc Wheel
1. Radial Runout

B. Tubeless Demountable Wheel
2. Lateral Runout

Fig. 3, Runout Check for Tires

Wheel and Tire Runout Measurements



A. Tubeless Aluminum Disc Wheel
B. Tubeless Steel Disc Wheel
1. Lateral Runout
2. Radial Runout

Fig. 4, Runout Check for Wheels

Troubleshooting Tables

Problem—Abnormal Tire Wear

Problem—Abnormal Tire Wear	
Possible Cause	**Remedy**
Tires are not inflated to the correct pressure.	Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. Refer to **Specifications, 400**.
Inflation pressures in a dual assembly are unequal.	Inflate all tires to a uniform pressure, within 5 psi (35 kPa). Refer to **Specifications, 400** for the proper cold inflation pressures.
Dual tires are mismatched.	Examine all tires and match them according to the specifications in this section.
Vehicle is vibrating severely.	Follow the recommendations under "Problem—Vehicle Vibration" in this subject.
Brakes are grabbing.	Examine and adjust the brakes according to the instructions in **Group 42** in this manual.
Axles are improperly aligned.	Align the axles according to the instructions in **Section 33.00** (front-axle) and **Section 35.00** (rear-axle).
Wheel bearings are loose or damaged, or bushings are excessively worn.	Examine, and repair or replace according to the instructions in **Section 33.01** (front axle) or **Section 35.01** (rear axle).
Wear is uneven among tire sets.	Rotate the tires according to the instructions in **Subject 140**.
Driver is abusing equipment.	Caution the driver.

Problem—Vehicle Vibration

Problem—Vehicle Vibration	
Possible Cause	**Remedy**
Axles are improperly aligned.	Align the axles according to the instructions in **Section 33.00** (front-axle) and **Section 35.00** (rear-axle).
Wheels, rims, or tires are out-of-round, bent, or distorted.	Replace damaged components.
Tires, wheels, rims, or brake drums are out-of-balance.	Determine the out of balance component and balance.
Tire beads are not properly seated.	Demount and mount the tire. Make certain adequate lubrication is used and, if necessary, use an inflation aid to help seat tubeless tire beads.
Tire and rim assembly is improperly installed on a spoke wheel.	Remove the tire and rim assembly and inspect it for out-of-round or rim chording. Replace the rim if it is damaged. Follow closely the tightening sequence and torque values listed.
Rim spacers are worn or distorted.	Replace the rim spacers.
Driveline, suspensions, or steering components are loose or worn.	Determine the location of the vibration, then repair or replace the loose or worn components.

Troubleshooting

Problem—Excessive On-the-Road Tire Failures

Problem—Excessive On-the-Road Tire Failures Possible Cause	Remedy
Tires are not inflated to the correct pressure.	Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. Refer to **Specifications, 400**.
Dual tires are mismatched.	Examine all tires and match them according to the specifications in this section.
Water or foreign material is inside the casing.	Clean and dry the tires and tubes prior to mounting. Make sure excess lubricant does not flow down into the tire. Store unmounted tires indoors, or under cover, to prevent moisture from collecting inside.
Tires are contaminated with oil.	Clean the tires and inspect the engine seals, transmission seals, axle-end and drive axle seals, oil filters and oil lines for leakage. Make sure the lubricant used in mounting does not contain a petroleum derivative.
Vehicle is vibrating severely.	Follow the recommendations under "Problem—Vehicle Vibration" in this subject.
Wheel or rim components are mismatched.	Check the catalog issued by the applicable wheel or rim manufacturer for the proper part numbers and sizes of approved components. Make sure that all parts of an assembly match in size, manufacturer, and classifications within a manufacturer’s line. Never use a component which does not bear clear, legible, and proper numbers and manufacturer’s identification, even if it appears to fit.
Parts are corroded, worn, or otherwise damaged.	Clean or replace parts as necessary.

Tire Pressure

Do not reduce the pressure of a hot tire if it exceeds the specified pressure. In normal driving, tire temperature and inflation pressure increase. Increases of 10 to 15 psi (70 to 105 kPa) are common. Higher pressures may be signs of overloading, underinflation, excessive speed, improper tire size, or any combination of these factors, and must be checked when the tire is cool.

IMPORTANT: The load and cold inflation pressure must not exceed the rim or wheel manufacturer's recommendations, even though the tire may be approved for a higher load or inflation. Some rims and wheels are stamped with a maximum load and maximum cold inflation rating. If they are not stamped, consult the rim or wheel manufacturer for the correct tire inflation pressure for the vehicle load. If the load exceeds the maximum rim or wheel capacity, the load must be adjusted or reduced.

For further information on rims and tires (other than Michelin), and for inflation and load limits, refer to the "Tire and Rim Association Yearbook." Contact the Michelin Tire Corporation for further information on their tires.

Disc Wheel Fastener Torque Values

For torque values for disc wheel fasteners, see **Table 1**.

Disc Wheel Fastener Torque			
Description	**Nut Size**	**Wheel Manufacturer**	**Torque: lbf·ft (N·m)**
*10-Hole and 8-Hole Hub-Piloted Disc Wheel With Two-Piece Flange Nuts**			
Front and Rear Wheel Nut	M22 x 1.5	All	450–500 (610–678)
Nuts on Double-Threaded Wheel Studs	M22 x 1.5	All	390–450 (529–610)
Double-Threaded Wheel Stud Retainer Nut	3/4–16	All	175–200 (235–270)
10-Hole Stud-Piloted Disc Wheel With Inner and Outer Nuts†			
Front Wheel Nut	1-1/8–16	All	450–500 (610–678)
Rear Wheel Inner Nut	3/4–16	All	450–500 (610–678)
Rear Wheel Outer Nut	1-1/8–16	All	450–500 (610–678)

* Torque values for hub-piloted wheels are given for lubricated threads. Lubricate threads with SAE 30W engine oil. Do not apply thread lubricant to ball seats of the nuts and wheels. Wipe it off if it is applied accidentally.

† Torque values for stud-piloted wheels are given for clean, dry threads.

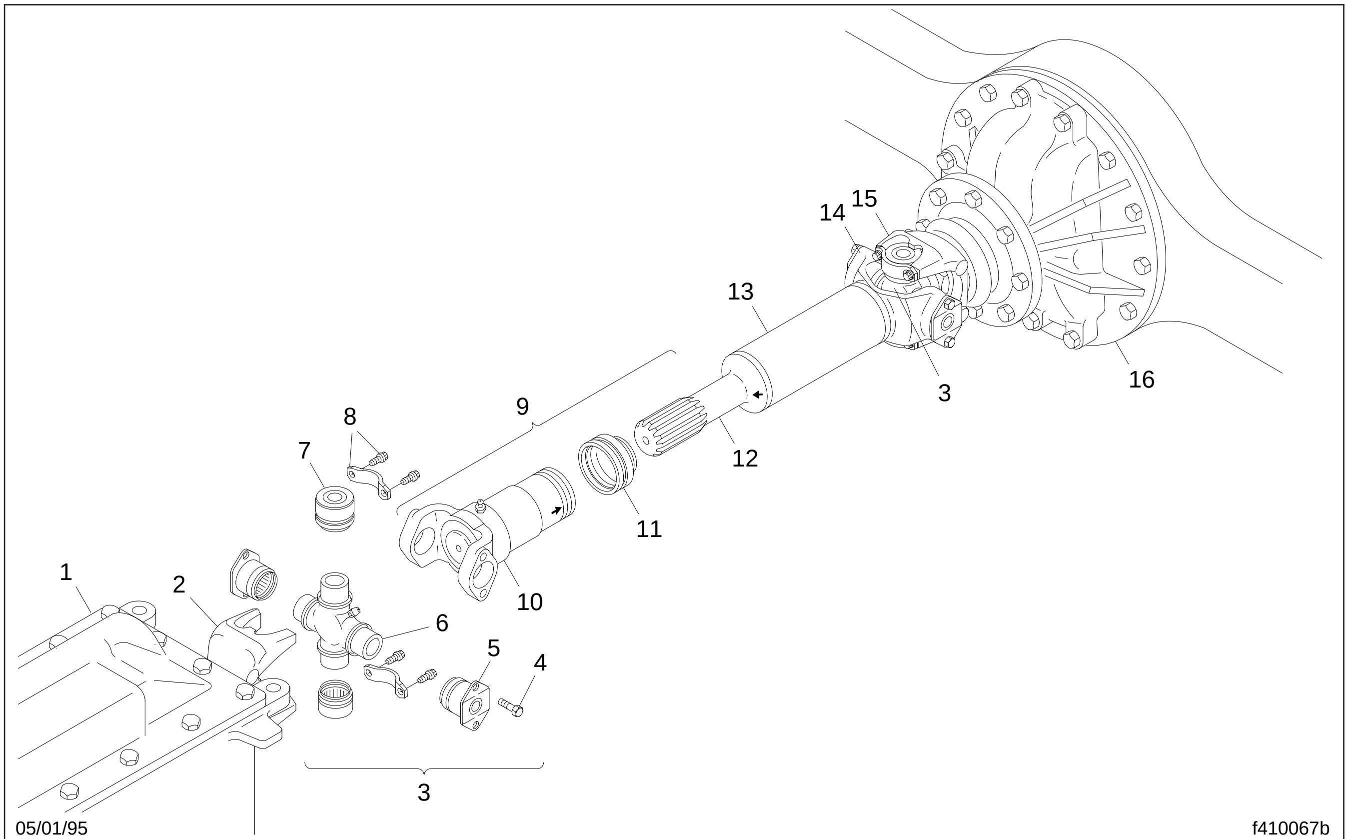
Table 1, Disc Wheel Fastener Torque

General Information

The simplest driveline consists of a transmission output-shaft end-yoke, an axle input-shaft end-yoke, and a single slip-jointed driveshaft connecting the two end-yokes. See **Fig. 1**. The driveshaft is made up of a universal joint (U-joint), a sleeve-yoke, a splined stub shaft, a driveshaft tube, a tube-yoke, and a second U-joint.

Driveline Configuration

The specific type and number of drivelines used on each vehicle depends on its number of transmissions, its number of drive axles, and its wheelbase. See **Fig. 2**. A driveline is used between each driving and driven component. A driveline connecting a main transmission (or an auxiliary transmission) to a single drive axle or forward-rear axle of a dual-drive vehicle is always referred to as a No. 2 driveline. See **Fig. 2**, examples A, B, C, D, and E. An interaxle driveline of a dual-drive vehicle is always called a No. 3 drive-



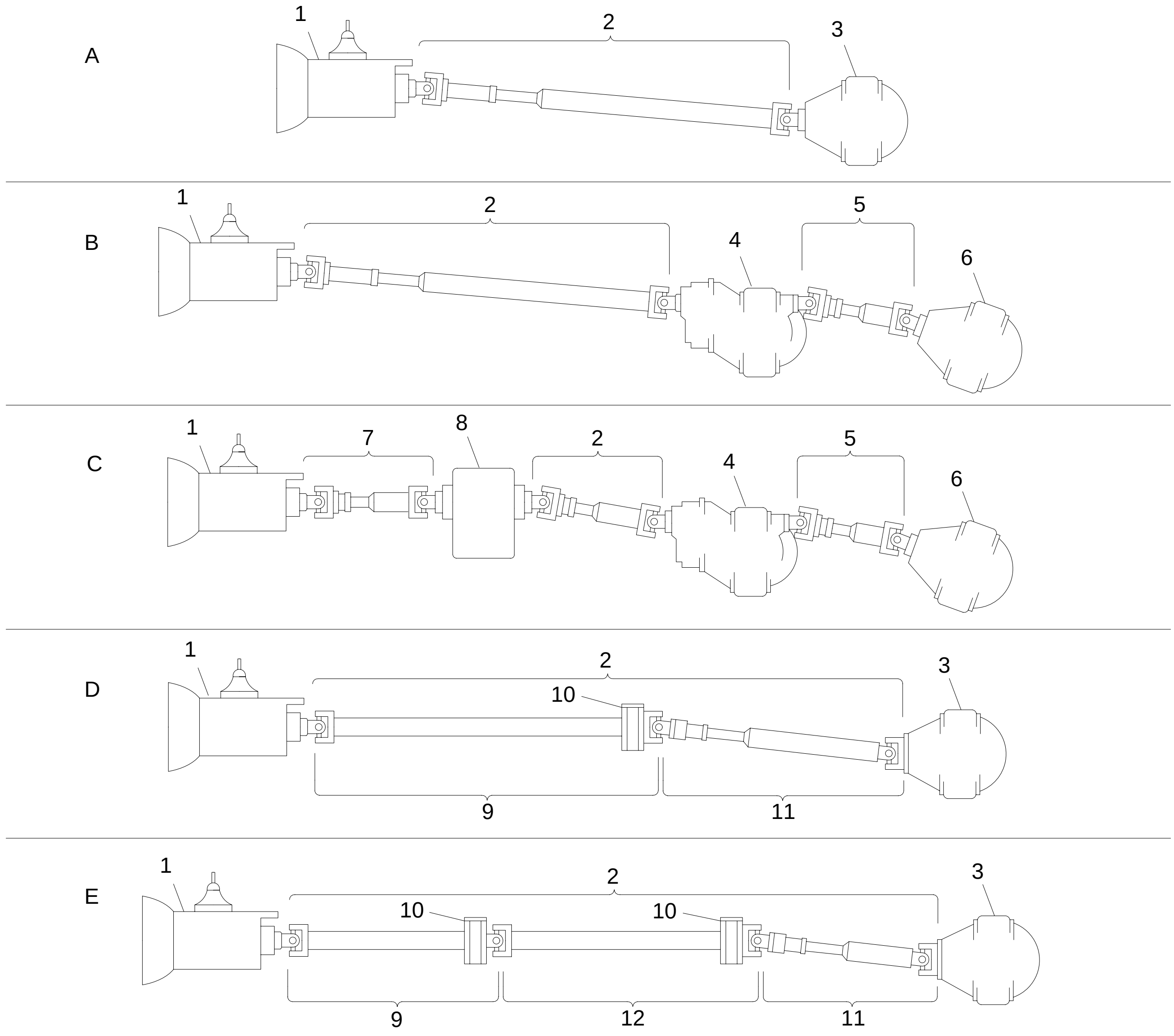
NOTE: Not all fasteners are shown.

1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Bearing Plate Self-Locking Capscrew
5. Bearing Cup (for full-round yoke)
6. U-Joint Cross
7. Bearing Cup (for half-round yoke)
8. Bearing Strap and Bearing-Strap Capscrew
9. Slip-Joint Assembly
10. Sleeve-Yoke (full-round)
11. Dust Cap
12. Splined Stub Shaft
13. Driveshaft Tube
14. Tube-Yoke (full-round)
15. Axle Input-Shaft End-Yoke (half-round)
16. Rear Axle

Fig. 1, Components of a Basic Driveline

line. See **Fig. 2**, examples B and C. A driveline connecting a main transmission to an auxiliary transmission is always referred to as a No. 1 driveline. See **Fig. 2**, example C.

A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, vehicles having a long wheelbase



1. Main Transmission
2. No. 2 Driveline
3. Rear Axle
4. Forward-Rear Axle
5. No. 3 Driveline
6. Rearmost Axle
7. No. 1 Driveline
8. Auxiliary Transmission
9. Primary Coupling Shaft
10. Midship Bearing
11. No. 2 Driveshaft
12. Intermediate Coupling Shaft

Fig. 2, Driveline Configurations

use a midship bearing, mounted on a frame crossmember, for additional support. See **Fig. 2**, example D. This allows the No. 2 driveline to be separated into two, shorter shafts (a coupling shaft and a No. 2 driveshaft), thus improving balance and stability.

Vehicles having an even longer wheelbase use two crossmember-mounted midship bearings, allowing the No. 2 driveline to be separated into three short shafts, joined by four U-joints. See **Fig. 2**, example E. The first shaft is the primary coupling shaft, the second is the intermediate coupling shaft, and the third is the No. 2 driveshaft.

Slip-Joints, U-Joints, and Yokes

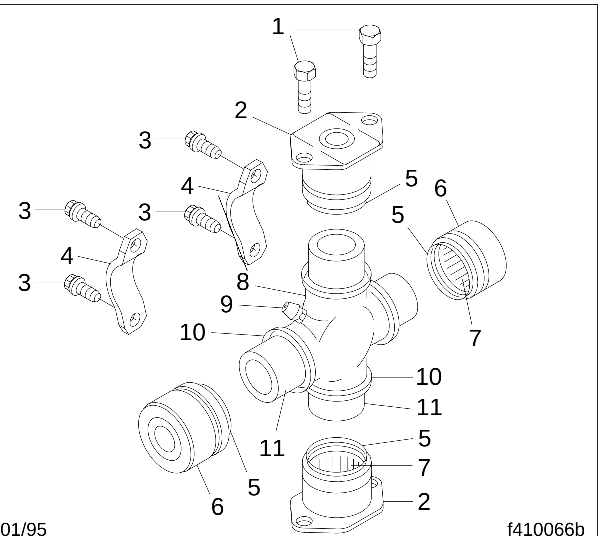
The basic function of the driveline is to send torque from the transmission to the axle in a smooth and continuous action. Because the vehicle axles are not attached directly to the frame, but are suspended by springs, they ride in an irregular, floating motion (when going over bumps or depressions), thus changing the distance between the transmission (or coupling shaft) and the rear axle, and the distance between the rear axles. The slip-joints of the No. 2 and No. 3 driveshafts, by expanding and contracting, allow for length changes between drivetrain components. Coupling shafts do not require a slip-joint.

Motion of the rear axle(s) also causes changes to the relative angles between drivetrain components. U-joints allow transfer of torque from an output shaft (or coupling shaft) to the driveshaft, and from the driveshaft to an input shaft, even though the angles between the shafts may be constantly changing.

Each U-joint consists of a cross with a close-tolerance ground cylindrical surface (trunnion) at the end of each of the four arms. Installed on each trunnion is a bearing cup lined with bearing needles. All bearing cups are sealed to retain lubricants, and to prevent entry of foreign material. See **Fig. 3**. In operation, the four bearing cups are held stationary in a pair of yokes, while the U-joint cross pivots on its trunnions.

Full-round yokes are installed at the front of coupling shafts and at both ends of the No. 2 and No. 3 driveshafts. All tube-yokes (yokes that are welded into driveshaft tubes) and all sleeve-yokes (yokes that are part of the internally splined half of slip-joints) are full-round yokes. See **Fig. 4**, items 4 and 9.

An end-yoke is an internally splined yoke, held on an externally splined shaft by a locknut. As standard



1. Bearing-Plate Capscrews
2. Bearing Cup (for full-round yoke)
3. Bearing-Strap Capscrew
4. Bearing Strap
5. Bearing-Cup Seal
6. Bearing Cup (for half-round yoke)
7. Bearing Needles
8. U-Joint Cross
9. Grease Fitting
10. U-Joint Cross Slinger
11. Trunnion

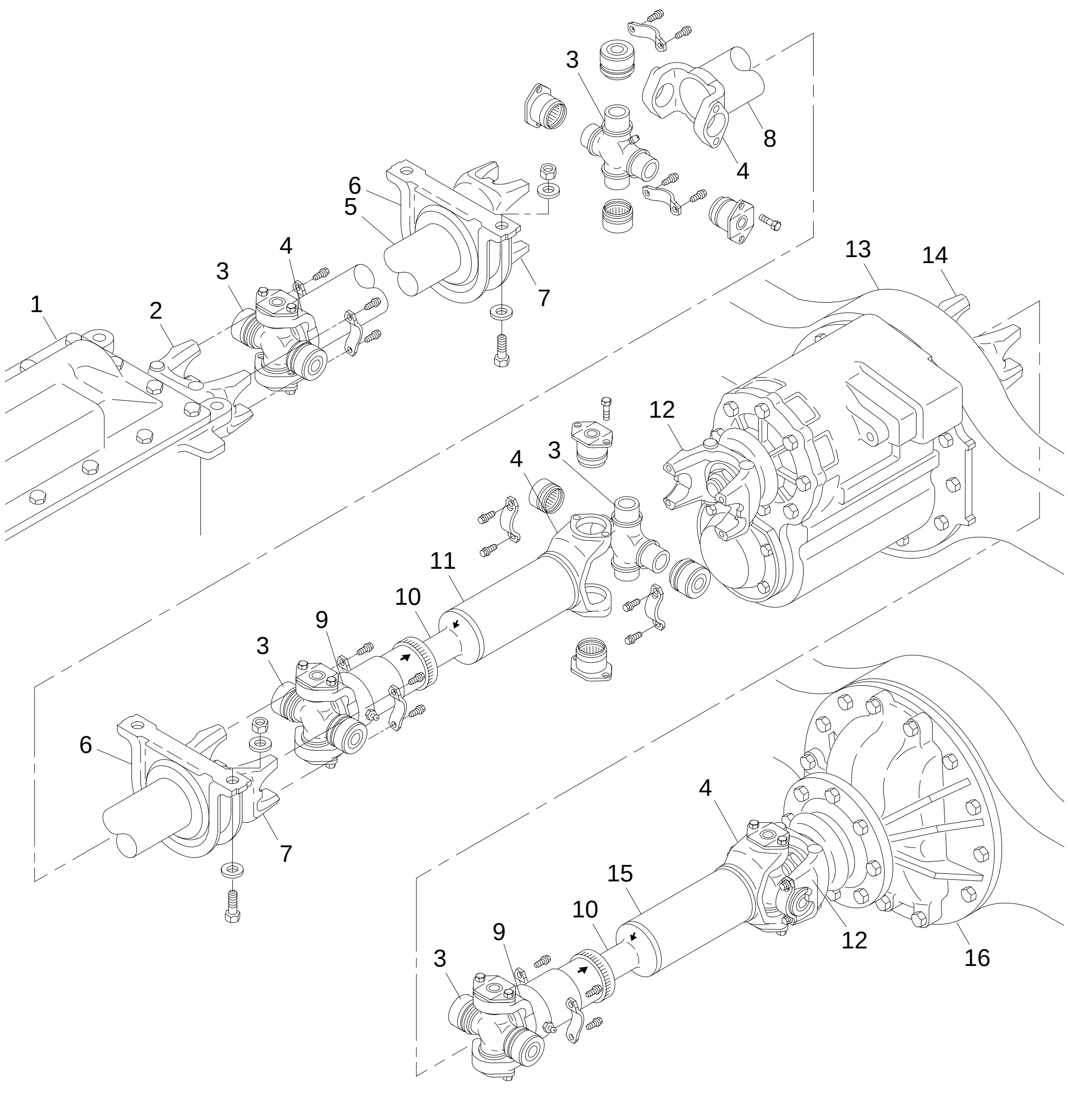
Fig. 3, Typical U-Joint

equipment, all No. 2 driveline end-yokes are half-round, with full-round optional. And, as standard equipment, all No. 3 driveline end-yokes are full-round, with half-round optional. End-yokes are installed on the transmission output shaft, on each axle input and output shaft, and behind the midship bearing of most coupling shafts. See **Fig. 4**, items 2, 7, 12, and 14.

Meritor 17T and 18T U-joints are coupled to half-round end-yokes by capscrews inserted through semicircular bearing straps that hold the bearing cups in place under tabs in the yoke cross-holes. See **Fig. 5**.

Meritor RPL Series U-joints are coupled to half-round end-yokes by capscrews inserted through the bearing cups. See **Fig. 6**.

U-joints are installed in full-round tube-yokes, sleeve-yokes, and end-yokes, by inserting the cross through from the inside of both yoke cross-holes, then install-

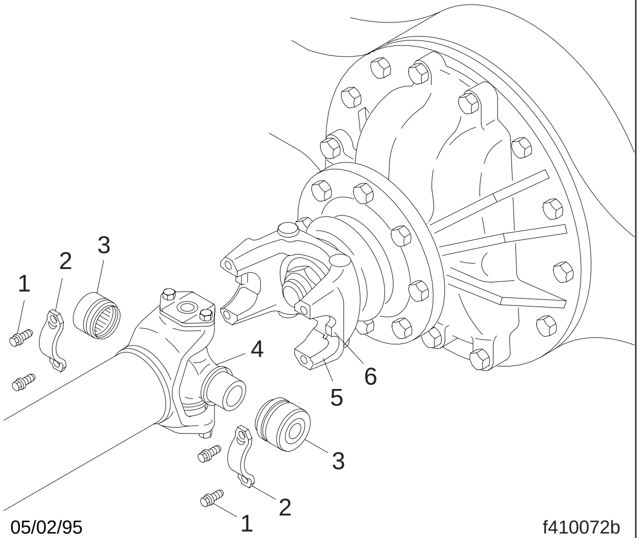


NOTE: Not all fasteners are shown.

1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Full-Round Tube-Yoke
5. Primary Coupling Shaft Tube
6. Midship Bearing Assembly
7. Coupling Shaft End-Yoke (half-round)
8. Intermediate Coupling Shaft Tube
9. Sleeve-Yoke (full-round)
10. Slip-Joint Assembly
11. No. 2 Driveshaft Tube
12. Axle Input-Shaft End-Yoke (half-round)
13. Forward-Rear Axle
14. Axle Output-Shaft End-Yoke (half-round)
15. No. 3 Driveshaft Tube
16. Rearmost Axle

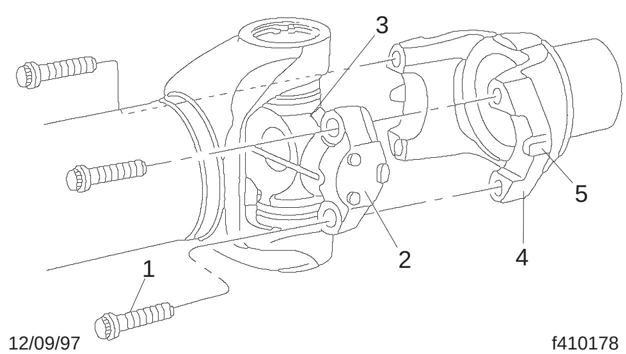
Fig. 4, Dual-Drive Installation With Primary and Intermediate Coupling Shafts

ing the bearing cups into the outsides of the yoke and over the ends of the trunnions. Snap rings or self-locking capscrews are installed into the yoke to secure the cups. See **Fig. 7**.



1. Bearing-Strap Capscrew
2. Bearing Strap
3. Bearing Cup
4. U-Joint Cross
5. Half-Round Yoke
6. Yoke Cross-Hole Tab

Fig. 5, Coupling of a U-Joint With a Half-Round End-Yoke

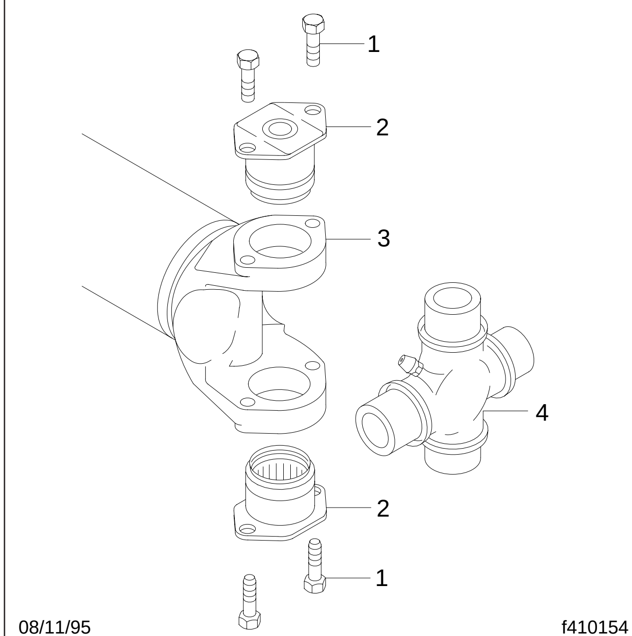


1. Capscrew
2. Bearing Cup
3. U-Joint Cross
4. Half-Round Yoke
5. Yoke Cross-Hole Tab

Fig. 6, Coupling of a RPL Series U-Joint

U-Joint Angles, Phasing, and Driveline Balance

Correct U-joint working angles, U-joint phasing, and driveline balance are vital to maintaining a quiet-running drivetrain and long life of drivetrain components (including driveline components).



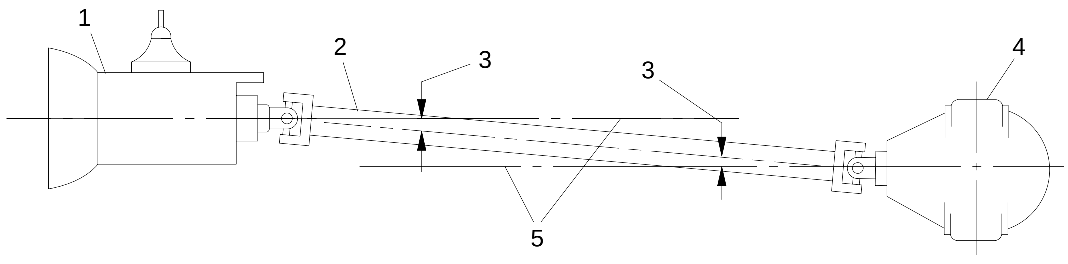
1. Bearing-Plate Self-Locking Capscrew
2. Bearing Cup (bearing-plate-type)
3. Full-Round Yoke
4. U-Joint Cross

Fig. 7, Installation of a U-Joint in a Full-Round Yoke

The U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component (or other driveshaft) to which the U-joint connects. See **Fig. 8**. Because the double oscillating motion of a U-joint that connects angled shafts causes a fluctuating speed difference between the shafts, the effect created by the U-joint at one end of the shaft must cancel the effect created by the U-joint at the other end. This is done by making U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase. If the yoke lugs at both ends of the shaft are lying in the same plane (a plane that bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 9**.

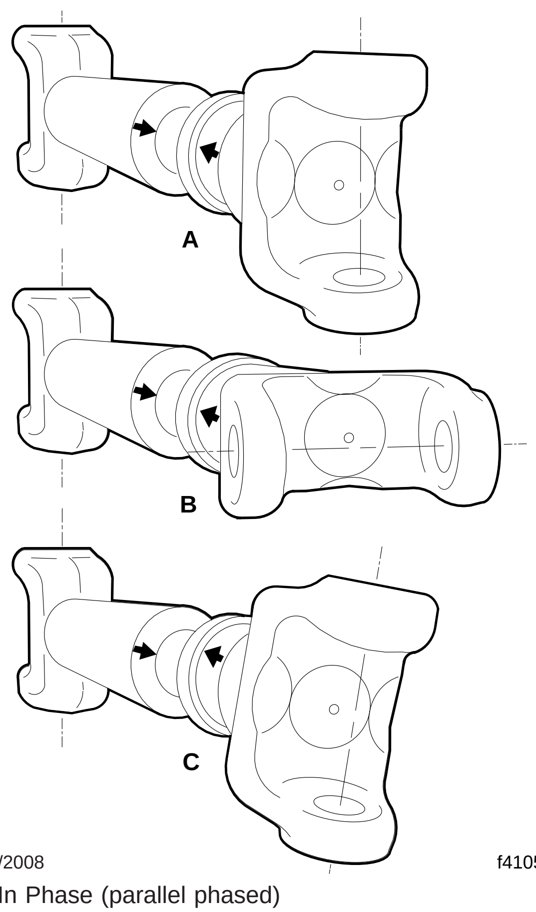
NOTE: Some driveshafts are designed and phased with their end yokes clocked 90 degrees from each other. This is referred to as cross phasing.

After manufacture, each driveline yoke is statically balanced. After assembly, each driveshaft and cou-



1. Transmission
2. No. 2 Driveshaft
3. U-Joint Working Angles
4. Rear Axle
5. Extended Centerlines

Fig. 8, U-Joint Working Angles



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 9, U-Joint Phasing

pling shaft is checked for out-of-roundness, straightened as necessary, then dynamically balanced.

Avoiding Driveline Problems

To ensure that U-joints turn in phase, sleeve-yokes, splined shafts, coupling shaft end-yokes, and coupling shafts, should be marked for assembly reference before disassembly. A misaligned slip-joint will seriously affect driveline balance (and U-joint phasing). Even if a slip-joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

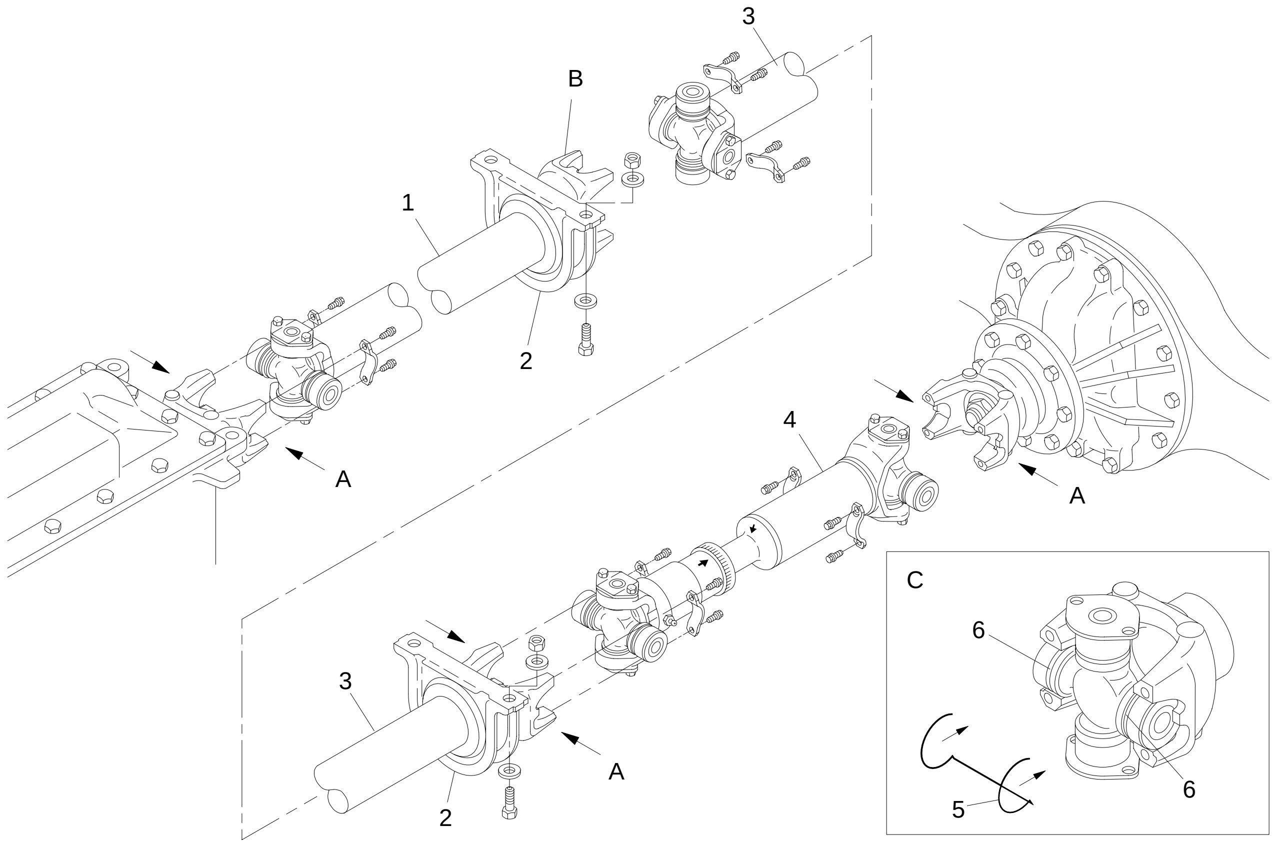
A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds that exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Any condition that allows excessive movement of a driveshaft will cause driveline imbalance: loose end-yoke nuts, loose midship bearing mounts, loose U-joint bearing cup retaining capscrews, worn U-joint trunnions and bearings, and worn slip-joint splines.

Among the most common causes of U-joint and slip-joint damage is lack of lubrication.

To keep a vehicle operating smoothly and economically, the driveline must be carefully checked and lubricated at regular intervals. For inspection and lubrication intervals and procedures, see **Group 41** of the *Columbia Maintenance Manual*.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

U-Joint Uncoupling (See Fig. 1 and Fig. 2)



NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.
B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.
C. Install a half-round bearing-cup retaining wire (or safety wire) before removing the bearing straps.

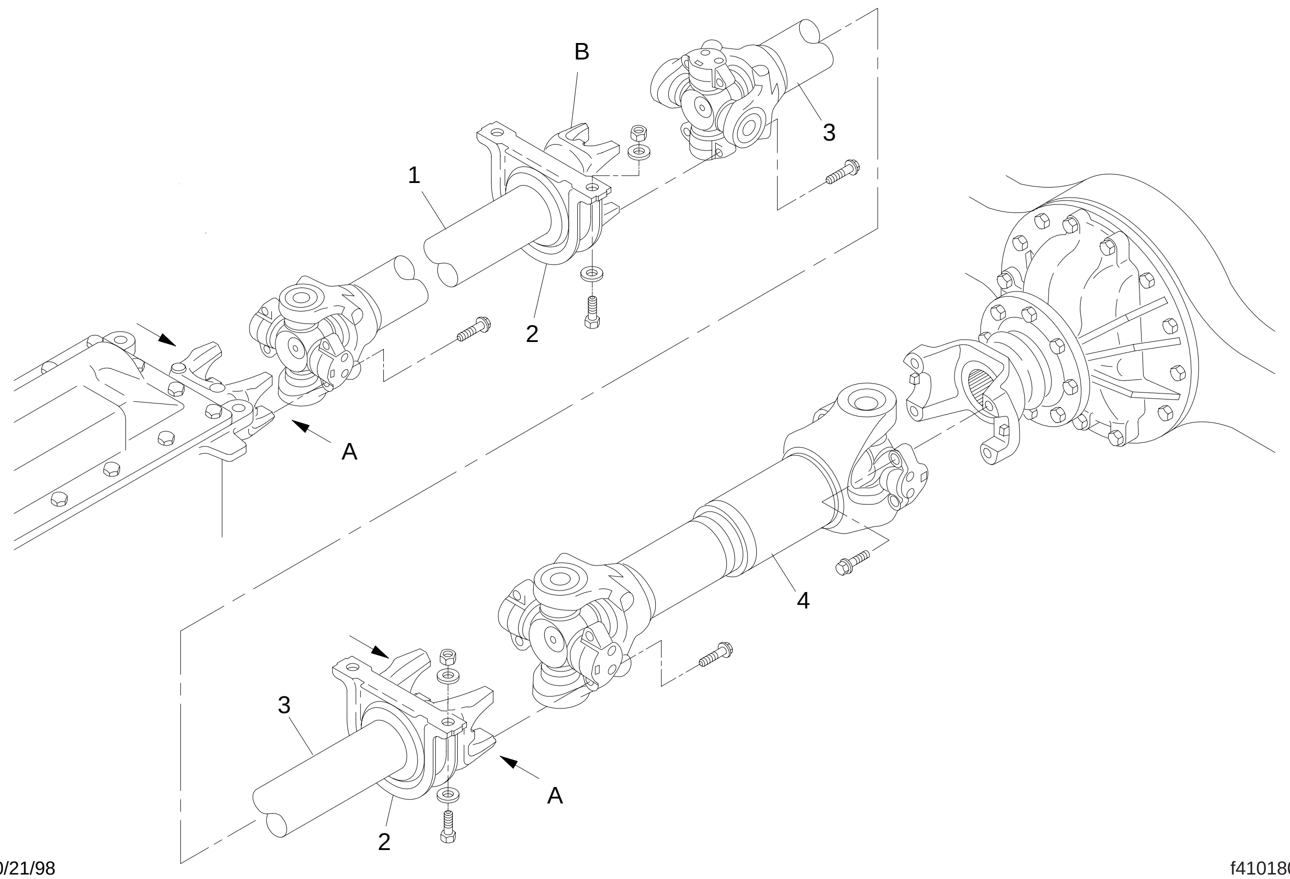
1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft
5. Half-Round Bearing-Cup Retaining Wire
6. Retaining-Wire Groove

Fig. 1, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes, Except RPL U-Joints

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle re-

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.
B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.

1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft

Fig. 2, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes, RPL U-Joints

moval (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate drive-shaft.

1. Roll the vehicle forward or backward as needed to turn the rearmost end-yoke (of the driveline that is being uncoupled) until the centerline through its cross-holes is horizontal. See **Fig. 1**, Ref. A and Ref. B.
2. Apply the parking brakes, and chock the tires.
3. If the half-round bearing cups do not already have a retaining wire installed, install a bearing-cup retaining wire. See **Fig. 1**, Ref. C. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.
4. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s). See **Fig. 1** and **Fig. 2**.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

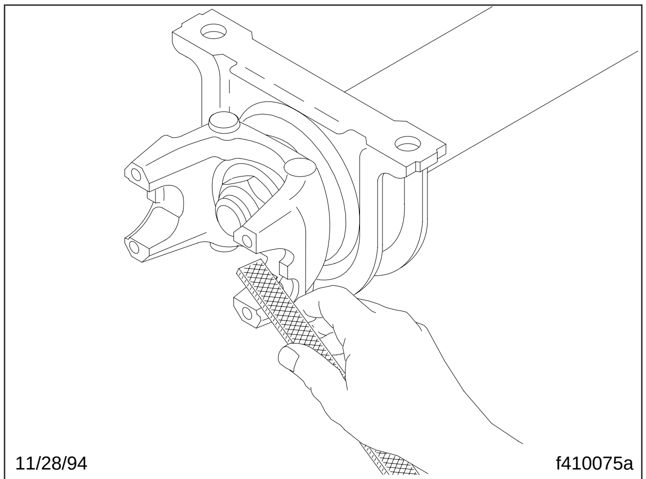
5. Remove the capscrews that secure the bearing cups or straps to the half-round yoke. Remove the bearing straps, if equipped.
6. Compress the slip-joint to remove the U-joint from the yoke.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

U-Joint Coupling (See Fig. 1 and Fig. 2)

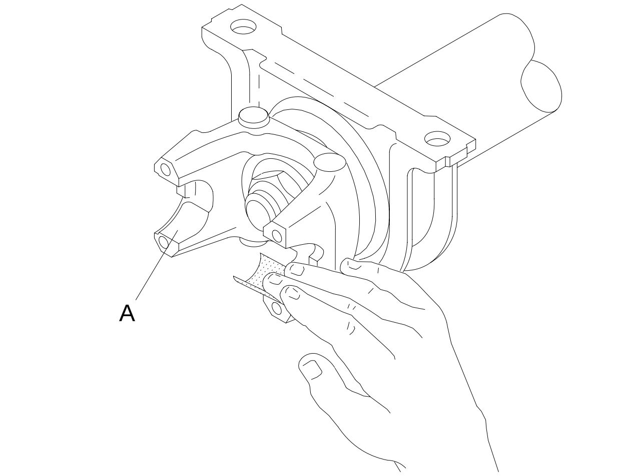
1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a half-round file, remove burrs or raised metal. See **Fig. 3**.



11/28/94 f410075a

Fig. 3, Remove Burrs from a Half-Round End-Yoke Cross-Hole

   - 1.3 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes and bearing straps. See **Fig. 4**.
   - 1.4 Turn the end-yoke until its cross-holes are horizontal. See **Fig. 1** and **Fig. 2**.
2. Check, clean, and lubricate the U-joint.



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A. Use fine emery cloth on this surface.

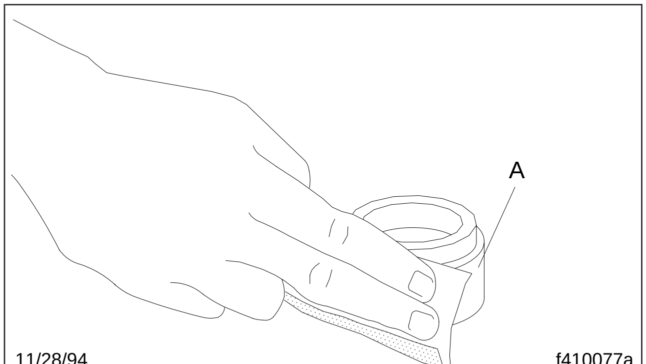
Fig. 4, Smooth a Half-Round End-Yoke Cross-Hole

   - 2.1 Remove the bearing-cup retaining wire or safety wire. See **Fig. 1**, Ref. C.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

   - 2.2 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 5**.



11/28/94 f410077a

A. Use fine emery cloth on this surface.

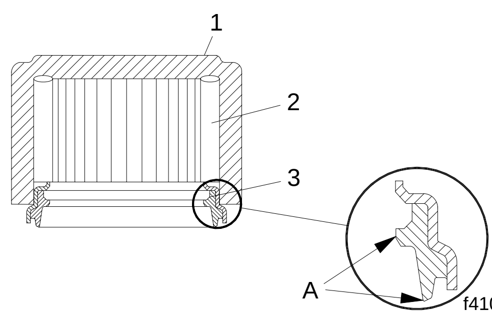
Fig. 5, Smooth a Half-Round End-Yoke U-Joint Bearing Cup

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

2.3 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary. See **Subject 140**.

2.4 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.

2.5 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 6**.



A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

Fig. 6, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup

2.6 Install the bearing cups on the cross.

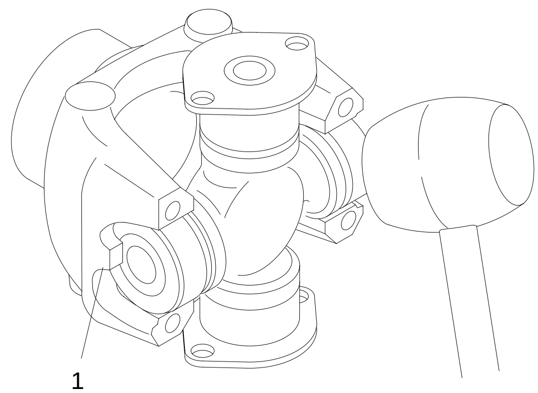
2.7 Install a bearing-cup retaining wire. See **Fig. 1**, Ref. C. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.

3. Extend the slip-joint, while pressing the cross and bearing cups into place in the yoke crossholes. Using a rubber or plastic mallet, gently tap the bearing cups to seat them in the yoke. See **Fig. 7**.

CAUTION

Do not use the capscrews and bearing straps (if equipped) to seat the bearing cups in the yoke. Seating the cross by tightening the bearing straps can deform the bearing straps, allowing the bearing cups to spin, which will cause rapid wear and serious damage to the U-joint.

4. Place the bearing straps (if equipped) over the cups. Install the capscrews, finger-tight.



1. Retaining Tab

Fig. 7, Seat a U-Joint in a Half-Round End-Yoke

WARNING

The self-locking capscrews must not be reused. Replace the capscrews with new ones. Also, do not undertighten or overtighten the capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle. Driveline separation can cause loss of vehicle control that could result in serious personal injury or death.

Separation of the driveline can also cause damage to the driveline, driveline components, or other areas of the vehicle.

5. Alternately tighten the capscrews in increments of 20 lbf·ft (27 N·m) to the applicable torque value in **Specifications 400**.

6. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 68 lbf·ft (92 N·m).

7. Lubricate the U-joint, following the procedure in Group 41 of the *Columbia Maintenance Manual*.

8. Remove the nylon support straps, then remove the chocks.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

U-Joint Uncoupling (See Fig. 1)

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft.

1. Roll the vehicle forward or backward as needed to turn the end-yoke (of the driveline that is being uncoupled) until the centerline through its cross-holes is vertical. See **Fig. 1**.
2. Apply the parking brakes, and chock the tires.
3. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s).
4. Remove and discard all four bearing-cup-plate self-locking capscrews.
5. Using one of the U-joint pullers listed in **Specifications, 400**, remove both bearing assemblies from the end-yoke cross-holes. See **Fig. 2**.
6. Compress the slip-joint and pivot the end of the U-joint cross to remove it from the yoke. Install the bearing cups on the U-joint cross, and secure them with tape.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

U-Joint Coupling (See Fig. 1)

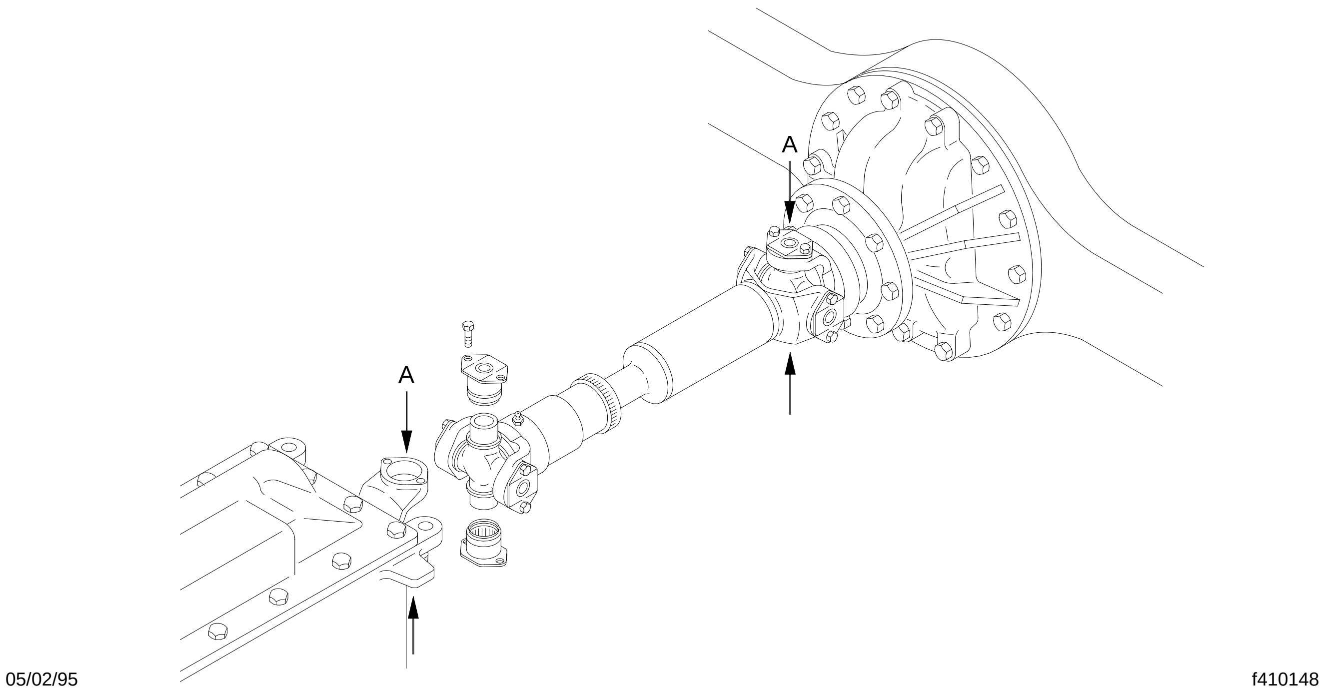
1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications, 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.
   - 1.3 Using a mill file, and holding it flat against the machined surface of the yoke lug, remove any burrs or raised metal. See **Fig. 4**.
   - 1.4 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes. See **Fig. 5**.
   - 1.5 Turn the end-yoke until the centerline through its cross-holes is vertical. See **Fig. 1**.
2. Check, clean, and lubricate the U-joint.
   - 2.1 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 6**.
   - 2.2 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary; see **Subject 140**.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

   - 2.3 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.
   - 2.4 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 7**.
3. Couple the U-joint cross to the end-yoke.
   - 3.1 Extend the slip-joint, while pivoting the U-joint cross into place in the yoke cross-holes.
   - 3.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



NOTE: Not all fasteners are shown.
A. End-yoke cross-hole centerline is vertical.

Fig. 1, U-Joint Uncoupling/Coupling of a Driveline With Full-Round End-Yokes

Using a Spicer trunnion (journal) locator (see **Specifications, 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing assembly over the projected trunnion, and aligning it with the cross-hole. See **Fig. 8**.

IMPORTANT: A Spicer trunnion (journal) locator should be used, to prevent damage to the U-joint trunnions and slingers.

3.3 By hand, press the bearing assembly flush with the face of the yoke. If the bearing assembly binds in the cross-hole, tap the *center* of the bearing plate with a rubber or rawhide mallet; do not tap the outer edges of the bearing plate. See **Fig. 9**.

3.4 Install *new* bearing-cup-plate self-locking capscrews (**Fig. 10**). Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

WARNING

Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.

3.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Repeat applicable substeps to install the opposite bearing.

3.6 Alternately tighten the bearing-cup-plate capscrews in increments of 5 lbf·ft (7 N·m), to the torque value in **Specifications, 400**.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

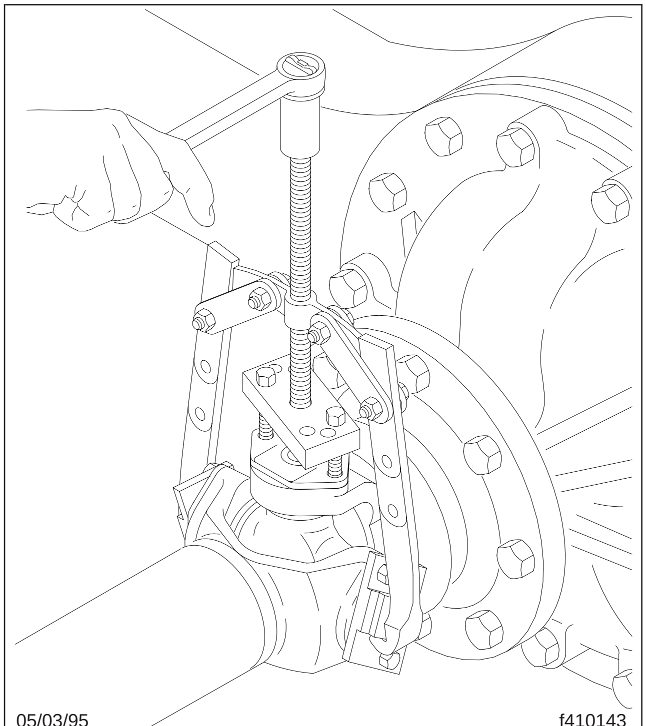
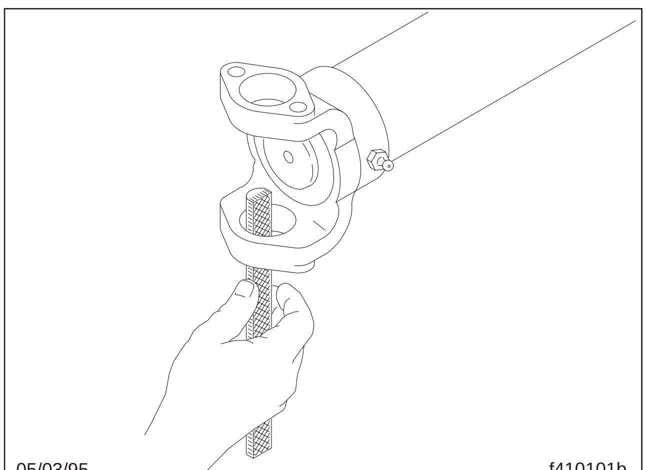


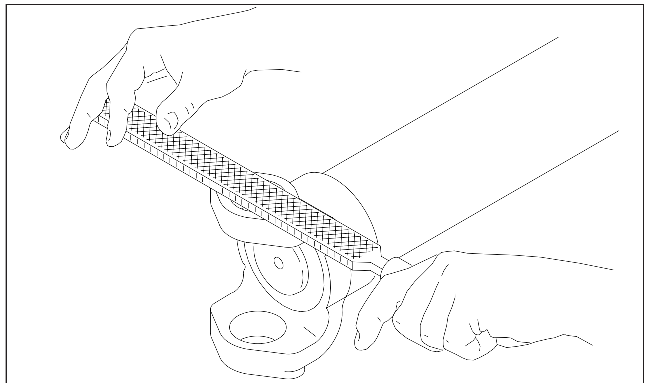
Fig. 2, Remove a Bearing Cup from a Full-Round End-Yoke



NOTE: Sleeve-yoke shown.

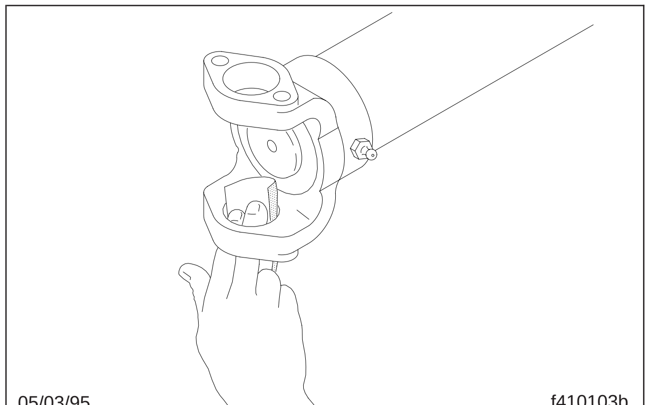
Fig. 3, Remove Burrs from a Full-Round Yoke Cross-Hole

4. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 68 lbf·ft (92 N·m).



NOTE: Sleeve-yoke shown.

Fig. 4, Remove Burrs from the Machined Surface of a Full-Round Yoke Lug

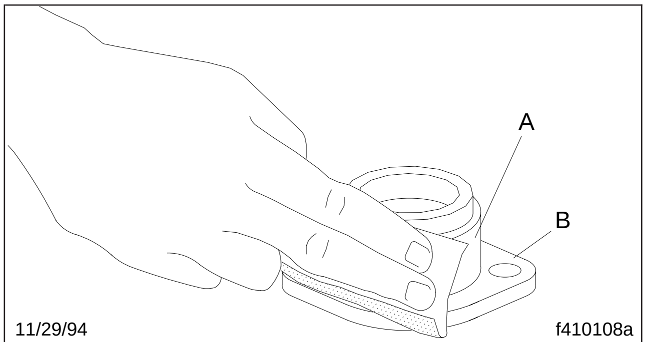


NOTE: Sleeve-yoke shown.

Fig. 5, Smooth a Full-Round Yoke Cross-Hole

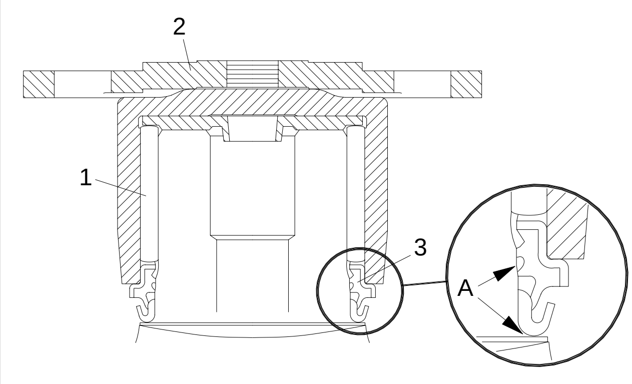
5. Lubricate the U-joint, following the procedure in Group 41 of the *Columbia Maintenance Manual*.
6. Remove the nylon support straps, then remove the chocks.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

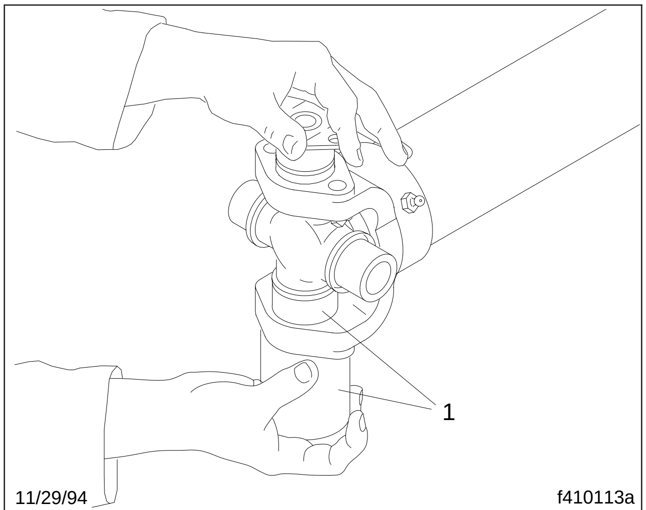
Fig. 6, Smoothing a Full-Round Yoke U-Joint Bearing Cup



A. Lubricate seal lips here.

1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

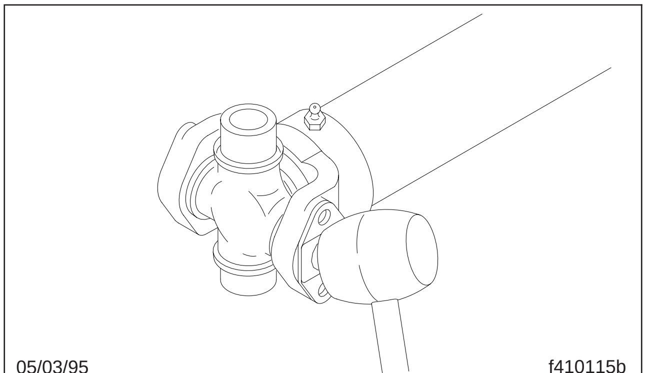
Fig. 7, Sectional View of a Full-Round Yoke U-Joint Bearing Cup



NOTE: Sleeve-yoke shown.

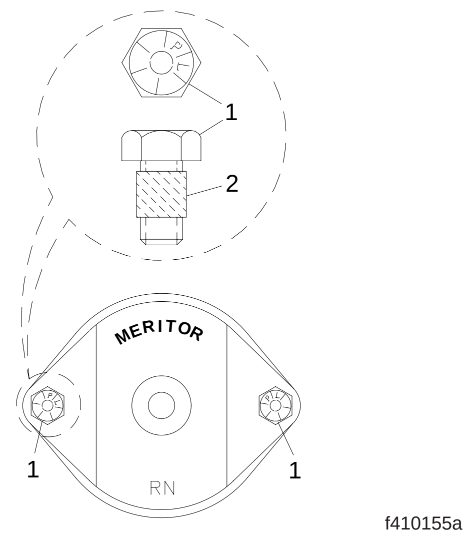
1. Trunnion Locator

Fig. 8, Use a U-Joint Trunnion Locator



NOTE: Sleeve-yoke shown.

Fig. 9, Seat a U-Joint Bearing Cup in a Full-Round Yoke



1. Self-Locking Capscrew
2. Adhesive Band

Fig. 10, Meritor U-Joint Fasteners for Full-Round Yokes

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft. See **Subject 100** for uncoupling from a *half-round* end-yoke, or see **Subject 110** for uncoupling from a *full-round* end-yoke.

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke.

No. 3 Driveshaft Removal

(See Fig. 1 and Fig. 2)

1. Uncouple the No. 3 driveshaft from the rearmost axle. If the No. 3 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 3 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the No. 3 driveshaft from the forward-rear axle. If the No. 3 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 3 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the No. 3 driveshaft out of the chassis.

No. 2 Driveshaft Removal

(See Fig. 3 and Fig. 4)

1. Uncouple the No. 2 driveshaft from the single or forward-rear axle. If the No. 2 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 2 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the No. 2 driveshaft from the transmission or coupling shaft. If the No. 2 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 2 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the No. 2 driveshaft out of the chassis.

Intermediate Coupling Shaft Removal **(See Fig. 5 and Fig. 6)**

1. If the No. 2 driveshaft is also being removed, remove it first.

   If the No. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.
2. Uncouple the intermediate coupling shaft from the No. 2 driveshaft. If the intermediate coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the intermediate coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Uncouple the intermediate coupling shaft from the primary coupling shaft. See **Fig. 7** and **Fig. 8**. If the primary coupling shaft has a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.
4. Lift the intermediate coupling shaft out of the chassis.

Primary Coupling Shaft Removal **(See Fig. 7 and Fig. 8)**

1. *For a vehicle with one coupling shaft:*

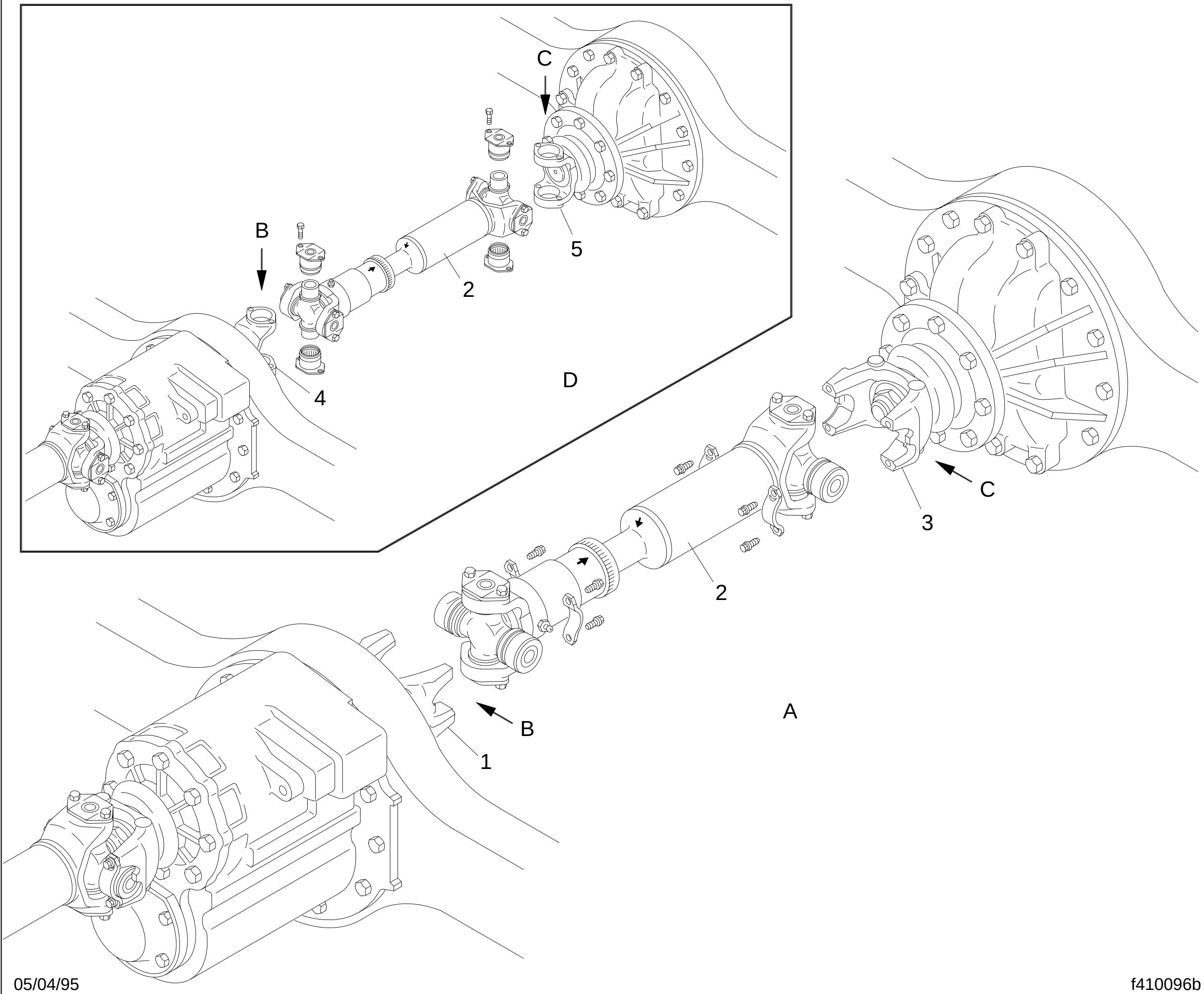
   If the No. 2 driveshaft is also being removed, remove it first.

   If the No. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.

   For a vehicle with two coupling shafts:

   If the No. 2 driveshaft is also being removed, remove it first; then, remove the intermediate coupling shaft.

Driveshaft Removal and Installation



NOTE: Not all fasteners are shown.

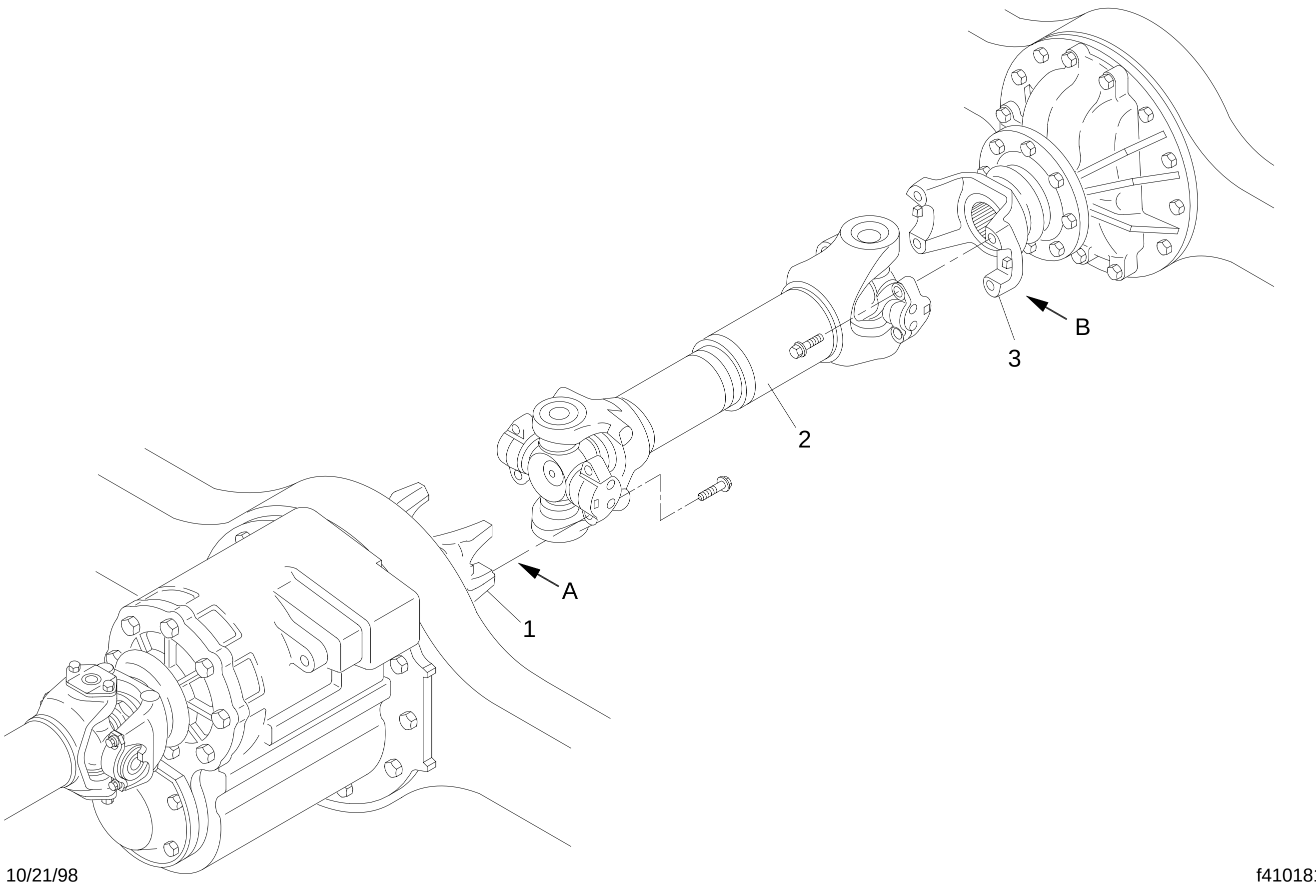
A. No. 3 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 3 Driveshaft Coupled to Full-Round End-Yokes

1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
3. Rearmost Axle Input-Shaft Half-Round End-yoke
4. Forward-Rear Axle Output-Shaft Full-Round End-Yoke
5. Rearmost Axle Input-Shaft Full-Round End-yoke

Fig. 1, Removal/Installation of a No. 3 Driveshaft Without RPL U-Joints

If the intermediate coupling shaft is also being removed (but not the No. 2 driveshaft), remove the intermediate coupling shaft first.

If only the primary coupling shaft is being removed, use nylon support straps to support the forward end of the No. 2 driveshaft and both ends of the intermediate coupling shaft. Then,



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.

B. Uncouple this end first; couple this end last.

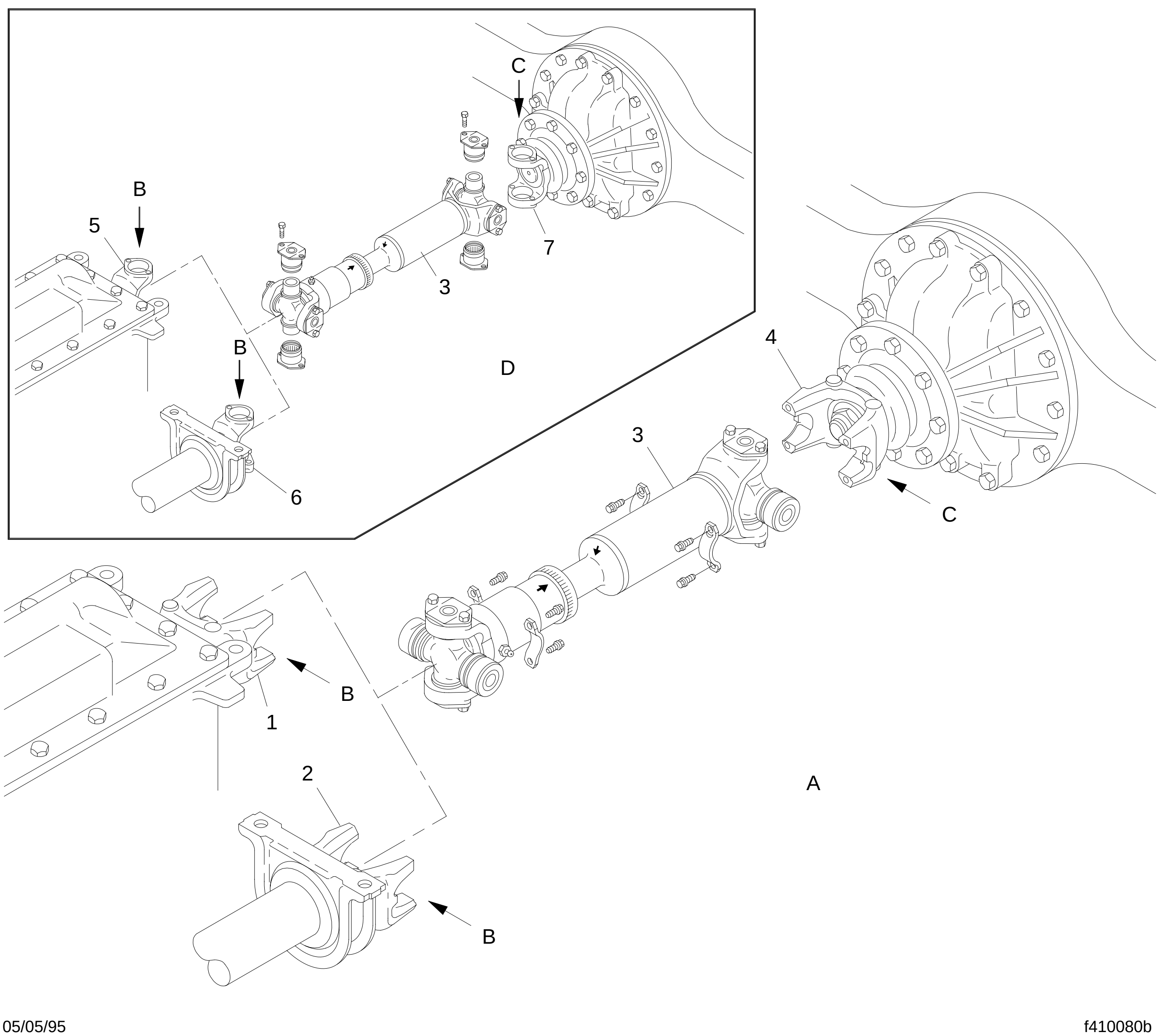
1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
3. Rearmost Axle Input-Shaft Half-Round End-Yoke

Fig. 2, Removal/Installation of a No. 3 Driveshaft With RPL U-Joints

remove the fasteners that attach the intermediate coupling shaft midship bearing to its bracket. See **Fig. 7** and **Fig. 8**.

2. If not already done, uncouple the primary coupling shaft from the No. 2 driveshaft or intermediate coupling shaft. If the primary coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Using two nylon support straps, support the primary coupling shaft. Then remove the fasteners that attach the primary coupling shaft midship bearing to its bracket. See **Fig. 7** and **Fig. 8**.
4. Uncouple the primary coupling shaft from the transmission. If the primary coupling shaft is coupled to a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft is coupled to a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.
5. Lift the primary coupling shaft out of the chassis.

Driveshaft Removal and Installation

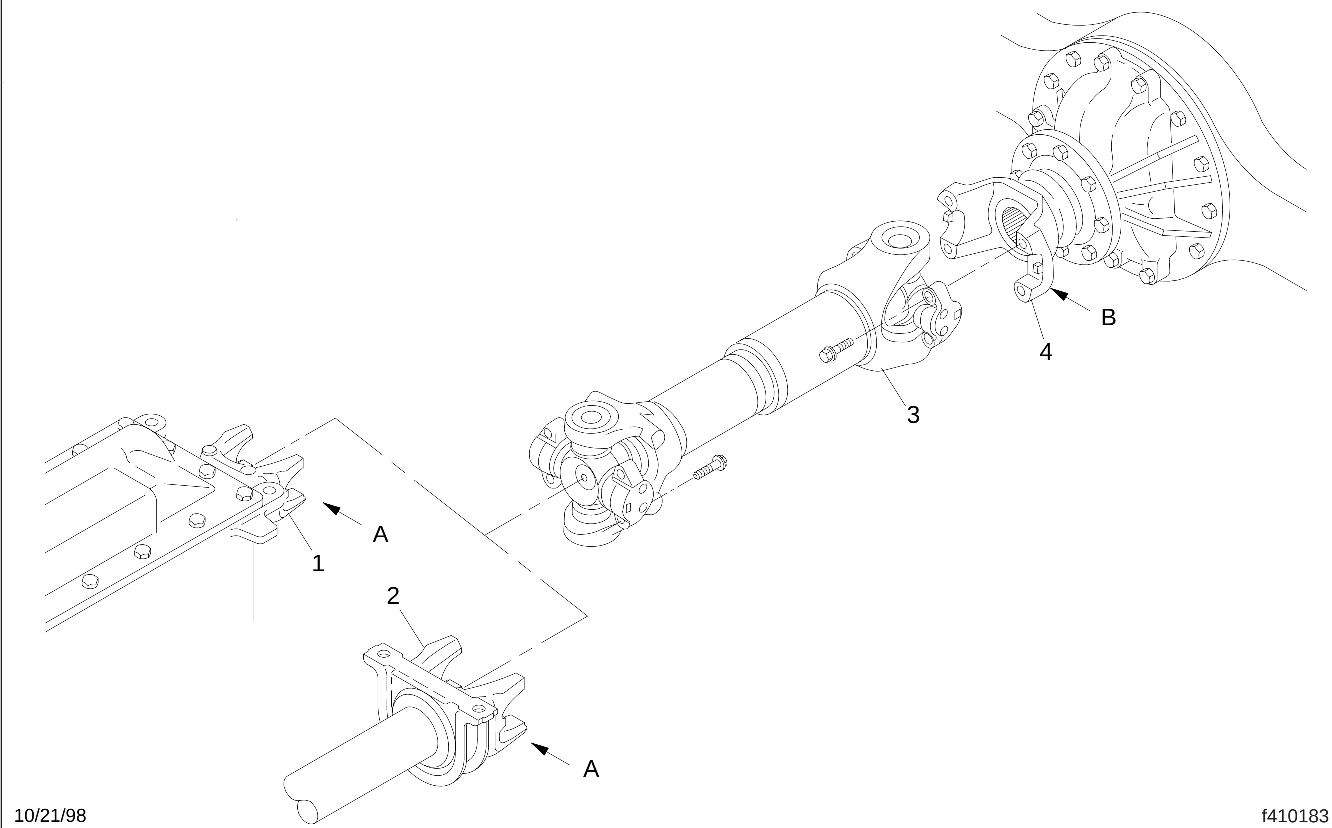


NOTE: Not all fasteners are shown.

A. No. 2 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveshaft Coupled to Full-Round End-Yokes

1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft
4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke
5. Transmission Output-Shaft Full-Round End-Yoke
6. Coupling Shaft Full-Round End-Yoke
7. Single Axle or Forward-Rear Axle Input-Shaft Full-Round End-Yoke

Fig. 3, Removal/Installation of a No. 2 Driveshaft Without RPL U-Joints



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.

B. Uncouple this end first; couple this end last.

1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft
4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke

Fig. 4, Removal/Installation of a No. 2 Driveshaft With RPL U-Joints

Primary Coupling Shaft Installation (See Fig. 7 and Fig. 8)

IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

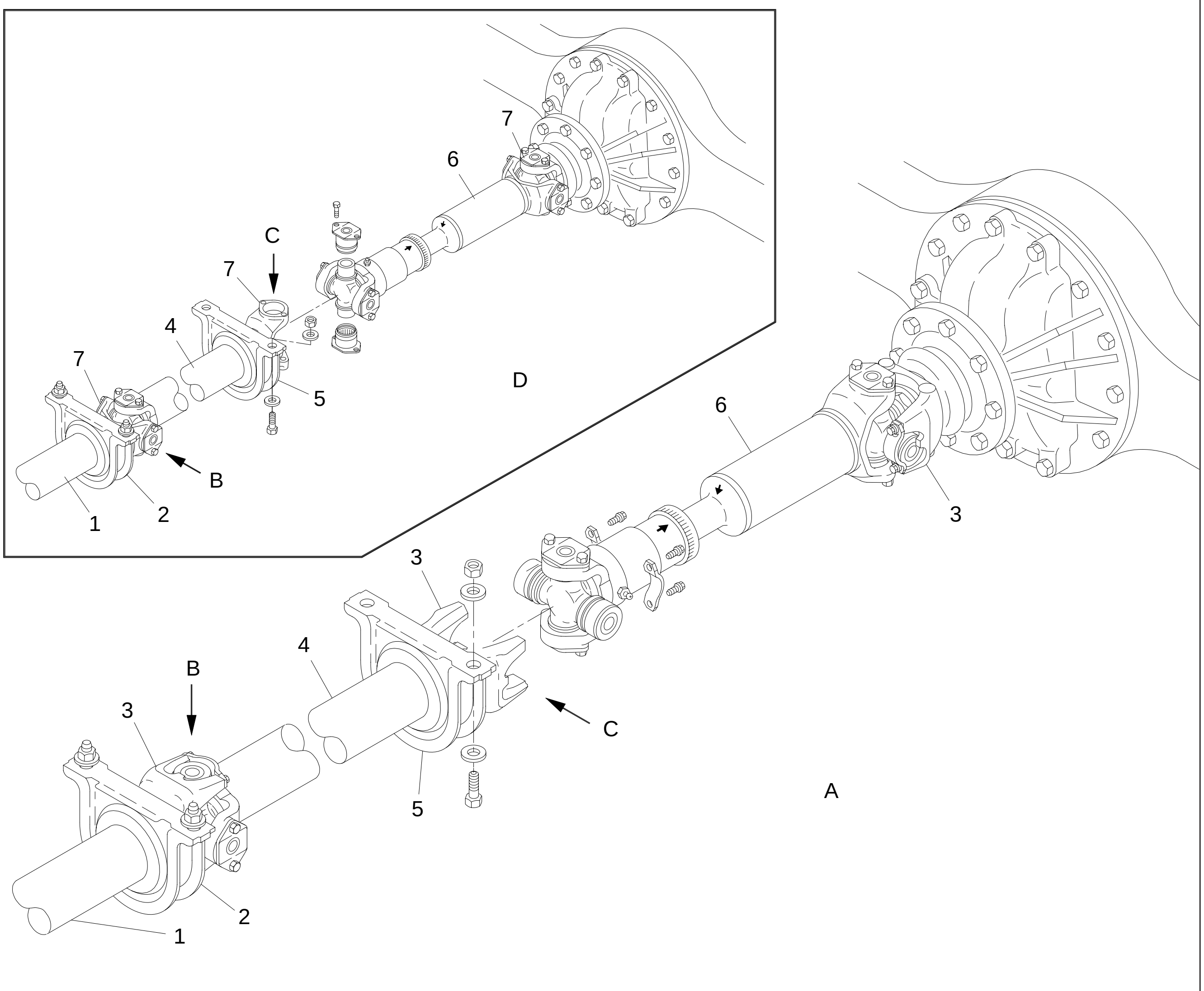
1. Place the primary coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the transmission end-yoke.
2. Couple the shaft to the transmission end-yoke. If the primary coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.
3. *For a vehicle with one coupling shaft:*

   If the No. 2 driveshaft was also removed, install it, as instructed in this subject.

   If the No. 2 driveshaft was not removed, couple it to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

   For a vehicle with two coupling shafts:

Driveshaft Removal and Installation

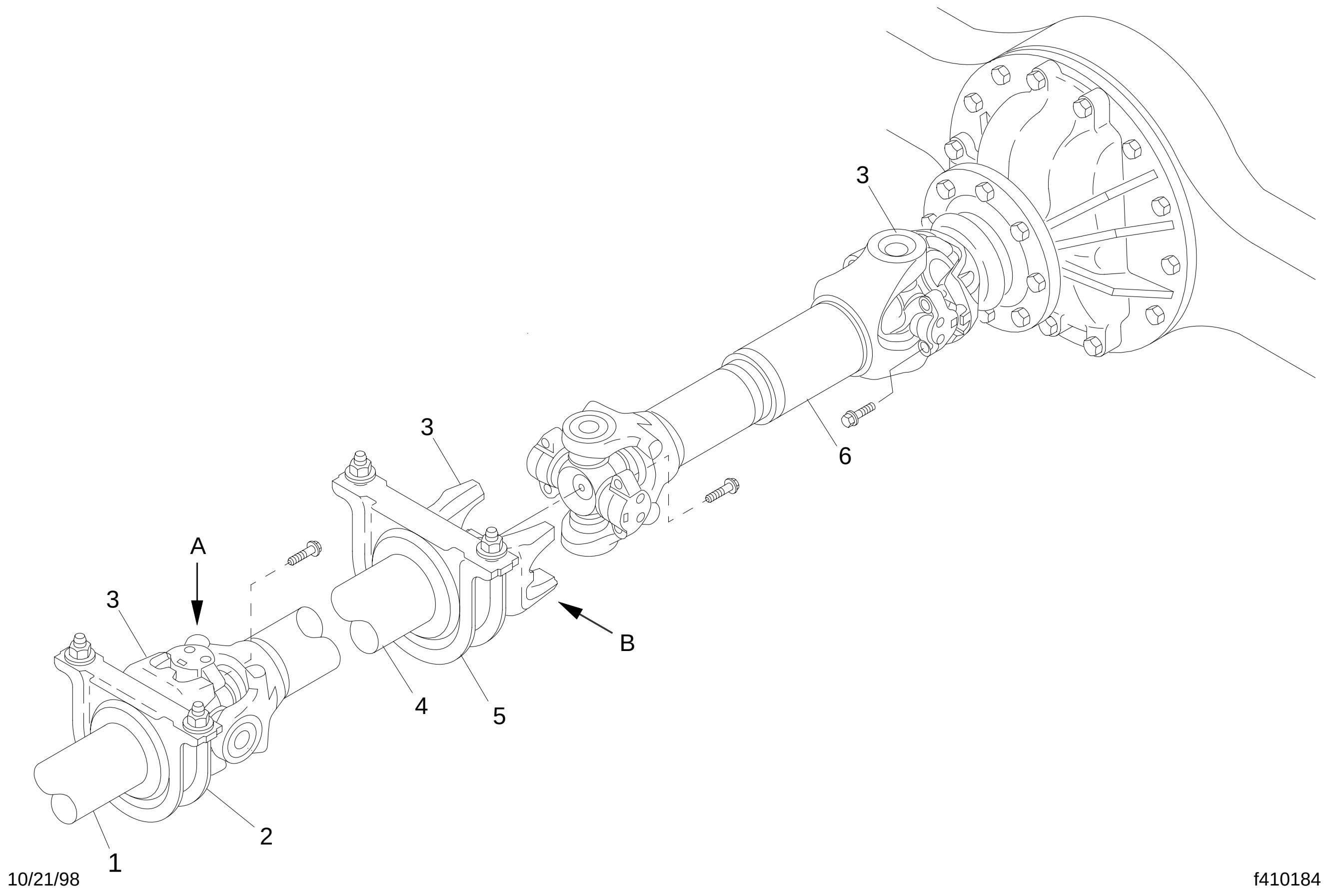


NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft
7. Full-Round End-Yoke

Fig. 5, Removal/Installation of an Intermediate Coupling Shaft Without RPL U-Joints



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.

B. Uncouple this end first; couple this end last.

1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft

Fig. 6, Removal/Installation of an Intermediate Coupling Shaft With RPL U-Joints

If the intermediate coupling shaft was also removed, install it, as instructed in this subject.

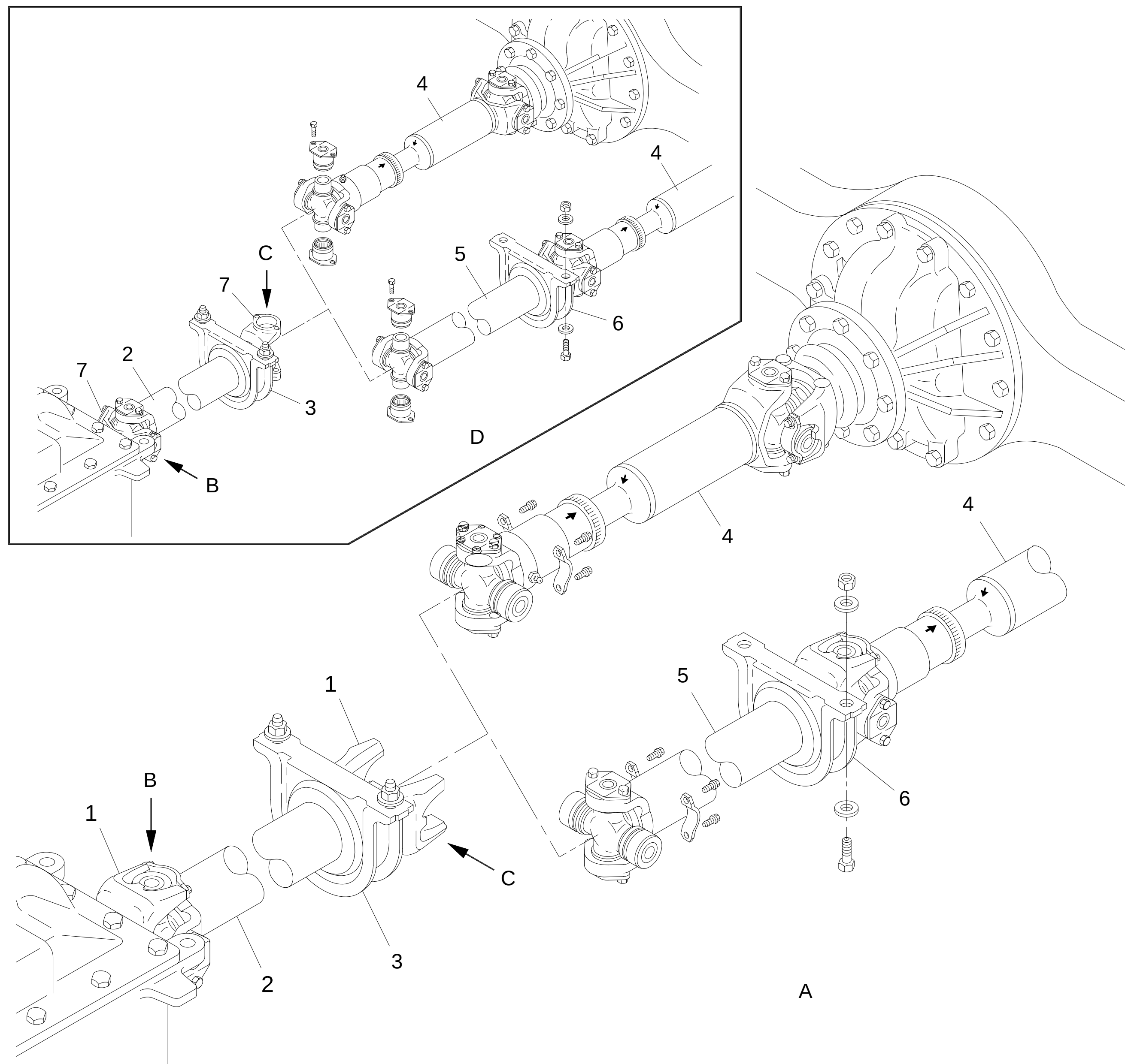
If only the primary coupling shaft was removed, couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

Intermediate Coupling Shaft Installation (See Fig. 5 and Fig. 6)

IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

1. If the primary coupling shaft was also removed, install it first, as instructed in this subject.
2. Place the intermediate coupling shaft under the vehicle and support it with nylon support straps

Driveshaft Removal and Installation

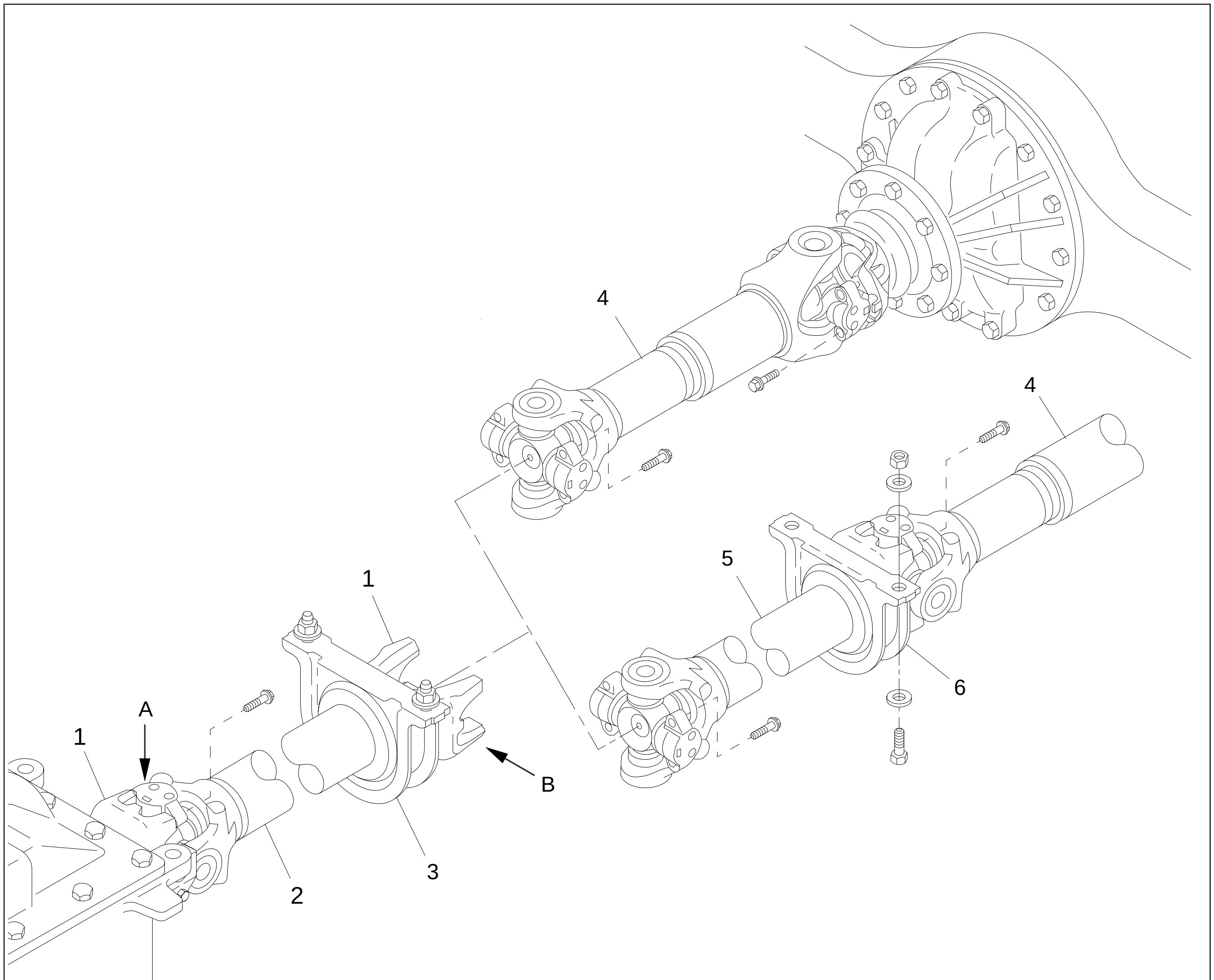


NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing
7. Full-Round End-Yoke

Fig. 7, Removal/Installation of a Primary Coupling Shaft Without RPL U-Joints



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.

B. Uncouple this end first; couple this end last.

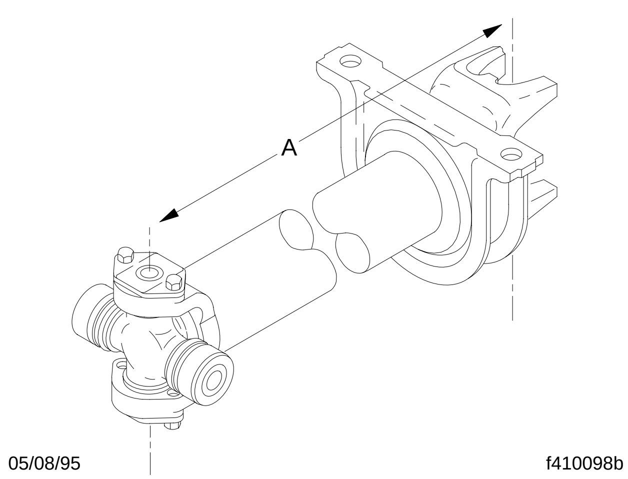
1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing

Fig. 8, Removal/Installation of a Primary Coupling Shaft With RPL U-Joints

so it can be coupled to the primary coupling shaft end-yoke.

3. Couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the intermediate coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.

4. If the No. 2 driveshaft was also removed, install it, as instructed in this subject.



A. Cross-hole centerlines of both yokes must be in alignment.

Fig. 9, U-Joint Phasing of a Coupling Shaft

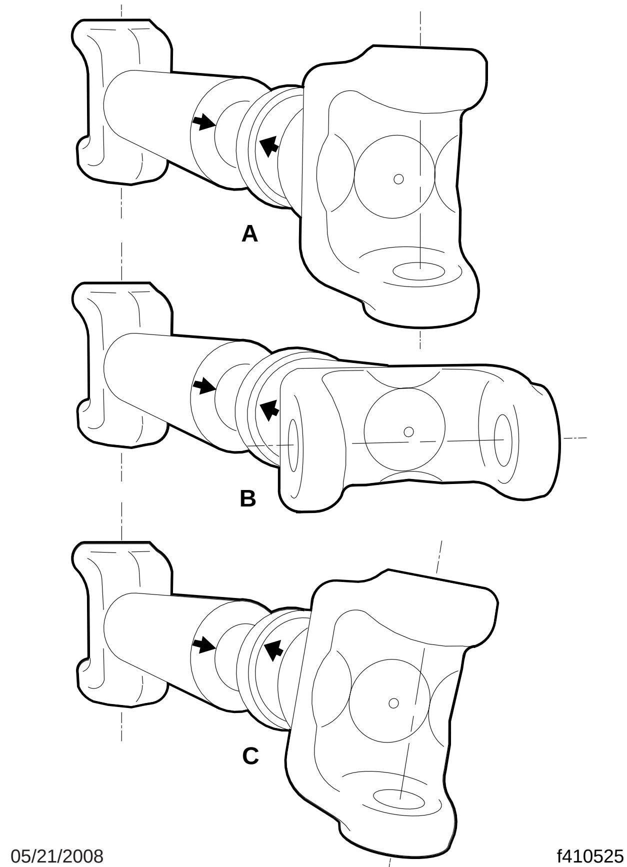
If the No. 2 driveshaft was not removed, couple it to the intermediate coupling shaft end-yoke. If the intermediate coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

No. 2 Driveshaft Installation

(See Fig. 3 and Fig. 4)

IMPORTANT: Before installing a No. 2 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

1. If a primary coupling shaft was also removed, install it first, as instructed in this subject.
2. If an intermediate coupling shaft was also removed, install it before installing the No. 2 driveshaft.
3. Place the No. 2 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
4. Couple the sleeve-yoke to the coupling shaft end-yoke or transmission output-shaft end-yoke, as applicable. If the No. 2 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the No. 2 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 10, U-Joint Phasing

5. Couple the No. 2 driveshaft to the axle input-shaft end-yoke. If the No. 2 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the No. 2 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

No. 3 Driveshaft Installation

(See Fig. 1 and Fig. 2)

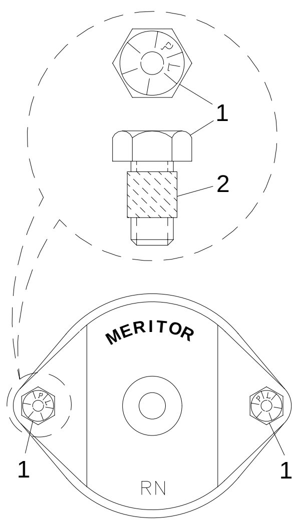
IMPORTANT: Before installing a No. 3 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

1. Place the No. 3 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
2. Couple the sleeve-yoke to the forward-rear axle output-shaft end-yoke. If the No. 3 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the No. 3 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
3. Couple the No. 3 driveshaft to the axle input-shaft end-yoke. If the No. 3 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the No. 3 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

U-Joint Removal

Full-Round Yokes

1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard all four bearing-plate self-locking capscrews. See **Fig. 1**.



04/13/98 f410155a

1. Self-Locking Capscrew
2. Adhesive Band

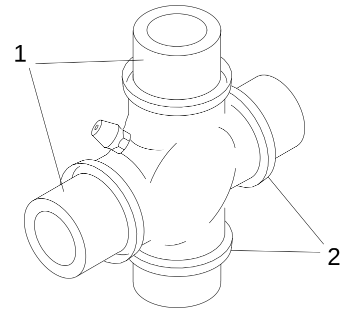
Fig. 1, Meritor U-Joint Fasteners for Full-Round Yokes

IMPORTANT: If the U-joint will be reinstalled, use care not to nick the cross trunnions or damage the slingers. See **Fig. 2**.

4. Using one of the U-joint pullers listed in **Specifications, 400**, remove both bearing cups from the yoke cross-holes. See **Fig. 3**. Remove the cross from the yoke.

RPL Series U-Joints

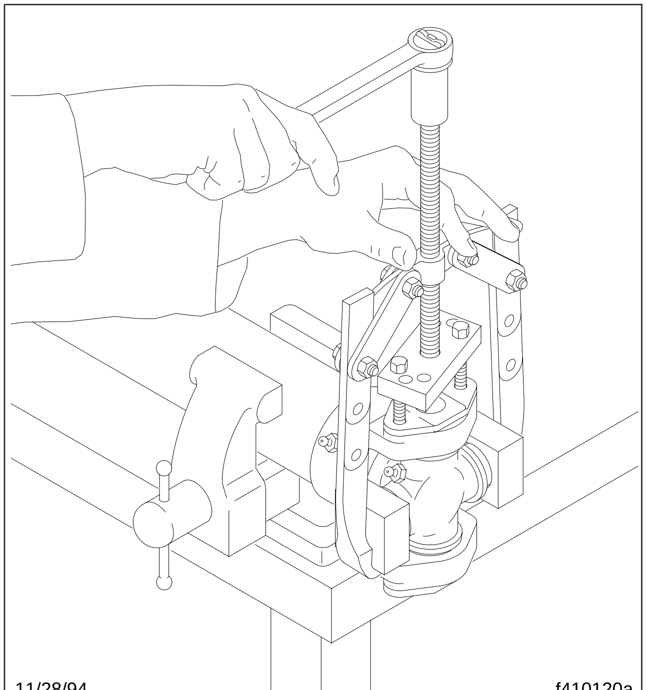
NOTE: Do not reuse RPL U-joints. Always replace an RPL U-joint with a new one after they have been disassembled and removed from a driveshaft.



11/28/94 f410088a

1. Trunnions
2. Slingers

Fig. 2, U-Joint Cross

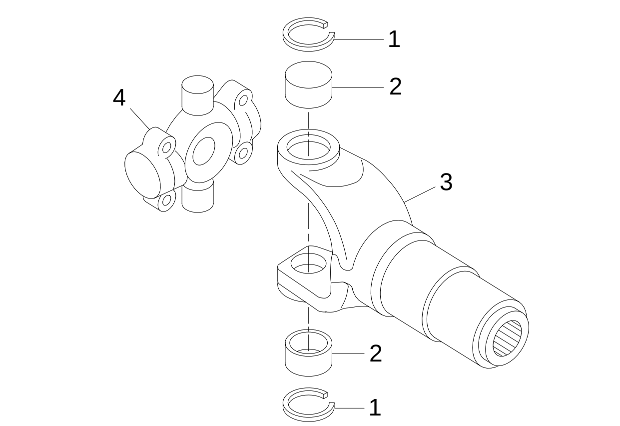


11/28/94 f410120a

Fig. 3, Removing a Bearing Cup from a Full-Round Yoke

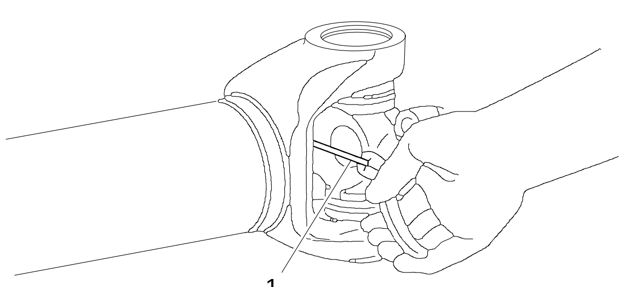
1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard snap rings. See **Fig. 4**.
4. Cut the weld strap (**Fig. 5**) that retains the bearing cups; remove both bearing cups. See **Fig. 6**.

Driveline Component Removal/Disassembly



1. Snap Ring
2. Bearing Cup
3. Full Round Yoke
4. Bearing Cup (RPL Joint)

Fig. 4, RPL U-Joint Components



1. Weld-Strap

Fig. 5, Cutting the Weld-Strap

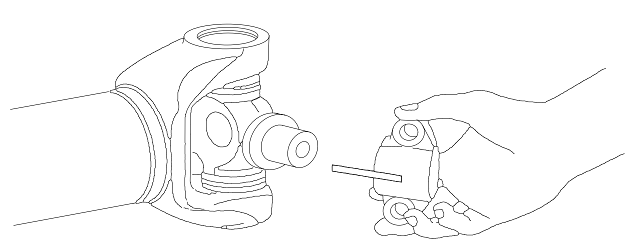
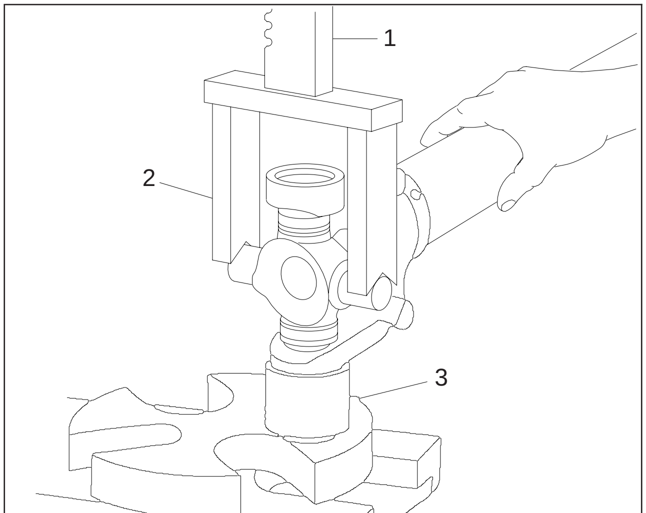


Fig. 6, Removing the Bearing Cups

5. Remove both bearing cups from the yoke cross-holes. See **Fig. 7**. Remove the cross from the yoke.



1. Press
2. Bridge
3. Bearing Cup Receiver

Fig. 7, Removing Bearing Cups from an RPL U-Joint

Slip-Joint Disassembly

Except RPL Drivelines

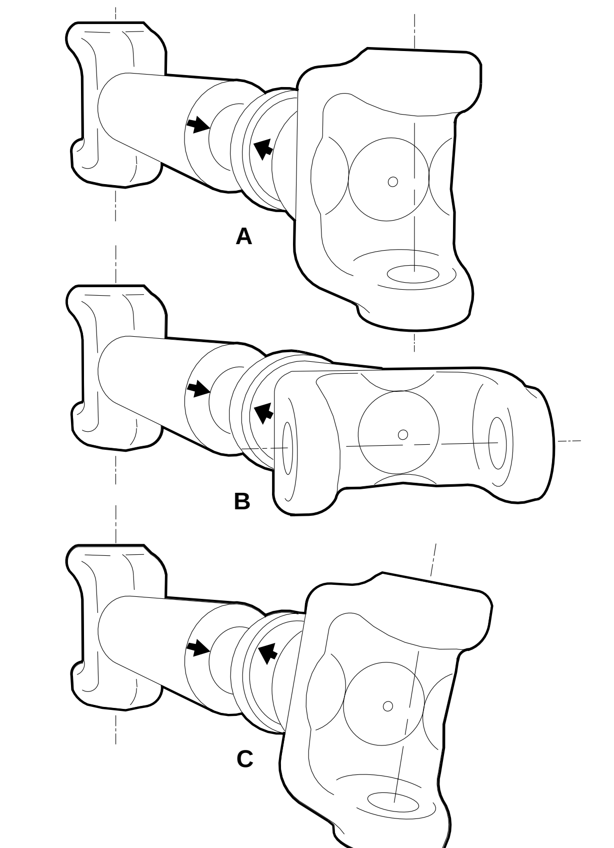
1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will ensure proper alignment of the slip-joint components when the driveshaft is assembled.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a strap wrench to unscrew the slip-joint dust cap from the sleeve-yoke, then pull the sleeve-yoke off of the splined shaft. Remove the dust cap, and (if so equipped) the steel washer and cork seal. See **Fig. 10**.

RPL Drivelines

1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

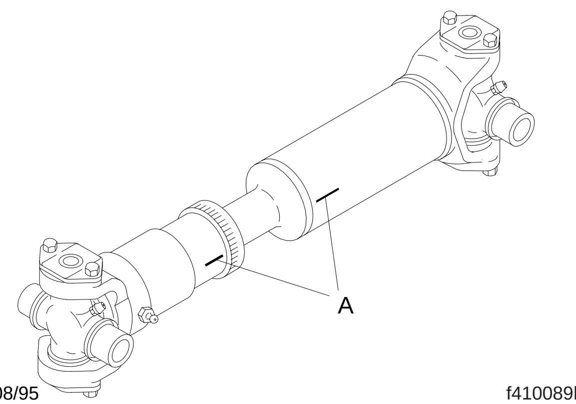
Fig. 8, U-Joint Phasing

ensure proper alignment of the slip-joint components when the driveshaft is assembled.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

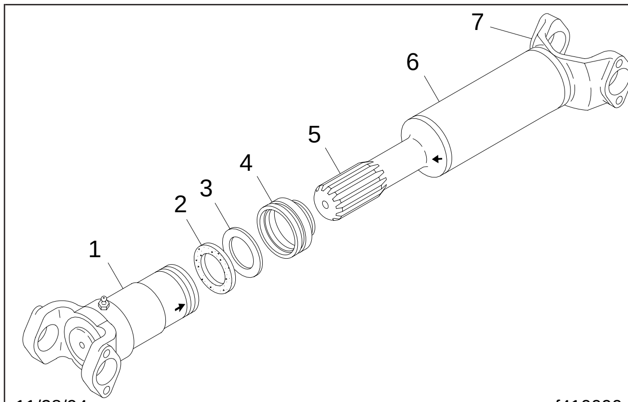
2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a brass hammer and punch to tap the shroud off the slip seal. See **Fig. 11**.

3. Use a screwdriver to pry the seal out of the groove in the slip yoke, then pull the sleeve-yoke off of the splined shaft. Remove the shroud and seal.



A. Use a marking stick or paint to add alignment marks.

Fig. 9, Slip-Joint Alignment Marks



1. Sleeve-Yoke
2. Cork Washer
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

Fig. 10, Slip-Joint Components

Transmission/Axle End-Yoke Removal

IMPORTANT: Before removing a transmission output-shaft end-yoke or an axle shaft end-yoke, do the steps under "End-Yoke Cleaning and Inspection," in **Subject 140**.

1. Uncouple the driveshaft from the end-yoke (**Subject 100** for a half-round yoke or **Subject 110** for

Driveline Component Removal/Disassembly

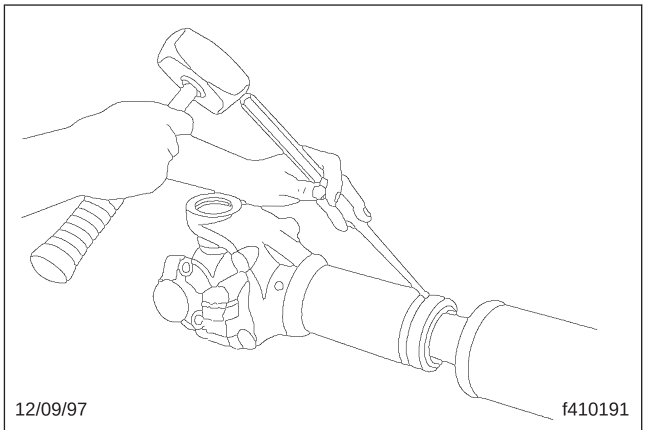


Fig. 11, Shroud Removal

a full-round yoke), or remove the driveshaft from the vehicle (**Subject 120**).

2. Remove the end-yoke locknut. See **Fig. 12**.

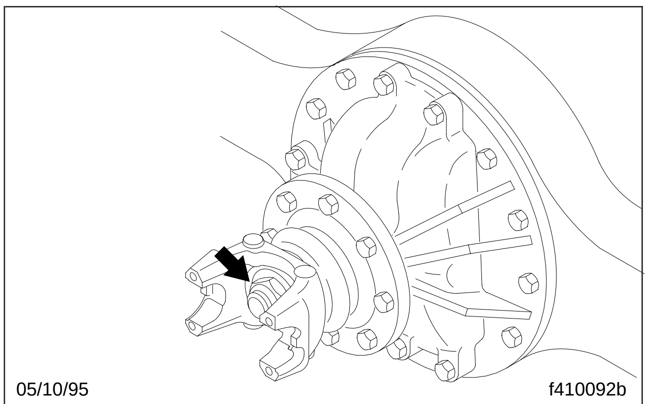
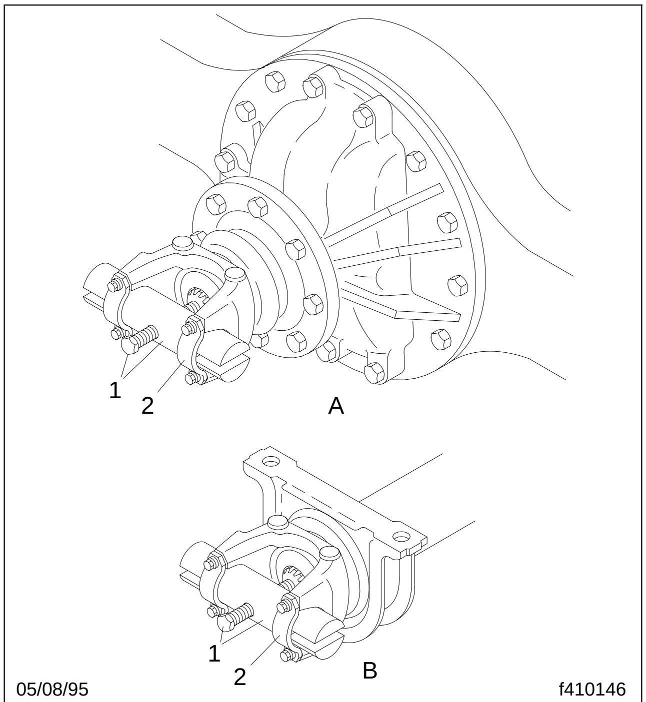


Fig. 12, Axle End-Yoke Locknut

3. Using a yoke puller, remove the end-yoke. See **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke.

Coupling Shaft End-Yoke and Midship Bearing Removal

NOTE: Vehicles manufactured after January 18, 2002, were built with a newly designed Meritor midship hanger bearing assembly. Separate dust shields, or "slingers," common to the previous design, are no longer required.



A. Axle End-Yoke
B. Coupling Shaft End-Yoke

1. Yoke Puller
2. Bearing Strap

Fig. 13, Removing a Half-Round End-Yoke

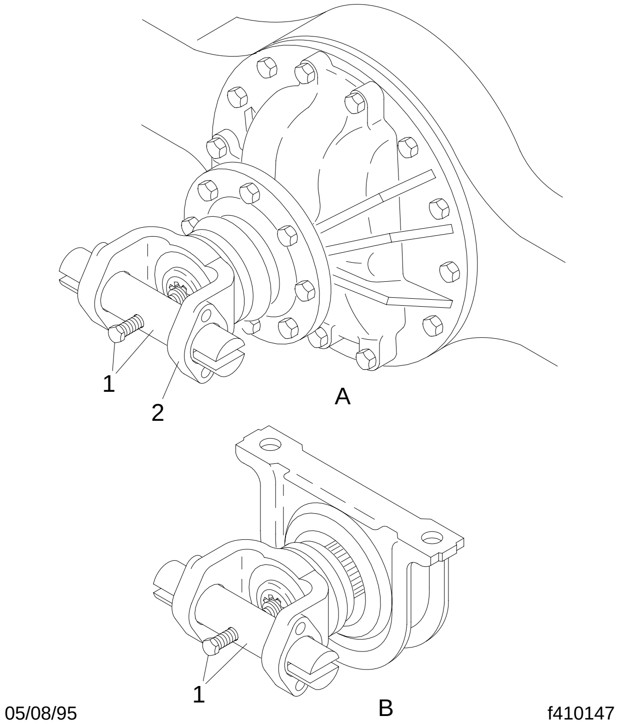
1. Remove the coupling shaft from the vehicle. See **Subject 120**.
2. Clamp the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove the end-yoke; see **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke. Then, remove the midship bearing and slingers (if equipped). See **Fig. 15**.

   3.1 Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks. See **Fig. 16**.

   3.2 Remove the coupling shaft end-yoke locknut.

   3.3 Using a yoke puller, remove the end-yoke. See **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke.

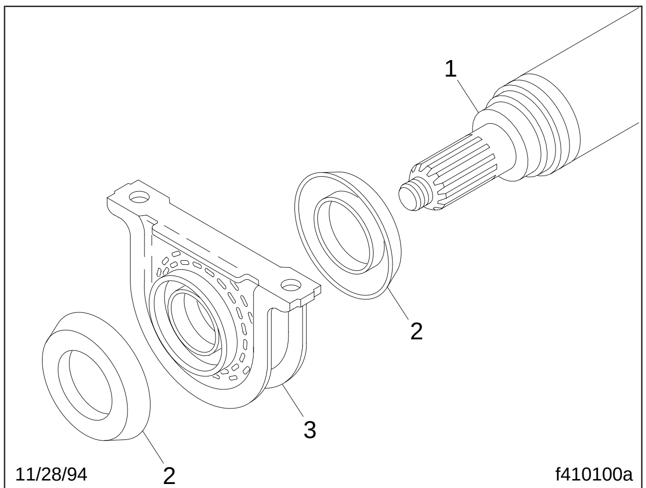
   3.4 Use a hammer and a brass drift to remove the midship bearing. See **Fig. 15**.



A. Axle End-Yoke
B. Coupling Shaft End-Yoke

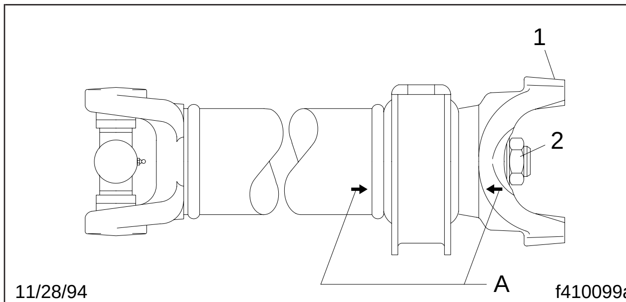
1. Yoke Puller
2. Full-Round End-Yoke

Fig. 14, Removing a Full-Round End-Yoke



1. Midship Bearing Shaft
2. Slinger
3. Midship Bearing

Fig. 15, Midship Bearing and Slingers



A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.

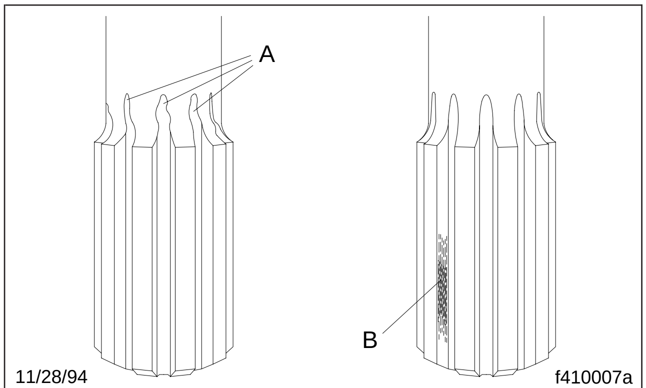
1. Half-Round End-Yoke
2. End-Yoke Locknut

Fig. 16, Alignment Marks on a Coupling Shaft With an End-Yoke

Driveshaft Tube, Slip-Joint, Sleeve-Yoke, and Tube-Yoke Cleaning and Inspection

1. With the driveshaft removed, scrape or soak away any foreign material.
2. Examine the driveshaft tube for dents, bends, twists, splitting weld-seams, and signs of missing balance weights.

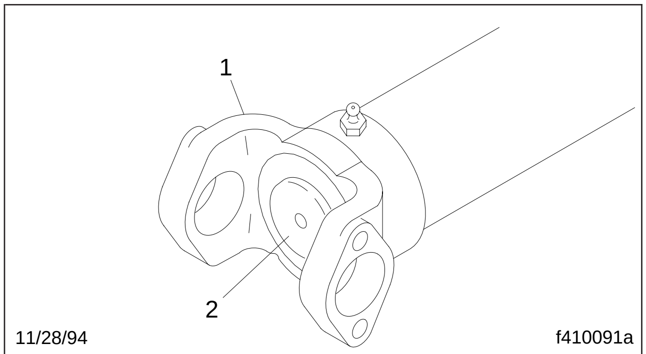
   Replace the driveshaft tube if damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement," in **Subject 150**. If balance weights appear to be missing, have the driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.
3. Clean the slip-joint (male and female) splines, then check them for twisting and galling. See **Fig. 1**. Replace both the sleeve-yoke and the splined shaft if the slip-joint is damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement," in **Subject 150**. Remove any burrs or rough spots using fine emery cloth.



A. Twisted Splines
B. Galling

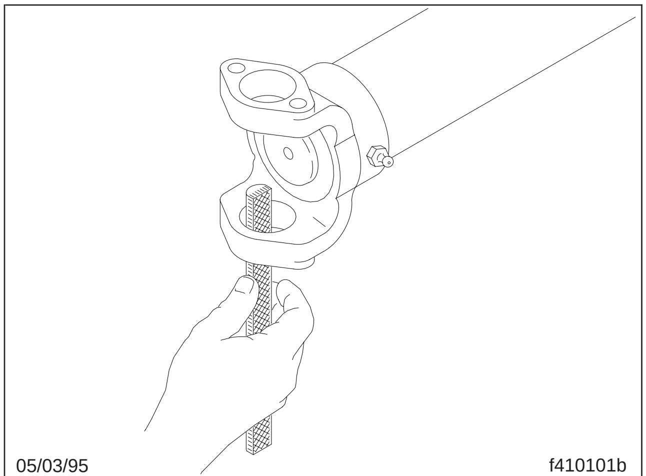
Fig. 1, Damaged Slip-Joint Splines

4. Check for a loose or missing sleeve-yoke plug. See **Fig. 2**. Repair or replace the plug as needed.
5. With the U-joint assemblies removed, check all driveshaft yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.



1. Sleeve-Yoke
2. Yoke Plug

Fig. 2, Sleeve-Yoke Plug



NOTE: Sleeve-yoke shown.

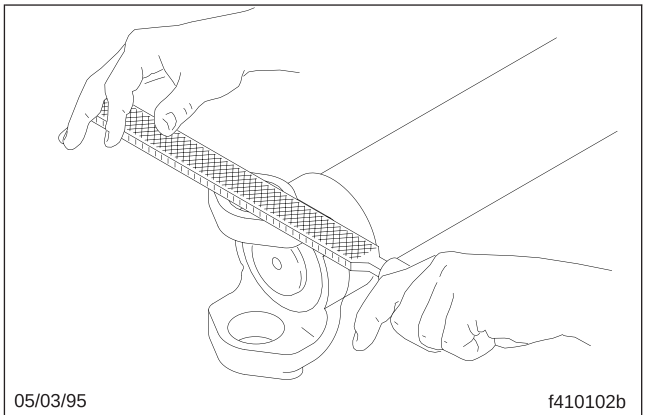
Fig. 3, Removing Burrs From a Full-Round Yoke Cross-Hole

6. Using a mill file, and holding it flat against the machined surface of the driveshaft yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 4**.
7. Using fine emery cloth, smooth and clean the entire surface of all driveshaft yoke cross-holes. See **Fig. 5**.

Midship Bearing Cleaning and Inspection

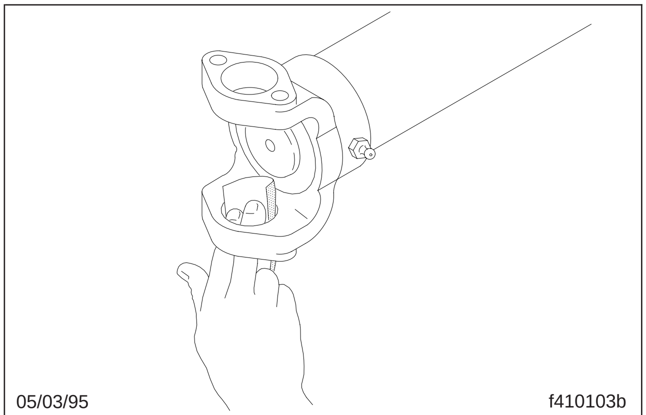
1. With the midship bearing removed from the coupling shaft, use clean rags or paper towels to

Driveline Component Cleaning and Inspection



NOTE: Sleeve-yoke shown.

Fig. 4, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug



NOTE: Sleeve-yoke shown.

Fig. 5, Smoothing a Full-Round Yoke Cross-Hole

wipe off the outside of the midship bearing, rubber cushion, and slingers (if equipped).

IMPORTANT: Do not immerse the midship bearing in cleaning solvent. The solvent will wash out the lubricant, requiring bearing-assembly replacement.

2. Check the midship bearing for roughness or rattles by holding the outside of the bearing while manually turning the inner bearing race. Replace the bearing assembly if there are any rough spots or rattles.
3. Check the rubber cushion for deterioration or oil-soaking, and replace the midship bearing assembly if needed.

End-Yoke Cleaning and Inspection

1. With the transmission output-shaft and axle shaft end-yokes installed, check them for cracks and looseness.

   Replace cracked yokes. If the end-yoke can be moved in or out on its shaft, or can be rocked on its shaft, uncouple the driveshaft from the end-yoke. Check the drive component's shaft seal for leakage or other visible damage that may have been caused by the loose yoke. Replace the shaft seal if needed. Tighten the end-yoke nut to the torque value given in **Specifications 400**. If the end-yoke is still loose after tightening the yoke nut, install a new yoke and yoke nut.

NOTE: If the end-yoke locknut is removed for any reason, install a new one.

2. With the U-joints uncoupled from the end-yokes, check all driveshaft and input/output shaft end-yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3** for full-round yokes, or see **Fig. 6** for half-round yokes.

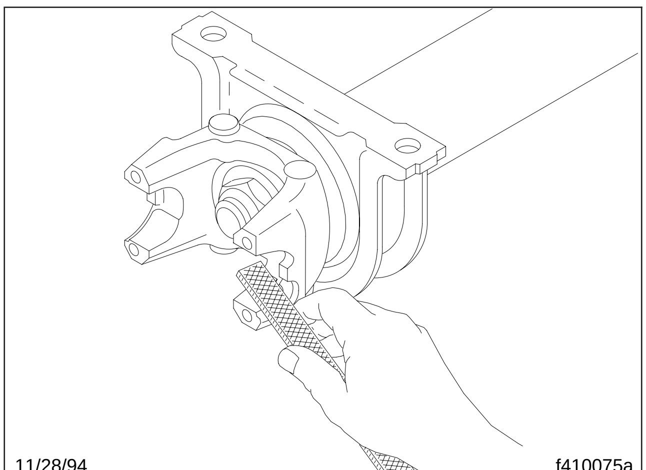
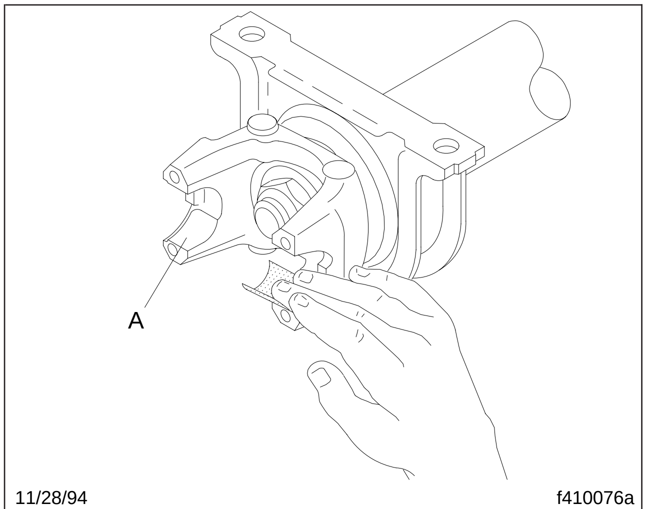


Fig. 6, Removing Burrs From a Half-Round End-Yoke Cross-Hole

3. Using a mill file, and holding it flat against the machined surface of the *full-round* end-yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 4**.

4. Smooth and clean the entire surface of all end-yoke cross-holes, using fine emery cloth. See **Fig. 5** for full-round yokes, or see **Fig. 7** for half-round yokes.



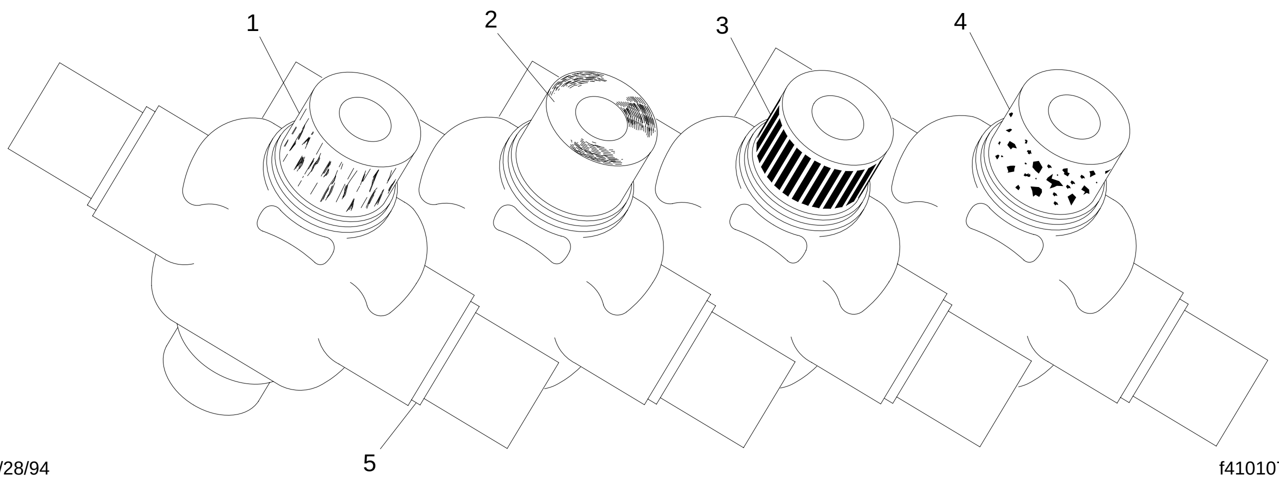
A. Use fine emery cloth on this surface.

Fig. 7, Smoothing a Half-Round End-Yoke Cross-Hole

U-Joint Cleaning and Inspection

1. With the U-joints removed from the yokes, and the bearing cups removed from the crosses, inspect the U-joint cross slingers for damage, then inspect the U-joint trunnions for spalling (flaking metal), end galling (displacement of metal), brinelling (grooves caused by bearing needles), and pitting (small craters caused by corrosion). See **Fig. 8**. If damaged, replace the U-joint assembly.
2. Using a hand-type grease gun, apply multipurpose chassis grease to the fitting on each U-joint cross until all old lubricant is forced out. See **Fig. 9**. Examine the old lubricant. If it appears rusty, gritty, or burnt, replace the U-joint assembly.
3. Soak the bearing cups in a non-flammable cleaner until particles of grease and foreign matter are loosened or dissolved. Do not disassemble the bearing cups; clean the bearing needles with a short, stiff brush, then blow them dry with compressed air. Check for minute particles of dirt or grit, and clean again if necessary.
4. Check each bearing cup for missing bearing needles. Check the bearing-cup seals for nicks. See **Fig. 10** for a half-round-yoke U-joint bearing cup, or see **Fig. 11** for a full-round-yoke U-joint bearing cup. Replace the U-joint assembly if any bearing needles are missing or any seals are damaged.
5. Apply a small quantity of multipurpose chassis grease to the bearing needles in each cup, then apply a small amount of light-weight oil to the lips of the bearing-cup seals. Rotate each bearing cup on the cross to check for wear. Replace the U-joint assembly if any bearing surfaces are worn.
6. Check the underside of each bearing-cup plate for burrs or raised metal. Use a mill file to remove any burrs or raised metal. See **Fig. 12**.
7. Using fine emery cloth, smooth and clean the outside surfaces of all bearing cups. See **Fig. 12** and **Fig. 13**.

Driveline Component Cleaning and Inspection



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1. Spalling
2. End Galling
3. Brinelling
4. Pitting
5. Slinger

Fig. 8, Damaged U-Joint Crosses

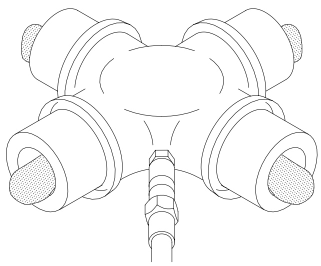

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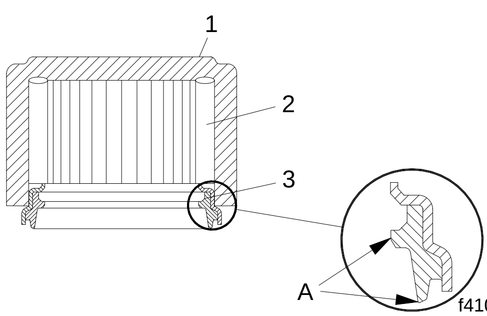
Fig. 9, Forcing Out Old Lubricant From a U-Joint Cross



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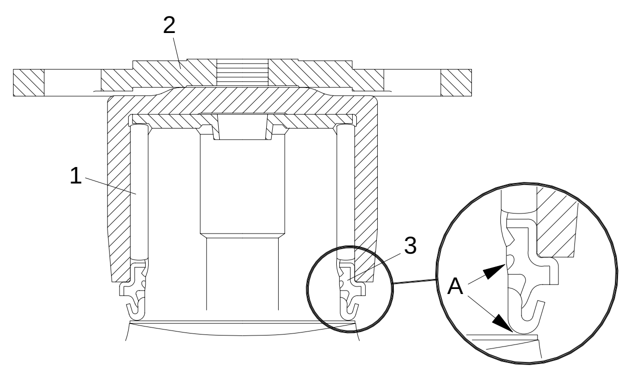
A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

Fig. 10, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup



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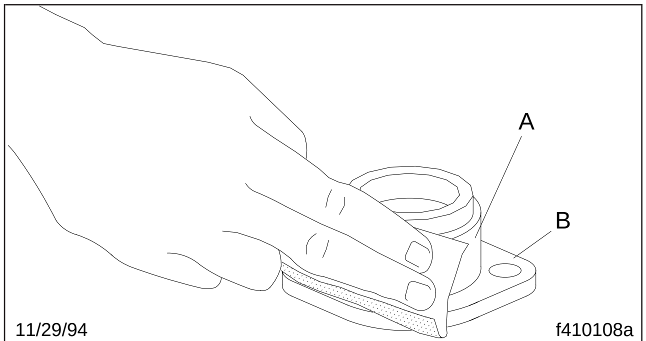
A. Lubricate seal lips here.

1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

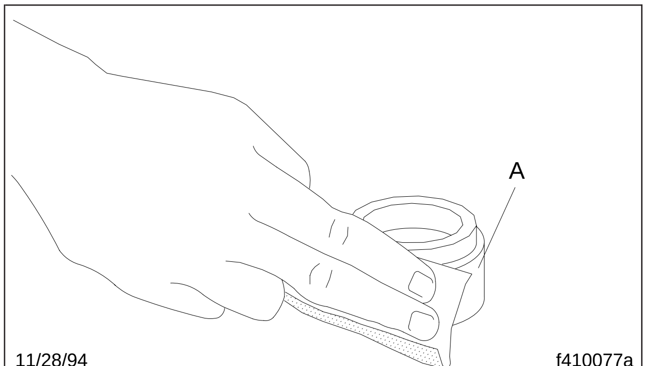
Fig. 11, Sectional View of a Full-Round Yoke U-Joint Bearing Cup

Driveline Component Cleaning and Inspection



A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

Fig. 12, Smoothing a Full-Round Yoke U-Joint Bearing Cup



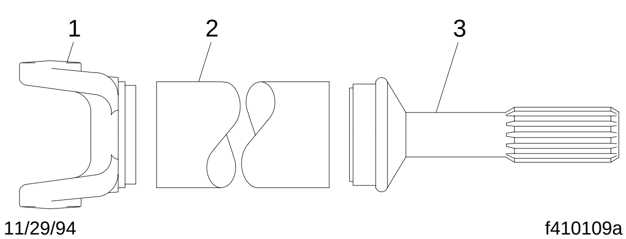
A. Use fine emery cloth on this surface.

Fig. 13, Smoothing a Half-Round Yoke U-Joint Bearing Cup

Driveshaft Tube, Stub Shaft (Slip-Joint), and Tube-Yoke Replacement

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

To replace a driveshaft tube, a tube-yoke, or a stub shaft (**Fig. 1**), the driveshaft must be chucked in a lathe, so the welds can be removed. Driveshaft rebuilding should be done by a machine shop that specializes in driveline repair.



1. Tube-Yoke
2. Driveshaft Tube
3. Stub Shaft

Fig. 1, Driveshaft Tube, Stub Shaft, and Tube-Yoke

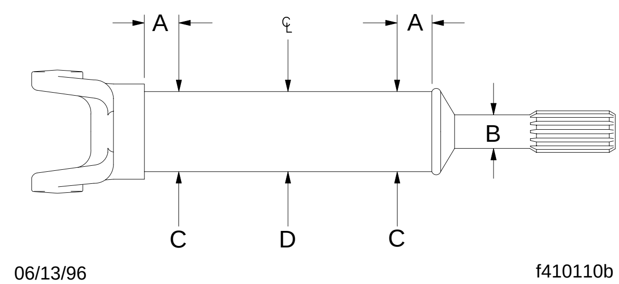
Runout limits for a new (rebuilt) driveshaft (**Fig. 2**) are:

- 0.005 inch (0.127 mm) T.I.R. (Total Indicator Reading) on the smooth portion of the stub shaft neck;
- 0.010 inch (0.254 mm) T.I.R. on the tube 3 inch (76 mm) from the front and rear welds;
- 0.015 inch (0.381 mm) T.I.R. at the center of the tube.

Balance the rebuilt driveshaft to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

Slip-Joint Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled



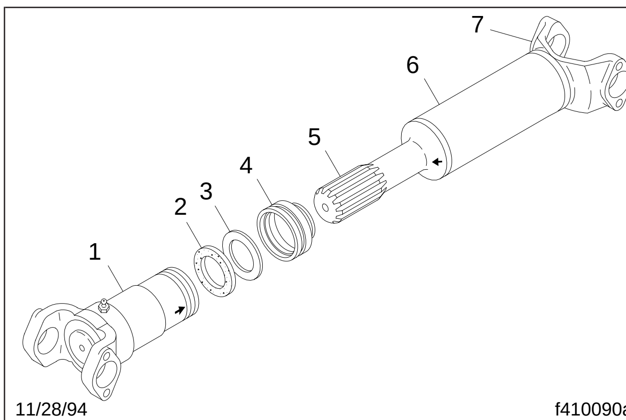
A. Measurement: 3 inches (76 mm)
B. Measurement: 0.005 inch (0.127 mm)
C. Measurement: 0.010 inch (0.2540 mm)
D. Measurement: 0.015 inch (0.381 mm)

Fig. 2, Runout Specifications for a Rebuilt (or New) Driveshaft

or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

Except RPL Drivelines

1. Place the slip-joint dust cap, and (if so equipped) steel washer and cork seal, over the splined shaft. See **Fig. 3**.



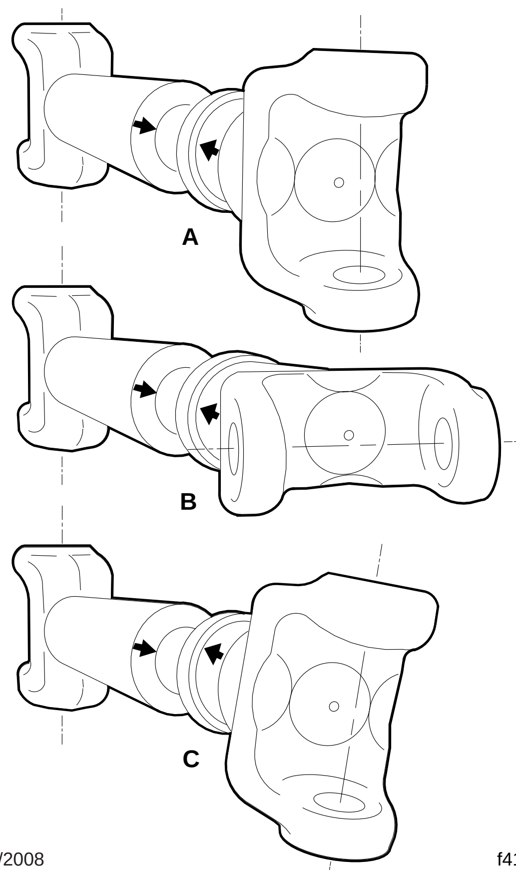
1. Sleeve-Yoke
2. Cork Washer
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

Fig. 3, Slip-Joint Components

2. Coat the splines of the shaft with multipurpose chassis grease.

Driveline Component Replacement or Installation/ Assembly

3. Insert the splined shaft in the sleeve-yoke, so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See Fig. 4 and Fig. 5.

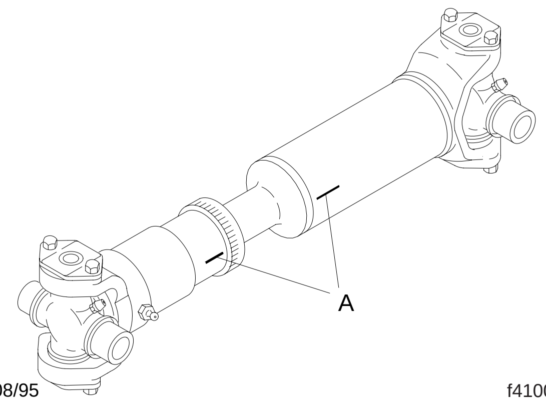


1. In Phase (parallel phased)
2. In Phase (cross phased)
3. Out of Phase

Fig. 4, U-Joint Phasing

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

4. Install the slip-joint dust cap. Use only enough torque to seat the steel washer and cork seal (if so equipped) snug against the end of the sleeve-yoke; do not overtighten.



A. Use a marking stick or paint to add alignment marks.

Fig. 5, Slip-Joint Alignment Marks

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.

RPL Drivelines

1. Remove the grease plug from the sleeve-yoke.
2. Coat the splines of the sleeve-yoke with multipurpose chassis grease.
3. Install the shroud on the splined shaft.
4. Install the seal onto the shroud.
5. Insert the splined shaft in the sleeve-yoke so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See Fig. 4 and Fig. 5.

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

6. Install the seal into the shaft groove.
7. Install the shroud. Use a brass hammer to tap the shroud over the seal.
8. Install the grease plug in the sleeve-yoke.

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.

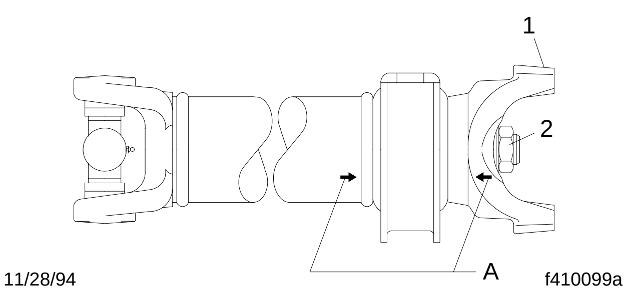
Midship Bearing and Coupling Shaft End-Yoke Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Place the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.

NOTE: Midship bearings are permanently lubricated when manufactured; it is not necessary to pack the bearing with grease.

2. Install the midship bearing on the coupling shaft. Press the bearing on by hand as far as it will go.
3. Install the end-yoke. See **Fig. 6**.
   - 3.1 Apply Loctite® 242 to the shaft threads where the end-yoke locknut will be installed.
   - 3.2 Align the marks added to the coupling shaft and end-yoke during removal, then place the end-yoke on the shaft so the yoke bores are aligned at both ends of the shaft. See **Fig. 6**.



A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.

1. Half-Round End-Yoke
2. End-Yoke Locknut

Fig. 6, Alignment Marks on a Coupling Shaft With an End-Yoke

   - 3.3 Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Then back the nut off slightly, and tighten it to the same torque.

U-Joint Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Also, components of the various makes of U-joints may not be interchangeable, and must be assembled only with compatible products. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

Worn bearing assemblies used with a new cross, or new bearing assemblies used with a worn cross will wear rapidly, making another replacement necessary in a short time. Always replace the cross and all four bearing assemblies at the same time.

If the slip-joint of a No. 2 or No. 3 driveshaft has been disassembled, assemble the slip-joint before installing the U-joints.

Full Round Yokes

1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

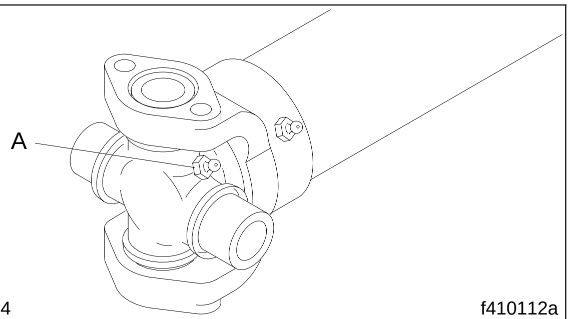
   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 6**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Inspect and lubricate the U-joint; see **Subject 140**.
4. Install the U-joint cross and bearing assemblies in the yoke.
   - 4.1 Position the U-joint cross in the driveshaft yoke so one grease fitting points toward

Driveline Component Replacement or Installation/ Assembly

the driveshaft, and aligns with the grease fitting on the sleeve-yoke (if so equipped). See **Fig. 7**.



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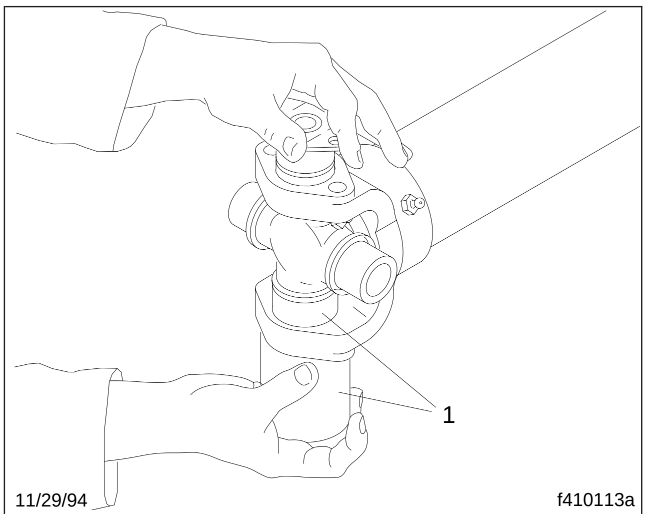
A. Install the cross with grease fitting pointing toward the driveshaft, and aligned with the sleeve-yoke grease fitting.

Fig. 7, U-Joint Grease Fitting Positioning

4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Using a Spicer trunnion (journal) locator (**Specifications 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing cup (plate-type) over the projected trunnion, and aligning it with the cross-hole. See **Fig. 8**.



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NOTE: Sleeve-yoke shown.

1. Trunnion Locator

Fig. 8, Use of a U-Joint Trunnion Locator

IMPORTANT: A Spicer trunnion (journal) locator should be used to prevent damage to the U-joint trunnions and slingers.

4.3 By hand, press the bearing-cup-plate flush with the face of the yoke. If the bearing cup binds in the cross-hole, tap the *center* of the bearing-cup plate with a leather or rubber mallet; do not tap the outer edges of the plate. See **Fig. 9**.

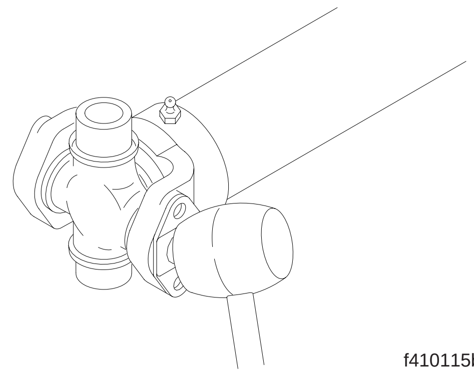

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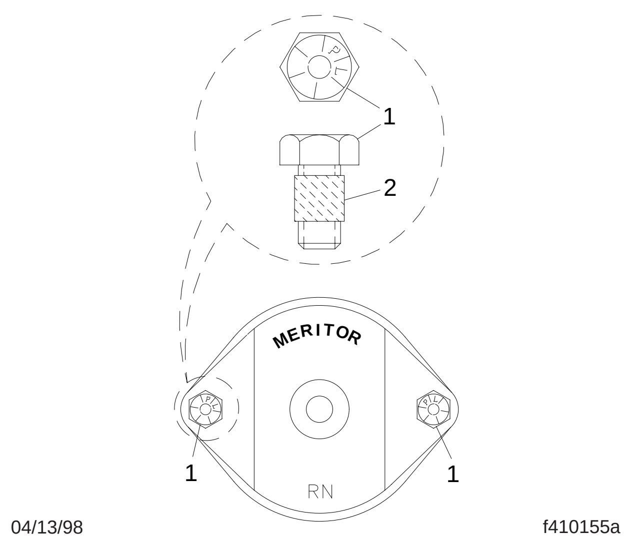
Fig. 9, Seating a U-Joint Bearing Cup In a Full-Round Yoke

4.4 Install *new* bearing-cup-plate self-locking capscrews. See **Fig. 10**. Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

WARNING

Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.

4.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Using the above procedure, install the opposite bearing assembly and its fasteners.



1. Self-Locking Capscrew
2. Adhesive Band

Fig. 10, Meritor U-Joint Fasteners for Full-Round Yokes

4.6 Slightly back off all four capscrews, then alternately tighten them in increments of 5 lbf·ft (7 N·m), to the applicable torque value in **Specifications 400**.

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

RPL Series U-Joints

NOTE: Do not reuse RPL U-joints. Always replace an RPL U-joint with a new one after they have been disassembled and removed from a driveshaft.

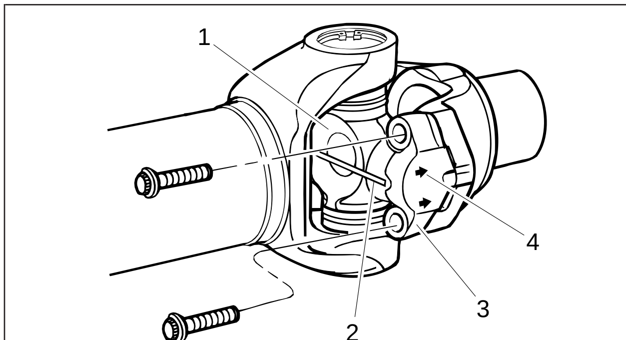
1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 6**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Inspect the U-joint. See **Subject 140**.
4. Install the U-joint cross and bearing assemblies in the yoke.

   4.1 Position the U-joint cross in the driveshaft yoke so that the wing bearing weld strap faces inboard, and the arrows point toward the end of the coupling yoke. See **Fig. 11**.



1. U-Joint Cross
2. Weld Strap
3. Wing Bushing
4. Arrows

Fig. 11, Fitting the U-Joint

   4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Place a bearing cup over the projected trunnion, and align it with the cross-hole.

   4.3 Press the bearing cup into the yoke slightly past the snap ring groove. See **Fig. 12**. Check that the bearing cup is aligned with the universal joint trunnion.

   4.4 Install the snap ring into the snap ring groove. See **Fig. 13**.

   4.5 Use a snap ring installation gauge to check that the snap ring is fully seated in the snap ring groove. See **Fig. 14**.

   4.6 Move the cross until it projects beyond the machined surface of the opposite yoke

Driveline Component Replacement or Installation/ Assembly

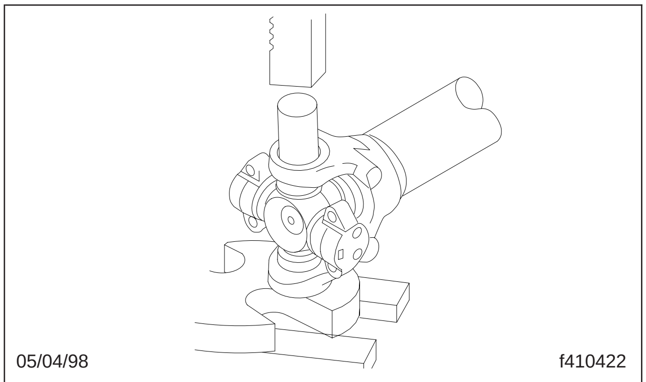
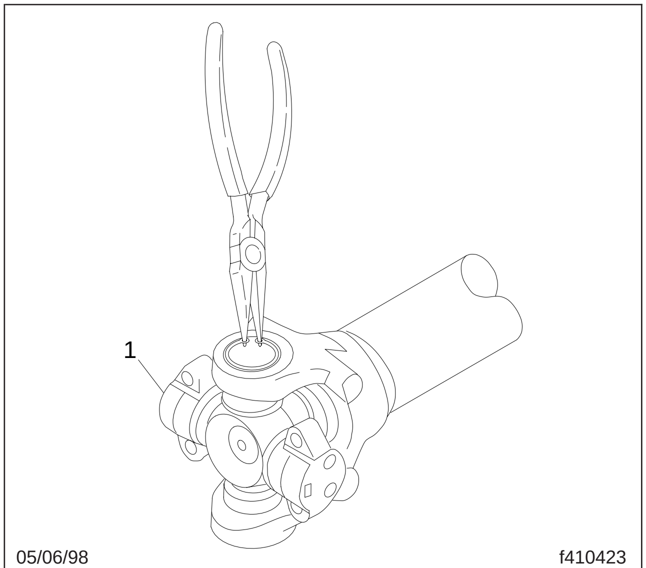


Fig. 12, Installing Bearing Cups, RPL Series U-Joint



1. U-Joint

Fig. 13, Installing the Snap Rings

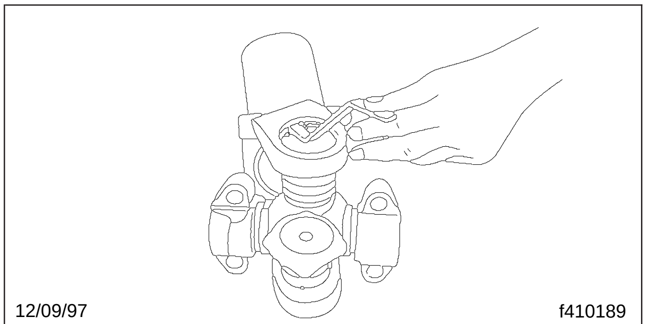
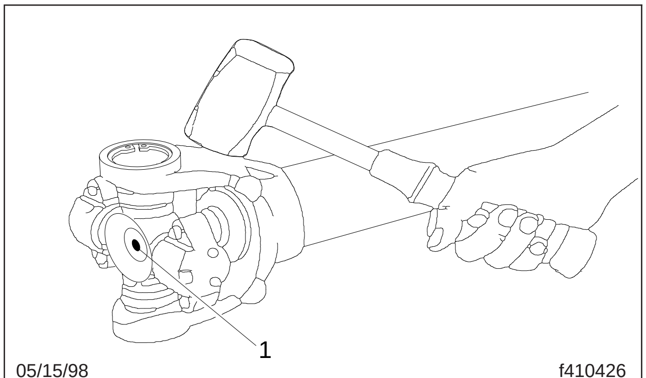


Fig. 14, Checking Snap Ring Installation

lug. Using the above procedure, install the opposite bearing cup assembly.

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

4.7 If the universal joint does not move freely, strike the yoke ear with a brass or copper hammer. See **Fig. 15**.



1. U-Joint Cross

Fig. 15, Striking the Yoke Ear

Transmission/Axle End-Yoke Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Apply Loctite® 242 to the input- or output-shaft threads where the end-yoke locknut will be installed. See **Fig. 16**.
2. By hand, install the end-yoke on the input or output shaft as far as it will go.
3. Install a new end-yoke locknut, and tighten it to the applicable torque value in **Specifications 400**.

Driveline Component Replacement or Installation/ Assembly

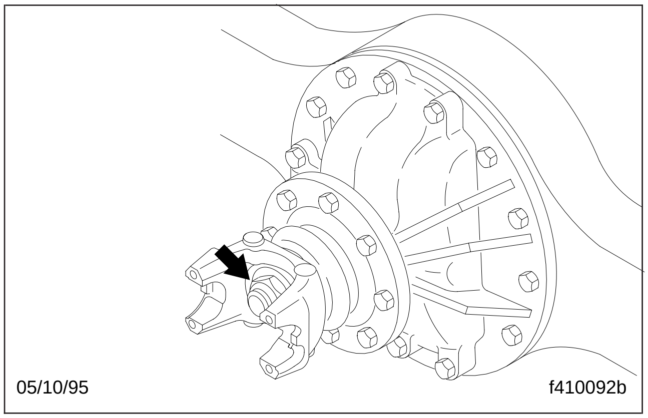


Fig. 16, Axle End-Yoke Locknut

Troubleshooting

Noise or vibration associated with the driveline can be caused by non-driveline parts. To find the cause of noise or vibration, first road test the loaded vehicle. Drive in all gears and at all speed ranges for which the vehicle was designed, including those at which problems are reported.

NOTE: Operating a vehicle at speeds that exceed its drivetrain design specifications may cause an out-of-balance vibration.

The following is a troubleshooting elimination process; checks should be made in the order listed. At each step where a problem is found, correct the problem before proceeding to the next step, then test drive the vehicle to see if other problems still exist. If no other problems exist, the elimination process may be ended at that step.

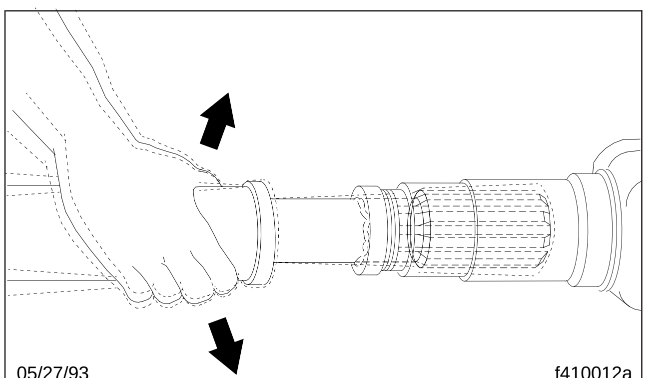
1. Check all tires for uneven wear and for out-of-roundness. Check for mismatched tires. Look for wheels and rims that are out of alignment. For instructions, see **Group 40**.
2. Check the rear suspension for loose or broken U-bolts; broken, shifted, or mismatched rear springs; or broken spring seats. If so equipped, check the air suspension for incorrect air spring height. Look for anything that could cause angular misalignment of the rear axle pinion(s). For instructions, see **Group 32**.
3. Check the frame rails and crossmembers for bends, twists, or breaks; for frame-alignment-checking and crossmember-replacement instructions, see **Group 31**.
4. Check the engine and transmission mounts; see **Group 01** (Engine) and **Group 26** (transmission). Check the coupling shaft's midship bearing mounts. Replace mountings that are deteriorated or oil-soaked; tighten loose mounting bolts. Oil-soaked or deteriorated mountings, or loose mounting bolts, can cause driveline angular misalignment.
5. Check for loose U-joint bearing-cup-plate and bearing-strap capscrews. Tighten any loose fastener to the applicable torque value in **Specifications 400**.

CAUTION

Do not overtighten the bearing-cup-plate or bearing-strap capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could result in serious vehicle damage.

6. Check all U-joint assemblies, slip-joint splines, and midship bearings for wear.
   - 6.1 Try to move each driveshaft up and down, and from side to side. If movement is greater than 0.006 in (0.15 mm) of a U-joint cross in its bearings, replace the U-joint assembly.
   - 6.2 If the midship bearing rattles or is loose on its shaft, replace it.
   - 6.3 Try to bend the sleeve-yoke and splined shaft up and down, and from side to side. See **Fig. 1**. If looseness is greater than 0.007 in (0.18 mm), replace the sleeve-yoke and splined shaft.

     If driveline components must be replaced, see **Subject 150**.



Try to bend the sleeve-yoke and splined shaft up and down, and from side to side.

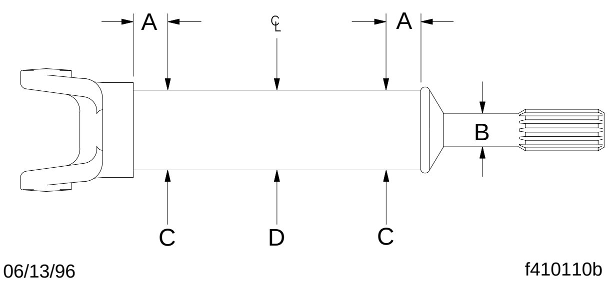
Fig. 1, Check for Slip-Joint Spline Wear

7. Check each driveshaft for an indication of missing balance weights. If any weights appear to be missing, have the driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.
8. Check each driveshaft for dents, bends, twists, or other damage.

If damaged, jack up the rear axle, support it on jackstands, place the transmission in neutral, and turn the driveshaft by hand to check runout.

The driveshaft must be straight within 0.015 inch (0.38 mm) on the slip-joint seal surface of the splined shaft, 0.020 inch (0.51 mm) on the tube 3 inch (76 mm) from the front and the rear welds, and 0.025 inch (0.635 mm) at the center of the tube. See **Fig. 2**.

If the driveshaft is not straight within specifications, replace the tube. See **Subject 150** for runout specifications for a *new* (or rebuilt) driveshaft.



A. Measurement: 3 inch (76 mm)
B. Measurement: 0.015 inch (0.38 mm)
C. Measurement: 0.020 inch (0.51 mm)
D. Measurement: 0.025 inch (0.635 mm)

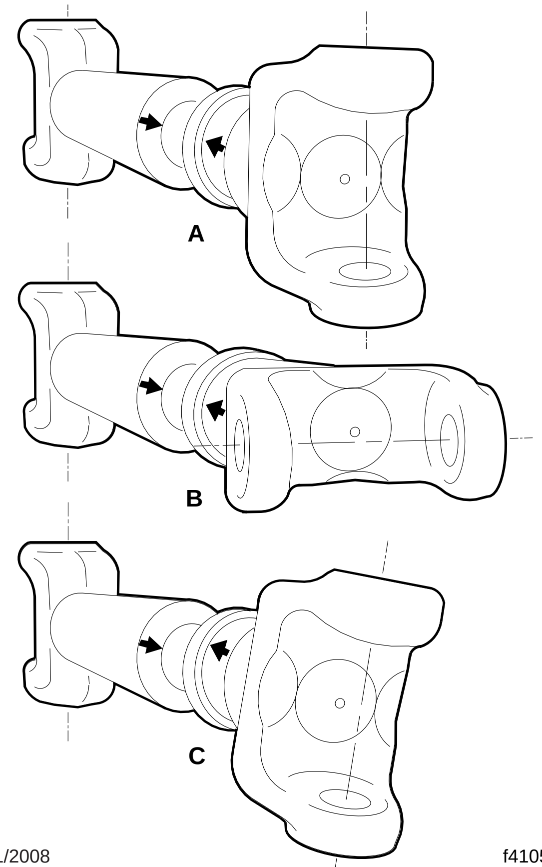
Fig. 2, Runout Specifications for a Used Driveshaft

9. Check each driveline for proper U-joint phasing. See **Fig. 3**.

   9.1 On No. 2 and No. 3 driveshafts, if the U-joints are out of phase, check the slip-joint for alignment marks. If necessary, disassemble the slip-joint, and align the marks.

   NOTE: To disassemble the slip-joint, uncouple the U-joint at one end of the driveshaft, unscrew the slip-joint seal from the sleeve-yoke, then pull the sleeve-yoke and splined shaft apart. Reverse the procedure to assemble the slip-joint.

   9.2 If no alignment marks are present, disassemble the slip-joint, and reassemble it with the U-joints in one of the two in-phase positions (180 degrees apart).



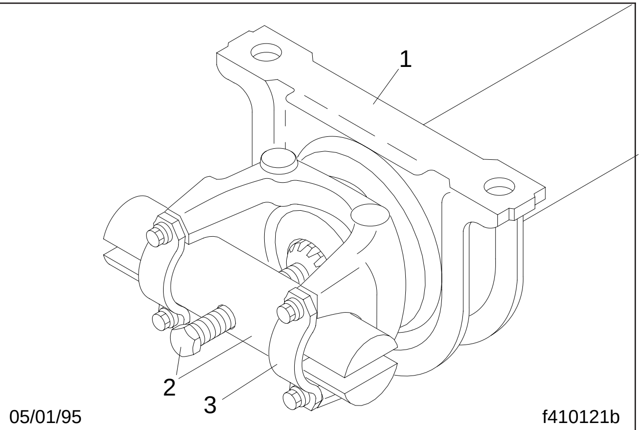
A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 3, U-Joint Phasing

   Test drive the vehicle, then assemble the slip-joint in the other in-phase position. Test drive the vehicle again.

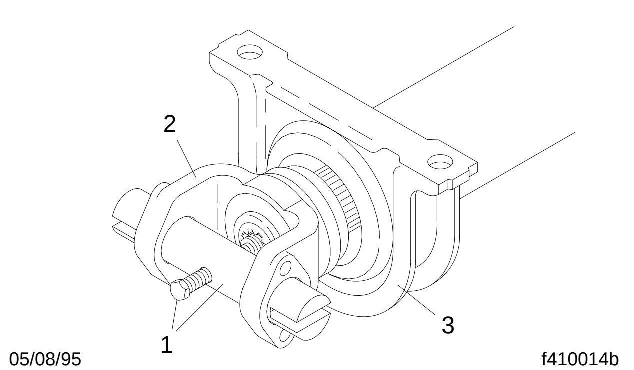
   Determine which in-phase position provides vibration-free operation. Assemble the slip-joint in the correct in-phase position, and mark the slip-joint with alignment marks.

   9.3 If the U-joints are out of phase on a coupling shaft, uncouple the U-joint from the coupling shaft end-yoke, then remove the end-yoke nut. Remove the end-yoke, using a yoke puller. See **Fig. 4** for a half-round end-yoke, or see **Fig. 5** for a full-round end-yoke. Align the end-yoke, then install it by hand. Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Slightly back off the nut, and again tighten it to the same torque. Couple the coupling shaft to the driveshaft U-joint.



1. Midship Bearing
2. Yoke Puller
3. Bearing Strap

Fig. 4, Remove a Half-Round End-Yoke from a Coupling Shaft



1. Yoke Puller
2. Full-Round Yoke
3. Midship Bearing

Fig. 5, Remove a Full-Round End-Yoke from a Coupling Shaft

10. Check the torque on all of the end-yoke nuts in the drivetrain; see the applicable torque values in **Specifications 400**.

    If any yoke nut was not at its specified torque, check the yoke for wear by trying to move it up and down, and back and forth. If the yoke can be rocked on its shaft, or moved in or out on its shaft, replace the yoke and yoke nut. See **Subject 150**.

    If the yoke is not worn, tighten the yoke nut to its torque value.

11. *On single-drive vehicles:*

    Have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    On dual-drive vehicles:

    11.1 Remove the No. 3 driveline; then, with the interaxle differential locked, test drive the vehicle.

    11.2 If vibration still exists, install the No. 3 driveline, then have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    If *no* vibration exists, check that both rear axle gear ratios are matched. If the gear ratios do not match, replace one of the gear sets with a gear set having the correct ratio, then install the No. 3 driveline.

    11.3 Have the No. 3 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    11.4 Have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

12. If so equipped, balance the coupling shaft(s) to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

Specifications

Transmission Output-Shaft End-Yoke Nut Fastener Torques			
Description		Size	Torque: lbf·ft (N·m)
Fuller	RT 8609	1-1/2–18	400–450 (542–610)
	T/X 14607 RT 8608 /7608LL RTO 11909MLL /14909MLL /11908LL RTX 16709 /15710 /16710 RT/X 11609 /11709 /12609 /12709 /13609 /13709 /14609 /14709 /11710 /12710 /13710 /14710 RTO/X 11708LL /14708LL RT/O/X 14715 /15715 RTLO 12610 /13610 /14610 /15610 /16610 /12713 /14713 /16713 /14718 /16718 /18718	2–16	450–500 (610–678)
Meritor	RM/O/X 9–115, –125, –135, –145, –155 RM/X 10–115, –125, –135, –145, –155, –165 RMO 13–145	2–16	450–500 (610–678)
Allison	HD Series	2–16	600–800 (813–1085)

Table 1, Transmission Output-Shaft End-Yoke Nut Fastener Torques

Midship Bearing Fastener Torques		
Location	Size	Torque: lbf·ft (N·m)
Coupling Shaft	1-1/4–18	475–525 (645–710)
Bracket to Crossmember Locknut	1/2–13	68 (92)
Bearing Mount to Bracket Locknut	1/2–13	68 (92)

Table 2, Midship Bearing Fastener Torques

Spicer U-Joint Capscrew Torque			
Series	Thread Size	Style	Torque lbf·ft (N·m)
1710 HD 1760 HD 1810 HD	1/2–20	Half Round	130–135 (176–183)
	3/8–24	Full Round	38–48 (52–65)
SPL100	3/8–24	Half Round	45–60 (61–81)
SPL140/HD/XL SPL170/XL SPL250/HD/XL	M12–1.25	Half Round	115–135 (156–183)

Table 3, Spicer U-Joint Capscrew Torque

Specifications

Meritor U-Joint Capscrew Torque			
Series	Thread Size	Style	Torque lbf·ft (N·m)
16T	3/8–24	Half Round	45–60 (61–81)
16N	5/16–24	Full Round	26–35 (35–47)
17T	1/2–20	Half Round	115–135 (156–183)
17N	3/8–24	Full Round	38–48 (52–65)
176T	1/2–20	Half Round	115–135 (156–183)
176N	3/8–24	Full Round	38–48 (52–65)
18T	1/2–20	Half Round	115–135 (156–183)
18N	3/8–24	Full Round	38–48 (52–65)
RPL20 G2 RPL250HD G2	1/2–20	Wing Yoke	115–135 (156–183)

Table 4, Meritor U-Joint Capscrew Torque

Axle End-Yoke Fastener Torques				
Position	**Brand**	**Model Number**	**Input Size**	**Torque: lbf·ft (N·m)**
Single Axle Input Shaft	Meritor	MS-21-14X	M39- 1.5	920-1130 (1250-1530)
		RS-23-160, RS-23-161, RS-23-186, RS-25-160, RS-26-185, RS-30-185,	M45-1.5	1000-1230 (1355-1670)
		RS-30-380, RS-38-380	1-1/2 -12 UNF	800-1100 (1085-1490)
	Detroit	DA-RS-17.5-4, DA-RS-19.0-4, DA-RS-21.0-4, DA-RS-23.0-4	M45-1.5	627-850 (850-1150)
First Carrier Input Shaft	Meritor	MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP	M 45-1.5	750-850 (1015-1150)
		RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P, RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P		
		RT-50-160, RT-50-160GP, RT-50-160P, RZ-166, RZ-166 R-SERIES		
		RT-52-185, RT-52-185G, RT-58-185, RT-52-380G, RT-70-380, RT-70-380P, RZ-186, RZ-188, RZ-188G	1-3/4x12 UN	
	Detroit	DA-RT-40.0-4, DA-RT-40.0-4 HT, DA-RT-44.0-4, DA-RT-44.0-4 HT, DA-RT-46.0-4 HH	M45-1.5	627-850 (850-1150)
	Dana Spicer	DT463P, DD404, DD405, DD405P, DDH40, DDH40P, DS404, DS404P, DS405, DS405P, DSH40, DSH40P, DST40, DST41, DDH44P, DSH44P	M42 X 1.5	840-1020 (1140-1385)
		S23-190, D46-170, D50-170P, D52-190P, D40-170, D40-170P, D46-170P	M48 X 1.5	800-1000 (1085-1355)

Axle End-Yoke Fastener Torques				
Position	**Brand**	**Model Number**	**Input Size**	**Torque: lbf·ft (N·m)**
First Carrier Output Shaft	Meritor	MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP	M 39 x 1.5	600-800 (815-1085)
		RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P, RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P		
		RT-50-160, RT-50-160GP, RT-50-160P, RZ-166, RZ-166 R-SERIES		
		RT-52-185, RT-52-185G, RT-58-185, RT-52-380G, RT-70-380, RT-70-380P, RZ-186, RZ-188, RZ-188G	1-1/2x12 UNF	450-650 (610-880)
	Detroit	DA-RT-40.0-4, DA-RT-40.0-4 HT, DA-RT-44.0-4, DA-RT-44.0-4 HT, DA-RT-46.0-4 HH	M39 x 1.5	520 - 700 (705-950)
	Dana Spicer	DT463P, DD404, DD405, DD405P, DDH40, DDH40P, DS404, DS404P, DS405, DS405P, DSH40, DSH40P, DST40, DST41, DDH44P, DSH44P	M39 X 1.5	680 - 832 (920-1130)
		S23-190, D46-170, D50-170P, D52-190P, D40-170, D40-170P, D46-170P	M42 x 1.5	800-1000 (1085-1355)
Second Carrier Input Shaft	Meritor	MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP	M 39 x 1.5	920-1130 (1250-1530)
		RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P		
		RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P, RT-50-160, RT-50-160GP, RT-50-160P, RT-52-185, RT-52-185G, RT-58-185	M45 x 1.5	1000-1230 (1355-1670)
		RT-52-380G, RT-70-380, RT-70-380P	1-1/2 - 12 UNF	800-1100 (1085-1490)
		RZ-166, RZ-166 R-SERIES, RZ-186	M45 x 1.5	600-800 (815-1085)
		RZ-188, RZ-188G	1-3/4 - 12 UN	600-800 (815-1085)
Second Carrier Output Shaft	Meritor	RZ-166, RZ-166 R-SERIES, RZ-186	M39 x 1.5	450-650 (610-880)
		RZ-188, RZ-188G	1-1/2 -12 UNF	450-650 (610-880)
Third Carrier Input Shaft	Meritor	RZ-166, RZ-166 R-SERIES, RZ-186, RZ-188, RZ-188G	M45 x 1.5	1000-1230 (1355-1670)

Table 5, Axle End-Yoke Fastener Torques

Specifications

Special Tools

Journal Locator (for installing u-joints in full-round yokes)

To order, contact your Dana Corporation Spicer Service Representative.

U-joint Removal Tool Kit (for removing u-joints from full-round yokes)

To order Owatonna Tool Kit No. 7057, contact:

Owatonna Tool Company
Owatonna, Minnesota 55060

End-Yoke Puller (for removing end-yokes from transmission output shafts, coupling shafts, and Rear axle input and output shafts)

To order End-Yoke Puller J 7804–01, contact:

Kent-Moore Tool Division
29784 Little Mack
Roseville, MI 48066–2298
Telephone: 1–800–328–6657 Telex: 244040 KMTR
UR FAX: (313) 774–9870

To order Yoke and Flange Remover SP–450, contact:

G & W Tool Company
907 South Dewey
Wagoner, OK 74467

Driveline Angularity

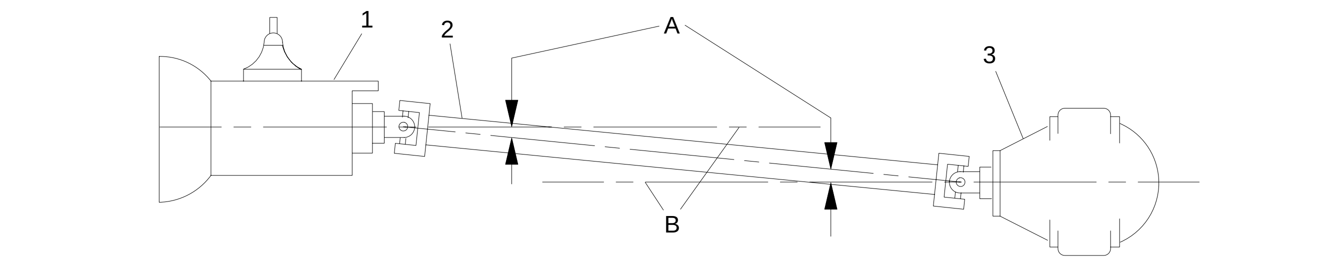
The most important consideration of driveline angularity is the U-joint working angle. A U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component to which the U-joint connects. See **Fig. 1**. Because the action of a U-joint causes a fluctuating speed difference between the shafts it connects, the effect created by the U-joint at the input-shaft end-yoke must cancel the effect created by the U-joint at the output-shaft end-yoke. This is done by making the U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase.

The U-joint working angles may be made approximately equal by either of two basic arrangements: a parallel arrangement (**Fig. 1**), or an intersecting arrangement (**Fig. 2**).

Driveline angularity may be adversely affected if rear suspension U-bolts are loose or broken; rear springs are broken, shifted, or mismatched; spring seats are broken; frame rails are bent, twisted, or broken; or transmission or engine mounts are loose or deteriorated.

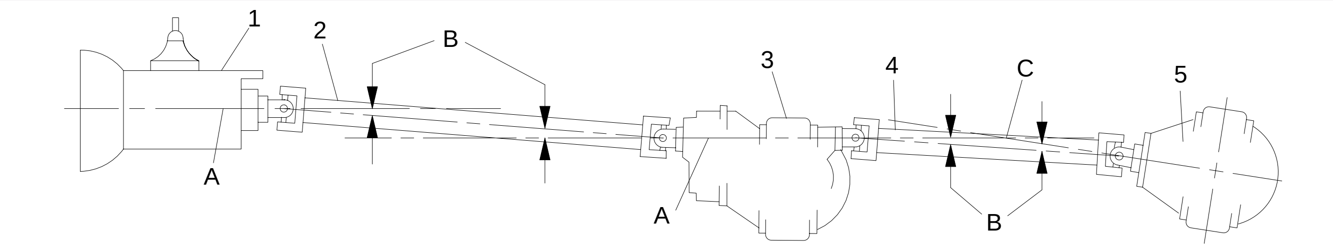
U-Joint Phasing

The fluctuating speed difference, caused by the action of a U-joint connecting angled shafts, can be cancelled only if the U-joint at the other end of the driveshaft is in phase with that U-joint (and the U-joint working angles are approximately equal). If the yoke lugs at both ends of the driveshaft are lying in the same plane (a plane which bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 3**.



A. Equal U-Joint Working Angles
B. Parallel Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Rear Axle

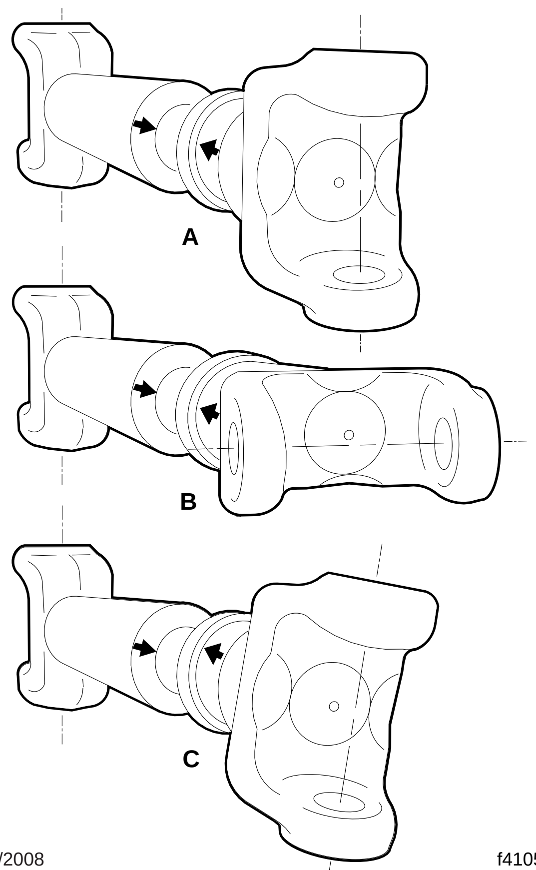
Fig. 1, Parallel Arrangement for Single-Drive Vehicles



A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Intersecting Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 2, Intersecting Planing Arrangements for Dual-Drive Vehicles

NOTE: Some driveshafts are designed and phased with their end yokes clocked 90 degrees from each other. This is referred to as cross phasing.



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A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 3, Driveline U-Joint Phasing

To ensure that the U-joints turn in phase, the sleeve-yoke and splined shaft of driveshaft slip-joints, and the coupling shaft and midship bearing end-yoke, should be marked for assembly reference before disassembly.

Driveline Balance

After manufacture, each driveline yoke is statically balanced. After assembly of the slip-joint, each driveshaft is checked for out-of-roundness, and straightened as necessary; then each shaft is dynamically balanced.

If the driveshaft slip-joint is disassembled for any reason, the sleeve-yoke and splined shaft should be marked for assembly alignment. Misaligned slip-joints will seriously affect the U-joint phasing and balance of the driveline. Even if the slip-joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

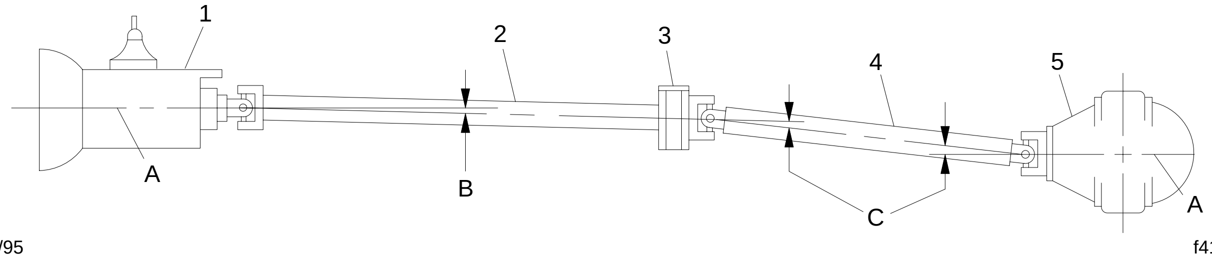
A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds that exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Loose end-yoke nuts, loose midship bearing or auxiliary transmission mounts, loose bearing retainer capscrews, worn U-joint trunnions or bearings, and worn slip-joint splines can lead to excessive movement of the driveshaft and cause driveline imbalance.

Midship Bearings

A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, most vehicles having a long wheelbase use a midship bearing, mounted on a crossmember in the frame, for additional driveline support. See Fig. 4. This allows the driveshaft to be separated into two shorter shafts, thus improving balance and stability.

Angularity Standards and Drivetrain Configuration

The U-joints require a minimum working angle of 1/2 degree to ensure needle-roller movement in the U-joint bearings. Without this movement, brinelling of the trunnion bearing-contact surfaces would occur. Suspension movement causes driveshaft angles to change (and therefore, needle-roller movement) in both of the U-joints attached to driveshafts that connect to the axles. However, no angle change occurs in the U-joints attached to a driveshaft that connects the main transmission to a midship bearing or auxiliary transmission. Their working angles must be established during installation.



A. Parallel Centerlines
B. 1/2 to 1 Degree
C. Working Angles Unequal by 1/2 to 1 Degree

1. Main Transmission
2. Coupling Shaft
3. Midship Bearing
4. No. 2 Driveshaft
5. Rear Axle

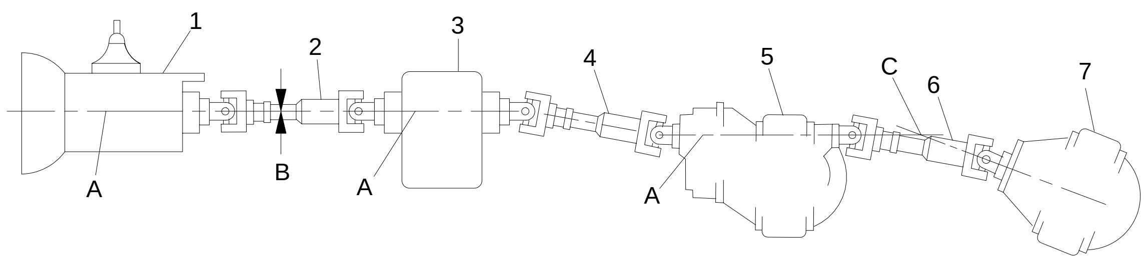
Fig. 4, Midship Bearing in a Single-Drive Vehicle

When a midship bearing is included in the drivetrain, it is installed so that the centerline of the coupling shaft is in horizontal (side-to-side) alignment within 1/2 degree, and within 1/2 to 1 degree of vertical alignment, with the centerline of the main transmission output shaft. See **Fig. 4**.

When an auxiliary transmission is included in the drivetrain, it is installed so that the centerline of the inter-transmission (no. 1) driveline is in exact horizontal (side-to-side) alignment (within 1/2 degree), and down 1/2 to 1 degree from vertical alignment, with the centerline of the main transmission output shaft. Further, the auxiliary transmission thru-shaft centerline must be parallel (horizontally and vertically) to the centerline of the main transmission output shaft, in order to achieve equal working angles. See **Fig. 5**.

Every U-joint has a maximum working angle, determined by the design and size of its cross assembly and yokes. Exceeding the maximum working angle can cause rapid U-joint wear, or in severe cases, destruction of the U-joint. For smooth operation and long drivetrain component life, the U-joint working angles must be kept small and approximately equal for each shaft.

The U-joint working angles may be made approximately equal by either of two basic arrangements: a parallel arrangement (**Fig. 1**) or an intersecting arrangement (**Fig. 2**). The parallel arrangement consists of installing the drivetrain components so that all of the input, output, and thru-shaft centerlines are approximately parallel. The intersecting arrangement (used only for some interaxle drivelines) consists of installing the drive components so that the rearmost



A. Parallel Centerlines
B. 1/2 to 1 Degree
C. Intersecting Centerlines

1. Main Transmission
2. No. 1 Driveline
3. Auxiliary Transmission
4. No. 2 Driveshaft
5. Forward-Rear Axle
6. No. 3 Driveshaft
7. Rearmost Axle

Fig. 5, Auxiliary Transmission in a Dual-Drive Vehicle

General Information

axle pinion shaft's extended centerline intersects the forward-rear axle thru-shaft's extended centerline approximately midway between the U-joints, when all of the other shafts (including the forward-rear axle thru-shaft) are approximately parallel.

All single-drive vehicles, and the forward-rear axles of dual-drive vehicles, use the parallel arrangement. Rearmost axles of dual-drive vehicles may use the parallel arrangement or the intersecting arrangement, depending on the drivetrain configuration.

The specific drivetrain configuration of each Freightliner vehicle consists of its wheelbase, number and type of axles, axle spacing, type of suspension, and number of transmissions. The specific drivetrain configuration determines the driveline arrangement and required installation angles of all the vehicle's drivetrain components.

The simplest drivetrain configuration consists of a single short driveline connecting a main transmission to a single-drive axle, in a parallel arrangement. This driveshaft is always referred to as the no. 2 driveshaft. The parallel arrangement always used on single-drive vehicles is shown in **Fig. 1**.

On dual-drive vehicles that have both axle input shafts of approximately the same height, a parallel arrangement is used. The driveshaft connecting the main (or auxiliary) transmission to the forward-rear axle is always referred to as the no. 2 driveshaft; and the interaxle driveshaft is always referred to as the no. 3 driveshaft. See **Fig. 6**, which shows a parallel arrangement when used on dual-drive vehicles.

Most dual-drive vehicles have a high thru-shaft on the forward-rear axle, and a low pinion on the rearmost axle. When the vehicle is on level ground, the interaxle (no. 3) driveshaft may create very sharp U-joint working angles with the input and output shafts when they are parallel. In normal driving, the U-joints could momentarily exceed their maximum working angle, and driveline or drivetrain damage could result. By using an intersecting arrangement at the no. 3 driveshaft, smaller U-joint working angles are created, promoting longer U-joint life and reduced driveline vibration. An intersecting arrangement used on dual-drive vehicles is shown in **Fig. 2**.

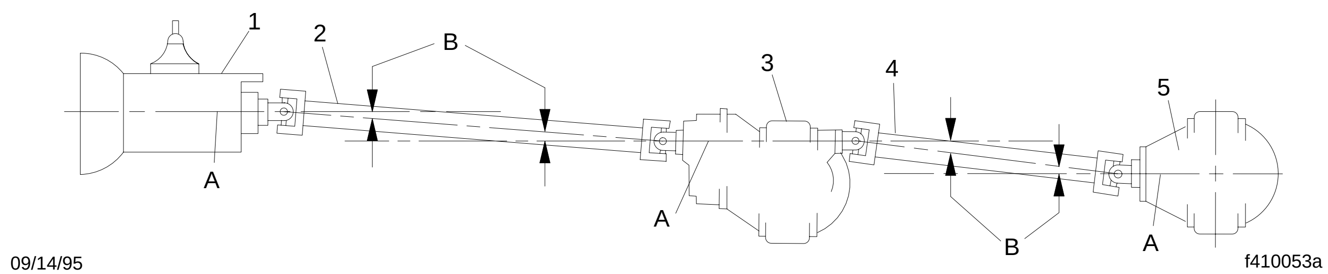
However, some axle spacings, axle models, and suspension designs allow additional axle movement or axle windup that requires additional clearances between the driveshaft and the frame or suspension components, or that creates other conditions that make the intersecting arrangement of the no. 3 driveshaft unsatisfactory. For those drivetrain configurations, it is necessary to use a modified parallel or modified-intersecting arrangement for the no. 3 driveshaft.

On drivetrain configurations that require a modified parallel arrangement, the rearmost-axle pinion shaft centerline is placed at an angle that is 2 degrees higher above horizontal than are the other input and output shafts. See **Fig. 7**.

On drivetrain configurations that require a modified-intersecting arrangement, the "proper" intersecting angle is determined, then the rearmost-axle pinion shaft centerline is placed at an angle that is 2 degrees closer to horizontal than the "proper" intersecting angle. See **Fig. 8**.

The axle pinion angles for all suspensions are factory-set for correct driveline angularity. On Freightliner spring suspensions, tapered axle planing shims at the springs maintain the correct axle pinion angle. On Hendrickson suspensions, spacers at the torque rods are used to maintain the correct axle pinion angles.

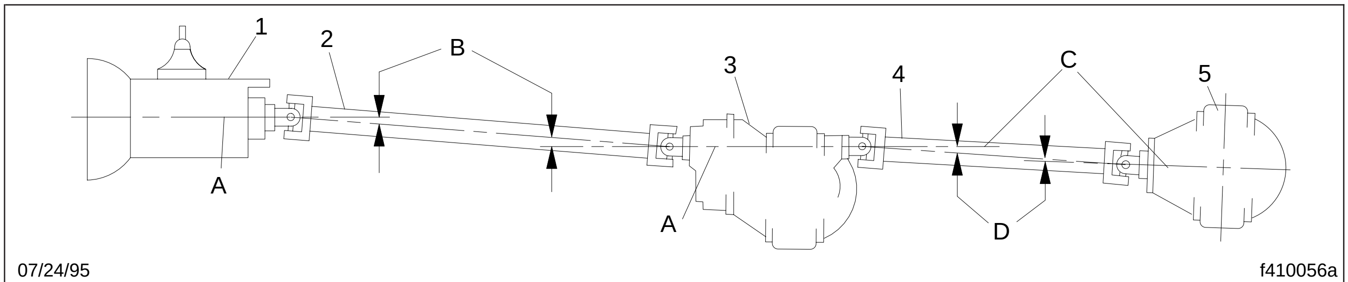
In the field, whenever axle or suspension components are changed, the axle pinion angles may also change. If this occurs, contact your district service manager for the correct axle pinion angle adjustment procedure.



A. Parallel Centerlines
B. Equal U-Joint Working Angles

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

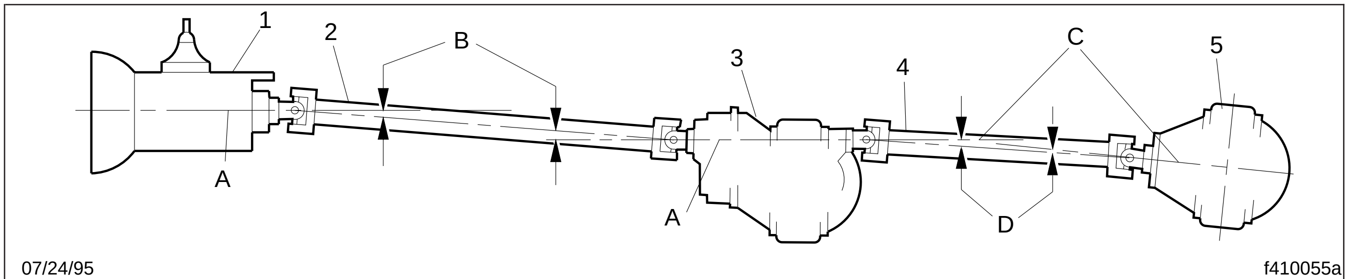
Fig. 6, Parallel Arrangement for Dual-Drive Vehicles



A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Modified-Parallel Centerlines
D. U-Joint Working Angles Not Equal by 2 Degrees

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 7, Modified-Parallel Arrangement for Dual-Drive Vehicles



A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Modified-Intersecting Centerlines
D. U-Joint Working Angles Not Equal by 2 Degrees

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 8, Modified-Intersecting Arrangement for Dual-Drive Vehicles

Use the procedure below for the type of tool being used. The Digital Angle Analyzer is the recommended tool.

Digital Angle Analyzer

Before checking the pinion angles or engine angle, check that the engine and transmission mounts are tight and in good condition. Loose or deteriorated mounts will cause inaccurate readings.

IMPORTANT: When using a digital angle analyzer (DAA) or digital level, be sure to always take readings from the same side of the vehicle. Also, keep the same end of the DAA pointed toward the front of the truck.

Using a DAA (**Fig. 1**), measure the engine angle, driveshaft angles, and pinion angles. Read all angles to the nearest one-tenth of a degree.

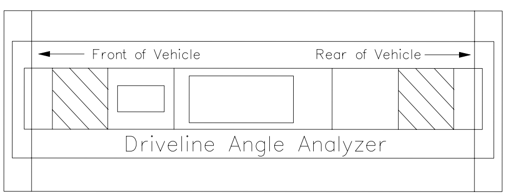


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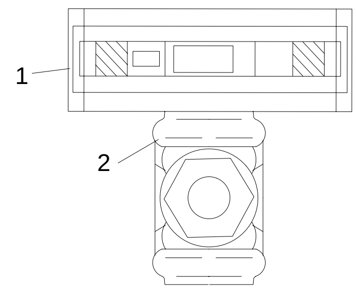
Fig. 1, Digital Angle Analyzer

After adjustment of any driveline angle, check the angle again. Also, verify ride height if the vehicle has an air suspension.

To measure the engine angle (transmission output-shaft angle) or axle pinion angles, do the following:

1. Inflate the vehicle tires to their normal operating pressure.
2. Park the unloaded vehicle on a level surface. Do not try to level the vehicle frame by jacking the front or rear axles. If the frame cannot be leveled from front to rear, determine and record the off-level inclination of the frame, and add or subtract that value from the measured values.
3. Chock the tires and place the transmission in neutral. Release the parking brakes.
4. The transmission output-shaft, coupling-shaft, and axle input- and output-yoke angles can be measured at either the top or bottom lug of the end-yoke being checked. For a full-round end-yoke, remove the bearing cup from the yoke lug. See **Section 41.00** for full-round end-yoke bearing cup removal.
5. Turn the end-yoke until the machined surface of the yoke lug is horizontal. See **Fig. 2**.



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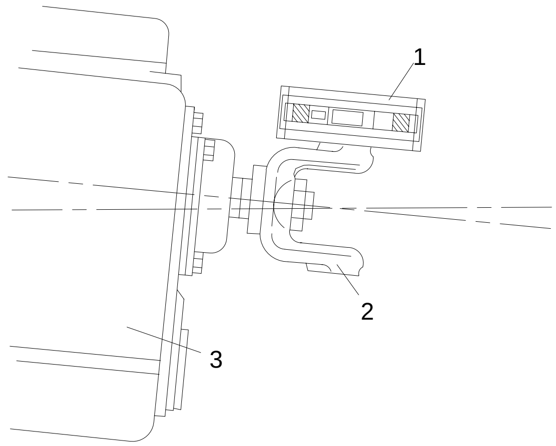
NOTE: Full-round end-yoke is shown.

1. Digital Angle Analyzer
2. End-Yoke

Fig. 2, Horizontal Positioning of Yoke Lug Machined Surface

6. To turn the driveshaft, raise one side of the rear (single-drive) or rearmost (dual-drive) axle until the tires are off the ground. Place a safety stand under the axle. With the transmission in neutral, and the interaxle differential (if equipped) unlocked, turn the tire to move the driveshaft.
7. Calibrate the digital level by placing it on the surface where the vehicle is parked at a 90-degree angle to the frame centerline. Zero the digital level.
8. Position the DAA alongside the U-joint trunnion, on the machined surface of the end-yoke, and at a 90-degree angle to the frame centerline. See **Fig. 2**. Then turn the end-yoke until the DAA reads 0 degrees. Remove the jack stand and lower the rear axle to the ground.
9. Calibrate the digital level by placing it on the surface where the vehicle is parked parallel to the frame centerline. Zero the digital level.
10. Without changing the position of the end-yoke, turn the DAA until it is parallel to the frame centerline. See **Fig. 3**. Record the measured angle of the pinion.

Engine and Pinion Angle Measurement



NOTE: Full-round end-yoke is shown.

1. Digital Angle Analyzer
2. End-Yoke
3. Transmission

Fig. 3, Measuring Pinion Angles

11. For a full-round end-yoke, install the bearing cup. See **Section 41.00** for full-round end-yoke bearing cup installation.

Spirit Level Protractor

Before checking the pinion angles or engine angle, check that the engine and transmission mounts are tight and in good condition. Loose or deteriorated mounts will cause inaccurate readings.

Using a digital angle meter, spirit level protractor (see **Fig. 4**), or the head of a machinists's protractor, measure the engine angle, driveshaft angles, and pinion angles. Read all angles to the nearest one-tenth of a degree (6 minutes).

After adjustment of any driveline angle, check the angle again.

To measure the engine angle (transmission output-shaft angle) or axle pinion angles, do the following:

1. Inflate the vehicle tires to their normal operating pressure.
2. Park the unloaded vehicle on a level surface. Do not try to level the vehicle frame by jacking the front or rear axles. If the frame cannot be leveled from front to rear, determine and record the off-level inclination of the frame, and add or subtract that value from the measured values.

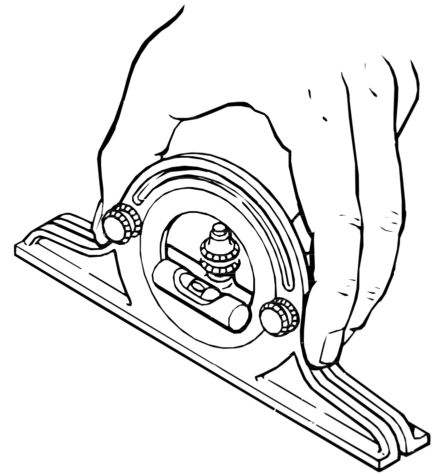


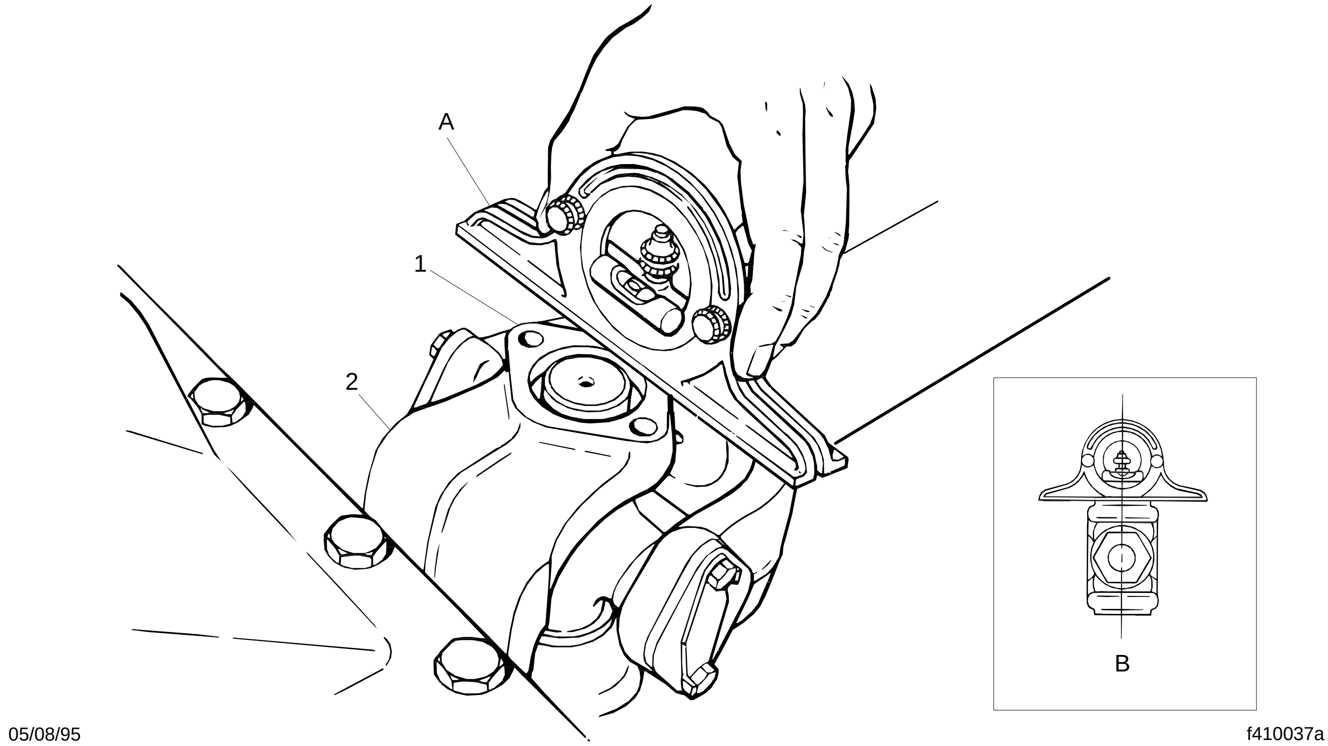
Fig. 4, Spirit Level Protractor

3. Chock the tires and place the transmission in neutral. Release the parking brakes.
4. The transmission output-shaft, coupling-shaft, and axle input- and output-yoke angles can be measured at either the top or bottom lug of the end-yoke being checked. For a full-round end-yoke, remove the bearing cup from the yoke lug. See **Section 41.00** for full-round end-yoke bearing cup removal.
5. Turn the end-yoke until the machined surface of the yoke lug is horizontal. See **Fig. 5**.

NOTE: To turn the driveshaft, raise one side of the rear (single-drive) or rearmost (dual-drive) axle until the tires are off the ground. Place a safety stand under the axle. With the transmission in neutral, and the interaxle differential (if equipped) unlocked, turn the tire to move the driveshaft.

6. Adjust the protractor scale to read 0 degrees. Position the protractor alongside the U-joint trunnion, on the machined surface of the end-yoke, and at a 90-degree angle to the frame centerline. See **Fig. 2**. Then turn the end-yoke until the bubble in the level vial is exactly between the two marks on the vial. Remove the jack stand and lower the rear axle to the ground.

Engine and Pinion Angle Measurement



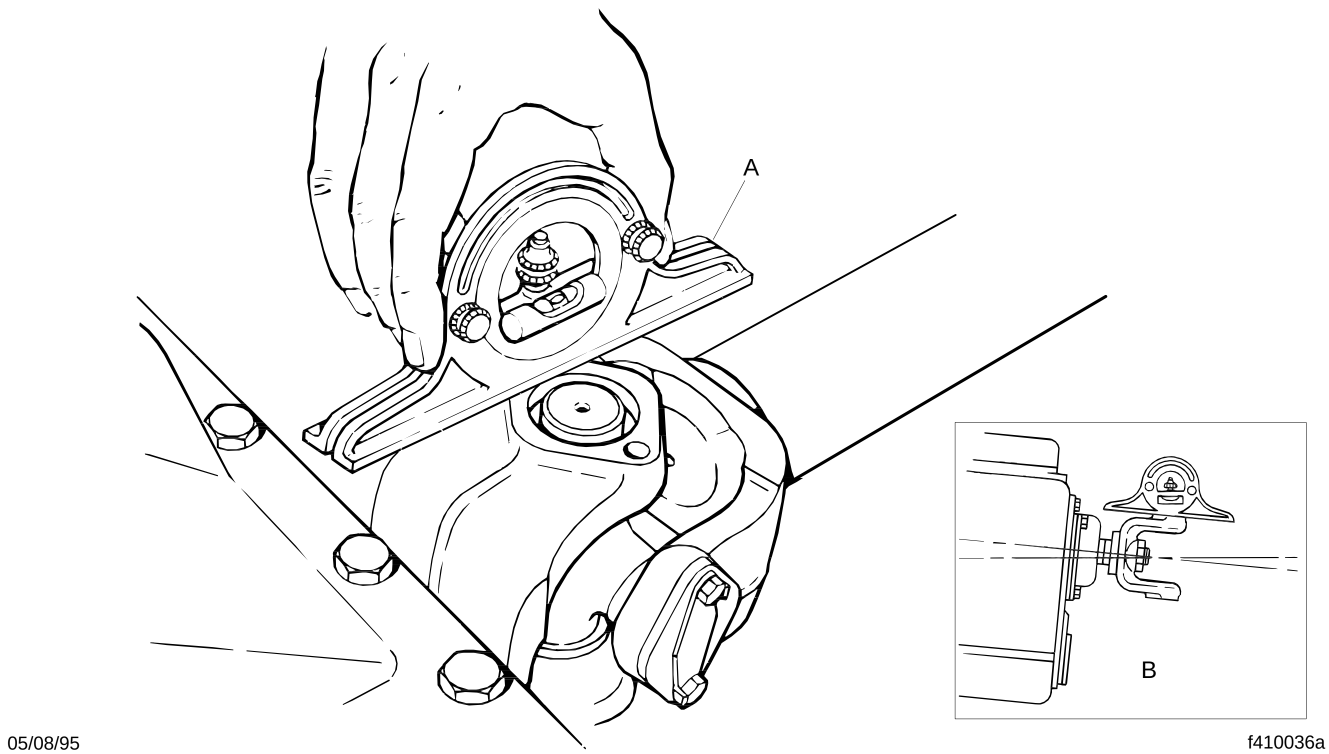
NOTE: Full-round end-yoke is shown.
A. Protractor held at right angle to vehicle frame centerline.
B. End view of end-yoke.

1. Machined Surface of Yoke Lug
2. End-Yoke

Fig. 5, Horizontal Positioning of Yoke Lug Machined Surface

7. Without changing the position of the end-yoke, turn the protractor until it is parallel to the frame centerline. See **Fig. 6**. Adjust the calibrated scale so the bubble is exactly between the two marks on the level vial. Record the calibrated scale reading opposite the "0" mark. Correct this value for any previously recorded off-level inclination.
8. For a full-round end-yoke, install the bearing cup. See **Section 41.00** for full-round end-yoke bearing cup installation.

Engine and Pinion Angle Measurement



NOTE: Full-round end-yoke is shown.

A. Protractor held parallel to vehicle frame centerline.

B. Side view of end-yoke.

Fig. 6, Measuring Pinion Angles

Driveline Angle Checking

If a vehicle is equipped with a Freightliner spring suspension, the axle pinion angles are factory-set using alignment shims at the rear springs. These shims have notches on the thick end of the shim. Count the number of notches in the thick end of each shim to make sure that the correct shim is used. Also, make sure the thick end of the shim is positioned correctly. See the applicable table in **Specifications 400** for shim identification and use. If the axle pinion angles on these suspensions are incorrect, contact your district service manager for the adjustment procedure.

If a vehicle is equipped with a Hendrickson suspension, spacers at the torque rods are used to maintain the correct axle pinion angles. If the measured axle pinion angles on these suspensions are not the same as the angles listed in the applicable table in **Specifications 400**, contact your district service manager for the adjustment procedure.

NOTE: In any of the following steps, if an off-level inclination was added to or subtracted from the engine angle, the same figure must be added to or subtracted from the coupling shaft or axle pinion reading before comparing the angles.

1. Check the engine angle at the transmission output-shaft end-yoke. The engine angle must be 3 degrees ±1/2 degree. For instructions, see **Subject 100**.

2. If the driveline includes a midship bearing, place a protractor on top of the coupling shaft. Align the protractor with the shaft centerline. See **Fig. 1**. Read the scale to the nearest one-tenth of a degree (6 minutes). The centerline of the coupling shaft must be 1/2 degree out of vertical alignment with the transmission output shaft. See **Fig. 2**. Compare this reading with the measured engine angle.

   If needed, adjust the midship bearing mounting to meet the above specification. Contact your district service manager for midship bearing mount adjusting procedures.

3. On single-drive installations, measure the rear axle pinion angle at the back of the no. 2 driveline; for instructions, see **Subject 100**.

   The measured rear axle pinion angle must be equal ±1 degree to the measured engine angle. If the rear axle pinion angle does not meet the above specification, contact your district service manager.

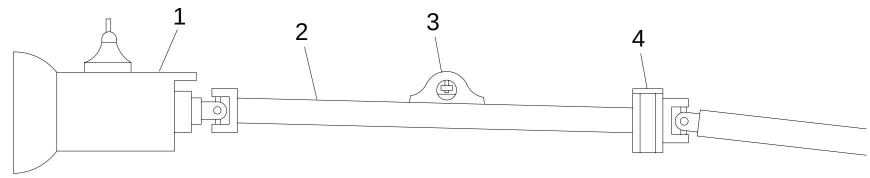
4. On dual-drive installations, measure the forward-rear-axle pinion angle (at the rear of the no. 2 driveline); for instructions, see **Subject 100**.

   The measured forward-rear-axle pinion angle must be equal ±1 degree to the measured engine angle. If the forward-rear-axle pinion angle does not meet the above specification, contact your district service manager.

   Measure the rearmost-axle pinion angle (at the rear of the no. 3 driveline); for instructions, see **Subject 100**.

   Compare the measured angle with that shown in the applicable table in **Specifications 400**. The measured rearmost-axle pinion angle must be equal ±1 degree to the angle shown in the table. If the measured angle is incorrect, contact your district service manager.

Driveline Angle Checking



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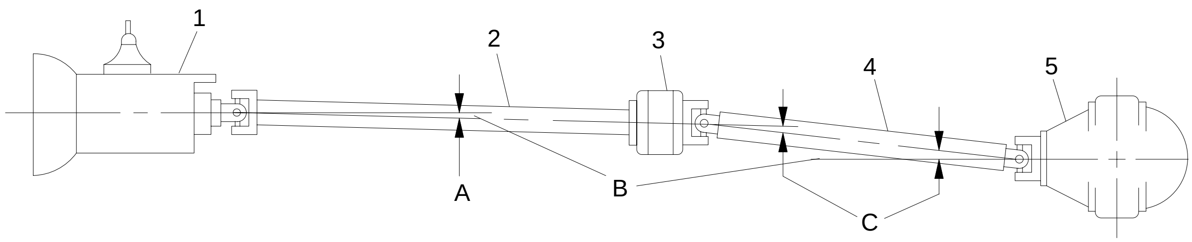
1. Transmission
2. Coupling Shaft
3. Protractor
4. Midship Bearing

Fig. 1, Coupling Shaft Angularity



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A. 1/2-Degree Minimum
B. Parallel Centerlines
C. Working Angles Unequal by 1/2 to 1 Degree

1. Transmission
2. Coupling Shaft
3. Midship Bearing
4. No. 2 Driveshaft
5. Rear Axle

Fig. 2, Midship Bearing in a Single-Drive Vehicle

Planing Angle Specifications

Engine Angle (for All Single-Drive-Axle Suspensions): Adjust to 5 degrees ±1/2 degree.

Engine Angle (for All Dual-Drive-Axle Suspensions): Adjust to 3-1/2 degrees ±1/2 degree.

Single-Drive-Axle Suspensions (All): Adjust rear axle pinion angle to 3 degrees ±1 degree.

Dual-Drive-Axle—Freightliner AirLiner Suspensions With Meritor RT–40/–44/–46 Axles: Adjust axle pinion angles to the values in **Table 1**, ±1 degree.

Dual-Drive-Axle—Freightliner AirLiner Suspensions With Eaton D–402 Axles: Adjust axle pinion angles to the values in **Table 2**, ±1 degree.

Dual-Drive-Axle—Freightliner AirLiner Suspensions With Eaton D–404 Axles: Adjust axle pinion angles to the values in **Table 3**, ±1 degree.

Dual-Drive-Axle—Freightliner Spring Suspensions (with Meritor RT–40/–44/–46 Axles, or Eaton D–402/–404 Axles): Adjust axle pinion angles to the values in **Table 4**, ±1 degree. See **Table 5** for shim notch decoding.

Dual-Drive-Axle—Hendrickson Suspensions With 52-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 6**, ±1 degree.

Dual-Drive-Axle—Hendrickson Suspensions With 54-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 7**, ±1 degree.

Dual-Drive-Axle—Hendrickson Suspensions With 56-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 8**, ±1 degree.

Dual-Drive-Axle—Hendrickson Suspensions With 60-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 9**, ±1 degree.

Dual-Drive-Axle—Hendrickson Suspensions With 72.5-Inch Axle Spacing: Adjust axle pinion angles to the values in **Table 10**, ±1 degree.

Freightliner AirLiner Suspensions With Meritor RT–40/–44/–46 Axles												
Axle Seat Angle (degrees)		Measured Suspension Height * (Inches)	Rear Suspension Load (pounds)									
			Unladen		30,000		34,000		36,000		40,000	
			Axle Pinion Angle (degrees)									
Fwd	Rear		Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear
3.0	5.5	2.375 (min)	2.1	10.6	3.0	11.5	3.2	11.7	3.3	11.8	3.5	12.0
		2.5	2.4	10.9	3.3	11.8	3.5	12.0	3.6	12.1	3.7	12.2
		2.625	2.7	11.2	3.6	12.1	3.8	12.3	3.8	12.3	4.0	12.5
		2.75	2.9	11.4	3.9	12.4	4.0	12.5	4.1	12.6	4.3	12.8
		2.87 (max)	3.2	11.7	4.2	12.7	4.3	12.8	4.4	12.9	4.6	13.1

* Measure suspension height at the forward drive-axle stop on the driver's side; see **Section 32.04** for complete instructions.

Table 1, Freightliner AirLiner Suspensions With Meritor RT-40/-44/-46 Axles

Specifications

Freightliner AirLiner Suspensions With Eaton D–402 Axles												
Axle Seat Angle (degrees)		Measured Suspension Height * (Inches)	Rear Suspension Load (pounds)									
			Unladen		30,000		34,000		36,000		40,000	
			Axle Pinion Angle (degrees)									
Fwd	Rear		Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear
3.0	3.0	2.375 (min)	2.1	8.1	3.0	9.0	3.2	9.2	3.3	9.3	3.5	9.5
		2.5	2.4	8.4	3.3	9.3	3.5	9.5	3.6	9.6	3.7	9.7
		2.625	2.7	8.7	3.6	9.6	3.8	9.8	3.8	9.8	4.0	10.0
		2.75	2.9	8.9	3.9	9.9	4.0	10.0	4.1	10.1	4.3	10.3
		2.87 (max)	3.2	9.2	4.2	10.2	4.3	10.3	4.4	10.4	4.6	10.6

* Measure suspension height at the forward drive-axle stop on the driver's side; see Section 32.04 for complete instructions.

Table 2, Freightliner AirLiner Suspensions With Eaton D-402 Axles

Freightliner AirLiner Suspensions With Eaton D–404 Axles												
Axle Seat Angle (degrees)		Measured Suspension Height * (Inches)	Rear Suspension Load (pounds)									
			Unladen		30,000		34,000		36,000		40,000	
			Axle Pinion Angle (degrees)									
Fwd	Rear		Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear	Fwd	Rear
3.0	4.5	2.375 (min)	2.1	9.6	3.0	10.5	3.2	10.7	3.3	10.8	3.5	11.0
		2.5	2.4	9.9	3.3	10.8	3.5	11.0	3.6	11.1	3.7	11.2
		2.625	2.7	10.2	3.6	11.1	3.8	11.3	3.8	11.3	4.0	11.5
		2.75	2.9	10.4	3.9	11.4	4.0	11.5	4.1	11.6	4.3	11.8
		2.87 (max)	3.2	10.7	4.2	11.7	4.3	11.8	4.4	11.9	4.6	12.1

* Measure suspension height at the forward drive-axle stop on the driver's side; see Section 32.04 for complete instructions.

Table 3, Freightliner AirLiner Suspensions With Eaton D-404 Axles

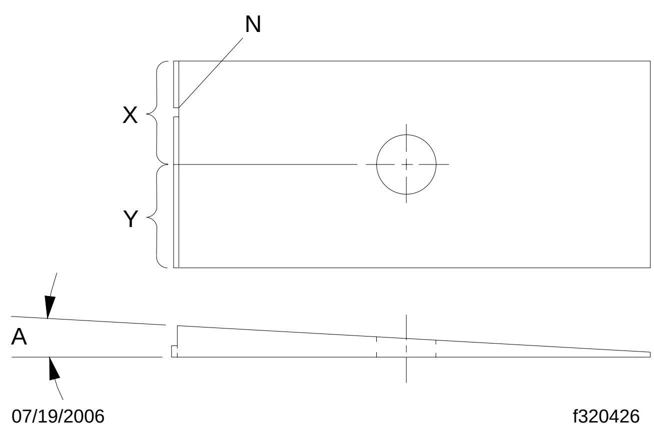
Freightliner Spring Suspensions (with Meritor RT–40/–44/–46 Axles, or Eaton D–402/–404 Axles)										
Axle Model	Forward-Rear Axle					Rearmost Axle				
	Pinion Angle (degrees)	Spring Seat Spacer	Shim Angle (degrees)	Orientation of Shim's Thick End	Number of Shim Notches *	Pinion Angle (degrees)	Spring Seat Spacer	Shim Angle (degrees)	Orientation of Shim's Thick End	Number of Shim Notches †
Meritor Axles (all axle spacings; laden and unladen)										
RT–40/–44/–46	3.0	Yes	None	—	—	11.0	None	1.0	Aft	2
Eaton Axles (all axle spacings; laden and unladen)										
D–402	3.0	None	None	—	—	10.0	None	None	—	—

Freightliner Spring Suspensions (with Meritor RT–40/–44/–46 Axles, or Eaton D–402/–404 Axles)										
Axle Model	Forward-Rear Axle					Rearmost Axle				
	Pinion Angle (degrees)	Spring Seat Spacer	Shim Angle (degrees)	Orientation of Shim's Thick End	Number of Shim Notches *	Pinion Angle (degrees)	Spring Seat Spacer	Shim Angle (degrees)	Orientation of Shim's Thick End	Number of Shim Notches †
D–404	3.0	Yes	None	—	—	10.5	None	0.5	Aft	1

* See **Table 5** for shim notch decoding.

† See **Table 5** for shim notch decoding.

Table 4, Freightliner Spring Suspensions (with Meritor RT-40/-44/-46 Axles, or Eaton D-402/-404 Axles)



Shim Angle *A* (degrees)	Notches (N) at *X*	Notches (N) at *Y*
0.5	One (total at x plus y)	
1.0	Two	none
1.5	Three	none
2.0	Four (total at x plus y)	
2.5	Five (total at x plus y)	
3.0	Six (total at x plus y)	
3.5	Zero	Zero
4.0	One	One
4.5	Two	One

Table 5, Shim Notch Decoding

Specifications

Hendrickson Suspensions With 52-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RS–400, –460	12.88	3.2	9.3	3.0	9.5	22.5	—	25	0.125
D402(P), D451P	RS–400, –460	14	3.3	9.2	3.0	9.5	22.5	—	25	0.125
D402(P), D451P	RT2–400	7.19	4.2	10.3	3.0	9.5	22.5	0.125	25	—
D402(P), D451P	RT2–460	6	4.4	10.4	3.0	9.5	22.5	0.125	25	—
D402(P), D451P	RT2–460	7.19	2.8	8.5	3.0	9.5	22.5	—	25.25	0.125
D402(P), D451P	RTE2–400	7.19	4.6	10.6	3.0	9.5	22	0.125	25.5	0.125
D402(P), D451P	RTE2–460	7.19	4.8	10.6	3.0	9.5	22.25	0.125	25.25	—
D404(P)	RS–400, –460	12.88	3.2	10.1	3.0	10.3	22.5	—	25.25	0.125
D404(P)	RS–400, –460	14	3.3	10.0	3.0	10.3	22.5	—	25.25	—
D404(P)	RT2–400	7.19	4.2	11.1	3.0	10.3	22.5	0.125	25.25	—
D404(P)	RT2–460	6	4.4	11.2	3.0	10.3	22.5	0.125	25.25	—
D404(P)	RT2–460	7.19	2.8	9.3	3.0	10.3	22.5	—	25.5	0.125
D404(P)	RTE2–400	7.19	4.6	11.4	3.0	10.3	22	0.125	25.75	0.125
D404(P)	RTE2–460	7.19	4.8	11.4	3.0	10.3	22.25	0.125	25.5	—
D461P	RS–400, –460	12.88	3.1	10.8	3.0	10.9	22.5	0.125	25.5	0.125
D461P	RS–400, –460	14	3.2	10.6	3.0	10.9	22.5	—	25.5	—
D461P	RT2–400	7.19	4.1	11.7	3.0	10.9	22.25	—	25.5	—
D461P	RT2–460	6	4.3	11.8	3.0	10.9	22.5	0.125	25.5	—
D461P	RT2–460	7.19	2.8	10.0	3.0	10.9	22.5	0.125	25.75	0.125
D461P	RTE2–400	7.19	4.5	12.1	3.0	10.9	22	0.125	26	0.125
D461P	RTE2–460	7.19	4.7	12.0	3.0	10.9	22.25	0.125	25.75	—
RT40/44–145(P)	RS–400, –460	12.88	3.2	11.6	3.0	11.8	22.5	—	25.75	0.125
RT40/44–145(P)	RS–400, –460	14	3.3	11.5	3.0	11.8	22.5	—	25.75	—
RT40/44–145(P)	RT2–400	7.19	4.2	12.6	3.0	11.8	22.25	—	25.75	—
RT40/44–145(P)	RT2–460	6	4.4	12.6	3.0	11.8	22.5	0.125	25.75	—
RT40/44–145(P)	RT2–460	7.19	2.8	10.8	3.0	11.8	22.5	—	26	0.125
RT40/44–145(P)	RTE2–400	7.19	4.6	12.9	3.0	11.8	22	0.125	26.25	0.125
RT40/44–145(P)	RTE2–460	7.19	4.8	12.9	3.0	11.8	22.25	—	26	—
RT46–160(P)	RS–400, –460	12.88	3.1	11.3	3.0	11.4	22.5	0.125	25.75	0.125
RT46–160(P)	RS–400, –460	14	3.2	11.1	3.0	11.4	22.5	—	25.75	0.125
RT46–160(P)	RT2–400	7.19	4.1	12.2	3.0	11.4	22.25	—	25.75	—
RT46–160(P)	RT2–460	6	4.3	12.3	3.0	11.4	22.5	0.125	25.75	—
RT46–160(P)	RT2–460	7.19	2.8	10.5	3.0	11.4	22.5	0.125	25.75	—

Hendrickson Suspensions With 52-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
RT46–160(P)	RTE2–400	7.19	4.5	12.6	3.0	11.4	22	0.125	26.25	0.125
RT46–160(P)	RTE2–460	7.19	4.7	12.5	3.0	11.4	22.25	0.125	26	—

Table 6, Hendrickson Suspensions With 52-Inch Axle Spacing

Hendrickson Suspensions With 54-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RS–400, –460	14	3.3	8.6	3.0	8.9	23.5	—	25.75	—
D402(P), D451P	RS–400, –460	12.88	3.2	8.7	3.0	8.9	23.5	—	25.75	0.125
D402(P), D451P	RT2–400	7.19	4.2	9.7	3.0	8.9	23.5	0.125	25.75	—
D402(P), D451P	RT2–460	6	4.4	9.8	3.0	8.9	23.5	0.125	25.75	—
D402(P), D451P	RTE2–400	7.19	4.6	10.0	3.0	8.9	23	0.125	26.25	0.125
D402(P), D451P	RTE2–460	7.19	4.8	10.0	3.0	8.9	23.25	0.125	26	—
D404(P)	RS–400, –460	14	3.3	9.4	3.0	9.7	23.5	—	26	—
D404(P)	RS–400, –460	12.88	3.1	9.5	3.0	9.7	23.5	—	26	0.125
D404(P)	RT2–400	7.19	4.2	10.5	3.0	9.7	23.25	—	26	—
D404(P)	RT2–460	6	4.4	10.6	3.0	9.7	23.5	0.125	26	—
D404(P)	RTE2–400	7.19	4.6	10.8	3.0	9.7	23	0.125	26.5	—
D404(P)	RTE2–460	7.19	4.8	10.8	3.0	9.7	23.25	0.125	26.25	—
D461P	RS–400, –460	14	3.2	10.0	3.0	10.2	23.5	—	26.25	—
D461P	RS–400, –460	12.88	3.1	10.1	3.0	10.2	23.5	0.125	26.25	0.125
D461P	RT2–400	7.19	4.1	11.1	3.0	10.2	23.25	—	26.25	—
D461P	RT2–460	6	4.3	11.1	3.0	10.2	23.5	0.125	26.25	—
D461P	RTE2–400	7.19	4.5	11.4	3.0	10.2	23	0.125	26.75	0.125
D461P	RTE2–460	7.19	4.7	11.3	3.0	10.2	23.25	0.125	26.5	—
RT40/44–145(P)	RS–400, –460	14	3.3	10.8	3.0	11.1	23.5	—	26.5	—
RT40/44–145(P)	RS–400, –460	12.88	3.1	10.9	3.0	11.1	23.5	—	26.5	0.125
RT40/44–145(P)	RT2–400	7.19	4.2	11.9	3.0	11.1	23.25	—	26.5	—
RT40/44–145(P)	RT2–460	6	4.4	12.0	3.0	11.1	23.5	0.125	26.5	—
RT40/44–145(P)	RTE2–400	7.19	4.6	12.2	3.0	11.1	23	—	27	—

Specifications

Hendrickson Suspensions With 54-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
RT40/44–145(P)	RTE2–460	7.19	4.8	12.2	3.0	11.1	23.25	0.125	26.75	—
RT46–160(P)	RS–400	14	3.2	10.6	3.0	10.8	23.5	—	26.5	0.125
RT46–160(P)	RS–460	14	3.2	10.6	3.0	10.8	23.5	—	26.5	—
RT46–160(P)	RS–400, –460	12.88	3.1	10.7	3.0	10.8	23.5	0.125	26.5	0.125
RT46–160(P)	RT2–400	7.19	4.1	11.7	3.0	10.8	23.25	—	26.5	—
RT46–160(P)	RT2–460	6	4.3	11.7	3.0	10.8	23.25	—	26.5	—
RT46–160(P)	RTE2–400	7.19	4.5	12.0	3.0	10.8	23	0.125	27	0.125
RT46–160(P)	RTE2–460	7.19	4.7	11.9	3.0	10.8	23.25	0.125	26.75	—

Table 7, Hendrickson Suspensions With 54-Inch Axle Spacing

Hendrickson Suspensions With 56-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RTE2–460	7.19	4.8	9.6	3.0	8.5	24.25	0.125	27	0.125
D404(P)	RTE2–460	7.19	4.8	10.3	3.0	9.2	24.25	0.125	27.25	0.125
D461P	RTE2–460	7.19	4.7	10.9	3.0	9.8	24.25	0.125	27.5	0.125
RT40/44–145(P)	RTE2–460	7.19	4.4	11.7	3.0	10.6	24.25	0.125	27.75	0.125
RT46–160(P)	RTE2–460	7.19	4.7	11.4	3.0	10.3	24.25	0.125	27.5	—

Table 8, Hendrickson Suspensions With 56-Inch Axle Spacing

Hendrickson Suspensions With 60-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RS–400, –460	12.88	3.1	7.6	3.0	7.8	26.5	—	28.25	—
D402(P), D451P	RS–400, –460	14	3.2	7.5	3.0	7.8	26.5	—	28.25	—
D402(P), D451P	RT2–400	7.19	4.2	8.6	3.0	7.8	26.5	0.125	28.5	0.125
D402(P), D451P	RT2–460	6	4.3	8.7	3.0	7.8	26.5	0.125	28.5	0.125
D402(P), D451P	RTE2–400	7.19	4.6	9.0	3.0	7.8	26	—	28.75	—

Hendrickson Suspensions With 60-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RTE2–460	7.19	4.7	8.9	3.0	7.8	26.25	0.125	28.75	0.125
D404(P)	RS–400, –460	12.88	3.1	8.3	3.0	8.5	26.5	—	28.5	—
D404(P)	RS–400, –460	14	3.2	8.2	3.0	8.5	26.5	—	28.5	—
D404(P)	RT2–400	7.19	4.2	9.3	3.0	8.5	26.25	—	28.75	0.125
D404(P)	RT2–460	6	4.3	9.4	3.0	8.5	26.5	0.125	28.75	0.125
D404(P)	RTE2–400	7.19	4.6	9.7	3.0	8.5	26	0.125	29	—
D404(P)	RTE2–460	7.19	4.7	9.6	3.0	8.5	26.25	0.125	29	0.125
D461P	RS–400, –460	12.88	3.1	8.9	3.0	9.0	26.5	0.125	28.75	—
D461P	RS–400, –460	14	3.2	8.8	3.0	9.0	26.5	—	28.75	—
D461P	RT2–400	7.19	4.1	9.9	3.0	9.0	26.25	—	29	0.125
D461P	RT2–460	6	4.3	9.9	3.0	9.0	26.5	0.125	29	0.125
D461P	RTE2–400	7.19	4.5	10.2	3.0	9.0	26	0.125	29.25	—
D461P	RTE2–460	7.19	4.6	10.1	3.0	9.0	26.25	0.125	29.25	0.125
RT40/44–145(P)	RS–400, –460	12.88	3.1	9.5	3.0	9.7	26.5	—	29	0.125
RT40/44–145(P)	RS–400, –460	14	3.2	9.4	3.0	9.7	26.5	—	29	—
RT40/44–145(P)	RT2–400	7.19	4.2	10.5	3.0	9.7	26.25	—	29	—
RT40/44–145(P)	RT2–460	6	4.3	10.6	3.0	9.7	26.5	0.125	29	—
RT40/44–145(P)	RTE2–400	7.19	4.6	10.9	3.0	9.7	26	—	29.5	—
RT40/44–145(P)	RTE2–460	7.19	4.7	10.8	3.0	9.7	26.25	0.125	29.25	—
RT46–160(P)	RS–400, –460	12.88	3.1	9.4	3.0	9.5	26.5	0.125	29	0.125
RT46–160(P)	RS–400, –460	14	3.2	9.3	3.0	9.5	26.5	—	29	—
RT46–160(P)	RT2–400	7.19	4.1	10.4	3.0	9.5	26.25	—	29	—
RT46–160(P)	RT2–460	6	4.3	10.4	3.0	9.5	26.25	—	29	—
RT46–160(P)	RTE2–400	7.19	4.5	10.7	3.0	9.5	26	0.125	29.5	—
RT46–160(P)	RTE2–460	7.19	4.6	10.8	3.0	9.5	26.25	0.125	29.25	—

Table 9, Hendrickson Suspensions With 60-Inch Axle Spacing

Specifications

Hendrickson Suspensions With 72.5-Inch Axle Spacing										
Axle Model	Suspension Model	Saddle Height (inches)	Planing Angle (degrees)				Suspension Control Rod			
			Unladen		Laden		Forward Axle		Rear Axle	
			Front	Rear	Front	Rear	Rod Length (inches)	Spacer Thickness (inches)	Rod Length (inches)	Spacer Thickness (inches)
D402(P), D451P	RS–460	12.88	3.1	5.9	3.0	6.0	32.75	—	34	0.125
D402(P), D451P	RS–460	14	3.2	5.8	3.0	6.0	32.75	—	34	0.125
D402(P), D451P	RT2–460	6	4.3	6.9	3.0	6.0	32.75	0.125	34	—
D402(P), D451P	RTE2–460	7.19	4.7	7.2	3.0	6.0	32.5	0.125	34.25	—
D404(P)	RS–460	12.88	3.1	6.4	3.0	6.5	32.75	0.125	34	—
D404(P)	RS–460	14	3.2	6.3	3.0	6.5	32.75	—	34.25	0.125
D404(P)	RT2–460	6	4.3	7.4	3.0	6.5	32.75	0.125	34.25	0.125
D404(P)	RTE2–460	7.19	4.7	7.7	3.0	6.5	32.5	0.125	34.5	0.125
D461P	RS–460	12.88	3.1	6.8	3.0	6.9	32.75	0.125	34.25	—
D461P	RS–460	14	3.1	6.7	3.0	6.9	32.75	—	34.25	—
D461P	RT2–460	6	4.2	7.9	3.0	6.9	32.75	0.125	34.5	0.125
D461P	RTE2–460	7.19	4.6	8.1	3.0	6.9	32.5	0.125	34.75	0.125
RT40/44–145(P)	RS–460	12.88	3.1	7.5	3.0	7.6	32.75	0.125	34.5	0.125
RT40/44–145(P)	RS–460	14	3.2	7.4	3.0	7.6	32.75	—	34.5	—
RT40/44–145(P)	RT2–460	6	4.3	8.5	3.0	7.6	32.75	0.125	34.5	—
RT40/44–145(P)	RTE2–460	7.19	4.6	8.6	3.0	7.6	32.5	0.125	34.75	—
RT46–160(P)	RS–460	12.88	3.1	7.3	3.0	7.4	32.75	0.125	34.5	0.125
RT46–160(P)	RS–460	14	3.1	7.2	3.0	7.4	32.75	0.125	34.5	—
RT46–160(P)	RT2–460	6	4.2	8.4	3.0	7.4	32.5	—	34.5	—
RT46–160(P)	RTE2–460	7.19	4.6	8.6	3.0	7.4	32.5	0.125	34.75	—

Table 10, Hendrickson Suspensions With 72.5-Inch Axle Spacing

General Description

CAUTION

The size of the tires installed at the factory is programmed into the electronic control unit (ECU). Installing different size tires could result in a reduced braking force, leading to longer stopping distances and possibly resulting in personal injury or property damage.

Columbia vehicles are equipped with a Meritor WABCO D-Version Antilock Braking System (ABS) with a frame-mounted electronic control unit.

The ABS is an electronic wheel speed monitoring and control system that works with the standard air brake system. It passively monitors vehicle wheel speed at all times, then controls wheel speed during emergency stops. As a result, the driver has full control of braking until the ECU senses that a lockup is about to occur.

The ABS includes signal-generating sensors activated by tone (tooth) wheels located on the hubs of the monitored wheels. See **Fig. 1**. The sensors transmit vehicle wheel speed information to the ECU. According to programmed specifications, the control unit signals the appropriate modulator valve to increase, reduce, or maintain air pressure in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations.

Columbia vehicles with a 4 x 2, 6 x 2, or 6 x 4 wheel configuration normally have the standard four-channel ABS with four wheel speed sensors and four modulator valves (4S/4M). Vehicles with tandem rear axles may be optionally equipped with a 6S/4M or 6S/6M ABS.

During normal braking conditions, the standard air brake system is in effect. If the vehicle is equipped with Automatic Traction Control (ATC), wheel spin is controlled during reduced-traction startup and acceleration.

Principles of Operation

The ABS has an electronic control unit that serves as the information processing and command center for the antilock braking system. The ECU is a digital microcomputer that receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the control unit regulates the braking force applied to each wheel by sending control signals to the modulator valves.

The major components of the Meritor WABCO pneumatic ABS system include the following:

- Wheel speed sensors
- An electronic control unit (ECU)
- Modulator valves (solenoid control valves)
- Automatic Traction Control (ATC) valve (optional)
- ABS warning and wheel-spin indicator lights
- Retarder relay

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power, ground cables, and the electrical harness connectors at the ABS electronic control unit (ECU). Electric currents produced during electric welding can damage various electronic components on the vehicle.

Wheel Speed Sensors

The wheel speed sensor assembly is a signal-generating device. The assembly includes a sensor (coil wrapped around a magnet), a tone wheel, and a sensor clip that holds the sensor in position near the tone wheel. See **Fig. 2**.

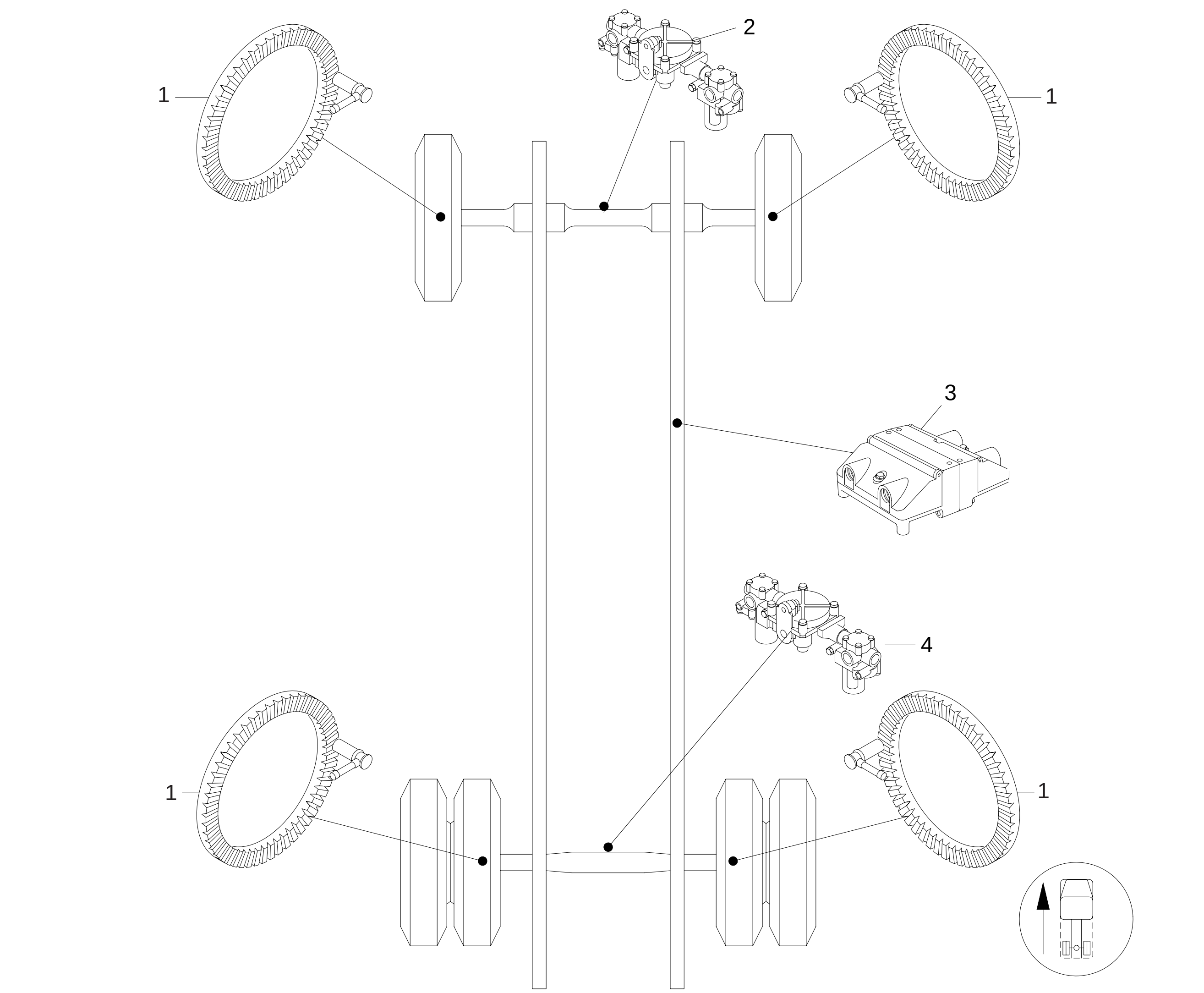
Each ABS-controlled wheel has a wheel speed sensor assembly with a tone wheel mounted on the hub. When the vehicle is moving, the teeth on the tone wheel cause interruptions in the magnetic field created by the sensor. The interruptions create electrical pulses that are sent to the electronic control unit where they are used to determine the wheel speed.

Electronic Control Unit (ECU)

The ECU contains microcomputers to monitor the front and rear control channels. See **Fig. 3**. It is mounted on the right-hand frame rail.

The ECU receives signals from the wheel speed sensors and uses them to calculate wheel speed and a vehicle reference speed. The unit is programmed to determine whether the wheels are slowing at a normal braking rate or at a higher rate, requiring ABS

General Information



1. Tone Wheel and Sensor
2. Front Modulator Valve Assembly
3. Electronic Control Unit (ECU)
4. Rear Modulator Valve Assembly

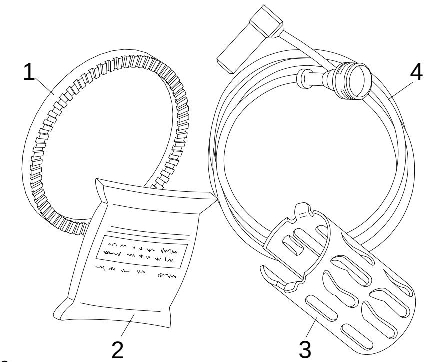
Fig. 1, ABS Component Location (4-channel, 4S/4M system shown)

braking control. If the ECU senses wheel slip or lockup, the appropriate control circuit signals the modulator valve(s) to release, hold, or reapply braking pressure.

The ECU also shuts down the engine brake and the exhaust brake, if equipped, when a wheel approaches a slip or lockup condition. When the wheels return to a normal rate of speed, the engine and exhaust brakes are reactivated automatically.

The ECU constantly monitors the wheel sensors, modulator valves, Automatic Traction Control valve (if equipped), and the electrical circuitry. After the ignition switch is turned on, the ABS warning light (TRACTOR ABS) and the ATC wheel spin indicator light (WHEEL SPIN) on the dash light for about 3 seconds. See **Fig. 4** for a typical instrument cluster.

During the self-test, the modulator valves and the ATC valve cycle on and off, creating clicking noises



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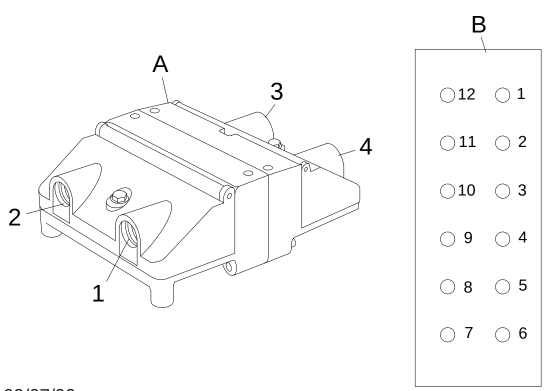
1. Tone Wheel
2. Lubricant
3. Sensor Spring Clip
4. Sensor

Fig. 2, Wheel Speed Sensor Components



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A. Frame-mounted ECU.
B. ECU connector pin locations.

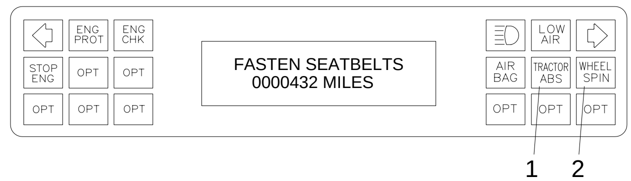
1. X1 Connector (gray)
2. X2 Connector (black)
3. X3 Connector (green)
4. X4 Connector (brown—6S/4M, 6S/6M only)

Fig. 3, Frame-Mounted ECU and Pin Locations

that may be heard inside the cab. These clicking noises are normal and do not indicate an ABS problem. After about 3 seconds, the lights go off only if all of the ABS and ATC components are functioning correctly.

On vehicles with Automatic Traction Control, after the self-test the ATC indicator light comes on if a drive wheel spins during startup or acceleration.

IMPORTANT: If the ABS warning light and the ATC indicator light do not work as described



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1. ABS Warning Light
2. ATC Indicator Light

Fig. 4, ABS and ATC Lights (ICU Level II [ICU 2L] shown)

above, repair the ABS/ATC system. See **Troubleshooting, 300** for fault diagnosis.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (such as a sensor, modulator valve, wiring connection, or short circuit), the ABS warning light comes on, a fault code is stored in ECU memory, and the control circuit where the failure occurred is switched to normal braking action. The remaining control circuit retains the ABS effect.

Even if the ABS system is completely inoperative, normal braking is maintained. An exception would be if a modulator valve or valve assembly is damaged and inoperative. These components are an integral part of the air brake system so normal braking may be impaired or inoperative.

For troubleshooting purposes, the ECU can communicate with the Meritor WABCO PC Diagnostics (recommended), ServiceLink, a hand-held Pro-Link electronic diagnostic tool through the J1587 diagnostic datalink connector or blink codes. The connector is located near the B-pillar on the driver's side and the diagnostic switch is on the B-pillar panel. Fault codes can be retrieved through the datalink connection, when necessary.

IMPORTANT: Do not open the ECU. Opening the ECU to gain access to the internal components will void the warranty.

Modulator Valves

Modulator valves control the air pressure in each affected brake chamber during an ABS operation. Depending on the signal received from the ECU, modulator valves prevent wheel lockup by reducing, maintaining, or increasing brake pressure. During normal braking applications, the ABS system is inactive and compressed air flows freely through the modulator valves to the brake chambers.

Each ABS-monitored wheel has its own modulator valve. The front and rear modulator valve assemblies are mounted on a crossmember near the brake chambers. See **Fig. 1**. The assembly includes two modulator valves, one mounted on each side of a service relay valve. If the vehicle has an ATC system, the ATC valve is mounted on the control port of the service relay valve.

Vehicles with tandem rear axles and a 4S/4M ABS share modulator valves. One wheel is sensed but the modulator valve controls both wheels on a side.

Each modulator valve assembly includes two solenoid control valves (one supply and one exhaust) and two diaphragms. See **Fig. 5**.

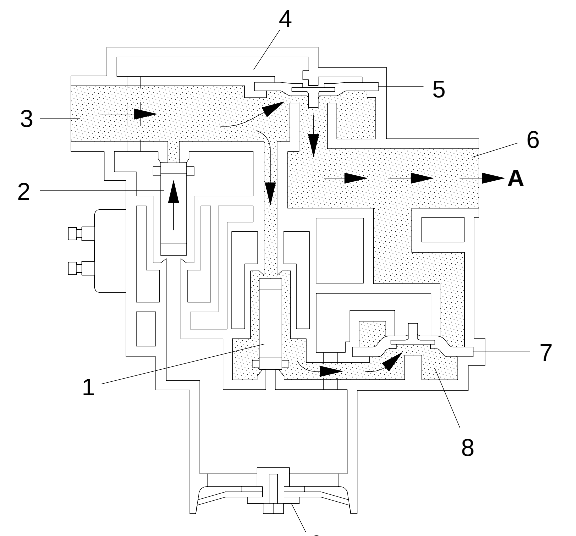
- The supply diaphragm opens and closes an air passage between the supply port and delivery port. It is controlled by the supply solenoid valve.
- The exhaust diaphragm opens and closes an air passage between the exhaust port and the delivery port. It is controlled by the exhaust solenoid valve.

The ECU energizes different combinations of these solenoid valves to perform four functions: normal braking (without ABS control), ABS brake release (exhaust), ABS brake hold, and normal brake reapply.

Normal Brake Control

The normal brake function (without ABS control) operates as follows:

- Before braking, the supply pilot chamber is open to the atmosphere through the exhaust port.
- When the brakes are applied, both solenoid valves in the ABS modulator valve are closed (de-energized). See **Fig. 5**.
- Increased air pressure entering the supply port unseats the supply diaphragm by increasing the pressure under the diaphragm. This opens the passage to the delivery port and allows air to flow directly through the valve and into the brake chamber.
- Air also flows through the exhaust valve. The increased pressure under the exhaust diaphragm seats the diaphragm, which closes the passage between the exhaust port and the delivery port.
- When the brake pedal is released, air pressure at the supply port decreases and the higher pressure in the brake chamber reverses the flow of air in the modulator valve. Air now flows from the delivery port to the supply port until the pressure is balanced. This releases the supply diaphragm and closes the passage between the two ports.
- The reduced pressure unseats the exhaust diaphragm and air is vented through the exhaust port to the atmosphere.



NOTE: Both solenoid valves are closed. The modulator valve is shown in the braking configuration with increased air pressure at the supply port (supply diaphragm unseated, exhaust diaphragm seated).

A. Air to brake chamber.

1. Exhaust Valve (closed)
2. Supply Valve (closed)
3. Supply Port
4. Supply Diaphragm (unseated)
5. Delivery Port
6. Exhaust Diaphragm (seated)
7. Exhaust Port

Fig. 5, Modulator Valve, Normal Brake Control (brake applied)

Brake Release (ABS Active)

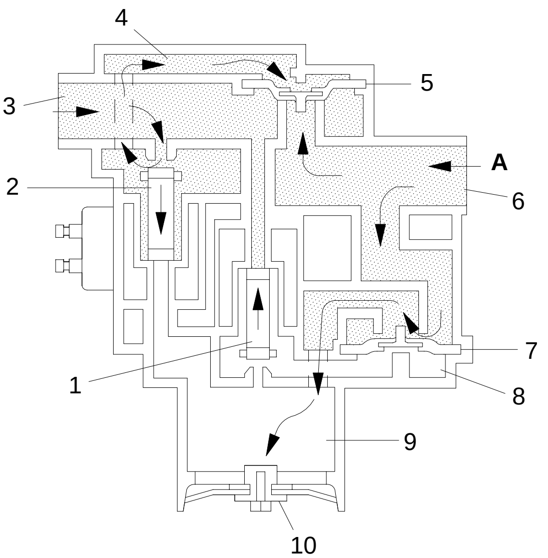
The ABS brake release (exhaust) function is triggered when the ECU determines that the brakes are about to lock.

- When a wheel is going to lock, the ECU opens (energizes) both solenoid valves in the ABS modulator valve. See **Fig. 6**.
- The open supply valve allows compressed air to enter the supply pilot chamber above the supply diaphragm. The increased pressure seats the diaphragm and stops air from entering the brake chamber.
- The open exhaust valve shuts off the supply of air entering the exhaust pilot chamber. It also creates an opening between the pilot and exhaust chambers.
- Air from the brake chamber enters through the delivery port. The pressure unseats the exhaust diaphragm, creating an opening between the delivery and exhaust chambers. Brake-chamber air is then released through the exhaust port.

Brake Hold Control (ABS Active)

The ABS brake hold function takes control during an emergency stop when the pedal control valve delivers more air than the brakes can handle without locking. The hold function occurs after the ABS has started to control the pressure in the brake chamber by releasing some of the air.

- When enough air is released through the exhaust port to stop the wheel from locking (ABS brake release), the exhaust valve is closed and air pressure is allowed to flow into the exhaust pilot chamber. See **Fig. 7**.
- The increased pressure under the exhaust diaphragm seats the diaphragm, which closes the passage between the exhaust port and the delivery port. This stops the flow of air from the brake chamber to the exhaust port.
- The supply valve stays open to maintain pressure in the supply pilot chamber and keep the supply diaphragm seated. This prevents further buildup of pressure in the brake chamber.
- The remaining air pressure in the brake chamber is held and remains constant for stopping the vehicle in the minimum distance.



NOTE: Both solenoid valves are open.

A. Air from brake chamber.

1. Exhaust Valve (open)
2. Supply Valve (open)
3. Supply Port
4. Supply Pilot Chamber
5. Supply Diaphragm (seated)
6. Delivery Port
7. Exhaust Diaphragm (unseated)
8. Exhaust Pilot Chamber
9. Exhaust Chamber
10. Exhaust Port

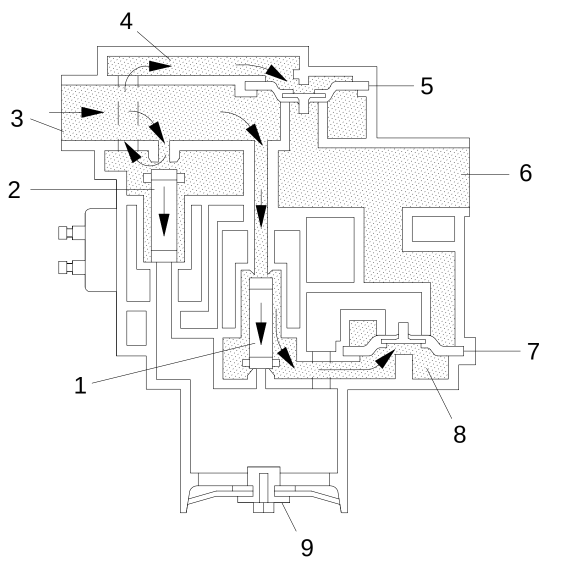
Fig. 6, Modulator Valve, Brake Release (exhaust)

Reapply Brake Control (ABS Active)

The last ABS function is the reapply brake control. To achieve maximum braking, the ECU determines when to reapply the air pressure that the pedal control valve is delivering. When appropriate, both ABS solenoid valves are closed, which returns the system to the normal brake control state shown in **Fig. 5**.

During an ABS event, the ECU cycles the modulator valve(s) through the sequence of ABS valve states (brake release, hold, and reapply) very rapidly in order to control wheel speed. The effect is similar to manually pumping the brakes on a vehicle without an ABS.

General Information



NOTE: The supply valve is open; the exhaust valve is closed.

1. Exhaust Valve (closed)
2. Supply Valve (open)
3. Supply Port
4. Supply Pilot Chamber
5. Supply Diaphragm (seated)
6. Delivery Port
7. Exhaust Diaphragm (seated)
8. Exhaust Port

Fig. 7, Modulator Valve, Brake Hold Control

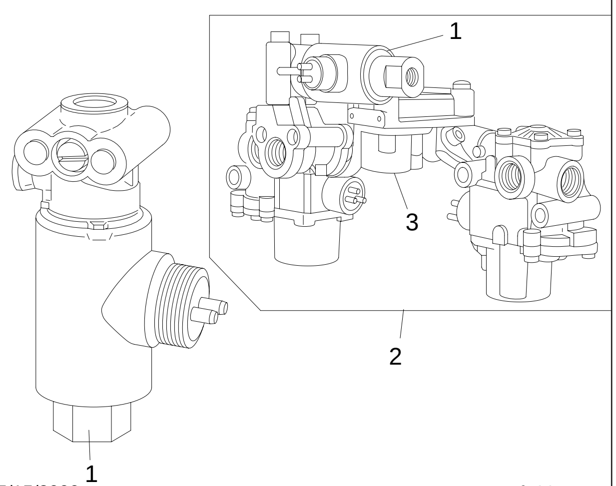
NOTE: The driver always controls the maximum amount of pressure applied to the brakes. Pressure to the brake chamber can never be more than the driver applies with the foot pedal. The ABS can override the pedal pressure to provide less brake pressure but not more.

Automatic Traction Control

If the vehicle is equipped with Automatic Traction Control (ATC), the ABS/ATC system automatically reduces wheel spin during low-traction startup or acceleration.

If a drive wheel starts to spin faster than the steer-axle wheels, the ATC system applies air pressure to brake that drive wheel. This transfers engine torque to the wheel or wheels that have better traction (differential braking). If two or more drive wheels spin, the ATC reduces the engine torque to provide improved traction, overriding the throttle pressure from the driver.

The ATC valve controls only the brake chambers for the drive wheels. It is mounted on the service relay valve (rear modulator valve assembly). See **Fig. 8**. The solenoid in the ATC valve controls an on/off air valve, which allows or prevents air flow to the control side of the service relay valve.



1. ATC Valve
2. Rear Modulator Valve Assembly
3. Service Relay Valve

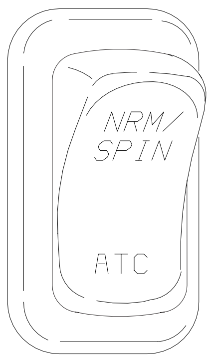
Fig. 8, ATC Valve

If a wheel spin from one side of the vehicle is detected, the ECU signals the ATC valve to open. This allows compressed air to enter the service relay valve and the normal ABS control system determines which brake to apply.

An ATC function switch on the dash allows the driver to select from two levels of drive-axle traction control (see **Fig. 9**):

- In the default position, the ATC reduces drive-axle wheel spin on icy, wet, or sand-covered roads.
- Pressing the NORM/SPIN switch increases the available traction on extra soft surfaces like snow, mud, or gravel by slightly increasing the permissible wheel spin. The greater wheel spin

may also be used to help burn through a thin layer of ice.



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NOTE: This is a momentary rocker switch, shown in the ATC (default) position.

Fig. 9, ATC Switch for Soft Surfaces

The ATC function turns on and off automatically; drivers do not have to select this feature. If a drive wheel spins during startup or acceleration, the ATC indicator lamp comes on, indicating the ATC is active. It goes out when the drive wheel stops spinning.

The NORM/SPIN mode overrides the ATC function. It must be manually selected by pressing the NORM/SPIN spring-loaded switch briefly after the vehicle is started. The ECU indicates the activation by a constant flashing of the WHEEL SPIN lamp. This mode is disengaged by pressing NORM/SPIN on the switch again or turning the ignition switch off.

ABS Warning and ATC Indicator Lights

The ABS warning light (TRACTOR ABS) receives power whenever the ignition switch is turned on. The ground paths for this indicator are through the ABS ECU, the blink-code switch, and relay. During the self-test, and whenever a malfunction occurs, the ECU completes the ground path and the ABS indicator on the dash comes on. See **Fig. 4**. The light is also used to display blink code diagnostics.

The warning light alerts the driver that the self-test is working or that an ABS system malfunction exists. After a wheel-sensor-related fault has been repaired, if the stored faults are cleared, the ABS warning light remains on until the vehicle is driven above a speed of 4 mph (6 km/h).

The ATC indicator light also receives power whenever the ignition switch is on. If the drive-axle wheels spin, the ATC indicator light turns on.

On vehicles equipped with Automatic Traction Control, if the NORM/SPIN switch (**Fig. 9**) is activated, the ABS ECU allows more wheel spin than normal and the ATC indicator blinks continuously until the switch is deactivated.

If the ATC wheel-spin indicator light stays on during normal vehicle operation, there is a malfunction in the ATC system.

Tire Size

For proper ABS/ATC operation with the standard ECU, the front and rear tire sizes must be within 14 percent of each other. When the tire-size range is exceeded, system performance can be affected and the warning lamp may come on.

Call Meritor WABCO at 1-800-535-5560 if you plan a tire-size difference greater than 14 percent.

Calculate the percentage difference of the tire sizes with the following equation:

Percentage Difference = {(steer-axle tire RPM ÷ drive-axle tire RPM) – 1} x 100, where RPM equals tire revolutions per mile.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

- Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires before working under the vehicle. Releasing air from the system can cause the vehicle to roll.
- Keep hands away from brake chamber push rods and slack adjusters; they will apply as the air pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes.
- Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed the recommended air pressure.
- Always wear safety glasses when working with compressed air. Never look into air jets or direct them toward anyone.
- Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs and injury can result if they are not correctly disassembled. Use only the correct tools and observe all precautions regarding use of those tools.

Replacement

IMPORTANT: Do not attempt to repair the wheel sensor wire (the wire that comes with the sensor). If the wire is damaged, replace the sensor assembly.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to **Section 54.00** for information on special terminals and connectors, and on ordering tools for them.

Front Axle

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires to prevent vehicle movement.
2. Twist and pull the sensor to remove it from the steering knuckle. See **Fig. 1**.

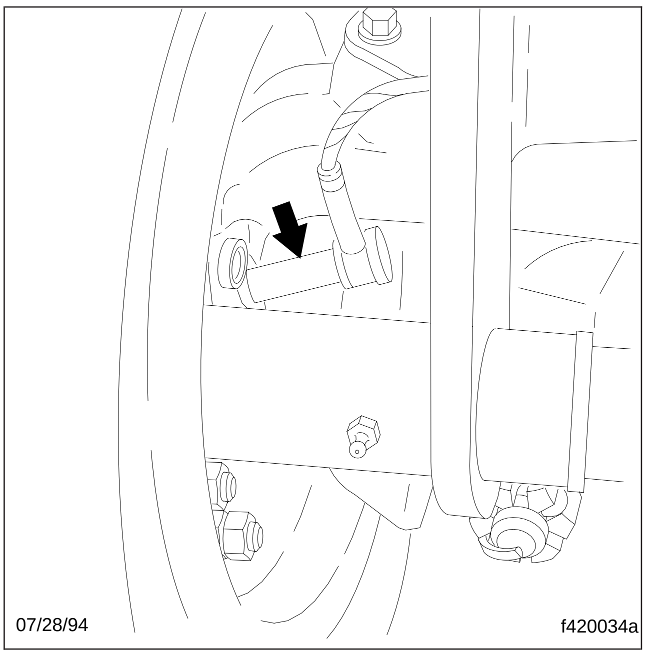


Fig. 1, Front Wheel Speed Sensor Removal

3. Remove the sensor cable from the steering knuckle top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the steering knuckle.
6. Connect the new sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.
8. Press the clamping bushing into the brake spider hole until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP 633, Pennzoil 707L, or an equivalent. Press the sensor into the clamping bushing until it is stopped by the tone wheel.
10. Remove the chocks from the rear tires.

Rear Axle

1. Park the vehicle on a flat surface, set the parking brake, and shut down the engine. Chock the front tires to prevent vehicle movement.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40**.
5. Remove the brake drum. For instructions, refer to **Group 35**.
6. Twist and pull the sensor to remove it from the mounting block in the axle housing.
7. Remove the clamping bushing.
8. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
9. Disconnect the sensor cable from the chassis harness.
10. Connect the new sensor cable to the chassis harness.
11. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
12. Press the clamping bushing into the mounting block until it stops.
13. Coat the sensor with Mobil HP, Valvoline EP633, Pennzoil 707L, or an equivalent. Using your

Wheel Speed Sensor Replacement

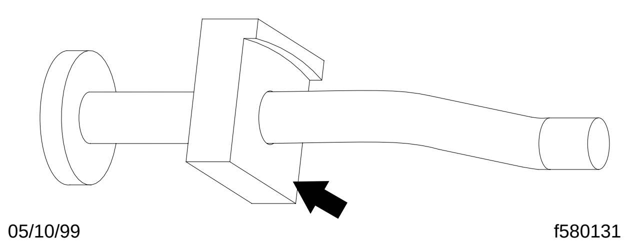
hand, push the sensor into the clamping bushing until it is stopped by the tone wheel.

14. Install the brake drum on the wheel hub. For instructions, refer to **Group 35**.
15. Adjust the rear axle brakes. For instructions, refer to the applicable brake section in this manual.
16. Install the wheel and tire assembly, and tighten the wheel nuts. Use the tightening sequence and torque values listed in **Group 40**.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11-17556-000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. See **Fig. 1**.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the front tires.



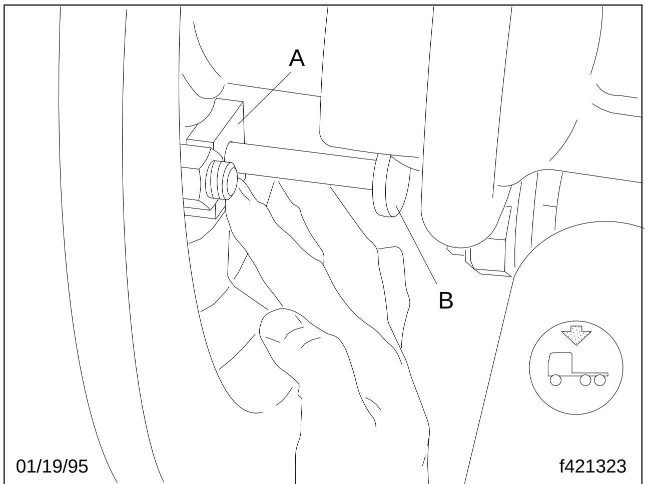
1. Adjustment Tool Slide

Fig. 1, ABS Sensor Adjustment Tool

2. Find the sensor access hole in the rear-axle flange.
   - 2.1 View the inboard side of the brake drum and axle from the rear. The ABS sensor wiring harness should be visible through a hole in the 12 o'clock position.
   - 2.2 Find the S-cam at either the 3 or 9 o'clock position.
   - 2.3 The sensor access hole is opposite the S-cam. The hole is approximately 3/4 inch (19 mm) in diameter.

IMPORTANT: Do not pry or push the sensor with sharp objects.

3. Insert service tool T11-17556-000 in the sensor access hole.
4. Place the slide of the tool on the axle flange to align the tool. See **Fig. 2**.
5. Tap the tool handle lightly with the palm of your hand. This ensures that the sensor is touching the tone wheel.
6. Remove the tool from the wheel and repeat the procedure on the other rear-axle speed sensor.



A. Place the slide against the axle flange.
B. Tap the handle with your hand.

Fig. 2, Position the Tool

7. Remove the chocks from the tires.

Removal

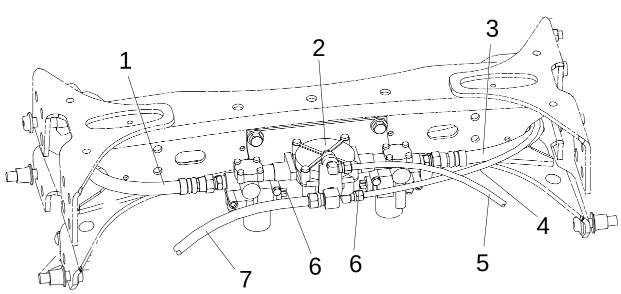
NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Section 54.00** for information on special terminals and connectors, and on ordering tools for them.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the front and rear tires.

WARNING

Release all the compressed air from the air reservoirs before disconnecting any air hose. Disconnecting air hoses from the modulator valves without first releasing the pressure in the air reservoirs can cause the hoses to swing uncontrollably, possibly resulting in personal injury or property damage. Before starting work on the brake system, read Safety Precautions, 100 in this section.

2. Release the pressure from the air reservoirs.
3. Mark the electrical connectors for ease of installation. Disconnect the wiring from the applicable modulator valve assembly. The assembly includes two modulator valves and a service relay valve. See **Fig. 1**.



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1. Delivery Air Line (to RH brake chamber)
2. Service Relay Valve
3. Delivery Air Line (to LH brake chamber)
4. Anti-compounding Line (black, to park brake quick-release/relay valve)
5. Control Air Line (green, from foot pedal valve)
6. Modulator Valve Electrical Connection
7. Supply Air Line (green, from primary air reservoir)

Fig. 1, Modulator Valve Assembly

4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the fasteners attaching the front modulator valve or rear valve assembly to the mounting bracket. Remove the valve or assembly.

NOTE: The modulator valve assemblies can be disassembled if replacement of the service relay valve, automatic traction control valve (if equipped), or one of the modulator valves is needed. For disassembly and assembly instructions, see **Subject 140**.

Installation

1. Install the new front modulator valve or rear modulator valve assembly on the mounting bracket. Tighten the fasteners 18 lbf·ft (24 N·m).
2. Connect the air lines to the valves, as marked during removal.
3. Connect the electrical cable connectors to the valves. Tighten only hand-tight.

Installation Checkout

1. Apply the brakes, turn the ignition switch on, and wait for the ABS indicator light to come on.
2. Listen to the modulator valves cycle one by one, then together diagonally as follows:
   - 4-Channel valve cycle: 1, 2, 3, 4; then 1 and 2 together followed by 3 and 4.
   - 6-Channel valve cycle: 1, 2, 3, 4, 5, 6; then 1, 2, and 3 together followed by 4, 5, and 6.
3. If a valve fails to cycle, turn the ignition switch off and make sure the electrical connections are tight. Then, turn the ignition switch on and listen to the valve cycle again.

   If a valve still fails to cycle, check for fault codes. See **Troubleshooting, 300** for fault-code identification.
4. Apply the brakes and check the modulator valve fittings for leaks. No air leakage is permitted.
5. Remove the chocks from the tires.

Modulator Valve Removal and Installation

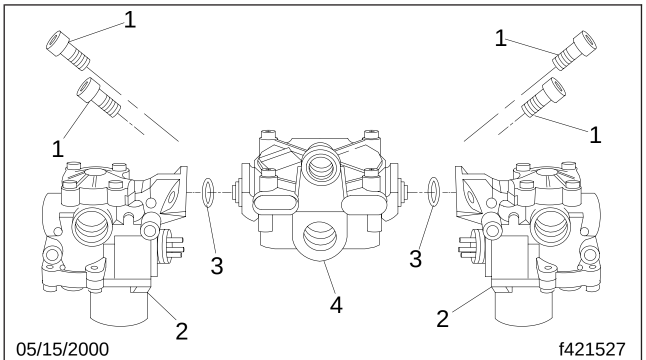
6. Test drive the vehicle to verify that the ABS warning light is functioning correctly.

Disassembly

NOTE: On vehicles equipped with Automatic Traction Control (ATC), the ATC valve can be replaced without removing the modular valve assembly if there is enough room to work.

1. Remove the modulator valve assembly from the crossmember. See **Subject 130** for instructions.
2. Remove the modulator valves from the service relay valve.

   2.1 Using a 6-mm Allen wrench, remove two Allen-head capscrews that attach each modulator valve to the service relay valve. See **Fig. 1**.



1. Capscrew, Allen-Head, M8
2. Modulator Valve
3. O-Ring
4. Service Relay Valve

Fig. 1, Modulator Valve Assembly

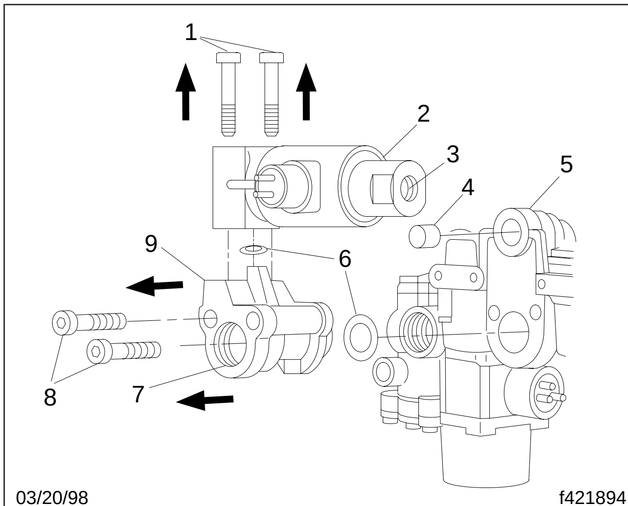
   2.2 Carefully separate the modulator valves from the service relay valve.

   2.3 Remove and discard the O-rings.

3. If the vehicle is equipped with Automatic Traction Control (ATC), remove the ATC valve from the service relay valve. See **Fig. 2**.

   3.1 Using a 5-mm Allen wrench, remove two Allen-head capscrews that attach the adaptor to the service relay valve. Remove the adapter/ATC valve assembly.

   3.2 Using a 6-mm Allen wrench, remove two Allen-head capscrews that attach the ATC valve to the adaptor. Separate the valve from the adaptor.



1. Capscrew, Allen-head, M8
2. ATC Valve
3. Control Port
4. Seal
5. Service Relay Valve
6. O-Ring
7. Supply Port
8. Capscrew, Allen-head, M6
9. Adaptor

Fig. 2, ATC Valve Mounting

   3.3 Remove and discard the seal and two O-rings.

Assembly

1. If the vehicle is equipped with Automatic Traction Control (ATC), install the ATC valve on the service relay valve.

   1.1 Clean the O-ring grooves on the adaptor. Lubricate the small replacement O-ring and install it in the top port in the adaptor.

   1.2 Using two new M8 Allen-head capscrews, install the ATC valve on the adaptor. Tighten the capscrews 12 to 13 lbf·ft (18 to 20 N·m).

   1.3 Lubricate the replacement seal and install it in the control port (upper port) of the service relay valve.

Modulator Valve Disassembly and Assembly

1.4 Lubricate the large replacement O-ring and install it in the groove in the supply port (lower port) of the service relay valve.

1.5 Using two new M6 Allen-head capscrews, install the adaptor on the service relay valve. Tighten the capscrews 48 to 60 lbf·in (542 to 678 N·cm).

2. Install the modulator valves on the service relay valve.

   2.1 Plug any unused ports on the replacement modulator valves.

   2.2 Clean the O-ring surfaces on the modulator and service relay valves. Lubricate the replacement O-rings and place them in the applicable grooves in the valves.

   2.3 Install each modulator valve on the service relay valve with two M8 Allen-head capscrews. Tighten the capscrews 13 to 15 lbf·ft (18 to 20 N·m).

3. Install the modulator valve assembly on the bracket on the crossmember. For instructions, see **Subject 130**.

Installation

IMPORTANT: Some ABS service hubs do not have a tone (tooth) ring installed on the hub. The tone ring must be ordered separately and installed on the hub before installation of the hub onto the axle. Tone rings are made of a special material and require a specific installation procedure for proper installation.

WARNING

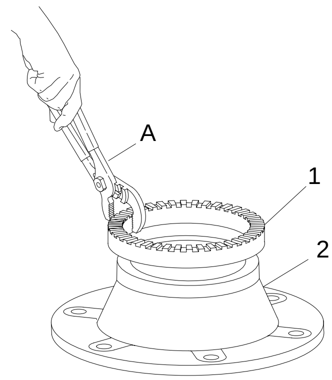
When installing an ABS system, special ABS hubs must be ordered. Machining older hubs to accommodate the installation of tone rings can cause problems due to insufficient hub bore wall thickness. Machining an older hub with insufficient hub bore wall thickness could result in cracking, causing bearing damage and wheel loss. This could cause an accident resulting in personal injury and property damage.

1. Submerge the tone ring in boiling water or place it in an oven at 250°F (121°C) for approximately 15 minutes.

CAUTION

Do not attempt to heat the tone ring with a torch as this can damage the ring.

2. Using pliers, remove the tone ring from the boiling water or oven and center it on the machined area of the hub bore. See **Fig. 1**.
3. While the tone ring is still hot, make sure it is properly centered on the machined surface. Using a rubber mallet, tap the tone ring until it bottoms out around the machined surface on the hub. See **Fig. 2**.
4. Install the hub on the axle. Place a dial indicator with a magnetic base so the dial indicator is against the tone-ring teeth. See **Fig. 3**.
5. Rotate the hub and check the ring for runout. The runout should be less than 0.005 inch (0.13 mm). See **Fig. 4**.
6. Install the wheel. For instructions, see **Group 40**.



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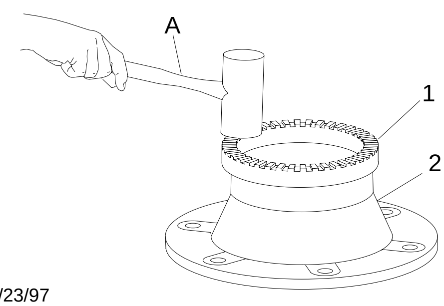
A. Use pliers to apply the ring.
1. Tone Ring 2. Hub

Fig. 1, Install the Ring on the Hub



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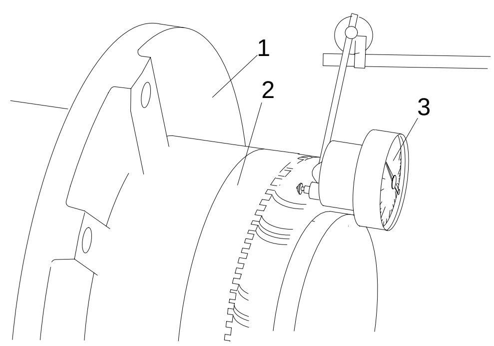
A. Use a rubber mallet.
1. Tone Ring 2. Hub

Fig. 2, Tap the Tone Ring



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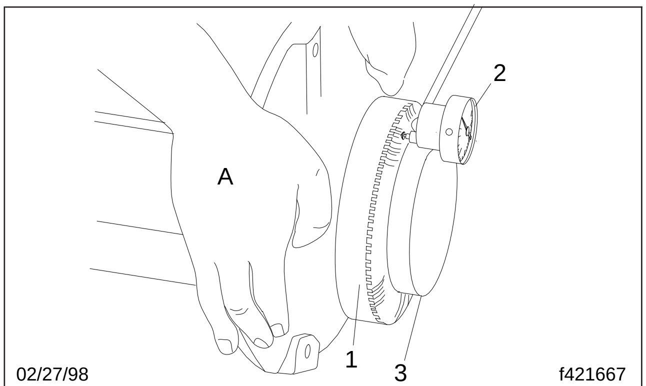
1. Hub
2. Tone Ring
3. Dial Indicator

Fig. 3, Position the Dial Indicator

ABS Tone Ring Installation on Service Hubs



A. Rotate the hub.
1. Tone Ring
2. Dial Indicator
3. Axle

Fig. 4, Check Tone-Ring Runout

Dynamometer Testing Vehicles with ATC

WARNING

Do not test a vehicle equipped with Automatic Traction Control (ATC) on a dynamometer unless the ATC system is disabled. Activation of the ATC on a dynamometer will cause unequal drive-wheel torque that can result in loss of vehicle control and personal injury or death.

Vehicles with ATC must have the ATC disabled before testing the vehicle on a dynamometer. Use one of the following methods to disable the ATC:

- Use the Meritor PC Diagnostics or the Pro-Link electronic diagnostic tool to disable the ATC.
- Press and hold the blink code switch for a least three seconds. Once the system identification code begins, the ATC system has been disabled. See **Table 1** for system ID codes.
- Removing the ABS circuit breaker or fuse, or removing the ECU power connector will disable both the ABS and ATC.

The ATC light on the dash comes on and stays on when the ATC is disabled.

System Identification Blink Codes *		
Blink Code	**Sensors/ Modulators**	**Wheel Positions**
1 Blink	6S/6M	6 x 2
2 Blinks	4S/4M	4 x 4
4 Blinks	6S/4M	6 x 4
5 Blinks	6S/6M	6 x 4

* The system identification blink code, followed by a 4-second pause, repeats until the ignition switch is turned off.

Table 1, System Identification Blink Codes

General Information

⚠ WARNING

Before testing a vehicle equipped with Automatic Traction Control (ATC) on a dynamometer, the ATC system must be disabled. See Subject 160 for instructions. Activation of the vehicle ATC on a dynamometer will cause unequal drive-wheel torque that can result in loss of vehicle control and personal injury or death.

Before testing a wheel speed sensor, modulator valve, or ATC valve, make sure the supply voltage to the antilock braking system (ABS) electronic control unit (ECU) is sufficient (see "ECU Supply Voltage Test") and check for leaks in the ABS pneumatic system.

The sensor and valve resistance tests are given in two steps. First, disconnect the applicable cable from the ECU and measure the resistance across the terminals in the cable connector. If the resistance is within the specified range, both the cable and the sensor or valve are good.

Next, if the resistance reading is not acceptable, disconnect the cable from the sensor or valve and measure the resistance across the sensor or valve terminals. This two-step procedure quickly determines whether the problem is in the cable or the component.

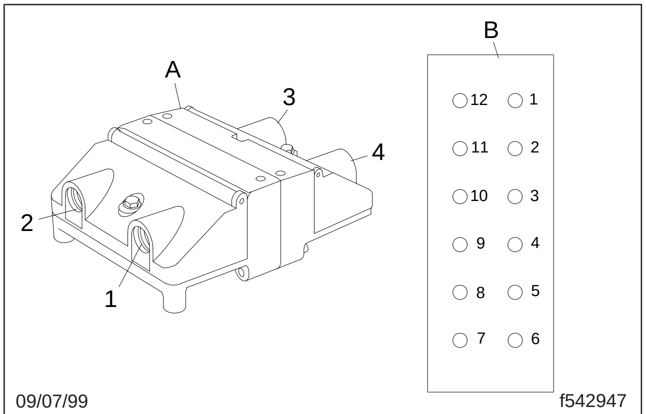
NOTE: The valve circuits and wheel sensors can be tested by Meritor PC diagnostics. If PC diagnostics indicate a problem, test the individual component to determine whether the component or the wiring has failed.

Wire Numbers and Connector Pin Locations

⚠ CAUTION

The ignition switch must be off when connecting or disconnecting connectors from the ECU. Power applied to the ECU during connector installation or removal could damage the pins.

The WABCO D-Version, frame-mounted ECU has several multi-pin connectors that must be disconnected to test the wheel speed sensors, modulator valves, or ATC valve. To disconnect the electrical connectors from the ABS ECU, remove the capscrews and lift the covers. See Fig. 1 to identify the pin locations on the ECU connector. Table 1 provides the wire numbers and circuit descriptions for testing the ABS/ATC components.



A. Frame-mounted ECU.
B. ECU connector pin locations.
1. X1 Connector (gray)
2. X2 Connector (black)
3. X3 Connector (green)
4. X4 Connector (brown—6S/4M, 6S/6M only)

Fig. 1, Frame-Mounted ECU and Pin Locations

ECU Supply Voltage Test

Use Meritor WABCO PC Diagnostics system to check the supply voltage to the ABS ECU. If the PC Diagnostics is not available, use the following procedure to check the voltage.

1. Park the vehicle on a level surface, set the parking brake, shut down the engine, and chock the rear tires.
2. Disconnect the X1 (gray) connector at the ABS ECU.
3. Turn the ignition switch on.
4. Connect a voltmeter between pin 1 and a good chassis ground. The voltmeter must indicate 9.5 to 14 volts.
5. Connect a voltmeter between pin 2 and a good chassis ground. The voltmeter must indicate 9.5 to 14 volts.

Testing

ABS/ATC Circuit Pin and Wire Numbers			
Pin Connector	**Pin Number**	**Wire Number**	**Circuit Description**
X1 Gray	1	376C	ECU Ignition Supply
	2	376C	ECU #2 Positive 12 Volt Supply
	3	376T	Wheel Spin Light and ATC Switch
	4	1587+	J1587+
	5	376R	Retarder Interrupt Signal
	6	1922-/1939-	J1922–/1939–
	7	1922+/1939+	J1922+/1939+
	9	1587	J1587–
	10	376L	ABS Light and Switch
	11	XGRD	ECU Ground
	12	XGRD	ECU Ground
X2 Black	1	—	Not used
	2	378LFI	Left Front Modulator Valve, In
	3	378RF0	Right Front Modulator Valve, Out
	4	378RFI	Right Front Modulator Valve, In
	5	377RF+	Right Front Sensor, High
	6	377RF–	Right Front Sensor, Low
	7	377LF–	Left Front Sensor, Low
	8	377LF+	Left Front Sensor, High
	9	378RF–	Right Front Modulator Valve, Ground
	10	378LF0	Left Front Modulator Valve, Out
	11	378LF–	Left Front Modulator Valve, Ground
	12	—	Not used
X3 Green	1	377LR+	Left Rear Sensor, High
	2	377LR–	Left Rear Sensor, Low
	3	377RR+	Right Rear Sensor, High
	4	377RR–	Right Rear Sensor, Low
	5	378T+	ATC Valve, High
	6	378T–	ATC Valve, Low
	7	378RR0	Right Rear Modulator Valve, Out
	8	378RR–	Right Rear Modulator Valve, Ground
	9	378RRI	Right Rear Modulator Valve, In
	10	378LR0	Left Rear Modulator Valve, Out
	11	378LR–	Left Rear Modulator Valve, Ground
	12	378LRI	Left Rear Modulator Valve, In

ABS/ATC Circuit Pin and Wire Numbers			
Pin Connector	**Pin Number**	**Wire Number**	**Circuit Description**
X4 Brown (third axle)	1	—	Not used
	2	—	Not used
	3	377LT+	Left Third-Axle Sensor, High
	4	377LT–	Left Third-Axle Sensor, Low
	5	377RT+	Left Third-Axle Sensor, High
	6	377RT–	Left Third-Axle Sensor, Low
	7	378RTO	Right Third-Axle Modulator Valve, In
	8	378RT–	Right Third-Axle Modulator Valve, Ground
	9	378RTI	Right Third-Axle Modulator Valve, Out
	10	378LTO	Left Third-Axle Modulator Valve, Out
	11	378LT–	Left Third-Axle Modulator Valve, Ground
	12	378LTI	Left Third-Axle Modulator Valve, In

Table 1, ABS/ATC Circuit Pin and Wire Numbers

6. Turn the ignition switch off.
7. If the voltage at the ECU is not within the specified range, check the battery voltage and test the wiring to the ECU and to ground.
8. Connect the X1 connector to the ECU and remove the chocks from the tires.

ABS Pneumatic System Test

To check for air leaks in the ABS pneumatic system, listen for the sound of escaping air at each valve. To confirm a slow air leak, apply a soap-and-water solution to air line fittings and watch for bubbles.

Wheel Speed Sensor Tests

Wheel Speed Sensor and Circuit Resistance

To check the resistance in a wheel speed sensor circuit, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the sensor cable connector from the ABS ECU. See **Table 1**.
3. Connect ohmmeter probes to the sensor connector terminals and read the resistance.
   - If the resistance is 900 to 2000 ohms, the cable and the sensor circuit are good. Proceed to the "Wheel Speed Sensor Voltage" test.
   - If the resistance is less than 900 ohms or greater than 2000 ohms, perform the next test, "Wheel Speed Sensor Resistance."

Wheel Speed Sensor Resistance

To check the resistance in a wheel speed sensor, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the wheel sensor cable from the chassis harness.
3. Connect ohmmeter probes to the pins on the sensor and read the resistance.
   - If the resistance reading is 900 to 2000 ohms but the resistance noted in the previous test, "Wheel Speed Sensor and Cable Resistance" was not, repair or replace the chassis harness wiring.

Testing

- If the resistance is less than 900 ohms or greater than 2000 ohms, clean the terminals and check the resistance again.
- If the resistance reading is still not correct, replace the sensor. See **Subject 110** for instructions.

4. Install the connectors and remove the chocks from the tires.

Wheel Speed Sensor Voltage

NOTE: PC diagnostics can be used for this test to compare speed signal output of all sensors. A problem will be indicated by low or erratic output.

To check the voltage output of a wheel speed sensor:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine.
2. Chock the tires of the axle not being tested. Raise the vehicle and put jack stands under the axle so the wheels can rotate.
3. Disconnect the applicable connector from the ABS ECU for the sensor being tested. See **Table 1**.
4. Set a digital multimeter to the AC voltmeter mode. Connect the probes to the cable connector terminals for the sensor being tested.
5. Rotate the wheel by hand at a speed of 30 rpm (one-half revolution per second) and read the voltage output. The wheel speed sensor must generate a minimum of 0.2 volt AC.
   - If the voltage is at least 0.2 volt AC, skip to the next step.
   - If the voltage reading is less than 0.2 volt AC, push the sensor in its holder until the sensor touches the tooth wheel. See **Subject 120** for instructions. Repeat the voltage test.
   - If the sensor output is still less than 0.2 volt AC, replace the sensor.
6. Install the connector on the ECU. Remove the jack stands, lower the vehicle, and remove the chocks from the tires.

Modulator Valve Tests

Modulator Valve Function Check

NOTE: Valves can be tested using the Meritor WABCO PC Diagnostics software or the following procedure.

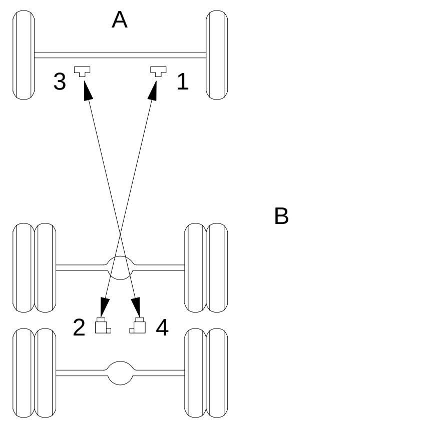
Modulator valves control the air pressure to each affected brake during an ABS function. To make sure the modulator valves are working, listen to them cycle during the ABS self-test.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Turn the ignition switch on.
3. When the ABS warning light comes on, listen for the modulator valves to cycle one by one, then together diagonally. See **Fig. 2**.
   - 4-Channel valve cycle: 1, 2, 3, 4; then 1 and 2 together followed by 3 and 4.
   - 6-Channel valve cycle: 1, 2, 3, 4, 5, 6; then 1, 2, and 3 together followed by 4, 5, and 6.
4. If the valves do not all cycle correctly, turn the ignition off and check the connectors for tightness. Repeat the self-test.
5. If the valves still do not cycle correctly, start the engine and check the air line connections to the valves for leaks. Shut down the engine and tighten the air line fittings. Repeat the self-test.
6. If the valves still do not cycle correctly, check for fault codes. Perform the next test, "Modulator Valve and Cable Resistance."

Modulator Valve and Cable Resistance

To check the resistance in a modulator valve and cable circuit, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the modulator valve connector from the ABS ECU. See **Table 1**.



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NOTE: During the self-test, the valves cycle one by one in order (1–2–3–4), then in pairs diagonally (1/2 and 3/4). A 4-channel valve cycle is shown.

A. Cab B. Curbside

1. Right Front Modulator Valve
2. Left Rear Modulator Valve
3. Left Front Modulator Valve
4. Right Rear Modulator Valve

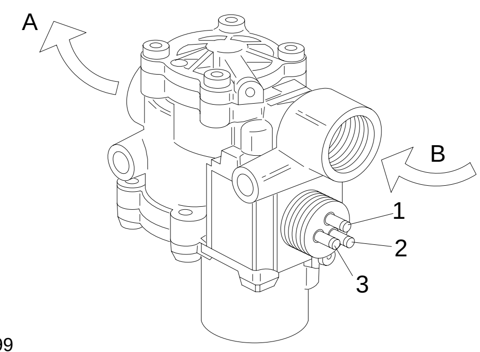
Fig. 2, Modulator Valve Self-Test Sequence

3. Connect ohmmeter probes to the cable connector pins for the modulator valve "In" solenoid and "Ground." Read the resistance. Then, move the probes to the "Out" and "Ground" pins and read the resistance.
4. The resistance in each solenoid coil and cable circuit must be 4 to 8 ohms.
   - If the resistance in each solenoid circuit is 4 to 8 ohms, the cable and modulator valve are good. Install the connector on the ECU and remove the chocks from the tires.
   - If the resistance in either solenoid circuit is less than 4 ohms or greater than 8 ohms, go to the next test, "Modulator Valve Resistance."

Modulator Valve Resistance

To check the resistance in the solenoid coils in an ABS modulator valve, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the cable connector from the modulator valve being tested. See **Table 1**.
3. Connect ohmmeter probes to the modulator valve "In" solenoid and "Ground" terminals and read the resistance. Then, move the probes to the "Out" and "Ground" terminals and read the resistance. See **Fig. 3** for the modulator terminal locations.



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A. Delivery Port B. Supply Port

1. Ground (Common)
2. Exhaust Solenoid (Out)
3. Supply Solenoid (In)

Fig. 3, Modulator Valve Terminals

4. The resistance in each solenoid coil must be 4 to 8 ohms.
   - If the resistance in each solenoid coil is 4 to 8 ohms but the resistance noted in the previous test, "Modulator Valve and Cable Resistance" was not, repair or replace the chassis harness.
   - If the resistance is less than 4 ohms or greater than 8 ohms, clean the terminals on the modulator valve and check the resistance again.
   - If the resistance is still not correct, replace the valve. See **Subject 130** for instructions.
5. Install the cable connectors and remove the chocks from the tires.

ATC Valve Tests

ATC Valve and Cable Resistance

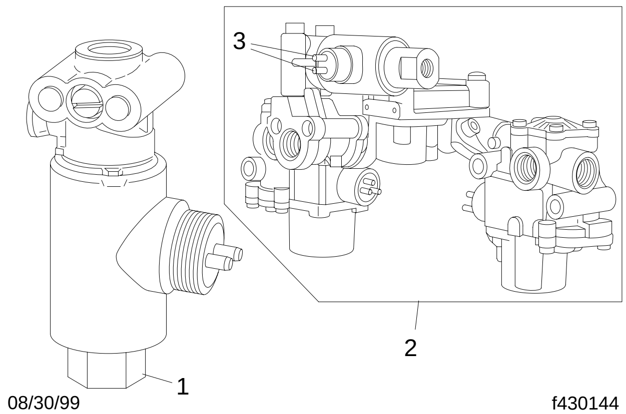
To check the resistance in the ATC valve and cable circuit, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the ATC valve connector (X3) from the ABS ECU. See **Table 1**.
3. Connect ohmmeter probes to the cable connector pins 5 and 6 for the ATC valve and read the resistance.
4. The resistance in the ATC solenoid coil and cable circuit must be 6.4 to 12 ohms.
   - If the resistance is 6.4 to 12 ohms, the ATC valve and cable are good. Install the cable connector on the ECU and remove the chocks from the tires.
   - If the resistance is less than 6.4 ohms or greater than 12 ohms go to the next test, "ATC Valve Resistance."

ATC Valve Resistance

To check the resistance in the solenoid coil in the ATC valve, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the cable connector from the ATC valve. See **Table 1**.
3. Connect ohmmeter probes to the ATC valve terminals and read the resistance. See **Fig. 4**.
4. The resistance of the ATC solenoid coil and its wiring must be 6.4 to 12 ohms.
   - If the resistance is 6.4 to 12 ohms but the resistance noted in the previous test, "ATC Valve and Cable Resistance" was not, repair or replace the electrical cable.
   - If the resistance is less than 6.4 ohms or greater than 12 ohms, clean the terminals on the ATC valve and check the resistance again.



1. ATC Valve
2. Rear Modulator Valve Assembly
3. ATC Solenoid Terminals

Fig. 4, ATC Valve Terminals

   - If the resistance is still not correct, replace the valve. See **Subject 140** for instructions.

5. Install the connectors and remove the chocks from the tires.

Troubleshooting

⚠ WARNING

Before testing a vehicle equipped with Automatic Traction Control (ATC) on a dynamometer, the ATC system must be disabled. See Subject 160 for instructions. Activation of the vehicle ATC on a dynamometer will cause unequal drive-wheel torque that can result in loss of vehicle control and personal injury or death.

This subject includes troubleshooting procedures for diagnosing problems indicated by the ABS warning light(s) or the ATC wheel spin indicator light (if equipped) on the instrument panel. If any of these lights come on after the initial self-test, use one of the following methods to identify the problem:

- Troubleshoot using the Meritor WABCO PC Diagnostics software.
- Troubleshoot using J1587 codes viewed on a computer with Freightliner's ServiceLink installed.
- ProLink 9000®
- Troubleshoot using the instrument panel blink codes.

The J1587-code method provides more information about the specific problem than can be obtained from the blink codes.

The ABS (and ATC, if equipped) system has built-in diagnostics to ensure that all components are operating correctly. The first step is an automatic self-test. Under normal conditions, the ABS warning light(s) (TRACTOR ABS and TRAILER ABS, if equipped) and ATC wheel spin indicator light (WHEEL SPIN) light up on the instrument cluster when the ignition is turned on. After about 3 seconds, these lights should go out if all of the vehicle's ABS/ATC components are working.

If any of the lights stay on, or come back on later, a problem within the ABS/ATC system has occurred. The driver can continue to drive the vehicle, but the ABS system could be partially or completely inoperative.

NOTE: The WHEEL SPIN indicator stays lit when the ATC is controlling wheel spin and blinks continuously if the ATC switch (NORM/SPIN) is activated. These are normal conditions and do not indicate a fault.

To check the type of fault code recorded, stop the vehicle and turn off the engine. Then, turn on the ignition switch, but don't start the engine. If the light stays on after the 3-second self-test, there is an active system fault that must be repaired to ensure proper system operation.

If the light does not stay on, a stored or intermittent fault has been recorded in the ABS electronic control unit (ECU) memory. Stored (historical) faults are faults that occurred during a previous operation of the vehicle but are not still active when the ignition switch is turned on. Intermittent faults may indicate a loose connector or broken wire.

If either light does not come on during the self-test, check the bulb, all related circuit breakers in the electrical panel, or the batteries (the ABS/ATC system requires at least 9.5 volts to function correctly).

If a fault has been corrected since the ABS warning light originally came on, the system must be calibrated by driving the vehicle a short distance at 4 mph (6 km/h) or more before the light will go out.

Using Meritor WABCO PC Diagnostics

Use Meritor PC diagnostics to view fault codes, test component operation, and clear historic faults. If more detailed fault troubleshooting is required, not the J1587 fault codes in PC diagnostics and look it up in the troubleshooting tables.

Using J1587 Fault Codes

Use Freightliner's ServiceLink to diagnose the ABS/ATC system if detailed fault codes are needed or if the diagnosis must be done remotely. Connect a computer, with ServiceLink installed, to the J1587 datalink connector located near the driver's side B-pillar. Follow the instructions found in the ServiceLink manual.

On vehicles equipped with a Level I or Level II instrument control unit (ICU) with the optional MODE/RESET button, the J1587 fault codes can be seen on the driver's display screen. When the MODE/RESET button is pressed, the three parts of the J1587 fault codes (MID, SID, and FMI) appear on the screen in sequence.

Troubleshooting for D-Version ABS

The J1587 fault codes are eight-digit numbers.

- The first three digits refer to the message identifier (MID) that indicates the ECU reporting the fault. The MID is 136 for the ABS/ATC ECU.
- The next three digits (preceded by a lowercase "s") represents the subsystem identifier (SID), which indicates the component at fault.
- The last two digits, the Failure Mode Identifier (FMI), represent the specific problem with the component.

The tables provided in "Troubleshooting Tables" all have an MID code of 136. Each table lists all the FMI codes for a specific component (SID). See **Table 1** for a list of the first six digits of the fault codes with their corresponding components and troubleshooting table references.

J1587 Fault Code Cross-Reference		
MID-SID	**Description**	**Troubleshooting Table**
	Wheel Sensor	
136-001	Left Front	**Table 4**
136-002	Right Front	**Table 5**
136-003	Left Rear	**Table 6**
136-004	Right Rear	**Table 7**
136-005	Left Third Axle *	**Table 8**
136-006	Right Third Axle *	**Table 9**
	Modulator Valve	
136-007	Left Front	**Table 10**
136-008	Right Front	**Table 11**
136-009	Left Rear	**Table 12**
136-010	Right Rear	**Table 13**
136-013	Retarder	**Table 14**
136-014	Ground, Diagonal 1	**Table 15**
136-015	Ground, Diagonal 2	**Table 16**
136-018	ATC Valve (if equipped)	**Table 17**
136-019	Not Used	**Table 18**
136-023	ABS Warning Lamp	**Table 19**
136-231 136-248	J1939 Datalink	**Table 20**
136-249	J1922 Datalink	**Table 21**
136-251	Voltage Diagonal 1 or 2	**Table 22**
136-253	Configuration Errors	**Table 23**
136-254	Miscellaneous Faults	**Table 24**

* Tag axle; 6S/4M and 6S/6M only.

Table 1, J1587 Fault Code Cross-Reference

Active faults cannot be cleared until they are repaired. A wheel sensor fault that has been repaired will not be cleared from memory until the vehicle has been driven at least 4 mph (6 km/h) to calibrate the system.

To erase all the stored fault codes from the ECU memory, refer to the ServiceLink manual. Make sure to make a note of all the stored fault codes before clearing them. Stored faults cannot be cleared if active faults exist.

Using the Instrumention Panel Blink Codes

NOTE: If troubleshooting the system with the Pro-Link 9000, use the instruction booklet that is supplied with the WABCO D-Version ABS cartridge.

Use the ABS CHECK switch and the ABS warning light to:

- Display any active or stored faults (press the ABS CHECK switch 1 second for the Diagnostic mode).
- Erase stored faults from the ECU memory or display the system identification code (press the ABS CHECK switch 3 seconds for the Clear All mode).

NOTE: For simplicity, the ABS warning light will be referred to as the ABS light in this procedure. The warning light(s) on your vehicle may indicate TRACTOR ABS (and TRAILER ABS, if equipped).

Displaying Fault Codes

Fault codes are displayed as follows:

- With the ignition switch on, press the ABS CHECK switch for about 1 second (Diagnostic mode), then release. The ABS light should go out during the 1-1/2 second pause. See **Fig. 1**.

- The ABS light will blink (flash) a number equal to the first digit of the two-digit fault code. The first digit is a number from one to eight.
- After a 1-1/2 second pause, the light will blink the second digit. The number of blinks for the second digit is from one to six.
- After a 4-second pause, the cycle repeats an active fault code until it is repaired.
- If there are no active faults but one or more stored faults are in the ECU memory, the system will display all recorded faults in sequence starting with the most recent, with a 4-second pause between codes.

For example, after the ABS CHECK switch is pressed 1 second and released, fault code 2–3 is indicated by two blinks, a pause of 1-1/2 seconds, followed by three blinks and a 4-second pause.

- If it is an active fault, the same fault code will repeat until the ignition switch is turned off. See **Fig. 1**.
- If it is a stored fault, the next fault in the ECU memory will be displayed after the 4-second pause. See **Fig. 2**. The last fault stored in memory is displayed first; each stored fault is displayed only once.
- If there are no fault codes in the ECU memory, blink code 1–1 is displayed, meaning the system is clear. See **Fig. 3**.

Identifying Blink Codes

The first digit in a blink code identifies the type of fault; the second digit indicates the specific location of the fault. See **Table 2** to identify the blink codes.

CAUTION

The ignition switch must be off when connecting or disconnecting connectors from the ECU. Power applied to the ECU during connector installation or removal could damage the pins.

Once a fault code has been identified, use a multimeter to check the electrical harness at the ABS ECU connectors. See **Testing, 170** for wire numbers and connector pin locations on the frame-mounted ECU.

Refer to the applicable table in "Troubleshooting Tables" for fault codes, pins to be tested, and the correct multimeter readings. Repair or replace the components and/or wiring if the readings are not correct.

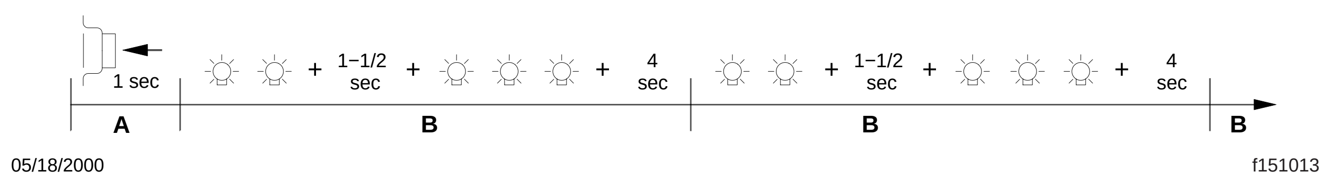
NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to **Group 54** for information on special terminals and connectors, and ordering tools for them.

Refer to the wiring diagrams in **Specifications, 400** when troubleshooting the ABS system.

After the repair is complete, drive the vehicle at least 4 mph (6km/h) to calibrate the ABS/ATC system. Then, shut down the engine and turn the ignition switch on to verify the fault is no longer active. After pressing the ABS CHECK switch 1 second, a 1–1 "no fault" blink code should be displayed if there are no stored faults in the ECU memory.

Erasing Stored Faults

An active fault code cannot be erased from ECU memory but stored faults can be erased all at once without being repaired. Make sure that all stored fault

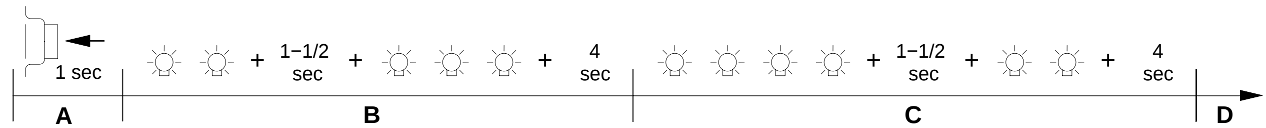


NOTE: An active fault code repeats until the ignition switch is turned off.

A. Press the ABS CHECK switch 1 second. The ABS light goes out during a 1-1/2 second pause.
B. Blink code 2–3: two blinks, a 1-1/2 second pause, three blinks, and a 4-second pause.

Fig. 1, Active Fault Codes Repeat (blink code 2-3 shown)

Troubleshooting for D-Version ABS



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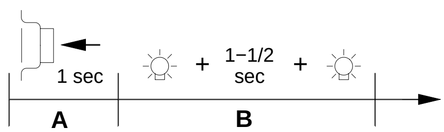
NOTE: The last fault stored is displayed first; each stored fault is displayed only once.

A. Press the ABS CHECK switch 1 second. The ABS light goes out during a 1-1/2 second pause.
B. The newest stored fault is displayed (blink code 2–3 is shown).
C. The second newest stored fault is displayed if one exists (blink code 3–2 is shown).
D. The third newest stored fault is displayed if one exists.

Fig. 2, Stored Fault Codes Display in Sequence



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A. Press the ABS CHECK switch 1 second. The ABS light goes out during a 1-1/2 second pause.
B. Blink code 1–1: one blink, a 1-1/2 second pause, and 1 blink.

Fig. 3, No Faults, System OK

codes are recorded before they are erased because they should be repaired as soon as possible.

Blink Code Cross-Reference

Blink Code	Description	Trouble-shooting
1	No Faults	—
	Modulator Valve	
2-1	Right Front	**Table 1**
2-2	Left Front	**Table 1**
2-3	Right Rear	**Table 1**
2-4	Left Rear	**Table 1**
2-5	Not Used (6M only)	—
2-6	Not Used (6M only)	—
	Wheel Sensor Air Gap	
3-1	Right Front	**Table 5**
3-2	Left Front	**Table 4**
3-3	Right Rear	**Table 7**
3-4	Left Rear	**Table 6**
3-5	Right Third Axle (6S/4M only)	**Table 9**
3-6	Left Third Axle (6S/4M only)	**Table 8**
	Sensor Short or Open Circuit	
4-1	Right Front	**Table 5**
4-2	Left Front	**Table 4**
4-3	Right Rear	**Table 7**
4-4	Left Rear	**Table 6**
4-5	Right Third Axle (6S/4M only)	**Table 9**
4-6	Left Third Axle (6S/4M only)	**Table 8**
	Sensor Erratic Signal	
5-1	Right Front	**Table 5**
5-2	Left Front	**Table 4**
5-3	Right Rear	**Table 7**
5-4	Left Rear	**Table 6**
5-5	Right Third Axle (6S/4M only)	**Table 9**
5-6	Left Third Axle (6S/4M only)	**Table 8**
	Tone Wheel	
6-1	Right Front	**Table 5**
6-2	Left Front	**Table 4**
6-3	Right Rear	**Table 7**
6-4	Left Rear	**Table 6**
6-5	Right Third Axle (6S/4M only)	**Table 9**
6-6	Left Third Axle (6S/4M only)	**Table 8**
	System Function *	
7-1	J1922 or J1939 Datalink	**Table 20** **Table 21**

Blink Code Cross-Reference		
Blink Code	Description	Trouble-shooting
		Table 24
7-2	ATC Valve	Table 17
7-3	Retarder Relay † (third brake)	Table 14
7-4	ABS Warning Light	Table 19
7-5	ATC Configuration	Table 23
7-6	Not Used	Table 18
	ECU	
8-1	Low Power Supply	Table 15
		Table 16
8-2	High Power Supply	Table 22
8-3	Internal Fault	Table 15
		Table 16
		Table 20
		Table 24
8-4	System Configuration	Table 23
		Table 24
8-5	Ground	—

* Reconfigure the ECU if fault messages appear for components not installed on the vehicle.

† The ECU detects only fault code 136 S013 03, indicating the retarder relay is shorted to power. See "Troubleshooting Tables," **Table 1**. If the retarder relay circuit is open or if it is shorted to ground, the system will not indicate a fault.

Table 2, Blink Code Cross-Reference

Stored faults can be erased from the ECU memory as follows:

- Press the ABS CHECK switch for 3 to 6 seconds (Clear All mode).
- After releasing the switch, the ABS light will go out during the 1-1/2 second pause.
- If there were stored faults but no active faults, the ABS light will blink eight times meaning all stored faults have been cleared. See **Fig. 4**. (If there are active faults, only the system identification code will be displayed. See **Fig. 5**.)
- After 4-second pause, the ABS light will display the system identification code followed by another 4-second pause repeatedly until the ignition switch is turned off.

If there are active faults, only the system identification code will be displayed. See **Fig. 5**.

The system identification code indicates the number of ABS wheel speed sensors (S) and modulator valves (M) installed on the vehicle. See **Table 3** for a list of system identification codes.

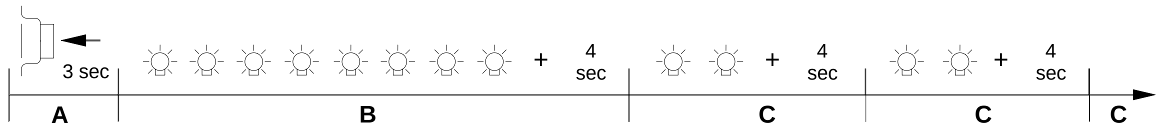
If a fault cannot be repaired or erased from ECU memory, contact your Meritor district service manager or call Meritor WABCO at 1-800-535-5560.

System Identification Blink Codes		
Blink Code	Sensors/ Modulators	Vehicle Wheel Positions
1 Blink	6S/6M	6 x 2
2 Blinks	4S/4M	4 x 4
4 Blinks	6S/4M	6 x 4
5 Blinks	6S/6M	6 x 4

Table 3, System Identification Blink Codes

Troubleshooting Tables

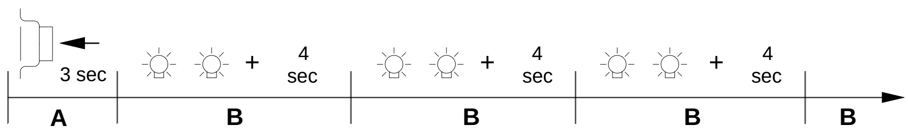
Troubleshooting for D-Version ABS



05/18/2000 f151015

A. Press the ABS CHECK switch 3 seconds. The ABS light goes out during a 1-1/2 second pause.
B. Eight quick blinks followed by a 4-second pause. (Faults cleared.)
C. The system ID code followed by a 4-second pause repeats until the ignition switch is turned off. (The system ID code for a 4 x 4 vehicle is two quick blinks.)

Fig. 4, Stored Faults Cleared



05/18/2000 f151016

A. Press the ABS CHECK switch 3 seconds. The ABS light goes out during a 1-1/2 second pause.
B. The system ID code followed by a 4-second pause repeats until the ignition switch is turned off.

Fig. 5, Faults Not Cleared (active faults still exist)

J1587 Fault 136-001 Left Front Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	001	01	Incorrect sensor air gap	1. Adjust the sensor. Check the AC voltage across pins 7 and 8 of the black X2 ECU connector while rotating the LF wheel 30 rpm.	Voltage is 0.2 Vac or greater	Sensor adjustment solved the problem.	3-2
					Voltage is less than 0.2 Vac	Check for excessive wheel bearing end play and hub runout. Repair as needed.	
136	001	02	Incorrect tire size			Check for correct tire size and mixed tire sizes. Check for correct number of teeth on tone wheel. Correct as needed.	5-2

J1587 Fault 136-001 Left Front Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	001	03	Sensor shorted to power	2. Measure the voltage across pins 7 of the X2 (black) connector and a good chassis ground. Repeat the test between pin 8 and ground.	Measurable voltage at either pin	Repair short to power in circuit(s) 377LF+ and 377LF– in chassis harness and sensor cable. If problem is in the sensor harness, replace the sensor.	4-2
					No voltage at either pin	Repeat the test and check for intermittent short to power in circuits 377LF+ and 377LF–. Suspect ECU is at fault if the problem persists.	
136	001	04	Short to ground	3. Measure the resistance between pin 7 of the X2 (black) connector and a good chassis ground. Repeat the test between pin 8 and ground.	Resistance between either pin and ground is less than 100,000 ohms	Repair the short to ground in circuit(s) 377LF+ and 377LF– in chassis harness or sensor cable. If problem is in sensor harness, replace the sensor.	4-2
					Resistance between either pin and ground is greater than 100,000 ohms	Repeat the test for intermittent short to ground in circuits 377LF+ and 377LF–. Suspect ECU is at fault if the problem persists	
136	001	05	Open circuit	4. measure the resistance between pins 7u and 8 of the X2 (black) connector.	Resistance is 900–2000 ohms	Repeat the test and check for intermittent open or short in circuits 377LF+ and 377LF–. Suspect ECU at fault if the problem persists.	4-2
					Resistance is greater than 2000 ohms OR less than 900 ohm.	Perform test 5.	
				5. Disconnect the sensor connector from the chassis harness. Measure the resistance between the pins on the sensor connector.	Resistance is 900–2000 ohms	Repair open or short in circuit(s) 377LF+ and 377LF– in chassis harness.	4-2
					Resistance is greater than 2000 ohms OR less than 900 ohms	Replace the sensor.	
136	001	06	Short circuit			Perform tests 4 and 5.	4-2

Troubleshooting for D-Version ABS

J1587 Fault 136-001 Left Front Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	001	07	Damaged tone ring			Inspect tone ring for damage and missing teeth. Make sure correct tooth wheel is installed (100-tooth is normal application). Repair as needed.	6-2
136	001	08	Excessive wheel slip			Check sensor adjustment. This fault usually occurs when there is excessive tire spin for more than 16 sec.	3-2
136	001	09	Wire mismatch	6. Check for mixed sensor connection. Using Meritor PC Diagnostics, spin each wheel individually. Check that output is from the correct sensor.		Correct wiring connections, as needed.	5-2
136	001	10	Intermittent signal	7. Adjust the sensor. Using the wheel sensor output screen in Meritor PC Diagnostics, spin the wheel or drive the vehicle and check for intermittent or erratic signal.	Signal output OK	Adjustment solved the problem. Make sure brake chatter is not causing the problem.	3-2
					Signal output incorrect	Check for intermittent wheel sensor circuit connections. Cause could be due to brake chatter. Repair as needed.	5-2
136	001	11	Erratic signal			Perform test 7.	
136	001	12	Frequency too high	8. Check sensor wiring and connectors for intermittent contact.	Wiring OK	Suspect ECU at fault if problem persists.	5-2
					Wiring incorrect	Repair wheel sensor circuit, as needed.	

Table 4, Left Front Wheel Sensor Troubleshooting (SID = s001)

Right Front Wheel Sensor Troubleshooting (SID = s002)					
J1587 Fault Code			**Problem**	**Diagnostic Procedure**	**Blink Code**
MID	**SID**	**FMI**			
136	002	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–1

Table 5, Right Front Wheel Sensor Troubleshooting (SID = s002)

Left Rear Wheel Sensor Troubleshooting (SID = s003)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	003	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 1 and 2 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–4

Table 6, Left Rear Wheel Sensor Troubleshooting (SID = s003)

Right Rear Wheel Sensor Troubleshooting (SID = s004)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	004	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 3 and 4 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–3

Table 7, Right Rear Wheel Sensor Troubleshooting (SID = s004)

Left Third Wheel Sensor Troubleshooting (SID = s005)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	005	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 3 and 4 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–6

Table 8, Left Third Wheel Sensor Troubleshooting (SID = s005)

Right Third Wheel Sensor Troubleshooting (SID = s006)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	006	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–5

Table 9, Right Third Wheel Sensor Troubleshooting (SID = s006)

Troubleshooting for D-Version ABS

Left Front Modulator Valve Troubleshooting (SID = s007)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	007	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X2 (black) connector, and between pins 2 and 11. A good measurement should be between 4 and 8 ohms.	2–2

Table 10, Left Front Modulator Valve Troubleshooting (SID = s007)

Right Front Modulator Valve Troubleshooting (SID = s008)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	008	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 3 and 9 of the X2 (black) connector, and between pins 4 and 9. A good measurement should be between 4 and 8 ohms.	2–1

Table 11, Right Front Modulator Valve Troubleshooting (SID = s008)

Left Rear Modulator Valve Troubleshooting (SID = s009)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	009	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X3 (green) connector, and between pins 12 and 11. A good measurement should be between 4 and 8 ohms.	2–4

Table 12, Left Rear Modulator Valve Troubleshooting (SID = s009)

Right Rear Modulator Valve Troubleshooting (SID = s010)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	010	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 7 and 8 of the X3 (green) connector, and between pins 9 and 8. A good measurement should be between 4 and 8 ohms.	2–3

Table 13, Right Rear Modulator Valve Troubleshooting (SID = s010)

Left Third Modulator Valve Troubleshooting (SID = s011)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	011	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X4 (brown) connector, and between pins 12 and 11. A good measurement should be between 4 and 8 ohms.	2–6

Table 14, Left Third Modulator Valve Troubleshooting (SID = s011)

Right Third Modulator Valve Troubleshooting (SID = s012)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	012	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 7 and 8 of the X4 (brown) connector, and between pins 9 and 8. A good measurement should be between 4 and 8 ohms.	2–5

Table 15, Right Third Modulator Valve Troubleshooting (SID = s012)

Retarder Troubleshooting (SID = s013)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	013	03	Shorted to power	Measure the voltage between pin 5 of the X1 (gray) connector and ground. If the measurement indicates a voltage, the relay circuit is shorted to power.	7–3

Table 16, Retarder Troubleshooting (SID = s013)

Ground (diagonal 1–right front, left rear) Troubleshooting (SID = s014)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	014	04	Voltage, diagonal 1, low voltage/open circuit	Check the 10A circuit breaker F43. Check pin 1 in the X1 (gray) connector for proper contact. Check circuit 16, 16E. Check the vehicle batteries and charging system.	8–1

Table 17, Ground (diagonal 1; right front, left rear) Troubleshooting (SID = s014)

Troubleshooting for D-Version ABS

Ground (diagonal 2–left front, right rear) Troubleshooting (SID = s015)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	015	04	Voltage, diagonal 2, low voltage/open circuit	Check the 10A circuit breaker. Check pin 1 in the X1 (gray) connector for proper contact. Check circuit 16A,16F.	8–1

Table 18, Ground (diagonal 2; left front, right rear) Troubleshooting (SID = s015)

ATC Valve Troubleshooting (SID = s018)					
J1587 Fault Code *			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	018	03	ATC valve, shorted to power	Measure the voltage between pin 5 of the X3 (green) connector and ground, and pin 6 of the X3 connector and ground. If measurements indicate a voltage, the ATC valve is shorted to power.	7–2

* Reconfigure the ECU if the fault message appears but ATC is not installed.

Table 19, ATC Valve Troubleshooting (SID = s018)

Warning Light Troubleshooting (SID = s023)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	023	05	Warning Light	Check the bulb and continuity of the warning light circuit. Was the blink code switch activated longer than 16 seconds? If so, cycle the ignition off and on to verify the fault.	7–4

Table 20, Warning Light Troubleshooting (SID = s023)

J1939 Datalink Troubleshooting (SID = s231)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	231	02	J1939 plausibility error	Check the speedometer calibration. Check for tire size mismatch.	7–1

Table 21, J1939 Datalink Troubleshooting (SID = s231)

J1922 Datalink Troubleshooting (SID = s249)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	249	05	The J1922 datalink has an open circuit.	Check the J1922 datalink connections. Check continuity of the datalink wires. Reconfigure the ECU if the fault message appears but no J1922 datalink is installed.	7–1

Table 22, J1922 Datalink Troubleshooting (SID = s249)

Overvoltage Troubleshooting (SID = s251)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	251	03	Overvoltage, diagonal 1 or 2	Check the alternator output and the battery voltage. Supply voltage is greater than 14 volts for more than 5 seconds.	8–2

Table 23, Overvoltage Troubleshooting (SID = s251)

Configuration Troubleshooting (SID = s253)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	253	01	ATC configuration	Check the wires responsible for parameter setting.	7–5
136	253	02	EEPROM or ABS configuration, wheel parameter incorrect	Cycle the ignition off and on. If the fault detection repeats, replace the ABS ECU.	8–4
136	253	12	EEPROM, checksum	Check the parameter setting. Diagnostic device disconnected during active diagnosis. Cycle the ignition off and on. If the fault detection repeats, replace the ABS ECU.	

Table 24, Configuration Troubleshooting (SID = s253)

Miscellaneous ABS/ATC Troubleshooting (SID = s254)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	254	02	Internal error	Cycle the ignition off and on. If the fault detection repeats, replace the ABS ECU.	8–3

Table 25, Miscellaneous ABS/ATC Troubleshooting (SID = s254)

Wiring Diagrams

The following figures illustrate detailed system wiring diagrams and harness wiring diagrams.

See **Fig. 1**, **Fig. 2**, and **Fig. 3** for ABS system wiring with J1922.

See **Fig. 4**, **Fig. 5**, and **Fig. 6** for ABS system wiring with J1939.

See **Fig. 7** and **Fig. 8** for modulator valve wiring

See **Fig. 9** for exhaust brake interrupt relay wiring.

See **Fig. 10** for ATC switch harness wiring.

See **Fig. 11** for ABS relay to engine brake wiring.

See **Fig. 12** for ABS harness at B-pillar wiring.

See **Fig. 13** for ABS diagnostic switch wiring.

Specifications

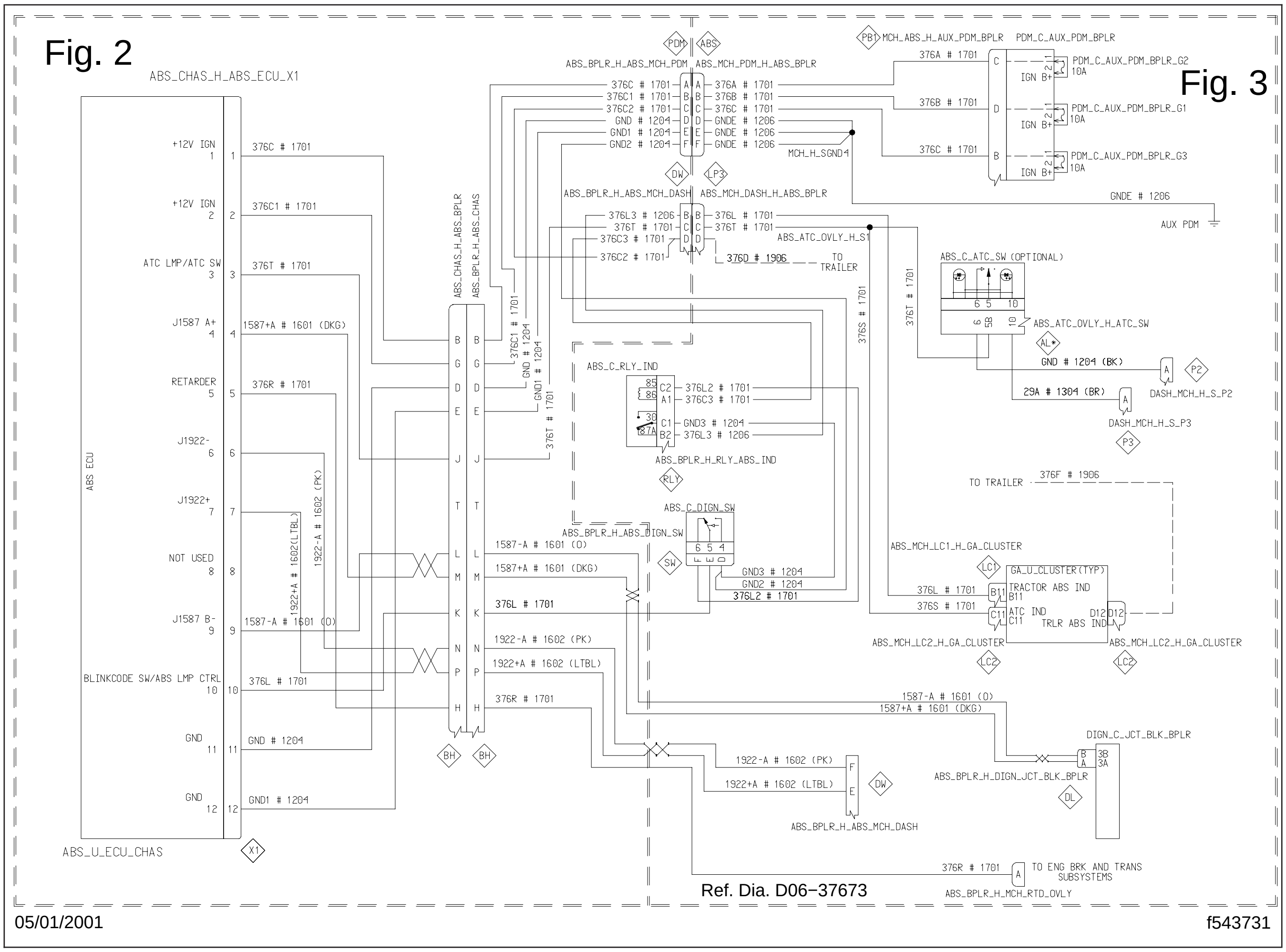


Fig. 1, ABS System Wiring with J1922

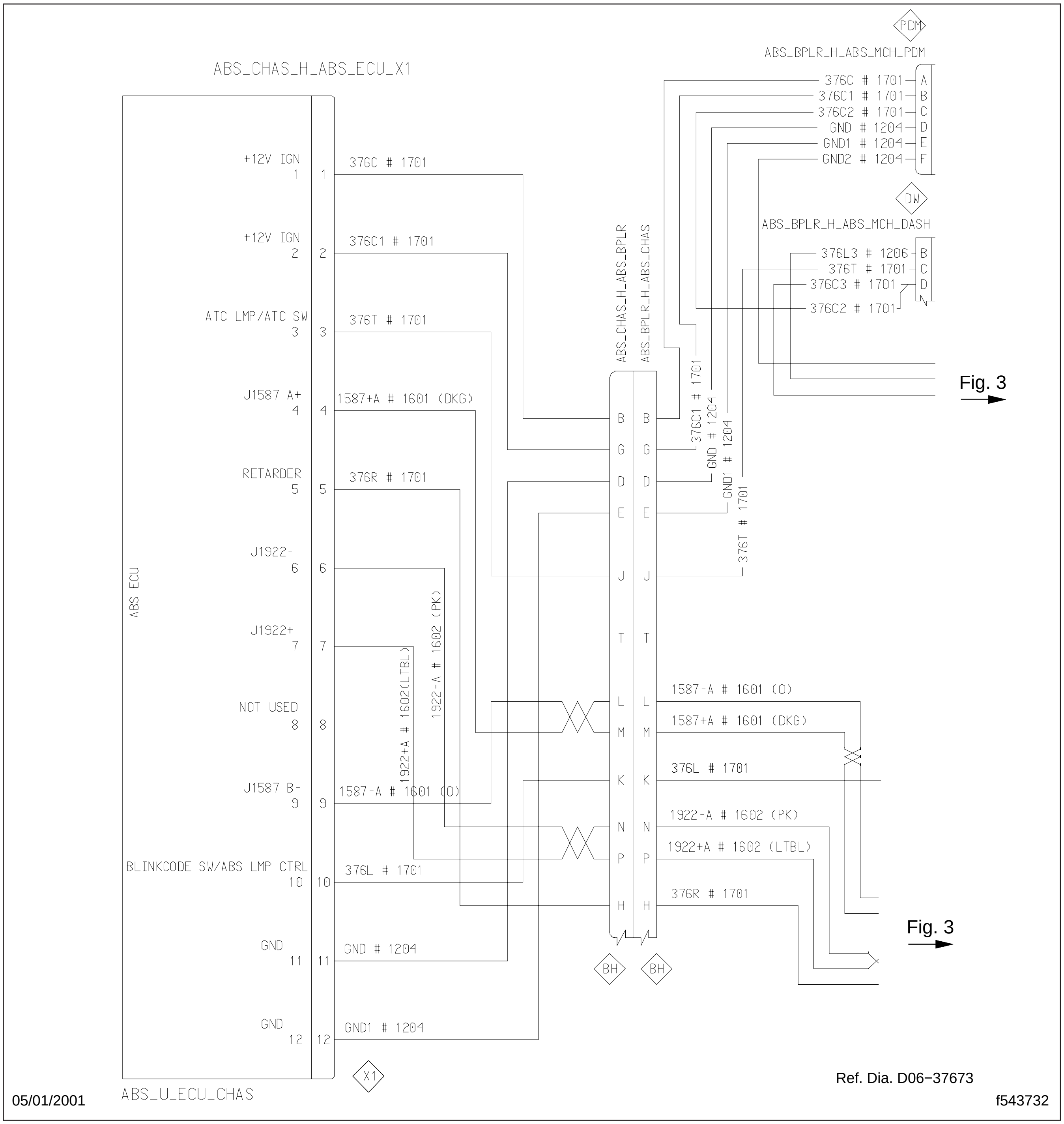


Fig. 2, ABS System Wiring with J1922 (detail)

Specifications

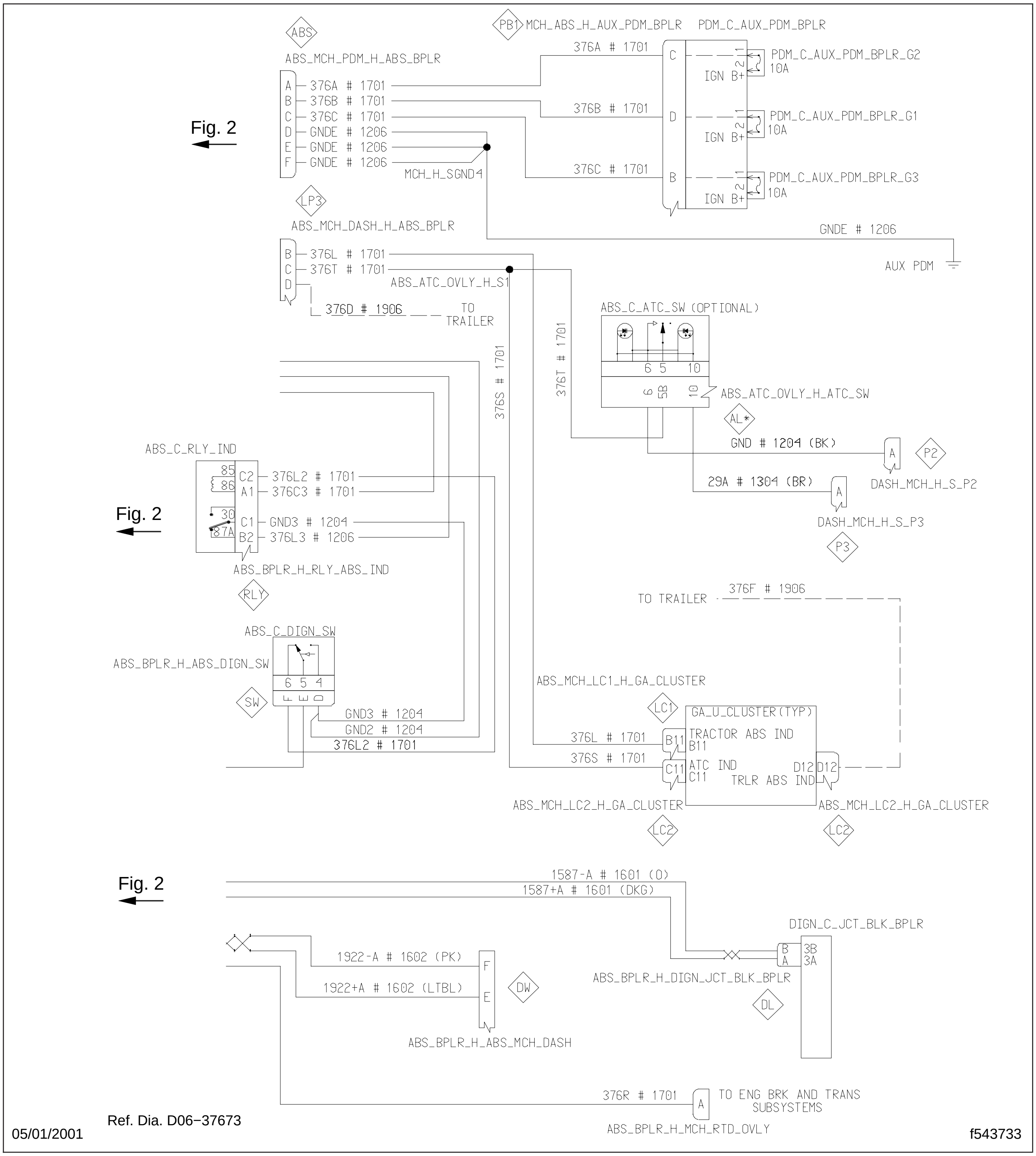


Fig. 3, ABS System Wiring with J1922 (detail)

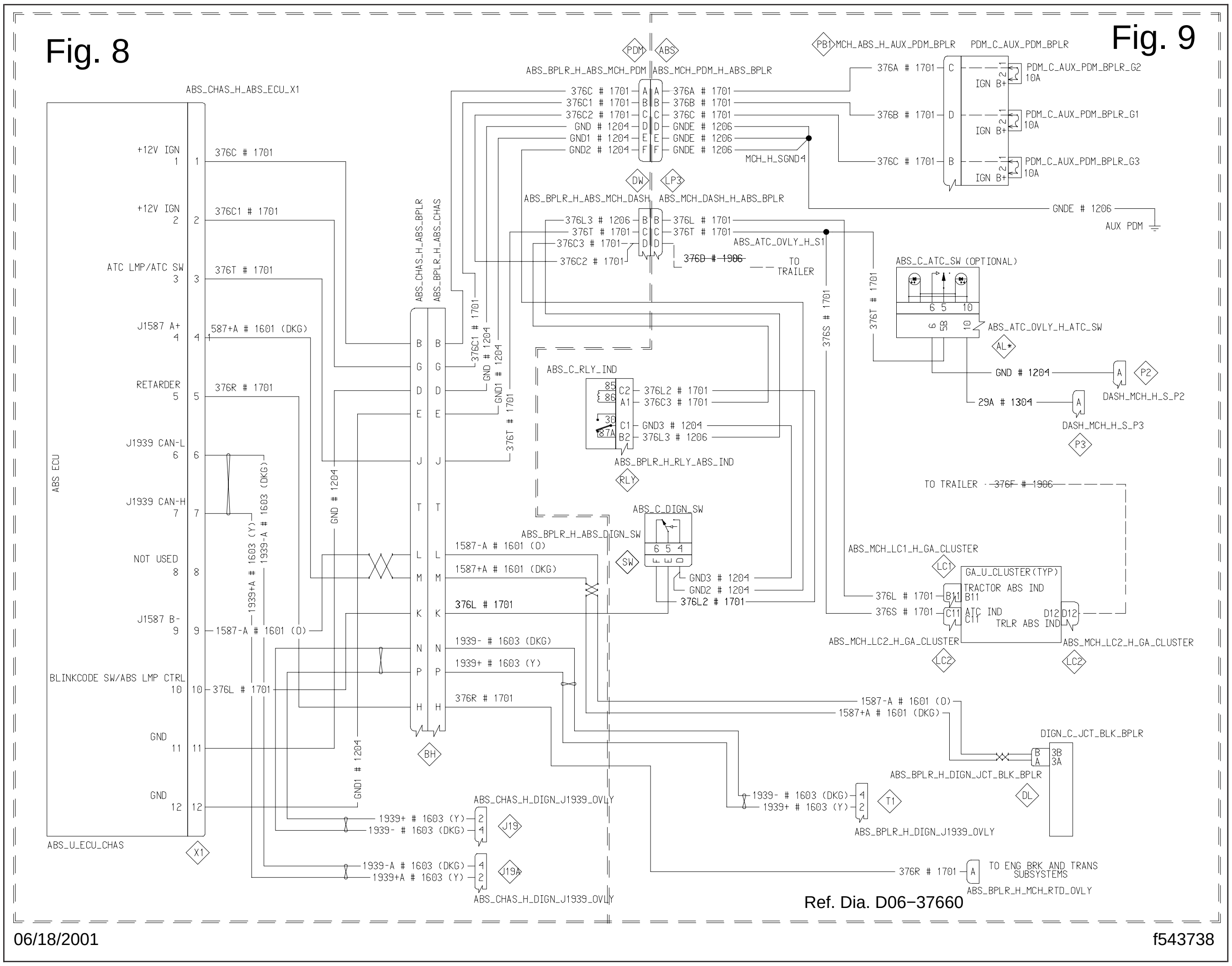


Fig. 4, ABS System Wiring with J1939

Specifications

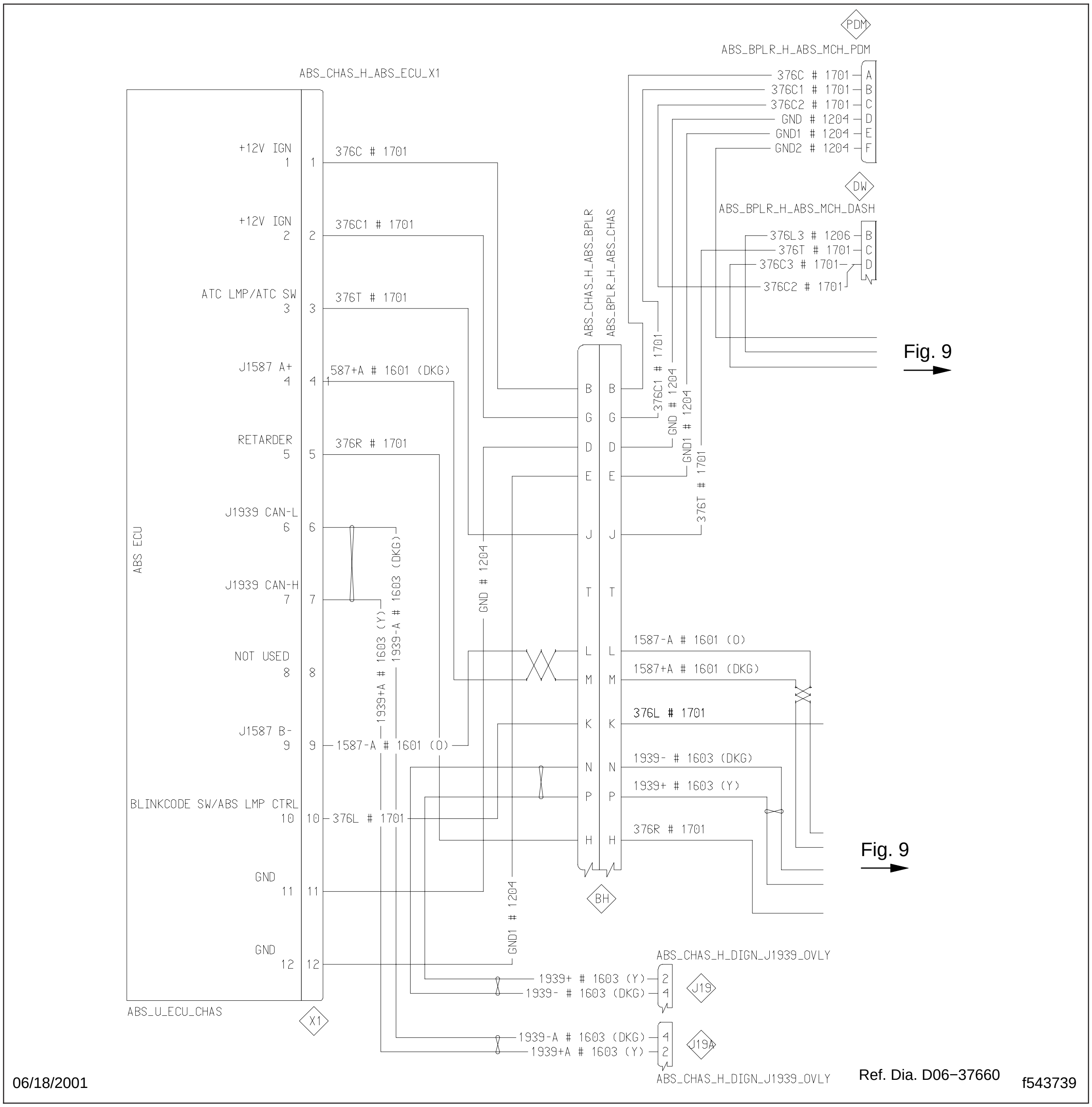


Fig. 5, ABS System Wiring with J1939 (detail)

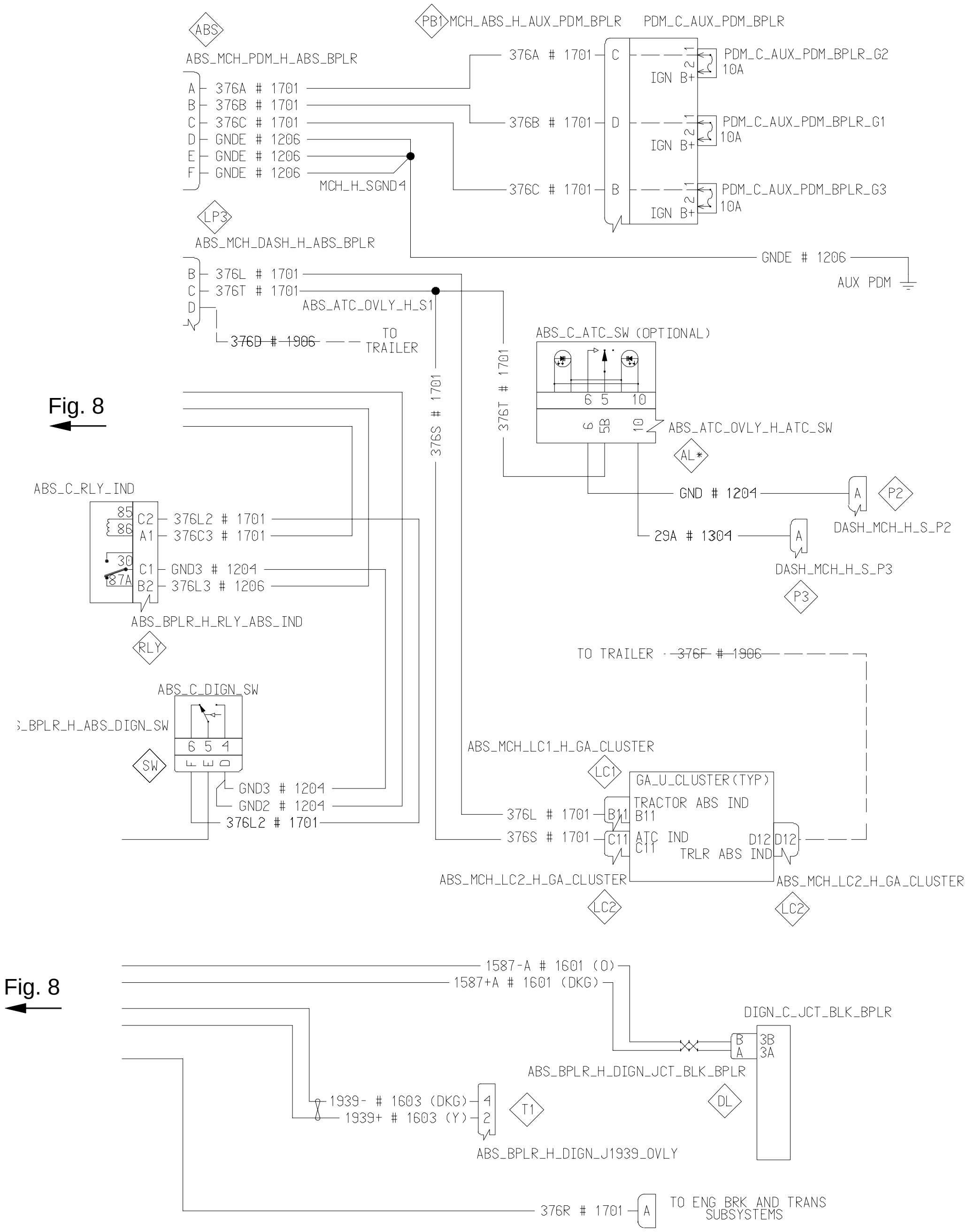


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Fig. 6, ABS System Wiring with J1939 (detail)

Specifications

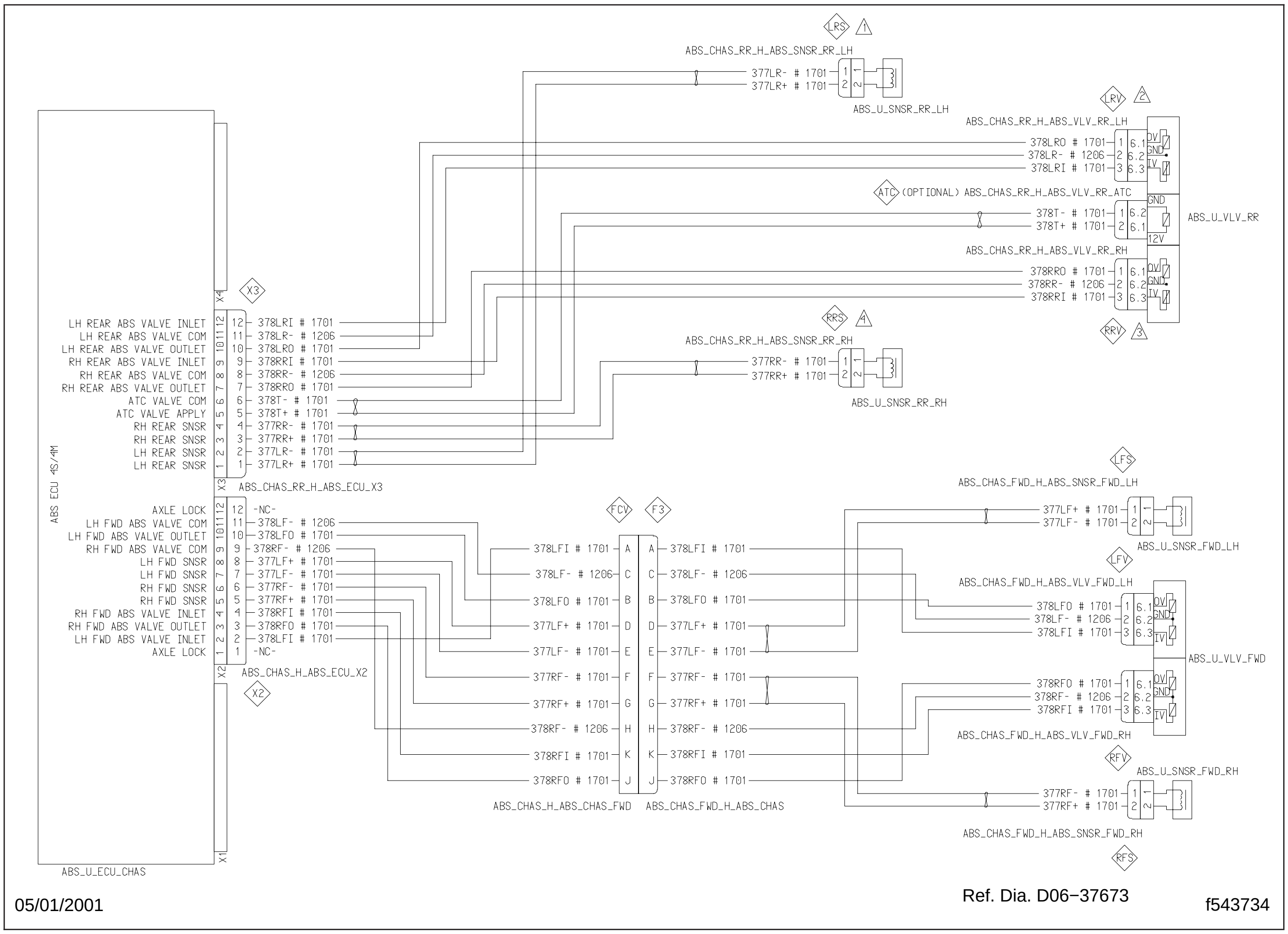


Fig. 7, Modulator Valve and Sensor Wiring

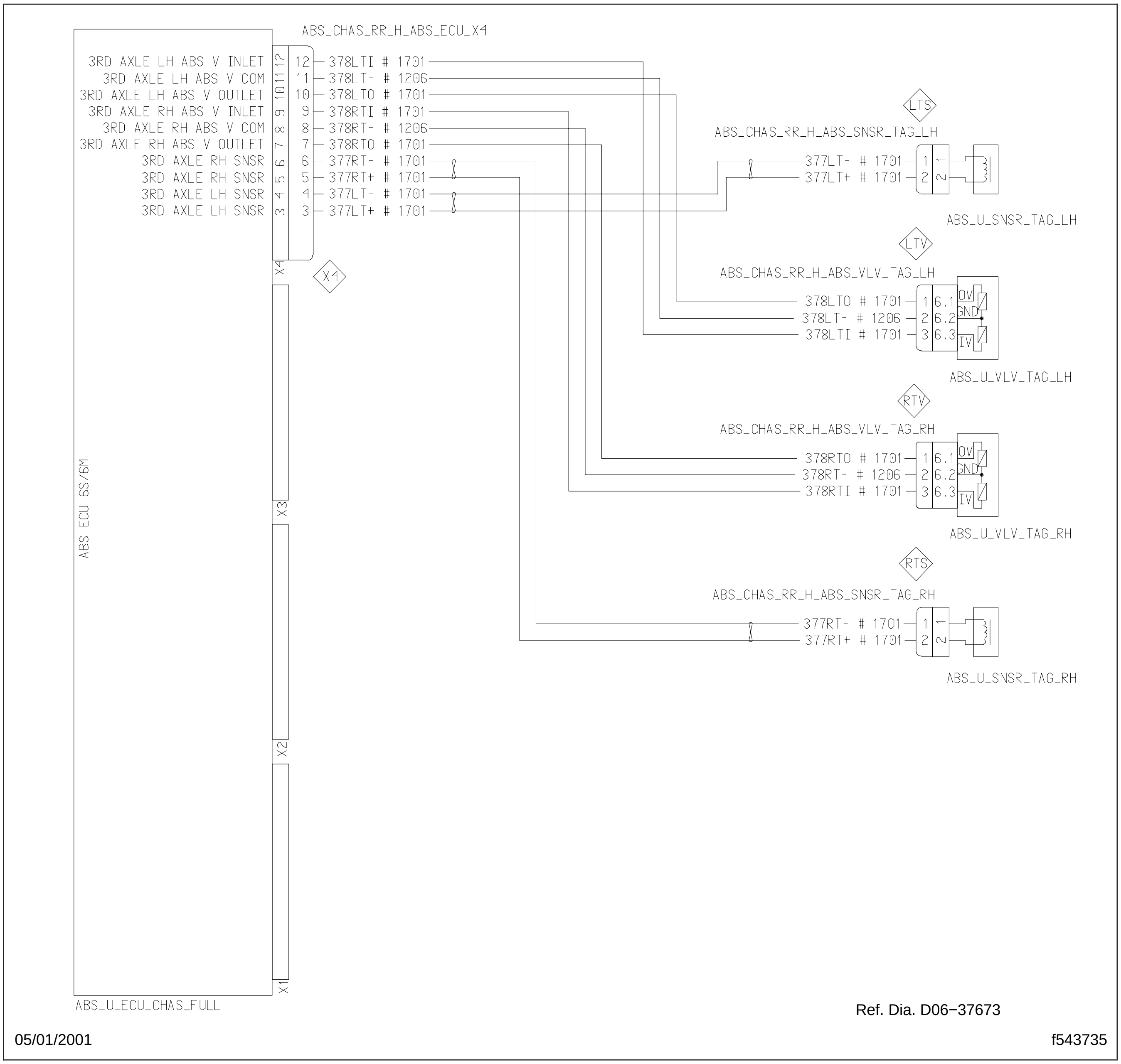


Fig. 8, Modulator Valve and Sensor Wiring (tag axle)

Specifications

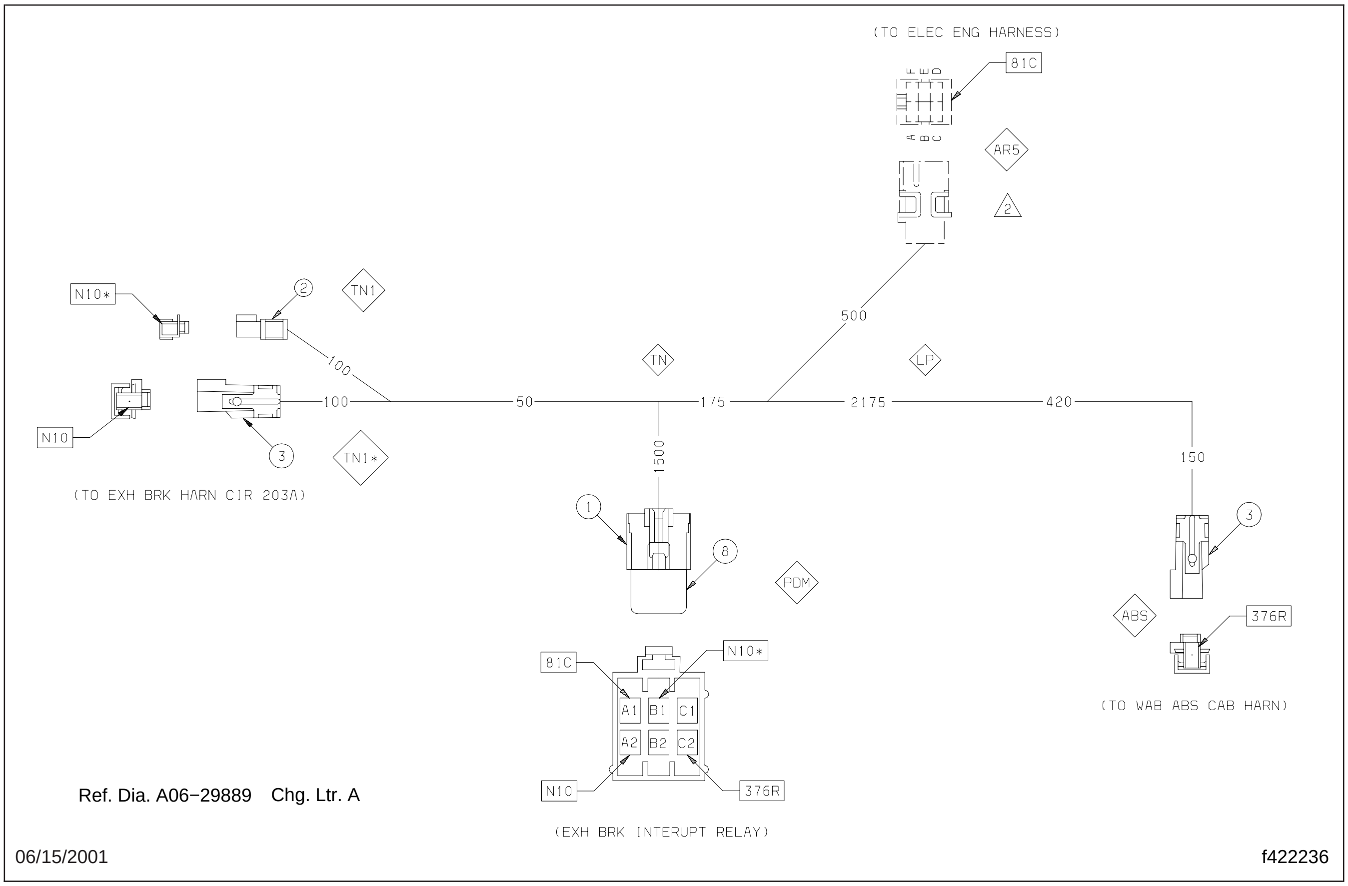
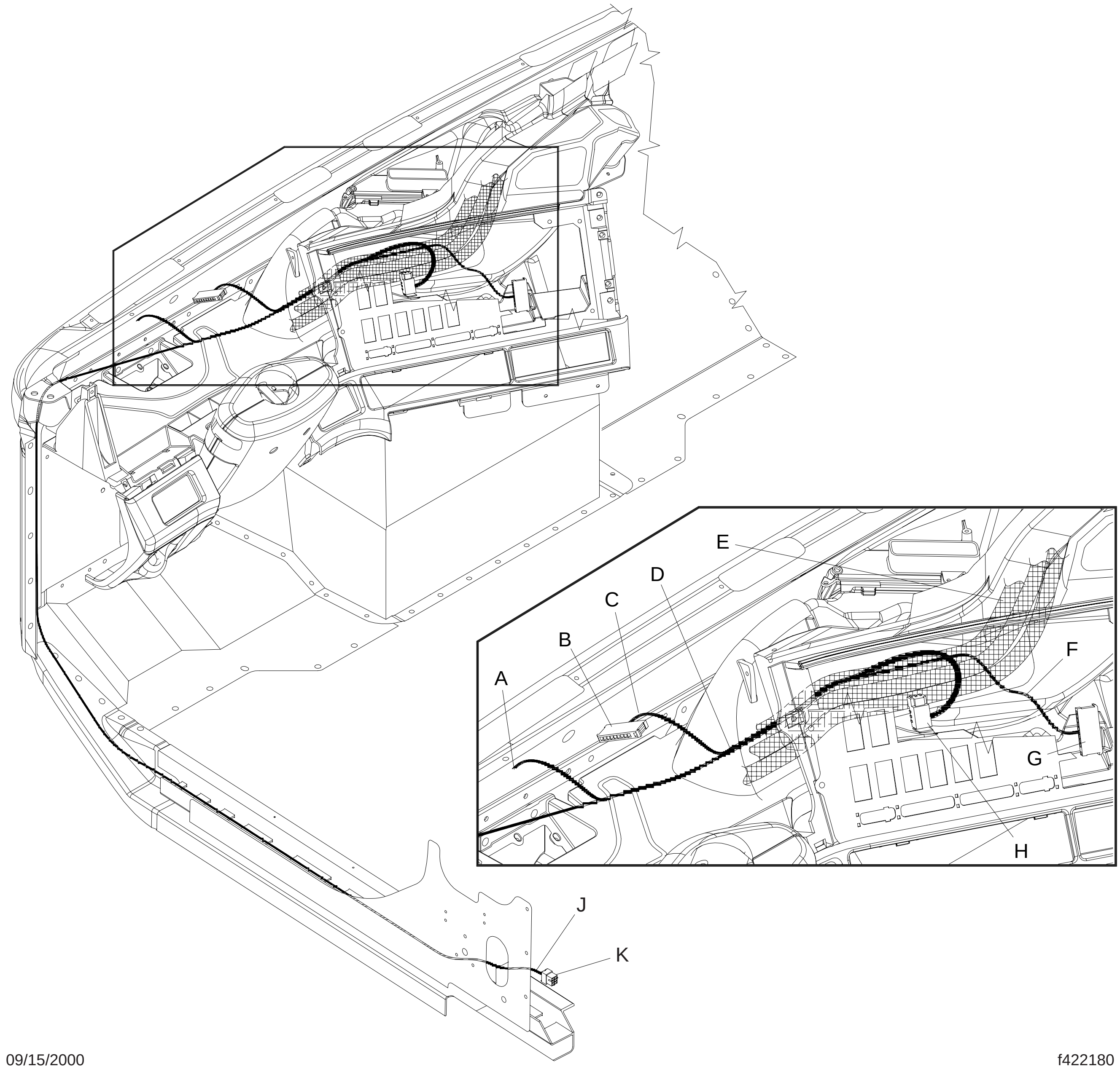


Fig. 9, Exhaust Brake Interrupt Relay Wiring



A. Circuit 376S
B. Splicepack
C. Ground Circuit
D. Harness
E. Main Cab Harness
F. Circuit 29A
G. Splicepack
H. ATC Switch Connect
J. Circuits 376S and 376T
K. Main Cab Harness Plug for ABS

Fig. 10, ATC Switch Harness

Specifications

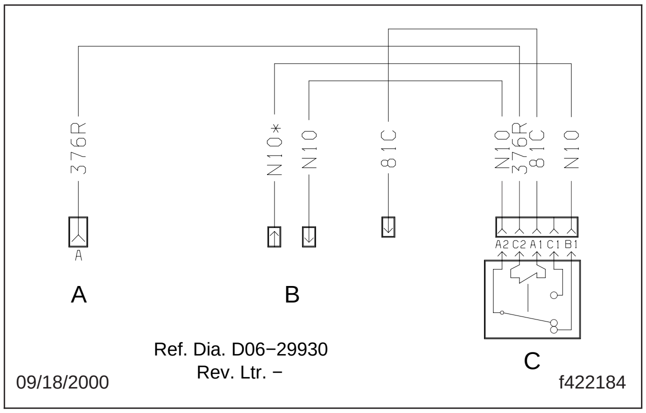
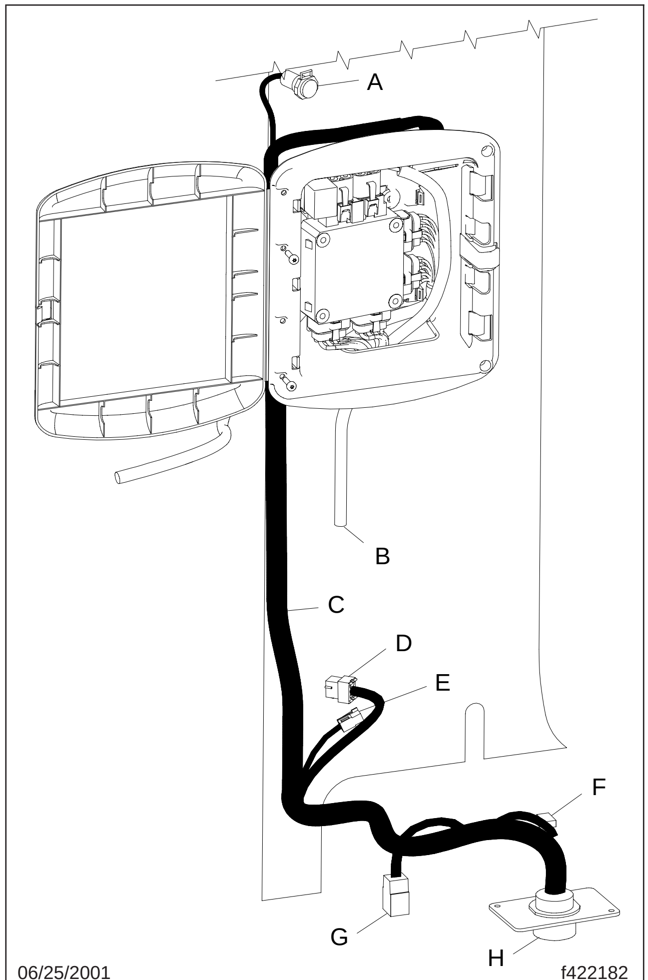
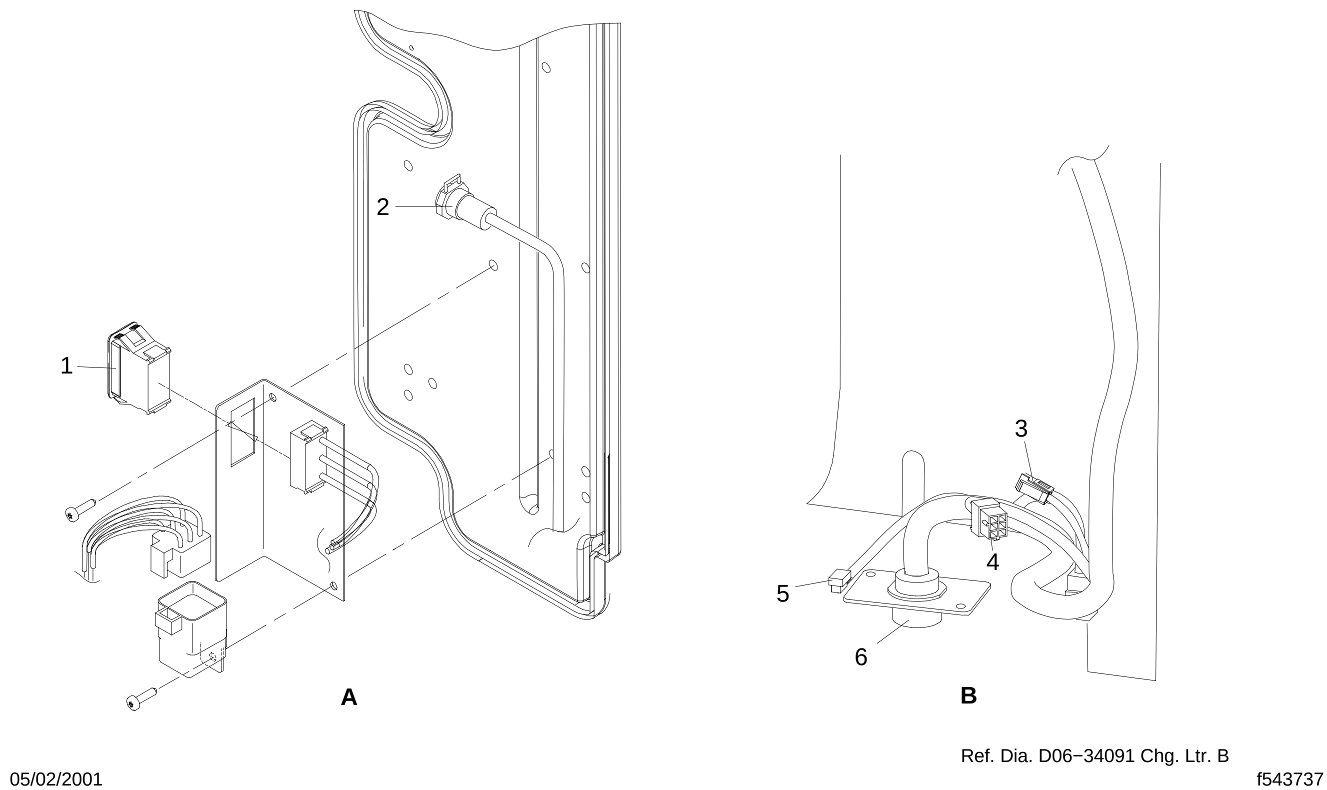


Fig. 11, ABS Relay to Engine Brake Wiring



A. To J1939 Distribution Area
B. Main Cab Harness
C. ABS Harness
D. To Main Cab Harness Circuits 376C, GND
E. Engine Retarder Circuit 376R
F. To Diagnostic Connector Circuits 1587+, 1587-
G. To Main Cab Harness Circuits 376C, 376L, 376T
H. To Chassis Harness

Fig. 12, ABS Harness at B-Pillar



A. ABS Switch at B-Pillar
1. ABS Diagnostic Switch
2. J1939 Connection
3. Engine Retarder Circuit 376R

B. ABS Harness Connection to Main Cab Harness
4. To Main Cab Harness
5. To Diagnostic Connector J1587
6. To Chassis Harness

Fig. 13, ABS Diagnostic Switch Wiring

General Description

Meritor Q Plus brakes are standard for both front and rear axles. These Cam-Master® brakes are air-actuated, cam-operated, foundation brakes. The main components in each brake assembly (wheel end) include the following:

- an S-head camshaft
- a brake spider
- a camshaft-and-chamber bracket
- two brake shoe and lining assemblies
- two retaining springs
- a return spring
- two anchor pins

The S-head camshaft transfers braking force from the slack adjuster to the brake shoe assemblies. The camshaft passes through the brake spider and camshaft-and-chamber bracket before connecting to the slack adjuster. See **Fig. 1**.

Each brake shoe is mounted on an anchor pin on the brake spider and is controlled (moved) by either the outward braking force of the S-head camshaft or the inward restoring force of the return spring.

The heavy-duty, double-web brake shoes have notches on one end of the webs that fit on the anchor pins. Two retaining springs secure the brake shoes to each other near the anchor pins, creating a hinge for brake-shoe movement. This design makes quick-change brake service possible.

Meritor steer axles have seven 0.656-inch-diameter holes for attaching the spider to the axle flange. An oversized eighth hole (0.687-inch diameter) in the axle flange is for an antilock brake system (ABS) wheel speed sensor bushing. See **Fig. 2**. The eighth hole is in the 10 or 2 o’clock position, depending on which side of the axle is viewed.

Q Plus MX500 brakes are extended maintenance brakes. These brakes can be identified by an identification tag affixed to the brake shoe. An additional identification tag is affixed to the brake camshaft-and-chamber bracket (on top of the plugged grease hole). MX500 brakes and Meritor automatic slack adjusters do not have grease fittings.

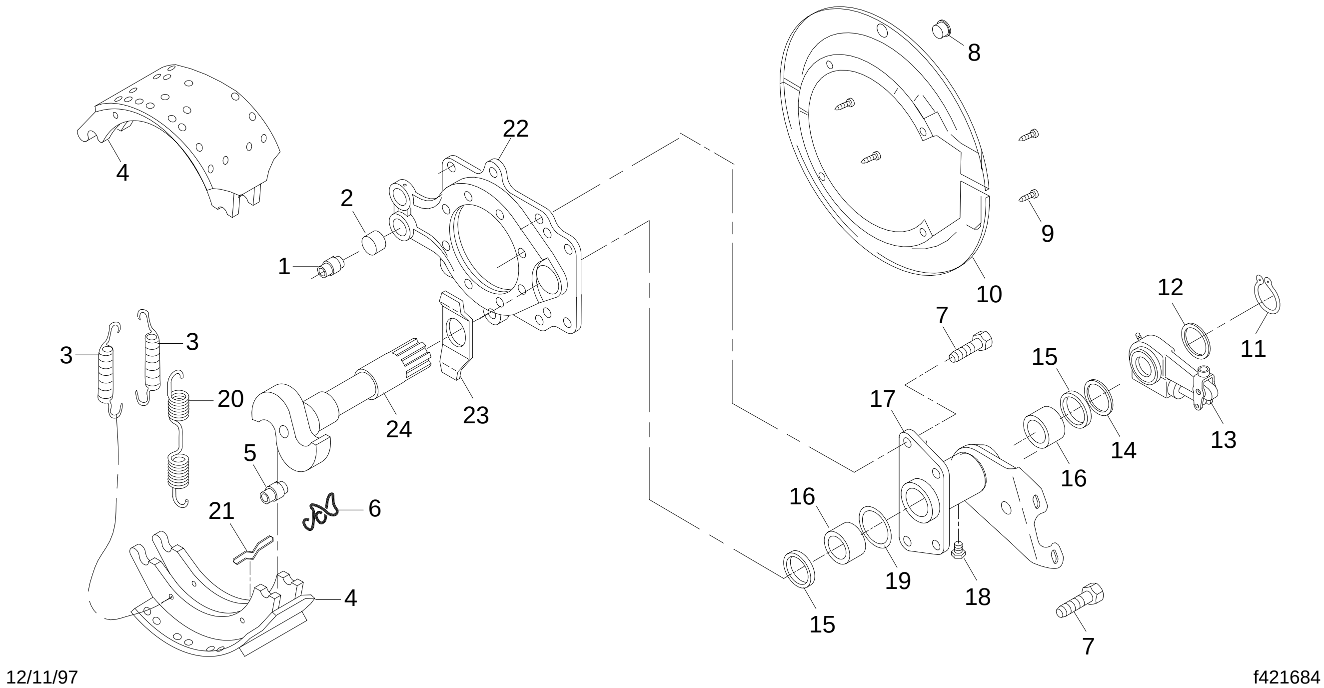
Principles of Operation

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a pushrod assembly.

The pushrod turns the slack adjuster and brake camshaft. As the camshaft turns, the S-type cam head forces the brake shoes against the brake drum and braking occurs.

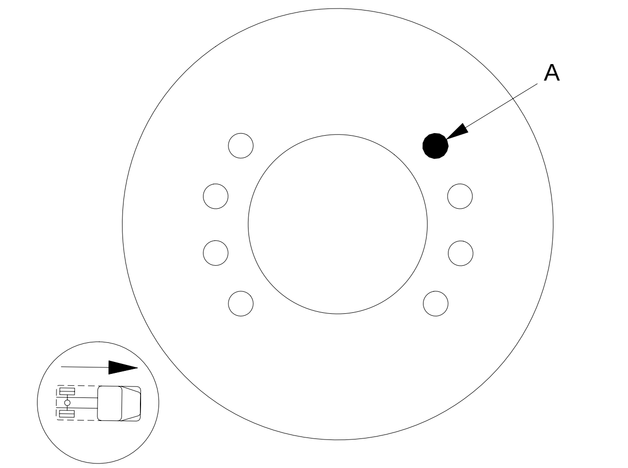
When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring return the camshaft, brake shoes, slack adjuster, and pushrod to their released positions.

General Information



1. Anchor Pin
2. Anchor Pin Bushing
3. Retaining Spring
4. Brake Shoe and Lining Assembly
5. Cam Roller
6. Roller Retainer
7. Capscrew, Chamber Bracket
8. Plug
9. Capscrew, Dust Shield
10. Dust Shield
11. Camshaft Snap Ring
12. Washer (spacer)
13. Automatic Slack Adjuster
14. Washer (thick spacer)
15. Camshaft Grease Seal
16. Camshaft Bushing
17. Camshaft-and-Chamber Bracket
18. Grease Fitting
19. Chamber Bracket Seal
20. Return Spring
21. Return Spring Pin
22. Brake Spider
23. Washer, Camhead
24. S-Head Camshaft

Fig. 1, Meritor Cam-Master Q Plus Brake (typical)



A. Oversized Hole (10 or 2 o’clock position) for ABS bushing.

Fig. 2, Hole for ABS Wheel Speed Sensor Bushing

General Safety Precautions

WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

Asbestos and Non-Asbestos Safety

WARNING

Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

Safety Precautions

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

WARNING

Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

IMPORTANT: When replacing the brake linings, use a dial indicator to measure the cam-to-bushing radial free play (the up-and-down and side-to-side free play of the camshaft) and the camshaft axial end play (the in-and-out end play of the camshaft).

Replace the bushings if the cam-to-bushing radial free play exceeds 0.020 inch (0.5 mm) of movement.

Remove the snap ring from the end of the slack adjuster and add shims between the slack adjuster and the snap ring if the axial end play exceeds 0.005 to 0.030 inch (0.13 to 0.80 mm) of movement.

For detailed instructions, see **Subject 150**.

Removal

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

WARNING

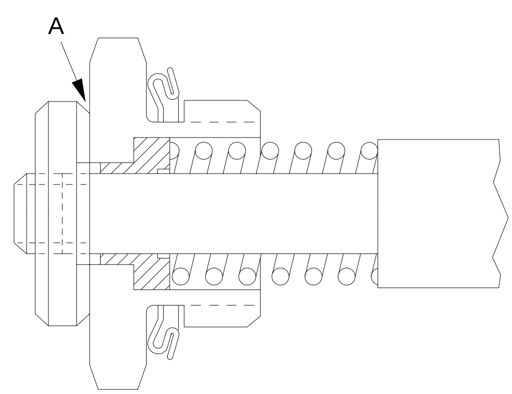
When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury or death.

3. If the brake has spring chambers, carefully cage and lock the springs so that the springs cannot actuate during disassembly.

NOTICE

For a Meritor automatic slack adjuster, disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

4. If your vehicle has a Meritor automatic slack adjuster, disengage the pull-pawl on the side of the adjuster.
   - 4.1 Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See **Fig. 1**.
   - 4.2 Wedge the tool in place until the end of the brake shoe installation. Pull-pawls are spring loaded. When the tool is removed, the pull-pawl will engage the teeth automatically.



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A. Insert a screwdriver here to pry the pull-pall button out about 1/32 inch (0.8 mm).

Fig. 1, Pull-Pall on Meritor Automatic Slack Adjusters

NOTE: On Haldex or Gunite automatic slack adjusters, an internal clutch resists turning the manual adjusting nut in the counterclockwise direction to back off the adjuster. A torque of approximately 13 lbf·ft (18 N·m) must be applied to overcome the resistance of the internal clutch.

5. For each wheel end, back off the automatic slack adjuster by turning the manual adjusting nut until

Brake Shoe Removal and Installation

the brake shoes are fully retracted and the drum clears the lining. See **Subject 130** for instructions.

- On Meritor adjustors, turn the square adjusting nut clockwise (as if tightening a right-hand threaded fastener).
- On Haldex or Gunite adjusters, turn the adjusting hexnut counterclockwise. You will hear a ratcheting sound.

6. Remove the wheels. For instructions, see **Section 40.00**, Subject 100.
7. Remove the brake drums. For instructions, see **Section 33.01**, Subject 100, for front axles or **Section 35.01**, Subject 100, for rear axles.
8. Remove the brake shoes.

8.1 Push down on the lower brake shoe, then pull on the roller retaining clip to remove the lower cam roller. See **Fig. 2**.

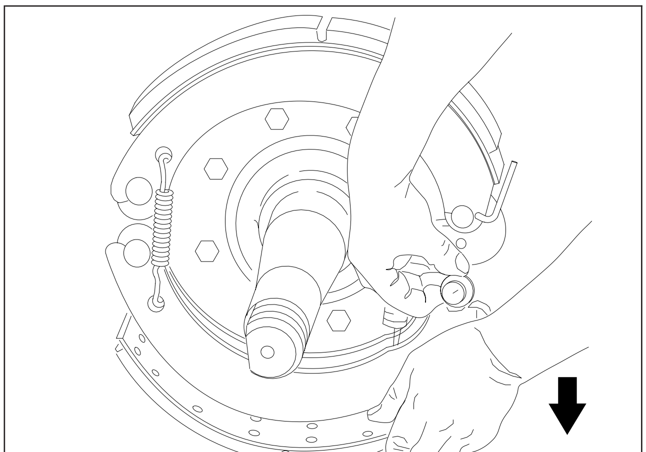
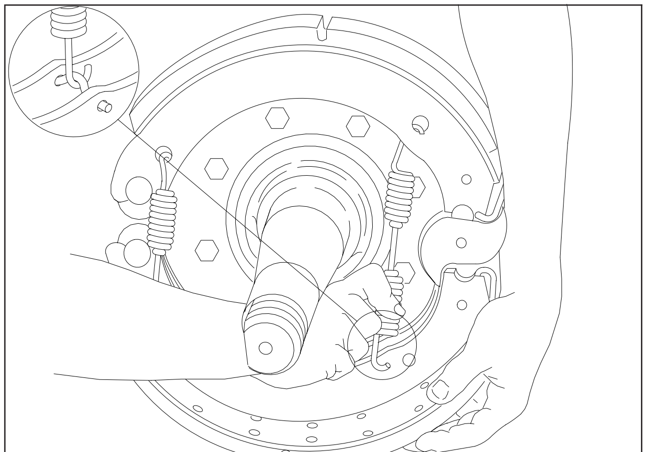


Fig. 2, Cam Roller Removal

8.2 Lift the upper brake shoe and pull on the roller retaining clip to remove the upper cam roller.

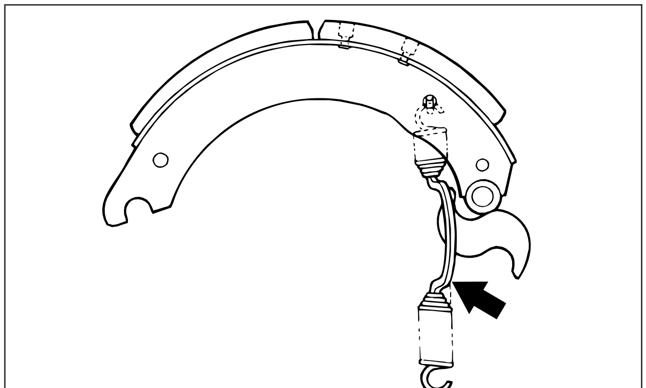
8.3 Lift the lower shoe to release tension on the brake return spring. Remove the spring. See **Fig. 3** and **Fig. 4**.

8.4 Rotate the lower shoe around the anchor pin on the spider to release tension on the two retaining springs. See **Fig. 5**. Remove the brake shoes.



Brake return spring with conventional straight tie bar.

Fig. 3, Return Spring Removal/Installation, Straight Tie Bar



Brake return spring with offset tie bar.

Fig. 4, Return Spring Removal/Installation, Offset Tie Bar

9. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

IMPORTANT: If the linings are being replaced, disassemble and inspect the camshaft-and-chamber bracket. For instructions, see **Subject 150**.

Installation

IMPORTANT: For best brake performance, do not mix Q Plus brakes with other brakes.

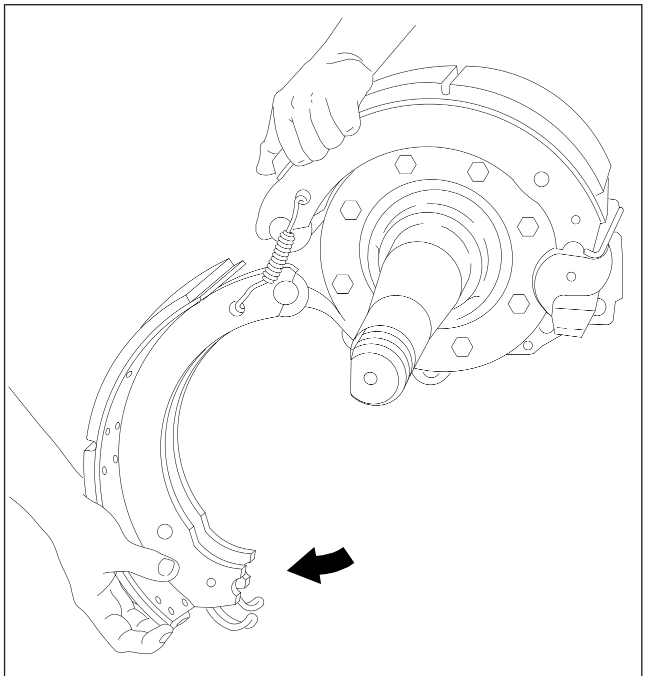


Fig. 5, Brake Shoe Removal

NOTE: Springs, rollers, and anchor pins should be replaced when installing new brake linings.

1. Install the brake shoes.

   IMPORTANT: Do not lubricate the cam-head surface or the center section of the cam rollers. For efficient operation, the cam interface must remain free of oil, grease, and other contaminants.

   1.1 Using an NLGI grade 1 or 2 multi-purpose chassis or temperature-resistant grease (Meritor O-616A, O-617A, O-617B, O-645, or O-692):

   - Lubricate the cam rollers on the journals where they touch the brake shoe webs.
   - Lubricate the anchor pins where they touch the brake shoe webs.

   1.2 Place the upper brake shoe in position on the upper anchor pin. Hold the lower brake shoe vertically against the lower anchor pin and install two new brake shoe retaining springs to link the upper and lower brake shoes. See **Fig. 6**.

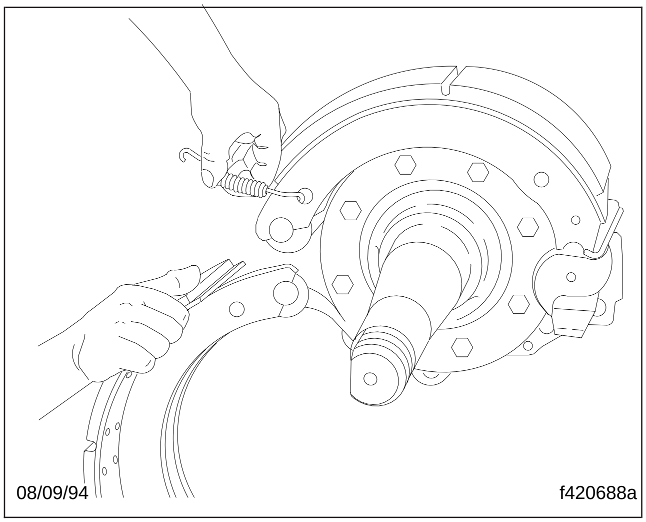


Fig. 6, Brake Shoe Retaining Spring Installation

NOTICE

If the offset tie bar shoe return spring is reversed during installation, it will rub a groove in the barrel of the hub, requiring the hub to be replaced.

   1.3 Rotate the lower brake shoe forward around the hub and install a new brake shoe return spring. Install the open end of the spring hooks toward the camshaft. See **Fig. 3** and **Fig. 4**.

   1.4 Pull the lower brake shoe away from the cam to allow enough space to install a new cam roller and retainer clip.

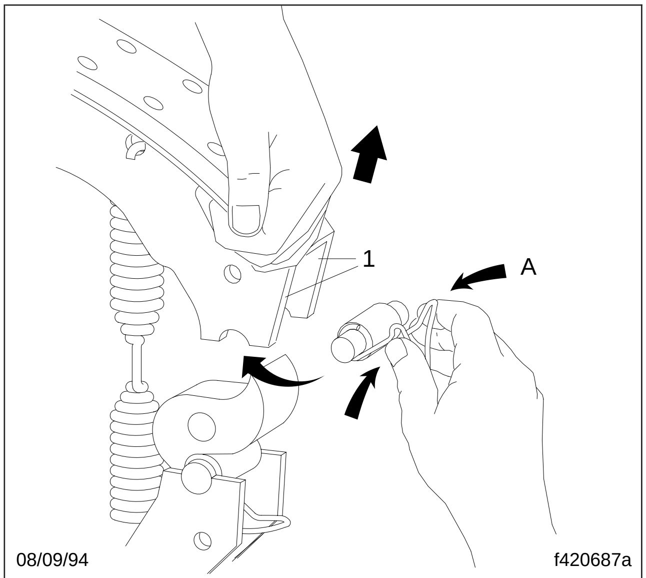
   Squeeze the ears of the retainer clip together to fit between the brake shoe webs on the cam end of the brake shoes. See **Fig. 7**.

   Push the retainer clips between the brake shoe webs until the ears lock in the holes in the webs. See **Fig. 8**.

2. Install the brake drums. For instructions, see **Section 33.01**, Subject 100, for front axles or **Section 35.01**, Subject 100, for rear axles.

3. Install the wheels. For instructions, see **Section 40.00**, Subject 100.

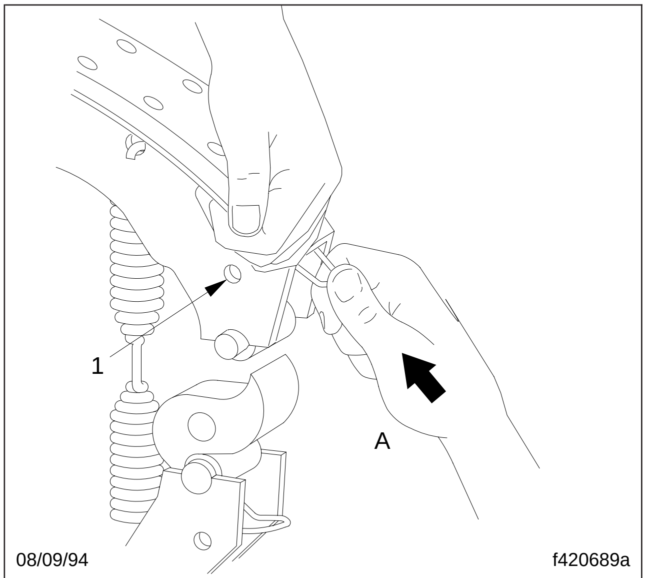
Brake Shoe Removal and Installation



A. Squeeze the ears of the retainer together.

1. Brake Shoe Webs

Fig. 7, Squeezing the Retainer



A. Push the retainer until the ears lock in the holes.

1. Web Hole

Fig. 8, Roller and Retainer Clip Installation

4. Adjust the brakes at the slack adjusters. For instructions, see **Subject 130**.

5. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

WARNING

When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

6. If the brakes have spring chambers, carefully release the springs.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

7. In a safe area, check for proper brake operation before you put the vehicle in service.
   7.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.
   7.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   7.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others shows a lack of braking effort on those wheels.

Brake Shoe and Lining Inspection

WARNING

Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Inspection

1. Remove the brake shoes using the instructions in **Subject 110**.
2. Check the linings.

   2.1 If the linings are grease- or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.

CAUTION

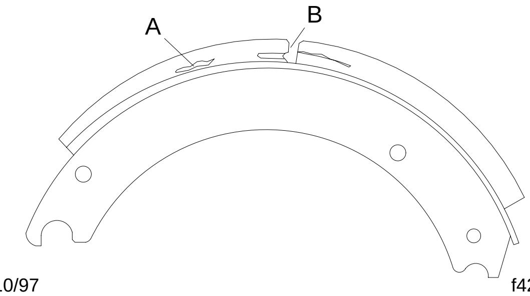
Do not let the brake linings wear to the point were the rivets or bolts touch the drums. Damage to the drums will occur if the linings are allowed to wear to this point.

   2.2 Replace the linings if the lining surface is closer than 1/32 inch (0.8 mm) to any rivet head.

   If bolts are installed, the linings should not be allowed to wear to the point where rivets or bolts may contact the brake drums.

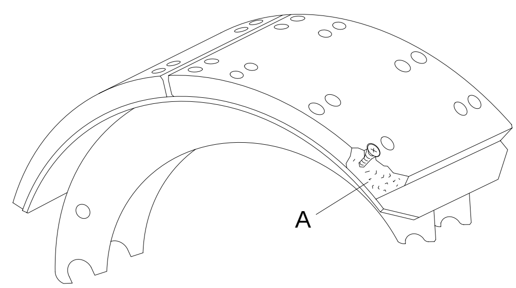
   2.3 The lining is considered worn-out and the vehicle should not be driven if:

   - Cracks on the lining surface exceed 1/16 inch (1.6 mm).
   - The lining edge shows cracks or voids over 1/16 inch (1.6 mm) in width and 1-1/2 inches (38 mm) in length. See **Fig. 1**.
   - Portions of the lining are missing exposing a rivet when viewed from the edge. See **Fig. 2**.
   - Cracks extend across the lining face and through the lining edge, or the lining is loose on the shoe. See **Fig. 3**.



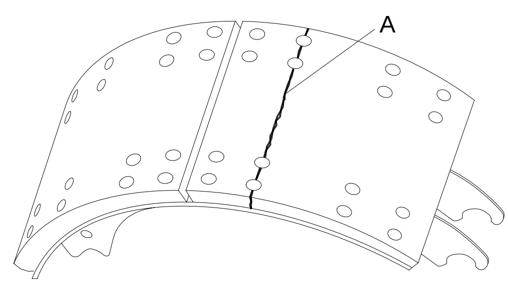
A. Cracks exceeding 1-1/2 inches (38 mm) in length.
B. Cracks or voids exceeding 1/16 inch (1.6 mm) in width.

Fig. 1, Cracks and Voids



A. Exposed fastening device.

Fig. 2, Portions of Brake Lining Missing



A. Cracks extending through the lining edge.

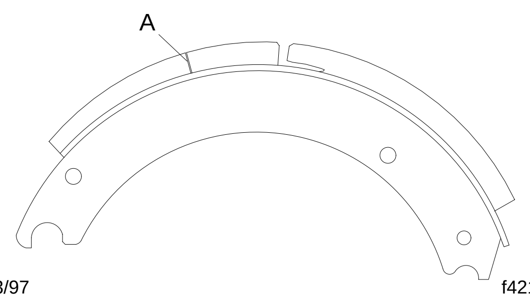
Fig. 3, Cracks in the Brake Lining

   2.4 The vehicle is still operational but the linings should be replaced as soon as possible if:

   - Horizontal or vertical cracks in the lining edge exhibit no loss of mate-

Brake Shoe and Lining Inspection

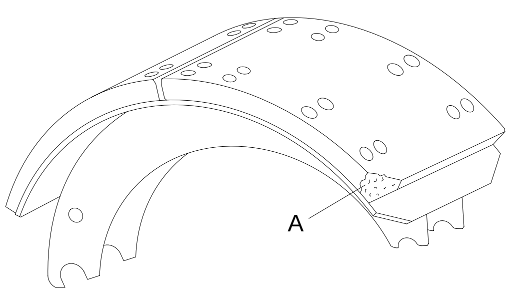
rial and do not exceed 1/16 inch (1.6 mm) in width or 1-1/2 inches (38 mm) in length. See **Fig. 4**.



A. Cracks not exceeding 1-1/2 inches (38 mm) in length or 1/16 inch (1.6 mm) in width.

Fig. 4, Cracks and Voids

- Corner portions of the lining are missing with no fastener exposed. See **Fig. 5**.



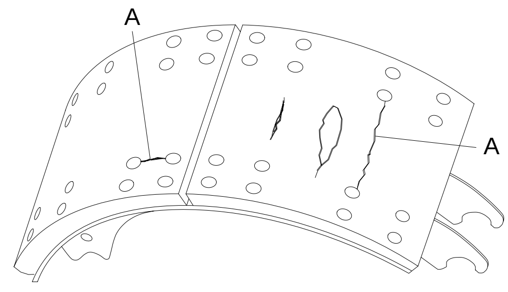
A. Corner segment is missing but no fastener is exposed.

Fig. 5, Portions of the Brake Lining Missing

- Surface cracks extend from hole to hole or if there is scoring and contamination from road debris. See **Fig. 6**.

3. Check the brake shoes for bent or cracked webs or tables, rust, broken welds, expanded or out-of-round rivet or bolt holes, and correct alignment. Replace the shoes if any of these conditions exist.

4. Check the brake shoes for visible wear (looseness) at the anchor pin holes and the camshaft roller recesses. Replace the shoe if needed.

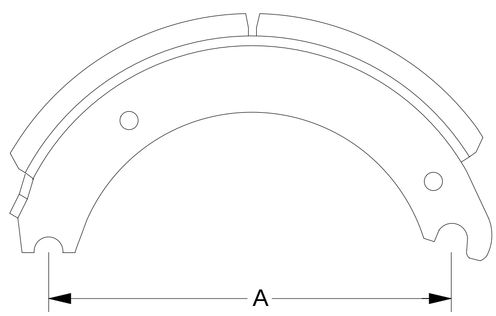


A. Cracks extending from hole to hole.

Fig. 6, Crack in the Brake Lining

5. Check the diameter of the anchor pin holes. The anchor pin holes must not exceed 1.009 inch (25.6 mm).

6. Check the distance from the center of the anchor pin hole to the center of the cam roller hole (the shoe span). The shoe span must not exceed 12-7/8 inches (327 mm). Replace the shoe if needed. See **Fig. 7**.



A. 12-7/8 inches (327 mm) maximum

Fig. 7, Measuring the Shoe Span

Pre-Adjustment Checks and General Adjustment Information

Before adjusting the brakes, check and adjust the following:

- Adjust the wheel bearings. For instructions, see **Section 33.01** or **Section 35.01** in this manual.
- Check the slack adjuster and the brake chamber for loose fasteners and tighten as necessary. For torque specifications, see **Specifications, 400**.

  For slack adjuster installation instructions, see **Section 42.13**, **Section 42.12**, or **Section 42.11** for Meritor, Haldex, or Gunite slack adjusters, respectively.

Brakes with automatic slack adjusters should never have to be manually adjusted while in service. The only time automatic slack adjusters should be manually adjusted is during installation or after the brakes have been relined.

For cam brakes, there are two brake chamber stroke measurement specifications: applied chamber stroke and free-stroke.

IMPORTANT: The U.S. Department of Transportation (DOT) Federal Highway Administration has issued the applied chamber stroke specifications for cam brakes. When the applied chamber stroke is checked and adjusted, it must not be greater than the DOT specification. See **Table 1**.

The specific procedure for adjusting the brake chamber stroke at the slack adjuster's manual adjusting nut may vary, depending on which slack adjuster is installed, but there are three basic steps in completing a manual brake chamber stroke adjustment:

1. Adjusting the approximate brake chamber stroke using the manual adjusting nut on the slack adjuster (coarse adjustment).
2. Measuring and adjusting the free-stroke.
3. Measuring and adjusting the applied chamber stroke (fine adjustment).

The stroke (free or applied chamber) is the distance that the large clevis pin moves when the brakes are applied. The type of force used to move the slack adjuster from its released position to its applied position (where the brake linings contact the brake drum) distinguishes the free-stroke from the applied chamber stroke.

- The free-stroke is measured using a lever to move the slack adjuster. The length of the free-stroke equals the clearance between the brake linings and the drum when the brakes are not applied.
- The applied chamber stroke is measured using an 80 to 90 psi (550 to 620 kPa) brake application to move the slack adjuster.

With the engine off, 100 psi (689 kPa) of air tank pressure will apply the required 80 to 90 psi (550 to 620 kPa) brake application for measuring the applied chamber stroke.

Brake Adjustment

Brake Chamber Stroke Specifications		
Chamber Type (Size)	Maximum Applied Stroke * inch (mm)	Free-Stroke, inch (mm)
Standard Stroke		5/8 to 3/4 (16 to 19)
16, 20, and 24	1-3/4 (44)	
30	2 (51)	
36	2-1/4 (57)	
Long Stroke †		
16, 20, and 24	2 (51)	
30	2-1/2 (64)	

* Specifications are relative to a brake application with 80-90 psi (550-620 kPa) air pressure in the brake chambers.
† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

The applied chamber stroke measurement can be used for diagnostic purposes. A stroke that is too long or too short may indicate excessive wear in the cam, cam bushings, return springs, or air chamber.

The applied chamber stroke should always be adjusted (minimized) to within the specified limit, but it should not be reduced to the point where the free-stroke is too short and the brakes drag. To check for brake drag, spin the wheel end, tap the rim lightly with a hammer, and listen for a drag noise (a sharp ringing sound).

Adjustment

MERITOR AUTOMATIC SLACK ADJUSTER

IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Fully release the brakes (the air chamber push-rod must be fully retracted).
4. Check the condition of the boot on the slack adjuster. It should be held in the correct position with a retaining clip. If the boot is torn or cracked, see **Section 42.13** for slack adjuster disassembly and inspection procedures.

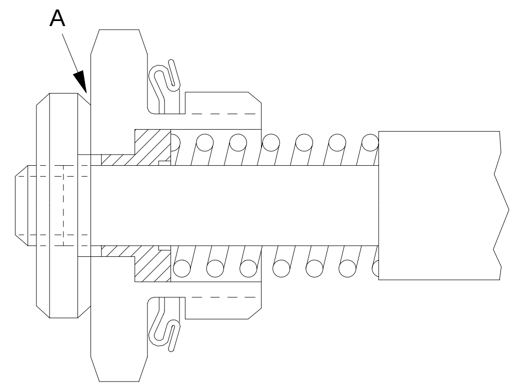
CAUTION

Before turning the manual adjusting nut on the slack adjuster, disengage the pull-pawl. Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

5. Using a screwdriver, pry the pull-pawl button out at least 1/32 inch (0.8 mm) to disengage the pull-pawl teeth from the slack adjuster actuator. See **Fig. 1**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

NOTE: When the screwdriver is removed, the pull-pawl will engage automatically.

6. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment). See **Fig. 2**.
   - 6.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.
   - 6.2 Then, turn the adjusting nut clockwise 1/2 turn.
7. Measure and adjust the free-stroke.



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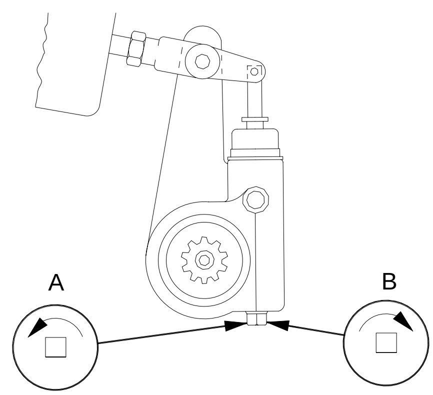
A. Insert screwdriver here.

Fig. 1, Disengage the Pull-Pawl



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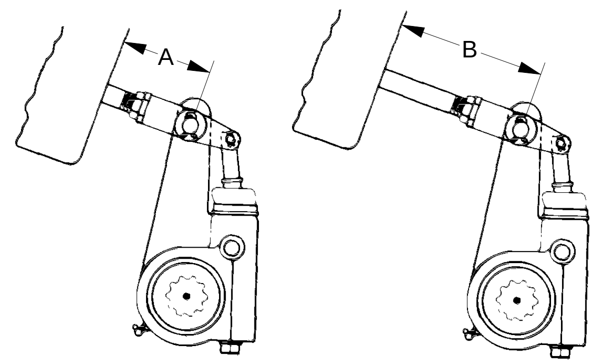
A. Shorten stroke. B. Lengthen stroke.

Fig. 2, Turn the Adjusting Nut

7.1 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 3**.

7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.

7.3 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension B. See **Fig. 3**.



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NOTE: For either free-stroke or applied chamber stroke, subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied by manual lever (free-stroke) or pressurized brake application (applied chamber stroke).

Fig. 3, Measuring the Stroke

7.4 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

7.5 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjusting nut 1/8 turn, as shown in **Fig. 2**. Then, measure the free-stroke again, and readjust it until it is correct.

8. Measure and adjust the applied chamber stroke (fine adjustment).

8.1 Start the engine and build the air pressure to 100 psi (689 kPa). Shut down the engine.

8.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. B. Record this measurement as dimension C.

8.3 Subtract dimension A from dimension C. The difference between these measurements is the true applied chamber stroke.

8.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**.

Brake Adjustment

CAUTION

The adjusted applied chamber stroke should be as short as possible but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.

8.5 If the applied chamber stroke is incorrect, turn the adjusting nut 1/8-turn counterclockwise to shorten the stroke, or 1/8-turn clockwise to lengthen it. See **Fig. 2**. Measure the applied stroke again and readjust it until it is correct.

8.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

9. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl with the actuator.
10. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

WARNING

Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

11. Check for proper brake operation. For instructions, see **Subject 110**.

HALDEX AUTOMATIC SLACK ADJUSTER

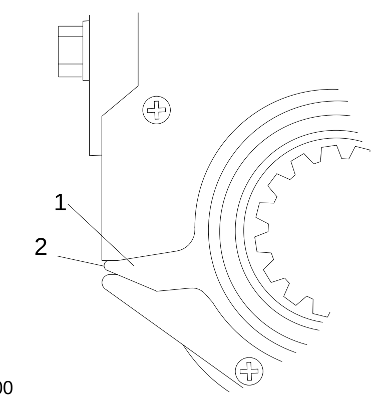
IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Fully release the brakes (the air chamber pushrod must be fully retracted).

CAUTION

The installation indicator must be aligned with the indicator notch on the slack adjuster. If the indicator is not within the notched area, the control arm is installed in the wrong position. This may result in tight brakes, excessive lining wear, and possible brake damage.

4. Make sure the installation indicator is aligned with the indicator notch on the slack adjuster. See **Fig. 4**. If the indicator is not within the notched area, the control arm is not installed correctly.



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1. Installation Indicator 2. Indicator Notch

Fig. 4, Installation Indicator

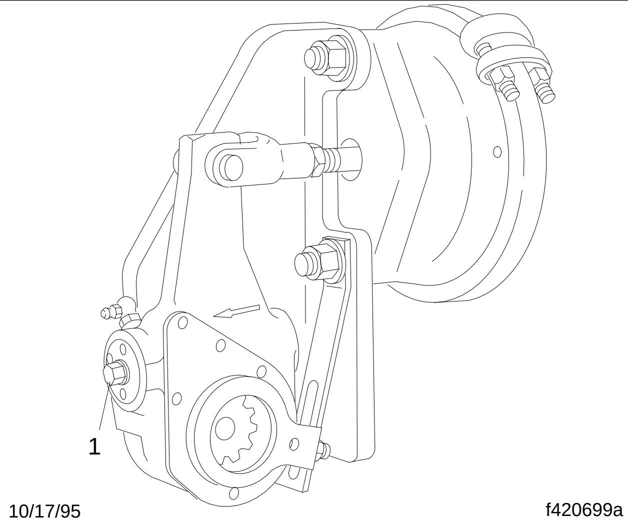
5. Measure how much torque is required to overcome the resistance of the internal clutch (internal clutch slippage).

5.1 Using a 7/16-inch torque wrench, turn the adjusting nut counterclockwise. See **Fig. 5**. You will hear a ratcheting sound.

5.2 If the clutch slips with a torque less than 13 lbf·ft (18 N·m), the slack adjuster must be replaced.

6. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment).

6.1 Turn the adjusting nut clockwise until the brake linings contact the brake drum.



1. Adjusting Hexnut

Fig. 5, Adjusting Hexnut

6.2 Then, turn the adjusting nut counterclockwise 1/2 turn. You will hear a ratcheting sound.

7. Measure and adjust the free-stroke.

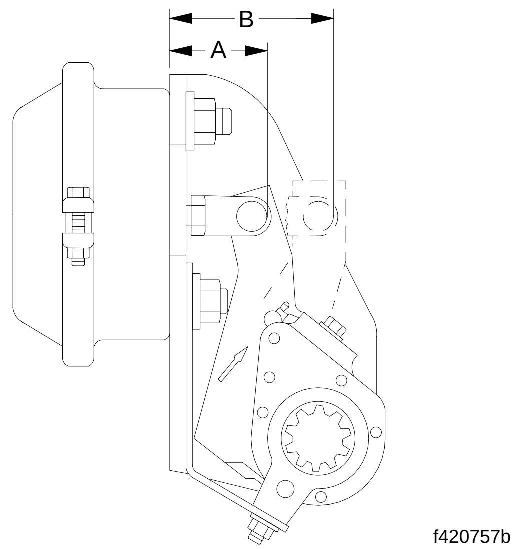
7.1 Measure the distance from the bottom of the brake chamber to the far side of the clevis pin. See **Fig. 6**. Record this measurement as dimension A.

7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the bottom of the brake chamber to the far side of the clevis pin. See **Fig. 6**. Record this measurement as dimension B.

7.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

7.4 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjusting nut in the required direction. Then, measure the free-stroke again and readjust it until it is correct.

8. Measure and adjust the applied chamber stroke (fine adjustment).



A. Brakes Released B. Brakes Applied

Fig. 6, Measure the Stroke

8.1 Start the engine and build the air pressure to 100 psi (689 kPa). Shut down the engine.

8.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the far side of the clevis pin hole. See **Fig. 6**, Ref. B. Record this measurement as dimension C.

8.3 Subtract dimension A from dimension C. The difference between these measurements is the applied chamber stroke.

8.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**. If the stroke is not correct, turn the adjusting nut in the required direction. Then, measure the applied chamber stroke again and readjust it until it is correct.

8.5 If the slack adjuster does not maintain the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

9. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

Brake Adjustment

WARNING

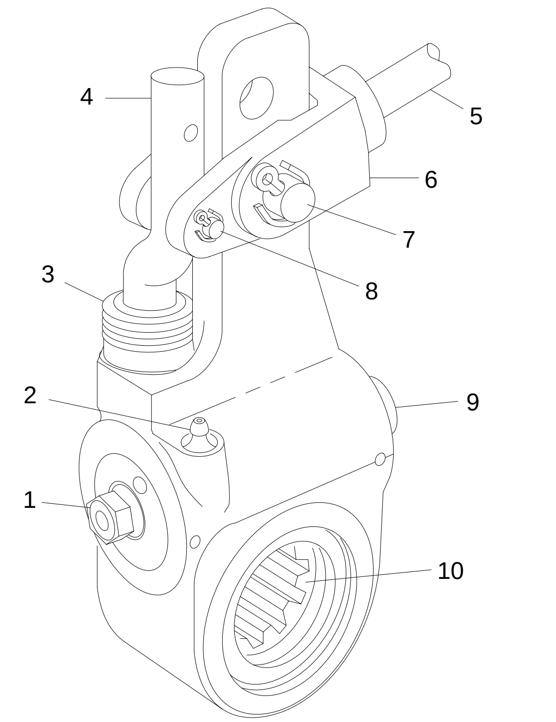
Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

10. Check for proper brake operation. For instructions, see **Subject 110**.

GUNITE AUTOMATIC SLACK ADJUSTER

IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

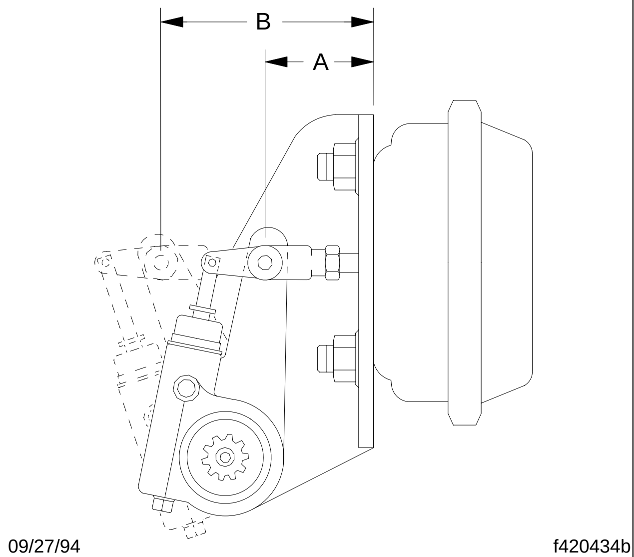
1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Fully release the brakes (the air chamber pushrod must be fully retracted).
4. Measure how much torque is required to overcome the resistance of the internal clutch (internal clutch slippage).
   - 4.1 Using a 7/16-inch torque wrench, turn the adjusting nut counterclockwise. See **Fig. 7**. You will hear a ratcheting sound.
   - 4.2 If the clutch slips with a torque less than 15 lbf·ft (20 N·m), the slack adjuster must be replaced.
5. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment).
   - 5.1 Turn the adjusting nut clockwise until the brake linings contact the brake drum.
   - 5.2 Turn the adjusting nut counterclockwise 1/2 turn. There should be about 30 lbf·ft (41 N·m) resistance. You will hear a ratcheting sound.
6. Measure and adjust the free-stroke.



1. Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Pushrod
6. Clevis
7. Clevis Pin, 1/2-in
8. Clevis Pin, 1/4-in
9. Grease Relief Opening
10. Slack Adjuster Spline

Fig. 7, Gunite Slack Adjuster

   - 6.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**. Record this measurement as dimension A.
   - 6.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.
   - 6.3 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**. Record this measurement as dimension B.
   - 6.4 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.
   - 6.5 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjust-



A. Brakes Released B. Brakes Applied

Fig. 8, Measure the Stroke

ing nut in the required direction. Then, measure the free-stroke again and readjust it until it is correct.

7. Measure and adjust the applied chamber stroke (fine adjustment).

   7.1 Start the engine and build air pressure to 100 psi (689 kPa). Shut down the engine.

   7.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**, Ref. B. Record this measurement as dimension C.

   7.3 Subtract dimension A from dimension C. The difference between these measurements is the applied chamber stroke.

   7.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**. If the stroke is not correct, turn the adjusting nut in the required direction. Then, measure the applied stroke again and readjust it until it is correct.

   7.5 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

8. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

WARNING

Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

9. In a safe area, check for proper brake operation before you put the vehicle in service.

   9.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

   9.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

   9.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others shows a lack of braking effort on those wheels.

⚠ WARNING

Before starting this procedure, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Replacement

IMPORTANT: Vehicle brake systems require the correct lining material to perform as originally designed. The type of lining material that is specified for the vehicle is based on several technical considerations and Department of Transportation (DOT) braking performance regulations. To ensure fewer relines and greater compatibility with the vehicle's brake system, use the same quality of friction lining material that was installed at the factory.

Always reline both wheels of a single axle and all wheels of a tandem axle at the same time.

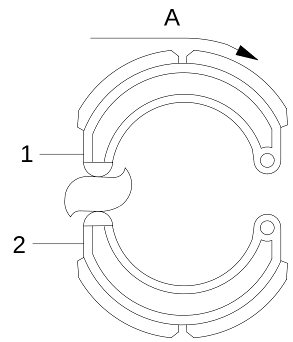
Always install the same linings and drums on both wheels of a single axle and all four wheels of a tandem axle. It is not necessary that both axles (front and rear) have the same linings and drum.

Combination linings with different friction ratings for the primary and secondary shoes are sometimes used. When combination friction lining sets are used, the lining blocks must be installed in the correct locations on the brake shoes.

NOTE: Always follow the instructions supplied with the replacement combination lining sets for correct installation. The primary linings must be installed on the primary shoe. The first shoe past the cam in the direction of the wheel rotation is the primary shoe.

The primary shoe can be either in the upper or the lower position, depending on the location of the cam. If the cam is behind the axle, then the upper shoe is the primary shoe. See **Fig. 1**. If the cam is in front of the axle, then the lower shoe is the primary shoe. See **Fig. 2**.

1. Remove the brake shoes. See **Subject 110** for instructions.



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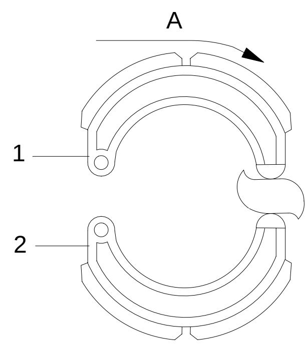
A. Wheel rotation.
1. Primary Shoe
2. Secondary Shoe

Fig. 1, Camshaft Behind the Axle



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A. Wheel rotation.
1. Secondary Shoe
2. Primary Shoe

Fig. 2, Camshaft Ahead of the Axle

2. Using a dial indicator, measure the cam-to-bushing radial free play (the up-and-down and side-to-side free play of the camshaft) and the camshaft axial end play (the in-and-out end play of the camshaft). For instructions, see **Subject 150**.
   - If the cam-to-bushing radial free play exceeds 0.020 inch (0.5 mm) of movement, replace the bushings.
   - The axial end play should be 0.005 to 0.030 inch (0.13 to 0.80 mm). If it exceeds 0.030 inch (0.80 mm) of movement, remove the snap ring securing the slack adjuster on the camshaft. Add shims between the slack adjuster and the snap ring.

Brake Shoe Lining Replacement

3. Remove the lining blocks from the brake shoes.

CAUTION

Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round, which could damage the brake shoe.

   3.1 If the lining blocks are riveted, use a suitable riveting mandrel to push out the old rivets.

   If the lining blocks are bolted, remove the bolts, lockwashers, and nuts.

   3.2 Separate the lining blocks from the brake shoes.

4. Check the brake shoes for rust, expanded rivet or bolt holes, broken welds, and incorrect alignment. Replace the shoes if any of these conditions exist.

5. If necessary, clean each brake shoe with solvent and wire brush the shoe table. Then, paint the brake shoe with rust-inhibitive paint.

6. Install the lining blocks on the brake shoes.

   IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are 1/4-inch diameter by 9/16-inch long, SAE no. 10, made of plated steel or brass.

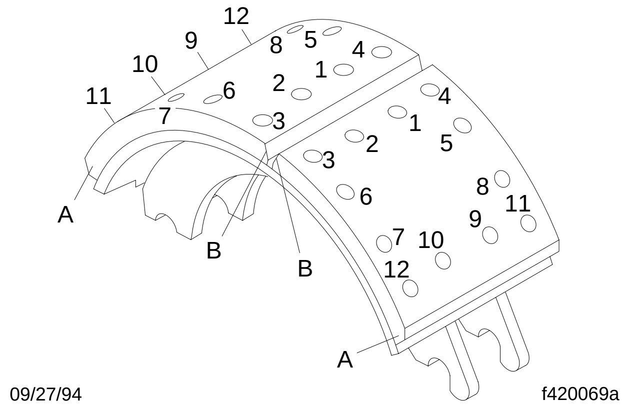
   6.1 If the lining blocks are riveted, align the brake shoe rivet holes with the corresponding lining block holes. Using a C-clamp, clamp the lining block to the brake shoe.

   Insert the correct size rivets in all the holes. Hold the rivets in place temporarily with masking tape.

   Fasten the rivets (from the lining block to the brake shoe) in the sequence shown in **Fig. 3**.

   6.2 If the lining blocks are bolted, align the brake shoe bolt holes with the corresponding lining block holes. Using a C-clamp, clamp the lining block to the brake shoe.

   Insert the correct size bolts and new lockwashers into all the holes and threads.



NOTE: The numbers represent the fastening sequence.

A. Toe B. Heel

Fig. 3, Rivet and Bolt Fastening Sequence

   Loosely install all the nuts, then tighten them in the sequence shown in **Fig. 3**.

   - Tighten 3/8-inch brass bolts 18 to 23 lbf·ft (24 to 31 N·m).
   - Tighten 1/4-inch brass bolts 80 to 100 lbf·in (900 to 1120 N·cm).

7. Check the lining installation by trying to insert a 0.010-inch (0.25-mm) feeler gauge along the edges between the linings and the shoe table. See **Fig. 4**.

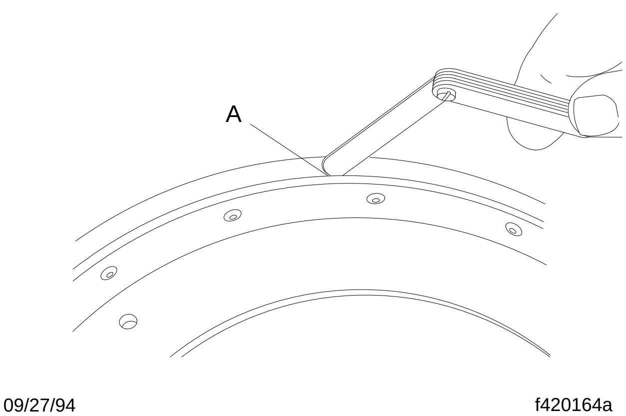
   It should not be possible to insert the feeler gauge anywhere along the edge, except beyond the last row of rivets at each end. A larger clearance of up to 0.025 inch (0.64 mm) can exist at the ends. See **Fig. 5**.

8. Circle-grind the brake lining to get the correct lining-to-drum contact.

   8.1 With the cam in the full-release position, grind the new brake linings 0.070 inch (1.8 mm) less than the drum diameter.

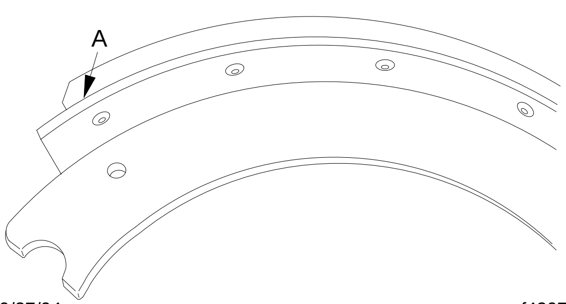
   8.2 Adjust the cam and grind the lining until there is an 80 percent lining-to-drum contact, which must be continuous and in the center of the lining.

9. Install the brake shoes, see **Subject 110** for instructions.



A. The clearance between the brake lining and shoe table must be less than 0.010 inch (0.25 mm).

Fig. 4, Check Clearance Along Edge



A. The clearance between the shoe table and the ends of the brake lining can be up to 0.025 inch (0.64 mm).

Fig. 5, Check Clearance at Ends

Brake Components Disassembly, Inspection, Cleaning, and Assembly

Disassembly and Inspection

WARNING

Before starting this procedure, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

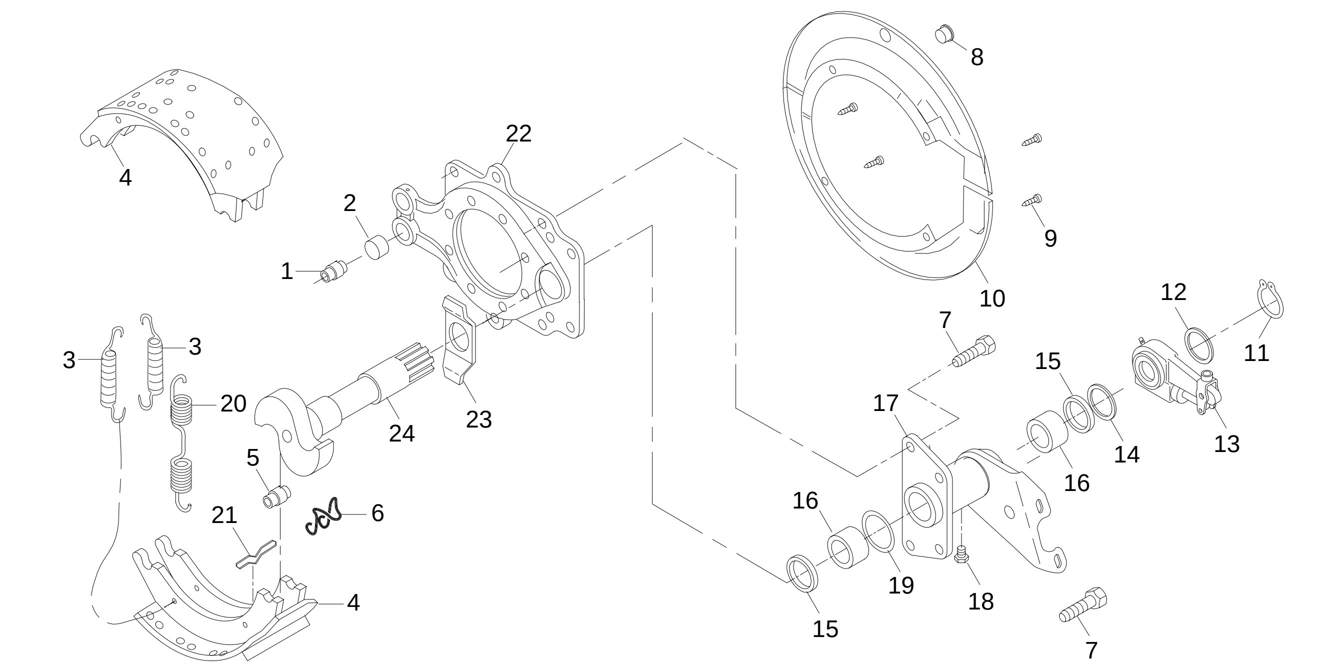
Three Q Plus brake assemblies are shown in the following figures:

- **Fig. 1**, Q Plus Brakes (other than MX500 Series)
- **Fig. 2**, MX500 Series with Cast Spider
- **Fig. 3**, MX500 Series with Stamped Spider

1. Remove the brake shoes. For instructions see **Subject 110**.

IMPORTANT: Meritor recommends that the brake drum not be turned or rebored (resurfaced). Turning or reboring drums can decrease the strength and heat capacity of the drum.

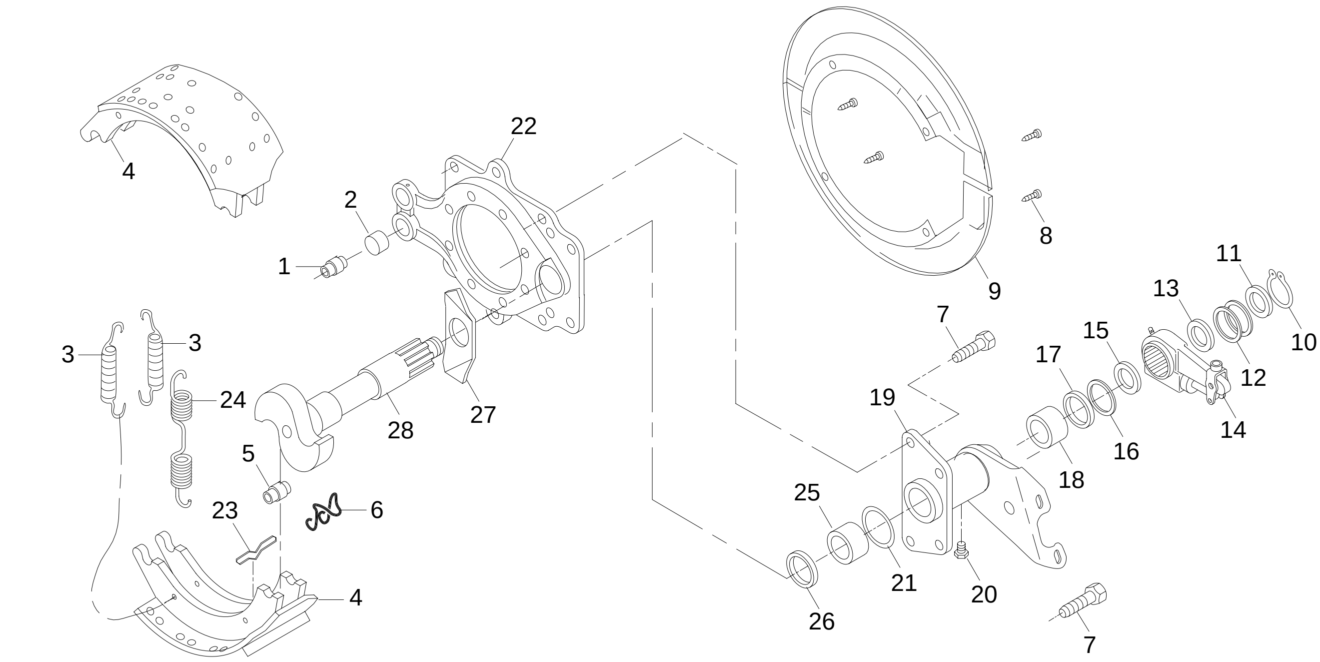
2. Inspect the brake drum. See **Fig. 4**.
   - 2.1 Check the drum for cracks. Replace any cracked drum.
   - 2.2 Check the drum for severe heat-checking, heat-spotting, scoring, pitting, distortion, and out-of-round. Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, see **Section 33.01** or **Section 35.01**.



1. Anchor Pin
2. Anchor Pin Bushing
3. Retaining Spring
4. Brake Shoe and Lining Assembly
5. Cam Roller
6. Roller Retainer
7. Capscrew, Chamber Bracket
8. Plug
9. Capscrew, Dust Shield
10. Dust Shield
11. Camshaft Snap Ring
12. Washer (spacer)
13. Automatic Slack Adjuster
14. Washer (thick spacer)
15. Camshaft Grease Seal
16. Camshaft Bushing
17. Camshaft-and-Chamber Bracket
18. Grease Fitting
19. Chamber Bracket Seal
20. Return Spring
21. Return Spring Pin
22. Brake Spider
23. Camhead Thrustwasher
24. S-Head Camshaft

Fig. 1, Q Plus Brake (other than MX500 Series)

Brake Components Disassembly, Inspection, Cleaning, and Assembly



NOTE: 16-1/2 inch Q Plus MX500 brake with cast spider shown.

1. Anchor Pin
2. Anchor Pin Bushing
3. Retaining Spring
4. Brake Shoe and Lining Assembly
5. Cam Roller
6. Roller Retainer
7. Capscrew, Chamber Bracket
8. Capscrew, Dust Shield
9. Dust Shield
10. Camshaft Snap Ring
11. Washer (spacer)
12. Washer (thin spacer)
13. Orange Seal, Automatic Slack Adjuster
14. Automatic Slack Adjuster
15. Seal, Automatic Slack Adjuster
16. Washer (thick spacer)
17. Camshaft Seal
18. Camshaft Bushing, 1-1/2 in. ID
19. Camshaft-and-Chamber Bracket
20. Pipe Plug
21. Chamber Bracket Seal
22. Brake Spider, Cast
23. Return Spring Pin
24. Return Spring
25. Camshaft Bushing, 1-5/8 in. ID
26. Orange Camshaft Seal
27. Camhead Thrustwasher
28. S-Head Camshaft

Fig. 2, Q Plus MX500 Brake (with cast spider)

2.3 Using a drum caliper or other measuring device, measure the inside diameter of the drum in several locations. Replace the drum if it exceeds the maximum diameter stamped on it.

3. Disconnect the slack adjuster from the pushrod clevis. For detailed instructions, see **Section 42.11** for Gunite®, **Section 42.12** for Haldex, or **Section 42.13** for Meritor automatic slack adjusters.

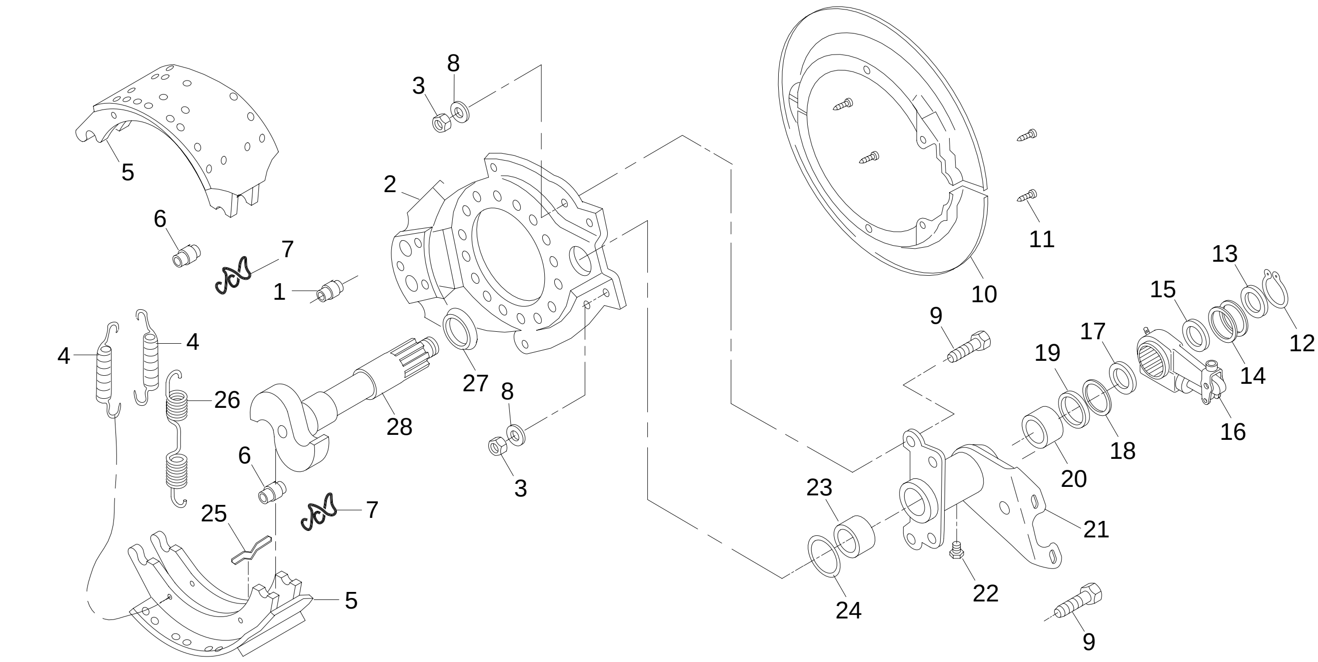
3.1 Remove the cotter pin from the clevis pin; remove the clevis pin. See **Fig. 5**.

CAUTION

For a Meritor automatic slack adjuster, disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

3.2 For a Meritor automatic slack adjuster, disengage the pull-pawl on the side of the adjuster. Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm) and wedge the tool in place. See **Fig. 6**. Pull-pawls are spring loaded. When the tool is removed,

Brake Components Disassembly, Inspection, Cleaning, and Assembly



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NOTE: 16-1/2 inch drive axle Q Plus MX500 brake with stamped spider shown.

1. Anchor Pin
2. Brake Spider, Stamped
3. Hexnut (4 qty.)
4. Retaining Spring
5. Brake Shoe and Lining Assembly
6. Cam Roller
7. Retainer
8. Washer, Hardened (4 qty.)
9. Bolt (4 qty.)
10. Dust Shield
11. Capscrew, Dust Shield
12. Camshaft Snap Ring
13. Washer (spacer)
14. Washer (thin spacer)
15. Orange Seal, Automatic Slack Adjuster
16. Automatic Slack Adjuster
17. Seal, Automatic Slack Adjuster
18. Washer (thick spacer)
19. Camshaft Seal
20. Camshaft Bushing, 1-1/2 in. ID
21. Camshaft-and-Chamber Bracket
22. Pipe Plug
23. Camshaft Bushing, 1-5/8 in. ID
24. Orange Camshaft Seal
25. Return Spring Pin
26. Return Spring
27. Camhead Thrustwasher
28. S-Head Camshaft

Fig. 3, Q Plus MX500 Brake (with stamped spider)

the pull-pawl will engage the teeth automatically.

IMPORTANT: Never pull the slack adjuster out of the pushrod clevis. Always turn the adjusting nut for positioning.

3.3 Using a wrench, turn the manual adjusting nut to back the slack adjuster out of the clevis.

- On Meritor adjustors, turn the square adjusting nut clockwise (as if loosening a right-hand threaded fastener).
- On Haldex or Gunite adjusters, turn the adjusting hexnut counterclockwise. You will hear a ratcheting sound.

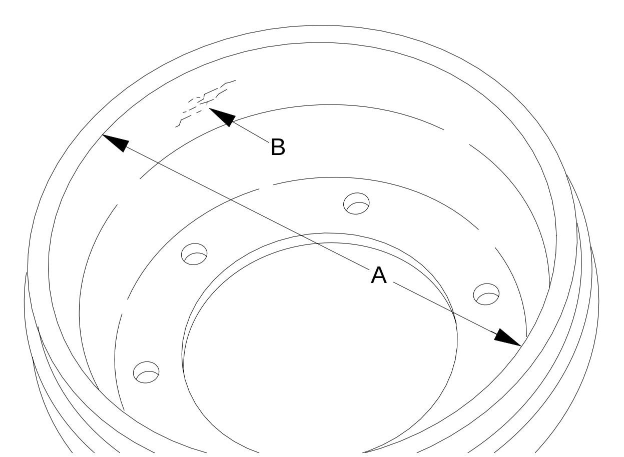
4. Check the camshaft radial free play. See **Fig. 7**.

   4.1 Using a dial indicator, measure the up-and-down and side-to-side free play of the camshaft.

   4.2 Replace the camshaft bushings if there is more than 0.020 inch (0.5 mm) of free play.

5. Remove the slack adjuster.

Brake Components Disassembly, Inspection, Cleaning, and Assembly



A. Check for diameter and out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 4, Brake Drum Inspection

5.1 From the slack adjuster side of the camshaft-and-chamber bracket, remove the snap ring and any washers, spacers, and seals from the camshaft. See **Fig. 1**, **Fig. 2**, or **Fig. 3**.

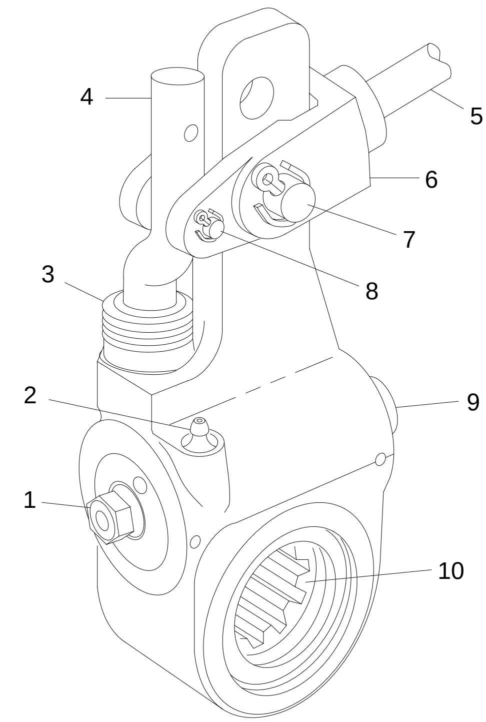
5.2 Remove the slack adjuster from the camshaft.

6. Inspect the slack adjuster for damage or binding.

6.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being turned in the counterclockwise direction. When checking these slack adjusters for binding, only rotate the manual adjusting nut in the clockwise direction.

6.2 Using a torque wrench that measures lbf·in (or N·cm), turn the manual adjusting nut clockwise so that the worm gear rotates a full 360 degrees (typically 22 turns of the wrench).



NOTE: Gunite automatic slack adjuster shown.

1. Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Pushrod
6. Clevis
7. Clevis Pin, 1/2-in
8. Clevis Pin, 1/4-in
9. Grease Relief Opening
10. Slack Adjuster Spline

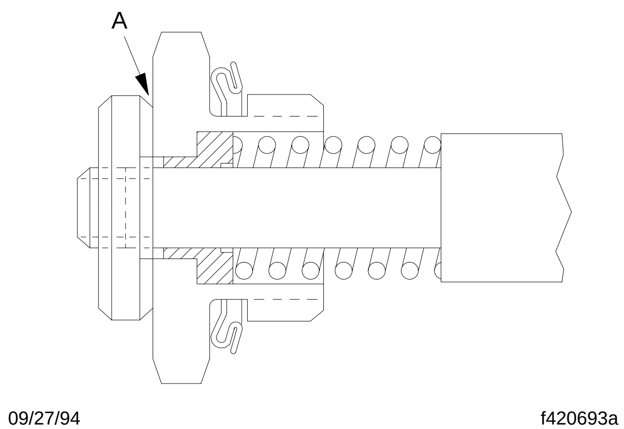
Fig. 5, Disconnect Slack Adjuster from Clevis

If there is binding, or if more than 25 lbf·in (280 N·cm) is needed to turn the slack adjuster, replace it. For instructions, see the applicable slack adjuster section in this group.

IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

7. Remove the camshaft by grasping its head and pulling the camshaft outboard from the brake spider and camshaft-and-chamber bracket. See **Fig. 8**. Then, remove the thrustwasher from the camshaft.

Brake Components Disassembly, Inspection, Cleaning, and Assembly



A. Insert a screwdriver here to pry the pull-pall out about 1/32 inch (0.8 mm).

Fig. 6, Disengage the Pull-Pall on Meritor Automatic Slack Adjusters

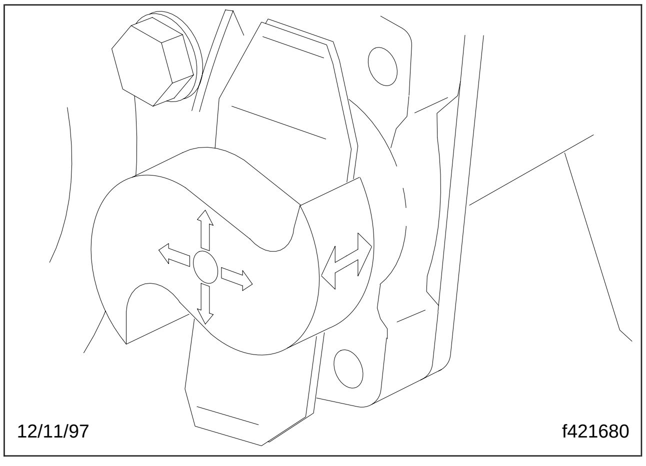


Fig. 7, Check Free Play

8. Check the camshaft spline end for cracks, corrosion, or worn or deformed splines. Replace the camshaft if it is damaged.
9. Check the camshaft bearing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.
10. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.
11. From the brake spider and slack adjuster ends of the camshaft-and-chamber bracket, remove and

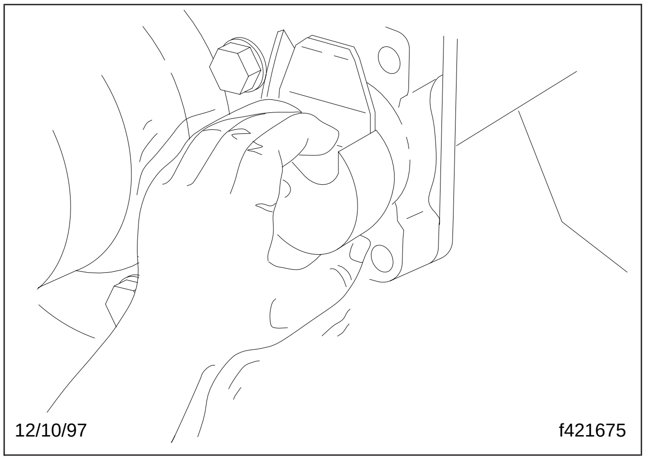


Fig. 8, Remove the Camshaft

inspect the camshaft grease seals. If a grease seal lip is nicked, cut, or distorted, replace it.

WARNING

When removing bushings with a driver, wear eye protection. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off, which could cause serious eye injury.

12. Using the correct size driver, remove the camshaft bushings from the camshaft-and-chamber bracket.
13. Check the camshaft bushings for wear. The inner surface must be smooth; if rough or abrasive, replace the bushings.
14. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft-and-chamber bracket.

    Check the chamber for a cracked housing, bent pushrod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace brake chamber parts as needed.
15. Remove and inspect the camshaft-and-chamber bracket. Remove and discard the gasket.

    Check the bracket for a bent, broken, or cracked arm and cracked welds. Replace the bracket if any of these conditions exist.
16. Remove the brake spider-to-axle attaching nuts, hardened washers, and bolts. Remove the brake spider from the axle flange.

Brake Components Disassembly, Inspection, Cleaning, and Assembly

17. If equipped, remove the four capscrews that attach the dust shield to the brake spider; remove the dust shield.
18. Inspect the brake spider and parts for damage; replace as needed.
    - 18.1 Check the bolt holes, cam area, and anchor pin area for cracks and check for expanded anchor pin holes. Replace if damaged.
    - 18.2 Check the anchor pins. If worn or loose, replace them.
    - 18.3 Check the anchor pin bushings for wear. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.

Cleaning

WARNING

Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

CAUTION

Do not clean ground or polished metal parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause parts to corrode.

For corrosion protection, do not apply brake grease or corrosion-preventive materials to the brake linings or the brake drum.

After removing the brake parts being serviced, do the following:

1. Clean the camshaft journals with an emery cloth.
2. Wire brush all parts exposed to mud, road dirt, and salt, including the exterior of the drum, brake spider, camshaft-and-chamber bracket, and dust shields (if equipped). If relining the shoes, thoroughly wire-brush the shoe tables, and paint them with a rust-inhibitive coating.

CAUTION

A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake components could occur.

3. Using an industrial vacuum cleaner with a HEPA filter system, remove any dust accumulation from the brake parts.
4. Wipe the interior of the drums with a damp rag to remove lining dust.
5. Prepare the brake parts for assembly.
    - 5.1 Thoroughly clean all the brake parts.

      For ground or polished metal parts, use a cleaning solvent to clean the parts and surfaces that are ground or polished.

      For rough metal parts, use a cleaning solvent or a weak alkaline solution in a hot solution tank to clean the parts. If a hot solution tank is used, leave the rough parts in the hot solution tank until they are completely cleaned and heated. Remove the rough parts from the hot solution tank and wash them with water until the alkaline solution is removed.
    - 5.2 Thoroughly dry all the brake parts with either compressed air or a clean soft cloth or paper towel.

WARNING

All worn or damaged brake parts must be replaced. If the brakes are assembled with worn or damaged parts, they may not perform to their capacity and a brake failure could occur, which could cause personal injury and property damage.

    - 5.3 Thoroughly inspect all the brake parts for wear or damage. It is very important that all the parts be carefully inspected before they are assembled. Repair or replace any worn or damaged parts.
    - 5.4 For parts that will be assembled, apply a thin layer of brake grease to the parts

after they have been cleaned, dried, and inspected to protect them from corrosion.

If the parts will be stored, apply a special material that prevents corrosion and rust on all surfaces. The parts should be stored in special paper (or other material) that prevents corrosion and rust.

Assembly

WARNING

Before starting the assembly procedure, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Install the dust shield, if equipped. See **Fig. 1**, **Fig. 2**, or **Fig. 3**.

   Position the dust shield against the brake spider and install the capscrews. Tighten the capscrews to the specifications in **Table 1**.

2. Install the brake spider.

   Place the brake spider on the axle flange. Install the mounting fasteners with hardened washers under the bolt head and nut. Tighten the nuts to the specifications in **Table 1** in a cross pattern. See **Fig. 9**.

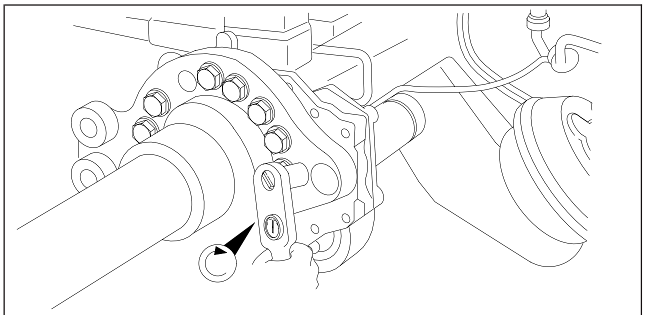


Fig. 9, Tighten the Brake Spider Fasteners

3. Install the camshaft-and-chamber bracket.

   Place the camshaft-and-chamber bracket and gasket against the brake spider and install the lockwashers and fasteners. Tighten the fasteners to the specifications in **Table 1**.

Fastener		Torque Specification	
Size	**Grade**	**lbf·ft**	**N·m**
Dust Shield Fasteners			
5/16–18	5	15 to 20	20 to 27
3/8–16	5	25 to 35	34 to 47
3/8–16	8	35 to 50	47 to 68
Brake Spider Fasteners			
7/16–20		60 to 75	81 to 102
1/2–20		85 to 115	115 to 156
9/16–18		135 to 165	176 to 224
5/8–18		180 to 230	244 to 312
Camshaft-and-Chamber Bracket Fasteners			
1/2–13 Capscrew (without nut)	5	65 to 85	88 to 116
1/2–13 Capscrew (without nut)	8	70 to 100	95 to 136
5/8–18 Bolt with Locknut		130 to 165	176 to 224
5/8–18 Bolt with Plain Hexnut		150 to 190	203 to 258

Table 1, Dust Shield, Spider, and Bracket Torque Specifications

Brake Components Disassembly, Inspection, Cleaning, and Assembly

NOTE: If replacing a brake chamber, make sure that the new chamber is the same size and make as the brake chamber on the other side of the axle.

4. Install the brake chamber.

   4.1 Place the brake chamber on the mounting flange (camshaft-and-chamber bracket) with the chamber mounting studs through the flange holes.

   4.2 Install the hardened flatwashers, lock-washers, and stud nuts.

   4.3 Tighten the brake chamber fasteners to the specifications in **Table 2**.

IMPORTANT: The grease seals are installed in both the brake spider and slack adjuster ends of the camshaft-and-chamber bracket. The grease seals must be installed with their lips toward the slack adjuster end of the camshaft-and-chamber bracket tube.

NOTE: To maximize lining life, Meritor recommends replacing the springs, rollers, anchor pins, and camshaft bushings when the linings are replaced. For Q Plus brakes with MX500 identification tags, if replacing the linings before the recommended service interval (3 years or 500,000 miles [800 000 km]), the camshaft bushings and the seals do not need to be replaced.

5. Using a seal driver, install the camshaft seals and the new camshaft bushings in the brake spider and slack adjuster ends of the camshaft-and-chamber bracket. See **Fig. 10**. Install the seals with their lips toward the slack adjuster. See **Fig. 11**.

6. Install the camshaft. See **Fig. 12**.

   6.1 Put the cam head thrustwasher on the camshaft with the bent flaps toward the brake spider.

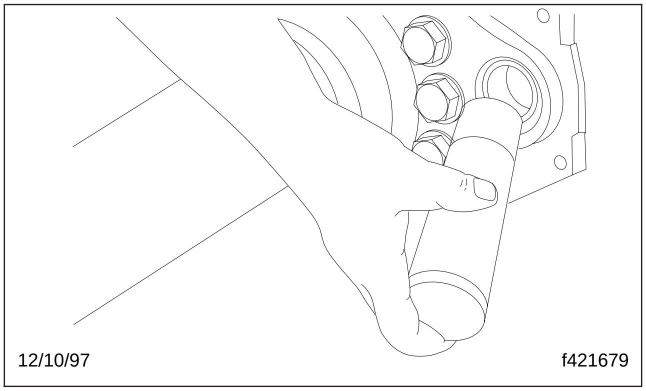
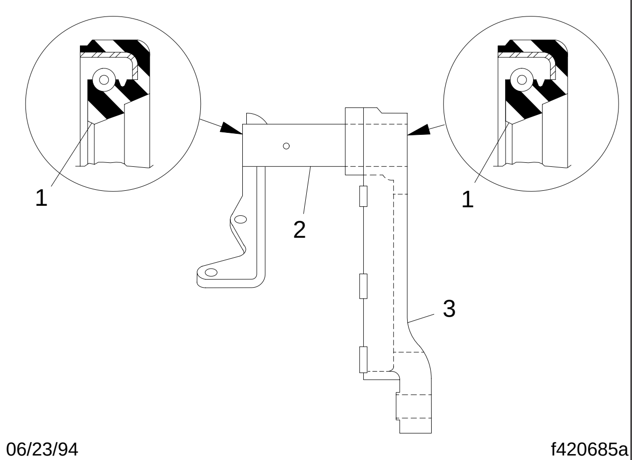


Fig. 10, Install the Seals and Bushings



NOTE: The seal faces the slack adjuster.

1. Seal Lip
2. Camshaft-and-Chamber Bracket
3. Brake Spider

Fig. 11, Positioning the Seals

Brake Components Disassembly, Inspection, Cleaning, and Assembly

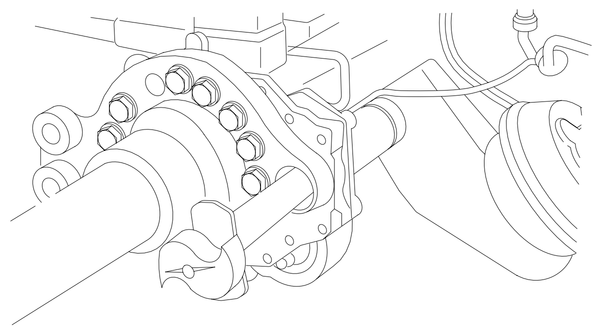


Fig. 12, Install the Camshaft

Chamber Type (Size)	Brake Chamber Torque Specifications, lbf·ft (N·m)		
	Midland	**MGM**	**Anchorlok**
16	35 to 50 (48 to 68)	35 to 40 (48 to 54)	Not Available
20	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)
24	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)
30	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)
36	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)
Spring Chamber	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)

Table 2, Brake Chamber Torque Specifications

6.2 Apply a thin film of grease on the inside of the camshaft bushings and journals. For the recommended grease specification, see **Specifications, 400**. Do not grease the camshaft head area.

6.3 Apply a thin film of rust preventive grease on the camshaft splines. For the recommended grease specification, see **Specifications, 400**.

6.4 Carefully slip the camshaft in the brake spider and the camshaft-and-chamber bracket tube. The camshaft should turn freely by hand.

7. Install the slack adjuster. For instructions, see **Section 42.11** for Gunite, **Section 42.12** for Haldex, or **Section 42.13** for Meritor automatic slack adjusters.

WARNING

When lubricating the camshaft-and-chamber bracket, if grease leaks out under the cam head, the camshaft grease seal is worn or damaged. If the seal is not replaced, the brake linings could be contaminated by grease and the vehicles stopping distance could be reduced, which could result in personal injury or property damage.

Brake Components Disassembly, Inspection, Cleaning, and Assembly

8. For all Cam-Master Q Plus brakes except MX500, pressure lube the camshaft-and-chamber bracket bushings.

   NOTE: Use meter-type fittings with a maximum 40 psi (276 kPa) pressure relief at the shutoff.

   8.1 Pump multipurpose chassis grease (NLGI grade 1 or 2) into the camshaft-and-chamber bracket until it appears at the slack adjuster end of the bracket. Use care that no grease enters the drum cavity. For recommended grease specification, see **Specifications, 400**.

   8.2 If grease leaks out under the cam head, the camshaft grease seal is worn, damaged, or installed backwards. See "Disassembly and Inspection" for grease seal replacement instructions.

NOTE: If the brake linings are being replaced on MX500 brakes before the service interval, the camshaft-and-chamber bracket and the slack adjuster do not need lubrication. The service interval is every 3 years or 500,000 miles (800 000 km), whichever comes first.

9. For MX500 brakes, when changing the brake linings at the service interval, lubricate the camshaft-and-chamber bracket and the automatic slack adjuster.

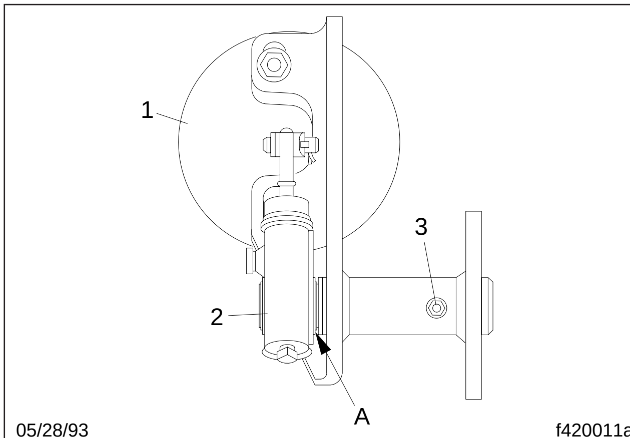
   9.1 Remove the identification tag from the camshaft-and-chamber bracket housing.

   9.2 Remove the grease plugs from both the camshaft-and-chamber bracket and the automatic slack adjuster.

   9.3 Install grease fittings.

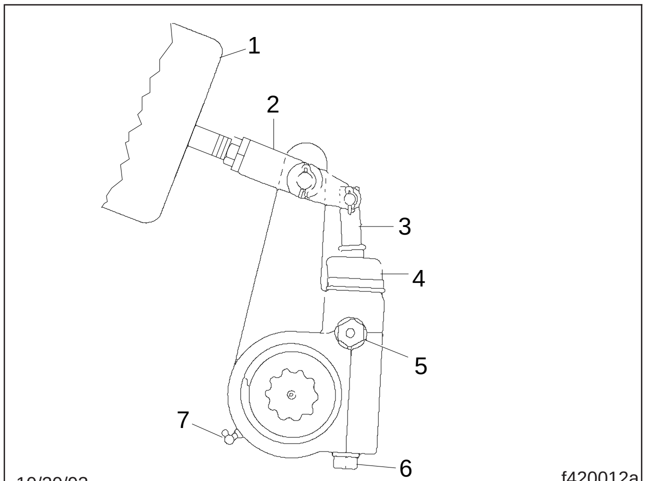
   9.4 Using Meritor-approved NLGI grade 2 synthetic polyurea grease (EVO-LUBE TEK-615), lubricate the brake assembly through the grease fitting in the bracket until new grease flows from the inboard seal. See **Fig. 13**.

   9.5 Using Meritor-approved NLGI grade 2 synthetic polyurea grease (EVO-LUBE TEK-615), lubricate the slack adjuster through the grease fitting until new grease flows out of the pull-pawl or camshaft seal. See **Fig. 14**.



A. Grease Exit
1. Brake Chamber
2. Slack Adjuster
3. Grease Fitting (or lube plug)

Fig. 13, Camshaft-and-Chamber Bracket Lubrication



1. Brake Chamber
2. Clevis
3. Actuator Rod
4. Boot
5. Pull-Pawl Seal
6. Adjusting Hexnut
7. Grease Fitting

Fig. 14, Slack Adjuster Lubrication

   9.6 Replace the grease fittings with new grease plugs and cover the bracket plug with a new identification tag.

10. Install the brake shoes. For instructions, see **Subject 110**.

Troubleshooting Tables

Problem—No Adjustment or Adjusted Stroke is Too Long

Problem—No Adjustment or Adjusted Stroke is Too Long	
Possible Cause	**Remedy**
The wrong slack adjuster is installed.	Replace the slack adjuster with the correct one.
The clevis is not installed correctly.	Check the slack adjuster installation. For instructions, see the appropriate slack adjuster section in this group.
There is excessive wear between the clevis and collar.	Check the gap between the clevis and the collar. The maximum allowable gap is 0.060 inch (1.5 mm). Replace the threaded clevis as necessary.
The jam nut at the clevis is loose.	Tighten the jam nut to specifications.
The large clevis pin bushing in the slack adjuster arm is worn.	Measure the inside diameter of the large clevis pin bushing. The inside diameter must not be larger than 0.53 inch (13.5 mm). Replace the bushing as necessary.
The return spring in the air chamber is weak or broken.	Check the air spring force. At the first movement of the push rod, the spring force must beat least 32 lbf (142.3 N). Replace the return spring or air chamber as necessary.
The spring brake is not fully retracting.	Repair or replace the spring brake.
The pull-pawl or the actuator is worn (the teeth are stripped).	Replace the pull-pawl or the actuator in the slack adjuster.
The slack adjuster has internal damage.	Inspect the slack adjuster. Repair or replace the slack adjuster as necessary. For instructions, see the appropriate slack adjuster section in this group.
There is excessive play between the slack adjuster gear and the splines of the camshaft.	Replace the camshaft and/or the slack adjuster as necessary.
Foundation brake components are worn.	Replace the components.

Problem—Linings Dragging or Adjusted Stroke is Too Short

Problem—Linings Dragging or Adjusted Stroke is Too Short	
Possible Cause	**Remedy**
The incorrect brake linings are installed	Install the correct Meritor approved brake linings.
The wrong slack adjuster is installed.	Replace the slack adjuster with the correct one.
The clevis is not installed correctly.	Check the slack adjuster installation. For instructions, see the appropriate slack adjuster section in this group.
The jam nut at the clevis is loose.	Tighten the jam nut to specifications.
The spring brake is not fully retracting.	Repair or replace the spring brake.
The manual (free-stroke) adjustment is incorrect.	Adjust the free-stroke and applied chamber stroke. For instructions, see **Subject 130**.
Poor contact between the linings and the drum, or the drum is out-of-round.	Repair or replace the drum or the linings.
There is a brake temperature imbalance.	Correct the brake balance.

Specifications

Q Plus Brake Torque Specifications			
Fastener Size	**Grade**	**lbf·ft**	**N·m**
Brake Shoe Lining Nuts			
1/4 in	5	80 to 20 lbf·in	900 to 1120 N·cm
3/8 in	5	18 to 23	24 to 31
Dust Shield Fasteners			
5/16–18	5	15 to 20	20 to 27
3/8–16	5	25 to 35	34 to 47
3/8–16	8	35 to 50	47 to 68
Brake Spider Fasteners			
7/16–20		60 to 75	81 to 102
1/2–20		85 to 115	115 to 156
9/16–18		135 to 165	176 to 224
5/8–18		180 to 230	244 to 312
Camshaft-and-Chamber Bracket Fasteners			
1/2–13 Capscrew (without nut)	5	65 to 85	88 to 116
1/2–13 Capscrew (without nut)	8	70 to 100	95 to 136
5/8–18 Bolt with Locknut		130 to 165	176 to 224
5/8–18 Bolt with Plain Hexnut		150 to 190	203 to 258

Table 1, Q Plus Brake Torque Specifications

Chamber Type (Size)	Brake Chamber Torque Specifications, lbf·ft (N·m)		
	Midland	**MGM**	**Anchorlok**
16	35 to 50 (48 to 68)	35 to 40 (48 to 54)	Not Available
20, 24, 30, 36	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)
Spring Chamber	70 to 100 (95 to 136)	100 to 115 (136 to 156)	With hexnut, 110 to 115 (149 to 203) With locknut, 85 to 95 (115 to 129)

Table 2, Brake Chamber Torque Specifications

Meritor Grease Specification			
Specification Number	**NLGI Grade**	**Grease Type**	**Outside Temperature, °F (°C)**
O-616-A	1	Clay Base	Down to –40 (–40)
O-617-A O-617-B	1 and 2	Lithium 12-Hydroxy Stearate or Lithium Complex	See Manufacturer's Specification
O-645	2	Synthetic Oil, Clay Base	Down to –65 (–54)
O-692	1 and 2	Lithium Base	Down to –40 (–40)

Specifications

Meritor Grease Specification			
Specification Number	**NLGI Grade**	**Grease Type**	**Outside Temperature, °F (°C)**
O-637	1 and 2	Calcium Base	See Manufacturer's Specification
O-641	—	Anti-Seize	See Manufacturer's Specification
O-695	2	Synthetic Polyurea	–40 (–40)

Table 3, Meritor Grease Specification

Component Lubrication						
Brake Type	**Meritor Grease Specification**					
	Clevis Pins	**Camshaft Splines**	**Anchor Pins**	**Brake Shoe Rollers**	**Camshaft Bushings**	**Slack Adjuster**
All Cam-Master Brakes Except Q Plus MX500	O-616-A O-637 O-641 O-645 O-692	O-616-A O-617-A O-617-B O-637 O-641 O-645 O-692	O-616-A O-617-A O-617-B O-645 O-692	O-616-A O-617-A O-617-B O-645 O-692	O-616-A O-617-A O-617-B O-645 O-692	O-616A O-645 O-692
Q Plus MX500 Brakes	O-695	O-695	O-617-A O-617-B O-645 O-692	O-617-A O-617-B	O-616-A O-617-A O-617-B O-645 O-692	O-695

Table 4, Component Lubrication

General Description

Dana Spicer extended service (E.S.) brakes can be installed on both the front and rear axles. See **Table 1** for brake model identification.

The brakes are actuated by an S-type cam head that is forged integrally with the camshaft and supported with nylon bushings. Cam pressure is applied through the cam rollers. **Figure 1** shows a Dana Spicer front axle brake.

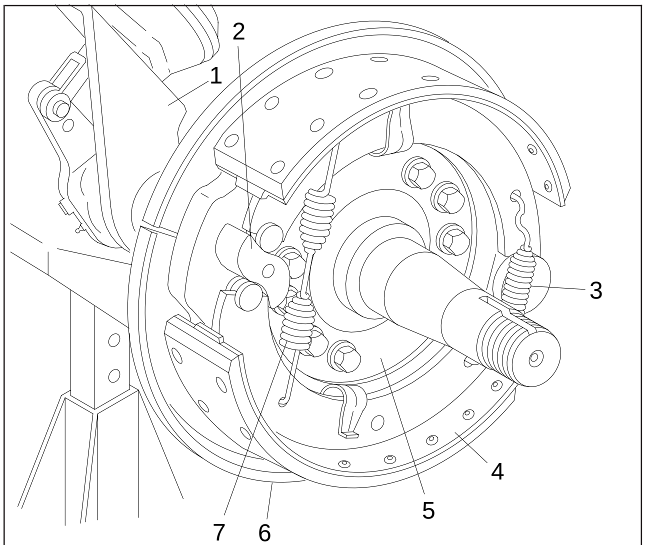
Dana Spicer Brake Model Identification Sample Model Number: ES-150-8D			
Code	**Definition**		
Service			
ES	Extended Service Brake		
Drum Diameter	(inch)	(mm)	
150	15	381	
165	16-1/2	419	
180	18	457	
Shoe Size	(inch)	(mm)	
4	4	102	
7	7	178	
8	8-5/8	219	
Configuration	(Shoe)	(Spider)	(Anchor Pin)
L	Fabricated	Fabricated	Single
D	Fabricated	Cast	Single

Table 1, Dana Spicer Brake Model Identification

Meritor steer axles have seven holes for attaching the spider to the axle flange. An eighth hole is left open on the brake spider, on both left and right sides of the steer axle. See **Fig. 2**.

The seven holes used for attaching the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter and is used for the antilock braking system (ABS) speed sensor bushing.

The front- and rear-axle brakes have significant differences, as shown in **Table 2**.



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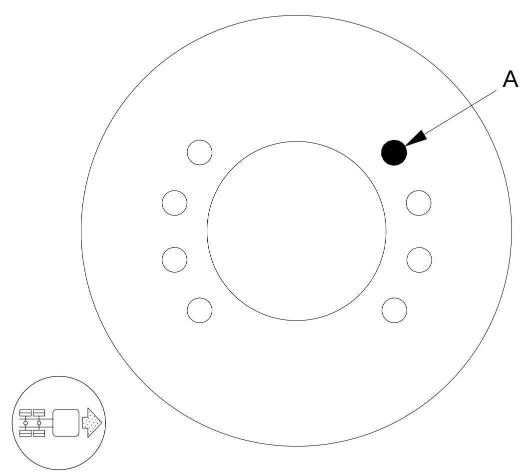
1. Air Chamber Bracket
2. S-Head Camshaft
3. Shoe Retaining Spring
4. Shoe Assembly
5. Spider
6. Dust Shield
7. Shoe Return Spring

Fig. 1, Front Axle Brake



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A. Open oversize-hole for ABS speed sensor bushing.

Fig. 2, Brake Spider Oversize Hole

General Information

Principles of Operation

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a pushrod assembly.

The pushrod turns the slack adjuster and brake camshaft. As the camshaft turns, the S-head forces the brake shoes against the brake drum and braking occurs.

When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring return the camshaft, brake shoes, slack adjuster, and pushrod to their released positions.

Dana Spicer E.S. Brake Characteristics		
Item	**Front Brakes**	**Rear Brakes**
Brake drums	15 in	15 or 16-1/2 in
Brake Shoe Lining	4 in 1-piece	7 or 8-5/8 in 2-piece
Brake Shoe Web	Single	Double
Cam Roller	Center groove	Bushing-type roller with protruding center pin and retainer clip
Hold-down Spring (clip)	Yes	No
Retaining Spring	1	2
Return Spring	1	1

Table 2, Dana Spicer E.S. Brake Characteristics

General Safety Precautions

WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

Asbestos and Non-Asbestos Safety

WARNING

Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

Safety Precautions

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

Removal

WARNING

Before doing this procedure, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

WARNING

When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

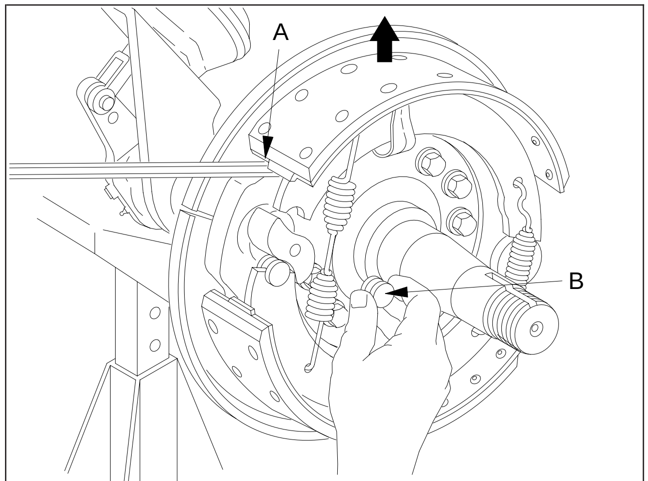
3. If the brake has spring chambers, carefully cage and lock the springs so that the springs cannot actuate during disassembly.
4. Remove the wheels. For instructions, see **Section 40.00**, Subject 100.
5. Remove the brake drums. For instructions, see **Section 33.01**, Subject 100, for front axles or **Section 35.01**, Subject 100, for rear axles.

CAUTION

Before you back off the automatic slack adjuster, refer to the applicable slack adjuster section in this manual or to the manufacturer's service information for instructions. Failure to do so could damage the slack adjusters.

6. Back off the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.
7. To remove the front brake shoes (4-inch shoes with single webs):

    7.1 Using a large screwdriver or lever, raise the upper shoe and remove the upper cam roller. See **Fig. 1**.



A. Lift the upper shoe to stretch the spring.
B. Remove the cam roller.

Fig. 1, Remove the Upper Cam Roller

    7.2 Reposition the tool and pry the lower shoe downward. Remove the lower cam roller.

    7.3 Using a large screwdriver or lever, stretch the shoe return spring and unhook it from the upper shoe web. See **Fig. 2**. Remove the spring from the lower web.

    7.4 Rotate the lower shoe downward around the anchor pin to remove the tension on the shoe retaining spring. See **Fig. 3**. Remove the retaining spring from the lower shoe. Remove the lower shoe from the spider.

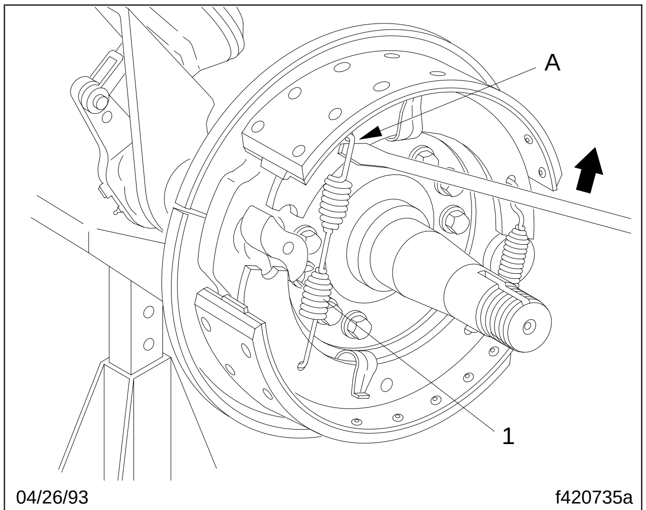
    7.5 Remove the upper shoe from the spider.

    7.6 Discard the cam rollers, shoe return spring, and shoe retaining spring.

8. To remove the rear brake shoes (7- or 8-5/8 inch shoes with dual webs):

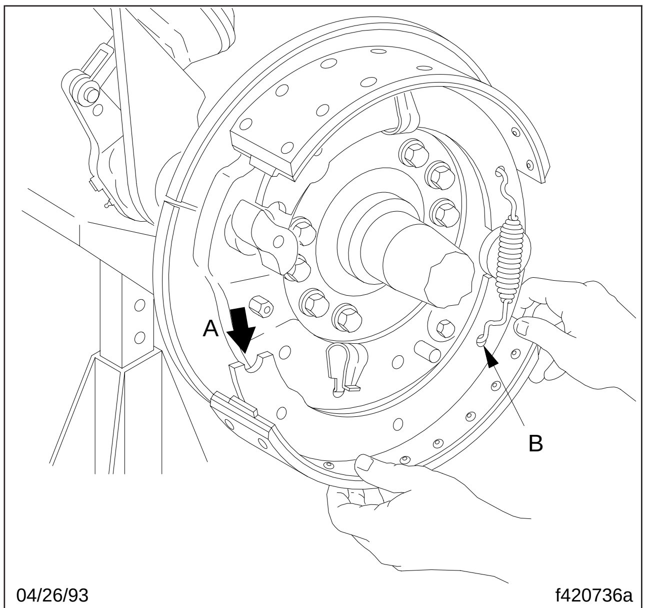
    8.1 Pry the roller retainer loops out of both shoe web holes. See **Fig. 4**. Pivot the roller retainer to swing the loops clear of the shoe webs.

Brake Shoe Removal and Installation



A. Stretch the return spring and unhook it from the shoe web.
1. Shoe Return Spring

Fig. 2, Stretch the Shoe Return Spring



A. Rotate the lower shoe around the anchor pin.
B. Unhook the retaining spring.

Fig. 3, Rotate the Lower Shoe Downward

8.2 Using a large screwdriver or lever, raise the upper shoe, stretching the return spring. See **Fig. 5**. Remove the cam roller and retainer as a unit.

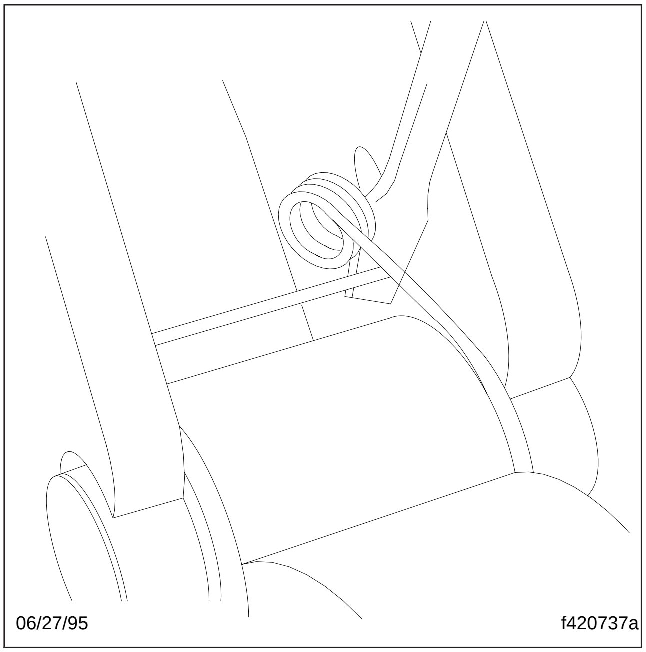
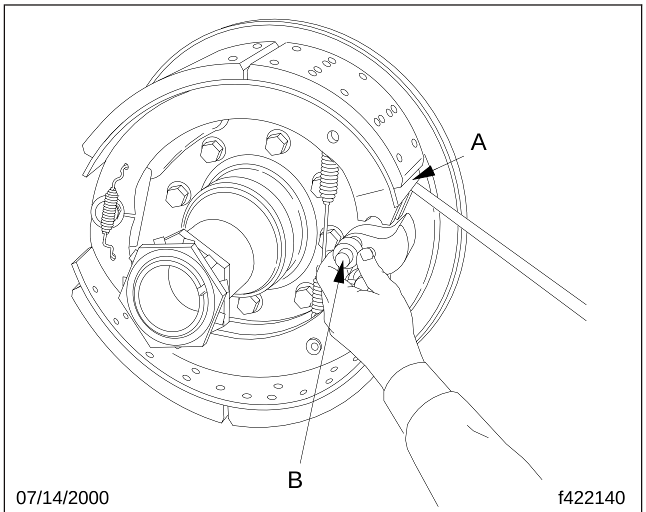


Fig. 4, Pry out the Roller Retainer Loops

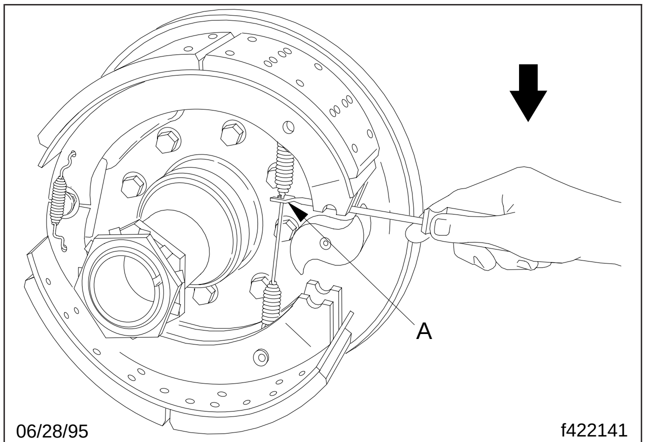
Pry the the lower shoe downward and remove the lower cam roller and retainer.



A. Lift upper shoe to stretch the return spring.
B. Remove the roller and retainer.

Fig. 5, Remove the Cam Roller

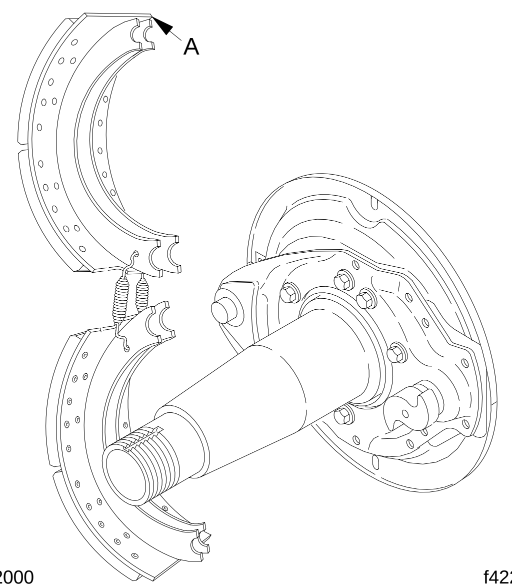
8.3 Position a suitable lever to engage the return-spring rod. See **Fig. 6**. Force the lever down to release the tension on the upper part of the spring. Remove the upper spring hook.



A. Pry up on the return spring for easy removal of the upper hook.

Fig. 6, Remove the Return Spring

8.4 Rotate both shoes around the anchor pin and remove the shoes from the spider. See **Fig. 7**.



A. Rotate both shoes around the anchor pin and remove the brake shoes from the spider.

Fig. 7, Remove the Brake Shoes

8.5 Discard the cam rollers and retainers, and the shoe return spring.

9. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

Installation

IMPORTANT: For best brake performance, do not mix Extended Service brakes with other Dana Spicer series brakes. Use the same brake series on the entire vehicle.

1. Make sure the spider, camshaft, air chamber bracket, and slack adjuster are serviceable and properly installed.

IMPORTANT: Do not lubricate the cam-head surface or the corresponding surface on the cam rollers. For efficient operation, the cam interface must remain free of oil, grease, and other contaminants.

2. Apply a thin film of NLGI grade 1, high-temperature, waterproof grease (Kendall M-621, or an equivalent) to the half-moon cutouts on the end of each shoe web where the web contacts the cam roller and anchor pin.

3. To install a single-web brake shoe assembly on a 15-inch front brake:

   3.1 Place the upper brake shoe web on the anchor pin and rotate the shoe assembly downward until the web is secured in the shoe hold-down spring (clamp).

   NOTE: The shoe hold-down spring is mounted on the spider between the anchor pin and the S-cam.

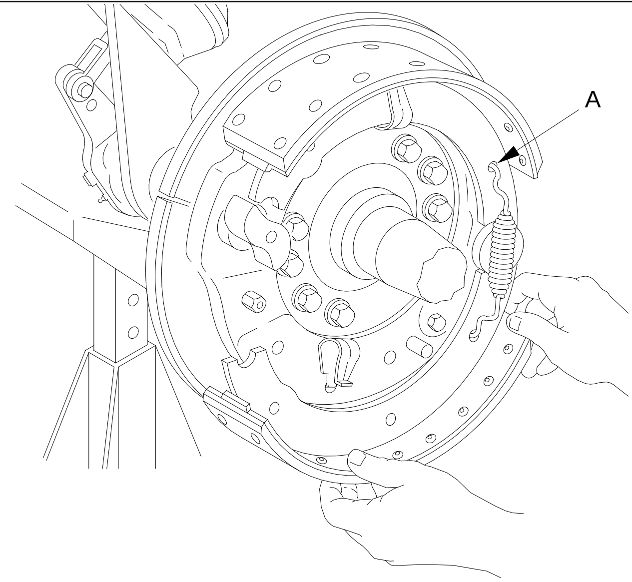
   3.2 Hook one end of a new shoe retaining spring in the hole in the upper shoe web so that the coil lays across the anchor pin. See **Fig. 8**.

   3.3 Hook the lower end of the retaining spring in the hole on the lower shoe web.

   3.4 Place the lower shoe web against the anchor pin and stretch the retaining spring enough to rotate the shoe assembly into place on the spider.

   3.5 Hook one end of a new shoe return spring in the hole in the lower shoe web.

Brake Shoe Removal and Installation



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A. Hook the retaining spring in the shoe web hole.

Fig. 8, Install a New Shoe Retaining Spring

Using a large screwdriver, stretch the shoe return spring to hook it in the upper shoe web hole. See **Fig. 2**.

3.6 Using a large screwdriver or lever, pry the upper shoe upward and install a new cam roller between the upper shoe web and the S-cam. See **Fig. 9**.

3.7 Pry the lower shoe downward and install a new cam roller between the lower shoe web and the S-cam.

4. To install a dual-web brake shoe assembly on a 15- or 16-1/2 inch rear brake:

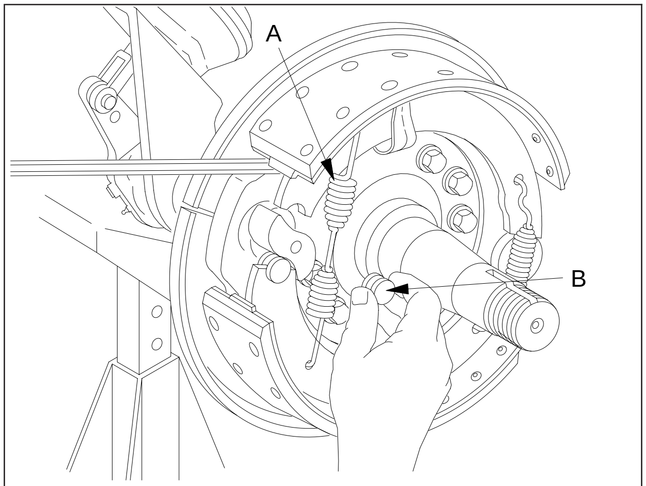
4.1 Hook the ends of a new retainer spring in the holes on the upper and lower webs. Install a second retainer spring on the webs on the back side of the brake shoe assembly.

4.2 Place the upper and lower shoes around the anchor pin. See **Fig. 10**.

4.3 Place a new return spring between the webs and hook the bottom of the spring in the hole in the lower shoe web.

4.4 With a suitable tool placed against the return spring rod, force the tool handle down to stretch the lower half of the spring. See **Fig. 6**. Hook the top of the return spring in the hole in the upper shoe web.

4.5 Assemble the roller retainer on the ends of the roller. See **Fig. 11**.



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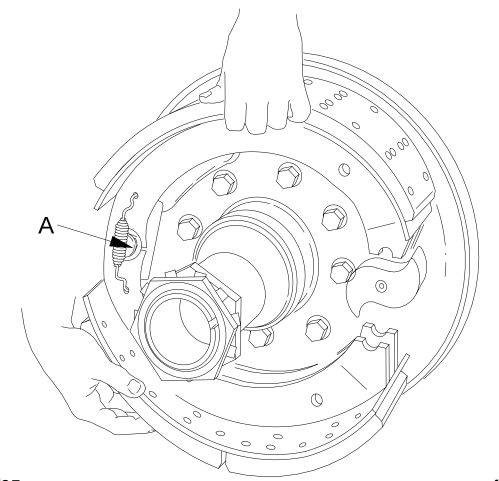
A. Install a new return spring.
B. Install the upper and lower cam rollers.

Fig. 9, Install the Cam Rollers



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A. With both retainer springs installed, place the upper and lower shoes around anchor pin.

Fig. 10, Position the Upper and Lower Shoes

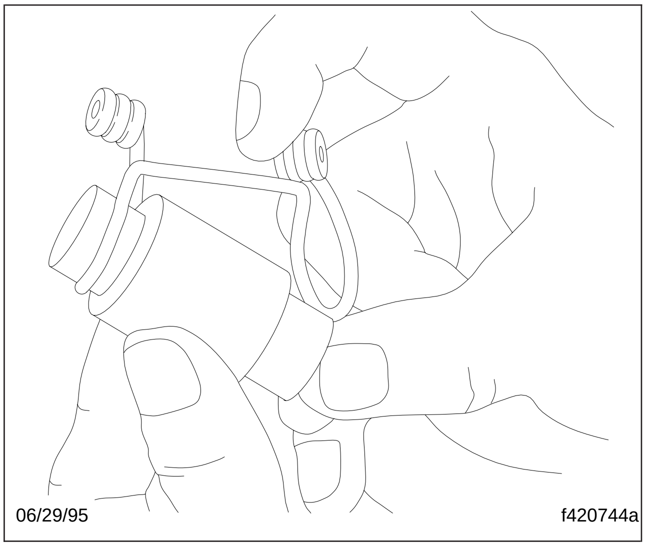


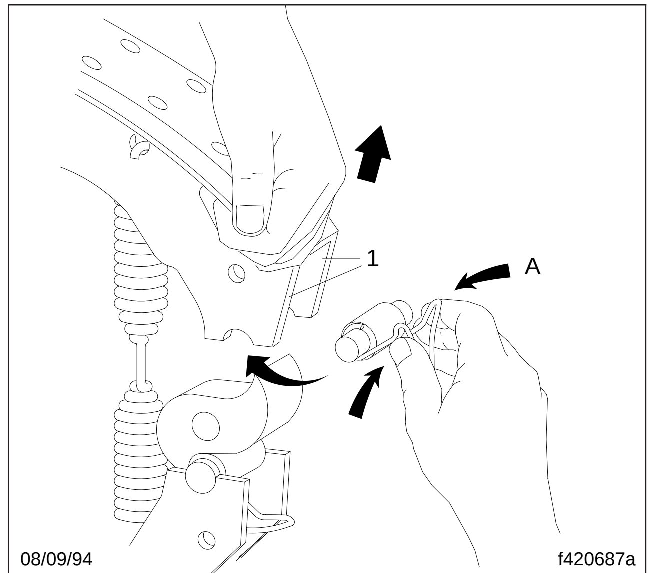
Fig. 11, Assemble the Roller Retainer

4.6 Lift the upper shoe assembly and insert the new roller and retainer assembly between the shoe webs and the S-cam. See Fig. 12.

Squeeze the retainer loops and swing the retainer assembly into position (Fig. 13), then snap the loops into the web holes. Make sure that both retainer loops are engaged in the web holes.

Repeat on the lower shoe.

5. Install the brake drums. For instructions, see Section 33.01, Subject 100, for front axles or Section 35.01, Subject 100, for rear axles.
6. Install the wheels. For instructions, see Section 40.00, Subject 100.
7. If working on the rear axle, manually uncage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this manual.
8. Adjust the brakes at the slack adjusters. For instructions, see Subject 150.
9. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.



A. Squeeze the ears of the retainer together.
1. Brake Shoe Web

Fig. 12, Install the Cam Rollers

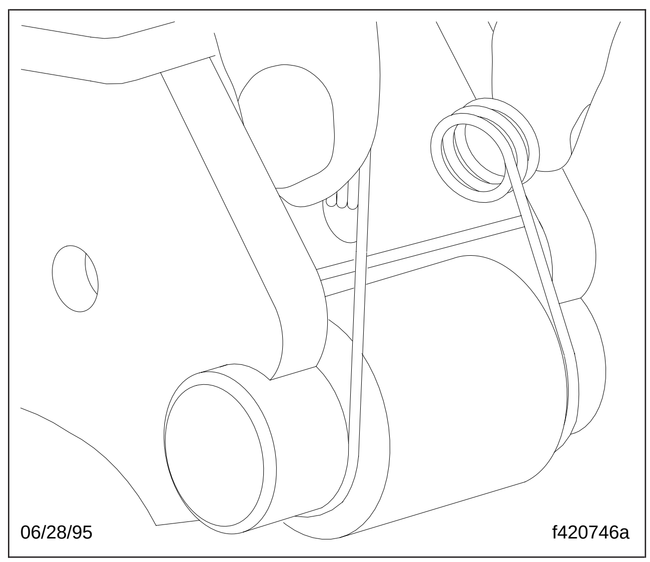


Fig. 13, Position the Retainer Assembly

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

Brake Shoe Removal and Installation

10. In a safe area, check for proper brake operation before you put the vehicle in service.
    - 10.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.
    - 10.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
    - 10.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others indicate a lack of braking effort on those wheels.

Inspection

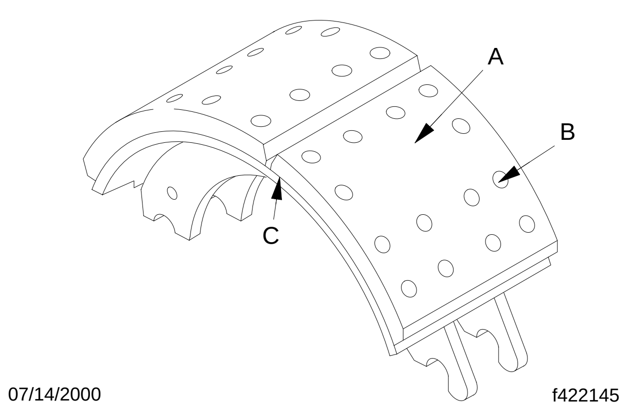
WARNING

Before starting this procedure, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Remove the brake shoes. Refer to **Subject 110** for instructions.
2. Inspect the brake shoe linings.

   On front-axle brakes, if the linings are grease- or oil-soaked, cracked, or worn to less than 3/16-inch (4.5-mm) thickness at any point, replace them. See **Fig. 1**. The lining surface should be no closer than 1/16 inch (1.5 mm) to any rivet head.

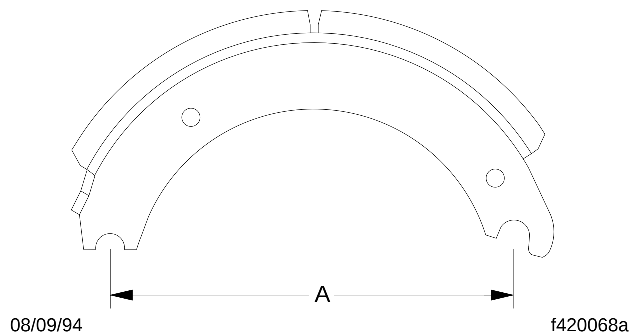
   On rear-axle brakes, if the linings are grease- or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.



A. Check for cracks or contamination.
B. The lining surface must not be closer than 1/16" (1.5 mm) to any rivet head.
C. The minimum lining thickness is 3/16" (4.5 mm).

Fig. 1, Inspect the Brake Shoe (15-inch series shown)

3. Check the shoes for bent or cracked webs or tables, broken welds, loose rivets, or out-of-round rivet holes. Replace the shoes if any of these conditions exist.



A. Measure the distance between recess centers.

Fig. 2, Shoe Span Measurement

4. Check the anchor pin for looseness and cam-shaft roller recesses in the shoe webs for visible wear. Replace the shoe if needed.
5. Check the shoe span. Measure the distance between the centerlines of the anchor pin and cam roller recesses in the shoe web. See **Fig. 2**.
   - On 15-inch series brakes, if the measurement is more than 11-3/4 inches (298 mm), replace the shoe.
   - On 16-1/2 inch series brakes, if the measurement is more than 12-9/16 inches (319 mm), replace the shoe.

Replacement

WARNING

Before starting this procedure, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

IMPORTANT: Vehicle brake systems require the correct lining material to perform as originally designed. The type of lining material that is specified for the vehicle is based on several technical considerations and Department of Transportation (DOT) braking performance regulations. To ensure fewer relines and greater compatibility with the vehicle's brake system, use the same quality of friction lining material that was installed at the factory.

Always reline both wheels of a single axle and all wheels of a tandem axle at the same time.

Always install the same linings and drums on both wheels of a single axle and all four wheels of a tandem axle. It is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes.

When the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

NOTE: Replace the springs each time the brakes are relined. Dana Spicer recommends replacement of the cam rollers at each reline.

1. Remove the brake shoes. For instructions, see **Subject 110**.

CAUTION

Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.

2. Using a suitable riveting mandrel, push out (do not drill out) the old rivets.
3. Clean the shoe table. For instructions, see **Subject 140**, "Cleaning."

CAUTION

Make sure that the replacement lining material conforms to FMSI 1308, a standard for lining size and shape only. Use of an improper FMSI lining specification or friction material type may cause brake dragging or grabbing, or improper brake performance.

4. Align the brake shoe and lining rivet holes. Using a C-clamp, clamp the lining to the brake shoe.

IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are:

- 1/4-inch (6-mm) diameter by 1/2-inch (13-mm) long,
- SAE no. 10-8, and
- made of zinc- or brass-plated steel.

5. Insert the correct size rivets into all the holes in the new block. Temporarily hold them in place with masking tape.
6. Secure the rivets in the correct sequence.
   - For front brake shoes with one-piece, 4-inch linings, start with the two middle holes and work toward the ends in a criss-cross pattern.
   - For rear brake shoes, follow the sequence shown in **Fig. 1**.
7. Check for a close fit between the lining and shoe table.

   Try to insert a 0.006-inch (0.15-mm) feeler gauge between the lining and shoe table along the edges. See **Fig. 2**. It should not be possible to insert the gauge anywhere along the edge, except at each end beyond the last row of rivets. A larger clearance may exist in these areas.
8. Remove the C-clamp and masking tape.

IMPORTANT: Always adjust the brakes at the slack adjusters after replacing the linings. For instructions, see **Subject 150.**

Brake Shoe and Lining Replacement

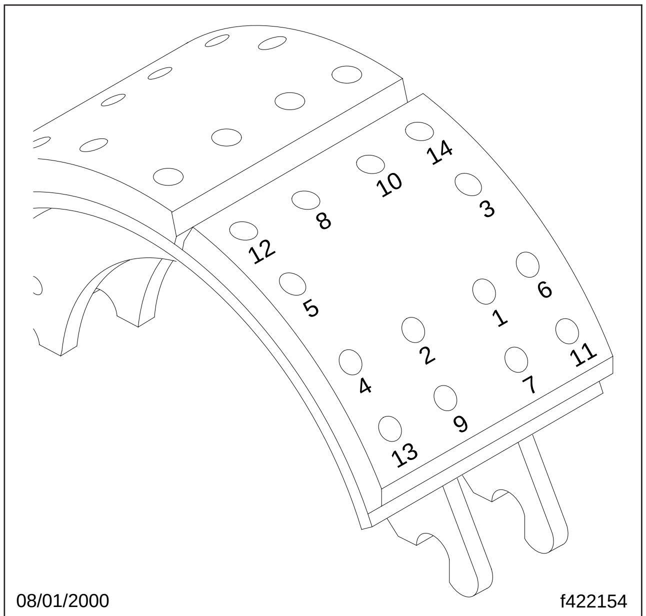
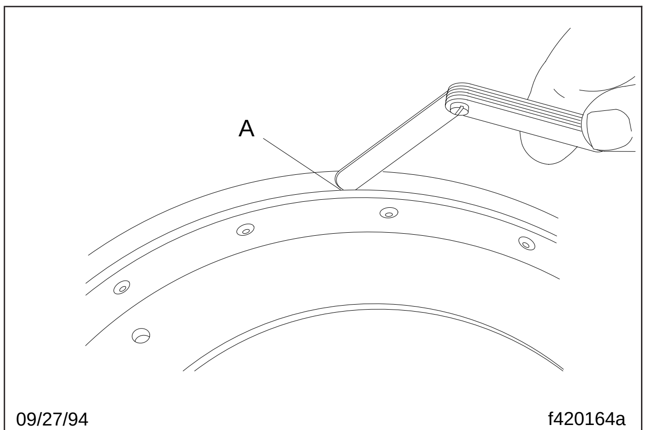


Fig. 1, Rear Lining Rivet Sequence



A. The clearance between the brake lining and shoe table must be less than 0.006 inch (0.15 mm).

Fig. 2, Check Fit Between Lining and Shoe Table

Brake Components Disassembly and Inspection, Cleaning, and Assembly

WARNING

Before starting this procedure, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Disassembly and Inspection

On front-axle brakes, the upper and lower brake shoe assemblies have single webs, one-piece brake shoe linings, and a single retaining spring. See **Fig. 1**.

On rear-axle brakes, the brake shoe assemblies have dual webs, two-piece brake shoe linings, and two retaining springs. **Figure 2** is an exploded view of a typical rear-axle brake assembly.

1. Remove the brake shoes. For instructions, see **Subject 110**.
2. Inspect the drum.
   - 2.1 Check the drum for cracks. Replace any cracked drum.
   - 2.2 Using a drum caliper or other measuring device, measure the inside diameter of the drum in several places. Replace the drum if it exceeds the maximum diameter stamped on it.
   - 2.3 Check the drum for heat checks, glazing, grooving, run-out, and out-of-round. See **Fig. 3**. Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, see **Section 33.01** or **Section 35.01**.

IMPORTANT: Never pull the slack adjuster out of the pushrod clevis. Always turn the adjusting nut for positioning.

3. Disconnect the slack adjuster from the pushrod clevis. For detailed instructions, see **Section 42.11** for Gunite, **Section 42.12** for Haldex, or **Section 42.13** for Meritor automatic slack adjusters.
   - 3.1 Remove the cotter pin from the clevis pin; remove the clevis pin. See **Fig. 4**.

CAUTION

For a Meritor automatic slack adjuster, disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

   - 3.2 For a Meritor automatic slack adjuster, disengage the pull-pawl on the side of the adjuster. Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm) and wedge the tool in place. See **Fig. 5**. Pull-pawls are spring loaded. When the tool is removed, the pull-pawl will engage the teeth automatically.

   IMPORTANT: Never pull the slack adjuster out of the pushrod clevis. Always turn the adjusting nut for positioning.

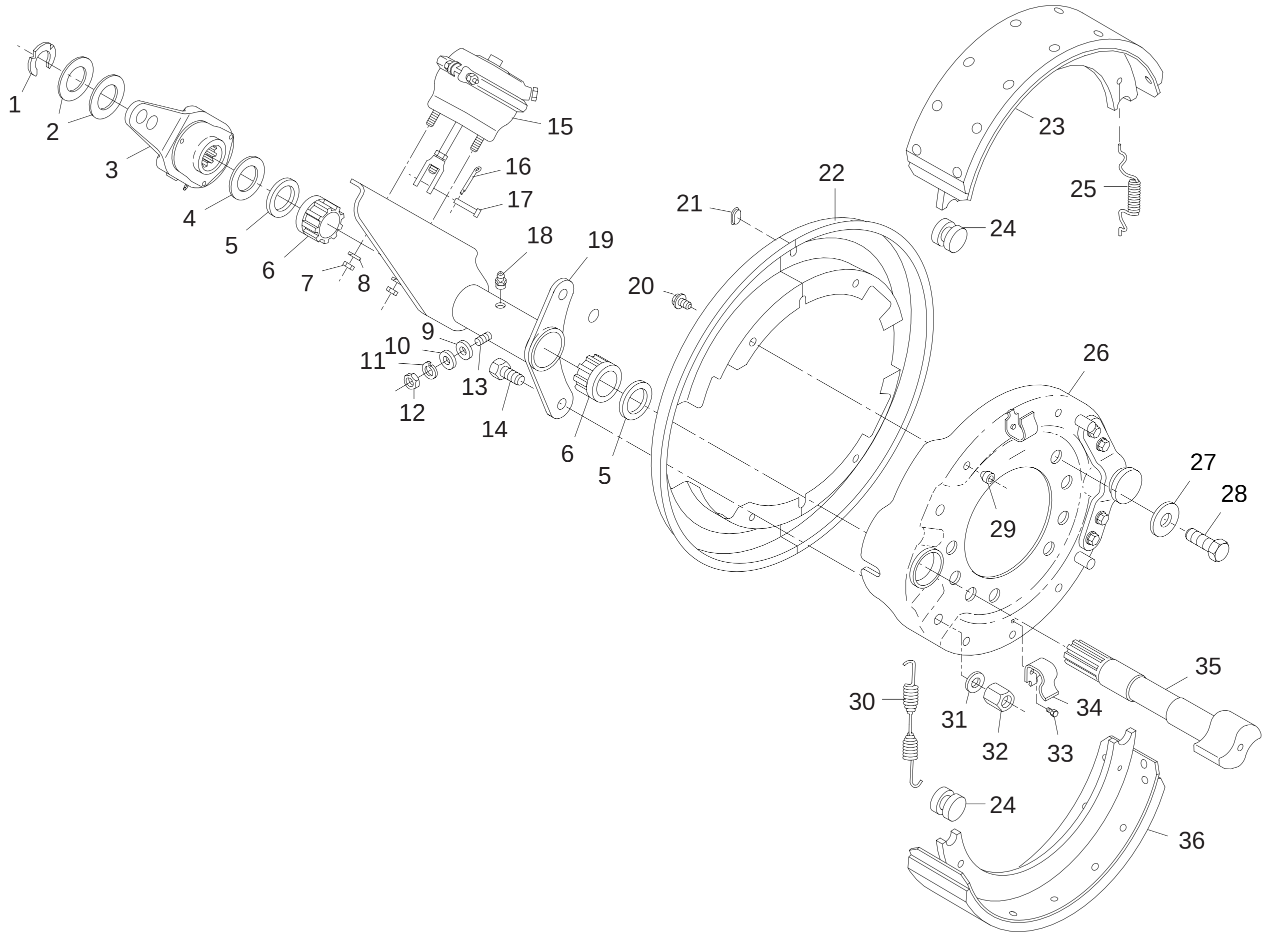
   - 3.3 Using a wrench, turn the manual adjusting nut to back the slack adjuster out of the clevis.
     - On Meritor adjustors, turn the square adjusting nut clockwise (as if loosening a right-hand threaded fastener).
     - On Haldex or Gunite adjusters, turn the adjusting hexnut counterclockwise. You will hear a ratcheting sound.
4. Using a dial indicator, measure the up-and-down and side-to-side end-play of the camshaft. Replace the bushings if there is more than 0.020 inch (0.5 mm) of movement.

CAUTION

Do not hammer on the slack adjuster to remove it. Damage to the adjuster or camshaft spline may result.

5. Remove the slack adjuster.
   - 5.1 From the slack adjuster side of the camshaft support bracket, remove the snap ring and any washers, spacers, and seals from the camshaft. See **Fig. 1** or **Fig. 2**.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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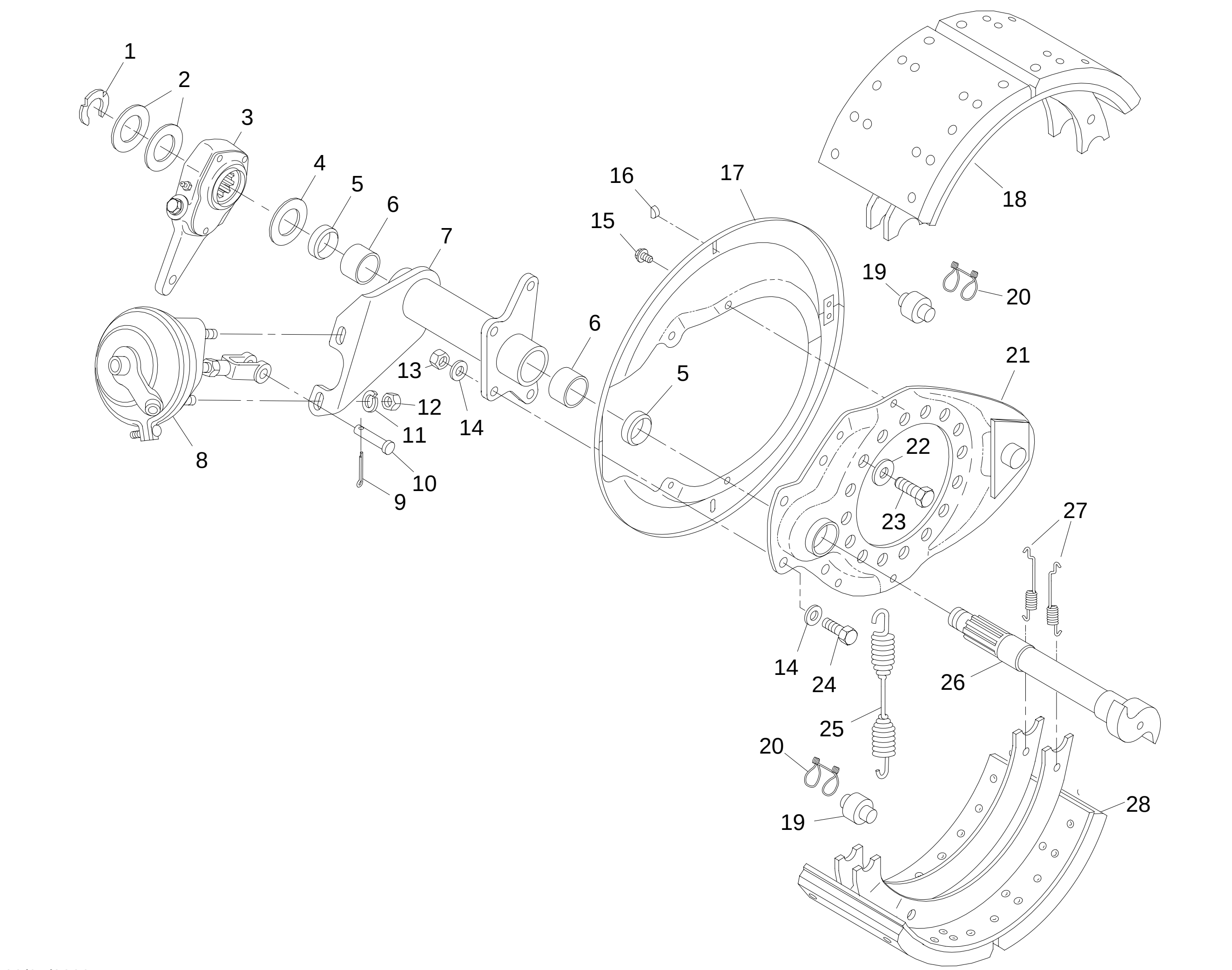
1. Snap Ring
2. Camshaft Outer Washers
3. Slack Adjuster
4. Camshaft Inner Washer
5. Grease Seal
6. Camshaft Bushing
7. Stud Nut
8. Lockwasher
9. Spacer
10. Plain Washer
11. Lockwasher
12. Nut
13. Stabilizing Screw
14. Bracket Mounting Bolt
15. Brake Chamber
16. Cotter Key
17. Clevis Pin
18. Grease Fitting
19. Camshaft Support Bracket
20. Dust Shield Screw
21. Lining Inspection Plug
22. Dust Shield
23. Upper Brake Shoe and Lining
24. Cam Roller
25. Retaining Spring
26. Brake Spider and Anchor Pin Assembly
27. Hardened Washer
28. Spider Mounting Bolt
29. Nutsert
30. Return Spring
31. Lockwasher
32. Barrel Nut
33. Bolt
34. Shoe Hold-Down Spring
35. Camshaft
36. Lower Brake Shoe and Lining

Fig. 1, Front Axle Brake

5.2 Remove the slack adjuster from the camshaft.

6. Check the slack adjuster for damage and binding.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



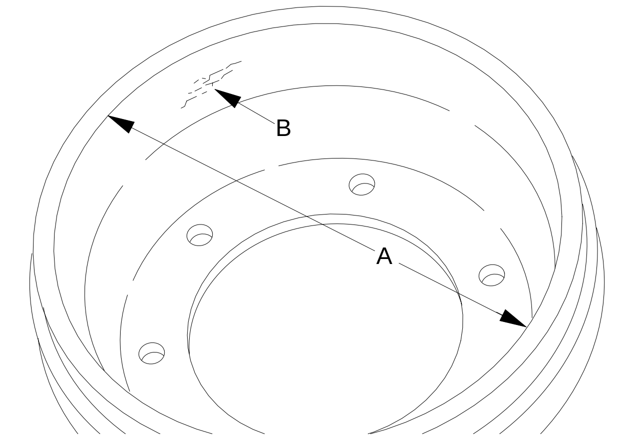
1. Snap Ring
2. Camshaft Outer Washers
3. Slack Adjuster
4. Camshaft Inner Washer(s)
5. Spring-Loaded Lip Seal
6. Camshaft Bushing
7. Camshaft Mounting Bracket
8. Brake Chamber
9. Clevis Pin Cotter Pin
10. Brake Chamber Clevis Pin
11. Lockwasher
12. Stud Nut
13. Locknut
14. Washer
15. Dust Shield Capscrew
16. Dust Shield Plug
17. Dust Shield (2-piece)
18. Upper Brake Shoe and Lining
19. Cam Roller and Pin
20. Retainer Clip
21. Spider (stamped spider shown)
22. Hardened Washer
23. Spider Mounting Bolt
24. Bracket Mounting Bolt
25. Return Spring
26. Camshaft
27. Retaining Springs
28. Lower Brake Shoe and Lining

Fig. 2, Rear Axle Brake (typical)

6.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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A. Measure the diameter and check for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 3, Check the Drum

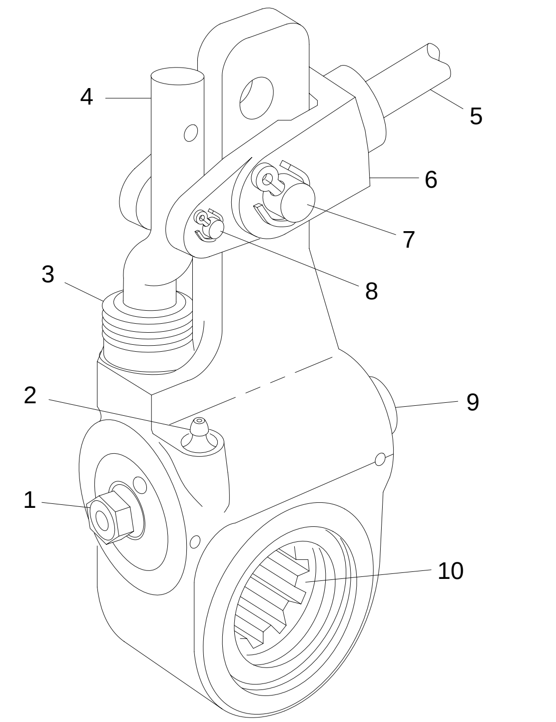
turned in the counterclockwise direction. When checking these slack adjusters for binding, only rotate the manual adjusting nut in the clockwise direction.

6.2 Using a torque wrench that measures lbf·in (or N·cm), turn the manual adjusting nut clockwise so that the worm gear rotates a full 360 degrees (typically 22 turns of the wrench).

If there is binding, or if more than 25 lbf·in (280 N·cm) is needed to turn the slack adjuster, replace it. For instructions, see the applicable slack adjuster section in this group.

IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

7. Check to see if a camhead thrustwasher is installed between the S-cam and the spider. If so, note the orientation for later installation. The orientation depends on the brake assembly model.
8. Remove the camshaft by grasping its head and pulling the camshaft outboard from the brake spider and camshaft support bracket.



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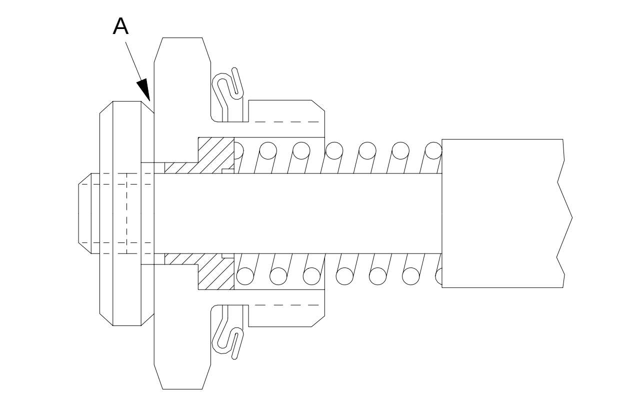
NOTE: A Gunite automatic slack adjuster is shown.

1. Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Pushrod
6. Clevis
7. Clevis Pin, 1/2-in
8. Clevis Pin, 1/4-in
9. Grease Relief Opening
10. Slack Adjuster Spline

Fig. 4, Disconnect Slack Adjuster from Clevis

Remove the camhead thrustwasher from the camshaft, if one is installed.

9. Check the camshaft spline end for cracks, or worn or deformed splines. Replace the camshaft if damaged.
10. Check the camshaft bushing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.
11. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the camhead surface.
12. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the



A. Insert a screwdriver here and pry the pull-pall out about 1/32 inch (0.8 mm).

Fig. 5, Disengage the Pull-Pall on Meritor Automatic Slack Adjusters

camshaft support bracket. Check the chamber and parts for problems.

Check the brake chamber for a cracked housing, bent pushrod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace parts as needed.

13. Remove and inspect the camshaft support bracket. Remove and discard the gasket. Check the bracket for a bent, broken, or cracked arm, and for cracked welds. Replace the bracket if any of these conditions exist.

WARNING

When removing bushings with a driver, wear eye protection. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off, which could cause serious eye injury.

14. Remove and inspect the old bushing and the grease seal.

    14.1 Check the camshaft bushing for wear. The inner surface must be smooth; if rough or abrasive, replace the bushing.

    14.2 Inspect the seal. Replace it if the lip is nicked, cut, or distorted.

15. On front brakes, check the stabilizing screw for bends, looseness, or damaged threads.

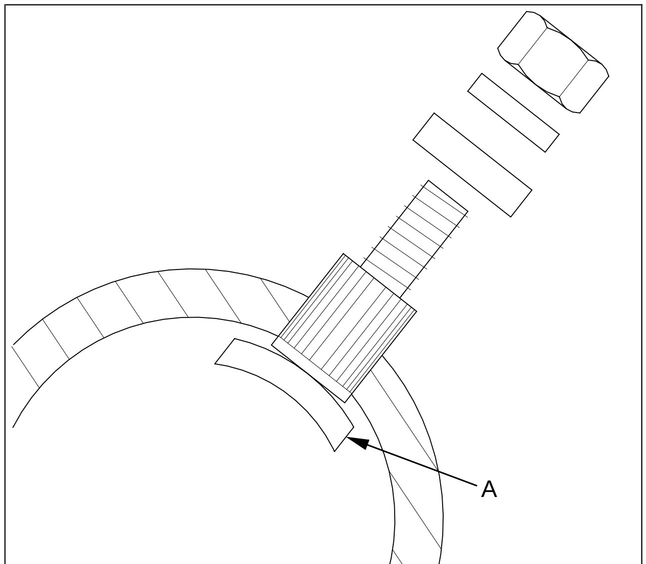
16. If necessary, replace the stabilizing screw.

WARNING

Wear eye protection when driving the screw into the camshaft bracket tube with a pin punch and hammer. Failure to wear eye protection could result in personal injury due to flying metal debris.

    16.1 Remove the damaged screw by driving it into the camshaft bracket tube with a pin punch and hammer.

    16.2 Aligning the curvature of the screw head with the curvature of the bracket tube, install the new screw. See **Fig. 6**.



A. Align the curvature of the head with the curvature of the camshaft bracket tube.

Fig. 6, Align the Screw Head

    16.3 Install the spacer, lockwasher, and nut. Tighten the nut 23 to 27 lbf·ft (31 to 37 N·m) to draw the screw serrations uniformly through the camshaft bracket tube wall.

    16.4 Remove the nut and washer before assembling the bracket on the spider.

17. Using a suitable piloted driver, install the new bushing or seal.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

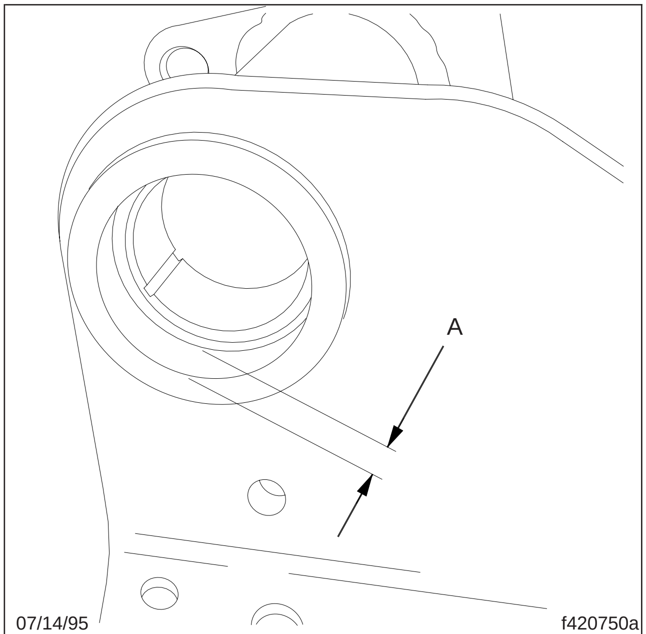
On front brakes, install the new bushing to a depth of 3/8 inch (9.5 mm) from each end of the bracket tube. See **Fig. 7**.

On rear brakes, install the new bushing to a depth of 22/32 inch (17.5 mm) at the slack adjuster end of the bracket tube and to a depth of 9/32 inch (7.1 mm) at the cam head end of the bracket tube.

Install the grease seal flush with the end of the air chamber bracket tube.

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the seal lip is facing toward the slack-adjuster end of the bracket tube. See **Fig. 8**.

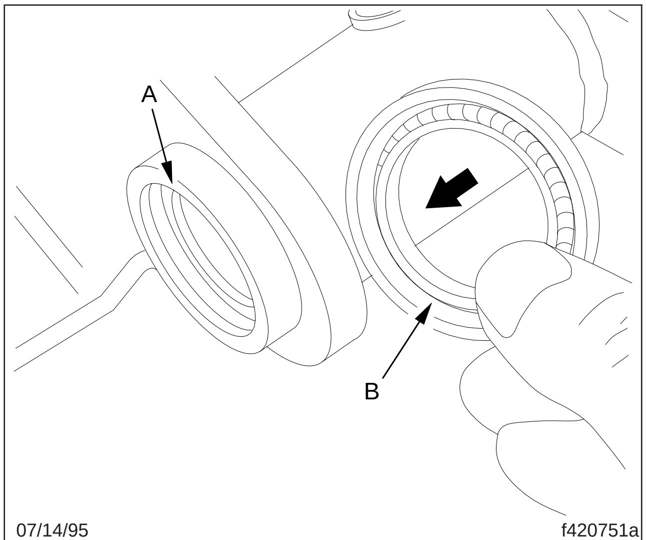
18. Remove the spider-to-axle attaching nuts, hardened washers, and bolts; remove the spider from the axle flange.



A. Recess the bushing (see text for specifications).

Fig. 7, Install the New Bushing

19. If equipped, remove the capscrews that attach the dust shield to the spider; remove the dust shield.
20. Inspect the spider and parts for damage; replace as needed.



A. Install seals flush with end of tube.
B. Lip side of both seals must face toward slack-adjuster end of the bracket.

Fig. 8, Install the Grease Seals

20.1 Check for cracks at the bolt holes, cam area, and around the anchor pin. Replace if damaged.

20.2 Check the anchor pin. See **Fig. 9**. If the pin is loose, or grooved more than 0.03 inch (0.8 mm) below the original surface, replace the spider assembly.

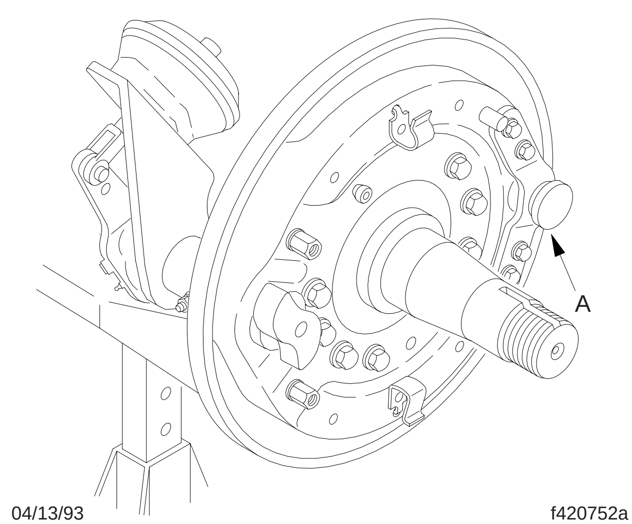
20.3 Check the anchor pin and brake spider bushings for deterioration. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.

20.4 On front brakes, check the anchor pin reinforcement plate attaching nuts (**Fig. 10**) for tightness. If needed, tighten the nuts 35 to 40 lbf·ft (47 to 54 N·m).

Check the anchor pin retaining nut for tightness. See **Fig. 10**. If needed, tighten the nut 475 to 525 lbf·ft (644 to 712 N·m).

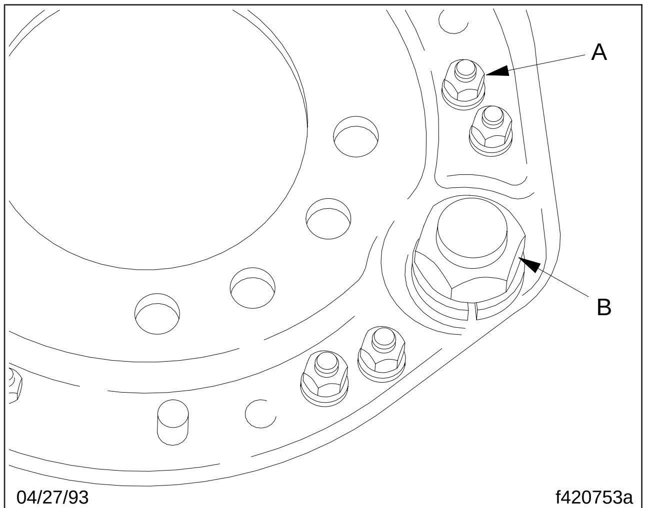
IMPORTANT: If the anchor pin turns while checking the retaining nut torque, replace the spider assembly. Dana Spicer recommends replacing the complete spider and pin assembly. Do not try to repair the spider assembly.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



A. Check for grooving and looseness.

Fig. 9, Check the Anchor Pin



A. Reinforcement Plate Nut
B. Anchor Pin Retaining Nut

Fig. 10, Check the Anchor Pin Nuts

Cleaning

CAUTION

Do not clean ground or polished metal parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause parts to corrode.

IMPORTANT: Do not apply brake grease or corrosion-preventive materials to the brake linings or the brake drum.

After removing the brake parts being serviced, do the following:

1. Clean the camshaft journals with an emery cloth.
2. Wire brush all parts that have been exposed to mud, road dirt, and salt, including the exterior of the drum, spider, brake chamber bracket, and dust shields (if equipped).

   If relining the shoes, thoroughly wire-brush the shoe tables and paint them with a rust-inhibitive coating.

CAUTION

A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake components could occur.

3. Using an industrial vacuum cleaner with a HEPA filter system, remove any dust accumulation from the brake parts.
4. Wipe the inside of the drums with a damp rag to remove lining dust.
5. Prepare the brake parts for assembly.

   5.1 Thoroughly clean all the brake parts.

   For ground or polished metal parts, use a cleaning solvent to clean the parts and surfaces that are ground or polished.

   For rough metal parts, use a cleaning solvent or a weak alkaline solution in a hot solution tank to clean the parts. If a hot solution tank is used, leave the rough parts in the hot solution tank until they are completely cleaned and heated. Remove the rough parts from the hot solution tank and wash them with water until the alkaline solution is removed.

   5.2 Thoroughly dry all the brake parts with a clean, lint-free cloth or paper towel, or use low-pressure filtered and compressed air.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

WARNING

All worn or damaged brake parts must be replaced. If the brakes are assembled with worn or damaged parts, they may not perform to their capacity and a brake failure could occur, which could cause personal injury and property damage.

5.3 Thoroughly inspect all the brake parts for wear or damage. It is very important that all the parts be carefully inspected before they are assembled. Repair or replace any worn or damaged parts.

5.4 For parts that will be assembled, apply a thin layer of brake grease to the parts after they have been cleaned, dried, and inspected to protect them from corrosion.

If the parts will be stored, apply a special material that prevents corrosion and rust on all surfaces. The parts should be stored in special paper (or other material) that prevents corrosion and rust.

Assembly

1. Install the dust shield (if equipped). See **Fig. 1** or **Fig. 2.**

   If installing a one-piece dust shield, place it against the spider and install the capscrews. Tighten the capscrews to the specifications in **Table 1**.

   If installing a two-piece dust shield, place both halves against the spider and tighten the attaching screws finger-tight. Reposition the dust shield halves to allow a uniform space of 1/8 inch (3 mm) along the mating edges. See **Fig. 11**. Tighten the screws to the specifications in **Table 1**.

NOTE: Because of the interference fit in the upper dust shield-to-brake chamber bracket area (**Fig. 12**) you may need to deform the upper dust shield slightly by hand to correctly align the upper half with the lower half.

2. Install the spider.

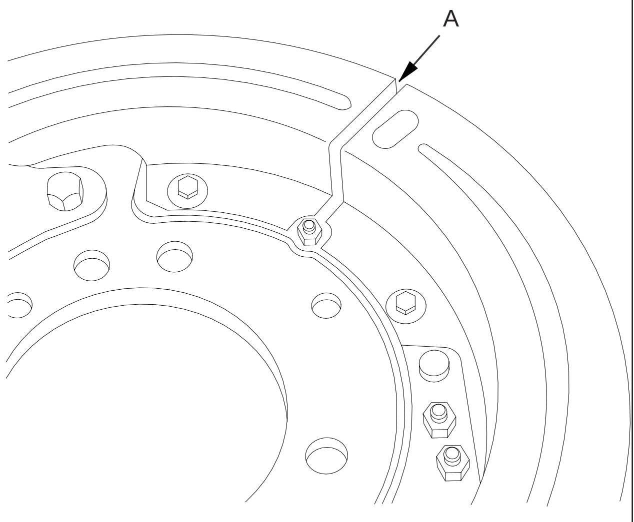
   Place the spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts to the specifications in **Table 1** in a cross pattern.

Brake Assembly Torque Specifications		
Description	**lbf·ft**	**N·m**
Dust Shield Fasteners		
One- and Two-Piece Dust Shield	11 to 16	15 to 22
Brake Spider Fasteners		
1/2–13	60 to 80	81 to 108
5/8–11 (hexhead capscrew)	130 to 160	176 to 217
5/8–11 (flanged hexhead capscrew)	160 to 200	217 to 271
Brake Chamber		
Midland 12, 16	30	41
Midland 20, 24, 30, 36	100	136
MGM 24, 30, 36	100 to 115	136 to 156
Camshaft Support Bracket Fasteners, 1/2–13	55 to 65	75 to 88
Stabilizing Screw (front brake)	23 to 27	31 to 37

Table 1, Brake Assembly Torque Specifications

Brake Components Disassembly and Inspection, Cleaning, and Assembly

3. Install the brake chamber and bracket.



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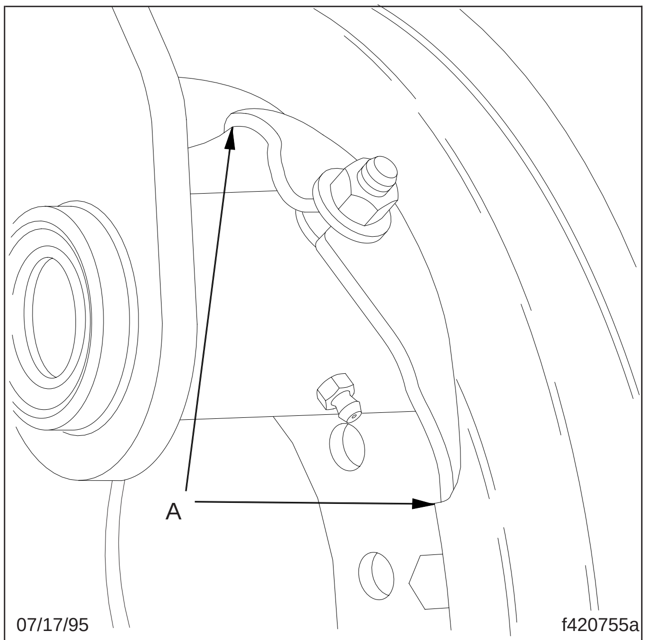
A. Uniform 1/8-inch (3-mm) gap.

Fig. 11, Two-Piece Dust Shield Installation



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A. Designed interference in these areas.

Fig. 12, Check the Fit at the Upper Dust Shield-to-Brake Chamber Bracket

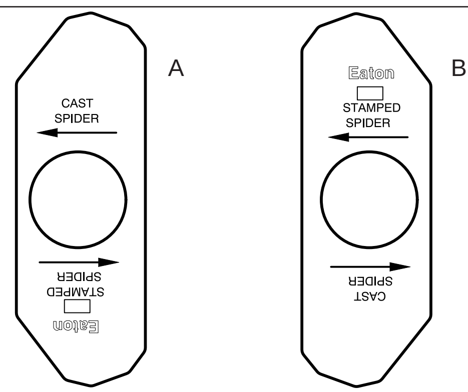
3.1 Place the brake chamber on the mounting bracket with the chamber mounting studs through the bracket holes. Install the lock-washers and stud nuts. Tighten the nuts to the specifications in **Table 1**.

3.2 Place the bracket against the spider, and install the lockwashers and barrel nuts. Tighten the nuts to the specifications in **Table 1**.

3.3 Install the washer, lockwasher, and nut on the stabilizing screw (if equipped). Tighten the nut to the specification in **Table 1**.

4. Install the camshaft in the spider.

4.1 If a camhead thrustwasher was removed during disassembly, reinstall it in the same orientation between the S-cam and the spider. See **Fig. 13**.



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A. Cast Spider: Place the camhead thrustwasher under the camhead with the CAST SPIDER arrow pointing toward the center of the spider. Exception: for model ES-150-8D, the arrow points away from the center of the spider.
B. Stamped Spider: Place the camhead thrustwasher under the camhead with the STAMPED SPIDER arrow pointing toward the center of the spider.

Fig. 13, Install Thrustwasher

4.2 Apply a thin film of chassis grease on the inside of the camshaft bushings and journals. Do not grease the camshaft head area.

4.3 Apply a thin film of rust preventive grease (Meritor 0-637 or an equivalent) on the camshaft splines.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

4.4 Carefully slip the camshaft into the spider and the mounting bracket tube.

4.5 Install the thick camshaft washer on the camshaft.

5. Install the slack adjuster on the camshaft, with the adjuster nut on the side opposite the brake chamber.
6. Install the thin outer washer(s) and snap ring.
7. Using a dial indicator, measure the end play of the camshaft.

7.1 With the slack adjuster centered between the brake chamber bracket and the snap ring groove, pull inboard on the slack-adjuster end of the camshaft to take up the end play.

7.2 Set the dial indicator to zero.

7.3 Push outboard on the slack-adjuster end of the camshaft and note the maximum reading.

7.4 There should be 0.005 to 0.045 inch (0.1 to 1.1 mm) of movement. Add or remove outer washers as needed to adjust the end play.

WARNING

When lubricating the camshaft bracket bushings, if grease leaks out under the cam head, the camshaft grease seal is worn or damaged. If the seal is not replaced, the brake linings could be contaminated by grease and the vehicles stopping distance could be reduced, which could result in personal injury or property damage.

NOTE: Use meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at the shutoff.

8. Pressure lube the camshaft bracket bushings.

   Pump multipurpose chassis grease (NLGI grade 1 or 2) into the chamber bracket until it appears at the slack-adjuster end of the bracket. Use care that no grease enters the drum cavity.

   If grease leaks out under the cam head, the camshaft grease seal is worn or damaged, or is installed backwards. Replace the seal.

9. Adjust the brakes at the slack adjusters. For instructions, refer to **Subject 150**.
10. Install the brake shoes. For instructions, see **Subject 110**.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

Pre-Adjustment Checks and General Adjustment Information

Before adjusting the brakes, check and adjust the following:

- Adjust the wheel bearings. For instructions, see **Section 33.01** or **Section 35.01** in this manual.
- Check the slack adjuster and the brake chamber for loose fasteners and tighten as necessary. For torque specifications, see **Specifications, 400**.

  For slack adjuster installation instructions, see **Section 42.12** or **Section 42.11** for Haldex or Gunite slack adjusters, respectively.

Brakes with automatic slack adjusters should never have to be manually adjusted while in service. The only time automatic slack adjusters should be manually adjusted is during installation or after the brakes have been relined.

For cam brakes, there are two brake chamber stroke measurement specifications: applied chamber stroke and free-stroke.

IMPORTANT: The U.S. Department of Transportation (DOT) Federal Highway Administration has issued the applied chamber stroke specifications for cam brakes. When the applied chamber stroke is checked and adjusted, it must not be greater than the DOT specification. See **Table 1**.

The specific procedure for adjusting the brake chamber stroke at the slack adjuster's manual adjusting nut may vary, depending on which slack adjuster is installed, but there are three basic steps in completing a manual brake chamber stroke adjustment:

1. Adjusting the approximate brake chamber stroke using the manual adjusting nut on the slack adjuster (coarse adjustment).
2. Measuring and adjusting the free-stroke.
3. Measuring and adjusting the applied chamber stroke (fine adjustment).

The stroke (free or applied chamber) is the distance that the large clevis pin moves when the brakes are applied. The type of force used to move the slack adjuster from its released position to its applied position (where the brake linings contact the brake drum) distinguishes the free-stroke from the applied chamber stroke.

- The free-stroke is measured using a lever to move the slack adjuster. The length of the free-stroke equals the clearance between the brake linings and the drum when the brakes are not applied.
- The applied chamber stroke is measured using an 80 to 90 psi (550 to 620 kPa) brake application to move the slack adjuster.

With the engine off, 100 psi (689 kPa) of air tank pressure will apply the required 80 to 90 psi (550 to 620 kPa) brake application for measuring the applied chamber stroke.

Brake Adjustment

Brake Chamber Stroke Specifications		
Chamber Type (Size)	**Maximum Applied Stroke*: inch (mm)**	**Free-Stroke: inch (mm)**
Standard Stroke		
16, 20, and 24	1-3/4 (44)	5/8 to 3/4 (16 to 19)
30	2 (51)	
36	2-1/4 (57)	
Long Stroke†		
16, 20, and 24	2 (51)	
30	2-1/2 (64)	

* Specifications are relative to a brake application with 80 to 90 psi (550 to 620 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

The applied chamber stroke measurement can be used for diagnostic purposes. A stroke that is too long or too short may indicate excessive wear in the cam, cam bushings, return springs, or air chamber.

The applied chamber stroke should always be adjusted (minimized) to within the specified limit, but it should not be reduced to the point where the free-stroke is too short and the brakes drag. To check for brake drag, spin the wheel end, tap the rim lightly with a hammer, and listen for a drag noise (a sharp ringing sound).

Adjustment

MERITOR AUTOMATIC SLACK ADJUSTER

IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Fully release the brakes (the air chamber pushrod must be fully retracted).
4. Check the condition of the boot on the slack adjuster. It should be held in the correct position with a retaining clip. If the boot is torn or cracked, see slack adjuster disassembly and inspection procedures for information.

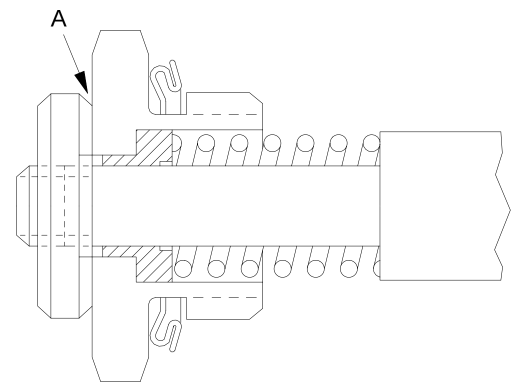
CAUTION

Before turning the manual adjusting nut on the slack adjuster, disengage the pull-pawl. Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

5. Using a screwdriver, pry the pull-pawl button out at least 1/32 inch (0.8 mm) to disengage the pull-pawl teeth from the slack adjuster actuator. See **Fig. 1**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

NOTE: When the screwdriver is removed, the pull-pawl will engage automatically.

6. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment). See **Fig. 2**.
   - 6.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.
   - 6.2 Then, turn the adjusting nut clockwise 1/2 turn.
7. Measure and adjust the free-stroke.



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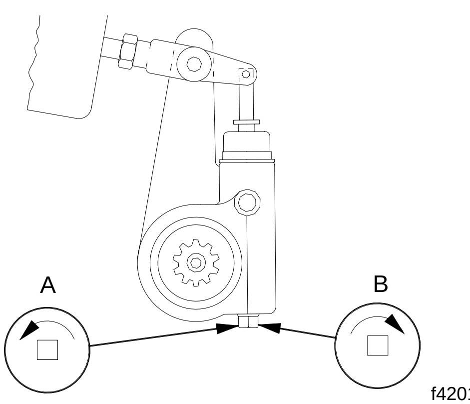
A. Insert screwdriver here.

Fig. 1, Disengage the Pull-Pawl



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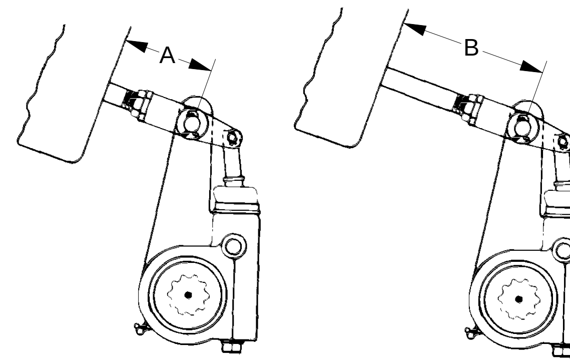
A. Shorten stroke.
B. Lengthen stroke.

Fig. 2, Turn the Adjusting Nut

7.1 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 3**.

7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.

7.3 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension B. See **Fig. 3**.



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NOTE: For either free-stroke or applied chamber stroke, subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied by manual lever (free-stroke) or pressurized brake application (applied chamber stroke).

Fig. 3, Measuring the Stroke

7.4 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

7.5 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjusting nut 1/8 turn, as shown in **Fig. 2**. Then, measure the free-stroke again, and readjust it until it is correct.

8. Measure and adjust the applied chamber stroke (fine adjustment).

8.1 Start the engine and build the air pressure to 100 psi (689 kPa). Shut down the engine.

8.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. B. Record this measurement as dimension C.

8.3 Subtract dimension A from dimension C. The difference between these measurements is the true applied chamber stroke.

8.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**.

Brake Adjustment

CAUTION

The adjusted applied chamber stroke should be as short as possible but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.

8.5 If the applied chamber stroke is incorrect, turn the adjusting nut 1/8-turn counterclockwise to shorten the stroke, or 1/8-turn clockwise to lengthen it. See **Fig. 2**. Measure the applied stroke again and readjust it until it is correct.

8.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

9. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl with the actuator.
10. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

WARNING

Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

11. Check for proper brake operation. For instructions, see **Subject 110**.

HALDEX AUTOMATIC SLACK ADJUSTER

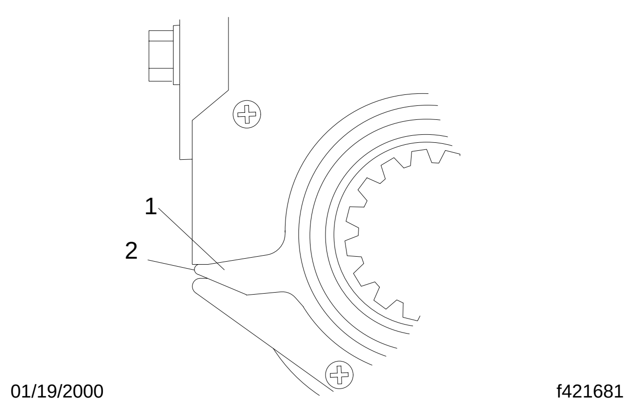
IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Fully release the brakes (the air chamber pushrod must be fully retracted).

CAUTION

The installation indicator must be aligned with the indicator notch on the slack adjuster. If the indicator is not within the notched area, the control arm is installed in the wrong position. This may result in tight brakes, excessive lining wear, and possible brake damage.

4. Make sure the installation indicator is aligned with the indicator notch on the slack adjuster. See **Fig. 4**. If the indicator is not within the notched area, the control arm is not installed correctly.



1. Installation Indicator 2. Indicator Notch

Fig. 4, Installation Indicator

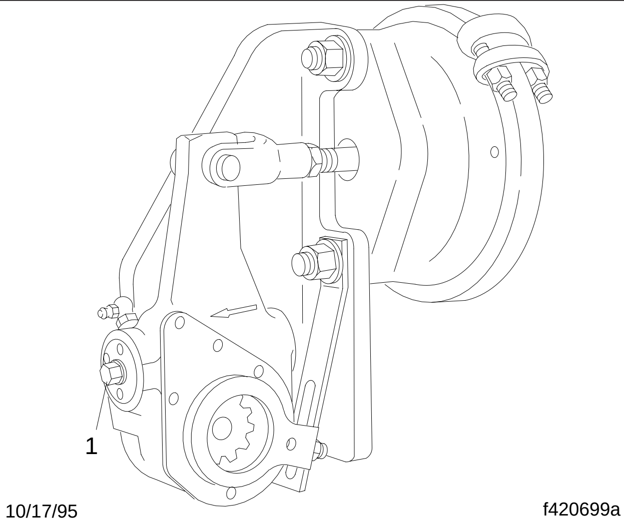
5. Measure how much torque is required to overcome the resistance of the internal clutch (internal clutch slippage).

5.1 Using a 7/16-inch torque wrench, turn the adjusting nut counterclockwise. See **Fig. 5**. You will hear a ratcheting sound.

5.2 If the clutch slips with a torque less than 13 lbf·ft (18 N·m), the slack adjuster must be replaced.

6. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment).

6.1 Turn the adjusting nut clockwise until the brake linings contact the brake drum.



1. Adjusting Hexnut

Fig. 5, Adjusting Hexnut

6.2 Then, turn the adjusting nut counterclockwise 1/2 turn. You will hear a ratcheting sound.

7. Measure and adjust the free-stroke.

7.1 Measure the distance from the bottom of the brake chamber to the far side of the clevis pin. See **Fig. 6**. Record this measurement as dimension A.

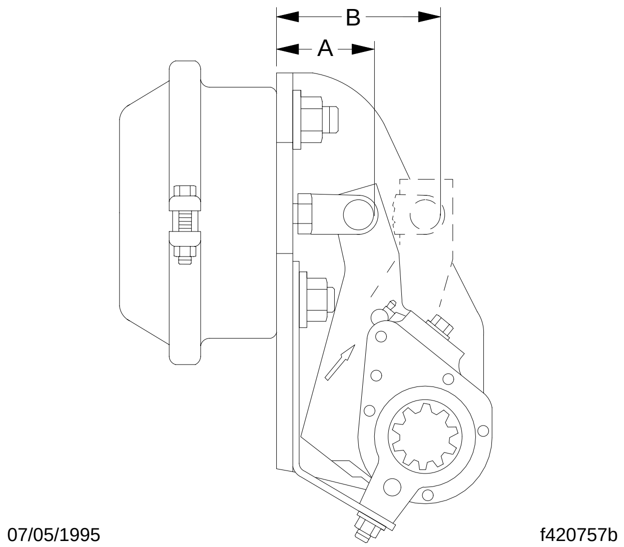
7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the bottom of the brake chamber to the far side of the clevis pin. See **Fig. 6**. Record this measurement as dimension B.

7.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

7.4 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjusting nut in the required direction. Then, measure the free-stroke again and readjust it until it is correct.

8. Measure and adjust the applied chamber stroke (fine adjustment).

8.1 Start the engine and build the air pressure to 100 psi (689 kPa). Shut down the engine.



A. Brakes Released B. Brakes Applied

Fig. 6, Measure the Stroke

8.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the far side of the clevis pin hole. See **Fig. 6**, Ref. B. Record this measurement as dimension C.

8.3 Subtract dimension A from dimension C. The difference between these measurements is the applied chamber stroke.

8.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**. If the stroke is not correct, turn the adjusting nut in the required direction. Then, measure the applied chamber stroke again and readjust it until it is correct.

8.5 If the slack adjuster does not maintain the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

9. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

Brake Adjustment

WARNING

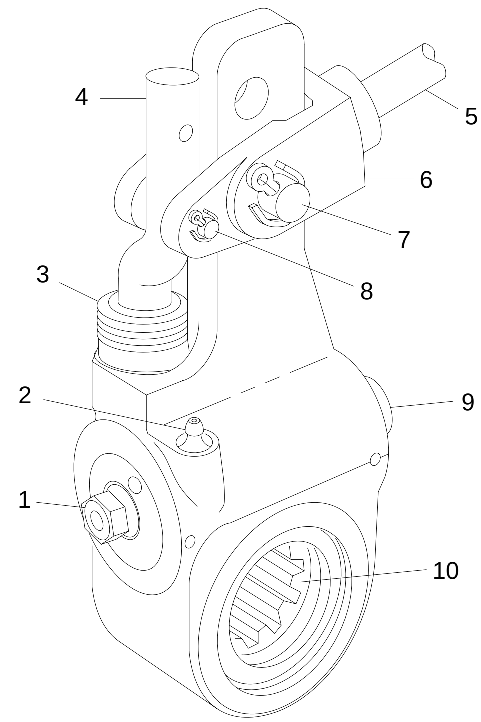
Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

10. Check for proper brake operation. For instructions, see **Subject 110**.

GUNITE AUTOMATIC SLACK ADJUSTER

IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Fully release the brakes (the air chamber pushrod must be fully retracted).
4. Measure how much torque is required to overcome the resistance of the internal clutch (internal clutch slippage).
   - 4.1 Using a 7/16-inch torque wrench, turn the adjusting nut counterclockwise. See **Fig. 7**. You will hear a ratcheting sound.
   - 4.2 If the clutch slips with a torque less than 15 lbf·ft (20 N·m), the slack adjuster must be replaced.
5. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment).
   - 5.1 Turn the adjusting nut clockwise until the brake linings contact the brake drum.
   - 5.2 Turn the adjusting nut counterclockwise 1/2 turn. There should be about 30 lbf·ft (41 N·m) resistance. You will hear a ratcheting sound.
6. Measure and adjust the free-stroke.



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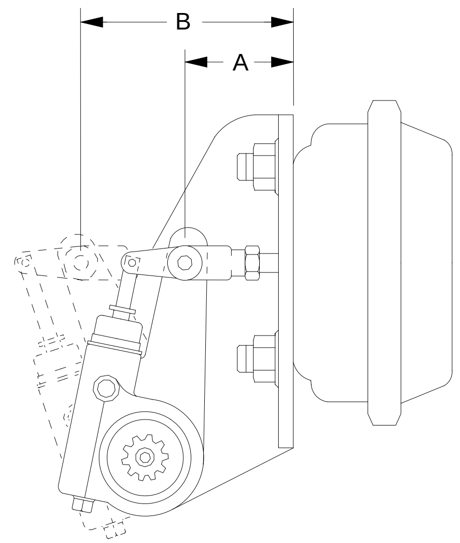
1. Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Pushrod
6. Clevis
7. Clevis Pin, 1/2-in
8. Clevis Pin, 1/4-in
9. Grease Relief Opening
10. Slack Adjuster Spline

Fig. 7, Gunite Slack Adjuster

   - 6.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**. Record this measurement as dimension A.
   - 6.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.
   - 6.3 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**. Record this measurement as dimension B.
   - 6.4 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.
   - 6.5 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjust-



A. Brakes Released B. Brakes Applied

Fig. 8, Measure the Stroke

ing nut in the required direction. Then, measure the free-stroke again and readjust it until it is correct.

7. Measure and adjust the applied chamber stroke (fine adjustment).

 7.1 Start the engine and build air pressure to 100 psi (689 kPa). Shut down the engine.

 7.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**, Ref. B. Record this measurement as dimension C.

 7.3 Subtract dimension A from dimension C. The difference between these measurements is the applied chamber stroke.

 7.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**. If the stroke is not correct, turn the adjusting nut in the required direction. Then, measure the applied stroke again and readjust it until it is correct.

 7.5 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

8. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

WARNING

Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

9. In a safe area, check for proper brake operation before you put the vehicle in service.

 9.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

 9.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

 9.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others shows a lack of braking effort on those wheels.

Specifications

Dana Spicer ES Brakes Torque Specifications		
Description	**lbf·ft**	**N·m**
Dust Shield Fasteners		
One-Piece Dust Shield Two-Piece Dust Shield	11 to 16	15 to 22
Brake Spider Fasteners		
1/2–13	60 to 80	81 to 108
5/8–11 (hexhead capscrew)	130 to 160	176 to 217
5/8–11 (flanged hexhead capscrew)	160 to 200	217 to 271
Camshaft Support Bracket Fasteners		
1/2–13	55 to 65	75 to 88
Stabilizing Screw (front brake)	23 to 27	31 to 37
Anchor Pin		
Reinforcement Plate Nuts	35 to 40	47 to 54
Retaining Nut	475 to 525	644 to 712

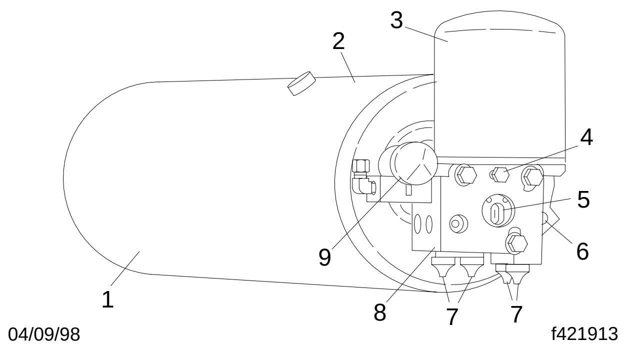
Table 1, Dana Spicer E.S. Brakes Torque Specifications

Brake Chamber Mounting Torque		
Manufacturer	**Chamber Size (square inches)**	**Torque lbf·ft (N·m)**
Midland	12, 16	30 (41)
	20, 24, 30, 36	100 (136)
MGM	24, 30, 36	100–115 (136–156)

Table 2, Brake Chamber Mounting Torque

General Information

The function of the dryer reservoir module (DRM) is to provide the vehicle with an integrated air dryer, secondary reservoir, purge reservoir, and governor. See **Fig. 1**.



1. Secondary Reservoir
2. Integrated Purge Reservoir
3. Desiccant Cartridge
4. Safety Valve
5. Heater/Thermostat Assembly
6. Auxiliary Delivery Port
7. Pressure Protection Valves
8. AD-IS Air Dryer
9. Governor

Fig. 1, Dryer Reservoir Module

The air dryer collects and removes air system contaminants in solid, liquid, and vapor form before they enter the brake system. It provides clean, dry air to the components of the brake system which increases the life of the system.

CHARGE CYCLE **(See Fig. 2)**

When the compressor is loaded, compressed air, oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer body.

As air travels through the air dryer assembly, its temperature falls, causing some of the contaminants to condense and drop to the bottom of the air dryer assembly, ready to be expelled at the next purge cycle.

The air then flows into the desiccant cartridge. Once in the desiccant cartridge, air flows through an oil separator which removes oil and solid contaminants.

Air then flows into the desiccant drying bed. Air flowing through the desiccant becomes progressively dryer as water vapor adheres to the desiccant material.

Dry air exits the bottom of the desiccant cartridge and flows through the center of the base assembly. The air then flows to the delivery check valve, to the safety valve and also through an orifice plug into the purge reservoir reservoir. Air traveling through the delivery check valve flows to the governor and two pressure protection valves.

As pressure builds during the initial charge, the purge reservoir fills. When the air pressure reaches 103 psi (710 kPa), the first pressure protection valve opens, filling the primary reservoir. When the primary reservoir pressure reaches 109 psi (752 kPa) the second pressure protection valve opens and air is supplied to the secondary reservoir and accessory pressure protection valves. When air pressure in the secondary reservoir reaches 55 and 85 psi (379 to 586 kPa) respectively, the two remaining pressure protection valves open and supply air to the accessories.

NOTE: There is no external air line from the air dryer to the secondary reservoir. Air is supplied by a line passing through the purge reservoir.

The air dryer will remain in the charge cycle until the air brake system pressure builds to the governor cutout setting of approximately 130 psi (896 kPa).

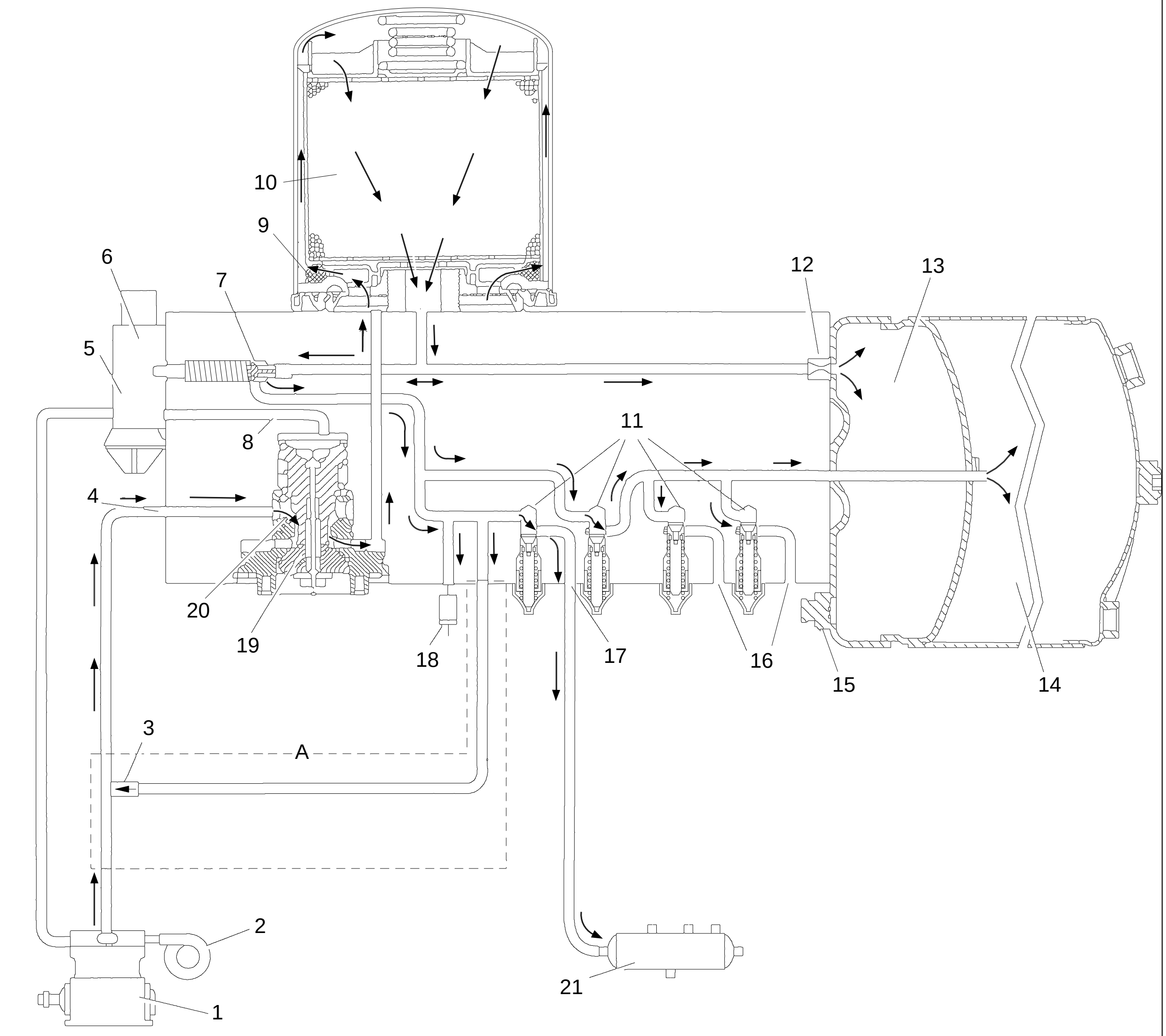
PURGE CYCLE **(See Fig. 3)**

When air brake system pressure reaches the cutout setting of the governor, the governor unloads the compressor and the purge cycle begins. When the governor unloads the compressor, it pressurizes the compressor unloader mechanism and the dryer control port. The purge piston moves in response to air pressure, causing the purge valve to open and the turbo cutoff valve to close. When the purge valve opens, water and contaminants are expelled. Air flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected in the oil separator are removed by air flowing from the purge reservoir, through the desiccant drying bed, and out through the open purge valve.

The purge cycle lasts only a few seconds and is detected by an audible burst of air at the air dryer exhaust.

The reactivation of the desiccant drying bed begins as dry air flows from the purge reservoir, through the purge orifice, and into the desiccant bed. Pressurized air from the purge reservoir expands after passing

General Information



A. Feedback Line: Used only with Type E and QE Holset Compressors.

1. Compressor
2. Engine Turbo
3. Check Valve
4. Inlet Port
5. Unloader Port
6. Governor
7. Delivery Check Valve
8. Purge Control Line
9. Oil Separator
10. Desiccant Bed
11. Pressure Protection Valves
12. Purge Orifice
13. Purge Reservoir
14. Secondary Reservoir
15. Purge Reservoir Drain Cock
16. Auxiliary Ports
17. Primary Port
18. Safety Valve
19. Purge Valve (closed)
20. Turbo Cutoff Valve (open)
21. Primary Reservoir

Fig. 2, Air Dryer Charge Cycle

through the purge orifice; its pressure is lowered and its volume is increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Approximately 30 seconds is required for the entire purge reservoir of a standard air dryer to flow through the desiccant dryer bed.

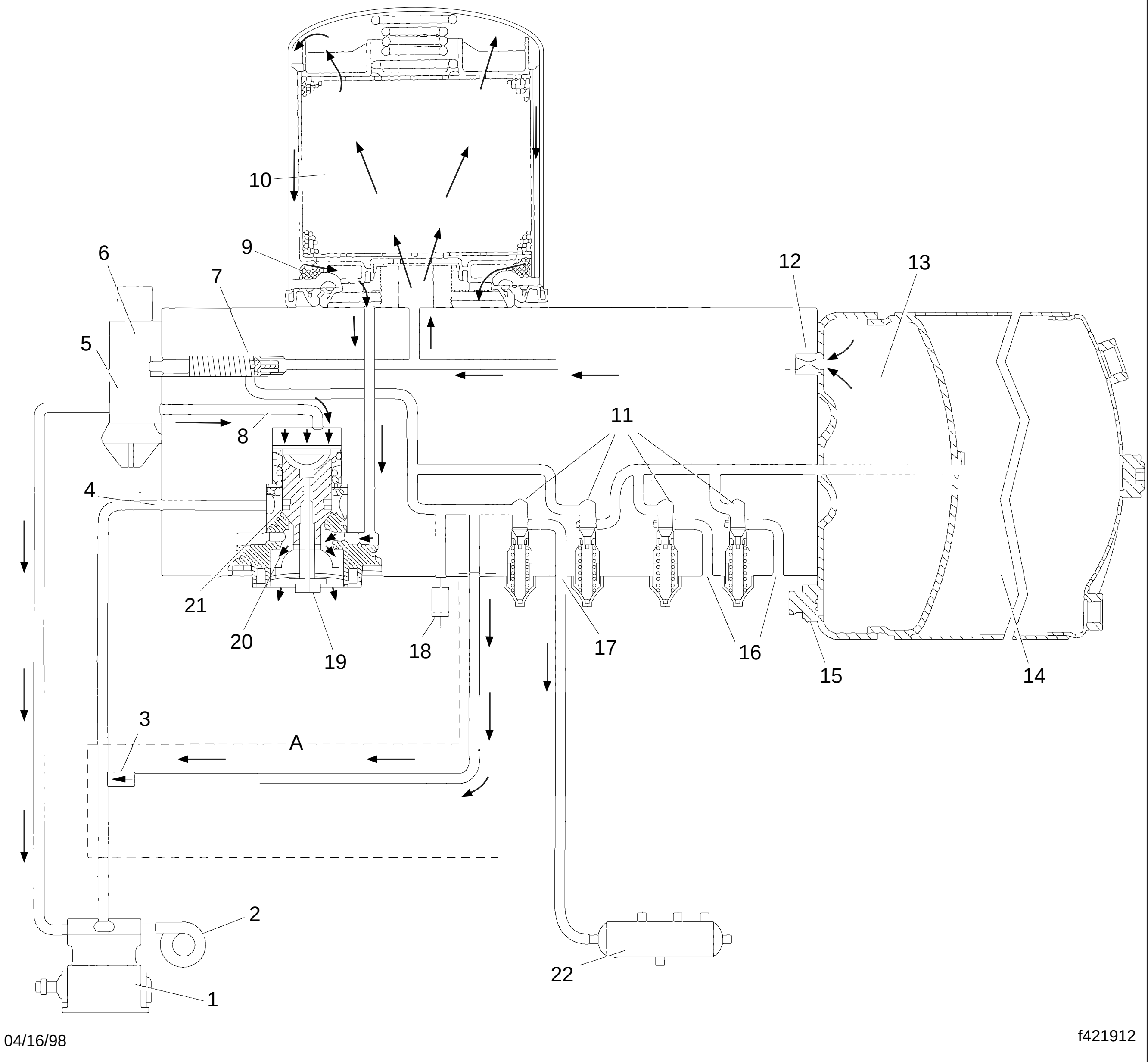
The delivery check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

Turbo Cutoff Feature

The primary function of the turbo cutoff valve is to prevent loss of turbocharger air pressure through the air dryer in systems where the compressor intake is connected to the engine turbocharger.

During the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the compressor discharge line and air dryer inlet port cannot enter the air dryer. This maintains turbocharger boost pressure to the engine.

General Information



A. Feedback Line: Used only with Type E and QE Holset Compressors.

1. Compressor
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3. Check Valve
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5. Unloader Port
6. Governor
7. Delivery Check Valve
8. Purge Control Line
9. Oil Separator
10. Desiccant Bed
11. Pressure Protection Valves
12. Purge Orifice
13. Purge Reservoir
14. Secondary Reservoir
15. Purge Reservoir Drain Cock
16. Auxiliary Ports
17. Primary Port
18. Safety Valve
19. Exhaust
20. Purge Valve (open)
21. Turbo Cutoff Valve (closed)
22. Primary Reservoir

Fig. 3, Air Dryer Purge Cycle

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

A. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.

B. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.

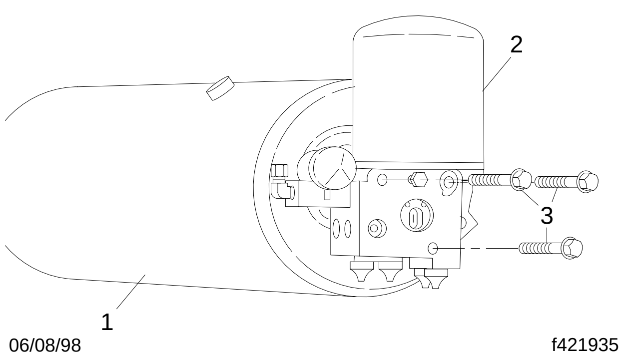
C. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.

D. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Replacement

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs.
3. Mark and remove the air lines from the air reservoir.
4. Unplug the wiring harness from the heater/thermostat assembly.
5. Remove the three capscrews fastening the air dryer to the air reservoir. See **Fig. 1**.



1. Air Reservoir
2. Air Dryer
3. Capscrews

Fig. 1, DRM (air dryer capscrews shown)

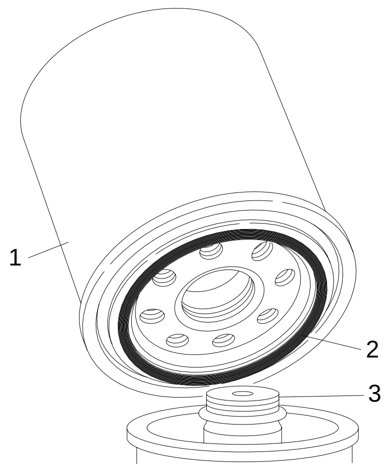
6. Remove the air dryer.
7. Remove the governor and delivery check valve from the air dryer. For instructions, see **Subject 130**.
8. Remove the desiccant cartridge. For instructions, see **Subject 120**.

Installation

1. Install the delivery check valve and governor onto the air dryer. For instructions, see **Subject 130**.
2. If removed, install the desiccant cartridge. For instructions, see **Subject 120**.
3. Install the air dryer, making sure the two O-rings are installed between the air dryer and air reservoir. Use the three capscrews to fasten the air dryer to the reservoir. Tighten the capscrews 30 to 35 lbf·ft (41 to 47 N·m). See **Fig. 1**.
4. Connect the air lines and plug the wiring harness into the heater/thermostat assembly.
5. Perform the operational tests in **Subject 170**.

Replacement (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.



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1. Desiccant Cartridge
2. Cartridge Sealing Ring
3. Threaded Base Post

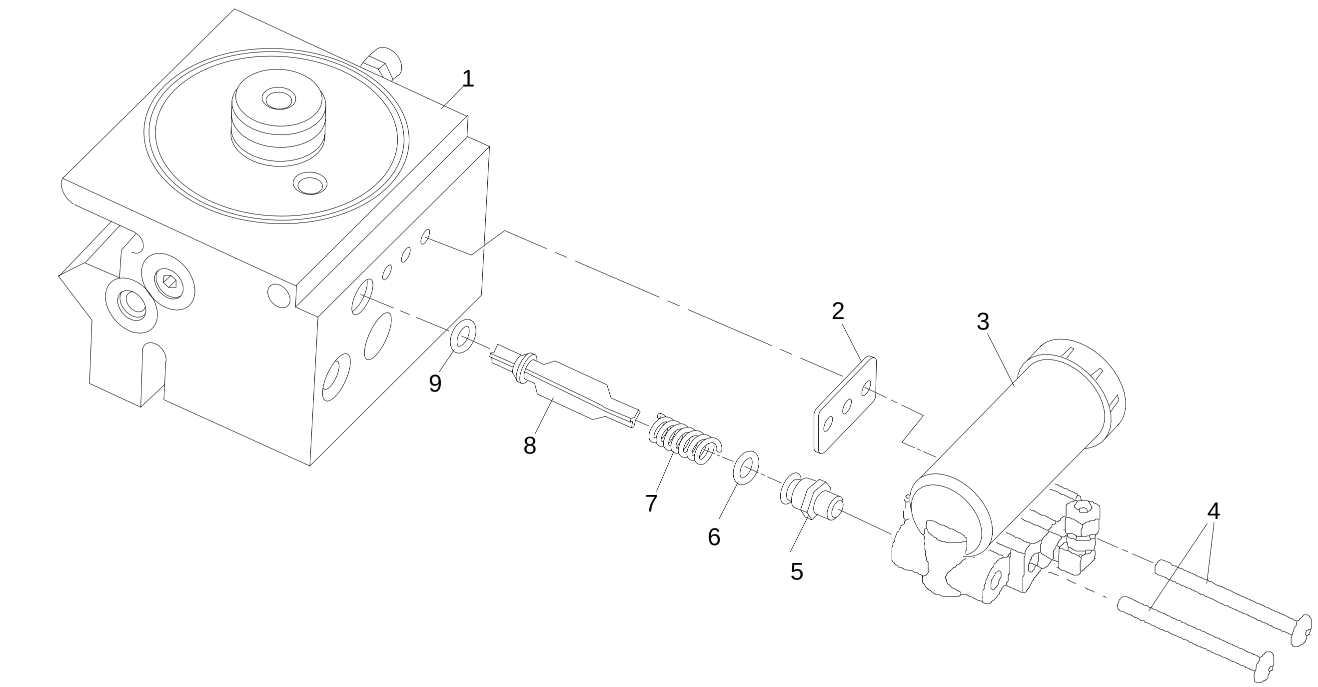
Fig. 1, Desiccant Cartridge Replacement

1. Park the vehicle, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs.
3. Using a strap wrench or equivalent, loosen the desiccant cartridge. Spin the cartridge off by hand and discard it.
4. On the new desiccant cartridge, lubricate the sealing rings with silicone grease.

IMPORTANT: Only use the silicone grease supplied with AlliedSignal replacement kits.

5. Screw the desiccant cartridge onto the body, by hand, until the seal makes contact with the body. Rotate the cartridge clockwise about one full turn. If necessary, use a strap wrench to tighten the cartridge.
6. Remove the chocks from the tires.

Replacement (See Fig. 1)



1. Air Dryer Base
2. Gasket
3. Governor
4. Capscrews
5. Adaptor
6. O-Ring
7. Spring
8. Check Valve Body
9. O-Ring

Fig. 1, Delivery Check Valve Replacement

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs.
3. Disconnect the air line from the governor and mark it for later reference. Remove the capscrews attaching the governor to the air dryer.
4. Remove the governor, adaptor fitting, and the adaptor O-ring. Remove the governor gasket and discard.
5. Remove the spring and check valve.
6. Lubricate the new smaller O-ring and check valve body with silicone grease.

IMPORTANT: Only use the silicone grease supplied with AlliedSignal replacement kits.

7. Install the O-ring on the check valve body and push the O-ring down, over the longer set of three guide lands, until it is in the O-ring groove of the check valve body.
8. Install one end of the check valve spring over the check valve's shorter set of three guide lands. Turn the valve about 1/4 turn while holding the spring, if necessary, to secure the valve in place. Install the assembled check valve body, O-ring, and spring in the delivery port so the O-ring rests on its seat and the free end of the spring is visible.
9. Install the adaptor fitting into the governor. Using the silicone grease, lubricate the remaining larger O-ring, and install it into the groove of the adap-

Delivery Check Valve and Governor Replacement

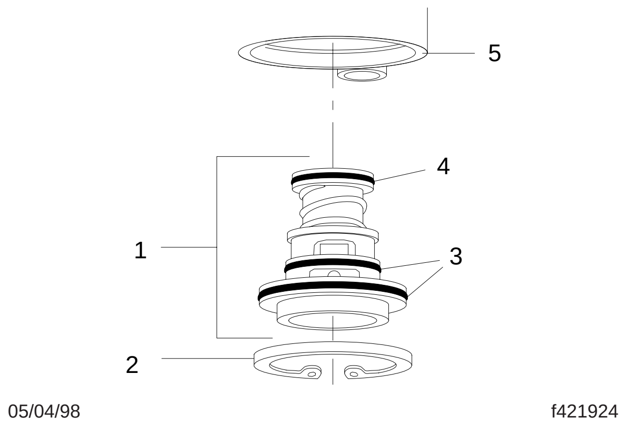
tor. Install the gasket supplied in the kit. Install the governor and torque the capscrews 10 lbf·ft (14 N·m).

10. Perform the operational tests in **Subject 170**.
11. Remove the chocks.

Purge Valve Replacement

Replacement (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.



1. Purge Valve Assembly
2. Retaining Ring
3. O-Rings
4. Quad-Ring
5. Air Dryer

Fig. 1, Purge Valve Replacement

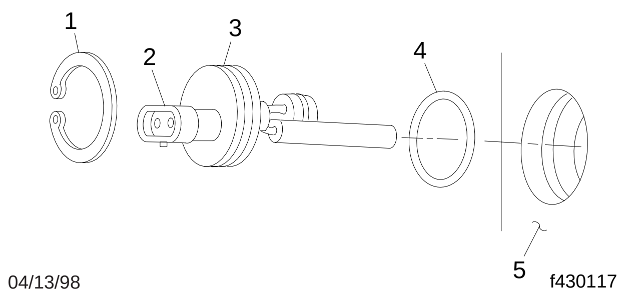
1. Shut down the engine, apply the parking brake, and chock the tires.
2. Drain the vehicle air reservoirs.
3. Remove the purge valve assembly from the air dryer end cover.
   - 3.1 Remove and discard the snap ring that secures the purge valve assembly in the end cover.
   - 3.2 Remove the purge valve assembly.
4. Lubricate the new O-rings and O-ring grooves of the new purge valve assembly.
5. Lubricate the end cover bore of the new purge valve assembly.

IMPORTANT: Use only the silicone grease supplied with the AlliedSignal replacement kit.

6. Install the two new O-rings on the purge valve housing cover and the new quad-ring on the purge piston.
7. Install the new purge valve assembly in the end cover while making sure the purge valve housing is fully seated against the end cover.
8. Install the new retaining ring in its groove in the end cover.
9. Perform the operational tests in **Subject 170**.
10. Remove the chocks from the tires.

Replacement (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.



1. Retaining Ring
2. Heater/Thermostat Connector Plug
3. Heater/Thermostat Assembly
4. O-Ring
5. Air Dryer Body

Fig. 1, Heater and Thermostat Assembly

1. Shut down the vehicle, apply the parking brake, and chock the tires.
2. Lift the lock tab on the vehicle wiring harness connector and disconnect it from the air dryer base.
3. Remove and discard the retaining ring that secures the heater and thermostat assembly in the air dryer body.
4. Carefully pull the heater and thermostat assembly straight out of the air dryer body and discard it.
5. Using the grease provided with the AlliedSignal replacement kit, lubricate the O-ring groove and O-ring of the new assembly with silicone grease.

IMPORTANT: Do not lubricate the heater stick or thermostat.

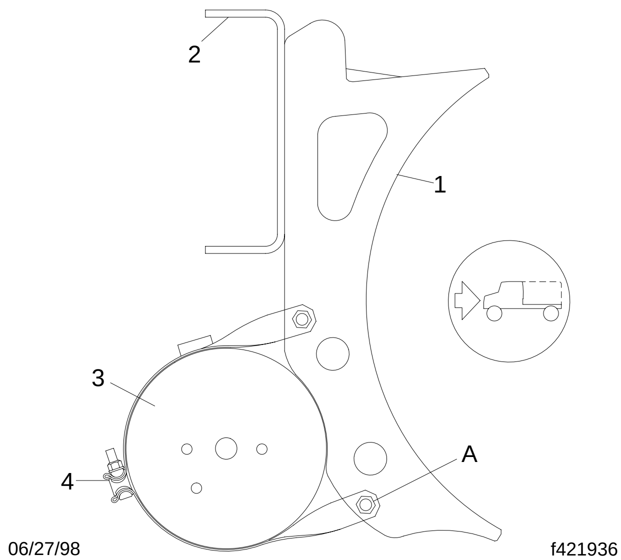
6. Install the O-ring on the heater/thermostat assembly. Then, slide the assembly into the air dryer body, making sure not to scrape insulation from the wires.
7. Install the retaining ring in the groove of the air dryer body, making certain that it is fully seated in the groove.
8. Remove the protective cover from the assembly.
9. Before proceeding, turn the ignition on without starting the engine. Make sure vehicle power is present at the contacts of the vehicle wire harness.
10. Remove the chocks from the tires.

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Drain the air system.
3. Mark and disconnect all reservoir air lines and couplers for later assembly. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the components after removing the reservoir from its mount.
4. Remove the air dryer. For instructions, see **Subject 110**.

NOTE: Loosen the bottom strap fastener first. See **Fig. 1**.

5. Remove the reservoir strap fasteners. Remove the reservoir.



A. Loosen this fastener.
1. Fuel Tank Bracket
2. Right Frame Rail
3. Air Reservoir
4. 3/8–16 Strap Fastener

Fig. 1, Air Reservoir, Fuel Tank Bracket Mounting

6. If access is limited, do the next step first. If not, place a new reservoir in the mount, and install the strap fasteners. Tighten the fasteners 30 to 40 lbf·ft (41 to 54 N·m). Tighten the lower strap fastener 136 lbf·ft (184 N·m).
7. As marked earlier, connect all air lines and couplers to the new reservoir, removing the caps as each component is installed. Tighten the connections as instructed elsewhere in this group.

   Install the air dryer. For instructions, see **Subject 110**.
8. Perform operational test in **Subject 170**.
9. Remove the chocks from the tires.

Operational Tests

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

1. Park the vehicle, shut down the engine, and chock the tires.
2. Install a pressure gauge in one of the spare governor ports labeled "RES."
3. Close all drain cocks and start the engine. Build the air system to governor cutout and shut down the engine.
4. Check all air lines and fittings leading to and from the air dryer for leakage. Note the pressure on the air gauge after the governor cutout pressure is reached, a rapid loss of pressure could indicate a leaking delivery port check valve or turbo cut-off valve.
5. To check for delivery check valve leakage, allow the system air pressure to charge and listen for the air dryer to purge. The purge should last about 30 seconds.
6. Gradually open the drain cock on the purge tank and exhaust any residual pressure.
7. Coat the drain cock with a soap solution. If leakage does not exceed a 1-inch (25.4-mm) bubble in 1 second, go to step 9.

   If leakage does exceed a 1-inch (25.4-mm) bubble in one second, proceed with the following step.
8. Apply the brakes a few times, bring the air pressure to a point below governor cut-in (about 95 psi [655 kPa]). The governor will then signal the end of the purge cycle, closing the turbo cut-off valve. Allow any delivery line air pressure to drain, then check again for leakage at the purge tank drain cock. If excessive leakage has stopped, the turbo cut-off valve should be checked.

NOTE: If after replacing the delivery check valve, rapid loss of system air pressure continues, the delivery check valve and turbo cut-off valve are still leaking. Check the valves.

9. Check the operation of the end cover heater and thermostat assembly during cold weather operation as follows:

   9.1 Check the electric power to the air dryer. With the ignition or engine kill switch in the ON position, check for voltage to the heater and thermostat assembly using a voltmeter or test-light. Unplug the electrical connector at the air dryer and place the test leads on each of the connections of the female connector on the vehicle power lead. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check to see if a good ground path exists.

   9.2 Test the thermostat and heater operation. Turn off the ignition switch and cool the thermostat and heater assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the air dryer connector half. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly and 6 to 9 ohms for the 24-volt heater assembly.

   Warm the thermostat and heater assembly to about 90°F (32°C) and check the resistance again. The resistance should exceed 1000 ohms. If the resistance values obtained are within the stated limits, the thermostat and heater assembly is operating properly. If the resistance values obtained are outside the stated limits, replace the heater and thermostat assembly. For instructions, see **Subject 150**.
10. Check the pressure protection valves. Observe the pressure gauges of the vehicle as system pressure builds from zero. The primarygauge should rise until it reaches approximately 109 psi (752 kPa), then level off as the second pressure protection valve opens and allow the secondary volume to build. When the secondary pressure gauge passes through approximately 55 and 85 psi (379 and 586 kPa) there should be an associated leveling off of pressure as the third and fourth pressure protection valves open. Then, both the primary and secondary gauges should reach their full pressure of about 130 psi (896 kPa)
11. Remove the chocks.

Troubleshooting Tables

Problem—Air Dryer is Constantly Purging (Cycling)

Problem—Air Dryer is Constantly Purging (Cycling) or Purging Excessively	
Possible Cause	**Remedy**
There is excessive system leakage.	Using a soap and water solution, test for leakage at the air line fittings, drain cock (or valve), and the safety valve in the primary reservoir. Repair or replace as necessary. NOTE: A drop of 3 psi (21 kPa) in system air pressure per minute is normal.
The application air lines are leaking excessively.	Check the application air line, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged component(s).
The delivery check valve leaking excessively	Replace the Check Valve. See **Subject 130**.
The compressor unloader O-rings are leaking excessively	Troubleshoot the compressor. See **Group 13**.

Problem—There is Water in the Air Reservoirs

Problem—There is Water in the Air Reservoirs	
Possible Cause	**Remedy**
Maximum air dryer inlet temperature is exceeded due to improper discharge line length or improper line material.	Check the length of the air lines. The lines should not have excessive slack. If excessive slack exists in any air lines, replace the lines. For instructions, see **Section 42.07**.
The air dryer is not purging.	See **Problem—System Will Not Charge**
Purge time is insufficient due to excessive system leakage.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The air by-passes the desiccant cartridge assembly.	If the vehicle uses a Holset compressor, inspect the feedback check valve for proper installation and operation.
The compressor is running loaded for long periods of time.	Check the vehicle air system for leakage.
The desiccant cartridge requires replacement	Replace the desiccant cartridge. See **Subject 120**.

Problem—Safety Valve on the Air Dryer is Exhausting Air

Problem—Safety Valve on the Air Dryer is Exhausting Air	
Possible Cause	**Remedy**
There is a defective delivery check valve in the end cover of the air dryer.	Test to determine if air is passing through the check valve. Repair or replace the check valve. For replacement, see **Subject 130**.
The air system pressure is over 140 psi (965 kPa).	Replace the governor.
The safety valve setting is too low.	Replace the safety valve.

Troubleshooting

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve	
Possible Cause	**Remedy**
The air dryer purge valve is leaking excessively.	Test for leakage. With the compressor loaded, apply soap solution on the purge valve exhaust. If necessary, replace the purge valve. For instructions, see **Subject 140**.
The governor is defective.	Check the governor for proper "cut-in" and "cut-out" pressure, and excessive leakage in both positions. Repair or replace the governor. For replacement instructions, see **Section 13.01**.
The purge valve is frozen open. The heater and thermostat, wiring, or blown fuse.	Perform the heater operating test in **Subject 160**.
There is excessive system leakage.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The air dryer delivery check valve is defective.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The turbo cutoff valve is leaking.	Repair or replace the turbo cutoff valve. For instructions, see **Subject 140**.
The purge valve control piston is leaking.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—The Air System Will Not Charge

Problem—The Air System Will Not Charge	
Possible Cause	**Remedy**
The inlet and outlet air connections are reversed.	Connect the compressor discharge to the air dryer supply port. Reconnect the lines properly.
Kinked or blocked discharge line.	Check to determine if air passes through the discharge line. Check for kinks, bends, excessive carbon deposits, or ice blockage.
There are excessive bends in the discharge line (water collects and freezes).	The discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
The turbo cutoff valve is stuck closed.	Repair or replace the turbo cutoff valve. For instructions, see **Subject 140**.
The purge valve is leaking excessively.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—The Air Dryer Does Not Purge or Exhaust Air

Problem—The Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
The governor adaptor is plugged.	Test to determine if air flows through the purge control port when the compressor is unloaded. Check for adaptor obstruction. See **Problem—Constant Exhaust of Air at the Air Dryer Purge Valve**
The air dryer purge valve is faulty.	If air is flowing through the purge valve in the "Remedy" above, repair or replace the purge valve. For replacement instructions, see **Subject 140**.
There are excessive bends in the discharge line (water collects and freezes).	The discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
The governor is defective.	Check the governor for proper "cut-in" and "cut-out" pressure, and excessive leakage in both positions. Repair or replace the governor. For replacement instructions, see **Section 13.01**.

Troubleshooting

Problem—The Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
The purge valve control piston is leaking.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—Desiccant Material is Being Expelled from the Air Dryer Purge Valve Exhaust

Problem—Desiccant Material is Being Expelled from the Air Dryer Purge Valve Exhaust	
Possible Cause	**Remedy**
The air dryer is not securely mounted.	Replace the air dryer. For instructions, see **Subject 110**.
The desiccant cartridge is saturated or malfunctioning.	Replace the air dryer. For instructions, see **Subject 110**.
The compressor is passing excessive oil.	Troubleshoot the compressor. See **Group 13**. If necessary, replace the air dryer. For instructions, see **Subject 110**.

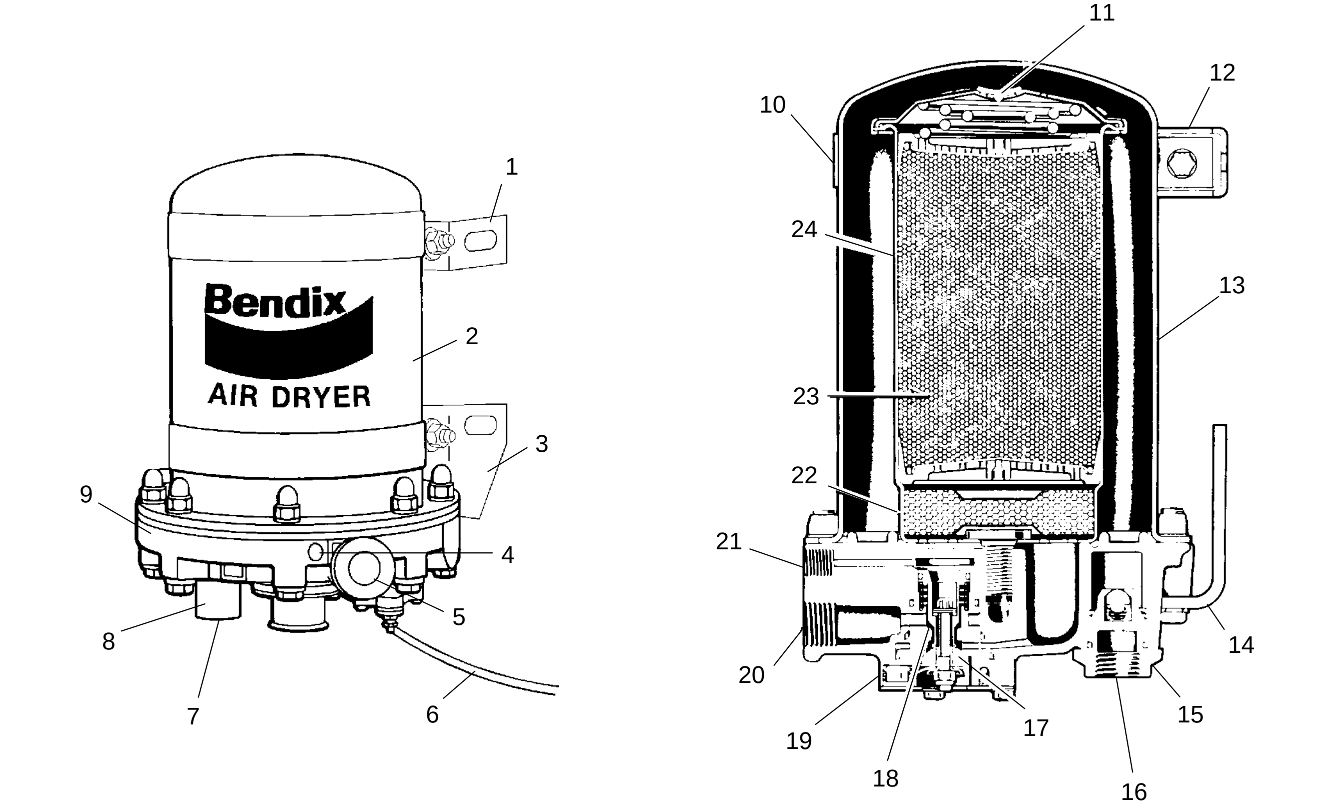
Problem—"Pinging" Noise is Excessive During Compressor Loading Cycle

Problem—"Pinging" Noise is Excessive During Compressor Loading Cycle	
Possible Cause	**Remedy**
The compressor is a single cylinder with high pulse cycles.	A slight "pinging" sound may be heard during system build up when a single cylinder compressor is used. No remedy is needed.

General Description

The function of the Bendix AD–9 air dryer (**Fig. 1**) is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

removable purge valve housing assembly features a purge valve mechanism and a turbocharger cutoff that are designed to prevent loss of engine turbo boost pressure during the purge cycle of the air dryer.



1. Upper Bracket
2. Outer Shell
3. Lower Bracket
4. Control Port
5. Supply Port
6. Wiring Harness
7. Delivery Port
8. Check Valve Assembly
9. End Cover
10. Upper Bracket Strap
11. Check Valve
12. Upper Bracket
13. Housing
14. Lower Bracket
15. Check Valve Assembly
16. Delivery Port
17. Purge Valve
18. Turbo Cutoff Piston
19. Purge Valve Housing Assembly
20. Supply Port
21. Control Port
22. Oil Separator
23. Desiccant Bed
24. Desiccant Cartridge

Fig. 1, Bendix AD-9 Air Dryer (cutaway view)

The AD–9 air dryer consists of the desiccant cartridge and a die-cast aluminum end cover secured to a cylindrical steel outer shell with eight capscrews and nuts. The end cover contains a check valve assembly, a safety valve, three threaded air connections and the purge valve housing assembly. The

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types. The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, can be serviced without removing the air dryer from the vehicle. The

General Information

screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.

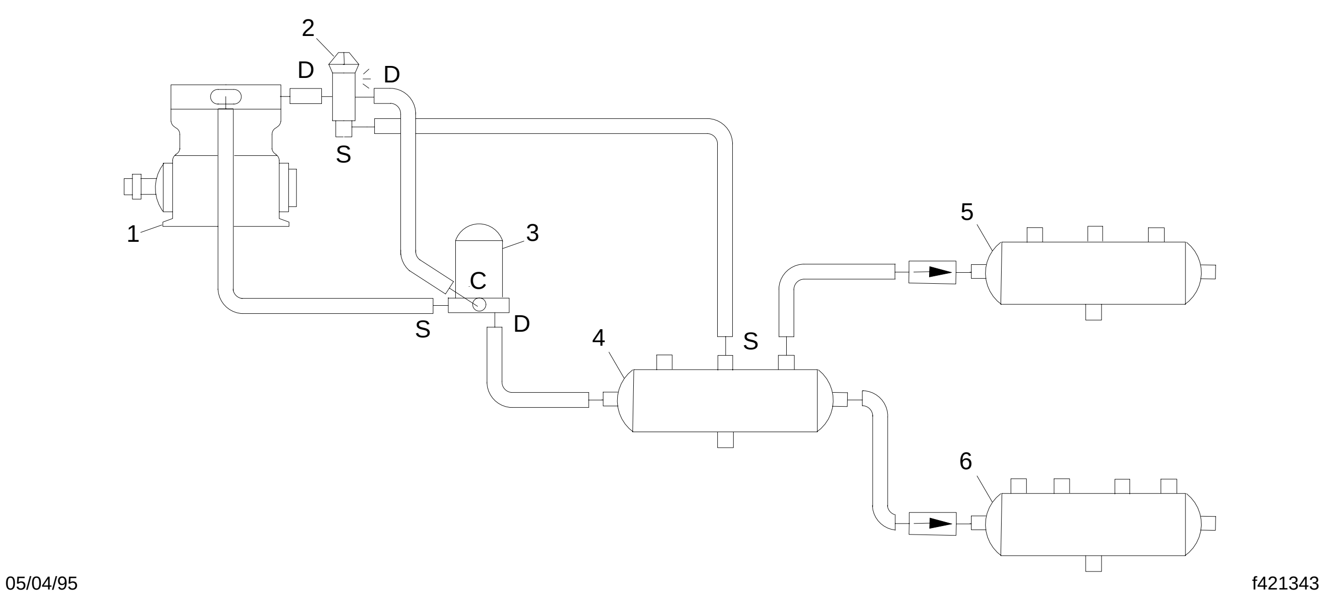
The AD–9 has three female pipe thread air connections; each is identified as follows in **Table 1**.

Port I.D.	Function/Connection
4-CON	Control Port (purge valve control and turbo cutoff)
11-SUP	Supply Port (air in)
2-DEL	Delivery Port (air out)

Table 1, Air Dryer Port Identification

There are 2 versions of the AD–9 air dryer available:

- Standard (see **Fig. 2**):



C. Control
1. Air Compressor
2. D–2 Governor
D. Delivery
3. Air Dryer
4. Supply
S. Supply
5. Primary
6. Secondary

Fig. 2, Standard Air Dryer Plumbing Diagram

The standard air dryer uses a metal seat turbo cutoff valve. The function of the metal seat is to prevent turbocharger boost pressure loss through the air dryer during the purge (compressor unloaded) mode. Some low level turbo air leakage can occur in the unloaded mode.

- Drop-In Air Dryer (see **Fig. 3**):

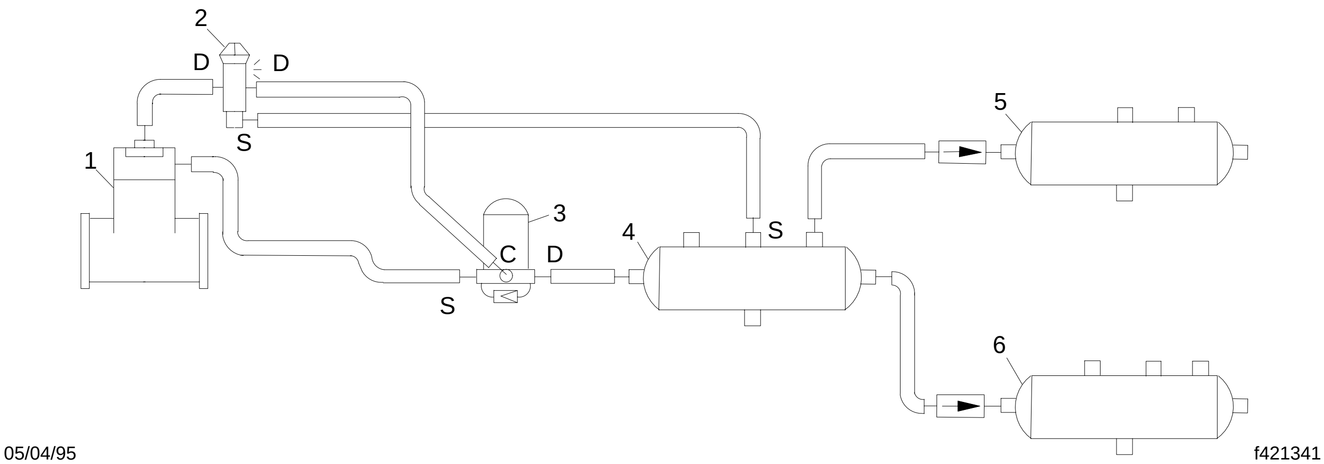
The drop-in style air dryer *can only be used* on vehicles equipped with Holset "E" and "QE" type air compressors. This air dryer eliminates any external plumbing requirements (such as the ECON valve, make-up line, and make-up line check valve). All of these components are an integral part of the air dryer.

Principles of Operation

The AD–9 air dryer alternates between two operational modes or cycles during operation: the charge cycle and the purge cycle.

CHARGE CYCLE (See Fig. 4)

When the compressor is loaded (compressing air), pressurized air, along with oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer end cover. As air travels through the end-cover assembly, its direction of flow changes several times, reducing the tem-



C. Control
1. Holset or Cummins Air Compressor
2. D–2 Governor
D. Delivery
3. Air Dryer
4. Supply
S. Supply
5. Primary
6. Secondary

Fig. 3, Drop-In Style Air Dryer Plumbing Diagram (with Holset or Cummins air compressor)

perature, causing contaminants to condense and drop to the bottom or sump of the air dryer end cover.

After exiting the end cover, air flows into the desiccant cartridge. Once in the cartridge, air first flows through an oil separator, which removes water, oil, oil vapor, and solid contaminants.

Air exits the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively drier as water vapor sticks to the desiccant material in a process known as adsorption. The desiccant cartridge, using the adsorption process typically removes 95 percent of the water vapor from the pressurized air.

Most of the dry air exits the desiccant cartridge through its integral single check valve to fill the purge volume between the desiccant cartridge and outer shell. Some air also exits the desiccant cartridge through the purge orifice adjacent to the check valve.

Dry air flows out of the purge volume through the single check valve assembly and out the delivery port to the first (supply) reservoir of the air system.

The air dryer remains in the charge cycle until air brake system pressure builds to the governor cutout setting.

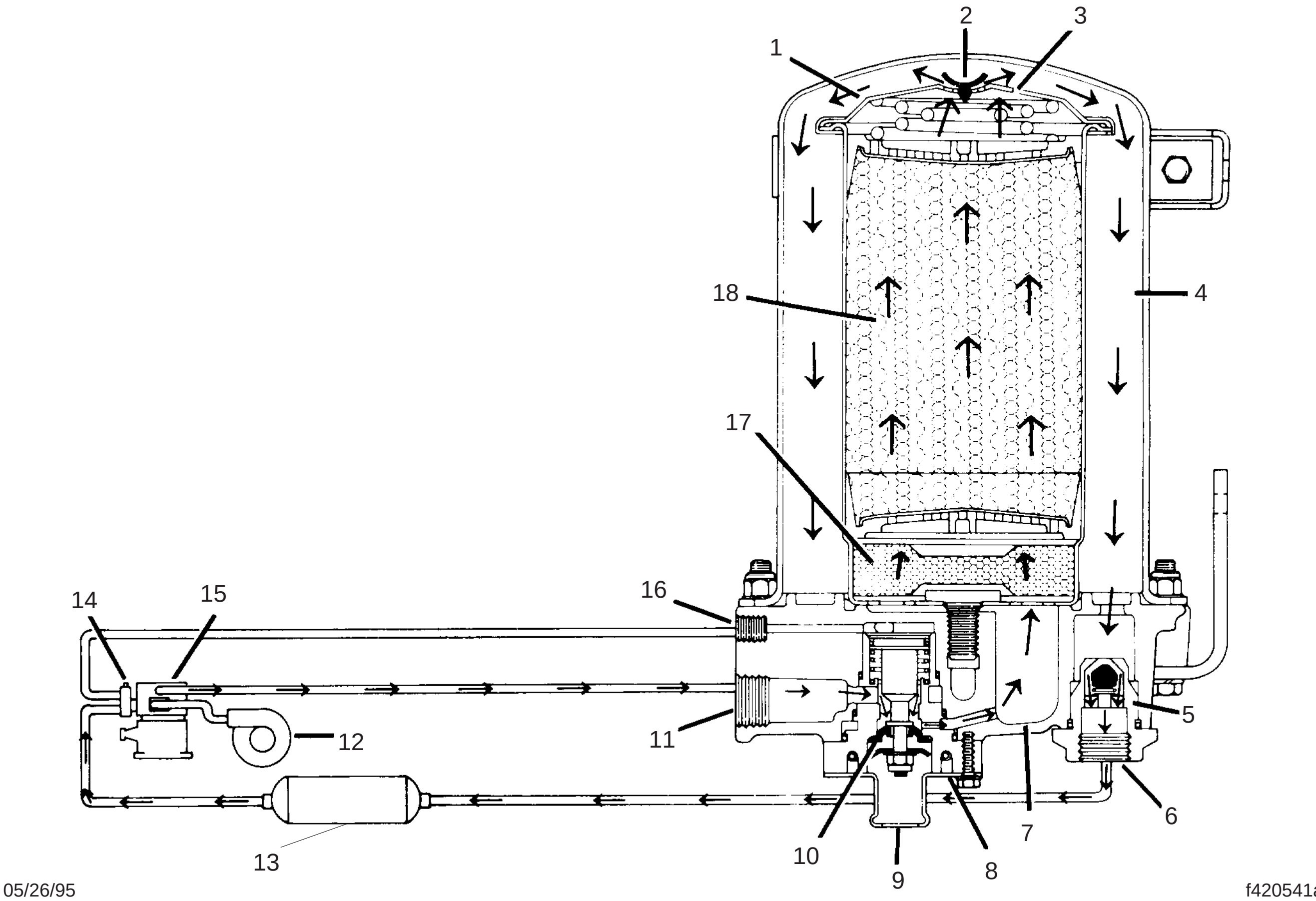
PURGE CYCLE (See Fig. 5)

When the brake system pressure reaches the governor cutout setting, the compressor unloads (air compression stopped), and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the unloader mechanism and line connecting the governor unloader port to the AD–9 end cover control port. The purge piston moves in response to air pressure causing the purge valve to open to atmosphere and partially close off the supply of air from the compressor. This is further discussed under "Turbo Cutoff Feature."

Contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air that was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression last only a few seconds and are signaled by an audible burst of air at the AD–9 exhaust. The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume through the desiccant cartridge purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its

General Information



1. Desiccant Cartridge	7. Sump	13. Reservoir
2. Check Valve	8. Heater Element	14. Governor
3. Orifice	9. Exhaust	15. Compressor
4. Purge Volume	10. Purge Valve	16. Control Port
5. Check Valve Assembly	11. Supply Port	17. Oil Separator
6. Delivery Port	12. Engine Turbocharger	18. Desiccant Bed

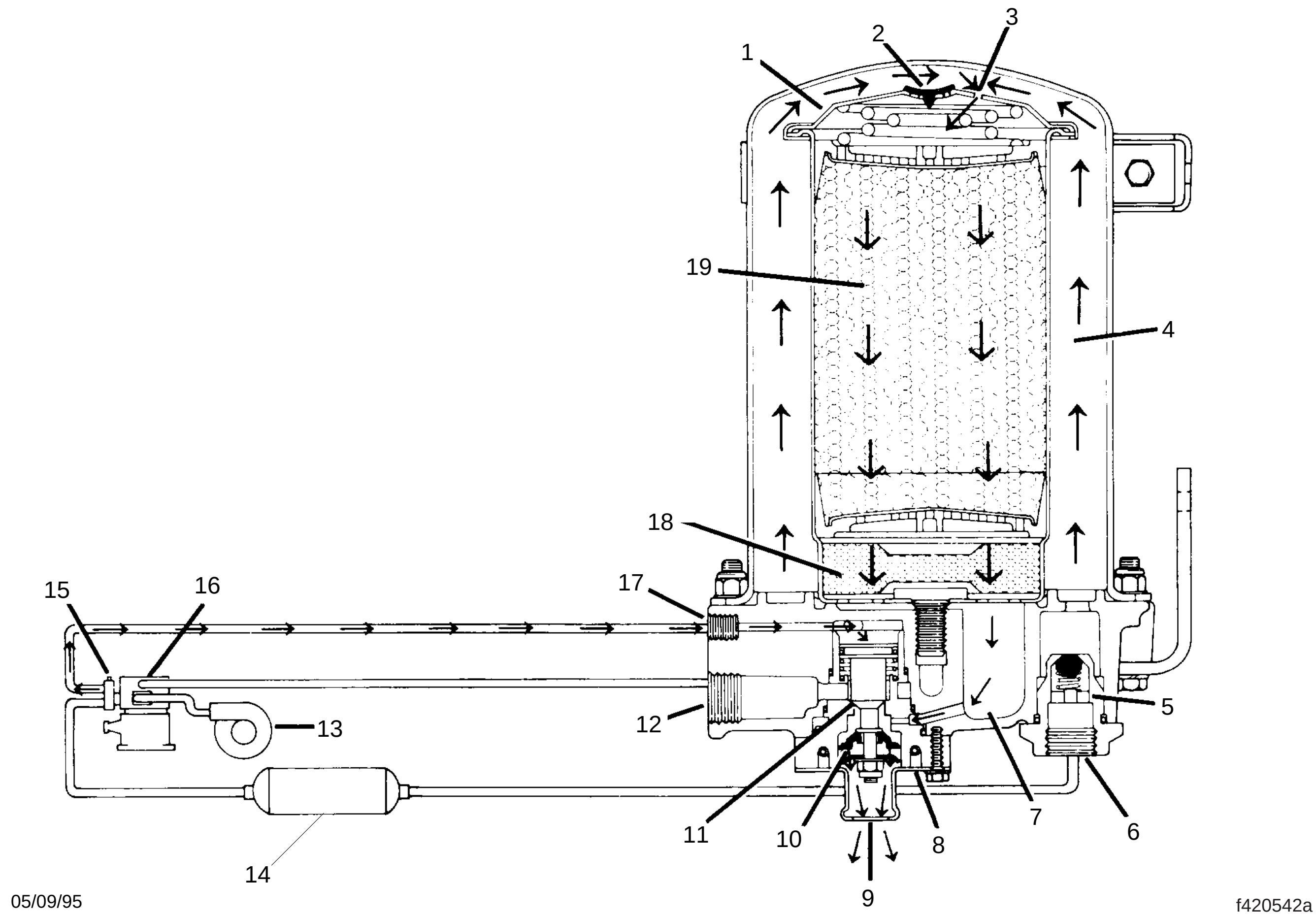
Fig. 4, AD-9 Charge Cycle

pressure is lowered and its volume increased. Dry air flowing through the drying bed reactivates the desiccant material by removing the water vapor sticking to it. Generally, it takes 15 to 30 seconds for the entire purge volume of a standard AD–9 to flow through the desiccant drying bed.

The end cover single check valve assembly prevents compressed air in the brake system from returning to the air dryer during the purge cycle. After the 30 second purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

The purge valve will remain open after the purge cycle is complete, and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.

NOTE: The air dryer should be periodically checked for operation and tested for leaks. Refer to the brake section in the vehicle maintenance manual for intervals and procedures.



1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge Volume
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Turbocharger Cutoff Piston
12. Supply Port
13. Engine Turbocharger
14. Reservoir
15. Governor
16. Compressor
17. Control Port
18. Oil Separator
19. Desiccant Bed

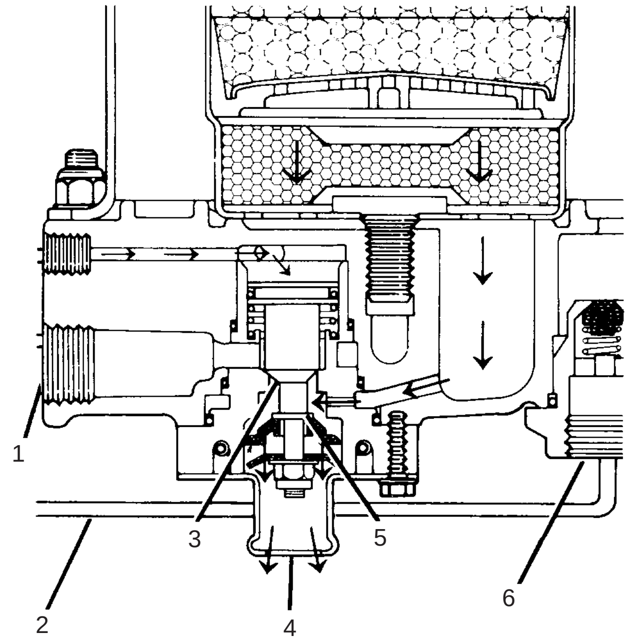
Fig. 5, AD-9 Purge Cycle

TURBO CHARGER CUTOFF FEATURE (See Fig. 6)

Primarily, the turbo cutoff valve prevents loss of engine turbocharger air pressure through the AD–9 in systems where the compressor intake is connected to the engine turbocharger. The turbo cutoff valve also reduces the puffing of air out the open exhaust when a naturally aspirated, single cylinder compressor equipped with an inlet check valve is in use.

At the beginning of the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve (tapered portion of the purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the discharge line and AD–9 supply port is restricted from entering the air dryer. While the turbo cutoff *effectively* prevents loss of turbocharger boost pressure to the engine, some seepage of air may be detected under certain conditions of com-

General Information



1. Supply Port
2. Discharge Line
3. Turbocharger Cutoff Piston
4. Exhaust
5. Purge Valve
6. Check Valve Assembly

Fig. 6, AD-9 Turbo Cutoff

pressor, engine, and turbocharger operation. Even so, there will be low pressure trapped in the discharge line.

Safety Precautions

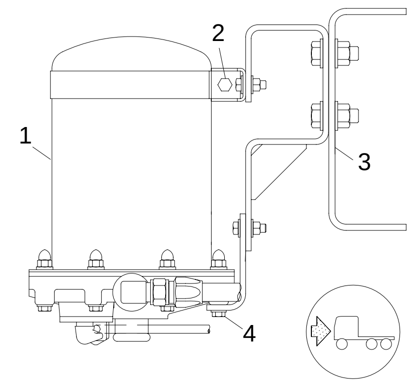
When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and shut down the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Don’t disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.

   Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

Air Dryer Removal and Installation

Removal (See Fig. 1)



1. Air Dryer
2. Upper Bracket Strap Capscrew
3. Right Frame Rail
4. End Cover Fastener

Fig. 1, Air Dryer Mounting

WARNING

Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Park the vehicle on a level surface and chock the tires.
2. Completely drain all of the reservoirs.
3. Remove the air dryer.
   - 3.1 Mark and disconnect the three air lines from the end cover, and note the position of end cover ports relative to the vehicle.
   - 3.2 Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the exhaust cover.
   - 3.3 Loosen the capscrew securing the upper bracket strap.
   - 3.4 Remove, save, and mark the two end cover capscrews, locknuts, and four special washers that retain the lower mounting bracket to the end cover. Also mark the two holes of the end cover (these receive the two longest capscrews.)
   - 3.5 Remove the air dryer from its mounting brackets.

Installation (See Fig. 1)

WARNING

Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Install the assembled air dryer on the vehicle.
   - 1.1 Position the air dryer up into the upper mounting bracket and strap. Align the two unused holes in the end cover with the bottom mounting bracket so that the bottom bracket supports the air dryer. The end cover should rest on the bracket.
   - 1.2 Using the two longest capscrews, four special washers, and two locknuts, secure the air dryer to the lower bracket. Tighten the two remaining capscrews 23 to 32 lbf·ft (31 to 434 N·m).
   - 1.3 Tighten the capscrew and nut on the upper mounting bracket strap 8 lbf·ft (11 N·m).
   - 1.4 As marked earlier in "Removal," connect the three air lines to the ports on the end cover.
   - 1.5 Connect the vehicle wiring harness to the air dryer heater and thermostat assembly connector by plugging it into the air dryer connector until its lock tab snaps in place.
2. Test the air dryer following instructions in the brake section in the vehicle maintenance manual.

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

NOTE: As a convenience when rebuilding the air dryer, several replacement parts and maintenance kits are available that do not require full disassembly. Use the instructions provided with these parts or kits.

Disassembly (See Fig. 1)

WARNING

Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

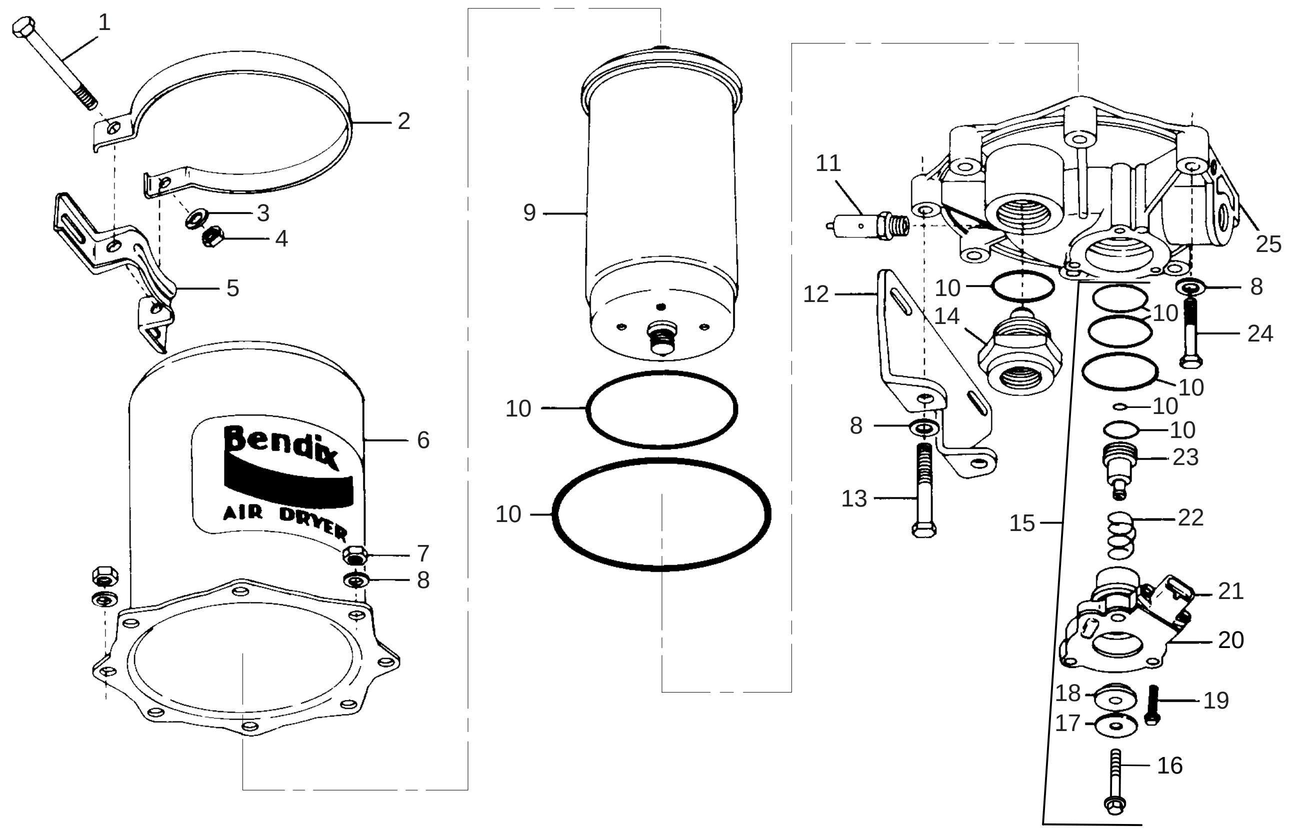
CAUTION

While servicing the air dryer, don't use a clamping device (vise, C-clamp, etc.) to hold any die cast aluminum part, as damage may result. To hold the end cover, install a pipe nipple in the supply port, and clamp the nipple in a vise.

1. Remove the air dryer from the vehicle. See **Subject 110**.
2. Remove the check valve assembly and O-ring. Remove the O-ring from the check valve assembly.
3. Remove the purge valve housing assembly.
   - 3.1 Remove the three self-tapping screws that secure the purge valve housing assembly to the end cover assembly.
   - 3.2 Pull the purge valve housing assembly out of the end cover assembly.
   - 3.3 Remove and discard the three O-rings from the exterior of the purge valve housing assembly.

   NOTE: These O-rings may lodge in and have to be removed from the end cover bores.
4. Remove the heater and thermostat assembly.
   - 4.1 Remove and discard the two screws that attach the heater and thermostat assembly to the purge valve housing.
   - 4.2 Gently rotate the electrical connector to the left until the thermostat clears the purge valve housing. Then, slide the heater element out, to the right and up. Discard the assembly.
5. Disassemble the purge valve housing assembly.

Air Dryer Disassembly, Cleaning and Inspection, and Assembly



1. 5/16-Inch x 4-1/2 Inch Upper Bracket Capscrew
2. Upper Bracket Strap
3. 5/16-Inch Lockwasher
4. 5/16-Inch Locknut
5. Upper Mounting Bracket
6. Housing
7. Locknut
8. 3/8-Inch Special Washer
9. Desiccant Cartridge
10. O-Ring
11. Safety Valve
12. Lower Mounting Bracket
13. 3/8-Inch Capscrew (Long)
14. Check Valve Assembly
15. Purge Valve Assembly
16. Purge Valve Bolt
17. Exhaust Diaphragm
18. Purge Valve
19. 1/4-Inch Tapping Screw
20. Purge Valve Housing
21. Heater and Thermostat Assembly
22. Return Spring
23. Purge Piston
24. 3/8-Inch Capscrew
25. End Cover

Fig. 1, AD-9 (exploded view)

5.1 If a flat non-extended exhaust cover is used, leave it intact while servicing the purge valve housing assembly.

If an extended type exhaust cover is used for the attachment of an exhaust hose, *carefully* separate the exhaust cover from the purge valve housing. *Use a thin flat blade to pry the exhaust cover off, taking care not to damage the potting material (RTV sealant) under the cover.*

5.2 Remove the bolt from the bottom of the purge valve housing assembly. Remove the diaphragm and the purge valve from the purge valve housing.

5.3 Remove the purge piston, the return spring and two O-rings (one on the outside and the other in the inside of the purge piston).

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

6. Remove the remaining six capscrews (Ref. 24), locknuts (Ref. 7), and twelve special washers (Ref. 8) that secure the end cover to the housing (Ref. 6). Separate the end cover and desiccant cartridge (Ref. 9) from the housing (Ref. 6).
7. Remove the end-cover-to-outer-housing O-ring.
8. Don't remove the safety valve (Ref. 11) from the end cover unless it is known to be inoperative. If replacement is needed, apply thread sealant or Teflon® tape on the threads of the replacement valve and tighten 120 to 400 lbf·in (1360 to 4520 N·m). Make sure the drain hole (slot) is facing down.
9. Place a strap or chain wrench around the desiccant cartridge (Ref. 9) so that it is about 2 to 3 inches (5 to 8 cm) away from the end cover. Rotate the cartridge counterclockwise until it completely separates from the end cover.

NOTE: Torque of up to 50 lbf·ft (68 N·m) may be needed to do this disassembly.

10. Remove the desiccant cartridge O-ring from the end cover.

Cleaning and Inspection

WARNING

Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.
2. Check for severe corrosion, pitting, and cracks on the inside and outside of all metal parts that will be reused. Superficial corrosion and pitting on the outside of the upper and lower body halves is acceptable.
3. Inspect the bores of both the end cover and the purge-valve housing for deep scuffing or gouges.
4. Make sure that all purge-valve housing and end cover passages are open and free of blockages.
5. Inspect the pipe threads in the end cover. Make sure they are clean and free of thread sealant.
6. Inspect the purge-valve housing bore and seats for excessive wear and scuffing.
7. Inspect the purge valve piston seat for excessive wear.
8. Inspect all air line fittings for corrosion. Clean all old thread sealant from the pipe threads.
9. Replace all removed O-rings with new ones that are provided in the kits.

   Replace parts that show any of the conditions described in the previous steps.

Assembly (See Fig. 1)

WARNING

Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-base lubricant. See Fig. 1 during assembly unless otherwise advised.

IMPORTANT: When installing the heater and thermostat assembly, make sure that the seal ring under the electrical connector is not twisted.

2. Install the heater and thermostat assembly.

   2.1 Insert the heater element into the slot in the purge valve housing until the connector contacts the housing.

   2.2 Gently push the connector and the thermostat to the left until the thermostat clears the cavity in the housing. Then, turn the connector to the right while pushing the thermostat all the way down into the cavity.

   Make sure that the connector is seated evenly against the housing.

   2.3 Install the two mounting screws. Tighten the screws 10 to 20 lbf·in (113 to 226 N·cm).

3. Assemble the purge-valve housing.

   3.1 Install the O-ring on the purge piston. Place the return spring in the purge-valve

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

housing. Place the O-ring in the bore of the purge piston. Insert the purge piston into the spring. Push the piston into the purge-valve housing until it bottoms.

3.2 While holding the purge piston in, install the following parts: the purge valve with its rubber side first, followed by the diaphragm and the bolt. Torque the purge valve bolt 60 to 80 lbf·in (680 to 900 N·cm).

3.3 Install the three O-rings in their correct locations on the purge-valve housing.

3.4 If an extended type exhaust cover was removed, install it on the purge-valve housing assembly, making sure the "bubble" portion is positioned over the thermostat.

3.5 Install the assembled purge-valve housing in the end cover; make sure you orient both parts so that the connector is about 10 degrees clockwise from the supply port. Also, make sure the purge-valve housing is fully seated against the end cover.

3.6 Secure the purge-valve housing to the end cover using the three self-tapping screws. Start all three screws by hand, then torque them 85 to 125 lbf·in (960 to 1400 N·cm).

4. Install an O-ring on the check-valve assembly, then install the assembly in the end cover using a socket. Tighten it 200 to 250 lbf·in (2260 to 2820 N·cm).

5. Install the desiccant cartridge in the end cover.

5.1 Install the smaller desiccant cartridge O-ring in its groove in the end cover. Using a light coat of barium grease, lubricate the bottom of the desiccant cartridge in the area that will contact the O-ring and end cover.

5.2 Screw the desiccant cartridge into the end cover until the cartridge contacts the O-ring. Using a strap or chain wrench positioned 2 to 3 inches (5 to 8 cm) from the bottom of the cartridge, turn the desiccant cartridge clockwise 180 to 225 degrees beyond the position where initial contact was made with the O-ring. Torque should not exceed 50 lbf·ft (68 N·m).

6. Install the housing over the desiccant cartridge.

6.1 Install the large O-ring on the shoulder in the end cover. Place the housing over the desiccant cartridge and align the holes.

6.2 Install the six capscrews, locknuts, and the twelve special washers, making sure they are positioned as referenced earlier. The two longer capscrews will be used to secure the air dryer to its mounting bracket.

6.3 Tighten the six capscrews and nuts in a star pattern (depending on lower bracket location) 23 to 32 lbf·ft (306 to 434 N·m). See **Fig. 2**.

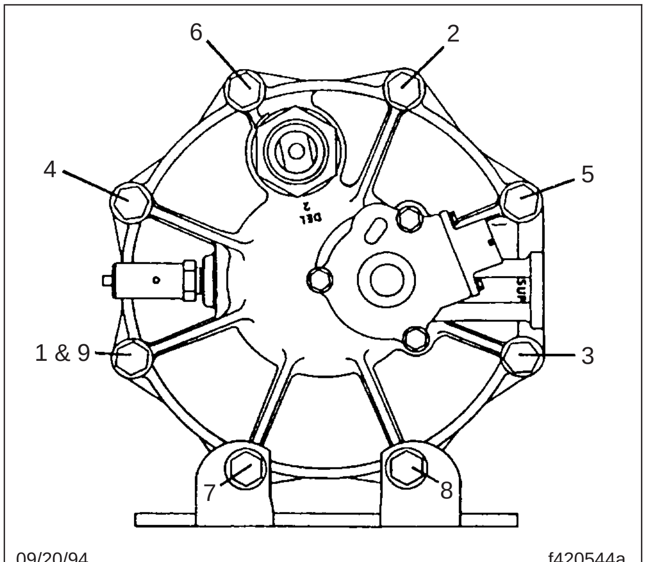


Fig. 2, End Cover to Housing Torque Pattern

NOTE: The two remaining bolt holes in the end cover and two 3/8-inch capscrews must be the ones marked during removal to ensure correct orientation of the ports and adequate length of the capscrews.

7. Connect the electrical connector to the heater and thermostat assembly.

8. Test the air dryer for proper operation. For instructions, see **Subject 130**.

Air Dryer Thermostat Testing

Testing

During cold-weather operation, check the operation of the end cover heater and thermostat assembly.

1. With the ignition on, check for voltage to the heater and thermostat assembly. Unplug the electrical connector at the air dryer, and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check that a good ground path exists.
2. Check the thermostat and heater operation. Turn off the ignition switch and cool the end cover assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly, and 6.8 to 9.0 ohms for the 24-volt heater assembly.

NOTE: Some early models of the AD–9 will have resistance readings of 1.0 to 2.5 ohms for the 12-volt heater assembly, and 4.8 to 7.2 ohms for the 24-volt heater assembly. If the resistance is higher than this, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

3. Warm the end cover assembly to over 90°F (32°C) and again check the resistance. It should exceed 1000 ohms. If it does, the thermostat and heater assembly is operating properly. If it doesn’t, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

Troubleshooting

Problem—Air Dryer Is Constantly Cycling or Purging

Problem—Air Dryer Is Constantly Cycling or Purging	
Possible Cause	**Remedy**
Excessive system leakage.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir
There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank.	Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.
Governor is inoperative.	Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions.
Leaking purge-valve housing assembly or O-rings in the air dryer end cover.	With the supply port open to atmosphere, apply 120 psi (830 kPa) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. Repair or replace as needed.
Compressor unloader mechanism is leaking excessively.	Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed.
Holset "E" type compressor.	Test the air dryer system. For instructions, refer to Bendix Product Bulletin PRO-08-19 entitled "Troubleshooting the Holset "E" Compressor System with Bendix Air Dryer."
Lack of air at the governor RES port (rapid cycling of the governor).	Test the governor for proper pressure at the RES port. Pressure should not drop below cut-in pressure when the compressor begins the unloaded cycle. If the pressure does drop, check for kinks or restrictions in the line connected to the RES port. The line connected to the RES port on the governor must be the same diameter, or larger than the lines connected to the UNL ports on the governor.

Problem—Water in the Vehicle Reservoirs

Problem—Water in the Vehicle Reservoirs	
Possible Cause	**Remedy**
Desiccant cartridge assembly contains excessive contaminants.	Replace the desiccant cartridge.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information.
Air system was charged from an outside air source that did not pass through an air dryer.	If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized.
Air dryer is not purging.	Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air."

Troubleshooting

Problem—Water in the Vehicle Reservoirs	
Possible Cause	**Remedy**
Purge (air exhaust) is insufficient due to excessive system leakage.	Refer to "Problem—Air Dryer Is Constantly Cycling or Purging."
Air bypasses the desiccant cartridge assembly.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed.
Purge (air exhaust) time is significantly less than the minimum allowable.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly.
Excessive air usage—air dryer not compatible with vehicle air system.	Install an accessory bypass system. Consult your Bendix representative for additional information.

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air	
Possible Cause	**Remedy**
Desiccant cartridge is plugged or saturated.	Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as needed.
The check valve in the air dryer end cover is inoperative.	Test to determine if air is passing through the check valve. Repair or replace as needed.
There is a problem in the fittings, hose, or tubing between the air dryer and the wet tank.	See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings.
Safety valve setting is lower than the maximum system pressure.	Reduce the system pressure, or install a safety valve with a higher pressure setting.

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure	
Possible Cause	**Remedy**
Air dryer purge valve is leaking excessively.	With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Purge control line is connected to the reservoir or exhaust port of the governor.	Connect the purge control line to the unloader port of the governor.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse.	Test the heater and thermostat, following instructions in this manual.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Troubleshooting

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure	
Possible Cause	**Remedy**
System is leaking excessively.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir
Purge valve stays open; supply air leaks to control side.	Replace the purge valve assembly O-rings.

Problem—Air Dryer Does Not Purge or Exhaust Air

Problem—Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
Purge control line is broken, kinked, frozen, plugged, or disconnected.	See if air flows through the purge control line when the compressor is unloaded. The purge control line must be connected to the unloader port of the governor.
Air dryer purge valve isn’t working.	See if air reaches the purge valve. If it does, repair the purge valve.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (may look like whitish liquid, paste, or small beads) or Unsatisfactory Desiccant Life	
Possible Cause	**Remedy**
This problem usually occurs with one or more of the previous problems.	Refer to the appropriate corrections listed previously.
Air dryer is not securely mounted; there is excessive vibration.	Vibration should be held to a minimum. Tighten the mounting fasteners.
Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly.	Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth.Check the installation.
Compressor is passing excessive oil.	Check for proper compressor installation; if symptoms persist, replace the compressor.
Heater and thermostat, wiring, or a fuse is at fault, and isn’t allowing the air dryer to purge during cold weather.	Test the heater and thermostat, following instructions in this manual.

Troubleshooting

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (may look like whitish liquid, paste, or small beads) or Unsatisfactory Desiccant Life	
Possible Cause	**Remedy**
Desiccant cartridge not attached properly to the end cover.	Check the torque and tighten if necessary. Refer to **Subject 120** for instructions.

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle	
Possible Cause	**Remedy**
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 in^3 (1475 cm^3) reservoir between the compressor and the air dryer.

Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)

Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)	
Possible Cause	**Remedy**
Air compressor inlet is pressurized by the engine turbocharger.	Some pressure leakage past the metal seat of the turbocharger cutoff feature of the AD-9 air dryer is normal, and may be heard. This slight loss of air will not affect the engine or turbocharger performance.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.

Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode

Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode	
Possible Cause	**Remedy**
Compressor does not "unload."	Check the governor installation: there is no air line from the governor to the compressor, or the line is restricted. Repair or replace as needed.

Figure 1 is a full view of the plumbing diagram for an air brake installation with two dash valves and an integrated Bendix DRM air dryer (Freightliner diagram D12-16283, revision C). See Fig. 2 and Fig. 3 for left and right partial views, respectively.

Figure 4 is a detailed view of the air manifold pressure switch assembly.

Figure 5 is a full view of the plumbing diagram for an air brake installation with two dash valves and a conventional air dryer (diagram D12-15087, revision H). See Fig. 6, Fig. 7, and Fig. 8 for left, center, and right partial views, respectively.

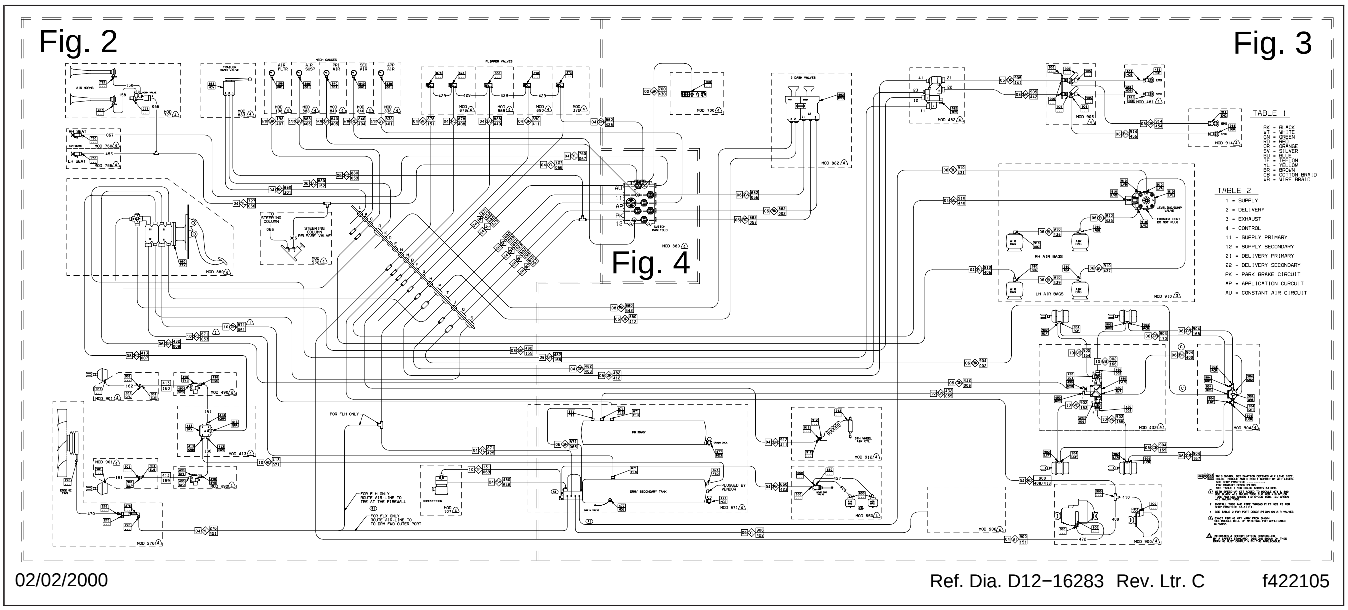


Fig. 1, Air Brake Plumbing, Two Dash Valves/Integral Bendix DRM Air Dryer (full view)

Specifications

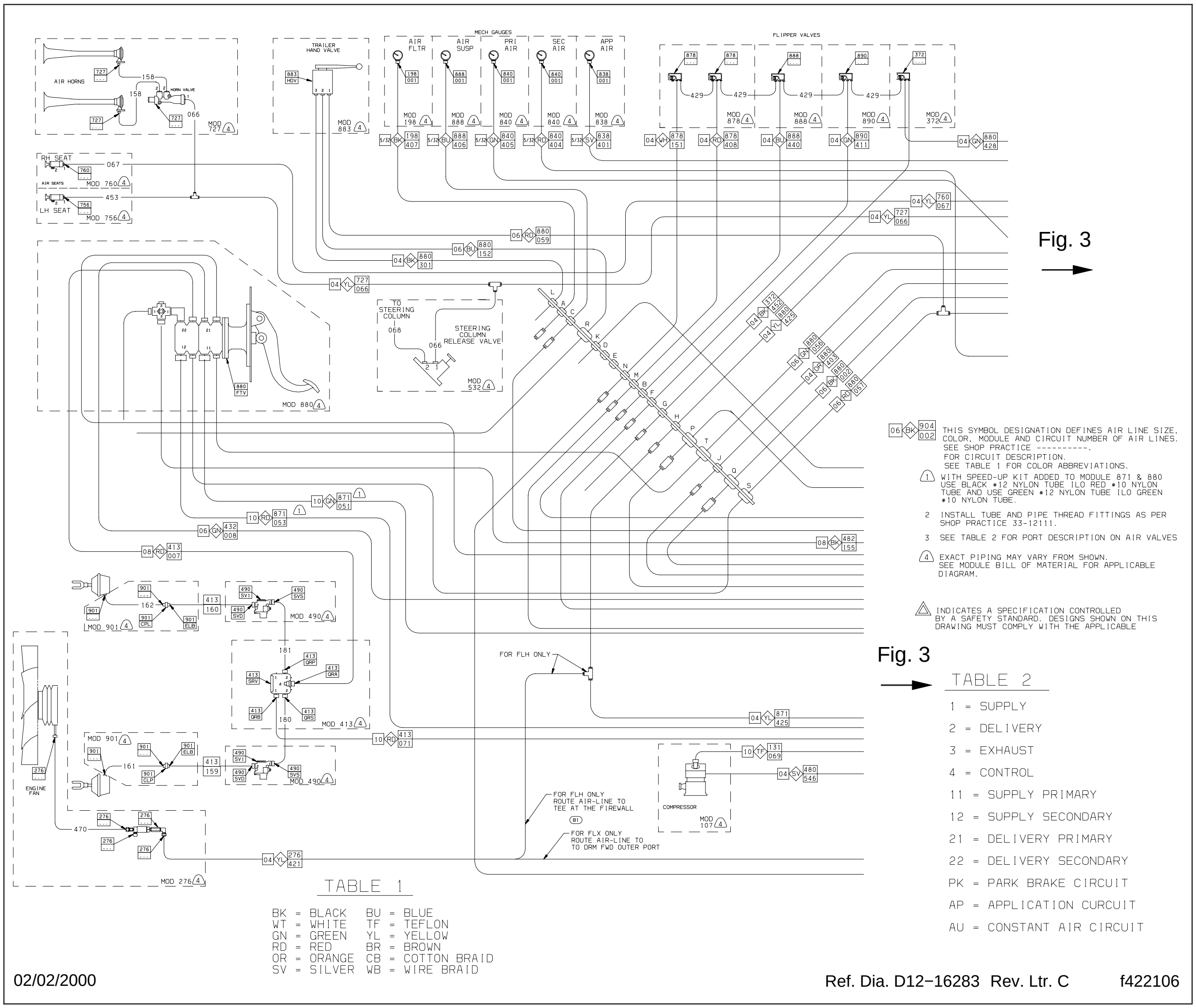
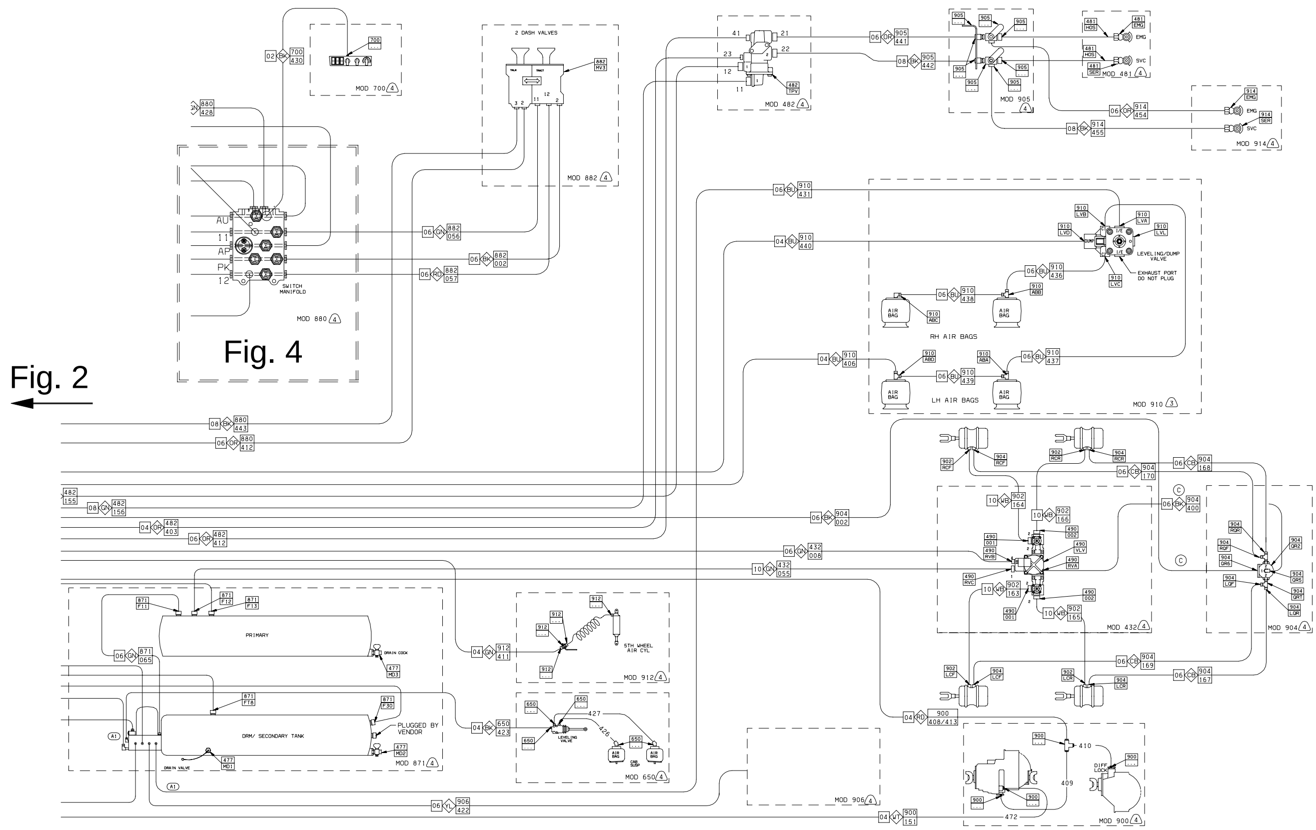


Fig. 2, Air Brake Plumbing, Two Dash Valves/Integral Bendix DRM Air Dryer (partial view)



06 BK 904 002 — THIS SYMBOL DESIGNATION DEFINES AIR LINE SIZE, COLOR, MODULE AND CIRCUIT NUMBER OF AIR LINES. SEE SHOP PRACTICE ----------. FOR CIRCUIT DESCRIPTION. SEE TABLE 1 FOR COLOR ABBREVIATIONS.

1. WITH SPEED-UP KIT ADDED TO MODULE 871 & 880 USE BLACK #12 NYLON TUBE ILO RED #10 NYLON TUBE AND USE GREEN #12 NYLON TUBE ILO GREEN #10 NYLON TUBE.
2. INSTALL TUBE AND PIPE THREAD FITTINGS AS PER SHOP PRACTICE 33-12111.
3. SEE TABLE 2 FOR PORT DESCRIPTION ON AIR VALVES
4. EXACT PIPING MAY VARY FROM SHOWN. SEE MODULE BILL OF MATERIAL FOR APPLICABLE DIAGRAM.

TABLE 1

BK = BLACK	BU = BLUE
WT = WHITE	TF = TEFLON
GN = GREEN	YL = YELLOW
RD = RED	BR = BROWN
OR = ORANGE	CB = COTTON BRAID
SV = SILVER	WB = WIRE BRAID

TABLE 2

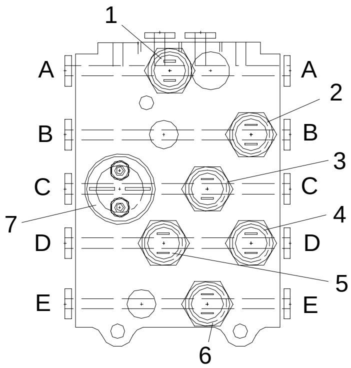
1 = SUPPLY	21 = DELIVERY PRIMARY
2 = DELIVERY	22 = DELIVERY SECONDARY
3 = EXHAUST	PK = PARK BRAKE CIRCUIT
4 = CONTROL	AP = APPLICATION CURCUIT
11 = SUPPLY PRIMARY	AU = CONSTANT AIR CIRCUIT
12 = SUPPLY SECONDARY	

INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE

02/02/2000 Ref. Dia. D12−16283 Rev. Ltr. C f422107

Fig. 3, Air Brake Plumbing, Two Dash Valves/Integral Bendix DRM Air Dryer (partial view)

Specifications



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A. Auxiliary Air Pressure Circuit
B. Primary Air Pressure Circuit
C. Application Air Pressure Circuit
D. Parking Brake Air Pressure Circuit
E. Secondary Air Pressure Circuit

1. Fan Pressure Switch
2. Primary Low Air Warning Pressure Switch
3. Cruise Control Cutout Pressure Switch
4. Engine Idle Timer Pressure Switch
5. Daytime Running Lights Pressure Switch
6. Secondary Low Air Warning Pressure Switch
7. Stop Light Pressure Switch

Fig. 4, Air Manifold and Pressure Switch Assembly

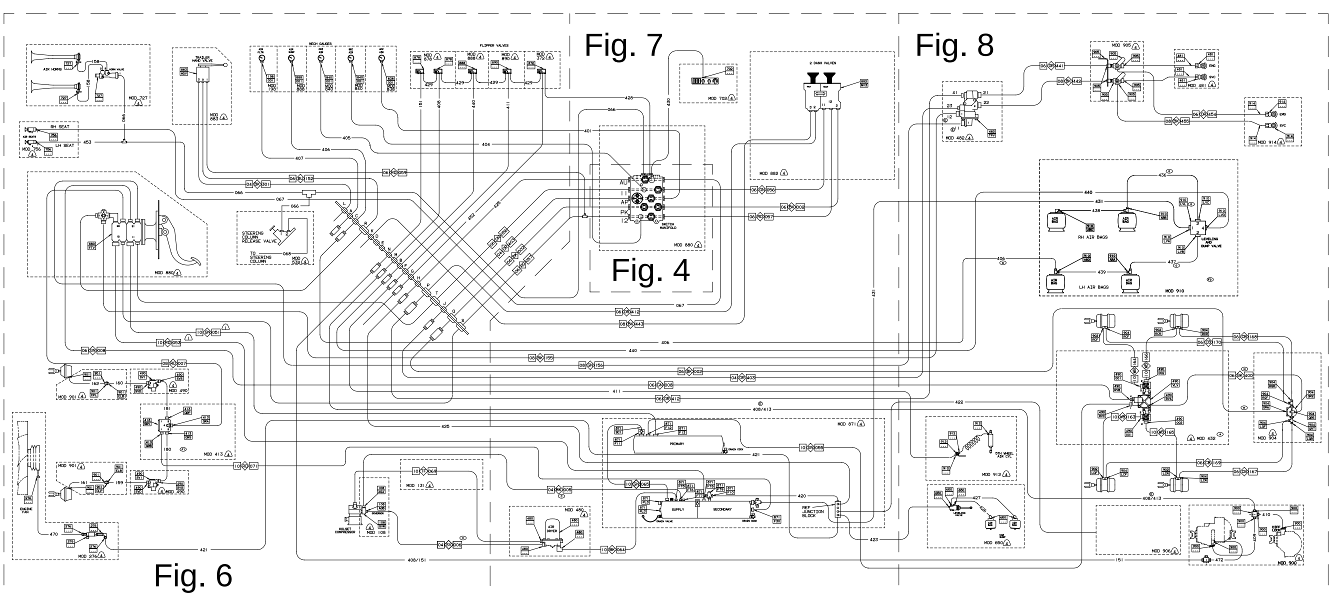

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Fig. 5, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (full view)

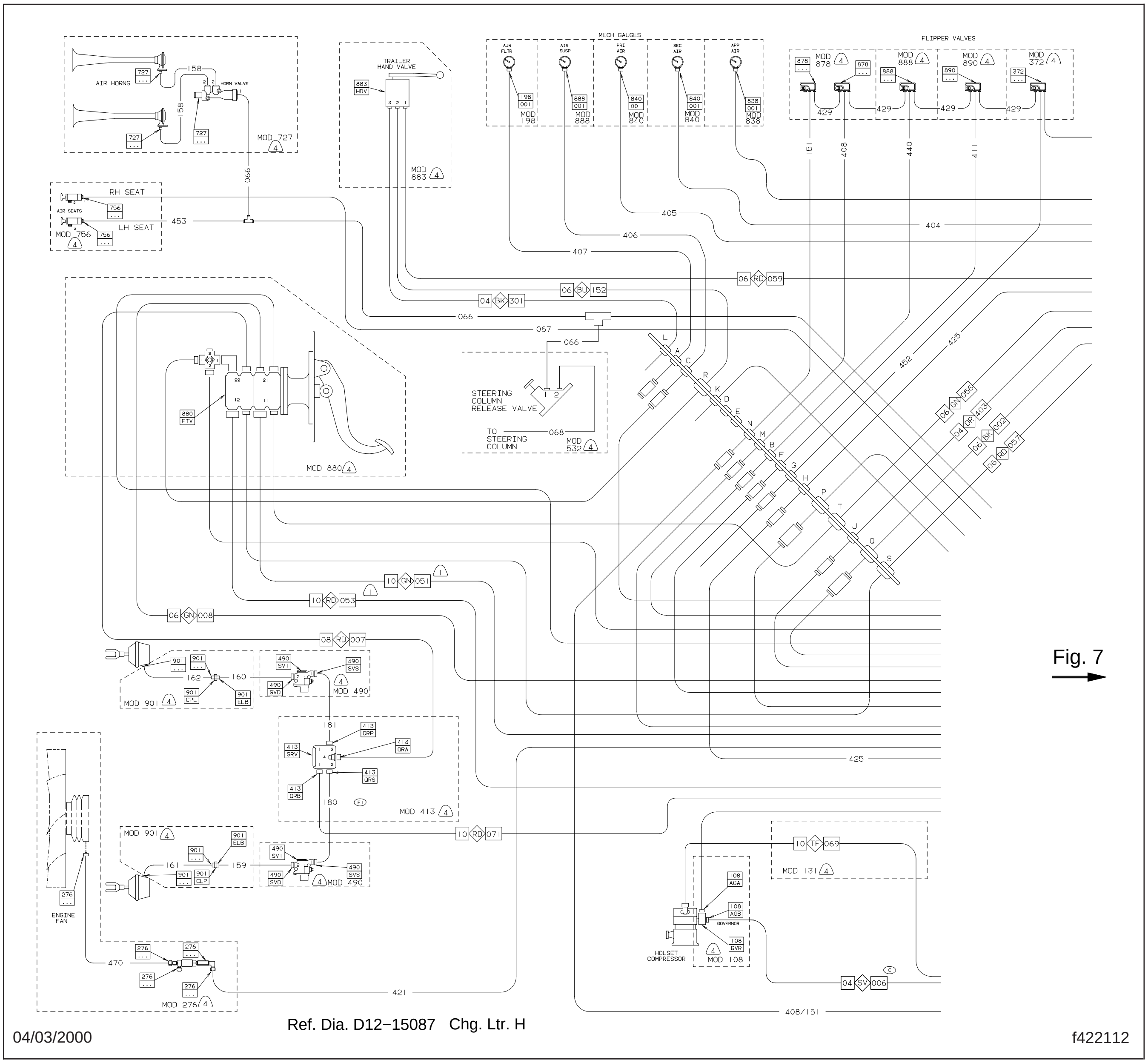


Fig. 6, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

Specifications

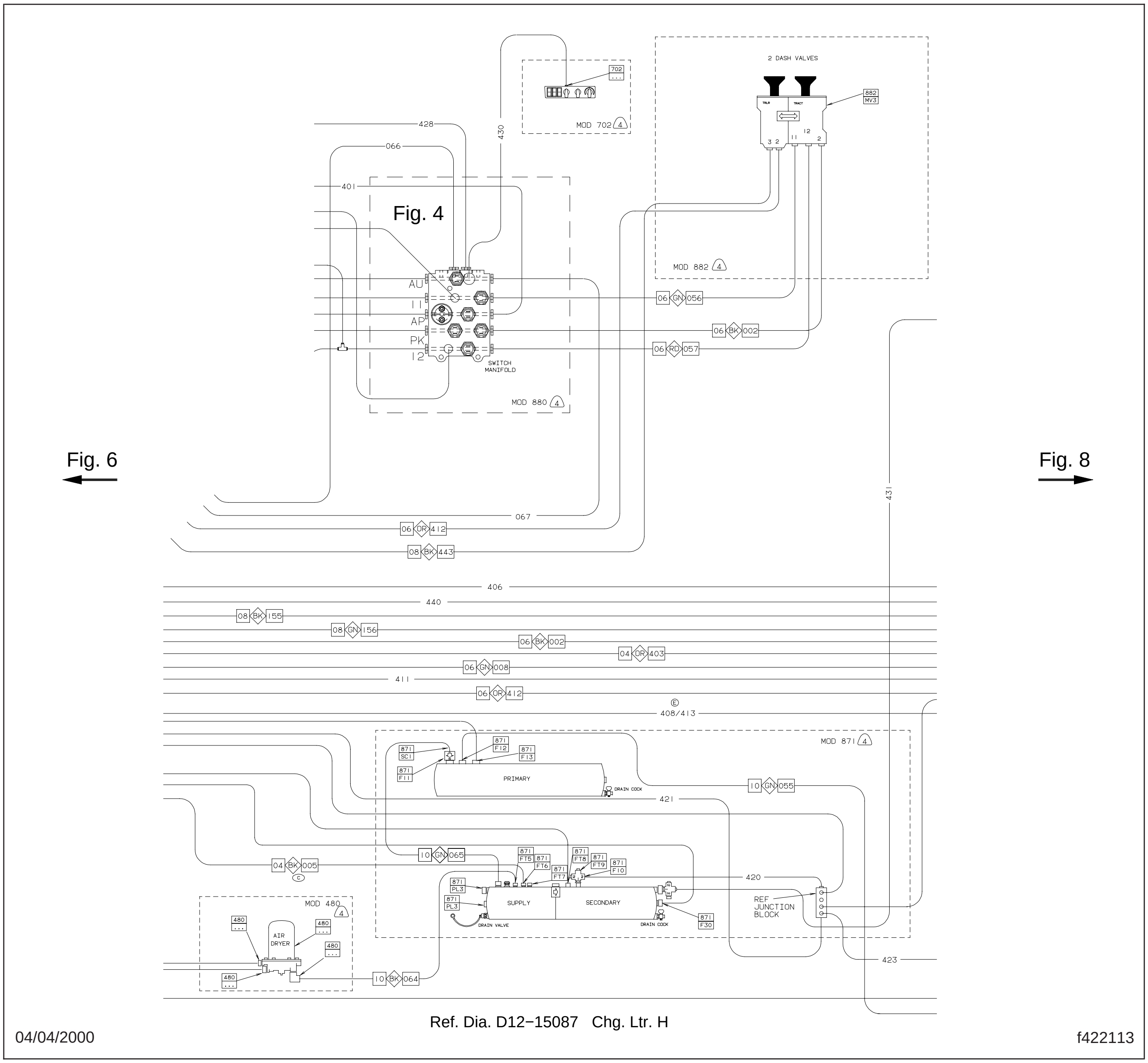


Fig. 7, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

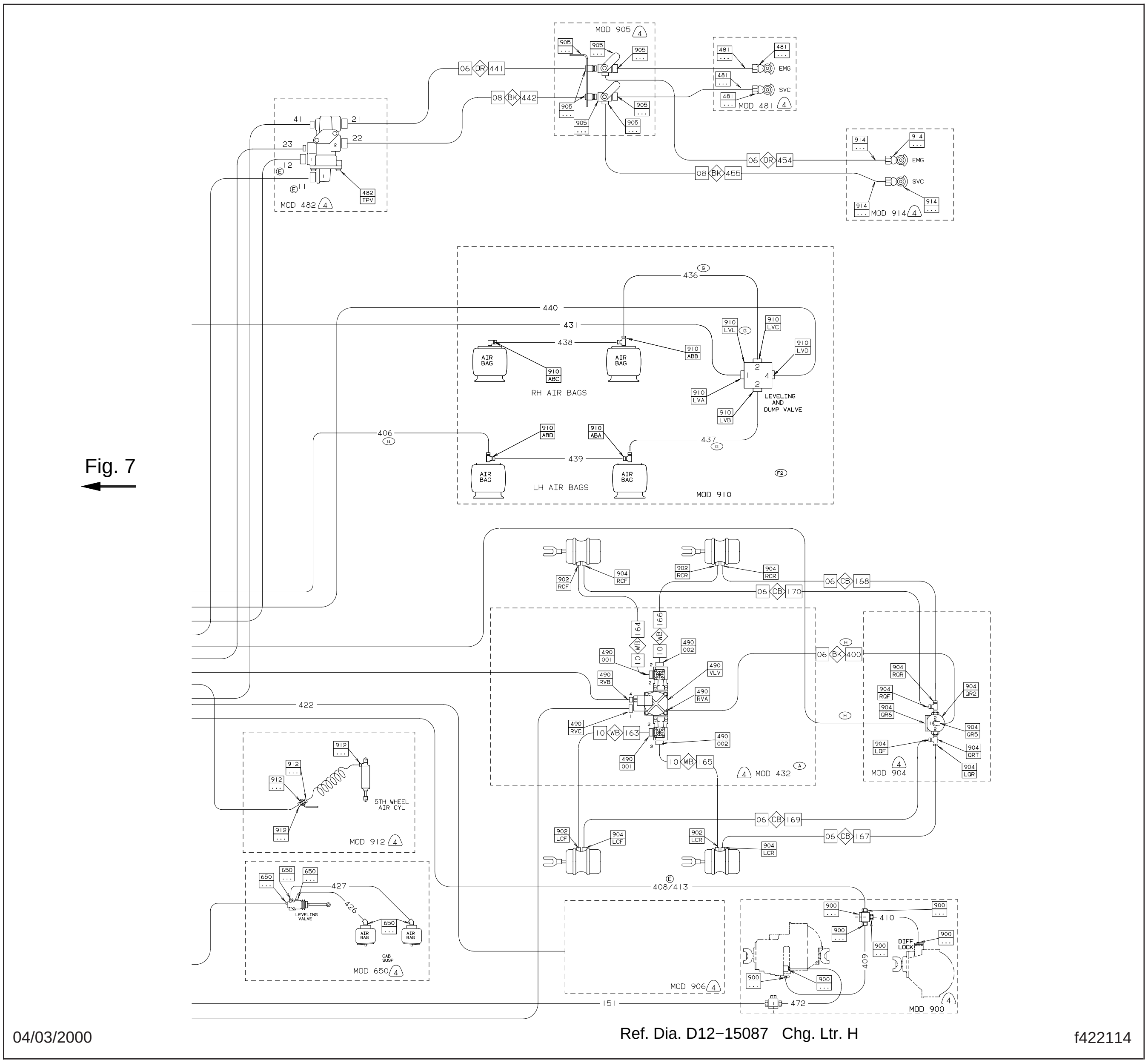


Fig. 8, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

General Information

NOTE: Vehicles with a Bendix Dryer Reservoir Module (DRM) have a separate primary reservoir. The secondary reservoir and purge reservoir are part of the DRM. See **Section 42.03** for more information on the DRM.

Air reservoirs serve two main purposes:

- They store compressed air used to apply the brakes and operate other air-powered devices, such as window lifts, windshield wipers, and seats.
- They provide a place where air, heated during compression, can cool and water vapor can condense into a liquid. Also, air reservoirs collect small amounts of oil passed by the compressor.

Each vehicle is equipped with three or more air reservoirs, depending on the number of rear axles. On all vehicles, each reservoir is identified as one of three types: supply, primary, or secondary.

A supply reservoir receives compressed air from an air dryer or directly from the compressor. Also referred to as the wet tank, its functions are to collect most of the water and oil condensate from the air, and to supply air to the other reservoirs. With a properly functioning air dryer, there should be little or no water or oil in any reservoir.

At the outlet port of the supply reservoir (the port leading to the primary reservoir) is a safety valve that protects the air system against excessive air pressure build-up. The supply reservoir is usually mounted on the left-hand frame rail.

Primary reservoirs are air sources for the brakes on the rear axles. One or more primary reservoirs are installed on a vehicle, depending on the number of rear axles and the air system configuration. Each reservoir is equipped with an inline check valve. The main primary reservoir is usually mounted on the right-hand frame rail.

A secondary reservoir is the air source for the front axle brakes. It is usually mounted on the left-hand frame rail. The secondary reservoir is usually the aft compartment of the internally isolated air tank mounted on the left-hand frame rail. The forward compartment is the supply reservoir. There is in internal check valve that feeds the secondary reservoir from the supply reservoir.

The secondary reservoir supplies air to a pressure protection valve. This valve prevents complete loss of secondary air pressure if there is an air leak in any non-brake accessory.

All air reservoirs are equipped with drain valves to eject the water and oil emulsion from the tanks.

Tests

NOTE: If the vehicle is equipped with an automatic moisture-ejection valve, see **Section 42.19**, Subject 110, for leak testing.

Be sure the air system is fully charged. Using a soap solution or leak detector, check for leaks on the outside surfaces of the reservoirs and drain valves. No leakage is permitted.

If leaks exist at the drain valve, note if they occur at the joint of the valve and coupler, or through the valve body. Proceed to **Subject 110**.

If leaks occur on the surfaces of the air reservoir, replace the tank. See **Subject 120** for instructions.

Replacement and Leak Elimination

NOTE: If the vehicle is equipped with an automatic moisture-ejection valve, see **Section 42.19** for replacement instructions.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Drain the air system. For instructions, see Chapter 11 in the *Columbia Driver's Manual*.
3. Using two wrenches (hold the coupler in place with one of them), unscrew the drain valve from the coupler. Clean off the threads inside the coupler on the reservoir, removing all sludge and sealant build-up.

   Obtain a new drain valve if leaks occurred through the body of the valve.

   If leaks occurred at the joint of the drain valve and coupler, clean off the sludge and sealant from the threads of the valve. Check for damaged threads on the valve and inside the coupler. Replace damaged parts. If no damage exists, leakage was probably due to inadequate tightening of the drain valve in the coupler.
4. Apply Loctite®, or an equivalent sealant, to the end threads of the drain valve or coupler, as applicable, and install finger-tight. Tighten one and one-half additional turns (use two wrenches if installing the drain valve).
5. Perform a leak test after completing the installation. If leaks occur at the joint of the drain valve and coupler, tighten the valve up to one additional turn to stop the leaks.
6. Remove the chocks from the tires.

Air Reservoir Replacement

Replacement

NOTE: For replacement of the Bendix Dryer Reservoir Module (DRM), see **Section 42.03**.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Drain the air system. For instructions, see Chapter 11 in the *Columbia Driver's Manual*.

NOTE: If access is limited, reverse the order of the next two steps and remove the air lines, couplers, and valves after removing the reservoir from its mount.

3. Mark or tag all reservoir air lines, couplers, and valves for later assembly, then disconnect the components. Cap the exposed ports tightly to keep out contaminants.
4. Remove the reservoir. See **Fig. 1** for a fuel tank bracket mounting and **Fig. 2** for a frame rail mounting.

   4.1 Loosen the reaction joint clamp bolts.

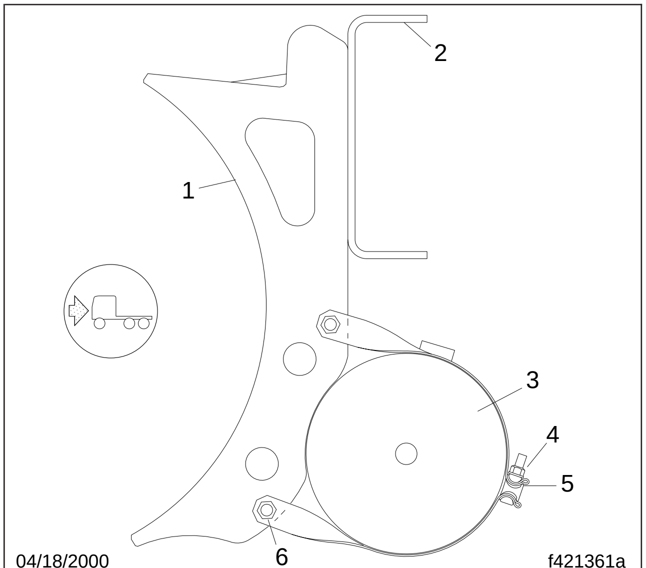
   NOTE: If the reservoir is mounted on the fuel tank bracket, loosen the bottom strap fastener first.

   4.2 Remove the reservoir strap fasteners.

   4.3 Remove the reservoir.

NOTE: If access is limited, connect the air lines, couplers, and valves before installing the new reservoir.

5. If there is sufficient work space, place a new reservoir in the mount and install the strap fasteners.
   - Tighten the strap fasteners 64 ft·lb (87 N·m).
   - Tighten the reaction joint clamp bolts 26 ft·lb (35 N·m).
6. Connect all air lines, couplers, and valves to the new reservoir, removing the caps as each component is installed. Tighten the connections as instructed in **Section 41.07**, Subject 100.
7. Remove the chocks from the tires.



1. Fuel Tank Bracket
2. Right Frame Rail
3. Air Reservoir
4. Reaction Joint Clamp Bolt
5. Mounting Strap Joint
6. Strap Fastener

Fig. 1, Air Reservoir, Fuel Tank Bracket Mounting

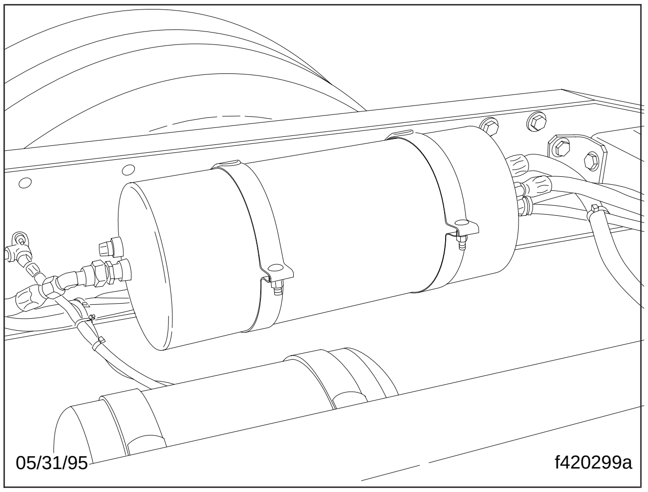


Fig. 2, Air Reservoir, Frame Rail Mounting

Internal Check Valve Replacement, Two-Chamber Air Reservoir

General Information

Contamination in two-chamber, wet/secondary, reservoirs may cause the inline check valve to become clogged or stuck closed. This can result in insufficient air buildup. If insufficient air buildup is noted, replace the check valve. If the check valve can not be removed (due to corrosion), it is acceptable to install a bypass line.

There are two styles of check valves that may have been installed in the tank. An internal check valve is threaded into the internal wall that separates the wet side and secondary side of the reservoir. Or an external check valve is mounted in a port on the top surface of the reservoir.

Internal Check Valve Replacement (located in the separator wall of the reservoir)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. Disconnect the air lines and remove the reservoir from the vehicle.
4. On the supply (wet) side of the reservoir, disconnect the pressure-protection valve, and the 90-degree elbow located on the end of the reservoir.
5. The check valve is located on the interior wall that separates the sides of the reservoir. To reach it, use a 1/4-inch drive, 1/2-inch deep-well socket with a 1/4- to 3/8-inch drive adapter, and necessary 3/8-inch extensions to reach the valve. Tape the socket and extensions, to ensure the valve will stay in the socket, and that the wrench assembly will stay together inside the tank. Insert the socket assembly through the end port of the reservoir, and remove the valve. See **Fig. 1** and **Fig. 2**.

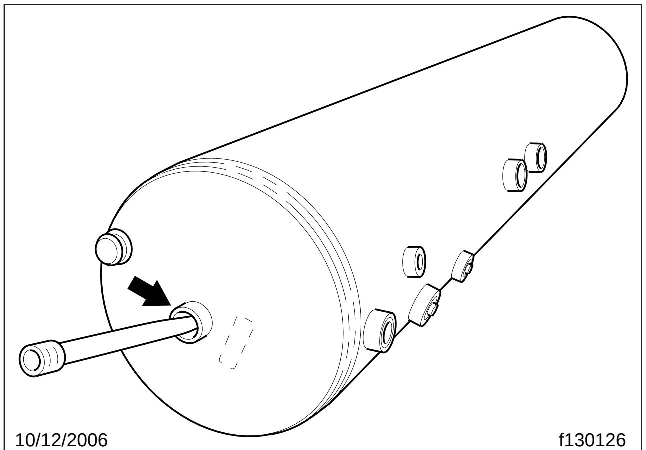
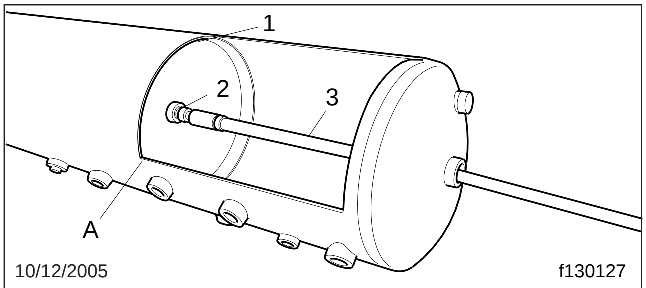


Fig. 1, Accessing the Internal Check Valve



A. Tank cut away for clarity.
1. Interior Wall
2. Check Valve
3. Socket with Extension

Fig. 2, Cutaway View of Split Air Reservoir

CAUTION

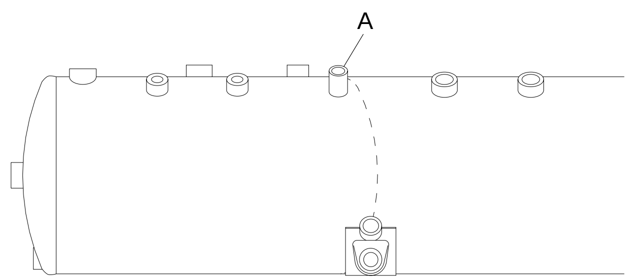
Take care not to drop the check valve into the reservoir when removing or installing it. The reservoir can not be used if the check valve is lost in it. A loose check valve could scratch the teflon coating of the interior of the reservoir, causing it to corrode. If the check valve is not recoverable, replace the reservoir.

6. Install a new check valve.
7. Attach the pressure-protection valve and the 90-degree elbow.
8. Install the reservoir on the vehicle and attach the air lines.
9. Charge the air system and inspect for leaks.

10. Remove the chocks from the tires.

Internal Check Valve Replacement (located in the side port of the reservoir)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. Remove the check valve assembly from the top port on the reservoir. See **Fig. 3** and **Fig. 4**.



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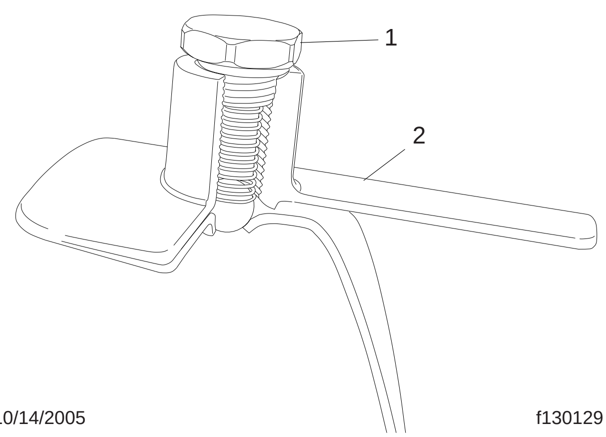
A. Check valve is located in this port.

Fig. 3, Check Valve Location



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1. Check Valve
2. Tank Shell (cut away)

Fig. 4, Cutaway View of the Check Valve Installation

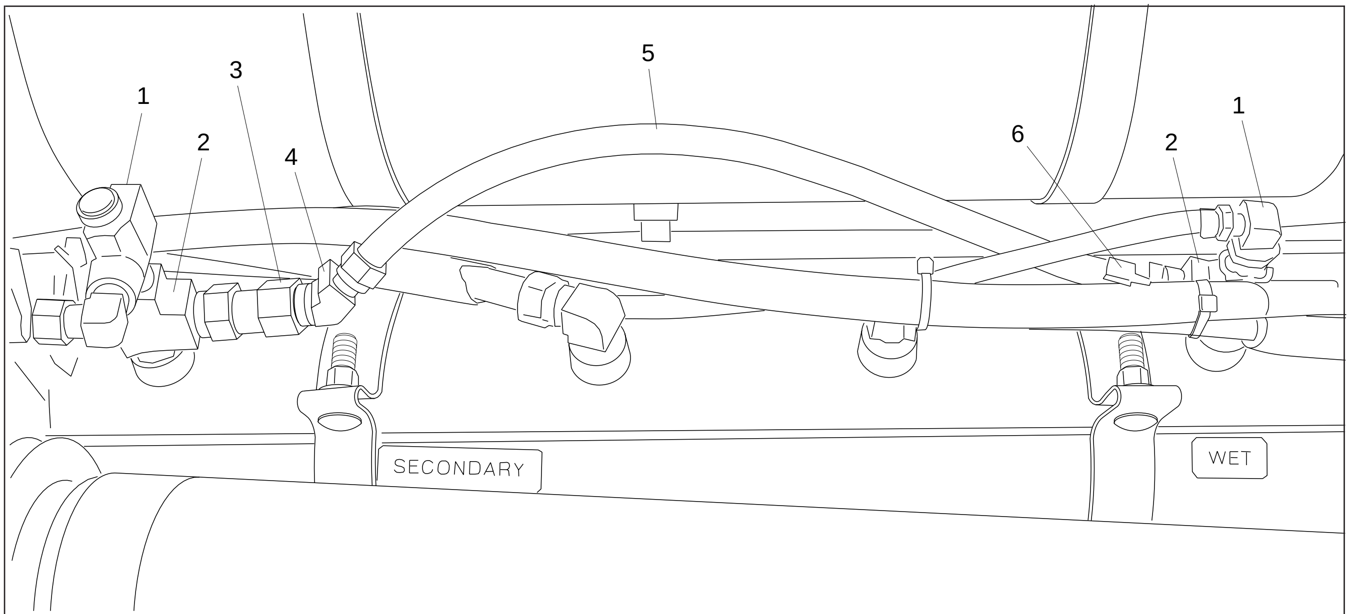
4. Install a new check valve.
5. Charge the air system and inspect for leaks.
6. Remove the chocks from the tires.

Bypass Line Installation

Check with the PDC for the appropriate bypass line kit for your vehicle.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. On the top port on both sides of the reservoir, disconnect the existing plumbing from the tank. Install a T-fitting, and connect the existing plumbing to the top port of the T-fitting. See **Fig. 5**.
4. On the secondary (dry) side of the reservoir, on the side port of the T-fitting, install a check valve, then a 45-degree elbow.
5. On the supply (wet) side of the reservoir, on the side port of the T-fitting, install the straight brass fitting.
6. Install a 1/2-inch air line between the 45-degree elbow on the secondary (dry) side, and the brass fitting on the supply (wet) side.
7. Charge the air system and inspect for leaks.
8. Remove the chocks from the tires.

Internal Check Valve Replacement



1. Existing Plumbing
2. T-Fitting
3. Check Valve
4. 45-Degree Elbow
5. 1/2-Inch Air Line
6. Brass Fitting

Fig. 5, Check Valve Bypass

Installing Air Lines

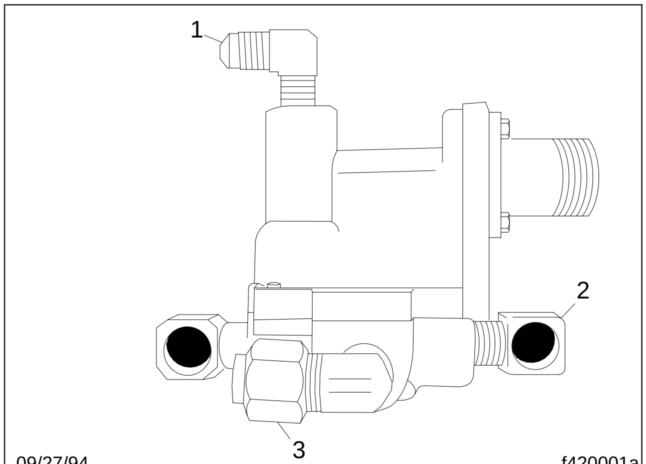
NYLON TUBES (See Fig. 1 and Fig. 2)

When installing a nylon tube, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate table in **Specifications 400**.

CAUTION

If the tubing is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

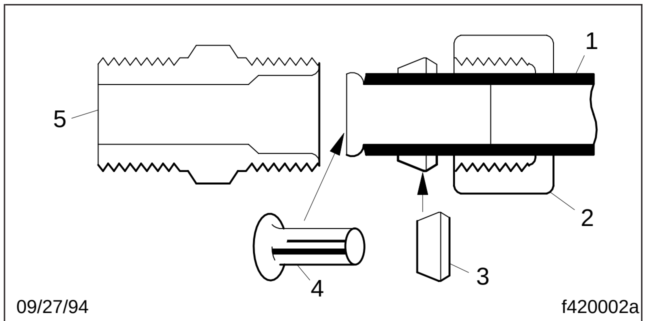
1. Cut the end of the tubing smooth and square.



1. Wire Braid Hose Fitting
2. Pipe Fitting
3. Nylon Tube Fitting

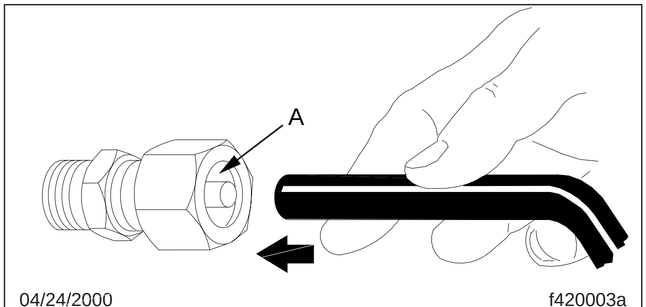
Fig. 1, Tube and Hose Fittings (for reference only)

2. Make sure the nylon tubing ends and fittings are free of grease and debris. If the tubing is crimped or otherwise damaged, replace it with new tubing.
3. Install a new sleeve in the nut.
4. Insert the squared end of the tubing in the fitting, until it bottoms in the body of the fitting. See **Fig. 3**.
5. Tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut a minimum of two turns (refer to the appropriate table in **Specifications 400**) or until one thread shows on the fitting body.



1. Nylon Tube
2. Nut
3. Sleeve
4. Brass Insert
5. Body

Fig. 2, Nylon Tube Fitting



A. Tube end must bottom before tightening the nut.

Fig. 3, Installing Nylon Tubing

WIRE BRAID HOSES (See Fig. 1)

When installing a wire braid hose, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate tables in **Specifications 400**.

CAUTION

If the hose is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

Make sure the wire braid hose assembly is free of grease and dirt. Replace the assembly if the hose or fitting is crimped or otherwise damaged.

Install the hose and tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the hose,

Installing Air Lines and Fittings

tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.

Installing Fittings

BRASS AND STEEL PIPE FITTINGS

(See Fig. 1)

For brass pipe fittings, both male and female parts, tighten as follows:

1. Make sure the fittings are free of grease, dirt, and old sealant. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the threads, then tighten securely, finger-tight.

NOTE: Always apply the sealant to the external thread, so that any excess will be scraped off externally rather than internally to the joint.

2. For fittings that must be positioned, tighten one additional turn from finger-tight using a wrench.

   Then, continue tightening until the fitting is correctly positioned.

   For fittings that do not require positioning, tighten 1-1/2 additional turns from finger-tight.

COPPER TUBE FITTINGS

For copper tube fittings, tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut the number of turns shown in the table in **Specifications 400.**

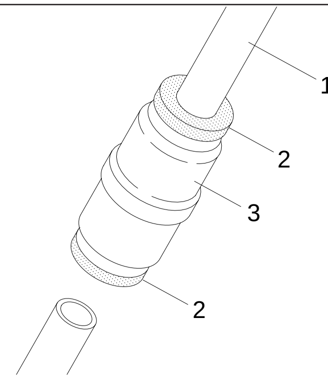
QUICK-CONNECT FITTINGS

NOTE: If damaged, quick-connect fittings must be replaced as an assembly.

1. Push in on the fitting collar to release the air line. Pull the line out of the fitting. See **Fig. 4**.
2. Push the air line all the way into the fitting. Pull the collar away from the fitting to secure the air line. Check and make sure that the air line is seated in the fitting.

TUBE AND PIPE FITTINGS ON PLASTIC COMPONENTS

For tightening specifications, refer to the table in **Specifications 400**.



1. Air Line
2. Collar
3. Fitting

Fig. 4, Quick-Connect Fitting

Specifications

Number	Inside Diameter: inch	Outside Diameter: inch	Minimum Bend Radius: inch (mm)
4	0.170	1/4	1.00 (25)
6	0.251	3/8	1.50 (38)
8	0.376	1/2	2.00 (51)
10	0.439	5/8	2.50 (64)
12	0.566	3/4	3.00 (76)

Table 1, Nylon Tube

Tube Size: inch	Additional Turns from Hand-Tight
1/4	3
3/8 or 1/2	4
5/8 or 3/4	3-1/2

Table 2, Additional Turns from Hand-Tight (Nylon Tube)

Number	Inside Diameter: inch	Outside Diameter: inch	Minimum Bend Radius: inch (mm)
4	3/16	0.52	3.00 (76)
5	1/4	0.58	3.38 (86)
6	5/16	0.67	4.00 (102)
8	13/32	0.77	4.63 (118)
10	1/2	0.92	5.50 (140)
12	5/8	1.08	6.50 (165)
16	7/8	1.23	7.38 (187)
20	1-1/8	1.50	9.00 (229)

Table 3, 211 Wire Braid (Medium Pressure) Hose (211 hose is identified by part number and size; for example, part numbers 211-4, 211-5, and so on)

Number	Inside Diameter: inch	Outside Diameter: inch	Minimum Bend Radius: inch (mm)
4	3/16	0.49	0.75 (19)
5	1/4	0.55	1.00 (25)
6	5/16	0.62	1.25 (32)
8	13/32	0.74	1.75 (44)
10	1/2	0.83	2.25 (57)
12	5/8	0.96	2.75 (70)
16	7/8	1.21	3.50 (89)
20	1-1/8	1.49	4.50 (114)

Table 4, 213 Wire Braid (Diesel) Hose (213 hose is identified by two green stripes 180 degrees apart, part numbers, and size; for example, part numbers 213-4, 213-5, and so on)

Number	Outside Diameter: inch	Additional Turns from Hand-Tight	
		Compression	Threaded Sleeve
2	1/8	1-1/4	1-1/2
3	3/16		
4	1/4		
5	5/16	1-3/4	
6	3/8	2-1/4	
8	1/2		
10	5/8		
12	3/4		
16	1		
20	1-1/4		

Table 5, Copper Tube Fittings

Description	Port Size: inch	Torque	
		lbf·in (N·cm)	lbf·ft (N·m)
Midland Quick Release Valve	3/8	60–90 (680–1020)*	—
	1/2	—	13–17 (18–23)*
Bendix MV-2/MV-3 Valve	1/4	—	10 (14)

* Tighten to the lower torque value. Then, if needed, turn the fittings to allow for the proper routing of the air lines.

Table 6, Tube and Pipe Fittings on Plastic Components

Specifications

Air System Nylon Tube Color Code			
System	**Color**	**Size: I.D.**	**Where Used**
Primary Air	Green	3/4 inch	Air tank to rear service supply (6x4 vehicles only)
		5/8 inch	Primary air tank to foot valve
		1/2 inch	Air tank to rear service supply (4x2 vehicles only)
		3/8 inch	Foot valve to rear service control
			Wet tank to primary air tank
Secondary Air	Red	5/8 inch	Secondary air tank to foot valve
		1/2 inch	Foot valve to front service brake
Tractor Protection	Green	1/2 inch	Foot valve primary delivery to tractor protection valve
	Black	5/8 inch	Tractor protection valve to service anchor coupling
		1/2 inch	Foot valve secondary delivery to tractor protection valve
	Orange	3/8 inch	Dash park valve to tractor protection valve
			Tractor protection valve to emergency anchor coupling
		1/4 inch	Tractor protection valve to stop light switch
Park Brake	Black	3/8 inch	Dash valve to park quick release valve
			Rear relay to park quick release valve
Air Supply	Black	1/2 inch	Air dryer to wet tank
		1/4 inch	Wet tank to air governor
	Silver	1/4 inch	Air governor to air dryer purge valve
	Yellow	3/8 inch	Pressure protection constant air
Non-Brake Applications	Blue	3/8 inch	Chassis air suspension
		1/4 inch	Air suspension dump control
	Brown	1/4 inch	Air suspension pressure gauge
	White	1/4 inch	Interaxle lock control
	Red	1/4 inch	Driver-controlled differential lock
	Green	1/4 inch	Sliding fifth-wheel control
	Yellow	1/4 inch	Fan air solenoid

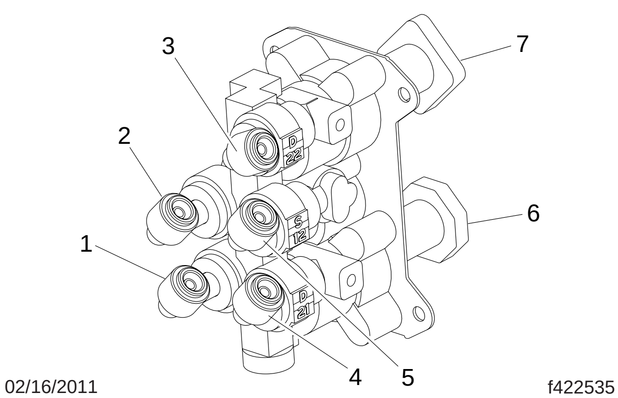
Table 7, Air System Nylon Tube Color Code

General Description

The dash-mounted MV-3 control module is a two-button, push-pull control valve housed in a single body, which includes a dual circuit supply valve and a check valve.

The valve body, plungers, and spools are made out of a nonmetallic, noncorrosive material. All air connections are at the back of the valve. See **Fig. 1**.

The MV-3 module has several functions: tractor protection; trailer service air control; system park; trailer park only; trailer charge with tractor spring brakes applied (tractor park only); and supply reservoir selection.

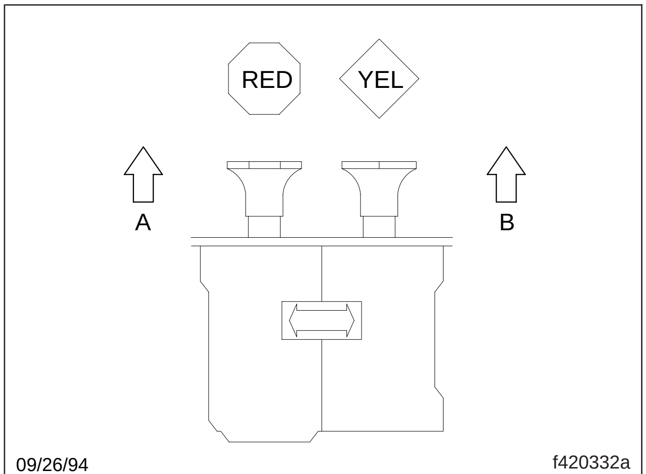


1. Exhaust
2. Primary Reservoir Supply
3. Delivery–Tractor Spring Brakes
4. Delivery–Trailer Supply
5. Secondary Reservoir Supply
6. Trailer Air Supply Knob
7. Parking Brake Control Valve Knob

Fig. 1, MV-3 Parking Brake Valve

The MV-3 includes a spring-loaded, dual-circuit supply valve, which selects the primary air reservoir as the air source for both control valves, unless the pressure in the primary air reservoir falls below that of the secondary air reservoir. Then, the dual-circuit supply valve will shuttle and establish the secondary air reservoir as the air source.

The trailer air supply valve, actuated by the red knob and the yellow knob, delivers air to the trailer supply line. See **Fig. 2**. The parking brake valve, actuated by a yellow knob, controls the spring parking brakes on the tractor, and when exhausted, simultaneously causes the trailer supply valve to trip and exhaust, thus applying both the tractor and the trailer parking brakes as required by federal regulations. See **Fig. 2**. The trailer parking brakes may be independently released by pushing only the trailer air supply valve (red) knob in.



A. Trailer Brakes Applied
B. Tractor Brakes Applied

Fig. 2, Trailer and Tractor Delivery Air Discharged (control knobs out)

Principles of Operation

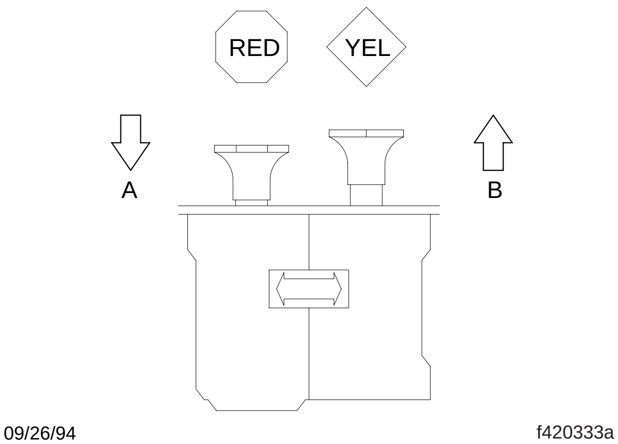
Initial Charge

With both the primary and the secondary systems completely discharged, both knobs are out. See **Fig. 2**. When system pressure reaches 65 psi (448 kPa), the red knob (trailer air supply) may be pushed in, and should stay in, charging the trailer system and releasing the trailer parking brakes. See **Fig. 3**. The yellow knob (parking brake) may now be pushed in, which will supply air to the tractor parking brakes, releasing them.

Normal Operation Position

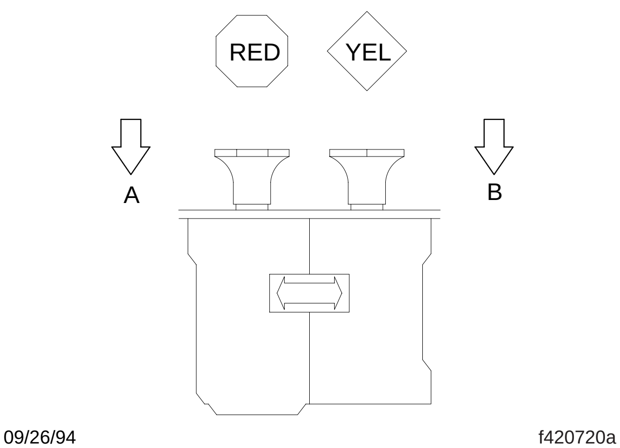
When both knobs are pushed in, air is supplied to the trailer and the tractor parking brakes; all parking brakes are released. See **Fig. 4**. This is the normal operating mode.

General Information



A. Trailer Brakes Released
B. Tractor Brakes Applied

Fig. 3, Trailer Parking Brakes Released (red control knob pushed in)

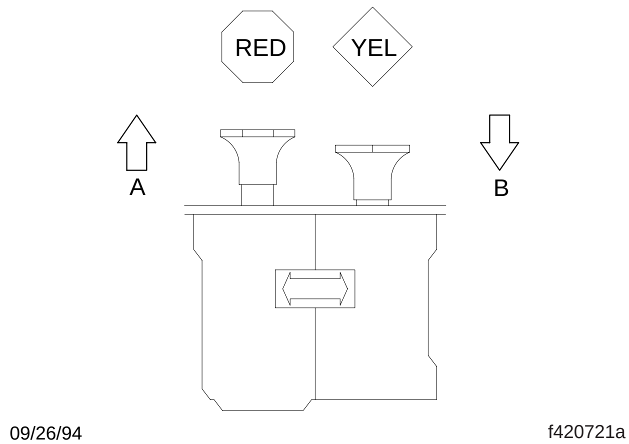


A. Trailer Brakes Released
B. Tractor Brakes Released

Fig. 4, Trailer and Tractor Brakes Released (both control knobs pushed in)

Actuation of Trailer Park or Emergency Brakes

To actuate the trailer parking brakes only, the red knob is pulled out, exhausting the trailer supply line. The trailer parking brakes are now applied, either by emergency air or parking brakes, depending on the type of trailer system. This mode would be used to uncouple from the trailer, and during bobtail operation. See **Fig. 5**.



A. Trailer Brakes Applied
B. Tractor Brakes Released

Fig. 5, Trailer Parking Brakes Applied (red control knob pulled out)

System Park

With both knobs pushed in, the parking brakes on both the tractor and the trailer may be actuated by pulling the yellow (parking brake) knob out. This exhausts the air from the tractor parking brakes and simultaneously causes the red (trailer air supply) knob to pop out, applying the trailer parking brakes (this complies with federal regulations that one control must apply all the parking brakes on the vehicle). See **Fig. 2**.

Trailer Charge

If both valves are out, parking the combination vehicle, and it is desired to recharge the trailer (leaving only the tractor parking brakes applied), the red knob may be pushed in, repressurizing the trailer supply line. This mode might also be used to park a combination vehicle with air-actuated emergency brakes on the trailer to provide demonstrated parking capability with the tractor spring brakes only. See **Fig. 3**.

Automatic Applications

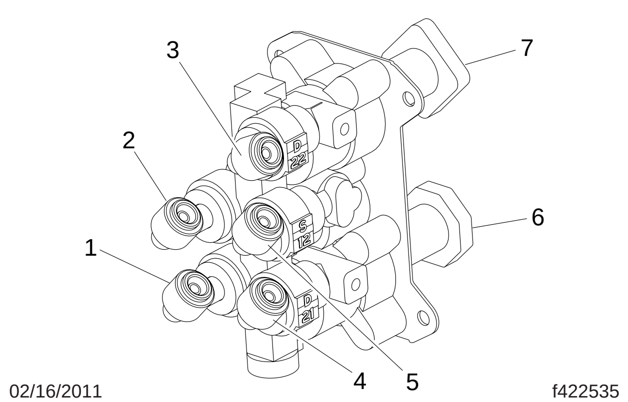
If air pressure drops to 20 to 45 psi (138 to 310 kPa) in both the primary and the secondary systems, the red knob (trailer air supply valve) will automatically pop out, applying the emergency or parking brakes on the trailer. If the red knob is held in manually and the pressure decreases to 25 to 35 psi (172 to 241 kPa), a tripper piston within the MV-3 valve will move upward, exhausting the trailer supply, and applying the trailer parking brakes. If air pressure drops in both the primary and the secondary systems, the yellow (parking brake) knob will pop out at about 20 to 40 psi (138 to 276 kPa), applying the tractor parking brakes.

A warning buzzer and light are activated when pressure in either the primary or the secondary system drops below 64 to 76 psi (441 to 524 kPa).

Tests

With the air brake system charged to 120 psi (827 kPa), check for leaks, using the following instructions. Repair or replace components as needed.

1. Apply a soap solution and check for leakage between the body and cover plate. Leakage at the exhaust port should produce less than a 1-inch (25-mm) bubble in five seconds.
2. With the trailer supply line sealed, push in the red knob. The knob must stay in. Leakage at the exhaust port must not exceed a 1-inch (25-mm) bubble in 5 seconds. See **Fig. 1**.



1. Exhaust
2. Primary Reservoir Supply
3. Delivery–Tractor Spring Brakes
4. Delivery–Trailer Supply
5. Secondary Reservoir Supply
6. Trailer Air Supply Knob
7. Parking Brake Control Valve Knob

Fig. 1, MV–3 Parking Brake Valve

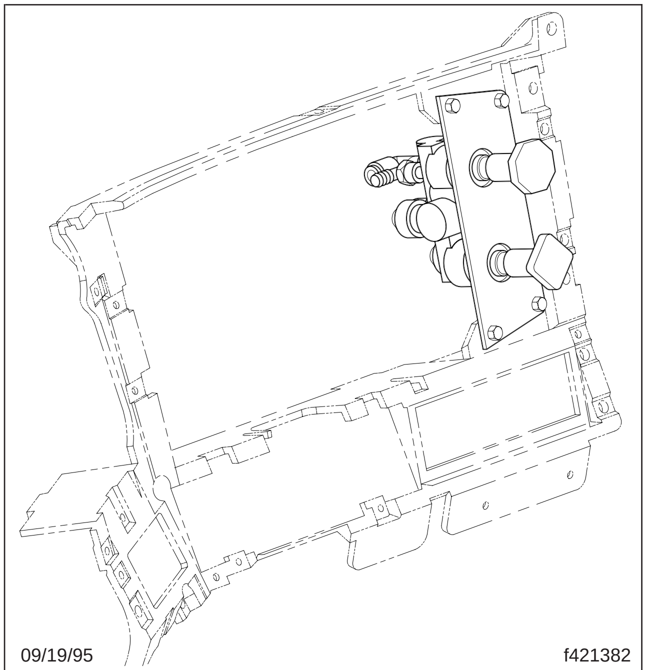
3. Slowly reduce pressure in both service reservoirs. The red knob must pop out at 20 to 35 psi (138 to 310 kPa).

NOTE: Trip-on pressure is the pressure at which the valve automatically changes position or "pops out." It is advised to use an accurate pressure gauge other than those in the truck when performing tests.

4. Hold the red knob in and continue to reduce pressure in all service reservoirs. Air must start to escape from the exhaust port when the trailer line pressure reaches 20 to 35 psi (138 to 241 kPa).
5. Release the red knob and rebuild the supply pressure to 120 psi (827 kPa). Push in the yellow knob; the yellow knob must remain in. Leakage at the exhaust port should not exceed a 1-inch (25-mm) bubble in 5 seconds.
6. Pull the red knob out. Slowly reduce pressure in all service reservoirs. There is not a federal trip pressure requirement for the yellow knob, but it will pop out at 20 to 30 psi (138 to 207 kPa).
7. Charge the system to 120 psi (827 kPa), and push both knobs in. Pull the red knob out. The yellow knob must remain in. Push the red knob in and pull the yellow knob out. The red knob must pop out at once.
8. Install a gauge to monitor tractor spring brake delivery pressure. Build 120 psi (827 kPa) pressure in the primary and secondary air reservoirs. Push in the yellow knob. Delivery pressure should equal the pressure in the primary air reservoir. Reduce the pressure in the primary air reservoir. The dual-circuit supply valve shuttle should switch to the secondary air reservoir. After the primary air reservoir pressure is reduced to zero, there should not be audible leakage at the primary air reservoir opening. Stop the leak that was created in the primary air reservoir.
9. Leaving the yellow knob in, recharge the secondary air reservoir to 120 psi (827 kPa). The delivery pressure should also read 120 psi (827 kPa). Recharge the primary air reservoir to 100 psi (690 kPa). Slowly vent the secondary air reservoir. As the secondary air reservoir pressure and the delivery line pressure descend, pressure should stabilize at about 100 psi (690 kPa).
10. Close all leakage points and charge both reservoirs to 120 psi (827 kPa). Position the red knob out and the yellow knob in. Develop a leak in the spring brake delivery line and hold the yellow knob in. See **Fig. 1**. The air reservoir pressures will go to zero. The dual-circuit supply valve shuttle should cycle during the leak-down period.
11. If the MV-3 fails to operate as described, or leakage exceeds the limits stated, replace or repair it using genuine Bendix parts.

Control Module Removal and Installation

Removal (See Fig. 1)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NOTE: Components have been removed from the auxiliary instrument panel for clarity.

Fig. 1, MV-3 Control Valve Mounting

WARNING

Wear eye protection when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

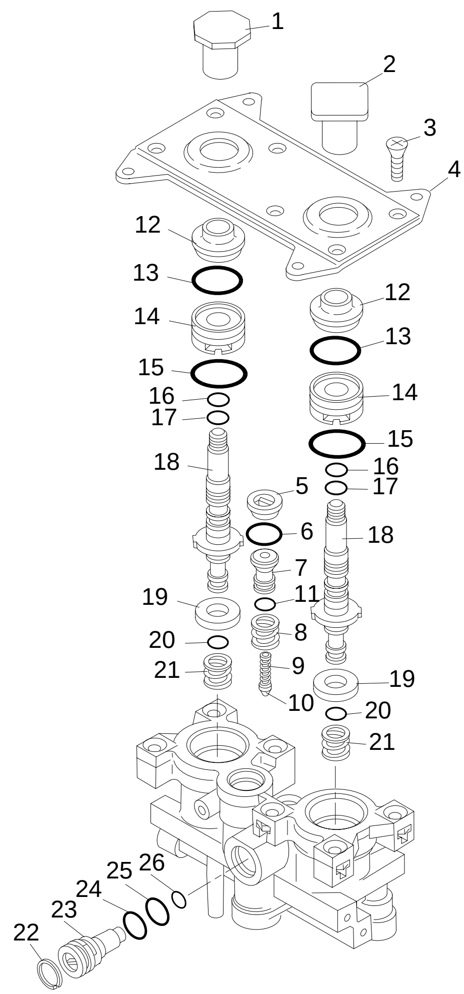
1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain the air tanks .
2. Remove the trim plate assembly from the radio and heater/air conditioner control panel.
3. Remove the screw from the right-hand trim cap. Remove the trim cap from the dash.
4. Unscrew the red and yellow knobs from the stems of the spools on the MV–3 valve by turning them in a counterclockwise direction. Mark these knobs in relation to the valve for later reference.
5. Remove the four screws that attach the auxiliary instrument panel in the dash. Pull the panel out to access the control module mounting screws.
6. Remove and save the four mounting screws and washers from the four corners of the cover plate.
7. With the valve and cover plate assembly pulled out slightly from the dash panel, mark the air lines, and remove the air lines from the back of the valve.
8. Pull the valve out of the dash.

Installation

1. Connect the air lines to the proper ports. The color of the air lines should match the colored collar at the valve fitting.
2. Align the valve in the dash and install the four screws and washers into the corners of the cover plate.
3. Attach the red and yellow knobs onto the threaded stems of the spools, making sure that they are oriented correctly as noted during removal.
4. Leak test the fittings, following the instructions under **Subject 100**.
5. Install the auxiliary instrument panel, right-hand trim cap, and the radio and heater/air conditioner trim plate assembly.
6. Remove the chocks.

Control Module Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. Red Knob
2. Yellow Knob
3. Screw
4. Cover Plate
5. Cap
6. O-Ring
7. Tripper Piston
8. Spring, Large Diameter
9. Spring, Small Diameter
10. Check Valve
11. O-Ring
12. Guide Cap
13. O-Ring
14. Guide Spool
15. O-Ring
16. O-Ring
17. O-Ring
18. Plunger
19. Exhuast Seal, Beveled
20. O-Ring
21. Spring
22. Retaining Ring
23. Cap and Dual Circuit Valve Assembly
24. O-Ring
25. O-Ring
26. O-Ring

Fig. 1, MV-3 Valve, Exploded View

1. Remove the six screws from the cover plate and carefully remove the cover plate from the valve.
2. Remove the cap and O-ring from the bore of the tripper valve. Remove the tripper piston, large spring, small spring, and check valve. These parts will all fall out of the cavity of the MV–3 by

Control Module Disassembly, Cleaning and Inspection, and Assembly

tilting the body forward. Remove the O-ring from its groove on the piston.

3. Remove the two main spools from the body of the MV–3 valve by grasping the stem and pulling firmly. Remove the spring from the bottom of each spool cavity.
4. Pull the guide cap and guide spool over the threaded end of one of the plungers. Remove the O-ring from the guide cap and the O-ring from the guide spool. Remove the other O-rings and the exhaust seal from the plunger.
5. Repeat the previous step on the remaining spool assembly.
6. Remove the retaining ring from the cavity of the MV–3 body that contains the dual circuit supply valve.
7. Using a pair of needle nose pliers, grasp the bar in the center of the cap and dual circuit supply valve and remove the dual circuit valve assembly. Remove the three O-rings from the valve or from the cavity of the body, if some have remained there. Other than the three external O-rings, don't disassemble the piston assembly further.

NOTE: If during the removal of this assembly from the body the cap dislodges from the rest of the valve, the remaining parts can be removed using bent wire. The spring, piston and O-ring that are internal to the dual circuit valve assembly are nonserviceable.

Cleaning and Inspection

The nonmetallic components making up most of the parts of the MV–3 *should not be immersed in any solvent type cleaner.* Old lubricant should be wiped out with a clean dry cloth.

If any visible damage to the body or the spools is found, replace the complete unit.

Assembly

DUAL CIRCUIT SUPPLY VALVE

1. Lubricate all O-rings, bores, and sliding surfaces with silicone lubricant Bendix 291126, Dow Corning 55-M, or equivalent.
2. Install O-rings onto the cap and dual circuit supply valve. Then install the assembly—small diameter first—into its cavity in the body.
3. Install the retaining ring (Ref. 22) making sure it is fully seated in its groove.

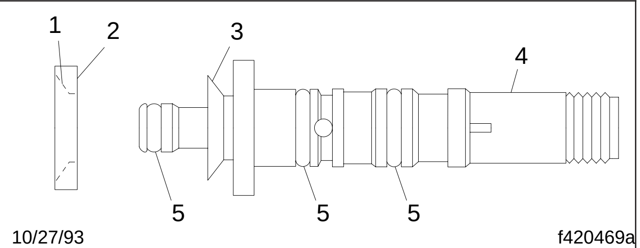
SPOOLS

1. Install the O-rings and the exhaust seal onto the stem of the plunger.

CAUTION

The exhaust seal (Ref. 19) must be installed so that its beveled surface mates with the beveled surface of the plunger.

2. Install the O-ring onto the guide spool and the O-ring onto the guide cap. See Fig. 2. Place the guide cap on top of the guide spool, and install the entire assembly over the threaded end of the plunger; press down firmly until it snaps into place.



1. Inside Bevel
2. Exhaust Seal
3. Mating Exhaust Seal Bevel
4. Plunger
5. O-Rings

Fig. 2, Plunger Assembly

3. Install the spring over the boss in the bottom of the spool cavity in the body of the MV–3 valve. Place the spool assembly into the body, keeping the spool square to the body. Press and turn the stem until the spool is fully seated in its cavity. Note the assembly is keyed and can be installed one way only.
4. Repeat the previous steps for the opposite spool.

SHUTTLE AND CHECK VALVE

1. Install the O-ring into its groove on the tripper piston; then install the O-ring onto the cap.

Control Module Disassembly, Cleaning and Inspection, and Assembly

2. Install the large spring on the piston and the small spring on the boss of the check valve.
3. Install the spring and check valve into their cavity in the body of the MV–3 valve (tapered end of thevalve to enter cavity first). Make sure the spring is centered in the bore.
4. Install the piston assembly into the cavity, making sure the spring mates with the bore of the piston.
5. Install the cap with O-ring.
6. Attach the cover plate to the valve body using the six screws. Torque them 25 lbf·in (280 N·cm).
7. Check the operation of the valve using the instructions in **Subject 100.**

General Description (See Fig. 1)

The dual circuit brake valve (foot valve) controls the air supply and delivery of the dual circuit brake system. The brake valve is mounted on the firewall.

APPLYING

The primary circuit of the brake valve is controlled by the brake pedal and a plunger. When the brake pedal is depressed, the plunger applies pressure on the spring seat, rubber spring, and the primary (upper) piston. The downward movement of the primary piston closes the upper exhaust valve, and then opens the upper inlet valve, allowing high-pressure air from port 11 to flow to low-pressure port 21.

The secondary circuit is pneumatically operated by the pressure from the primary circuit. Primary circuit pressure on top of the relay piston first closes the lower exhaust valve, and then opens the lower inlet valve, allowing high-pressure from port 12 to flow to low-pressure port 22.

HOLDING

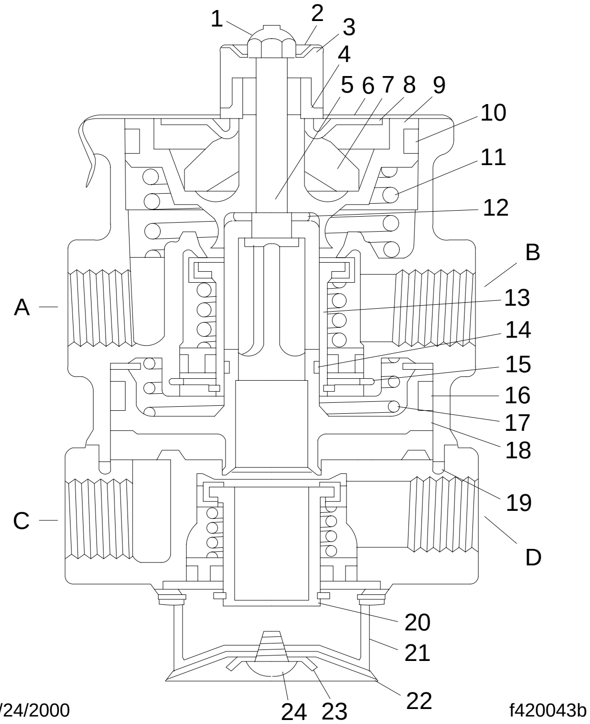
As air pressure builds in the primary circuit, the pressure under the primary piston will match the pressure of the rubber spring. This allows the piston to move up enough to close the upper inlet valve, and prevent the flow of air from the primary air tank into the brake valve. The exhaust port remains closed.

RELEASING

When the pedal is released, the push rod releases pressure from the spring seat, rubber spring, and the primary (upper) piston. Air pressure builds to push the piston up, opening the upper exhaust valve and allowing air from the primary circuit to escape through the exhaust port.

In the secondary circuit, the release of primary air pressure allows air under the relay piston, pushing the piston up and opening the lower exhaust valve. All remaining air pressure is vented through the exhaust port.

General Information



A. Port 21: to primary air circuit
B. Port 11: from primary air tank
C. Port 22: to secondary air circuit
D. Port 12: from the seondary air tank

1. Locknut
2. Spring Seat
3. Stem Spring
4. Spring Seat Nut
5. Primary Piston Stem
6. Primary Piston Retainer
7. Rubber Spring
8. Spring Seat
9. Primary Piston
10. Primary Piston O-Ring
11. Primary Piston Return Spring
12. Small Washer
13. Upper Inlet and Exhaust Valve Assembly
14. Small O-Ring
15. Retaining Ring
16. Large O-Ring
17. Relay Piston Spring (if equipped)
18. Relay Piston
19. Rubber Seal Ring
20. Lower Inlet and Exhaust Valve Assembly
21. Exhaust Cover
22. Exhaust Diaphragm
23. Washer
24. Phillips Head Screw

Fig. 1, Bendix E-6 Dual Circuit Foot Valve (sectional view)

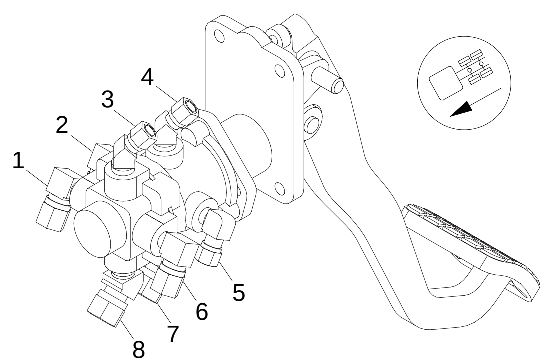
Bendix E–6 Brake Valve Operating and Leakage Checks

Operating Checks

IMPORTANT: If there is a change in the way a vehicle brakes, or if low pressure warnings occur, check the operation of the air system. Although the brake system may continue to work, do not operate the vehicle until the braking circuits, including the pneumatic and mechanical devices, have been repaired and are operating normally. Always check the brake system for proper operation after doing brake work, and before returning the vehicle to service.

Check for the proper brake valve operation as follows:

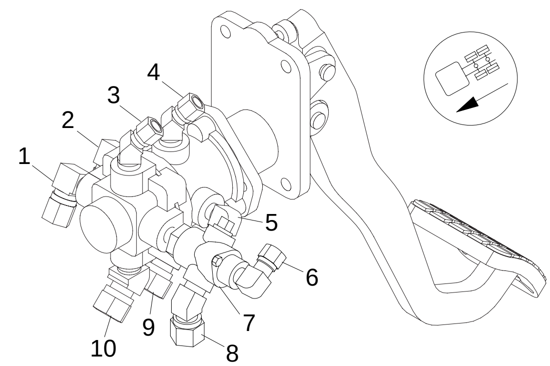
1. Apply the parking brakes, and chock the tires.
2. Connect test gauges to the primary and secondary delivery ports (ports 21 and 22) on the brake valve. See **Fig. 1** and **Fig. 2**.



1. Secondary Delivery Circuit to Front Brake Valve
2. Delivery Circuit to Rear Brake Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Primary Delivery Circuit to Tractor Protection Valve
6. Secondary Delivery Circuit to Tractor Protection Valve (if not equipped with a hand valve)
7. Primary Supply Circuit to Primary Supply Reservoir
8. Secondary Supply Circuit to Secondary Supply Reservoir

Fig. 1, Brake Valve Plumbing Circuits

NOTE: When checking the delivery pressure of the primary and secondary circuits, use test gauges that are accurate.



1. Secondary Delivery Circuit to Front Brake Valve
2. Primary Delivery Circuit to Rear Brake Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Primary Delivery Circuit to Tractor Protection Valve
6. Delivery Circuit to Trailer Hand Valve
7. Double Check Valve
8. Secondary Delivery Circuit to Tractor Protection Valve
9. Primary Supply Circuit to Primary Supply Reservoir
10. Secondary Supply Circuit to Secondary Supply Reservoir

Fig. 2, Brake Valve Plumbing Circuits (with double-check valve)

3. Start the engine and build air pressure to 120 psi (827 kPa).
4. Depress the pedal to several different positions; check the pressure on the test gauges to ensure that it varies equally and proportionately with the movement of the brake pedal.
5. Fully depress the brake pedal, then release it. After a full application is released, the reading on the test gauges should promptly fall to zero.

NOTE: Pressure in the primary delivery circuit will be about 2 psi (14 kPa) greater than pressure in the secondary delivery circuit (if both supply reservoirs are at the same pressure). This is normal for this valve.

6. Go to "Leakage Check."

Leakage Check

1. Make and hold a pressure application of 80 psi (552 kPa).

Bendix E–6 Brake Valve Operating and Leakage Checks

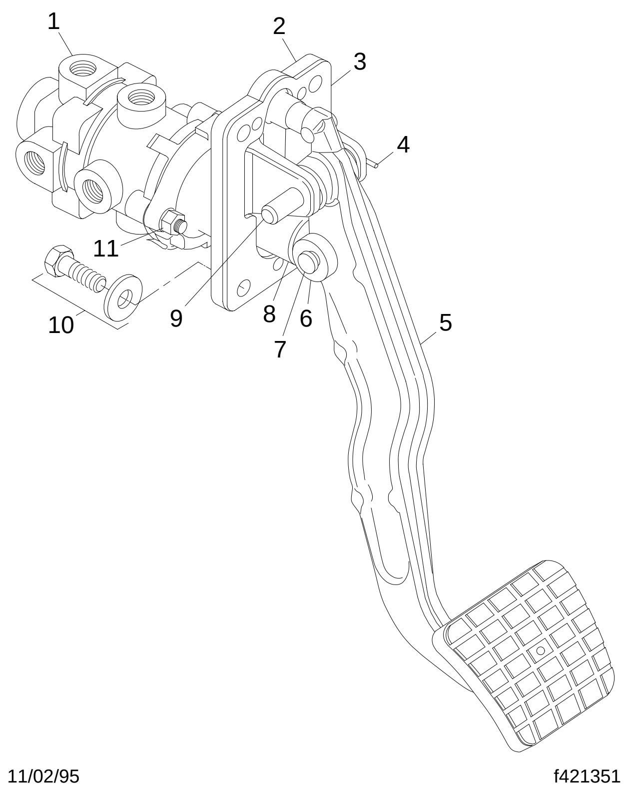
2. Check the air line fittings for leaks: tighten or replace fittings as needed.
3. Coat the exhaust port and body of the valve with a soap solution, and check for leakage. The leakage permitted is a 1-inch (25-mm) bubble in 3 seconds.

   If the brake valve does not function as described above, or if leakage is excessive, replace it with a new or remanufactured unit.

   Repeat the leakage test before placing the brake valve in service.
4. Remove the chocks from the tires.

Bendix E–6 Brake Valve Removal and Installation

Removal (See Fig. 1)



1. Brake Valve
2. Mounting Plate Adaptor
3. Gasket
4. Roll Pin
5. Brake Pedal Assembly
6. Roller
7. Roller Pivot Pin
8. Plunger
9. Shaft Pivot Pin
10. 5/16–18 Capscrew and Flatwasher
11. 5/16–18 Locknut and Washer

Fig. 1, Brake Valve Mounting

1. Chock the tires, then tilt the hood. For instructions, refer to the vehicle driver's manual.

WARNING

When draining the air system, don't look into the air lines/ports or direct them toward another person, because dirt or sludge particles may be in the airstream. Do not disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can result in personal injury.

2. Drain all of the air reservoirs.
3. Mark the brake valve air supply and delivery lines for assembly reference. Disconnect the air lines from the brake valve, and plug them to keep out contaminants.
4. Remove the brake valve.
   - 4.1 Remove the 5/16-18 capscrews and flatwashers that attach the brake valve and mounting adaptor to the front cab mount plate.
   - 4.2 Remove the 5/16-18 locknuts and washers that attach the brake valve to the mounting adaptor.
   - 4.3 Remove the plunger from the mounting adaptor. Wipe off the old grease from the plunger and adaptor.
5. Note the locations and positions of the double check valve (if equipped), then remove them from the brake valve. Clean off the dirt and old sealant from the threads of the valve and elbows.

Installation (See Fig. 1)

WARNING

When applying sealant, make sure that excess sealant doesn't get inside either the male or the female fittings. Loose foreign material inside the air plumbing may clog a valve, causing a loss of brake control, which could result in personal injury.

1. If equipped with a hand brake valve, apply a small quantity of Loctite® Pipe Sealant (with Teflon® 59241), or an equivalent sealant, to the male threads of each of the double check valves and the elbows.

   Install the double check valves and elbows in the ports of the brake valve. Tighten each valve finger-tight, then tighten them one additional turn with a wrench. As needed, further tighten them until they are properly positioned.

Bendix E–6 Brake Valve Removal and Installation

2. Lubricate the sliding surface of the brake plunger with barium grease, part number BW 246671 or Pennzoil Adhezoplex EP 2. Install the plunger in the mounting adaptor.
3. Using the 5/16–18 locknuts and washers, attach the mounting adaptor to the brake valve. Tighten the capscrews 10–13 lbf·ft (14–18 N·m).
4. Install the brake valve and mounting adaptor on the outside of the front cab mount plate. Install the adaptor mounting capscrews and flatwashers. Tighten the capscrews 10–13 lbf·ft (14–18 N·m).
5. Connect the air lines, as previously marked. Tighten the nuts finger-tight. Using a wrench, further tighten the nuts until there is resistance, then tighten one-sixth additional turn.
6. Check and secure the air lines and electrical wires so they can’t interfere with the movement of the brake pedal.
7. Return the hood to the operating position. For instructions, refer to the vehicle driver’s manual.
8. Perform the operating and leakage checks. For instructions, see **Subject 100.**
9. Remove the chocks from the tires.
10. Test drive the vehicle in a safe area at low speed. Make several brake applications to be sure the vehicle comes to a safe stop.

Bendix E–6 Brake Valve Disassembly, Cleaning and Inspecting, and Assembly

Disassembly (See Fig. 1)

1. Remove the valve from the vehicle. For instructions, see **Subject 110**.
2. Remove the screw that attaches the exhaust diaphragm and washer to the exhaust cover.
3. Remove the four screws that attach the exhaust cover to the lower valve body.
4. Remove the lower inlet and exhaust valve assembly.
5. Remove the four hexhead capscrews and washers that attach the lower and upper valve bodies. Separate the valve bodies.
6. Remove the rubber seal ring from the lower valve body.
7. Apply thumb pressure to the primary piston, then lift out and up on the three lock tabs of the primary piston retainer.

WARNING

The locknut and spring seat are used to restrain the primary piston return spring, stem spring, and the relay piston spring. The combined force of these springs is about 50 pounds (220 N). When removing these springs, use care to prevent them from flying out and possibly causing personal injury. Manually or mechanically hold down these springs when removing the locknut.

8. Using a 3/8-inch wrench, hold the locknut on the threaded end of the primary piston stem. Insert a screwdriver in the exhaust passage through the center of the valve, and engage the slotted head of the stem.
9. Using the screwdriver to keep the stem from turning, remove the locknut, spring seat, and the stem spring.
10. Being careful to avoid damaging the valve seats, remove the relay piston, relay piston spring, and the primary piston and primary piston return spring.
11. Remove the small washer from the cavity in the lower side of the primary piston.
12. Turn the spring seat nut counterclockwise, and separate the spring seat nut, spring seat, and the rubber spring. Remove the primary piston O-ring.
13. Remove the small and large O-rings from the relay piston.
14. Remove the retaining ring. Remove the upper inlet and exhaust valve assembly.

Cleaning and Inspecting

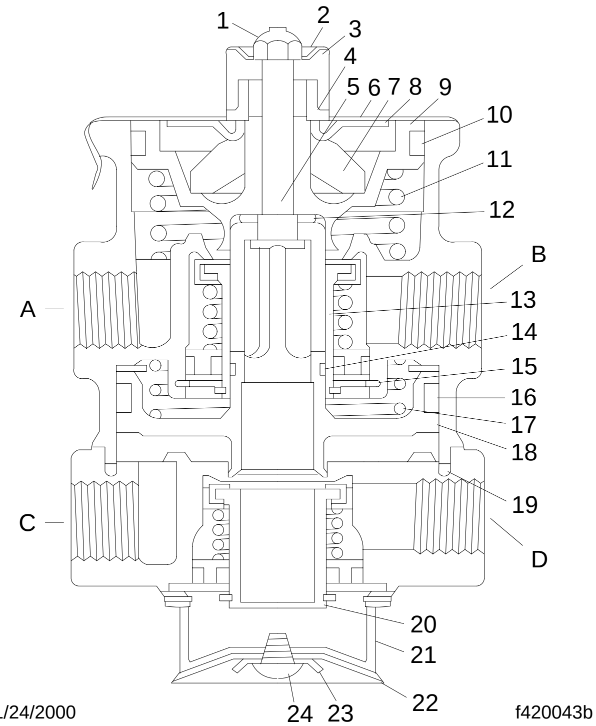
Wash all metal parts in mineral spirits and dry them thoroughly with compressed air. Inspect the valve seat surfaces of the pistons and the valve housings for conditions that could cause leakage. Inspect air line fittings for corrosion, and replace corroded fittings.

Assembly (See Fig. 1)

NOTE: Keep the work area, tools, and brake valve parts clean during assembly.

1. Using Dow Corning 55-M pneumatic grease, or equivalent, lightly grease all the new O-rings, O-ring grooves, piston bores, and all sliding surfaces.
2. Place the upper inlet and exhaust assembly in the upper body, and secure the assembly with the retaining ring. Make sure that the retaining ring is seated in its groove.
3. Install the large and small O-rings on the relay piston.
4. Install the primary piston O-ring in the piston O-ring groove.
5. Install the rubber spring, concave side down, in the primary piston. Place the spring seat, flat side up, over the rubber spring.
6. Install the spring seat nut and turn the nut clockwise until the top surface of the spring seat is even with the top surface of the piston. Set this assembly aside.
7. Place the relay piston spring, if equipped, in the concave portion of the relay piston. Install the relay piston through the upper inlet and exhaust assembly, and into the underside of the upper valve body.
8. Place a screwdriver (blade up) in a vise. Place the primary piston stem in the relay piston. Position the upper valve body over the screwdriver

Bendix E–6 Brake Valve Disassembly, Cleaning and Inspecting, and Assembly



A. Port 21: to primary air circuit
B. Port 11: from primary air tank
C. Port 22: to secondary air circuit
D. Port 12: from the seondary air tank

1. Locknut
2. Spring Seat
3. Stem Spring
4. Spring Seat Nut
5. Primary Piston Stem
6. Primary Piston Retainer
7. Rubber Spring
8. Spring Seat
9. Primary Piston
10. Primary Piston O-Ring
11. Primary Piston Return Spring
12. Small Washer
13. Upper Inlet and Exhaust Valve Assembly
14. Small O-Ring
15. Retaining Ring
16. Large O-Ring
17. Relay Piston Spring (if equipped)
18. Relay Piston
19. Rubber Seal Ring
20. Lower Inlet and Exhaust Valve Assembly
21. Exhaust Cover
22. Exhaust Diaphragm
23. Washer
24. Phillips Head Screw

Fig. 1, Bendix E-6 Dual Circuit Foot Valve (sectional view)

blade, with the blade engaged in the slotted head of the piston stem.

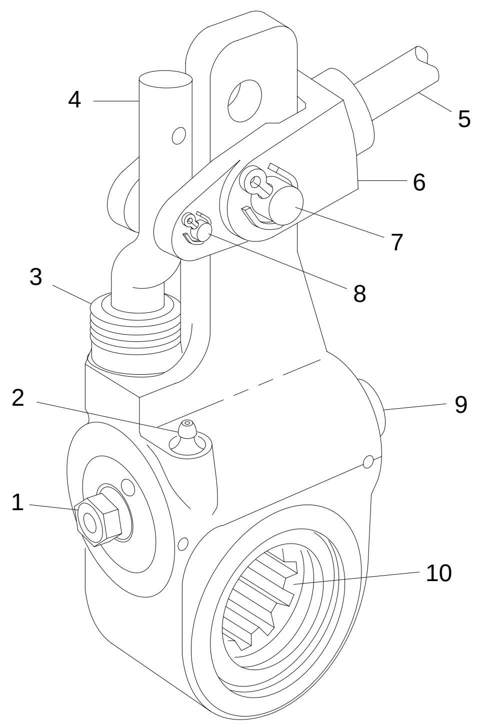
9. Place the small washer over the stem.
10. Install the primary piston return spring in the upper valve body piston bore.
11. Install the primary piston and rubber spring assembly (assembled previously) over the stem, and into the upper valve body piston bore.

WARNING

The locknut and spring seat are used to restrain the primary piston return spring, stem spring, and the relay piston spring. The combined force of these springs is about 50 pounds (222 N). When installing these springs, use care to prevent them from flying out and possibly causing personal injury. Manually or mechanically hold down these springs when installing the locknut.

12. Push down and hold the primary and relay pistons in the upper valve body.
13. Place the stem spring over the spring seat nut (Ref. 4). Place the spring seat over the stem.
14. Install the locknut on the stem. Tighten the locknut 20 to 30 lbf·in (220 to 340 N·cm).
15. Install the primary piston retainer over the piston. Make sure that all three lock tabs have engaged the outer lip of the valve body.
16. Install the rubber seal ring in the lower valve body.
17. Attach the lower and upper valve bodies. Install the four hexhead capscrews and washers. Tighten the capscrews 11 lbf·ft (15 N·m).
18. Install the lower inlet and exhaust valve assembly (Ref. 20).
19. Install the four screws that attach the exhaust cover to the lower valve body.
20. Install the screw that attaches the exhaust diaphragm and washer to the exhaust cover.
21. Install the brake valve. For instructions, see **Subject 110.**

General Information (See Fig. 1)



1. 7/16-Inch Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Push Rod
6. Clevis
7. 1/2-Inch Clevis Pin
8. 1/4-Inch Clevis Pin
9. Grease Relief Opening
10. Slack Adjuster Spline

Fig. 1, Gunite Slack Adjuster

The Gunite automatic slack adjuster has two main functions:

- As a lever it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the drum.
- As an automatic slack adjuster, it maintains the lining-to-drum clearance needed for proper brake chamber push rod stroke.

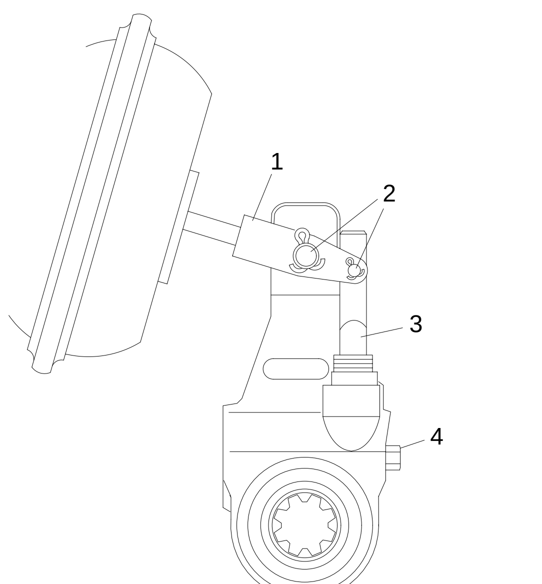
The slack adjuster is installed between the brake chamber push rod and the brake camshaft. A clevis connects the brake chamber push rod to the top of the slack adjuster. The bottom of the slack adjuster is splined to the brake camshaft. The splines hold the slack adjuster internal gear to the camshaft, so the camshaft turns when the slack adjuster moves. When the brakes are applied, the brake chamber push rod moves outward forcing the slack adjuster and camshaft to rotate. This movement forces the brake shoes against the drum.

The brakes are adjusted when the slack adjuster senses an increase in the lining-to-drum clearance. The slack adjuster's internal worm shaft and ratchet shorten excessive lining-to-drum clearance. This provides maximum leverage for the brake chamber push rod. The automatic slack adjuster adjusts the brakes at the beginning of the brake application.

Slack Adjuster Removal and Installation

IMPORTANT: This automatic slack adjuster cannot be rebuilt. If it is damaged or inoperative, replace the unit.

The factory installed brake chambers have welded clevises on the pushrod. See **Fig. 1**. On replacement brake chambers, the clevis is threaded onto the pushrod, and has a jam nut installed. See **Fig. 2**.

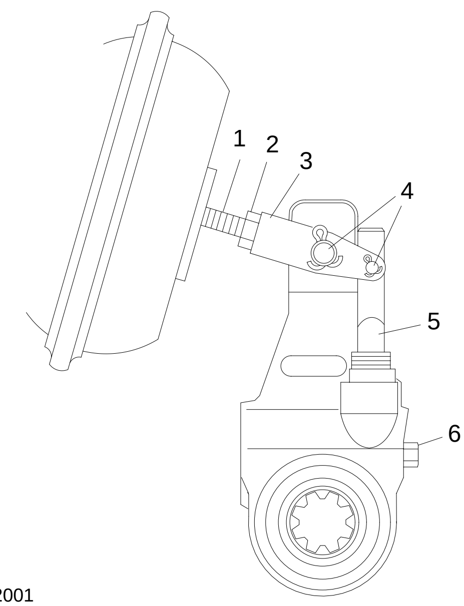


1. Brake Chamber Pushrod and Clevis Assembly
2. Cotter Pins and Clevis Pins
3. Link
4. Adjusting Hexnut

Fig. 1, Slack Adjuster (attached to welded clevis)

Removal

1. Park the vehicle on a level surface, and chock the tires. If you are removing a rear slack adjuster, cage the parking brake power spring. For instructions, refer to the applicable brake chamber section in this group.
2. Remove the cotter pins and clevis pins.
3. Rotate the adjusting hexnut counterclockwise until the slack adjuster clears the clevis.
4. Remove the snap ring from the brake camshaft, then slide the slack adjuster off the camshaft.



1. Brake Chamber Pushrod (threaded)
2. Jam Nut
3. Threaded Clevis
4. Cotter Pins and Clevis Pins
5. Link
6. Adjusting Hexnut

Fig. 2, Slack Adjuster (attached to threaded clevis)

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes full released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Coat the camshaft splines, and the splines of the slack adjuster gear with an anticorrosive grease.
2. Using the old snap ring, install the automatic slack adjuster on the brake camshaft.
3. Turn the adjusting hexnut clockwise to rotate the slack adjuster toward the brake chamber until the holes line up.

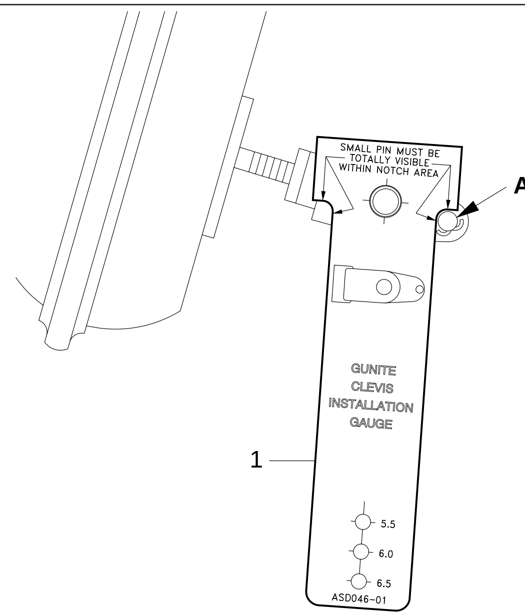
Slack Adjuster Removal and Installation

4. Install the clevis pins and cotter pins.

WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

5. If the pushrod has a threaded clevis, use the gauge supplied with the new slack adjuster to check the adjustment of the clevis. See **Fig. 3**.



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A. Adjust the clevis in or out to position the 1/4-inch clevis pin within the notched area of the gauge.

1. Installation Gauge

Fig. 3, Checking the Clevis Adjustment

5.1 Position the 1/2-inch hole in the gauge over the end of the 1/2-inch clevis pin.

5.2 Align the applicable 1/4-inch hole in the bottom of the gauge over the center of the camshaft.

5.3 Check that the 1/4-inch pin is visible in the notched area of the gauge. If the pin is not in the right location, back off the slack adjuster and readjust the pushrod length, then repeat this step.

NOTE: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the pushrod travels its maximum stroke.

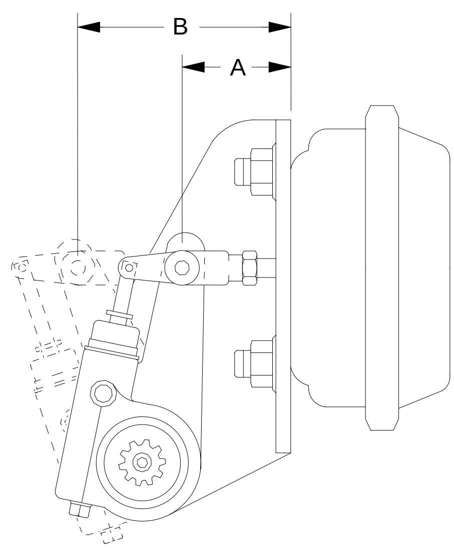
6. Set the initial free-stroke.

6.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.

6.2 Turn the adjusting hexnut counterclockwise one-half turn. There should be about 30 lbf·ft (41 N·m) resistance, and a ratcheting sound will be heard.

7. Measure the brake chamber applied stroke.

7.1 With the brakes fully released, use a ruler to measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 4**.



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A. Brakes Released B. Brakes Applied

Fig. 4, Make these Measurements

7.2 Build air pressure to at least 85 psi (586 kPa). Apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis

Slack Adjuster Removal and Installation

pin. See **Fig. 4**. The difference between the measurements is the brake chamber stroke.

7.3 The brake chamber stroke must be within the range shown in **Table 1**. If it is not, check the foundation brakes for problems such as worn cams, bushings, pins and rollers, or broken springs. Repair or replace as needed. For instructions, refer to the applicable brake section in this group. Then, repeat the two previous steps.

8. If a rear axle slack adjuster was installed, manually uncage the parking brake. Refer to the applicable brake chamber section in this group for instructions.
9. Apply the parking brakes.
10. Remove the chocks from the tires.
11. In a safe area, check for proper brake operation, as follows.

11.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.

11.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.

11.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

Brake Chamber Stroke Specifications			
Chamber Type (Size)	**Maximum Applied Stroke*: inch (mm)**	**Free-Stroke: inch (mm)**	
		New Brake Installation	**In Service Brake**
Long Stroke†			
16 and 20	2-1/2 (64)	5/8 to 3/4 (16 to 19)	1/2 to 5/8 (13 to 16)
24 and 30	3 (76)		

* Specifications are relative to a brake application with 80–90 psi (550–620 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

Specifications

Lubricant Type	Temperature
Lubriplate Aero	Above –40°F (–40°C)
Texaco Multifak EP–2 Mobil Grease 77	Above –20°F (–29°C)

Table 1, Approved Lubricants

Standard Clamp Type Brake Chamber Data			
Type	**Outside Diamater: inches (cm)**	**Rated Stroke: inches (cm)**	**Maximum Stroke at Which Brakes Must be Readjusted: inches (cm)**
9	5-1/4 (13.3)	1.75 (4.5)	1 3/8 (3.5)
12	5 11/16 (14.4)	1.75 (4.5)	1 3/8 (3.5)
16	6 3/8 (16)	2.25 (5.7)	1 3/4 (4.5)
20	6 25/32 (17)	2.25 (5.7)	1 3/4 (4.5)
24	7 7/32 (18.3)	2.25 (5.7)	1 3/4 (4.5)
30	8 3/32 (20.5)	2.50 (6.35)	2 (5)
36 *	9 (22.8)	3.00 (7.6)	2 1/4 (5.7)

* If type 36 chamber is used, slack length should be less than 6".

Table 2

Long Stroke Clamp Type Brake Chamber Data			
Type	**Outside Diamater: inches (cm)**	**Rated Stroke: inches (cm)**	**Maximum Stroke at Which Brakes Must be Readjusted: inches (cm)**
16	6 3/8 (16)	2.50 (6.35)	2 (5)
20	6 25/32 (17)	2.50 (6.35)	2 (5)
24	7 7/32 (18.3)	2.50 (6.35)	2 (5)
24 *	7 7/32 (18.3)	3.00 (7.6)	2 1/2 (6.35)
30 *	8 3/32 (20.5)	3.00 (7.6)	2 1/2 (6.35)

* Identified by square air port bosses.

Table 3

General Information

General Description

The Haldex (SAB) automatic slack adjuster serves two main functions:

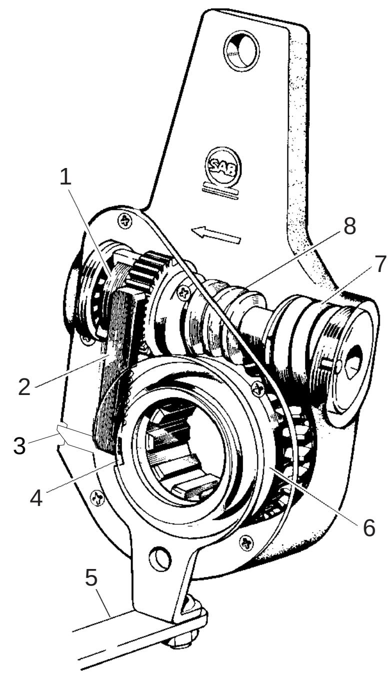
- As a lever, it converts the straight-line force of the air brake chamber pushrod to torque on the brake camshaft. Rotation of the camshaft spreads the brake shoes out against the brake drum, applying the brakes.
- As an adjuster, it maintains cam brake chamber pushrod stroke and lining-to-drum clearance automatically during normal use.

Principles of Operation

When the brakes are applied, the slack adjuster rotates and moves the shoes into contact with the drum. The clearance notch (**Fig. 1**) corresponds to the normal lining-to-drum clearance. Different notches are available to meet the requirements of various vehicles and brake duty cycles. As the brake application continues, the rack moves upward and rotates the one-way clutch which slips in this direction.

As the brake torque increases, the coil-spring load is overcome and the wormshaft is displaced axially, releasing the cone clutch.

When the brake begins its return stroke, the coil spring load returns to normal and the cone clutch is again engaged. The rack is pulled back to its original position in the notch. Any additional travel brought about by brake lining wear causes the rack to turn the locked one-way clutch and rotates the wormshaft through the locked cone clutch. The wormshaft then rotates the worm wheel and camshaft, adjusting the brakes.



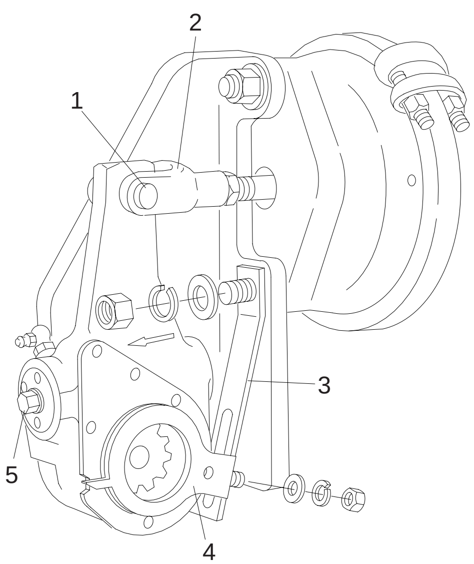
1. Clutch Assembly
2. Enclosed Rack
3. Installation Indicator (aligned with indicator notch)
4. Clearance Notch
5. Control Arm Anchor Bracket (design varies depending on the axle)
6. Worm Wheel
7. Coil Spring
8. Wormshaft

Fig. 1, Haldex Slack Adjuster

Slack Adjuster Removal and Installation

Removal

1. With the vehicle parked on a level surface, set the parking brakes, and shut down the engine. Chock the tires.
2. If a rear-axle slack adjuster will be removed, release the parking brakes and cage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this group.
3. Remove the anchor bracket fasteners and the anchor bracket. See **Fig. 1**.



1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

Fig. 1, Anchor Bracket Removal/Installation

4. Remove the cotter pin from the clevis pin. Remove the clevis pin.
5. Remove the snap ring that secures the slack adjuster on the camshaft.

CAUTION

Do not use an impact wrench on the adjusting hexnut. To do so may damage the slack adjuster or camshaft.

6. Using a 7/16-inch box wrench, turn the adjusting hexnut counterclockwise to move the adjuster arm out of the clevis. A minimum of 13 lbf·ft (18 N·m) is required to overcome the internal clutch. You will hear a ratcheting sound.
7. Remove the slack adjuster from the camshaft.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Check that the brake-chamber pushrod is fully retracted.
2. Apply antiseize compound to the camshaft splines.

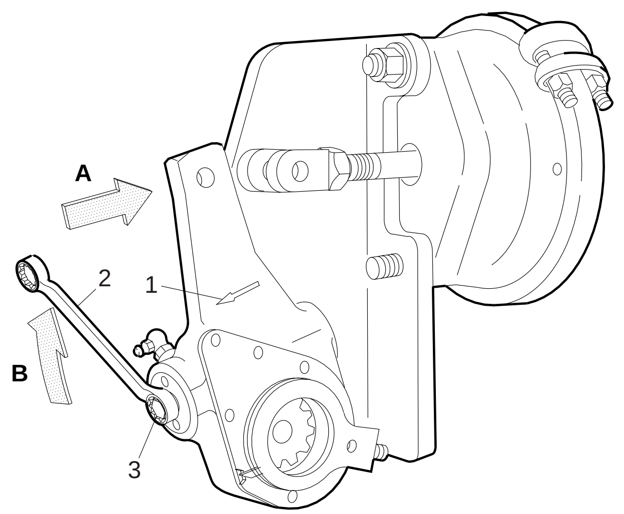
IMPORTANT: When correctly installed, the brake-chamber pushrod pushes in the direction of the arrow on the slack adjuster housing.

3. Install the slack adjuster on the camshaft, with the adjusting hexnut pointing away from the brake chamber. See **Fig. 2**.
4. Using a snap ring, secure the slack adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 0.060-inch (1.52-mm) movement on the shaft.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting hexnut for positioning.

5. Using a 7/16-inch box wrench, turn the adjusting hexnut clockwise until the slack adjuster hole is aligned with the pushrod clevis hole. See **Fig. 2**.
6. Apply antiseize compound to the clevis pin, and insert the pin in the clevis hole. Do not install the cotter pin at this time.

Slack Adjuster Removal and Installation



A. Use only the adjusting hexnut to align the slack adjuster with the pushrod clevis.
B. Turn the adjusting hexnut clockwise.

1. Direction of Applied Stroke
2. Box Wrench, 7/16 inch
3. Adjusting Hexnut

Fig. 2, Slack Adjuster Installation

CAUTION

Never hammer the control arm. Hammering may damage the slack adjuster or camshaft splines.

7. Rotate the control arm away from the adjusting hexnut toward the brake chamber until it comes to a definite internal stop. Make sure the installation indicator is in the center of the indicator notch on the slack adjuster. See **Fig. 3**.

IMPORTANT: If the installation indicator is not aligned with the indicator notch, the brakes will be too tight.

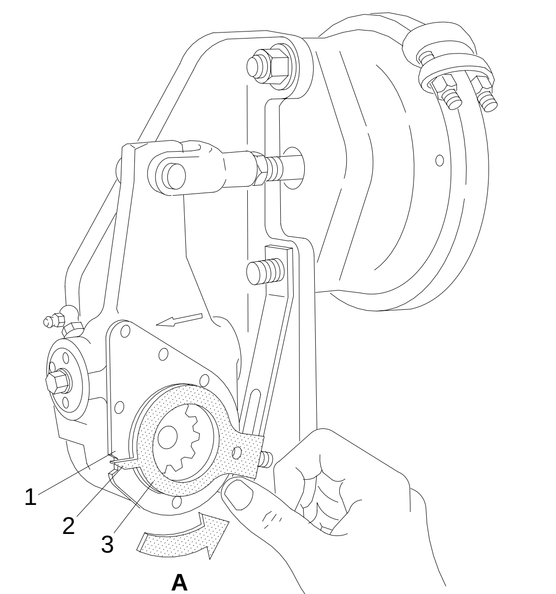
NOTE: The anchor bracket and slack adjuster housing design will vary, depending on the axle. The anchor bracket mounting location is determined by the length of the control arm.

8. Install the control-arm anchor bracket, as follows. See **Fig. 1**.

   8.1 Tighten the anchor bracket fastener at the control arm 10 to 15 lbf·ft (14 to 20 N·m), making sure the control arm does not move from its position.

   8.2 Tighten the fastener at the brake chamber mounting stud according to the brake chamber manufacturer's specifications.

9. Adjust the brakes. See "Brake Adjustment".



NOTE: The installation indicator must be aligned with the indicator notch.

A. Rotate the control arm counterclockwise until it stops.

1. Indicator Notch
2. Installation Indicator
3. Control Arm

Fig. 3, Aligning the Control Arm

Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake

Slack Adjuster Removal and Installation

system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

1. Adjust the brake lining clearance by manually turning the adjusting hexnut clockwise until the brake lining contacts the brake drum, then back off the hexnut counterclockwise 1/2 turn. You will hear a ratcheting sound.

IMPORTANT: Incorrect installation can cause dragging brakes.

2. Make sure the brakes are still fully released, then check the position of the installation indicator on the control arm. It must be within the indicator notch on the slack adjuster.

   If the indicator is out of position, loosen the control arm fasteners and repeat the control-arm adjustment procedure. Then, tighten the bracket fasteners.

WARNING

Install and lock a new cotter pin in the clevis pin. Failure to do so could allow the pushrod to disengage from the slack adjuster, causing a loss of braking ability that could result in personal injury and property damage.

3. Install and lock a new cotter pin in the clevis pin.

IMPORTANT: Ensure that the air system has at least 100 psi prior to uncaging the brake chamber. This will aid in the uncaging of the parking brake since the parking brake should be fully released.

4. If a rear-axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this group.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

IMPORTANT: To check the brake adjustment, measure both the applied and free strokes.

NOTE: The location of the measurements is the same for both strokes but the applied stroke is measured with the brakes applied, while a lever is used to manually move the slack adjuster to measure the free stroke.

5. Measure the free stroke, as follows. The free stroke is the distance the slack adjuster has to travel to move the brake shoes against the drum.

   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement A.

   5.2 Using a lever, move the slack adjuster until the brake shoes contact the drum. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

   5.3 Subtract measurement A from measurement B to determine the free stroke. For new brake installations, the free stroke should be 5/8 to 3/4 inch (16 to 19 mm). For in-service brakes, the free stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not in this range, refer to **Troubleshooting 300**.

6. Measure the applied stroke, as follows.

   6.1 With the brakes released (pushrod fully retracted), measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 4**. Record the exact distance as measurement A.

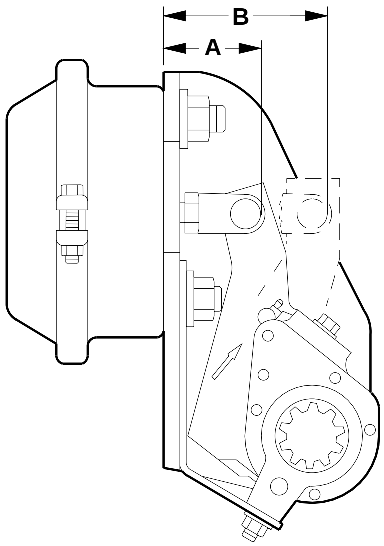
   6.2 Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

   6.3 Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 1**.

   6.4 If the stroke varies or is greater than the maximum allowed length, refer to **Troubleshooting 300**.

7. Apply the parking brakes.

Slack Adjuster Removal and Installation



NOTE: Measurements are from the bottom of the brake chamber to the far side of the clevis-pin hole.

A. Measurement with brakes released.
B. Measurement with brakes applied at 80 psi (551 kPa).

Fig. 4, Brake Applied Stroke Check

8. Remove the chocks from the tires.

9. In a safe area, check for proper brake operation, as follows.

   9.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.

   9.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.

   9.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

Chamber Size	Maximum Applied Stroke: inch (mm)	Free Stroke: inch (mm)	
		New Brake Installation	In-Service Brake Installation
16	1-3/4 (44)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
20			
24	1-7/8 (48)		
30	2 (51)		

Table 1, Brake Chamber Stroke Specifications

Troubleshooting

Problem—Tight or Dragging Brakes

Problem—Tight or Dragging Brakes Possible Cause	Remedy
The control arm anchor bracket is not positioned properly.	See instructions in **Subject 100**.
System air pressure is too low to fully release the spring brake.	Check that the air governor cuts out at the recommended setting.
A spring brake diaphragm is ruptured or a piston seal is leaking.	Replace the diaphragm or spring brake piston seal.
A return spring in the brake chamber is broken.	Replace the spring brake return spring.
The pushrod binds on the chamber housing.	Check for correct alignment and correct chamber mounting bracket. Adjust or replace parts as needed.
The air supply does not exhaust completely.	Test the air system valves for leakage and correct operation.
The brake drums are out-of-round.	Turn the brake drums, if possible. If the maximum allowable diameter of any brake drum has been exceeded, replace the drum. Also, turn or replace the other drum on the axle. For turning the drums, refer to the brake manufacturer's service manual.
Extreme differences exist in lining-to-drum clearances between shoes on the same wheel.	Check for proper operation of the brake mechanism. Lubricate or overhaul as needed.
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions see **Group 33** or **Group 35** in this manual.
The brake shoe return spring is broken.	Replace the brake shoe return spring.

Problem—Brake Chamber Pushrod Travel Is Excessive

Problem—Brake Chamber Pushrod Travel Is Excessive Possible Cause	Remedy
The control arm anchor bracket is loose, broken, or bent.	Tighten or replace the anchor bracket as required.
There is excessive wear between the anchor bracket bolt and the control arm slot.	Replace the worn parts.
The control arm assembly is damaged or worn, resulting in lateral movement between the control arm and the cover plate.	Replace the slack adjuster.
The camshaft bushings are worn.	Replace the worn camshaft bushings.
The camshaft binds.	Lubricate the camshaft or overhaul the brake mechanism as needed.
The brake chamber mounting is loose.	Tighten the brake chamber mounting fasteners.
The slack adjuster is bound against the camshaft housing. There is no end play.	Check that the correct camshaft and camshaft tube have been used and that they are assembled correctly. Overhaul the brake mechanism as needed.

Troubleshooting

Problem—Brake Chamber Pushrod Travel Is Excessive	
Possible Cause	**Remedy**
The slack adjuster clutch assembly is worn.	Replace the slack adjuster.

General Information

The Meritor automatic slack adjuster has two main functions:

- As a lever, it converts the straight-line force of the brake chamber pushrod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the brake drum.
- As an automatic adjuster, it maintains the brake chamber pushrod stroke, which controls the lining-to-drum clearance during operation.

The Meritor automatic slack adjuster automatically adjusts the clearance between the brake lining and the brake drum when needed. As long as the push-rod stroke does not exceed the desired length, no adjustment takes place.

When linings wear, the clearance increases, causing the pushrod to move a greater distance to apply the brakes. If the chamber stroke exceeds the design limit, the automatic slack adjuster adjusts the push-rod's return stroke to control the clearance and re-sets the stroke to the correct length.

As the brake is applied, the brake chamber pushrod and clevis move outward, forcing the slack adjuster arm to rotate around the camshaft centerline. The clevis outward movement also pulls the actuator rod and piston upward. See **Fig. 1**.

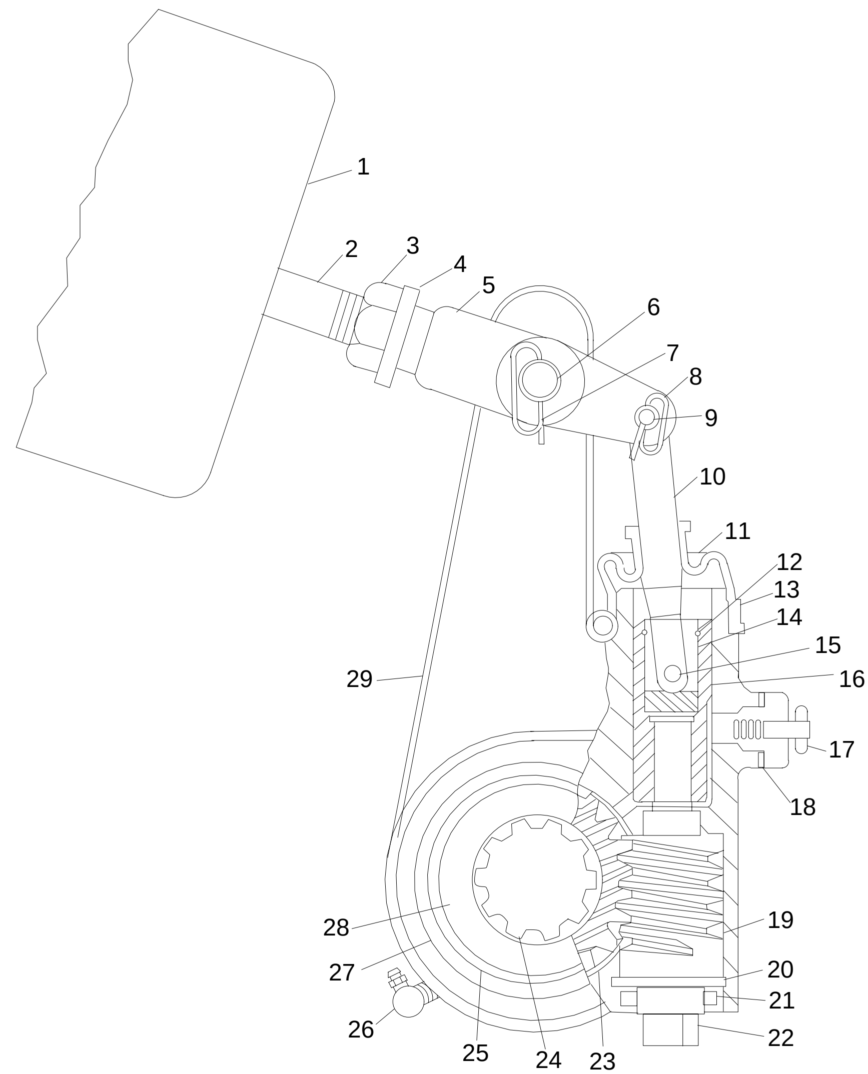
Inside the slack adjuster, the piston, actuator (adjust-ing sleeve), and pull-pawl work together to adjust the length of the pushrod stroke as the brake linings wear. The actuator has internal splines and angled serrations on the outside.

- The internal splines on the actuator mesh with the splined end of the worm so that any rota-tion of the actuator turns the worm.
- Angled serrations on the exterior surface of the actuator correspond to those on the spring-held pawl and provide a ratcheting effect. The pawl serrations allow free upward movement of the actuator but lock on the actuator serra-tions on downward movements.

When lining wear becomes excessive, the brake chamber pushrod stroke goes beyond the desired length. The piston then travels higher and contacts the retaining ring near the top of the actuator, pulling the actuator up. As the actuator moves upward and reaches a preset distance, it slides over one serra-tion on the pawl.

When the pushrod moves back toward the brake chamber, the actuator is forced downward. Because the curved serrations in the pawl and actuator are locked together on the downward stroke, the actuator turns slightly. This action causes the worm to turn, advancing the gear and the camshaft to automati-cally adjust the brake.

General Information



1. Brake Air Chamber
2. Brake Chamber pushrod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Retainer Clip (large)
8. Retainer Clip (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Sleeve)
17. Pull-Pawl Assembly (shown 90 degrees out of position)
18. Gasket
19. Worm
20. Worm Retaining Snap Ring
21. Worm Seal
22. Manual Adjusting Nut
23. Gear-to-Body Seal
24. Camshaft Splines
25. Gear Retaining Ring
26. Grease Fitting (if equipped)
27. Gear Thrustwasher
28. Gear
29. Slack Adjuster Housing

Fig. 1, Meritor Slack Adjuster

Slack Adjuster Removal and Installation

Removal

1. With the vehicle parked on a level surface, set the parking brakes, and shut down the engine. Chock the tires.

WARNING

Manually cage each parking brake chamber power spring in the release (no application) position before continuing. Loss of brake chamber air pressure will cause sudden application of the parking brakes, which could result in personal injury.

2. If the rear slack adjusters will be removed, release the parking brakes, then cage the power spring of the parking brake chamber.
3. Remove the retainer clips from the large and small clevis pins. Remove the clevis pins. See **Fig. 1**.

CAUTION

Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

4. Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See **Fig. 2**.

   Wedge the tool in place. Pull-pawls are spring-loaded; when the tool is removed, the pull-pawl will engage the teeth automatically.
5. Using a wrench, manually turn the square adjusting nut clockwise to move the slack adjuster away from the clevis. See **Fig. 3**.
6. Remove the snap ring, washer(s), and seal (if equipped) that secure the slack adjuster in place on the brake camshaft; save them for later installation.
7. Remove the slack adjuster from the camshaft.
8. Note the location and number of any remaining spacing washers on the camshaft. Remove the spacers and seal (LX500 and MX500 series only), and save them for later installation.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Inspect the parts and prepare the slack adjuster for installation.
2. Check the brake camshaft splines for wear or corrosion.

IMPORTANT: The following lubricants provide corrosion protection. Do not mix them with other types of lubricants.

3. Coat the camshaft splines and the splines of the slack adjuster gear with Meritor 0-637, Meritor 0-695 (LX500 and MX500 only), Southwest SA 8249496, or an equivalent.
4. Apply the service brake several times. Make sure the return spring retracts the pushrod quickly and completely. Replace the return spring or brake chamber, if needed.
5. Slide the spacing washer(s) on the camshaft.

   On LX500 and MX500, install the slack adjuster seal with the lip facing the brake spider.
6. If reinstalling the same slack adjuster:

   6.1 Slide the slack adjuster on the camshaft, with the actuator rod on the side opposite the brake chamber.

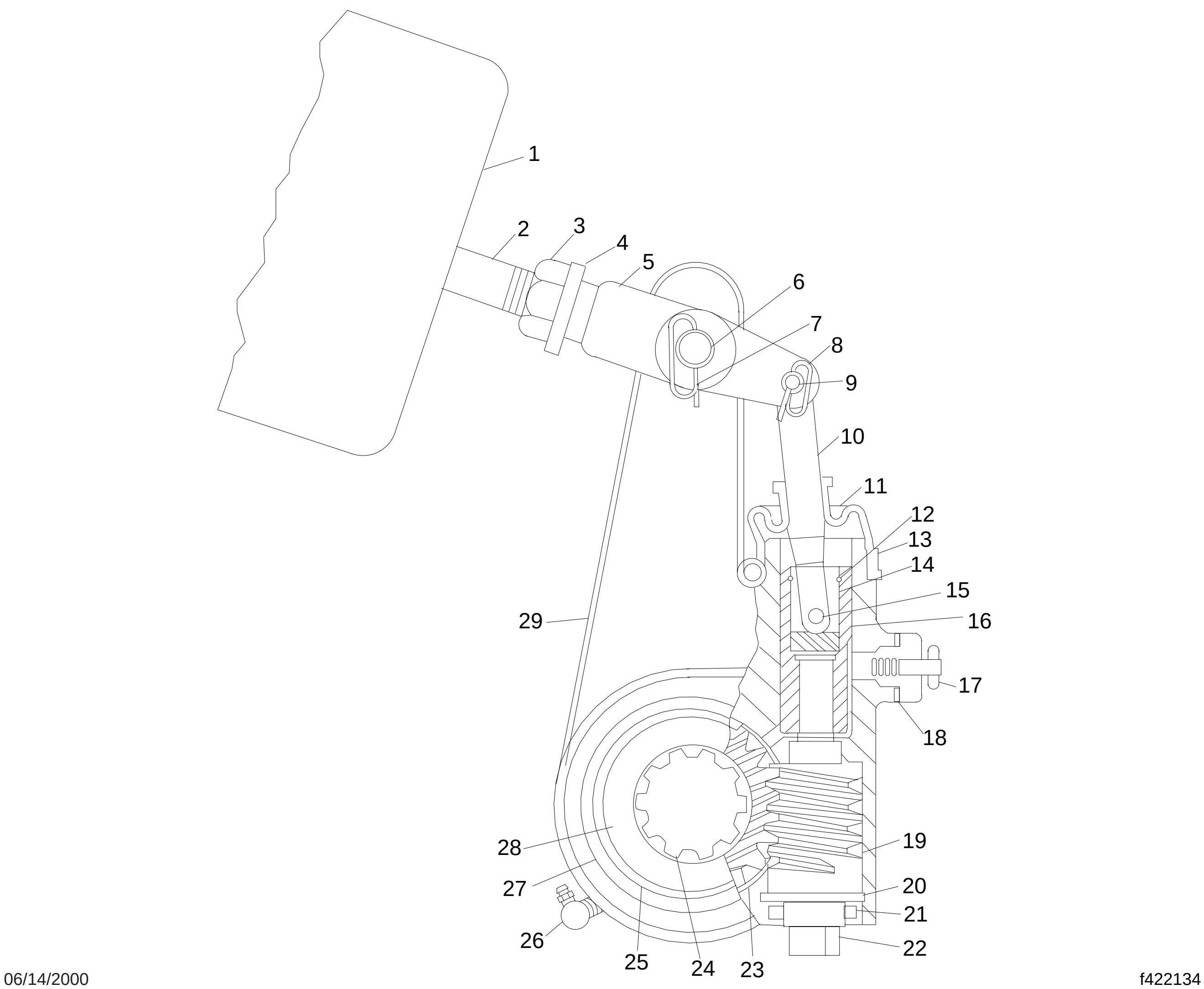
   6.2 On LX500 and MX500, install the orange slack adjuster seal on the camshaft. The lip on the seal must face the snap ring.

   6.3 Install the outer washer(s) and snap ring on the camshaft.

CAUTION

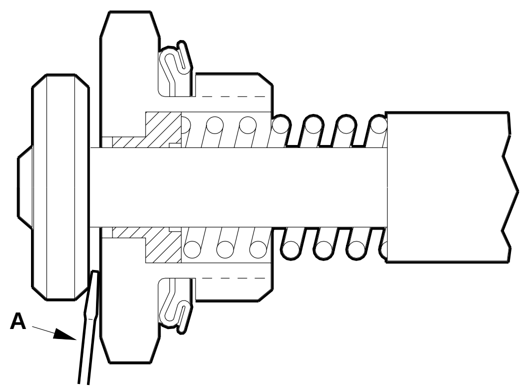
Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could

Slack Adjuster Removal and Installation



1. Brake Air Chamber
2. Brake Chamber Pushrod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Retainer Clip (large)
8. Retainer Clip (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Sleeve)
17. Pull-Pawl Assembly (shown 90 degrees out of position)
18. Gasket
19. Worm
20. Worm Retaining Snap Ring
21. Worm Seal
22. Manual Adjusting Nut
23. Gear-to-Body Seal
24. Camshaft Splines
25. Gear Retaining Ring
26. Grease Fitting (if equipped)
27. Gear Thrustwasher
28. Gear
29. Slack Adjuster Housing

Fig. 1, Meritor Automatic Slack Adjuster



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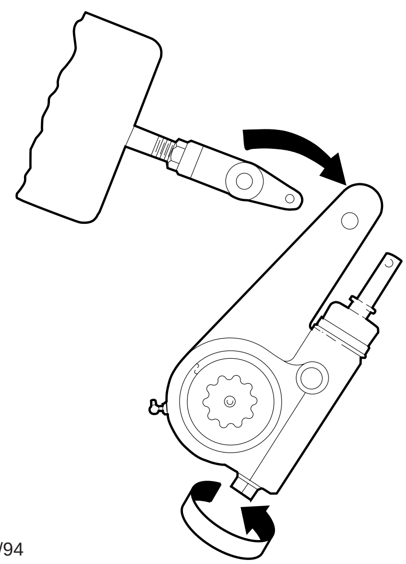
A. Insert a screwdriver here to pry the pull-pawl button out about 1/32 inch (0.8 mm).

Fig. 2, Pull-Pawl Assembly



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Turn the manual adjusting nut clockwise.

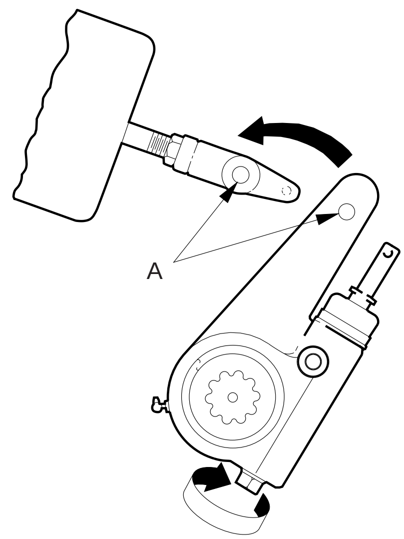
Fig. 3, Slack Adjuster Removal

damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

6.4 Using a screwdriver or an equivalent tool, pry the pawl button out at least 1/32 inch (0.8 mm). See **Fig. 2**. Wedge the tool in place.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting nut for positioning.

6.5 Using a wrench, turn the manual adjusting nut counterclockwise to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 4**.



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A. Turning the adjusting nut counterclockwise, align the large holes in the slack adjuster and clevis.

Fig. 4, Slack Adjuster Installation

7. If installing a new slack adjuster:

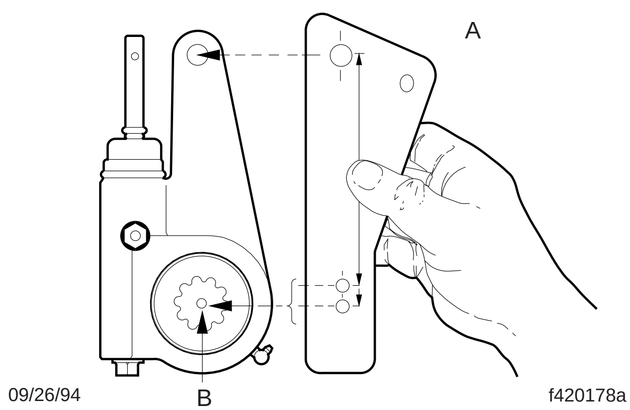
7.1 Using an installation template, measure the old and new slack adjusters. Measure from the center of the large clevis-pin hole to the center of the camshaft opening. See **Fig. 5**.

Make sure the old and new slack adjusters are the same length.

7.2 Slide the slack adjuster on the camshaft, with the actuator rod on the side opposite the brake chamber.

7.3 On LX500 and MX500 series, install the orange slack adjuster seal on the camshaft. The lip on the seal must face the snap ring.

Slack Adjuster Removal and Installation



A. Using a template, measure the slack adjuster arm length.
B. Camshaft Center

Fig. 5, Slack Adjuster Measurement

7.4 Install the outer washer(s) and snap ring on the camshaft.

7.5 Using a dial indicator, measure the in-and-out (axial) end play of the camshaft. If necessary, add the appropriate number of spacing washers to achieve the correct axial end play.

- For all Cam-Master brakes, except LX500 and MX500 series, there should be no more than 0.060 inch (1.52 mm) movement.
- For LX500 and MX500, the axial end play should be no more than 0.020 inch (0.51 mm).

CAUTION

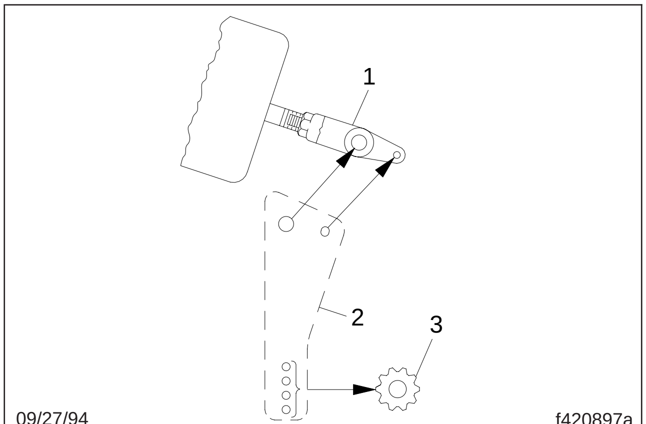
Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

7.6 Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See **Fig. 2**. Wedge the tool in place.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting nut for positioning.

7.7 Using a wrench, turn the manual adjusting nut counterclockwise to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 4**.

7.8 With the brakes fully released, place the installation template over the clevis and camshaft end. See **Fig. 6**.



Place the template over the clevis and camshaft end.

1. Clevis
2. Template
3. Camshaft End

Fig. 6, Template Placement

7.9 Temporarily insert the large clevis pin through the large holes in the template and the clevis.

7.10 Select the hole in the lower part of the template that matches the length of the slack adjuster. Hold the template in place on the center of the camshaft with a pencil.

7.11 Make sure the small hole in the clevis is completely visible through the 1/8-inch hole at the top of the template.

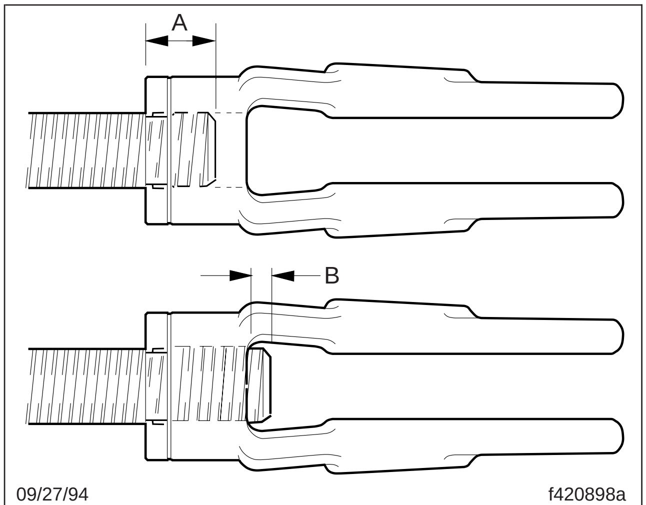
If it is not, loosen the clevis jam nut, and turn the clevis adjusting nut to adjust the position of the clevis on the pushrod until the small clevis hole is completely visible.

IMPORTANT: The pushrod must be installed in the clevis at least 1/2 inch (13 mm) and not extend beyond it more than 1/8-inch (3-mm).

7.12 Make sure there is at least 1/2 inch (13 mm) of thread engagement between the clevis and the pushrod. Also, check that the pushrod does not extend through the clevis more than 1/8-inch (3-mm). See **Fig. 7**.

If necessary, cut the pushrod, install a new pushrod, or install a new brake chamber.

7.13 Temporarily insert the small clevis pin through the template, clevis, and actuator rod to make sure the alignment is correct. Repeat the adjustment, if necessary. When the alignment is correct, remove both clevis pins and the template.



A. Minimum 1/2 inch (13 mm).
B. Maximum 1/8 inch (3 mm).

Fig. 7, Check Pushrod Engagement

8. Apply antiseize compound to the two clevis pins.
9. Insert both clevis pins with their pinheads on the inboard side of the slack adjuster. Be sure the small clevis pin is inserted through the hole in the actuator rod. Install new retaining clips to secure the clevis pins.
10. If it was loosened, tighten the clevis jam nut to the following values.
    - For 1/2–20 threads, tighten the clevis jam nut 20 to 30 lbf·ft (27 to 41 N·m).
    - For 5/8–18 threads, tighten the jam nut 25 to 50 lbf·ft (34 to 68 N·m).
11. Lube the slack adjuster through the grease fitting until the lubricant is forced out through the pawl slot or through the gear splines around the inboard snap ring.
12. Adjust the brakes. See "Brake Adjustment" below.

Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

1. If a rear axle slack adjuster was installed, manually uncage the parking brake.
2. Fully release the brakes (the air chamber pushrod must be fully retracted).

CAUTION

Before turning the manual adjusting nut on the slack adjuster, disengage the pull-pawl. Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

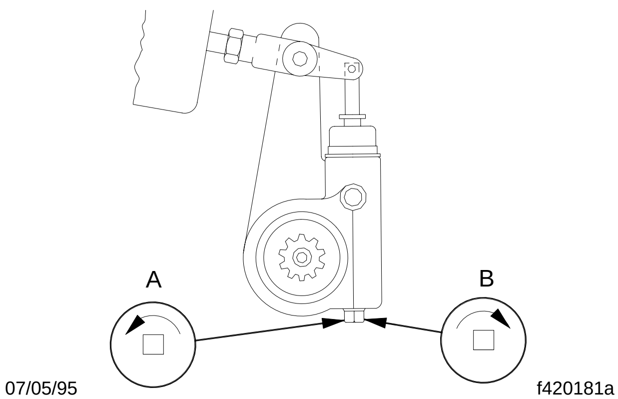
3. Using a screwdriver, pry the pull-pawl button out at least 1/32 inch (0.8 mm) to disengage the pull-pawl teeth from the slack adjuster actuator. See **Fig. 2**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

Slack Adjuster Removal and Installation

NOTE: When the screwdriver is removed, the pull-pawl will engage automatically.

4. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment), as follows. See **Fig. 8**.

   4.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.



A. Shorten stroke.
B. Lengthen stroke.

Fig. 8, Adjusting the Stroke

   4.2 Then, turn the adjusting nut clockwise 1/2 turn.

5. Measure and adjust the free-stroke, as follows.

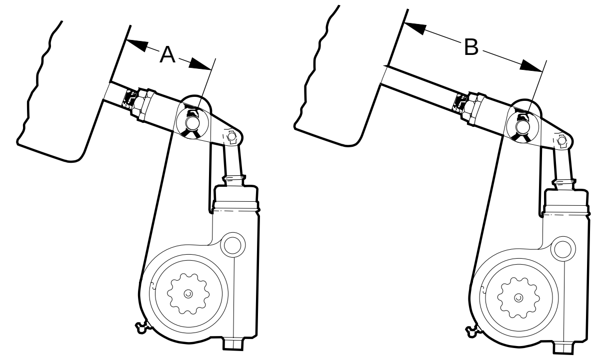
   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 9**.

   5.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.

   Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension B. See **Fig. 9**.

   5.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

   5.4 The free-stroke for a new brake installation should be 5/8 to 3/4 inch (16 to 19 mm). For a brake that is in service, the free-stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not, turn the adjusting nut 1/8 turn, as shown in **Fig. 8**. Then, measure the free-stroke again; readjust it until it is correct.



NOTE: For either free-stroke or applied chamber stroke, subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied by manual lever (free-stroke) or pressurized brake application (applied chamber stroke).

Fig. 9, Measuring the Stroke

6. Measure and adjust the applied chamber stroke (fine adjustment), as follows.

   6.1 If system pressure is not already at 100 psi (689 kPa), start the engine and build air pressure, then shut down the engine.

   6.2 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 9**.

   6.3 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 9**, Ref. B. Record this measurement as dimension B.

   6.4 Subtract dimension A from dimension B. The difference between these measurements is the true applied chamber stroke.

CAUTION

The adjusted applied chamber stroke should be as short as possible but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.

6.5 The applied chamber stroke must not exceed the maximum value specified in **Table 1**.

If the applied chamber stroke is incorrect, turn the adjusting nut 1/8-turn counterclockwise to shorten the stroke, or 1/8-turn clockwise to lengthen it. See **Fig. 8**. Measure the applied stroke again and readjust it until it is correct.

6.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Section 42.01, Subject 150**.

7. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl with the actuator.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

8. In a safe area, check for proper brake operation before you put the vehicle in service, as follows.

8.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

8.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others show a lack of braking effort on those wheels.

Brake Chamber Stroke Specifications			
Chamber Type (Size)	**Maximum Applied Stroke*: inch (mm)**	**Free-Stroke: inch (mm)**	
		New Brake Installation	**In-Service Brake**
Long Stroke†			
16 and 20	2-1/2 (64)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
24 and 30	3 (76)		

* Specifications are relative to a brake application with 80–90 psi (550–620 kPa) air pressure in the brake chambers.
† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

Specifications

Chamber Size	Slack Adjuster Arm Length	
	inch	mm
9, 12, 16, 20, 24, 30	5	127
9, 12, 16, 20, 24, 30, 36	5-1/2	140
24, 30, 36	6	152
30, 36	6-1/2	165

Table 1, Slack Adjuster Arm Length

Lubricant	Ambient Temperature
Meritor 0-616-A Texaco Thermotex EP No. 1 Shell Darina No. 1 Texaco Hytherm EP No. 1 Aralub 3837 Tribolube 12, Grade 1 Meritor 0-692 Amoco Super Permalube No. 2 Citco Premium Lithium EP No. 2 Exxon Ronex MP No. 2 Kendall L-427 Super Blu No. 2 Mobilith AW No. 1 Sohio Factran EP No. 2	Above –40°F (–40°C)
Meritor 0-645 Mobil 28 Meritor 0-695	Below –40°F (–40°C)

Table 2, Lubricant Specifications

Chamber Size	Maximum Chamber Stroke, in (mm)	
	Standard Stroke	Long Stroke
9 12	1-3/8 (35)	—
16 20	1-3/4 (44)	2 (51)
24	1-3/4 (44)	2 (51)— *2-1/2 inch rated stroke* 2-1/4 (63)— *3-inch rated stroke*
30	2 (51)	2-1/2 (57)

Specifications

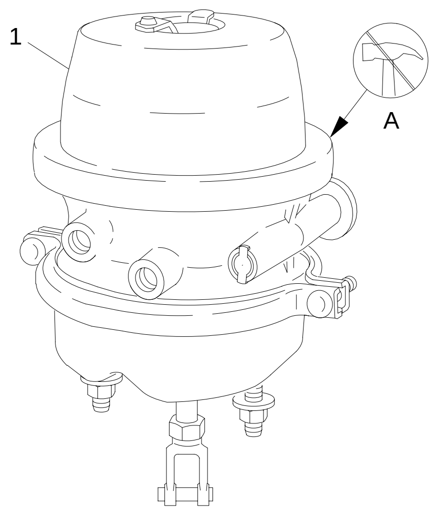
Chamber Size	Maximum Chamber Stroke, in (mm)	
	Standard Stroke	Long Stroke
36	2-1/4 (57)	—

Table 3, Maximum Adjusted Brake Chamber Stroke

General Information

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



A. Do not remove the factory-sealed clamp ring.
1. Model TR Brake Chamber

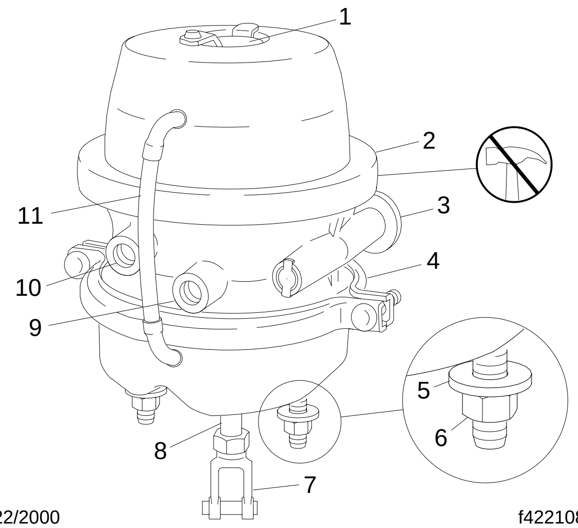
Fig. 1, Brake Chamber

IMPORTANT: On MGM "TR" Series chambers, the parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit.

General Description

MGM "TR" Series tandem cam brake chamber consists of a service brake section and a parking/ emergency spring brake section. See Fig. 2. The service brake section is the smaller section near the clevis assembly.

In the service brake section, the flange case and non-pressure chamber contain a service return spring, piston rod assembly, and service brake diaphragm.



Do not remove the factory-sealed clamp ring.

1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Spring Brake Air Inlet
10. Park Brake Air Inlet
11. External Breather Tube (optional)

Fig. 2, Model TR-T (TR Series) Brake Chamber

In the parking/emergency brake section, the flange case and the head contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a piston, a power spring, and a detachable release bolt.

All MGM brake chambers are mounted to brackets on the axle using prevailing torque locknuts and hardened flatwashers.

MGM "TR" Series chambers may be equipped with an external breather tube that protects the parking brake chamber from contaminants. These chambers are called Model "TR-T" chambers. See Fig. 2.

General Information

Principles of Operation

SERVICE BRAKES

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

Then, when the brake pedal is released, air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod, and slack adjuster to return to their normal positions, releasing the brakes.

PARKING/EMERGENCY BRAKES

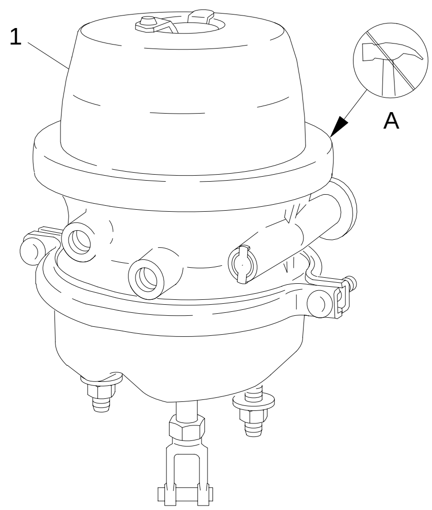
During parking brake release, compressed air enters the parking brake chamber and acts upon the diaphragm and piston, fully compressing the power spring. When the power spring is compressed, the parking brakes are released; the service brakes can then be operated at the brake pedal.

During parking brake application, air is exhausted from the parking brake chamber. The power spring releases, forcing the piston and parking brake diaphragm toward the flange case. The resulting motion on the push rod forces the service brake diaphragm and piston rod outward, applying the brakes.

Manual Release of Spring Brake (Caging)

DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1), for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



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A. Do not remove the factory-sealed clamp ring.
1. Model TR-T (TR Series) Brake Chamber

Fig. 1, Brake Chamber

Manual Caging (Parking Brake Release)

1. Chock the tires.
2. Remove the end cover cap from the center-hole in the head of the chamber. See **Fig. 2**.

DANGER

Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

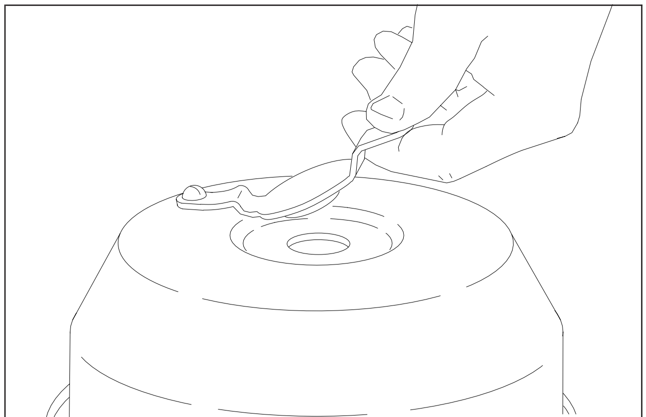

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Fig. 2, Remove the End-Cover Cap

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.

Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the MGM service manual.

3. Manually release the parking brake (cage the power spring).

 3.1 Using a hand wrench (*don't use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. See **Fig. 3**.

 IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

 3.2 Insert the release bolt into the center-hole in the chamber head. See **Fig. 4**). Insert the bolt until it bottoms out into the hole in the piston inside the chamber.

 IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged the piston correctly, repeat this step. Repeat it until you are absolutely sure.

Manual Release of Spring Brake (Caging)

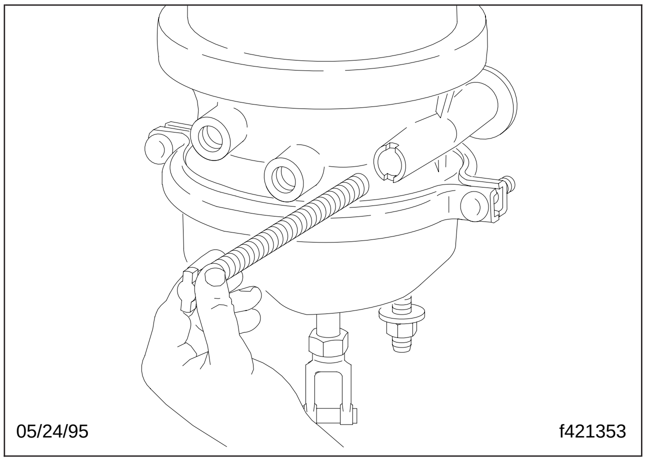


Fig. 3, Remove the Release Bolt

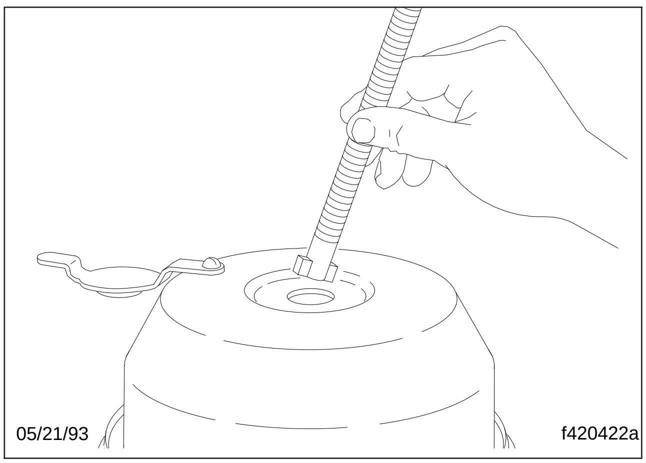


Fig. 4, Insert the Release Bolt

3.3 Turn the release bolt one-quarter turn clockwise, and pull the bolt out to lock its formed end into the piston.

IMPORTANT: If the bolt doesn't lock into the piston in less than 1/2-inch (13-mm) outward movement, repeat these steps until you are sure it does lock.

3.4 Then, holding the bolt locked into the piston, install the flatwasher and release nut on the end of the release bolt, and turn down the nut against the flatwasher until it is finger-tight. See **Fig. 5**.

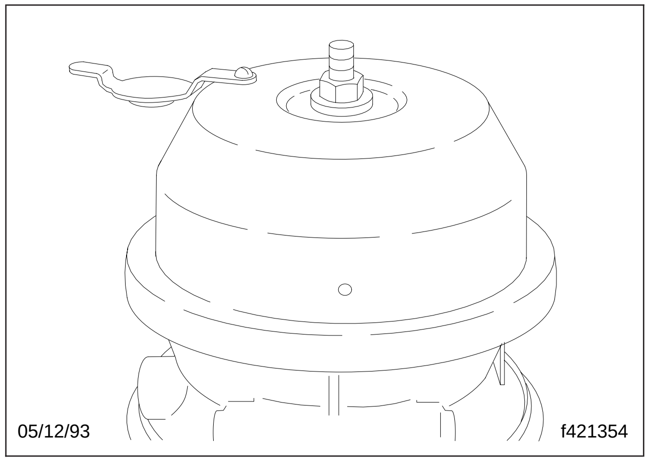
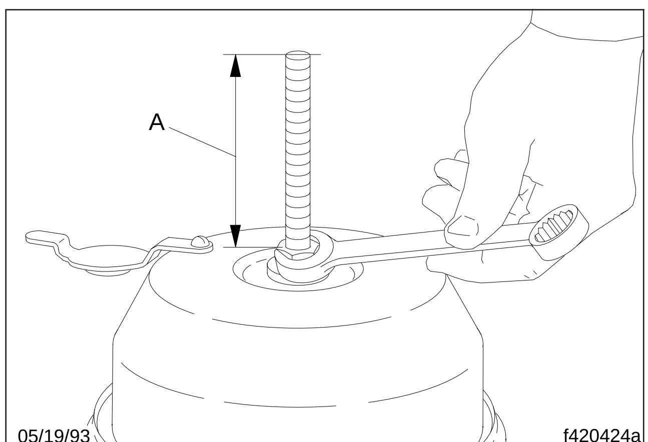


Fig. 5, Flatwasher and Release Nut Installed

CAUTION

Don't exceed 50 lbf·ft (68 N·m) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

3.5 Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the bolt extends above the nut 3.5 inches (76 mm) on type 2430 and 3030 chambers and 4 inches (102 mm) on type 3036 and 3636 chambers. See **Fig. 6**.



Don't exceed the 3-inch (76-mm) length.

A. Measure this distance.

Fig. 6, Turn the Release Nut

Manual Release of Spring Brake (Caging)

IMPORTANT: Don't exceed the 3-inch (76-mm) length.

4. Once the power spring has been caged, exhaust the compressed air from the parking brake.

Manual Reset (Parking Brake Reset)

1. Uncage the power spring.

   1.1 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

CAUTION

Don't exceed 50 lbf·ft (68 N·m) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

   1.2 Use a hand wrench to turn the release nut *counterclockwise* until the bolt bottoms out in the unit.

   1.3 Remove the nut and flatwasher.

   1.4 Push the release bolt into the piston and turn the release bolt one-quarter turn counterclockwise to unlock its formed end from the piston. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench (*don't use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. MGM recommends 10 lbf·ft (14 N·m) torque on the nut against the flatwasher. See **Fig. 7**.

3. Snap the end cover cap in place over the center-hole in the chamber head. See **Fig. 8**.

CAUTION

If the optional external breather tube or end cover cap is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chamber, dirt and debris cause the internal parts to deteriorate and shorten their lives. Operating the unit without the external breather tube or end cover cap in place voids the MGM warranty.

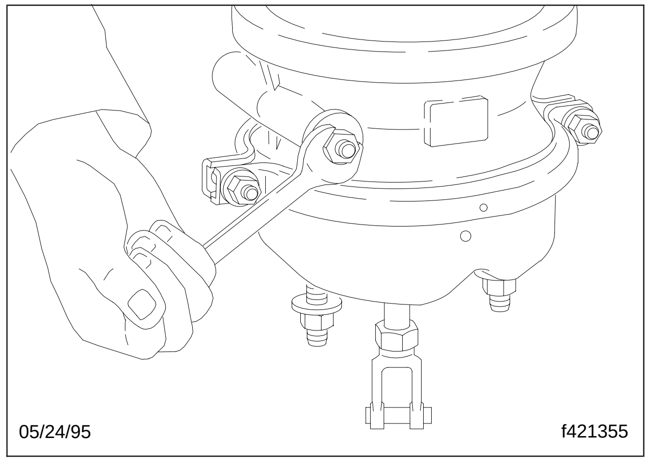


Fig. 7, Tighten the Release Nut

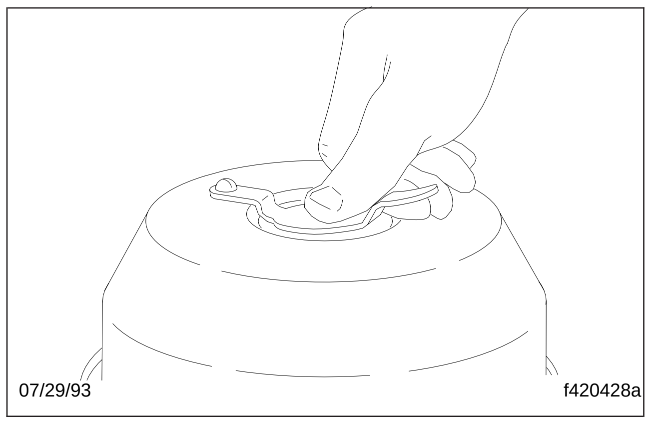


Fig. 8, Snap the End Cover Cap in Place

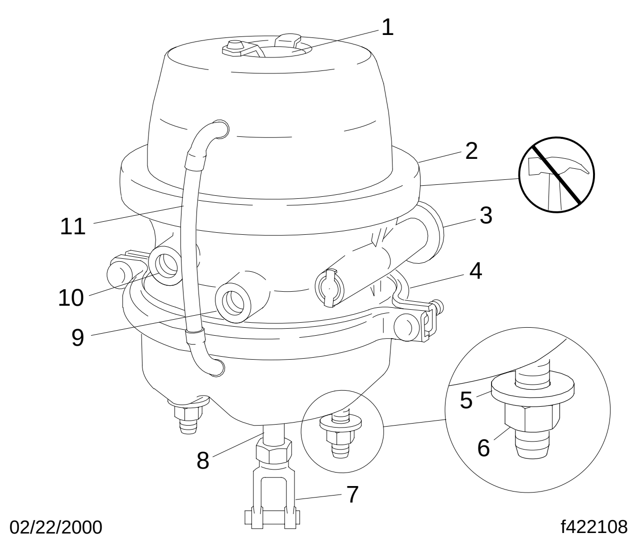
4. Check the plastic end cover cap periodically, and replace it with a new one at once if damaged or missing.

5. Remove the chocks from the tires.

Service Brake Diaphragm Replacement

DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



Do not remove the factory-sealed clamp ring.

1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Spring Brake Air Inlet
10. Park Brake Air Inlet
11. External Breather Tube (optional)

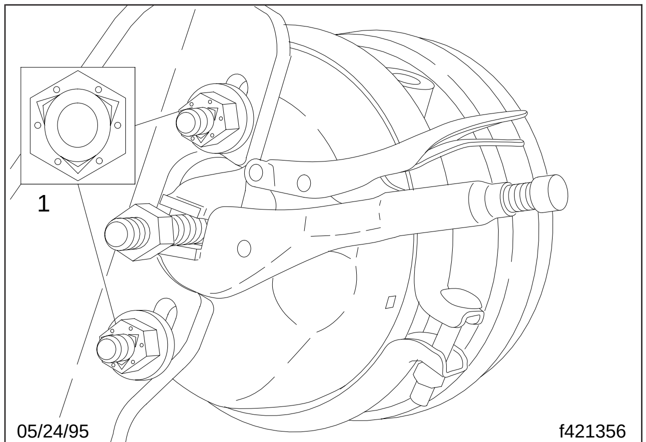
Fig. 1, Model TR-T (TR Series) Brake Chamber

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released. See Fig. 2.



1. Prevailing Torque Locknut

Fig. 2, Lock the Piston Rod in Place

WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, see Subject 100.

3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

   On chambers equipped with an external breather tube, disconnect the tube and elbow from the service brake chamber.

DANGER

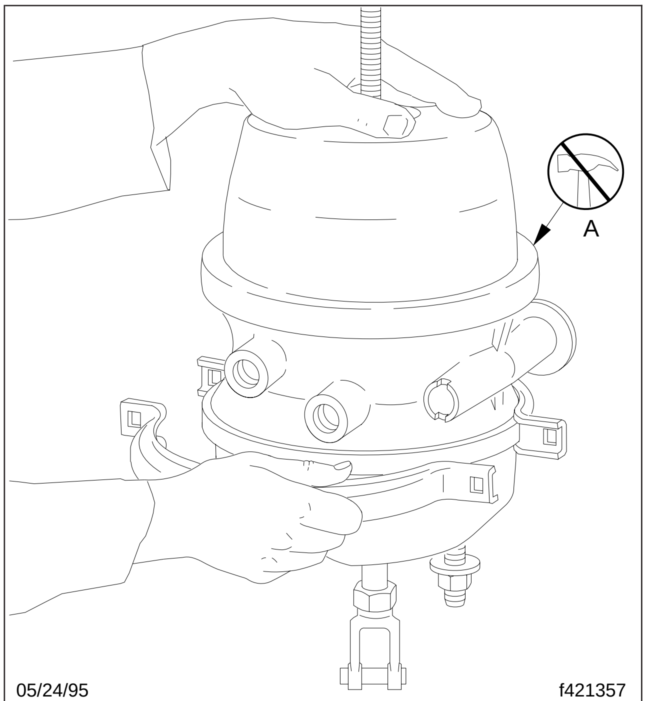
Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Service Brake Diaphragm Replacement

4. Remove the parking brake section from the service brake section.

   4.1 Using a hand wrench (*don’t use an impact wrench*), remove the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

   4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber. See **Fig. 3**.



A. Do not remove the factory-sealed clamp ring.

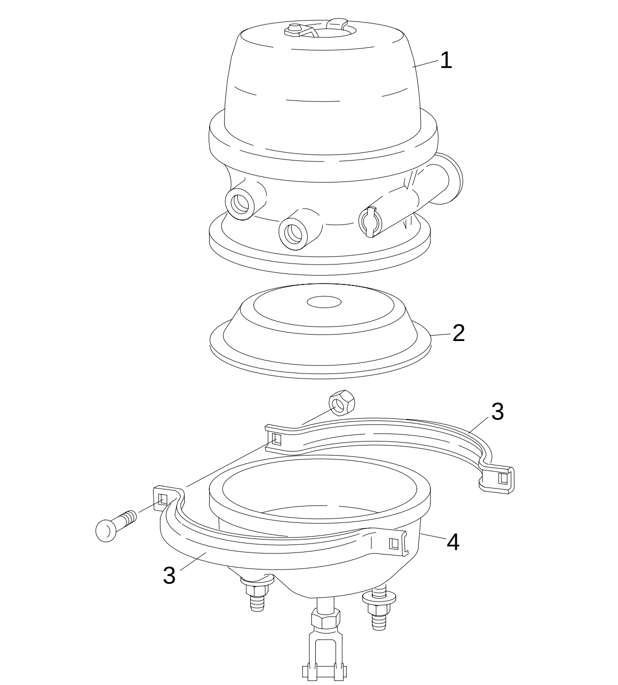
Fig. 3, Remove the Service Clamp Ring

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts with genuine MGM-engineered replacement parts.
2. Place the new service brake diaphragm in the bottom recess of the parking brake section. See **Fig. 4**.



1. Parking/Emergency Brake Section
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4, Brake Chamber Parts

3. Install the (new, if needed) parking/emergency brake section.

   3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

   3.2 Check that the release bolt is fully extended outward. For instructions, see **Subject 100**.

   3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are

Service Brake Diaphragm Replacement

positioned to mate with the vehicle air supply lines.

4. Install the service brake clamp ring.

   4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

   4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp nut in increments of 5 to 10 lbf·ft (6.8 to 13.6 N·m) while constantly rechecking the alignment of mating parts.

   If realignment is needed, loosen the nuts again, and repeat this substep.

   4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).

6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

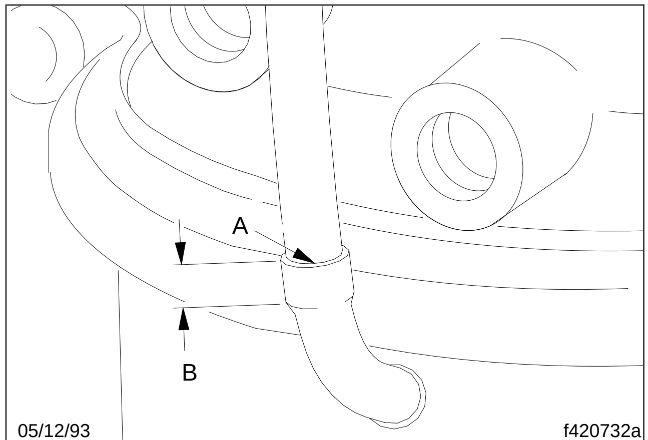
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

DANGER

Do not attempt to remove the factory-sealed clamp ring.(see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.

9. On chambers equipped with an external breather tube, make sure that the open end of the tube is free of grease, dirt, and other debris. Then, apply a high-quality rubber cement to the tube and insert it into the elbow at least 1/2 inch (13 mm). See Fig. 5. Insert the tube into the service brake chamber.



A. Apply adhesive (rubber cement) here.
B. Check for 1/2" (13 mm) minimum engagement.

Fig. 5, Install the External Breather Tube

10. With air pressure now exhausted from the service brake chamber, but held on the parking brake, uncage the power spring, and snap the end cover cap in place. For instructions, see Subject 100.

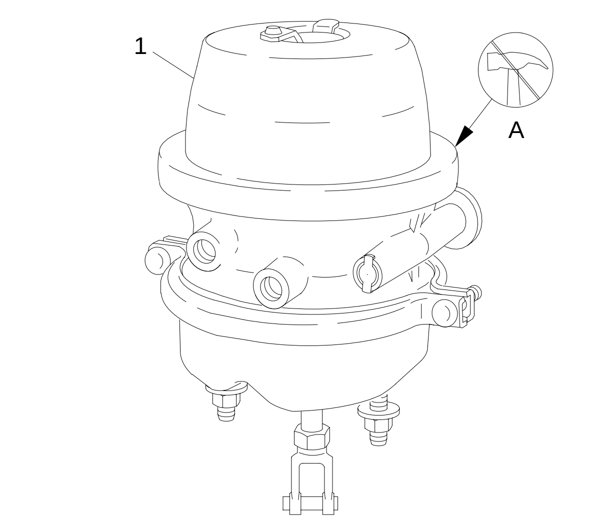
11. Adjust the brakes at the slack adjuster. Refer to the appropriate section in this manual.

IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Combination Service and Parking Brake Chamber Removal and Installation

DANGER

Do not attempt to remove the factory-sealed parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



A. Do not remove the factory-sealed clamp ring.
1. Model TR-T (TR Series) Brake Chamber

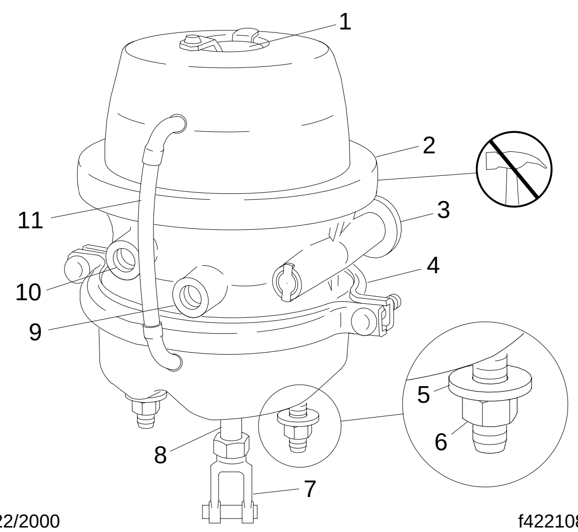
Fig. 1, Brake Chamber

Removal (See Fig. 2)

WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

1. Manually release the parking brake (cage the power spring). For instructions, see **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the brake chamber from the vehicle.



Do not remove the factory-sealed clamp ring.
1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Spring Brake Air Inlet
10. Park Brake Air Inlet
11. External Breather Tube (optional)

Fig. 2, Model TR-T (TR Series) Brake Chamber

3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

NOTE: Automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

3.2 Make sure the parking brake has been released manually (the power spring has been caged). For instructions, see **Subject 100**. Also, make sure that the service brake piston is fully retracted (in the brakes "OFF" position). Then, record both of the following dimensions in either mm or inches, measuring outward from the base of the service brake chamber (see **Fig. 3**):

Combination Service and Parking Brake Chamber Removal and Installation

X dimension: to end of threaded piston rod

Y dimension: to centerline of (large) clevis pin

IMPORTANT: New chambers are attached to automatic slack adjusters The X dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut (**Fig. 4**) to exactly duplicate the "rod only" length *before* the clevis assembly is installed on the piston rod.

3.3 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

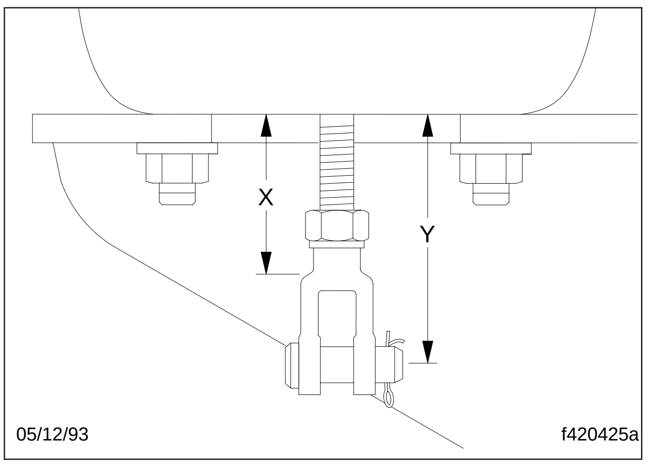


Fig. 3, Measure X and Y

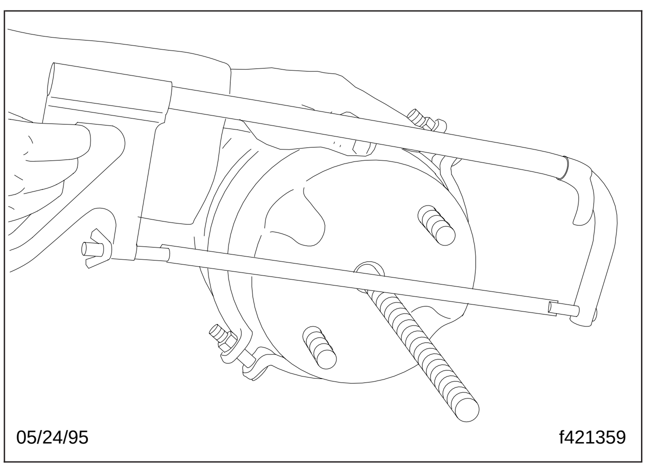


Fig. 4, Cut the Service Piston Rod

Installation (See Fig. 2)

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and install the chamber on the bracket, paying close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

WARNING

Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 100 to 115 lbf·ft (136 to 156 N·m). Make sure the flatwasher is installed between the locknut and the mounting bracket.

   On chambers equipped with an external breather tube, make sure that the tube is installed in the side of the chamber that faces away from the road surface. An improperly installed breather tube voids the MGM warranty.

4. Check mating and alignment with the vehicle air lines. If alignment is okay, skip this step.

Combination Service and Parking Brake Chamber Removal and Installation

DANGER

Do not attempt to remove the factory-sealed parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

Alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. Install the slack adjuster. Refer to the applicable slack adjuster section in this group for installation instructions.
6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom within ±3° in any direction from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.
7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 30 lbf·ft (41 N·m).

DANGER

Do not attempt to remove the factory-sealed parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, see **Subject 100**.
10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Specifications

Description	Torque lbf·ft (N·m)
Spring Brake Release Bolt Nut (in storage pocket)	10 (14)
Service Brake Clamp Ring Nut	25–30 (34–41)
Brake Chamber Mounting Stud Nut	100–115 (136–156)
Air Hose Fitting-to-Chamber	30 (41)

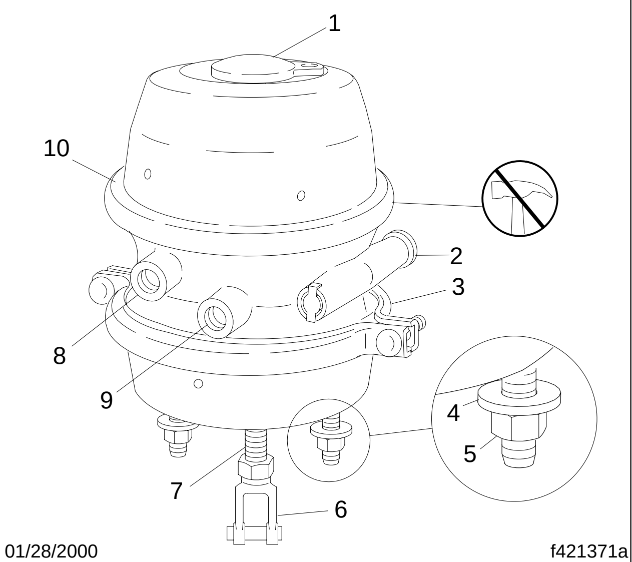
Table 1, Torque Values

General Information

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: The parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit.



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1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Locknut
6. Clevis Assembly
7. Piston Rod
8. Park Brake Air Inlet
9. Service Brake Air Inlet
10. Factory Sealed Clamp Ring (**do not remove**)

Fig. 1, Brake Chamber

Anchorlok brake chambers consist of a service brake section and a parking/emergency spring brake section. See Fig. 1. The service brake section is the smaller section near the clevis assembly.

In the service brake section, the service brake chamber contains a service return spring, piston rod assembly, and service brake diaphragm.

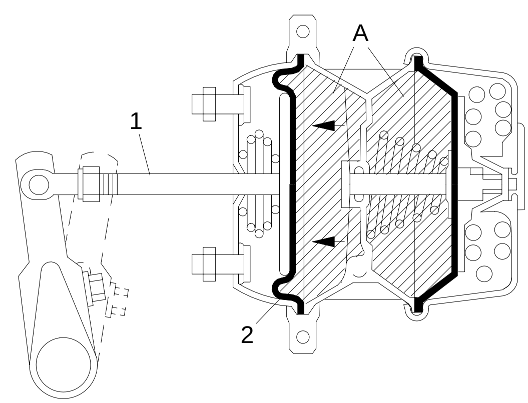
In the parking/emergency brake section, the adaptor and the parking brake chamber contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a pressure plate, a power spring, and a detachable release bolt.

All Anchorlok brake chambers are mounted to brackets on the axle using prevailing torque locknuts and hardened flatwashers.

Principles of Operation

SERVICE BRAKES

As the brake pedal is depressed, compressed air enters the service brake chamber through a port (ref. 9, Fig. 1). Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes. See Fig. 2.



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A. Air in these Chambers

1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 2, Service Brakes Applied / Parking Brakes Released

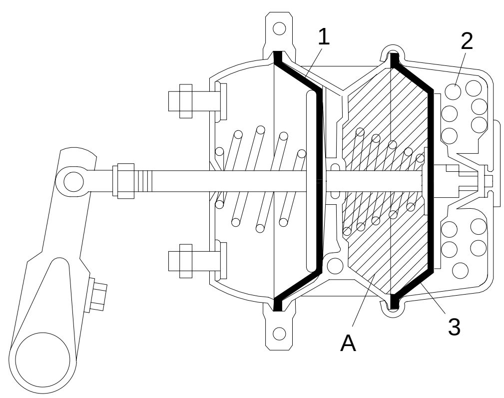
Then, when the brake pedal is released (see Fig. 3), air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod

General Information

assembly, and slack adjuster to return to their normal positions, releasing the brakes.

PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking/emergency brake chamber below the diaphragm, forcing the diaphragm against the pressure plate to compress the power spring and release the parking/emergency brake. See **Fig. 3**. During parking brake application, a control valve in the cab exhausts air from the parking/emergency brake chamber. This allows the power spring to extend and apply the brakes. See **Fig. 4**.



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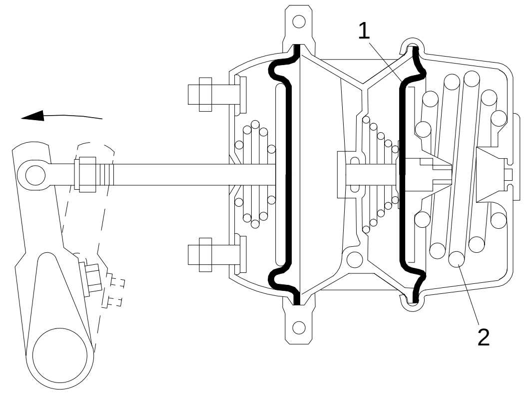
A. Air in this Chamber

1. Service Brake Diaphragm
2. Power Spring
3. Parking/Emergency Brake Diaphragm

Fig. 3, Parking and Service Brakes Released

Emergency brake application begins when air pressure in the service brake reservoir drops below about 80 to 85 psi (550 to 585 kPa). Maximum parking brake force is applied when air is entirely exhausted fom the parking/emergency brake chamber.



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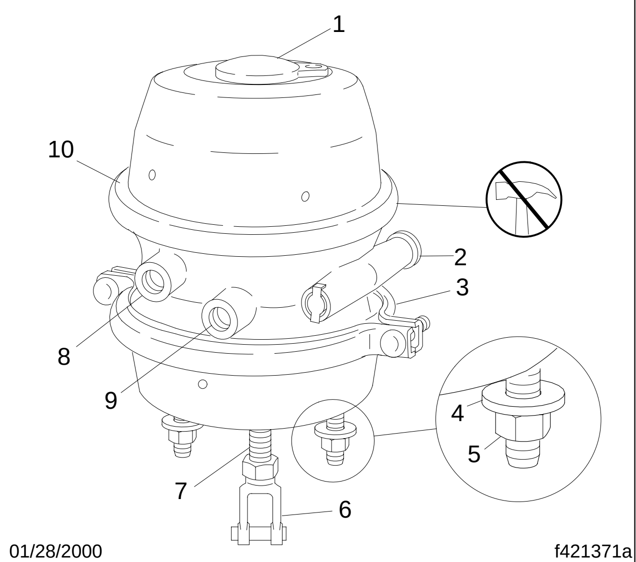
1. Parking/Emergency Brake Diaphragm
2. Power Spring

Fig. 4, Parking/Emergency Brakes Applied

Manual Caging (Parking Brake Release)

DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Locknut
6. Clevis Assembly
7. Piston Rod
8. Park Brake Air Inlet
9. Service Brake Air Inlet
10. Factory Sealed Clamp Ring (**do not remove**)

Fig. 1, Brake Chamber

1. Chock all tires.
2. Remove the dust plug from the center-hole in the head of the chamber. See **Fig. 2**.

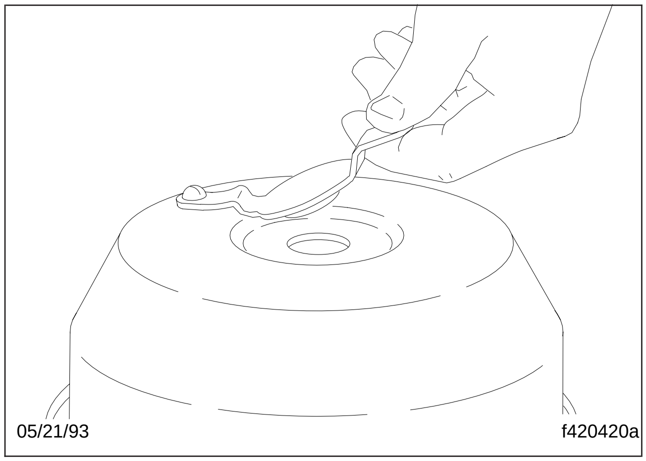


Fig. 2, Remove the Dust Plug

DANGER

Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber.

3. Manually release the parking brake (cage the power spring).

   3.1 Using a hand wrench, (*Do not use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. See **Fig. 3**.

   IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

   3.2 Insert the release bolt into the center-hole in the chamber head. See **Fig. 4**. Continue to insert the bolt until it bottoms out into the hole in the pressure plate inside the chamber.

   IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged

Manual Release of Spring Brake (Caging)

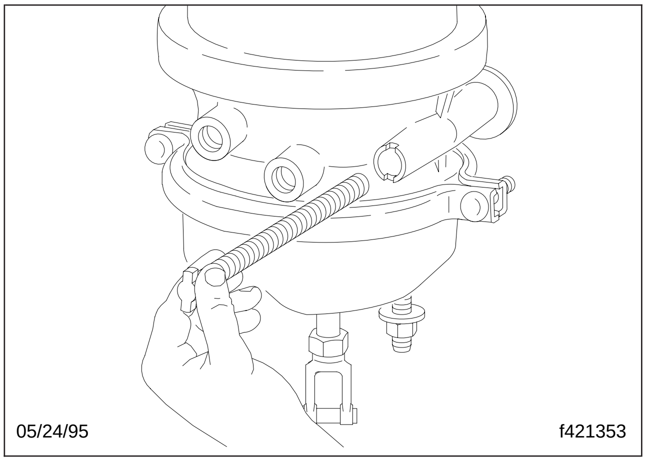


Fig. 3, Remove the Release Bolt

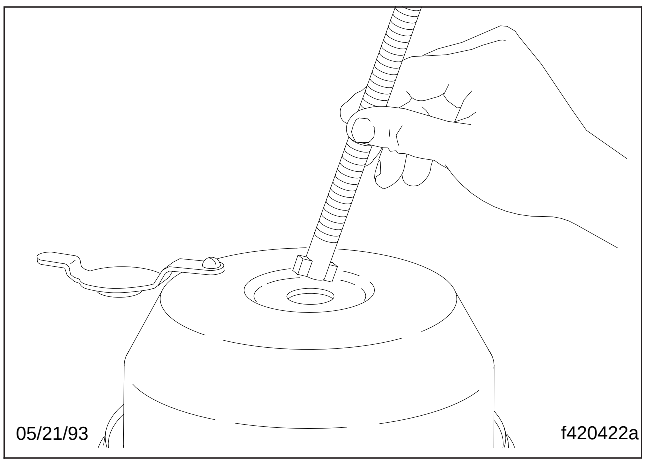


Fig. 4, Insert the Release Bolt

the pressure plate correctly, repeat this step. Repeat it until you are absolutely sure.

3.3 Turn the release bolt one-quarter turn clockwise. Pull to seat the formed end of the release bolt in the recess of the pressure plate.

3.4 Holding the release bolt locked into the pressure plate, install the flatwasher and release nut on the end of the bolt, and turn down the nut against the flatwasher until it is finger-tight. See **Fig. 5**.

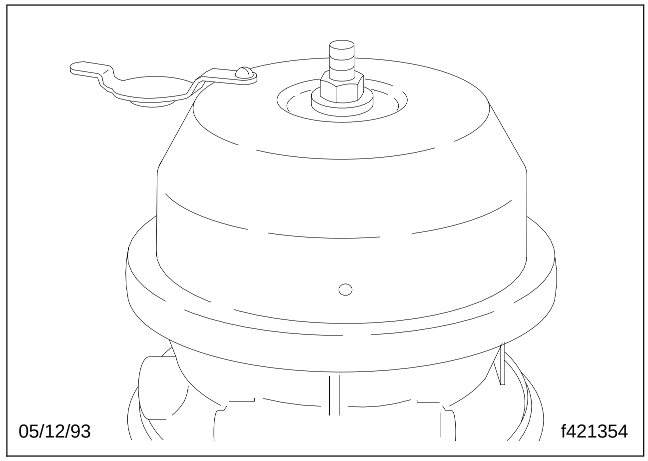


Fig. 5, Flatwasher and Release Nut Installed

DANGER

Exhaust all air pressure before tightening the release nut more than finger-tight. Tightening this nut under pressure can damage the pressure plate and result in sudden release of the power spring, causing death or severe personal injury.

CAUTION

If equipped with S-cam, do not exceed 35 lbf·ft (47 N·m) torque on the release nut; if equipped with wedge brakes, do not exceed 20 lbf·ft (27 N·m) torque on the release nut.

3.5 Using a hand wrench (*do not use an impact wrench*), turn the release nut clockwise until the power spring is caged (see **Fig. 6**).

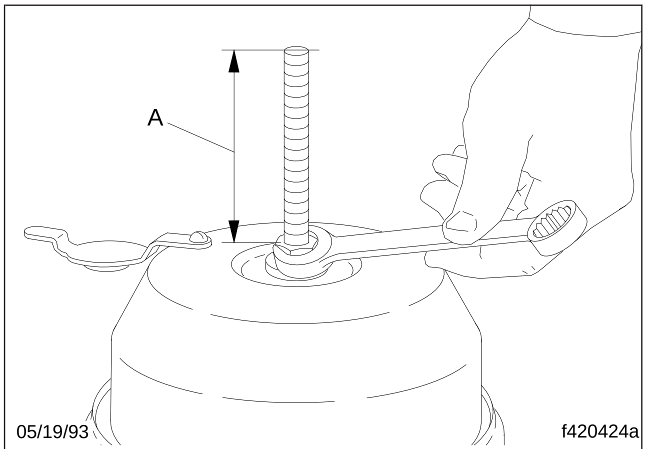
The bolt should extend above the nut at least 2.915 inches (74 mm) on 24-inch chambers, or 2.875 inches (73 mm) on 30-inch chambers.

IMPORTANT: Do not exceed these bolt lengths. If the bolt lengths can't be obtained without exceeding the recommended maximum torque values, replace the tandem brake chamber.

Uncaging the Park Brake

1. Uncage the power spring.

Manual Release of Spring Brake (Caging)



A. Measure this distance.

Fig. 6, Turn the Release Nut

CAUTION

Do not use an impact wrench on this nut. Too much torque could damage the pressure plate and prevent manual release of the parking brake.

1.1 Use a hand wrench to turn the release nut *counterclockwise* until the power spring extends back into the parking/emergency brake chamber.

NOTE: When the power spring is fully extended, force will no longer be felt on the release nut.

1.2 Remove the nut and flatwasher.

1.3 Turn the release bolt one-quarter turn counterclockwise and unlock the bolt from the receptacle in the pressure plate. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench, (*do not use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. Tighten the nut 5 to 8 lbf·ft (6.8 to 10.8 N·m). See **Fig. 7**.

3. Snap the dust plug in place over the center-hole in the chamber head. See **Fig. 8**.

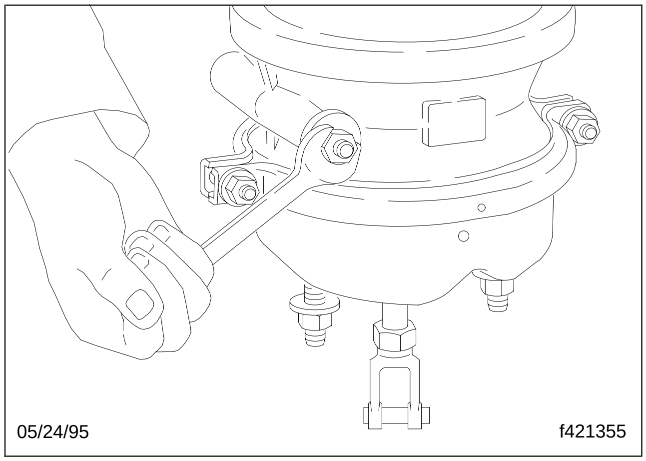


Fig. 7, Tighten the Release Nut

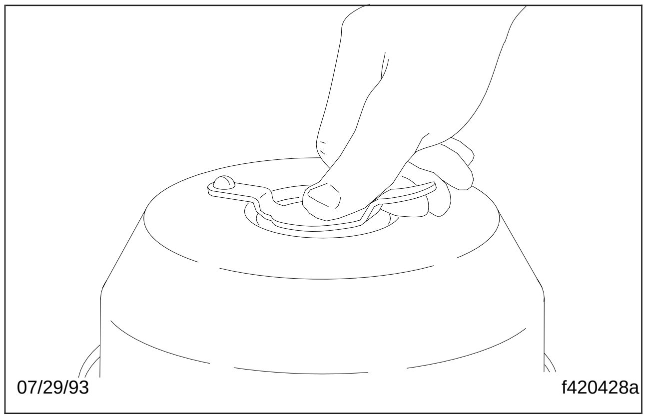


Fig. 8, Snap the Dust Plug in Place

CAUTION

If a dust plug is missing or incorrectly installed, road dirt and debris can enter the brake chamber and cause the internal parts to deteriorate.

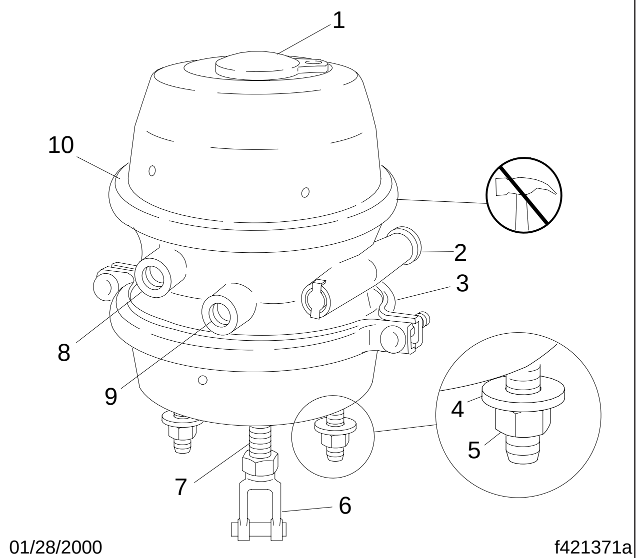
4. Check the plastic dust plug, and replace it with a new one at once if damaged or missing.

5. Remove the chocks from the tires.

Service Brake Diaphragm Replacement

DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Locknut
6. Clevis Assembly
7. Piston Rod
8. Park Brake Air Inlet
9. Service Brake Air Inlet
10. Factory Sealed Clamp Ring (**do not remove**)

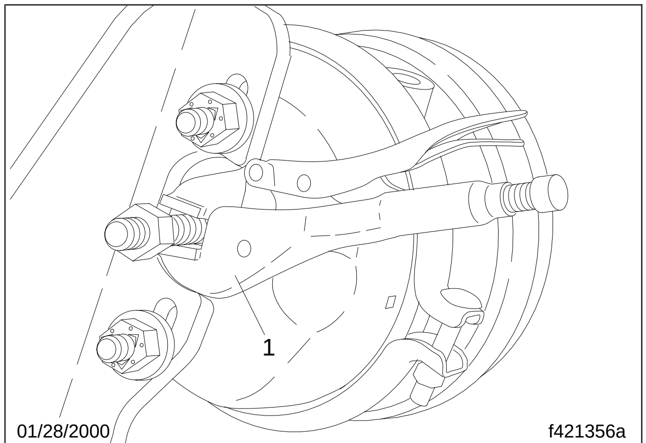
Fig. 1, Brake Chamber

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released. See Fig. 2.



1. Vice Grips

Fig. 2, Lock the Extended Rod with Vice Grips

WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, see Subject 100.
3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

DANGER

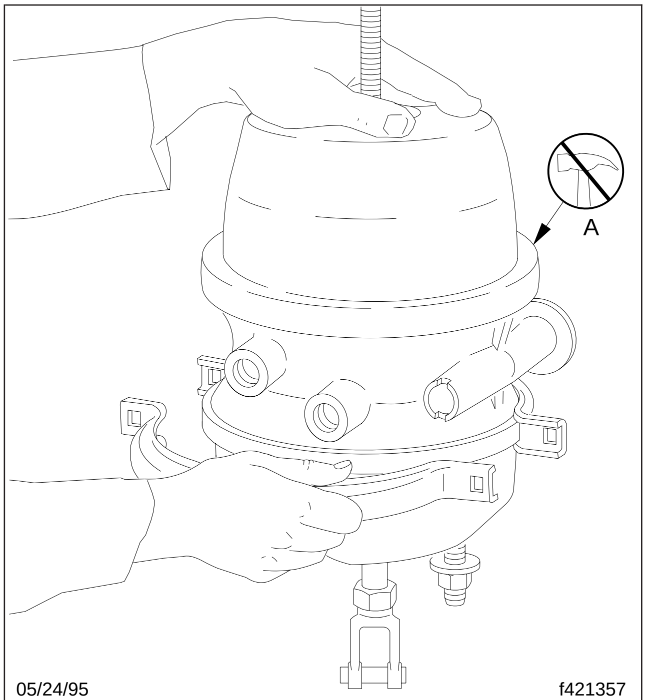
Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4. Remove the parking brake and adaptor from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the *service* brake clamp ring (*do not disassemble the parking brake section*).

Service Brake Diaphragm Replacement

4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber. See **Fig. 3**.



A. Do not remove the factory-sealed clamp ring.

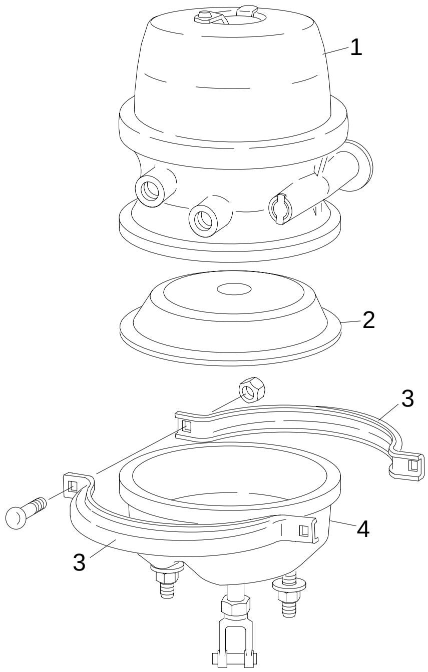
Fig. 3, Remove the Service Clamp Ring

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts.
2. Place the new service brake diaphragm in the bottom recess of the adaptor. See **Fig. 4**.
3. Install the (new, if needed) parking/emergency brake section.



1. Parking/Emergency Brake and Adaptor
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4, Brake Chamber Parts

3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

3.2 Check that the release bolt is fully extended outward. For instructions, see **Subject 100**.

3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

4. Install the service brake clamp ring.

4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp nut 20 to 30 lbf·ft (27.1 to 40.6 N·m) while

Service Brake Diaphragm Replacement

constantly rechecking the alignment of mating parts.

4.3 Lightly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. If re-alignment is needed, loosen the nuts again, and repeat this step.

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 10 lbf·ft (13.5 N·m).
6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 10 lbf·ft (13.5 N·m).
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

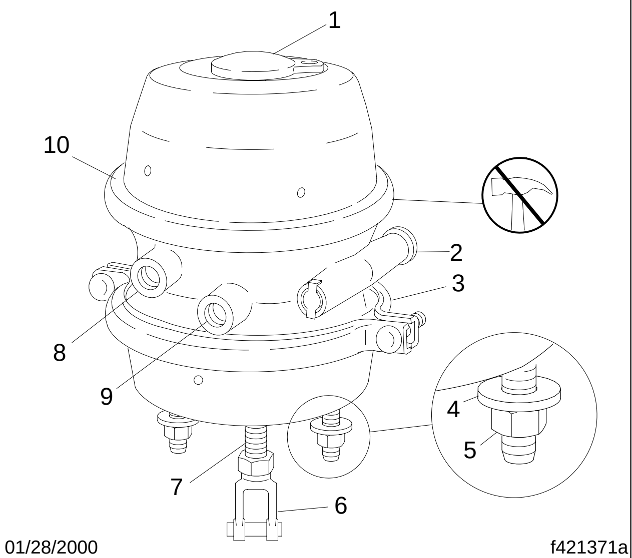
8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 20 to 30 lbf·ft (27.1 to 40.6 N·m) torque on the clamp hexnuts.
9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, uncage the power spring on the park brake chamber, and snap the dust plug in place. For instructions, see **Subject 100**.
10. Adjust the brakes at the slack adjuster. Refer to the appropriate section in this manual.

IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, see the applicable slack adjuster section in this group.

Combination Service and Parking Brake Chamber Removal and Installation

DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Locknut
6. Clevis Assembly
7. Piston Rod
8. Park Brake Air Inlet
9. Service Brake Air Inlet
10. Factory Sealed Clamp Ring (**do not remove**)

Fig. 1, Brake Chamber

Removal

WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

1. Manually release the parking brake (cage the power spring). For instructions, see **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the brake chamber from the vehicle.
   3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

   NOTE: Automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   3.2 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

Installation

1. If installing a new brake chamber unit, do the following steps:
   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the= rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the locknuts and hardened flatwashers from each of the mounting studs on the chamber.
2. Clean the face of the mounting bracket, and position the chamber on the bracket. Pay close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

Combination Service and Parking Brake Chamber Removal and Installation

WARNING

Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 130 lbf·ft (176 N·m). Make sure that the hardened flatwasher is installed between the locknut and the mounting bracket.
4. Check mating and alignment with the vehicle air lines. If the alignment is okay, skip to the next step.

DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

Alternately tighten each clamp nut in while constantly rechecking the alignment of mating parts. Tighten the nuts 20 to 30 lbf·ft (27.1 to 40.6 N·m).

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Lightly tap around the circumference of the service clamp ring to ensure full seating of the clamp.

5. Connect the slack adjuster. Refer to the applicable slack adjuster section in this group for installation instructions.
6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.
7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 10 lbf·ft (13.55 N·m).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 10 lbf·ft (13.55 N·m).

DANGER

Do not attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 20 to 30 lbf·ft (27.1 to 40.6 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, uncage the power spring, and snap the dust plug in place. For instructions, see **Subject 100**.
10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and

Combination Service and Parking Brake Chamber Removal and Installation

foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Specifications

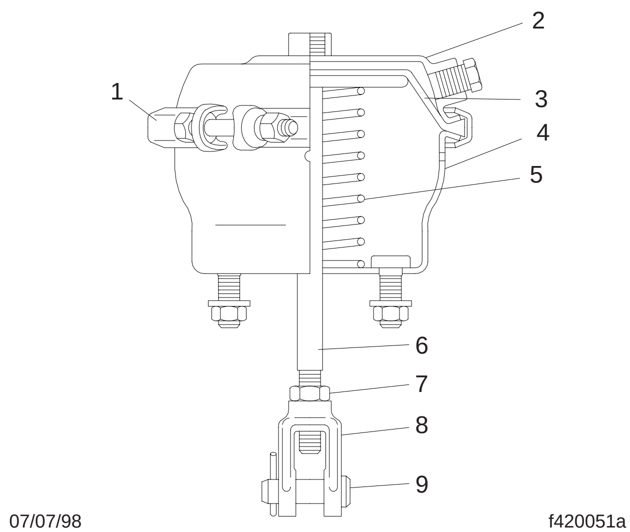
Torque Values	
Description	**Torque lbf·ft (N·m)**
Spring Brake Release Bolt Nut:	
(in storage pocket)	5 to 8 (6.7 to 10.8)
(caged—on S-cam brakes)	25 to 35 (34 to 47)
(caged—on wedge brakes)	20 (27)
Service Brake Clamp Ring Nut	20 to 30 (27 to 40.6)
Brake Chamber Mounting Stud Locknut	130 (176)
Air Hose Fitting-to-Chamber	10 (13.5)

Table 1, Torque Values

General Description

Brake chambers convert the energy of compressed air into the mechanical force and motion needed to apply the brakes. Two chambers operate the brakes, one on each side of the axle.

Each brake chamber consists of two dished metal sections: the cover assembly and the body assembly, which are separated by a nylon-neoprene diaphragm. A metal two-segment clamp ring holds the assemblies together. See **Fig. 1**.



1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

In front of the diaphragm are the body, piston rod assembly, and a piston rod spring. The threaded piston rod assembly extends through the bottom of the body and connects to the clevis. See **Fig. 1**.

Different sized brake chambers are identified by numbers, which specify the effective area of the diaphragm. For example, a type 16 brake chamber has 16 square inches of effective area.

Principles of Operation

The greater the air pressure admitted to the brake chamber, the greater the force applied by the piston rod. Piston rod force is determined by multiplying the delivered air pressure by the effective diaphragm area. For example, if 60 psi (415 kPa) is admitted to a type 16 brake chamber, the force on the end of the piston rod is about 960 lb (436 kg).

When the brake pedal is depressed, air pressure from the brake valve passes through the port in the brake chamber cover to move the diaphragm and piston rod assembly forward. This compresses the spring, and applies a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

When the brake pedal is released, compressed air behind the diaphragm exhausts through the quick release valve. The spring then allows the piston rod assembly and diaphragm to return to their previous positions.

Brake Chamber Operating and Leakage Tests

NOTE: For both of these tests, the air system must be pressurized to at least 80 psi (550 kPa).

Operating Test

1. Chock the tires.
2. Apply the brakes. Check that each piston rod moves out promptly, without binding.
3. Release the brakes. Check that each piston rod returns to the released position promptly, without binding.
4. Check the brake chamber stroke. It should be as short as possible without causing the brakes to drag. If needed, adjust the travel of the piston rod at the slack adjuster. For instructions, refer to the foundation brake section in this manual.

Leakage Test

1. Apply the brakes and hold them on full line pressure of at least 80 psi (550 kPa).
2. Using a soap solution, coat the clamp ring. Leakage is excessive if it produces a 1-inch (25-mm) bubble within five seconds.

CAUTION

Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

3. If the leakage is excessive, tighten the clamp ring flange nuts evenly until the leakage is reduced. For acceptable torque ranges, see **Specifications 400**.
4. Using a soap solution, coat the area around the piston-rod hole. No leakage is permitted. If there is leakage, replace the diaphragm. For instructions, see **Subject 110**.

Brake Chamber Diaphragm Replacement

Replacement

NOTE: This procedure is for service of a leaking brake chamber *diaphragm only*. If there are any other problems, refer to the applicable subjects elsewhere in this section.

1. Chock the tires.

WARNING

Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Back off the slack adjuster; for instructions, refer to the applicable slack adjuster section in this manual. Pull out the piston rod. See **Fig. 1**. Clamp the rod at the chamber body to protect it from damage.
4. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. See **Fig. 2**.
5. Replace the diaphragm.

   5.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.

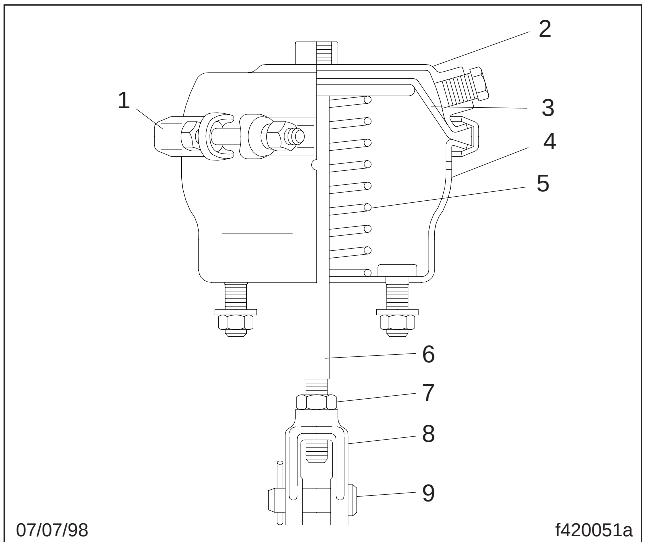
   5.2 Remove the cover assembly, and replace the diaphragm.

CAUTION

Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

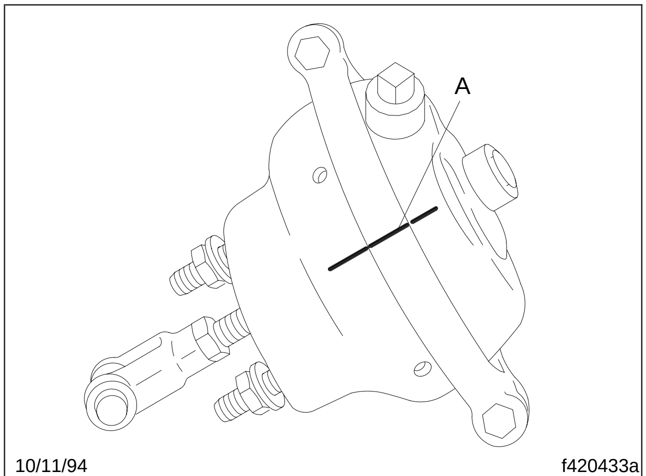
   5.3 Position the cover assembly and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly to eliminate leakage. For acceptable torque ranges, see **Specifications 400**.

6. Release the clamp on the piston rod.



1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View



A. Reference Line

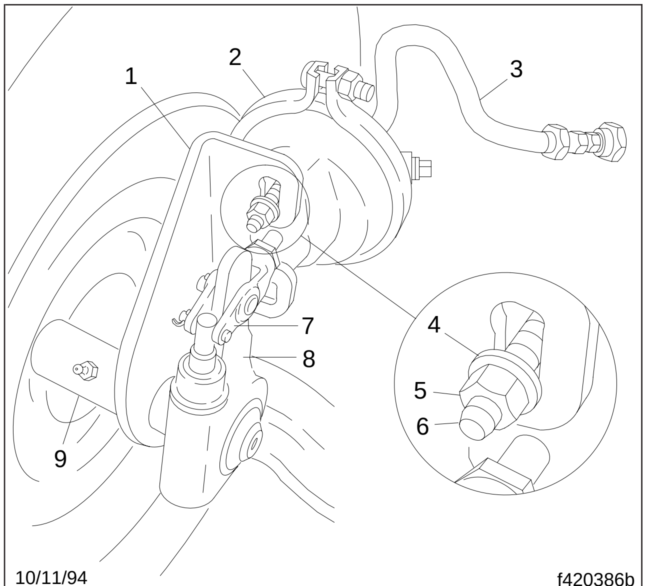
Fig. 2, Mark a Reference Line

Brake Chamber Diaphragm Replacement

7. Do both of the tests in **Subject 100**.
8. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this manual.
9. Remove the chocks from the tires.

Brake Chamber Removal and Installation

Removal (See Fig. 1)



1. Chamber Mounting Bracket
2. Brake Chamber
3. Air Line
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Chamber Mounting Stud
7. Clevis Assembly
8. Slack Adjuster (Automatic Type)
9. Camshaft Tube

Fig. 1, Brake Chamber Mounting

1. Chock the tires.

WARNING

Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in severe personal injury.

Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Carefully disconnect the air line from the brake chamber.
4. Remove the brake chamber.
   - 4.1 Remove the cotter pin(s) from the clevis pin(s).

   NOTE: Automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   - 4.2 Remove the clevis pin(s) from the slack adjuster.
   - 4.3 From each mounting stud, remove any installed nuts and washers. Remove the brake chamber from the vehicle.

Installation (See Fig. 1)

1. Before installing a new chamber, be sure the new chamber is the same size and make as the brake chamber on the other side of the axle.
2. Install the brake chamber.
   - 2.1 Attach the brake chamber to the mounting bracket using a hardened flatwasher and prevailing torque locknut. Install the flatwasher between the locknut and the mounting bracket.
   - 2.2 Tighten the locknuts. See Table 1 for the correct torque value.

Description	Chamber Size (in ^{2})	Torque lbf·ft (N·m)
Brake Chamber Mounting-Stud Locknuts	12	30 (41)
	16 (7/16-inch Stud)	40 (54)
	16 (1/2-inch Stud)	75 (102)
	20	100 (136)
	24	100 (136)

Table 1, Mounting-Stud Locknut Torque Values

   - 2.3 Connect the clevis pins to the slack adjuster.
   - 2.4 Install and lock new cotter pin(s) to secure the clevis pin(s).

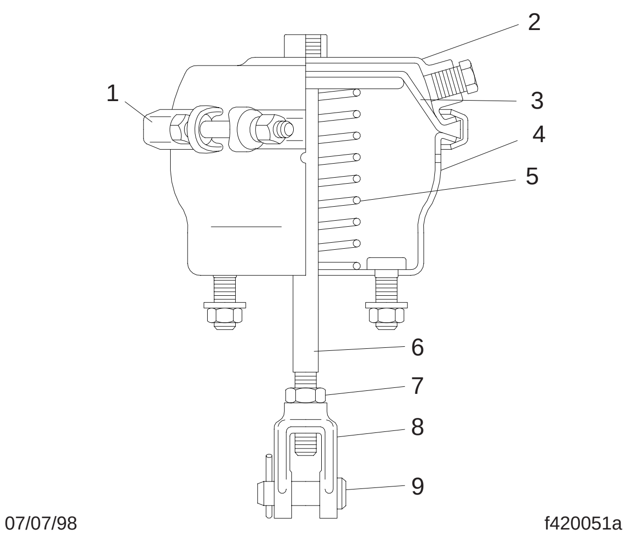
   NOTE: Automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

Brake Chamber Removal and Installation

3. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this manual.
4. Connect the air line to the brake chamber.
   - 4.1 Check that the hoses are properly supported and, if needed, clamped to provide good clearance.
   - 4.2 Before connecting the air line, make sure the fittings are clean and free of debris.
   - 4.3 Connect the air line as follows: tighten the nut finger-tight. Using a wrench, further tighten the nut until there is resistance, then tighten one-sixth turn more.
5. Do both of the tests in **Subject 100**.
6. Remove the chocks from the tires.

Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

Disassembly (See Fig. 1)

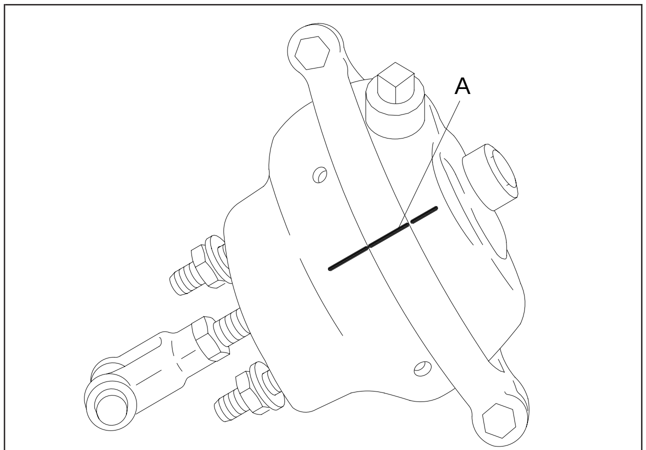


1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

NOTE: If the brake chamber is to be disassembled without removing the body assembly from the vehicle, first back off the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

1. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. See **Fig. 2**.
2. Pull out the piston rod. Clamp the rod at the chamber body to protect it from damage.
3. Disassemble the brake chamber.
   - 3.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 3.2 Remove the cover assembly and the diaphragm.
   - 3.3 Remove the clevis locknut and clevis from the piston rod, and release the clamp on the piston rod, being careful to contain the piston rod assembly and body until the return spring is relaxed.
   - 3.4 Remove the piston rod assembly and spring.



A. Reference Line

Fig. 2, Mark a Reference Line

Inspection and Cleaning

1. Clean all metal parts with cleaning solvent.
2. Inspect all parts for wear or damage; replace as needed.
   - 2.1 Check the cover and the body for dents. If any are too deep to be pounded out, replace as needed.
   - 2.2 Check the diaphragm for wear or deterioration and replace it if necessary. Midland recommends replacement of the diaphragm whenever the service brake chamber is opened for inspection.
   - 2.3 Inspect all other parts not considered serviceable. Replace if necessary.

Assembly

1. Stand the piston rod assembly upright on a flat surface (if the chamber was removed from the vehicle).
2. Assemble the brake chamber.

Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

2.1 Place the return spring on the piston rod.

2.2 Place the body on the piston rod assembly, and press the body down, working against the tension of the spring, until the body bottoms out on the flat surface. Clamp the rod at the body, making sure to protect the rod from damage. Insert the piston rod assembly through the body and clamp the rod (if the body wasn't removed from the vehicle).

2.3 Place the diaphragm in the body.

CAUTION

Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

2.4 Position the cover assembly and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly to eliminate leakage. For acceptable torque ranges, see **Specifications 400.**

3. Install the clevis locknut and clevis, and release the clamp on the piston rod.
4. If the brake chamber was removed from the vehicle, install it. For instructions, see **Subject 120**.
5. Do both of the tests found in **Subject 100.**

Specifications

Description	Chamber Size: in ^{2}	Torque: lbf·ft (N·m)
Brake Chamber Mounting-Stud Locknuts	12	30 (41)
	16 (7/16-inch Stud)	40 (54)
	16 (1/2-inch Stud)	75 (102)
	20	100 (136)
	24	100 (136)

Table 1, Mounting-Stud Locknut Torque Values

Description	Chamber Size: in ^{2}	Torque: lbf·in (N·cm)
Clamp Ring Flange Nuts	12	200–250 (2260–2820)
	16	200–250 (2260–2820)
	20	110–225 (1240–2540)
	24	150–225 (1700–2540)

Table 2, Clamp Ring Torque Values

Description	Chamber Size: in ^{2}	Torque: lbf·ft (N·m)
Piston Rod Nuts	12	20–30 (27–41)
	16 (7/16-inch Stud)	20–30 (27–41)
	16 (1/2-inch Stud)	20–30 (27–41)
	20	33–90 (45–122)
	24	33–90 (45–122)

Table 3, Piston Rod Nut Torque Values

General Information

This troubleshooting guide is designed to help locate causes of problems originating in the air brake system. The corrective measures given are not intended to replace the detailed service information found in other sections of this manual or in the component manufacturer's service manuals. If the vehicle is equipped with ABS (antilock brake system), refer to the applicable section in this group for troubleshooting the ABS system.

Before attempting to isolate the causes of an air brake system problem, do the following:

1. Check the operation of the air compressor. Refer to the engine manufacturer's service manual.

   Check the pressure levels of the air reservoirs. See the pretrip inspection and daily maintenance chapter of the *Columbia Driver's Manual*.
2. Be sure that all relay valves are operating. See Group 42 of the *Columbia Maintenance Manual*.
3. Check the operation of the brake chambers as instructed in Group 42 of the *Columbia Maintenance Manual*.
4. Examine all tubing for kinks, dents, and other damage. Replace damaged tubing.
5. Examine all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
6. Examine all air line fittings. Tighten loose connections; replace fittings that are damaged. For instructions, refer elsewhere in this group.
7. Examine leaking pipe connections for cracks or thread damage; replace as needed. If there is no damage, retighten the fitting. For instructions, refer elsewhere in this group.

Safety Precautions

WARNING

Follow the manufacturer's procedures while working on any air device. Some parts are subject to mechanical (spring) or pneumatic propulsion and may cause personal injury or property damage when released. Failure to take all necessary precautions during servicing of the air brake system can result in personal injury or property damage.

Compression and storage of air in the air brake system is comparable to the energy in a coiled spring: when released, it may present a hazard. Because of this, certain precautions are required.

1. Chock the tires. This will prevent accidental rolling of the vehicle when air is released from the brake system.
2. Don't disconnect pressurized hoses because they will whip as air escapes from the line. Drain the air system before disconnecting the air hoses.
3. When draining the air system, do not look into the air jets or direct them toward another person: dirt particles or sludge may be carried in the air stream.
4. As air pressure is drained and the parking/ emergency brakes apply, keep your hands away from the brake chamber push rods and parking brake chambers, which will activate automatically with the loss of pressure.

Troubleshooting Tables

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied	
Possible Cause	**Remedy**
The vehicle is overloaded.	Observe the recommended maximum load limits.
There is low air pressure in the brake system, about 60 psi (413 kPa) or lower.	The drain cock on the air reservoir was left open; close the drain cock.
	Check the compressor output pressure; correct as necessary.
	Check the setting of the air governor with an accurate test gauge. Adjust the air governor to the recommended specification.
The application air lines are leaking excessively.	Check the application air lines, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged component(s).
Brake valve delivery pressure is below normal.	Lubricate the brake valve parts; overhaul the unit, if necessary.
Wear or glazing of the brake linings is present.	Install new brake linings on the brake shoes on both sides of the axle.
Adjustment or lubrication of the brakes is needed.	Adjust or lubricate the brakes.
The automatic slack adjusters are not operating.	Lubricate the automatic slack adjusters and check for binding, damaged, or inoperative slack adjuster parts. Replace damaged or inoperative parts, or eliminate the cause of the binding.
The cam has flipped over.	Replace the linings and the cam on each end of the axle.
One or more of the brake drums is broken or cracked.	Replace the brake drum(s).
Wrong size brake linings were installed.	Replace the brake linings with the recommended size.
Wrong size brake chambers were installed.	Replace the brake chambers with the recommended size.
A camshaft bracket or chamber mounting bracket is bent or broken.	Replace the camshaft bracket or chamber mounting bracket.
The brake chamber mounting stud nuts or brake chamber mounting bracket is loose.	Tighten the brake chamber to its mounting bracket or the mounting bracket to the foundation brake housing.
There is a ruptured diaphragm in the service brake.	Replace the diaphragm.

Problem—Service Brakes Release Too Slowly

Problem—Service Brakes Release Too Slowly	
Possible Cause	**Remedy**
The brake shoe anchor pins are frozen.	Inspect the anchor pins. If damaged, replace them; if not damaged, lubricate them.
Lubrication of the brake system components is inadequate.	Lubricate those components requiring periodic lubrication.
The brake foot valve is not returning to the fully released position.	Check for obstructions which might prevent the brake foot valve from returning to the fully released position. Remove any obstructions.

Troubleshooting

Problem—Service Brakes Release Too Slowly	
Possible Cause	**Remedy**
The exhaust port of the brake foot valve or quick-release valve is plugged.	Clear the exhaust port of obstructions.
The brake foot valve or quick-release valve is inoperative.	Overhaul or replace the inoperative valve, as needed.
The camshaft and bushings are binding.	Clean and lubricate the camshaft bushings.
The brake shoe return spring is weak or broken.	Replace the spring.

Problem—Service Brakes Do Not Apply or Apply Too Slowly

Problem—Service Brakes Do Not Apply or Apply Too Slowly	
Possible Cause	**Remedy**
Lubrication of the foundation brake assembly is needed.	Lubricate those components requiring periodic lubrication.
There is insufficient air pressure in the brake system.	Check all parts of the air pressure system for leaks or inoperative components.
The brake foot valve or relay valve is inoperative.	Repair or replace the brake foot valve or relay valve.
The camshaft bushings are binding.	Clean and lubricate the camshaft bushings.

Problem—Service Brakes Apply When the Parking Brakes Are Released With Air Pressure

Problem—Service Brakes Apply When the Parking Brakes Are Released With Air Pressure	
Possible Cause	**Remedy**
The air delivery lines to the brake chamber have been reversed.	Reverse the connections of the brake chamber air lines.

Problem—Service Brakes Do Not Release

Problem—Service Brakes Do Not Release	
Possible Cause	**Remedy**
The brake shoes are incorrectly adjusted.	Adjust the brakes. Also, make sure the slack adjuster is operating correctly. If not, overhaul or replace the slack adjuster.
The brake foot valve may not be in the fully released position.	Lubricate the brake foot valve if needed.
The brake foot valve is inoperative.	Overhaul or replace the brake foot valve.
There is restriction in the tubing, hose, or exhaust port of the brake foot valve or quick-release valve.	Check for bends or obstructions on the exhaust side of the service brakes. Remove any obstructions; plumb the air lines so that bends are minimal.
A broken power spring may be blocking the parking brake piston movement.	Replace the power spring or replace the parking brake assembly, whichever is recommended by the parking brake manufacturer.

Troubleshooting

Problem—Service Brakes Grab or Pull

Problem—Service Brakes Grab or Pull	
Possible Cause	**Remedy**
There is not enough weight on the vehicle (underloaded).	Add weight to the vehicle, reducing brake sensitivity.
Adjustment of the brakes on one axle is uneven.	Adjust the brakes.
Lubrication of the brake system components is inadequate.	Lubricate those components requiring periodic lubrication.
The brake mechanism is binding.	Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened.
The clevis pin or camshaft is binding at one or more wheels.	Clean and lubricate the camshaft bushings.
A brake spider is loose.	Tighten the mounting bolts or replace the brake spider.
A slack adjuster is damaged.	Replace the damaged component.
The air chamber push rods or slack adjusters are a different length.	Replace the components with the correct size and material.
The brake foot valve is inoperative.	Overhaul or replace the brake foot valve, as needed.
If equipped with cam brakes, there is a flat or dent on the S-head camshaft or on the cam roller(s).	Replace the damaged component(s).
Grease has saturated the brake linings or the linings are glazed.	Install a matched set of linings on both sets of brake shoes on that axle. Clean, turn, or replace both brake drums. For instructions on turning drums, refer to the brake manufacturer’s service manual.
The brake linings are loose or broken.	Install a matched set of linings on both sets of brake shoes on that axle.
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new, matched set of brake linings. Clean, turn, or replace both brake drums on that axle. For instructions on turning drums, refer to the brake manufacturer’s service manual.
A brake shoe is distorted or broken.	Replace the brake shoe. Install a new, matched set of linings on both sets of brake shoes on that axle.
The pilot pads are damaged, allowing the brake drum to be installed out-of-round.	Replace the wheel hub.
A brake drum is out-of-round to unacceptable limits.	Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, refer to the brake manufacturer’s service manual.
One or more brake drums is scored or broken.	Replace both of the drums on that axle.

Problem—Uneven Service Brakes

Problem—Uneven Service Brakes	
Possible Cause	**Remedy**
The wrong brake linings were installed, or the linings were not replaced in pairs.	Replace the brake linings with the recommended size. Install new linings on both sets of axle brake shoes.

Troubleshooting

Problem—Uneven Service Brakes	
Possible Cause	**Remedy**
Grease has saturated the brake linings or the linings are glazed.	Install new linings on both axle brake shoes. Clean the brake drums.
The return spring for the brake shoe release or the service brake has broken.	Replace all broken springs.
The brake drum is out-of-round to unacceptable limits.	Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, refer to the brake manufacturer's service manual.
A service brake chamber diaphragm is leaking.	Tighten the clamp ring. If leaks persist, replace the service brake diaphragm.
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions, see **Group 33** or **Group 35** of this manual.
A brake spider is damaged.	Replace the brake spider.
The brake shoes are bent or stretched.	Replace the axle brake shoes on each wheel.
Grease, oil, or dirt is on the linings.	Replace the linings on each set of axle brake shoes. Clean the brake drums.

Problem—Dragging Service Brake

Problem—Dragging Service Brake	
Possible Cause	**Remedy**
The service brake return spring is broken.	Replace the service brake return spring.
The service-application air is not exhausting or not exhausting fast enough, due to blockage in the control valve, the quick-release valve, or the limiting and quick-release valve.	Test the air system valves for leakage and operation.
A brake shoe retracting spring is broken.	Replace the brake shoe retracting spring.
Binding is occurring in the camshaft linkage.	Lubricate the camshaft linkage. Replace bent or broken parts.

Problem—Insufficient Parking Brake Application When Dash Control Valve Is Activated

Problem—Insufficient Parking Brake Application When Dash Control Valve Is Activated	
Possible Cause	**Remedy**
The brakes are improperly adjusted.	Adjust the brakes.
A power spring is broken.	Replace the parking/emergency brake section.
A power spring in a parking brake is manually caged.	Release the power spring by screwing in the release bolt.

Troubleshooting

Problem—Dragging Brakes Due to Parking Brake Mechanism

Problem—Dragging Brakes Due to Parking Brake Mechanism	
Possible Cause	**Remedy**
The system air pressure is insufficient to fully release the parking brake.	Be sure that all air lines are clear. Check that the air governor cutout settings meet recommended specifications.
A parking brake diaphragm is ruptured or a piston seal is ineffective.	Replace the diaphragm or parking brake piston seal.

Problem—Air Pressure Will Not Rise to Normal

Problem—Air Pressure Will Not Rise to Normal	
Possible Cause	**Remedy**
The air pressure gauge(s) on the dash is (are) registering inaccurately.	Check the dash gauge(s) with an accurate test gauge. Replace the dash gauge(s) as needed.
There is excessive leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
The compressor is inoperative (including excessive leakage of the compressor).	Rebuild or replace the compressor.
The air reservoir drain cock has been left open.	Close the drain cock.
The air governor cutout setting is not adjusted correctly.	Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification.
There is inadequate clearance at the compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
If so equipped, the compressor drive belt is slipping.	Adjust or replace the compressor drive belt.
Carbon is building up in the compressor cylinder head or discharge line.	Remove the carbon. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory rebuilt or a new unit.
The driveshaft coupling is broken	Replace the coupling.

Problem—Air Pressure Rises Above Normal

Problem—Air Pressure Rises Above Normal	
Possible Cause	**Remedy**
The air reservoir pressure dash gauge is inaccurate.	Check the dash gauge with an accurate test gauge. Replace the dash gauge as needed.
The compressor air governor is out of adjustment.	Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification.
The air governor is not operating.	Repair or replace the air governor.

Troubleshooting

Problem—Air Pressure Rises Above Normal	
Possible Cause	**Remedy**
There is too much clearance at the air compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
The air compressor unloading valve is stuck closed.	
The air compressor unloading valve cavities or the unloading valve passage is blocked with carbon.	

Problem— Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released

Problem— Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released	
Possible Cause	**Remedy**
The brake foot valve is leaking.	Repair or replace the brake foot valve.
The air compressor discharge valve is leaking.	Repair or replace the discharge valve. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory-rebuilt or a new unit.
The air governor is leaking.	Repair or replace the air governor.

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied	
Possible Cause	**Remedy**
A service or parking brake chamber is leaking.	Tighten the clamp ring(s). If leaks persist, replace the diaphragm(s) or assembly.
The brake foot valve or relay valve is leaking.	Repair or replace the component(s) or assembly.

Problem—Compressor Knocks (Continuously or Intermittently)

Problem—Compressor Knocks (Continuously or Intermittently)	
Possible Cause	**Remedy**
There is a loose drive pulley, belt, coupling, or gear (as indicated).	Tighten or replace the component. If applicable, inspect the pulley shaft for damage. Replace the shaft, if damaged.
Backlash is in the compressor drive gears on the drive coupling.	Repair or replace the compressor drive gears or drive coupling.
The air compressor bearings are damaged or worn.	Replace the bearings.
There are carbon deposits in the compressor cylinder head.	Remove the carbon deposits or replace the compressor.

Troubleshooting

Problem—Pressure Relief Valve Activates

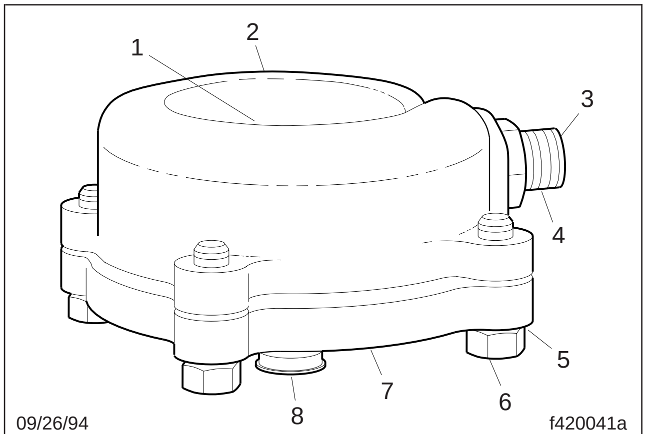
Problem—Pressure Relief Valve Activates	
Possible Cause	**Remedy**
The pressure relief valve is out of adjustment.	Adjust the pressure relief valve, or install a new one.
There is excessive air pressure in the brake system.	Refer to the problem "Air Pressure Rises Above Normal."

Problem—Oil or Water in the Brake System

Problem—Oil or Water in the Brake System	
Possible Cause	**Remedy**
Excessive oil is passing through the air compressor.	Rebuild or replace the compressor.
If so equipped, the air compressor air strainer is dirty.	Clean the strainer or install a new one.
Draining of the air reservoirs needs to be performed more often.	Drain the air reservoirs daily.
If so equiped, the air dryer desiccant cartridge is oil saturated.	Install a new desiccant cartridge.

General Description

The DV–2 automatic reservoir drain valve (**Fig. 1**) automatically removes contaminants and water from the wet-air tank each time the brakes are applied. The drain valve is attached to a drain cock located on the bottom of either end of the wet-air tank. Since the brake application valve is protected by a check valve between the wet-and dry-air tanks, any leak or failure will not reduce the supply of air that is in the dry part of the system. If the leak is severe, it could prevent the continued resupply of air as it is used up when applying the brakes. A failed drain valve will allow moisture to build up in the wet tank which in turn could reach the dry tank, and then travel into the air brake system where it could cause brake failure. A leaking drain valve allows wet tank leakdown which in turn can cause premature wear on the air compressor during vehicle operation as the air compressor continues to run to maintain wet tank air pressure.



1. Top Reservoir Port
2. Valve Body
3. Hexhead Nipple
4. Side Reservoir Port
5. Lockwasher (4 qty.)
6. Capscrew (4 qty.)
7. Valve Cover
8. Exhaust Port

Fig. 1, DV-2 Valve

Principles of Operation

With no pressure in the system, the drain valve's inlet and exhaust valves are closed. See **Fig. 2**. Upon charging the system, a slight pressure opens the inlet valve which permits air and contaminants to collect in the sump. See **Fig. 3**. The inlet valve remains open when pressure is rising in the system until the air compressor cuts off, allowing the spring action of the valve guide in the sump cavity to close the inlet valve. The inlet valve and the exhaust valve are now both closed. See **Fig. 4**. When the wet tank pressure drops approximately 2 psi (14 kPa), the air pressure in the sump cavity opens the exhaust valve and allows moisture and contaminants to be ejected from the sump cavity until pressure in the sump cavity drops sufficiently to close the exhaust valve. See **Fig. 5**.

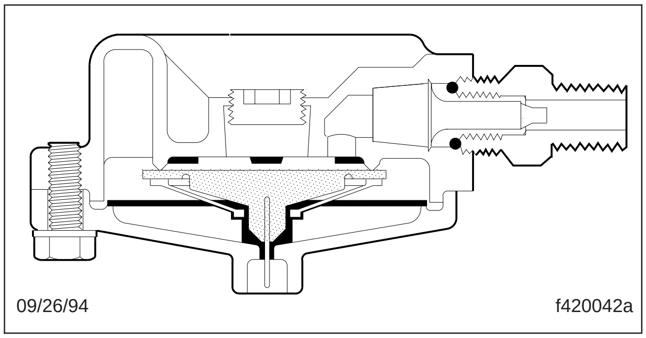


Fig. 2, No System Pressure

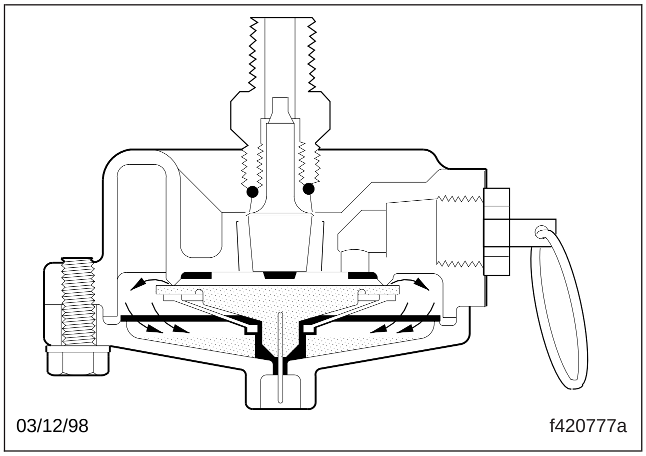


Fig. 3, Start of System Pressure Charging

The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected depends upon the sump pressure and the wet tank pressure drop that occurs each time air is used from the system.

General Information

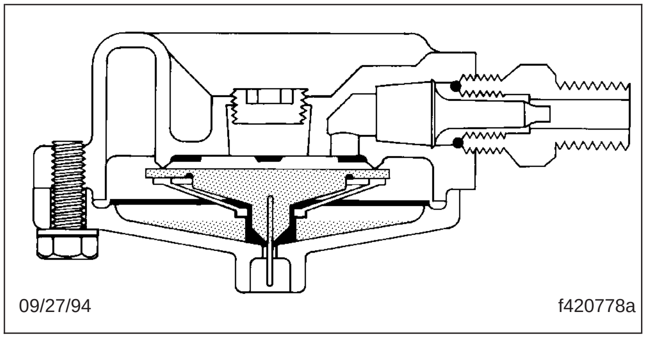


Fig. 4, System Pressure Rising

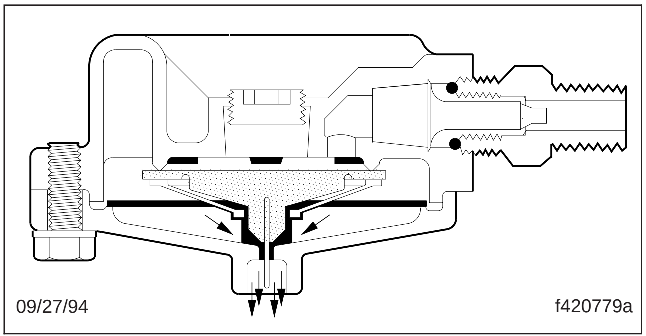


Fig. 5, Exhaust Cycle

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Always chock the vehicle's wheels and shut down the engine when working under a vehicle. Depleting vehicle air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing air pressure. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been depleted.
3. Never exceed recommended air pressure and always wear safety glasses when working with air pressure. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating Test

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

Perform the following test after repairing or replacing the DV–2 valve to ensure that the valve is functioning properly.

With the system charged, apply the brakes several times. Each time the brakes are applied, an exhaust of air should occur from the exhaust port of the drain valve. If no air comes out, push the wire stem located inside the exhaust port. If no air comes out after pushing the wire stem, there may be a plugged filter in the adapter which should be replaced.

If the drain valve does not function properly, repair or replace it following instructions in this section.

Leakage Test

Perform the following test after repairing or replacing the DV–2 valve to ensure that the valve is functioning properly.

With the system charged and pressure stabilized in the system, there should be no leaks at the drain valve exhaust port. A constant slight exhaust of air at the drain valve exhaust port could be caused by excessive leakage in the air brake system.

If the drain valve is leaking excessively, repair or replace it following instructions in this section.

Drain Valve Removal and Installation

Removal

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

1. Chock the tires, and drain the air system.
2. Remove the drain valve assembly from the end of the wet tank air reservoir.

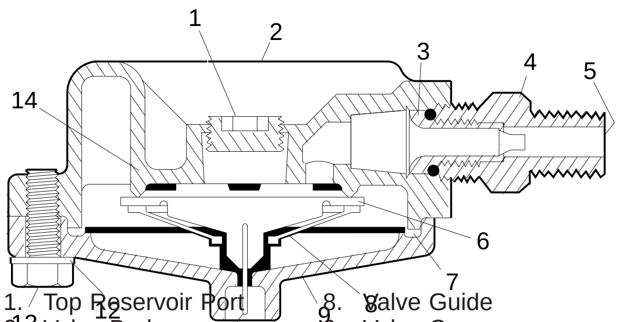
Installation

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

1. Using a cleaning solvent, thoroughly flush and clean the wet tank reservoir to avoid early fouling at the drain valve. Aerate the wet tank thoroughly if solvents were used during cleaning.
2. Install the drain valve assembly on the wet tank by tightening the hexagonal nipple until the drain valve is positioned so that the valve body is parallel to the bottom of the wet tank with the exhaust port facing straight down. Make sure that the exhaust port is clear of any air, electric, or fuel lines. Make sure the drain valve is attached tight enough to prevent leakage.
3. Close the drain cocks to the wet and dry air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the drain valve following the instructions in **Subject 110**.

Drain Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. Top Reservoir Port
2. Valve Body
3. Filter Retainer
4. Hexhead Nipple
5. Side Reservoir Port
6. Inlet and Exhaust Valve
7. Valve Sealing Ring
8. Valve Guide
9. Valve Cover
10. Exhaust Port
11. Wire Stem
12. Lockwasher (4 qty.)
13. Capscrew (4 qty.)
14. Inlet Valve Seat

Fig. 1, DV-2 Valve (cutaway view)

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

1. Remove the drain valve following the instructions in **Subject 120**.
2. Remove the four capscrews that hold the valve cover to the valve body.
3. Remove the valve cover and sealing ring.
4. Remove the valve guide, and the inlet and exhaust valve from the valve body.
5. Remove the hexhead nipple from the valve body.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

WARNING

Use eye protection when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the drain valve in an approved cleaning solvent. Dry the metal parts of the disassembled moisture ejection valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for wear cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise deteriorated, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked, or otherwise damaged, replace them with new parts.
4. Clean and examine the filter. If it will not clean completely, or is torn or damaged, replace it with a new filter.

CAUTION

Do not reassemble the drain valve with a dirty filter; to do so could result in failure of the drain valve in service.

Assembly (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions 100**.

Before assembling the drain valve, apply a light film of grease on the inlet valve seat.

CAUTION

Do not apply oil to the inlet and exhaust valve.

1. Install the valve sealing ring into its groove in the valve cover.
2. Install the valve guide over the inlet and exhaust valve.
3. Install the valve guide, and the inlet and exhaust valve as an assembly into the valve cover. The wire stem will project through the exhaust port.
4. Install the valve body on the valve cover and install the lockwashers and capscrews. Tighten the capscrews 6 to 8 lbf·ft (8 to 11 N·m).
5. Install the hexhead nipple onto the valve body, and tighten it 4 to 6 lbf·ft (5.5 to 8 N·m).

Drain Valve Disassembly, Cleaning and Inspection, and Assembly

6. Install the drain valve on the wet tank following the instructions in **Subject 120**.

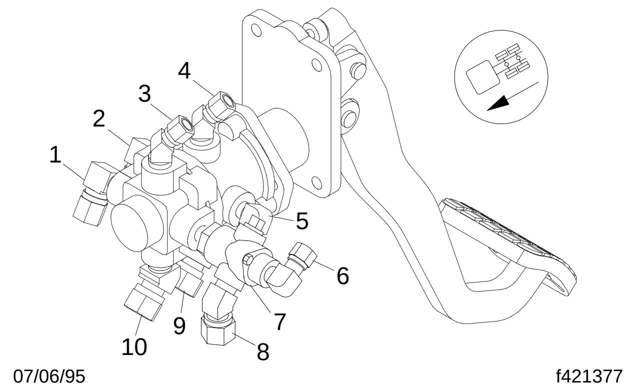
Specifications

Description	Torque lbf·ft (N·m)
Valve Cover Capscrews	6 to 8 (8 to11)
Hexhead Nipple (to valve body)	4 to 6 (5.5 to 8)

Table 1, Torque Values

General Information

General Description (See Fig. 1)



1. Secondary Delivery Circuit to Front Brake Valve
2. Primary Delivery Circuit to Rear Brake Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Primary Delivery Circuit to Tractor Protection Valve
6. Delivery Circuit to Trailer Hand Valve
7. Double Check Valve
8. Secondary Delivery Circuit to Tractor Protection Valve
9. Primary Supply Circuit to Primary Supply Reservoir
10. Secondary Supply Circuit to Secondary Supply Reservoir

Fig. 1, Brake Valve and Double Check Valve Plumbing Circuits

The Bendix DC–4 shuttle type double check valve is normally used only when the vehicle is equipped with a trailer hand control valve. Double check valves are used in the air brake system to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure. A shuttle type valve has a movable shuttle to seal off the lower pressure source and allow the air from the higher pressure source to flow.

In this case, the valve allows air to be supplied to the trailer brakes from either the hand control valve or the foot valve, whichever supplies the higher pressure. This allows the trailer brakes to be applied with either the hand valve or the foot valve. If both the foot and hand valves are applied simultaneously, the DC–4 valve will supply air to the trailer brakes from whichever valve is applying higher pressure.

Principles of Operation

As pressurized air enters either end of the double check valve inlet port, the moving shuttle responds to the greater pressure source and seals the opposite port. The air flow continues out the delivery port of the valve. The position of the shuttle will reverse if the pressure levels are reversed. Double check valves are designed so the shuttle cannot interfere with the backflow of air in the exhaust mode.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and shut down the engine before working under a vehicle. Dropping air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jet or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if they are not correctly disassembled. Use only the correct tools, and observe all precautions regarding use of those tools.

Operating and Leakage Test

1. If testing the valve while in the vehicle, proceed as follows:

   1.1 Push in and release the foot brake pedal while checking that the brakes apply and release on both the tractor and trailer.

   1.2 Apply and release the trailer control valve while checking that only the trailer brakes apply and release.

   1.3 Apply the trailer control valve and check the exhaust port of the foot brake valve for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in 5 seconds is allowable. Release the valve.

   1.4 Disconnect the air line from the trailer control valve exhaust port. Push the foot brake pedal until it stops and hold it in place. Check the trailer control valve exhaust port for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in five seconds is allowable.

   1.5 Connect the air line to the trailer control valve exhaust port.

   1.6 If the double check valve does not function as described, or if the leakage is excessive, replace it. See **Subject 120** for instructions.

   If the valve cannot be replaced, repair it using Bendix parts. See **Subject 130** for instructions.

2. Connect two separately controlled air supplies to the inlet ports.

3. If bench testing the valve, proceed as follows.

   3.1 Apply and release air to one inlet port (foot brake pedal) while checking that the test gauge registers the application and release.

   3.2 Apply and release air to the other inlet port (trailer control valve) while checking that the gauge registers the application and release.

   3.3 Disconnect the line from one of the double check valve inlet ports. Apply air to the opposite inlet port while checking the first port for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in 5 seconds is allowable. Connect the line to the inlet port. Repeat this step, checking the opposite inlet port for leaks.

   3.4 If the double check valve does not function as described, or if the leakage is excessive, replace it. See **Subject 120** for instructions.

   If the valve cannot be replaced, repair it using Bendix parts. See **Subject 130** for instructions.

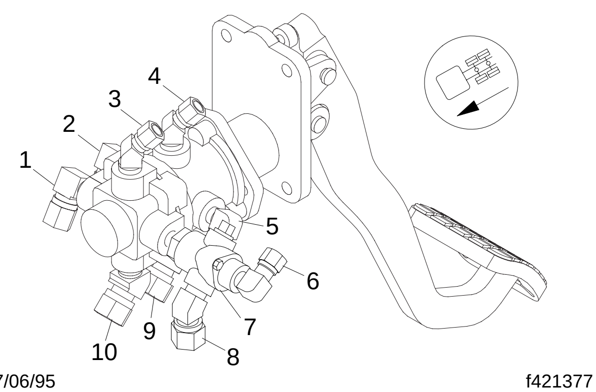
Double Check Valve Removal and Installation

Removal

WARNING

Wear safety goggles when draining the air system or disconnecting an air line because dirt or sludge particles could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Drain the air from the air reservoirs.
2. Disconnect the air lines from the double check valve. See **Fig. 1**.



1. Secondary Supply Circuit to Front Brake Valve
2. Delivery Circuit to Rear Brake Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Primary Delivery Circuit to Tractor Protection Valve
6. Delivery Circuit to Trailer Hand Valve
7. Double Check Valve
8. Secondary Delivery Circuit to Tractor Protection Valve
9. Primary Supply Circuit to Primary Supply Reservoir
10. Secondary Supply Circuit to Secondary Supply Reservoir

Fig. 1, Brake Valve and Double Check Valve Plumbing Circuits

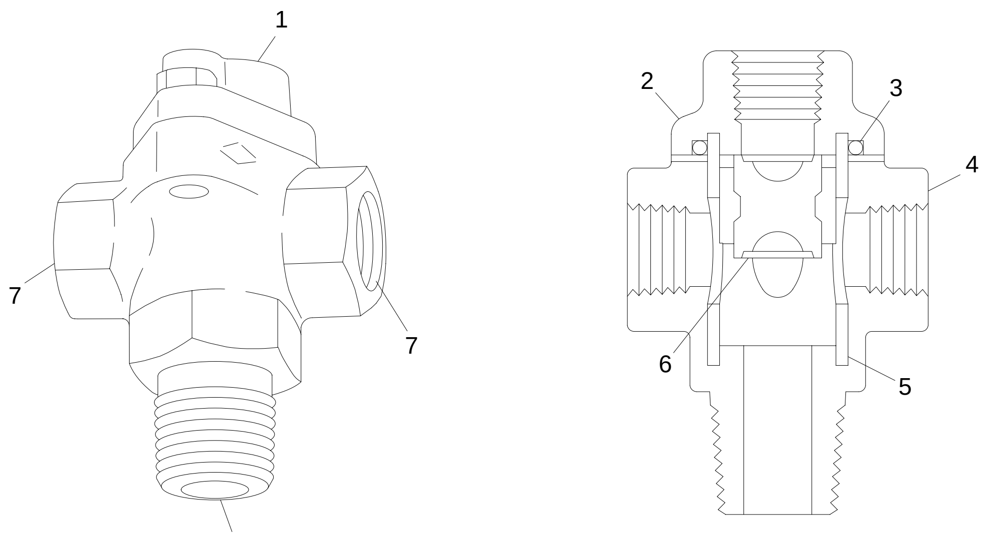
3. Unscrew the double check valve from the foot brake valve.

Installation

1. Screw the double check valve into the foot brake valve. Tighten the valve firmly.
2. Connect the air lines to the double check valve as marked. Tighten the air lines firmly.

Double Check Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. Supply Port
2. End Cap
3. O-Ring
4. Valve Body
5. Shuttle Guide
6. Shuttle Valve
7. Delivery Port

Fig. 1, Double Check Valve

1. Remove the valve from the vehicle. For Instructions, see **Subject 120**.
2. Remove the end cap from the valve.
3. Remove the O-ring.
4. Remove the shuttle valve and shuttle guide.

Cleaning and Inspection

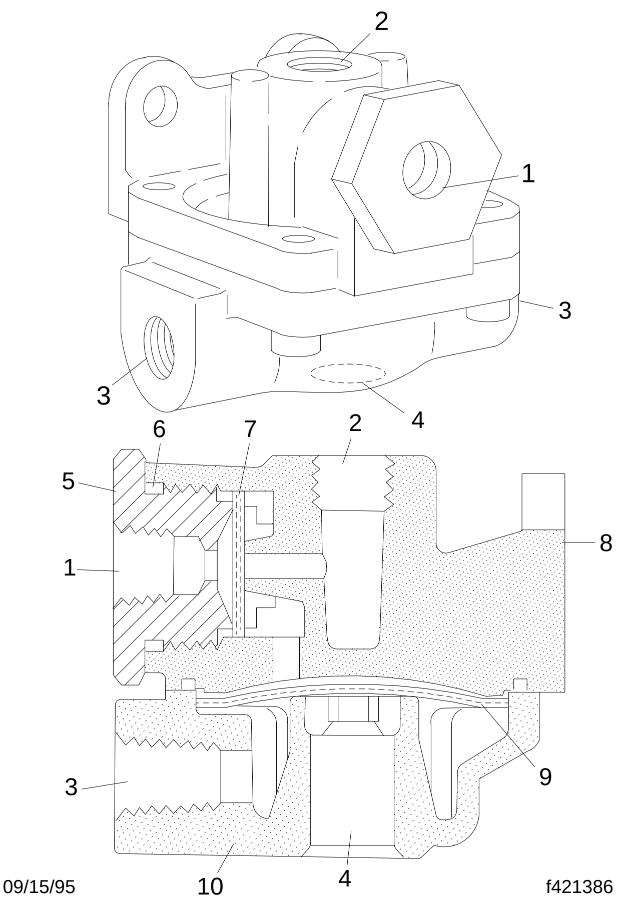
1. Clean all metal parts in a cleaning solvent.
2. Inspect all metal parts for signs of cracks, wear, or deterioration. Replace all parts not considered serviceable.
3. Replace all rubber parts.

Assembly

1. Install the shuttle valve and shuttle guide in the valve body.
2. Coat the O-ring with BW 650M silicone lubricant (BW 291126). It is not necessary to lubricate the shuttle valve.
3. Install the O-ring.
4. Install the end cap on the valve body.
5. Install the valve on the vehicle. For instructions, see **Subject 120**.
6. Test the valve. For instructions, see **Subject 110**.

General Description

The QR–1C quick release valve (**Fig. 1**) is a dual function valve. Its primary function is to speed up the release of air pressure from the park brake chambers. Additionally, the valve works as an anti-compound device. The double check valve feature prevents a service and parking brake application from occuring at the same time.



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR-1C Valve and Cross Section

The QR–1C valve is generally mounted near the rear axle. A balance line from the relay valve delivery port (port 2 on the WABCO combination valve) is connected to the balance port on top of the QR–1C quick release valve; the two side ports are for brake chamber connections; the supply port is connected to the delivery port of the parking brake control valve, and the exhaust port is located at the bottom of the valve.

Principles of Operation (See Fig. 1)

PARKING BRAKES RELEASED

When the parking brakes are released, air from the parking brake control valve flows through the QR–1C valve. This forces the double check diaphragm and the quick release diaphragm to flex and seal the balance and exhaust ports. Air flows into the inlet ports of the parking brake chambers from the QR–1C valve delivery ports.

PARKING BRAKES APPLIED

When the parking brakes are applied, supply line air pressure to the QR–1C valve is exhausted through the parking brake control valve. As air pressure is exhausted from one side of the double check diaphragm and the quick release diaphragm, both diaphragms flex in the opposite direction to open the balance and exhaust ports. Parking brake pressure is released at the exhaust port of the QR–1C valve while a small amount of air trapped between the two diaphragms is released through a relay valve or the foot valve exhaust port.

ANTI-COMPOUNDING

When a service brake application is made with the parking brakes applied, service air enters the balance port and flows through the QR–1C valve into the inlet ports of the parking brake chambers. This prevents application of the service and parking brakes at the same time. Service air passing through the QR–1C valve flexes the double check and quick release diaphragms, sealing the supply and exhaust ports. When the service brake application is released, air is exhausted from the parking brakes.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and shut down the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

QR–1C Quick Release Valve Operating and Leakage Tests

Operating and Leakage Tests

WARNING

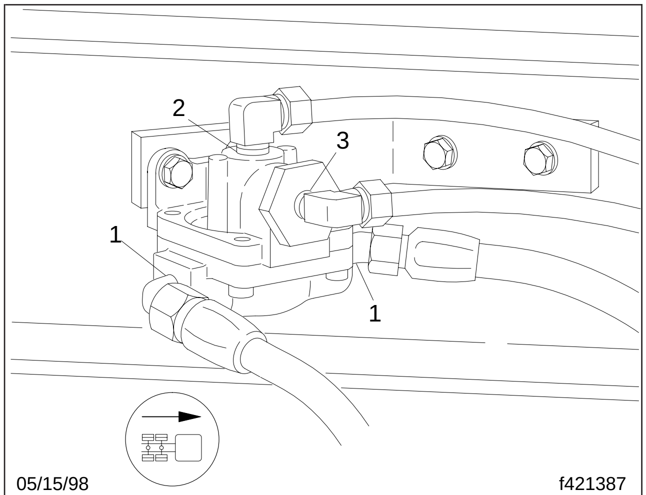
Before working on or around air brake systems and components, review Safety Precautions 100. Failure to do so could result in personal injury.

The following tests should also be performed after repairing or replacing the QR–1C valve to ensure that it is functioning properly.

1. Chock the tires.
2. Build system air pressure to 120 psi (827 kPa).
3. Release the parking brakes.
4. Remove the air line from the valve balance port. Coat the exhaust and balance ports with a soap solution; leakage of a 1-inch (25-mm) bubble in five seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes; the QR–1C valve should exhaust air at the exhaust port.
6. Build system air pressure to 120 psi (827 kPa).
7. Remove the air line from the valve supply port. With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of a 1-inch (25-mm) bubble in five seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

QR–1C Quick Release Valve Removal and Installation

Removal (See Fig. 1)



NOTE: Valve mounting inside the left frame rail shown.
1. Delivery Port
2. Balance Port
3. Supply Port

Fig. 1, QR-1C Valve Mounting (plumbing and location will vary depending on vehicle configuration)

WARNING

Before working on or around air brake systems and components, review Safety Precautions 100. Failure to do so could result in personal injury.

1. Chock all of the tires.
2. Drain the air brake system.
3. Mark and disconnect the air lines from the quick release valve.
4. Remove the mounting bolts and the valve.

Installation (See Fig. 1)

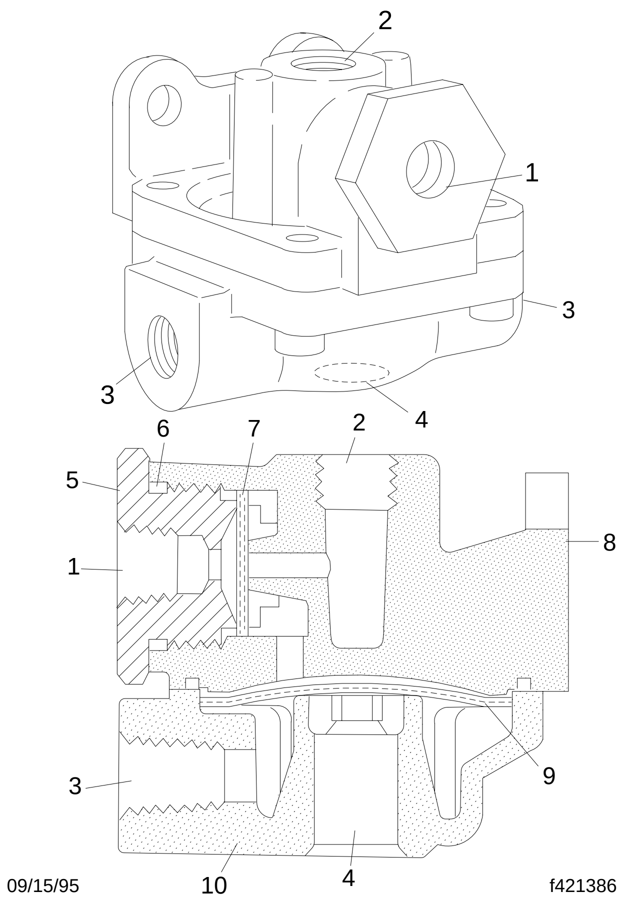
WARNING

Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Install the quick release valve with the exhaust port facing down. Securely tighten the mounting bolts.
2. Connect the air lines to the quick release valve in the locations previously marked.
3. Perform the operating and leakage tests in **Subject 110**.

QR–1C Quick Release Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR-1C Valve and Cross Section

1. Remove the quick release valve from the vehicle following the instructions in **Subject 120**.
2. Mark the valve body and cover for ease of installation.
3. Remove the cap nut at the supply port. Remove the sealing ring from the cap nut.
4. Remove the double check diaphragm.
5. Remove the four screws holding the valve cover on the valve body.
6. Separate the cover from the body and remove the sealing ring and the quick release diaphragm.

Cleaning and Inspection

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.
2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

Assembly

1. Install the sealing ring on the cap nut.
2. Install the double check diaphragm in the valve body.
3. Install the cap nut. Tighten the nut 150 to 400 lbf·in (1700 to 4520 N·cm).
4. Install the quick release diaphragm in the cover.
5. Install the valve cover on the body. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
6. Install the quick release valve, following the instructions in **Subject 120**.
7. Do the operating and leakage test as instructed in **Subject 110**.

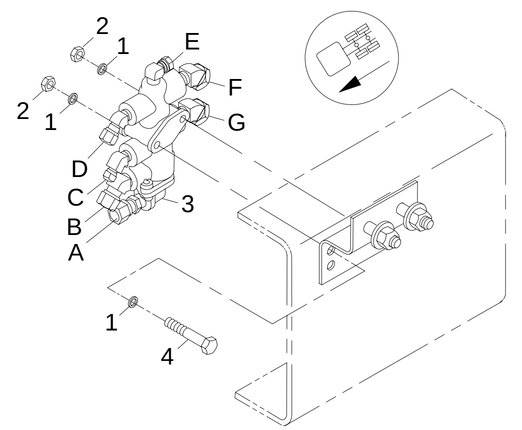
General Information

General Description

The Allied Signal/Bendix TP–3DC is a tractor protection valve that includes an integral double check valve. The TP–3DC serves two purposes. First, as required by Federal law, the valve protects the tractor brakes in the event of trailer breakaway or a severe air system leak. Second, when used with a dash-mounted trailer supply control valve, the TP–3DC valve can be used to shut off the trailer control line before the trailer is disconnected.

The TP–3DC also includes an integral single check valve that prevents air from getting trapped in the trailer control line. Trapped air in this line could cause service/spring brake compounding and, if the trailer is parked with air applied, a trailer roll-away situation.

There are several different mounting locations for the TP–3DC tractor protection valve. A common mounting location is in the frame rail channel. See **Fig. 1**.

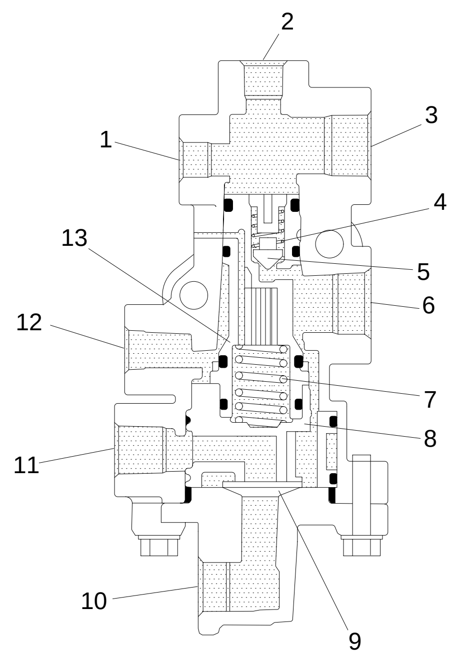


A. From service brake foot valve, primary circuit
B. From service brake foot valve, secondary circuit
C. To air manifold (stop lamp switch)
D. From trailer supply valve
E. To proportioning relay (if installed)
F. To trailer emergency port
G. To trailer service port

1. 1/4" Flatwasher
2. 1/4–20 Locknut
3. TP–3DC Tractor Protection Valve
4. 1/4–20 Capscrew

Fig. 1, TP-3DC Mounting Location and Connections

TP–3DC valve port designations and internal components are shown in **Fig. 2**.



1. Tractor Supply Port
2. Auxiliary Supply Port
3. Trailer Supply Port
4. Check Valve Spring
5. Check Valve
6. Trailer Control Port
7. Valve Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Tractor Control Port(Secondary)
12. Stop Lamp Switch Port
13. Plunger

Fig. 2, TP-3DC, Sectional View

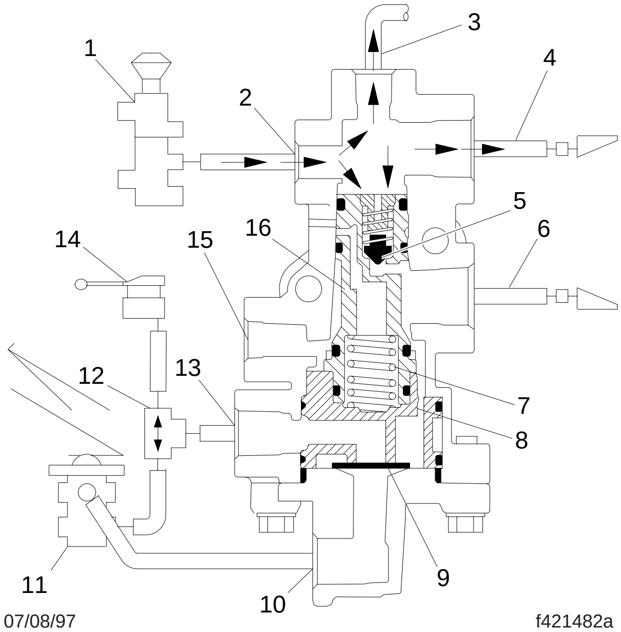
Principles of Operation

INITIAL CHARGE (See Fig. 3)

Pushing in the red trailer air supply knob on the instrument panel causes air to flow into the TP–3DC valve at the tractor supply port. Air flows through the valve housing, exiting via the auxiliary supply port (if used) and the trailer supply port, to pressurize the trailer brake system and release the trailer parking brakes.

As air pressure builds in the trailer supply circuit, the single check valve seats, and the valve plunger be-

General Information



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 3, Initial Charge

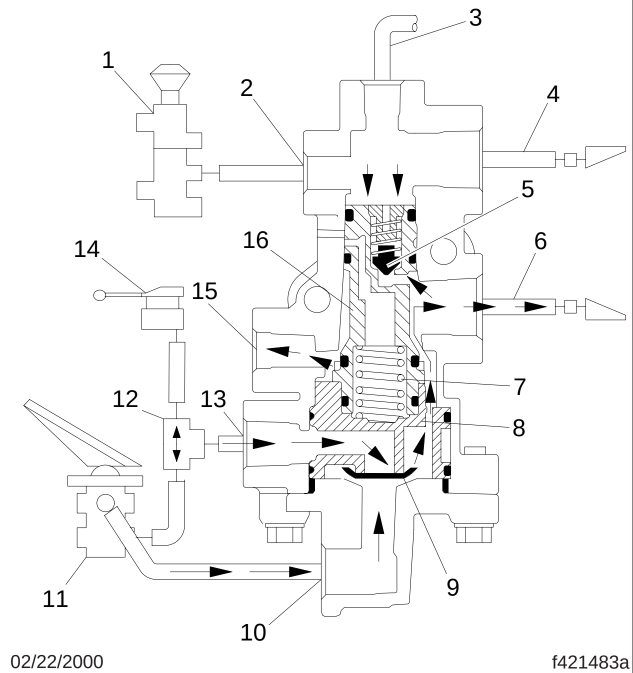
gins to move (against spring pressure) toward the guide. When pressure reaches about 45 psi (310 kPa), the inlet valve opens.

The TP–3DC valve is in the "run" mode, and ready to receive and deliver a service brake application from either the foot valve or the hand valve.

SERVICE BRAKE APPLICATION

(See Fig. 4)

When the foot pedal is pressed, air flows to the TP–3DC valve tractor control primary and secondary ports. If the trailer control valve is also used, the external double check delivers the higher pressure (trailer control or foot valve secondary) to the TP–3DC Tractor Control secondary port.



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Valve Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 4, Service Brake Application

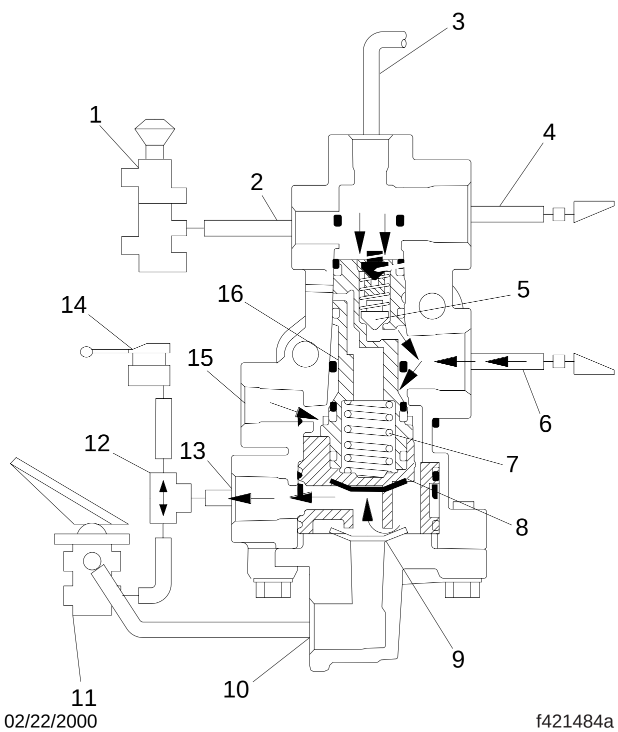
Inside the TP–3DC valve, the higher pressure (primary or secondary) moves the diaphragm to seal off the port at the lower pressure.

With the plunger bottomed against the guide and the inlet valve open (as described earlier), the higher pressure air flows through the valve to the trailer control port and the stop lamp switch, applying the brakes and activating the stop lamps.

NOTE: While air pressure also reaches the TP–3DC single check valve, the valve stays closed because supply pressure is acting on the other side.

SERVICE BRAKE RELEASE

(See Fig. 5)



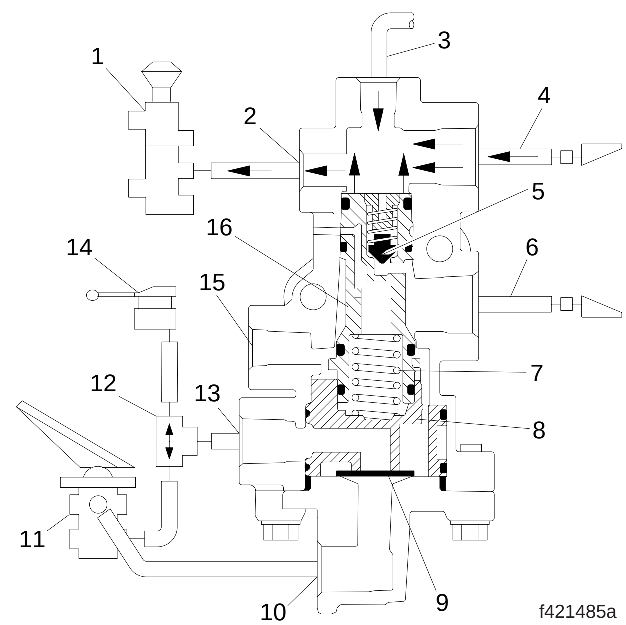
1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Valve Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 5, Service Brake Release

When the foot pedal is released, air stops flowing into the TP–3DC valve at the tractor control primary or secondary port. At the same time, air in the trailer control line returns to the valve, flowing back through the open inlet valve.

The air forces the diaphragm to seat, sealing off the tractor control primary port. The air then exits the valve at the tractor control (secondary) port and flows to the foot valve or hand valve where it is exhausted.

TRACTOR PROTECTION (See Fig. 6)



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Valve Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

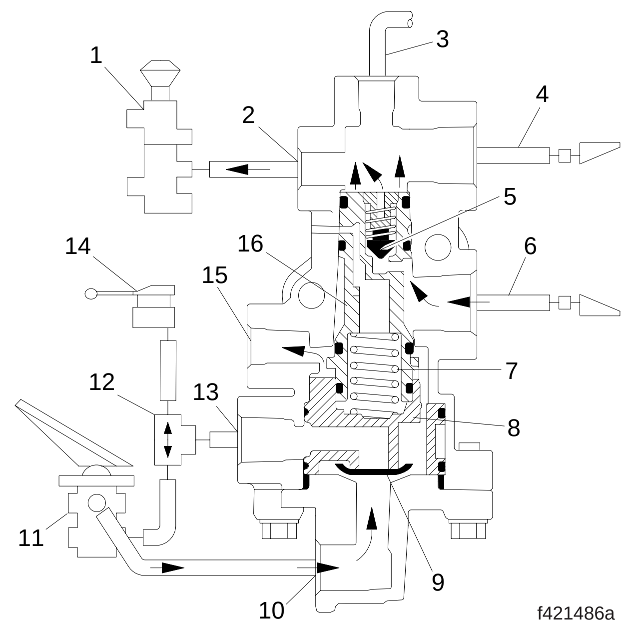
Fig. 6, Tractor Protection

If the red trailer air supply knob on the instrument panel is pulled out (or if a large leak develops in the trailer supply circuit), pressure in the trailer supply circuit (and the auxiliary supply circuit, if used) is vented. When pressure drops to about 20 to 30 psi (138 to 207 kPa), the pressure can no longer overcome the spring force inside the TP–3DC valve and the inlet valve closes.

With the inlet valve closed, air pressure from the brake foot or hand control valves will not reach the trailer control circuit when the brakes are applied.

General Information

ANTI-COMPOUNDING (See Fig. 7)



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 7, Anti-Compounding

If the red trailer air supply knob on the instrument panel is pulled out while the service brakes are applied, the single check valve in the TP–3DC prevents simultaneous spring and service brake application. As pressure in the trailer supply circuit drops, the spring in the TP–3DC valve forces the inlet valve closed (as described above in "Tractor Protection." Any pressure in the trailer control circuit is relieved by passing first through the single check valve and then exhausting at the trailer supply valve.

If the service brakes (hand or foot) are released and applied again, the closed inlet valve prevents air pressure from reaching the trailer control circuit.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and shut down the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions 100**.

1. Chock the tires, start the engine, and run it until the air system is fully charged.
2. Shut down the engine and place the trailer air supply valve in the emergency position (red knob pulled out).
3. Disconnect the trailer control line hose coupling. Then make a service application with either the foot valve or trailer control valve and check for leakage at the hose coupling with a soup and water solution. Leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.
4. Release the service brake application and place the trailer supply valve in the "run" position (red knob pushed in). Connect the trailer control valve to a test gauge.
5. Make a service brake application and note that service air pressure is present at the trailer control line hose coupling.
6. With the ignition on, make and hold a service brake application and note that the stop lights function.
7. Disconnect the air line at the TP–3DC tractor control port (primary) and plug the line. Using a soap-and-water solution, make a service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.
8. Reconnect the air line to the tractor control port (primary) and disconnect the air line at the tractor control port (secondary). Then, plug the disconnected line. Make and service brake application and check for leakage at the open tractor control port using a soap-and-water solution. Leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.

IMPORTANT: If the valve does not function as described, or if leakage is excessive, repair or replace the valve.

9. Remove the chocks.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions 100**.

1. Chock the tires, and open the air reservoir drain cocks to bleed the air from the system.
2. Remove the trailer hose assemblies from the TP–3DC valve. Disconnect the tractor service and supply lines. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
3. Remove the fasteners attaching the TP–3DC valve to the vehicle, and remove the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions 100**.

1. Place the TP–3DC valve on the vehicle, and attach it with bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).

NOTE: The delivery line from the trailer air supply valve is connected to the tractor emergency port of the TP–3DC valve. See **Fig. 1**. The delivery line from the brake valve (double check valve) is connected to the tractor service port of the TP–3DC valve. Trailer hose assemblies are installed in the trailer emergency and trailer service ports of the TP–3DC valve.

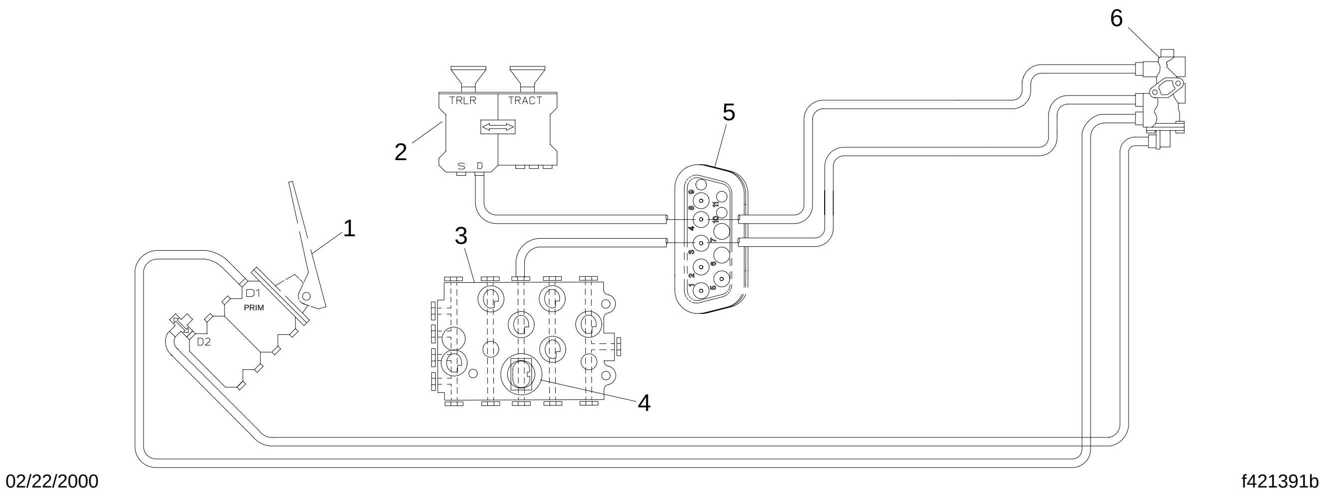
2. Remove the caps from the air lines, and depending on the type of air hose, use the following instructions to connect the air hoses to the TP–3DC valve:

   If equipped with nylon tube air hoses, connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts at least two turns, or until no threads show on the fitting.

   If equipped with wire braid hoses, connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until there is resistance. Tighten one-sixth turn more. Do not overtighten.

3. Close the drain cocks to the air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the TP–3DC valve following the instructions in **Subject 110**.

Removal and Installation

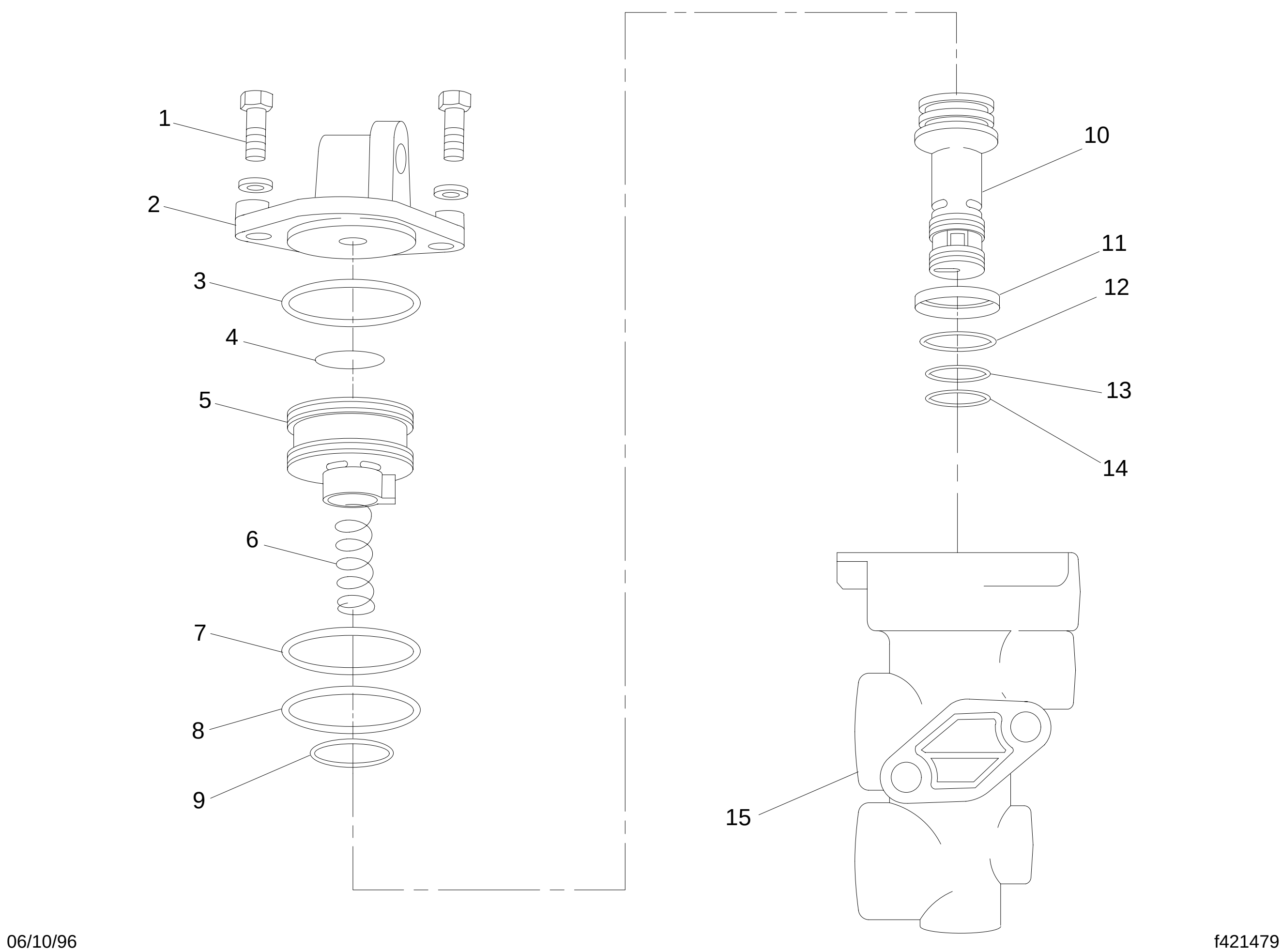


1. Foot Valve
2. Dash Valves
3. Air Manifold and Pressure Switch
4. Stop Lamp Switch
5. Pass-Thru Grommet
6. TP–3DC Valve

Fig. 1, TP-3DC Plumbing Diagram

Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. 1/4" Hex/Torx Screw
2. Valve Cover
3. O-Ring
4. Diaphragm
5. Guide
6. Valve Spring
7. O-Ring
8. O-Ring
9. O-Ring
10. Plunger
11. Collar
12. O-Ring
13. O-Ring
14. O-Ring
15. Valve Body

Fig. 1, Exploded View of TP-3DC Valve

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions 100**.

1. Remove the valve from the vehicle, retaining the mounting hardware. For instructions, see **Subject 120**.
2. Scribe a line across the valve cover and valve body to ensure proper alignment during assembly.
3. Remove the two 1/4-inch screws which secure the valve cover to the valve body and allow the

Disassembly, Cleaning and Inspection, and Assembly

valve spring to expand until the valve cover can be removed.

4. Remove the cover O-ring and discard it.
5. Remove the diaphragm from the valve body and discard it.
6. Remove the guide from the valve body.
7. Remove the O-rings from the guide and discard them.
8. Remove the valve spring from the plunger, then the plunger from the valve body.
9. Remove the O-rings from the plunger and discard them.
10. Remove the collar and the O-ring from the plunger. Discard the O-ring, but keep the collar.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions 100**.

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the TP–3DC valve in cleaning solvent, then dry them using compressed air.
2. Examine the cover, body, guide, and plunger for corrosion, excessive wear, cracks, or other damage. If any of these conditions are found on a part, replace the part with a new one.
3. Check the spring for distortion and corrosion. If the spring is distorted or corroded, replace it.
4. Check the valve body bores for deep scratches or gouging.

Assembly

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions 100**.

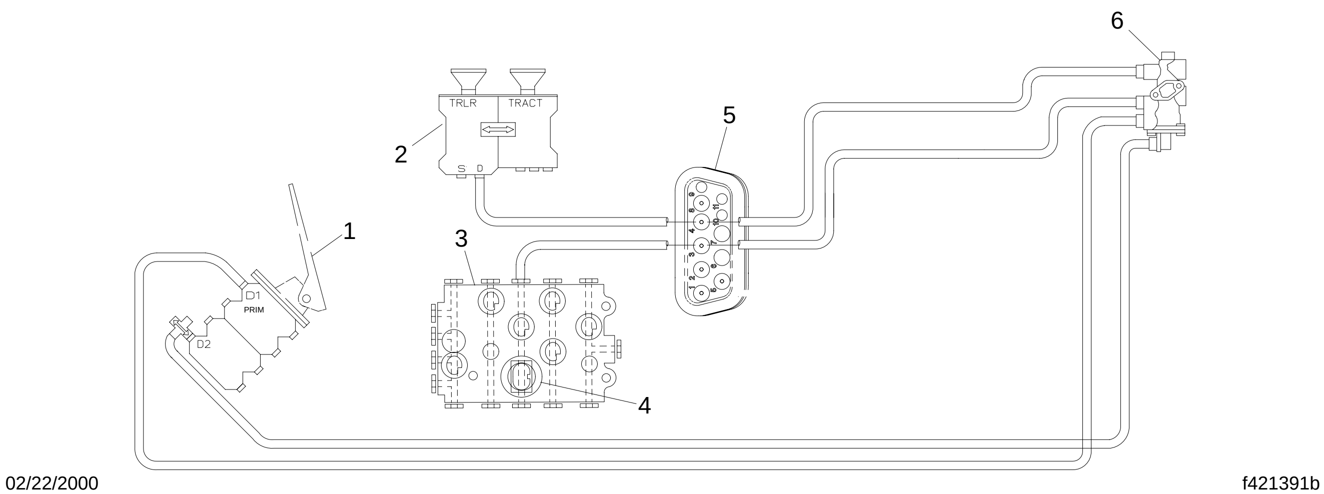
1. Lubricate the O-rings, O-ring grooves, body bores, and all sliding parts with the lubricant provided in the overhaul kit (Bendix silicone lubricant #291126 or equivalent).
2. Install the O-rings on the plunger.
3. Install the O-ring on the plunger and then the collar over the O-ring. Make sure that the collar is fully seated and firmly in place over the O-ring.
4. Install the plunger into the valve body and the spring into the plunger.
5. Install the O-rings in their grooves on the guide.
6. Align the indexing tab on the guide with the notch in the valve body and install the guide in the valve body.
7. Place the diaphragm in its recess on the guide.
8. Place the O-ring on the cover.
9. Place the cover on the guide and press them down, against spring pressure, until the cover is seated against the valve body.
10. Install the two 1/4-inch screws and tighten them 30 to 60 lbf·in (340 to 675 N·cm).
11. Install the TP–3DC valve on the vehicle following the instructions in **Subject 120**.

Specifications

See **Fig. 1** for a TP–3DC plumbing diagram.

Torque Values		
Description	**Torque lbf·in (N·cm)**	**Torque lbf·ft (N·m)**
Valve Cover Capscrews	30–60 (340–675)	—
Valve Mounting Capscrews	—	11–15 (15–20)

Table 1, Torque Values



1. Foot Valve
2. Dash Valves
3. Air Manifold and Pressure Switch
4. Stop Lamp Switch
5. Pass-Thru Grommet
6. TP–3DC Valve

Fig. 1, TP-3DC Plumbing Diagram

General Information

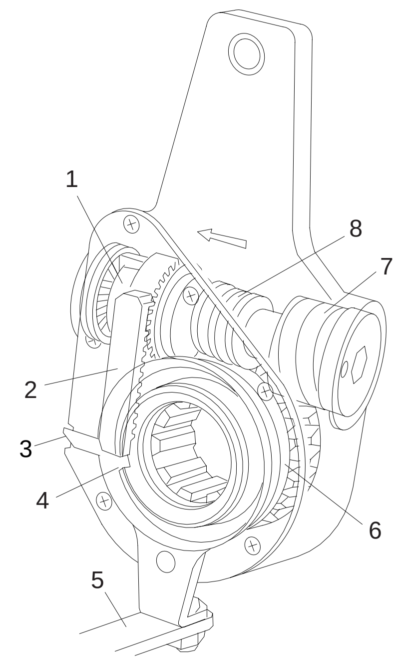
The Dana® Spicer® automatic slack adjuster serves two main functions:

- As a lever, it converts the straight-line force of the air brake chamber pushrod to torque on the brake camshaft. Rotation of the camshaft spreads the brake shoes out against the brake drum, applying the brakes.
- As an adjuster, it maintains cam brake chamber pushrod stroke and lining-to-drum clearance automatically during normal use.

When the brakes are applied, the slack adjuster rotates and moves the shoes into contact with the drum. The clearance notch corresponds to the normal lining-to-drum clearance. See **Fig. 1**. Different notches are available to meet the requirements of various vehicles and brake duty cycles. As the brake application continues, the rack moves upward and rotates the one-way clutch that slips in this direction.

As the brake torque increases, the coil-spring load is overcome and the wormshaft is displaced axially, releasing the cone clutch.

When the brake begins its return stroke, the coil spring load returns to normal and the cone clutch is again engaged. The rack is pulled back to its original position in the notch. Any additional travel brought about by brake lining wear causes the rack to turn the locked one-way clutch and rotates the wormshaft through the locked cone clutch. The wormshaft then rotates the worm wheel and camshaft, adjusting the brakes.



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NOTE: Older slack adjusters may not have an installation indicator.

1. Clutch Assembly
2. Enclosed Rack
3. Installation Indicator (aligned with indicator notch)
4. Clearance Notch
5. Control Arm Anchor Bracket (design varies depending on the axle)
6. Worm Wheel
7. Coil Spring
8. Wormshaft

Fig. 1, Dana Spicer Slack Adjuster

Safety Precautions

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

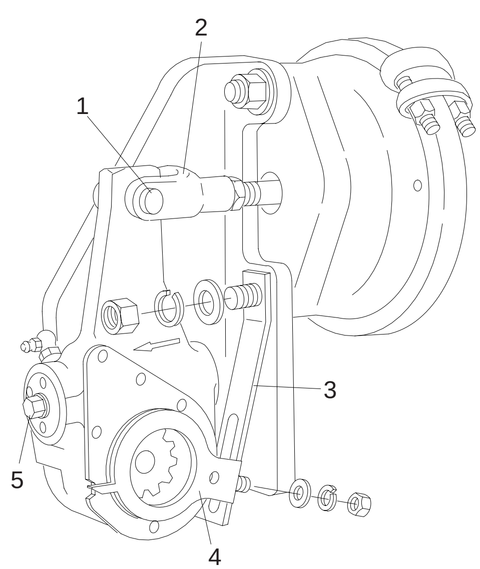
Slack Adjuster Removal and Installation, and Brake Adjustment

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. If a rear axle slack adjuster will be removed, release the parking brakes and cage the power spring of the parking brake chamber. For instructions, see the appropriate brake chamber section in this group.
3. Remove the anchor bracket fasteners and the anchor bracket. See **Fig. 1**.



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1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

Fig. 1, Anchor Bracket Location

4. Remove the cotter pin from the clevis pin. Remove the clevis pin.
5. Remove the snap ring that secures the slack adjuster on the camshaft.

CAUTION

Do not use an impact wrench on the adjusting hexnut. To do so may damage the slack adjuster or camshaft.

6. Using a 7/16-inch box wrench, turn the adjusting hexnut counterclockwise to move the adjuster arm out of the clevis. A minimum of 13 lbf·ft (18 N·m) is required to overcome the internal clutch. You will hear a ratcheting sound.
7. Remove the slack adjuster from the camshaft.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing a new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Check that the brake chamber pushrod is fully retracted.
2. Apply antiseize compound to the camshaft splines.

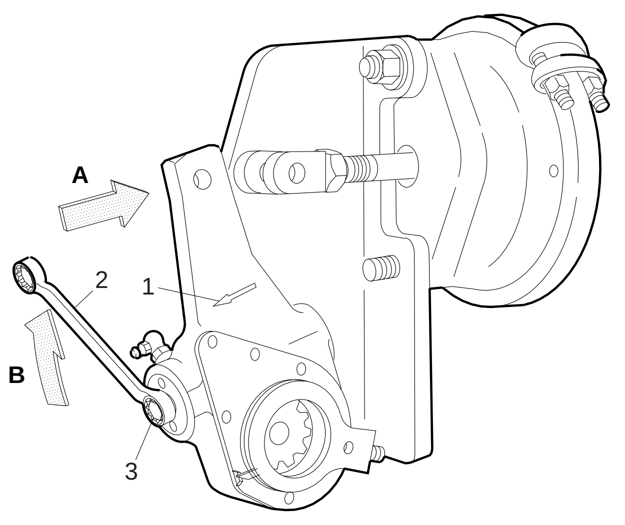
IMPORTANT: When correctly installed, the brake chamber pushrod pushes in the direction of the arrow on the slack adjuster housing.

3. Install the slack adjuster on the camshaft with the adjusting hexnut pointing away from the brake chamber. See **Fig. 2**.
4. Using a snap ring, secure the slack adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 0.060-inch (1.52-mm) movement on the shaft.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting hexnut for positioning.

5. Using a 7/16-inch box wrench, turn the adjusting hexnut clockwise until the slack adjuster hole is aligned with the pushrod clevis hole. See **Fig. 2**.

Slack Adjuster Removal and Installation, and Brake Adjustment



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A. Use only the adjusting hexnut to align the slack adjuster with the pushrod clevis.
B. Turn the adjusting hexnut clockwise.

1. Direction of Applied Stroke
2. 7/16-Inch Box Wrench
3. Adjusting Hexnut

Fig. 2, Slack Adjuster Installation

6. Apply antiseize compound to the clevis pin and insert the pin in the clevis hole. Do not install the cotter pin at this time.

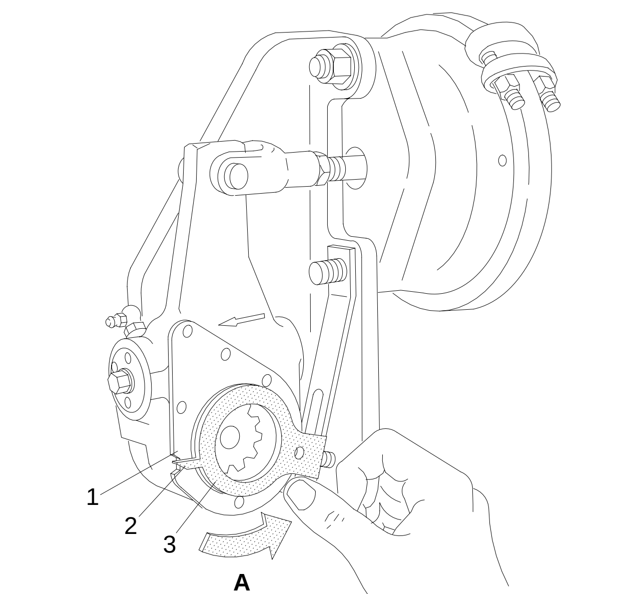
CAUTION

Never hammer the control arm. Hammering may damage the slack adjuster or camshaft splines.

7. Rotate the control arm away from the adjusting hexnut toward the brake chamber until it comes to a definite internal stop. Make sure the installation indicator is in the center of the indicator notch on the slack adjuster. See Fig. 3.

IMPORTANT: If the installation indicator is not aligned with the indicator notch, the brakes will be too tight.

NOTE: The anchor bracket and slack adjuster housing design will vary, depending on the axle. The anchor bracket mounting location is determined by the length of the control arm.



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NOTE: The installation indicator must be aligned with the indicator notch.

A. Rotate the control arm counterclockwise until it stops.

1. Indicator Notch
2. Installation Indicator
3. Control Arm

Fig. 3, Rotating the Control Arm

8. Install the control arm anchor bracket. See Fig. 1.
   - 8.1 Tighten the anchor bracket fastener at the control arm 10 to 15 lbf·ft (14 to 20 N·m), making sure the control arm does not move from its position.
   - 8.2 Tighten the fastener at the brake chamber mounting stud according to the brake chamber manufacturer's specifications.
9. Adjust the brakes. See "Brake Adjustment".

Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

Slack Adjuster Removal and Installation, and Brake Adjustment

WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

1. Adjust the brake lining clearance by manually turning the adjusting hexnut clockwise until the brake lining contacts the brake drum, then back off the hexnut counterclockwise 1/2 turn. You will hear a ratcheting sound.

IMPORTANT: Incorrect installation can cause dragging brakes.

2. Make sure the brakes are still fully released, then check the position of the installation indicator on the control arm. It must be within the indicator notch on the slack adjuster.

   If the indicator is out of position, loosen the control arm fasteners and repeat the control-arm adjustment procedure. Then, tighten the bracket fasteners.

WARNING

Install and lock a new cotter pin in the clevis pin. Failure to do so could allow the pushrod to disengage from the slack adjuster, causing a loss of braking ability that could result in personal injury and property damage.

3. Install and lock a new cotter pin in the clevis pin.

IMPORTANT: Ensure that the air system has at least 100 psi prior to uncaging the brake chamber. This will aid in the uncaging of the parking brake since the parking brake should be fully released.

4. If a rear-axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this group.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

IMPORTANT: To check the brake adjustment, measure both the applied and free strokes.

NOTE: The location of the measurements is the same for both strokes but the applied stroke is measured with the brakes applied, while a lever is used to manually move the slack adjuster to measure the free stroke.

5. Measure the free stroke, as follows. The free stroke is the distance the slack adjuster has to travel to move the brake shoes against the drum.

   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement A.

   5.2 Using a lever, move the slack adjuster until the brake shoes contact the drum. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

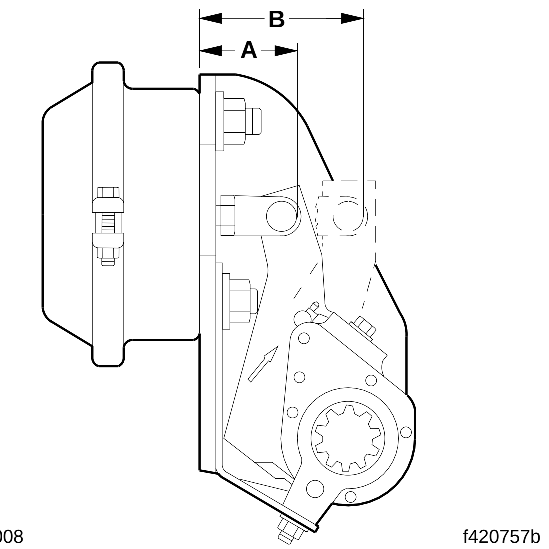
   5.3 Subtract measurement A from measurement B to determine the free stroke. For new brake installations, the free stroke should be 5/8 to 3/4 inch (16 to 19 mm). For in-service brakes, the free stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not in this range, refer to **Troubleshooting 300**.

6. Measure the applied stroke, as follows.

   6.1 With the brakes released (pushrod fully retracted), measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 4**. Record the exact distance as measurement A.

   6.2 Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far

Slack Adjuster Removal and Installation, and Brake Adjustment



NOTE: Measurements are from the bottom of the brake chamber to the far side of the clevis-pin hole.

A. Measurement with brakes released.
B. Measurement with brakes applied at 80 psi (551 kPa).

Fig. 4, Brake Applied Stroke Check

side of the clevis-pin hole. Record the exact distance as measurement B.

6.3 Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 1**.

6.4 If the stroke varies or is greater than the maximum allowed length, refer to **Troubleshooting 300**.

7. Apply the parking brakes.
8. Remove the chocks from the tires.
9. In a safe area, check for proper brake operation, as follows.

9.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.

9.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.

9.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

Chamber Size	Maximum Applied Stroke: inch (mm)	Free Stroke: inch (mm)	
		New Brake Installation	In-Service Brake Installation
16	1-3/4 (44)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
20			
24	1-7/8 (48)		
30	2 (51)		

Table 1, Brake Chamber Stroke Specifications

Operational Checks and Troubleshooting Tables

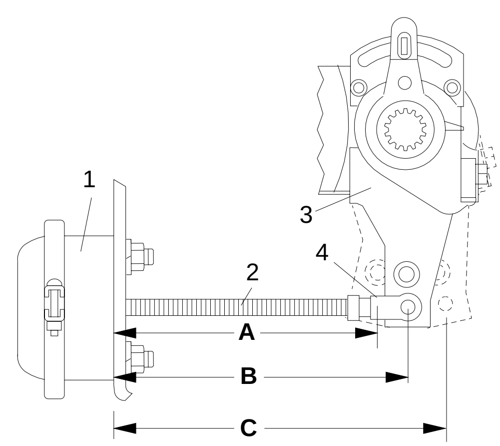
WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Before performing any of the following procedures:

- Chock the wheels to prevent the vehicle from rolling.
- Ensure that the air system tank pressure is 90 to 100 psi (620 to 689 kPa).
- Check that the brake chamber push-rod is fully retracted; apply air to the release spring brake.

Refer to Fig. 1 when making slack adjuster stroke measurements.



A. Fully retracted
B. Drum contact using a lever
C. Full brake application at 90 to 100 psi (620 to 689 kPa) reservoir pressure
1. Brake Chamber
2. Push-Rod
3. Slack Adjuster
4. Clevis

Fig. 1, Slack Adjuster Stroke Measurement

Applied Stroke

The applied stroke (see Fig. 1) of the brake should be checked per Commercial Vehicle Safety Alliance (CVSA) guidelines with full brake applicaton at 90 to 100 psi (620 to 689 kPa) reservoir pressure. The applied stroke should be at or less than the specified adjustment limits listed in Table 1.

Stroke Specifications		
Chamber Size	Maximum Applied Stroke: Inch (mm)	Desired Free Stroke: Inch (mm)
12	1-3/8 (35)	5/8–3/4 (16–20)
16 and 20	1-3/4 (44)	
24	1-3/4 (44)	
24L	2 (51)	
24LS	2-1/2 (64)	
30	2 (51)	
30LS	2-1/2 (64)	

Table 1, Stroke Specifications

Free Stroke

Free stroke is the amount of movement of the adjuster arm required to move the brake shoes against the drum. With brakes released, measure from the face of the chamber to the center of the clevis pin "A". Use a lever to move the brake adjuster until the brake shoes contact the drum. The difference between the fully retracted and drum contact measurement "B" minus "A" is the free stroke. See Fig. 1. The free stroke range should fall between 5/8 and 3/4 inch (16 to 20 mm).

Free Stroke Within Range

If the free stroke is good, but the applied stroke is too long, there is probably a problem with the foundation brake. Check the components listed in Table 3, and reference CVSA out-of-service criteria.

Free Stroke Above the Range

If the free stroke is above the range and the applied stroke is too long, there is a problem with the foundation brake or the adjuster. Check the components listed in Table 2.

Troubleshooting

Free Stroke Above the Range		
Component	**Cause**	**Action**
Camshaft	Binding	Remove, replace, lubricate camshaft
Camshaft Bushing	Excessive movement	Remove and replace cam bushings per OEM specs
	Binding shaft	Lubricate camshaft bushings or replace
Air Chamber Return Spring	Broken, weak, missing	Replace chamber
Air Chamber Push Rod	Binding on chamber housing	Check adjuster for proper shimming, and air chamber position for proper adjuster arm length
Air System	Not exhausting completely	Check for cause of air problem and repair
Shoe Return Springs	Broken, weak, missing	Replace springs
Automatic Brake Adjusters	Unknown	Check automatic brake adjuster for proper installation; see **Subject 110**.
		See *Automatic Brake Adjuster Checking Procedures* and *Automatic Brake Adjuster Operational Check* in this subject

Table 2, Free Stroke Above the Range

Free Stroke Within Range		
Component	**Cause**	**Action**
Brake Drums	Cracked or out of round	Replace or check drum runout
Brake Shoes	Shoe span out of spec	Replace shoes as needed; see **Subject 110**
	Uneven lining wear	Check spider concentricity
	Shoe pad missing	Remove and replace shoes
	Cracked shoes	
Camshaft Bushing	Excessive movement	Remove and replace cam bushing per OEM specs
Camshaft	Flat spots on cam head	Replace camshaft
	Cracked/broken splines	
	Worn bearing journals	
Chamber Bracket	Broken/bent	Replace bracket
Clevis Yoke and Pin	Worn	Remove and replace
Return Springs	Broken, stretched, or missing	Remove and replace springs
Rollers	Flat spots, grooved pin, worn	Remove and replace roller and pin
	Wrong size	Remove and replace with correct parts
Spider Anchor Pins	Grooved or scored/worn	Replace spider or pins as needed

Table 3, Free Stroke Within Range

Free Stroke Below the Range

If the free stroke is less than 5/8 inch (16 mm), a dragging brake can occur. Check the components listed in **Table 4**.

Free Stroke Below the Range		
Component	**Cause**	**Action**
Wheel Bearing	Out of adjustment	Readjust wheel bearing. See **Group 33** or **Group 35** for procedures.
Automatic Brake Adjusters	Unknown	Check automatic brake adjusters for proper control arm position. See **Subject 110**.
		See *Automatic Brake Adjuster Checking Procedures* and *Automatic Brake Adjuster Operational Check* in this subject.

Table 4, Free Stroke Below the Range

Automatic Brake Adjuster Checking Procedures

If the brake adjuster is not maintaining the proper applied stroke, before removing the brake adjuster, check the condition of the foundation brakes. See **Table 3**, **Table 2**, and **Table 4** for procedures. If after inspecting the foundation brakes no apparent problems are found, inspect the automatic brake adjuster to determine if it is operating properly. The inspection can be performed on or off the vehicle using the following procedures.

- Chock the wheels to prevent the vehicle from rolling.
- Ensure that the air system tank pressure is 90 to 100 psi (620 to 689 kPa).
- Check that the brake chamber push-rod is fully retracted; apply air to the release spring brake.
- If air is not available, the spring brake must be manually caged back.
- Do not use air tools on the brake adjuster.

See **Table 5** for on-vehicle inspection or **Table 6** for off-vehicle inspection.

Automatic Brake Adjuster Operational Check

Functional operation of the brake adjuster can be performed on the vehicle by using the following procedure:

1. Chock the wheels to prevent the vehicle from rolling.
2. Ensure that the air system tank pressure is 90 to 100 psi (620 to 689 kPa).
3. Check that the brake chamber push-rod is fully retracted; apply air to the release spring brake.

   If air is not available, the spring brake must be manually caged back.
4. Manually de-adjust the brakes (turn adjustment hex counterclockwise one full turn) to create an excessive drum to lining clearance condition. A ratcheting sound should occur.
5. Make a full service brake application.

   On release, allow sufficient time for the brake to fully retract. During the brake release, observe rotation of the adjustment hex by attaching a wrench on the hex or scribing the hex, which will make this rotation easier to see. This rotation indicates that an excessive clearance condition has been determined by the brake adjuster, and it is making an adjustment to compensate. On each subsequent brake release, the amount of adjustment and push rod travel will be reduced until the desired clearance is achieved.
6. If rotation of the adjustment hex is not observed, refer to the foundation brake operational check and troubleshooting procedures in this subject.
7. If the foundation brake assembly checks out okay and the hex still does not turn, check the control arm and mounting bracket for possible worn, bent, or broken components.
8. If the control arm and mounting bracket function properly, replace the adjuster and hardware. See **Subject 110** for procedure.

Troubleshooting

On-Vehicle Inspection		
Component	**Cause**	**Action**
Tight or dragging brakes	Control arm mispositioned	Realign the control arm and anchor bracket. See **Subject 110**.
Excessive chamber push rod travel	Improper anchor bracket connection to control arm	If anchor bracket to control arm connection is loose, worn, bent, or broken, re-secure or replace it.
	Low clutch torque	Rotate the 7/16-inch adjustment hex one full turn counterclockwise. If the torque is less than 13 lbf·ft (18 N·m), or no ratcheting sound occurs, replace the adjuster.
	Unknown	See *Automatic Brake Adjuster Operational Check* in this subject.

Table 5, On Vehicle Inspection

Off-Vehicle Inspection		
Problem	**Cause**	**Action**
Adjuster not functioning properly	Low clutch torque	Place the adjuster arm in a vise. Rotate the 7/16-inch adjustment hex counterclockwise one full turn to check de-adjustment torque. After control arm stops rotating, a minimum of 13 lbf·ft (18 N·m) will be required and a ratcheting sound should occur. If the torque is less than 13 lbf·ft (18 N·m), or no ratcheting sound occurs, replace the adjuster.
	Control arm slippage	Place the adjuster arm in a vise. Rotate the control arm counterclockwise until it rotates to an INTERNAL STOP. If the installation indicator goes past the indicator notch or does not stop rotating (arm slips freely), replace the adjuster.
	Unknown	If torque is above 13 lbf·ft (18 N·m), scribe a line on the adjustment hex. Manually pull the brake adjuster control arm clockwise then push back counterclockwise until the installation indicator stops in the indicator notch. The hex should move in a clockwise direction when the control arm of the brake adjuster is pushed back counterclockwise. If the hex does not move, replace the adjuster.
	Worn/missing control arm wear bushing, and/or anchor stud pin	Remove and replace the pin and bushings. If the adjuster has passed the above checks, re-install it on vehicle using new hardware.

Table 6, Off Vehicle Inspection

Specifications

Approved Slack Adjuster Lubricants	
Adjuster Type	**Lubricant Type**
Low Lube	N/A (sealed unit)
Standard	Standard Chassis Grease

Table 1, Approved Lubricants

Long Stroke Type Brake Chamber	
Type	**Adjustment Limit Inches (cm)**
16L	2 (5)
20L	2 (5)
24L	2 (5)
24LS	2-1/2 (6)
30LS	2-1/2 (6)

Table 2, Adjustment Limit of Long Stroke Type Brake Chamber

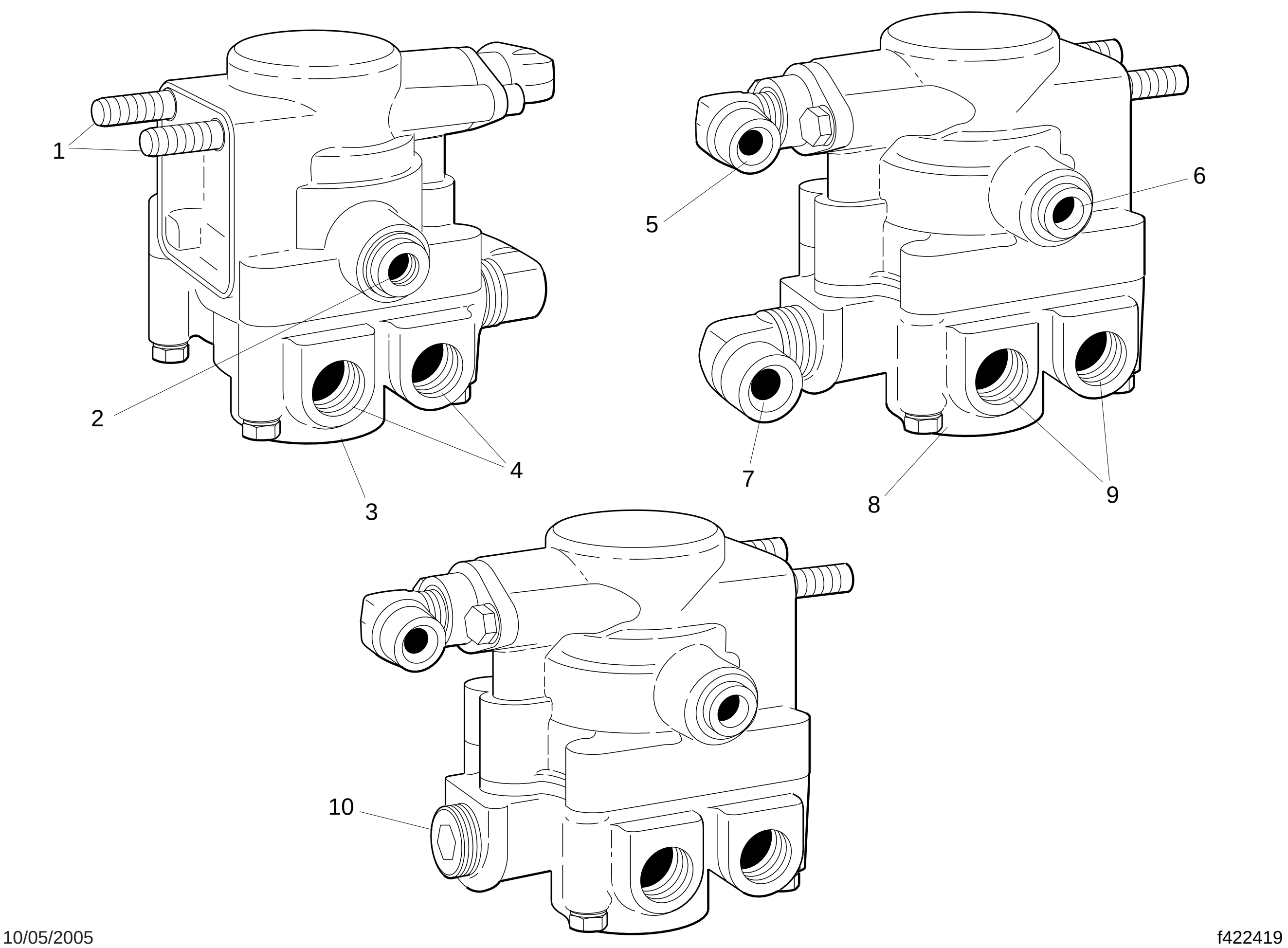
General Information

Description

The Bendix SR-7™ spring brake modulating valve (see **Fig. 1** and **Fig. 2**) is used in conjunction with a dual air brake system and spring brake actuator, and performs the following functions:

- Provides a rapid application of the spring brake actuator when parking.
- Modulates the spring brake actuator application using the dual brake valve should a primary failure occur in the service brake system.
- Prevents compounding of service and spring brake forces.

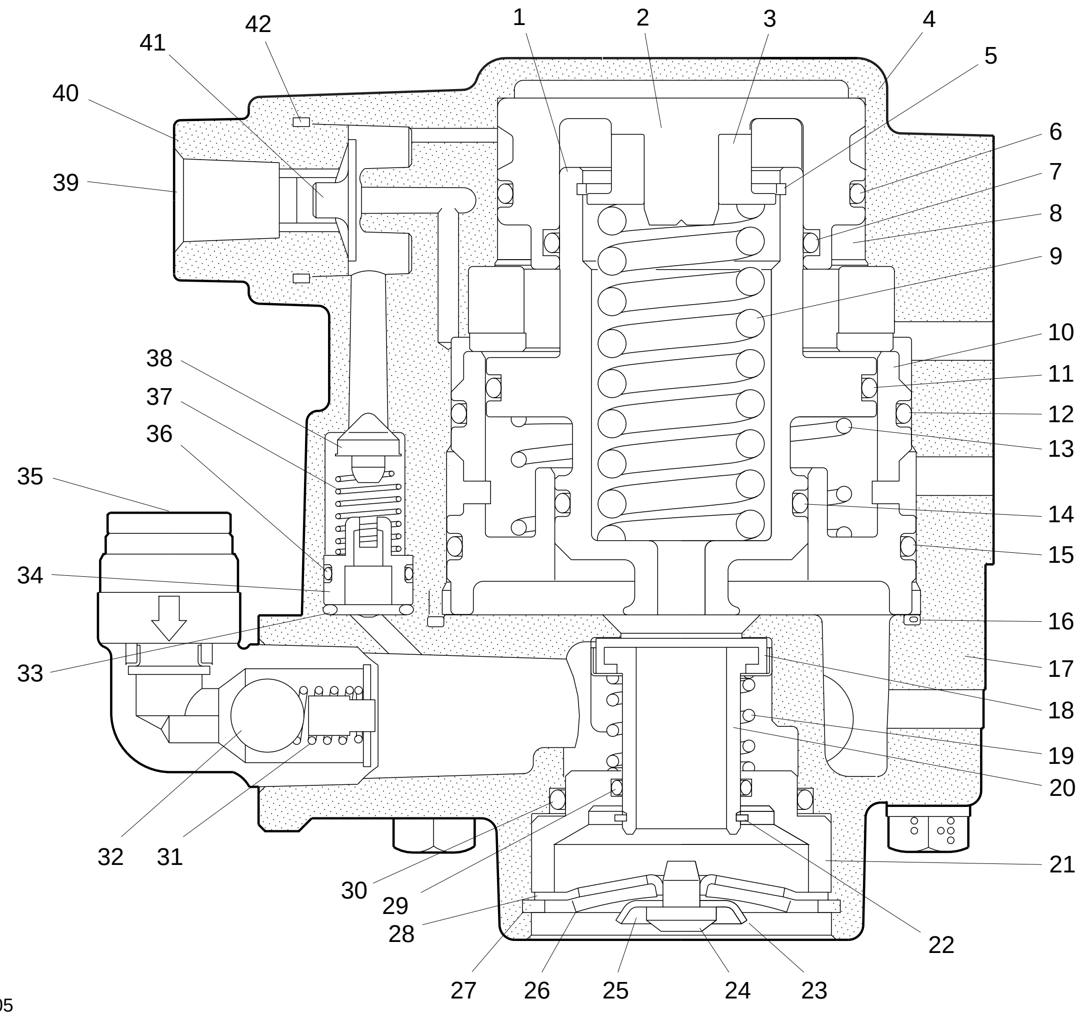
The SR-7 valve has one park control, one service control, one supply, one balance, four delivery NPT ports, and an exhaust port protected by an exhaust diaphragm. The valve incorporates two mounting studs for mounting the valve to the frame rail or crossmember.



1. Mounting Studs
2. 42 Control Port
3. Exhaust
4. Delivery
5. 41 Park Control (from dash valve)
6. 41 Balance Port
7. Supply Port
8. Exhaust
9. Delivery
10. Pipe Plug (QRV applications only)

Fig. 1, SR-7 Spring Brake Modulating Valve (exterior views)

General Information



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1. Main Piston
2. Control Piston
3. Spring Guide
4. Upper Body
5. Retaining Ring
6. O-Ring
7. O-Ring
8. Spacer
9. Main Piston Spring
10. Static Piston
11. O-Ring
12. O-Ring
13. Static Piston Spring
14. O-Ring
15. O-Ring
16. O-Ring
17. Lower Body
18. Valve Retainer
19. Spring
20. Inlet/Exhaust Valve
21. Lower Valve Guide
22. Retaining Ring
23. Exhaust Port
24. #10 Torx Screw
25. Diaphragm Washer
26. Diaphragm
27. Retaining Ring
28. Valve Seat
29. O-Ring
30. O-Ring
31. Spring
32. Ball Check Valve
33. O-Ring
34. Check Valve Guide
35. Supply Port
36. O-Ring
37. Spring
38. Inline Single Check Valve
39. Park Control Port
40. Check Valve Cover
41. Double Check Valve
42. O-Ring

Fig. 2, SR-7 Spring Brake Modulating Valve (sectional view)

CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

Operation

The operation guidelines in this subject represent the relay-valve-based SR-7. A quick-release-based valve functions similarly to the relay-valve-based version with the exception that all air delivered to the spring brakes passes through the park control port through the inline single check valve. The SR-7 quick release style can be easily identified by the pipe plug in the supply port of the valve. See **Fig. 1**. For vehicle-specific plumbing diagrams, go to **EZWiring**.

Charging the Spring Brake Actuators Below 107 psi (737 kPa)

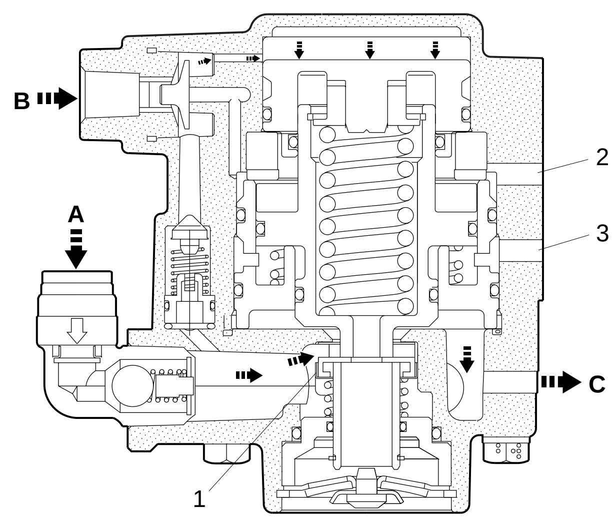
With the air brake system charged and the parking brakes released (by pushing in the dash valve button), air enters the park control port. This opens the SR-7 valve, to supply air pressure to the spring brake chambers. As illustrated, air pressure in the chambers is below 107 psi (737 kPa) (nominal). See **Fig. 3**.

Charging the Spring Brake Actuators Above 107 psi (737 kPa)

Once the SR-7 valve delivery pressure reaches 107 psi (nominal), the inlet and exhaust are closed (valve lap position). This maintains the spring brake hold-off pressure at 107 psi (nominal). See **Fig. 4**.

Normal Service Application

During a service brake application, the valve remains in the lap position. The SR-7 valve monitors the presence of air pressure in both primary and secondary delivery circuits. See **Fig. 5**.



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A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes

1. Inlet/Exhaust Valve Open
2. Balance Port
3. Control Port

Fig. 3, Charging the Spring Brake Actuators Below 107 psi (737 kPa)

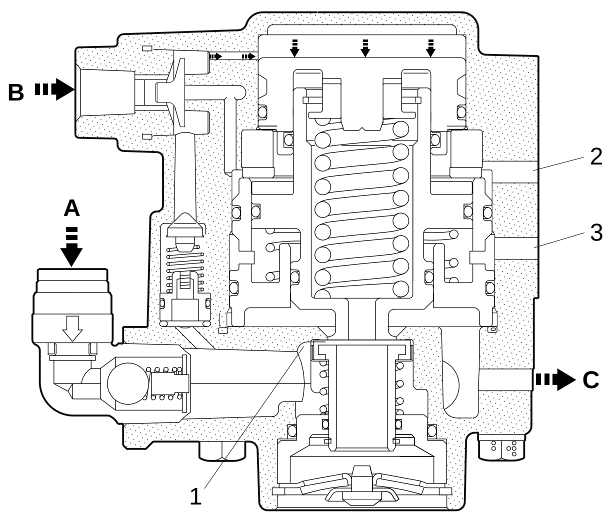
Parking

Actuating the park brakes (by pulling out the dash valve button) exhausts spring brake air pressure through the SR-7 valve exhaust port. See **Fig. 6**.

Service Application with Loss of Air in Primary Circuit

With the parking brakes released (dash valve button in) and the absence of air in the primary circuit delivery, a service brake application from the secondary circuit causes the pressure in the spring brakes to be exhausted proportionally to this application. This is known as spring brake modulation. A 30 psi (207 kPa) service brake application will exhaust the spring brake pressure to approximately 60 psi (414 kPa). See **Fig. 7**.

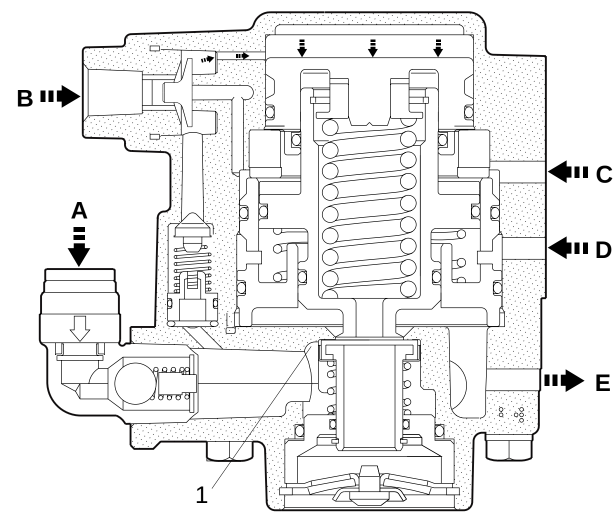
General Information



A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes

1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 4, Charging the Spring Brake Actuators Above 107 psi (737 kPa)



A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes

1. Inlet/Exhaust Valve Seated

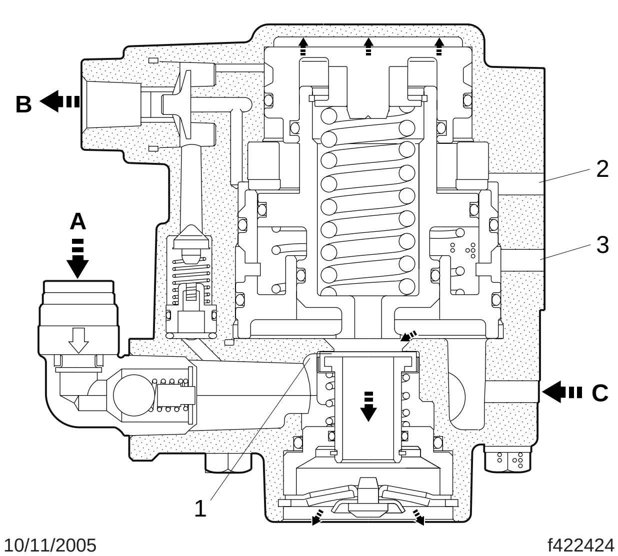
Fig. 5, Normal Service Application

Service Application with Loss of Air in Secondary Circuit

With the parking brakes released (dash valve button in) and the absence of air in the secondary circuit reservoir, the external single check valve in the supply port seals to prevent air leakage to atmosphere from the SR-7 valve. The dash valve delivery air flows through the inline single check valve and becomes SR-7 valve supply air. This air is delivered to maintain at least 107 psi (737 kPa) (nominal) in the spring brake chambers. See **Fig. 8**.

Anticompounding

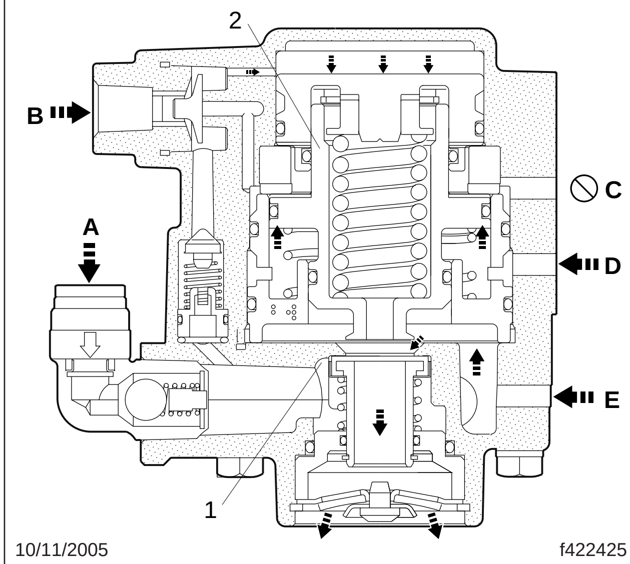
The SR-7 valve provides anticompounding of the service and spring brake forces. When the park brakes are actuated (by pulling out the dash valve button), a service brake application will cause the SR-7 valve to deliver air pressure to the spring brake chambers. Thus the vehicle is held stationary using a service brake application. When the service brake application is released, the delivery pressure is exhausted from the spring brake chambers and the vehicle remains parked using the spring brake actuators. See **Fig. 9**.



A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes

1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 6, Parking

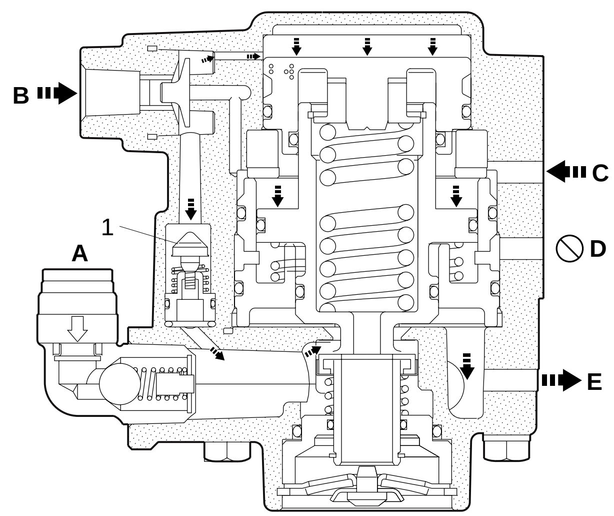


A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—loss of primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes

1. Inlet Valve Seated
2. Main Piston Moves Up

Fig. 7, Service Application with Loss of Air in Primary Circuit

General Information



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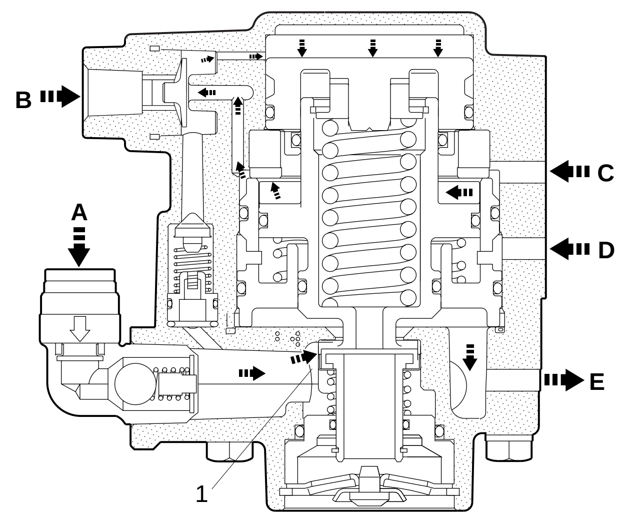
A. Secondary reservoir no pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—loss of secondary circuit pressure
E. Delivery to spring brakes

1. Inline Single Check Valve

Fig. 8, Service Application with Loss of Air in Secondary Circuit



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A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes

1. Inlet/Exhaust Valve Open

Fig. 9, Anticompounding

Safety Precautions

Before attempting to work on the air brake system, observe the following precautions:

- Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.
- When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.
- Hoses will whip dangerously if disconnected under pressure. Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.
- As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber pushrods and spring actuators that apply automatically with the loss of pressure. This also applies when checking the service brake system.
- Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.
- Used reservoirs must not be used as replacements, in order to eliminate the possibility of component failure.
- The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured, in order to prevent valve failure.
- Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.
- To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

Removal

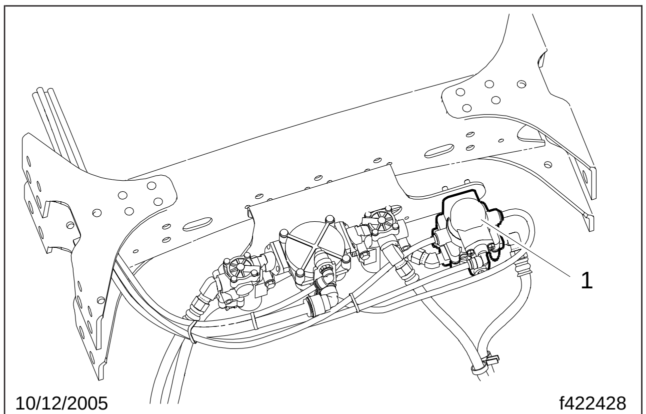
WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so could result in personal injury.

CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.
2. Drain the air system.
3. Identify all the air lines attached to the valve, for reinstallation. See **Fig. 1** for a view of a typical installation, or access EZWiring for vehicle-specific plumbing diagrams.



1. SR-7 Valve

Fig. 1, SR-7 Spring Brake Modulating Valve Installation (typical)

4. Disconnect all the air lines from the valve.
5. Remove the two mounting nuts that secure the valve to the crossmember bracket, and remove the valve.
6. If the valve is being replaced, note the orientation of all fittings, then remove the fittings for use on the new valve.

Installation

1. If a new valve is being installed, install the fittings removed from the old valve.
2. Position the valve on the crossmember bracket and install the mounting nuts. Tighten to 15 to 18 lbf·ft (20 to 24 N·m).
3. Attach all the air lines as noted during removal.
4. Before returning the vehicle to service, perform the operating and leakage tests in **Subject 120**, *Tests*.

Operating Test

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so could result in personal injury.

CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

1. Chock the tires.
2. Charge the air brake system to governor cut-out pressure.
3. Place the parking control valve in the PARK position. Observe that the spring brake actuators apply promptly.
4. Remove one line from a delivery port of the SR-7 valve and install a test gauge that is known to be accurate. See **Fig. 1** for the port locations.
5. Place the parking control valve in the RELEASE position. Observe that the spring brake actuators fully release.
6. With the parking control valve still in the RELEASE position, note the gauge pressure reading. Correct spring brake actuator hold-off pressure is 107 psi (737 kPa) nominal.
7. Place the parking control valve in the PARK position. The gauge reading should drop to zero promptly. A lag (more than 3 seconds) in the drop of pressure would indicate faulty operation.
8. With the parking control valve still in the PARK position, gradually apply the foot brake valve and note a pressure reading increase on the gauge installed in the SR-7 valve delivery port.
9. Place the parking control valve in the RELEASE position.
10. Drain the reservoir that supplies the rear service brake circuit; apply the foot brake valve several times and note that the pressure reading on the gauge decreases each time the foot brake valve is applied (spring brake modulation). After the foot brake valve has been applied several times, the pressure reading on the gauge will drop to the point where release of the spring brake actuators will no longer occur.

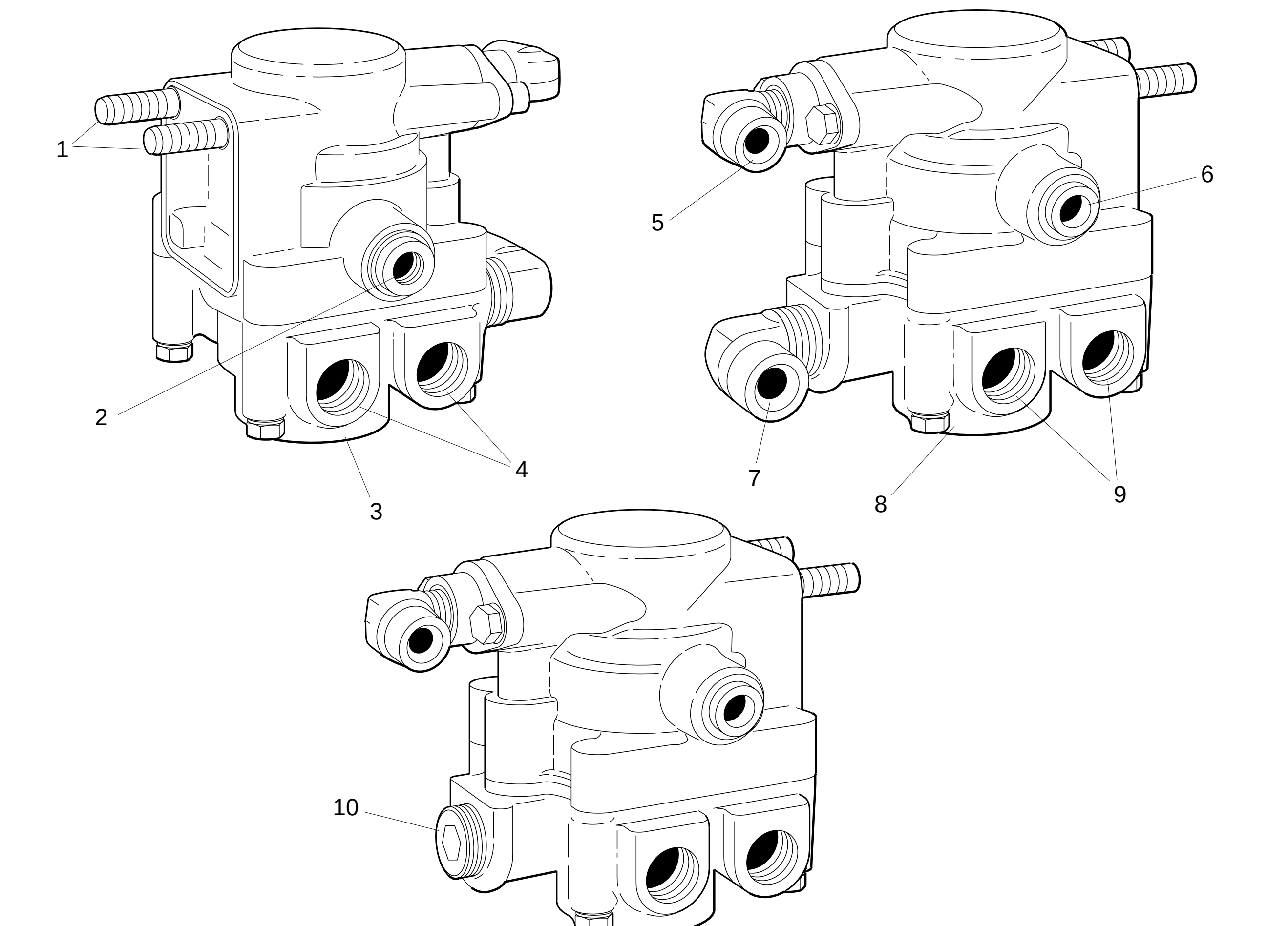
NOTE: The SR-7 valve is not serviceable. If the valve does not function as described, replace it.

Leakage Test

Place the park control valve in the RELEASE position; using a soap solution, coat all ports including the exhaust port. A 1-inch (25-mm) bubble in three seconds is permitted.

NOTE: The SR-7 valve is not serviceable. If the valve does not function as described, or if leakage is excessive, replace it.

Tests

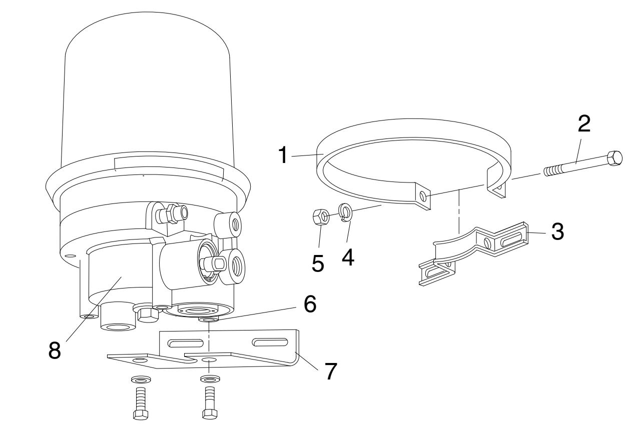


1. Mounting Studs
2. 42 Control Port
3. Exhaust
4. Delivery
5. 41 Park Control (from dash valve)
6. 41 Balance Port
7. Supply Port
8. Exhaust
9. Delivery
10. Pipe Plug (QRV applications only)

Fig. 1, SR-7 Spring Brake Modulating Valve (exterior views)

General Information

The function of the AD-IP Integral Purge Air Dryer, shown in **Fig. 1**, is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system. It provides clean, dry air to the components of the brake system, which increases the life of the system and reduces maintenance costs.



1. Mounting Strap
2. 5/16-Inch Bolt
3. Saddle Bracket
4. Lockwasher
5. Nut
6. End Cover Mounting Holes
7. Lower Mounting Bracket
8. Air Dryer

Fig. 1, Bendix AD-IP Air Dryer

The AD-IP air dryer consists of a desiccant cartridge secured to a die-cast aluminum end cover with a single, central bolt. The end cover contains a check valve assembly, safety valve, heater and thermostat assembly, three pipe thread air connections, and the purge valve assembly. The removable purge valve assembly incorporates the purge valve mechanism and a turbocharger cutoff feature that is designed to prevent loss of engine turbocharger boost pressure during the purge cycle of the AD-IP air dryer. For ease of serviceability, all replaceable assemblies can be replaced without removal of the air dryer from its mounting on the vehicle.

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types.

The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, can be serviced **without** removing the air dryer from the vehicle. The screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.

The AD-IP has three female pipe thread air connections identified in **Table 1**.

Air Dryer Port Identification	
Port I.D.	**Function/Connection**
CON 4	Control Port (purge valve control and turbo cutoff)
SUP 11	Supply Port (air in)
DEL 2	Delivery Port (air out)

Table 1, Air Dryer Port Identification

Principles of Operation

The AD-IP air dryer alternates between two operational modes or cycles during operation: the charge cycle, shown in **Fig. 2**, and the purge cycle, shown in **Fig. 3**.

Charge Cycle

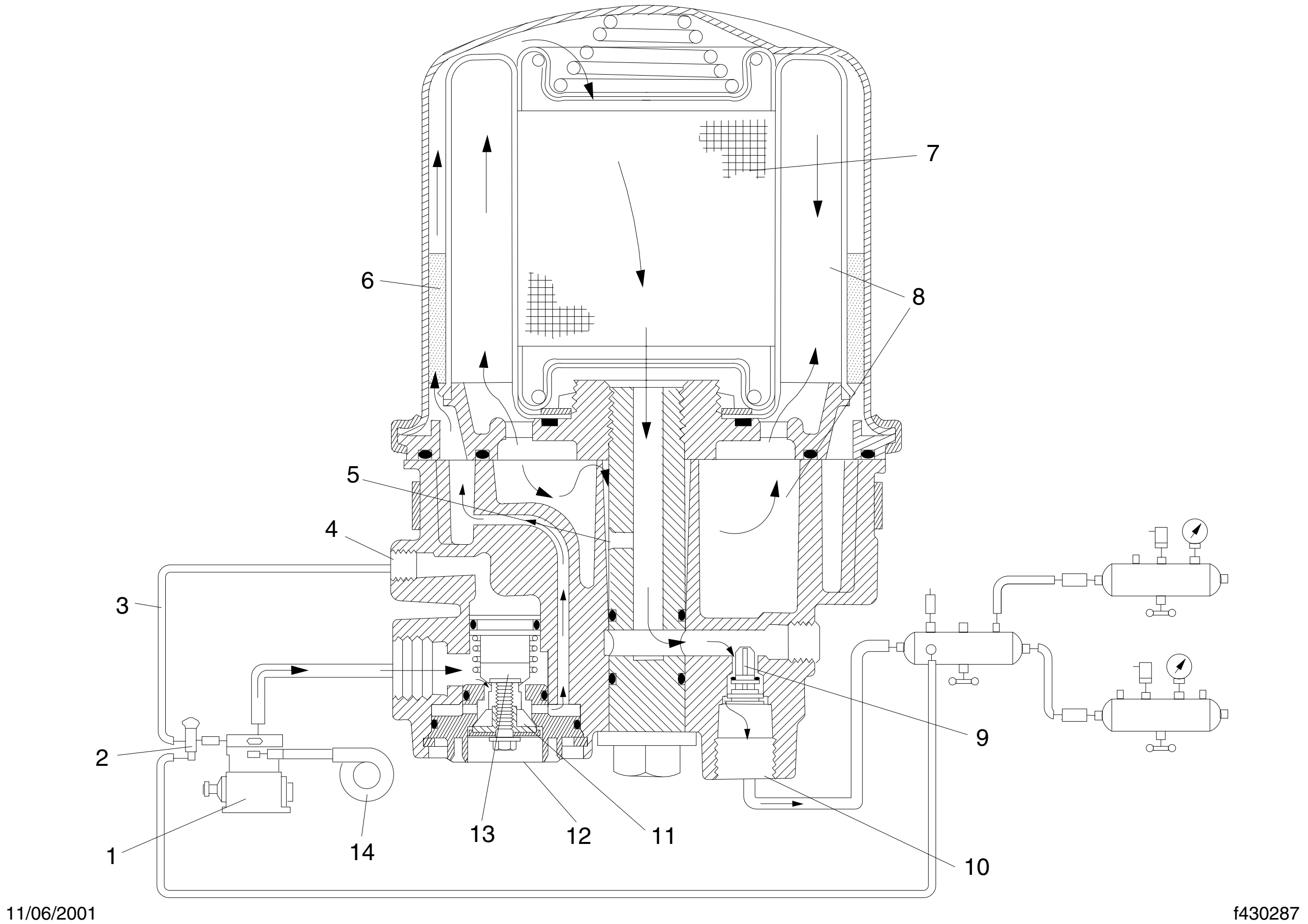
When the compressor is loaded (compressing air), compressed air, along with oil, oil vapor, water, and water vapor flows through the compressor discharge line to the supply port of the air dryer body.

As air travels through the end cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense, and to drop to the bottom or sump of the air dryer end cover.

After exiting the end cover, the air flows into the desiccant cartridge. Once in the desiccant cartridge, air first flows through an oil separator located between the outer and inner shells of the cartridge. The separator removes water in liquid form as well as oil and solid contaminants.

Air, along with the remaining water vapor, is further cooled as it exits the oil separator and continues to flow upward between the outer and inner shells. Upon reaching the top of the cartridge the air reverses its direction of flow and enters the desiccant drying bed. Air flowing down through the column of desiccant becomes progressively dryer as water

General Information



1. Compressor
2. Governor
3. Purge Control Line
4. Control Port
5. Purge Orifice
6. Oil Separator
7. Desiccant Bed
8. Purge Volume
9. Delivery Check Valve
10. Discharge Port
11. Purge Valve
12. Exhaust
13. Turbo Cutoff Valve
14. Engine Turbocharger

Fig. 2, AD-IP Charge Cycle

vapor adheres to the desiccant material in a process known as adsorption. The desiccant cartridge, using the adsorption process, typically removes most of the water vapor from the pressurized air.

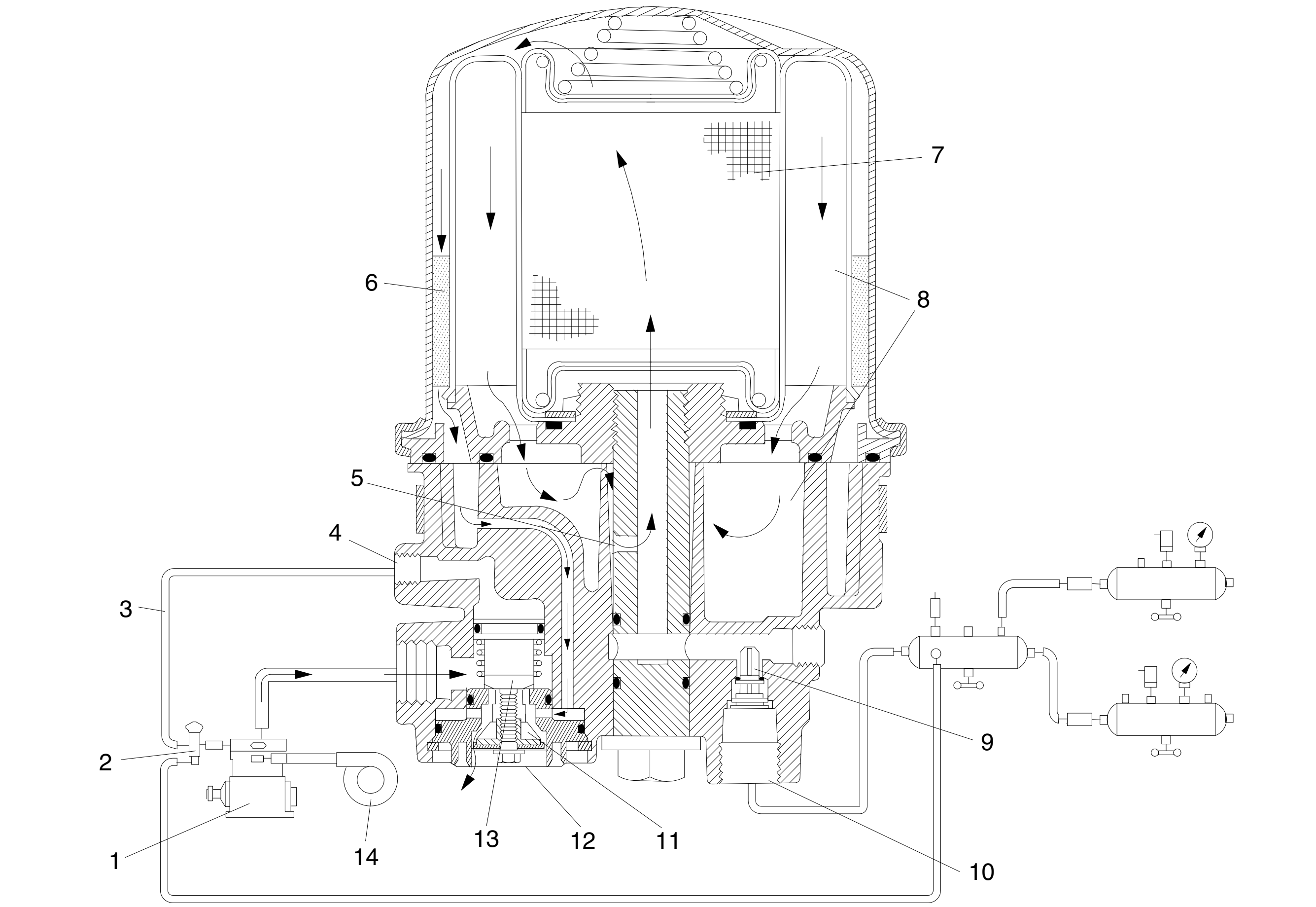
Dry air exits the bottom of the desiccant cartridge and flows through the center of the bolt used to secure the cartridge to the end cover. Air flows down the center of the desiccant cartridge bolt, through a cross-drilled passage and exits the air dryer delivery port through the delivery check valve.

Dry air flowing through the center of the desiccant cartridge bolt also flows out the cross-drilled purge orifice and into the purge volume.

The air dryer will remain in the charge cycle until the air brake system pressure builds to the governor cutout setting.

Purge Cycle

As air brake system pressure reaches the cutout setting of the governor, the governor unloads the compressor (air compressor stops compressing air) and



1. Compressor
2. Governor
3. Purge Control Line
4. Control Port
5. Purge Orifice
6. Oil Separator
7. Desiccant Bed
8. Purge Volume
9. Delivery Check Valve
10. Discharge Port
11. Purge Valve
12. Exhaust
13. Turbo Cutoff Valve
14. Engine Turbo

Fig. 3, AD-IP Purge Cycle

the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the compressor unloader mechanism and the line connecting the governor unloader port to the AD-IP end cover control port. The purge piston moves in response to air pressure, causing the purge valve to open to the atmosphere and the turbo cutoff valve to close off the supply of air from the compressor (this will be further discussed under the *Turbocharger Cutoff Feature* heading). Water and contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air which was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the purge volume through the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression lasts only a few seconds and is evidenced by an audible burst of air at the AD-IP exhaust.

The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume

General Information

through the purge orifice in the desiccant cartridge bolt, then through the center of the bolt and into the desiccant bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Generally 30 seconds are required for the entire purge volume of a standard AD-IP to flow through the desiccant drying bed.

The delivery check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the 30-second purge cycle is complete, the desiccant has been reactivated or dried. The air dryer is ready for the next charge cycle to begin. However, the purge valve will remain open and will not close until air brake system pressure is reduced and the governor signals the compressor to charge the system.

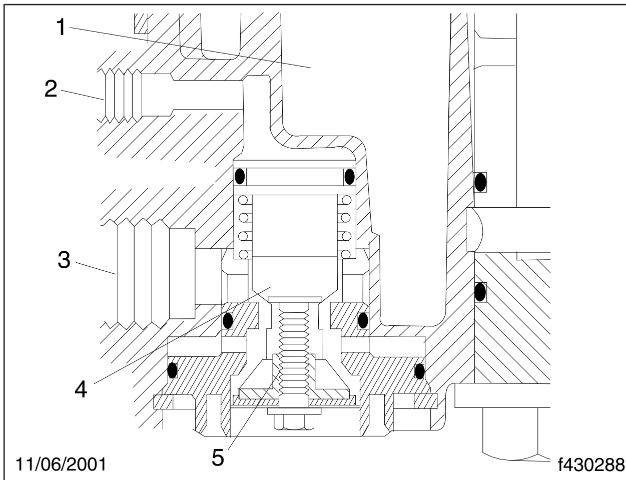
NOTE: The air dryer should be periodically checked for operation and tested for leaks. Refer to **Group 42** of the vehicle maintenance manual for intervals and procedures.

Turbocharger Cutoff Feature

NOTE: The air compressor is naturally aspirated; the air passes from the vehicle air filter directly to the air compressor intake.

The primary function of the turbo cutoff valve is to prevent loss of engine turbocharger air pressure through the AD-IP in systems where the compressor intake is connected to the engine turbocharger. The turbo cutoff valve also removes the "puffing" of air out of the open purge exhaust, when a naturally aspirated, single-cylinder compressor, equipped with an inlet check valve, is in use. See **Fig. 4**.

At the beginning of the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve (tapered portion of purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the compressor discharge line and AD-IP inlet port cannot enter the air dryer. In this manner, the turbo cutoff effectively maintains turbocharger boost pressure to the engine.



1. Purge Volume
2. Control Port
3. Supply Port
4. Turbo Cutoff Valve
5. Purge Valve

Fig. 4, AD-IP Turbo Cutoff

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

- Chock the tires and shut down the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.

  Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.

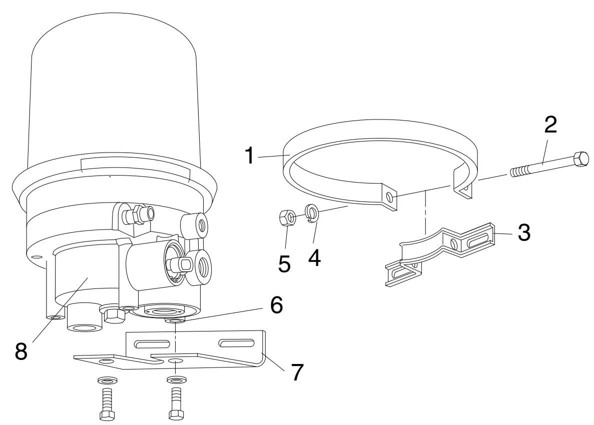
Removal and Installation

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Completely drain all of the reservoirs.
3. Mark and disconnect the three air lines from the end cover, and note the position of end cover ports relative to the vehicle.
4. Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the purge valve assembly.
5. Remove the four bolts that secure both the upper and lower mounting brackets to the vehicle, and remove the air dryer from the vehicle. See **Fig. 1**.



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1. Mounting Strap
2. 5/16-Inch Bolt
3. Saddle Bracket
4. Lockwasher
5. Nut
6. End Cover Mounting Holes
7. Lower Mounting Bracket
8. Air Dryer

Fig. 1, Bendix AD-IP Air Dryer

6. Mark the relationship of the saddle bracket to the end cover assembly. Remove the 5/16-inch bolt, washer, and nut that secures the upper mounting strap to the saddle bracket. Remove the upper mounting strap from the end cover assembly.
7. Mark the relationship of the lower bracket to the end cover assembly. Remove the two 3/8-inch end cover capscrews and two washers that retain the lower mounting bracket to the end cover.
8. Remove the air dryer from its mounting brackets.

Installation

1. Install the lower mounting bracket on the end cover and secure it using the two 3/8-inch capscrews and washers. Tighten the capscrews 25 to 30 lbf·ft (34 to 41 N·m). See **Fig. 1**.
2. Install the saddle bracket and mounting strap on the end cover, and using the 5/16-inch bolt, washer, and nut secure the strap to the saddle bracket. Tighten the 5/16-inch nut on the upper mounting bracket 60 to 100 lbf·in (678 to 1130 N·cm).
3. Install the AD-IP on the vehicle using the four bolts that secure both the upper and lower mounting brackets.
4. As marked earlier in "Removal," connect the three air lines to the ports on the end cover.
5. Connect the vehicle wiring harness to the air dryer heater and thermostat assembly connector by plugging it into the air dryer connector until its lock tab snaps in place.
6. Test the air dryer, following instructions in **Group 42** of the vehicle maintenance manual.

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

NOTE: As a convenience when rebuilding the air dryer, several replacement parts and maintenance kits are available that do not require full disassembly. Use the instructions provided with these parts or kits.

Disassembly

NOTE: Refer to **Fig. 1** during disassembly.

NOTICE

While servicing the air dryer, do not use a clamping device (vise, C-clamp, etc.) to hold any die cast aluminum part, as damage may result. To hold the end cover, install a pipe nipple in the supply port, and clamp the nipple in a vise.

1. Remove the air dryer from the vehicle. See **Subject 110**.
2. Loosen the desiccant cartridge bolt, then separate the desiccant cartridge from the end cover. Pull the desiccant cartridge bolt out of the end cover. See **Fig. 1**.

CAUTION

Disassembly of the desiccant cartridge assembly should not be attempted! Detail parts for the cartridge are not available and the cartridge contains a 150 lb spring which can not be mechanically caged. Releasing the spring could cause serious personal injury.

3. Remove both O-rings from the desiccant cartridge bolt.
4. Remove the retaining ring that secures the purge valve assembly in the end cover.
5. Remove the 1/4-inch shoulder bolt from the bottom of the purge valve housing assembly, using a 3/8-inch socket wrench and a large blade screwdriver, inserted in the slot on top of the purge piston. Remove the exhaust diaphragm, and the purge valve from the purge valve housing.
6. Remove the O-rings from the purge valve housing.
7. Remove the purge piston and the return spring. Remove the O-ring from the purge piston.
8. Remove the retaining ring that secures the delivery check valve assembly in the end cover. Remove and separate the perforated plate, spring, check valve body, and O-ring.
9. Remove the retaining ring that secures the heater and thermostat assembly in the end cover. Gently pull the heater and thermostat out of the end cover and remove the O-ring.
10. Using a 9/16-inch wrench, remove the safety valve assembly from the end cover.

Cleaning and Inspection

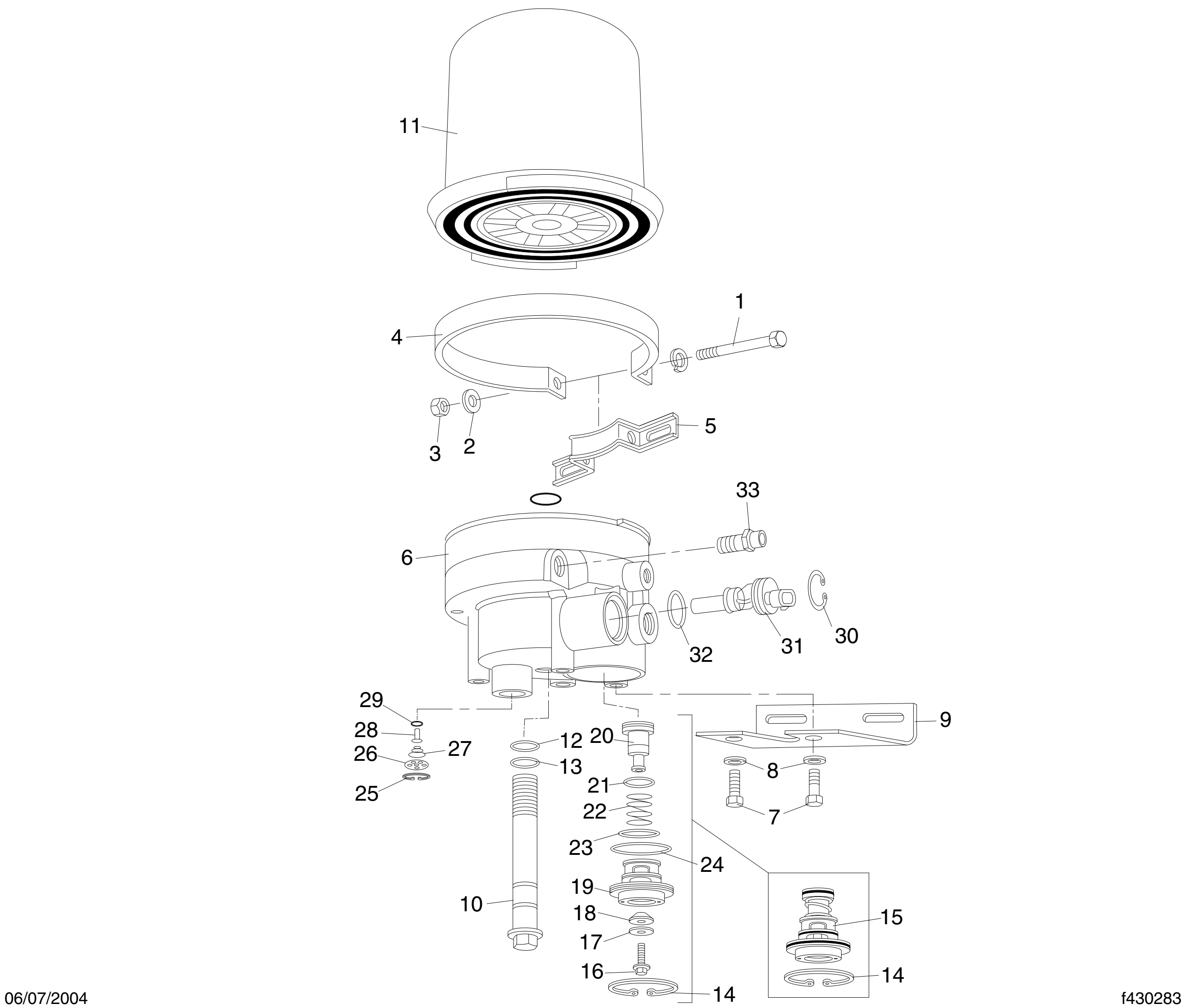
1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.

NOTE: Do not clean the desiccant cartridge.

2. Check for severe corrosion, pitting, and cracks on the inside and outside of all metal parts that will be reused. Superficial corrosion and pitting on the outside of the upper and lower body halves is acceptable.
3. Inspect the bores of both the end cover and the purge-valve housing for deep scuffing or gouges.
4. Make sure that all purge-valve housing and end cover passages are open and free of blockages.
5. Inspect the pipe threads in the end cover. Make sure they are clean and free of thread sealant.
6. Inspect the purge-valve housing bore and seats for excessive wear and scuffing.
7. Inspect the purge valve piston seat for excessive wear.
8. Make certain that the purge orifice in the cartridge bolt is open and free of obstructions.
9. Inspect all air line fittings for corrosion. Clean all old thread sealant from the pipe threads.
10. Replace all removed O-rings with new ones that are provided in the kits.

    Replace parts that show any of the conditions described in the previous steps.

Air Dryer Disassembly, Cleaning and Inspection, and Assembly



1. 5/16-Inch Bolt
2. 5/16-Inch Lockwasher
3. 5/16-Inch Locknut
4. Upper Bracket Strap
5. Saddle Bracket
6. End Cover
7. 3/8-Inch Capscrew
8. 3/8-Inch Lockwasher
9. Lower Mounting Bracket
10. Cartridge Bolt
11. Desiccant Cartridge
12. O-Ring
13. O-Ring
14. Retaining Ring
15. Purge Valve Cartridge Assembly
16. Shoulder Bolt
17. Exhaust Diaphragm
18. Purge Valve
19. Purge Valve Housing
20 Purge Valve Piston
21 O-Ring
22. Piston Return Spring
23. O-Ring
24. O-Ring
25. Retaining Ring
26. Perforated Plate
27. Check Ring Spring
28. Check Valve
29. O-Ring
30. Retaining Ring
31. Heater/Thermostat Assembly
32. O-Ring
33. Safety Valve Assembly

Fig. 1, AD-IP (exploded view)

Assembly

1. Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-base lubricant. See **Fig. 1** during assembly unless otherwise advised.
2. Install and center the exhaust diaphragm over the shoulder bolt, making certain that the diaphragm ID is over the bolt shoulder. Then install the purge valve on the shoulder bolt, making certain its metal support side is against the diaphragm.
3. Push the purge piston into the housing until it bottoms, and insert a large blade screwdriver in the piston's slotted head. While depressing the purge piston with the screwdriver, install the shoulder bolt with exhaust diaphragm and purge valve in the piston. Tighten the shoulder bolt 60 to 80 lbf·in (678 to 904 N·cm).
4. Install the two O-rings on the purge valve housing, placing each in its appropriate location. Install the assembled purge valve housing in the end cover while making certain the purge valve housing is fully seated against the end cover. Secure the purge valve housing in the end cover, using the retaining ring. Make certain the retaining ring is fully seated in its groove in the end cover.
5. Using a 9/16-inch wrench, install the safety valve assembly into the end cover.
6. Install the O-ring on the check valve body, and push the O-ring down, over the three guide lands until it is in the O-ring groove of the check valve body. Install the check valve spring on the check valve body so that the small coils of the spring slip over the check valve body. Install the assembled check valve body, O-ring, and spring in the end cover so that the O-ring rests on its seat in the end cover, and the spring is visible.
7. Install the O-ring on the heater and thermostat assembly. After making certain the sponge-rubber cushion is positioned between the connector body and thermostat, gently push the heater and thermostat assembly into the end cover, making certain the heating element enters the small diameter bore in the larger heater and thermostat bore in the end cover. Secure the heater and thermostat assembly in the body, using the retaining ring. Make certain the retaining ring is fully seated in its groove in the end cover.
8. Install both O-rings on the desiccant cartridge bolt, and using a twisting motion, insert the assembled desiccant cartridge bolt in the end cover.
9. Install the desiccant cartridge on the end cover, making certain the cartridge is properly seated and flush on the end cover.

NOTE: It may be necessary to rotate the cartridge slightly until the anti-rotation lugs are properly aligned and they allow the cartridge to rest flush against the end cover.

10. Tighten the desiccant cartridge bolt 50 lbf·ft (68 N·m), to secure the desiccant cartridge to the end cover.
11. Install the air dryer. For instructions, see **Subject 110**.

Testing

During cold-weather operation, check the operation of the end cover heater and thermostat assembly.

1. With the ignition on, check for voltage to the heater and thermostat assembly. Unplug the electrical connector at the air dryer, and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check that a good ground path exists.
2. Check the thermostat and heater operation. Turn off the ignition switch and cool the end cover assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly, and 6.8 to 9.0 ohms for the 24-volt heater assembly.
3. Warm the end cover assembly to over 90°F (32°C) and again check the resistance. It should exceed 1000 ohms. If it does, the thermostat and heater assembly is operating properly. If it doesn't, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

Troubleshooting

Problem—Air Dryer Is Constantly Cycling or Purging

Problem—Air Dryer Is Constantly Cycling or Purging	
Possible Cause	**Remedy**
Excessive system leakage.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is 1 psi/min (7 kPa/min) per service reservoir
There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank.	Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.
Governor is inoperative.	Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions.
Leaking purge-valve housing assembly or O-rings in the air dryer end cover.	With the supply port open to atmosphere, apply 120 psi (830 kPa) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. Repair or replace as needed.
Compressor unloader mechanism is leaking excessively.	Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed.
Lack of air at the governor RES port (rapid cycling of the governor).	Test the governor for proper pressure at the RES port. Pressure should not drop below cut-in pressure when the compressor begins the unloaded cycle. If the pressure does drop, check for kinks or restrictions in the line connected to the RES port. The line connected to the RES port on the governor must be the same diameter, or larger than the lines connected to the UNL ports on the governor.

Problem—Water in the Vehicle Reservoirs

Problem—Water in the Vehicle Reservoirs	
Possible Cause	**Remedy**
Desiccant cartridge assembly contains excessive contaminants.	Replace the desiccant cartridge.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft. (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information.
Air system was charged from an outside air source that did not pass through an air dryer.	If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized.
Air dryer is not purging.	Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air."
Purge (air exhaust) is insufficient due to excessive system leakage.	Refer to "Problem—Air Dryer Is Constantly Cycling or Purging."
Air bypasses the desiccant cartridge assembly.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed.

Troubleshooting

Problem—Water in the Vehicle Reservoirs	
Possible Cause	**Remedy**
Purge (air exhaust) time is significantly less than the minimum allowable.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly.
Excessive air usage—air dryer not compatible with vehicle air system.	Install an accessory bypass system. Consult your Bendix representative for additional information.

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air	
Possible Cause	**Remedy**
Desiccant cartridge is plugged or saturated.	Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as needed.
The check valve in the air dryer end cover is inoperative.	Test to determine if air is passing through the check valve. Repair or replace as needed.
There is a problem in the fittings, hose, or tubing between the air dryer and the wet tank.	See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings.
Safety valve setting is lower than the maximum system pressure.	Reduce the system pressure, or install a safety valve with a higher pressure setting.

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure	
Possible Cause	**Remedy**
Air dryer purge valve is leaking excessively.	With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Purge control line is connected to the reservoir or exhaust port of the governor.	Connect the purge control line to the unloader port of the governor.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse.	Test the heater and thermostat, following instructions in this manual.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
System is leaking excessively.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is 1 psi/min (7 kPa/min) per service reservoir.
Purge valve stays open; supply air leaks to control side.	Replace the purge valve assembly O-rings.

Troubleshooting

Problem—Air Dryer Does Not Purge or Exhaust Air

Problem—Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
Purge control line is broken, kinked, frozen, plugged, or disconnected.	See if air flows through the purge control line when the compressor is unloaded. The purge control line must be connected to the unloader port of the governor.
Air dryer purge valve isn't working.	See if air reaches the purge valve. If it does, repair the purge valve.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (may look like whitish liquid, paste, or small beads) or Unsatisfactory Desiccant Life	
Possible Cause	**Remedy**
This problem usually occurs with one or more of the previous problems.	Refer to the appropriate corrections listed previously.
Air dryer is not securely mounted; there is excessive vibration.	Vibration should be held to a minimum. Tighten the mounting fasteners.
Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly.	Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth. Check the installation.
Compressor is passing excessive oil.	Check for proper compressor installation; if symptoms persist, replace the compressor.
Heater and thermostat, wiring, or a fuse is at fault, and isn't allowing the air dryer to purge during cold weather.	Test the heater and thermostat. See **Group 83** in this manual.
Desiccant cartridge not attached properly to the end cover.	Check the torque and tighten if necessary. Refer to **Subject 120** for instructions.

Troubleshooting

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle	
Possible Cause	**Remedy**
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 in^3 (1475 cm^3) reservoir between the compressor and the air dryer.

Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)

Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)	
Possible Cause	**Remedy**
Air compressor inlet is pressurized by the engine turbocharger.	Some pressure leakage past the metal seat of the turbocharger cutoff feature of the AD-9 air dryer is normal, and may be heard. This slight loss of air will not affect the engine or turbocharger performance.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.

Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode

Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode	
Possible Cause	**Remedy**
Compressor does not "unload."	Check the governor installation: there is no air line from the governor to the compressor, or the line is restricted. Repair or replace as needed.

General Information

The function of the Integrated Solution Air Dryer (AD-IS®) and reservoir system is to provide vehicles with an air dryer, purge reservoir, governor, and a number of the charging valve components in one system. See **Fig. 1**.

The AD-IS® air dryer and reservoir system collects and removes air system contaminants in solid, liquid, and vapor form before they enter the brake system. It provides clean, dry air to the components of the brake system, which increases the life of the system.

Charge Cycle

Figure 2 shows the charge cycle.

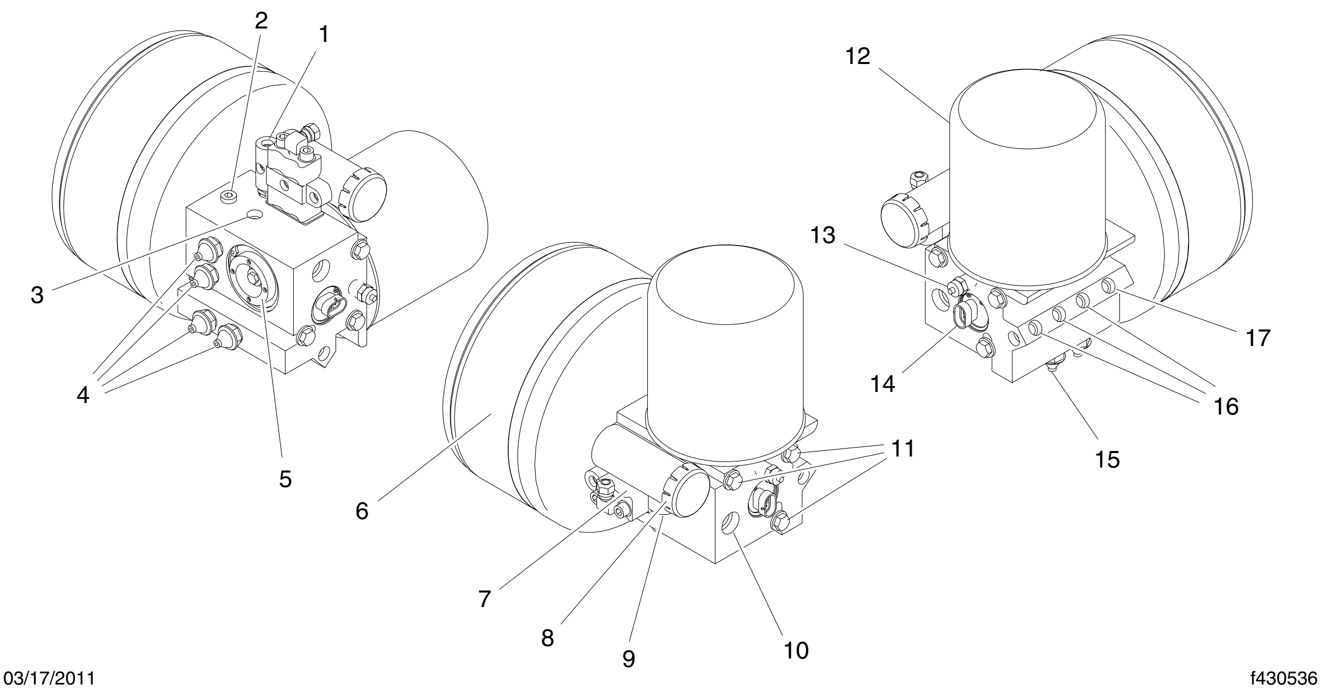
When the compressor is loaded, compressed air, oil, oil vapor, water, and water vapor flow through the compressor discharge line to the inlet port of the air dryer body.

As air travels through the air dryer assembly, its temperature falls, causing some of the contaminants to condense and drop to the bottom of the air dryer assembly, ready to be expelled at the next purge cycle.

The air then flows into the desiccant cartridge. Once in the desiccant cartridge, air flows through an oil separator which removes oil and solid contaminants.

Air then flows into the desiccant drying bed. Air flowing through the desiccant becomes progressively dryer as water vapor adheres to the desiccant material.

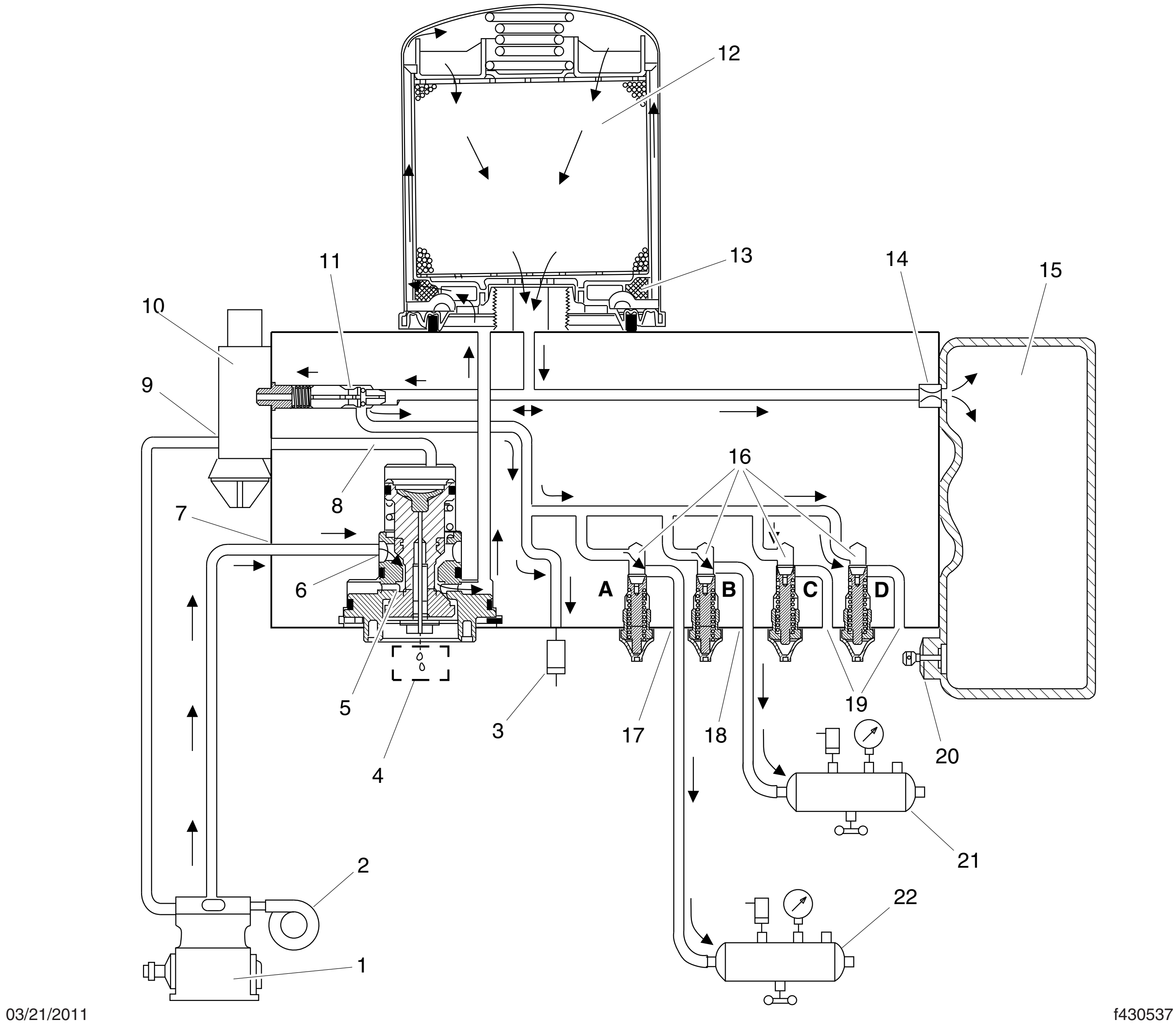
Dry air exits the bottom of the desiccant cartridge and flows through the center of the base assembly.



1. Governor Reservoir
2. Delivery to Secondary Reservoir
3. Delivery to Primary Reservoir
4. Pressure Protection Valves
5. Purge Valve
6. Purge Reservoir
7. Governor Unloader
8. Governor
9. Governor Exhaust
10. Supply from Compressor
11. Mounting Bolts (3)
12. Desiccant Cartridge
13. Safety Valve
14. Heater/Thermostat
15. Pressure Protection Valves (4)
16. Auxiliary Delivery Ports (4)
17. Auxiliary Delivery Ports (2)

Fig. 1, AD-IS Air Dryer

General Information



1. Compressor
2. Engine Turbo
3. Safety Valve
4. Purge Control Channel Drain
5. Purge Valve (closed)
6. Turbo Cutoff Valve (open)
7. Inlet Port
8. Purge Control Channel
9. Unloader Port
10. Governor
11. Delivery Check Valve (open)
12. Desiccant Bed
13. Oil Separator
14. Purge Orifice
15. Purge Reservoir
16. Pressure Protection Valves
17. Primary Port
18. Secondary Port
19. Auxiliary Ports
20. Purge Reservoir Drain Valve
21. Secondary Reservoir
22. Primary Reservoir

Fig. 2, Air Dryer Charge Cycle

The air then flows to the delivery check valve, to the safety valve and also through an orifice plug into the purge reservoir. Air traveling through the delivery check valve flows to the governor and the four pressure protection valves.

As pressure builds during the initial charge, the purge reservoir fills. When the air pressure reaches 106 psi (731 kPa), the four pressure protection valves open and air is supplied to the primary reservoir, secondary reservoir, and accessories. If the pressure protection valves are preset to different values, the valves open in order of the lowest to the highest setting when charging a flat system.

The air dryer will remain in the charge cycle until the air brake system pressure builds to the governor cutout setting of approximately 130 psi (896 kPa).

Purge Cycle

Figure 3 shows the purge cycle.

When air brake system pressure reaches the cutout setting of the governor, the governor unloads the compressor and the purge cycle begins. When the governor unloads the compressor, it pressurizes the compressor unloader mechanism and the dryer control port. The purge piston moves in response to air pressure, causing the purge valve to open and the turbo cutoff valve to close. When the purge valve opens, water and contaminants are expelled. Air flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected in the oil separator are removed by air flowing from the purge reservoir, through the desiccant drying bed, and out through the open purge valve.

The purge cycle lasts only a few seconds and is detected by an audible burst of air at the air dryer exhaust.

The reactivation of the desiccant drying bed begins as dry air flows from the purge reservoir, through the purge orifice, and into the desiccant bed. Pressurized air from the purge reservoir expands after passing through the purge orifice; its pressure is lowered and its volume is increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Approximately 30 seconds is required for the entire purge reservoir of a standard air dryer to flow through the desiccant dryer bed.

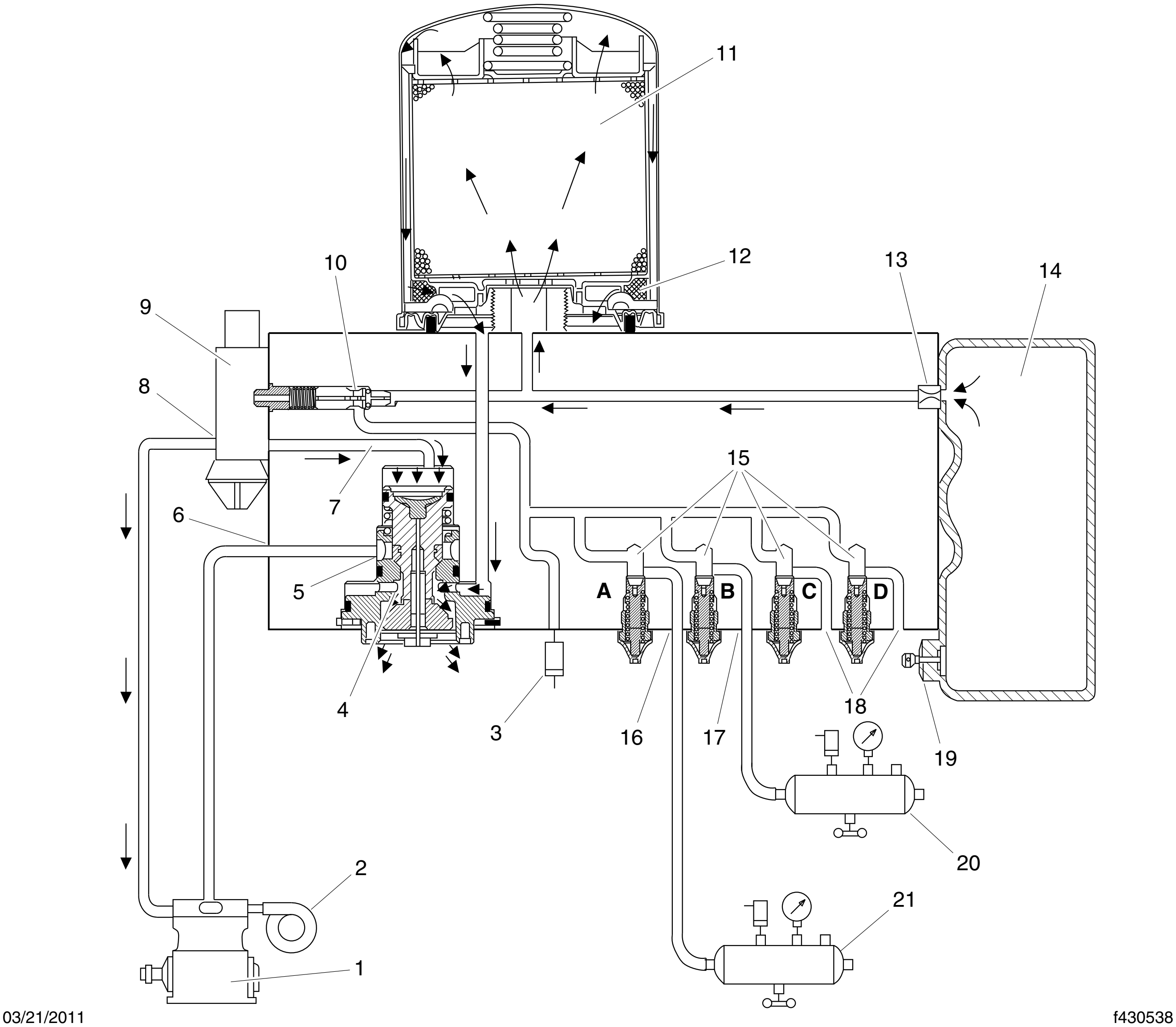
The delivery check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

Turbo Cutoff Feature

The primary function of the turbo cutoff valve is to prevent loss of turbocharger air pressure through the air dryer when the dryer is in the unloaded mode.

During the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the compressor discharge line and air dryer inlet port cannot enter the air dryer. This maintains turbocharger boost pressure to the engine.

General Information



NOTE: All pressure protection valves are shown open.

1. Compressor
2. Engine Turbo
3. Safety Valve
4. Purge Valve (open)
5. Turbo Cutoff Valve (closed)
6. Inlet Port
7. Purge Control Channel
8. Unloader Port
9. Governor
10. Delivery Check Valve (closed)
11. Desiccant Bed
12. Oil Separator
13. Purge Orifice
14. Purge Reservoir
15. Pressure Protection Valves
16. Primary Port
17. Secondary Port
18. Auxiliary Ports
19. Purge Reservoir Drain Valve
20. Secondary Reservoir
21. Primary Reservoir

Fig. 3, Air Dryer Purge Cycle

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

- Chock the tires and shut down the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Don’t disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.

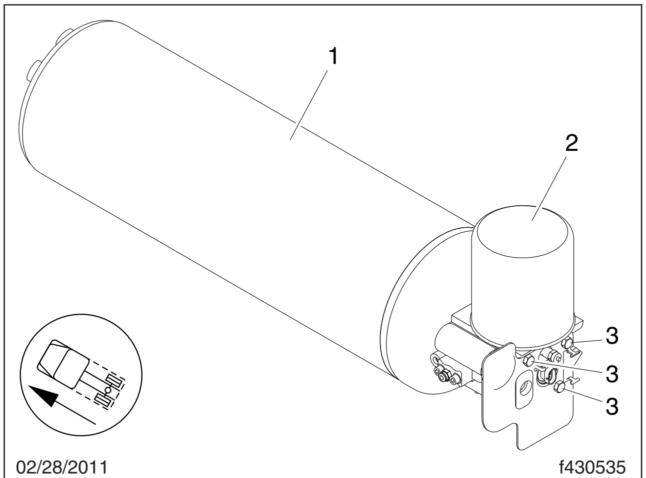
  Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoirs.
3. Mark and remove the air lines from the air reservoir.
4. Unplug the wiring harness from the heater/thermostat assembly.
5. Remove the three capscrews that fasten the air dryer to the air reservoir. See **Fig. 1**. Remove the air dryer.



1. Air Reservoir
2. Air Dryer
3. Capscrews

Fig. 1, AD-IS Air Dryer

6. Remove the governor and delivery check valve from the air dryer. For instructions, see **Subject 130**.
7. Remove the desiccant cartridge. For instructions, see **Subject 120**.
8. Install the delivery check valve and governor onto the new air dryer. For instructions, see **Subject 130**.
9. If removed, install the desiccant cartridge. For instructions, see **Subject 120**.
10. Install the air dryer, making sure the two O-rings are installed between the air dryer and air reservoir. Use the three capscrews to fasten the air dryer to the reservoir. Tighten the capscrews 30 to 35 lbf·ft (41 to 47 N·m). See **Fig. 1**.
11. Connect the air lines and plug the wiring harness into the heater/thermostat assembly.
12. Perform the operational tests in **Subject 170**.

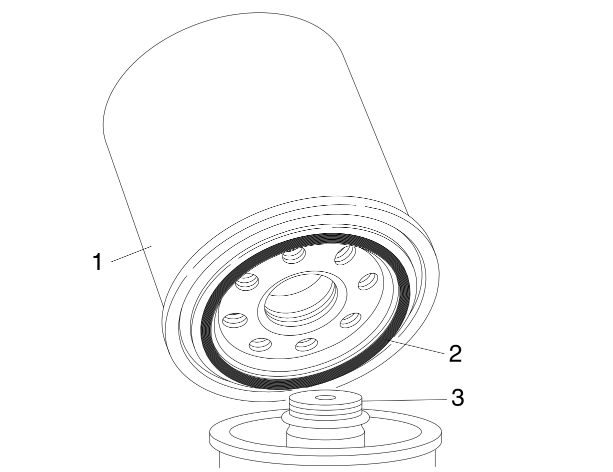
Desiccant Cartridge Replacement

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

Refer to **Fig. 1** for desiccant cartridge replacement.



1. Desiccant Cartridge
2. Cartridge Sealing Ring
3. Threaded Base Post

Fig. 1, Desiccant Cartridge Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoirs.
3. Using a strap wrench or equivalent, loosen the desiccant cartridge. Spin the cartridge off by hand and discard it.
4. On the new desiccant cartridge, lubricate the sealing rings with silicone grease.

IMPORTANT: Only use the silicone grease supplied with AlliedSignal replacement kits.

5. Screw the desiccant cartridge onto the body, by hand, until the seal makes contact with the body. Rotate the cartridge clockwise about one full turn. If necessary, use a strap wrench to tighten the cartridge.

Delivery Check Valve and Governor Replacement

WARNING

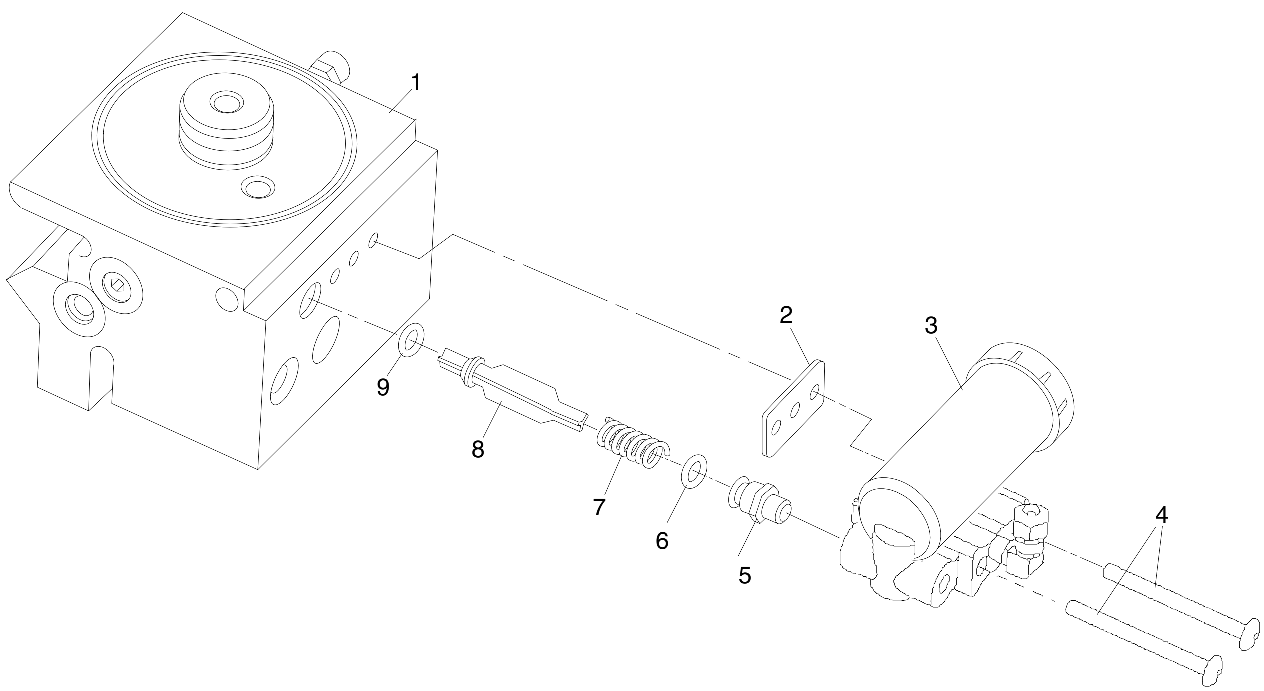
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoirs.
3. Disconnect the air line from the governor and mark it for later reference. See **Fig. 1**. Remove the capscrews that attach the governor to the air dryer.
4. Remove the governor, adaptor fitting, and the adaptor O-ring. Remove the governor gasket and discard it.
5. Remove the spring and check valve.
6. Lubricate the new smaller O-ring and check valve body with silicone grease.

IMPORTANT: Only use the silicone grease supplied with AlliedSignal replacement kits.

7. Install the O-ring on the check valve body and push the O-ring down, over the longer set of three guide lands, until it is in the O-ring groove of the check valve body.
8. Install one end of the check valve spring over the check valve's shorter set of three guide lands. Turn the valve about 1/4 turn while holding the spring, if necessary, to secure the valve in place. Install the assembled check valve body, O-ring, and spring in the delivery port, so the O-ring rests on its seat and the free end of the spring is visible.



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1. Air Dryer Base
2. Gasket
3. Governor
4. Capscrews
5. Adaptor
6. O-Ring
7. Spring
8. Check Valve Body
9. O-Ring

Fig. 1, Delivery Check Valve Replacement

Delivery Check Valve and Governor Replacement

9. Install the adaptor fitting into the governor. Using the silicone grease, lubricate the remaining larger O-ring, and install it into the groove of the adaptor. Install the gasket supplied in the kit. Install the governor, and torque the capscrews 10 lbf·ft (14 N·m).
10. Perform the operational tests in **Subject 170**.

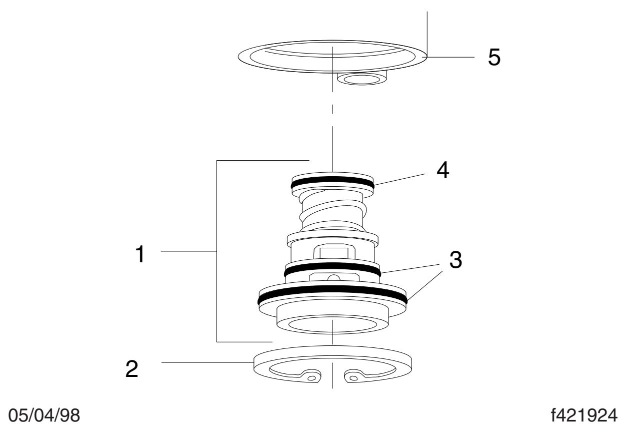
Purge Valve Replacement

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

Refer to **Fig. 1** for purge valve replacement.



1. Purge Valve Assembly
2. Retaining Ring
3. O-Rings
4. Quad-Ring
5. Air Dryer

Fig. 1, Purge Valve Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the vehicle air reservoirs.
3. Remove and discard the snap ring that secures the purge valve assembly in the end cover.
4. Remove the purge valve assembly from the air dryer end cover.
5. Lubricate the new O-rings, and O-ring grooves of the new purge valve assembly.
6. Lubricate the end cover bore of the new purge valve assembly.

IMPORTANT: Use only the silicone grease supplied with the AlliedSignal replacement kit.

7. Install the two new O-rings on the purge valve housing cover, and the new quad-ring on the purge piston.
8. Install the new purge valve assembly in the end cover while making sure the purge valve housing is fully seated against the end cover.
9. Install the new retaining ring in its groove in the end cover.
10. Perform the operational tests in **Subject 170**.

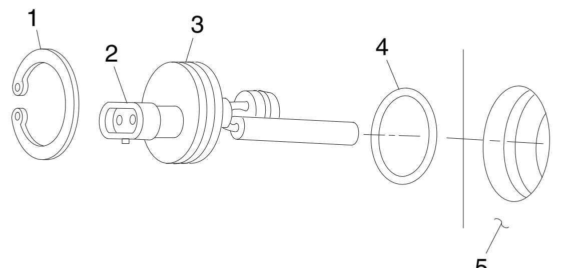
Heater and Thermostat Replacement

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Lift the lock tab on the vehicle wiring harness connector and disconnect it from the air dryer base. See **Fig. 1**.



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1. Retaining Ring
2. Heater/Thermostat Connector Plug
3. Heater/Thermostat Assembly
4. O-Ring
5. Air Dryer Body

Fig. 1, Heater and Thermostat Assembly

3. Remove and discard the retaining ring that secures the heater and thermostat assembly in the air dryer body.
4. Carefully pull the heater and thermostat assembly straight out of the air dryer body and discard it.
5. Using the silicone grease provided with the AlliedSignal replacement kit, lubricate the O-ring groove and O-ring of the new assembly.

IMPORTANT: Do not lubricate the heater stick or thermostat.

6. Install the O-ring on the heater/thermostat assembly. Then, slide the assembly into the air dryer body, making sure not to scrape insulation from the wires.
7. Install the retaining ring in the groove of the air dryer body, making certain that it is fully seated in the groove.
8. Remove the protective cover from the assembly.
9. Turn the ignition on without starting the engine. Make sure vehicle power is present at the contacts of the vehicle wire harness.

Air Reservoir Replacement

WARNING

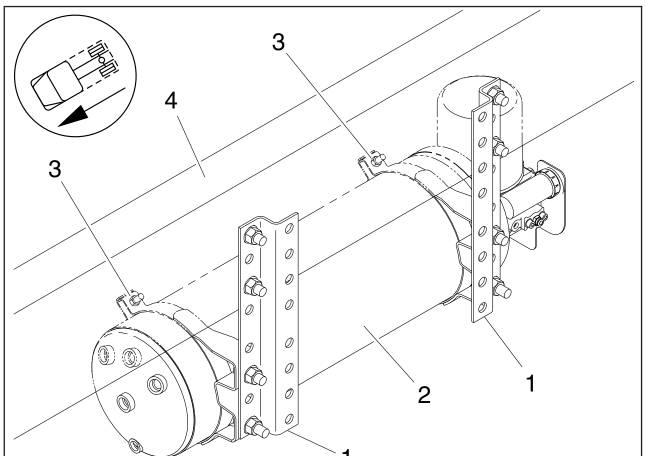
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air system.
3. Mark and disconnect all reservoir air lines and couplers for later assembly. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the components after removing the reservoir from its mount.
4. Remove the air dryer. For instructions, see **Subject 110**.

NOTE: Loosen the bottom strap fastener first. See **Fig. 1**.

5. Remove the reservoir strap fasteners. Remove the reservoir.



1. Mounting Bracket
2. Air Reservoir
3. Strap Fastener
4. Frame Rail

Fig. 1, Air Reservoir, Frame Rail Mounting

6. If access is limited, do the next step first. If not, place a new reservoir in the mount, and install the strap fasteners. Tighten the fasteners 35 lbf·ft (47 N·m). Tighten the bottom strap fastener 136 lbf·ft (184 N·m).
7. As marked earlier, connect all air lines and couplers to the new reservoir, removing the caps as each component is installed. Tighten the connections as instructed elsewhere in this group.

   Install the air dryer. For instructions, see **Subject 110**.
8. Perform the operational test in **Subject 170**.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Operational Tests

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Install a pressure gauge in one of the spare governor ports labeled "RES."
3. Close all drain cocks and start the engine. Build the air system to governor cutout, then shut down the engine.
4. Check all air lines and fittings leading to and from the air dryer for leakage. Note the pressure on the air gauge after the governor cutout pressure is reached, a rapid loss of pressure could indicate a leaking delivery port check valve or turbo cut-off valve.
5. To check for delivery check valve leakage, allow the system air pressure to charge and listen for the air dryer to purge. The purge should last about 30 seconds.
6. Gradually open the drain cock on the purge tank and exhaust any residual pressure.
7. Coat the drain cock with a soap solution. If leakage does not exceed a 1-inch (25-mm) bubble in 1 second, go to step 9.

   If leakage does exceed a 1-inch (25-mm) bubble in one second, proceed with the following step.
8. Apply the brakes a few times, bring the air pressure to a point below governor cut-in (about 95 psi [655 kPa]). The governor will then signal the end of the purge cycle, closing the turbo cut-off valve. Allow any delivery line air pressure to drain, then check again for leakage at the purge tank drain cock. If excessive leakage has stopped, the turbo cut-off valve should be checked.

NOTE: If after replacing the delivery check valve, rapid loss of system air pressure continues, the delivery check valve and turbo cut-off valve are still leaking. Check the valves.

9. Check the operation of the end cover heater and thermostat assembly during cold-weather operation as follows:

   9.1 Check the electric power to the air dryer. With the ignition or engine kill switch in the ON position, check for voltage to the heater and thermostat assembly using a voltmeter or test-light. Unplug the electrical connector at the air dryer and place the test leads on each of the connections of the female connector on the vehicle power lead. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check to see if a good ground path exists.

   9.2 Test the thermostat and heater operation. Turn off the ignition switch and cool the thermostat and heater assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the air dryer connector half. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly and 6 to 9 ohms for the 24-volt heater assembly.

   Warm the thermostat and heater assembly to about 90°F (32°C) and check the resistance again. The resistance should exceed 1000 ohms. If the resistance values obtained are within the stated limits, the thermostat and heater assembly is operating properly. If the resistance values obtained are outside the stated limits, replace the heater and thermostat assembly. For instructions, see **Subject 150**.
10. Check the pressure protection valves. Observe the pressure gauges of the vehicle as system pressure builds from zero. The primary gauge should rise until it reaches approximately 109 psi (752 kPa), then level off as the second pressure protection valve opens and allows the secondary volume to build. When the secondary pressure gauge passes through approximately 55 and 85 psi (379 and 586 kPa) there should be an associated leveling off of pressure as the third and fourth pressure protection valves open. Then, both the primary and secondary gauges should reach their full pressure of about 130 psi (896 kPa).

Troubleshooting

Problem—Air Dryer Is Constantly Cycling or Purging

Problem—Air Dryer Is Constantly Cycling or Purging	
Possible Cause	**Remedy**
Excessive system leakage.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir
There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank.	Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed.
The check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at the opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.
Governor is inoperative.	Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions.
Compressor unloader mechanism is leaking excessively.	Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed.

Problem—Water in the Vehicle Reservoirs

Problem—Water in the Vehicle Reservoirs	
Possible Cause	**Remedy**
Desiccant cartridge assembly contains excessive contaminants.	Replace the desiccant cartridge.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information.
Air system was charged from an outside air source that did not pass through an air dryer.	If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized.
The air dryer is not purging.	Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air."
Purge (air exhaust) is insufficient due to excessive system leakage.	Refer to "Problem—Air Dryer Is Constantly Cycling or Purging."
Air bypasses the desiccant cartridge assembly.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed.
Purge (air exhaust) time is significantly less than the minimum allowable.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly.
Excessive air usage—air dryer not compatible with vehicle air system.	Install an accessory bypass system. Consult your Bendix representative for additional information.

Troubleshooting

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air	
Possible Cause	**Remedy**
The check valve is defective.	Test to determine if air is passing through the check valve. Repair or replace as needed.
Safety valve setting is lower than the maximum system pressure.	Reduce the system pressure, or install a safety valve with a higher pressure setting.
System pressure is too high.	Using an accurate gauge, test the system. Replace the governor if needed.
There are excessive pressure pulsations from the compressor.	Increase the volume in the discharge line. This can be done by adding a 90 in^3 (1475 cm^3) [or larger] reservoir between the compressor and the air dryer and reservoir system.

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure	
Possible Cause	**Remedy**
Air dryer purge valve is leaking excessively.	With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse.	Test the heater and thermostat, following instructions in this manual.
The check valve is inoperative.	Refer to "Problem—Air Dryer Is Constantly Cycling or Purging."
The turbo cut-off valve is leaking.	Repair or replace the purge valve assembly.
The purge valve control piston quad-ring is leaking.	Repair or replace the purge valve assembly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
Pressure protection valves in the air dryer will not open.	Replace the air dryer; pressure protection valves are not serviceable.

Problem—Air Dryer Does Not Purge or Exhaust Air

Problem—Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
The air dryer purge valve is not working.	Make certain that air reaches the purge valve control port by installing a T-fitting with a pressure gauge into the governor unloader port. Repair the purge valve if needed.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse.	Test the heater and thermostat. Refer to **Subject 170** for instructions.

Troubleshooting

Problem—Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
The purge valve control piston quad-ring is leaking.	Repair or replace the purge valve assembly.

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (may look like whitish liquid, paste, or small beads); or, Unsatisfactory Desiccant Life

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (may look like whitish liquid, paste, or small beads) or Unsatisfactory Desiccant Life	
Possible Cause	**Remedy**
This problem usually occurs with one or more of the previous problems.	Refer to the appropriate corrections listed previously.
The air dryer is not securely mounted; there is excessive vibration.	Vibration should be held to a minimum. Tighten the mounting fasteners.
Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly.	Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth. Check the installation.
Compressor is passing excessive oil.	Check for proper compressor installation; if symptoms persist, replace the compressor.
Heater and thermostat, wiring, or a fuse is at fault, and isn't allowing the air dryer to purge during cold weather.	Test the heater and thermostat. Refer to **Subject 170** for instructions.
Desiccant cartridge is not attached properly to the end cover.	Check the torque and tighten if necessary. Refer to **Subject 120** for instructions.

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle	
Possible Cause	**Remedy**
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 in^3 (1475 cm^3) reservoir between the compressor and the air dryer.

Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode

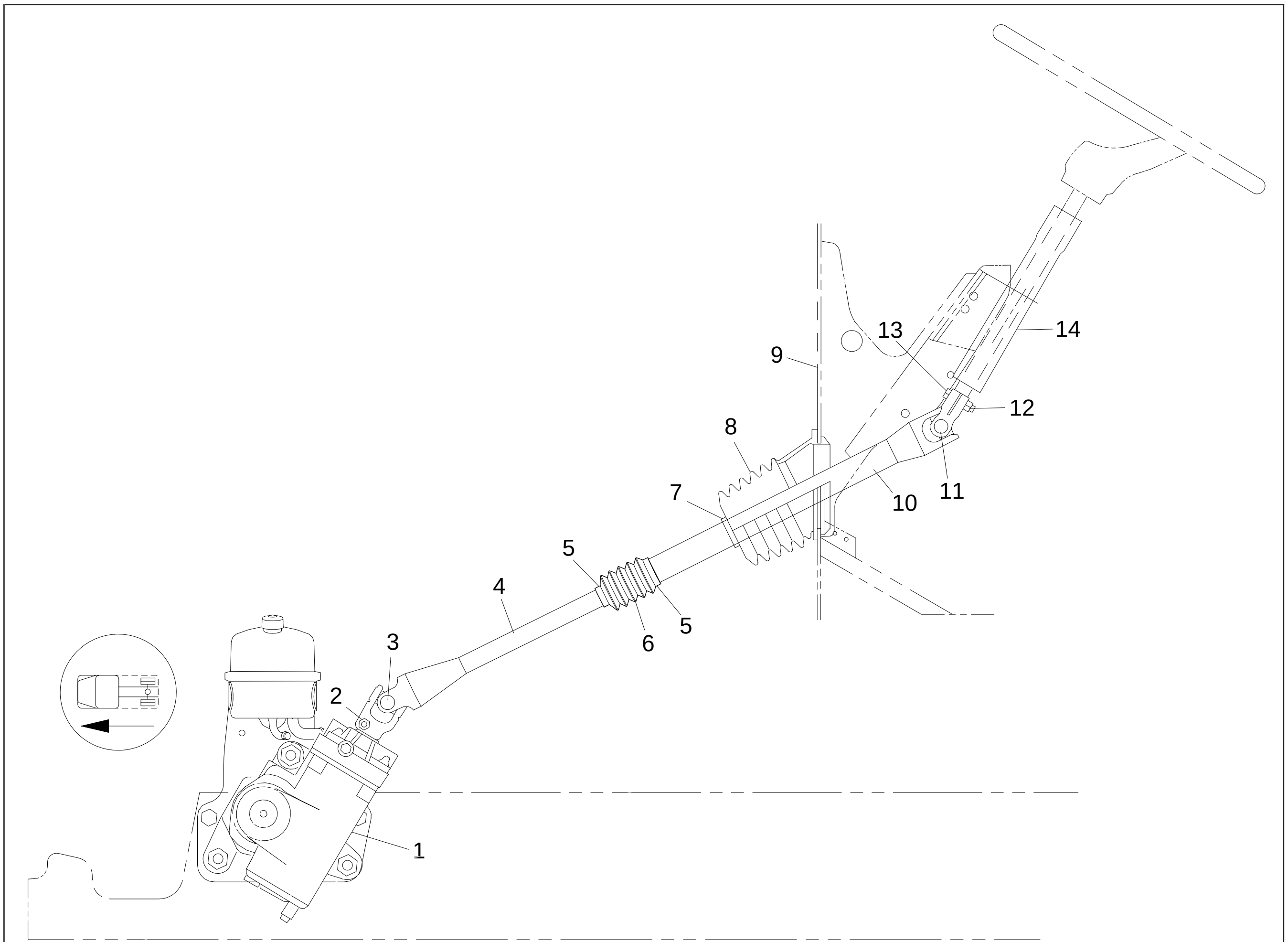
Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode	
Possible Cause	**Remedy**
Compressor does not "unload."	Check the air hose from the governor to the compressor for a missing, kinked, or restricted line. Repair or replace the air hose as needed. Repair or replace the compressor unloader.

General Description

A single aluminum steering driveline connects the steering column to the steering gear by means of a telescoping shaft with integral yokes, an upper and a lower end yoke, and a pair of universal joints. See **Fig. 1**.

The upper end yoke is internally serrated to match the external serrations at the end of the steering column shaft; the lower end yoke is internally serrated to match the external serrations on the steering gear input shaft. Each end yoke is secured to its respective shaft by a pinch bolt that engages a notch in the shaft.

The universal joint at each end of the steering driveline allows the transfer of steering motion from the steering column shaft, to the steering driveline, and



1. Power Steering Gear
2. Lower End Yoke Pinch Bolt Nut
3. Lower End Yoke Assembly
4. Yoke Shaft (inner tube)
5. Boot Clamp
6. Steering Driveline Boot
7. Upper Driveline Boot Bushing
8. Upper Steering Driveline Boot
9. Frontwall
10. Slip Yoke (outer tube)
11. Upper End Yoke Assembly
12. Upper End Yoke Pinch Bolt Nut
13. Upper End Yoke Pinch Bolt
14. Steering Column Assembly

Fig. 1, Steering Driveline

General Information

to the steering gear input shaft, even though the driveline is at an angle to both of the other shafts. Each universal joint cross rides in four needle bearing cups, two carried in the end yoke, and two carried in the steering driveline's integral yoke. The needle bearing cups are held in place in each yoke by snap rings.

Steering Driveline Removal and Installation

Removal

NOTE: It is not necessary to loosen the steering wheel and column assembly to do this procedure.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Shut down the engine, apply the parking brakes, chock the rear tires, and tilt the hood.
3. Detach the upper driveline boot bushing from the boot and slide it down the outer tube. See **Fig. 1**.
4. From inside the cab, disconnect the upper end yoke.

    4.1 Detach the lower portion of the steering column cover and remove it.

    NOTE: To facilitate assembly, mark the upper end yoke in relation to the steering column shaft before disassembling these parts.

    4.2 Remove and discard the pinch bolt and nut from the upper end yoke. Do not reuse the bolt or the nut.

CAUTION

Be careful when disconnecting the steering driveline from the steering column. Excessive force could damage the steering gear input valve attached to the opposite end of the steering shaft.

    4.3 Remove the upper end yoke from the steering column shaft.

5. Disconnect the lower end yoke.

    5.1 Remove and discard the pinch bolt and nut from the lower end yoke. Do not reuse the bolt or nut. See **Fig. 2**.

    5.2 Remove the yoke from the steering gear input shaft. Do not turn the steering gear input shaft when removing the lower end yoke.

CAUTION

Do not use a torch to break the threads loose when removing the lower end yoke. Heat will damage the seals in the power steering gear.

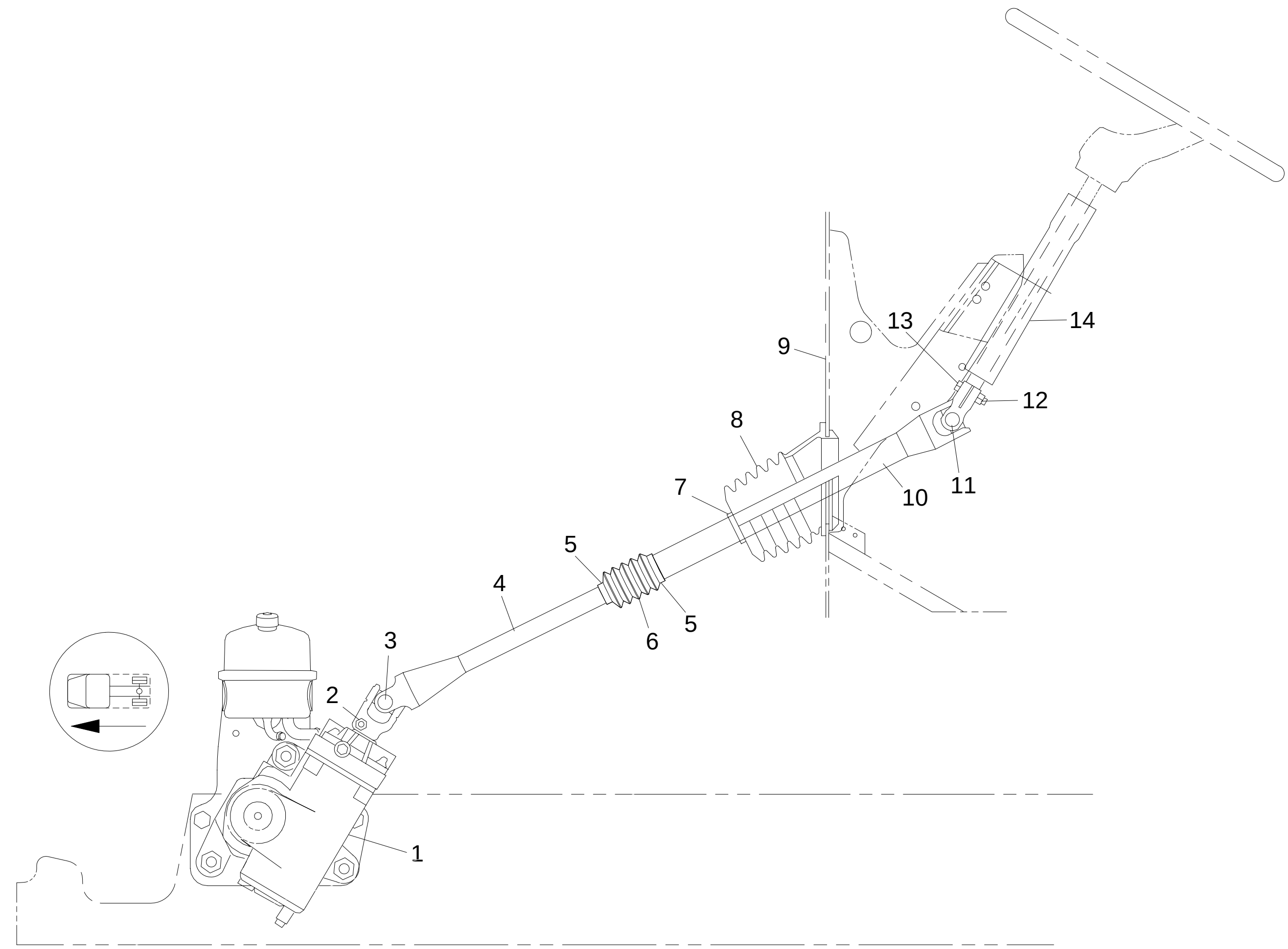
6. Pull the steering driveline forward through the upper boot and out of the engine compartment. If the upper boot is dislodged from its seat in the frontwall, place it back in position in its seat.

Installation

IMPORTANT: When installing the replacement steering driveline, be sure to connect the yoke shaft (inner tube) to the steering gear and connect the slip yoke (outer tube) to the steering column. See **Fig. 1**.

1. Thoroughly clean the end yokes, the steering driveline, and the steering gear input shaft with a clean, dry cloth.
2. Apply a thin film of grease to the yoke splines. Use lithium-based grease, NLGI grade 2.
3. Insert the upper end of the new steering driveline through the upper boot and partially into the cab.
4. Install the lower end yoke on the steering gear input shaft. Before installing a new 7/16–20 nut, ensure that the flats, inside the lower end yoke and on the steering gear input shaft, mate with each other. The lower end yoke is properly installed on the input shaft, with the pinch bolt centered in the input shaft notch, if the new 7/16–20 pinch bolt can slip in and out of the end yoke easily. Install the new nut and tighten it 55 to 65 lbf·ft (75 to 88 N·m).
5. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut. See **Fig. 3**.
6. Before attaching the upper end yoke to the steering column, ensure that the front tires are pointing straight ahead and that the steering gear is centered.
7. Slide the upper end yoke onto the steering column shaft, then install a new 7/16–20 pinch bolt. Before installing a new 7/16–20 nut, make sure that the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it

Steering Driveline Removal and Installation



1. Power Steering Gear
2. Lower End Yoke Nut
3. Lower End Yoke Assembly
4. Yoke Shaft (inner tube)
5. Boot Clamp
6. Steering Driveline Boot
7. Upper Driveline Boot Bushing
8. Upper Steering Driveline Boot
9. Frontwall
10. Slip Yoke (outer tube)
11. Upper End Yoke Assembly
12. Upper End Yoke Nut
13. Upper End Yoke Pinch Bolt
14. Steering Column Assembly

Fig. 1, Steering Driveline Installation

can slip in and out of the end yoke easily. Install the new nut and tighten it 55 to 65 lbf·ft (75 to 88 N·m).

8. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.
9. Inside the cab, install the lower steering column cover.
10. Install the upper boot bushing.
11. With the front tires pointing straight ahead, the steering wheel should be within ±10 degrees of center as shown in **Fig. 4**.

    If not, remove the steering wheel and install it in the correct position. For instructions, see **Section 46.02**, Subject 100.
12. Lower the hood.

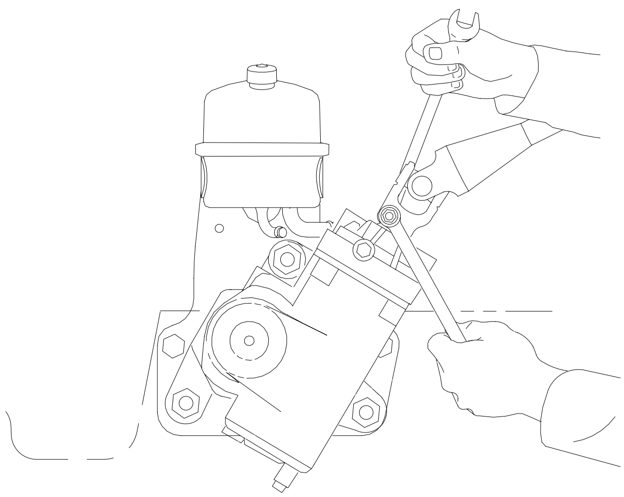


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Fig. 2, Disconnect the Lower End Yoke

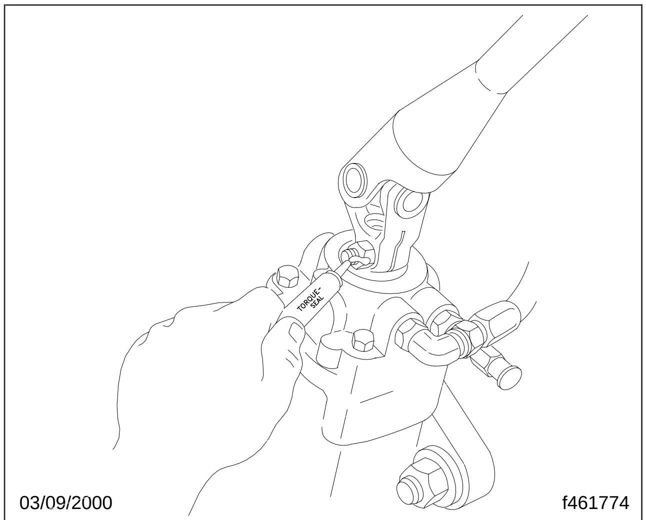

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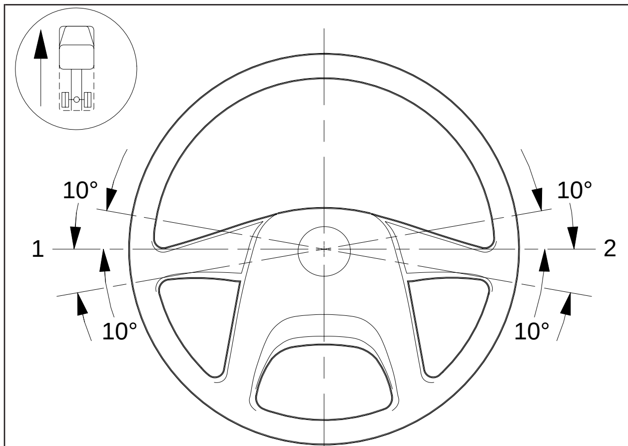
Fig. 3, Apply Torque Seal

13. Leave the parking brakes applied and the chocks at the rear tires.

⚠ WARNING

Driving a vehicle with hard steering or binding in the steering system could result in partial or complete loss of steering control during vehicle operation, possibly causing personal injury and property damage.



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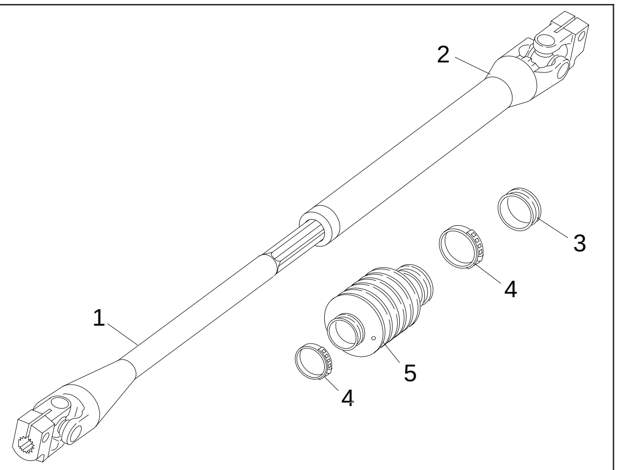
1. 9 o'Clock Position
2. 3 o'Clock Position

Fig. 4, Steering Wheel Centered

14. Start the vehicle and turn the steering wheel from side to side to check for hard steering or binding. If there is difficulty, check the assembly and installation of the driveline parts. If the cause is not the driveline, see the applicable steering gear section in this group.
15. Remove the chocks from the rear tires.

Replacement

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Shut down the engine, apply the parking brakes, chock the tires, and tilt the hood.
3. Disconnect the lower end yoke.
   - 3.1 Remove the pinch bolt nut and the pinch bolt from the lower end yoke. Discard the nut and the bolt.
   - 3.2 Remove the yoke from the steering gear input shaft. Don't turn the steering gear input shaft when removing the lower end yoke. Push the yoke shaft (inner tube) into the slip yoke (outer tube) as you remove the lower end yoke. See **Fig. 1**.



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1. Yoke Shaft (inner tube)
2. Slip Yoke (outer tube)
3. Upper Driveline Boot Bushing
4. Steering Driveline Boot Clamp
5. Steering Driveline Boot

Fig. 1, Steering Driveline and Boot

IMPORTANT: Boot replacement requires Oetiker® boot clamp pliers (p/n 1096–10) and a Spicer slip member boot replacement kit (p/n 212112X). The replacement kit includes 2 clamps, 1 boot, 2 ounces (57 grams) of grease, and steering driveline disassembly and assembly instructions.

4. Mark the location of the end of the boot as it is installed on the yoke shaft. Also, mark the position of the yoke shaft in relation to the slip yoke.
5. Separate the boot clamps and discard them.

WARNING

Be careful not to gouge or damage the aluminum shaft when removing the boot clamps. Gouging or damaging the shaft boot-sealing surface can allow entry of contaminants and can cause premature wear and failure of the steering driveline. Failure of the steering driveline can result in separation of the driveline from the vehicle. A separated steering driveline can result in a loss of steering control, possibly causing serious injury or death.

6. Separate the yoke shaft from the slip yoke and remove and discard the boot. See **Fig. 1**.
7. Thoroughly clean, degrease, and dry the full length and depth of the splines on both the yoke shaft and the slip yoke.
8. Inspect the yoke shaft and the slip yoke splines for damage. If any damage to the splines or the spline coating is present, replace the entire steering driveline assembly.

WARNING

Failure to replace damaged steering driveline components can cause steering driveline failure. Failure to remove all old grease and contaminants or allowing mineral spirits to dry on the slip members can result in damaged steering driveline components, which can lead to steering driveline failure. Failure of a steering driveline can result in impaired steering and possible loss of vehicle control, which can result in property damage, personal injury, or death.

9. Slide the new, small boot clamp over the splined section of the yoke shaft.
10. Apply a small amount of liquid soap to the inner diameter of the small end of the new boot and slide it over the yoke shaft splines. Align the end of the boot with the location mark made before removal.

Steering Driveline Boot Replacement

11. Apply all of the grease from the kit to the internal splines of the slip yoke. Ensure that all of the splined teeth around the diameter of the slip yoke are filled with grease to a depth of at least one inch.

WARNING

Inadequate lubrication can cause steering driveline failure. Failure of a steering driveline can result in impaired steering and possible loss of vehicle control, which can result in property damage, personal injury, or death.

12. Slide the new, large boot clamp over the splined end of the slip yoke.

NOTE: Be sure the upper driveline boot bushing is installed on the slip yoke before inserting the yoke shaft into the slip yoke.

13. Insert the yoke shaft into the slip yoke. See **Fig. 1**.
14. Extend and collapse the driveline assembly several times to ensure an even distribution of the grease along the slip member.
15. Thoroughly remove any grease from the boot groove in the slip yoke and seat the large end of the boot in the groove.
16. Slide the large boot clamp over the large boot end.
17. Using Oetiker boot clamp pliers, tighten the clamp.

WARNING

Failure to properly install and tighten boot clamps can allow entry of contaminants into the steering driveline which can cause steering driveline failure. Failure of a steering driveline can result in impaired steering and possible loss of vehicle control, which can result in property damage, personal injury, or death.

IMPORTANT: Take care not to gouge or scratch the aluminum shaft or tear the boot when relieving pressure in the boot in the next step.

18. Relieve pressure in the boot by carefully sliding a small screwdriver between the small diameter boot end and the yoke shaft.

NOTE: Ensure that (when relaxed) the boot measures 4 inches (10.2 cm) before attempting the next step.

19. Slide the small boot clamp over the small boot end. Ensure that the end of the boot aligns with the location mark made before disassembly.
20. Using Oetiker boot clamp pliers, tighten the clamp.
21. Before installing the driveline assembly in the vehicle, extend and collapse the assembly several times and ensure that the boot clamps are secure. If the clamps are not secure, check to make sure that they are properly tightened and seated. If the clamps are still loose, repeat the boot removal and installation procedures and install new clamps.

WARNING

Do not reuse the steering shaft boot clamps. Reuse of the boot clamps can cause steering driveline failure. Failure of a steering driveline can result in impaired steering and possible loss of vehicle control, which can result in property damage, personal injury, or death.

22. Before attaching the lower end yoke to the steering gear input shaft, ensure that the front tires are pointing straight ahead, that the steering gear is centered, and that the driveline slides freely.
23. Install the lower end yoke on the steering gear input shaft. Before installing the new pinch bolt nut, ensure that the flats, inside the lower end yoke and on the steering gear input shaft, mate with each other. The lower end yoke is properly installed on the input shaft if the new pinch bolt can slip in and out of the end yoke easily. Install a new pinch bolt nut, and tighten it 55 to 65 lbf·ft (75 to 88 N·m).
24. Apply Torque Seal OGP F900WHITE to the exposed pinch bolt threads and to the locknut. See **Fig. 2**.
25. Remove the chocks from the tires, and lower the hood.

Steering Driveline Boot Replacement

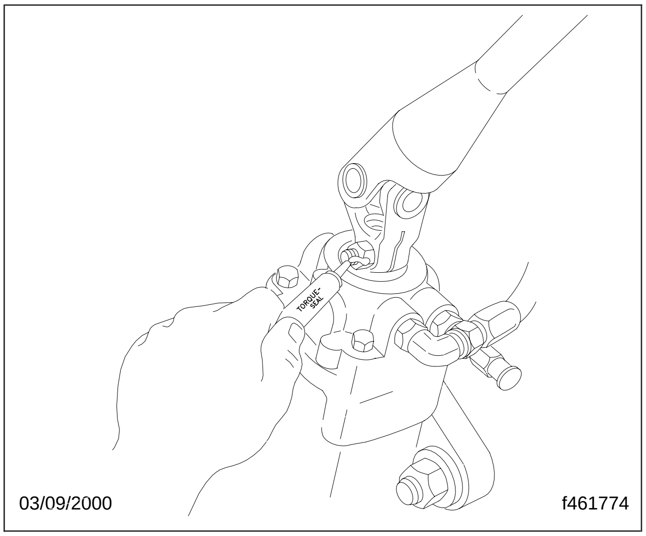
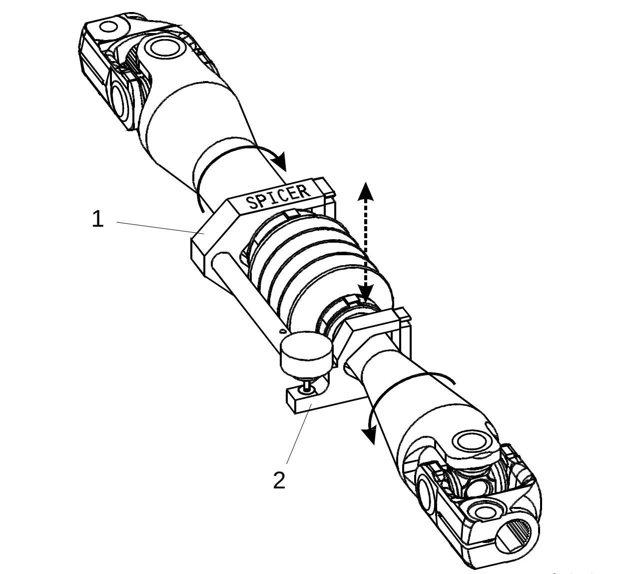


Fig. 2, Apply Torque Seal OGP F900WHITE

Spicer Lite® Aluminum Steering Shaft Wear Inspection

Slip Member Assembly Inspection

1. Shut down the engine and remove the key from the ignition. Apply the parking brakes, chock the tires, and open the hood.
2. Attach the steering shaft wear gauge, PN STWI–2, to the steering shaft.
3. Loosen the set screws on clamp A and clamp C so that the smaller blocks can swing freely.
4. Attach clamp A to the slip yoke and clamp C to the yoke shaft. See **Fig. 1**. Make sure the pieces are close enough to each other so that the gauge can rest on clamp C.



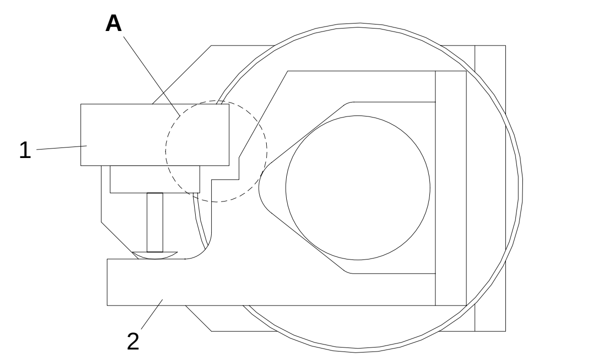
1. Clamp A
2. Clamp C

Fig. 1, Slip Member Inspection

4.1 The word "Spicer" on clamp A and the dial indicator on the gauge should be parallel to the extension arm of clamp C.

4.2 Make sure the dial indicator button is perpendicular to the surface it rests on and that only the bottom surface of the button is in contact with clamp C.

4.3 The outline of the gauge should line up with the step in the outline of clamp C, but not contact it. See **Fig. 2**.



A. The outline of the gauge should line up with the step in the outline of clamp C.
1. Gauge
2. Clamp

Fig. 2, Correct Placement of the Gauge and Clamp C

5. Tighten the set screws.
6. Measure for slip member backlash (circumferential looseness).

6.1 Using both hands, one on each side of the gauge, apply direct torque to the shaft by turning the shaft in opposite directions as indicated by the arrows in **Fig. 1**. While turning the shaft, note the total dial indicator travel.

6.2 Record the total distance traveled by the dial indicator at the spline, that is, the difference between the high and low values. If the backlash value is greater than the limiting value in **Table 1**, replace the slip member assembly.

WARNING

Failure to replace the slip member assembly if the limiting value is exceeded will cause impaired steering and possible loss of vehicle control, which could result in property damage, serious injury, or death. In order to avoid this potential hazard, replace the slip member assembly when the limiting value is exceeded.

7. Measure for broken back (radial looseness).

7.1 Apply a load of 5 pounds to the shaft and perpendicular to the dial indicator face as indicated by the dashed line in **Fig. 1**.

Spicer Lite® Aluminum Steering Shaft Wear Inspection

Then apply a load of 5 pounds 180 degrees opposite to the shaft.

NOTE: Loop a wire or tie strap around the shaft between the boot and clamp C. Using a spring scale, pull on the loop to five pounds.

7.2 Record the total dial indicator travel, that is, the difference between the high and low values. If the broken back value is greater than the limiting value in **Table 1**, replace the slip member assembly.

Limiting Values		
Slip Member Assembly		U-Joint Kit
Broken Back	Backlash	
0.060 inch (1.524 mm)	0.040 inch (1.016 mm)	0.011 inch (0.280 mm)

Table 1, Limiting Values

WARNING

Failure to replace the slip member assembly or U-joint kit if the limiting value is exceeded will cause impaired steering and possible loss of vehicle control, which could result in property damage, serious injury, or death. In order to avoid this potential hazard, replace the slip member assembly when the limiting value is exceeded.

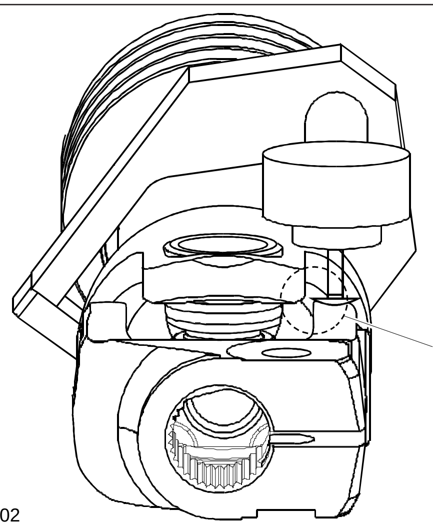
8. Remove the chocks from the tires and close the hood.

Universal Joint Kit Inspection

1. Shut down the engine and remove the key from the ignition. Apply the parking brakes, chock the tires, and open the hood.
2. Attach the steering shaft wear gauge, PN STWI–2, to the steering shaft, but use only one V-clamp at a time.
3. Use clamp A for the slip yoke and clamp B for the yoke shaft.
4. Attach the V-clamp to the shaft near the U-joint kit. Adjust the angles of the V-clamp and the arm of the gauge so that the arm is perpendicular to the kit and the button rests on the lug of the end fitting.

NOTE: The dial indicator button should not rest on the lug ear of the aluminum shaft.

5. Line up the inside edge of the bottom surface of the button with the inside edge of the end fitting lug ear. See **Fig. 3**.



A. Line up the inside edge of the bottom surface of the button with the inside edge of the end fitting lug ear.

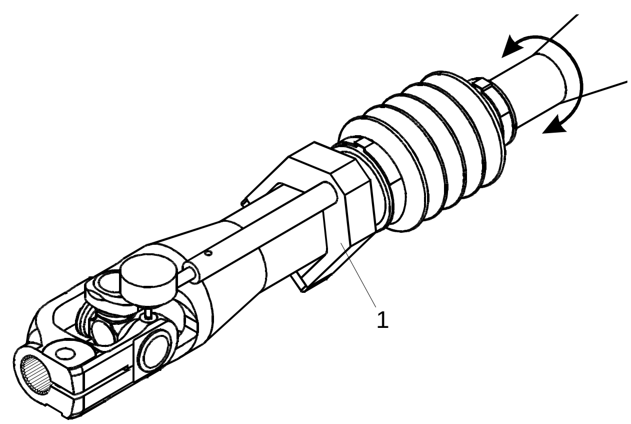
Fig. 3, Correct Placement of the Button and Lug Ear

6. Make sure the dial indicator face is parallel to the plane of the end fitting. Tighten the set screws with your fingers.
7. Measure for universal joint backlash (circumferential looseness).

7.1 While holding the end fitting motionless, use your other hand on one side of the gauge to apply direct torque to the shaft. Turn the shaft in opposite directions as shown by the arrows in **Fig. 4**. While turning the shaft, note the total dial indicator travel.

7.2 Record the total distance traveled by the dial indicator at the U-joint, that is, the difference between the high and low values. If the lash value is greater than the

Spicer Lite® Aluminum Steering Shaft Wear Inspection



1. Clamp A (clamp B not shown)

Fig. 4, Universal Joint Kit Inspection

limiting value in **Table 1**, replace the U-joint kit.

WARNING

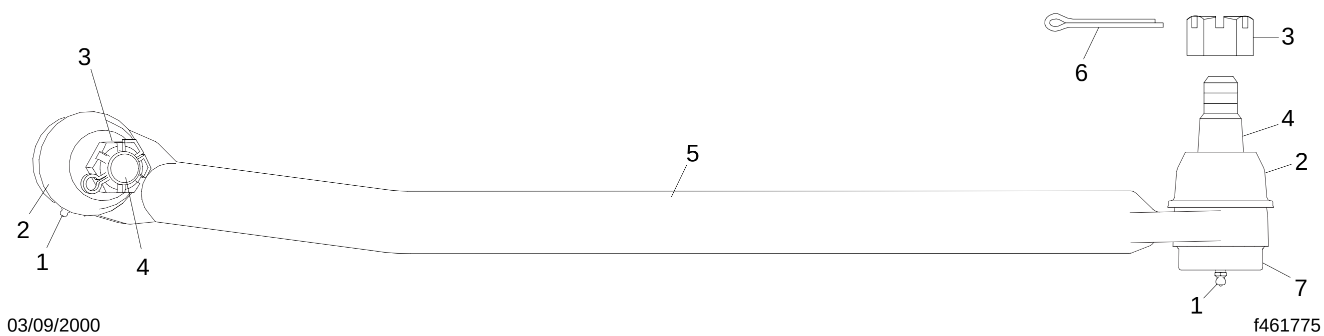
Failure to replace the U-joint kit if the limiting value is exceeded will cause impaired steering and possible loss of vehicle control, which could result in property damage, serious injury, or death. In order to avoid this potential hazard, replace the U-joint kit when the limiting value is exceeded.

8. Remove the chocks from the tires and close the hood.

General Description

A fixed-length drag link assembly connects the steering gear pitman arm to the axle steering arm. The ball stud and socket assemblies at each end of the drag link prevent binding when the relative angles of the pitman arm and steering arm change, which happens when the vehicle is steered or the front axle moves up or down.

Both ball-stud sockets of a fixed-length drag link assembly are an integral part of the drag link; they cannot be moved to change its length. See **Fig. 1**. The ball studs and sockets are a dual-seat design.



1. Grease Fitting
2. Ball Stud Cover
3. Castle Nut
4. Tapered Ball Stud
5. Drag Link
6. Cotter Pin
7. Dust Cap

Fig. 1, Fixed-Length Drag Link Assembly

Drag Link Removal and Installation

Removal

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. *Do not move the tires from the straight-ahead position during removal or at any time while the drag link is removed.*
2. Apply the parking brakes and chock the rear tires.
3. Tilt the hood.
4. At both ends of the drag link, remove the cotter pins and castle nuts from the ball studs. See **Fig. 1**.
5. Using a ball stud removal tool, remove the ball studs from the pitman arm and the axle steering arm.
6. Check the ball stud cover for damage. If needed, replace the cover using the instructions in **Subject 120**.

Installation

1. Insert the axle-end ball stud up through the bottom of the axle steering arm, then install the castle nut, finger-tight.
2. Turn the steering wheel as needed to align the hole in the lower end of the pitman arm with the forward ball stud. Insert the ball stud in the pitman arm from the inboard side. Install the castle nut. See **Fig. 1**.
3. Tighten both of the castle nuts:
    - 3/4–16; 90 to 170 lbf·ft (122 to 230 N·m)
    - 7/8–14; 160 to 300 lbf·ft (217 to 407 N·m)

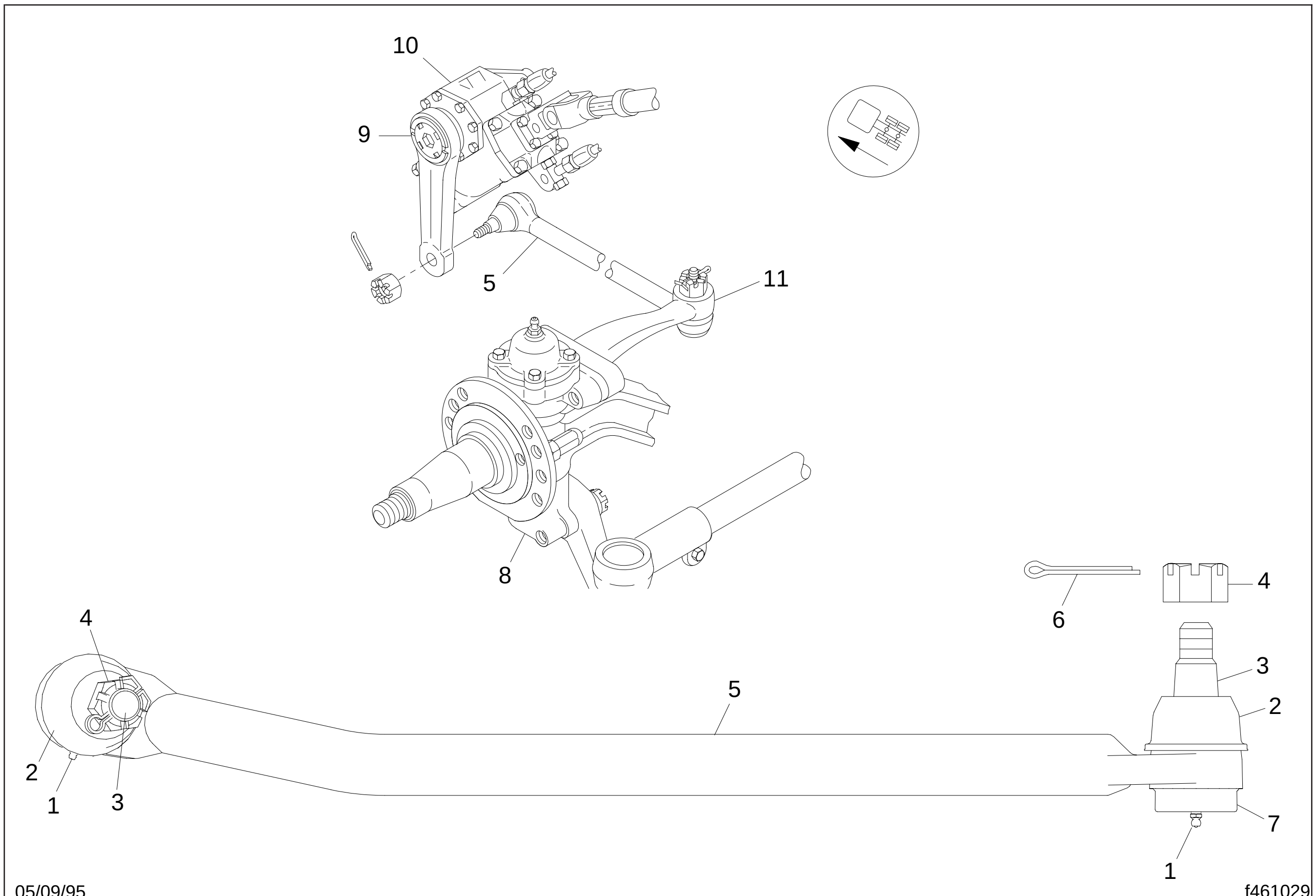
    If needed, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. *Do not back off the nut to align it with the cotter pin hole.*
4. Install and lock a new cotter pin in each of the ball studs and nuts.

WARNING

Install and lock new cotter pins in the ball studs and nuts. Failure to do so could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

5. Check the vehicle maintenance manual to determine if lubrication of the drag link is required. If so, follow the instructions in the maintenance manual.
6. Check the axle stop settings, and adjust them if needed. For instructions, see **Group 33**.
7. Check the settings of the steering gear poppet valves (TRW) or relief valve plungers (Sheppard). Adjust them if needed. For instructions on checking and adjusting, see the applicable steering gear section elsewhere in this group.
8. With the front tires pointing straight ahead, and no load on the vehicle, the steering wheel spokes should be within ±10 degrees of center as shown in **Fig. 2**. If not, remove the steering wheel and install it in the correct position.
9. Lower the hood.
10. Remove the chocks from the tires.

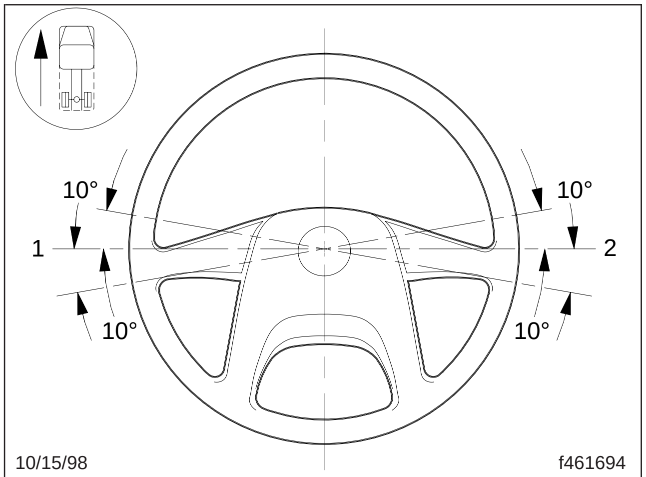
Drag Link Removal and Installation



1. Grease Fitting
2. Ball Stud Cover
3. Tapered Ball Stud
4. Castle Nut
5. Drag Link
6. Cotter Pin
7. Dust Cap
8. Front Axle
9. Pitman Arm
10. Steering Gear (Sheppard M–100 shown)
11. Axle Steering Arm

Fig. 1, Drag Link Installation

Drag Link Removal and Installation



1. 9 o’Clock
2. 3 o’Clock

Fig. 2, Steering Wheel Centered

Testing

WARNING

All steering mechanisms are essential to the safe operation of the vehicle. Follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause personal injury or property damage.

Have someone gently turn the steering wheel back and forth; check for looseness between the ball stud end, and both the pitman arm and steering arm. Also check for looseness of the ball stud nut.

If the ball stud *end* is loose, replace the drag link. If the ball stud *nut* is loose, replace the nut and cotter key. Tighten the ball stud nut as follows (see **Table 1**):

Size	Torque lbf·ft (N·m)
3/4–16	90 to 170 (122 to 230)
7/8–14	160 to 300 (217 to 407)

Table 1, Torque Values

Grasp the drag link near the pitman arm end, push and pull laterally to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, see **Subject 100**. If there is 1/8-inch (3-mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grasp the drag link near the steering arm end. Push and pull vertically to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, see **Subject 100**. If there is 1/8-inch (3-mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Pump fresh grease into the drag link until the old grease is purged.

Replacement

1. Remove the drag link, see **Fig. 1**. For instructions, see **Subject 100**.

CAUTION

Use care when removing the ball stud cover with a screwdriver. Damage to the sealing surface of the socket forging could occur.

2. Using a screwdriver, press or tap on the flanged portion of the cover and remove it from the ball stud socket assembly.
3. Using a clean rag, wipe off all grease and dirt from around the ball stud and socket throat.
4. Grease the socket throat and ball stud with a multipurpose chassis grease NLGI Grade 2 (8% 12-hydroxy lithium stearate grease) or NLGI Grade 1 (6% 12-hydroxy lithium stearate grease); Grade 2 is preferred. Using the same grease, fill the new ball stud cover three-quarters full.
5. Position the socket assembly in a large vise, or on a press so that the ball stud is perpendicular to the socket stem.

CAUTION

Do not use a screwdriver, chisel, or punch (or any other sharp-pointed tool) to install the ball stud cover. Using these types of tools could cut and damage the cover.

IMPORTANT: To install the stud cover, use a section of tubing that has an inside diameter as close as possible to the outside diameter of the stud cover. Also, make sure that the inside edge of the tube is chamfered (angled) to avoid cutting the rubber stud cover.

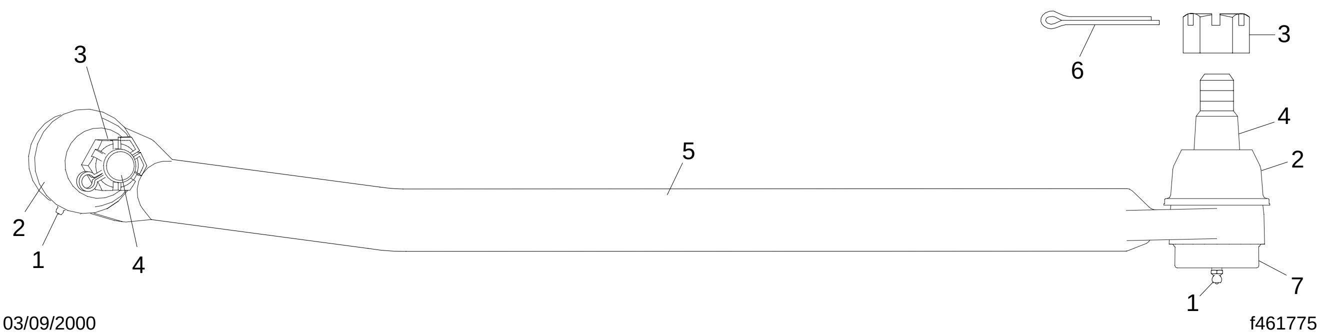
6. Using a section of tubing, press on the new stud cover. The cover is in place when the flanged portion of the cover is seated on the machined section (sealing face) of the socket forging.

CAUTION

Do not apply excessive pressure when pressing on the seal. Too much pressure during installation could deform the cover and result in incorrect sealing.

7. Install the drag link. For instructions, see **Subject 100**.

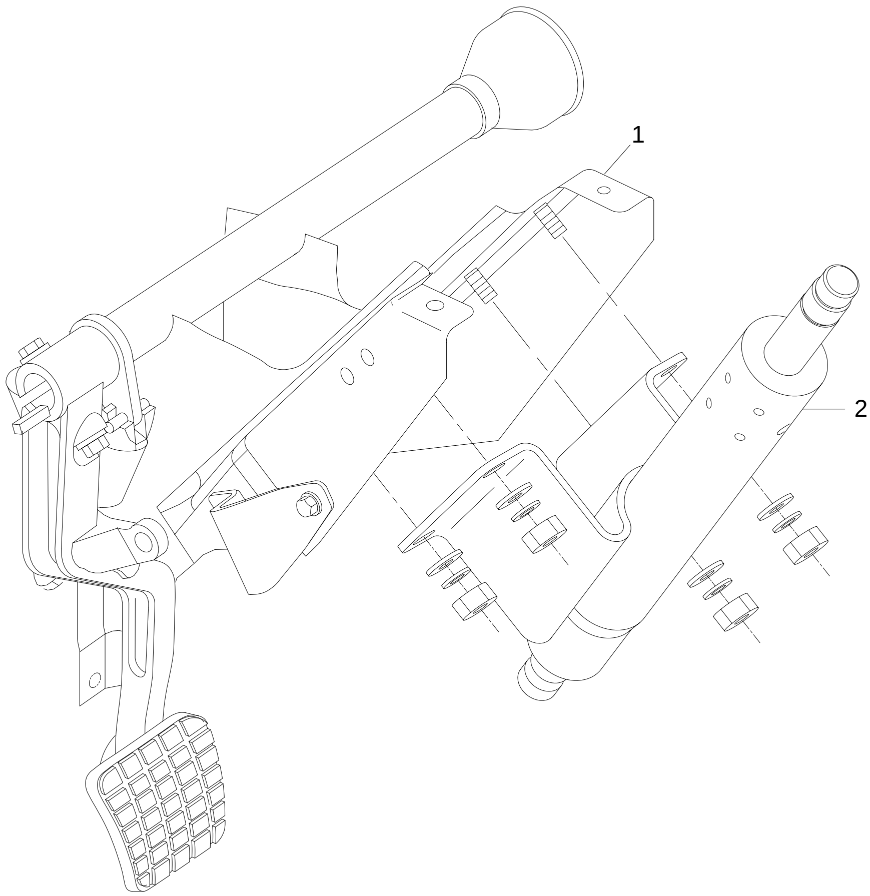
Ball Stud Cover Replacement



1. Grease Fitting
2. Ball Stud Cover
3. Castle Nut
4. Tapered Ball Stud
5. Drag Link
6. Cotter Pin
7. Dust Cap

Fig. 1, Drag Link Assembly

General Information (See Fig. 1)



1. Steering Column Bracket Assembly
2. Fixed Steering Column

Fig. 1, Steering Column Assembly Installation

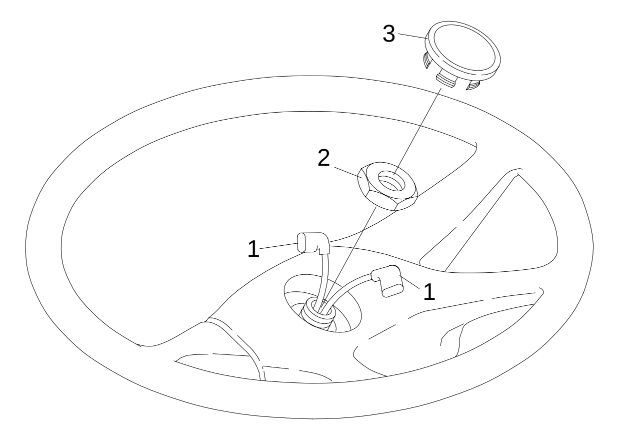
The steering wheel is cushion-rimmed, with a button for the electric horn mounted in the center of the wheel hub.

A turn signal switch attaches to the steering column just below the steering wheel. If the vehicle is equipped with a trailer brake control valve, it is attached to the right side of the steering column.

Major parts of the steering column assembly are a jacket (tube), bearing assemblies (staked in place in the top and bottom of the jacket), a steering column shaft, and wiring and contact assemblies for the electric horn. At the upper end of the steering column shaft are threads to accept a wheel nut, and straight external serrations to match the internal serrations of the steering wheel hub. The lower end has straight external serrations to match the internal serrations of the steering driveline upper end-yoke. The steering column assembly is attached to the dash steering column bracket with four fasteners that are hidden by the steering column cover. A lower steering column cover extends from the under-dash cover to the floor. The steering column assembly is not repairable; if any steering column parts are damaged or badly worn, the steering column assembly must be replaced.

Steering Wheel Removal and Installation

Removal (See Fig. 1)



1. Horn Cable Assembly
2. Wheel Nut
3. Horn Button Cover

Fig. 1, Steering Wheel Installation

NOTE: Remove the steering wheel only if the steering wheel or steering column is being replaced. If the wheel or column is being removed to allow servicing of the dash, remove the steering wheel and column as an assembly. For instructions, see **Subject 110**.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be performed. Do not turn the steering wheel at any time during this procedure.

   Apply the parking brakes, and chock the tires.
2. Using a small screwdriver, pry under the outermost ring of the steering wheel horn button. Lift the horn button from the steering wheel hub, then disconnect the wire terminals at the horn button.

IMPORTANT: The steering wheel has an alignment mark within the hub. After removing the wheel nut, mark the column shaft at the wheel alignment mark to ensure proper installation of the wheel.

3. Without turning the steering wheel, remove the wheel nut from the end of the wheel tube shaft.

   Using a steering wheel puller, remove the wheel from the shaft.

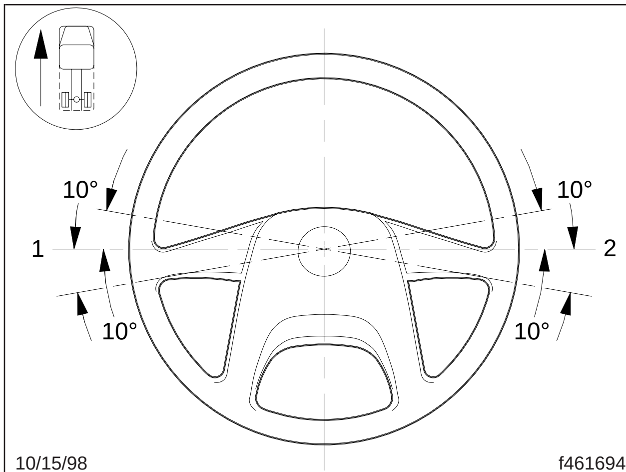
IMPORTANT: Be careful when you are removing the steering wheel, or you could damage the horn wires. A steel block measuring 1-5/8 x 5/8 x 1/4 inch (41 x 16 x 6.4 mm) can be used with the puller to protect the wires during steering wheel removal.

Installation (See Fig. 1)

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead, and the steering gear is centered.

1. With the marks on the column and steering wheel aligned, place the steering wheel on the steering column. Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 2**.

   Insert the horn ground wires (from the center of the wheel tube shaft) through the center of the wheel nut. Install the wheel nut, and tighten it 55 to 65 lbf·ft (75 to 88 N·m).



1. 9 o'Clock
2. 3 o'Clock

Fig. 2, Steering Wheel Centered

2. Connect the ground wire terminals to the horn button. With the steering wheel in the straight-ahead position, push the horn button into place in the steering wheel hub.

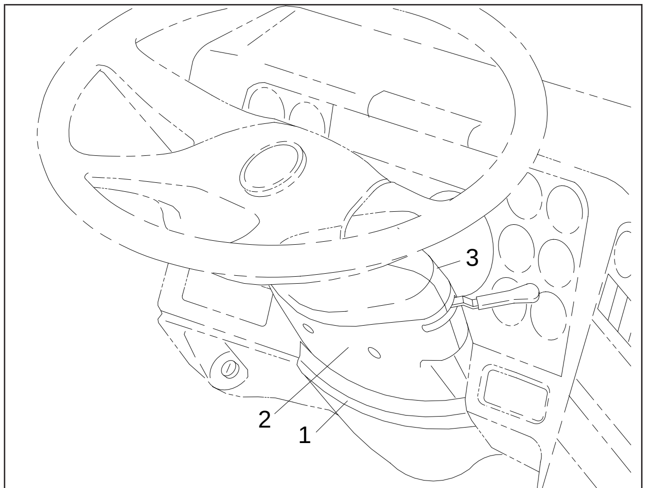
Steering Column Assembly Removal and Installation

Removal

1. Park the vehicle on a level surface. Make sure the front tires are pointing forward. Apply the parking brakes. Shut down the engine. Chock the tires.

IMPORTANT: Once the vehicle is parked, do not turn the steering wheel at any time during the following procedures.

2. Disconnect the batteries.
3. Remove the lower steering column cover seal. See **Fig. 1**.



1. Lower Steering Column Cover Seal
2. Lower Steering Column Cover
3. Upper Steering Column Cover

Fig. 1, Steering Column Covers

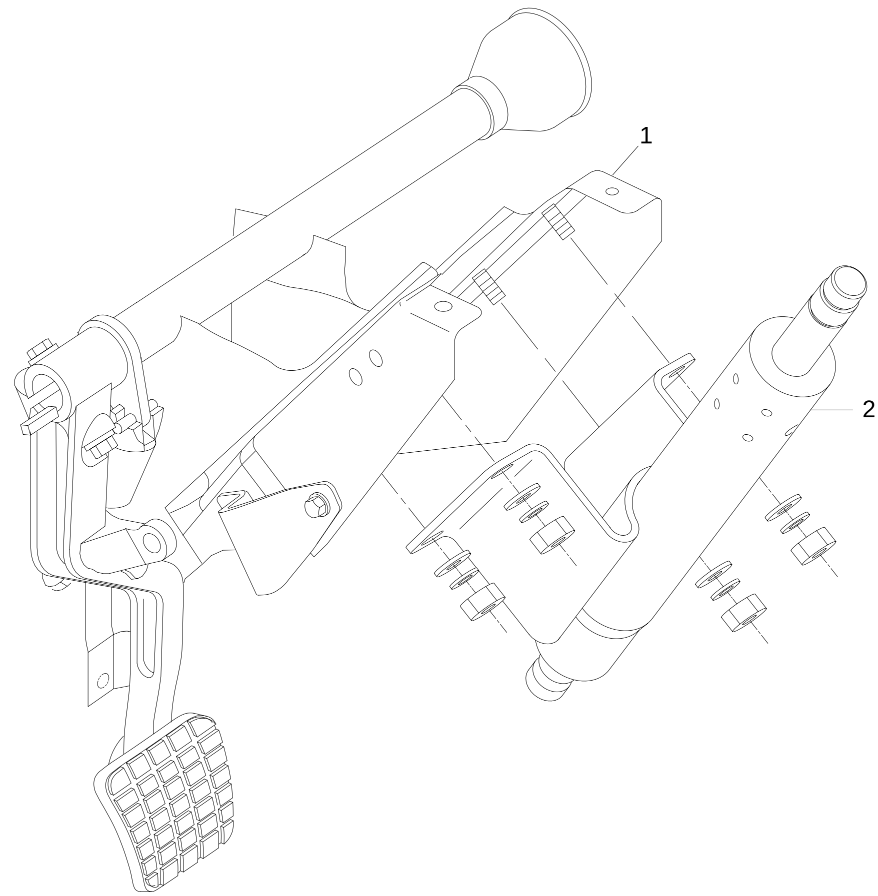
4. Remove the steering column cover panels from the front and back of the column.
5. Remove and discard the pinch bolt and nut from the upper end yoke.
6. Remove the two screws that attach the trailer brake control valve mounting bracket to the steering column. Remove the control valve (and the horn ground wire) from the steering column.
7. Remove the two screws that attach the turn signal switch mounting bracket. Remove the turn signal switch mounting assembly from the steering column. Disconnect the wiring connector from the turn signal switch.
8. Remove the upper end yoke from the steering column shaft.
9. Remove the nuts and washers that attach the steering column to the mounting bracket.

   Remove the steering column assembly from the vehicle. See **Fig. 2**.

Installation

1. Position the steering column on the steering column mounting bracket. See **Fig. 2**. Tighten the nuts 26 lbf·ft (35 N·m).
2. Wipe the end of the column shaft with a clean, dry cloth.
3. Slide the upper end yoke on the column shaft. Install a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke easily. Install a new nut. Tighten the nut to one of the following torque specs:
   - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
   - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut
4. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and to the nut.
5. Place the turn signal switch mounting assembly on the steering column. Align the switch so that it is pointed directly to the left, toward the driver's door. Install and firmly tighten the mounting screws. Connect the turn signal harness connector.
6. Insert the horn ground wire through the bracket. Position the trailer brake control valve mounting bracket on the steering column. Install and firmly tighten the mounting screws.
7. Install the lower steering column cover seal.
8. Position the steering column cover panels on the front and back of the column. Both panels have fittings that should snap into the column. Install two fasteners and attach the two panels together. See **Fig. 1**.

Steering Column Assembly Removal and Installation



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1. Steering Column Bracket Assembly
2. Fixed Steering Column

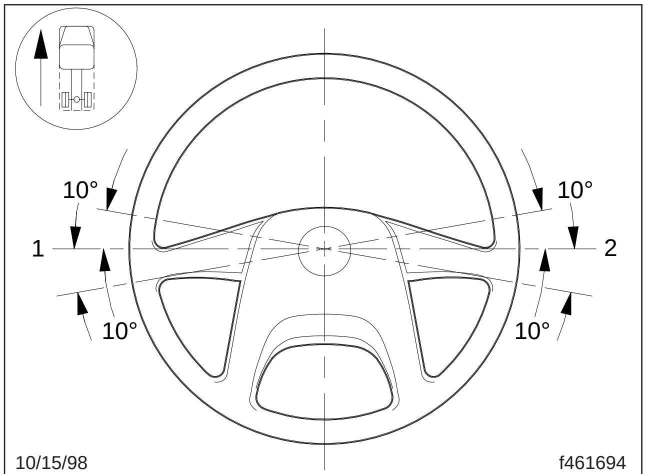
Fig. 2, Steering Column Assembly Installation

9. Check the position of the steering wheel when the front tires are pointing forward. The steering wheel should be within ±10 degrees of center as shown in **Fig. 3**.

   If necessary, remove the steering wheel and reposition it. See **Subject 100** for instructions.

10. Connect the batteries.
11. Remove the chocks from the tires.
12. Test drive the vehicle and make sure the steering column assembly operates smoothly. If it does not operate smoothly, repeat the service operations.

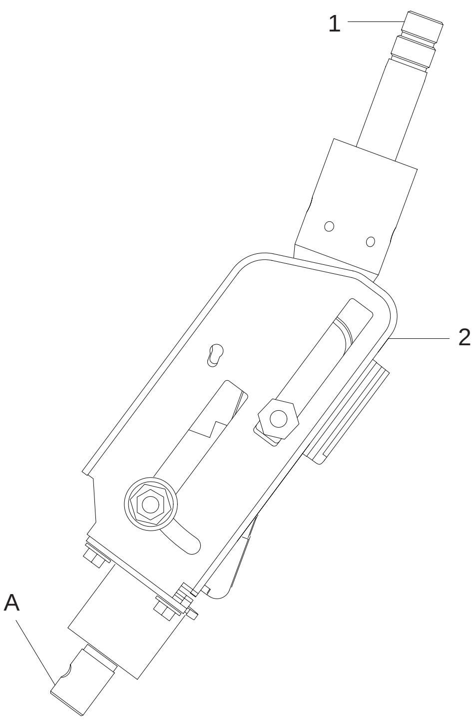
Steering Column Assembly Removal and Installation



1. 9 o'Clock Position
2. 3 o'Clock Position

Fig. 3, Steering Wheel Centered

General Information (See Fig. 1)

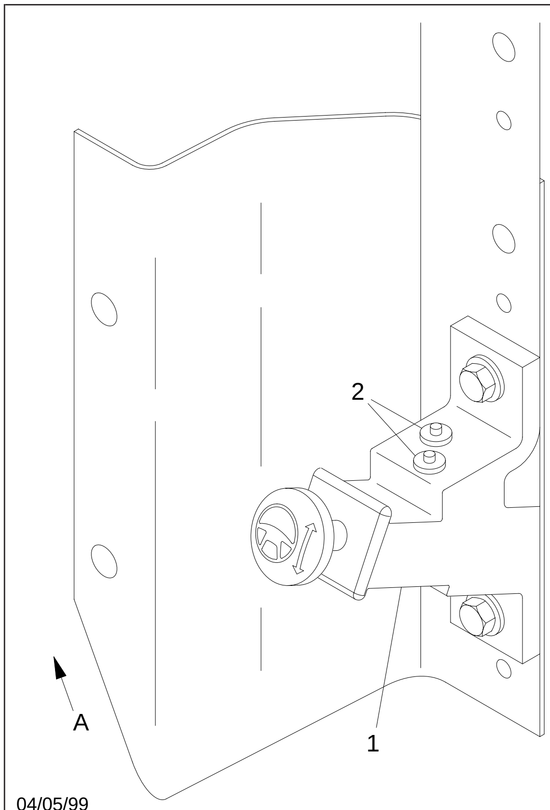


A. Steering driveline upper end yoke attaches here.
1. Tilt Steering Column Shaft
2. Tilt Column Assembly

Fig. 1, Tilt Steering Column Assembly

The tilt function of the tilt steering column is controlled by a foot-operated release valve. See **Fig. 2**. For operating instructions, see the *Columbia Driver's Manual*.

At the upper end of the tilt steering column assembly are threads to accept a wheel nut, and tapered external serrations to match the internal serrations of the steering wheel hub. At the lower end, the shaft is serrated to connect with the steering driveline upper end yoke.



A. Driver's door opening
1. Column Release Valve
2. Air Line Connections

Fig. 2, Tilt Column Release Valve

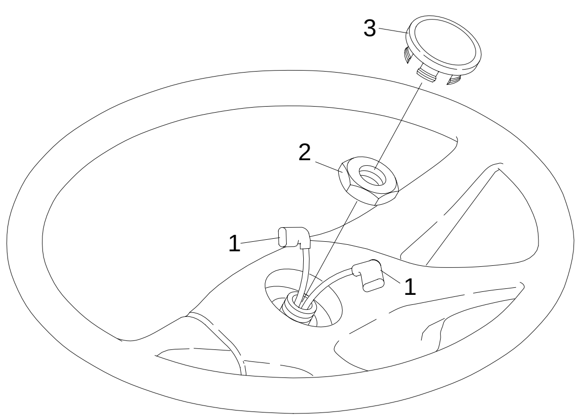
Steering Wheel Removal and Installation

Removal of Steering Wheel Without an Air Bag

NOTE: Remove the steering wheel only if the steering wheel or steering column is being replaced. If the wheel or column is being removed to allow servicing of the dash, remove the steering wheel and column as an assembly. For instructions, see **Subject 110**.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be performed. Do not turn the steering wheel at any time during this procedure.

   Apply the parking brakes, and chock the tires.
2. Using a small screwdriver, pry under the outermost ring of the steering wheel horn button. Lift the horn button from the steering wheel hub, then disconnect the wire terminals at the horn button. See **Fig. 1**.



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1. Horn Cable Assembly
2. Wheel Nut
3. Horn Button Cover

Fig. 1, Steering Wheel Removal

IMPORTANT: The steering wheel has an alignment mark within the hub. After removing the wheel nut, mark the column shaft at the wheel alignment mark to ensure proper installation of the wheel.

3. Without turning the steering wheel, remove the wheel nut from the end of the wheel tube shaft. See **Fig. 1**. Using a steering wheel puller, remove the wheel from the shaft.

IMPORTANT: Be careful when you are removing the steering wheel, or you could damage the horn wires. A steel block measuring 1-5/8 x 5/8 x 1/4 inch (41 x 16 x 6.4 mm) can be used with the puller to protect the wires during steering wheel removal.

Removal of Steering Wheel With an Air Bag

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 2**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 3**.

NOTE: Remove the steering wheel only if the steering wheel or steering column is being replaced. If the wheel or column is being removed to allow servicing of the dash, remove the steering wheel and column as an assembly. For instructions, refer to **Subject 110**.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where service operations will be performed.

   Apply the parking brakes and chock the tires.

CAUTION

Do not turn the steering wheel or the steering shaft at any time during this procedure. Doing so may damage the clockspring.

2. Disconnect the batteries by removing the negative terminal first, then the positive terminal.

Steering Wheel Removal and Installation

WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

Consider undeployed air bags to be dangerous and capable of deploying at any time. Follow the safety guidelines and handling instructions in Section 46.07, Subject 110. Failure to observe safety and handling information could cause the unintentional deployment of the air bag, which could result in severe injury or death.

3. Disconnect the air bag circuit from the air bag sensor module or the SPACE module.

   3.1 On vehicles with an air bag/SPACE system, disconnect the DSS connector at the back of the SPACE module. See **Fig. 2**.

   3.2 On vehicles with an air bag only system installed from May 12, 2000, disconnect the AS2 connector under the B pillar cover. See **Fig. 3**.

4. Pull the lower steering column cover off of the dash.
5. Remove the fastener cover plugs from the steering column cover.
6. Remove the T25 Torx®-head fasteners and the steering column cover. See **Fig. 4**.
7. Remove the T30 Torx-head fasteners underneath the steering wheel. See **Fig. 5**.
8. Carefully lift the air bag module from the steering wheel and disconnect the air bag connector (and the horn switch connector if equipped) from the air bag. See **Fig. 6**.
9. Remove the air bag module.
10. Without turning the steering wheel, remove the wheel nut. See **Fig. 6**. Using a steering wheel puller, remove the wheel from the shaft.
11. Tape the upper and lower portions of the clockspring together to prevent the clockspring from turning. See **Fig. 7**.
12. Inspect the clockspring and clockspring connector. Replace the clockspring if there is any melting or damage. For clockspring replacement instructions, see **Section 46.07**, Subject 120.

Installation of Steering Wheel Without an Air Bag

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead, and that the steering gear is centered.

1. With the marks on the column and steering wheel aligned, place the steering wheel on the steering column. Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 8**.

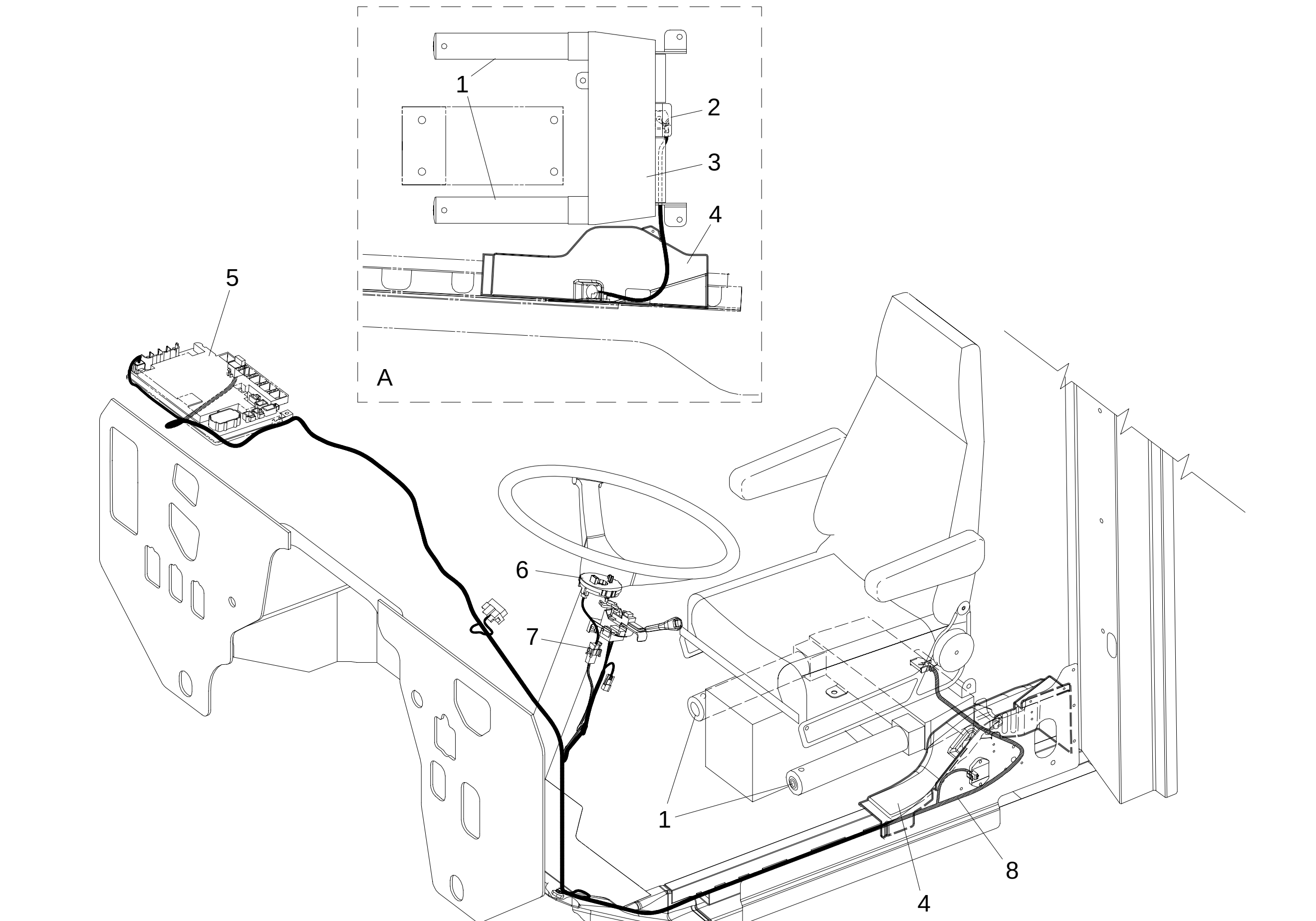
   Insert the horn ground wires (from the center of the wheel tube shaft) through the center of the wheel nut. Install the wheel nut, and tighten it 55 to 65 lbf·ft (75 to 88 N·m).

2. Connect the ground wire terminals to the horn button. With the steering wheel in the straight-ahead position, push the horn button into place in the steering wheel hub.

Installation of Steering Wheel With an Air Bag

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead and the steering gear is centered.

1. Pull the air bag connector from the steering column through the cutout above the center hole on the steering wheel. See **Fig. 7**.
2. Remove the tape from the clockspring.
3. Align the tab on the clockspring with the cutout below the center hole on the steering wheel, and place the steering wheel on the steering column. See **Fig. 7**. Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 8**. Install the wheel nut and tighten 55 to 65 lbf·ft (75 to 88 N·m).
4. Connect the air bag connector to the air bag module and carefully set the air bag module on the steering wheel.
5. Attach the air bag module to the steering wheel using T30 Torx-head fasteners.



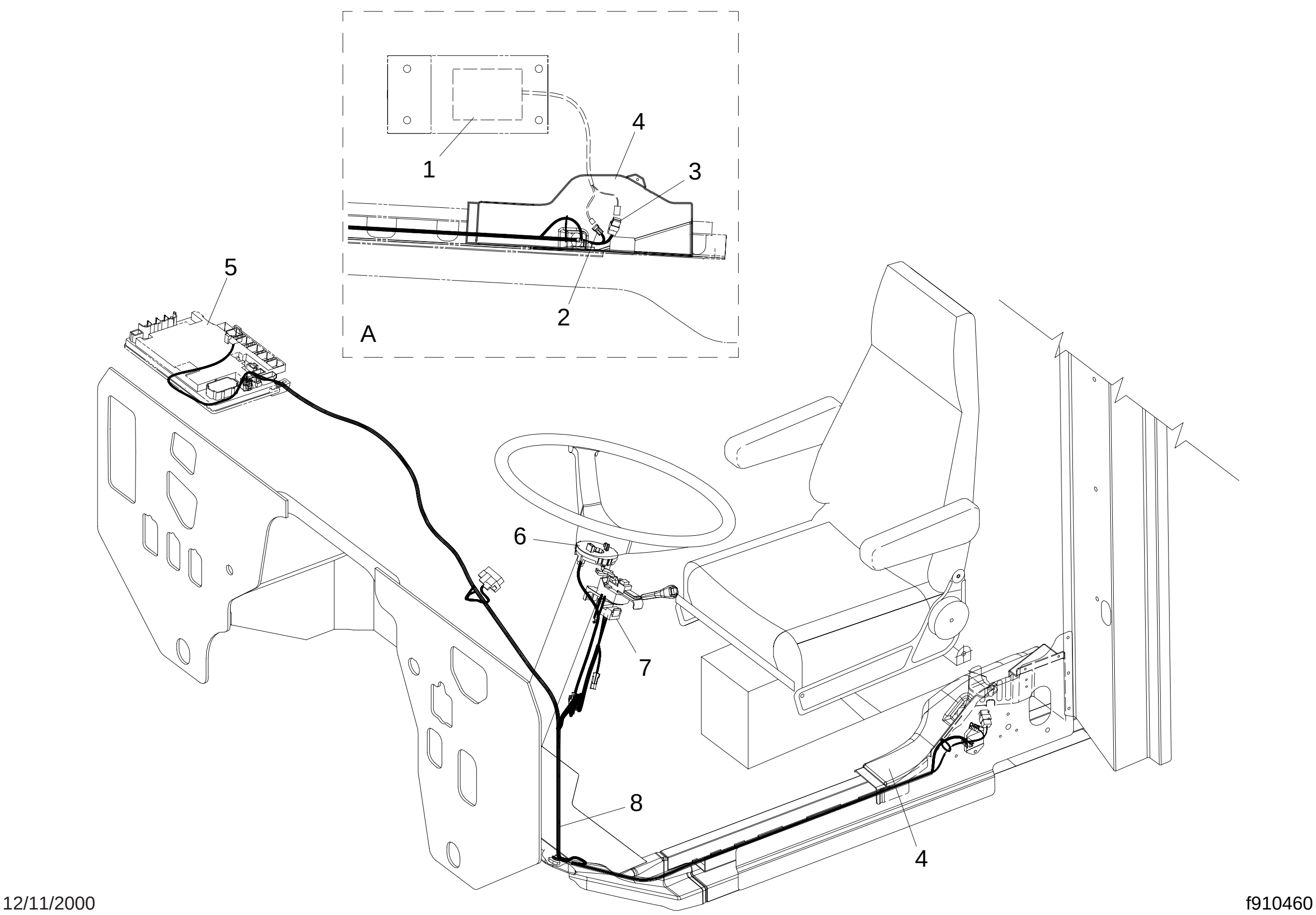
12/11/2000 f910459

A. Top view of Air Bag/SPACE System
1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag/SPACE Systems Installed Prior to May 12, 2000

6. Attach the steering column cover to the steering column using T25 Torx-head fasteners.
7. Attach the fastener cover plugs to the steering column cover.
8. Attach the lower steering column cover to the dash.
9. Reactivate the air bag by connecting the DSS connector on air bag/SPACE systems or by connecting the AS2 connector on air bag only systems built from May 12, 2000.
10. Connect the batteries.
11. Remove the chocks from the tires.

Steering Wheel Removal and Installation

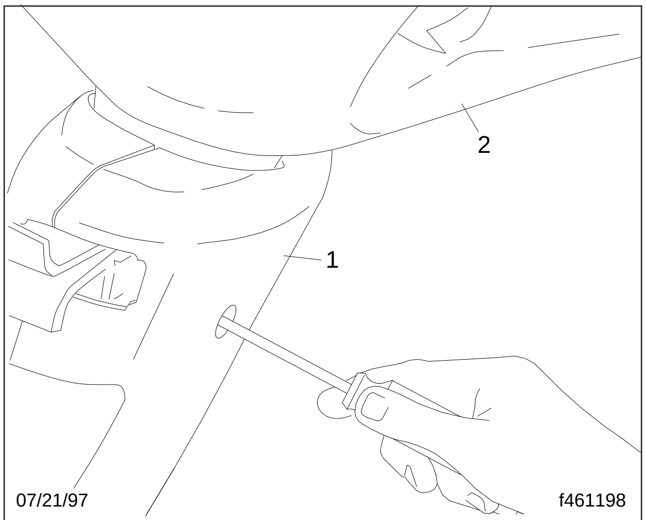


A. Top view of Air Bag Sensor Module

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

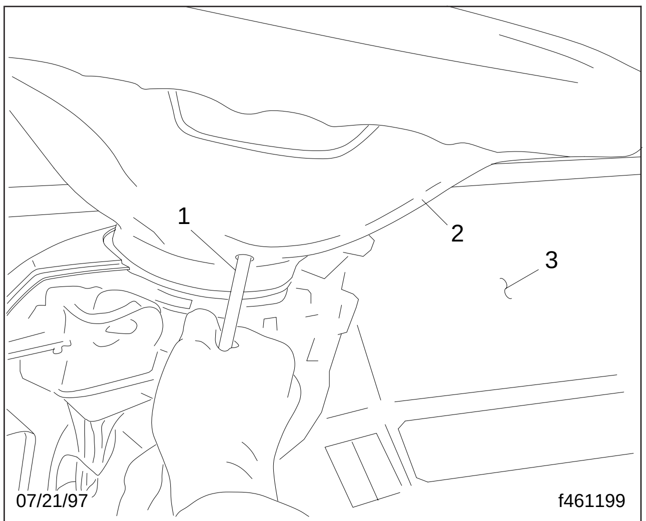
Fig. 3, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

Steering Wheel Removal and Installation



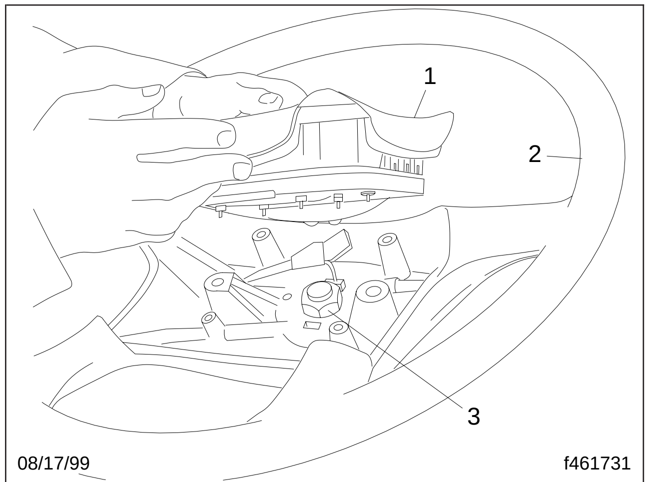
1. Steering Column Cover
2. Steering Wheel

Fig. 4, Remove the Steering Column Cover



1. Torx Screwdriver
2. Steering Wheel
3. B-Panel Dash

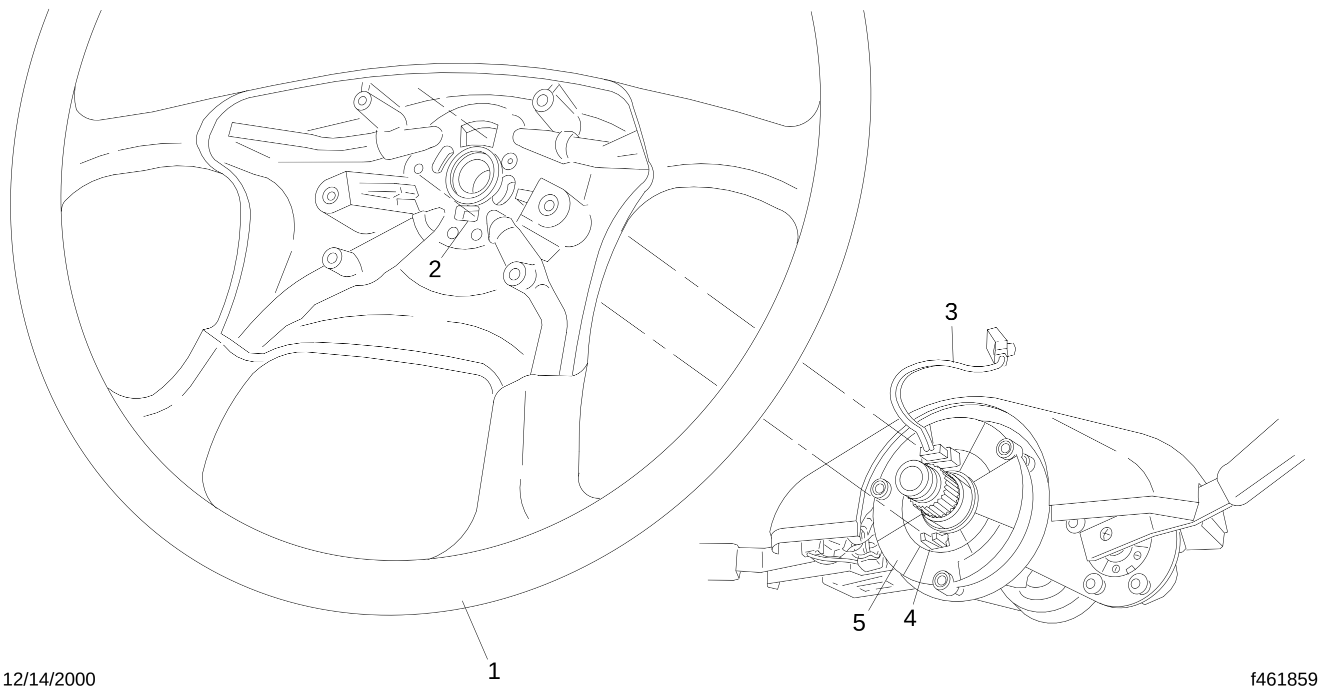
Fig. 5, Remove the Fasteners



1. Air Bag Module
2. Steering Wheel
3. Wheel Nut

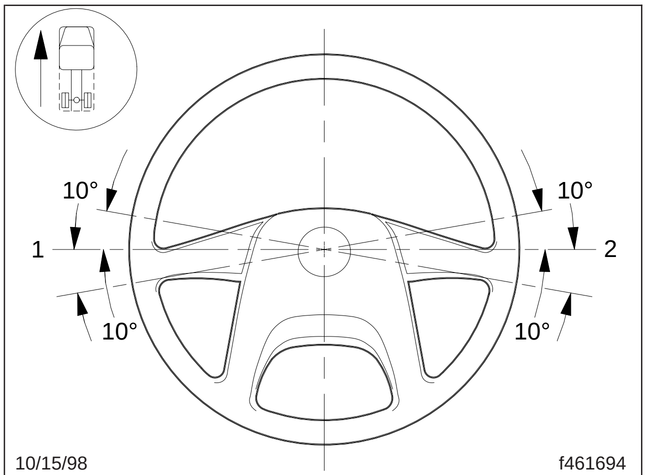
Fig. 6, Lift Off the Air Bag Module

Steering Wheel Removal and Installation



1. Steering Wheel
2. Cutout
3. Air Bag Cable Assembly
4. Tab
5. Clockspring

Fig. 7, Installation of Steering Wheel With an Air Bag



1. 9 o'Clock
2. 3 o'Clock

Fig. 8, Steering Wheel Centered

Removal

NOTE: If the steering wheel is not being replaced, see **Subject 100** for steering wheel removal and installation instructions.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where service operations will be performed.

   Apply the parking brakes and chock the tires.

CAUTION

Do not turn the steering wheel or the steering shaft at any time during this procedure. Doing so may damage the clockspring.

2. Depress the column adjustment control pedal and tilt the column until it is as far away from the dash as possible.
3. If the steering wheel is equipped with an air bag, disconnect the batteries and wait two minutes before proceeding.

WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

Undeployed air bags can be dangerous and are capable of deploying at any time. Follow the safety guidelines and handling instructions in Section 46.07, Subject 110. Failure to observe safety and handling information could cause the unintentional deployment of the air bag, which could result in severe injury or death.

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag/SPACE system and the air bag only system installed prior to May 12, 2000 have a SPACE module. If the vehicle has a SPACE system, gas cylinders are also located under the driver's seat. See **Fig. 1**. The air bag only system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

4. If the steering wheel is equipped with an air bag, deactivate the air bag by disconnecting the DSS connector on air bag/SPACE systems installed prior to May 12, 2000. See **Fig. 1**. If the vehicle has an air bag only system installed from May 12, 2000, disconnect the AS2 connector. See **Fig. 2**.
5. Using a T25 Torx®-driver, remove the lower steering column cover seal. See **Fig. 3**.

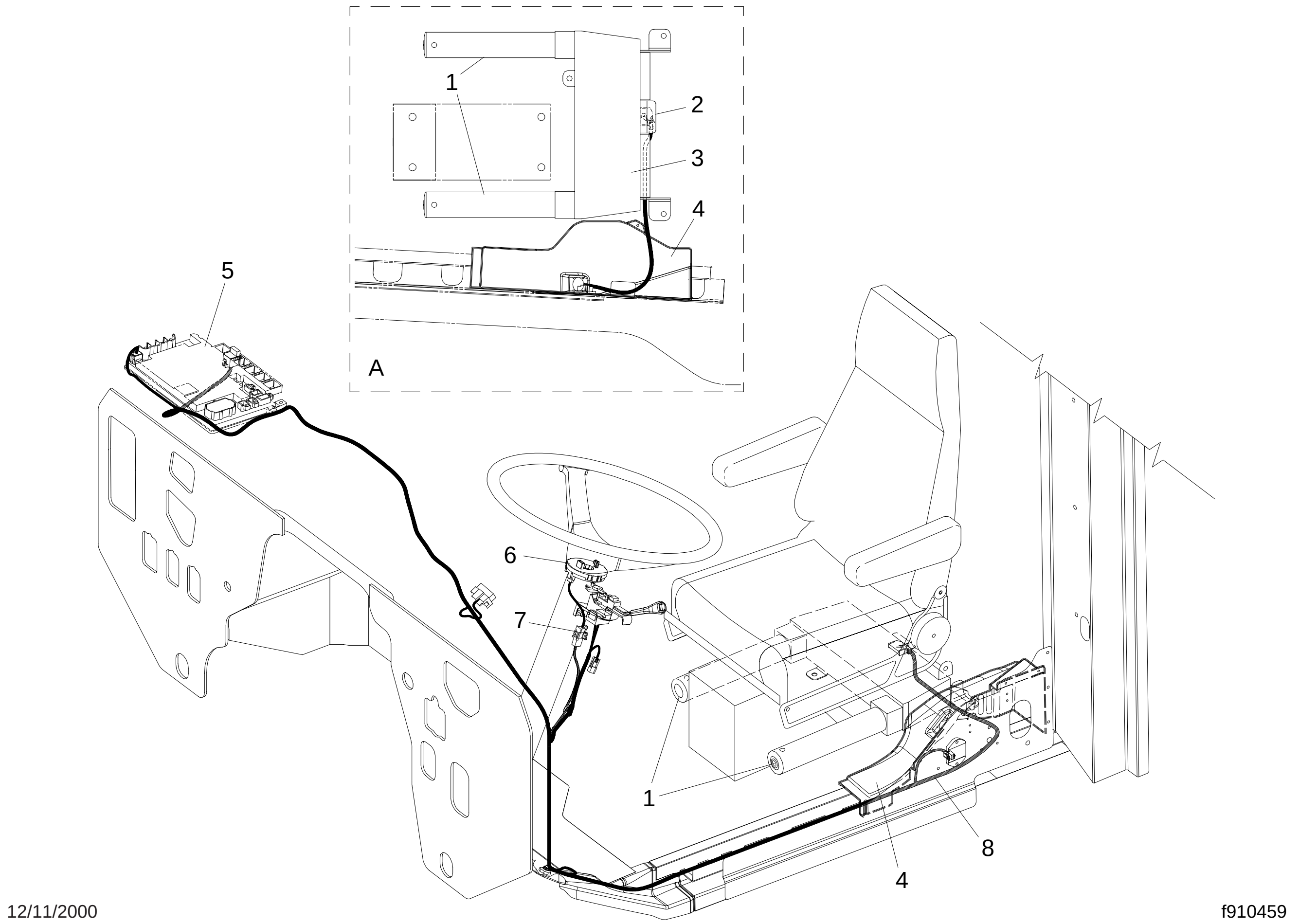
   Remove the upper and lower steering column covers.
6. Remove and discard the pinch bolt and nut from the upper end yoke.
7. Remove the two screws that attach the trailer brake control valve mounting bracket to the steering column. Remove the control valve (and the horn ground wire) from the steering column.
8. Remove the two screws that attach the turn-signal switch mounting bracket. Remove the turn-signal switch assembly from the steering column. Disconnect the wiring connector from the turn-signal switch.
9. At the steering column, disconnect the air line between the foot-operated release valve and the steering column.
10. Remove the upper end yoke from the steering column shaft.
11. Remove the nuts and washers that attach the steering column to the mounting bracket.

    Remove the steering column assembly from the vehicle. See **Fig. 4**.

Installation

1. Position the steering column on the steering column mounting bracket. See **Fig. 4**. Tighten the nuts 26 lbf·ft (35 N·m).
2. Connect the air line from the steering column to the foot-operated release valve.
3. Clean the end of the column shaft with a clean dry cloth.

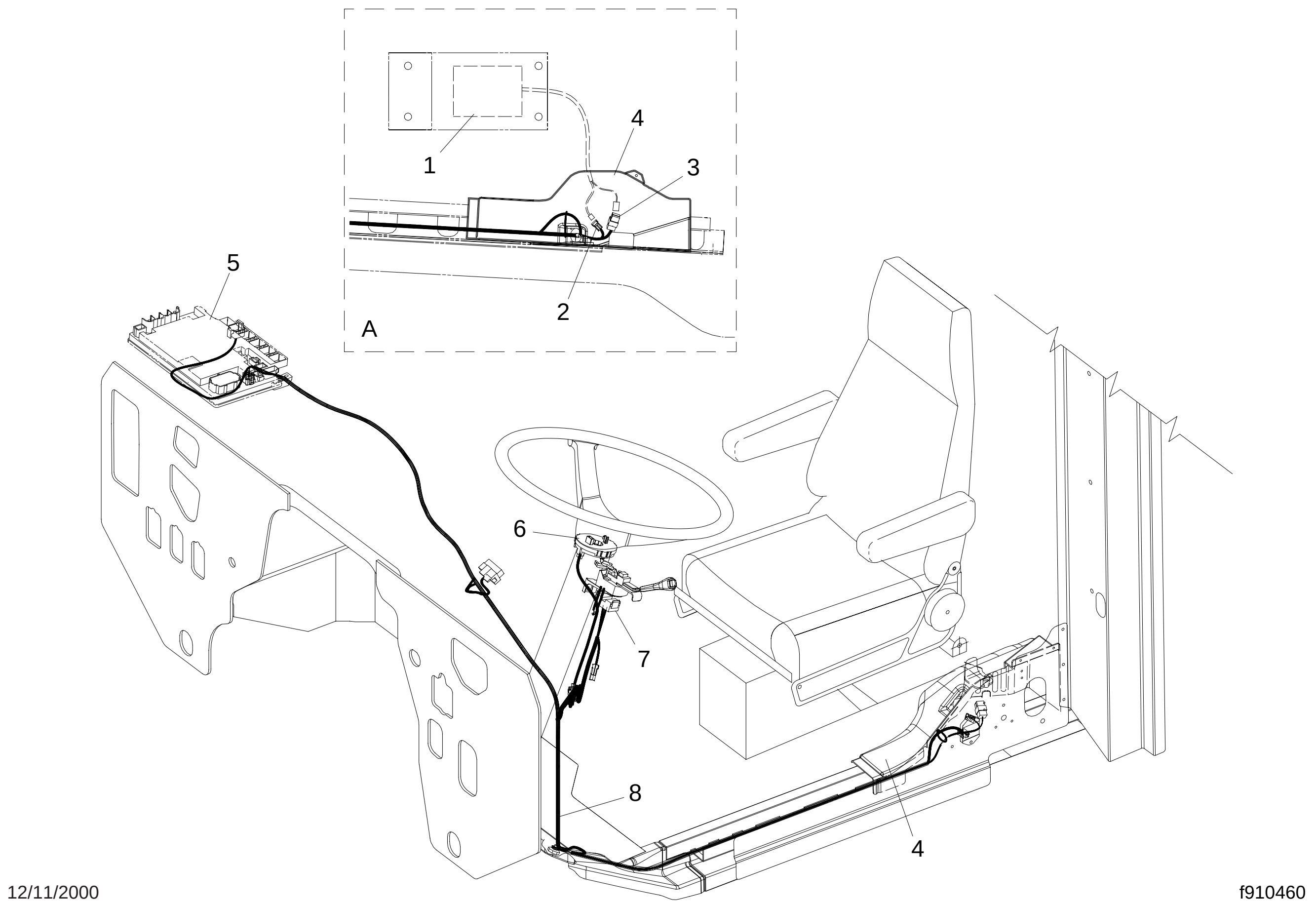
Tilt Column Removal and Installation



A. Top view of Air Bag/SPACE System
1. Gas Cylinder (SPACE system only)
2. DSS (Driver-Side SPACE) Connector
3. Driver-Side SPACE Module
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag/SPACE Systems Installed Prior to May 12, 2000

4. Slide the upper end yoke on the column shaft, then install a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new nut. Tighten the nut to one of the following torque specs:
   - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
   - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut
5. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and to the nut.
6. Place the turn-signal switch assembly on the steering column. If the turn signal assembly is on the left side of the steering column, align the switch so that it is pointed directly to the left. If the turn signal assembly is on the right side of the steering column, align the turn-signal switch so that it is pointed directly to the right. Install and firmly tighten the mounting screws. Connect the turn signal harness connector.



A. Top view of Air Bag Sensor Module
1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Only Systems Installed From May 12, 2000

NOTE: Make sure there is slack in the turn signal harness. This will allow the turn signal switch assembly to move with the tilt column assembly.

7. Position the trailer brake control valve mounting bracket on the steering column. Insert the horn ground wire through the bracket. Install and firmly tighten the mounting screws.

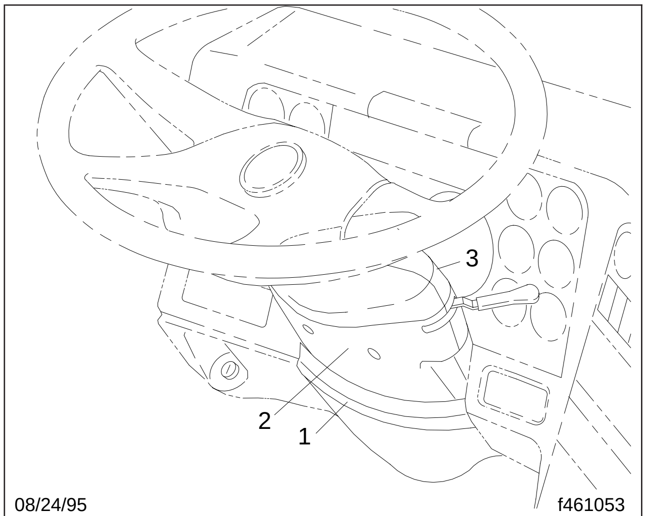
8. If the steering wheel is equipped with an air bag, reactivate the air bag by connecting the DSS connector on air bag/SPACE systems built prior to May 12, 2000, or by connecting the AS2 connector on air bag only systems built from May 12, 2000.

9. Install the lower steering column cover seal.

   Position the steering column cover panels on the front and back of the column. Both panels have fittings that should snap into the column. Install two fasteners and attach the two panels together. See **Fig. 3**.

10. If the steering wheel is equipped with an air bag, connect the batteries.

Tilt Column Removal and Installation



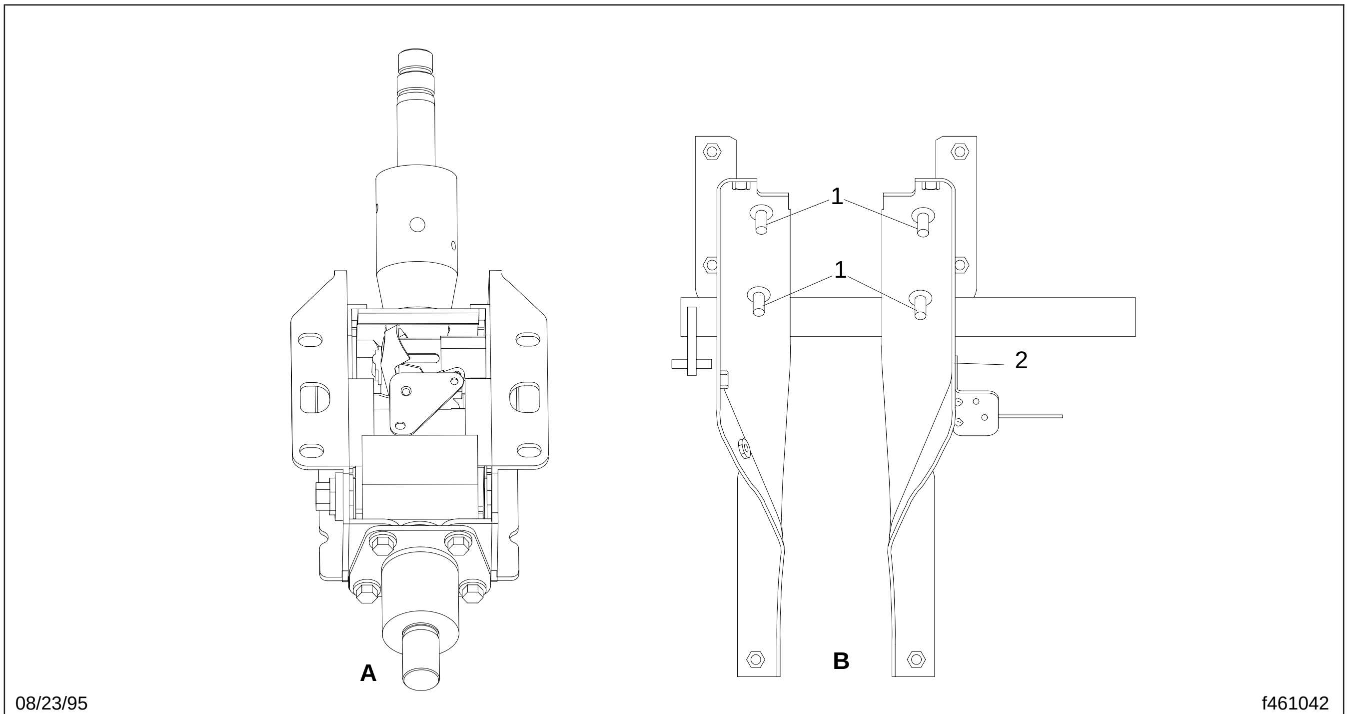
1. Lower Steering Column Cover Seal
2. Lower Steering Column Cover
3. Upper Steering Column Cover

Fig. 3, Tilt Steering Column, Left-Hand Drive Shown

11. Check the position of the steering wheel when the front tires are straight ahead. The steering wheel should be within ±10 degrees of center as shown in **Fig. 5**.

    If necessary, remove the steering wheel and reposition it. Refer to **Subject 100** for instructions.

12. Remove the chocks from the tires.
13. Test drive the vehicle and make sure that the steering column assembly operates smoothly. If it does not, repeat the service operations.

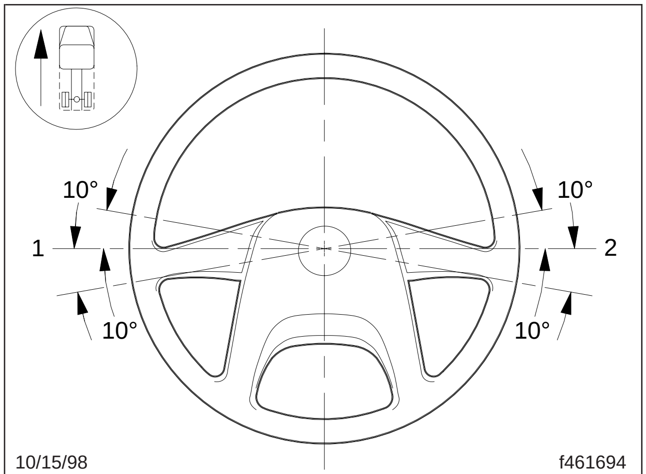


A. Tilt column viewed from the rear.
1. Tilt Column Mounting Studs

B. Mounting bracket viewed from the front.
2. Steering Column Mounting Bracket

Fig. 4, Tilt Steering Column Mounting

Tilt Column Removal and Installation



1. 9 o'Clock Position
2. 3 o'Clock Position

Fig. 5, Steering Wheel Centered

General Description

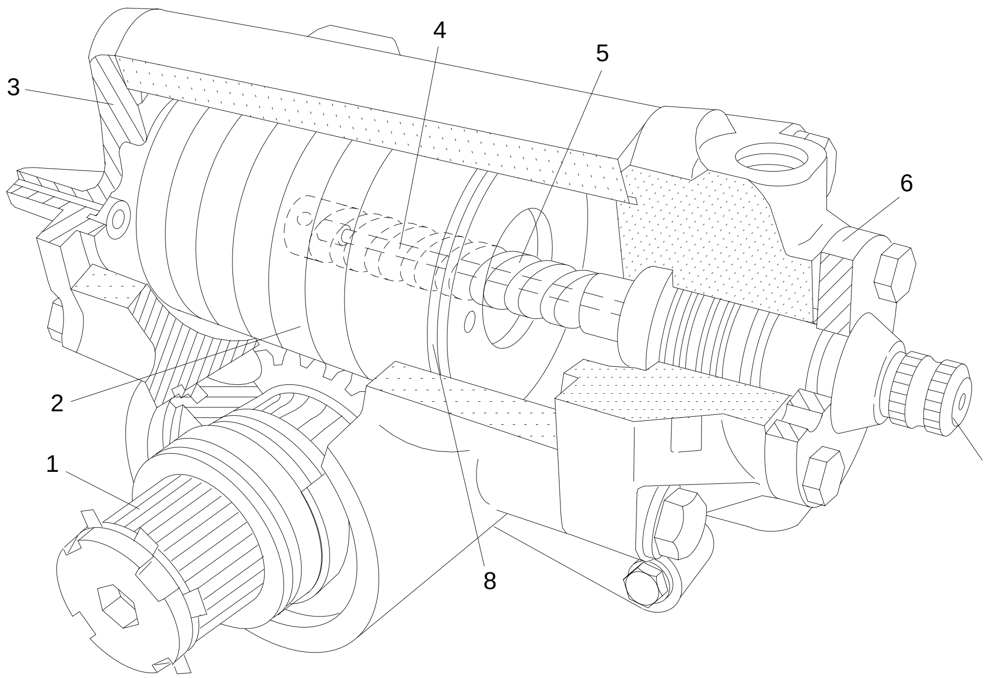
The Sheppard M100 integral power steering gear provides full-time hydraulic steering. This gear is installed as an option on vehicles with a front axle capacity of up to 14,000 pounds (6350 kg).

The steering gear is mounted on the left frame rail. It connects the steering driveline to an input shaft that is connected to a sector shaft and the pitman arm.

Principles of Operation

When the steering wheel is turned, the force is transmitted to the steering gear input (actuating) shaft via the steering driveline. See **Fig. 1**. The input shaft is connected to the rotary valve and a torsion bar. When the input shaft turns, the twisting force on the torsion bar turns the rotary valve, which causes the fluid pressure to build up at one end of the piston. The rotary valve shaft fits into one end of the piston and the fluid pressure buildup, together with the recirculating ball mechanism, forces the piston to move in one direction inside the bore of the gear housing. The rack teeth on the piston mesh with the teeth on the sector (output) shaft so that the sector shaft rotates when the piston moves. When the sector shaft turns, it moves the pitman arm. The pitman arm in turn connects to the steering linkage, which turns the wheels.

General Information



1. Sector (output) Shaft
2. Piston Rack
3. Cylinder Head
4. Torsion Bar
5. Rotary Valve Shaft Ball Thread
6. Bearing Cap Cover
7. Input (actuating) Shaft
8. Piston Ring

Fig. 1, Sheppard M100 Power Steering Gear

Steering Gear Removal and Installation

Removal

IMPORTANT: Before removing the steering gear, see **Section 46.11, Subject 300** to identify the problem.

1. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance stopping at the place where the work is to be done. Apply the vehicle parking brakes and chock the tires.

CAUTION

Do not turn the steering wheel or the steering shaft more than a half turn (except for alignment purposes) during the removal and installation procedures. Doing so may damage the clockspring in a vehicle equipped with an air bag.

2. Clean all outside dirt from around the fittings and hose connections.
3. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later reference during installation. Seal the lines and the fittings to keep dirt out.
4. Disconnect the pitman arm from the steering gear. See **Fig. 1**. For instructions, see **Subject 160**.
5. Disconnect the steering driveline from the steering gear input shaft.
   - 5.1 Remove and discard the pinch bolt and nut from the lower end of the steering driveline yoke.

CAUTION

Do not pound the U-joint or input shaft coupling on or off the input shaft. Internal damage to the steering gear can result.

   - 5.2 Remove the steering driveline yoke from the steering gear input shaft.
6. Clean the entire assembly before removing the gear.

WARNING

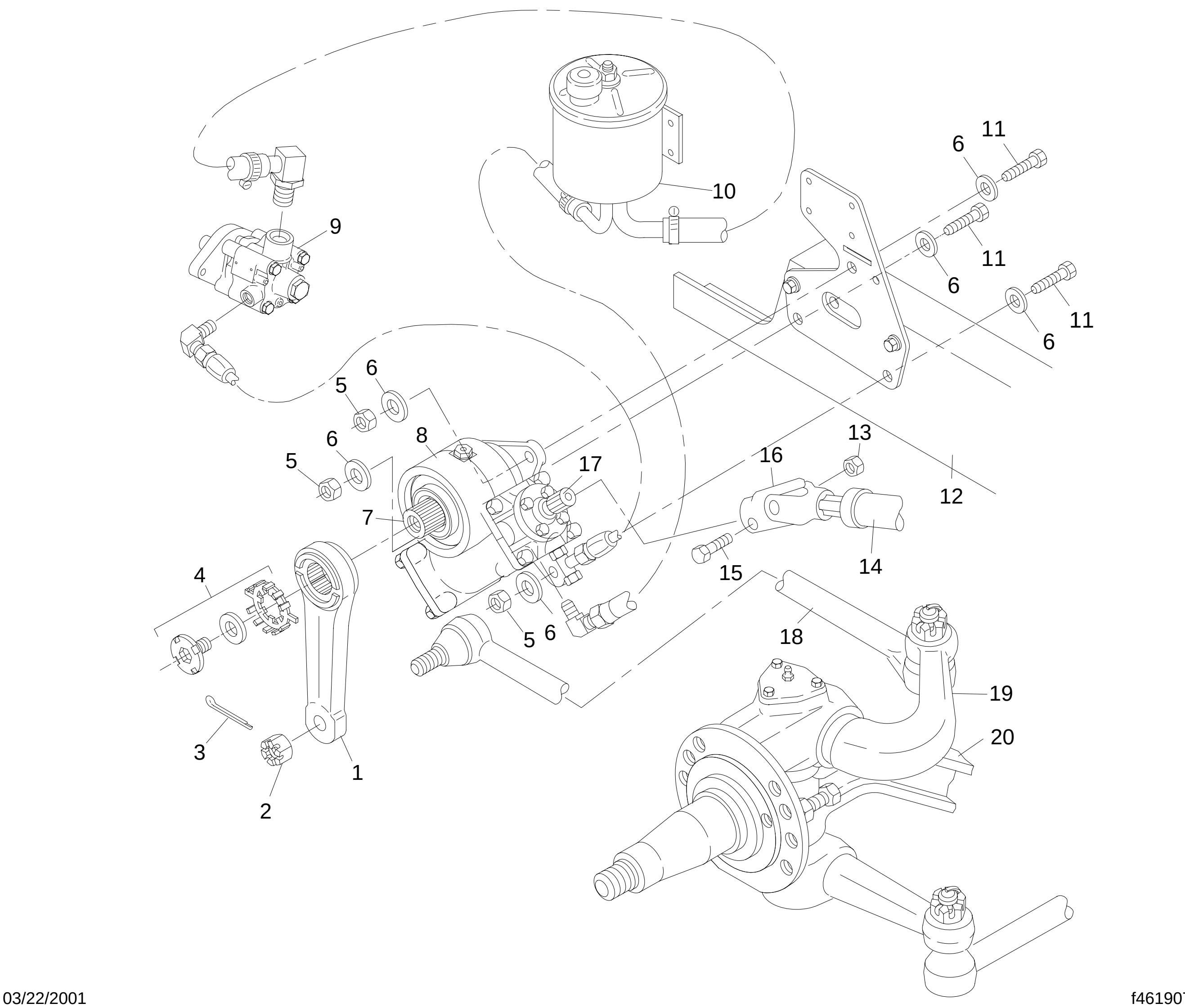
The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

7. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear and place the steering gear on a clean surface.

Installation

1. Align the holes in the steering gear housing with the holes in the frame rail. Place a washer over each bolt and install the three bolts. Install a washer and nut on the end of each bolt and tighten the nuts 388 lbf·ft (526 N·m).
2. Install the pitman arm on the steering gear. For instructions, see **Subject 160**.
3. Connect the steering driveline to the steering gear input shaft.
   - 3.1 Clean the steering gear input shaft and the inside of the steering driveline yoke.
   - 3.2 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut to one of the following torque specs:
     - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
     - 30 to 35 lbf·ft (41 to 478 N·m) for an M10 x 1.25 pinch bolt and nut
   - 3.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut.
4. Connect the hydraulic lines to the gear as marked earlier or as shown in the plumbing diagram in **Specifications 400**. Tighten the nut on each fitting finger tight. Then, with a wrench, tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.
5. Position the steering wheel so that it is within ±10 degrees of center as shown in **Fig. 2**.
6. Connect the pitman arm to the steering gear. For instructions, see **Subject 160**.
7. Adjust the automatic relief plunger. For instructions, see **Subject 130**.

Steering Gear Removal and Installation



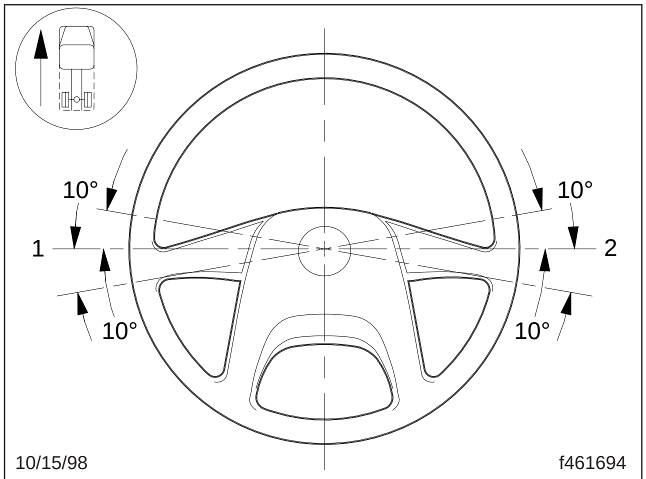
NOTE: Not all fasteners are shown.

1. Pitman Arm
2. Castle Nut
3. Cotter Pin
4. Pitman Arm Retainer Assembly
5. Nut
6. Washer
7. Sector (output) Shaft
8. Steering Gear
9. Power Steering Pump
10. Power Steering Reservoir
11. Bolt
12. Frame Rail
13. Nut
14. Steering Driveline
15. Pinch Bolt
16. Lower End Yoke
17. Input (actuating) Shaft
18. Drag Link
19. Axle Steering Arm
20. Front Axle

Fig. 1, Sheppard M100 Power Steering Gear Installation

8. Refer to **Subject 170** and do the checks as instructed.

Steering Gear Removal and Installation



1. 9 o’Clock Position
2. 3 o’Clock Position

Fig. 2, Steering Wheel Centered

Input Shaft Seal Replacement

Disassembly

1. Turn off the engine, apply the parking brakes, and chock the tires.

IMPORTANT: Do not remove the steering gear for this procedure.

2. Open the hood.
3. Remove the pinch bolt on the lower end yoke of the steering shaft.
4. Remove the lower yoke from the steering gear input shaft. If necessary, secure the shaft so it will not interfere with your work.

IMPORTANT: Do not pull the slip shaft out of the steering shaft. Installation of the slip shaft requires rephasing.

5. Place a drain pan under the power steering gear. Draining the system is not necessary, but some fluid will be lost.

CAUTION

Do not turn the input shaft during repairs. Damage to the steering gear will result.

6. Remove the rubber boot. See **Fig. 1**.
7. Remove the capscrews that attach the bearing cap cover to the bearing cap and remove the bearing cap cover.

IMPORTANT: The thrust washer will stick to the bearing cap cover. Install the thrust washer on the bearing cap before proceeding.

8. Place the bearing cap cover on a clean work surface. Pry the salt seal out of the bearing cap cover and discard the seal. See **Fig. 2**.
9. Press the oil seal out of the bearing cap cover cover using a suitable size socket or seal driver. Use of an arbor press is recommended. See **Fig. 3**. Discard the oil seal.
10. Remove the O-ring from the bearing cap cover. Discard the O-ring.
11. Clean the bearing cap cover with a suitable solvent.

Assembly

1. Place the bearing cap cover face down on a clean work surface. With the garter spring visible inside the oil seal, install the oil seal in the bearing cap cover using a suitable size driver and an arbor press. Coat the outside diameter of the oil seal with clean chassis lube. The garter spring will be visible when the oil seal is properly installed.
2. Install a new O-ring in the bearing cap cover. Make sure the oil seal is properly installed before proceeding.
3. With the lip of the salt seal facing out, press a new salt seal into the bearing cap cover until it is flush with the face of the cover. See **Fig. 4**.

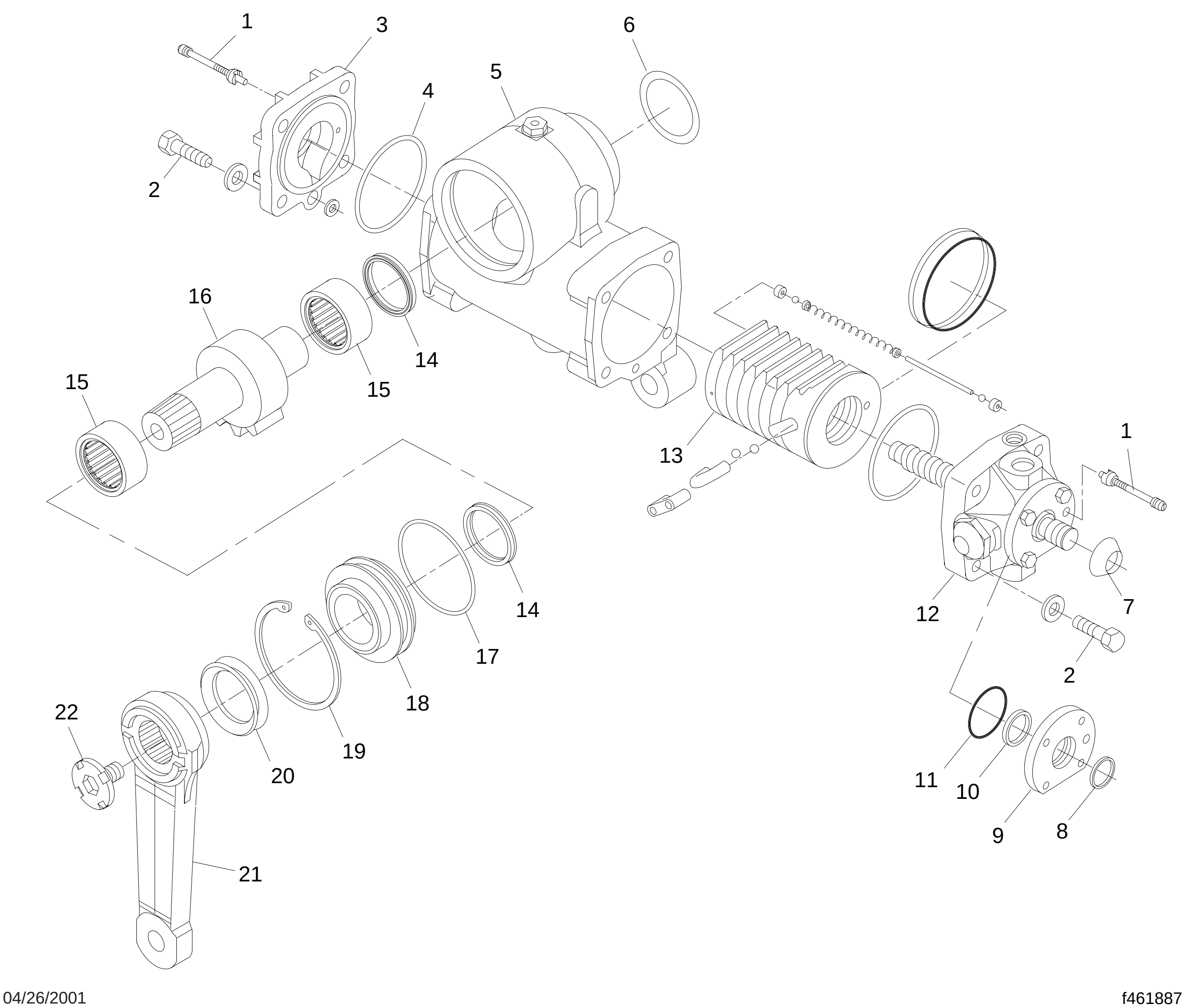
NOTE: Tape the input shaft splines before installing the bearing cap cover to prevent seal damage.

4. Using capscrews, attach the bearing cap cover to the bearing cap and torque the capscrews 53 to 64 lbf·ft (72 to 87 N·m).

NOTE: Two rubber boots are included in the replacement kit. Choose the rubber boot that will provide the tightest fit on the input shaft.

5. Install the rubber boot on the input shaft. Make sure the boot is below the spline and contacts the bearing cap cover when installed.
6. Remove the tape from the splines and install the U-joint following the instructions in **Section 46.04**, Subject 100.
7. Check the fluid level in the power steering reservoir and fill if necessary.
8. Start the vehicle and check for leaks.
9. Remove the drain pan and return the hood to the operating position.
10. Remove the chocks from the tires.

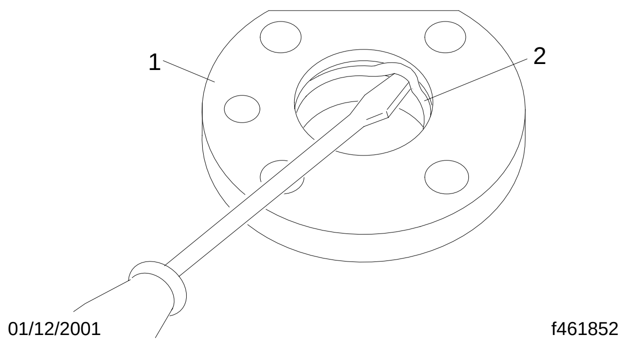
Input Shaft Seal Replacement



1. Automatic Relief Plunger
2. Capscrew
3. Cylinder Head
4. O-Ring
5. Steering Gear Housing
6. Frame Side Dust Cover
7. Rubber Boot
8. Salt Seal
9. Bearing Cap Cover
10. Oil Seal
11. O-Ring
12. Bearing Cap
13. Piston Rack
14. Oil Seal
15. Roller Bearing
16. Sector Shaft
17. O-Ring
18. Sector Shaft Cover
19. Snap Ring
20. Sector Shaft Boot
21. Pitman Arm
22. Pitman Arm Retainer

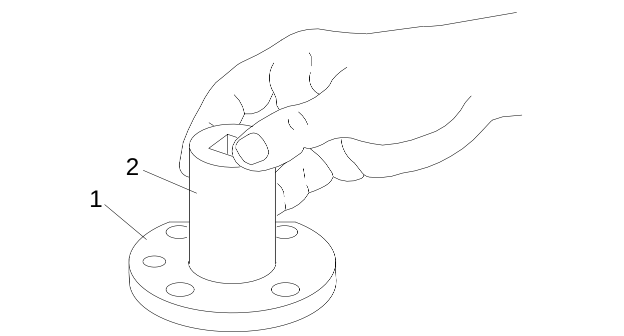
Fig. 1, Steering Gear Assembly

Input Shaft Seal Replacement



1. Bearing Cap Cover 2. Salt Seal

Fig. 2, Remove the Salt Seal



1. Bearing Cap Cover 2. Socket

Fig. 3, Remove the Oil Seal

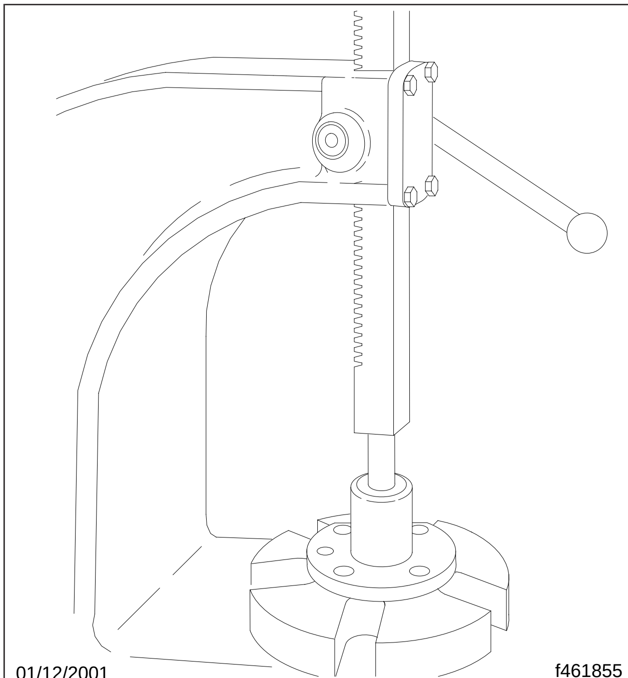


Fig. 4, Install the Salt Seal

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.

NOTE: Removal of the power steering gear is not necessary to perform this procedure. Partial disassembly of the steering gear is required to replace the sector shaft seals. Be sure to time the sector shaft after replacement.

2. Open the hood.
3. Disconnect the pitman arm from the steering gear. For instructions, see **Subject 160**.
4. Remove and discard the rubber boot on the sector shaft.
5. If the snap ring cover is equipped with a protective cap, pry the cap out of the bore.

IMPORTANT: When working with snap ring covers, you will need to remove the factory installed silicone protectant from the snap ring and carefully clean the cover area before disassembly.

6. Remove the snap ring on the sector shaft cover. See **Fig. 1**.
7. Clean the shaft before removing the sector shaft cover.

CAUTION

Do not turn the steering wheel or the steering shaft during this procedure. Turning either the steering wheel or steering shaft will result in steering gear damage.

NOTE: A slide hammer may be used to remove the sector shaft.

8. Remove the sector shaft cover and sector shaft from the housing. Separate the cover from the sector shaft. Discard the sector shaft.

NOTE: It may be necessary to remove the dust cover from the frame side of the sector shaft. Use a gasket scraper or screwdriver to remove the frame side dust cover.

9. Pry the excluder seal from the sector shaft cover. Using a seal pick, remove the oil seal from the sector shaft cover and the steering gear housing. Remove the O-ring from the cover. Discard all seals.

NOTE: Lightly coat the new seals with clean motor oil to facilitate installation of the sector shaft.

IMPORTANT: The sector shaft oil seal has a lip. Do not press on the lip of the oil seal when installing. Press only on the body of the seal. It will be necessary to bend the oil seal when installing. Once the seal is installed, you may have to work the seal into place with your fingers or a blunt seal pick to properly seat the seal.

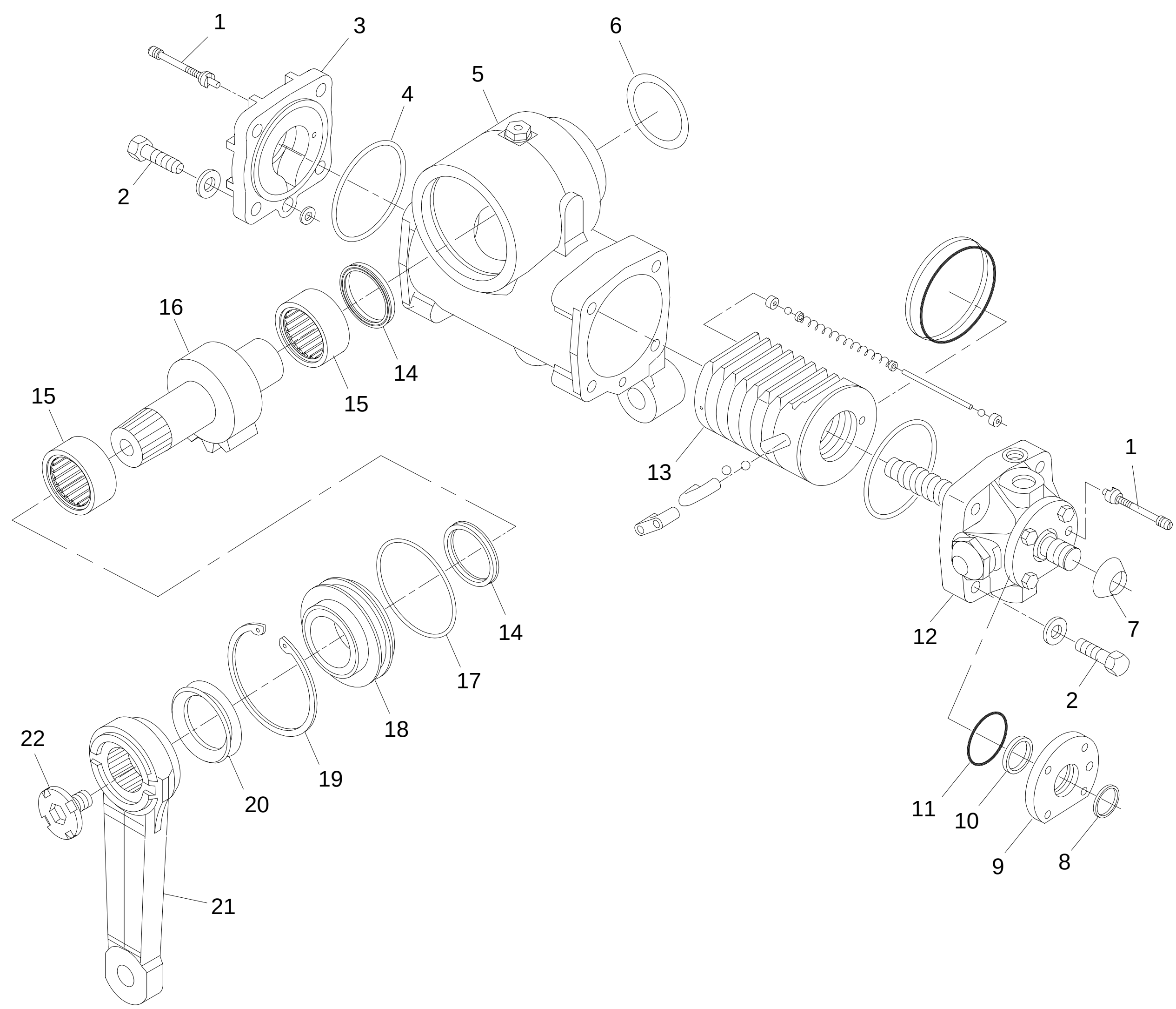
10. Install a new oil seal in the steering gear housing and the sector shaft cover. When properly fitted, the oil seal will ride between the bearing and the cover. The black lip of the seal must face the inside of the steering gear and the blue side must face the outside of the steering gear.
11. Install a new sector shaft in the housing. Make sure that the timing mark on the sector shaft is placed between the two timing marks on the piston rack. See **Fig. 2**. It may be necessary to tap on the sector shaft to properly seat it into the housing.
12. Install the sector shaft cover on the steering gear. Make sure that the cover is properly seated when installing. Snap ring covers must be flush or below the snap ring groove to be properly installed.
13. Using a snap ring, attach the sector shaft cover to the steering gear. Tighten the capscrews 72 to 81 lbf·ft (98 to 110 N·m).

WARNING

When installing a snap ring style cover, the cover must be flush or below the groove in the housing. Improper installation could result in separation of the cover, possibly resulting in personal injury.

14. Apply a coat of clean chassis lube in the lip of the excluder seal. With the lip of the excluder seal facing out and using an appropriate size seal driver, install the excluder seal in the cover. See **Fig. 3**. Apply a bead of grease over the ex-

Sector Shaft Replacement



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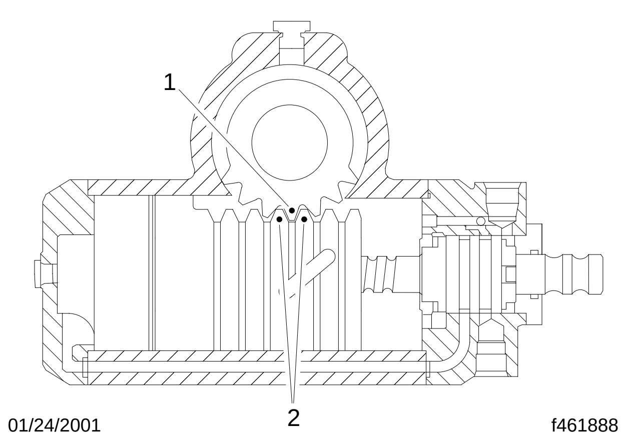
1. Automatic Relief Plunger
2. Capscrew
3. Cylinder Head
4. O-Ring
5. Steering Gear Housing
6. Frame Side Dust Cover
7. Rubber Boot
8. Salt Seal
9. Bearing Cap Cover
10. Oil Seal
11. O-Ring
12. Bearing Cap
13. Piston Rack
14. Oil Seal
15. Roller Bearing
16. Sector Shaft
17. O-Ring
18. Sector Shaft Cover
19. Snap Ring
20. Sector Shaft Boot
21. Pitman Arm
22. Pitman Arm Retainer

Fig. 1, Steering Gear Assembly

cluder seal and slide the rubber boot over the sector shaft.

15. Install the pitman arm. For instructions, see **Subject 160**.



1. Sector Shaft Timing Mark
2. Piston Rack Timing Marks

Fig. 2, Align the Timing Marks

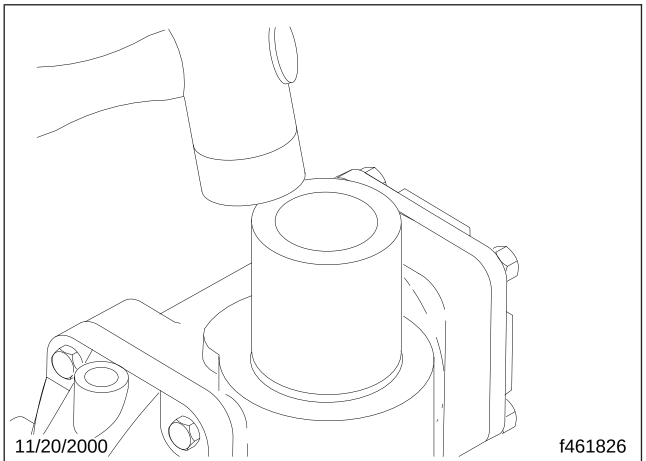


Fig. 3, Installing the Excluder Seal

16. Fill the system with steering fluid. Start the engine. Check the fluid level in the power steering reservoir and add more fluid if necessary.
17. Return the hood to the operating position.
18. Remove the chocks from the tires.

Adjustment

The only circumstances in which the automatic relief plungers require adjusting are when the tire size is changed, the wheel cut is reduced, or a replacement steering gear is installed. Do not adjust the automatic relief plungers under any other circumstances.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.

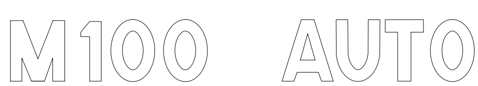


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Fig. 1, Automatic Relief Plunger Identifier

4. Remove the plastic caps from both plunger bosses.

CAUTION

Make sure there are no sharp edges on the punch that could damage the bore. Take care when using the punch to ensure that the relief plunger bore is not damaged. If the relief plunger bore is damaged, a leak may occur.

5. Using a 1/4-inch punch and ball peen hammer, carefully drive the relief plunger in until it bottoms in the bore. Repeat this procedure for the other relief plunger.
6. Replace the plastic caps.
7. Set the automatic relief plungers. For instructions, see **Subject 140**.
8. Return the hood to the operating position.
9. Remove the chocks from the tires.

Setting the Automatic Relief Plunger

The only circumstances in which the automatic relief plungers need to be set are when the tire size is changed, the wheel cut is extended, or a replacement steering gear is installed. Do not set the automatic relief plungers under any other circumstances.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.

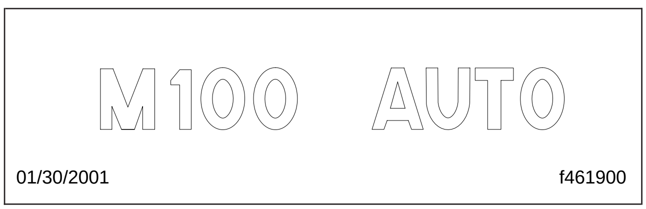


Fig. 1, Automatic Relief Plunger Identifier

4. Using a jack, raise the vehicle until the front wheels are off the ground.

NOTE: Check that the axle stops are set correctly before setting the relief plungers. For instructions on checking the axle stop adjustment, see **Section 46.11, Subject 300**.

5. Start the engine and turn the tires to a full-lock position in both directions. With the tires off the ground, the automatic relief plungers will be set to the correct position when the spindle contacts the axle stop.

NOTE: As the tires reach the end of travel, you will feel the piston contact the relief plunger. Continue turning the tires until the spindle reaches the axle stop bolt.

6. Return the tires to the straight-ahead position.
7. Lower the vehicle until the tires contact the ground. Remove the jack.
8. Shut off the engine.
9. Return the hood to the operating position.
10. Remove the chocks from the tires.

Automatic Relief Plunger Repair Procedure

There is a relief plunger in the cylinder head and one in the bearing cap. Follow the appropriate set of procedures for the relief plunger you are repairing.

Repair Procedure for the Cylinder Head Automatic Relief Plunger

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Remove the steering driveline. For instructions, see **Section 46.04**, Subject 100.
4. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.

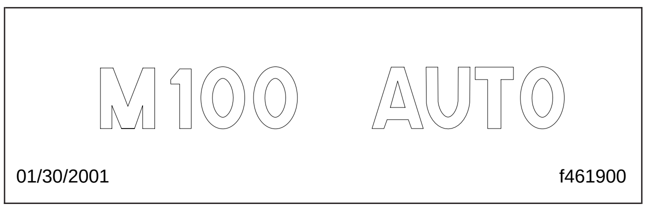


Fig. 1, Automatic Relief Plunger Identifier

5. Place a drain pan under the steering gear.
6. Mark the cylinder head and the steering gear housing for later reference during installation. Remove the capscrews that attach the cylinder head to the housing. Remove the cylinder head.
7. Remove the plastic cap from the plunger boss.

CAUTION

When driving the relief plunger assembly, do not allow the 1/4-inch punch to contact the bore and do not hit the plunger with excessive force. Failure to follow these directions could result in damage to the steering gear or relief plunger assembly.

8. Place the cylinder head in a vise. Using a 1/4-inch punch and hammer, carefully drive the relief plunger assembly in until it bottoms in the bore.

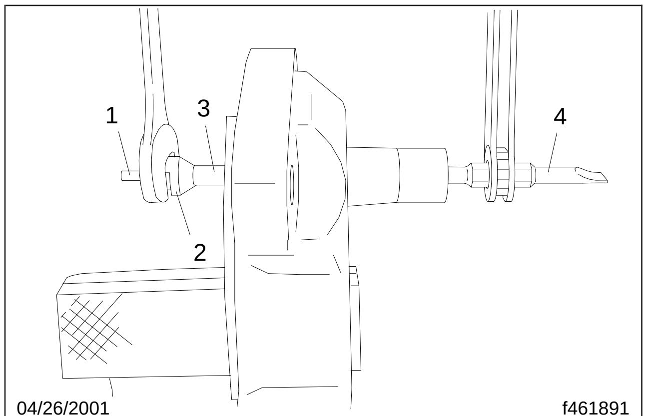
   The spring pin, flange, and plunger body should be accessible for repair at this point.

CAUTION

Do not allow the screwdriver bit to slip off the plunger body. Damage to the bore could result.

NOTE: The relief plunger flange is held in place with patch lock and the threads are staked at the factory. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to remove the flange.

9. Carefully insert a screwdriver bit into the plunger bore to hold the slotted head of the relief plunger body in place. Using an open-end wrench to hold the flange in place, carefully turn the flange to remove the flange from the plunger body. See **Fig. 2**. Discard the flange.



1. Plunger Body
2. Flange Nut
3. Spring Pin
4. Screwdriver Bit

Fig. 2, Remove the Flange

10. Remove the plunger body from the spring pin and discard the plunger body. It may be necessary to tap the plunger body to remove it from the spring pin. Use of a 1/8-inch pin punch is recommended.

IMPORTANT: Check the plunger bore for nicks or gouges before installing the plunger assembly. Be careful not to introduce dirt or contaminants in the plunger bore when reassembling.

11. Coat the O-ring on the new plunger assembly with a light coat of grease. Install the plunger body through the spring pin. See **Fig. 3**.

Automatic Relief Plunger Repair Procedure

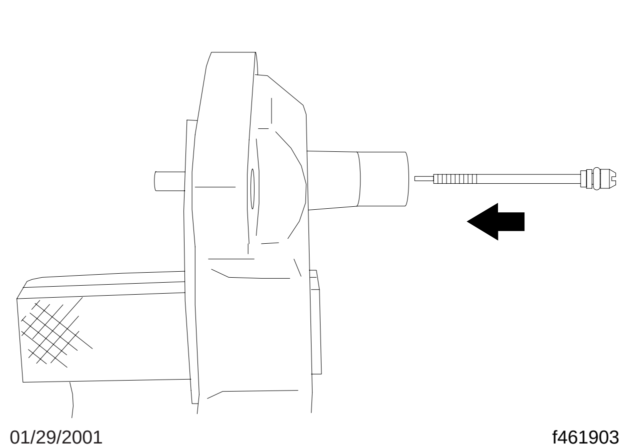


Fig. 3, Install the Plunger Body

NOTE: The plunger body has patch lock on the threads. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to overcome the patch lock.

12. Use a screwdriver bit and ratchet to hold the plunger body in place. Using an open-end wrench, install the flange on the plunger body until the flange contacts the spring pin.

WARNING

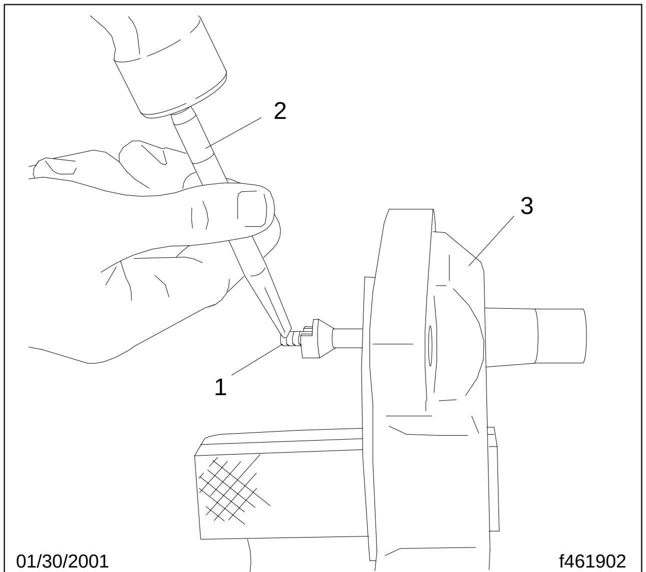
The flange must contact the spring pin. If it does not, a leak or steering gear damage may result. This could cause steering failure, possibly resulting in personal injury or property damage.

WARNING

Use extreme caution when staking the threads of the plunger body. Hitting the threads too hard could bend the plunger, which could cause steering failure, possibly resulting in personal injury or property damage.

13. With the flange against the spring pin, use a center punch to stake the threads of the plunger body. See **Fig. 4**. Be careful not to bend the plunger when staking the threads.

14. Align the marks on the cylinder head with the marks on the steering gear housing and install the cylinder head on the housing using the cylinder head capscrews. Tighten the capscrews 114 to 124 lbf·ft (154 to 168 N·m).



1. Plunger Body
2. Center Punch
3. Cylinder Head

Fig. 4, Stake the Threads

15. Install the plastic cap on the plunger boss.
16. Install the steering driveline. For instructions, see **Section 46.04**, Subject 100.
17. Fill the power steering reservoir with an approved fluid.
18. Start the engine. Check the fluid level in the power steering reservoir and add more fluid if necessary. Check for leaks.
19. Set the automatic relief plunger. For instructions, see **Subject 140**.
20. Remove the drain pan.
21. Return the hood to the operating position.
22. Remove the chocks from the tires.

Repair Procedure for the Bearing Cap Automatic Relief Plunger

1. Turn off the engine, apply the parking brakes, and chock the tires.

Automatic Relief Plunger Repair Procedure

2. Open the hood.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger boss.
4. Place a drain pan under the steering gear.
5. Mark the bearing cap and steering gear housing for reassembly.
6. Disconnect the steering driveline from the steering gear input shaft. For instructions, see **Subject 100**.
7. Remove the plastic cap from the plunger boss.

CAUTION

When driving the relief plunger assembly, do not allow the 1/4-inch punch to contact the bore and do not hit the plunger with excessive force. Failure to follow these directions could result in damage to the steering gear or relief plunger assembly.

8. Using a 1/4-inch punch and hammer, carefully drive the relief plunger assembly in until it bottoms in the bore.
9. Remove the four capscrews that attach the bearing cap to the steering gear housing.

CAUTION

Do not force the input shaft when turning it out of the housing. The shaft could bind and steering gear damage could result.

10. Separate the bearing cap assembly from the housing by turning the input shaft out of the housing. Turn the shaft until it stops.

CAUTION

Do not allow the screwdriver bit to slip off the plunger body. Damage to the bore could result.

NOTE: The relief plunger flange is held in place with patch lock and the threads are staked at the factory. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to remove the flange.

11. Carefully insert a screwdriver bit into the plunger bore to hold the slotted head of the relief plunger body in place. Using an open-end wrench to hold the flange in place, carefully turn the flange to remove the flange from the plunger body. See **Fig. 5**. Discard the flange.

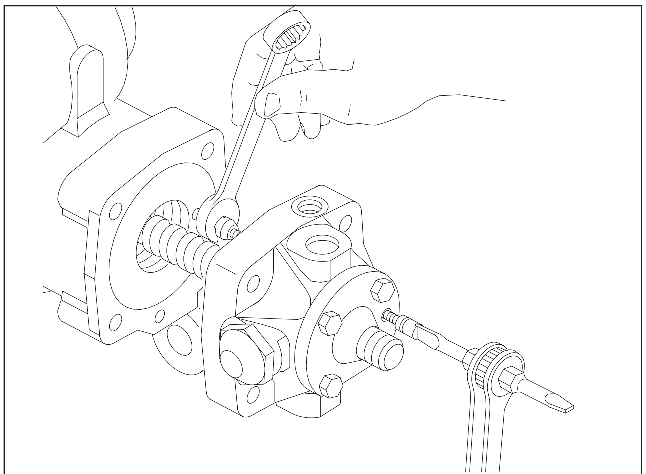


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Fig. 5, Remove the Flange

12. Remove the plunger body from the spring pin and discard the plunger body. It may be necessary to tap the plunger body to remove it from the spring pin. Use of a 1/8-inch pin punch is recommended.

IMPORTANT: Check the plunger bore for nicks or gouges before installing the plunger assembly. Be careful not to introduce dirt or contaminants in the plunger bore when reassembling.

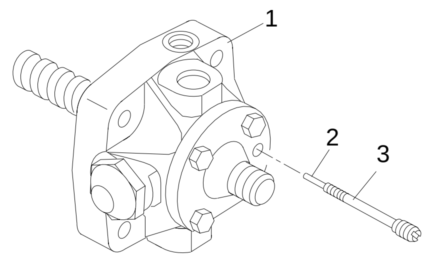
13. Coat the O-ring on the new plunger assembly with a light coat of grease. Install the plunger body through the spring pin. See **Fig. 6**.

WARNING

The flange must contact the spring pin. If it does not, a leak or steering gear damage may result. This could cause steering failure, possibly resulting in personal injury or property damage.

NOTE: The plunger body has patch lock on the threads. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to overcome the patch lock.

Automatic Relief Plunger Repair Procedure



1. Bearing Cap
2. Plunger Body
3. Spring Pin

Fig. 6, Install the Plunger Body

14. Use a screwdriver bit and ratchet to hold the plunger body in place. Using an open-end wrench, install the flange on the plunger body until the flange contacts the spring pin.

WARNING

Use extreme caution when staking the threads of the plunger body. Hitting the threads too hard could bend the plunger, which could cause steering failure, possibly resulting in personal injury or property damage.

15. With the flange against the spring pin, use a center punch to stake the threads of the plunger body. See **Fig. 4**. Be careful not to bend the plunger when staking the threads.
16. Align the marks on the bearing cap with the marks on the steering gear housing and install the bearing cap on the housing using the bearing cap capscrews. Tighten the capscrews 114 to 140 lbf·ft (154 to 190 N·m).
17. Install the plastic cap on the plunger boss.
18. Connect the steering driveline to the steering gear input shaft. For instructions, see **Subject 100**.
19. Fill the power steering reservoir with an approved fluid.
20. Start the engine. Check the fluid level in the power steering reservoir and add more fluid if necessary. Check for leaks.
21. Set the automatic relief plunger. For instructions, see **Subject 140**.
22. Remove the drain pan.
23. Return the hood to the operating position.
24. Remove the chocks from the tires.

Removal

NOTE: This procedure is for removing the pitman arm from the steering gear. If replacement of the pitman is required, the pitman arm must also be removed from the drag link.

Special Tool: A Sheppard pitman arm puller, Kent-Moore part number ZTSE4439, or a three-jaw puller will be required to remove the pitman arm.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.

DANGER

Do not use a hammer or apply heat to the pitman arm to remove it. Doing so could damage the sector shaft, the pitman arm, or the seals and possibly lead to loss of vehicle control resulting in death or serious personal injury.

IMPORTANT: Do not bend the aligning tabs out of the pitman arm.

3. Using a punch, bend the retaining tabs out of the pitman arm retainer.
4. Lubricate the face of the retainer with clean chassis lube.

IMPORTANT: Failure to lubricate the face of the retainer will cause difficulty in removing the pitman arm.

5. Disconnect the pitman arm from the steering gear.
   - 5.1 Slide the pitman arm puller over the pitman arm. Align the hole in the puller with the Allen socket in the retainer.
   - 5.2 Insert the Allen drive socket through the puller and into the retainer socket. Use an impact wrench to back off the retainer. The retainer will act as a jack screw to disconnect the pitman arm from the steering gear.

Installation

Proper installation of the pitman arm is critical to the safe operation of the vehicle. Correct torque values are very important. Always follow these procedures when installing a pitman arm.

WARNING

If the pitman arm is not installed to the proper specifications, it can come loose causing an accident which could result in death or severe personal injury.

1. Align the timing marks on the pitman arm with the timing marks on the sector shaft and install the pitman arm on the sector shaft. The timing marks will appear like those in **Fig. 1** or **Fig. 2**.

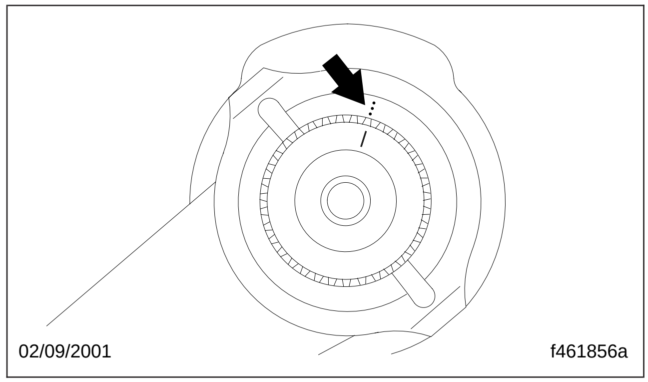


Fig. 1, Align the Timing Marks

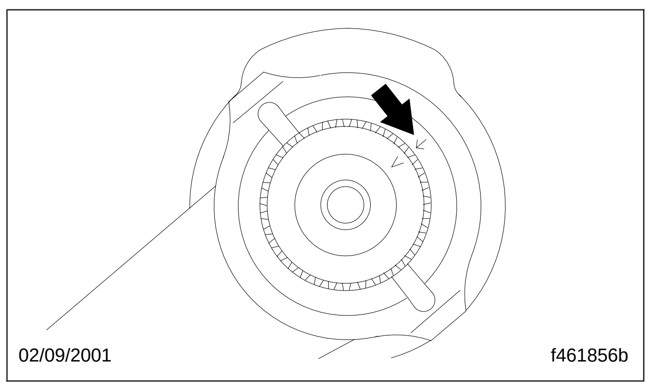


Fig. 2, Align the Timing Marks

2. Install the pitman arm retainer on the sector shaft. Be sure to align the tabs in the notches of the pitman arm. Coat the threads of the retainer with antiseize compound. A coating of antiseize should be applied to both sides of the friction washer if a new retainer is being used.
3. Torque the retainer 350 lbf·ft (475 N·m).

Pitman Arm Removal and Installation

WARNING

Do not back off the torque value to align the tabs. If the pitman arm is not installed to the proper specifications, it can come loose causing an accident which could result in death or severe personal injury.

4. Continue torquing the retainer past the specified value until two of the notches in the retainer align with the tabs of the washer.

WARNING

Once the retainer is torqued to specifications and locked in place, do not retorque the retainer. Constant torquing of the retainer may cause the pitman arm to come loose causing an accident which could result in death or severe personal injury.

5. Using a punch and hammer, bend the retaining tabs of the washer in to the notches on the retainer. See **Fig. 3**. Apply torque seal, OGP F900WHITE, to the tabs.

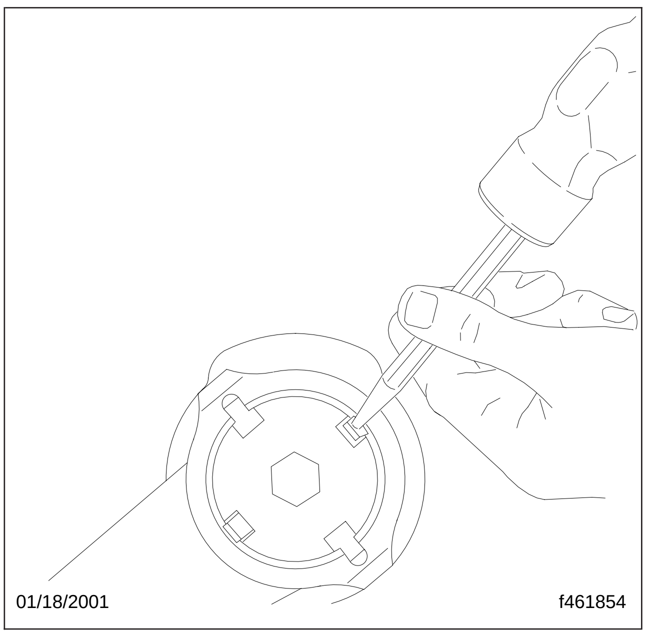


Fig. 3, Bend the Retaining Tabs

6. Reset the automatic relief plungers. For instructions, see **Subject 140**.
7. Lower the hood.
8. Remove the chocks from the tires.

Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

WARNING

Do the checks below. Failure to do these checks could result in damage to the power steering system and a loss of hydraulic assist. This could limit steering control, possibly resulting in personal injury or property damage.

1. Place a thermometer in the power steering reservoir. Warm the hydraulic system to a normal operating temperature of 150 to 160°F (66 to 71°C) by starting the engine and operating it at low idle while turning the steering wheel through several full-left and full-right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the oil level (a sign that air is trapped in the system). If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.

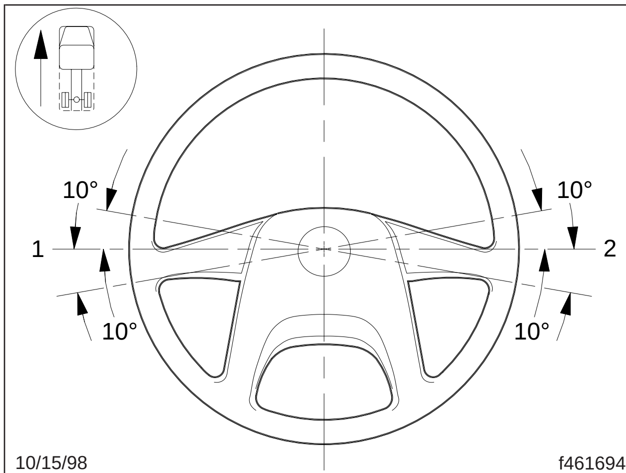
2. With the engine turned off and warm, check the power steering reservoir fluid level using the instructions in Group 46 in the *Columbia Maintenance Manual*.

3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 inch (19 mm). If clearance is less than the above, reset the axle stops.

4. Check that the relief plungers are set correctly. If needed, adjust them. For instructions on adjusting the automatic relief plungers, see **Subject 130**.

5. If there are still problems with the power steering system, refer to **Section 46.11, Subject 300** and perform the troubleshooting procedures. Otherwise go to the next step.

6. Test drive the vehicle or take a ride with the driver. Check the steering wheel spoke position. If during straight-ahead driving on a level road, the steering wheel spokes are not centered as shown in **Fig. 1**, remove the steering wheel and reposition it.

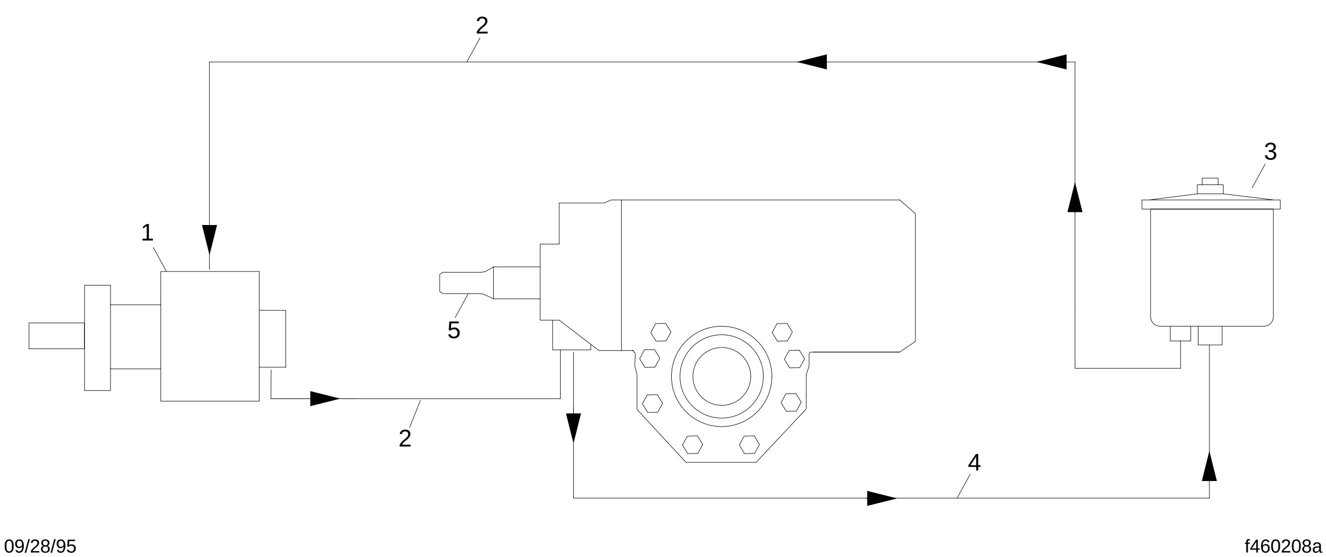


1. 9 o'Clock Position
1. 3 o'Clock Position

Fig. 1, Steering Wheel Centered

Specifications

See **Fig. 1** for a plumbing diagram of the power steering system.



1. Power Steering Pump
2. Supply Line
3. Power Steering Reservoir
4. Return Line
5. Power Steering Gear

Fig. 1, Plumbing Diagram of the Power Steering System

General Description

The TRW PS Series power steering pump supplies power steering fluid for the operation of the power steering gear. The main parts of the power steering pump are the housing, input shaft, cam ring, rotor, vanes, control valve, and cover assembly.

Principles of Operation

The input shaft, powered by the adaptor gear in the engine gear case or by the crankshaft pulley, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port and into the system. The fluid operates the steering gear. Eventually the fluid returns to the power steering reservoir, and then back to the power steering pump.

If the system pressure gets too high, a relief valve inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the relief valve seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.

Steering Pump Removal and Installation

Removal

1. Apply the parking brake, shut down the engine, chock the tires, and open the hood.
2. Clean all dirt from around the fittings and hose connections.
3. Place a container under the pump, then disconnect the hoses from the fittings on the pump. Plug the hoses and cap the fittings to keep out dirt and to prevent fluid from leaking.
4. Remove the pump.
   - 4.1 Remove the capscrews and washers that attach the pump to the engine accessory drive mounting flange. Hold the pump as you remove the second mounting bolt.
   - 4.2 Pull the pump straight out from the engine. Keep it level to avoid spilling fluid.
5. Turn the pump upside down over the container and let the fluid drain out.
6. Discard the gasket from the pump mounting flange.

Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. Install the pump.
   - 2.1 Install a new gasket on the pump mounting flange, then place the pump on the engine accessory drive mounting.
   - 2.2 Install the washers and capscrews, and tighten them 27 to 32 lbf·ft (37 to 43 N·m).
3. Connect the inlet hose from the power steering reservoir to the inlet port. Tighten it 26 lbf·ft (35 N·m).
4. Connect the outlet hose from the power steering gear to the outlet port.
5. Bleed the power steering system.
   - 5.1 Check the fluid level in the power steering reservoir. If necessary, fill it to the correct level.
   - 5.2 Start the engine and let it idle for several minutes.
   - 5.3 Turn the wheels to a full-left and full-right turn. Repeat this about three times.
   - 5.4 Check the fluid level in the power steering reservoir. Add fluid as necessary to the full line on the reservoir or dipstick.
   - 5.5 Shut down the engine.
6. Close the hood and remove the chocks from the tires.

Steering Pump Disassembly, Inspection, and Assembly

CAUTION

Be careful when working on the pump housing; it is aluminum and can be easily damaged. When putting the pump in a vise, pad the vise jaws and clamp only the cover. Tighten the vise just enough to hold the pump.

Disassembly

WARNING

Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury.

NOTE: Prepare for fluid drainage before disassembling the pump.

1. Remove the power steering pump from the engine. For instructions, see **Subject 100**.
2. Carefully remove the end plug from the pump housing. Remove the spring if it did not come out with the end plug. See **Fig.1** .
3. Remove and discard the O-ring from the plug.

IMPORTANT: TRW does not recommend disassembly of the control valve spool assembly.

4. Remove the control valve spool assembly by hand, or by pushing it with a small rod. Do not push on the small screen in the relief valve seat assembly.
5. Using a solvent-proof marker, make a mark across the housing and the cover. See **Fig.2**. Remove the screws and washers that hold the housing and the cover together. Using a twisting motion, separate the housing from the cover.
6. Remove the spring.
7. Using a solvent-proof marker, draw a line across the top plate and the bottom plate. See **Fig.3**.
8. Holding the cam ring in place, remove the top plate. Remove and discard the O-ring and backup O-ring.
9. Holding the bottom plate in place, remove the cam ring. Note and record whether the dots near the locating pin holes on the cam ring are up or down. See **Fig.4**.
10. Look for wear on the outside edge of the vanes. Note and record the direction of the wear for assembly. Carefully remove the rotor and vanes, as the vanes will slip from their slots in the rotor.
11. Remove the locating pins. Make marks on the outside of the cover (not on the sealing surface) to note from which holes the locating pins were removed.
12. Remove the bottom plate.
13. Turn the cover over and remove the large retaining ring.
14. Press out the input shaft and ball bearing assembly.
15. Remove the spacer from the cover.
16. Using care not to damage the bore, remove the shaft seal.

Inspection

1. Clean all the parts, using a solvent compatible with the power steering fluid. Then, using filtered compressed air, dry all the parts.

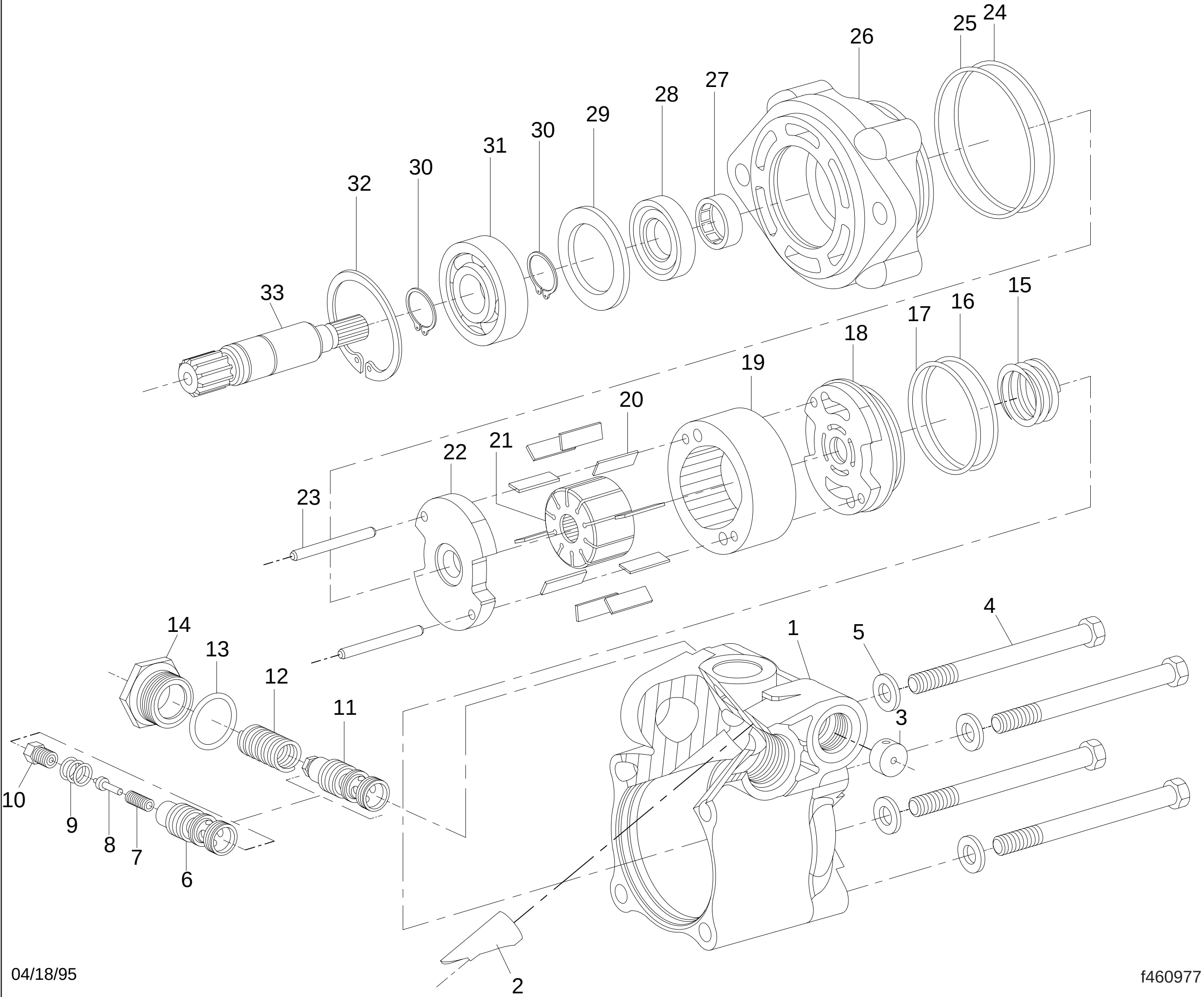
NOTE: Replace any parts that are damaged or worn.

2. Inspect the housing for cracks, stripped threads, a damaged valve bore, and damaged sealing areas. See **Fig.5**.
3. Inspect the cover for nicks in the O-ring seal grooves. Make sure that the seal drain hole is open, and that the seal bore is free of nicks and other damage. See **Fig.6**.

   Make sure that the surface on which the bottom plate rests is flat and free of nicks and other damage.
4. Check that the needles roll freely in the needle bearing. If needed, replace the needle bearing as follows.

   4.1 Place the cover in a press with the flange side down. Using an 11/16-inch socket, press the needle bearing out of the cover.

Steering Pump Disassembly, Inspection, and Assembly



1. Pump Housing
2. Boost Tube
3. Orifice
4. Capscrew
5. Washer
6. Spool
7. Spring
8. Poppet
9. Shims
10. Relief Valve Seat Assembly
11. Control Valve Spool Assembly
12. Spring
13. O-Ring
14. End Plug
15. Spring
16. O-Ring
17. Backup O-Ring
18. Top Plate
19. Cam Ring
20. Vane
21. Rotor
22. Bottom Plate
23. Locating Pin
24. Small O-Ring
25. Large O-Ring
26. Cover
27. Needle Bearing
28. Shaft Seal
29. Spacer
30. Small Retaining Ring
31. Ball Bearing
32. Large Retaining Ring
33. Input Shaft

Fig. 1, Power Steering Pump

Steering Pump Disassembly, Inspection, and Assembly

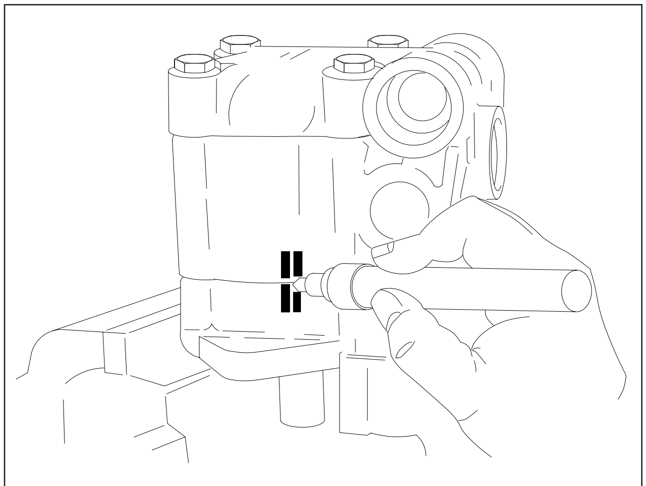


Fig. 2, Mark the Housing and the Cover

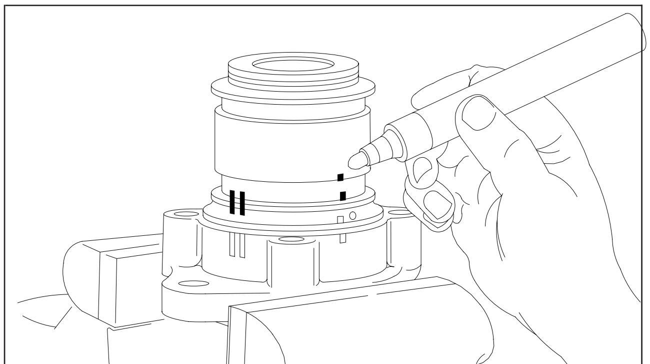


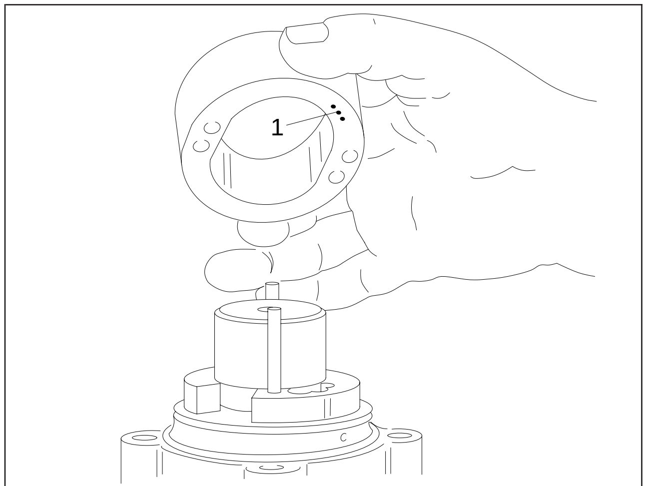
Fig. 3, Mark the Top Plate and the Bottom Plate

CAUTION

Make sure that the press is clean and free of debris. Debris could damage the face of the cover, which will affect pump operation.

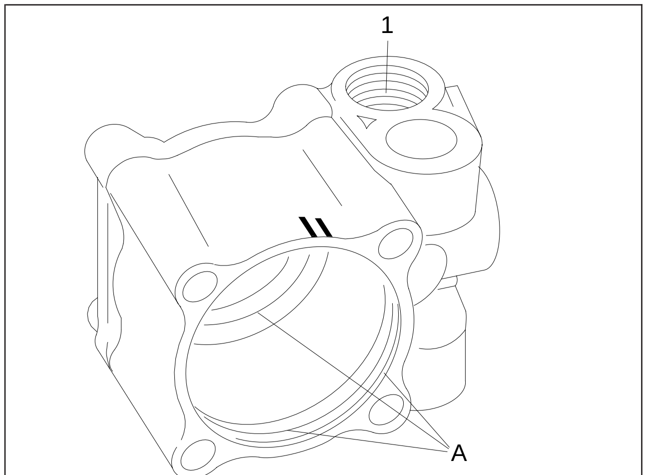
4.2 Put the cover in a clean press with the flange side up. Make sure that the lettered side of the needle bearing is facing toward the press.

4.3 Using a 7/8-inch deep socket, press the new needle bearing into the cover until it is flush with the inside surface of the cover.



1. Dots

Fig. 4, Check if the Dots are Up or Down

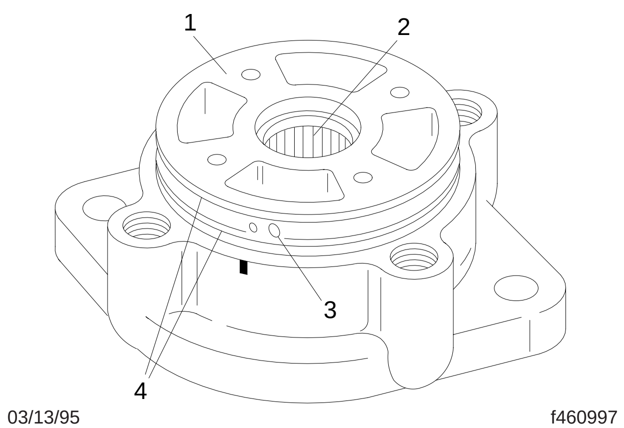


A. Sealing Areas
1. Valve Bore

Fig. 5, Inspect the Housing

5. Inspect the top plate for seal area nicks, and abnormal wear or erosion. A polished pattern from the rotor and vanes is normal. Grooves you can feel with your fingernail are not normal.
6. Look for abnormal wear, erosion, or surface damage on the inside of the cam ring.
7. Check the vanes on the rotor for damage or for too much play in the rotor slots. If you can move

Steering Pump Disassembly, Inspection, and Assembly



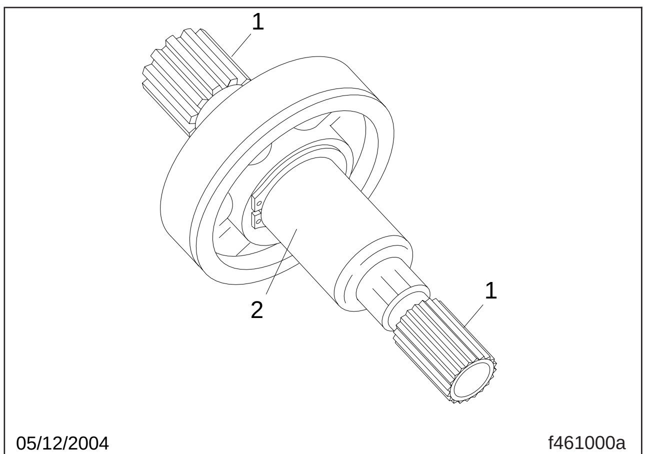
1. Bottom Plate Surface
2. Needle Bearing
3. Seal Drain Hole
4. Seal Grooves

Fig. 6, Inspect the Cover

the vanes from side to side in the slots, replace the whole rotor assembly.

NOTE: If the vanes are removed, make sure that they are installed with the rounded edge out.

8. Check the bottom plate for abnormal wear patterns.
9. Check the input shaft for damaged splines and abnormal wear grooves around the seal area. See Fig.7. Replace the input shaft as follows if there are grooves that can be detected with your fingernail.



1. Splines
2. Shaft Seal Area

Fig. 7, Check the Input Shaft

9.1 Remove the retaining ring (engine drive end) from the shaft.

Remove the Woodruff key, if so equipped.

9.2 Applying pressure to the engine drive end of the input shaft, press the input shaft from the ball bearing.

9.3 Press the new input shaft (from the small splined end) into the ball bearing until the shaft bottoms out on the retaining ring.

9.4 Install the retaining ring on the input shaft with the sheared edge pointing away from the bearing. Make sure that the retaining ring is properly seated.

IMPORTANT: TRW does not recommend disassembly of the control valve spool assembly.

10. Check the control valve spool assembly for wear or chipping. If needed, back flush with air and solvent. Check the assembly for nicks or burrs.

Assembly

CAUTION

Make sure that the press is clean and free of debris. Debris could damage the face of the cover, which will affect pump operation.

1. Coat the outside surface of the shaft seal with a petroleum-based chassis grease. With the lettered side facing toward the needle bearing, press the seal into the cover. The installed seal should be flush with, or just below, the sealing surface on the cover.
2. Grease the inside surface of the shaft seal using a petroleum-based chassis grease.
3. Install the spacer. Make sure that it lies flat.

CAUTION

Do not allow the splines to contact the shaft seal. The splines could damage the shaft seal.

4. Insert the input shaft (small splined end first) into the cover. Do not allow the splines to contact the shaft seal. Insert the shaft into the seal by hand until the ball bearing contacts the cover.

Steering Pump Disassembly, Inspection, and Assembly

Using a 7/8-inch socket, press the shaft and bearing into the cover.

CAUTION

When placing the cover in a padded vise, do not use excessive clamping force. This could damage the cover.

5. Place the cover in a padded vise and install the large retaining ring with the sheared edge out.

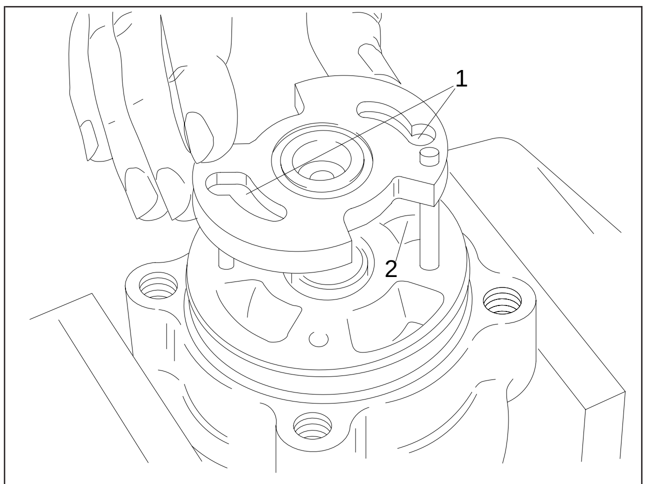
   Turn the cover assembly over.

6. Install the new large and small O-rings in the cover. Make sure that they are seated properly.

7. Using the marks made during disassembly as a guide, install the locating pins.

IMPORTANT: In one of the four cutouts in the cover there is a bar. When installed, the bottom plate must cover this bar.

8. Install the bottom plate with the pockets facing up. See Fig.8. Make sure that the marks made during disassembly are aligned.



1. Pockets 2. Bar

Fig. 8, Install the Bottom Plate

9. Install the cam ring with the dots facing up or down as noted during disassembly. Make sure that the cam ring is flush with the large outside diameter of the bottom plate, and that the marks made during disassembly are aligned. See Fig.9.

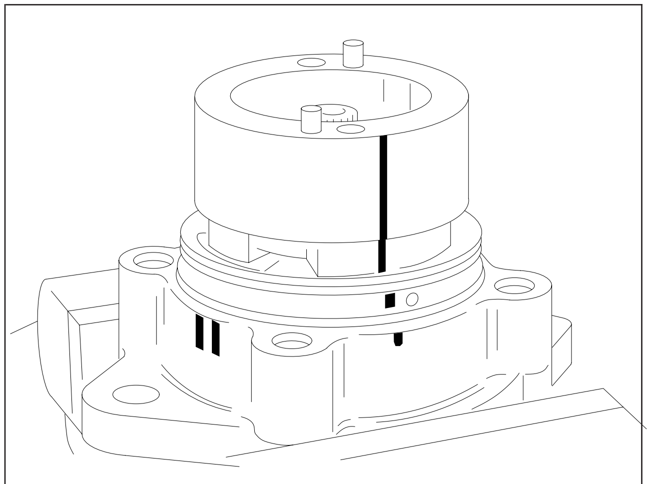


Fig. 9, Install the Cam Ring

10. Install the rotor and vanes. Make sure that the squared edge on each vane points toward the center of the rotor.

11. Install the top plate with the pin holes down. Make sure that the locating pins are engaged in the pin holes, not in the pockets.

    Make sure that the top plate is flush with the cam, and that the marks made during disassembly are aligned.

NOTE: The backup O-ring will fit tighter on the top plate after loosely wrapping (no twisting) it around two fingers, then allowing it to unwrap.

12. Install the backup O-ring on the top plate. Seat the O-ring at the bottom of the groove.

13. Install a new O-ring (without allowing it to roll) on the top plate. Seat the O-ring at the top of the groove.

14. Grease both the O-ring and the backup O-ring.

CAUTION

The housing may have sharp edges. Use care to not cut your finger when applying grease to the housing.

15. Grease the sealing areas of the housing. See Fig.10.

16. Place the spring on the top plate.

Steering Pump Disassembly, Inspection, and Assembly

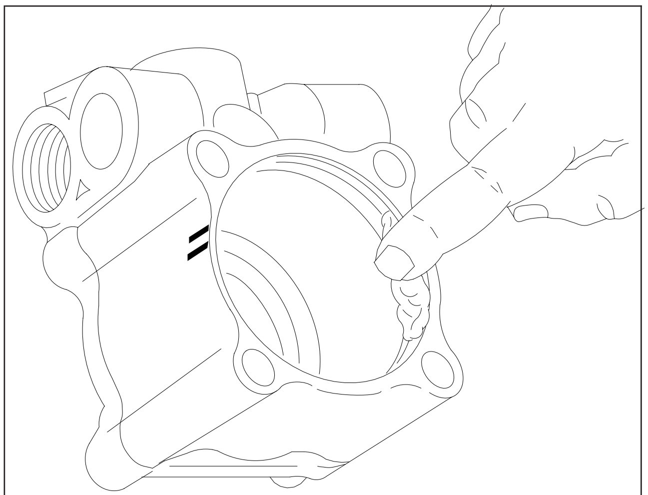


Fig. 10, Grease the Sealing Areas

17. Place the housing over the cover assembly. Make sure that the marks made during disassembly are aligned.

CAUTION

Evenly thread the capscrews into the cover. If not evenly threaded into the cover, damage could occur to the seals, top plate, or housing.

18. Install the capscrews and washers. Evenly thread the capscrews into the cover. Alternately tighten the capscrews 30 lbf·ft (41 N·m).
19. Screw the relief valve seat assembly into the control valve spool assembly. Tighten the assembly 87 lbf·in (982 N·cm).

NOTE: Placing the spool assembly in a collet will assist the tightening procedure.

20. Insert the valve spool assembly (screen end last) into the housing. Make sure that the spool slides freely in the housing.
21. Install the spring in the housing.
22. Install a new O-ring on the end plug.
23. Lightly grease the O-ring and the end plug threads. Install the end plug and tighten 30 lbf·ft (41 N·m).
24. Install the Woodruff key into the new input shaft if it was removed during the input shaft replacement.
25. Turn the pump by hand and make sure that it turns freely.
26. Install the power steering pump on the engine. For instructions, see **Subject 100**.

Specifications

Approved Power Steering Fluids		
Fluid Type	**Approved Fluid**	
Automatic Transmission Fluid *	Dexron® II	
	Dexron® III	
Heavy-Duty Engine Oil *	Union	10W–40
IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002.	Texaco	10W–40
	Chevron	10W–40
	Mobil Super	10W–40
	Union	15W–40
	Unocal	15W–40
	Shell Rotella T	30W

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is used in the power steering system.

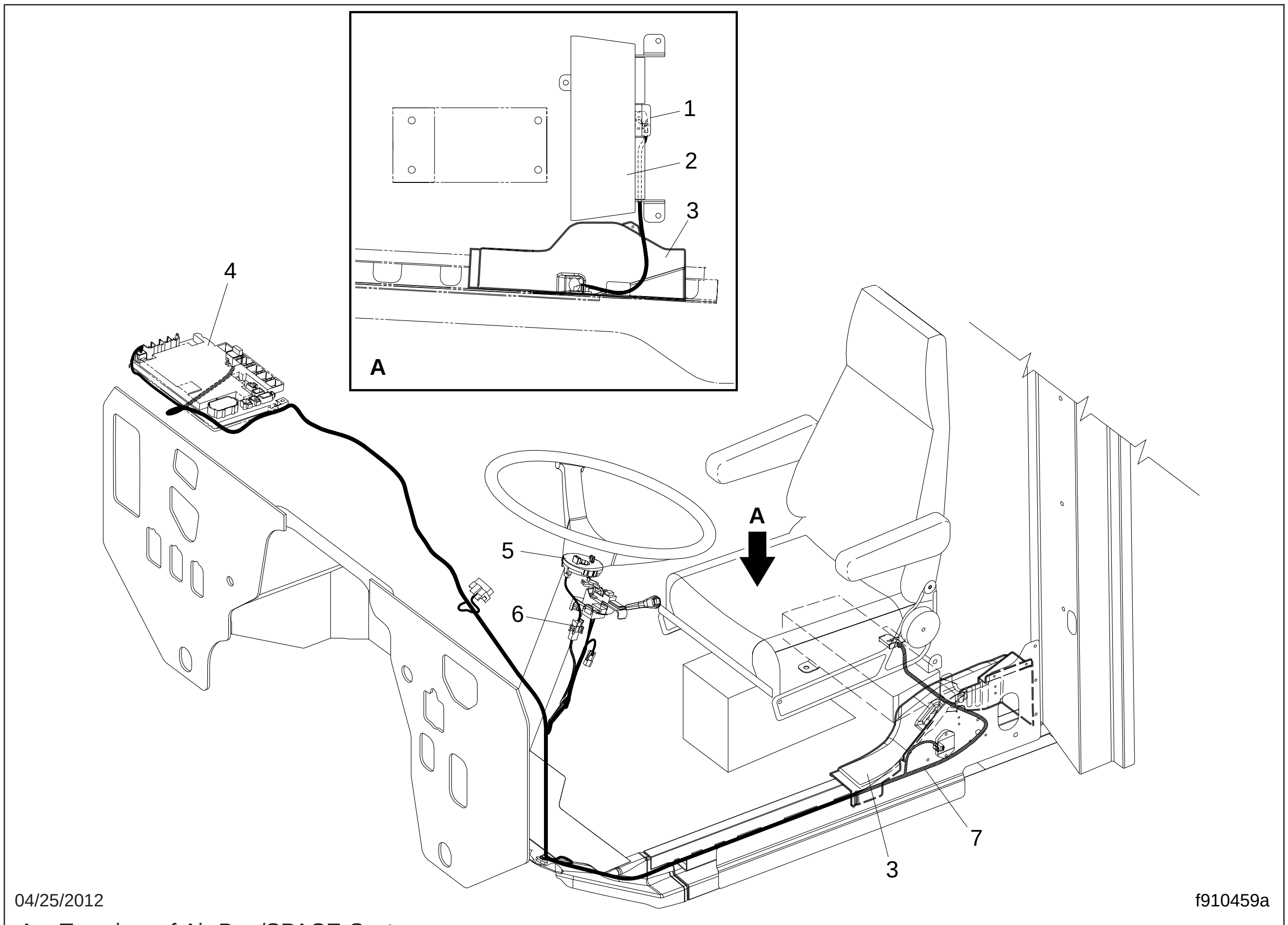
Table 1, Approved Power Steering Fluids

General Information

NOTE: A new air bag system became available on May 12, 2000. This system is different from the air bag system installed prior to May 12, 2000. In this section, only the newer air bag system installed from May 12, 2000 is covered.

To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag system installed prior to May 12, 2000 has a SPACE module; see **Fig. 1**. The air bag system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat; see **Fig. 2**.

The air bag system, when used with seat belts, provides additional protection to the driver in severe

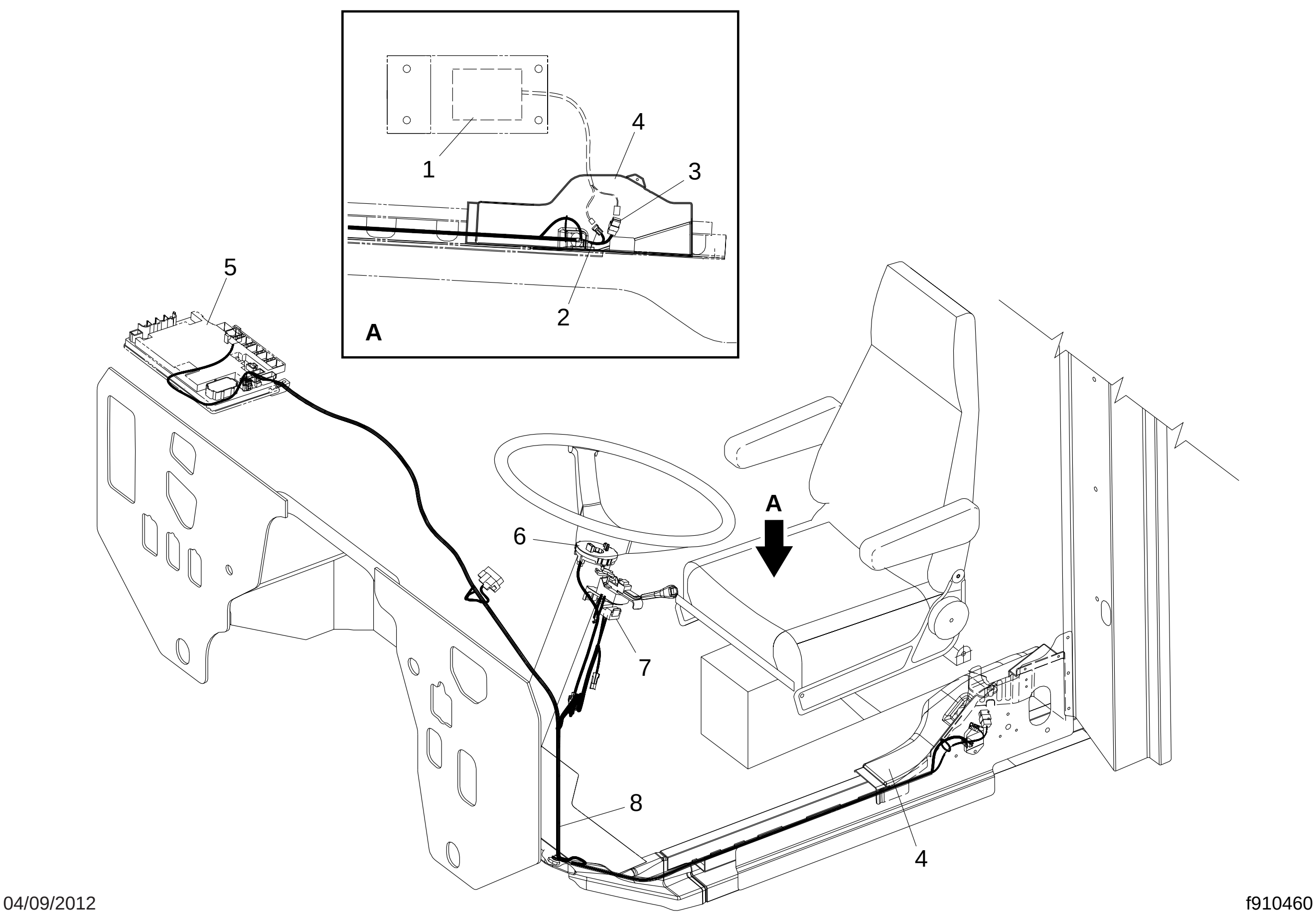


A. Top view of Air Bag/SPACE System.

1. Driver-Side SPACE (DSS) Connector
2. Driver-Side SPACE Module
3. B-Pillar Cover
4. Power Distribution Module
5. Clockspring
6. Supplemental Restraint System (SRS) Connector
7. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag Systems Installed Prior to May 12, 2000

General Information



A. Top view of air bag sensor module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Systems Installed From May 12, 2000

frontal collisions. The air bag is located in the steering wheel hub.

WARNING

Damaged seat belts or seat belts that were worn in an accident must be replaced and their anchoring points must be checked. Failure to do so may result in personal injury or death.

The operational readiness of the air bag system is indicated by a supplemental restraint system (SRS) indicator on the dash. The SRS indicator comes on when starting the engine and then goes off. The indicator will remain on if there is a problem with the system. The vehicle should be serviced if the indicator does not come on or if it remains on.

Replacement

NOTE: A new air bag system became available on May 12, 2000. This system is different from the air bag system installed prior to May 12, 2000. In this section, only the newer air bag system installed from May 12, 2000 will be covered.

WARNING

Before performing any work on the air bag system, review all service literature and comply with all warnings and precautions in this subject and in Subject 110. Unintentional or improper air bag deployment can result in injury or death.

Damaged or deployed air bag systems should be inspected for leaking propellant chemicals before any attempt is made to remove, replace, or handle the components. If a leak is found, contact LifeGuard Technologies (1-866-765-5835) for handling instructions.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the batteries and wait two minutes before proceeding.

WARNING

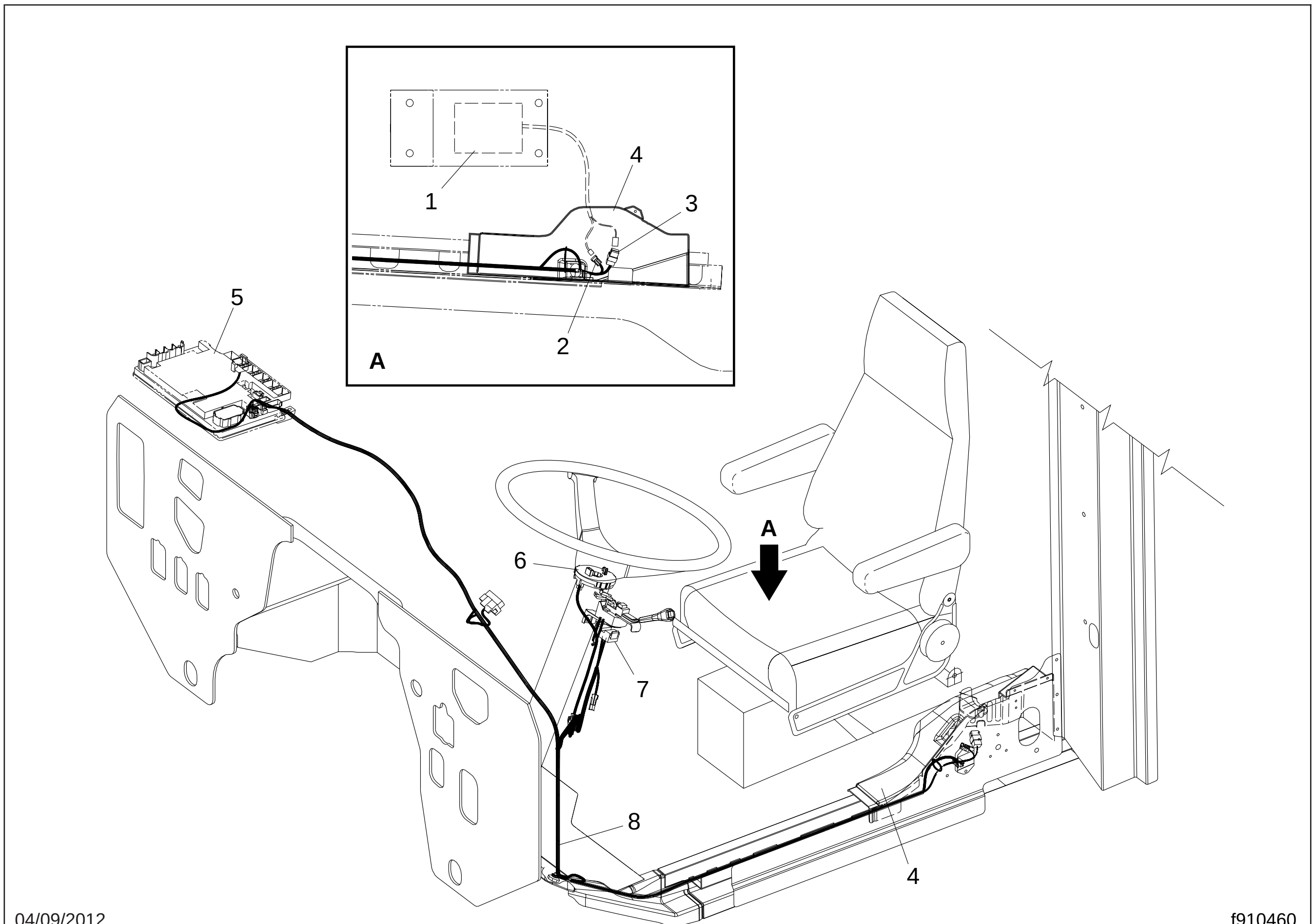
Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

3. Disconnect the AS2 connector under the B pillar cover; see **Fig. 1**.
4. Remove the fastener cover plugs from the steering wheel lower column cover; see **Fig. 2**.
5. Using a T25 Torx® driver, remove the fasteners and the column cover.
6. Using a T30 Torx driver, loosen the retainer screws underneath the steering wheel; see **Fig. 3**.
7. Carefully lift the air bag from the steering wheel and disconnect the air bag connector and the horn switch connector, if equipped, from the air bag; see **Fig. 4**, **Fig. 5**, and **Fig. 6**.
8. Remove the air bag.
9. Inspect the clockspring and clockspring connector. Replace the clockspring if there is any melting or damage. For clockspring replacement instructions, see **Subject 120**.
10. Connect the horn switch connector, if equipped, and the electrical wiring from the clockspring to the new air bag module, then position the air bag module on the steering wheel.
11. Tighten the air bag retaining screws at the bottom of the steering wheel.
12. Using the fasteners, attach the steering wheel lower column cover to the dash.
13. Install the fastener plugs.
14. Connect the AS2 connector.
15. Make sure nobody is in the cab, then connect the batteries.
16. While standing outside the cab and away from the front of the air bag, turn the ignition on. The SRS indicator should come on for several seconds and then go out. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.

    Follow the appropriate procedure in **Troubleshooting 300**, if:

    - There are active fault codes;
    - The SRS indicator remains on;
    - The SRS indicator does not come on for several seconds before going out.

Air Bag Replacement

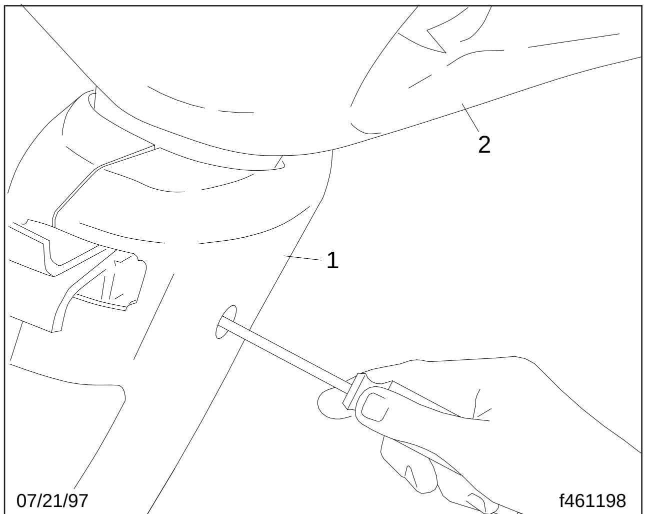


A. Top view of air bag sensor module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

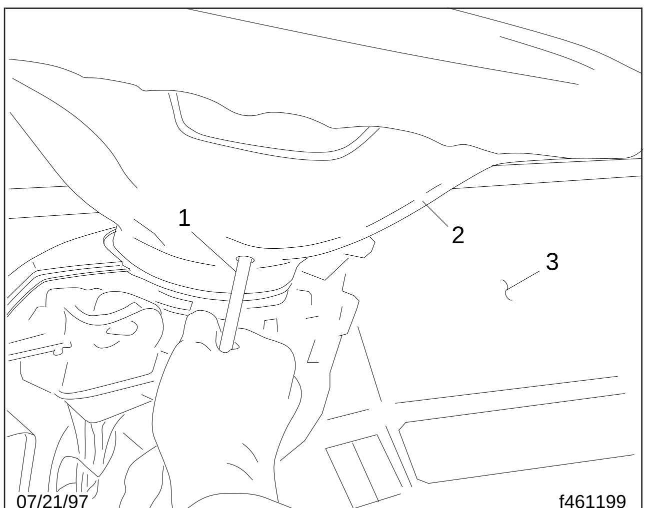
Fig. 1, Air Bag Harness Routing

Air Bag Replacement



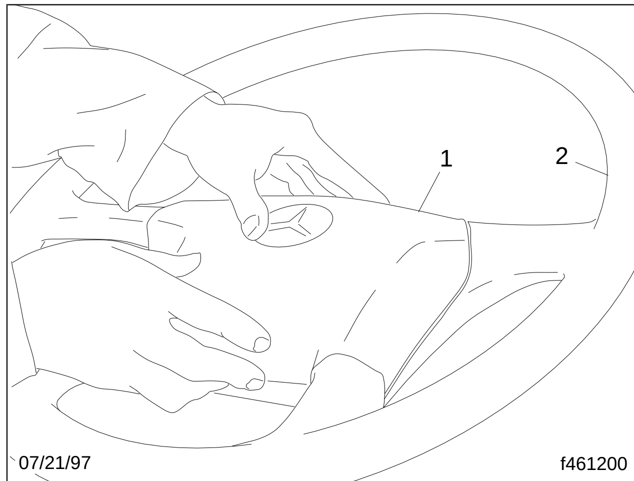
1. Steering Wheel Lower Column Cover
2. Steering Wheel

Fig. 2, Removing the Lower Column Cover



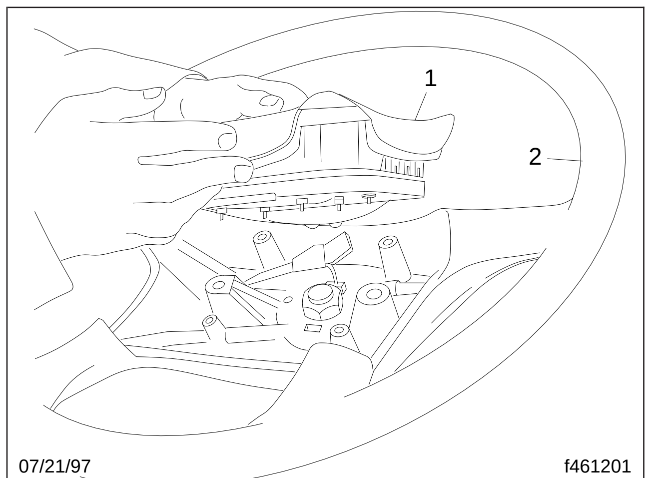
1. Screwdriver
2. Steering Wheel
3. B-Panel of Dash

Fig. 3, Loosening the Air Bag Retainer Screws



1. Air Bag Module
2. Steering Wheel

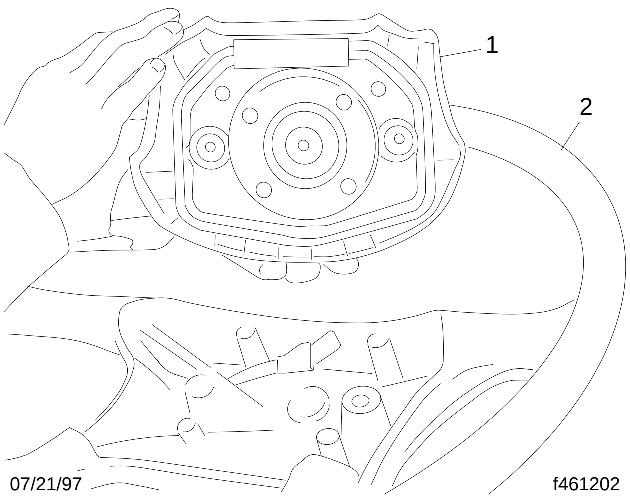
Fig. 4, Air Bag Module Installed



1. Air Bag Module
2. Steering Wheel

Fig. 5, Lifting the Air Bag Module

Air Bag Replacement



1. Air Bag Module Removed
2. Steering Wheel

Fig. 6, Air Bag Removed

Safety Guidelines for the Air Bag System

⚠ WARNING

The components and chemicals used in the air bag system are hazardous. The system contains components that use combustible chemicals; care must be taken when replacing or handling system components. Damaged or deployed air bag systems should be inspected for leaking propellant chemicals before any attempt is made to remove, replace, or handle the components. If a leak is found, contact LifeGuard Technologies (1-866-765-5835) for handling instructions.

The surface of the deployed air bag may contain small amounts of sodium hydroxide (which is a by-product of the gas generant combustion) and metallic sodium. Sodium hydroxide may be irritating to the skin and eyes. Always wear rubber gloves and safety glasses when handling a deployed air bag. Immediately wash your hands and exposed skin areas with water and a mild soap. Flush your eyes immediately if exposed to sodium hydroxide.

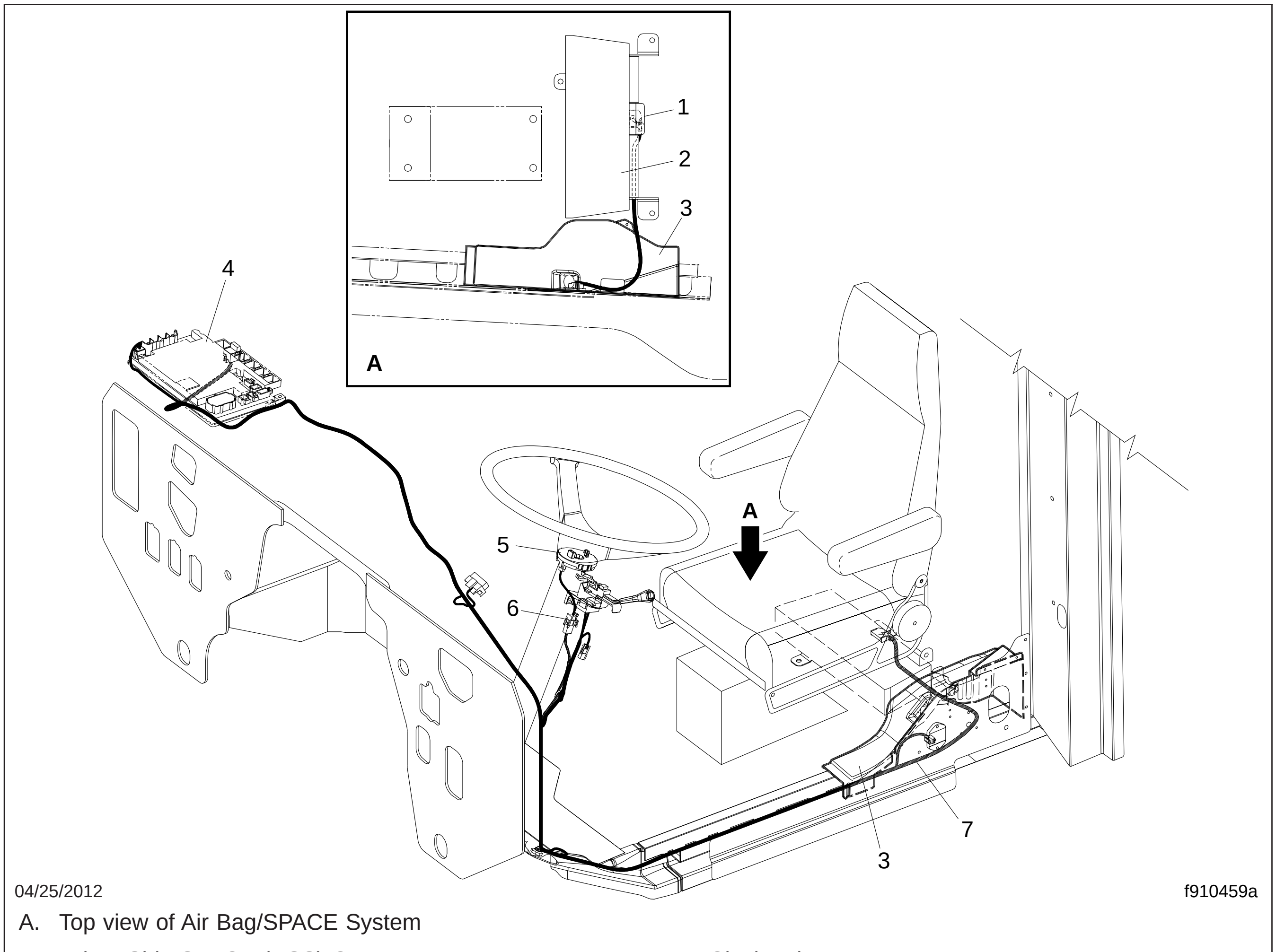
Consider undeployed air bags to be dangerous and capable of deploying at any time. Before performing any work on these systems, review all service literature and comply with the following warnings and precautions. Unintentional or improper deployment of the air bag system can result in injury or death.

- **Carry undeployed air bags with the bag and the trim cover pointed away from your body.**
- **Place undeployed air bags face up on a surface in an enclosed area.**
- **Do not place objects near or on top of an undeployed air bag.**
- **Store undeployed and undamaged air bag modules in a cool, dry, enclosed area.**
- **Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the air bag system. Do not allow system chemicals to contact other liquids, combustibles, and flammable materials. Doing so could cause chemical burns or personal injury.**
- **Do not attempt to disassemble the air bag inflator unit or breach the integrity of the sealed metallic inflator case.**
- **Do not cut, drill, braze, solder, weld, probe, or strike any part of the air bag system.**
- **Do not expose the air bag module to electricity. Never probe a circuit on the air bag side of a connector unless the harness or air bag is disconnected between the test point and the air bag.**
- **Do not attempt to adapt, reuse, or install an air bag system in any vehicle other than the specific vehicle for which it is designed.**
- **Do not cut wires or tamper with the connector between the vehicle wiring harness and the air bag module unless the troubleshooting diagnostics specifically direct you to do so. Cutting or removing the connector from the system will disable the safety shunt and could cause unintentional deployment.**
- **Allow deployed air bag systems to cool after deployment.**
- **Air bag systems should be deployed in an open area or outdoors to prevent accidental fires.**
- **Wear rubber gloves and safety glasses when handling a deployed air bag.**
- **Store, transport, dispose of, and recycle air bag system components in accordance with all applicable federal, state, and local regulations.**
- **When reactivating the system for the first time after repairs have been made, stand outside of the cab and away from the front of the air bag while turning on the ignition. Check that the SRS indicator comes on for a few seconds and then goes out. Make sure there are no active fault codes.**
- **Keep all heavy objects in the cab secured.**

Clockspring Replacement

NOTE: The following clockspring replacement procedure is for the air bag system that became available May 12, 2000.

To determine which type of supplemental protection system is installed in the vehicle, look at the module under the driver's seat. The air bag system installed prior to May 12, 2000 has a SPACE module. See **Fig. 1**. The air bag system that became available on May 12, 2000 has an air bag sensor module located under the driver's seat. See **Fig. 2**.

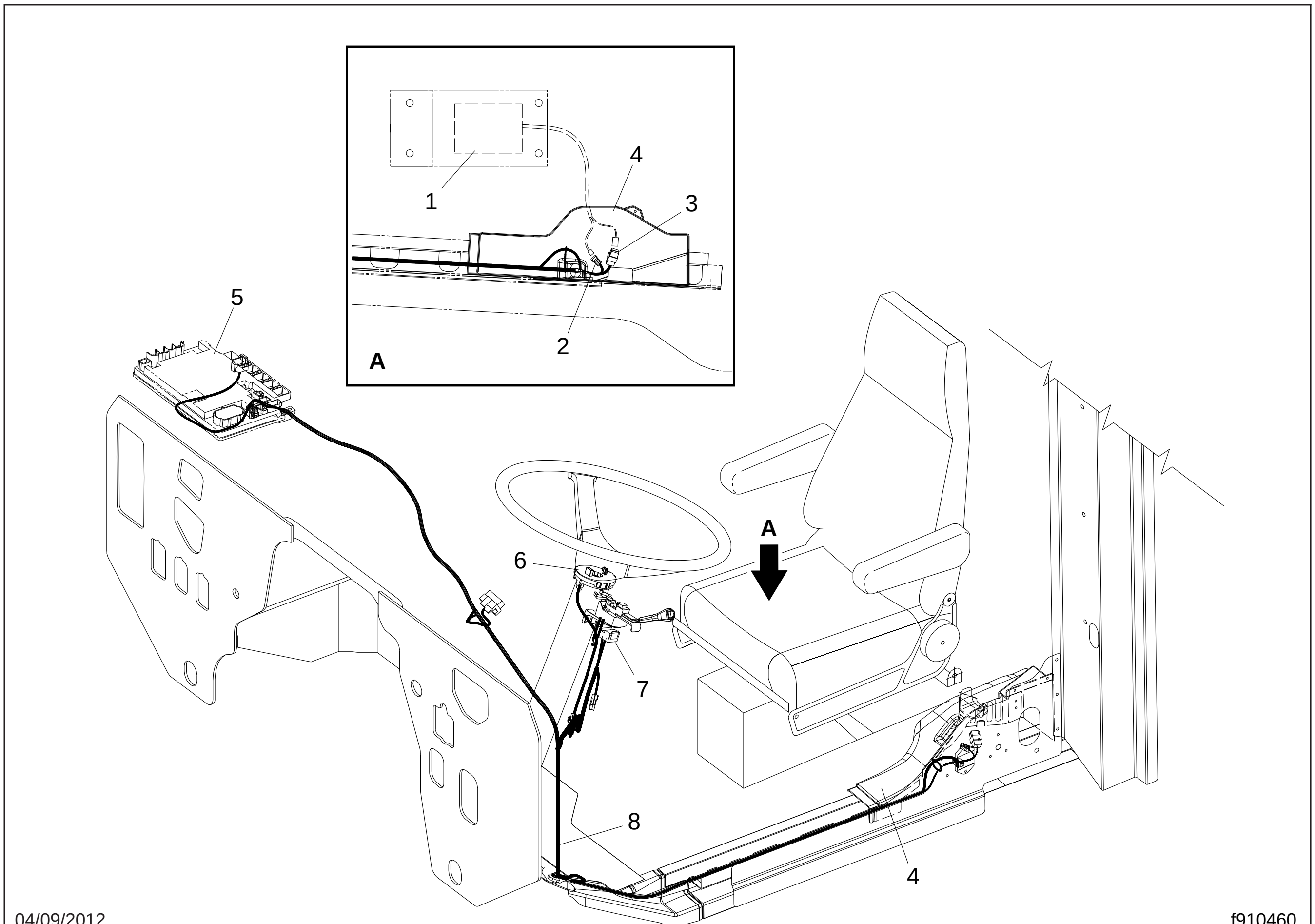


A. Top view of Air Bag/SPACE System

1. Driver-Side SPACE (DSS) Connector
2. Driver-Side SPACE Module
3. B-Pillar Cover
4. Power Distribution Module
5. Clockspring
6. Supplemental Restraint System (SRS) Connector
7. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag Systems Installed Prior to May 12, 2000

Clockspring Replacement



A. Top view of Air Bag Sensor Module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 2, Air Bag Harness Routing on Air Bag Systems Installed From May 12, 2000

NOTICE

Do not turn the steering wheel or the steering shaft at any time during this procedure. Doing so may damage the clockspring.

1. Park the vehicle on a level surface with the wheels straight ahead. Shut down the engine and set the parking brakes. Chock the rear tires.
2. Disconnect the batteries and wait two minutes before proceeding.
3. Disconnect the AS2 connector. See **Fig. 2**.
4. Remove the air bag; see **Subject 100**.
5. Remove the steering wheel; see **Section 46.03, Subject 100**.
6. Tape the upper and lower portions of the clockspring together to prevent it from turning.
7. Disconnect the connector located under the clockspring mounting plate on top of the steering column.

8. Loosen the screws that attach the clockspring to the clockspring bracket. It is not necessary to remove the screws in order to remove the clockspring.
9. Remove the clockspring.
10. If the steering column shaft has been allowed to rotate independently of the front wheels since the clockspring replacement procedure began, recenter the clockspring.
    - 10.1 While holding the lower portion of the clockspring stationary, rotate the upper portion counterclockwise until resistance is felt. Stop rotation as soon as some resistance is felt or the clockspring may become damaged.
    - 10.2 While holding the lower portion of the clockspring stationary, rotate the upper portion clockwise three full turns.
    - 10.3 Turn the upper portion of the clockspring clockwise until the the mounting holes in the upper portion of the clockspring are aligned with the screws in the lower portion of the clockspring. Tape the upper and lower portions together until the steering wheel is installed.
11. Using screws, attach the clockspring to the clockspring bracket.
12. Reconnect the connector from the clockspring to the air bag wiring harness. If the clockspring is taped together, remove the tape.
13. Install the steering wheel; see **Section 46.03, Subject 100**.
14. Install the air bag; see **Subject 100**.
15. Reconnect the AS2 connector. See **Fig. 2**.
16. Make sure nobody is in the cab, then connect the batteries.
17. While standing outside the cab and away from the front of the air bag, turn the ignition on. The SRS indicator should come on for several seconds and then go out. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.

    Follow the appropriate procedure in **Troubleshooting 300**, if:

    - There are active fault codes;
    - The SRS indicator remains on;
    - The SRS indicator does not come on for several seconds before going out.

Air Bag Disposal Procedure

WARNING

Air bags are designed to work in specific vehicle makes and models. Air bag modules and components can not be adapted, reused, or installed in any vehicle other than the vehicle they are designed and manufactured for. Any attempt to adapt, reuse, or install an air bag module or component in any other vehicle can result in death or severe injury to vehicle occupants in the event of an accident.

IMPORTANT: The storage, transportation, disposal, or recycling of air bag modules or components must be performed in accordance with all applicable federal, state, and local regulations including, but not limited to, those governing building and fire codes, environmental protection, occupational health and safety, and transportation.

NOTE: If a vehicle is going to be scrapped and the air bag or SPACE system has not been deployed, contact your District Service Manager for instructions on how to proceed.

1. Remove the inflator from a deployed air bag module. Send the inflator to a recycler for reclamation of the steel and aluminum components.
2. Separate the air bag from the recyclable steel and aluminum components.
3. The plastic materials may be recycled or disposed of in common trash.

Air Bag Sensor Module Replacement

Replacement

NOTE: Before replacing the air bag sensor due to a lighted SRS warning lamp, make sure that all historic (inactive) fault codes are cleared. The SRS warning lamp will stay on even after the repairs indicated by the fault codes are corrected. After correcting the faults, use ServiceLink to clear all historic (inactive) codes. The SRS lamp should now be off, unless an uncorrected fault exists.

WARNING

Consider undeployed air bags to be dangerous and capable of deploying at any time. Before performing any work on the air bag system, review all service literature and comply with the warnings and precautions in Subject 110 and in this subject. Unintentional or improper air bag deployment can result in injury or death.

Damaged or deployed air bag systems should be inspected for leaking propellant chemicals before any attempt is made to remove, replace, or handle the components. If a leak is found, contact LifeGuard Technologies (1-866-765-5835) for handling instructions.

- **Do not attempt to service or to dissassemble the air bag sensor module. The sensor module cannot be serviced.**
- **Do not cut, drill, braze, solder, weld, strike, or probe any part of the air bag sensor module.**
- **Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the air bag sensor module.**
- **Do not attempt to adapt, reuse, or install an air bag sensor module in any vehicle other than the specific vehicle for which it is designed.**
- **Do not cut wires or tamper with the connectors between the vehicle wiring harness and the air bag sensor module. Cutting or removing the electrical connectors could cause unintentional deployment of the air bags.**
- **Do not expose the air bag sensor module to electricity. Never probe a circuit.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

WARNING

Before removing the mounting capscrews from the sensor module, be sure to disconnect the batteries and disconnect the wiring from the sensor module. Failure to follow these precautions may result in the air bag being unintentionally deployed, which could cause severe bodily injury or death.

2. Disconnect the batteries and wait two minutes before proceeding.

WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

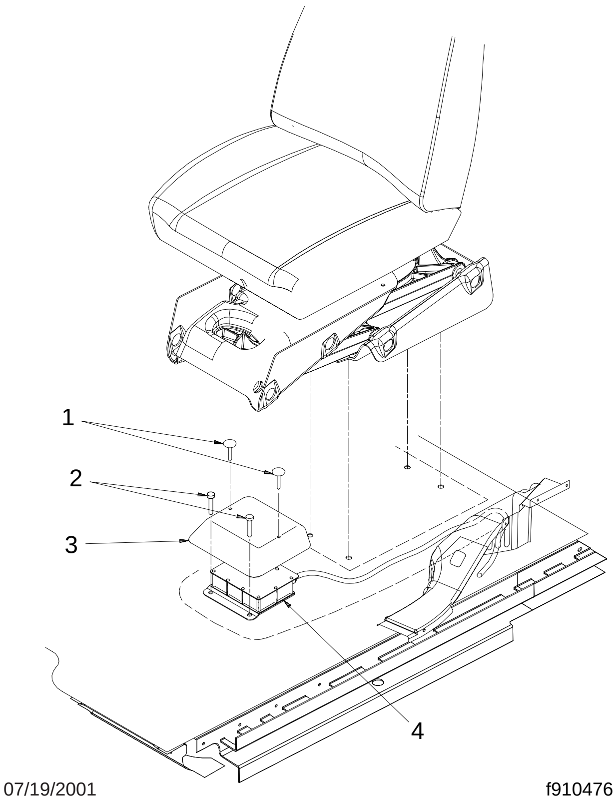
3. Raise the seat to its maximum position. If the seat is equipped with a seat shroud, lift the shroud to access the air bag sensor module.
4. Remove the plastic retainers that attach the sensor module cover to the sensor module and remove the cover. See **Fig. 1** or **Fig. 2**.
5. Disconnect the wiring from the sensor module at the AS2 connector under the B pillar cover.
6. Remove the sensor module.
   - On vehicles with an EzyRider seat, remove the capscrews that attach the sensor module to the cab floor. See **Fig. 1**.
   - On vehicles with a nonproprietary seat, remove the capscrews that attach both the sensor module and the seat to the cab floor. The front mounting capscrews for the seat may need to be loosened to remove the sensor module. See **Fig. 2**.

WARNING

Do not substitute the air bag sensor mounting fasteners. Use the fasteners provided with the sensor to ensure adequate engagement.

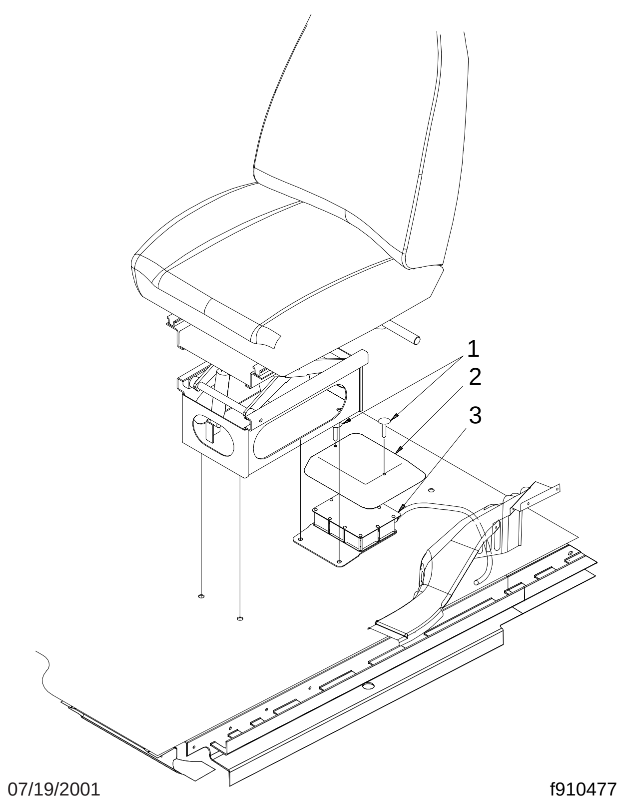
7. Install the new sensor module.

Air Bag Sensor Module Replacement



1. Sensor Module Cover Plastic Retainer
2. Sensor Module Capscrew
3. Sensor Module Cover
4. Sensor Module

Fig. 1, EzyRider Seat With Air Bag Sensor Module



1. Sensor Module Cover Plastic Retainer
2. Sensor Module Cover
3. Sensor Module

Fig. 2, Nonproprietary Seat With Air Bag Sensor Module

- On vehicles with an EzyRider seat, use two capscrews to attach the sensor module to the cab floor. Tighten the capscrews 25 to 29 lbf·ft (34 to 39 N·m).
- On vehicles with a nonproprietary seat, use two capscrews to attach both the sensor module and the seat to the cab floor. If the front mounting capscrews for the seat were loosened, tighten the capscrews. Tighten the capscrews 35 to 40 lbf·ft (47 to 54 N·m).

WARNING

Before attaching the wiring to the sensor module and before connecting the batteries, be sure to attach and tighten the mounting capscrews to the sensor module. Failure to follow these precautions may result in the air bag being unintentionally deployed, which could cause personal injury or property damage.

8. Attach the wiring to the sensor module.
9. Using two plastic retainers, attach the sensor module cover to the sensor module.
10. Lower the seat. If the seat is equipped with a seat shroud, lower the shroud around the base of the seat.
11. Connect the batteries.

NOTE: The following procedures are for the air bag system that became available May 12, 2000.

Deactivating the Air Bag System

WARNING

Consider undeployed air bags to be dangerous and capable of deploying at any time. Before performing any work on the air bag system components, review all service literature and comply with the warnings and precautions in this subject and in Subject 110. Unintentional or improper deployment of the air bag system can result in injury or death.

NOTE: Deactivate the air bag only when directed to do so in the troubleshooting procedure.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the batteries and wait two minutes before proceeding.

WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

3. Disconnect the AS2 connector. See **Fig. 1**.
4. Remove the fastener cover plugs from the steering wheel lower column cover. See **Fig. 2**.
5. Remove the fasteners and the column cover.
6. Loosen the retainer screws underneath the steering wheel. See **Fig. 3**.
7. Carefully lift the air bag from the steering wheel and disconnect the air bag connector (and the horn switch connector if equipped) from the air bag. See **Fig. 4**, **Fig. 5**, and **Fig. 6**.
8. Remove the air bag.
9. Reconnect the AS2 connector.
10. Reconnect the batteries.

Reactivating the Air Bag System

NOTE: Reactivate the air bag only when directed to do so in the troubleshooting procedure.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Make sure that the connectors in the air bag system are connected, except for the air bag connector and the AS2 connector.
3. Disconnect the batteries and wait two minutes before proceeding.

WARNING

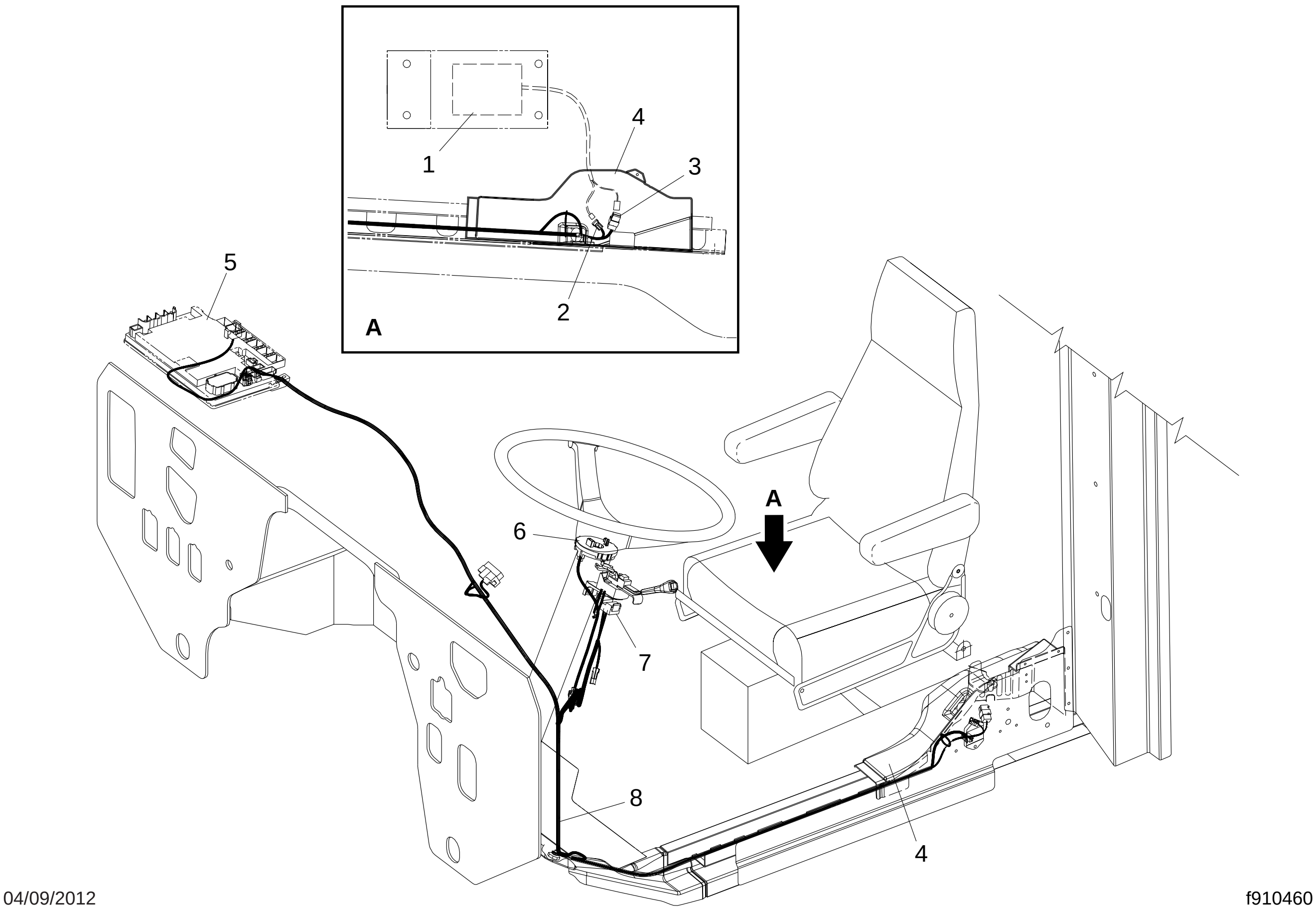
Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

4. Connect the electrical wiring from the clockspring (and from the horn switch connector if equipped) to the new air bag module, then position the air bag module on the steering wheel.
5. Tighten the air bag retaining screws at the bottom of the steering wheel.
6. Using the fasteners, attach the steering wheel lower column cover to the dash.
7. Replace the fastener plugs.
8. Connect the AS2 connector. See **Fig. 1**.
9. Make sure nobody is in the cab, then connect the batteries.
10. While standing outside the cab and away from the front of the air bag, turn the ignition on. The SRS indicator should come on for several seconds and then go out. If the SRS indicator goes out and there are no active fault codes, the system is functioning properly.

    Follow the appropriate procedure in **Troubleshooting 300**, if:

    - There are active fault codes;

Deactivating and Reactivating Procedures



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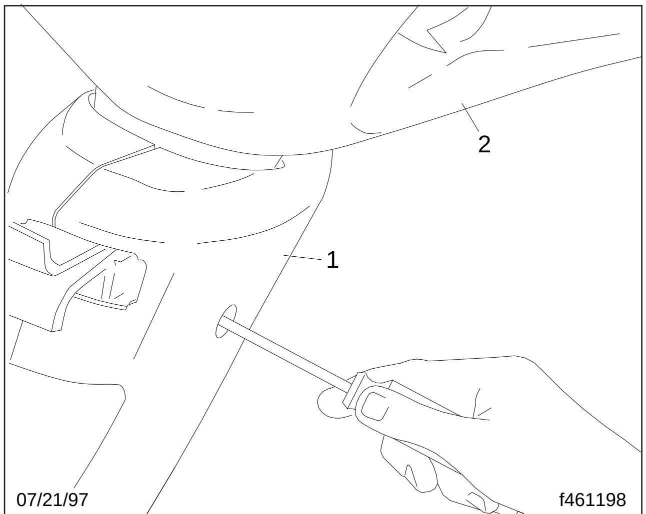
A. Top view of Air Bag Sensor Module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B-Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing

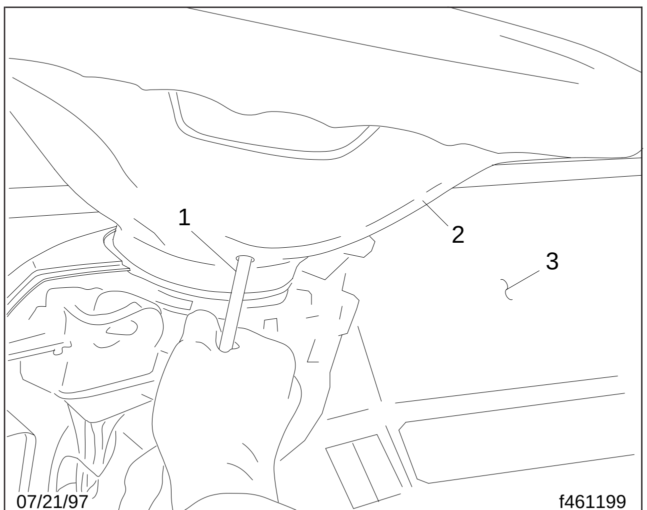
- The SRS indicator remains on;
- The SRS indicator does not come on for several seconds before going out.

Deactivating and Reactivating Procedures



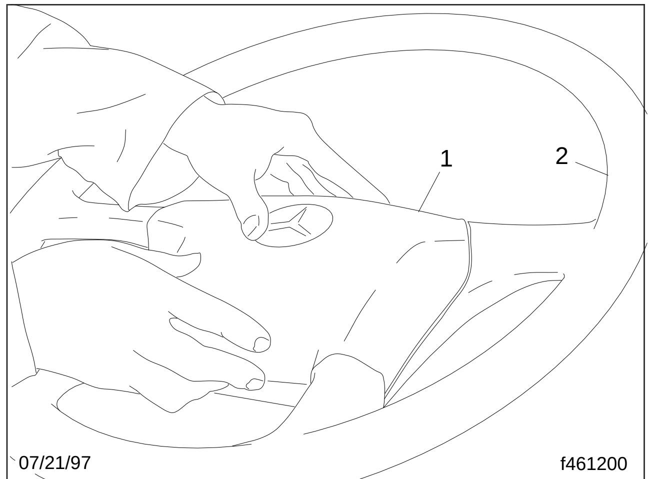
1. Steering Wheel Lower Column Cover
2. Steering Wheel

Fig. 2, Remove the Fastener Cover Plugs



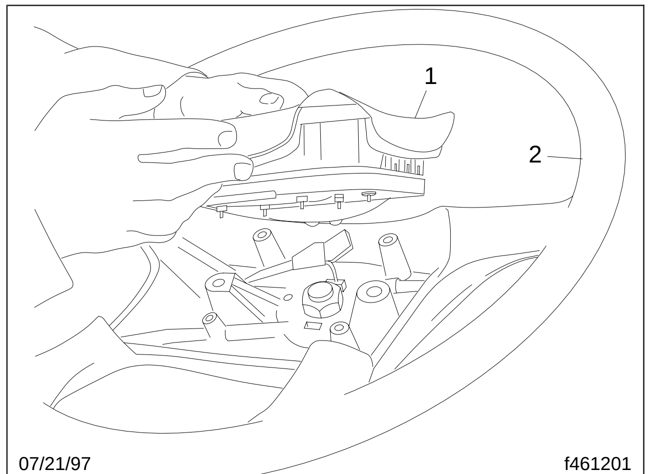
1. Screwdriver
2. Steering Wheel
3. B Dash Panel

Fig. 3, Loosening the Air Bag Retainer Screws



1. Air Bag Module
2. Steering Wheel

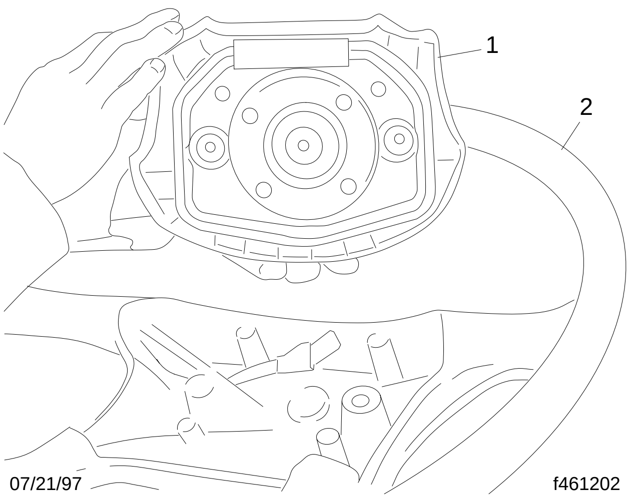
Fig. 4, Air Bag Module Installed



1. Air Bag Module
2. Steering Wheel

Fig. 5, Lift the Air Bag Module

Deactivating and Reactivating Procedures



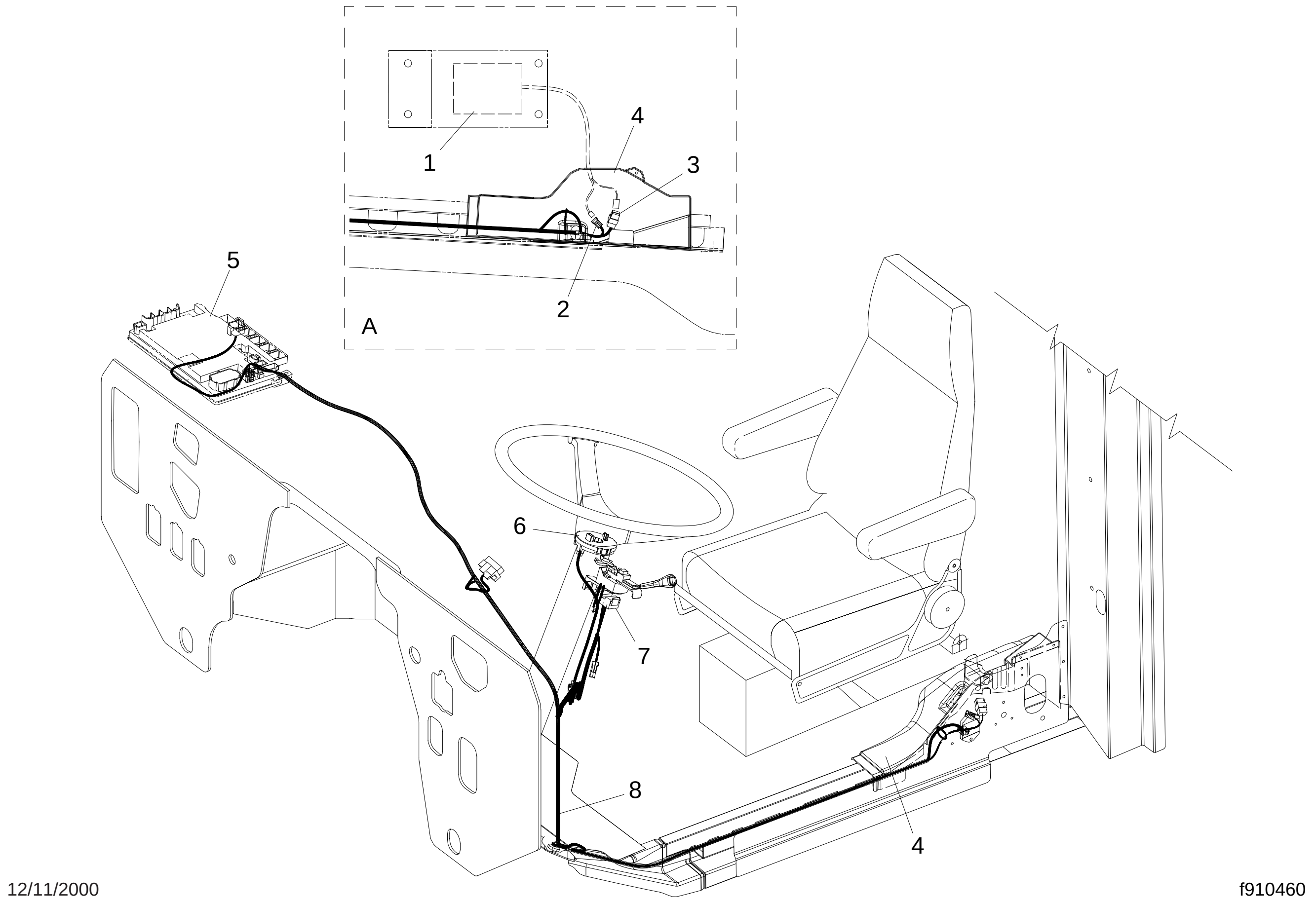
1. Air Bag Module Removed
2. Steering Wheel

Fig. 6, Air Bag Removed

Troubleshooting

The air bag sensor module is located under the driver's seat; see **Fig. 1**.

See **Fig. 2** for the air bag system wiring diagram for vehicles manufactured before December 4th, 2006. See **Fig. 3** for vehicles manufactured on or after December 4th, 2006.



A. Top view of air bag sensor module.

1. Air Bag Sensor Module
2. AS2 Connector
3. AS1 Connector
4. B Pillar Cover
5. Power Distribution Module
6. Clockspring
7. SRS1 (Supplemental Restraint System) Connector
8. Air Bag Wiring Harness

Fig. 1, Air Bag Harness Routing on Air Bag System

Troubleshooting the Air Bag System

IMPORTANT: When directed to deactivate or reactivate the system in a troubleshooting procedure, refer to the appropriate deactivating or reactivating procedure in **Subject 150**.

Troubleshooting

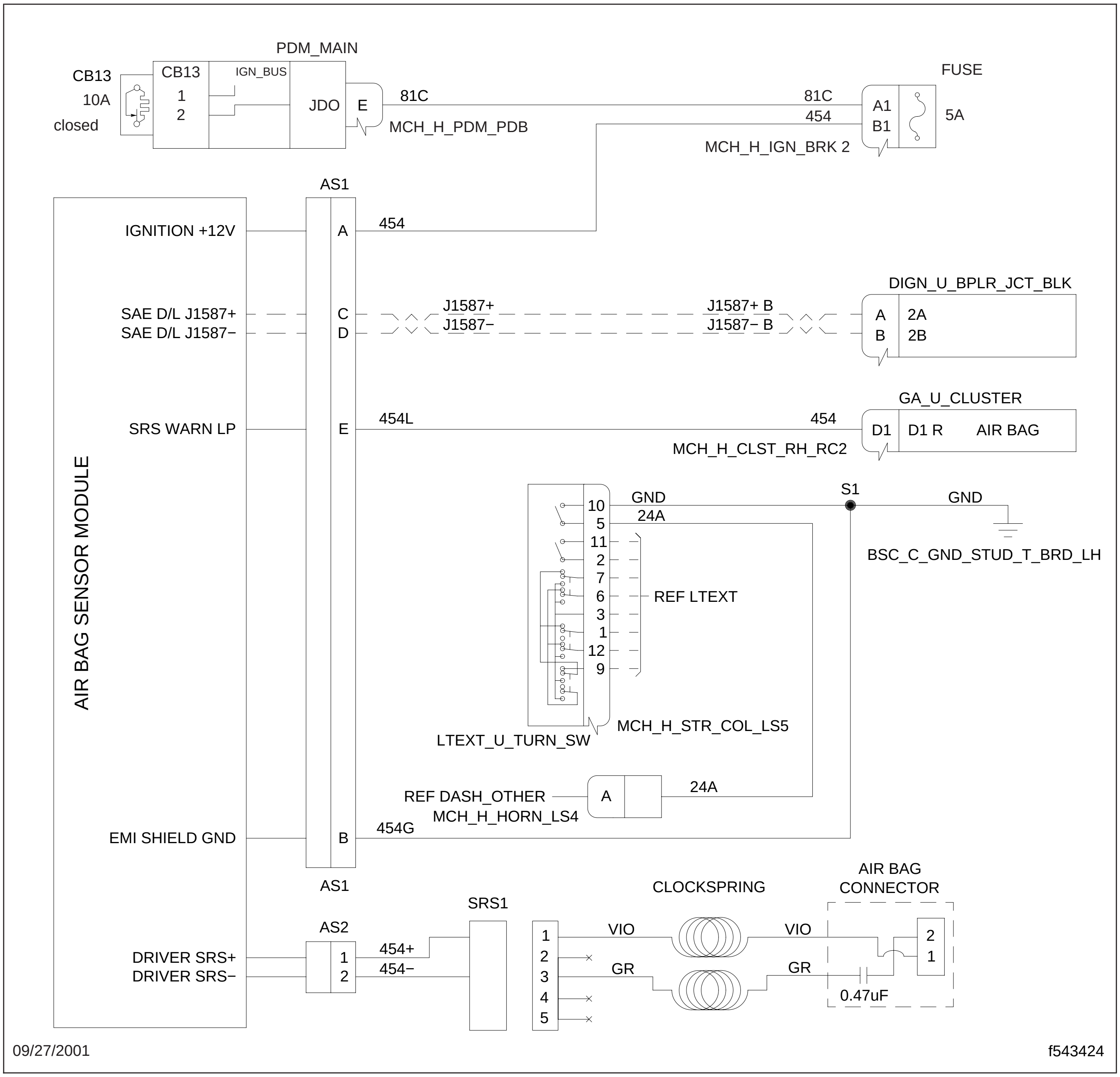


Fig. 2, Air Bag System Wiring Diagram, Before December 4th, 2006

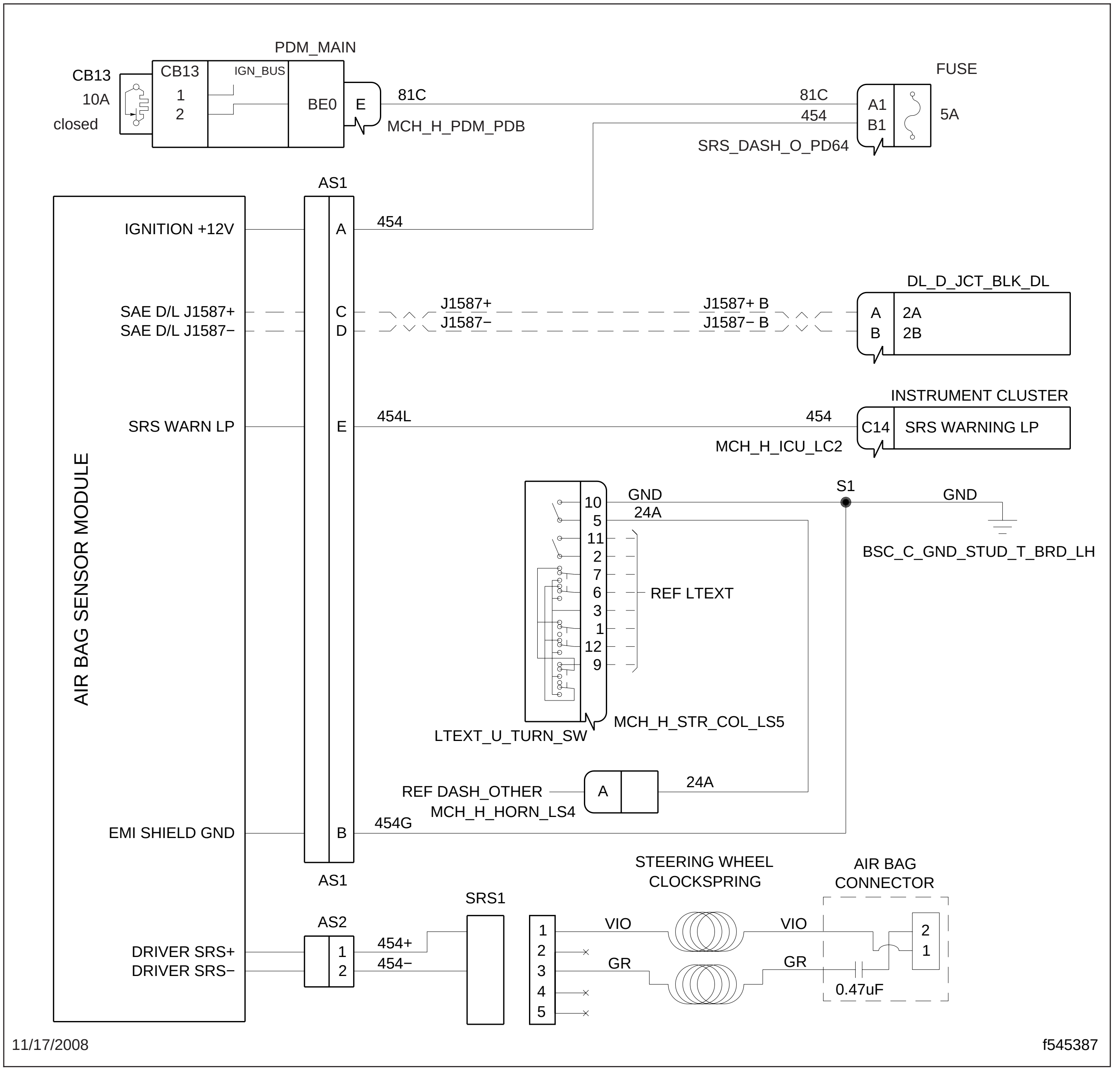


Fig. 3, Air Bag System Wiring Diagram, On or After December 4th, 2006

Troubleshooting

See **Table 1** for the fault codes, fault code descriptions, and the figure numbers for the corresponding troubleshooting diagrams.

NOTE: If the fault codes were active previously, you must clear the historic codes, or the SRS lamp will stay on.

Troubleshooting Diagrams for the Air Bag System		
Fault Code	**Fault Code Description**	**Figure Number**
232-001-03	air bag loop wiring—short to power	**Fig. 4**
232-001-04	air bag loop wiring—short to ground	**Fig. 5**
232-001-05	air bag loop wiring—open circuit	**Fig. 6** and **Fig. 7**
232-001-06	air bag loop wiring—wiring shorted	**Fig. 8**
232-003	air bag sensor loops improperly terminated	**Fig. 9**
232-004	air bag sensor loops improperly terminated	**Fig. 9**
232-005-03	SRS warning lamp short to power	**Fig. 10**
232-005-04	SRS warning lamp short to ground	**Fig. 11**
No Fault Code	SRS indicator not working	**Fig. 12**
No Fault Code	SRS indicator stays on and/or connection to vehicle through J1587 diagnostic connector is not possible	**Fig. 13**
232-240-14	frontal collision detected*	No Figure. Air bag deployed during frontal collision; replace the airbag sensor module and deployed components.
232-253-02	SRS module calibration memory checksum error (internal error)*	No Figure. SRS module has an internal memory error and must be replaced.
232-254-07	air bag module is not communicating with the J1587 datalink or it has lost power — the roll call fault code will only display on the ICU, not on ServiceLink®	**Fig. 14**
232-254-12	SRS module bad intelligent device (internal error)*	No Figure. SRS module has an internal memory error and must be replaced.

* This fault cannot be cleared from memory

Table 1, Troubleshooting Diagrams for the Air Bag System

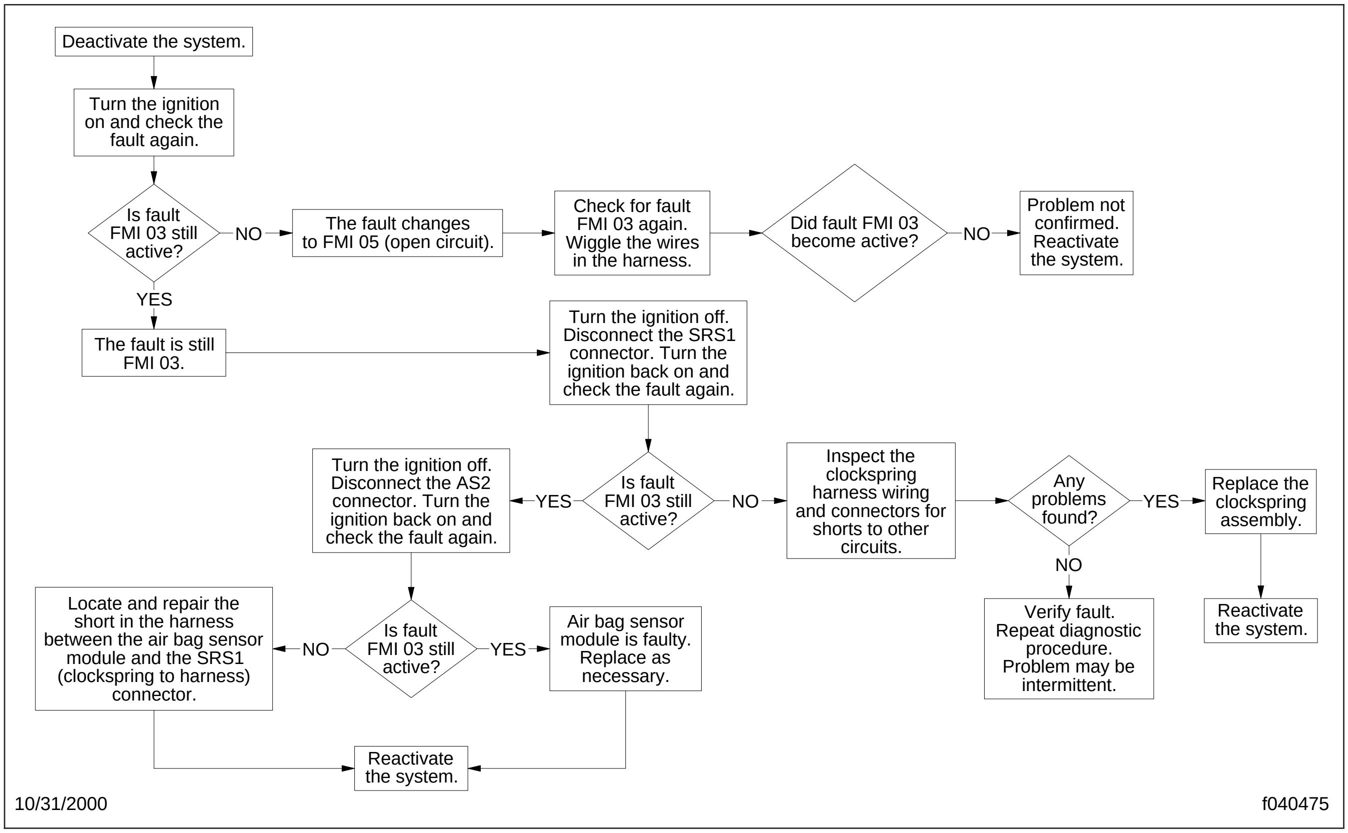


Fig. 4, Troubleshooting Diagram for Fault Code 232-001-03, Air Bag Loop Wiring—Short to Power

Troubleshooting

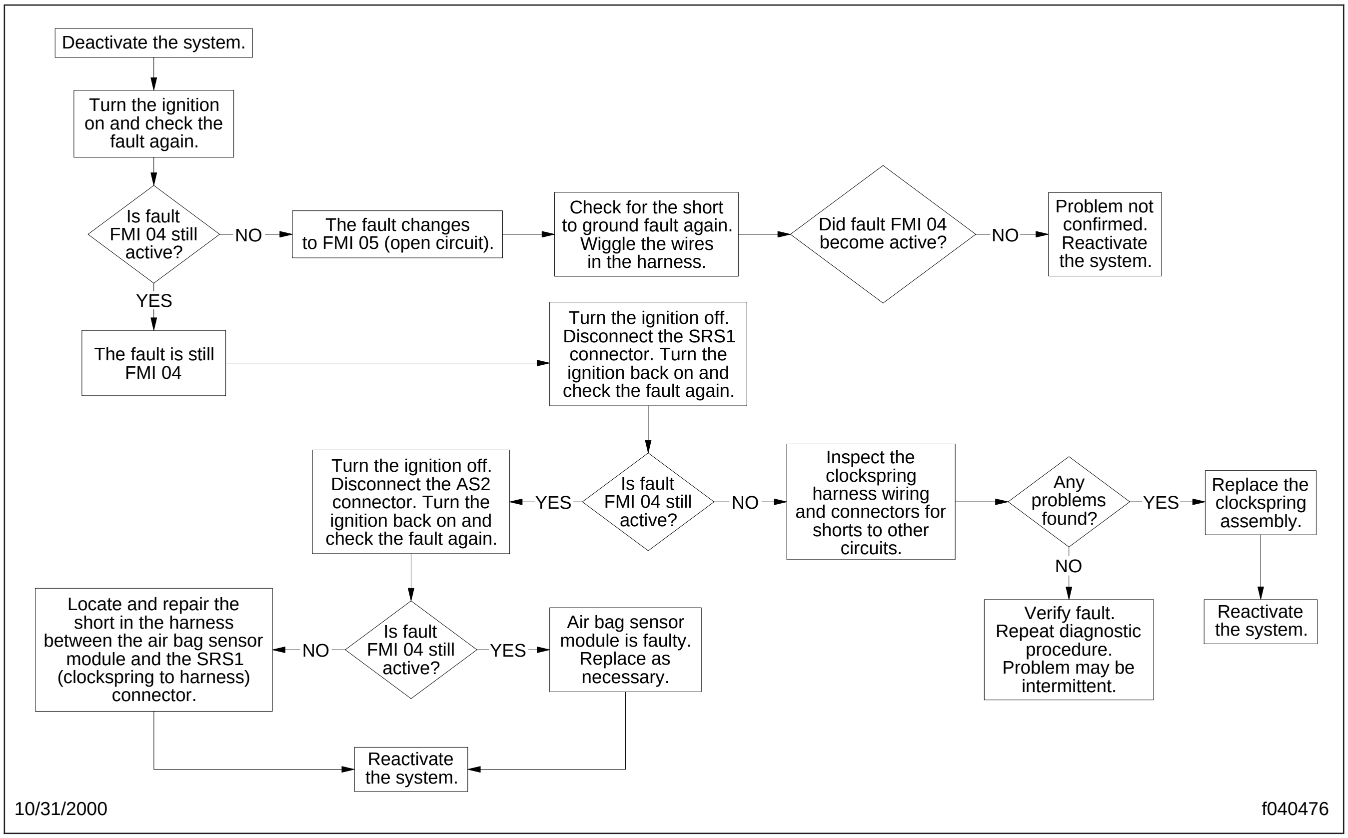


Fig. 5, Troubleshooting Diagram for Fault Code 232-001-04, Air Bag Loop Wiring—Short to Ground

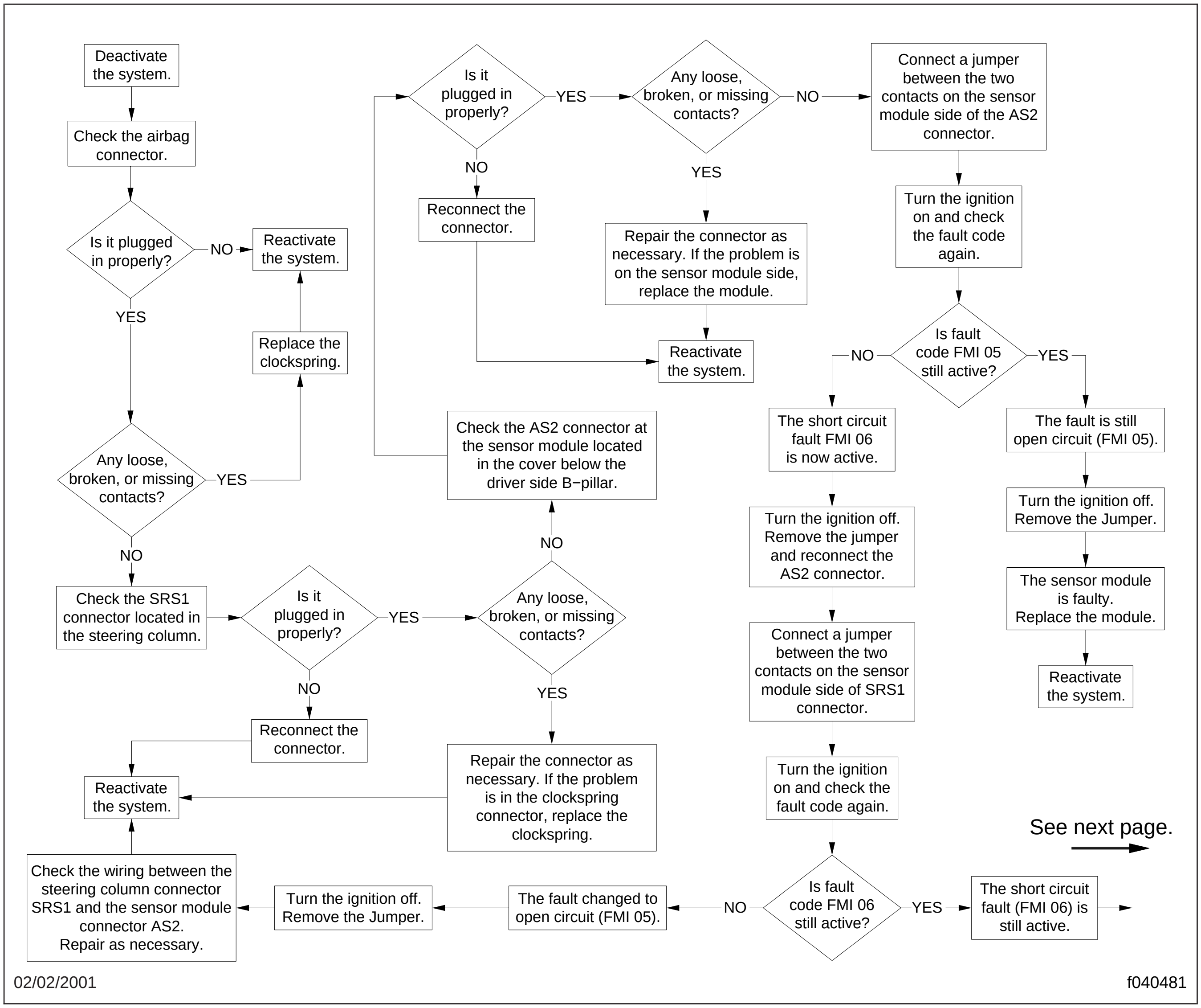


Fig. 6, Troubleshooting Diagram for Fault Code 232-001-05, Air Bag Loop Wiring—Open Circuit, Part 1

Troubleshooting

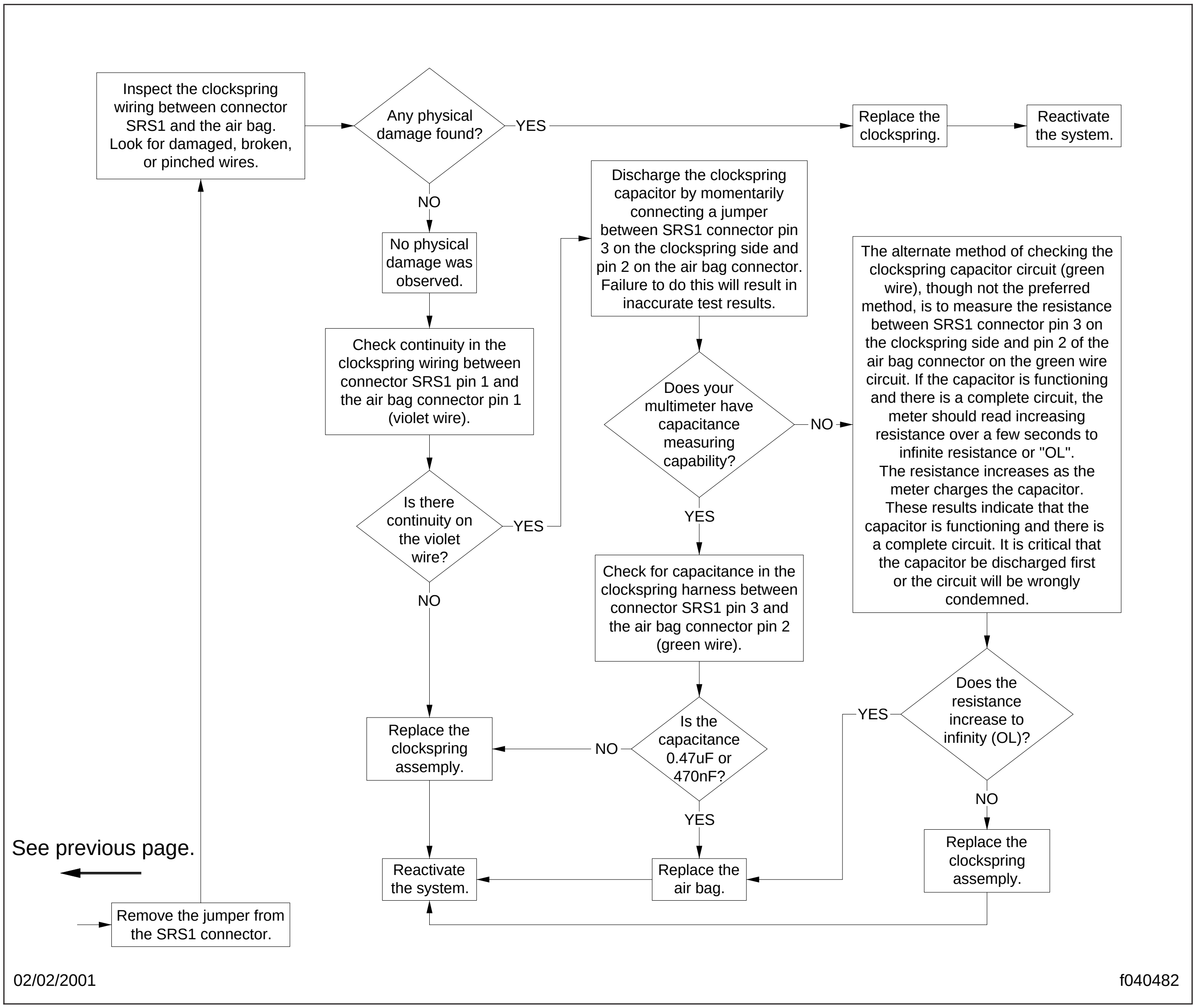


Fig. 7, Troubleshooting Diagram for Fault Code 232-001-05, Air Bag Loop Wiring—Open Circuit, Part 2

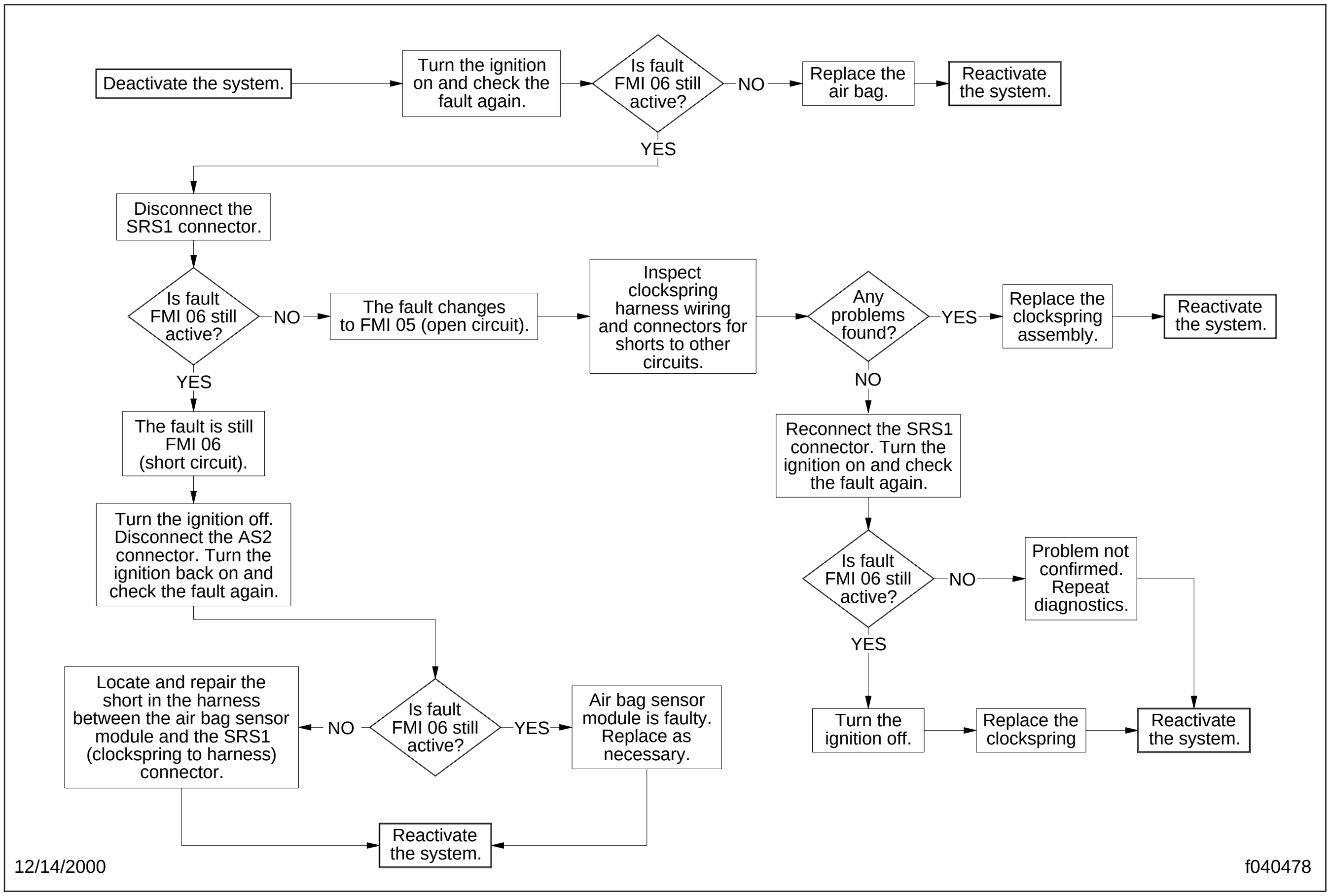


Fig. 8, Troubleshooting Diagram for Fault Code 232-001-06, Air Bag Loop Wiring—Wiring Shorted

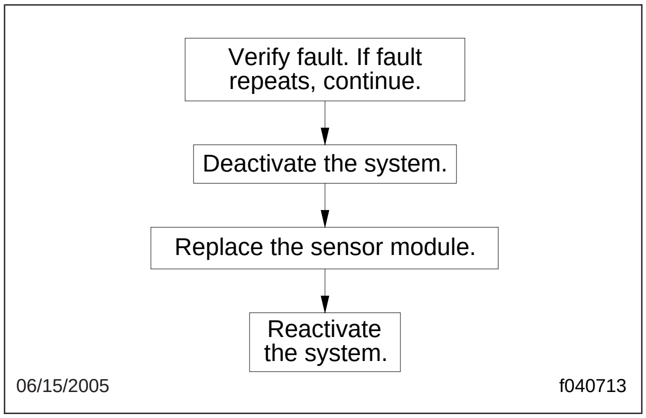


Fig. 9, Troubleshooting Diagram for Fault Codes 232-003 or 232-004, Air Bag Sensor Loops Improperly Terminated

Troubleshooting

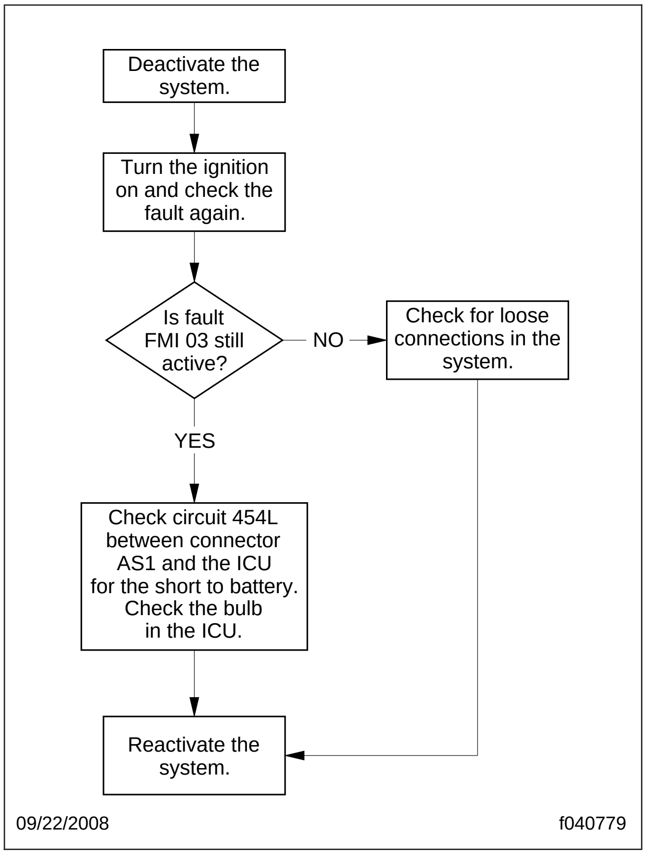


Fig. 10, Troubleshooting Diagram for Fault Code 232-005-03, SRS Warning Lamp Short to Power

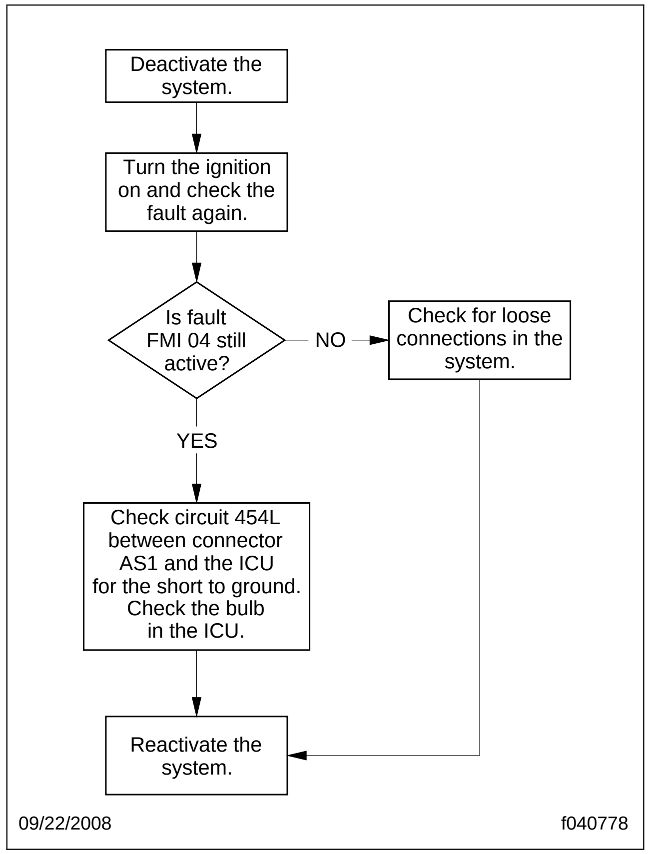


Fig. 11, Troubleshooting Diagram for Fault Code 232-005-04, SRS Warning Lamp Short to Ground

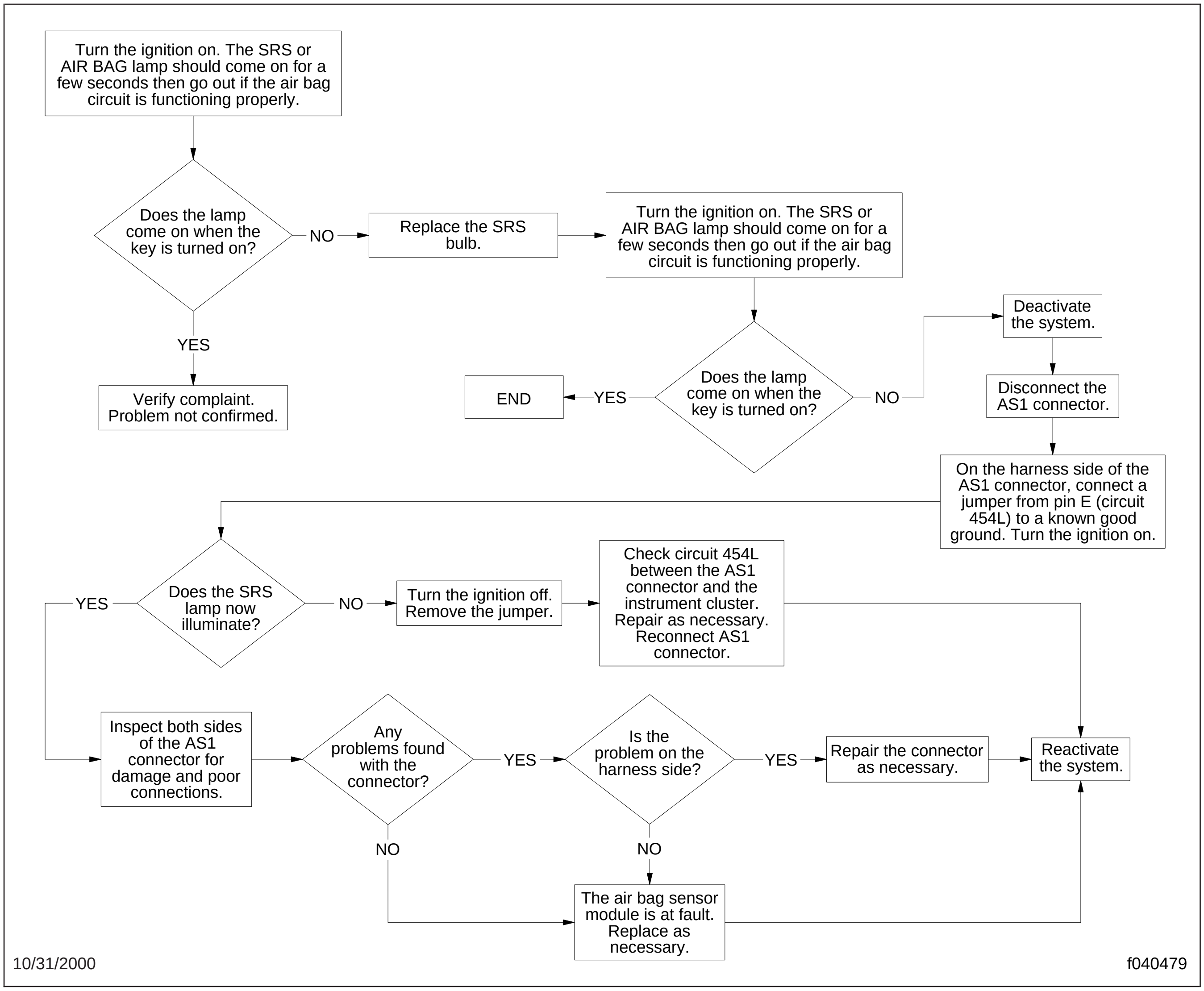


Fig. 12, Troubleshooting Diagram for No Fault Code, the SRS Indicator is Not Working

Troubleshooting

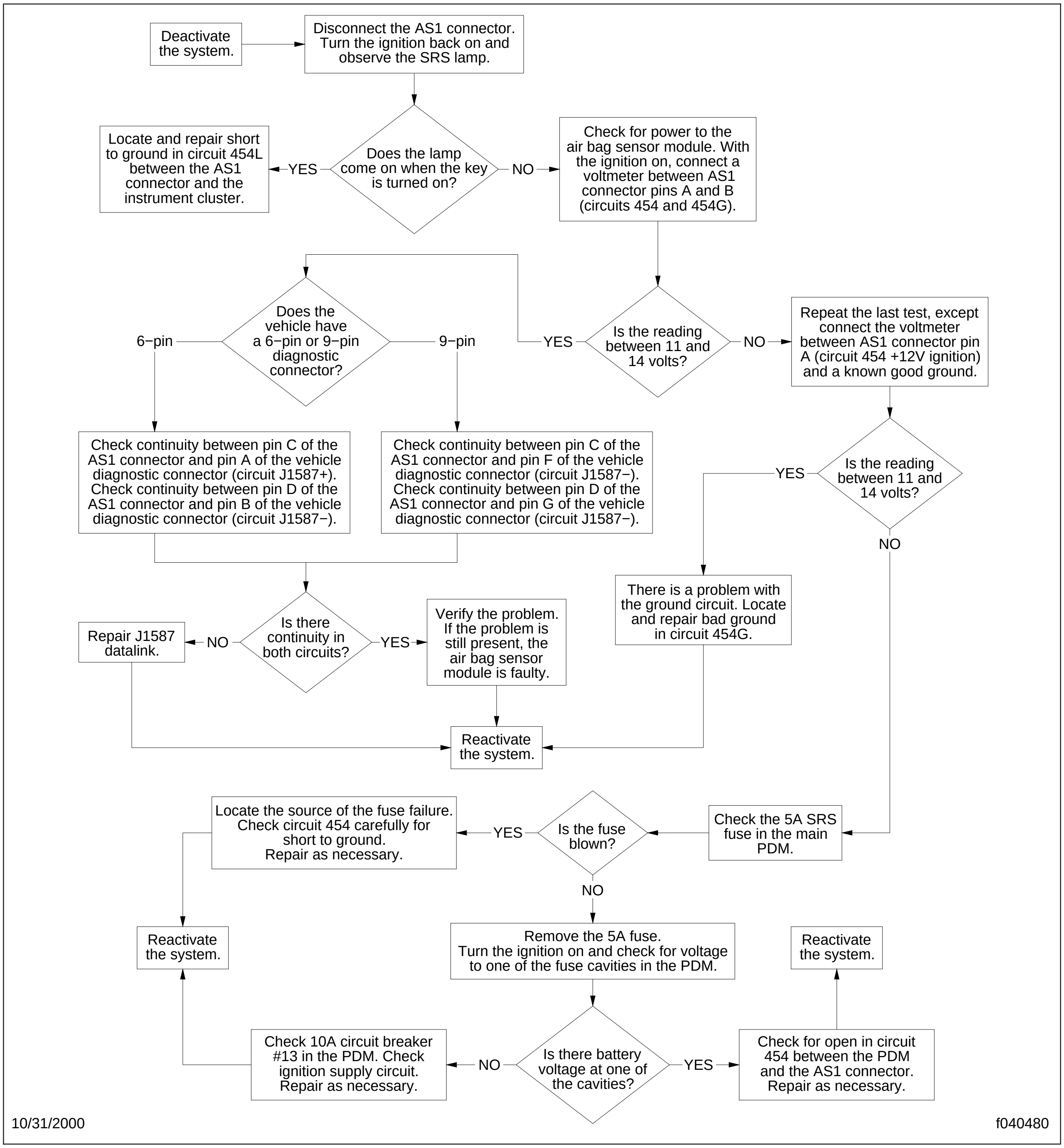


Fig. 13, Troubleshooting Diagram When the SRS Indicator Stays On and/or When a Connection to the Vehicle Through the J1587 Diagnostic Connector is Not Possible

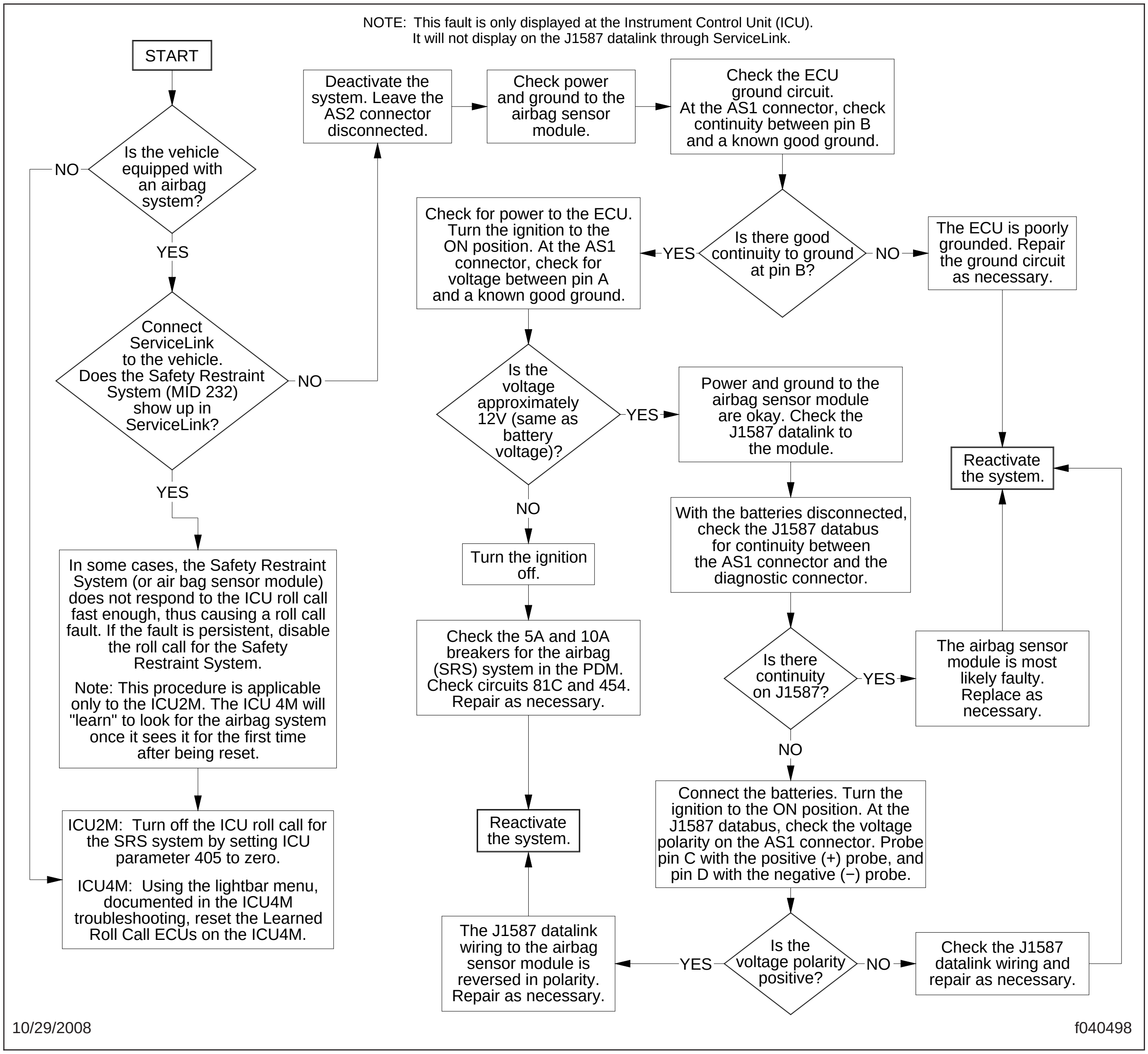


Fig. 14, Troubleshooting Diagram for Fault Code 232-254-07, the Air Bag Module is Not Communicating With the J1587 Datalink or It Has Lost Power

General Information

The ZF steering driveline is a ball-splined telescopic shaft that consists of a cardan shaft with internal splines and a special-pattern shaft with external splines. Two rows of ball bearings run in these splines and form a positive rotating link that does not transmit noise. This design ensures freedom from radial play but light-action axial displacement with an effective stroke of ±1.18 inches (±30 mm). The ball-splined telescopic shaft has a low rate of wear and needs no maintenance.

Steering Driveline Removal and Installation

Removal

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Shut down the engine, apply the parking brakes, chock the tires, and open the hood.
3. Remove the driver's knee bolster below the steering column. See **Fig. 1**.
   - 3.1 Pull out on the bottom of the bolster.
   - 3.2 Push up on the bolster and pull it off.
4. Make a timing mark on the upper end yoke and the lower spline of the steering column. See **Fig. 2**.
5. Remove and discard the pinch bolt and nut from the lower end of the steering driveline.
6. Remove and discard the pinch bolt and nut from the upper end of the steering driveline.
7. Remove the steering driveline.
8. If the steering driveline is being replaced, remove the steering boot bushing from the steering driveline. See **Fig. 3**.

Installation

1. If the steering driveline is being replaced, install the steering boot bushing on the upper end of the new driveline.
2. Insert the upper end of the steering driveline through the steering boot and partially into the cab.
3. Align the timing mark on the upper end yoke with the timing mark on the lower spline on the steering column. Using a new M10 x 1.25 pinch bolt and nut, attach the upper end yoke to the steering column. Torque the bolt 30 to 35 lbf·ft (41 to 47 N·m).
4. Using a new M10 x 1.25 pinch bolt and nut, attach the steering driveline to the steering gear input shaft. Torque the bolt 30 to 35 lbf·ft (41 to 47 N·m).
5. Place the lower edge of the steering boot in the groove of the steering boot bushing. See **Fig. 3**.
6. Install the driver's knee bolster.
   - 6.1 Put the tabs in the upper slots.
   - 6.2 Push the lower portion of the bolster in place.
7. Return the hood to the operating position.
8. Remove the chocks from the tires.

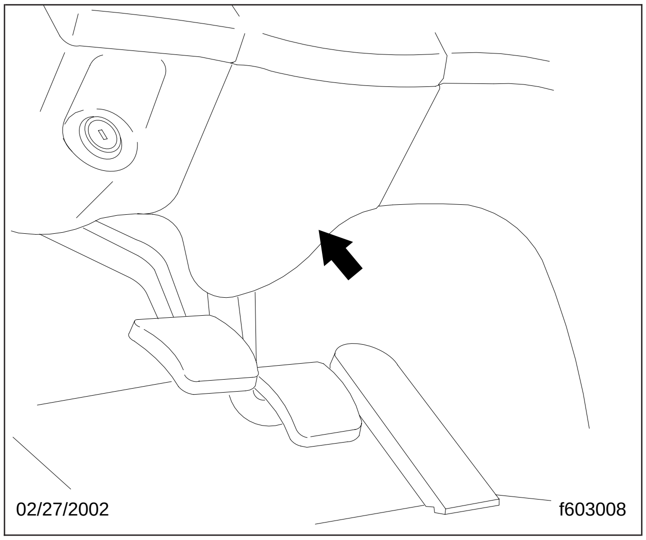
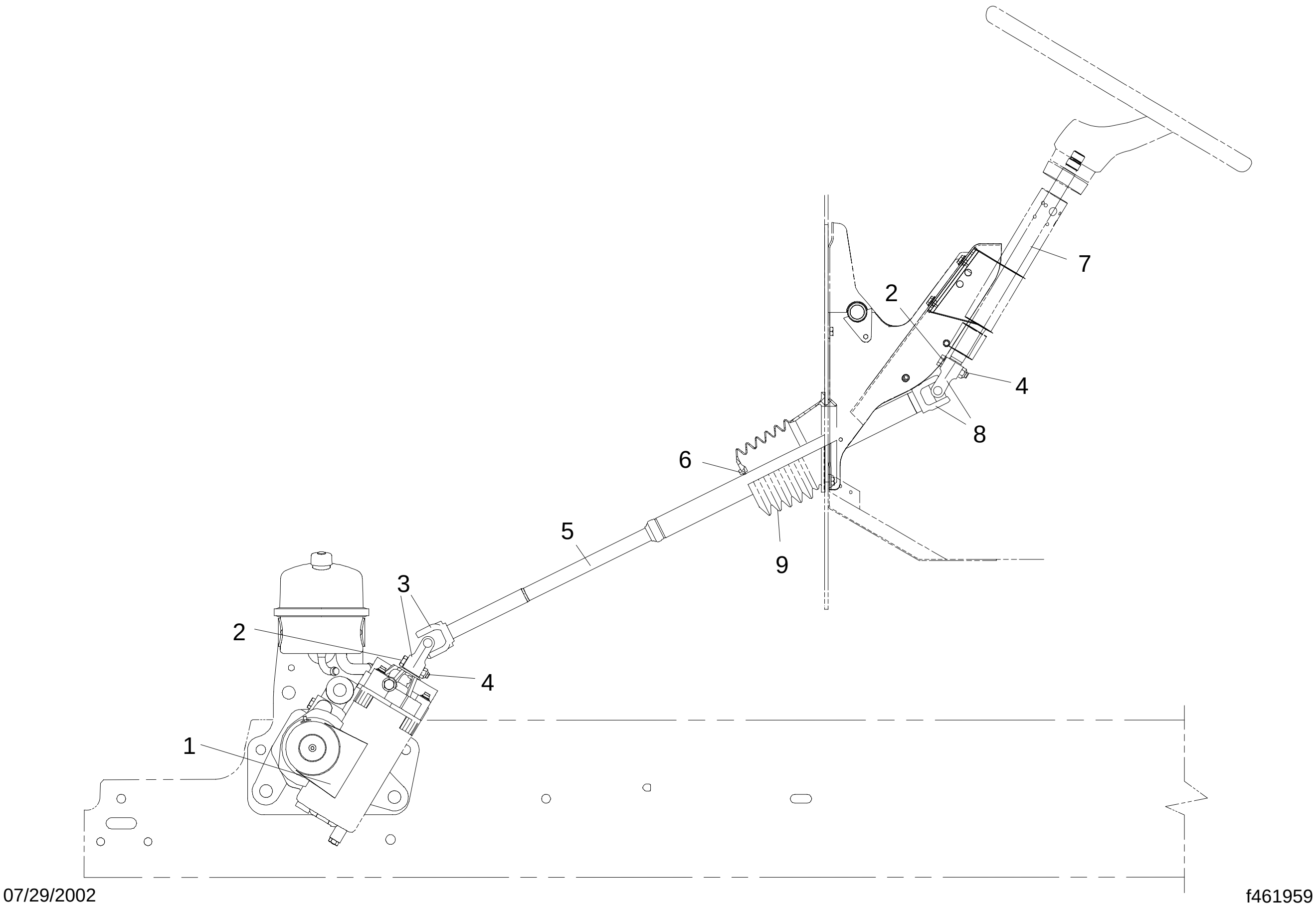


Fig. 1, Driver's Knee Bolster

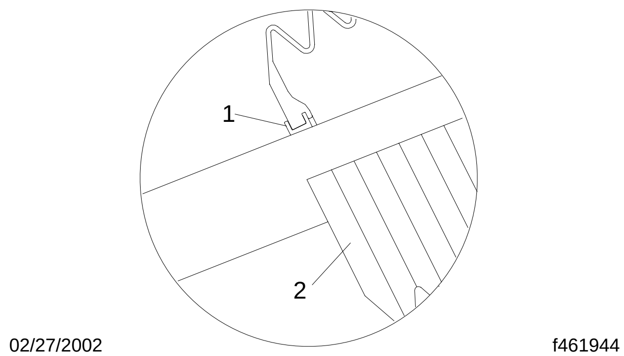
Steering Driveline Removal and Installation



1. Steering Gear
2. Pinch Bolt
3. Lower End Yokes
4. Nut
5. Steering Shaft
6. Steering Boot Bushing
7. Steering Column
8. Upper End Yokes
9. Steering Boot

Fig. 2, Steering Driveline

Steering Driveline Removal and Installation



1. Steering Boot Bushing
2. Steering Boot

Fig. 3, Steering Boot

General Information

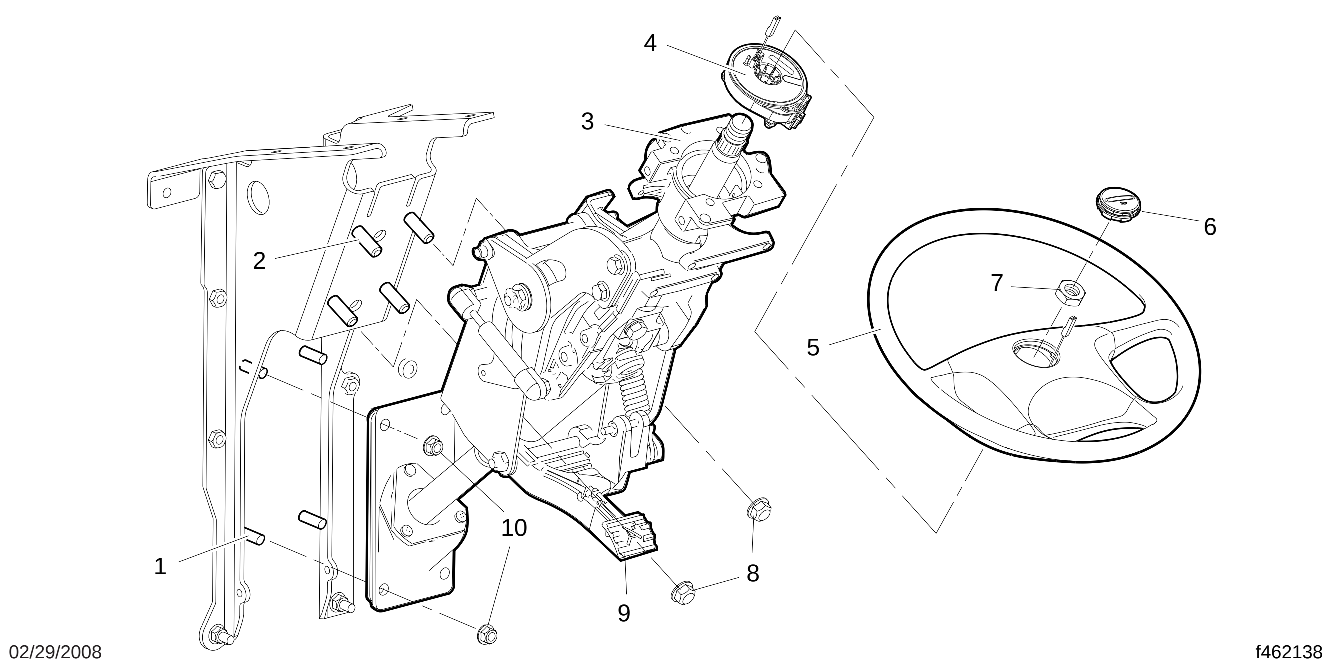
The TRW adjustable steering column can be tilted or telescoped by pressing down on the foot pedal at the base of the column and moving the wheel to the desired position. The locking mechanism uses spring force to keep the column stationary.

The column is attached to the frontwall by both a mounting bracket behind the bulk of the column assembly, and mounting studs that connect to the frontwall bearing plate where the column shaft passes through the frontwall. The end of this shaft connects to the steering driveline (I-shaft) in the engine compartment. See **Fig. 1**.

Steering wheels have different removal and installation procedures if they include an air bag: in wheels without an air bag, the horn button must be removed to access the wheel nut; in wheels with an air bag, the air bag must be deactivated, and the wheel cover module must be removed, to access the wheel nut.

In steering wheels without an air bag, the slip ring that attaches to the column, and connects to the horn button, is not a true clockspring, and has unlimited rotation. In steering wheels with an air bag, this ring is a clockspring with limited rotation, so care must be taken to secure the two halves of the clockspring while the steering wheel or I-shaft is removed for service.

A turn signal switch attaches to the steering column just below the steering wheel. If the vehicle is equipped with a trailer brake control valve, or SmartShift control, it is attached to the right side of the steering column. The steering column assembly is not repairable; if any steering column parts are damaged or badly worn, the steering column assembly must be replaced.



1. Frontwall Bearing Studs
2. Column Mounting Bracket Studs
3. Steering Column
4. Slip Ring
5. Steering Wheel
6. Horn Button
7. Steering Wheel Nut
8. M10 Nut
9. Column Position Adjustment Pedal
10. M8 Nut

Fig. 1, Steering Column Assembly, No Air Bag

Steering Wheel, No Air Bag

Removal

1. With the vehicle parked on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Remove the horn button by prying it out around the edges.
3. Disconnect the horn connectors.

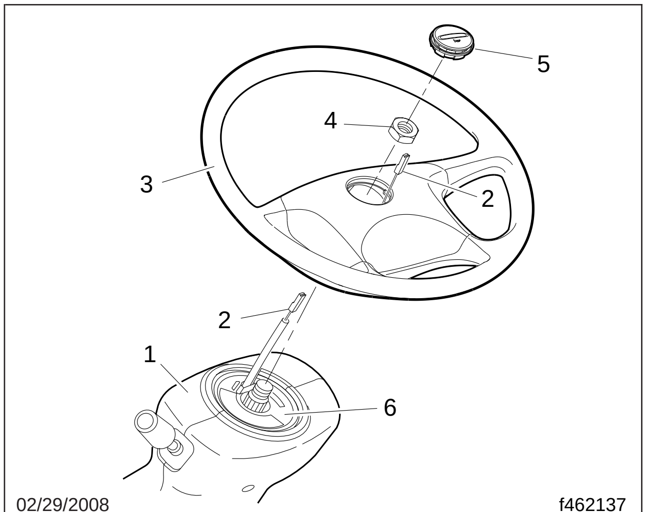
IMPORTANT: The steering wheel does not have threaded wheel-puller holes. The tapered fit between the steering wheel and the column is designed to be released by hand.

4. Loosen the nut that holds the steering wheel on the steering column, but leave it on the shaft until the wheel has been released from the tapered fit.
5. Remove the wheel from the tapered fit by striking it from below, at the rim/spoke intersections, with both hands.
6. Remove the steering wheel nut and the wheel.

Installation

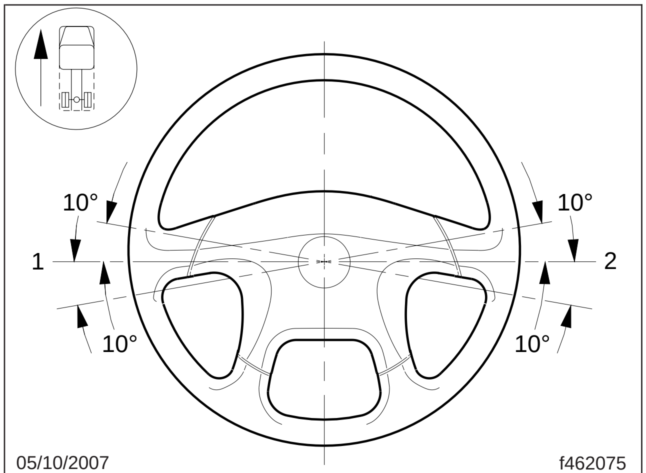
NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead, and the steering gear is centered.

1. Thread the horn wires through the hole above the center of the steering wheel, and set the steering wheel on the steering column; see Fig. 1.
2. Make sure that the steering wheel is within ±10 degrees of center as shown in Fig. 2.
3. Install a new steering wheel nut and tighten it 33 to 41 lbf·ft (45 to 55 N·m).
4. Connect the horn connectors to the horn button and install the horn button.



1. Steering Column
2. Horn Button Connectors
3. Steering Wheel
4. Steering Wheel Nut
5. Horn Button
6. Slip Ring

Fig. 1, Steering Wheel Cover Module and Connectors, No Air Bag



1. 9 o'Clock
2. 3 o'Clock

Fig. 2, Steering Wheel Position

Steering Wheel, Air Bag

Removal

IMPORTANT: Before proceeding, read and review all safety guidelines in **Section 46.07, Subject 110.**

1. With the vehicle parked on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the batteries and wait two minutes before disconnecting any air bag circuits. The leads must be disconnected from the batteries;

Steering Wheel Removal and Installation

the battery cuttoff switch will not cut power from the entire system, and should not be used.

WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

Undeployed air bags can be dangerous and are capable of deploying at any time. Follow the safety guidelines and handling instructions in Section 46.07, Subject 110. Failure to observe safety and handling information could cause unintentional deployment of the air bag, which could result in severe injury or death.

3. Remove the fasteners on the dash-facing side of the steering wheel that hold the steering wheel cover module in place.
4. Remove the steering wheel cover module.
5. Disconnect the steering wheel switch and air bag connectors from the steering wheel cover module, and disconnect the horn wires from the microswitch leads. See **Fig. 3**.

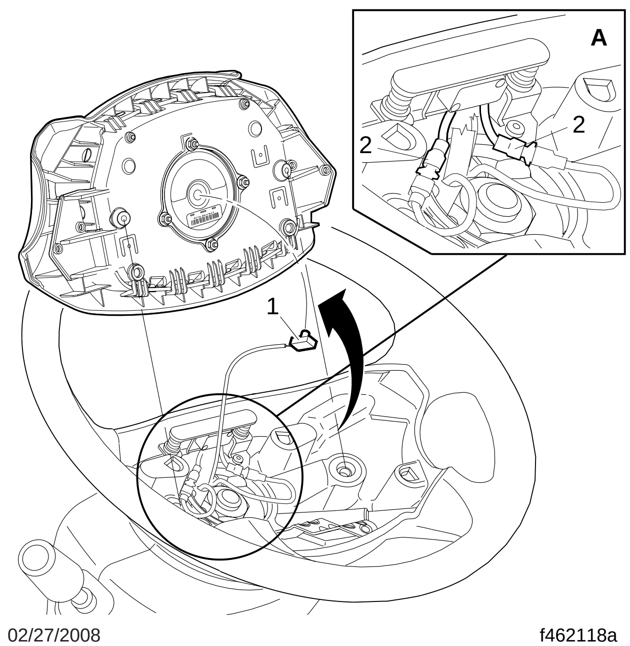
IMPORTANT: The steering wheel does not have threaded wheel-puller holes. The tapered fit between the steering wheel and the column is designed to be released by hand.

6. Loosen the nut that holds the steering wheel on the steering column, but leave it on the shaft until the wheel has been released from the tapered fit.
7. Remove the wheel from the tapered fit by striking it from below, at the rim/spoke intersections, with both hands.
8. Remove the steering wheel nut and the wheel.
9. Secure the clockspring with tape to prevent it from turning while the steering wheel is gone.

Installation

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead, and the steering gear is centered.

1. Remove the tape that keeps the clockspring from turning.

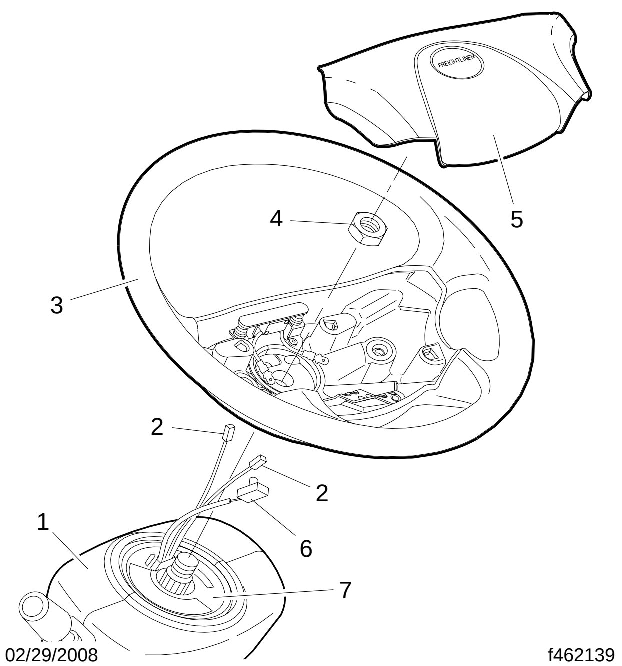


A. Enlarged View
1. Steering Wheel Switch Connector
2. Horn Switch Connectors

Fig. 3, Steering Wheel Cover Module and Connectors, Air Bag

2. Thread the switch, air bag, and horn connectors through the hole above the center of the steering wheel, and set the steering wheel on the steering column; see **Fig. 4**.
3. Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 2**.
4. Install a new steering wheel nut and tighten it 33 to 41 lbf·ft (45 to 55 N·m).
5. Connect the steering wheel switch and air bag connectors to the steering wheel cover module, and connect the horn button connectors to the microswitch leads; see **Fig. 3**.
6. Install the steering wheel cover module into the steering wheel.
7. Install the air bag retaining screws through the bottom of the steering wheel.
8. Connect the batteries.

Steering Wheel Removal and Installation



1. Steering Column
2. Horn Switch Connectors
3. Steering Wheel
4. Steering Wheel Nut
5. Steering Wheel Cover Module
6. Air Bag Connector
7. Clockspring

Fig. 4, Steering Wheel Cover Module and Connectors, Air Bag

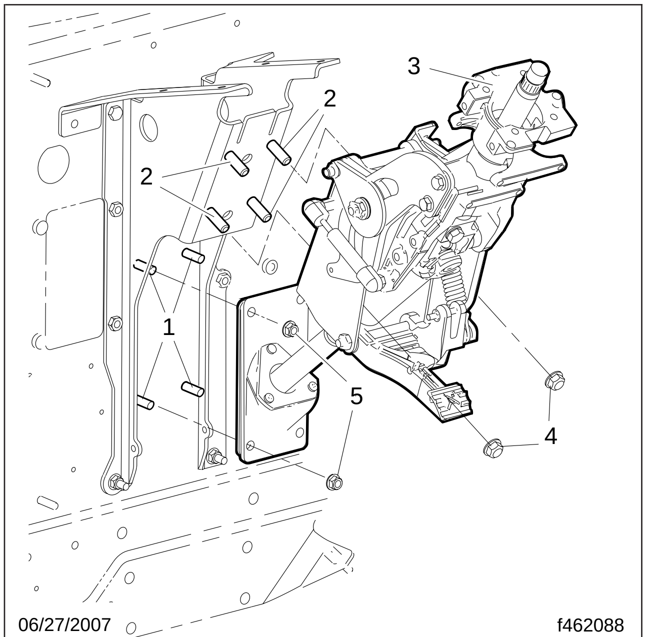
Steering Column Removal and Installation

Removal

1. Remove the steering wheel; see **Subject 100**.
2. Remove the fasteners that hold the dash knee bolster to the dash, then remove the bolster.
3. Remove the four column cover fasteners on the back and the two on the front of the column, and remove the covers.
4. Remove the turn signal wiring harness bracket from the column.
5. Disconnect the turn signal harness from the stalk switch by depressing the plastic retaining tabs on the connector body while detaching the harness.
6. Disconnect the SmartShift lever, and trailer brake assembly, if equipped.
7. Remove and discard the pinch bolt and nut from the end yoke of the steering I-shaft, and disconnect the yoke from the steering column shaft end.
8. Remove the nuts that hold the frontwall bearing housing to the frontwall. See **Fig. 1**.
9. Support the column and remove the nuts that hold the column to the column mounting bracket, and remove the column. See **Fig. 2**.

Installation

1. Position the column on the frontwall mounting studs and column mounting bracket studs, then install new fasteners and tighten hand-tight.
2. Ensure the column is mounted flush with the column mounting bracket and the frontwall, then tighten the column mounting bracket nuts 23 to 34 lbf·ft (31 to 46 N·m), and the frontwall bearing nuts 8 to 12 lbf·ft (11 to 16 N·m).
3. Connect the I-shaft yoke to the steering column shaft end and install a new pinch bolt and nut. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and nut.
4. Install and connect the SmartShift lever and trailer brake assembly, if equipped.
5. Install the turn signal harness bracket and connect the turn signal wiring harness to the turn signal.
6. Install the column covers and dash knee bolster.



1. Frontwall Bearing Studs
2. Steering Column Mounting Bracket Studs
3. Steering Column
4. M10 Nut
5. M8 Nut

Fig. 1, Steering Column Installation

7. Install the steering wheel. See **Subject 100**.

Steering Column Removal and Installation

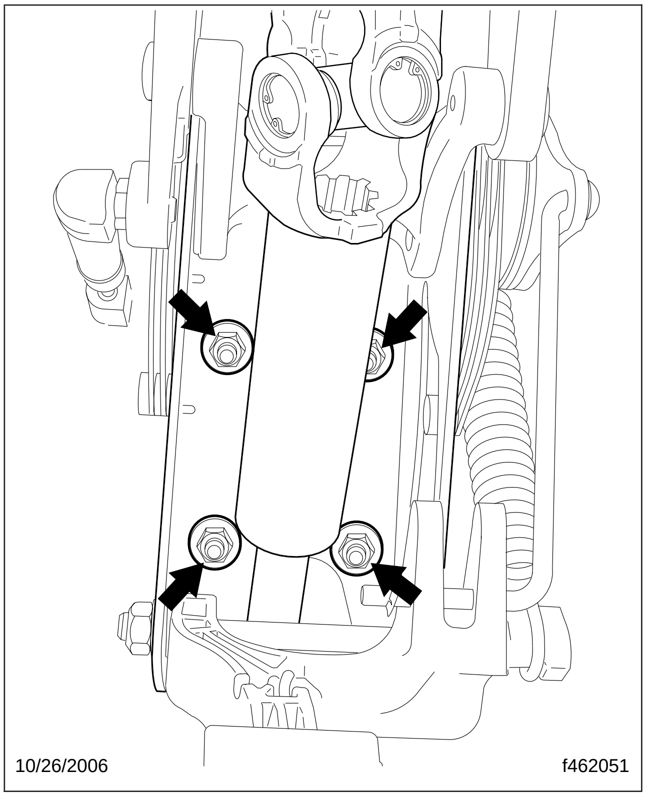


Fig. 2, Location of Column Mounting Bracket Fasteners

General Description

NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (**trucksteering.trw-.com**) for additional information.

The TRW THP and PCF power steering gears are integral hydraulic power steering gears that contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The rotary control valve directs the flow of hydraulic fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder in a dual steering gear system) at the proper flow rate and pressure. As the steering wheel is turned faster or slower, more or less fluid is required by the gear.

Principles of Operation

When the driver turns the steering wheel, that force travels from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to the force exerted by the torsion bar, the worm shaft moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. As the rack piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm, which pulls or pushes the drag link. The drag link moves the axle steering arm, steering the vehicle.

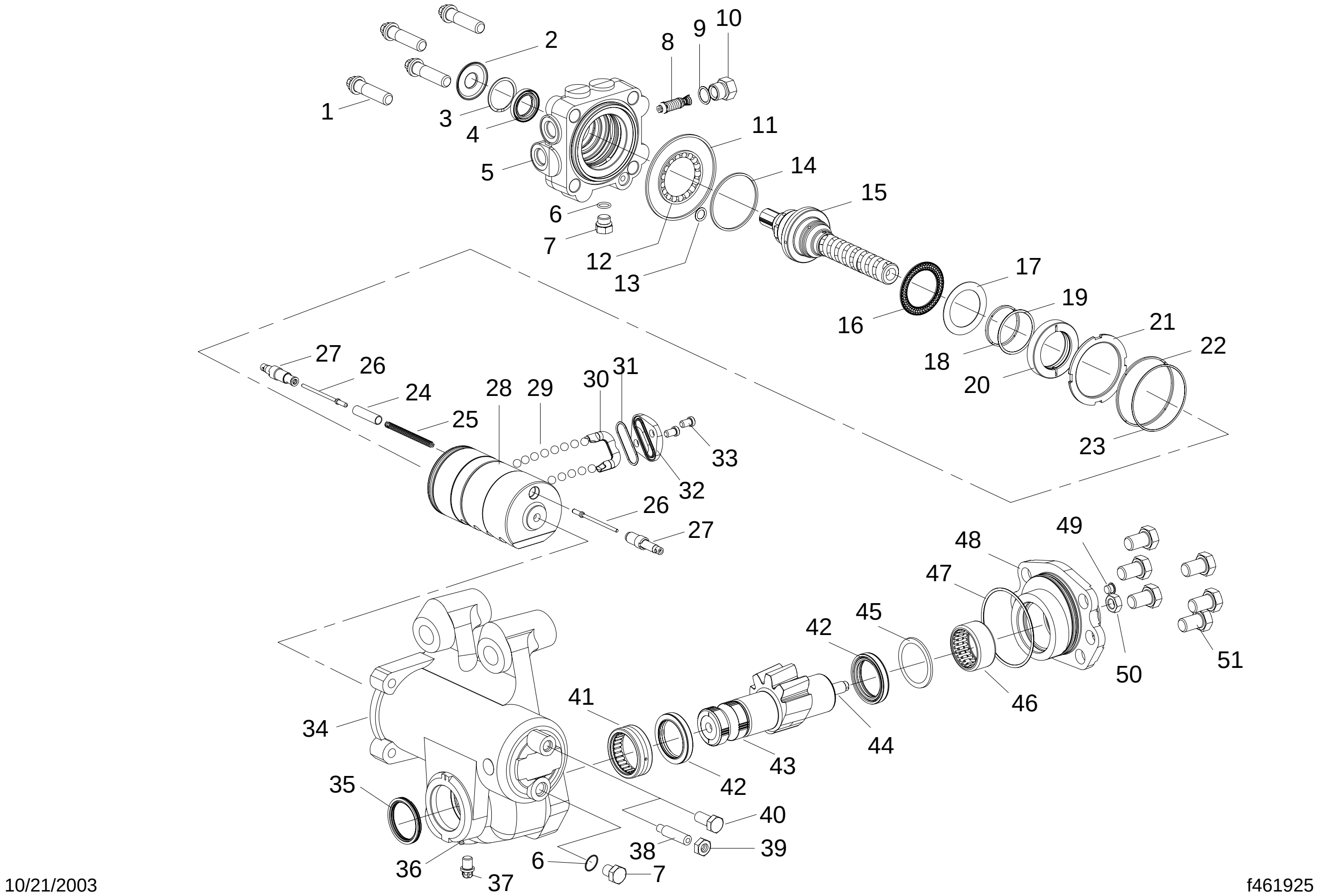
The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). The pressurized fluid assists in moving the rack piston up or down in the cylinder bore.

Most THP and PCF steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. As the front wheels reach the axle stop—the farthest the wheels can turn in either direction—one poppet or the other, depending on the direction of the turn, will trip to prevent steering system damage. The tripped poppet reduces pressure in the gear, heat generated by the power steering pump, and outside forces acting on the steering linkage.

Some THP and PCF steering gears are also supplied with an internal pressure relief valve (PRV). The PRV limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

See **Fig. 1** for an exploded view of the steering gear.

General Information



1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, TRW THP/PCF Steering Gear

Steering Gear Removal and Installation

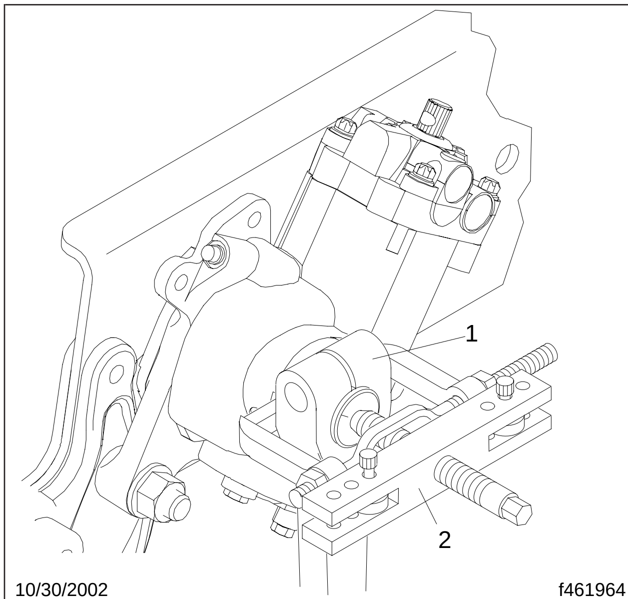
Removal

1. Verify that the axle stops are adjusted correctly. Ensuring correct axle stop adjustment will eliminate the possibility of resetting steering gear poppet valves after the gear is installed. See **Group 33** for instructions.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work is to be done.
3. Shut down the engine, apply the parking brakes, and chock the tires.
4. Disconnect the batteries and open the hood.
5. Clean all fittings and hose connections on the steering gear until they are free of dirt.
6. Drain the fluid from the power steering system. Disconnect the hydraulic lines from the steering gear, marking the lines for later reference. Plug the lines and the fittings to keep out dirt.
7. Remove the pitman arm.
   - 7.1 Remove and discard the pinch bolt, nut, and washer (if applicable) that attach the pitman arm to the steering gear sector shaft.
   - 7.2 Using a two-jaw puller, remove the pitman arm from the steering gear sector shaft. See **Fig. 1**.
8. Disconnect the steering driveline from the steering gear input shaft.
   - 8.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

NOTICE

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   - 8.2 Remove the end yoke from the input shaft.



1. Pitman Arm 2. Two-Jaw Puller

Fig. 1, Pitman Arm Removal

WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

9. Remove the fasteners that secure the steering gear to the frame rail. Remove the steering gear.

Installation

1. Mount the steering gear on the frame rail and install the mounting fasteners. Tighten the fasteners 342 to 434 lbf·ft (464 to 588 N·m).
2. Center the steering gear so that the timing mark on the sector shaft is aligned with the timing mark on the steering gear. Keep the steering gear centered as the installation continues.
3. Connect the steering driveline to the steering gear input shaft.
   - 3.1 Align the hole in the steering driveline lower end yoke with the indentation on the input shaft.

Steering Gear Removal and Installation

3.2 Using a new pinch bolt and nut, attach the driveline lower end yoke to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

3.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

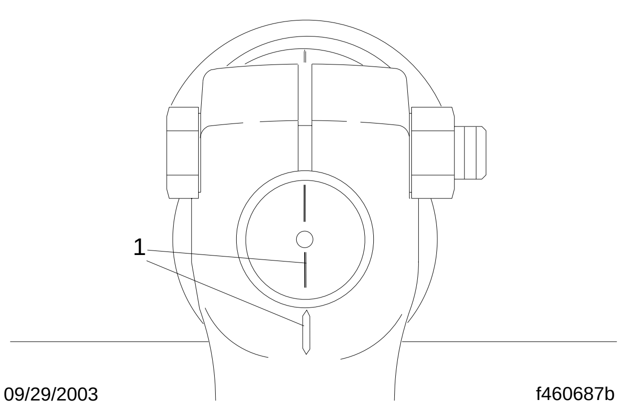
WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, wear safety glasses and maintain a firm grip on the chisel at all times. Otherwise, the chisel may fly loose, which could cause an injury.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. To wedge the slot open, drive a chisel into the slot using a ball-peen hammer. Hold the chisel in place and install the pitman arm on the sector shaft. Remove the chisel from the slot.

4. Install the pitman arm.

4.1 Make sure that the timing mark on the pitman arm is aligned with the timing mark on the sector shaft. See **Fig. 2**.



1. Timing Marks Aligned

Fig. 2, Typical Pitman Arm and Timing Marks

4.2 Using a new pinch bolt, nut, and washer (if applicable), attach the pitman arm to the steering gear sector shaft.

4.3 Tighten the nut 230 lbf·ft (312 N·m).

4.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

5. If the hydraulic line fittings were removed, attach them to the steering gear. Tighten the fittings 37 lbf·ft (50 N·m). Tighten the jam nut on the pressure line fitting to a maximum 41 lbf·ft (56 N·m).

6. Remove the plugs from the hydraulic lines. Connect the hydraulic lines to the steering gear. Tighten the nut on each fitting finger tight, then use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.

7. Connect the batteries.

8. Fill and bleed the steering system. For instructions, refer to **Subject 110**.

9. Close the hood and perform the post-service checks in **Subject 150**.

Filling and Air Bleeding the System

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

1. Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
2. Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

3. Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.
4. Start the engine again. Turn the steering wheel from full-left to full-right several times. If needed, add more fluid to the reservoir.

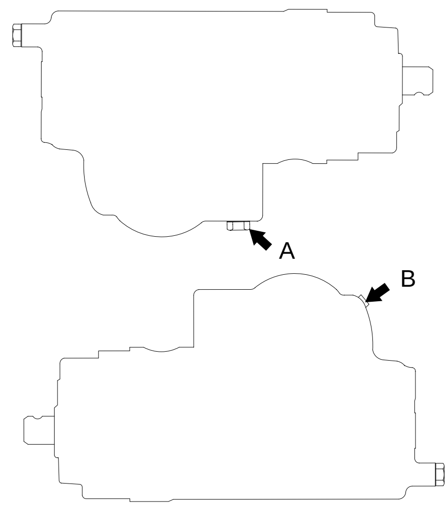
   Automatic bleed systems should now be free of trapped air.

   If the vehicle has a manual bleed system (**Fig. 1**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

5. With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

   Repeat this step until all air is out of the system.
6. Tighten the bleed screw 45 lbf·in (509 N·cm).



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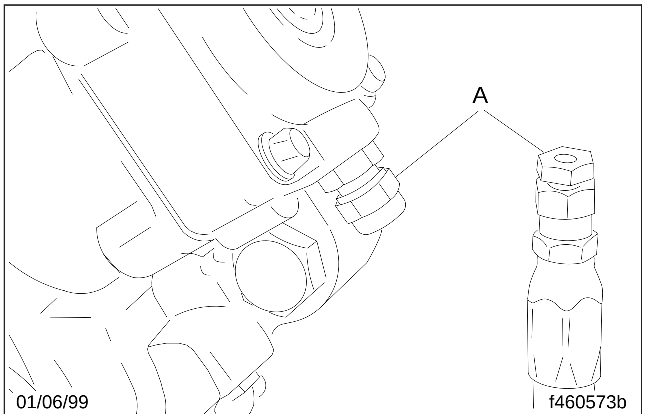
A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

Fig. 1, Steering Gear Bleed Systems

Replacement

NOTE: The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Cap the return port of the steering gear with a high pressure fitting.



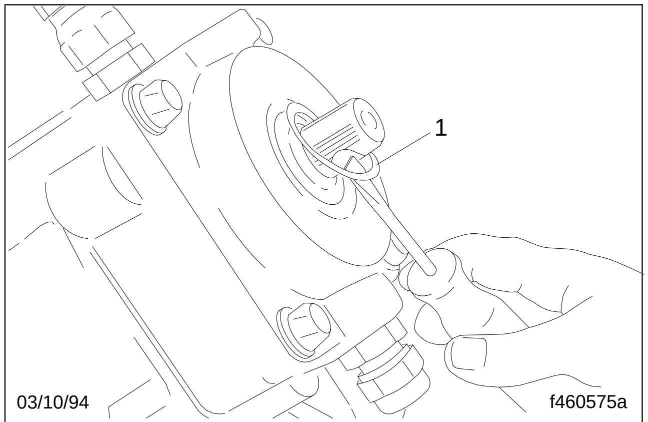
A. Cap the return line and the return port.

Fig. 1, Disconnected Return Line

NOTICE

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

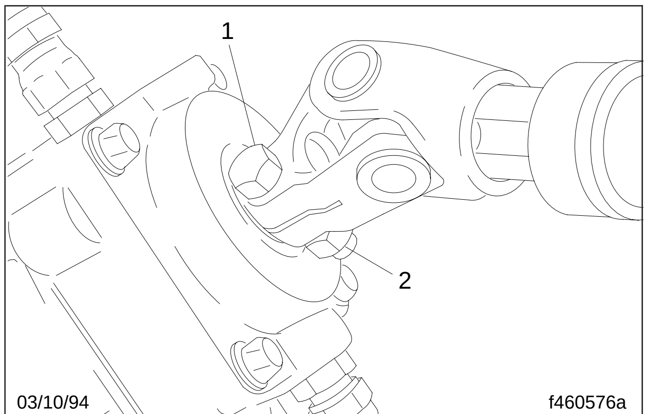
3. Disconnect the steering driveline from the steering gear input shaft.
4. Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove all grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, remove the retaining ring. See **Fig. 2**. Be careful not to scratch the bore with the screwdriver.



1. Retaining Ring

Fig. 2, Retaining Ring Removal

7. Using a pinch bolt and nut, attach the steering driveline to the input shaft but do not tighten the nut. See **Fig. 3**.



1. Pinch Bolt
2. Pinch Bolt Nut

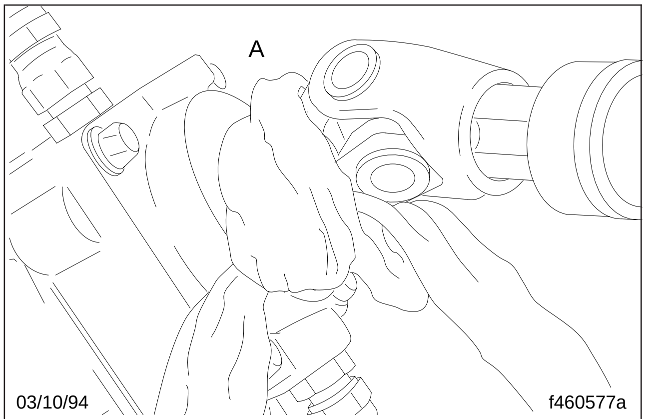
Fig. 3, Pinch Bolt Installation

8. Tie or wrap a shop towel around the input shaft and place a drain pan under the steering gear to catch the oil. See **Fig. 4**.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and

Input Shaft Seal Replacement

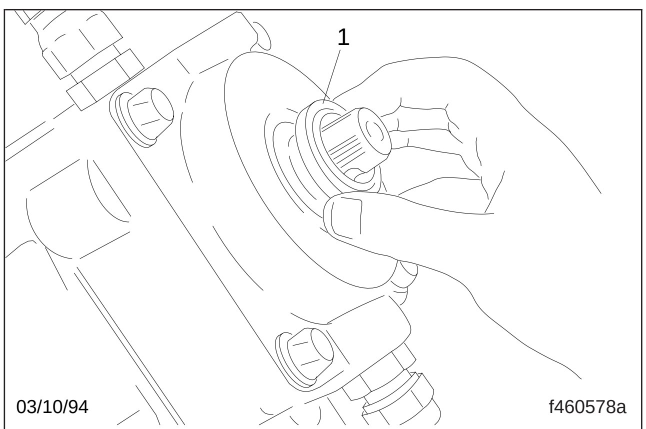


A. Cover the input shaft area.

Fig. 4, Shop Towel Covering the Input Shaft

spillage on the roadway, which could cause personal injury or property damage.

9. If needed, fill the power steering reservoir with automatic transmission fluid.
10. With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
11. Remove the shop towel, pinch bolt, and input yoke. Remove the input shaft seal. See **Fig. 5**.



1. Input Shaft Seal

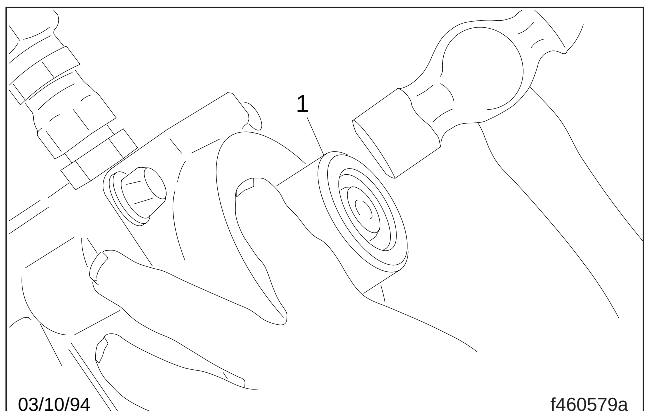
Fig. 5, Input Shaft Seal Removal

12. Inspect the seal area of the valve housing for seal fragments. Remove all seal fragments.
13. Check the input shaft seal for heat damage. If the seal is stiff and brittle, it is probably heat damaged. Determine and fix the cause of excessive heat in the vehicle.

⚠ WARNING

Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.

14. Install a new input shaft seal.
    14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
    14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. See **Fig. 6**. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.



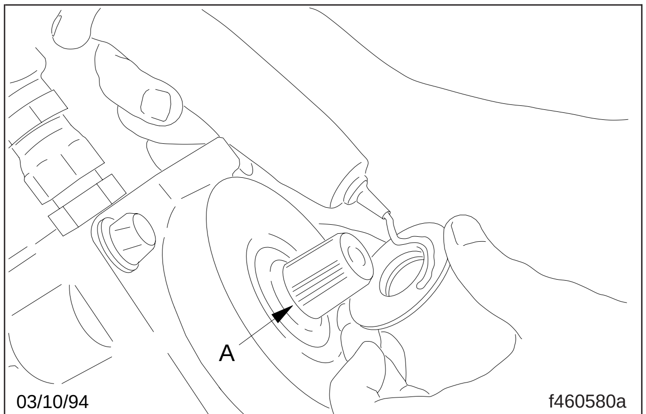
1. Seal Installer Tool

Fig. 6, Seal Installer Tool Position

15. Install a new retaining ring in the groove.
16. Using Exxon Polyrex EP2 grease (045422), pack the end of the valve housing bore.
17. Install a new dirt and water seal.
    17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal.

17.2 Apply Exxon Polyrex EP2 grease to the new dirt and water seal and install it on the input shaft. See **Fig. 7**. Seat it in the groove behind the serrations and against the valve housing.

Wipe any excess grease from the valve housing bore and input shaft once the seal has been installed.



A. Seat the seal here.

Fig. 7, Dirt and Water Seal Installation

18. Using a new pinch bolt and nut, attach the steering driveline to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
19. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.
20. Connect the return line to the steering gear return port.
21. Bleed the air from the system. For instructions, see **Subject 110**.

Sector Shaft Adjustment

Adjustment

NOTE: If the steering gear is installed on the frame rail, sector shaft adjustment can only be completed if the adjusting screw jam nut (located on the side cover) is accessible.

1. Apply the parking brakes and chock the rear tires.
2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The sector shaft is now at its center of travel. Shut down the engine.
3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Remove the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
5. Loosen the adjusting screw jam nut.
6. If no lash was detected in step 4, use a screwdriver to turn the sector shaft adjusting screw counterclockwise until you feel lash at the sector shaft. See **Fig. 1**.

IMPORTANT: Do not use more than 10 lbf·ft (14 N·m) of force when tightening the adjusting screw.

7. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the sector shaft. From this position, turn the screw clockwise 1/8 to 3/16 of a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).
8. Turn the steering wheel 1/4 of a turn each side of center then back to center and check the pitman arm for lash. There should be no lash. If lash is detected, loosen the jam nut and repeat the previous step as well as this step.
9. Using a castle nut, attach the drag link to the pitman arm. Tighten the castle nut using the appropriate torque value:

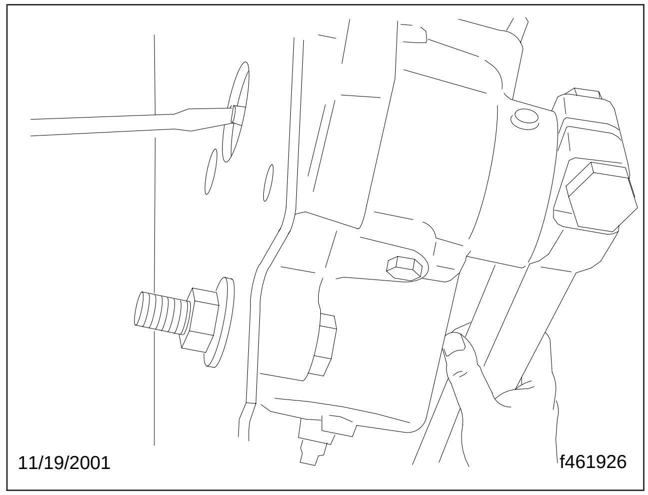


Fig. 1, Adjusting the Sector Shaft

- 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
- 7/8–14: 160 to 300 lbf·ft (217 to 407 N·m)

WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.

10. Continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

NOTICE

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high-pressure seal and contaminate the hydraulic fluid.

11. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.

Poppet Adjustment on a Single Gear

Resetting the Poppet Valves

1. Check that the axle stops are adjusted properly. See **Group 33** for instructions.
2. Start the engine and allow the vehicle to idle for 5 to 10 minutes to warm the hydraulic fluid.
3. Shut down the engine, apply the parking brakes, and chock the rear tires.
4. Hold the poppet screw with a wrench and turn the sealing nut back toward the wrench until the nut is flush with the base of the hex area of the poppet screw.
5. Make sure that the engine is off and the wheels are in the straight-ahead position.

NOTICE

Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.

6. Using a 7/32-inch Allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing. See **Fig. 1**.

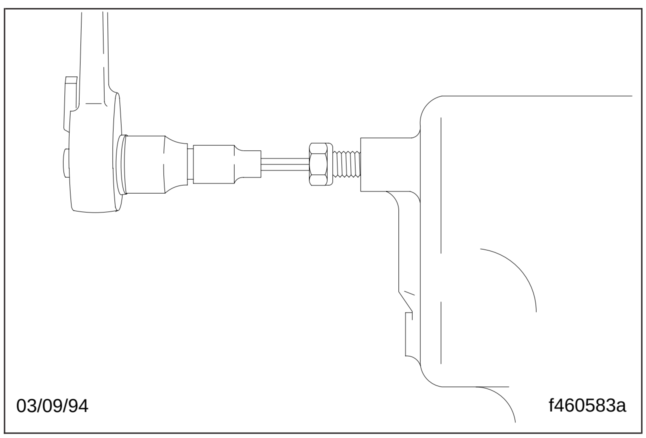


Fig. 1, Adjusting Screw and Nut Assembly

7. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.
8. Push the upper poppet out to prepare it for setting.
   - 8.1 Start the engine and let it idle.
   - 8.2 Note which sector shaft timing mark is nearest the housing piston bore.

NOTICE

Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.

   - 8.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the wheel in this direction until axle stop contact is made.
   - 8.4 Pull hard on the steering wheel. Put up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel.
9. Set the upper poppet.
   - 9.1 Turn the steering wheel in the opposite direction (the timing mark will move away from the adjusting screw) until the other axle stop is contacted.
   - 9.2 Pull hard on the steering wheel. Put up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel.
   - 9.3 Release the steering wheel and shut off the engine.
10. Loosen the sealing nut and back out the adjusting screw until the adjusting screw is one inch (2.5 cm) past the nut. See **Fig. 2**. Tighten the nut against the housing.
11. Set the lower poppet.
   - 11.1 Start the engine and let it idle.
   - 11.2 Turn the steering wheel in the original direction (the timing mark will move toward the adjusting screw) until axle stop contact is made.
   - 11.3 Hold the steering wheel in this position with up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.
12. Position the adjusting screw.

Poppet Adjustment on a Single Gear

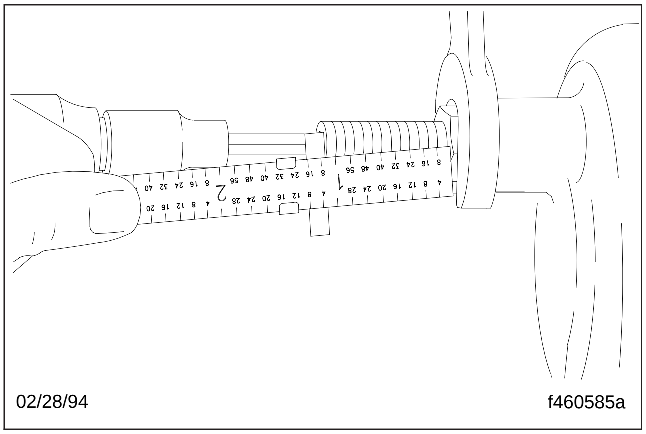


Fig. 2, Adjusting Screw Position

12.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

12.2 Using an Allen wrench and finger pressure only, turn the adjusting screw clockwise until the Allen wrench stops. Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

12.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

WARNING

If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in personal injury or property damage.

IMPORTANT: Once the poppet adjusting screw and sealing nut are in place, and the poppet valves have been manually adjusted, the adjustment procedure must be repeated if steering travel is either increased or decreased in the future.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

13. The poppets have now been completely reset. Check the power steering reservoir. The power steering fluid level should be between the MIN COLD mark and the middle mark just above it. If needed, add fluid.
14. Lower the vehicle.

Post-Service Checks

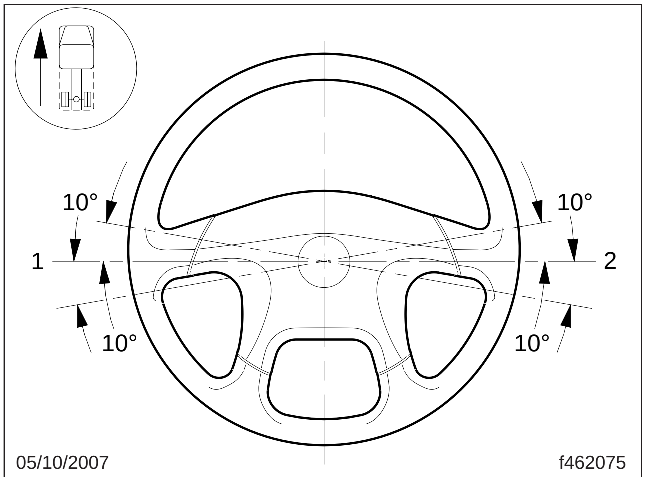
After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

WARNING

Failure to check the following items could result in damage to the power steering system. This could cause loss of steering assist and spillage on the roadway, which could cause personal injury or property damage.

1. Operate the engine at idle while turning the steering wheel through several full-left and full-right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).

   If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system. Refer to **Subject 110** for instructions.
2. With the engine turned off and warm, check the power steering reservoir fluid level. If needed, add power steering fluid.
3. At full-left and full-right turns, be sure the axle stops on the rear side of the spindle are set so there is at least 1/2 inch (13 mm) of clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be at least 3/4 inch (19 mm). If clearance is less than the above, reset the axle stops.
4. Check that the poppets are set correctly. If needed, adjust them. For instructions, refer to **Subject 140**.
5. Test drive the vehicle. Check the steering wheel spoke position. If, during straight-ahead driving on a level road, the steering wheel spokes are not within ±10 degrees of the 9 o'clock and 3 o'clock positions, remove the steering wheel and reposition it. See **Fig. 1**.



1. 9 o'Clock Position
2. 3 o'Clock Position

Fig. 1, Steering Wheel Centered

Specifications

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

THP and PCF power steering gears use automatic transmission fluid that meets Dexron II, Dexron III, Mercon, or ATF +4™ specifications.

Exxon Polyrex® EP2 Grease (045422) is approved for use on steering gear components.

Special tools can be ordered from:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
1-800-328-6657

SPX Kent-Moore Tools	
Tool Name	**Part Number**
Bearing and Seal Tool	J37071 and J37071–A
Special Tool	J36452–A
Bearing Adjuster Tool	J37070
Seal Driver Tool	J37073
Adjuster Locknut Tool	J37464

Table 1, SPX Kent-Moore Tools

Troubleshooting Procedures

General Information

A *Checklist for Troubleshooting Power Steering Problems*, form STI-492, has been developed to accompany the procedures below. Form STI-492 can be downloaded or printed **here** after logging into **www.AccessFreightliner.com**.

Each step and substep in these troubleshooting procedures corresponds to a step or substep on form STI-492. Use **Table 1** to determine which steps should be completed, based on the customer's complaint. It is very important that the information provided by the driver is communicated accurately to prevent wasting of diagnostic time. For example, if complaints include "Pulling to one side" and "Noisy steering," steps 1, 3, 4, 5, and 6 will be the tests for the most likely failure modes.

Start with the lowest test number and work up to the highest. For example, when completing steps 1, 3, and 6 to determine the cause of a vehicle pulling to one side, start with step 1 and finish with step 6.

Troubleshooting Steps

NOTE: Some of these inspections and procedures can be found in the Pretrip and Post-Trip Inspections and Maintenance chapter in the vehicle driver's/operator's manual.

Steps 1 through 4 may have been performed by the customer. Verify the vehicle service history with the customer to prevent redundant testing.

All measurements and readings must be recorded on STI-492.

Refer to the applicable section in this manual to repair or replace steering system components.

1. Check the tire pressure and load.

   1.1 Check the tires for damage.

   1.2 Check that the front tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

   Low pressure causes increased steering effort due to friction with the road surface. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side.

<table>
<tr><th colspan="13">Steering Complaint and Troubleshooting Steps Checklist</th></tr>
<tr><th rowspan="2">LH</th><th rowspan="2">RH</th><th rowspan="2">Both</th><th rowspan="2">Complaint</th><th colspan="9">Troubleshooting Steps</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th></tr>
<tr><td></td><td></td><td></td><td>Hard or heavy steering</td><td rowspan="5">•</td><td rowspan="5">•</td><td rowspan="5"></td><td rowspan="5">•</td><td rowspan="5">•</td><td rowspan="5">•</td><td rowspan="5">•</td><td rowspan="5">•</td><td rowspan="5">•</td></tr>
<tr><td></td><td></td><td></td><td>Low assist</td></tr>
<tr><td></td><td></td><td></td><td>Binding</td></tr>
<tr><td></td><td></td><td></td><td>Locking</td></tr>
<tr><td></td><td></td><td></td><td>Occasional loss of assist</td></tr>
<tr><td></td><td></td><td></td><td>Reduced wheel cut</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>•</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Pulling to one side*</td><td>•</td><td></td><td>•</td><td></td><td></td><td>•</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Darting/oversteering</td><td rowspan="2">•</td><td rowspan="2">•</td><td rowspan="2">•</td><td rowspan="2">•</td><td rowspan="2"></td><td rowspan="2">•</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td><td>Wandering</td></tr>
<tr><td></td><td></td><td></td><td>Noisy steering</td><td></td><td></td><td></td><td>•</td><td>•</td><td>•</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>External seals leaking</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">•</td><td rowspan="2">•</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">•</td></tr>
<tr><td></td><td></td><td></td><td>Excessive heat</td></tr>
</table>

* If there is consistent pull to one side, a braking issue could feel like a steering assist problem. Refer to **Group 42** in this manual to ensure the brake system is functioning properly.

Table 1, Steering Complaint and Troubleshooting Steps Checklist

Troubleshooting Procedures

1.3 Check that the rear tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

1.4 Check that the tire sizes are correctly matched, and whether duplex or oversized tires (that were not originally specified for the vehicle) have been installed.

Extra tire width causes increased steering effort due to extra friction with the road surface. If the axle stops were turned out to reduce wheel cut due to a change in tires, the power steering gear poppets may need to be adjusted.

1.5 Communicate with the driver or operator to determine whether the vehicle is operated at or over the rated load.

Increased load causes greater steering effort. Make sure the vehicle is being operated within rated capacities.

2. Check fifth wheel lubrication and condition.

A dry fifth wheel plate makes it difficult to change direction. Check the plate surface for burrs, gouges, and irregularities.

3. Check vehicle alignment and wheel bearing adjustment.

3.1 Check the vehicle service history for the last known alignment, and inspect tire wear for indications that an alignment needs to be completed.

3.2 Check front axle caster and camber measurements.

3.3 Ensure wheel bearings and rear axle are in good condition, and that toe is set correctly.

3.4 Ensure the rear axle is properly aligned.

4. Check for loose and binding components. Check whether any steering components need maintenance or adjustment.

4.1 Check for proper lubrication of the drag link, tie rods, and knuckle pins. Apply lubrication as needed.

4.2 Check the COE steering column, if equipped. Chock the rearmost tires. With the engine shut down, turn the steering wheel and check for looseness or binding. Make sure all components are free to move, but are not excessively loose.

4.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed.

4.4 Check the sector shaft adjustment.

- With the vehicle on the ground, the engine idling, and the front tires pointed straight ahead, turn the steering wheel until slight motion is observed at the front wheels.
- Align a reference mark on the steering wheel to a rule, then, with the engine running, slowly turn the steering wheel in the opposite direction until motion is again detected at the wheels.
- Measure the lash (free play) at the rim of the steering wheel.

Excessive lash exists if steering wheel movement exceeds 2-1/2 inches (64 mm) with a 20-inch (508-mm) steering wheel, or 2-1/4 inches (57 mm) with an 18-inch (457-mm) steering wheel.

4.5 Check that the front wheels self-return without binding.

- With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables).
- Disconnect the drag link from the steering arm.
- By hand, pull one tire to the axle stop and release. The tire should self-return to almost straight ahead.
- Repeat with the opposite tire.

If a tire does not return to near straight ahead, check for binding or lack of lubrication in the steering axle kingpin bushings or tie rod linkage.

- Connect the drag link and tighten the castle nut, then install a new cotter pin.

Troubleshooting Procedures

4.6 Inspect all suspension fasteners and components for wear or looseness.

5. Check the steering system for leaks and restrictions, and test the system back pressure.

5.1 Inspect hoses, fittings, and seals for damage or leaks.

- With the engine idling, inspect for kinked or collapsed hoses. Repair or replace any collapsed or kinked hoses. If collapsed hoses are found, ensure the steering system is filled with the correct automatic transmission fluid.
- Inspect fittings for leaks. Repair leaking fittings; replace parts as needed.
- Inspect all external seals. Replace leaking seals.

  Inspect the seal bores and sealing surfaces for scrapes or burrs. Make sure the seals are installed correctly using the recommended tools.
- If you replaced the steering gear input shaft seal and found it to be excessively hard, test the system operating temperature in step 6.

5.2 Inspect the steering gear for external leakage.

- Clean the area around the input shaft and inspect the input shaft for signs of leakage after operating the vehicle under normal conditions through steering maneuvers.
- Inspect the sector shaft for signs of leakage. A well greased or heavily used steering gear may weep oil from the grease seal, but a confirmed leak will be evidenced by fluid collecting while the vehicle is being operated under normal conditions.
- Inspect the vent plug in the trunnion housing for signs of leakage. Any fluid in or around the rubber vent plug indicates leakage from an internal steering gear seal.

NOTICE

Do not turn the steering wheel or allow system pressure to exceed the rating of the gauge during the following test. Damage to the gauge could occur.

5.3 Check total steering system back pressure.

- Install a low pressure gauge—300 psi (2068 kPa) maximum—between the steering pump and the steering gear.
- Check for correct fluid level. If necessary, add fluid. If bubbles or foam appear in the reservoir, check hose fittings for looseness or leaks.
- With the engine idling, read the total system back pressure on the pressure gauge.
- If the total system back pressure is greater than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, replace the steering fluid filter and re-test the system. If the system back pressure is still excessive, go to the next substep.

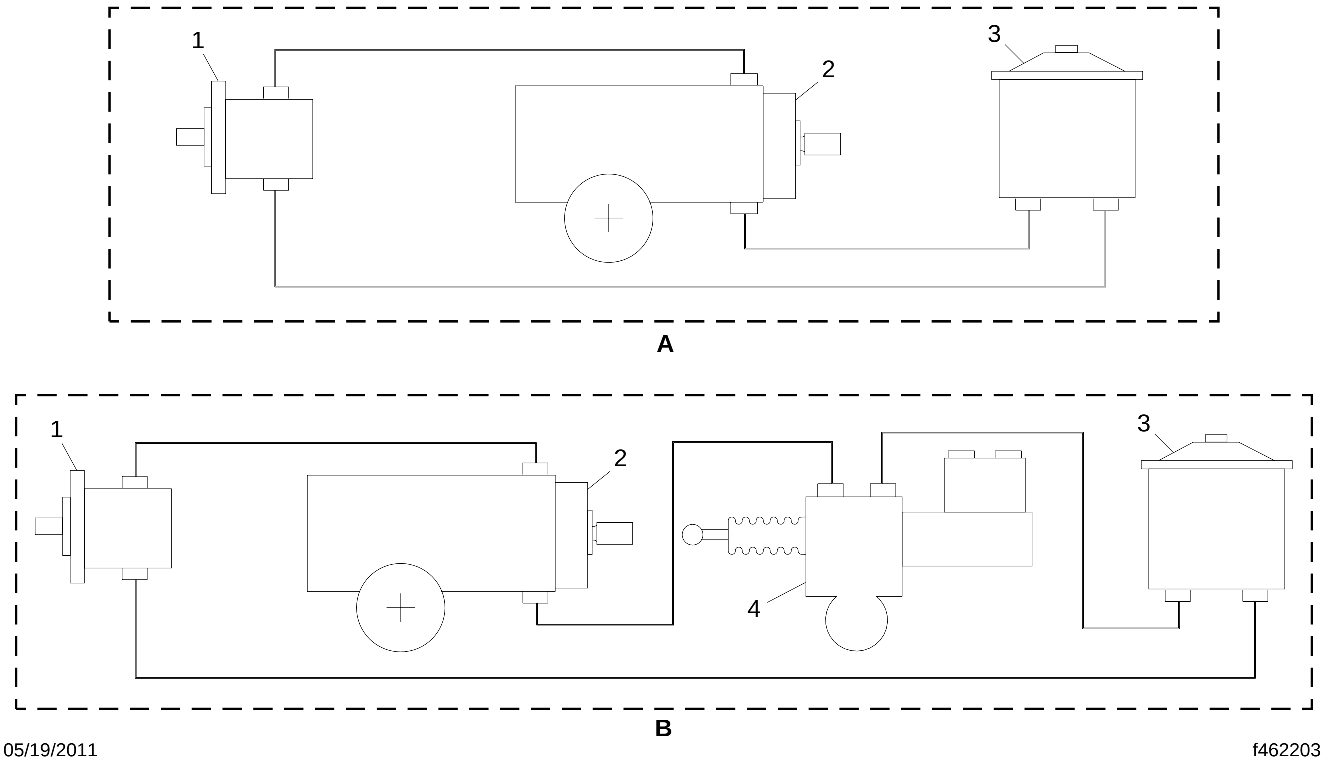
  If the total system back pressure is less than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, restriction is not a problem—go to step 6.

5.4 Leave the low pressure gauge in place and check individual steering system components for excessive restriction. See **Fig. 1** for a plumbing diagram.

- Bypass the steering gear by disconnecting the steering gear input and output lines from the gear and coupling them together. See **Fig. 2** for an example.

  If the drop in system pressure from the value found in substep 5.3 is greater than 55 psi (379 kPa), the steering gear has excessive restriction. If the drop in pressure is less than 55 psi (379 kPa), reconnect the

Troubleshooting Procedures



A. Vehicles With Air Brakes
B. Vehicles With Hydraulic Brakes
1. Steering Pump
2. Steering Gear
3. Reservoir
4. Brake Booster

Fig. 1, Plumbing Diagrams

gear input and output lines to the gear and continue with this substep.

- If the vehicle is equipped with hydraulic brakes, bypass the brake booster by disconnecting the booster input and output lines and coupling them together.

  If the drop in system pressure from the value found in substep 5.3 is greater than 40 psi (276 kPa), the brake booster has excessive restriction. If the drop in pressure is less than 40 psi (276 kPa), reconnect the booster input and output lines and continue with this substep.

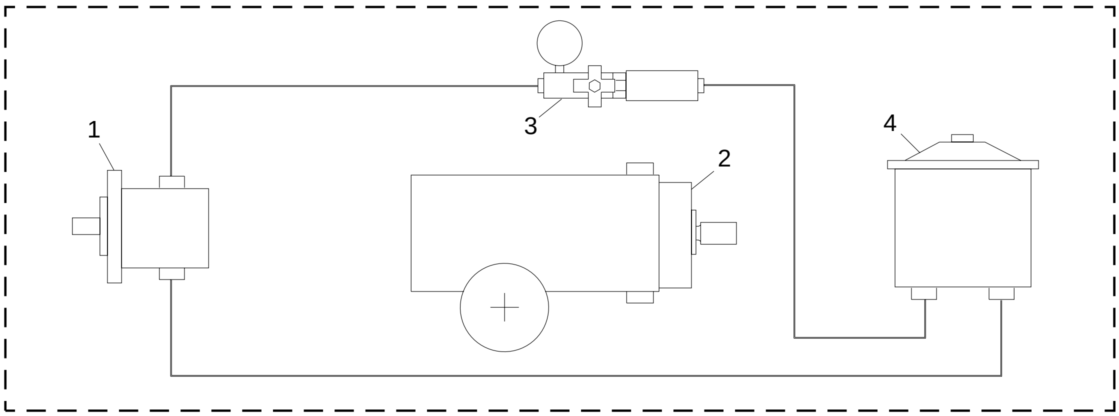
- Test each hydraulic line in the power steering system individually by bypassing them one at a time, as was done with the steering gear and brake booster, if equipped.

  If the drop in system pressure from the value found in substep 5.3 is greater than 12 psi (83 kPa) for any one line, replace the line and test total system back pressure again.

6. Check steering pump performance. Power steering fluid temperature should be approximately 180°F (82°C) to best replicate fluid temperatures under normal driving conditions.

   If the system fails the tests in the following substeps, replace the pressure relief valve (PRV) and complete the tests in the substeps below again. If the system fails again, replace the pump.

Troubleshooting Procedures



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1. Steering Pump
2. Steering Gear
3. Low Pressure Gauge
4. Reservoir

Fig. 2, Testing Steering Gear Restriction

Install the PSSA between the steering pump and the gear for the following substeps. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.

NOTICE

Do not leave the load valve closed for longer than five seconds during the following test. Doing so could damage the power steering system.

6.1 Check for erratic pump response.

- Slowly close the load valve and watch the pressure and flow readings as the valve closes, then open the valve immediately.
- If the pressure rises rapidly or appears uncontrolled, open the load valve immediately.
- If the response was erratic, replace the PRV or pump, as required. If the response was smooth and controlled, go to the next substep.

6.2 Check the pump relief pressure.

- Slowly close the load valve. When the valve is completely closed, read the pressure gauge, then open the valve.
- If the pump relief pressure does not exceed the relief pressure in **Table 2** or **Table 3**, refer to the pump manufacturer's service literature to verify the exact relief pressure for the pump.
- If the pump relief pressure does not exceed the relief pressure in **Table 2**, **Table 3**, or the pump manufacturer's specifications, replace the PRV or pump, as required.
- If the pump relief pressure exceeds the relief pressure in **Table 2** or **Table 3**, it is acceptable. Go to the next substep.

6.3 Test the pump relief valve reaction at idle.

- Run the engine at idle and note the flow rate with the load valve open.

Troubleshooting Procedures

Minimum Measured Pump Flow and Relief Pressure at Engine Idle				
Power Steering Gear	**Flow at 1500 rpm, No Load: gpm (L/min)**	**Flow at 1000 psi (6900 kPa): gpm (L/min)**	**Flow at 1800 psi (12 400 kPa): gpm (L/min)**	**Typical Relief Pressure: psi (kPa)**
Sheppard M100	3.7 (14.0)	2.8 (10.6)	2.3 (8.7)	2175 ± 100 (15 000 ± 700)*
TRW TAS40	3.7 (14.0)	2.1 (7.9)†	1.6 (6.1)	
TRW TAS55		2.4 (9.1)†	1.9 (7.2)	
TRW TAS65		2.8 (10.6)†	2.3 (8.7)	
TRW TAS85		3.3 (12.5)	2.8 (10.6)	
TRW TAS65 With C28 or C32 Linear Cylinder	5.8 (22.0)	4.9 (18.5)	4.4 (16.7)	
TRW TAS65 With RCS65				
TRW TAS85 With C28 or C32 Linear Cylinder		5.4 (20.4)†	4.9 (18.5)	
TRW TAS85 With RCS65				
ThyssenKrupp LZS5 Rack and Pinion	3.7 (14.0)	3.3 (12.5)	2.8 (10.6)	2300 ± 116 (15 500 ± 800)

* On vehicles with TRW TAS steering gears and hydraulic brakes, typical relief pressure is 2375 ± 100 psi (16 375 ± 690 kPa).

† Approximate value based on flow at 1800 psi (12 400 kPa).

Table 2, Minimum Measured Pump Flow and Relief Pressure at Engine Idle

Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle				
Power Steering Gear	**Flow at 1500 rpm, No Load: gpm (L/min)**	**Flow at 1000 psi (6900 kPa): gpm (L/min)**	**Flow at 2300 psi (15 860 kPa): gpm (L/min)**	**Typical Relief Pressure: psi (kPa)**
Sheppard HD94	3.7 (14.0)	2.6 (9.8)	1.8 (6.8)	2683 ± 100 (18 500 ± 700)
TRW THP45		2.2 (8.3)	1.4 (5.3)	
TRW THP60 or PCF60		2.6 (9.8)	1.8 (6.8)	
TRW THP60 With Linear Cylinder	5.8 (22.0)	4.1 (15.5)	3.3 (12.5)	
TRW THP60 With RCH45				

Table 3, Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle

- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this action three times. The flow rate should return to the flow rate first noted with the load valve open.
- If the flow rate does not return smoothly and quickly, the pump relief valve is not working correctly. Replace the replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.4 Test the pump relief valve reaction at 1500 rpm.

- Run the engine at 1500 rpm and note the flow rate with the load valve open.
- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this ac-

tion three times. The flow rate should return to the flow rate first noted with the load valve open.

- If the flow rate does not return smoothly and quickly, replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.5 Test the flow of the pump at idle with a load applied.

For vehicles with low-pressure steering gears, run the engine at idle and slowly close the load valve until the pressure gauge reads 1000 psi (6900 kPa). Read the flow rate on the gauge, then set the pressure to 1800 psi (12 400 kPa). Read the flow gauge, then open the load valve. Compare the values to those in **Table 2**.

For vehicles with high-pressure steering gears, use 1000 psi (6900 kPa) and 2300 psi (15 860 kPa) as the test load pressures. See **Table 3** for minimum flow rate.

6.6 Test the maximum flow of the pump with no load applied.

- Run the engine at 1500 rpm, make sure the load valve is completely open, and read the flow gauge.
- If the flow rate is below the minimum indicated in **Table 2** or **Table 3**, replace the PRV or pump, as required.
- If the flow rate is above 5.5 gpm (20.8 L/min) on a vehicle with a single steering gear, or 7.7 gpm (28.8 L/min) on a vehicle with an assist cylinder installed, replace the pump.

7. Test the steering gear internal leakage.

Select TRW integral steering gears and all ThyssenKrupp rack and pinion steering gears are equipped with an internal PRV that significantly limits maximum supply pressure to protect the steering gear. These gears, unlike gears on vehicles fitted with hydraulic brake boosters, cannot be tested for internal leakage by plugging the internal PRV in the gear. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® for the specific VIN to determine if the steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If a TRW steering gear has an internal PRV but no hydraulic brake booster, see the following heading, **Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV**, for instructions on setting up the necessary test components before proceeding with the following substeps.

ThyssenKrupp rack and pinion steering gears are also equipped with an internal PRV, but cannot be tested for internal leakage.

IMPORTANT: Make sure the fluid temperature is approximately 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

7.1 Run the engine at idle with the load valve open.

WARNING

Keep fingers clear of the stop bolt and spacer block during the following test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the stop bolts or eject the spacer block, which could cause serious personal injury.

7.2 Place an unhardened steel spacer, 1-inch (25-mm) thick, between the axle and the stop bolt on one side of the axle.

The spacer should have an extension or handle long enough to keep fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

NOTICE

While running the following test, do not hold the steering wheel in the full-turn position for more than five seconds. Doing so could damage the pump.

Troubleshooting Procedures

7.3 Have someone turn the steering wheel, applying enough force to completely close the rotary valve.

Complete closure of the rotary valve requires approximately 20 lbf (27 N) pull on the steering wheel, and will be indicated by a pressure reading nearly equal to the system relief pressure (tested in substep 6.2).

7.4 Hold the steering wheel in the full-turn position. Note the steering gear internal leakage on the PSSA.

7.5 Repeat the previous substeps for the opposite turn.

The maximum permissible internal leakage for a single gear is 1.0 gpm (3.8 L/min). If leakage is greater in either turning direction, replace the steering gear components as needed.

For systems with two or more steering gears and/or linear cylinders, the total acceptable internal leakage is 1.0 gpm (3.8 L/min) for each steering gear/ram in the system. Maximum internal leakage on a dual-gear system is 2.0 gpm (7.6 L/min). If the leakage is more than 2.0 gpm (7.6 L/min) on a dual-gear system, isolate the auxiliary cylinder from the system using the substeps that follow.

7.6 Disconnect the auxiliary cylinder hydraulic lines at the main gear auxiliary ports.

7.7 Plug the main steering gear ports with suitable steel or high-pressure plugs or caps.

7.8 Repeat the internal leakage test.

If the internal leakage is less than 1 gpm (3.8 L/min), repair or replace the auxiliary gear or linear cylinder. If the internal leakage is greater than 1 gpm (3.8 L/min), repair or replace the main gear.

8. Check the steering gear poppet relief valve and stop bolt adjustment.

NOTE: Poppets limit the steering assist when the front wheels approach the stop bolts. Improper adjustment can apply excessive force to the steering linkage, or cause loss of assist, as the steering wheel approaches either full-left or full-right turn.

8.1 Check the steering system for stop bolt adjustment.

Make sure the stop bolt settings limit the steering travel so there is ½-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.

8.2 Make sure the pitman arm is situated on the steering gear sector shaft correctly. Check that the pitman arm and sector shaft timing marks are aligned.

NOTICE

If power steering pump relief pressure is reached while the steering wheel is at full lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.

8.3 Check the poppet relief pressure.

- Install the PSSA between the steering pump and the steering gear. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.
- Run the engine at idle with the load valve open. Turn the steering wheel to either full-lock position. Note the pressure gauge reading, then repeat for the opposite turn.
- The pressure should drop slightly before the stop bolts are contacted. If the pressure increases (from contact with the stop bolts), the poppets must be manually reset.

  If the pressure is relieved and assist is lost when the wheel is too far from the axle stop bolts, refer to the applicable section in this manual for gear-specific information.
- After poppet replacement or adjustment, test again for correct poppet relief function and record the new pressure.

8.4 Check for normal hissing sound at full turn.

NOTE: Noise from the power steering system does not necessarily mean there is a problem. Some noises are normal and are the result of proper operation.

See **Table 4** for possible causes and remedies for common noises associated with the power steering system and power steering pump.

8.5 Check for abnormal power steering noise.

Listen for a hissing sound at less than full turn. If a hissing sound is heard, check the steering gear poppet and the axle stop adjustment.

NOTICE

If the temperature exceeds 250°F (121°C), damage to hoses, seals, and other components may result if the vehicle continues to operate at excessive steering system temperatures. If this temperature is exceeded, stop the test and record the last noted temperature on STI-492.

9. Test the system operating temperature.

- Run the engine at governed speed.
- Observe the power steering fluid temperature until it stabilizes.
- Record the power steering fluid temperature in 10-minute intervals until 40 minutes have passed.
- If the temperature does not exceed 250°F (121°C) during the test, excessive heat due to system components is probably not the cause of the complaint. The system may still experience overheating due to driving and load conditions.

  If the temperature exceeds 250°F (121°C), excessive steering system back pressure or excessive pump flow may be the cause of the high temperature problem. If system back pressure or restriction values found in substeps 5.3 and 5.4 above were close to the maximum allowable, complete step 5 again. If steering pump flow and relief pressures found in step 6 above were close to the maximum allowable, complete step 6 again.
- If excessive heat continues to be a problem, a cooler may need to be added to the system.

Power Steering System Noise	
Noise	**Remedy**
Growling or other abnormal steering noise	Check the fluid level. Check for air bubbles and foam. Check for hose and fitting leaks. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.
A change from the usual pump sound	Check the steering fluid reservoir for air bubbles and foam. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.
Clicking noise during a turn	Check for loose steering components. Tighten any loose steering components. Check the front suspension for insufficient spring pin shims. Add front spring pin shims if needed.
Hissing when the steering wheel is at or near full turn	This is normal; no action is needed.
Steering Pump intake line is plugged	Drain the system. Clear the intake line if needed. Fill the system.
Air leak at the pump or reservoir connections, fittings, or shaft seal	Check all the connections by pouring power steering fluid over them, and listening for a reduction in sound. Tighten all connections as needed.
Pump input shaft is misaligned	Replace the pump.

Table 4, Power Steering System Noise

Troubleshooting Procedures

Power Steering System Analyzer Setup

The hydraulic power steering system is tested with a Power Steering System Analyzer (PSSA), and with the hydraulic fluid at operating temperature. The PSSA and adaptor kit are available from SPX Kent-Moore.

A PSSA is a combination of a flow meter, a shutoff valve, and a high-pressure gauge. See **Fig. 3**. The PSSA will allow you to measure flow and pressure, and provide a load on the pump in the hydraulic lines of the steering system.

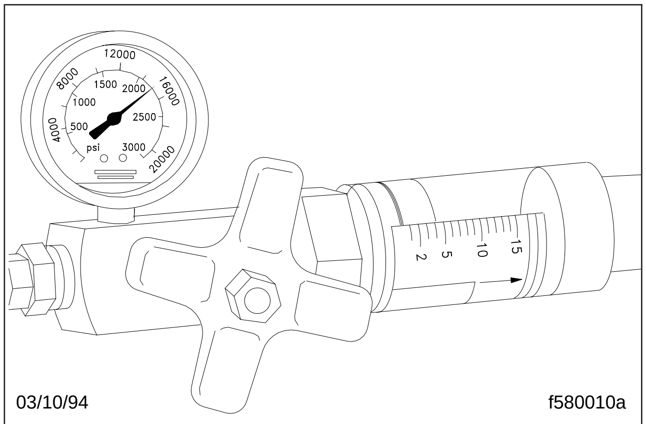


Fig. 3, Power Steering System Analyzer

1. Install a PSSA between the pump high-pressure line and the steering gear.
2. Fill and bleed the steering system as needed.

NOTICE

Do not leave the load valve fully closed for longer than five seconds. Doing so could damage the power steering system.

3. Run the engine at idle.
4. Partially close the load valve on the PSSA until the pressure gauge reads 1000 psi (6895 kPa).
5. Open the valve when the fluid temperature reaches about 180°F (82°C).

Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV

Select TRW steering gears are equipped with an internal PRV that limits maximum supply pressure to protect the steering gear. These gears cannot be tested for internal leakage using the standard procedure. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® to determine if a specific TRW steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If your TRW steering gear has an internal PRV, complete the following steps to set up the necessary internal leakage test components. See **Table 5** for a list of required leakage test components. The plumbing fittings and hose part numbers are recommended, but may be replaced with identical parts from other suppliers, if necessary.

The ThyssenKrupp rack and pinion steering gear is also equipped with an internal PRV, but cannot currently be tested for internal leakage.

IMPORTANT: The front wheels must be raised or on turnplates during this procedure.

1. Turn the engine off. Remove the relief valve cap, O-ring, and relief valve from the steering gear. See **Fig. 4**.
2. Install the relief valve plug, J-37130, in the internal PRV hole. Install the relief valve cap and O-ring over the plug.
3. Assemble the relief valve cartridge body, relief valve, and tee fittings as shown in **Fig. 4**.
4. Install the PSSA and other test components as shown in **Fig. 4**.
5. Open the external relief valve (**Fig. 4**, Item 15) on the relief valve cartridge. Ensure the PSSA shutoff valve is fully open.
6. Raise the front wheels off the ground and turn the steering wheel to the right and left full-lock positions five times to bleed air from the system.
7. Start the engine and bleed the remaining air out of the system by continuing to turn the wheel from side to side.

Troubleshooting Procedures

NOTICE

Do not leave the PSSA shutoff valve fully closed for longer than five seconds. Doing so could damage the power steering system.

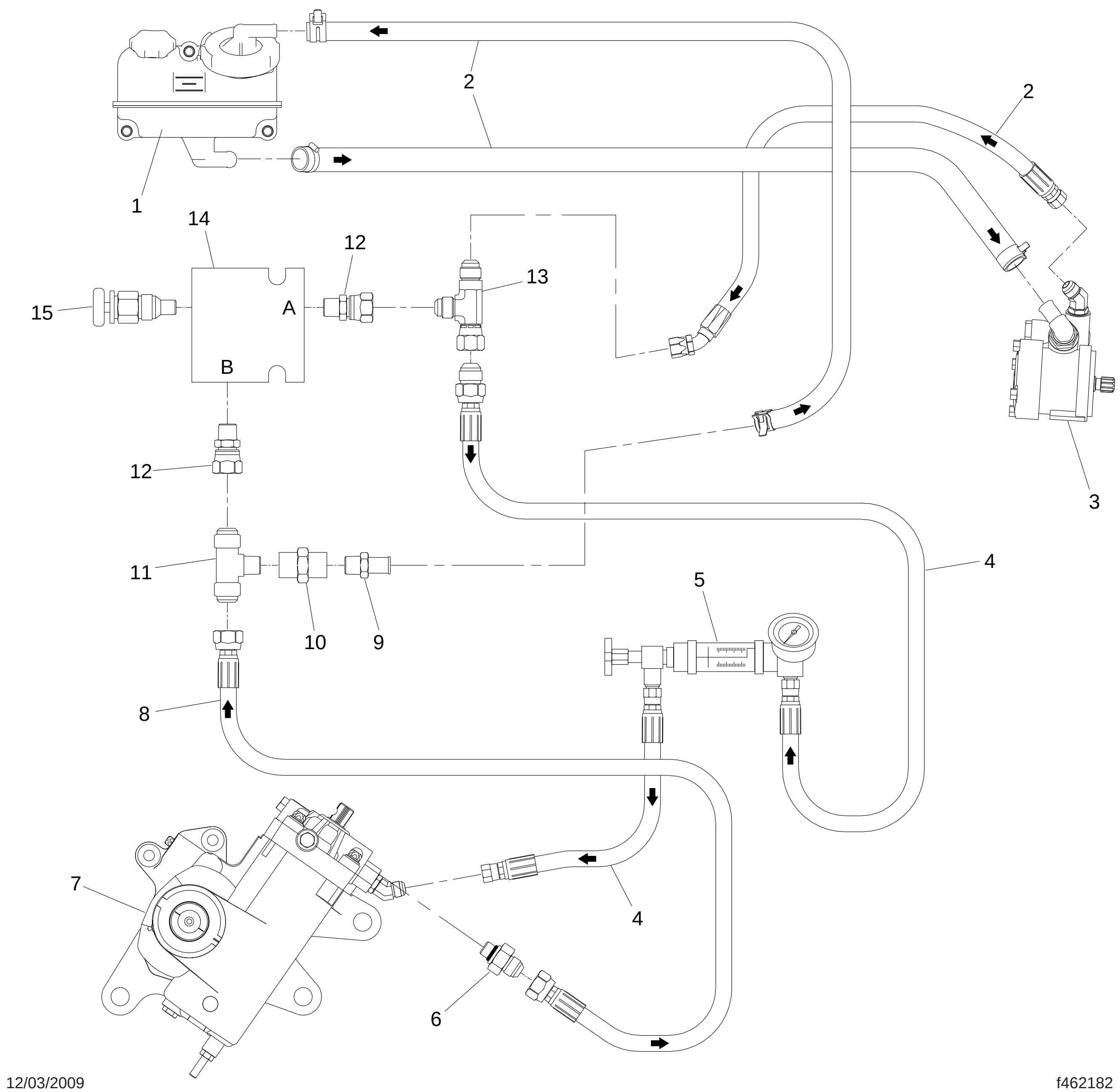
8. With the engine on, close the shutoff valve on the PSSA.
9. Set the system relief pressure by closing the external relief valve (**Fig. 4**, Item 15) until the gauge on the PSSA reaches 2,000 psi (13 790 kPa), then fully open the shutoff valve on the PSSA.
10. Continue with the steering gear internal leakage test (step 9 of the **Troubleshooting Steps** heading above).

Internal Leakage Test Components			
Part	**Available From**	**Part Number (Vendor P/N)**	**Item #, Fig. 4**
Power Steering System Analyzer (PSSA)	SPX Kent-Moore	J-26487	5
PSSA Adaptor Kit	SPX Kent-Moore	J-28593	—
Relief Valve Plug	SPX Kent-Moore	J-37130	—
Connector, Straight Thread with O-Ring	Daimler Trucks PDC	23-11470-088	6
Power Steering Hose, 42"	Daimler Trucks PDC	14-12694-042	8
Connector, 3/8" Male NPT to 5/8" Beaded Hose Barb	Daimler Trucks PDC	23-11321-001	9
Pipe Coupling, 3/8" NPT	Parker Hannifin	PH 3/8 GG S (3/8 GG-S)	10
Tee, Male JIC with Male NPT Branch*	Parker Hannifin	PH 8STXS (8 STX-S)	11
Swivel Adaptor, 3/8" Male NPT to Female 37 degree JIC (qty 2)	Weatherhead	WH 9100X8X6 (9100x8x6)	12
Swivel Nut Run Tee	Parker Hannifin	PH 8 R6X S (8 R6X-S)	13
3/8" Female NPT Aluminum Relief Valve Threaded Cartridge Body	Parker Hannifin	B10-2-A6P (PH B102A6P)	14
Aluminum Hydraulic Threaded Cartridge Relief Valve with Knob	Parker Hannifin	PH RAH101K30 (RAH101K30)	15

* Use steel 37 degree JIC fittings only.

Table 5, Internal Leakage Test Components

Troubleshooting Procedures



A. High-Pressure Input Port
B. Low-Pressure Output Port

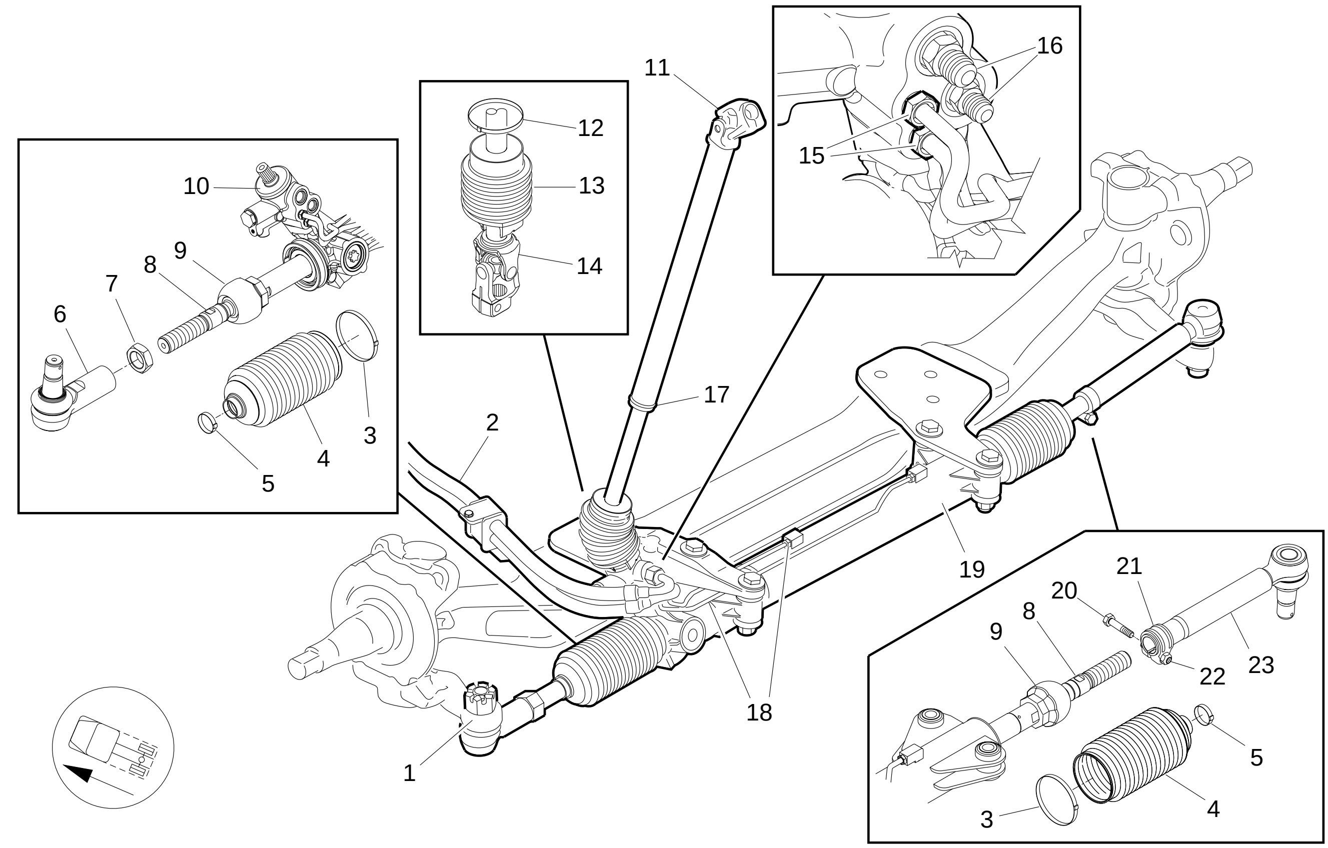
1. Power Steering Fluid Reservoir
2. Existing Power Steering Fluid Lines (Qty 3)
3. Power Steering Pump
4. PSSA Fluid Lines (Qty 2)
5. PSSA
6. Connector, Straight Thread with O-Ring
7. Power Steering Gear (TAS85 shown)
8. Power Steering Hose, 42"
9. Connector, Male NPT to Beaded Hose Barb
10. Pipe Coupling
11. Tee, Male JIC with Male NPT Branch
12. Swivel Adaptor (Qty 2)
13. Swivel Nut Run Tee
14. Relief Valve Threaded Cartridge Body
15. External Relief Valve, Threaded Cartridge Type

Fig. 4, Internal Leakage Test Component Installation

Principles of Operation

The rack and pinion steering system is mounted to the front axle with two brackets, and connected by outer tie rods to the tie rod arms that pivot the wheels. See **Fig. 1**. When the steering wheel is turned, the intermediate steering shaft turns the input shaft, rotating the torsion bar and pinion gear within the rack housing. When the torsion bar twists, power steering fluid provides power assist, via a rack-mounted piston, to the pinion gear, moving the rack. The rack, with a tie rod at each end, then moves the tie rod arms.

General Information



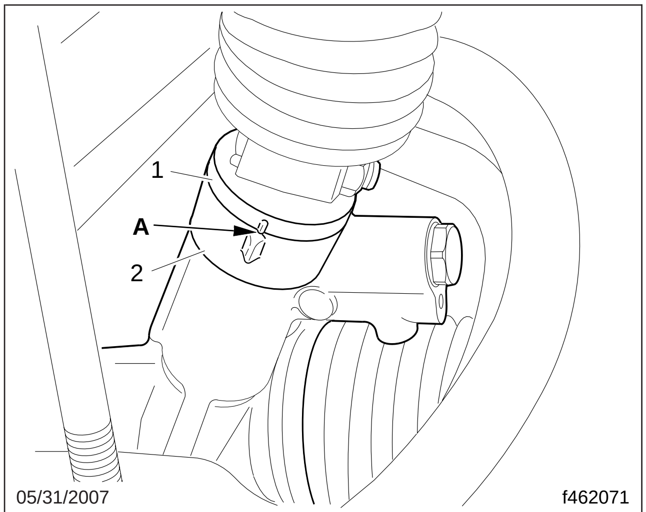
1. Steering Tie Rod Arm
2. Power Steering Fluid Lines
3. Large Bellows Clamp
4. Bellows
5. Small Bellows Clamp
6. Driver-Side Outer Tie Rod
7. Tie Rod Jam Nut
8. Inner Tie Rod Flat
9. Inner Tie Rod Ball Joint
10. Input Shaft Seal Cover
11. I-Shaft Upper Yoke
12. I-Shaft Lower Yoke Boot Clamp
13. I-Shaft Lower Yoke Boot
14. I-Shaft Lower End Yoke
15. Transfer Line Tube Fittings
16. Power Steering Fluid Line Fittings
17. I-Shaft Slip Joint
18. Transfer Lines
19. Rack and Pinion Gear
20. Pinch Bolt
21. Tie Rod Clamp
22. Tie Rod Clamp Nut
23. Passenger-Side Outer Tie Rod

Fig. 1, Rack and Pinion Steering System

Alignment

Rack and pinion steering gears require a different alignment procedure from integral (recirculating ball) steering gears, and can only be aligned using a calibrated, computerized, multiwheel alignment tool, operated by a certified service technician.

1. Complete the setup needed for the computerized alignment tool (identical to the setup for integral steering gears).
2. With the wheels on turnplates, center the rack travel by aligning the timing pointers on the input shaft seal cover and the input shaft housing. (**Fig. 1**).



A. Align the pointers.

1. Input Shaft Seal Cover
2. Input Shaft Housing

Fig. 1, Rack and Pinion Pointer Alignment

3. Whenever the computerized alignment program requires that the steering wheel be pointed straight ahead, the steering rack on-center pointers should be aligned.

NOTE: Do not clock the steering wheel; it is clocked at the end of the procedure.

4. Adjust each tie rod length to obtain the specified toe-in dimension, as follows.

   4.1 Loosen the driver-side tie rod jam nut, see **Fig. 2**. If necessary, hold the inner tie rod in place with a backup wrench on the inner tie rod flat (**Fig. 2**, Item 3).

   4.2 With the gear on-center, place a wrench on the driver-side inner tie rod flat and align the left tire by rotating the inner tie rod.

   Total left side toe-in should be between 0 and 0.085 degrees.

   4.3 Tighten the tie rod jam nut 285 to 305 lbf·ft (386 to 413 N·m).

   4.4 Loosen the passenger-side tie rod clamp nut, see **Fig. 2**.

   4.5 With the gear on-center, place a wrench on the passenger-side inner tie rod flat and align the right tire by rotating the inner tie rod.

   Total right side toe-in should be between 0 and 0.085 degrees.

   4.6 Tighten the tie rod clamp nut 30 to 36 lbf·ft (41 to 48 N·m).

   IMPORTANT: Total toe-in for both sides should be as close to 0 degrees as possible, and no greater than 0.17 degrees.

NOTICE

Maximum wheel cut should not exceed 46 degrees. Excessive wheel cut may damage the inner tie rod.

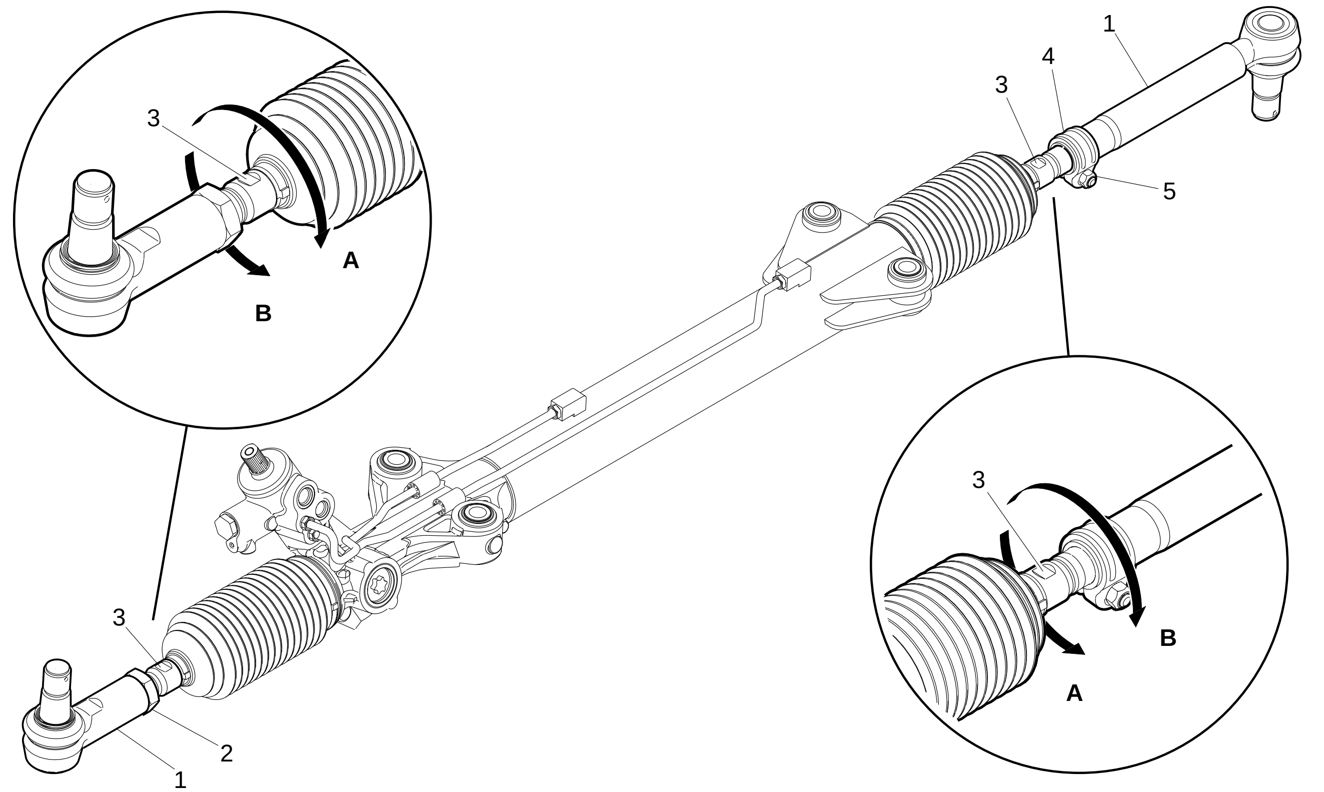
5. Turn the wheels as far right and left as possible to check for interference between the wheels/tires and other components. There must be at least 1/2 inch (13 mm) clearance from any fixed object, and 3/4 inch (19 mm) from any moving object.

IMPORTANT: The spline/pinch bolt connections between the steering gear and the last U-joint in the column fit in only one position, so reclocking the splined connections after alignment is not possible.

6. Make sure that the steering wheel is within 10 degrees of center as shown in **Fig. 3**. If not, remove and center the wheel, as follows.

   6.1 *If the vehicle has an airbag, deactivate and remove the airbag module according*

Rack and Pinion Alignment



A. Counterclockwise rotation *increases* the toe-in angle
B. Clockwise rotation *decreases* the toe-in angle

1. Outer Tie Rod
2. Tie Rod Jam Nut
3. Inner Tie Rod Flat
4. Tie Rod Clamp
5. Tie Rod Clamp Nut

Fig. 2, Rack and Pinion Gear Assembly

to the instructions in **Section 46.07**. If the vehicle does not have an airbag, remove the horn button by prying it out around the edge.

6.2 Loosen the nut that holds the steering wheel on the steering column, but leave it on the shaft until the wheel has been released from the tapered fit.

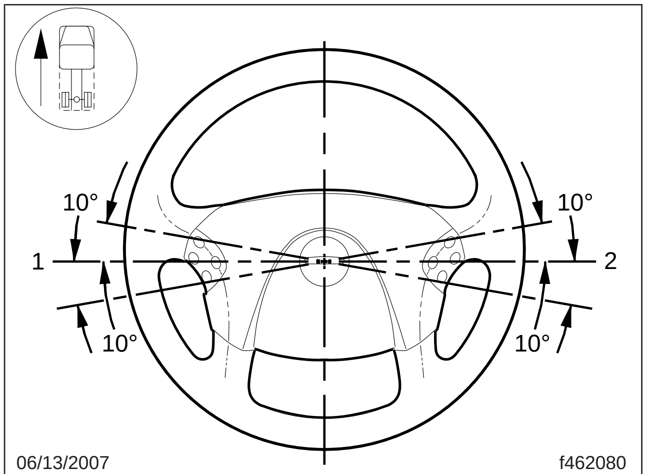
6.3 Remove the wheel from the tapered fit by striking it upward from below, at the rim/spoke intersections, with both hands.

6.4 Remove and discard the steering wheel nut, and install and center the steering wheel.

6.5 Install a new steering wheel nut and tighten it 33 to 41 lbf·ft (45 to 55 N·m).

6.6 *If the vehicle has an airbag, install and reactivate the airbag according to the instructions in* **Section 46.07**. If the vehicle does not have an airbag, install the horn button.

Rack and Pinion Alignment



1. 9 o'clock
2. 3 o'clock

Fig. 3, Steering Wheel Centered

Rack and Pinion Removal and Installation

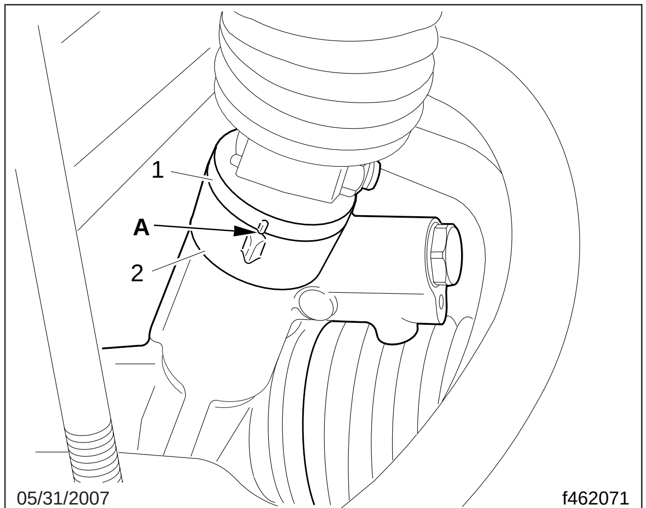
Removal

1. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done.
2. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
3. Clean all fittings and hose connections on the steering gear until they are free of dirt.
4. While holding the power steering fluid line fittings in place with a backup wrench, disconnect the fluid lines from the steering gear. Plug the lines and the fittings to keep out dirt and prevent fluid leakage.
5. Remove and discard the cotter pins and castellated nuts from the outer tie rods.

   Disconnect the outer tie rods from the tie rod arms.
6. Disconnect the end yoke of the steering I-shaft from the rack and pinion input shaft. Discard the pinch bolt and nut.
7. Remove and discard the steering gear mounting bolts and nuts that connect the rack and pinion to the axle steering gear brackets, then remove the gear.

Installation

1. Install the steering gear on the axle steering gear brackets, using new mounting bolts and nuts. Tighten the fasteners 202 to 256 lbf·ft (274 to 347 N·m).
2. Attach the outer tie rods of the rack and pinion gear to the tie rod arms, using new castellated nuts. Tighten the castellated nuts 240 lbf·ft (325 N·m). Continue to tighten until the the next castellated nut slot aligns with the hole in the ball stud and insert the new cotter pin.
3. Center the rack travel and align the timing pointers on the input shaft seal cover and the input shaft housing. See **Fig. 1**.
4. Using a new pinch bolt and nut, attach the steering I-shaft to the steering gear input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).



A. Align the pointers.

1. Input Shaft Seal Cover
2. Input Shaft Housing

Fig. 1, Rack and Pinion Pointer Alignment

5. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and nut.
6. If needed, install power steering fluid line fittings (**Fig. 2**, Item 5) on the steering gear and tighten 30 to 35 lbf·ft (41 to 47 N·m).
7. Connect the power steering fluid lines to the fittings, ensuring that the hoses do not touch the axle or each other. While holding the fittings in place with a backup wrench, tighten the pressure hose 43 to 47 lbf·ft (58 to 64 N·m) and the return hose 55 to 61 lbf·ft (75 to 83 N·m).

NOTICE

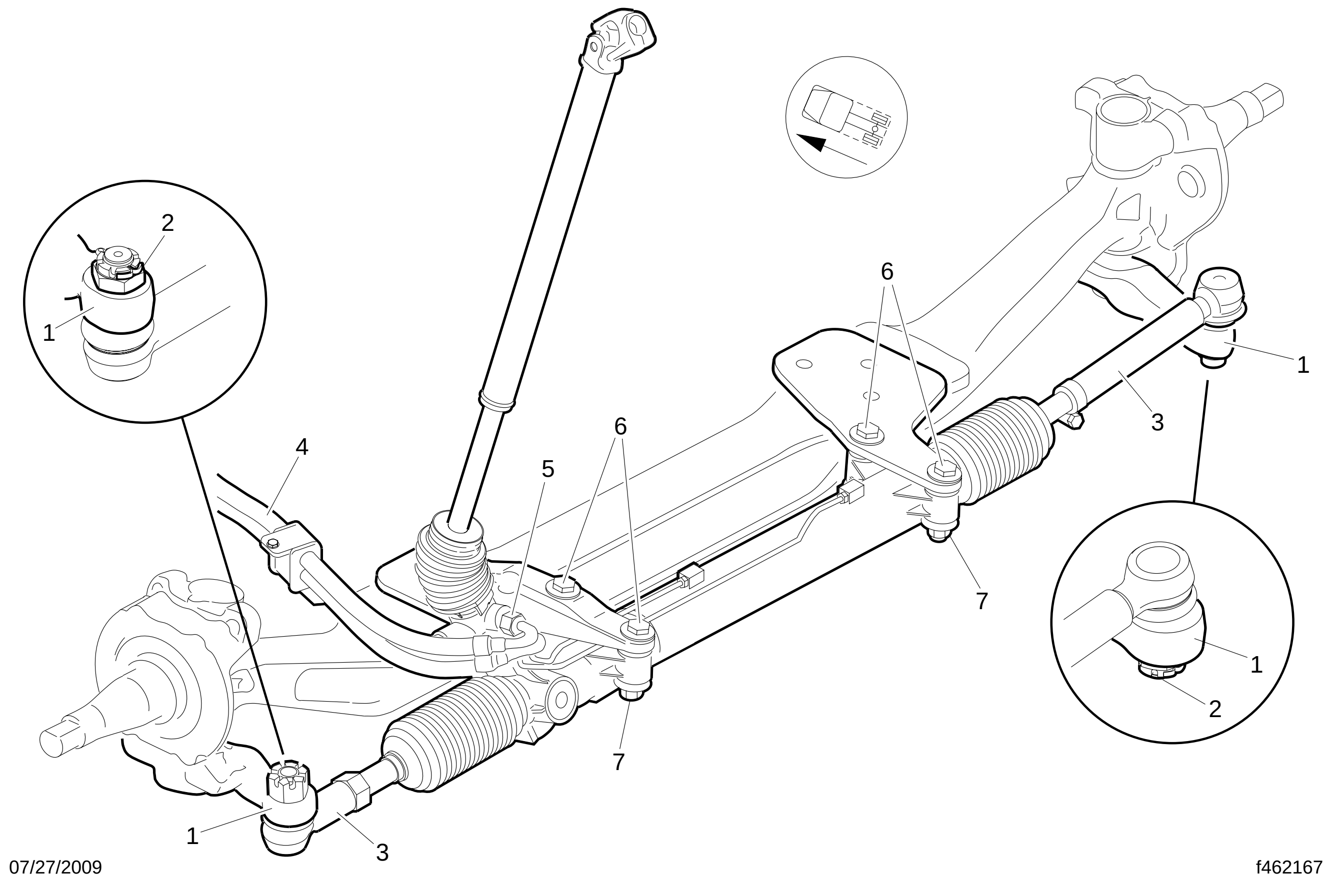
Do not loosen or tighten the hard transfer line tube fittings. Tightening the tube fittings can cause the O-ring seal to leak.

8. Fill and bleed the power steering system.

   8.1 Raise the front wheels off the ground and support the vehicle with jack stands.

   8.2 Fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.

Rack and Pinion Removal and Installation



1. Steering Tie Rod Arm
2. Castellated Nut
3. Outer Tie Rod
4. Power Steering Fluid Lines
5. Power Steering Fluid Line Fittings
6. Steering Gear Mounting Bolts
7. Steering Gear Mounting Nuts

Fig. 2, Rack and Pinion Steering Gear Assembly

8.3 With the engine off, turn the wheel fully left and right five times to bleed the air from the rack.

8.4 Start the engine and turn the steering wheel fully left and right several times to bleed the remaining air from the system.

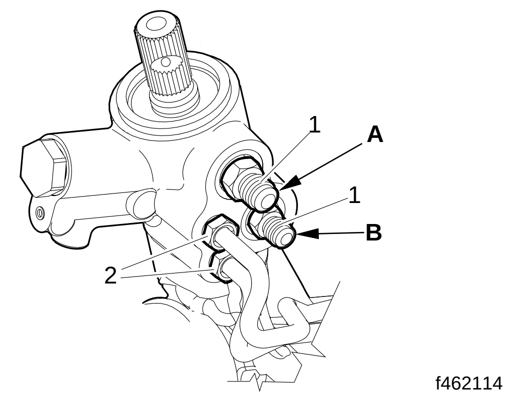
8.5 If the steering system needs additional bleeding, repeat the previous substep after the fluid in the reservoir has had time to release any air.

8.6 Remove the jack stands and lower the vehicle.

9. Set the toe-in using the instructions in **Subject 100**.

Replacement

1. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done.
2. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
3. Clean all fittings and connections until they are free of dirt and debris.
4. While holding the fittings in place with a backup wrench, disconnect the power steering fluid lines from the steering gear. Plug the lines and the fittings to keep out dirt and prevent fluid leakage.
5. Remove and discard the pinch bolt and nut from the I-shaft end yoke, and disconnect the end yoke from the input shaft.
6. Clean the valve and input shaft seal cover until they are free of dirt and debris.
7. Work the input shaft seal cover off with a screwdriver.
8. Remove the dust cover.
9. Remove the retaining ring with retaining ring pliers.
10. Clean the area thoroughly to prevent any contaminants from entering the gear after the seal is removed.
11. Wrap the input shaft and seal area with a clean cloth to prevent fluid spray when removing the seal, then remove the input shaft seal by blowing compressed air into the outlet port. See **Fig. 1**.
12. Install the protective cap on the input shaft.
13. Apply grease, Renolit JP1619N (Mercedes-Benz DBL 6804.70), on the input shaft seal lip, then install the new seal on the input shaft.
14. Position the depth tool over the input shaft and press the seal into the housing by lightly tapping on the tool with a rubber mallet until the tool hits the upper edge of the housing. Check the position of the seal after each tap to make sure it stays level. The seal is correctly installed when it is fully under the retaining ring groove.
15. Install the retaining ring with retaining ring pliers. The ring must be seated fully in the retaining ring groove.

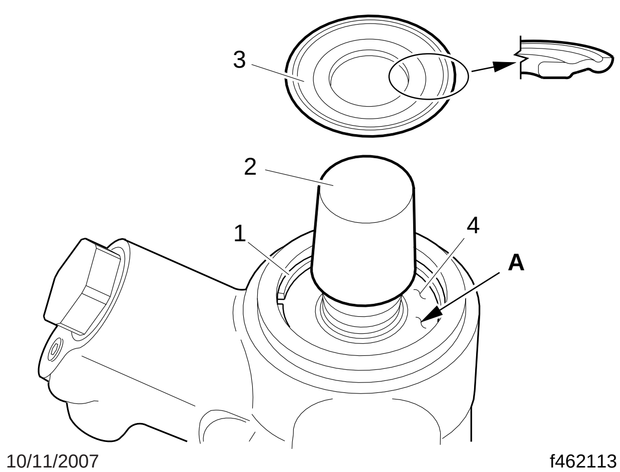


A. Apply air to the outlet port to remove the input shaft seal.
B. Seal the inlet port while applying air.

1. Power Steering Fluid Line Fittings
2. Transfer Line Tube Fittings

Fig. 1, Removal of the Input Shaft Seal

16. Apply grease to the top of the seal, completely covering the seal. See **Fig. 2**.



A. Cover top of seal with grease.

1. Retaining Ring
2. Protective Cap
3. Dust Cover
4. Input Shaft Seal

Fig. 2, Dust Cover Installation

IMPORTANT: The dust cover must be installed with the outer lip upward to properly protect the shaft components.

Input Shaft Seal Replacement

17. Install the dust cover, making sure the outer lip of the cover curves upward. Wipe away any excess grease.
18. Remove the protective cap from the input shaft.
19. Install the input shaft seal cover on the input shaft.
20. Using a new pinch bolt and nut, attach the steering I-shaft to the steering gear input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
21. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and nut.
22. Check the power steering fluid line fittings for a torque value of 30 to 35 lbf·ft (41 to 47 N·m). Tighten them if needed.
23. Connect the power steering fluid lines to the fittings, ensuring that the hoses do not touch the axle or each other. While holding the fittings in place with a backup wrench, tighten the pressure hose 43 to 47 lbf·ft (58 to 64 N·m) and the return hose 55 to 61 lbf·ft (75 to 83 N·m).

NOTICE

Do not loosen or tighten the hard transfer line tube fittings (Fig. 1, Item 2). Tightening the tube fittings can cause the O-ring seal to leak.

24. Fill and bleed the power steering system.
    - 24.1 Raise the front wheels off the ground and support the vehicle with jack stands.
    - 24.2 Fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
    - 24.3 With the engine off, turn the wheel fully left and right five times to bleed the air from the rack.
    - 24.4 Start the engine and turn the steering wheel fully left and right several times to bleed the remaining air from the system.
    - 24.5 If the steering system needs additional bleeding, repeat the previous substep after the fluid in the reservoir has had time to release any air.
    - 24.6 Remove the jack stands and lower the vehicle.

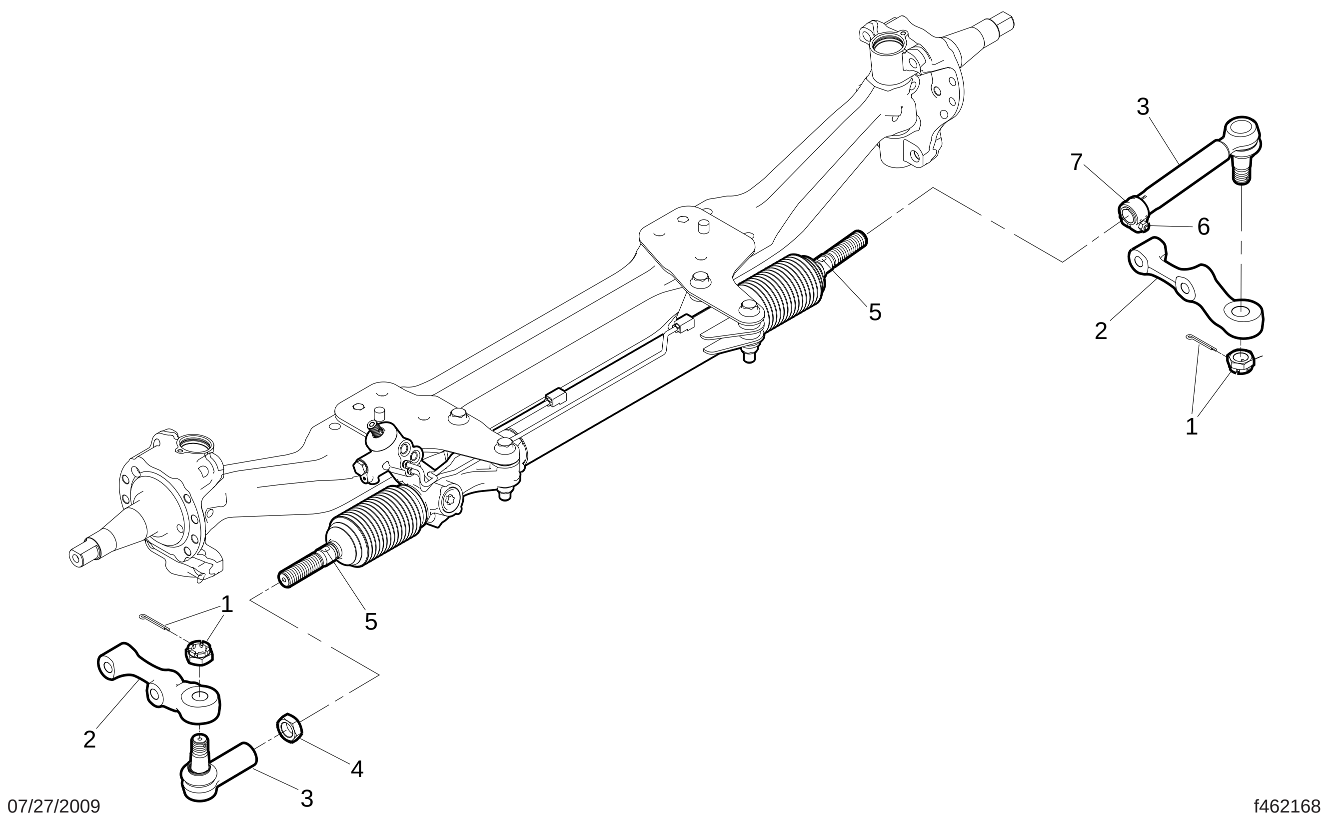
Replacement

1. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done.
2. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
3. For driver-side outer tie rod replacement, proceed as follows. See **Fig. 1**.
   - 3.1 Remove and discard the cotter pin and castellated nut.
   - 3.2 Loosen the jam nut. Note the number of exposed threads and the position of the outer tie rod to ease installation.
   - 3.3 Remove the outer tie rod from the tie rod arm.
   - 3.4 Unthread the outer tie rod from the inner tie rod. If necessary, hold the inner tie rod in place with a backup wrench on the inner tie rod flat.

     Discard the outer tie rod.
   - 3.5 Remove and discard the jam nut.
   - 3.6 Install the new jam nut.
   - 3.7 Install the new outer tie rod on the inner tie rod. Ensure that the outer tie rod position and number of exposed threads is the same as noted during step 3.2.
   - 3.8 Tighten the jam nut.
4. For passenger-side outer tie rod replacement, proceed as follows. See **Fig. 1**.
   - 4.1 Remove and discard the cotter pin and castellated nut.
   - 4.2 Remove the outer tie rod from the tie rod arm.
   - 4.3 Loosen the tie rod clamp. Note the number of exposed threads and the position of the outer tie rod to ease installation.
   - 4.4 Unthread the outer tie rod from the inner tie rod. If necessary, hold the inner tie rod in place with a backup wrench on the inner tie rod flat.

     Discard the outer tie rod.
   - 4.5 Install the new outer tie rod on the inner tie rod. Ensure that the outer tie rod position and number of exposed threads is the same as noted during step 4.2.
   - 4.6 Tighten the tie rod clamp.
5. Attach the outer tie rod of the rack and pinion to the tie rod arm with a new castellated nut. Tighten the castellated nut 240 lbf·ft (325 N·m). Continue to tighten until the the next castle nut slot aligns with the hole in the ball stud and insert the new cotter pin.
6. Align the rack and pinion gear using the instructions in **Subject 100**.
7. On the driver side, tighten the jam nut 285 to 305 lbf·ft (386 to 413 N·m). On the passenger side, tighten the clamp nut 30 to 36 lbf·ft (41 to 48 N·m).

Outer Tie Rod Replacement

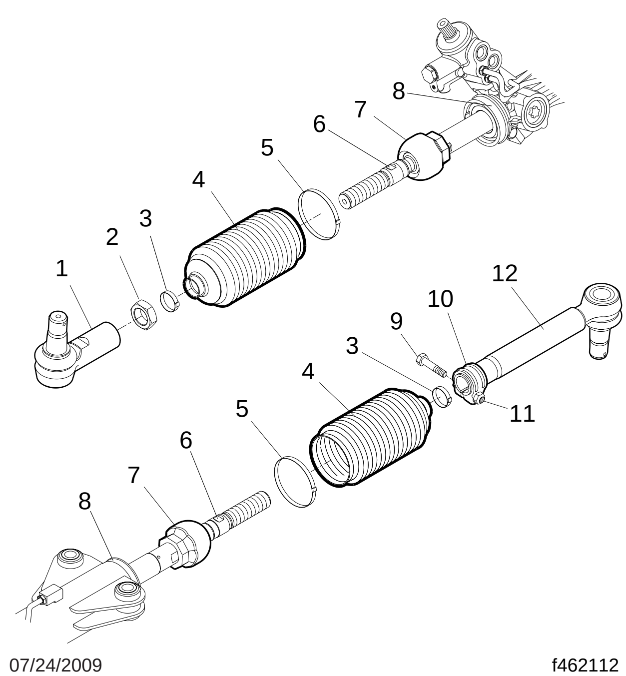


1. Castellated Nut and Cotter Pin
2. Steering Tie Rod Arm
3. Outer Tie Rod
4. Tie Rod Jam Nut
5. Inner Tie Rod Flat
6. Tie Rod Clamp Nut
7. Tie Rod Clamp

Fig. 1, Rack and Pinion Outer Tie Rod Assembly

Replacement

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires. Open the hood.
2. Loosen the jam nut on the driver side, or the tie rod clamp on the passenger side. Note the number of exposed threads, and the position of the outer tie rod, to ease installation.
3. Unthread the inner tie rod from the outer tie rod until the inner tie rod and bellows assembly is free from the outer tie rod. If necessary, use a backup wrench on the inner tie rod flat (**Fig. 1**, Item 6) to turn the inner tie rod.



1. Driver-Side Outer Tie Rod
2. Tie Rod Jam Nut
3. Small Oetiker Clamp
4. Bellows
5. Large Oetiker Clamp
6. Inner Tie Rod Flat
7. Inner Tie Rod Ball Joint
8. Bellows Seat
9. Pinch Bolt
10. Tie Rod Clamp
11. Tie Rod Clamp Nut
12. Passenger-Side Outer Tie Rod

Fig. 1, Tie Rod and Bellows Assembly

4. Remove both Oetiker bellows clamps.
5. Remove and discard the bellows clamps and bellows.
6. Inspect the gear for corrosion or evidence of hydraulic fluid. If either is found, replace the rack and pinion gear.
7. Loosely install new small and large Oetiker bellows clamps onto the bellows.
8. Ensure the bellows seats on the gear housing and on the inner tie rods are free of dirt and debris.
9. Install the bellows onto the gear.
10. Ensure the bellows are seated properly on the housing and tie rod.
11. Ensure the Oetiker clamps are properly seated in the clamp grooves on the bellows. Using an Oetiker clamp tool (**Fig. 2**), crimp the small and large Oetiker bellows clamp ears until the ear width is 0.08 to 0.16 in (2 to 4 mm).

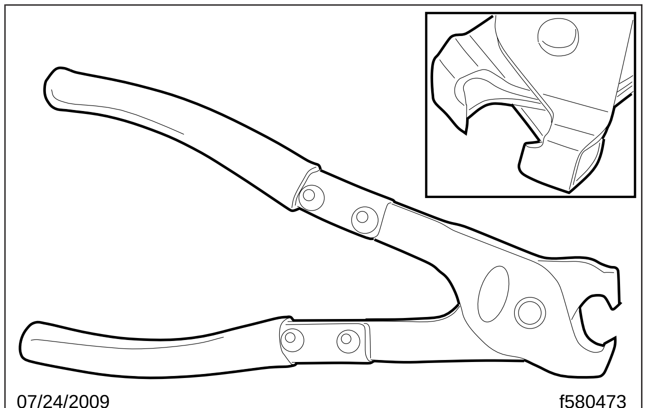


Fig. 2, Oetiker Clamp Tool

12. Install the jam nut on the driver side, or the tie rod clamp on the passenger side.
13. Thread the inner tie rod into the outer tie rod.
14. Tighten the jam nut on the driver side, or tie rod clamp nut on the passenger side.
15. Align the rack and pinion using the instructions in **Subject 100**.
16. Tighten the jam nut 285 to 305 lbf·ft (386 to 413 N·m), or tighten the tie rod clamp nut 30 to 36 lbf·ft (41 to 48 N·m).

Bellows Replacement

17. Inspect the bellows to ensure that they have not been torn, punctured, or otherwise damaged during installation.

General Description

NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (**www.rhsheppard.com/home.htm**) for additional information.

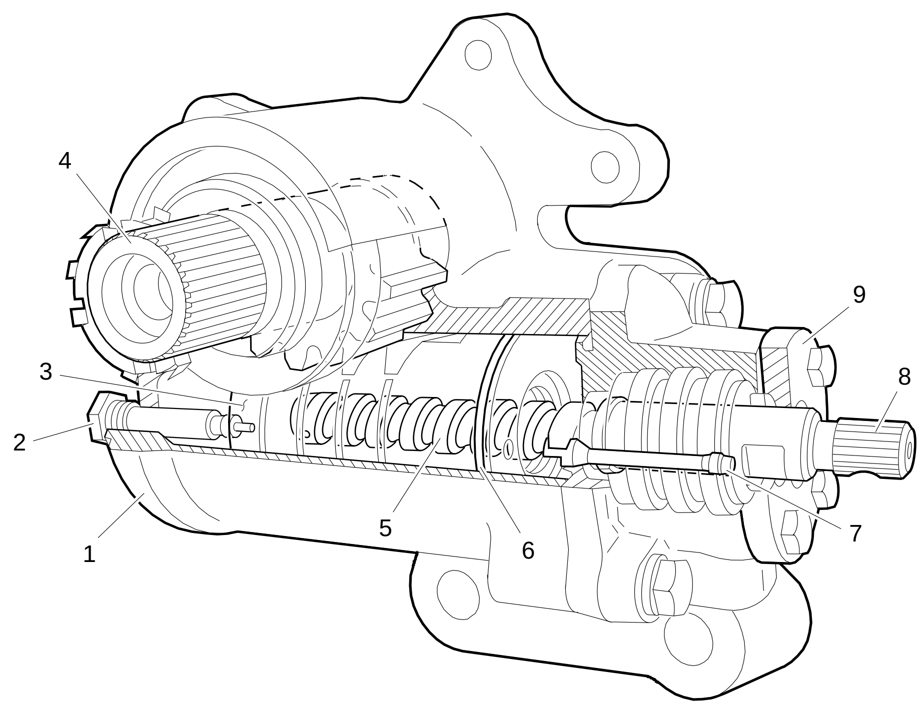
The Sheppard HD94 integral power steering gear (see **Fig. 1**) is a full-time hydraulic steering unit that uses pressurized hydraulic fluid to help the driver turn the front wheels. The HD94 is designed for vehicles with a front axle capacity between 10,000 and 14,600 pounds (4545 and 6635 kg). The Sheppard HD94 gear can steer a vehicle within this front axle weight rating through a turn at low speed and engine idle.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The maximum operating pressure for the Sheppard HD94 steering gear is 2683 psi (18 499 kPa). As the steering wheel is turned faster or slower, more or less fluid is required by the gear.

Principles of Operation

When the engine is running, a constant low-pressure flow of hydraulic fluid through the steering gear allows for instant response as the steering wheel is turned. The constant flow also helps to absorb road shock and eliminate steering wheel kick.

When the driver turns the steering wheel, the force is transmitted to the steering gear input shaft via the



1. Cylinder Head
2. Automatic Relief Plunger (in cylinder head)
3. Piston Rack
4. Sector Shaft
5. Rotary Valve Shaft
6. Piston Ring
7. Automatic Relief Plunger (in bearing cap cover)
8. Input Shaft
9. Bearing Cap Cover

Fig. 1, Sheppard HD94 Steering Gear

General Information

steering driveline. The input shaft is connected to a torsion bar within the steering gear. As the input shaft turns, the twisting force on the torsion bar turns the rotary valve, which causes the fluid pressure to build up at one end of the piston. The fluid pressure buildup forces the piston to move inside the bore of the gear housing. The rack teeth on the piston mesh with the teeth on the sector shaft so that the sector shaft rotates when the piston moves. As the sector shaft turns, it moves the pitman arm. The pitman arm connects to the steering linkage, which turns the wheels.

The Sheppard HD94 steering gear is equipped with two automatic relief plungers, one located in the cylinder head and one in the bearing cap cover near the input shaft. The plungers reduce system temperature and excessive stress on the mechanical components of the steering system by preventing the system from reaching full pump pressure when the axle stops contact the axle.

Steering Gear Removal and Installation

Removal

1. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the place where the work is to be done. Shut down the engine, apply the parking brakes, and chock the tires.

NOTICE

Do not turn the steering wheel or the steering shaft more than a half turn (except for alignment purposes) during the removal and installation procedures. Doing so may damage the clockspring in a vehicle equipped with an air bag.

2. Clean all outside dirt from around the fittings and hose connections.
3. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later reference during installation. Seal the lines and the fittings to keep dirt out.
4. Disconnect the pitman arm from the steering gear. For instructions, see **Subject 110**.
5. Disconnect the steering driveline from the steering gear input shaft, as follows.

   5.1 Remove and discard the pinch bolt and nut from the lower end yoke of the steering driveline yoke.

NOTICE

Do not pound the U-joint or input shaft coupling on or off the input shaft. Internal damage to the steering gear can result.

   5.2 Remove the steering driveline yoke from the steering gear input shaft.

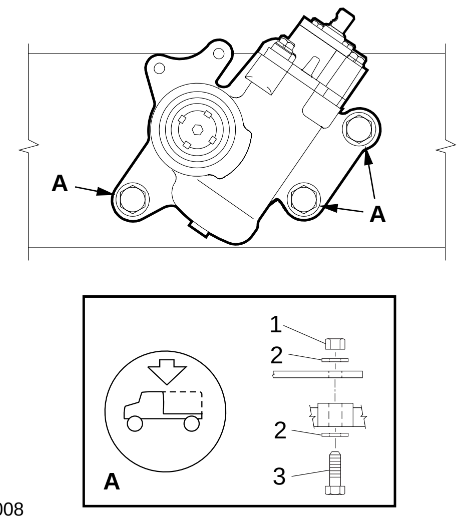
WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

6. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear and place it on a clean surface.

Installation

1. Align the holes in the steering gear housing with the holes in the frame rail. See **Fig. 1**. Place a washer over each bolt and install the three bolts. Install a washer and nut on the end of each bolt and tighten the nuts 388 lbf·ft (526 N·m).



A. Steering Gear Mounting Fasteners

1. Nut
2. Washer
3. Bolt

Fig. 1, Steering Gear Installation

2. Install the pitman arm on the steering gear. For instructions, see **Subject 110**.
3. Position the steering wheel so that it is within ±10 degrees of center as shown in **Fig. 2**.
4. Connect the steering driveline to the steering gear input shaft, as follows.

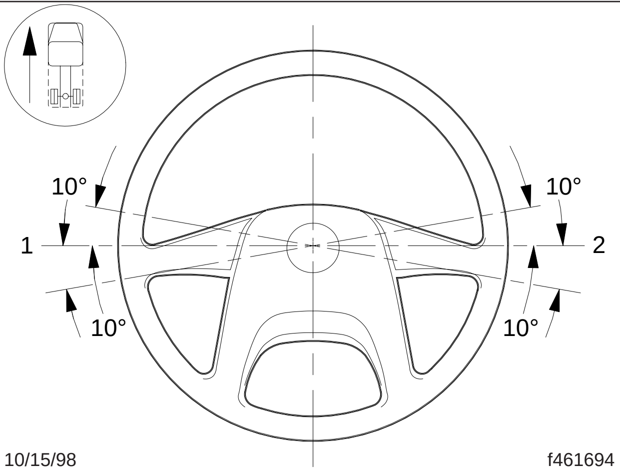
   4.1 Clean the steering gear input shaft and the inside of the steering driveline yoke.

NOTICE

Do not turn the steering wheel at this time. Doing so can cause air to enter the system, possibly causing an unexpected loss of power steering assist.

   4.2 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut to one of the following torque specs.

Steering Gear Removal and Installation



1. 9 o'Clock Position 2. 3 o'Clock Position

Fig. 2, Steering Wheel Centered

- 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
- 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut

4.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate that the nut has been properly tightened.

5. Connect the hydraulic lines to the gear as marked earlier. Tighten the nut on each fitting finger-tight. Then with a wrench, tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

   Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate that the nut has been properly tightened.

6. Fill and bleed the system. For instructions, see **Subject 150**.
7. Adjust the automatic relief plungers. For instructions, see **Subject 130**.

Removal

NOTE: This procedure is for removing the pitman arm from the steering gear. If replacement of the pitman arm is required, the pitman arm must also be removed from the drag link.

NOTE: The pitman arm is easiest to remove while the steering gear is installed on the vehicle.

1. Shut down the engine, apply the parking brakes, and chock the tires.

DANGER

Do not use a hammer or apply heat to the pitman arm to remove it. Doing so could damage the sector shaft, the pitman arm, or the seals, and possibly lead to loss of vehicle control resulting in death or serious personal injury.

IMPORTANT: The pitman arm has alignment tabs, while the retainer has restraining tabs. Do not bend the alignment tabs out of the pitman arm.

2. Using a punch, bend the restraining tabs out of the retainer.
3. Using an Allen drive socket and an impact wrench, remove the retainer. If the retainer is undamaged, it may be reused. Otherwise, replace the retainer.
4. Lubricate the end of the sector shaft with clean chassis lube. Failure to lubricate the face of the retainer will cause difficulty in removing the pitman arm.
5. Slide the pitman arm puller over the pitman arm. Align the hole in the puller with the sector shaft and washer.
6. Insert the Allen drive socket through the puller and into the retainer socket. Use an impact wrench to back off the retainer. The retainer will act as a jack screw to disconnect the pitman arm from the steering gear.

Installation

WARNING

If the pitman arm is not installed to the proper specifications, it could come loose, causing an accident that could result in death or severe personal injury.

1. Align the timing marks on the pitman arm with the timing marks on the sector shaft. See Fig. 1. Install the pitman arm on the sector shaft.

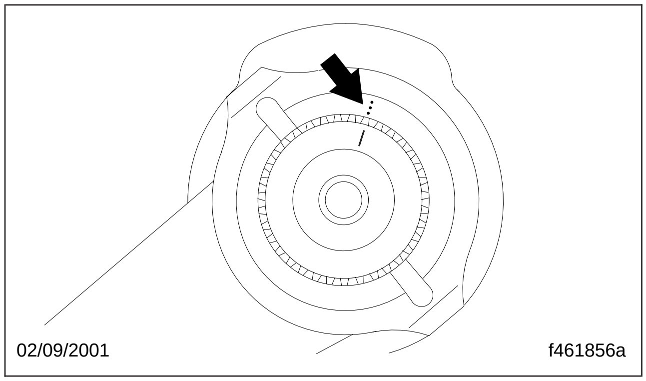


Fig. 1, Timing Mark Alignment

2. Install the pitman arm retainer on the sector shaft. Be sure to align the restraining tabs of the retainer with the notches of the pitman arm. Coat the retainer threads with anti-seize compound. If using a new retainer, apply a coat of anti-seize to both sides of the friction washer.
3. Tighten the retainer 350 lbf·ft (475 N·m).

WARNING

Do not back off the torque value to align the tabs. If the pitman arm is not installed to the proper specifications, it could come loose, causing an accident that could result in death or severe personal injury.

4. Continue tightening the retainer past the specified value until two of the notches in the retainer align with the tabs of the washer.

Pitman Arm Removal and Installation

WARNING

Once the retainer is tightened to specifications and locked in place, do not retighten the retainer. Constant tightening of the retainer may cause the pitman arm to come loose, causing an accident that could result in death or severe personal injury.

5. Using a punch and hammer, bend the restraining tabs of the washer into the notches on the retainer. See **Fig. 2**. Apply torque seal, OGP F900WHITE, to the tabs.

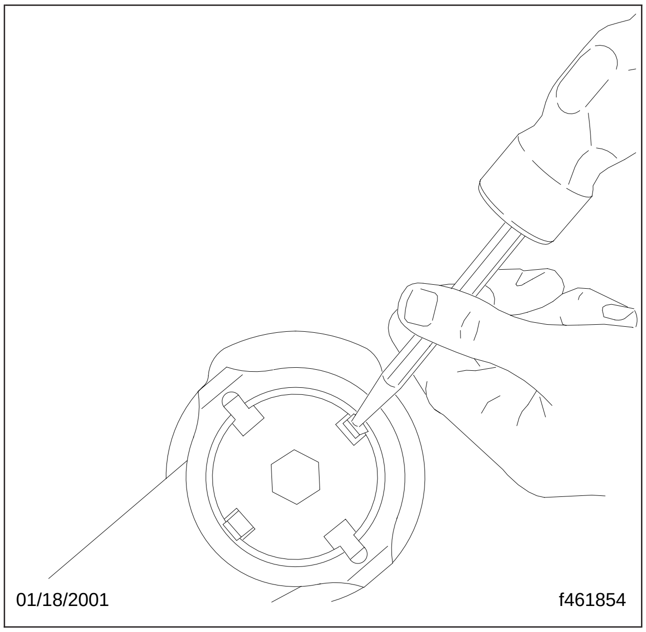


Fig. 2, Bending the Restraining Tabs

6. Reset the automatic relief plungers. For instructions, see **Subject 130**.

Input Shaft Seal Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.

IMPORTANT: Do not remove the steering gear for this procedure.

2. Disconnect the steering driveline from the steering gear input shaft.

   2.1 Remove and discard the pinch bolt and nut from the lower end yoke of the steering driveline yoke.

NOTICE

Do not pound the U-joint or input shaft coupling on or off the input shaft. Internal damage to the steering gear can result.

   2.2 Remove the steering driveline yoke from the steering gear input shaft. If necessary, secure the steering shaft so it will not interfere with your work.

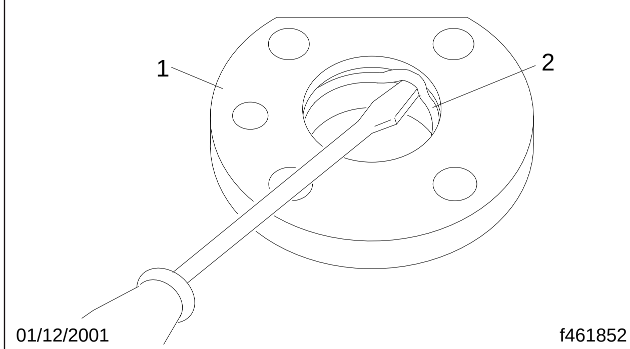
NOTICE

Do not turn the input shaft during repairs. Damage to the steering gear will result.

3. Place a drain pan under the power steering gear. Draining the system is not necessary, but some fluid will be lost.
4. Remove the rubber boot from the input shaft.
5. Clean all outside dirt from around the input shaft.
6. Remove the four capscrews that attach the bearing cap cover to the bearing cap, and remove the bearing cap cover.

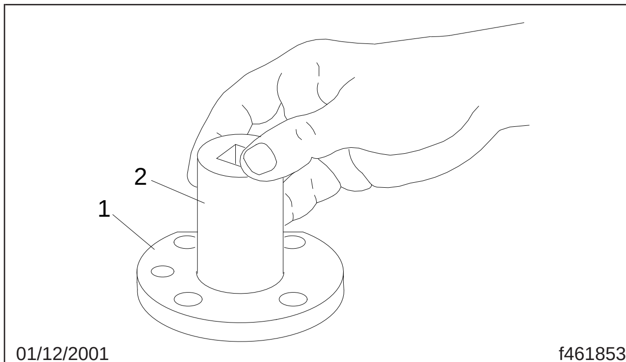
IMPORTANT: The thrustwasher may stick to the bearing cap cover. If it does, reinstall the thrustwasher on the bearing cap before proceeding.

7. Place the bearing cap cover on a clean work surface. Pry the salt seal out of the bearing cap cover, and discard the seal. See **Fig. 1**.
8. Tap the input (high pressure) seal out of the bearing cap cover using a suitable size socket or seal driver, and discard the seal; see **Fig. 2**.
9. Remove the O-ring from the bearing cap cover, and discard the O-ring.



1. Bearing Cap Cover 2. Salt Seal

Fig. 1, Salt Seal Removal



1. Bearing Cap Cover 2. Socket

Fig. 2, Input Seal Removal

10. Clean the bearing cap cover with a suitable solvent.
11. Place the bearing cap cover face down on a clean work surface. Using a suitable size driver and an arbor press, tap the new input seal into the bearing cap cover with the gold spring facing the bottom of the cover. Coat the outside diameter of the input seal with clean chassis lube.
12. With the lip facing out, press a new salt seal into the bearing cap cover until it is flush with the face of the cover. See **Fig. 3**. Make sure the seal lip, or silver spring, is facing the top of the cover.
13. Install a new O-ring onto the outside of the cover. Tap the cover washer, if equipped, into the cover.
14. Fill the area between the seals with clean chassis grease. Lubricate the O-ring and seal lips

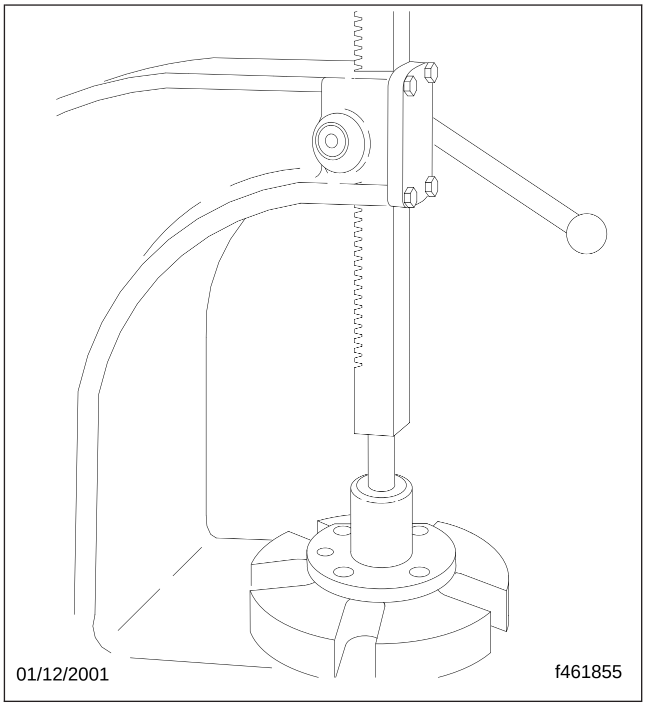


Fig. 3, Salt Seal Installation

with grease. If the cover has a grease fitting, remove it and fill the hole with silicone sealant.

15. Tape the input shaft splines before installing the bearing cap cover, to prevent seal damage.
16. Using four capscrews, attach the bearing cap cover to the bearing cap, making sure not to roll the lip of the input seal. Align the hole in the bearing cap cover with the relief plunger hole in the bearing cap, and tighten the capscrews 53 to 64 lbf·ft (72 to 87 N·m).

NOTE: Two rubber boots are included in the replacement kit. Choose the boot that will provide the tightest fit on the input shaft.

17. Install a rubber boot over the input shaft. Make sure the boot is below the splines and contacts the bearing cap cover when installed.
18. Remove the tape from the input shaft splines.
19. Slide the steering driveline lower end yoke onto the input shaft and install a new M10 x 1.25 pinch bolt and nut. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

20. If needed, fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
21. Start the engine and check for leaks.

Sector Shaft Seal Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.

NOTE: Removal of the power steering gear is not necessary to perform this procedure. Partial disassembly of the steering gear is required to replace the sector shaft seals. Mark the sector shaft timing if a new sector shaft is being installed.

2. Disconnect the pitman arm from the steering gear. For instructions, see **Subject 110**.

NOTICE

Do not turn the steering wheel or the steering shaft during this procedure. Turning either the steering wheel or steering shaft will result in steering gear damage.

3. Start the engine and allow the pressure in the steering system to push the sector shaft cover out of the housing. Shut down the engine when the cover exits the housing.
4. Remove and discard the rubber V-boot on the sector shaft.
5. If the snap ring cover is equipped with a protective cap, pry the cap out of the bore with a screwdriver. Do not damage the housing.

IMPORTANT: When working with snap ring covers, remove the factory-installed silicone protectant from the snap ring and carefully clean the cover area before disassembly.

Seal Replacements

6. Remove the adhesive plastic dust cover, if equipped, from the back of the housing. Clean any paint or corrosion from the housing so that the cover slides freely out of the housing.
7. Remove the snap ring from the housing.

NOTE: A slide hammer may be used to remove the sector shaft.

8. Remove the sector shaft cover and sector shaft from the housing. Separate the cover from the sector shaft.
9. Using a seal pick, pry the excluder seal from the sector shaft cover. Remove the two-piece L-seal from the housing, if equipped, or remove the O-ring from the sector shaft cover. Discard all seals.

IMPORTANT: The sector shaft oil seals are two-piece seals. It is necessary to bend the seals to install them. Once a seal is installed, work it into place with your fingers or a blunt seal pick until it is properly seated. Push only on the body of the seal and not on the seal lip. Damage to the seal lip will cause an oil leak. The seals should look perfectly round when installed.

10. Install one new oil seal into the steering gear housing, and one new oil seal into the sector shaft cover. When properly fitted, the black lip of the seals will face the inside of the gear.

    Lubricate the seals with clean chassis lube.
11. Install the two-piece L-seal as follows.

    11.1 Insert the black pressure seal into the housing with the L-side facing out.

    11.2 Insert the backup ring into the L-side of the pressure seal. When assembled correctly, the back-up ring will be on the side of the pressure seal facing out.

    11.3 Apply a coat of clean chassis lube to the L-seal.
12. Apply a coat of clean chassis lube to the lip of the excluder seal, if equipped, and install the excluder seal over the sector shaft splines and into the seal groove of the cover. See Fig. 4.
13. Install the sector shaft in the housing. Make sure that the timing mark on the sector shaft is placed between the two timing marks on the piston. See

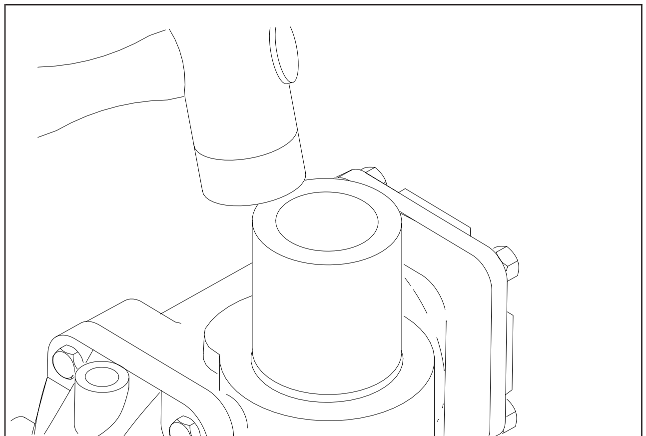
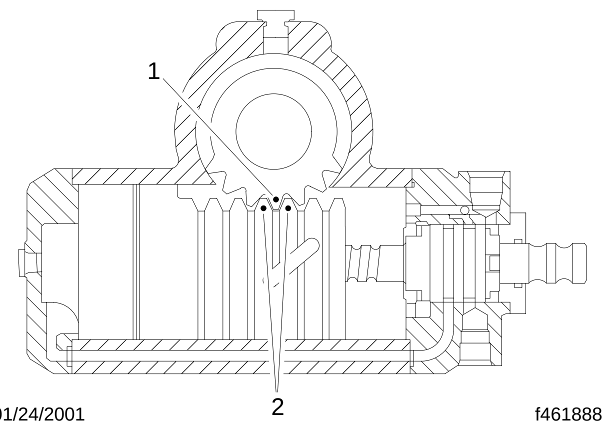


Fig. 4, Excluder Seal Installation

Fig. 5. It may be necessary to tap on the sector shaft to properly seat it into the housing.



1. Sector Shaft Timing Mark
2. Piston Rack Timing Marks

Fig. 5, Timing Mark Alignment

14. Install the sector shaft cover over the sector shaft. When properly installed, the sector shaft cover should be flush with or below the snap ring groove in the housing.

CAUTION

When installing a snap-ring-style cover, the cover must be flush or below the groove in the hous-

Seal Replacements

ing. Improper installation could result in separation of the cover, possibly resulting in personal injury.

15. Install the snap ring, or install the cover retaining bolts or retaining clips.

    Tighten retaining bolts 72 to 87 lbf·ft (98 to 118 N·m). Tighten retaining clips 31 to 38 lbf·ft (42 to 52 N·m).

16. Install the snap ring protective cover into the housing, over the snap ring, by lightly tapping on the outside diameter of the cover until it seats in the bore.
17. Pack the rubber V-boot with clean chassis lube, and slide the V-boot over the sector shaft splines until the lip contacts the sector shaft cover. If installing a boot with one lip larger than the other, ensure that the larger lip is facing the pitman arm. Clean all excess grease from the sector shaft splines.
18. Clean the housing with solvent, apply a small bead of RTV silicone on the edge of the frame-side dust cover disk, and apply the disk over the sector shaft bore.
19. Install the pitman arm. For instructions, see **Subject 110**.
20. Fill and bleed the system. For instructions, see **Subject 150**.

Automatic Relief Plunger Adjustment and Setting

Relief plungers prevent the power steering pump from operating at maximum relief pressure at the end of steering travel. When properly adjusted, the relief plungers reduce system temperature and excessive stress on the mechanical components of the steering system by preventing the system from reaching full pump pressure when the axle stops contact the axles. A relief plunger is located in each end of the steering gear. One plunger is located in a small hole in the bearing cap cover next to the input shaft, while the other is located near the cylinder head.

NOTICE

Failure to set or adjust the automatic relief plungers could result in damage to the steering system. Relief plungers must be set or adjusted whenever a steering gear is replaced.

Adjusting Automatic Relief Plungers

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the side of the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps over the plunger bosses.

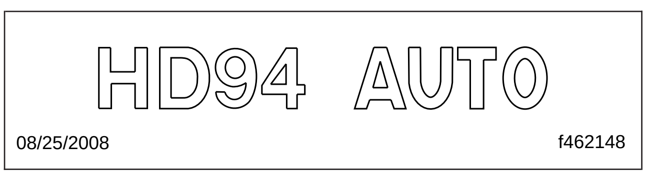


Fig. 1, Automatic Relief Plunger Identifier

3. Remove the plastic caps from both plunger bosses.

NOTICE

Make sure there are no sharp edges on the punch that could damage the bore. Take care when using the punch to ensure that the relief plunger bore is not damaged. If the relief plunger bore is damaged, a leak may occur.

4. Using a 1/4-inch punch and ball-peen hammer, carefully drive the relief plunger in until it bottoms in the bore. Repeat this procedure for the other relief plunger.
5. Install the plastic caps on the plunger bosses.
6. Set the automatic relief plungers using the procedure in "Setting Automatic Relief Plungers."

Setting Automatic Relief Plungers

NOTE: Check that the axle stops are set correctly before setting the relief plungers.

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the side of the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps over the plunger bosses.
3. Using a jack, raise the vehicle until the front wheels are off the ground.
4. Start the engine and let it idle. Ensure the axle stops are set for maximum wheel cut with a minimum of 1 inch (25 mm) clearance between the tire and any part of the chassis.
5. Turn the wheels from side to side until the axle stops contact the axle. This allows the piston in the steering gear to contact the automatic plunger assemblies and push them back to their set positions. The axle stops must make contact with the axle.

NOTE: As the tires reach the end of travel, you will feel the piston contact the relief plunger. Continue turning the tires until the spindle reaches the axle stop bolt.

6. Return the tires to the straight-ahead position and lower the vehicle until the tires contact the ground.
7. Turn the steering wheel to a full-lock position in both directions, checking for chassis flexion when the axle stops contact the axle. If the chassis flexes, adjust the automatic relief plungers using the procedure in "Adjusting Automatic Relief Plungers."

Automatic Relief Plunger Repair

Under normal use, automatic relief plungers do not need regular maintenance. The automatic relief plunger is serviceable only as a kit and is only required if a leak is present. See **Specifications 400** for part numbers. Follow the appropriate procedure for the relief plunger in need of repair.

Cylinder Head Automatic Relief Plunger Repair

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing; see **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.

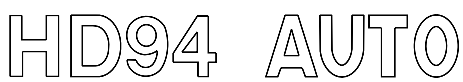


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Fig. 1, Automatic Relief Plunger Identifier

3. Place a drain pan under the steering gear.
4. Remove the plunger cartridge from the cylinder head.
5. Remove the plastic plug from the plunger boss.

NOTICE

When driving the relief plunger assembly, do not allow the 1/4-inch punch to contact the bore, and do not hit the plunger with excessive force. Failure to follow these directions could result in damage to the steering gear or relief plunger assembly.

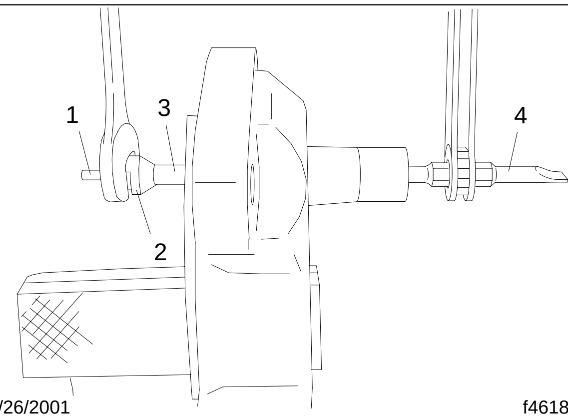
6. Place the cartridge in a vise. Using a 1/4-inch punch and hammer, carefully drive the relief plunger assembly in until it bottoms in the bore. The spring pin, flange, and plunger body should now be accessible for repair.

NOTICE

Do not allow the screwdriver bit to slip off the plunger body. Damage to the bore could result.

NOTE: The relief plunger flange is held in place with patch lock, and the threads are staked at the factory. It will require approximately 15 to 20 lbf·in (170 to 225 N·cm) to remove the flange.

7. Carefully insert a screwdriver bit (mounted in a ratchet) into the plunger bore to hold the slotted head of the relief plunger body in place. Using an open-end wrench to hold the flange across the flat sides, carefully turn the flange to remove it from the plunger body; see **Fig. 2**. Discard the flange.



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1. Plunger Body
2. Flange
3. Spring Pin
4. Screwdriver Bit

Fig. 2, Flange Removal

8. Remove the plunger body from the spring pin and discard the plunger body. It may be necessary to tap the plunger body to remove it from the spring pin. Use of a 1/8-inch pin punch is recommended.

IMPORTANT: Check the plunger bore for nicks or gouges before installing the plunger assembly. Be careful not to introduce dirt or contaminants in the plunger bore when reassembling.

9. Cover the O-ring on the new plunger assembly with a light coat of grease. Install the plunger body through the spring pin; see **Fig. 3**.

WARNING

The flange must contact the spring pin. If it does not, a leak or steering gear damage may result. This could cause steering failure, possibly resulting in personal injury or property damage.

Automatic Relief Plunger Repair

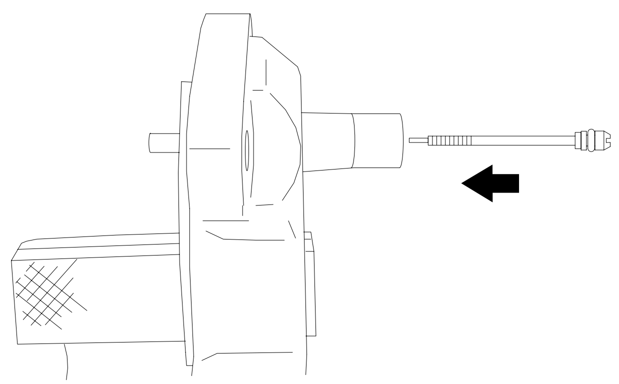


Fig. 3, Plunger Body Installation

10. Use a screwdriver bit and ratchet to hold the plunger body in place. Using an open-end wrench, install the flange on the plunger body until the flange contacts the spring pin.
11. Install the plunger cartridge in the cylinder head. Tighten the capscrews 30 to 50 lbf·ft (41 to 68 N·m).
12. Install the plastic plug on the plunger boss.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

13. If needed, fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
14. Start the engine and check for leaks.
15. Set the automatic relief plungers. For instructions, see **Subject 130**.

Bearing Cap Automatic Relief Plunger Repair

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing; see **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger boss.
3. Place a drain pan under the steering gear.
4. Mark the bearing cap and steering gear housing for reassembly.
5. Disconnect the steering driveline from the steering gear input shaft. For instructions, see **Subject 100**.
6. Remove the plastic plug from the plunger boss.

NOTICE

When driving the relief plunger assembly, do not allow the 1/4-inch punch to contact the bore, and do not hit the plunger with excessive force. Failure to follow these directions could result in damage to the steering gear or relief plunger assembly.

7. Using a 1/4-inch punch and hammer, carefully drive the relief plunger assembly in until it bottoms in the bore.
8. Remove the four capscrews that attach the bearing cap to the steering gear housing.

NOTICE

Do not force the input shaft when turning it out of the housing. The shaft could bind and steering damage could result.

9. Separate the bearing cap assembly from the housing by turning the input shaft out of the housing. Turn the shaft until it stops.

NOTICE

Do not allow the screwdriver bit to slip off the plunger body. Damage to the bore could result.

10. Carefully insert a screwdriver bit (mounted in a ratchet) into the plunger bore to hold the slotted head of the relief plunger body in place. Using an open-end wrench to hold the flange across the flat sides, carefully turn the flange to remove it from the plunger body; see **Fig. 4**. Discard the flange.

Automatic Relief Plunger Repair

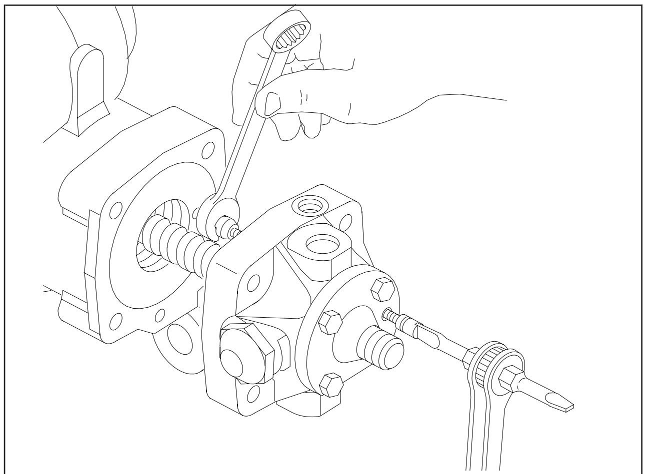


Fig. 4, Flange Removal

NOTE: The automatic relief plunger flange is held in place with patch lock, and the threads are staked at the factory. It will require approximately 15 to 20 lbf·in (170 to 225 N·cm) to remove the flange.

11. Remove the plunger body from the spring pin and discard it. It may be necessary to tap the plunger body to remove it from the spring pin. Use of a 1/8-inch pin punch is recommended.

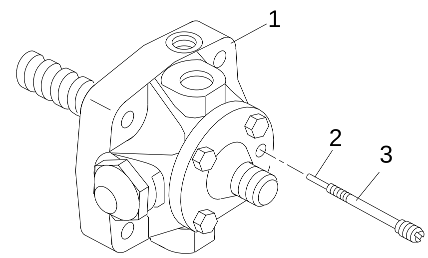
IMPORTANT: Check the plunger bore for nicks or gouges before installing the plunger assembly. Be careful not to introduce dirt or contaminants into the plunger bore when reassembling.

12. Cover the O-ring on the new plunger assembly with a light coat of grease. Install the plunger body through the spring pin; see **Fig. 5**.

WARNING

The flange must contact the spring pin. If it does not, a leak or steering gear damage may result. This could cause steering failure, possibly resulting in personal injury or property damage.

13. Use a screwdriver bit and ratchet to hold the plunger body in place. Using an open-end wrench, install the flange on the plunger body until the flange contacts the spring pin.
14. Align the marks on the bearing cap with the marks on the steering gear housing, and install the bearing cap on the housing using the bearing cap capscrews. Tighten the capscrews 114 to 140 lbf·ft (154 to 190 N·m).



1. Bearing Cap
2. Plunger Body
3. Spring Pin

Fig. 5, Plunger Body Installation

15. Install the plastic cap on the plunger boss.
16. Connect the steering driveline to the steering input shaft. For instructions, see **Subject 100**.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

17. If needed, fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
18. Start the engine and check for leaks.
19. Set the automatic relief plungers. For instructions, see **Subject 130**.

Air Bleeding the System

Most single steering gears can be bled simply by turning the steering wheel all the way from one axle stop to the other. Some gears, however, require bleeding through a bleeder screw.

Typical Steering Gear

1. Shut down the engine and apply the parking brakes.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

2. Fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
3. With the weight of the vehicle on the ground, start the engine and allow it idle.
4. Turn the wheels to full left. Hold the wheel in pressure for about five seconds once you reach an axle lock.
5. Turn the wheels to full right. Hold the wheel in pressure for about five seconds once you reach an axle lock.
6. Repeat steps 4 and 5 three more times.

Steering Gear Equipped With a Bleeder Plug

NOTE: This procedure requires two technicians.

1. Shut down the engine, apply the parking brakes, and chock the tires.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

2. Fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
3. Find the bleeder plug on the sector shaft bore above the pitman arm.
4. Find and remove the tape covering the 1/8-inch Allen bleeder screw in the center of the head.
5. Start the engine and allow it to idle.
6. Turn the wheels to full left. Using a 1/8-inch Allen wrench, open the bleeder screw about four turns.

IMPORTANT: Do not remove the bleeder screw from the bleeder plug. A check ball behind the screw may be lost.

7. With the bleeder screw open, turn the wheels to full right. At the full right turn position, close the bleeder screw.

IMPORTANT: When the bleeder screw is open, turn the steering wheel to the right only. Turning the steering wheel to the left with the bleeder screw open will introduce additional air into the system.

8. Turn the steering wheel back to full left and repeat the two steps above, until no aeration is found in the bled oil.
9. Check the fluid level in the power steering reservoir and fill if necessary.

Specifications

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

Sheppard HD94 power steering gears use ATF fluid that meets Dexron III or TES-389 specifications.

Tools and replacement/repair kits can be ordered from:

R. H. Sheppard Co., Inc.
101 Philadelphia Street
Hanover, Pennsylvania 17331-0877
1-800-274-7437

General Description

NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (**trucksteering.trw.com**) for additional information.

TRW TAS power steering gears are integral hydraulic power steering gears that contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The rotary control valve directs the flow of hydraulic fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder in a dual steering gear system) at the proper flow rate and pressure. As the steering wheel is turned faster or slower, more or less fluid is required by the gear.

Principles of Operation

When the driver turns the steering wheel, that force travels from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to the force exerted by the torsion bar, the worm shaft moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. As the rack piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm, which pulls or pushes the drag link. The drag link moves the axle steering arm, steering the vehicle.

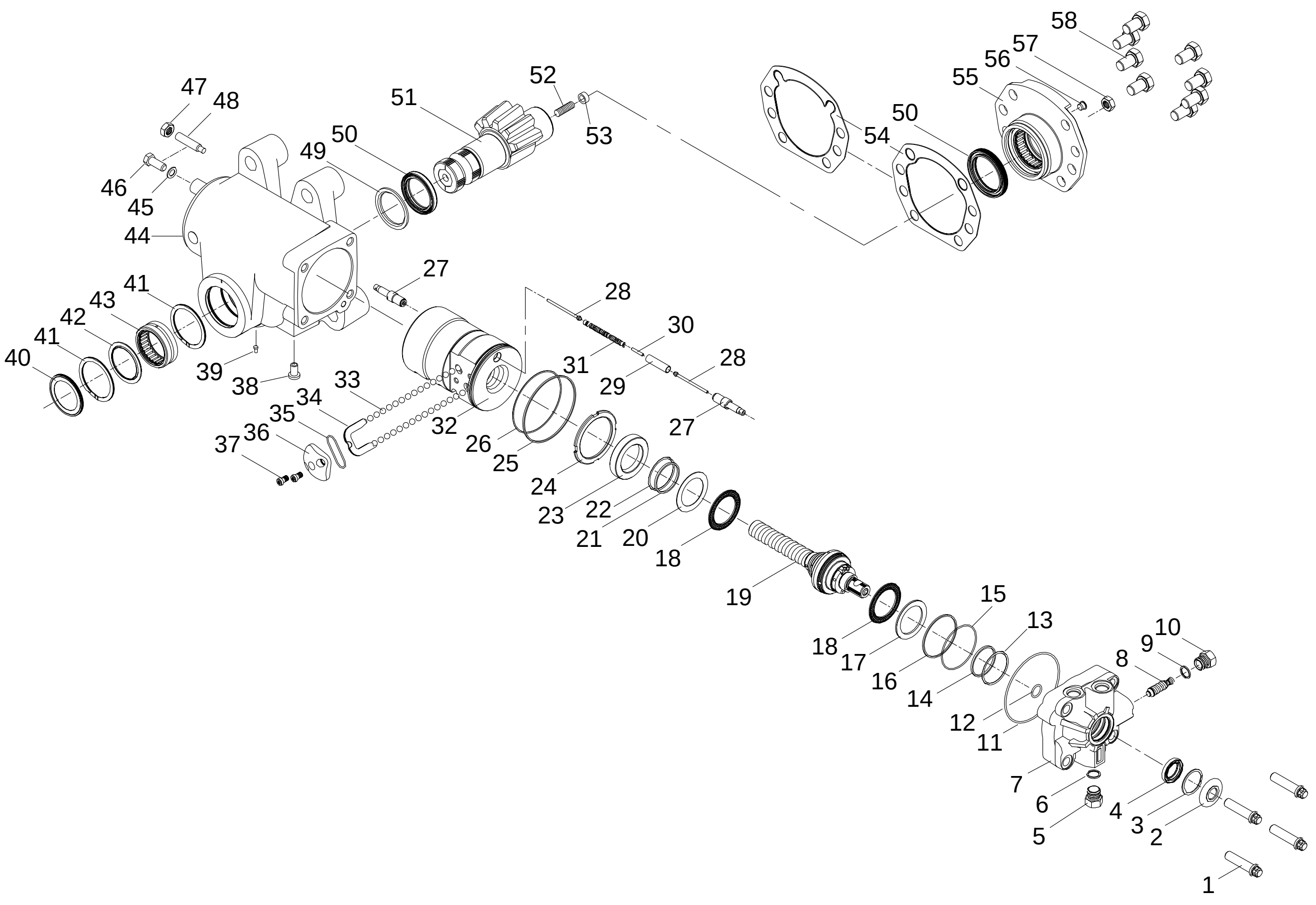
The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). The pressurized fluid assists in moving the rack piston up or down in the cylinder bore.

Most TAS steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. As the front wheels reach the axle stop—the farthest the wheels can turn in either direction—one poppet or the other, depending on the direction of the turn, will trip to prevent steering system damage. The tripped poppet reduces pressure in the gear, heat generated by the power steering pump, and outside forces acting on the steering linkage.

Some TAS steering gears are also supplied with an internal pressure relief valve (PRV). The PRV limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

See **Fig. 1** for an exploded diagram of a TRW TAS power steering gear.

General Information



1. Bolts, Valve Housing
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Auxiliary Port Plug
6. O-Ring, Auxiliary Port Plug
7. Valve Housing
8. Relief Valve
9. O-Ring, Relief Valve
10. Relief Valve Cap
11. Seal Ring, Large
12. Seal Ring, Small
13. Seal Ring
14. O-Ring
15. Seal Ring
16. O-Ring, Valve Housing
17. Thrust Washer, Thick
18. Roller Thrust Bearing
19. Input Shaft/Valve/Worm Assembly
20. Thrust Washer, Thin
21. Seal Ring
22. O-Ring
23. Bearing Adjuster
24. Adjuster Locknut
25. Seal Ring, Rack Piston
26. O-Ring, Backup
27. Poppet Adjuster Seat and Sleeve Assembly
28. Poppet
29. Push Tube
30. Spacer Rod
31. Poppet Spring
32. Rack Piston
33. Steel Balls
34. Ball Return Guide Halves
35. Seal, Ball Return Guide Cap
36. Ball Return Guide Cap
37. Torx® Screws
38. Plug, Auto-Bleed
39. Grease Fitting
40. Dirt and Water Seal, Trunnion
41. Retaining Ring
42. Dirt Seal
43. Roller Bearing
44. Gear Housing
45. Washer, Stopscrew
46. Fixed Stop Screw, Poppet
47. Service Sealing Jam Nut
48. Service Poppet Adjusting Screw
49. Washer, Spacer
50. Output Seal
51. Sector Shaft
52. Adjusting Screw, Shaft
53. Retainer, Adjusting Screw
54. Gasket, Side Cover
55. Side Cover and Bushing/Bearing Assembly
56. Vent Plug, Side Cover
57. Jam Nut
58. Special Bolts, Side Cover

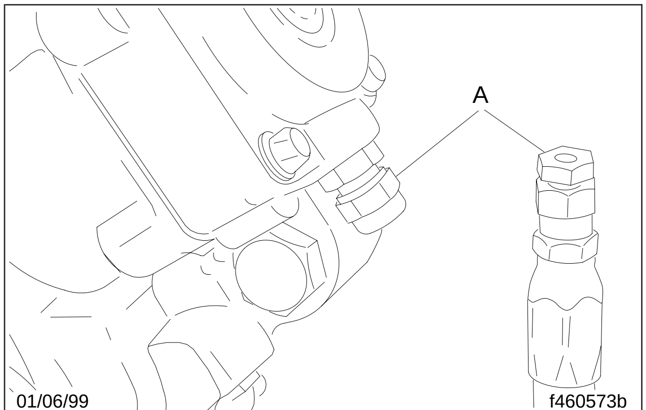
Fig. 1, TRW TAS85 Power Steering Gear Components

Steering Gear Adjustments

Input Shaft Seal Replacement

NOTE: The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Cap the return port of the gear with a high-pressure fitting.



A. Cap the return line and the return port.

Fig. 1, Disconnected Return Line

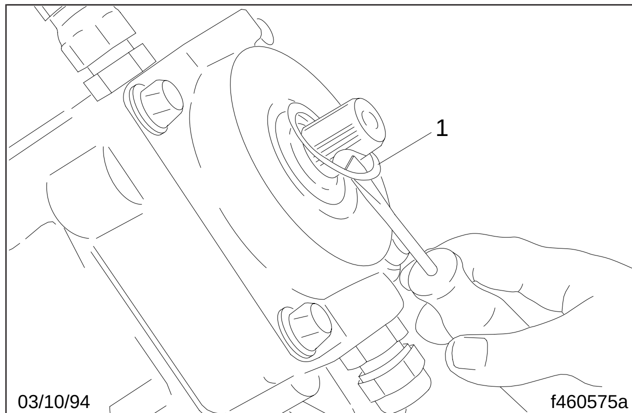
NOTICE

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

3. Disconnect the steering driveline from the steering gear input shaft.
   3.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

   IMPORTANT: Do not turn the steering gear input shaft when removing the lower end yoke.

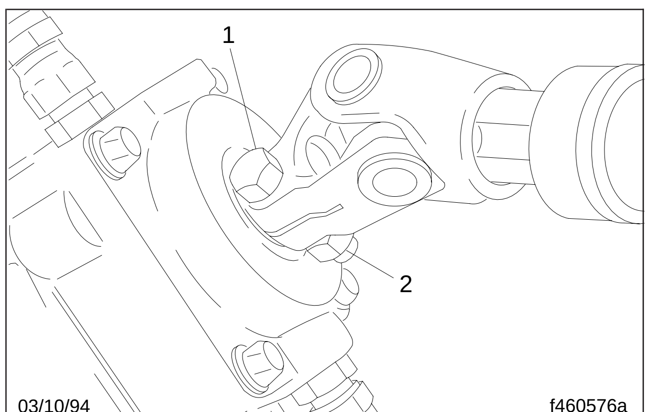
   3.2 Remove the lower end yoke from the input shaft. Push the driveline shaft into the driveline tube as you remove the lower end yoke.
4. Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove all grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, remove the retaining ring. See **Fig. 2**. Be careful not to scratch the bore with the screwdriver.



1. Retaining Ring

Fig. 2, Retaining Ring Removal

7. Slip the driveline lower end yoke back on the input shaft, then insert but do not tighten the pinch bolt. See **Fig. 3**.

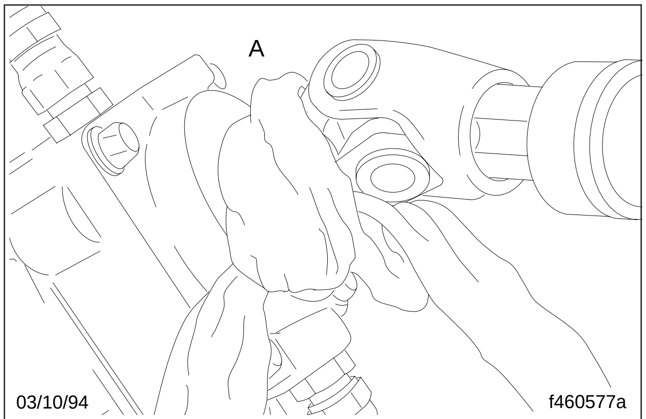


1. Pinch Bolt
2. Pinch Bolt Nut

Fig. 3, Pinch Bolt Installation

Steering Gear Adjustments

8. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil. See Fig. 4.



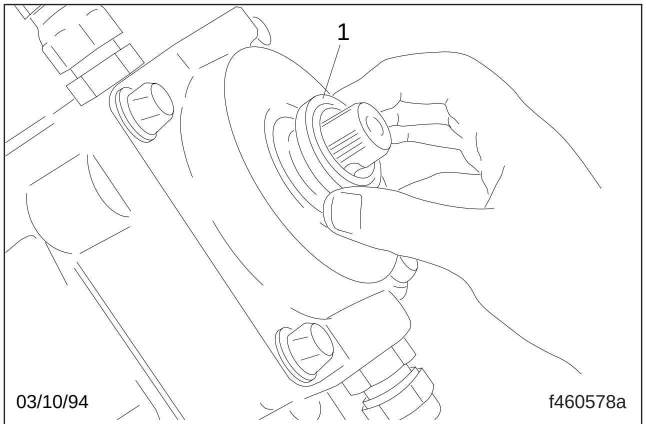
A. Cover the input shaft area.

Fig. 4, Shop Towel Covering the Input Shaft

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

9. If needed, fill the power steering reservoir with automatic transmission fluid.
10. With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
11. Remove the shop towel, pinch bolt, and input yoke. Remove the input shaft seal. See Fig. 5.
12. Inspect the seal area of the valve housing for seal fragments. Remove any seal fragments.
13. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of any excessive heat in the vehicle. Discard the old seal.



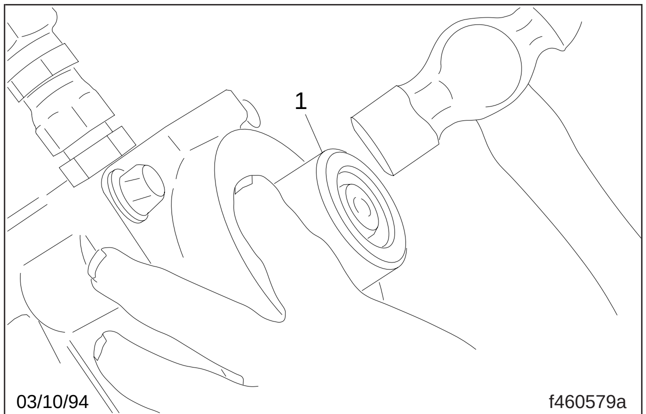
1. Input Shaft Seal

Fig. 5, Input Shaft Seal Removal

WARNING

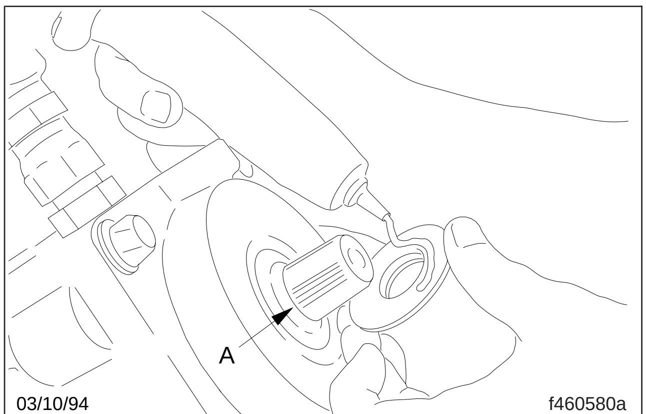
Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.

14. Install a new input shaft seal.
    14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
    14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. See Fig. 6. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.
15. Install a new retaining ring in the groove.
16. Using Exxon Polyrex EP2 grease, pack the end of the valve housing bore and around the input shaft with clean grease.
17. Install a new dirt and water seal.
    17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal.
    17.2 Apply Exxon Polyrex EP2 grease to the new dirt and water seal and install it on the input shaft. See Fig. 7. Seat it in the



1. Seal Installer Tool

Fig. 6, Seal Installer Tool Position



A. Seat the seal here.

Fig. 7, Dirt and Water Seal Installation

groove behind the serrations and against the valve housing.

Wipe any excess grease from the valve housing bore and input shaft once the seal has been installed.

18. Connect the steering driveline to the steering gear input shaft.

    18.1 Clean the input shaft and the inside of the driveline yoke.

    18.2 Apply a thin film of grease to the yoke splines.

    18.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

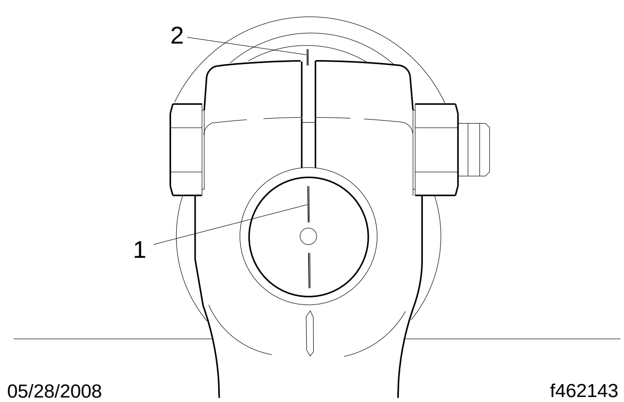
    18.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

19. Connect the return line to the steering gear return port.
20. Fill and air bleed the steering system. For instructions, see **Subject 120**.
21. Perform the post-service checks in **Subject 130**.

Sector Shaft Adjustment

NOTE: If the steering gear is installed on the frame rail, sector shaft adjustment can only be completed if the adjusting screw jam nut (located on the side cover) is accessible.

1. Apply the parking brakes and chock the rear tires.
2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The sector shaft is now at its center of travel. See **Fig. 8**. Shut down the engine.



1. Housing Timing Mark
2. Sector Shaft Alignment Mark

Fig. 8, Timing Mark Placement

3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Disconnect the drag link from the pitman arm.

Steering Gear Adjustments

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. See **Fig. 9**. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.

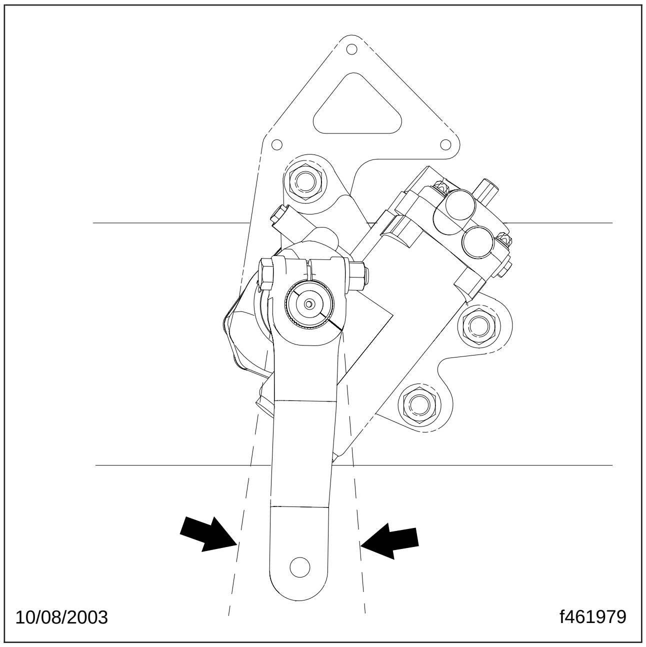


Fig. 9, Lash Check

5. Loosen the adjusting screw jam nut.
6. If no lash was detected in step 4, use a screwdriver to turn the sector shaft adjusting screw counterclockwise until you feel lash at the sector shaft. See **Fig. 10**.

IMPORTANT: Do not use more than 10 lbf·ft (14 N·m) of force when tightening the adjusting screw.

7. Slowly turn the adjusting screw clockwise until no lash is felt at the pitman arm. From this position, turn the adjusting screw clockwise 1/8 to 3/16 of a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).

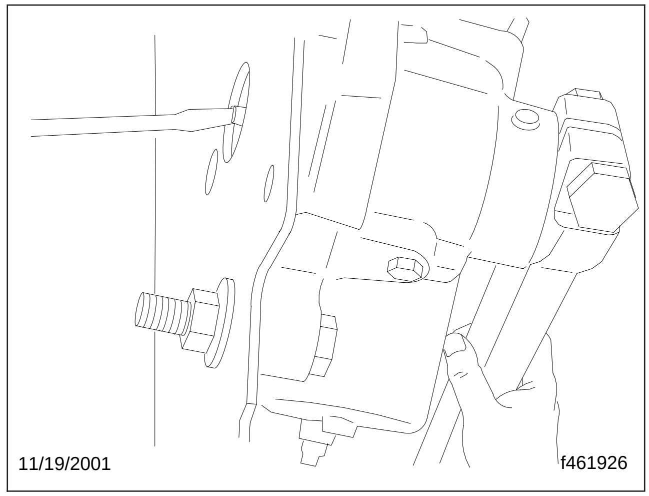


Fig. 10, Adjusting the Sector Shaft

8. Turn the steering wheel 1/4 of a turn to each side of center and recheck the pitman arm for lash. If lash is detected, adjust the sector shaft again.
9. Using a castle nut, attach the drag link to the pitman arm. Tighten the castle nut using the appropriate torque value.
   - 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
   - 7/8–14: 160 to 300 lbf·ft (217 to 407 N·m)

WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.

10. Continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

NOTICE

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high-pressure seal and contaminate the hydraulic fluid.

11. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.

Resetting the Poppet Valves

IMPORTANT: The axle stops must be set so that there are at least 1-3/4 steering wheel turns from a straight-ahead position to both a full-left and a full-right turn; otherwise the poppet valves will not work.

1. Verify that the axle stops are adjusted properly. See **Group 33** for instructions.
2. Start the engine and allow the vehicle to idle for 5 to 10 minutes to warm the hydraulic fluid.
3. Shut down the engine, apply the parking brakes, and chock the rear tires.
4. Hold the poppet screw with a wrench and turn the sealing nut back toward the wrench until the nut is flush with the base of the hex area of the poppet screw.
5. Make sure that the engine is off and the wheels are in the straight-ahead position.

NOTICE

Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.

6. Using a 7/32-inch Allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing. See **Fig. 11**.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

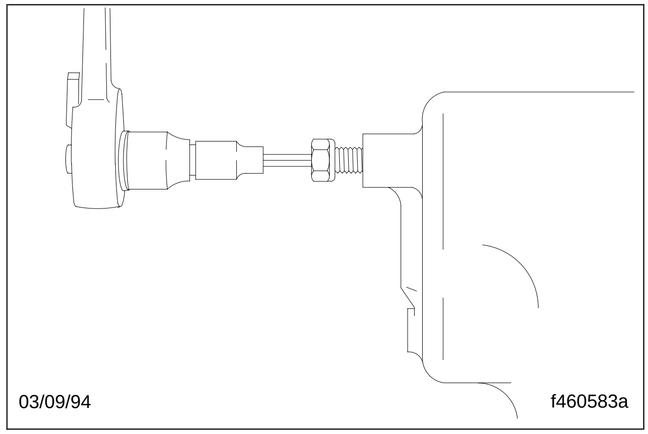


Fig. 11, Adjusting Screw and Nut Assembly

7. Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
8. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.
9. Push the upper poppet out to prepare it for setting.
   - 9.1 Start the engine and let it idle.
   - 9.2 Note which sector shaft timing mark is nearest the housing piston bore.

NOTICE

Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.

   - 9.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the wheel in this direction until axle stop contact is made.
   - 9.4 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.
10. Set the upper poppet.
   - 10.1 Turn the steering wheel in the opposite direction (the timing mark will move away from the adjusting screw) until the other axle stop is contacted.

Steering Gear Adjustments

10.2 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.

10.3 Release the steering wheel and shut off the engine.

11. Loosen the sealing nut and back out the adjusting screw until the adjusting screw is 1 inch (2.5 cm) past the nut. See **Fig. 12**. Tighten the nut against the housing.

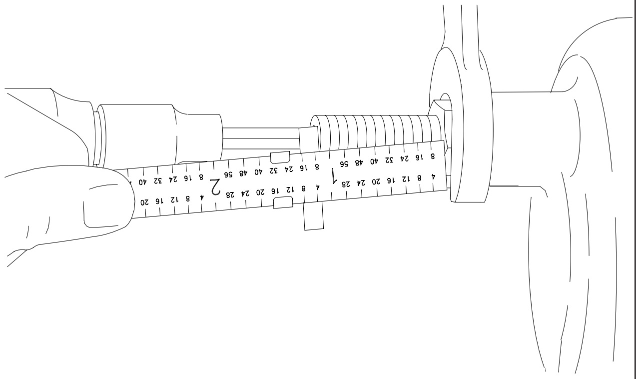


Fig. 12, Adjusting Screw Position

12. Set the lower poppet.

12.1 Start the engine and let it idle.

12.2 Turn the steering wheel in the original direction (the timing mark will move toward the adjusting screw) until axle stop contact is made.

12.3 Hold the steering wheel in this position with up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.

13. Position the adjusting screw.

13.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

IMPORTANT: Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

13.2 Using an Allen wrench and finger pressure only, turn the adjusting screw clockwise until the Allen wrench stops.

WARNING

If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in personal injury or property damage.

13.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

14. The poppets have now been completely reset. Check the power steering reservoir. If needed, add fluid.

15. Lower the vehicle.

Steering Gear Removal and Installation

Removal

1. Verify correct axle stop adjustment. Ensuring correct axle stop adjustment now will eliminate the need to reset the steering gear poppet valves after the gear is installed. For instructions, refer to **Group 33**.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work is to be done.
3. Shut down the engine, apply the parking brakes, and chock the tires.
4. Clean all fittings and hose connections on the steering gear until they are free of dirt.
5. Drain the fluid from the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later reference. Seal the lines and the fittings to keep out dirt.
6. Disconnect the pitman arm from the steering gear sector shaft.
   6.1 Remove and discard the pinch bolt, washer, and nut from the pitman arm.
   6.2 Remove the pitman arm using a suitable puller, then swing the pitman arm and drag link out of the way.
7. Disconnect the steering driveline from the steering gear input shaft.
   7.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

NOTICE

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   7.2 Remove the lower end yoke from the input shaft.

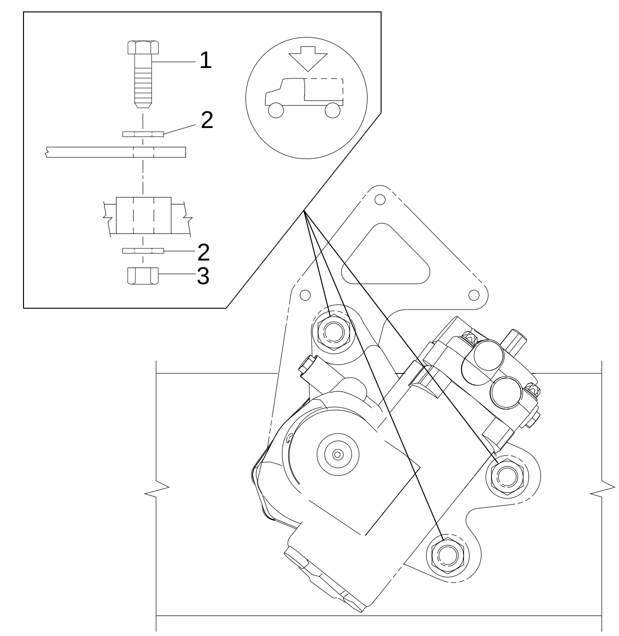
WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

8. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

Installation

1. Install the steering gear and fasteners as shown in **Fig. 1**. Tighten the fasteners 427 lbf·ft (579 N·m).



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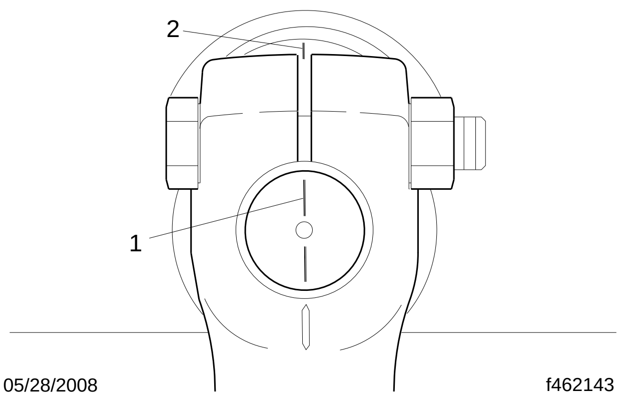
1. Bolt
2. Washer
3. Nut

Fig. 1, Steering Gear Installation

2. Center the steering gear so that the timing mark on the sector shaft is aligned with the timing mark on the steering gear housing. See **Fig. 2**. Keep the steering gear centered as the installation continues.
3. Connect the steering driveline to the steering gear input shaft.
   3.1 Clean the steering gear input shaft and the inside of the driveline yoke.
   3.2 Apply a thin film of grease to the yoke spline.

Steering Gear Removal and Installation



1. Housing Timing Mark
2. Sector Shaft Alignment Mark

Fig. 2, Timing Mark Placement

3.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

3.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

WARNING

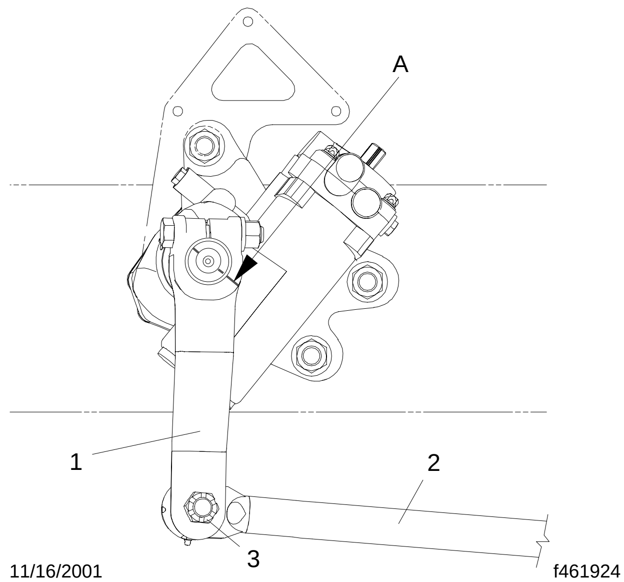
Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place. Install the pitman arm on the sector shaft. Remove the chisel from the slot.

4. Install the pitman arm.

4.1 Position the pitman arm on the steering gear, aligning the timing mark as shown in **Fig. 3**.

4.2 Using a new pinch bolt, nut, and washer (if applicable), attach the pitman arm to the steering gear sector shaft.



A. The timing mark on the pitman arm must line up with the timing mark on the sector shaft.

1. Pitman Arm
2. Drag Link
3. Castle Nut

Fig. 3, Pitman Arm

Tighten the nut 200 to 230 lbf·ft (272 to 313 N·m).

4.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

5. If they were removed, attach the hydraulic line fittings to the steering gear. Tighten the fittings 38 lbf·ft (52 N·m). Tighten the pressure line fitting jam nut 41 lbf·ft (56 N·m).
6. Remove the plugs from the hydraulic lines. Connect the lines to the steering gear as previously marked. Tighten the nut on each fitting finger tight. Then, use a wrench to tighten the nut until there is firm resistance. Tighten 1/6 of a turn more.
7. Connect the batteries.
8. Fill and bleed the steering system. For instructions, refer to **Subject 120**.
9. Close the hood and perform the post-service checks in **Subject 130**.

Filling and Air Bleeding the System

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

1. Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
2. Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

3. Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.
4. Start the engine again. Steer the vehicle from full left to full right several times. Check and, if necessary, refill the reservoir.

   Automatic bleed systems should now be free of trapped air. Skip to the last step in this procedure.

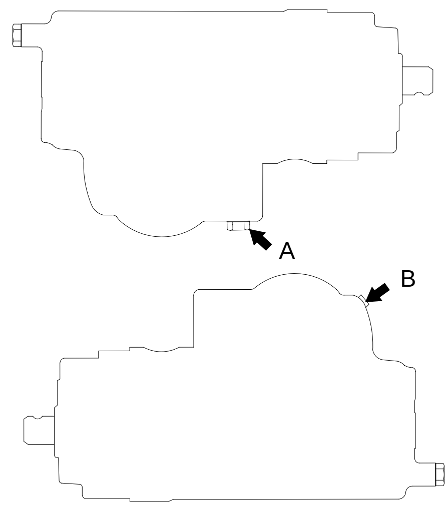
   If the vehicle has a manual bleed system (**Fig. 1**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

5. With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

   Repeat this step until all air is out of the system.

   Tighten the bleed screw 45 lbf·in (509 N·cm).



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A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

Fig. 1, Steering Gear Bleed Systems

Post-Service Checks

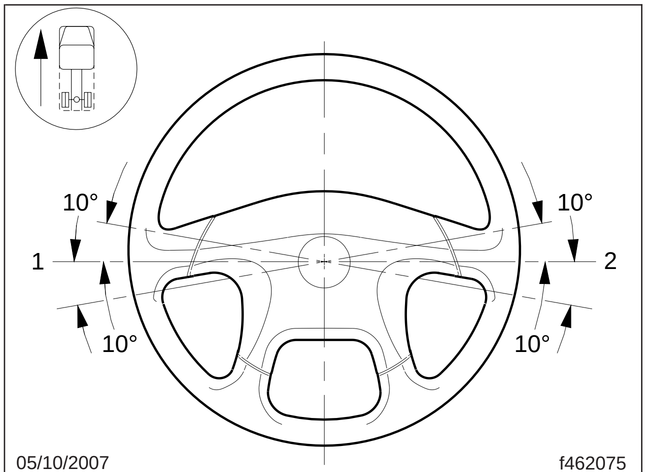
After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

WARNING

Failure to check the following items could result in damage to the power steering system. This could cause loss of steering assist and spillage on the roadway, which could cause personal injury or property damage.

1. Operate the engine at low idle while turning the steering wheel through several full-left and full-right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).

   If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.
2. With the engine turned off and warm, check the power steering reservoir fluid level. If needed, add power steering fluid.
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 of an inch (19 mm). If clearance is less than this, reset the axle stops.
4. Check that the poppets are set correctly. If necessary, adjust them. For instructions, see **Subject 100**.
5. If there are still problems with the power steering system, perform the troubleshooting procedures in **Section 46.11**. Otherwise, go to the next step.
6. Test drive the vehicle and check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be pointing within ±10 degrees of the 9 o'clock and 3 o'clock positions on a four-spoke steering wheel. If not, remove the steering wheel and install it in the correct position. See **Fig. 1**.



1. 9 o'Clock Position
2. 3 o'Clock Position

Fig. 1, Steering Wheel Centered

Specifications

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

TRW TAS power steering gears use automatic transmission fluid that meets Dexron II, Dexron III, Mercon, or ATF +4™ specifications.

Exxon Polyrex® EP2 Grease (045422) is approved for use on steering gear components.

Special tools can be ordered from:

SPX Kent-Moore
28635 Mount Road
Warren, Michigan 48092-3499
1-800-328-6657

SPX Kent-Moore Tools	
Tool	**Part Number**
Bearing Adjuster Tool	J37070
Poppet Adjuster Seat Tool	J36452
Seal Installer Tool	J37073

Table 1, SPX Kent-Moore Tools

General Information

The fuel system delivers fuel to the engine. It consists of the engine fuel system components, the fuel tanks and tank mounting components, and the fuel lines and shut-off valves.

The engine fuel system components include fuel filters, injectors, fuel transfer pumps, and a fuel governor. For service and maintenance procedures, refer to the applicable engine manufacturer's service and maintenance manuals.

The fuel tanks, which provide a clean storage area for fuel, are held in place by metal straps and brackets that transfer the load to the vehicle frame. A cab access step assembly or an air fairing attaches to the fuel-tank straps and brackets.

Flexible, reinforced fiber-braid hoses (fuel lines) bring fuel from the tank to the engine, and return surplus fuel from the engine to the tank.

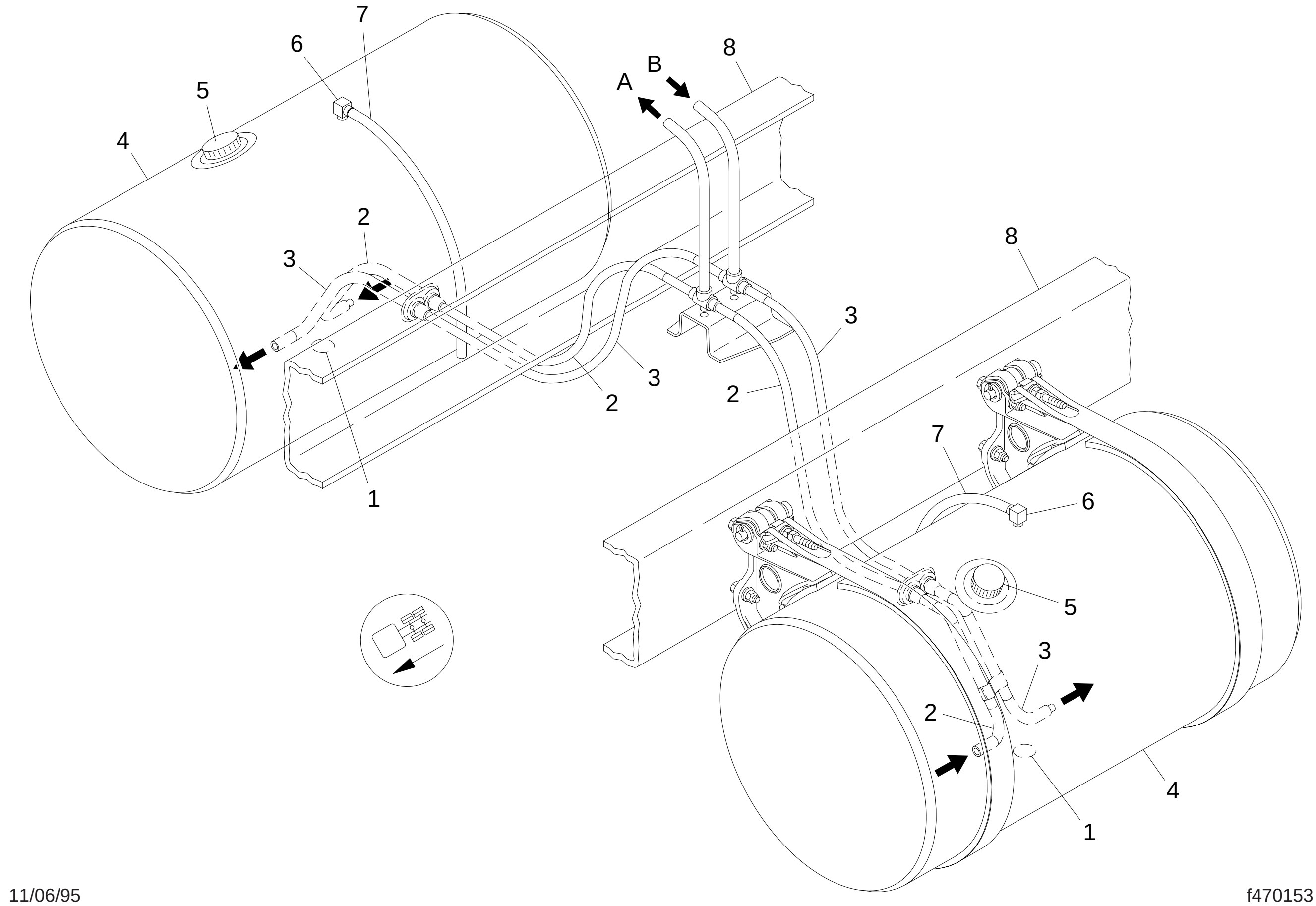
The EquiFlo® Inboard Fuel System is standard on all single-tank vehicles and recommended for all dual-tank systems. See **Fig. 1**. This system includes the following:

- inboard-routed fuel lines
- suction and return lines installed in a common fuel-tank opening
- fuel-tank vent and line located on the top of the tank
- a new quarter-turn, non-vented fuel cap

The fuel lines are routed inboard of the frame rails to the shut-off valves (if equipped), which are normally located on the left-hand frame rail.

Fuel is drawn equally from, and returned to, each tank so that their levels remain equal. The suction and return fuel lines, although entering the fuel tank through the same opening, are designed to direct the fuel flow to the bottom of the tank. See **Fig. 1**. This ensures thorough mixing of the fuel before it is drawn up by the suction line so that vapor can disperse (and warm fuel is not recirculated in electronic engines).

General Information



NOTE: Arrows indicate direction of flow.

A. To fuel pump
B. From engine

1 Drain
2. Supply (Suction) Line
3. Return Line
4. Fuel Tank
5. Fuel Cap
6. Vent
7. Vent Line
8. Frame Rail

Fig. 1, EquiFlo Inboard Fuel System

Fuel Tank Replacement

Replacement

If there is any damage to the fuel tank, replace it.

IMPORTANT: Fuel tanks made after January 1, 1973, are subject to U.S. Federal Motor Carrier Safety Regulation 393.67. This law calls for certain standards relating to strength, leakage, and venting. These standards are achieved through the use of specific materials and construction methods. *These standards also apply to replacement fuel tanks.*

WARNING

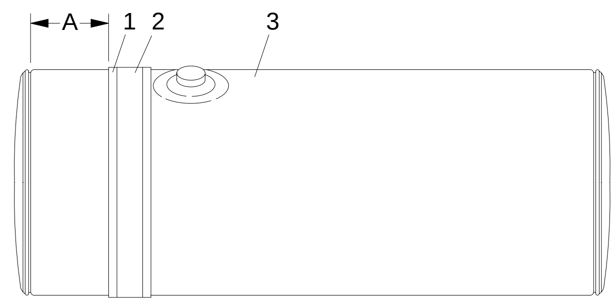
Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

1. Remove the chassis fairings. For instructions, refer to **Section 31.04**, Subject 100.

IMPORTANT: On dual tank installations with fuel shutoff valve(s), close the valve(s) before draining the tank.

2. Drain the fuel from the tank.
   - 2.1 Remove the drain plug from the fuel tank that is to be replaced.
   - 2.2 Drain the fuel into a suitable container of sufficient volume to hold the amount of fuel in the tank.
   - 2.3 If the fuel is to be re-used, store it in a clean container, and keep it free from contaminants.
3. Disconnect the fuel suction line and return line from the tank, and cap the lines.
4. Remove and clean all of the pipe plugs, and save them for installation on the new tank.
5. Before removing the fuel tank bands, measure the distance from the forward edge of the fuel tank to the edge of the fuel tank band. See **Fig. 1**.
6. To prevent the fuel tank from rolling during and after removal, nail several 2-by-4 or 4-by-4 wooden blocks to the top of a pallet about 18 inches (46 mm) apart, then place the pallet on the forks of a fork lift. See **Fig. 2**.

   Move the fork lift and pallet into place to support the fuel tank as the tank bands are being removed.



A. Measure the distance from the end of the tank to the edge of the band isolator.
1. Band Isolator
2. Fuel Tank Band
3. Fuel Tank

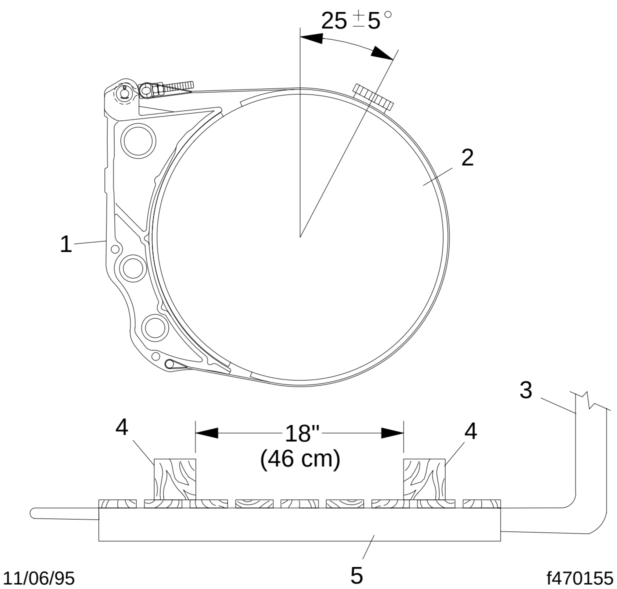
Fig. 1, Measuring the Band Installation Distance

7. Using a 15/16-inch socket with extender bar, loosen the jam nut on each tank band eye bolt. Remove the jam nut, inner hexnut, and washer. See **Fig. 3**.

   Drop the tank bands and isolators. Leave the tensioner lug inside the band.
8. Remove the fuel tank from the fuel tank bracket.
9. After removing the tank, inspect the tank bands, isolators, and brackets for damage. Replace worn or damaged parts with new parts. Refer to **Subject 120** for bracket replacement procedures; refer to **Subject 110** for band replacement procedures.
10. Using the fork lift and pallet, place the fuel tank in its approximate installed position. Make sure the tank is rotated so the vent is located at the top. See **Fig. 2**.

    Install the forward tank band and band isolator loosely.
    - 10.1 Holding the tank on the forklift, attach the band and isolator to the eye bolt.

Fuel Tank Replacement



Make sure the tank is rotated so the vent is located at the top.

Note: The fuel filler neck should be rotated 25 degrees outboard of vertical on standard tanks and 15 degrees on auxiliary tanks.

1. Fuel Tank Bracket
2. Fuel Tank
3. Lift-Truck Fork
4. 4 x 4 Wooden Block
5. Wooden Pallet

Fig. 2, Preventing the Fuel Tank From Rolling

10.2 Install a hardened flatwasher and the inner 5/8–11 hexnut, but do not tighten it yet.

11. Move the new tank fore or aft until the distance between the forward edge of the tank and the tank band is equal to the distance measured in **Fig. 1**.

NOTE: On vehicles equipped with side fairings, the fuel tank filler neck does not have to be centered in the fill door opening of the side fairing. The centerline of the fuel tank cap is to be within 1 inch (25 mm) of either side of the centerline of the fill door opening. See **Fig. 4**. Do not move the fuel tanks to center the fuel tank filler neck in the fill door opening.

12. Install the other tank band around the tank; then insert the isolators under the brackets so that the relief in each isolator aligns with the tank longitudinal weld seam. See **Fig. 3**.

CAUTION

Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by over-tightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.

13. Tighten the inner hexnuts alternately in stages until each is tightened 30 to 35 lbf·ft (41 to 47 N·m). When both hexnuts have been tightened, install a jam nut on each hexnut. Hold each hexnut with a 15/16-inch wrench while tightening its jam nut 30 lbf·ft (41 N·m).

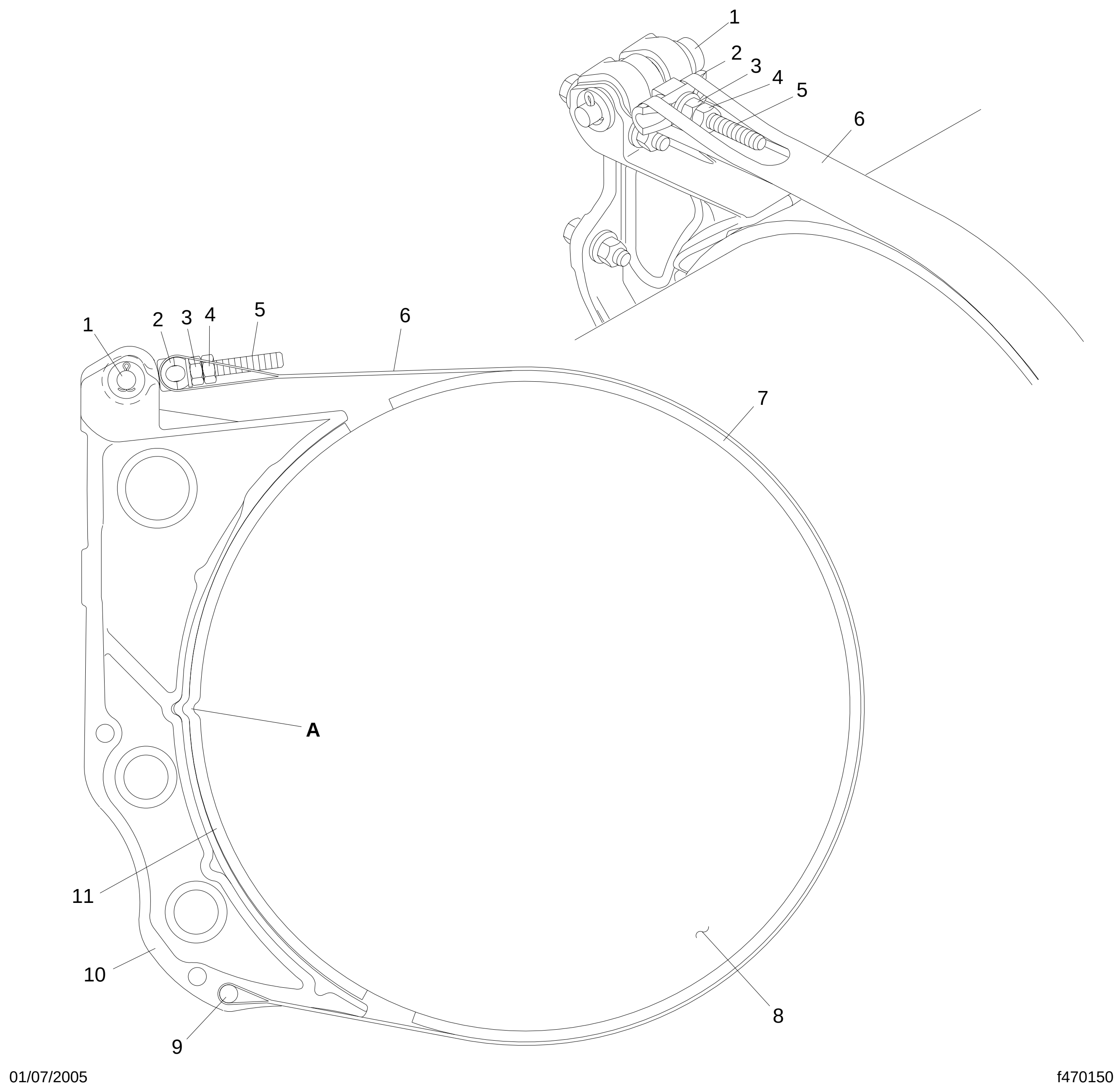
14. Make certain the fuel lines are clean, then install them on their fittings on the fuel tank.

    Coat the pipe plug threads with Loctite® 592, or an equivalent. Install pipe plugs in any remaining open threaded holes.

15. Install the chassis fairings. For instructions, see **Section 31.04**, Subject 100.

16. Fill the fuel tank with clean fuel. Prime the engine fuel pump. See the engine manufacturer's operation and maintenance manual.

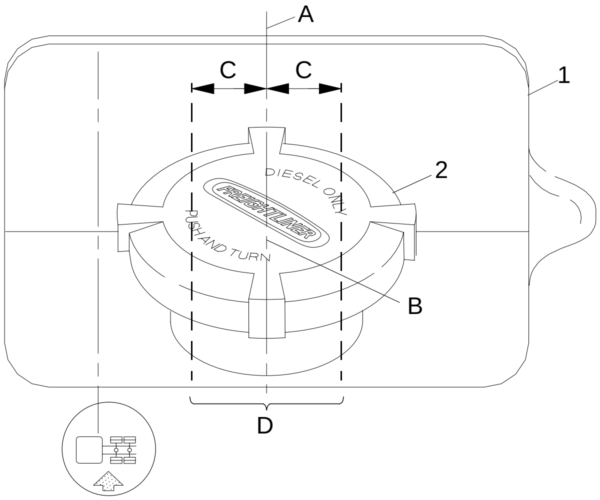
    On dual tank installations with fuel shutoff valve(s), open the valve(s).



1. Large Clevis Pin
2. Tensioner Lug
3. Hexnut, 5/8–11
4. Jam Nut, 5/8–11
5. Eye Bolt
6. Fuel Tank Band
7. Band Isolator
8. Fuel Tank
9. Small Clevis Pin
10. Fuel Tank Bracket
11. Bracket Isolator

Fig. 3, Fuel Tank Band Assembly

Fuel Tank Replacement



A. Centerline of fill door opening
B. Centerline of fuel cap
C. 1 inch (25 mm)
D. Fuel cap centerline to be within this area.
1. Fill Door Opening 2. Fuel Cap

Fig. 4, Fuel Cap Installation

Replacement

1. Remove the chassis fairings. For instructions, refer to **Section 31.04**, Subject 100.
2. Using a floor jack or fork lift and protective padding, support the fuel tank.
3. Remove the nuts and washer from the tank band eye bolt at the outboard end of the tank bracket. See **Fig. 1**.
4. Drop the tank band. Inspect both the band and bracket isolators for wear or damage, and replace if needed.
5. Remove the band.
   - 5.1 Remove the small clevis pin from the bottom end of the fuel tank bracket, freeing the band.
   - 5.2 Remove the band from the fuel tank.
6. Install the band.
   - 6.1 Position the small end of the new band in place on the bottom edge of the fuel tank bracket.
   - 6.2 Install the small clevis pin and two hardened flatwashers onto the fuel tank bracket and band, and fasten it in place with a cotter pin.
7. Apply Alumilastic® compound or equivalent to the bracket where it contacts the band.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

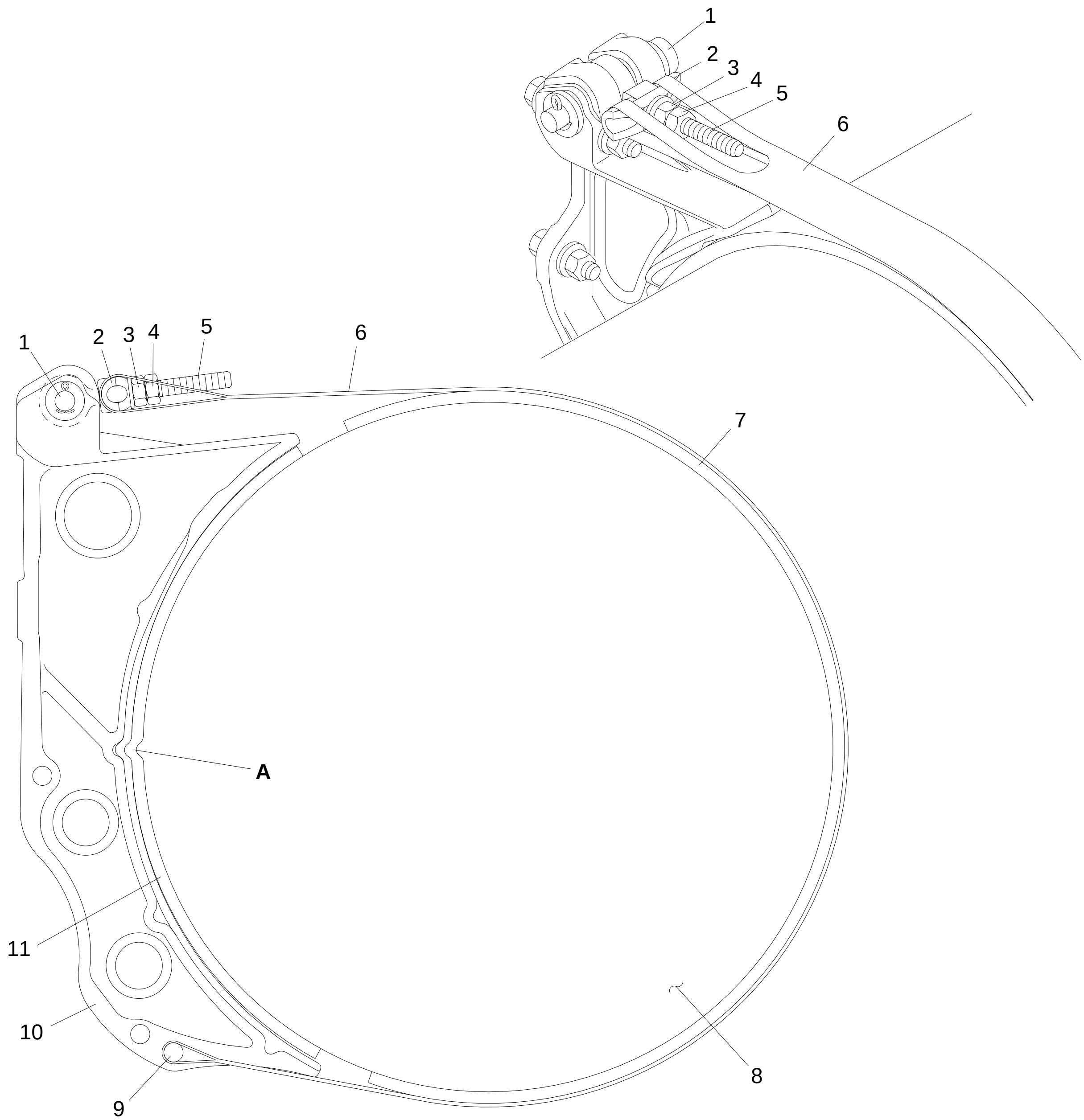
8. Position the new tank band, with band isolator, around the tank. Insert the bracket isolator under the bracket so that a relief in the isolator aligns with the tank longitudinal weld seam. See **Fig. 1**.

CAUTION

Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.

9. Attach the upper end of the band and tighten the band nuts.
   - 9.1 Position the large end of the band, with tensioner lug in place, on the end of the eye bolt.
   - 9.2 Install a hardened flatwasher and the inner hexnut. Tighten the inner hexnut 30 to 35 lbf·ft (41 to 47 N·m).
   - 9.3 Install a jam nut on the hexnut. Hold the hexnut with a 15/16-inch wrench while tightening its jam nut 30 lbf·ft (41 N·m).
10. Repeat this procedure to replace the other band. When both bands have been replaced, check both inner hexnuts and both jam nuts for tightness.
11. Install the chassis fairings. For instructions, refer to **Section 31.04**, Subject 100.

Fuel Tank Band Replacement



1. Large Clevis Pin
2. Tensioner Lug
3. Hexnut, 5/8–11
4. Jam Nut, 5/8–11
5. Eye Bolt
6. Fuel Tank Band
7. Band Isolator
8. Fuel Tank
9. Small Clevis Pin
10. Fuel Tank Bracket
11. Bracket Isolator

Fig. 1, Fuel Tank Band Assembly

Fuel Tank Bracket Replacement

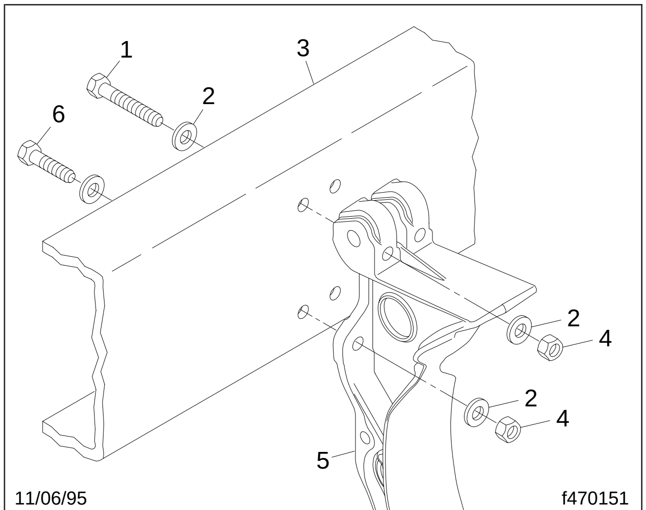
Replacement

1. Support the tank and remove the fuel tank band from the bracket that is being replaced. See **Subject 110** for instructions.
2. Remove the fasteners that attach the bracket to the frame rail and remove the bracket. See **Fig. 1**.
3. Install the bracket.
   - 3.1 Apply Alumilastic® compound, or equivalent, between the fuel tank bracket and the frame rail.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

   - 3.2 Position the new tank bracket against the outside of the frame rail. See **Fig. 1**.
   - 3.3 Insert two 5/8–11 x 4-inch bolts with washers through the top holes in the frame rail and bracket.
   - 3.4 Insert two 5/8–11 x 2-1/4 inch bolts with washers through the bottom holes in the frame rail and bracket.
   - 3.5 Install hardened washers and hexnuts on all four bolts. Tighten the hexnuts 160 lbf·ft (217 N·m).
   - 3.6 Install the fuel tank band. See **Subject 110** for instructions.



1. Large Mounting Bolt, 5/8–11 x 4 in
2. Hardened Flatwasher
3. Frame Rail
4. Hexnut, 5/8–11
5. Fuel Tank Bracket
6. Small Mounting Bolt, 5/8–11 x 2-1/4 in

Fig. 1, Fuel Tank Bracket Installation

Flushing

In the event of a catastrophic failure of the high-pressure fuel pump, it is necessary to clean the fuel tanks and all other system components between the tanks and the engine. For information about cleaning the engine components after a failure, refer to the engine manufacturer's service literature.

IMPORTANT: Always follow EPA and local regulations when disposing of contaminated fuel.

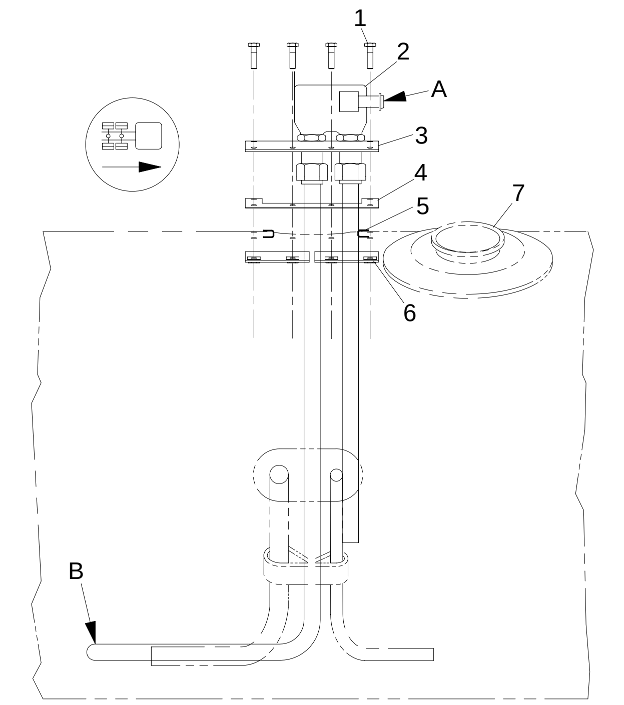
1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain all of the fuel from the tank(s) into a suitable container. Dispose of the contaminated fuel in an appropriate manner.
3. Remove the tank(s) from the vehicle. For instructions, refer to **Subject 100**.

IMPORTANT: If the fuel tanks are equipped with anti-siphon devices, replace the tanks following the instructions in **Subject 100**, then skip to Step 8.

4. Thoroughly steam clean the inside of the tank until all water leaving the drain hole looks clean.
5. Install a 1/2-inch NPT magnetic drain plug, and cap any other open outlets.
6. Put two gallons of diesel fuel in the tank, and install the cap. Slosh the diesel around in the tank making sure it reaches all interior surfaces. This should collect most of any remaining contaminants in the tank.
7. Drain the fuel from the tank into a suitable container, and install the 1/2-inch NPT magnetic drain plug. Dispose of the contaminated fuel in an appropriate manner.
8. If equipped, remove the fuel/water separator(s) from the system. For instructions, refer to **Group 47**.
9. Remove and discard the filter element. Then thoroughly clean the unit.
10. Install a new filter element.
11. Remove all of the fuel lines from the system and replace them with new lines.
12. Install the fuel/water separator. For instructions, refer to **Group 47**.
13. Install the fuel tank(s) on the vehicle. For instructions, refer to **Subject 100**.

General Information

The Arctic Fox fuel heater Model C406 is installed in the fuel tank facing the fuel filler neck. See **Fig. 1**. The fuel heater comes in two different lengths to accommodate 23- and 27-inch cylindrical tanks.



NOTE: Right-hand tank shown.

A. Orient coolant fittings toward the fuel filler neck.
B. Install fuel heater with lower loop pointing aft.

1. Mounting Capscrew
2. Fuel Heater
3. Mounting Flange
4. Gasket
5. Mounting Clip
6. Backing Plate
7. Fuel Filler Neck

Fig. 1, Arctic Fox Fuel Heater

Twelve 1/4-inch capscrews bolt the heater to the tank, attaching to a mounting flange that is an integral part of the heater head. A heating coil, consisting of a coolant tube in the form of a closed loop, extends down into the tank.

To prevent overheating, the unit is equipped with a temperature probe that monitors fuel temperature. It is connected to a bypass thermostat that controls an automatic coolant shut-off valve.

Principles of Operation

Hot engine coolant is routed through the heating coil, warming the fuel as it passes. A bypass thermostat shuts off the coolant flow when the fuel in the tank reaches a temperature of approximately 80°F (27°C).

The hot coolant is then directed through a bypass circuit within the thermostat head, which sends it straight back to the engine. For this reason, the head of the fuel heater stays hot even when the heating circuit has been bypassed.

Arctic Fox Fuel Heater Replacement

Replacement

IMPORTANT: When installed in the fuel tank, the clearance between the bottom of the fuel heater and the inside of the tank wall must be at least 1 inch (25 mm) and no more than 2 inches (51 mm).

1. Apply the parking brakes, shut down the engine, and chock the tires.

WARNING

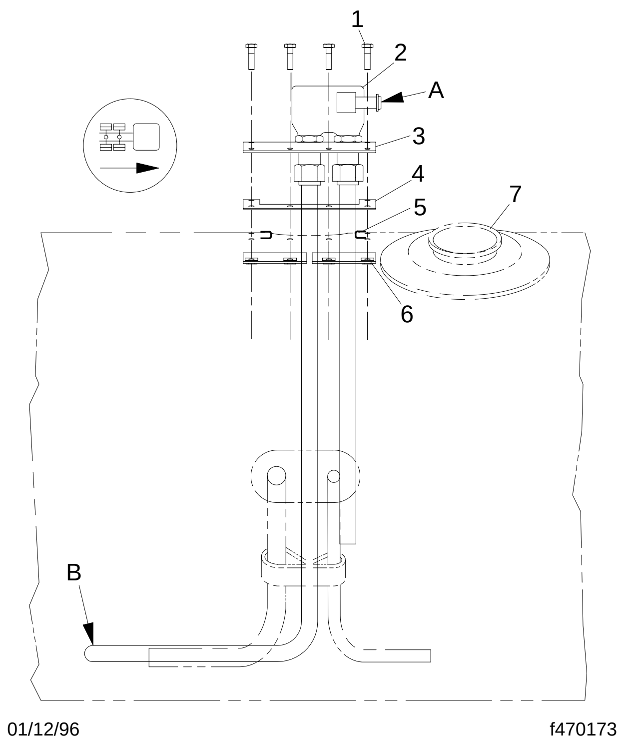
Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant. Refer to **Section 20.01**, Subject 100, for instructions.
3. Mark the coolant fittings and lines. Disconnect the coolant lines from the fittings on the fuel heater.

WARNING

Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

4. Remove the twelve 1/4-inch capscrews attaching the fuel heater mounting flange to the fuel tank. See **Fig. 1**.
5. Remove the fuel heater from the fuel tank.
   5.1 Carefully work the fuel heater coil out of the fuel tank around the backing plate.
   5.2 Remove the fuel heater gasket.
6. Install the new fuel heater in the fuel tank.
   6.1 Position a new gasket on the hole in the fuel tank. Align the holes in the gasket with those in the tank.
   6.2 Insert the heater coil into the tank, making sure that it does not contact anything inside the tank, such as the tank wall, the fuel gauge, the standpipe, or tank baffles.



NOTE: Right-hand tank shown.

A. Orient coolant fittings toward the fuel filler neck.
B. Install fuel heater with lower loop pointing aft.

1. Mounting Capscrew
2. Fuel Heater
3. Mounting Flange
4. Gasket
5. Mounting Clip
6. Backing Plate
7. Fuel Filler Neck

Fig. 1, Arctic Fox Fuel Heater Installation

   6.3 Line up the heater mounting flange with the gasket and the holes in the tank, and insert the twelve 1/4-inch mounting capscrews. Tighten the capscrews 40 to 60 lbf·in (460 to 680 N·cm).

   NOTE: Be sure the heads of the capscrews are snug to the top of the mounting flange.

   6.4 Now tighten each capscrew 78 to 95 lbf·in (880 to 1080 N·cm).
7. Using the sequence shown in **Fig. 2**, recheck each capscrew for 78 to 95 lbf·in (880 to 1080 N·cm).

IMPORTANT: To ensure that the gasket seals properly, follow the tightening sequence exactly.

Arctic Fox Fuel Heater Replacement

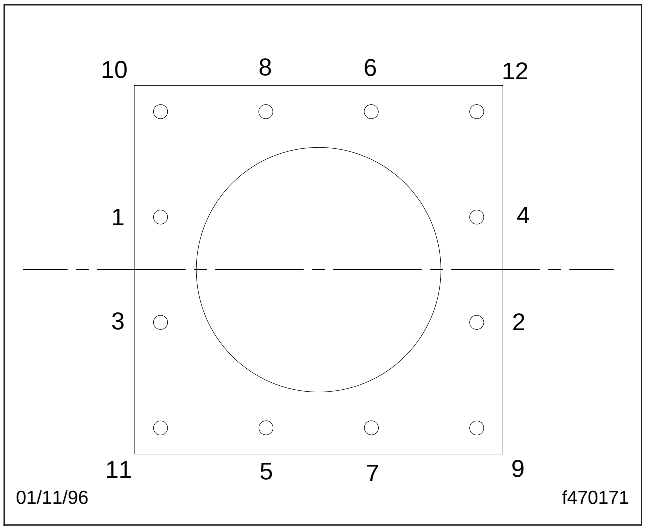


Fig. 2, Fastener Tightening Order

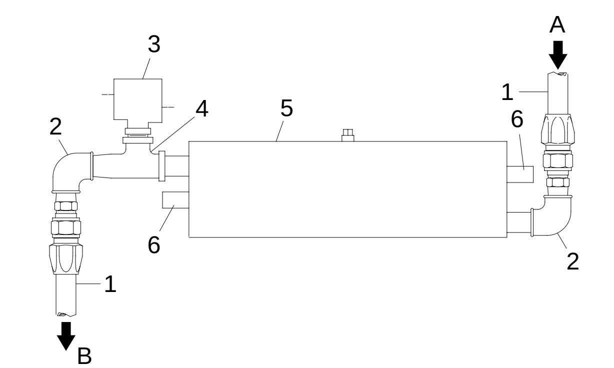
8. Connect the coolant lines to the heater, as marked. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings finger-tight plus 1/4 turn.

IMPORTANT: Keep all lines as straight as possible.

9. Fill the cooling system with clean coolant. Refer to **Section 20.01**, Subject 100, for instructions.
10. Start the engine and check for coolant leaks. With the engine shut down, repair any leaks.
11. Lower the hood and remove the chocks from the tires.

General Information

The Webb in-line fuel heater (**Fig. 1**) is clamped to a mounting bracket, which in turn is bolted to the frame rail. Hot engine coolant circulates through the heater, heating the fuel in the supply line.



01/27/2000 f470174

A. From fuel tanks
B. To engine or fuel/water separator

1. Fuel Line
2. 90° Elbow
3. Thermostat
4. Tee
5. Fuel Heater
6. Coolant Port

Fig. 1, Webb In-Line Fuel Heater

To prevent overheating, the heater is equipped with an automatic coolant shut-off valve.

Webb In-Line Fuel Heater Replacement

Replacement

1. Apply the parking brakes, shut down the engine, and chock the rear tires. Open the hood.

WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

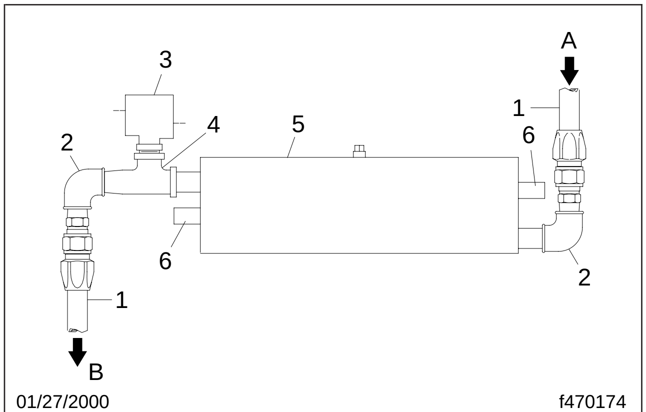
2. Drain the coolant. Refer to **Section 20.01** for instructions.
3. On dual tank installations with shutoff valves, close the valves. Open the fuel filler cap to relieve pressure in the fuel system.

WARNING

Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

IMPORTANT: Place a container under the fuel- and coolant-line fittings to catch any residual fluid when the fittings are loosened and the lines removed.

4. Remove the fuel-line fittings (large fittings). See **Fig. 1**. Remove the coolant line fittings (small fittings).
5. Remove the fuel heater from the bracket. See **Fig. 2**.
   5.1 Remove the 1/2–13 hexnuts, washers, and bolts attaching the two heater clamps to the mounting bracket.
   5.2 Remove the fuel heater from the mounting bracket.
6. Install the new fuel heater on the bracket.
   6.1 Position the heater clamps on the mounting bracket and install the 1/2–13 mounting bolts, washers, and hexnuts.
   6.2 Tighten each hexnut 67 lbf·ft (84 N·m).

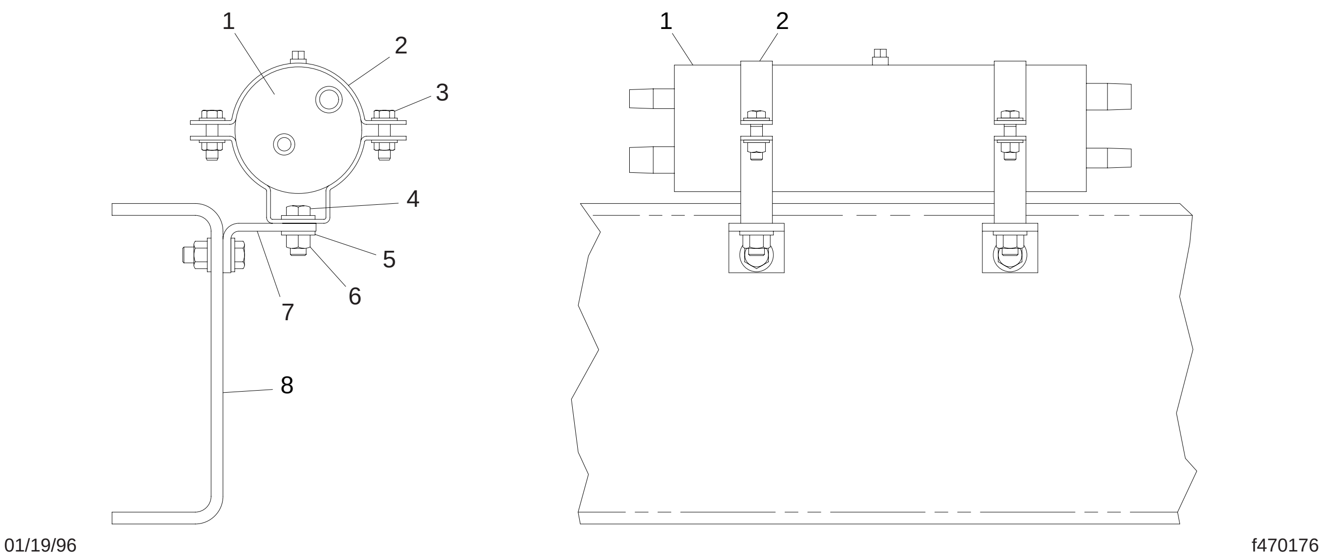


A. From fuel tanks
B. To engine or fuel/water separator
1. Fuel Line
2. 90° Elbow
3. Thermostat
4. Tee
5. Fuel Heater
6. Coolant Port

Fig. 1, Webb In-Line Fuel Heater

7. Install the input and output lines on the fuel heater. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings finger-tight plus 1/4 turn.
   - Connect the fuel lines to the heater.
   - Connect the coolant lines to the heater, as marked.
8. On dual tank installations with fuel shutoff valves, open the valves. Check the fuel filler cap to make sure it is tight.
9. Fill the cooling system with clean coolant. Refer to **Section 20.01** for instructions.
10. Start the engine and check for fuel and coolant leaks. With the engine shut down, repair any leaks.
11. Close the hood and remove the chocks from the tires.

Webb In-Line Fuel Heater Replacement

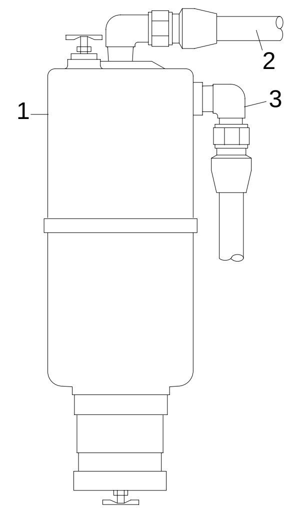


1. Fuel Heater
2. Heater Clamp
3. Heater Clamp Bolt
4. Mounting Bolt, 1/2–13
5. Washer, 1/2 in
6. Hexnut, 1/2–13
7. Mounting Bracket
8. Frame Rail

Fig. 2, Webb In-Line Fuel Heater Mounting

General Description

The Con Met fuel/water separator (**Fig. 1**) removes water and solid contaminants from diesel fuel. Installed on the left frame rail between the fuel tank and the fuel transfer pump, the separator has no moving parts and contains no filters.



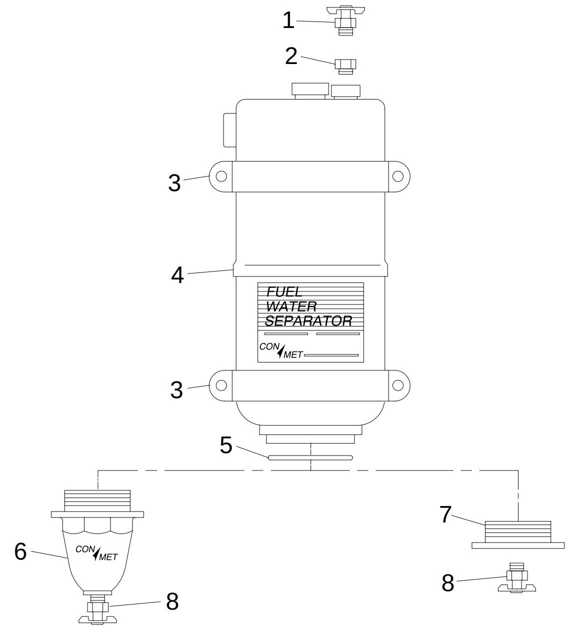
1. Fuel/Water Separator
2. Intake Line
3. Exhaust Line

Fig. 1, Con Met Fuel/Water Separator, Basic Model

It is available in a basic model or with a sight bowl. All fuel and coolant line fittings are 1/2-inch NPT.

Principles of Operation

Diesel fuel enters at the top of the separator (**Fig. 2**) and flows down through a specially-designed baffle, causing the water in the fuel to coalesce in large droplets which then accumulate in the bottom of the unit and can be drained by opening a valve.



NOTE: Either bottom closure or sight bowl is installed, not both.

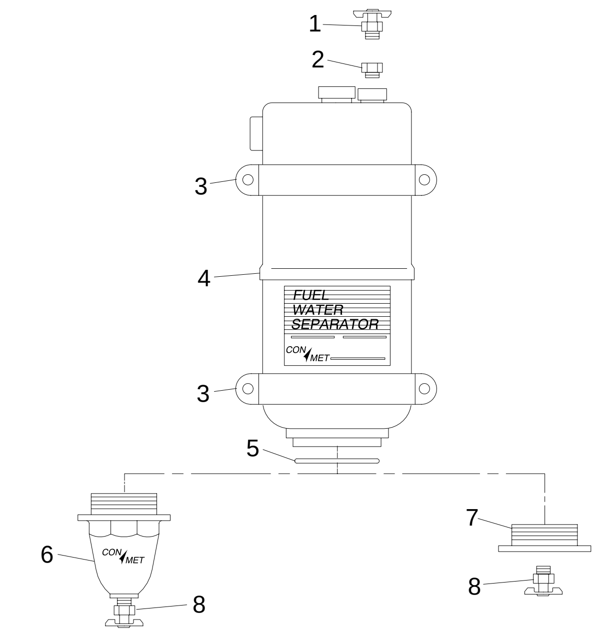
1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. Gasket
6. Sight Bowl
7. Bottom Closure
8. Drain Valve

Fig. 2, Separator Model with Sight Bowl Option

Con Met Fuel/Water Separator Removal and Installation

Removal

1. Apply the parking brakes, shut down the engine, chock the tires, and open the hood.
2. Drain the fuel/water separator. See **Fig. 1**.



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NOTE: Either bottom closure or sight bowl is installed, not both.

1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. Gasket
6. Sight Bowl
7. Bottom Closure
8. Drain Valve

Fig. 1, Con Met Fuel/Water Separator

2.1 Place a suitable container under the separator body.

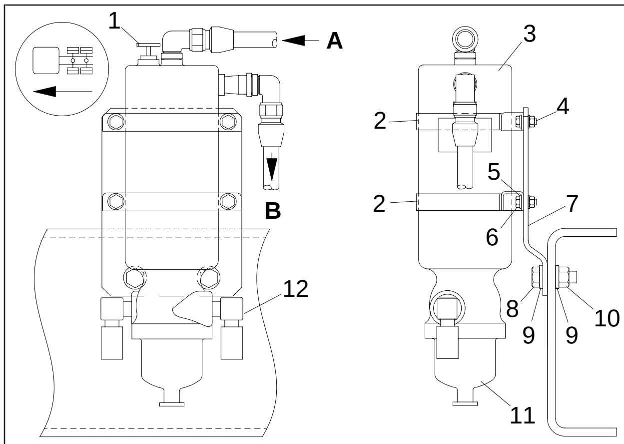
2.2 With the engine shut down, open the drain valve on the bottom of the separator body.

2.3 If the accumulated water does not drain immediately, open the vacuum breaker valve on the top of the separator body.

2.4 When the unit is completely drained, close the drain valve.

2.5 If opened, close the vacuum breaker valve.

3. Disconnect the 1/2-inch NPT fuel line fittings to the intake and exhaust lines on the separator body.
4. Remove the 5/8–18 bolts, lockwashers, and hexnuts that secure the mounting bands to the mounting bracket. See **Fig. 2**. Remove the fuel/water separator from the vehicle.



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A. From Fuel Tanks
B. To Engine

1. Vacuum Breaker Valve
2. Mounting Band
3. Separator Body
4. Mounting Band Bolt, 5/16–18
5. Lockwasher
6. Hexnut, 5/16–18
7. Mounting Bracket
8. Mounting Bracket Bolt, 5/8–11
9. Hardened Flatwasher
10. Locknut, 5/8–11
11. Sight Bowl (if installed)
12. Coolant Line (if installed)

Fig. 2, Con Met Fuel/Water Separator Mounting

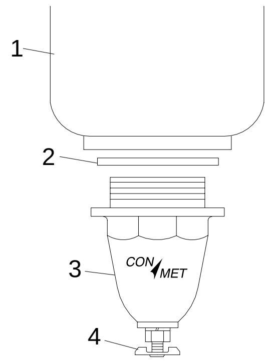
5. If installed, remove the sight bowl and clean it. See **Fig. 3**.

5.1 Unscrew the sight bowl from the separator body.

5.2 Wipe the sight bowl clean using a soft cloth.

5.3 Inspect the gasket for damage and install a new one if necessary. Lubricate the gasket with a thin film of engine oil and install it on the sight bowl.

Con Met Fuel/Water Separator Removal and Installation



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1. Separator Body
2. Gasket
3. Sight Bowl
4. Drain Valve

Fig. 3, Sight Bowl

5.4 Lubricate the threads on the sight bowl with a thin film of engine oil.

5.5 Hand tighten the sight bowl until the gasket has fully contacted the separator body, then tighten 1/4 to 1/3 turn more.

5.6 Make sure the drain valve is tightened and closed.

Installation

1. Check the mounting bracket locknuts for tightness. If necessary, tighten the locknuts 113 lbf·ft (153 N·m).
2. Mount the fuel/water separator vertically on the mounting bracket. Install the mounting bands, and secure them with 5/16–18 bolts, lockwashers, and hexnuts. Tighten the hexnuts 15 lbf·ft (20 N·m). See **Fig. 2**.
3. Attach the 1/2-inch NPT fuel line fittings to the inlet and outlet ports on the separator body.
4. Apply Loctite® 271 (or equivalent) to the threads on the 1/2-inch NPT fuel line fittings. Install the fittings on the inlet and outlet ports on the separator body. Tighten all fittings finger-tight plus 1/4 turn.
5. Prime the fuel/water separator with clean diesel fuel.

   5.1 Open the vacuum breaker valve.

   5.2 Fill the unit with clean diesel fuel.

   5.3 Close the vacuum breaker valve and be sure it is tight.

IMPORTANT: To prevent fuel leaks, be sure the vacuum breaker valve is closed securely.

6. Start the engine and check for leakage. With the engine shut down, repair any leaks.
7. Close the hood and remove the chocks from the tires.

Troubleshooting

Problem—Leaking Air in the Fuel System

Problem—Leaking Air in the Fuel System	
Possible Cause	**Remedy**
The vacuum breaker valve is loose.	Tighten the vacuum breaker valve. Make sure it is tight.
There are loose or broken fuel fittings, valves, or filters.	Tighten or repair the fuel fittings, valves, or filters as needed.

Problem—Leaking Fuel

Problem—Leaking Fuel	
Possible Cause	**Remedy**
The sight bowl is loose.	Tighten the sight bowl. For instructions, refer to **Subject 100**.
The sight bowl is cracked or broken.	Replace the sight bowl. For instructions, refer to **Subject 100**.
There are loose or broken fittings somewhere within the fuel system, including in the return lines.	Tighten or repair the fuel fittings as needed.

Specifications

Fastener Torque Specifications		
Fastener	Size	Torque: lbf·ft (N·m)
Mounting Band Hexnut	5/16–18	15 (20)
Mounting Bracket Locknut	5/8–11	113 (153)

Table 1, Fastener Torque Specifications

General Information

General Description

The fuel/water separator is mounted on the frame rail, between the fuel tank and the fuel pump. Fuel drawn to the engine travels through the fuel/water separator, which removes water and solid contaminants. The fuel/water separator includes a spin-on filter element and a sight bowl. See **Fig. 1**. The fuel/water separator may also be equipped with the following optional components:

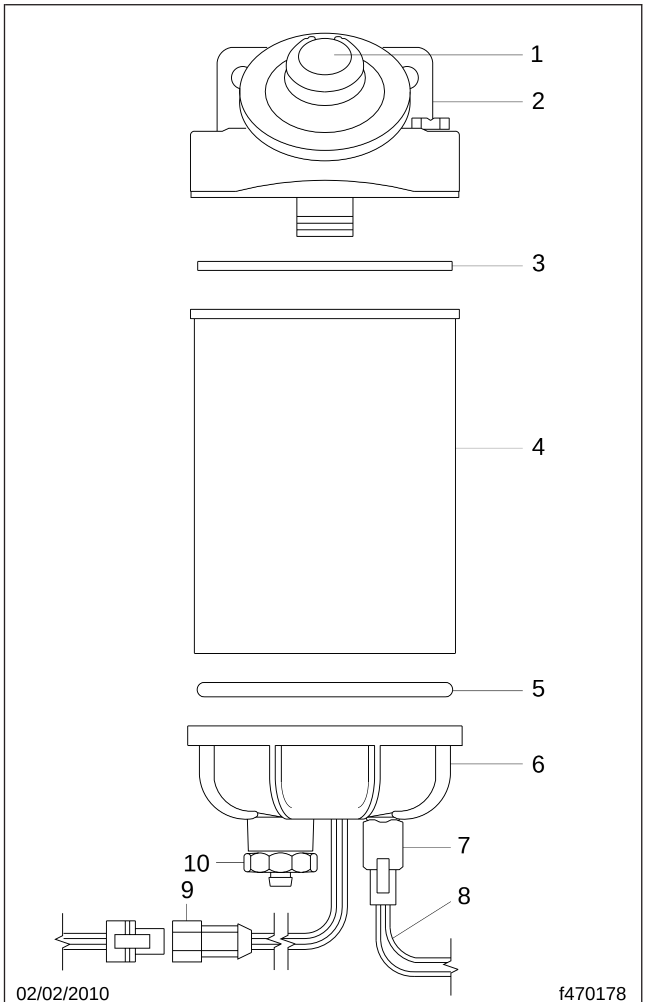
- Ignition-controlled heater to melt ice and wax in the fuel
- Water sensor probe to alert the operator to drain the sight bowl
- Manual priming pump to easily prime the fuel/water separator

Principles of Operation

Diesel fuel enters at the top of the separator and flows down past the heater element, if equipped, to the top of the filter element. As the fuel flows down the sides of the element, the heavier contaminants fall directly to the collection bowl. The filter element itself contains a resin that repels water and forces it to bead and fall to the collection bowl.

Filtered fuel is drawn out through the top of the separator, and the water and solid contaminants remain in the collection bowl. As water collects, it completes the circuit between the two prongs of the water sensor probe, if equipped, and a warning light on the dash alerts the operator to drain the bowl.

The heater is operated by turning on the ignition switch for 5 minutes before starting the engine.



1. Priming Pump
2. Mounting Head
3. Gasket
4. Filter Element
5. O-Ring
6. Sight Bowl
7. Water Sensor Probe
8. Water Sensor Probe Wiring Harness
9. Heater Wiring Harness
10. Drain Plug

Fig. 1, Fuel/Water Separator Assembly

Removal and Installation

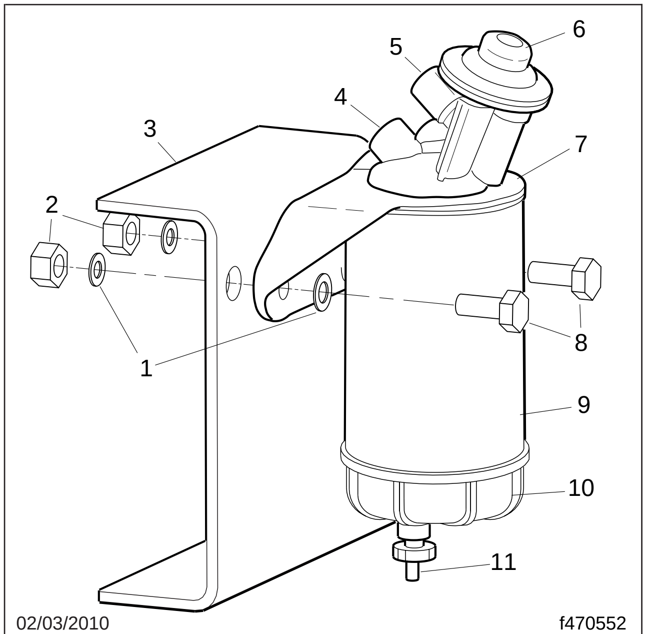
Removal

1. Shut down the engine, apply the parking brake, and chock the tires.

   Open the hood.
2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump. See **Fig. 1**.



1. Washers (qty 2)
2. Nuts (qty 2)
3. Frame Rail
4. Fuel Outlet Port
5. Fuel Inlet Port
6. Priming Pump
7. Mounting Head
8. Mounting Bolts (qty 2)
9. Filter Element
10. Sight Bowl
11. Drain Plug

Fig. 1, Fuel/Water Separator Assembly and Installation

4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

WARNING

Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

5. Disconnect the fuel lines from the fuel/water separator.
6. If equipped, disconnect the wiring harnesses from the water sensor probe and the heater element.
7. Remove the fuel/water separator mounting bolts, and remove the fuel/water separator from its mounting bracket.

Installation

1. Mount the fuel/water separator on the frame rail mounting bracket, and install the mounting bolts. Tighten the bolts 40 lbf·ft (55 N·m).
2. Remove the sight bowl and the filter element as a unit from the new fuel/water separator.
3. Using clean motor oil or diesel fuel, lubricate the gasket in the top of the filter element.
4. Make sure the drain in the sight bowl is closed, then fill the filter element and bowl assembly with clean fuel.
5. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
6. If equipped, connect the wiring harnesses to the water sensor probe and the heater.
7. Connect the fuel lines to the fuel/water separator. Tighten all fittings finger-tight plus 1/4 turn.
8. Prime the fuel/water separator.

   If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

   If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.
9. Start the engine and check for leaks.
10. Shut down the engine and repair any leaks.

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.

   Open the hood.
2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

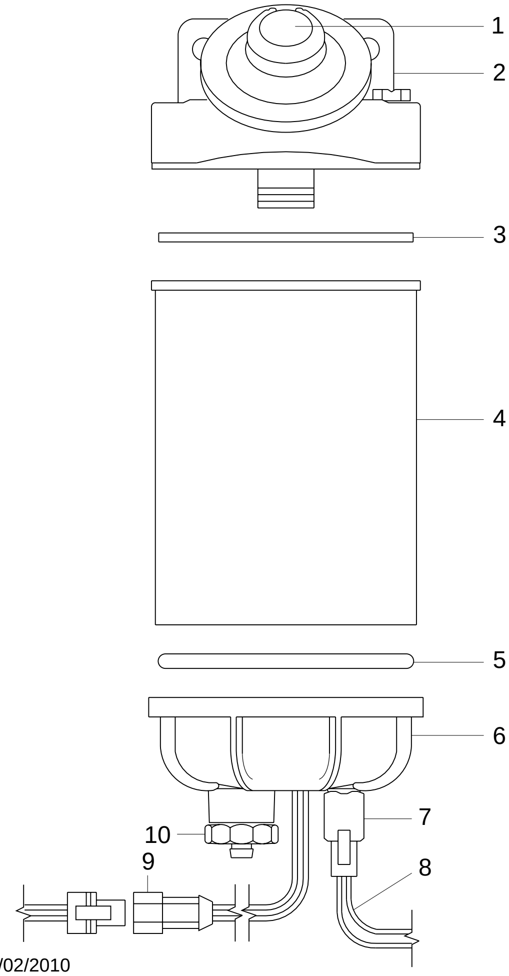
3. Turn the drain plug counterclockwise to open it. If equipped, operate the pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

WARNING

Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

5. If equipped, disconnect the wiring harnesses from the water sensor probe and the heater. See **Fig. 1**.
6. Spin off the sight bowl and the filter element as a unit. Remove the gasket from the top of the filter element.
7. Remove the sight bowl from the filter element. Clean the O-ring seating surface.
8. Apply a thin coating of clean diesel fuel or engine oil to the O-ring and the new gasket.
9. Spin the sight bowl onto the new filter element and then fill the filter element and sight bowl assembly with clean diesel fuel.
10. Spin the entire assembly onto the mounting head and tighten by hand until snug.
11. Connect the heater and water sensor wiring harnesses, if equipped.
12. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.



1. Priming Pump
2. Mounting Head
3. Gasket
4. Filter Element
5. O-Ring
6. Sight Bowl
7. Water Sensor Probe
8. Water Sensor Probe Wiring Harness
9. Heater Wiring Harness
10. Drain Plug

Fig. 1, Fuel/Water Separator Assembly

If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.

13. Start the engine and check for leaks.
14. Shut down the engine and repair any leaks.

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.

   Open the hood.
2. Place a suitable container under the fuel/water separator.

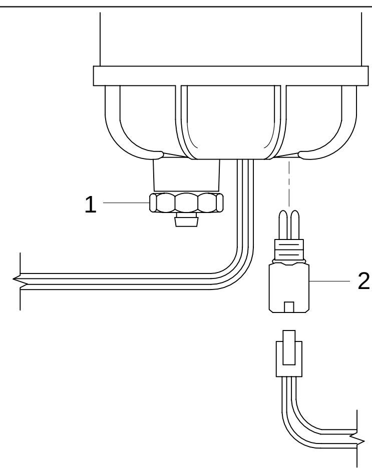
IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

WARNING

Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

5. If equipped, disconnect the wiring harness from the water sensor probe. See **Fig. 1**.



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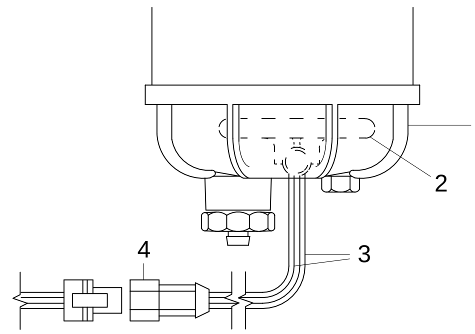
1. Drain Plug
2. Water Sensor Probe

Fig. 1, Water Sensor Probe

6. Disconnect the heater wiring harness. See **Fig. 2**.



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1. Sight Bowl
2. Heating Element
3. Heater Wires
4. Heater Wiring Harness

Fig. 2, In-Bowl Heater

7. Spin off the sight bowl and the filter element as a unit.
8. Remove the sight bowl from the filter element.
9. Remove the O-ring from the lip of the new sight bowl. Lubricate the O-ring with a thin film of clean engine oil or diesel fuel and put it back in the sight bowl.
10. Install the sight bowl on the bottom of the filter element and hand-tighten until it is snug.
11. Make sure the drain in the sight bowl is closed, then fill the filter element and bowl assembly with clean fuel.
12. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
13. Connect the heater wiring harness.

    If equipped, connect the water sensor wiring harness to the water sensor probe.
14. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

    If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.
15. Start the engine and check for leaks.
16. Shut down the engine and repair any leaks.

Water Sensor Probe Replacement

Replacement

1. Apply the parking brakes, shut down the engine, and chock the tires.

   Open the hood.
2. Place a suitable container under the fuel/water separator.

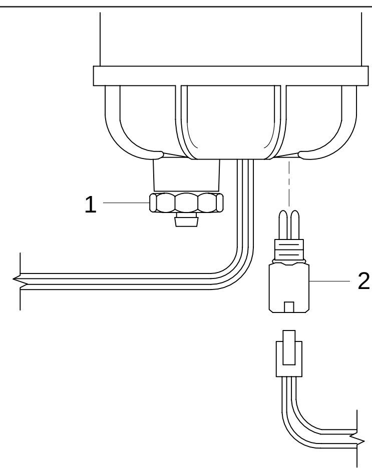
IMPORTANT: When draining fluid from a fuel/ water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

WARNING

Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

5. Disconnect the water sensor wiring harness from the water sensor probe. See **Fig. 1**.



1. Drain Plug 2. Water Sensor Probe

Fig. 1, Water Sensor Probe

6. Spin off the sight bowl and filter element as a unit.
7. Unscrew the water sensor probe from the base of the sight bowl.
8. Install a new water sensor probe in the base of the sight bowl.
9. Make sure the drain plug in the base of the sight bowl is closed snugly.
10. Fill the filter element and sight bowl assembly with clean diesel fuel.
11. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
12. Connect the water sensor wiring harness to the water sensor probe.
13. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

    If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.
14. Start the engine and check for leaks.
15. Shut down the engine and repair any leaks..

Troubleshooting

Problem—Air Leaking into the Fuel System

Problem—Air Leaking into the Fuel System	
Possible Cause	**Remedy**
The drain is not closed.	Tighten the drain valve.
The sight bowl or filter element is loose.	Hand-tighten the sight bowl or filter element until snug.
There are loose, broken, or clogged fuel fittings, valves, or filters.	Tighten, clean, or repair the fuel fittings, valves, or filters as needed.

Problem—High Water Light Does Not Illuminate For 2 to 5 Seconds When Ignition is Turned to ACCESSORY

Problem—High Water Light Does Not Illuminate For 2 to 5 Seconds When Ignition is Turned to ACCESSORY	
Possible Cause	**Remedy**
Wiring connections are loose.	Tighten connections as needed.
Fuel/water separator is not grounded.	Check that power is on, and the fuel/water separator is grounded.
Wiring is damaged.	Check for damaged wiring and replace as needed. See EZWiring for a diagram of the sensor circuit.
Water sensor probe is damaged.	Replace the water sensor probe. See **Subject 130** for instructions.

General Information

The Hayden fuel cooler (**Fig. 1**) consists of a heat exchanger, fuel tubing, and a rubber mounting block.

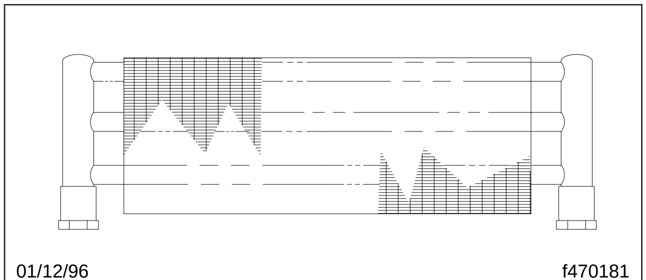


Fig. 1, Hayden Fuel Cooler

The heat exchanger bolts to a mounting bracket that attaches to the frame rail. A retaining plate and biscuits protect the exposed side of the installation.

Fuel in the return line flows through the cooler and exchanges heat with the air flowing underneath the vehicle during operation. The cooled fuel then returns to the fuel tanks.

Hayden Fuel Cooler Removal and Installation

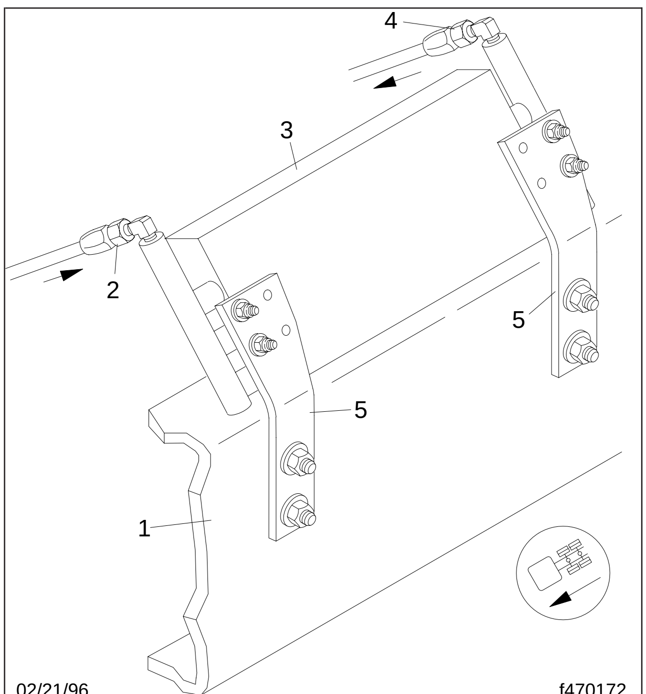
Removal

1. Apply the parking brakes, shut down the engine, and chock the rear tires. Open the hood.

WARNING

Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

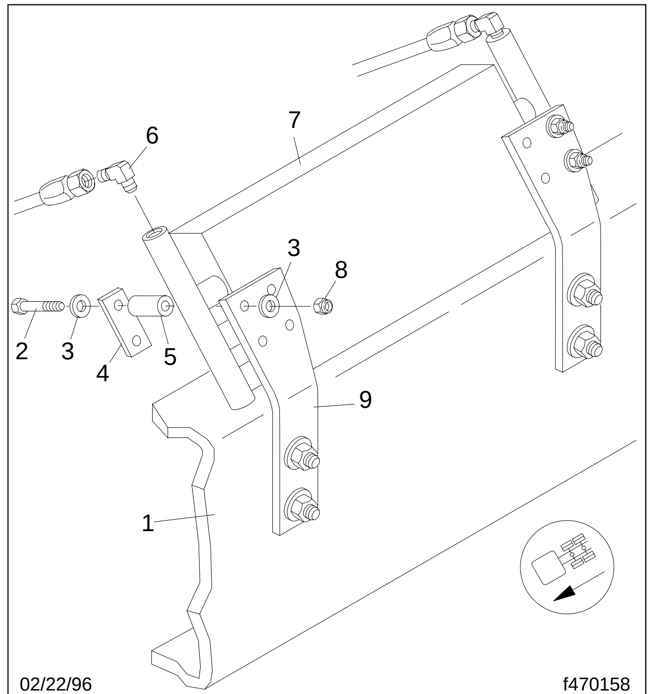
2. Mark the fuel fittings and lines. Disconnect the fuel lines from the fittings on the fuel cooler. See **Fig. 1**. Have a basin ready to catch the fuel that comes out of the lines. Tie up the fuel lines to prevent dripping.



1. Frame Rail
2. Fuel Fittings (from engine)
3. Heat Exchanger
4. Fuel Fittings (to fuel tank)
5. Mounting Bracket

Fig. 1, Fuel Cooler Fittings

3. Remove the fuel cooler from its mounting bracket. See **Fig. 2**.



1. Frame Rail
2. Bolt, 5/16–18
3. Washer
4. Retaining Plate
5. Biscuit
6. 90° Elbow
7. Heat Exchanger
8. Locknut, 5/16–18
9. Mounting Bracket

Fig. 2, Fuel Cooler Mounting

3.1 Remove the four 5/16–18 locknuts and rear washers from the mounting bracket.

3.2 Remove the bolts, front washers, biscuits, and retaining plates.

3.3 Drain the fuel in the fuel cooler into a basin.

Installation

1. Install the fuel cooler on its mounting bracket.

1.1 Position the retaining plates, biscuits, front washers, and 5/16–18 bolts on the fuel cooler and mounting bracket.

1.2 Install the 5/16–18 locknut and rear washer. Tighten the locknuts 25 to 30 lbf·in (280 to 340 N·cm).

2. Connect the fuel lines to the fuel cooler.

Hayden Fuel Cooler Removal and Installation

2.1 Apply Loctite® 271 (or equivalent) to all fitting threads.

CAUTION

To avoid damaging the connections, use a back-up wrench on the heat exchanger fittings when tightening the fuel line fittings.

2.2 Connect the fuel lines and tighten the fittings finger-tight plus 1/4 turn.

3. Prime the engine fuel pump; refer to the engine manufacturer’s operation and maintenance manual.
4. Start the engine and check for fuel leaks. With the engine shut down, repair any leaks.
5. Close the hood and remove the chocks from the tires.

Troubleshooting

Problem—Heat Exchanger Is Not Cooling the Fuel

Problem—Heat Exchanger Is Not Cooling the Fuel	
Possible Cause	**Remedy**
The cooling fins are dirty.	**CAUTION** **Do not direct a high-pressure stream of water at the fuel cooler. This will damage the fins.** Wearing eye protection, clean the heat exchanger fins carefully. If necessary, use water flowing at low pressure to remove debris lodged in the fins.
The cooling fins are bent.	Using a 12 fin/inch fin comb, straighten any bent fins.
The heat exchanger is clogged with contaminated fuel.	Using a compatible fuel system fluid, flush out the heat exchanger in both directions (through both fittings).
There are hairline cracks in the heat exchanger.	Replace the fuel cooler.
The heat exchanger's fuel tubing is dented badly enough to restrict fuel flow past the heat exchanger.	Replace the fuel cooler.

Problem—Fuel Cooler Is Leaking

Problem—Fuel Cooler Is Leaking	
Possible Cause	**Remedy**
The fuel line connections are loose.	Tighten the connections until the leaks disappear. Do not tighten more than finger-tight plus 1/4 turn, and use a back-up wrench on the heat exchanger fitting. Start the engine and make sure there are no more leaks.
The sealant on the fittings is not adequate.	Remove the fittings, clean off any dried or cracked sealant, and apply Loctite® 271 (or equivalent) to all fitting threads.
The fitting(s) are cracked or stripped.	Replace the fitting(s).

Specifications

Fastener Torque Values			
Fastener Description	Size	Torque Value	
		lbf·ft (N·m)	lbf·in (N·cm)
Mounting Locknuts	5/16–18	—	25–30 (280–340)
Fuel Line Fittings	—	Finger-tight plus 1/4 turn	

Table 1, Fastener Torque Values

General Information

Fuel/water separators are mounted between the fuel tank and the fuel pump. Fuel drawn to the engine travels through the fuel/water separator, which removes water and impurities. See **Fig. 1** for an example of a Fuel Pro 382, or **Fig. 2** for an example of a Fuel Pro 482.

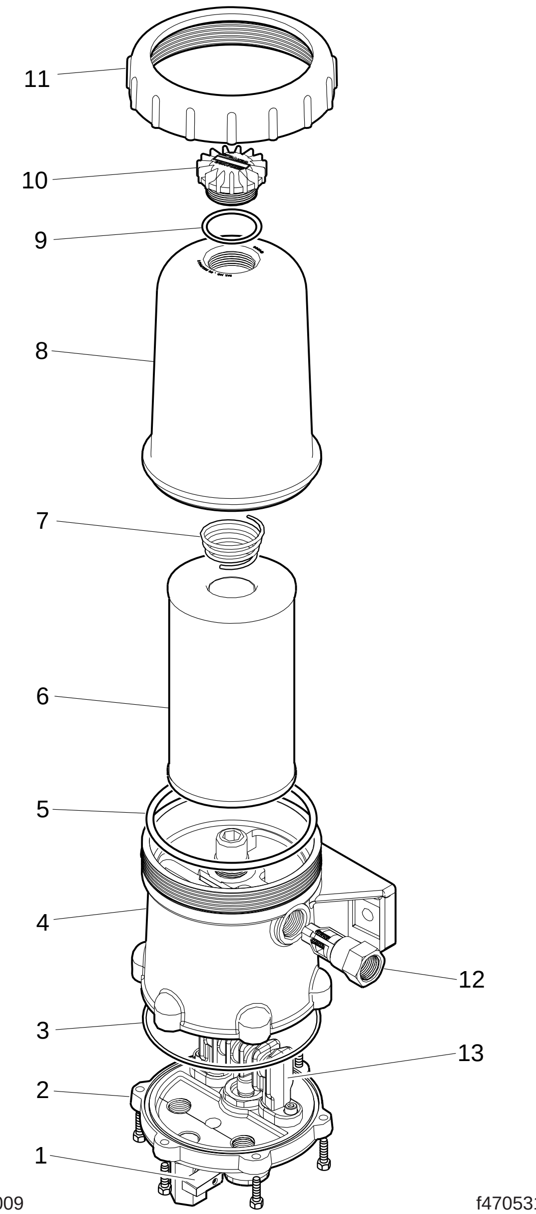
At the fuel/water separator inlet port, a check valve prevents the fuel from draining back to the fuel tank. Large pieces of dirt and water separate from the fuel in the lower housing, and collect in the bottom to be drained out when the drain valve is opened. From the lower housing, the fuel level rises into the clear cover, which contains the replaceable filter. In the clear cover, the fuel passes through the filter element into the center of the filter, and to the outlet port.

When the filter is new, the fuel is able to pass through the lower part of the filter element. As the element's lower portion clogs, the fuel level rises in order to pass through the filter. This process continues until the filter element is clogged all the way to the top.

For efficiency, the filter should be changed only when the fuel level has reached the top of the filter element. There is no significant restriction to fuel flow until the element is completely clogged.

DAVCO fuel/water separators come in a number of different configurations. There may be an electric heating element installed in the lower housing or there may be fluid heating in the lower housing. If there is fluid heat, the warming fluid may be fuel returning from the engine or engine coolant. **Fig. 3** shows the patterns that fuel and heating fluids follow in fluid-heated units. Configurations may vary between fuel/water separator models.

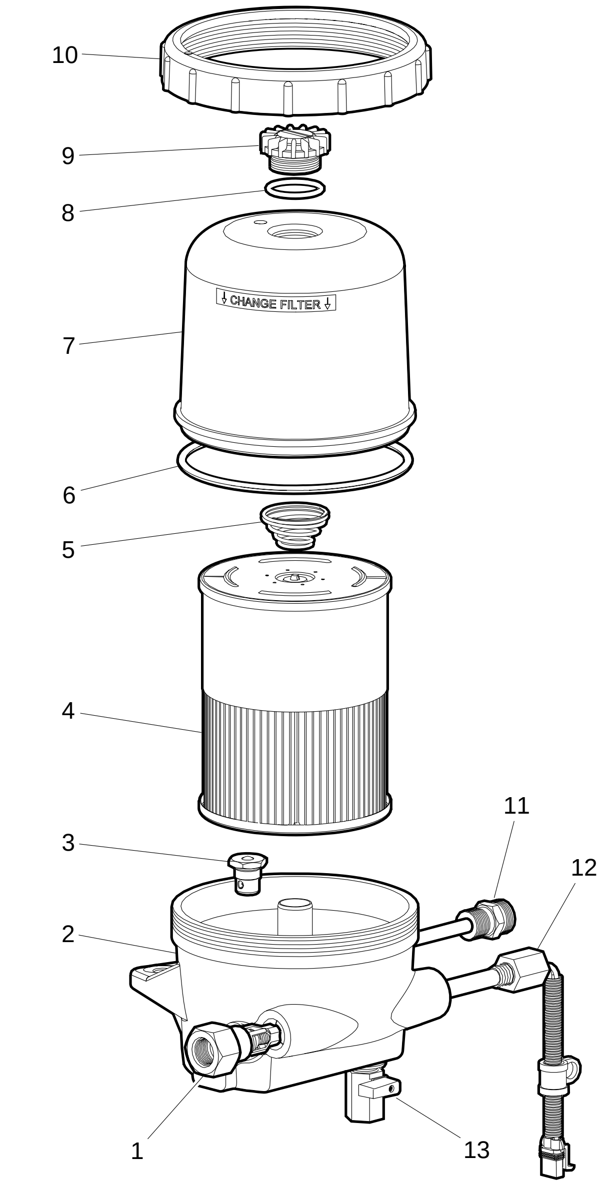
NOTE: The Daimler Trucks North America Learning Center (accessible through **www.AccessFreightliner.com**) and DAVCO (**www.DavcoTec.com**) offer excellent online resources for understanding, testing, and diagnosing fuel/water separator problems.



1. Drain Valve
2. Bottom Plate Assembly
3. Bottom Plate O-Ring
4. Lower Housing
5. Cover O-Ring
6. Filter Element
7. Spring
8. Clear Cover
9. Vent Cap O-Ring
10. Vent Cap
11. Collar
12. Inlet Port/Check Valve
13. Heat Exchanger

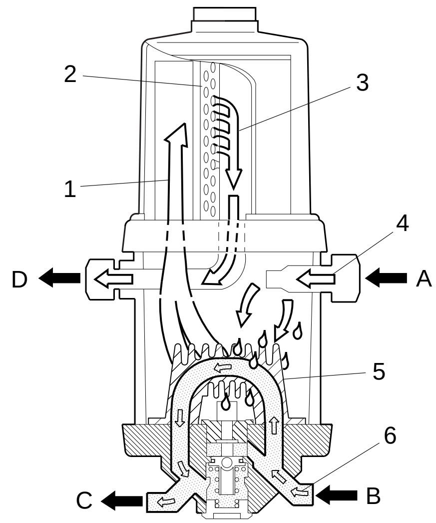
Fig. 1, DAVCO Fuel Pro 382

General Information



1. Inlet Port/Check Valve
2. Lower Housing
3. Bypass Valve
4. Filter Element
5. Spring
6. Cover O-Ring
7. Clear Cover
8. Vent Cap O-Ring
9. Vent Cap
10. Collar
11. 120VAC Pre-Heater
12. 12VDC Pre-Heater
13. Drain Valve

Fig. 2, DAVCO Fuel Pro 482



A. Fuel Inlet Flow
B. Heating Fluid Inlet Flow
C. Heating Fluid Outlet Flow
D. Fuel Outlet Flow

1. Unfiltered, Heated Fuel
2. Filter Element
3. Filtered Fuel
4. Fuel From Fuel Tank
5. Heat Exchanger
6. Heating Fluid From Engine

Fig. 3, DAVCO Fluid Circulation, Fluid-Heated Units

Fuel Pro® 382

WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

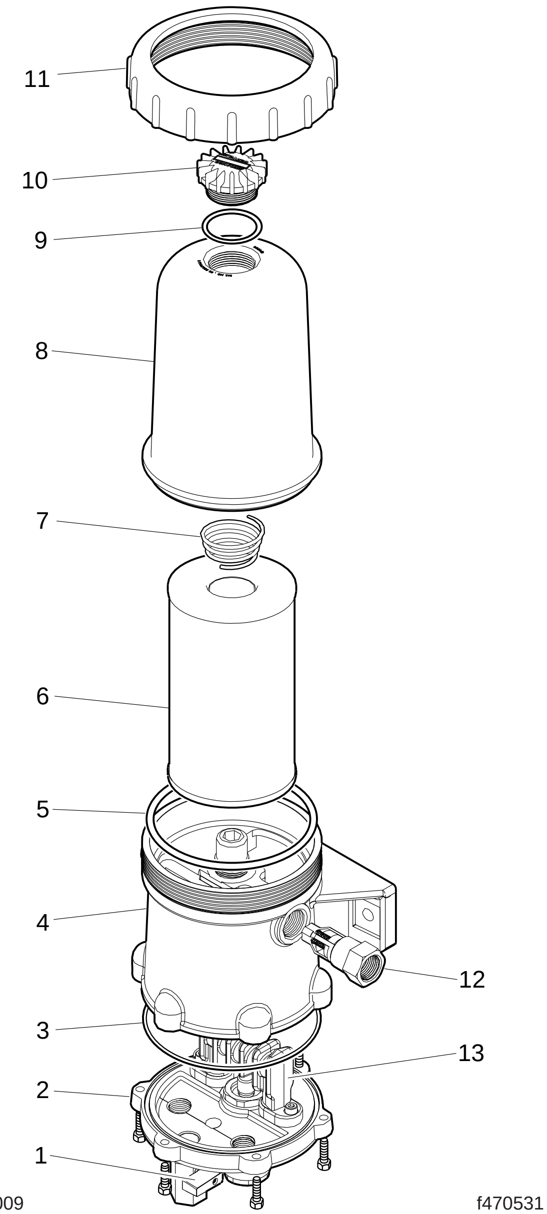
If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

Most service procedures are done with the fuel/water separator in place, but some procedures, such as pressure testing, require that the fuel/water separator be removed from the vehicle.

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve (**Fig. 1**, Item 1) has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap and open the drain valve to drain the fuel completely, then close the drain valve.
4. Unplug the electric heating element, if equipped, or disconnect the heating fluid lines.
5. Disconnect the fuel outlet line.
6. Disconnect the fuel inlet line. If the inlet line is difficult to reach, loosen the connection, then fully disconnect it after the fuel/water separator is removed from the frame rail.
7. Remove the fuel/water separator mounting fasteners and remove the fuel/water separator from the frame rail. If the fuel inlet line was not completely disconnected in the previous step, disconnect it.



1. Drain Valve
2. Bottom Plate Assembly
3. Bottom Plate O-Ring
4. Lower Housing
5. Cover O-Ring
6. Filter Element
7. Spring
8. Clear Cover
9. Vent Cap O-Ring
10. Vent Cap
11. Collar
12. Inlet Port/Check Valve
13. Heat Exchanger

Fig. 1, DAVCO Fuel Pro 382

Installation

IMPORTANT: All fittings, including the locking collars, must be very clean as they are installed. A piece of grit or a damaged surface on a sealing face or in threads can cause air leaks.

Use teflon pipe thread sealant to ensure that the tapered thread fuel line fittings will not leak. Do not use sealer on compression fittings and do not seal the fittings with tape, which will eventually leak.

1. If the inlet fuel line is inaccessible when the fuel/water separator is mounted on the vehicle, loosely connect the inlet fuel line before mounting the fuel/water separator on the frame rail.

   To minimize restrictions, keep fuel line routing as smooth as possible, with no low-hanging loops that could trap water. If the fuel line is being made to length on the job, be sure that the inner liner of the hose is not cut by the fitting. Be certain the interior of all fuel lines is clean and free of debris before connecting them, and confirm that all fittings are clean.
2. Mount the fuel/water separator on the frame rail and install the mounting fasteners.

NOTICE

The lower housings on DAVCO fuel/water separators are made of aluminum. To avoid damaging threads, be careful not to overtighten fasteners or fittings on the fuel/water separator.

3. If the fuel inlet line was loosely connected previously, tighten it. If it was not connected, connect and tighten it.
4. Connect the fuel outlet line.
5. Install the electric heating element, if equipped, and connect the wiring harness, or connect the fluid heater lines. It does not matter which direction the heating fluid flows through the housing; the lines can be reversed.
6. Prime the system
   - 6.1 Ensure that the drain valve is closed.
   - 6.2 Remove the vent cap from the cover, and fill the housing to the top with clean diesel fuel.
   - 6.3 Install and hand-tighten the vent cap.
   - 6.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 6.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.
   - 6.6 Check for leaks and shut down the engine.

Fuel Pro 482

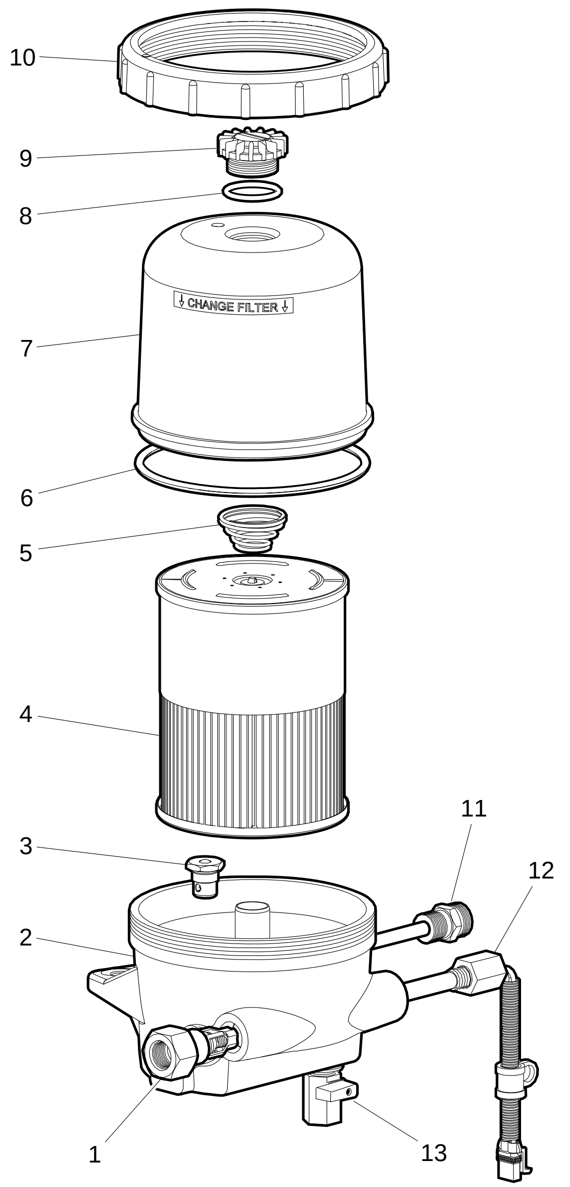
Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve (**Fig. 2**, Item 1) has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap and open the drain valve to drain the fuel completely, then close the drain valve.
4. Unplug the electric heating element, if equipped, or disconnect the heating fluid lines.
5. Disconnect the fuel outlet line.
6. Disconnect the fuel inlet line. If the inlet line is difficult to reach, loosen the connection, then fully disconnect it after the fuel/water separator is removed from the frame rail.
7. Remove the fuel/water separator mounting fasteners and remove the fuel/water separator from the frame rail. If the fuel inlet line was not completely disconnected in the previous step, disconnect it.

Installation

1. Connect the fuel line inlet and outlet fittings on the fuel/water separator. The fittings should insert into the unit at a 45-degree angle.



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1. Inlet Port/Check Valve
2. Lower Housing
3. Bypass Valve
4. Filter Element
5. Spring
6. Cover O-Ring
7. Clear Cover
8. Vent Cap O-Ring
9. Vent Cap
10. Collar
11. 120VAC Pre-Heater
12. 12VDC Pre-Heater
13. Drain Valve

Fig. 2, DAVCO Fuel Pro 482

2. Mount the fuel/water separator on the frame rail and install the mounting fasteners.

NOTICE

The lower housings on DAVCO fuel/water separators are made of aluminum. To avoid damaging threads, be careful not to overtighten fasteners or fittings on the fuel/water separator.

3. Connect the fuel outlet and inlet lines and, using a wrench, tighten the tube fittings up to 3-1/2 turns beyond hand-tight.
4. Prime the system
   - 4.1 Ensure that the drain valve is closed.
   - 4.2 Remove the vent cap from the cover, and fill the housing to the top with clean diesel fuel.
   - 4.3 Use the hand primer pump on the engine module to purge the air from the fuel lines.
   - 4.4 Install and hand-tighten the vent cap.
   - 4.5 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one minute to purge air from the fuel lines.
   - 4.6 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.
   - 4.7 Check for leaks and shut down the engine.

Filter Replacement

⚠ WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

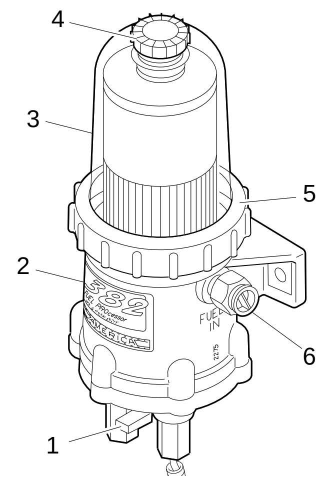
If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap (**Fig. 1**, Item 4) and open the drain valve (**Fig. 1**, Item 1) to drain the fuel completely, then close the drain valve.
4. Using a DAVCO Collar Wrench (**Fig. 2**), remove the clear cover and collar.

NOTE: Broken vent cap and collar warranty claims will not be accepted if any tool other than a DAVCO Collar Wrench is used for removal. During installation, the vent cap and collar are to be **hand-tightened only**, not tightened with a wrench. Use part number 482017 on Fuel Pro 482 units; part number 380134 on Fuel Pro 382 units.

5. Remove the filter, cover O-ring, and vent cap O-ring. Dispose of them in an environmentally acceptable manner.
6. Clean all threads and sealing surfaces very thoroughly. Even a small amount of dirt will prevent the fuel/water separator from sealing, and an air leak may result.



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1. Drain Valve
2. Lower Housing
3. Clear Cover
4. Vent Cap
5. Collar
6. Inlet Port/Check Valve

Fig. 1, DAVCO Fuel/Water Separator (Fuel Pro 382 Shown)

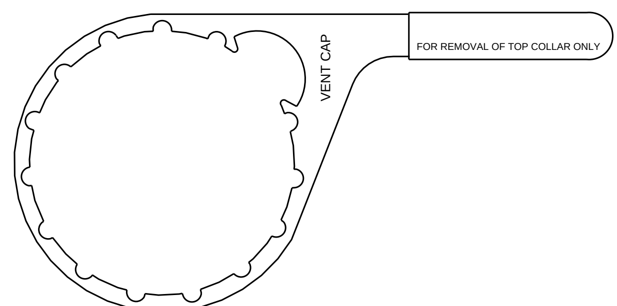

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Fig. 2, DAVCO Collar Wrench

7. On Fuel Pro 382 units, install the grommet on the bottom of the new filter.
8. Install the new filter and grommet assembly and cover O-ring on the housing.
9. Install the clear cover and the collar. Hand-tighten the collar.
10. Prime the system
    - 10.1 Ensure that the drain valve is closed.
    - 10.2 Fill the housing to the top with clean diesel fuel.

Filter Replacement

10.3 Install and hand-tighten the vent cap O-ring and vent cap.

10.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

10.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

10.6 Check for leaks and shut down the engine.

Emergency Temporary Filter Replacement, Fuel Pro 382

WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap (**Fig. 1**, Item 4) and open the drain valve (**Fig. 1**, Item 1) to drain the fuel completely, then close the drain valve.
4. Using a DAVCO Collar Wrench (**Fig. 2**), remove the clear cover and collar.

NOTE: Broken vent cap and collar warranty claims will not be accepted if any tool other than a DAVCO Collar Wrench, part number 380134, is used for removal. During installation, the vent cap and collar are to be **hand-tightened only**, not tightened with a wrench.

5. Remove the filter and dispose of it in an environmentally acceptable manner.
6. Clean all threads and sealing surfaces very thoroughly. Even a small amount of dirt will prevent the fuel/water separator from sealing, and an air leak may result.
7. Ensure that the drain valve is closed.
8. Remove the filter grommet from the filter stud, if equipped.
9. Fill the housing to the top with clean diesel fuel.
10. Install a standard engine spin-on filter (part number FF105 or equivalent) on the filter stud.
11. Install the cover O-ring, clear cover, and the collar. Hand-tighten the collar.
12. Fill the housing to the top with clean diesel fuel.
13. Install and hand-tighten the vent cap O-ring and vent cap.
14. Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
15. Check for leaks and shut down the engine.

Check Valve and Bypass Valve Replacement

Check Valve Replacement

WARNING

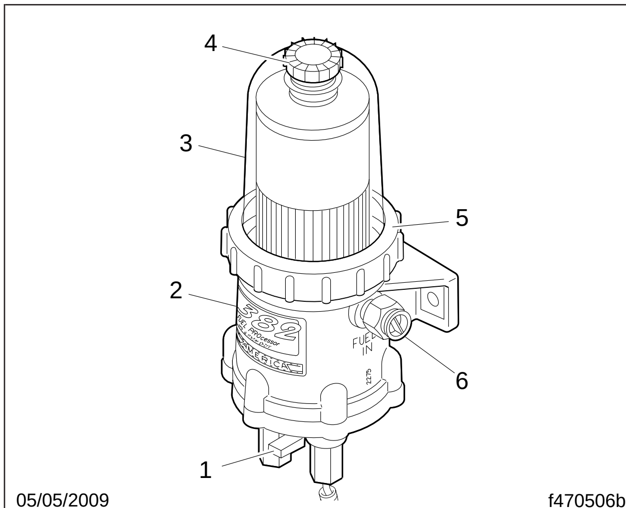
Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

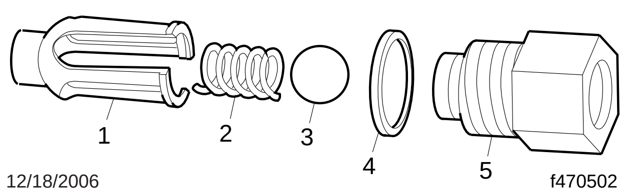
   The drain valve has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap (**Fig. 1**, Item 4) and open the drain valve (**Fig. 1**, Item 1) to drain the fuel completely. Close the drain valve.
4. Place a shop towel under the fuel inlet fitting. Hold the check valve body in place with an open-end wrench and remove the fuel inlet hose from the fitting. Continue holding the check valve body in place and, using a flare-nut wrench, carefully remove the fuel inlet fitting. Drain any residual fuel into the container.
5. Remove the check valve assembly from the fuel/water separator housing.
6. Remove and discard the check ball, spring, and plastic retainer. See **Fig. 2**.
7. Carefully clean the threads on the check valve body. Install the new check ball, spring, and plastic retainer on the check valve body.

   The plastic retainer snaps into a groove in the check valve body.



1. Drain Valve
2. Lower Housing
3. Clear Cover
4. Vent Cap
5. Collar
6. Inlet Port/Check Valve

Fig. 1, DAVCO Fuel/Water Separator (Fuel Pro 382 Shown)



1. Plastic Spring Retainer
2. Retaining Spring
3. Check Ball
4. Seal (Diesel Pro® units only)
5. Check Valve Body

Fig. 2, Check Valve Assembly

8. Clean the threads on the fuel inlet fitting and fuel/water separator housing. Apply a teflon pipe thread sealant to the check valve body threads.
9. Install the check valve body in the fuel/water separator housing. Do not use tape to seal the fuel fittings; it may eventually leak.

   Tighten the check valve body 44 to 60 lbf·ft (60 to 81 N·m) on a Fuel Pro 382, or 45 lbf·ft (61 N·m) on a Fuel Pro 482.
10. Install the fuel inlet fitting, and connect the fuel inlet line.

Check Valve and Bypass Valve Replacement

11. Prime the system

 11.1 Ensure that the drain valve is closed.

 11.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.

 11.3 Install and hand-tighten the vent cap.

 11.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

 11.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

 11.6 Check for leaks and shut down the engine.

Bypass Valve Replacement, Fuel Pro 482

WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

 The drain valve has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap (**Fig. 1**, Item 4) and open the drain valve (**Fig. 1**, Item 1) to drain the fuel completely. Close the drain valve.
4. Using a DAVCO Collar Wrench (**Fig. 3**), remove the clear cover and collar.

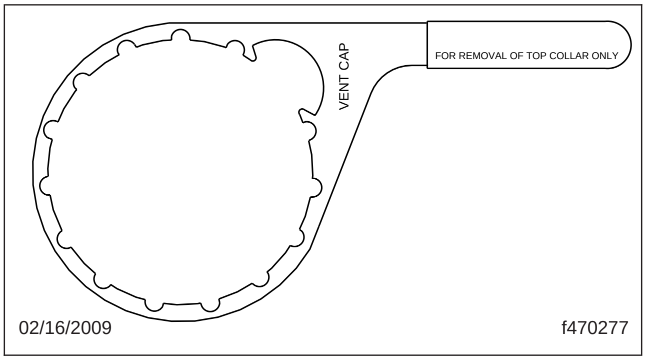


Fig. 3, DAVCO Collar Wrench

NOTE: Broken vent cap and collar warranty claims will not be accepted if any tool other than a DAVCO Collar Wrench is used for removal. During installation, the vent cap and collar are to be **hand-tightened only**, not tightened with a wrench. Use part number 482017 on Fuel Pro 482 units; part number 380134 on Fuel Pro 382 units.

5. Remove the filter, cover O-ring, and vent cap O-ring. Dispose of them in an environmentally acceptable manner.
6. Carefully clean the cover, collar, and threads on the fuel/water separator housing.
7. Flush the inside of the fuel/water separator housing with clean diesel fuel to clear it of any debris.
8. Remove the bypass valve assembly. Dispose of it in an environmentally acceptable manner.
9. Install the new bypass valve assembly in the base of the fuel/water separator housing. Tighten the bypass valve 20 lbf·ft (27 N·m).
10. Install the new filter on the housing.
11. Install the clear cover, cover O-ring, and the collar. Hand-tighten the collar.
12. Prime the system

 12.1 Ensure that the drain valve is closed.

Check Valve and Bypass Valve Replacement

12.2 Fill the housing to the top with clean diesel fuel.

12.3 Install and hand-tighten the vent cap O-ring and vent cap.

12.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

12.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

12.6 Check for leaks and shut down the engine.

The Daimler Trucks North America Learning Center (accessible through **www.AccessFreightliner.com**) and DAVCO (**www.DavcoTec.com**) offer excellent online resources for understanding, testing, and diagnosing fuel/water separator problems.

Identifying Bubble Types

Vapor Bubbles

Vapor bubbles are harmless and are present in all diesel fuel systems. Vapor bubbles are often mistaken for air bubbles, but *do not affect engine performance.*

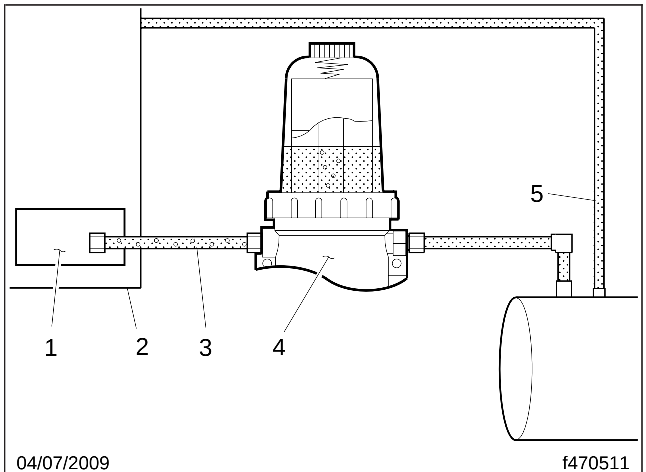
Vapor bubbles (see **Fig. 1**) may be visible in a diagnostic sight tube installed between the fuel/water separator and the fuel pump. They consist of harmless fuel vapor and trapped air, may vary from champagne-size to 1/4-inch (6-mm) diameter, and may increase in volume or size as the engine rpm increases. The lower pressure inside a fuel/water separator filter, caused by the suction of the fuel pump pulling fuel through the fuel/water separator, creates vapor bubbles. These vapor bubbles are normal and harmless to engine operation. In the fuel pump, the fuel is pressurized and the vapor bubbles dissolve. Vapor bubbles do not appear on the fuel return side of the system.

There is no troubleshooting or repair procedure required for vapor bubbles. Vapor bubbles do not cause performance issues and will not be present downstream of the fuel pump.

Air and Gas Bubbles

Air or gas bubbles indicate harmful leaks, and can cause hard starting and impaired engine performance. All diesel fuel holds some trapped air, caused by the natural splashing that occurs in the fuel tank. But excessive air bubbles, severe enough to degrade engine performance, indicate an air leak on the suction side of the fuel system, from the fuel tank into the fuel pump.

Air bubbles visible in the clear cover of a DAVCO fuel/water separator may indicate an air leak in the fuel system upstream of the bubbles, or in the fuel/water separator; see **Fig. 2**. If there are no bubbles visible in the clear cover but the engine runs rough, there may be an air leak at or between the fuel/water separator outlet port and the fuel pump inlet. These



1. Fuel Pump
2. Engine
3. Fuel Outlet Line, Vapor Bubbles Visible
4. Fuel/Water Separator, Vapor Bubbles Visible *Inside* Filter, *No* Bubbles Visible in Clear Cover
5. Fuel Return Line (no bubbles)

Fig. 1, Harmless Vapor Bubbles

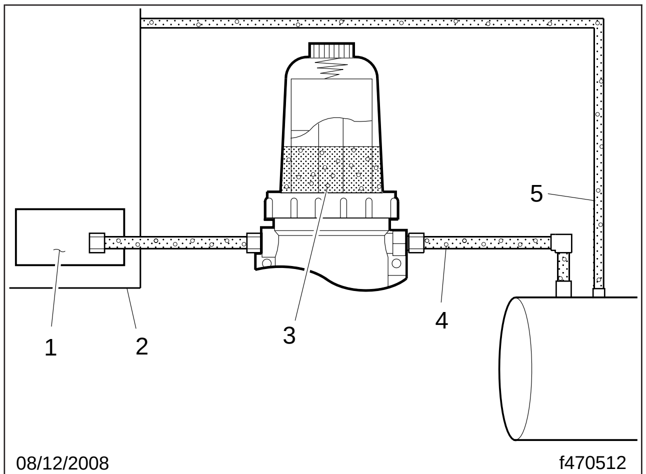
bubbles will be visible in a diagnostic sight tube installed between the fuel pump and the fuel/water separator, and in a diagnostic sight tube installed in the fuel return hose.

Exhaust gas bubbles may also be visible in the clear filter cover. They are the result of leaking fuel injector seals, which can allow combustion gases to enter the fuel system, pass through the fuel return line into the fuel tank, and be drawn into the fuel/water separator. They may be visible in a diagnostic sight tube installed in the fuel return line. To test for combustion gas in the fuel, disconnect the return line at the tank, submerge the end in a bucket of fuel, run the engine, and watch for bubbles. As they pop, these bubbles may smell like exhaust fumes.

In extreme cases, these combustion gas bubbles cause enough aeration in the fuel tank to create visible bubbles in the clear cover of the fuel/water separator and impair engine performance. See the engine manufacturer’s documentation for diagnosis and repair of injector seal leakage.

Use the following procedures to determine which bubbles are present in the fuel system, and whether repair is necessary.

Troubleshooting



1. Fuel Pump
2. Engine
3. Fuel/Water Separator, Bubbles Visible in Clear Cover
4. Fuel Inlet Line, Bubbles Visible
5. Fuel Return Line, Bubbles Visible

Fig. 2, Air Bubbles Indicating a Leak

Initial Diagnostic Procedure

1. Apply the parking brake, chock the tires, and turn on the engine.
2. Check for air bubbles in the fuel/water separator clear cover.
3. If no bubbles are visible in the clear cover, but the engine continues to run rough, lopes, or has loss of power, there may be an air leak between the fuel/water separator outlet and the fuel pump inlet.

   If so, bubbles should be visible in a diagnostic sight tube installed at the fuel pump inlet. Air bubbles may also be visible in a diagnostic sight tube installed in the fuel return line to the fuel tank.
4. Replace fuel lines and tighten fittings as needed.

Testing Procedures

Air Leak in the Fuel System

Air leaks are sometimes caused by:

- loose fittings;
- a faulty inlet check valve;
- faulty O-rings;
- leakage elsewhere in the fuel system;
- or dirt on threads and sealing surfaces.

Air leaks originating between the fuel tank and the fuel/water separator cause air bubbles visible in the clear cover, as shown in **Fig. 2**.

If there are symptoms of sucking air and there are no bubbles in the clear cover, look for the air leak at:

- the outlet fitting;
- the fuel pump inlet connection;
- the fuel hose connections;
- or at the vent cap O-ring.

1. Shut down the engine, apply the parking brake, and chock the tires.

WARNING

Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

2. Remove the fuel hose from the fuel pump inlet port.
3. Install a jumper hose from the inlet port into the fuel tank through the fill cap, or into a container of fuel.
4. Start the engine and look for bubbles in the clear filter cover. If the air bubbles are eliminated, the air source (and the leak) is at either the fuel tank fittings, or the hose connections.

   If air bubbles persist after the tank fittings and hose connections are secured, the leak may be in the fuel/water separator.
5. If the leak is suspected to be in the fuel/water separator, disconnect all fuel connections, coat

the threads with liquid or paste sealer, and reconnect the fuel connections and tighten them securely.

Air Pressure Testing

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve to drain the fuel to just below the collar level, then close the drain valve.
4. Remove the fuel/water separator from the chassis. For instructions, see **Subject 100**.

WARNING

Wear goggles and skin protection when pressure-testing a fuel/water separator, and be careful not to perform this test near a source of possible ignition, such as an open flame. Never exceed the maximum pressure stipulated for the test, and do not perform this test if the clear cover appears to be damaged.

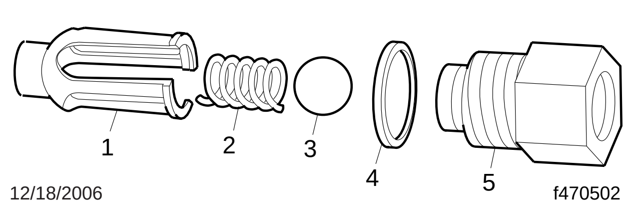
5. Plug the fuel outlet port. Do not remove the filter, filter cover, collar, vent cap, drain valve, or check valve. Do not remove the electric heating element (if equipped), and do not plug the fluid heat ports (if equipped).
6. Apply 15 psi (207 kPa) air pressure at the fuel inlet. Immerse the unit in a tank of water and look for air bubbles.
7. If no bubbles appear, the air leak is not in the fuel/water separator.
8. Install the fuel/water separator onto the chassis frame rail. For instructions, see **Subject 100**.
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

Filter Element Restriction Check

A properly assembled DAVCO fuel/water separator does not restrict fuel flow until the fuel level has risen to the top of the filter. If the fuel level has risen to the top of the filter, replace the filter.

Check Valve Operation Test, Fuel Pro Configurations

When air is introduced into the fuel system, (e.g. when draining fluid or when replacing the fuel filter), the check valve (**Fig. 3**) works to keep the fuel system primed from the fuel tank to the fuel/water separator.



1. Plastic Spring Retainer
2. Retaining Spring
3. Check Ball
4. Seal
5. Check Valve Body

Fig. 3, Check Valve Assembly, Fuel Pro Configurations

To test for proper check valve operation, remove the fuel inlet line, then open the vent cap. Fuel should not flow out of the check valve, although a slight seepage of fuel is normal. If fuel drains back out of the check valve, complete the following procedure.

Troubleshooting

1. Shut down the engine, apply the parking brake, and chock the tires.

WARNING

Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve to drain the fuel to just below the collar level, then close the drain valve.
4. Place a shop towel under the fuel inlet fitting. Hold the check valve body in place with an open-end wrench and, using a flare-nut wrench, carefully remove the fuel inlet fitting. Drain any residual fuel into the container.
5. Remove the check valve assembly from the fuel/water separator housing, see **Fig. 3**.
6. Clean and inspect the check valve body. If the valve body is damaged, or if the ball seat is not smooth, replace the valve. For instructions, see **Subject 110**.
7. If the valve body and ball seat are not damaged, clean the threads on the check valve body, fuel inlet fitting, and the lower housing.
8. Apply a soft-set pipe thread sealant to the check valve body threads. Install the check valve body in the fuel/water separator housing. Do not use tape to seal the fuel fittings; it will eventually leak.

   Tighten the check valve body 44 to 60 lbf·ft (60 to 81 N·m) on a Fuel Pro fuel/water separator, or 25 to 40 lbf·ft (34 to 54 N·m) on a Diesel Pro fuel/water separator
9. Prime the system

   9.1 Ensure that the drain valve is closed.

   9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.

   9.3 Install and hand-tighten the vent cap O-ring and vent cap.

   9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

   9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

   9.6 Check for leaks and shut down the engine.

Other Conditions Visible Inside the Cover

The clear filter covers fitted to DAVCO fuel/water separators provide the opportunity to monitor several aspects of fuel condition and engine status, as described in **Table 1**.

Conditions Visible Inside DAVCO Clear Filter Covers		
If You See:	**What to Do:**	**Comments:**
Amber-colored fuel below the top of the filter element	Nothing, the filter is doing its job	Do not change the filter.

Conditions Visible Inside DAVCO Clear Filter Covers		
If You See:	**What to Do:**	**Comments:**
Amber-colored fuel with dark patches in places on the filter element	Dark patches indicate bacteria or algae may be present. Use Fleetguard Monitor Kit CC2650 to test for microbiological activity.	It may be necessary to use a microbicide, and suggest vehicle operator carry extra filters.
Extremely dark or cloudy fuel with thick black film or sludge collecting on the filter element	Black film or sludge on the filter media indicates the presence of asphaltenes. It may be necessary to use an asphaltene conditioner.	Do not assume this is oil from the engine. Monitor the vehicle for oil consumption. Refer to engine manufacturer's service literature for more information.
Bubbles inside the clear cover	Check for air leaks anywhere in the fuel system. Any leak in any fitting will cause bubbles to appear in the clear cover.	This problem will lead to power complaints; it must be remedied.
No bubbles in the cover, but the engine is running rough	Check for air leaks between the fuel/water separator outlet port and the fuel pump inlet. Check and tighten all fuel fittings in the area of the leak.	Do not replace the fuel/water separator.
Coolant in the fluid drained from the fuel/water separator	Check for leaks in the engine, where fuel and coolant are near each other. The most common problem place is the injector cup.	Do not allow the equipment to be operated until the problem is found and repaired.
Anything not listed here	Call DAVCO at 1-800-328-2611, or email: customerservice@DavcoTec.com.	—

Table 1, Conditions Visible Inside DAVCO Clear Filter Covers

Electric Heater, Thermoswitch, and Fluid Heater Tests

Any one of several types of heaters and thermoswitches may be fitted to DAVCO fuel/water separators. They include 12 VDC heaters, 120 VAC heaters, combination heater thermoswitches, and fluid heaters. The voltage and wattage ratings are stamped on the hex or the sheath of each component.

Test procedures under these headings apply to the following heater types, as specified:

- Electric Heater
- 12 VDC Thermoswitch
- Combination Heater Thermoswitch
- Fluid Heat

The following equipment is recommended to test DAVCO heaters and thermoswitches:

- A precision low-resistance ohmmeter capable of measuring 0.1 ohm or less
- A clamp-on DC current-flow meter
- A means of chilling a thermoswitch, such as ice, dry ice, or compressed carbon dioxide
- A flameless source of heat, such as an infrared heat lamp
- A vortex tube to heat and cool a thermoswitch

Electric Heater

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the heater from the wiring harness.
3. Connect the ohmmeter leads to the pins of the heater (for heaters with one pin, connect to the pin and the bushing).
4. Read the resistance and use **Table 2** to determine whether the heater is within the acceptable resistance range.
5. Connect the heater wiring harness.

Electric Heater Test Parameters		
Electric Heater	**Watts**	**Resistance Range: Ohms**
12 VDC (two pin)	250	0.6–0.8

Troubleshooting

Electric Heater Test Parameters		
Electric Heater	Watts	Resistance Range: Ohms
12 VDC (single pin)	250	0.4–0.5
12 VDC (single pin)	150	0.8–1.1
120 VAC	75	173–203
120 VAC	37	369–411

Table 2, Electric Heater Test Parameters

12 VDC Thermoswitch

1. Shut down the engine, apply the parking brake, and chock the tires.

WARNING

Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve to drain the fuel to just below the collar level, then close the drain valve.
4. Disconnect the thermoswitch wiring harness, see Fig. 4. Remove the thermoswitch from the fuel/water separator.

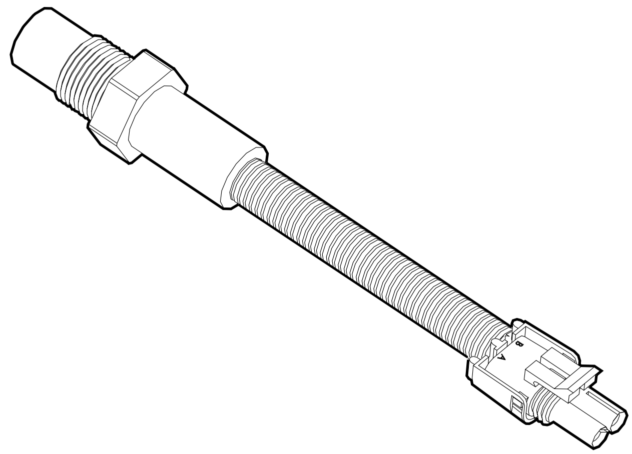


Fig. 4, 12 VDC Thermoswitch

5. Connect the ohmmeter leads to the pins of the thermoswitch.
6. Lower the thermoswitch temperature to below 40°F (4.4°C). The resistance shown on the ohmmeter should be less than 0.1 ohm.
7. Raise the thermoswitch temperature to above 60°F (15.5°C). The resistance should be more than 10 megohms.
8. Install the thermoswitch in the fuel/water separator. Connect the thermoswitch wiring harness.
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.
   - 9.6 Check for leaks and shut down the engine.

Combination Heater Thermoswitch

1. Shut down the engine, apply the parking brake, and chock the tires.

WARNING

Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve to drain the fuel to just below the collar level, then close the drain valve.
4. Disconnect the heater/thermoswitch unit from the wiring harness, see **Fig. 5**.
5. Connect the ohmmeter leads to the heater/thermoswitch pins.
6. Lower the heater/thermoswitch unit temperature to below 40°F (4.4°C).

   The resistance shown on the ohmmeter should be:

   - 0.8 to 1.1 ohms for a 12 VDC 150 W unit
   - 0.2 to 2.5 ohms for a 24 VDC 250 W unit

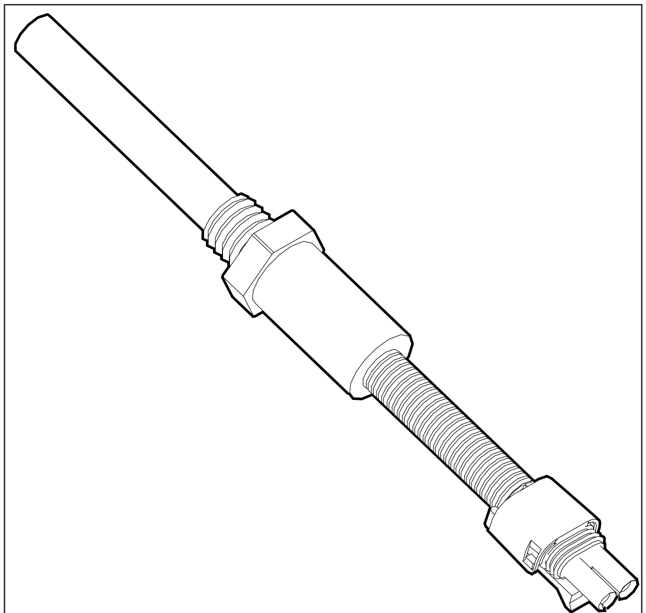


Fig. 5, Combination Heater Thermoswitch

7. Raise the heater/thermoswitch unit temperature to above 70°F (21°C). The heater/thermoswitch unit should show an open circuit.
8. Install the heater/thermoswitch in the fuel/water separator. Connect the heater/thermoswitch wiring harness.
9. Prime the system

   9.1 Ensure that the drain valve is closed.

   9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.

   9.3 Install and hand-tighten the vent cap.

   9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

   9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

   9.6 Check for leaks and shut down the engine.

Troubleshooting

Fluid Heat Exchanger

1. Shut down the engine, apply the parking brake, and chock the tires.

WARNING

Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

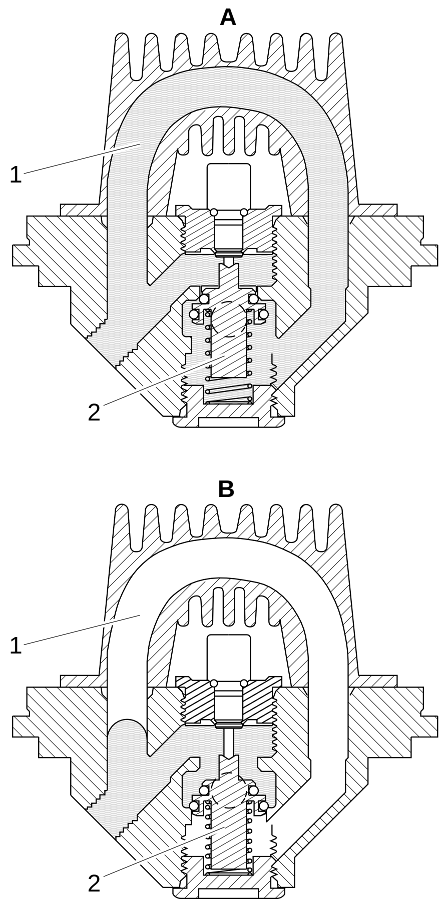
IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve to drain the fuel to just below the collar level, then close the drain valve.
4. Disconnect the heating fluid lines from the bottom plate. These will be either engine coolant lines or return fuel lines. Plug engine coolant lines after removing them from the bottom plate of the housing.
5. Remove the bottom plate and lower housing O-ring.
6. When the fuel entering the fuel/water separator is cold, the thermovalve moves up, allowing warming fluid to enter the heater loop in the heat exchanger. When the fuel is warm, the thermovalve moves down, causing the warming fluid to bypass the heater loop and return directly to the tank. See **Fig. 6**.

   While looking into the fluid port of the bottom plate (**Fig. 7**), flow cold water over the thermovalve for 30 seconds, then run hot water over the thermovalve to determine whether the thermovalve spool is opening and closing.

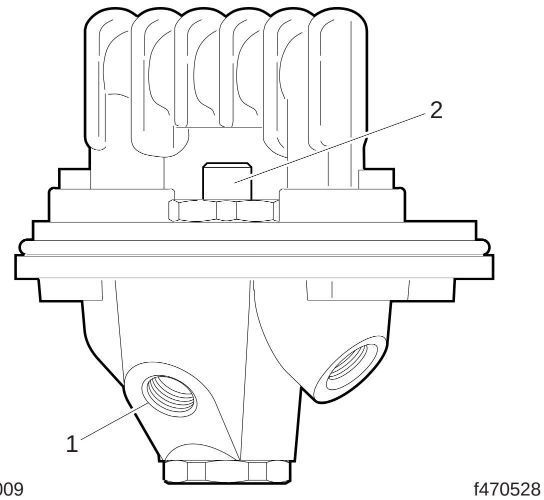


A. Fuel is Cold, Thermovalve Is Up
B. Fuel is Warm, Thermovalve is Down

1. Heater Loop
2. Thermovalve

Fig. 6, Heat Exchanger Fluid Flow

7. Replace the lower housing O-ring, and install the bottom plate on the fuel/water separator. Install the screws on the bottom plate and tighten them 8 to 10 lbf·ft (11 to 14 N·m).
8. Connect the heating fluid lines.
9. Prime the system



1. Fluid Port
2. Top of Thermovalve Spool

Fig. 7, Fluid Heater Thermovalve Test

9.1 Ensure that the drain valve is closed.

9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.

9.3 Install and hand-tighten the vent cap.

9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

9.6 Check for leaks and shut down the engine.

Water-in-Fuel Sensor Tests

There are two types of Davco water-in-fuel (WIF) sensors. Both operate the same way. One is equipped with a 2-pin Grey Deutsch connector, the other is equipped with a 2-pin Metri-Pack connector. Both are 82kΩ. Both are tested in the same manner. See **Fig. 8** for the sensor with the Deutsch connector, and **Fig. 9** for the sensor with the Metri-Pack connector. The units have a built in resistor that allows the ECM to recognize the sensor. Part of this test checks that resistor.

Testing

1. Drain the DAVCO Fuel Pro.
2. Disconnect the WIF sensor from the chassis harness.
3. Remove the WIF sensor.
4. Inspect the WIF sensor.

   4.1 Inspect the probe tips for deposits, corrosion, or missing probe tips. Clean the tips as needed, or replace the sensor if it is damaged.

   4.2 Inspect the connector terminals for damage or corrosion. Clean or replace as needed.

   4.3 Inspect the wiring at the WIF body. Improper harness routing can result in failure at this location.

5. Test the WIF sensor at the connector using a Digital Multi-Meter.

   5.1 Set the meter to the OHM mode auto range, or select manual mode range 0–100kΩ.

   5.2 Check the resistance across the pins at the connector.

   The WIF sensor resistance value should be 82kΩ ± 5% (77.9kΩ to 86.1kΩ).

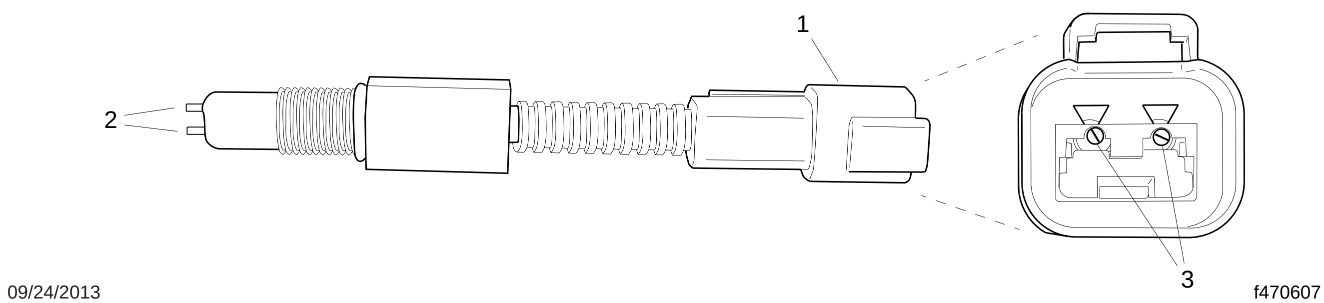
   If the resistance is outside of specification, replace the sensor.

   If the resistance is within specification, the sensor is good and the issue is unrelated to the sensor.

NOTE: The ECM is looking for the 82kΩ load to confirm the sensor is connected. Therefore, with a good WIF sensor an existing WIF-related code can also indicate an issue with chassis wiring.

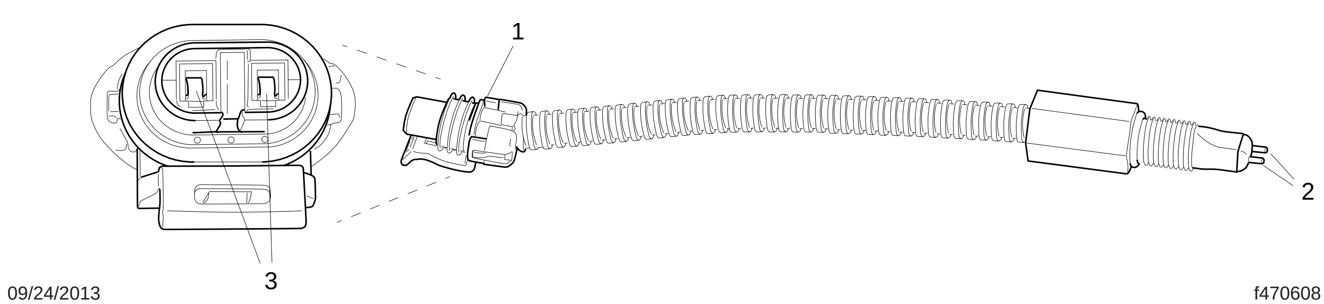
6. Check the chassis wiring for potential issues.

Troubleshooting



1. Connector
2. Probes
3. Connector Contacts

Fig. 8, WIF Sensor with Deutsch Connector



1. Connector
2. Probes
3. Connector Contacts

Fig. 9, WIF Sensor with Metri-Pack Connector

Specifications

Torque Values				
	Fuel Pro 382		Fuel Pro 482	
Component	lbf·ft (N·m)	lbf·in (N·cm)	lbf·ft (N·m)	lbf·in (N·cm)
Inlet Port/Check Valve	44–60 (60–81)	—	45 (61)	—
Water in Fuel Sensor	—	20–24 (226–271)	—	20–24 (226–271)
Electric Heating Element	15–30 (20–41)	—	15–30 (20–41)	—
Drain Valve	25 (34)	—	25 (34)	—
Housing Assembly Screws	8–10 (11–14)	—	—	—
Bypass Valve Assembly	—	—	20 (27)	—

Table 1, Torque Values

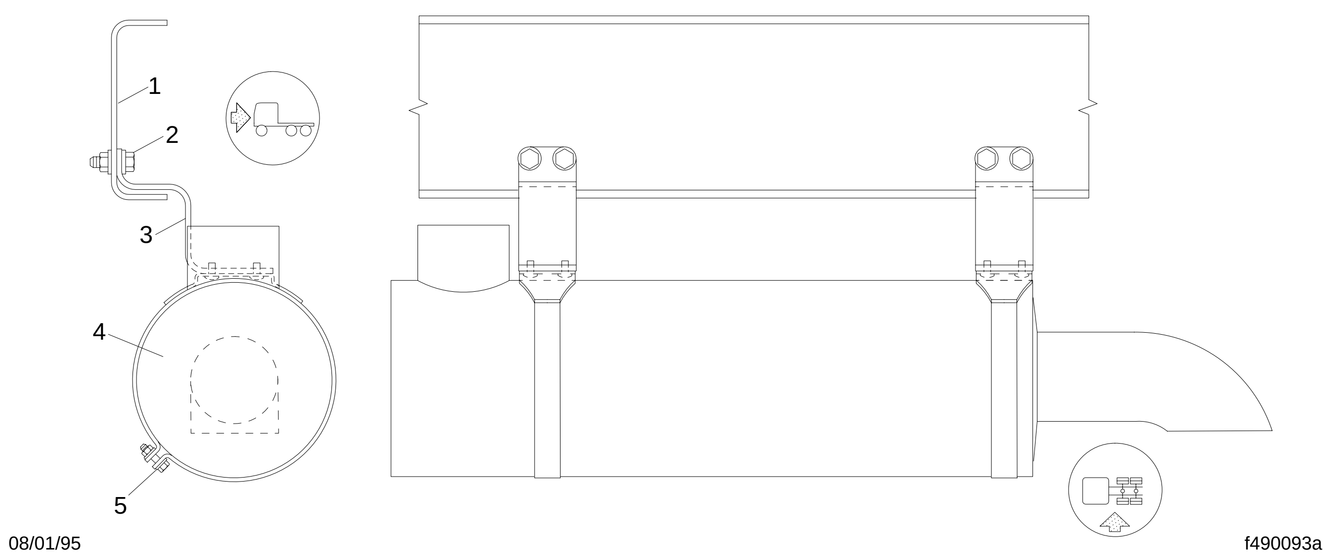
General Information

The exhaust system routes hot exhaust gas away from the cab, and reduces engine exhaust noise. Vehicles can have either a horizontally mounted or a vertically mounted exhaust system. Vehicles are available either with or without a vertical exhaust stack.

System components include the engine outlet exhaust pipe, muffler, muffler mounting components, saddle clamps, wide-band exhaust clamps, flex pipe, exhaust stack, and exhaust system heat shields.

A vehicle can have single or dual mufflers.

The muffler can be mounted horizontally (see **Fig. 1**) where it is supported by brackets which are bolted to inside of the frame rails.



1. Frame Rail
2. Capscrew, 5/8–11x1.75, grade 8; Nut; Washer
3. Muffler Mounting Bracket
4. Muffler
5. Capscrew, 5/16–18x1.75, grade 8; Nut; Washer

Fig. 1, Horizontal Muffler Mounting

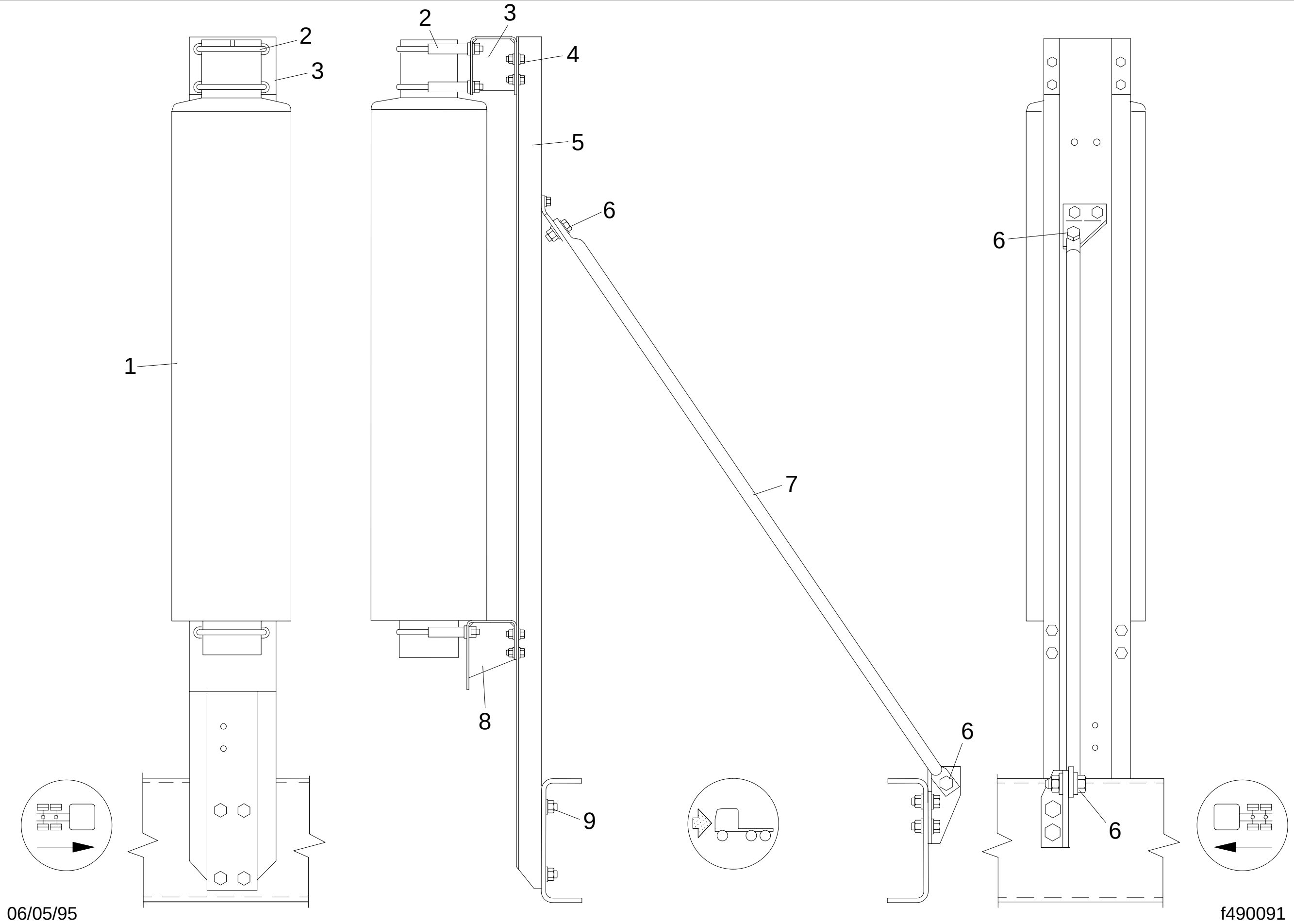
The muffler can be mounted outboard (see **Fig. 2**, **Fig. 3**, or **Fig. 4**) where it is supported by uprights which are bolted to the outside of the frame rails.

The muffler can be cab *and* frame-rail mounted (see **Fig. 5**) where it is supported by a frame rail bracket and a bracket bolted to the back of the cab. This installation uses rubber isolators between the muffler and the cab, and between the muffler and the frame rail bracket.

Most exhaust installations consist of an engine exhaust pipe, sometimes called the turbo pipe, mounted to the rear of the turbocharger and secured with a V-clamp. From there, flex pipe and exhaust piping route the exhaust to the muffler. A bracket attached to the frame rail or the cab mounting uses a clamp to hold and support the engine exhaust piping as it runs to the muffler. Band clamps connect all piping joints between the turbocharger and the muffler, and hold the exhaust piping to the muffler.

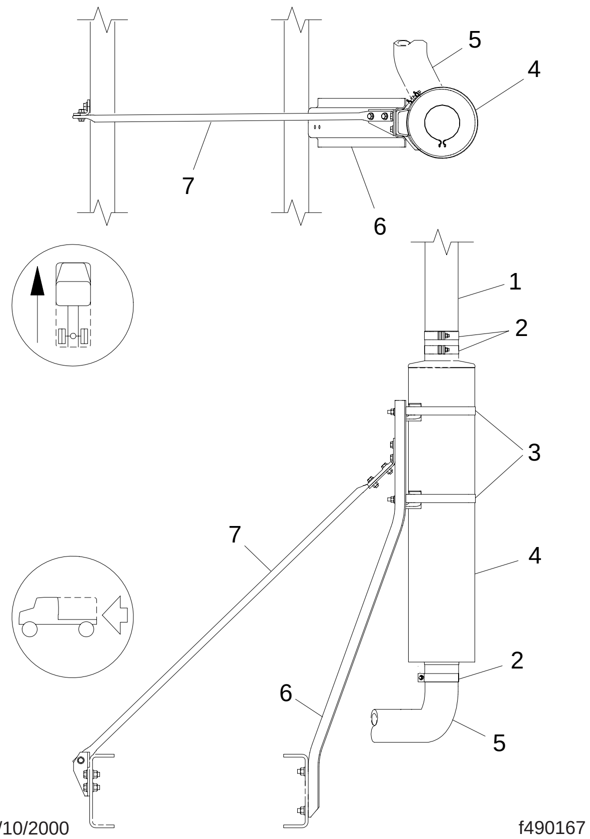
The exhaust piping can be mounted to the frame rail (see **Fig. 6**, **Fig. 7**, or **Fig. 8**).

General Information



1. Muffler
2. Saddle Clamp, 5-Inch
3. Upper Muffler Mounting Bracket
4. Capscrew, 3/8–16x1.25, grade 8; Nut; Washer
5. Muffler Mounting Upright
6. Capscrew, 5/8–11x1.25, grade 8; Nut; Washer
7. Muffler Mounting Brace
8. Lower Muffler Mounting Bracket
9. Capscrew, 5/8–11x1.75, grade 8; Nut; Washer

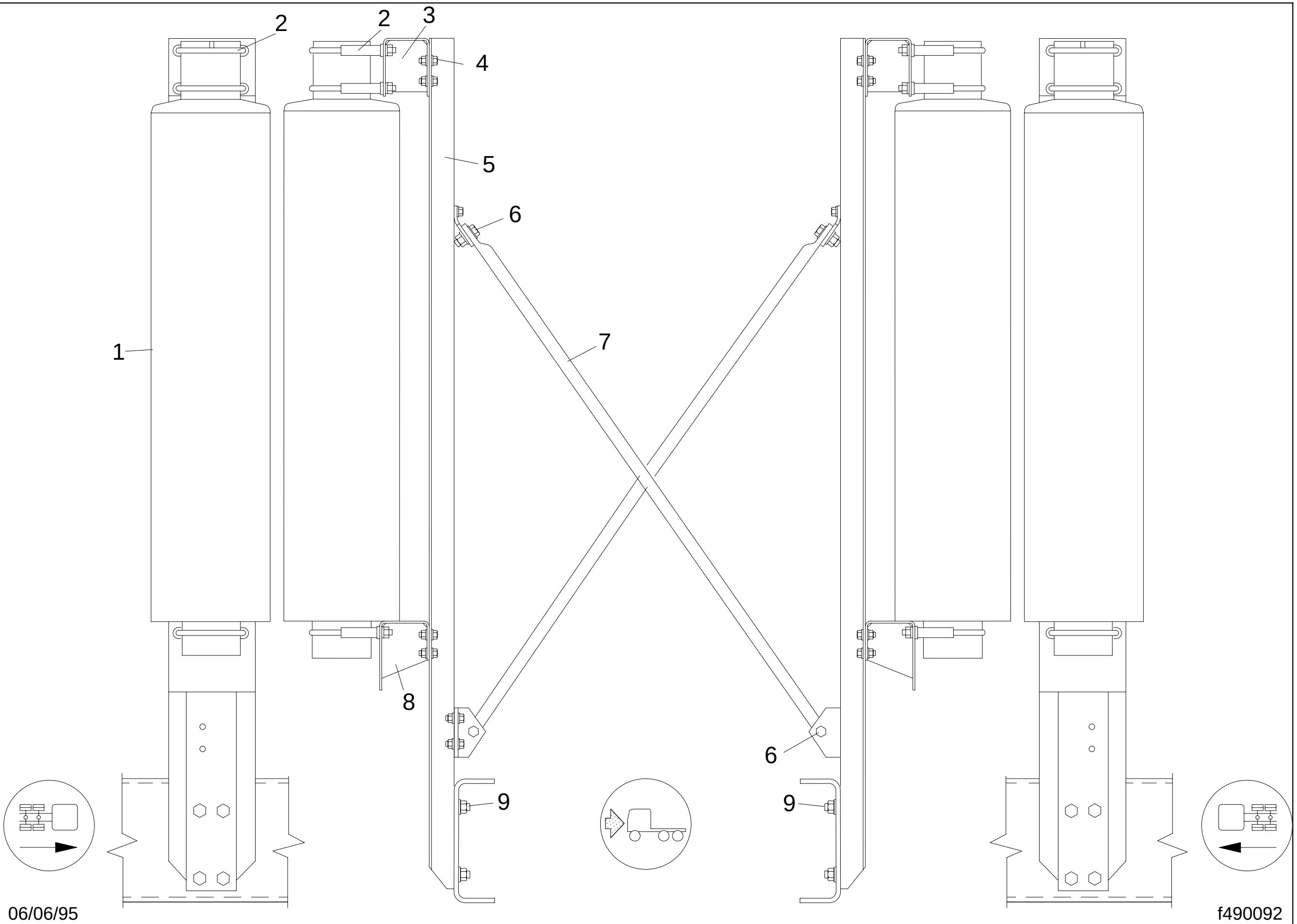
Fig. 2, Single Stationary Outboard Muffler Mounting



1. Top Stack
2. Accuseal® Clamp, 5-Inch
3. Muffler Band
4. Muffler
5. Exhaust Pipe from Engine
6. Muffler Mounting Upright
7. Muffler Mounting Brace

Fig. 3, Single Stationary Outboard Muffler Mounting

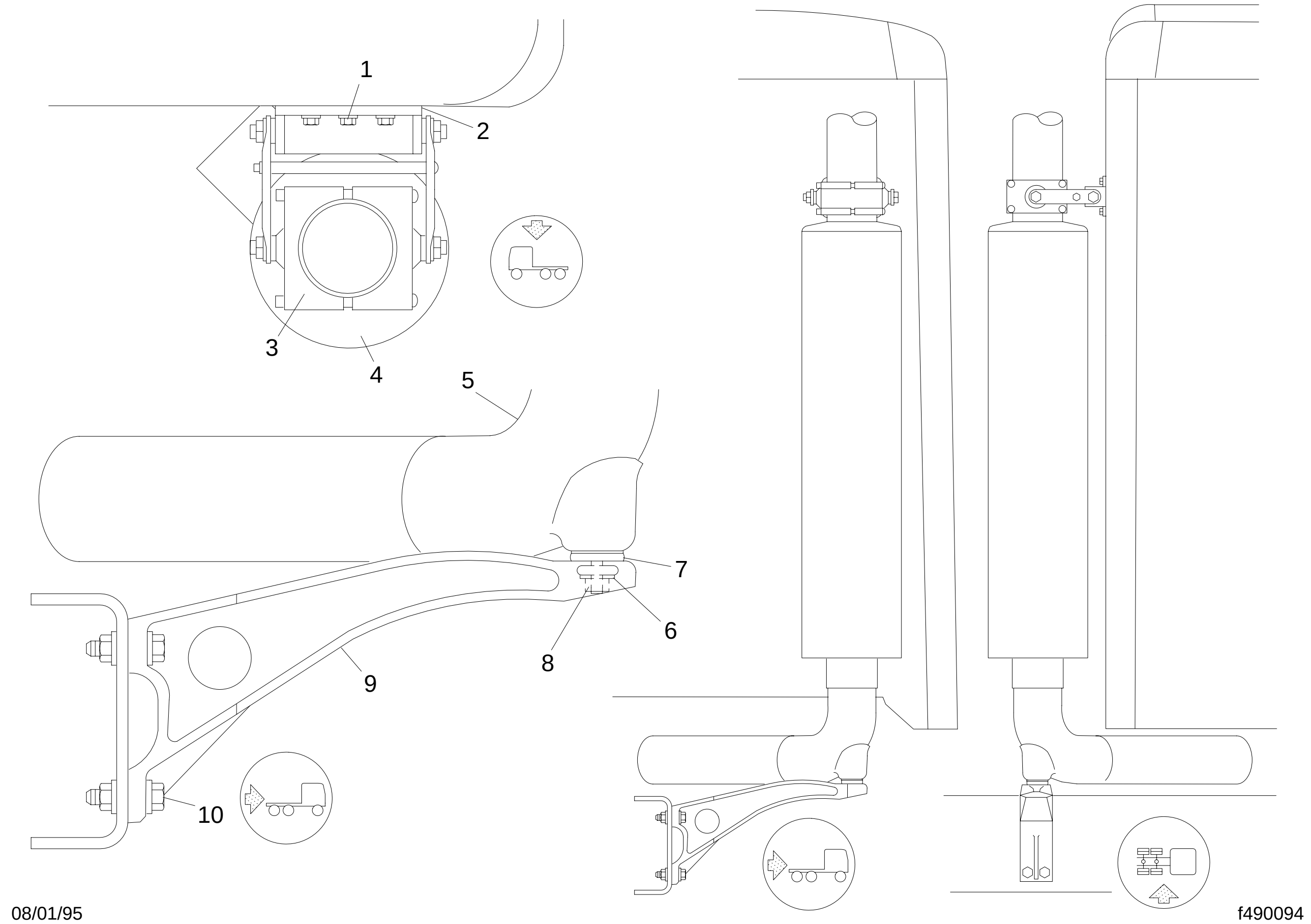
General Information



1. Muffler
2. Saddle Clamp, 5-Inch
3. Upper Muffler Mounting Bracket
4. Capscrew, 3/8–16x1.25, grade 8; Nut; Washer
5. Muffler Mounting Upright
6. Capscrew, 5/8–11x1.25, grade 8; Nut; Washer
7. Muffler Mounting Brace
8. Lower Muffler Mounting Bracket
9. Capscrew, 5/8–11x1.75, grade 8; Nut; Washer

Fig. 4, Dual Stationary Outboard Muffler Mounting

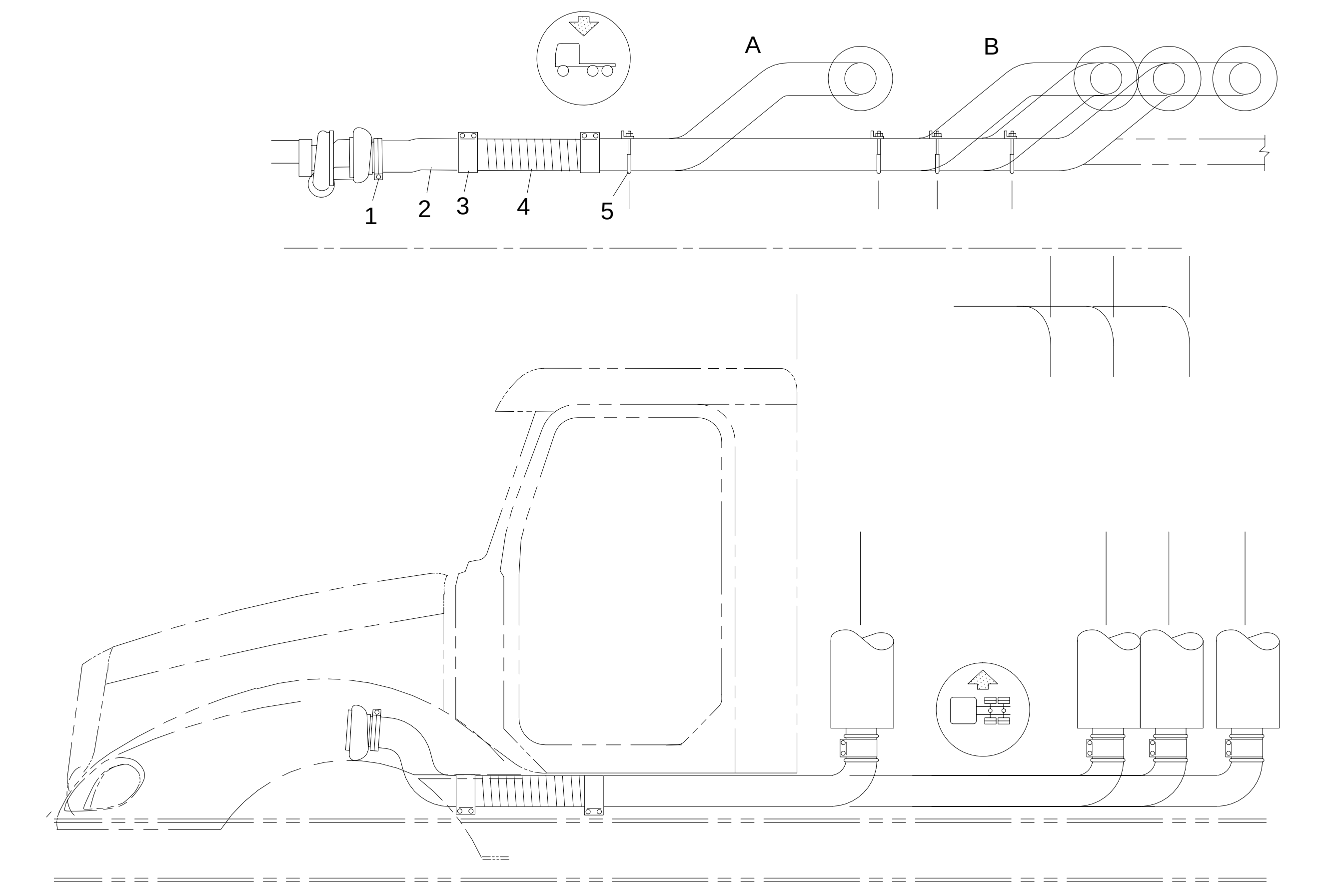
General Information



1. Capscrew 5/16–18, Stainless Steel; Washer
2. Gasket
3. Upper Muffler Mounting Bracket (Shackle Assembly)
4. Muffler
5. Muffler Pipe Elbow
6. Flatwasher
7. Isolator
8. Nut, 1/2–13, grade C
9. Lower Muffler Mounting Bracket
10. Capscrew, 5/8–11x1.75, grade 8; Nut; Washers

Fig. 5, Cab and Frame-Rail Mounted Muffler

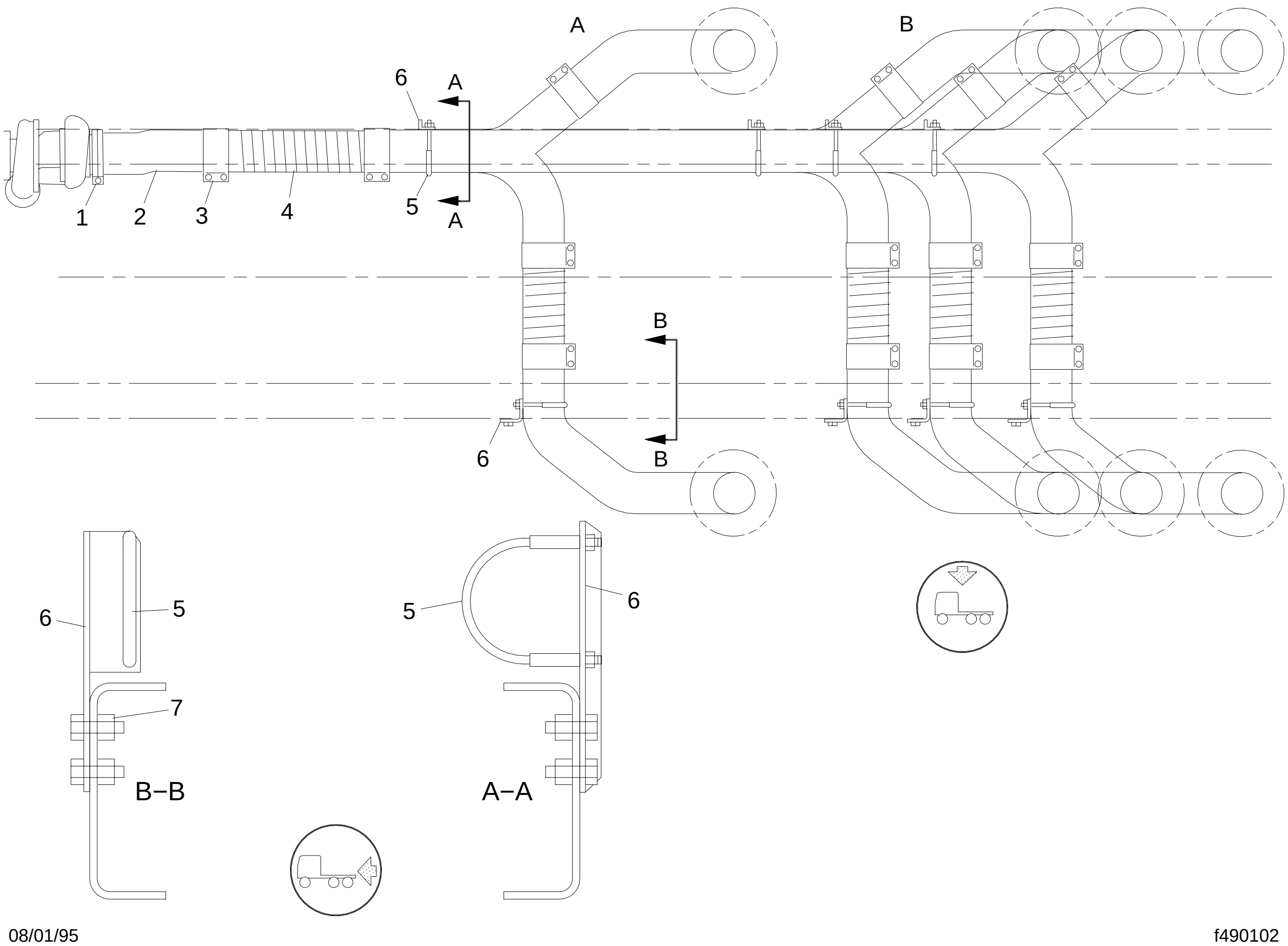
General Information



A. Muffler Location Day Cab
B. Muffler Location with Sleeper Cab

1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. Tube Support Bracket and Clamp, 5-Inch

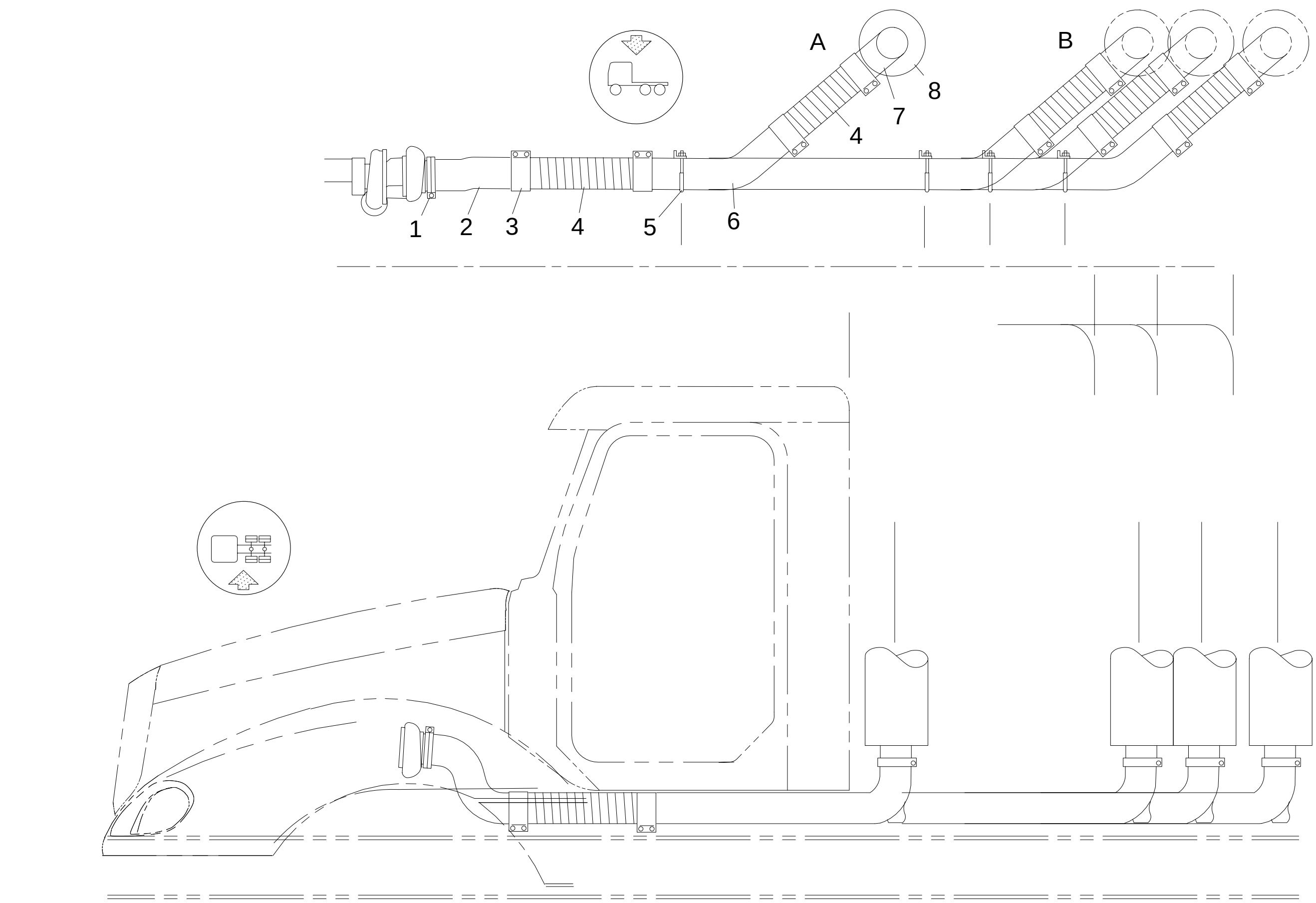
Fig. 6, Exhaust Piping for Single Stationary Outboard-Mounted Muffler



A. Muffler Location Day Cab
B. Muffler Location with Sleeper Cab
1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. U-Bolt Tube Clamp, 5-Inch
6. Exhaust Piping Bracket
7. Capscrew, 5/8–11x1.75, grade 5; Nut; Washers

Fig. 7, Exhaust Piping for Dual Stationary Outboard-Mounted Mufflers

General Information



A. Muffler Location Day Cab
B. Muffler Location with Sleeper Cab

1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. Tube Support Bracket and Clamp, 5-Inch
6. Exhaust Pipe, 5-inch, 40° Bend
7. Muffler Mounting Pipe
8. Muffler

Fig. 8, Exhaust Piping for Cab and Frame-Rail Mounted Muffler

Exhaust Ducting, Frame Rail-Mounted, Removal and Installation

Removal

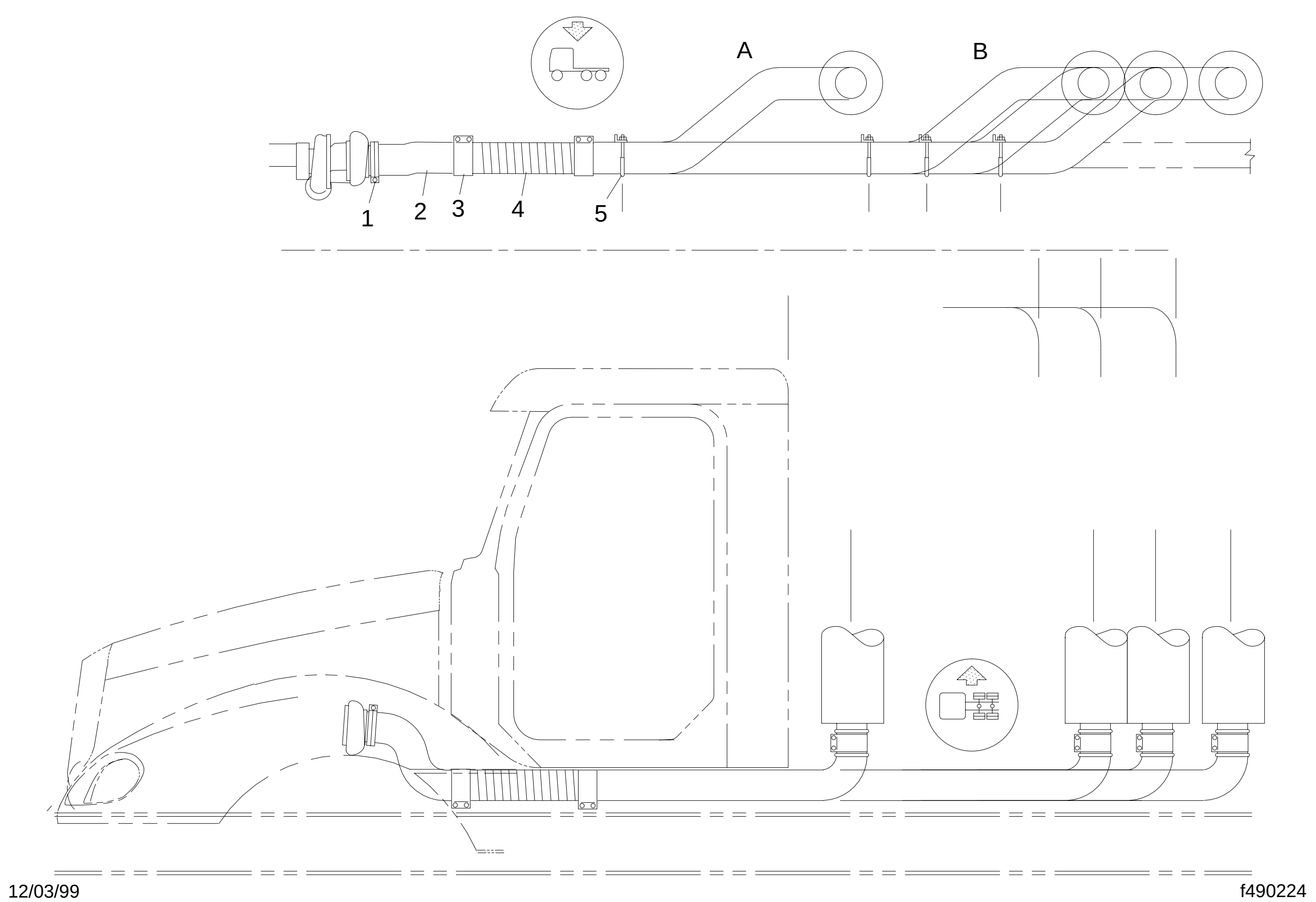
NOTE: Refer to the following figures for typical exhaust ducting installations:

For vehicles with a single stationary outboard-mounted muffler, see **Fig. 1**.

For vehicles with dual stationary outboard-mounted mufflers, see **Fig. 2**.

For vehicles with a single cab and frame rail-mounted muffler, see **Fig. 3**.

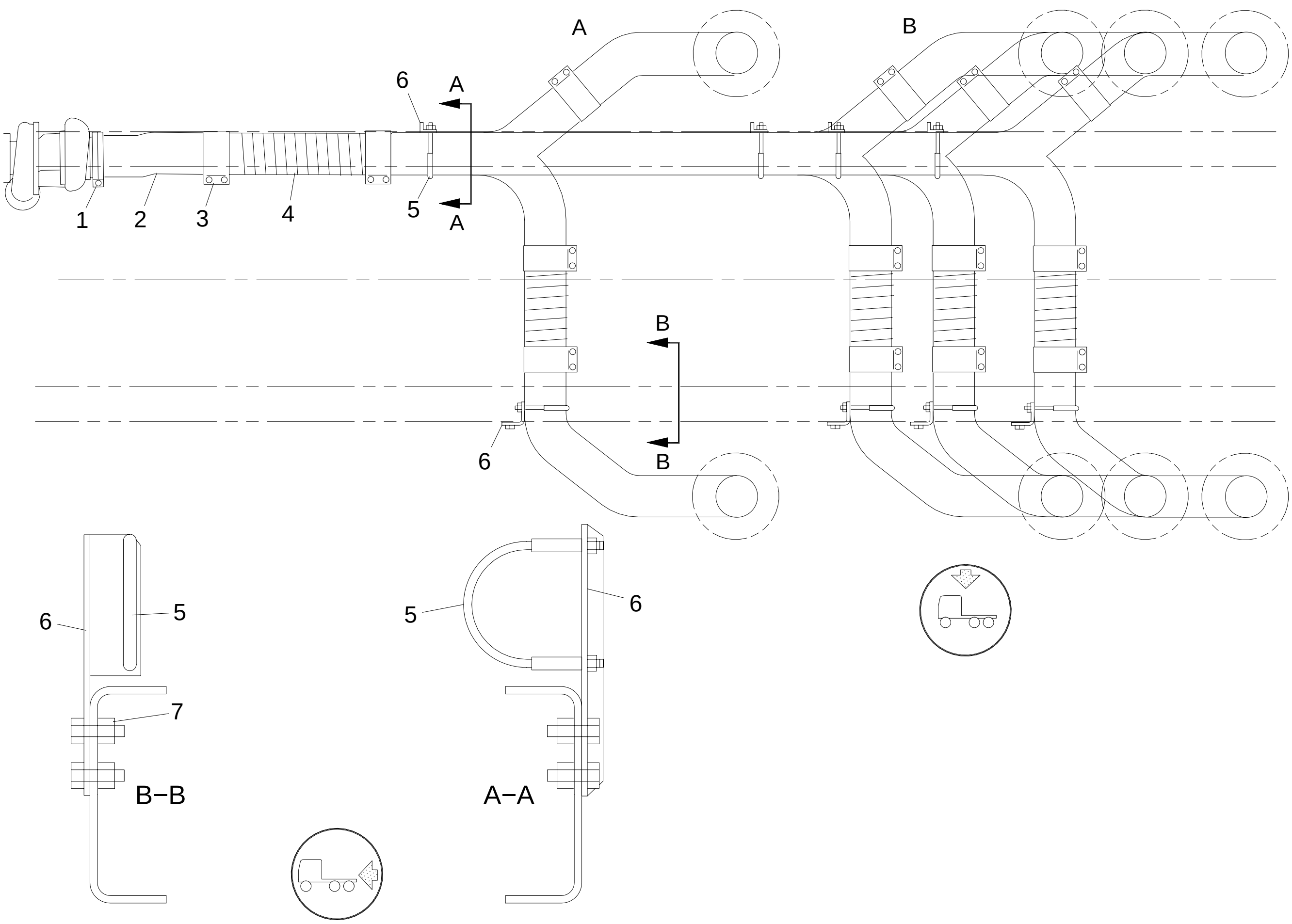
1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Loosen the V-clamp that holds the exhaust pipe to the rear of the turbocharger, and remove the pipe from the turbocharger.
3. Open the U-bolt tube clamps that hold the ducting to the frame-rail-mounted brackets, and remove the ducting from the clamps.
4. Loosen the clamp that holds the ducting to the bottom (inlet) of the muffler, and disconnect the ducting from the muffler.



A. Muffler Location Day Cab
B. Muffler Location with SleeperCab
1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. Tube Support Bracket and Clamp, 5-Inch

Fig. 1, Exhaust Piping for Single Stationary Outboard-Mounted Muffler

Exhaust Ducting, Frame Rail-Mounted, Removal and Installation



A. Muffler Location Day Cab
B. Muffler Location with SleeperCab

1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. U-Bolt Tube Clamp, 5-Inch
6. Exhaust Piping Bracket
7. Capscrew, 5/8–11 x 1.75, grade 5; Nut; Washers

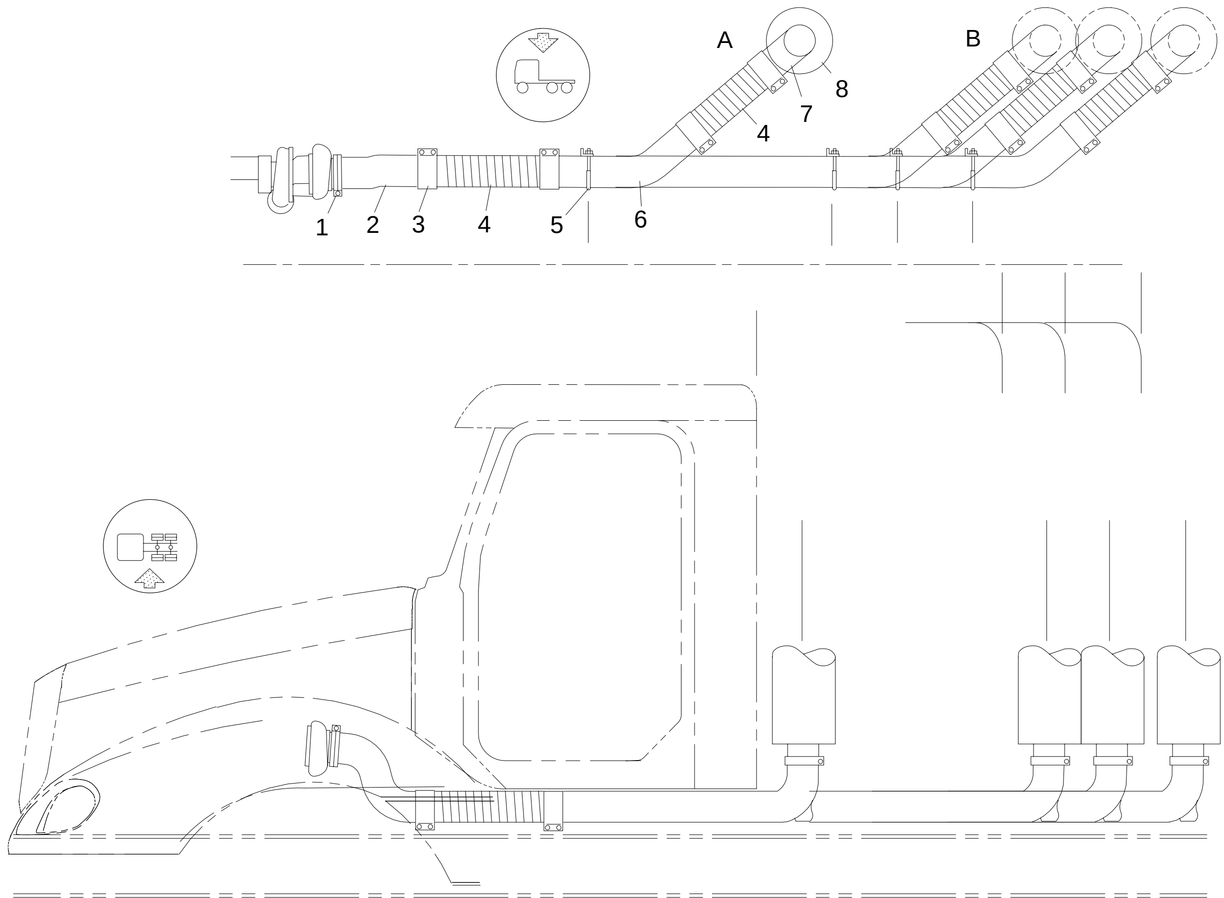
Fig. 2, Exhaust Piping for Dual Stationary Outboard-Mounted Mufflers

5. Remove the wide-band clamps as needed to remove the ducting from the vehicle. Remove the ducting from the vehicle.

Installation

1. Position the ducting on the vehicle.
2. Connect the engine turbo pipe to the turbocharger, and tighten the V-clamp 85 lbf·in (940 N·cm).
3. Connect the ducting to the frame rail-mounted brackets, and tighten the U-bolt tube clamps 24 lbf·ft (33 N·m).
4. Connect the ducting to the bottom of each muffler, and tighten the muffler inlet clamp 33 lbf·ft (45 N·m).
5. Install a new flexpipe as follows:

Exhaust Ducting, Frame Rail-Mounted, Removal and Installation



A. Muffler Location Day Cab
B. Muffler Location with Sleeper Cab
1. V-Clamp, 5-Inch
2. Engine Turbo Pipe
3. Wide-Band Clamp, 5-Inch
4. Flexpipe, 5-Inch
5. Tube Support Bracket and Clamp, 5-Inch
6. Exhaust Pipe, 5-inch, 40° Bend
7. Muffler Mounting Pipe
8. Muffler

Fig. 3, Exhaust Piping for Cab and Frame-Rail Mounted Muffler

5.1 Position the flexpipe according to the flow-direction indicators on the tubing. See **Fig. 4**.

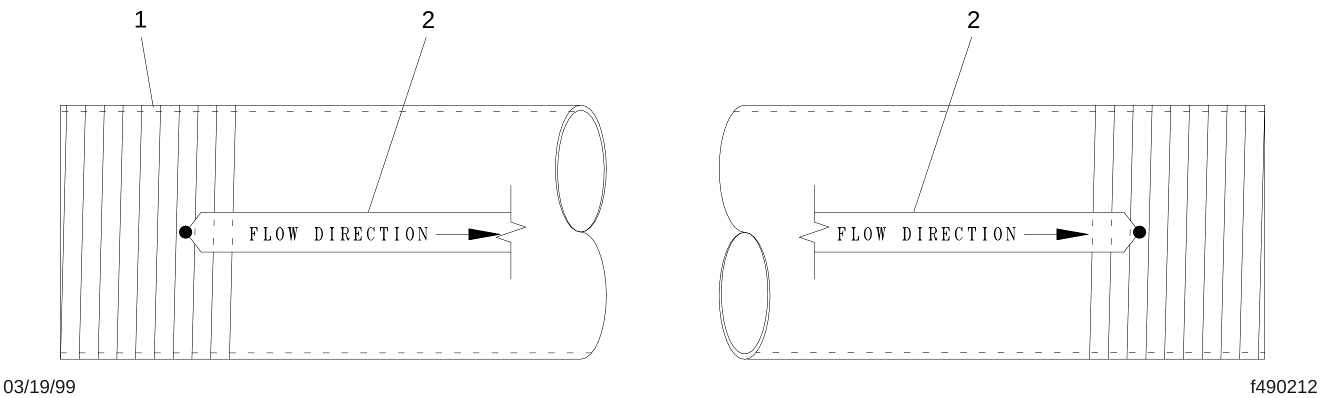
Connect one end of the new flexpipe to the exhaust pipe.

5.2 Make sure the flow-direction indicators on the flexpipe are straight and taut. They also serve as installation guides to indicate the correct amount of pipe extension.

6. Install the wide-band exhaust clamps that were loosened or removed. For instructions, refer to **Subject 120**.

7. Remove the chocks from the tires.

Exhaust Ducting, Frame Rail-Mounted, Removal and Installation



1. Flexpipe
2. Flow-Direction Indicator

Fig. 4, Exhaust Flexpipe

Heat Shield Removal and Installation

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Note the position of the heat shield and heat shield mounting bands.
3. Remove the bolts that hold the ends of the shield mounting bands together.
4. Remove the heat shield and mounting bands from the muffler.

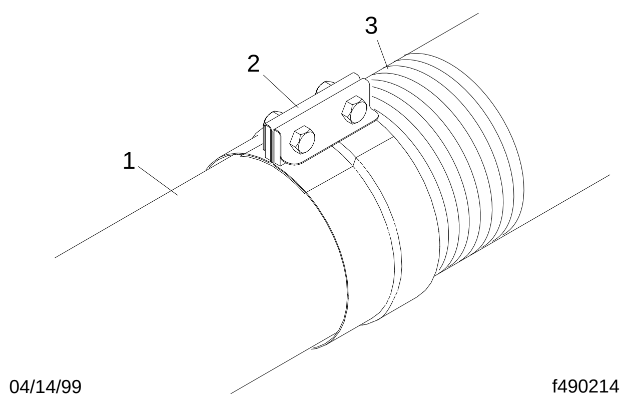
Installation

1. Position the heat shield and heat shield mounting bands on the muffler.
2. Use the bolts and nuts to connect the ends of the bands, and tighten the bolts until the mounting bands are tight around the muffler.
3. Remove the chocks from the tires.

Wide-Band Exhaust Clamp Replacement

Replacement (See Fig. 1)

1. Remove and discard the leaking or damaged wide-band exhaust clamp.
2. Insert one end of the flex tubing into the large-diameter side of the exhaust clamp until it contacts the step in the center of the clamp.
3. Insert about 3 inches (76 mm) of the exhaust piping into the small-diameter side of the exhaust clamp.



1. Exhaust Tubing
2. Exhaust Clamp
3. Flex Tubing

Fig. 1, Wide-Band Exhaust Clamp

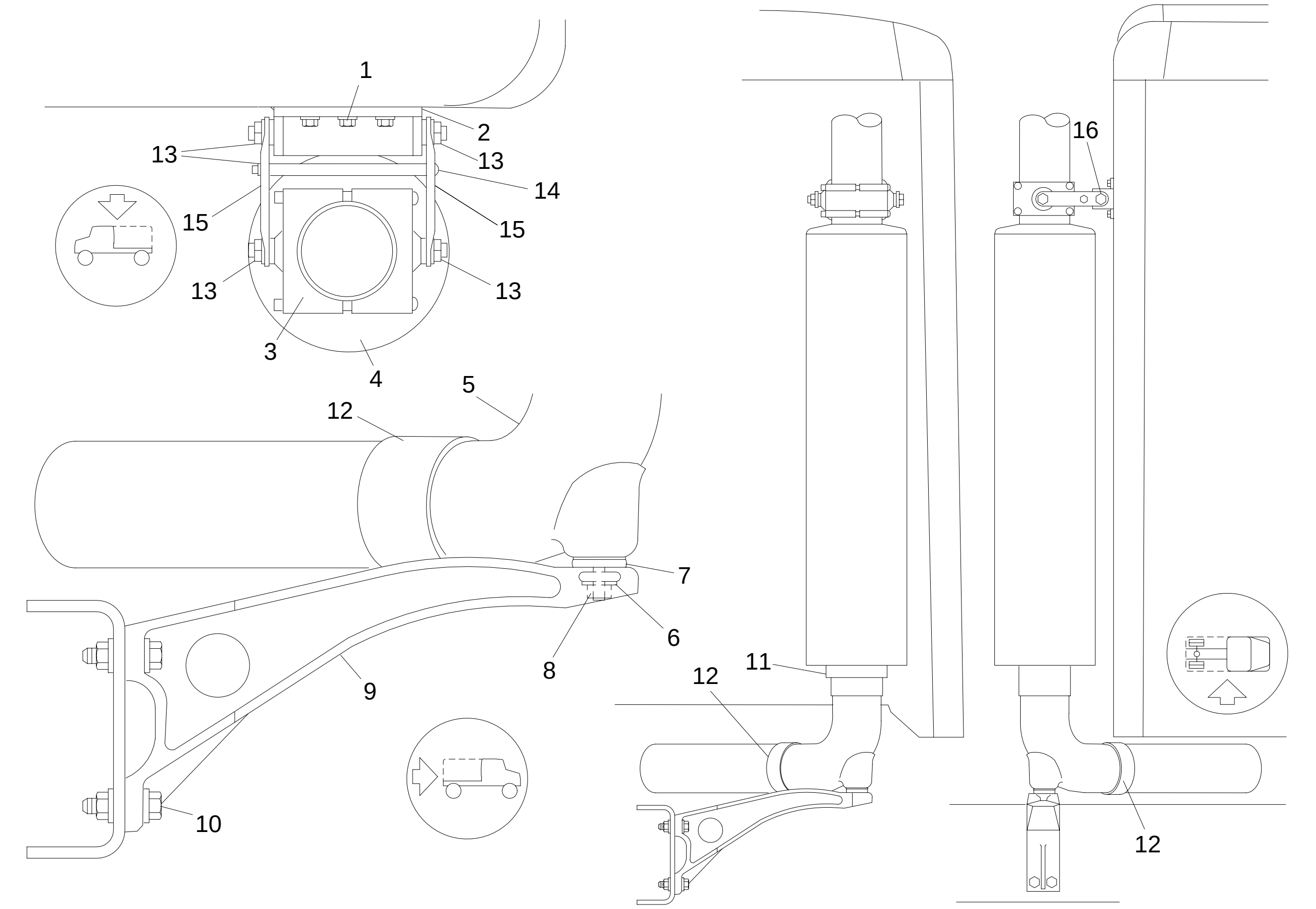
4. Make sure again that the end of the flex pipe is up against the step at the middle of the exhaust clamp.
5. Tighten snugly the hexbolt on the large-diameter (flex tubing) side of the clamp.
6. Tighten the hexbolt on the small-diameter side of the clamp 45 lbf·ft (54 N·m).
7. Tighten the hexbolt on the large-diameter side of the clamp 45 lbf·ft (54 N·m).
8. Check the hexbolt on the small-diameter side of the clamp. If needed, tighten 45 lbf·ft (54 N·m).
9. Run the engine, and check for leaks. If needed, remove and install the exhaust clamp again.

Muffler Elbow Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.

4. Remove the nut, flatwasher, and isolator located underneath the muffler elbow. Remove the muffler elbow.



1. Capscrew 5/16–18, Stainless Steel; Washer
2. Gasket
3. Upper Muffler Mounting Bracket (Shackle Assembly)
4. Muffler
5. Muffler Elbow
6. Flatwasher
7. Isolator
8. Nut, 1/2–13, Grade C
9. Lower Muffler Mounting Bracket
10. Capscrew, 5/8–11 x 1.75, Grade 8; Nut; Washers
11. Band Clamp
12. Wide-Band Clamp
13. Nut
14. Bolt
15. Shackle Bracket
16. Keyed End of Shackle Bracket

Fig. 1, Cab and Frame Rail-Mounted Muffler

2. Remove the muffler. For instructions, refer to **Subject 150**.

3. Remove the wide band exhaust clamp between the muffler elbow and the exhaust flex pipe.

Installation (See Fig. 1)

1. Attach a new wide-band clamp to the horizontal flex pipe, but do not tighten.

Muffler Elbow Removal and Installation

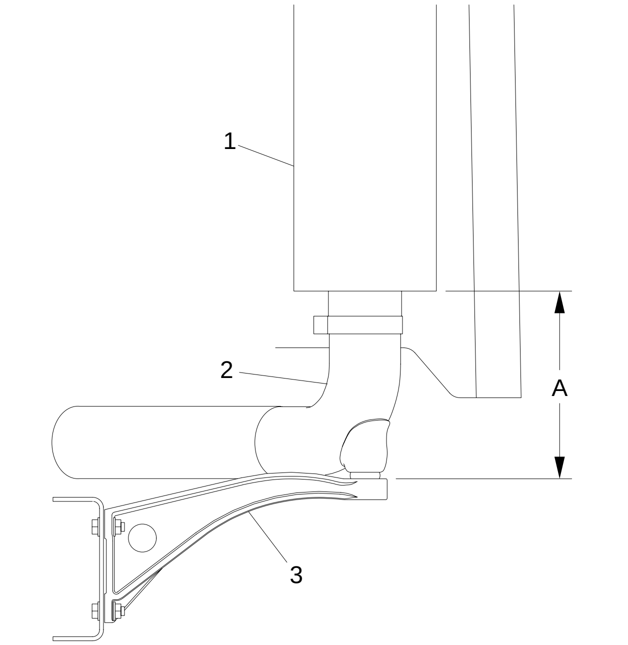
2. Place the isolator on the muffler elbow stud.
3. Place the muffler elbow on the lower muffler mounting bracket.
4. Attach the muffler elbow to the horizontal flex pipe by placing the horizontal flex pipe over the muffler elbow.
5. Place the flatwasher and nut on the muffler elbow stud. Tighten the nut to 68 ± 8 lbf·ft (92 ± 11 N·m).
6. Place the band clamp over the muffler elbow, but do not tighten.
7. Position the muffler on the muffler elbow. The elbow should slip up, inside the muffler inlet pipe. The distance from the bottom edge of the muffler to the mounting point on the top of the chassis-mounted lower bracket should be 13 to 13-1/2 inches (330 to 343 mm). See **Fig. 2**.

   If the installation is correct, the upper shackle assembly arms should be horizontal within ±5 degrees.
8. Position the band clamp around the muffler and muffler elbow, and tighten the band clamp 50 lbf·ft (68 N·m).
9. Install the shackle brackets on the upper muffler mounting bracket. One end of each shackle bracket is keyed. Position the keyed end of the shackle bracket on the stud closest to the cab. See **Fig. 1**.

CAUTION

Be sure that the keyed end of the shackle bracket is aligned with the mating shoulder. If the keyed shackle bracket is not aligned with the mating shoulder, damage to the shoulder may occur.

10. Position the top of the muffler in the upper muffler mounting bracket.
11. Install the bolt and nuts on the upper muffler mounting bracket, and tighten the large nuts 64 lbf·ft (87 N·m). Tighten the small nut 24 lbf·ft (33 N·m).
12. Tighten the wide-band clamp. For instructions, refer to **Subject 120**.
13. Remove the chocks from the tires.



A. Measurement from muffler to top mounting on bracket: 13 to 13-1/2 inches (330 to 343 mm).
1. Muffler
2. Muffler Pipe Elbow
3. Lower Muffler Mounting Bracket

Fig. 2, Muffler-to-Bracket Measurement

Exhaust Stack Removal and Installation

Removal

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. *If working with a cab and frame rail-mounted muffler,* loosen the five nuts that clamp the cab-mounted muffler bracket around the top of the muffler and the stack.

   If working with any other vertical muffler, loosen the saddle clamps at the top of the muffler.
3. Lift the stack out of the muffler.

Installation

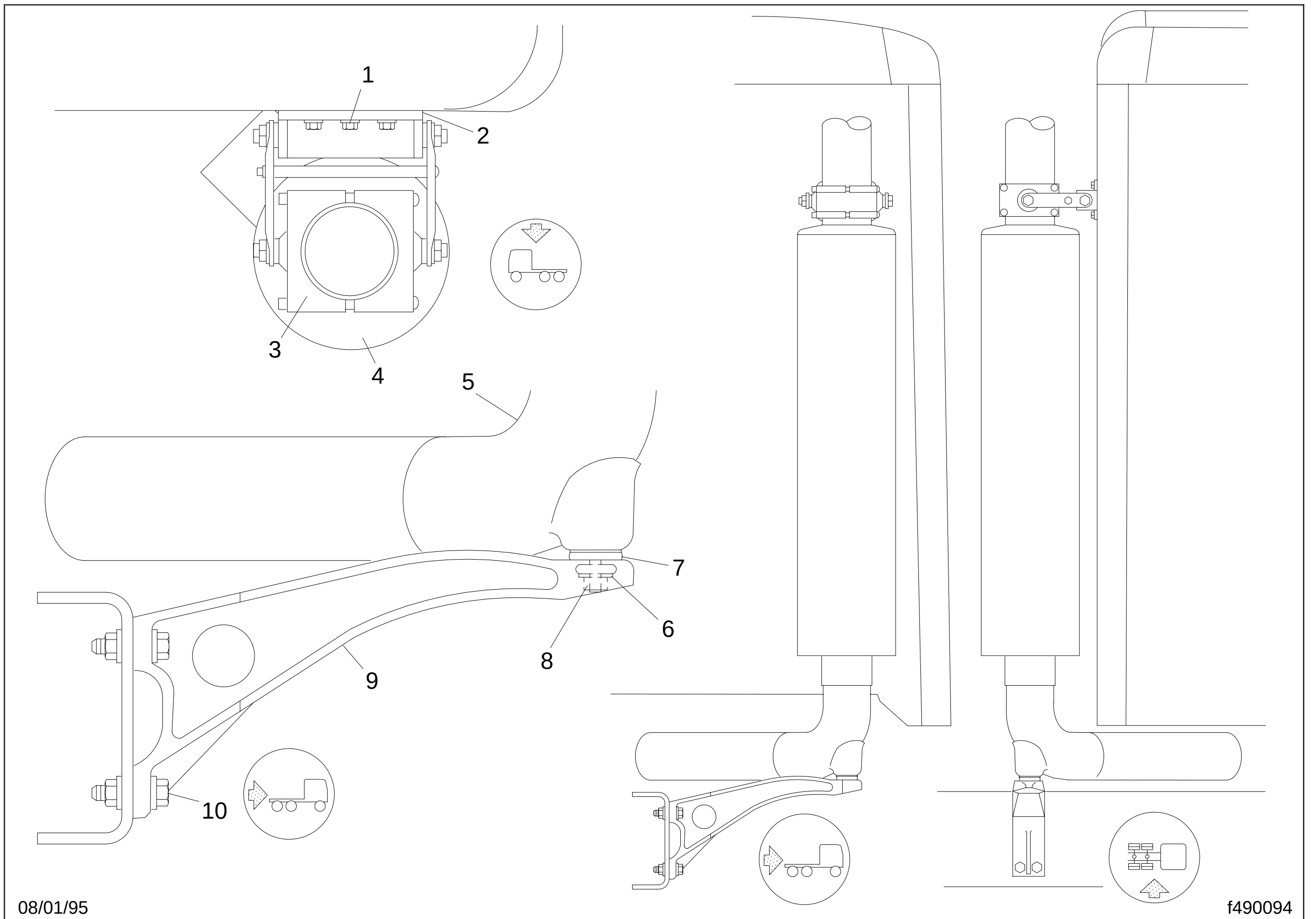
1. Insert the stack into the top of the muffler.
2. Secure the stack to the muffler.

   If working with a cab and frame rail-mounted muffler, tighten the four large nuts in the cab-mounted muffler bracket 74 lbf·ft (100 N·m) and the small nut 24 lbf·ft (33 N·m).

   If working with any other vertical muffler, tighten the saddle clamps at the top of the muffler 24 lbf·ft (33 N·m).
3. Remove the chocks from the tires.

Cab and Frame-Rail Mounted Muffler (See Fig. 1)

REMOVAL



1. Capscrew 5/16–18, Stainless Steel; Washer
2. Gasket
3. Upper Muffler Mounting Bracket (shackle assembly)
4. Muffler
5. Muffler Pipe Elbow
6. Flatwasher
7. Isolator
8. Nut, 1/2–13, Grade C
9. Lower Muffler Mounting Bracket
10. Capscrew, 5/8–11 x 1.75, Grade 8; Nut; Washers

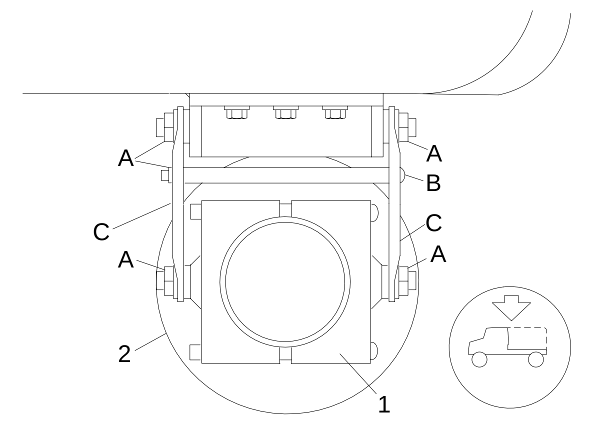
Fig. 1, Cab and Frame-Rail Mounted Muffler

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the top stack. For instructions, refer to **Subject 140**.
3. Loosen the band at the bottom of the muffler.
4. Remove the five nuts, one bolt, and two shackle brackets on the upper muffler mounting bracket as shown in **Fig. 2**.
5. Lift the muffler from the muffler pipe elbow, and remove the muffler from the vehicle.

INSTALLATION

1. Position the muffler on the muffler pipe elbow. The elbow should slip up, inside the muffler inlet pipe. The distance from the bottom edge of the

Muffler Replacement



A. Remove these nuts.
B. Remove this bolt.
C. Remove these shackle brackets.
1. Upper Muffler Mounting Bracket (shackle assembly)
2. Muffler

Fig. 2, Removing the Muffler

muffler to the mounting point on the top of the chassis-mounted lower bracket should be 13 to 13-1/2 inches (330 to 343 mm). See **Fig. 3**.

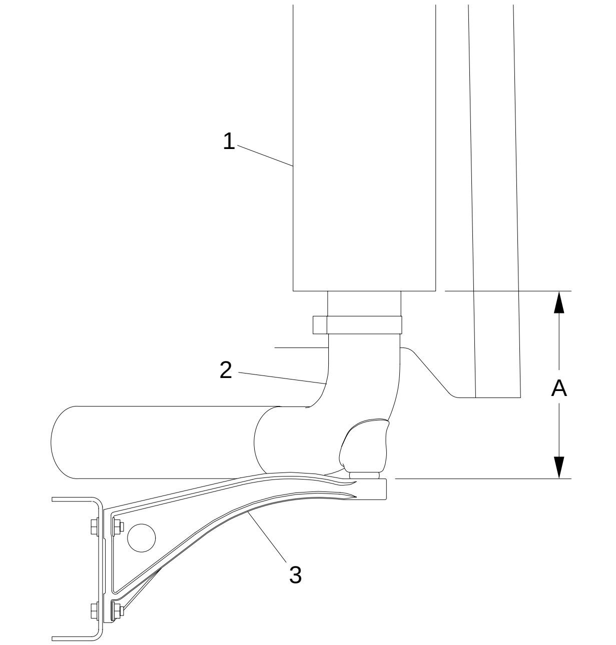
If the installation is correct, the upper shackle assembly arms should be horizontal within ±5 degrees.

2. Position the clamp around the muffler and muffler pipe elbow, and tighten the clamp 50 lbf·ft (68 N·m).
3. Position the top of the muffler in the upper muffler mounting bracket.
4. Install the shackle brackets on the upper muffler mounting bracket. One end of each shackle bracket is keyed. Position the keyed end of the shackle bracket on the stud closest to the cab.

CAUTION

Be sure that the keyed end of the shackle bracket is aligned with the mating shoulder. If the keyed shackle bracket is not aligned with the mating shoulder, damage to the shoulder may occur.

5. Install the bolt and nuts, and tighten the large nuts 64 lbf·ft (87 N·m). Tighten the small nut 24 lbf·ft (33 N·m).



A. Measurement from muffler to top mounting on bracket: 13 to 13-1/2 inches (330 to 343 mm).
1. Muffler
2. Muffler Pipe Elbow
3. Lower Muffler Mounting Bracket

Fig. 3, Muffler-to-Bracket Measurement

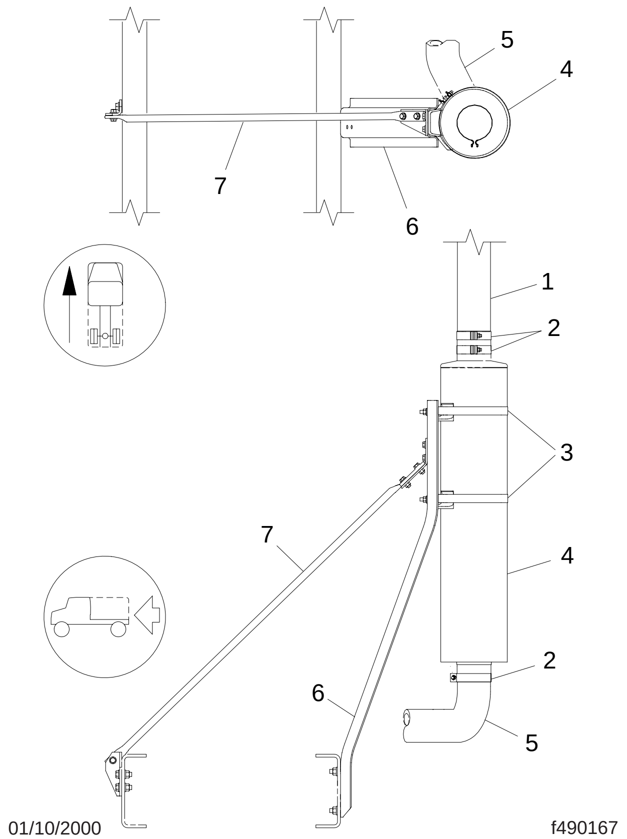
6. Install the top stack. For instructions, refer to **Subject 140**.
7. Remove the chocks from the tires.

Frame-Rail Mounted Muffler

(See Fig. 4)

REMOVAL

1. Park the vehicle, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the top stack. For instructions, refer to **Subject 140**.
3. Remove the heat shield from the muffler. See **Subject 110** for instructions.
4. Loosen the clamp at the bottom of the muffler.
5. Loosen the two muffler bands that hold the muffler to the muffler mounting upright.



1. Top Stack
2. Accuseal® Clamp, 5-Inch
3. Muffler Band
4. Muffler
5. Muffler Clamp
6. Exhaust Pipe from Engine
7. Muffler Mounting Upright
8. Muffler Mounting Brace

Fig. 4, Frame-Rail Mounted Muffler

6. Lift the muffler straight up and remove it from the vehicle.

INSTALLATION

1. Put the muffler in place against the mounting upright.
2. Install the muffler bands onto the muffler and the muffler mounting brackets. Tighten the bands 22 lbf·ft (30 N·m).
3. Install the heat shield. See **Subject 110** for instructions
4. Install the top stack. See **Subject 140** for instructions.
5. Connect the exhaust pipe from the engine to the bottom of the muffler. Tighten the band 50 lbf·ft (68 N·m).
6. Remove the chocks from the tires.

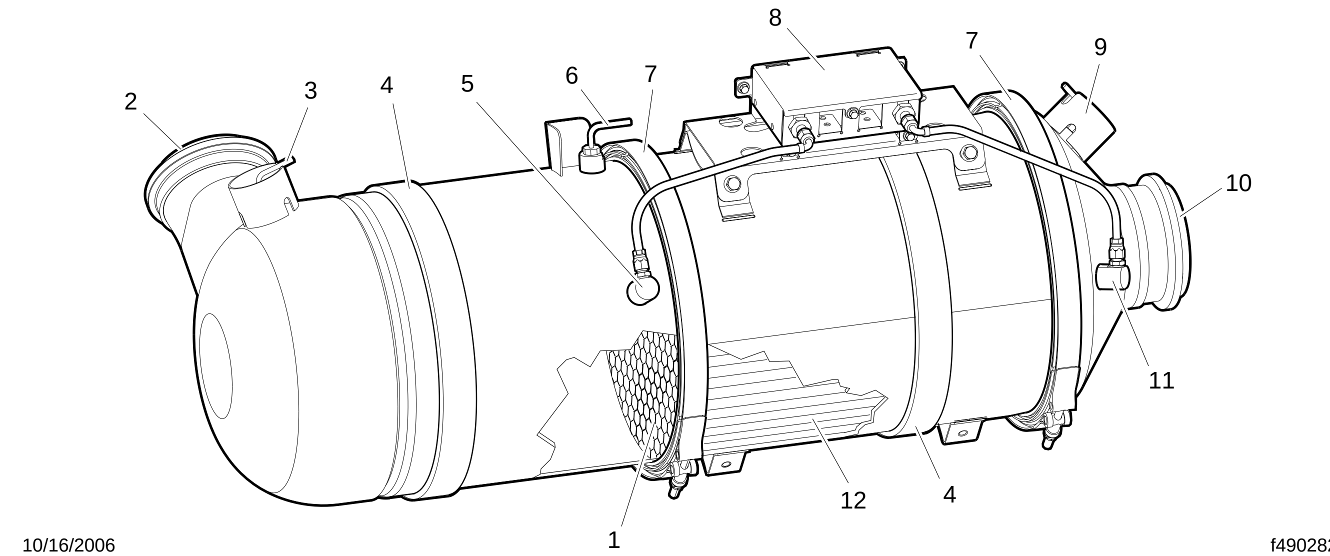
General Information

The aftertreatment system (ATS), introduced to meet the requirements of the EPA07 emission control regulations, includes all the piping and equipment between the turbocharger outlet and the tip of the exhaust pipe. It resembles the exhaust system on pre-EPA07 vehicles, but includes an aftertreatment device (ATD) instead of a muffler (see **Fig. 1**), and other equipment. Monitoring and operation of the ATS is controlled by an electronic control module (ECM).

EPA07 emissions regulations limit NOx to just over 1 gram per brake horsepower hour (g/bhp-hr) and particulate matter cannot exceed 0.01 g/bhp-hr. EPA07 engines require ultralow sulphur diesel (ULSD) fuel, for low emissions and long life of the diesel particulate filter (DPF), a honeycomb soot filter inside the ATD.

Engine manufacturers use different methods and equipment to reduce emissions from their engines, but an ATD is used on all of them. The ATD is always chassis-mounted, but can be mounted either vertically or horizontally. ATS exhaust piping is stainless steel.

Inside the ATD, the exhaust first passes through the diesel oxidation catalyst (DOC) where combustion gases are chemically broken down to water and carbon dioxide, then through the (DPF), where solid particles are trapped. The trapped particles are almost completely vaporized in the DPF in regeneration, sometimes shortened to the term, "regen." The soot from engine oil additives which cannot be vaporized is burned to ash and held in the DPF until it eventually builds up, and the DPF must be removed and physically cleaned.



1. Diesel Particulate Filter (DPF) Ceramic Honeycomb Substrate Openings
2. Marmon Fitting at Inlet from Turbocharger
3. Diesel Oxidation Catalyst (DOC) Intake Temperature Sensor
4. ATD Mounting Band
5. DPF Intake Pressure Sensor
6. DOC Outlet Temperature Sensor (connection to sensor housing not shown)
7. DPF V-Band Mounting Clamps
8. Sensor Housing
9. DPF Outlet Temperature Sensor (connection to sensor housing not shown)
10. Exhaust Outlet Marmon Fitting
11. DPF Outlet Pressure Sensor
12. DPF Substrate Tubes

Fig. 1, ATD Components (typical)

IMPORTANT: To minimize soot buildup on the DPF, low-ash oil is necessary for maximum service between physical cleanings. Only low-ash oil should be used in EPA07 engines.

NOTE: Freightliner documentation deals only with removal and installation of the components of the ATS. Refer to the engine manufacturer's service literature for all testing, disassembly, cleaning, and repair of the ATD and other components.

IMPORTANT: The ATS is part of an integrated engine and emissions management system, controlled by the ECM. Follow the engine manufacturer's procedures, and use the correct equipment when diagnosing or working on any part of the ATS.

Regeneration

There are two types of regeneration; passive and active.

Passive regeneration happens whenever the ATD internal temperature is 572°F (300°C) or higher. This happens during normal loaded vehicle operation, and exhaust gas temperature is no higher than normal. Under load and at highway speeds, passive regeneration may be all that is necessary to keep the DPF clear. But running light loads, or at low speeds, does not generate enough heat in the ATD for passive regeneration, and soot builds up in the DPF.

As soot builds up in the DPF, it creates back pressure and decreases engine efficiency. So at intervals determined by the ECM, which keeps track of measurements such as engine hours, fuel consumed, and mileage, the ATS raises the temperature inside the ATD to burn the built-up soot to ash. This reduces the back pressure and allows the DPF to continue operating efficiently for tens of thousands of miles.

During active regeneration, engine rpm rise to fast-idle speed and extra fuel is injected into the ATD to raise its interior temperature very high, over 1112°F (600°C), and turn the trapped soot to harmless ash. There are two types of active regeneration; at-speed and parked.

- When conditions permit, the ECM automatically initiates at-speed regeneration. The exact conditions for regeneration vary, according to the engine manufacturer's design. Generally, it can happen only when the vehicle speed is above 7.5 mph, and active regeneration stops when the vehicle slows to 5 mph or below.
- Parked regeneration is initiated by a driver or technician when the vehicle is safely parked with the exhaust outlet well away from any flammable substance, a specific sequence of procedures is followed, and the driver pushes the regeneration button on the dashboard. The parked regeneration sequence varies according to engine and vehicle configuration, but it must be exactly followed or regeneration cannot happen. Follow the exact sequence prescribed for the vehicle, according to the engine manufacturer's literature.

EPA07 Aftertreatment Device Removal and Installation

Removal

These instructions are generalized, because vehicle configurations vary widely. The basic procedures apply to all aftertreatment systems. For service and repair beyond removal and installation, refer to the engine manufacturer's service literature.

NOTE: For test or service procedures on components of the ATS, consult the engine manufacturer's service literature.

The ATD assembly weighs from 125 to 150 pounds (57 to 68 kg) and must be protected from impact or sharp jolts. Dropping the ATD, or subjecting it to jarring impact can crack the diesel particulate filter (DPF) inside, which is built on a ceramic substrate. If that happens, the DPF is ruined and must be replaced.

A secure support is necessary to remove and install the ATD safely. The ATD must be held securely to protect it from falling, or hitting hard against something else.

The horizontal ATD lifting device (TLZ00785) is designed to handle a horizontal ATD. Vertical ATDs require a shop hoist secured to the lifting ears on top.

The aftertreatment device (ATD) is constructed so that its exterior operating temperature is comparable to that of a standard muffler, but during active regeneration, when a fuel mist is injected to raise its temperature and destroy soot deposits, its interior (see **Fig. 1**) and the outlet become hot enough to melt or ignite many common materials.

WARNING

Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.

To avoid potentially serious burns or material damage:

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

1. Set the parking brake and chock the tires.

NOTE: Never attempt to start the vehicle with the ATD removed or with the ATD sensors disconnected, unless the engine manufacturer's documentation allows it for a diagnostic procedure.

2. Disconnect the connections at the sensor housing and the diesel oxidation catalyst (DOC) inlet temperature sensor. See **Fig. 1**.
3. Mark the Marmon fitting joints and mounting bracket orientation to the ATD, so that it can be installed exactly as it was removed. See **Fig. 2**.

NOTE: There are guide pins (see **Fig. 3**) to position the ATD during vehicle manufacture, but they are designed to break off if they are stressed. The most important thing about ATD mounting is that the other ATS components, particularly the bellows, must align correctly.

4. If the ATD is horizontally mounted, raise the ATD-handling device into place against it, so that the ATD is supported securely. If the ATD is vertically mounted, attach a shop crane or similar device to the lifting ears and take up the slack so that the lifting device is beginning to take the weight of the ATD.
5. The exhaust pipe may require support, such as a rope sling, to support it when the ATD is removed. If such support is required, install it now.

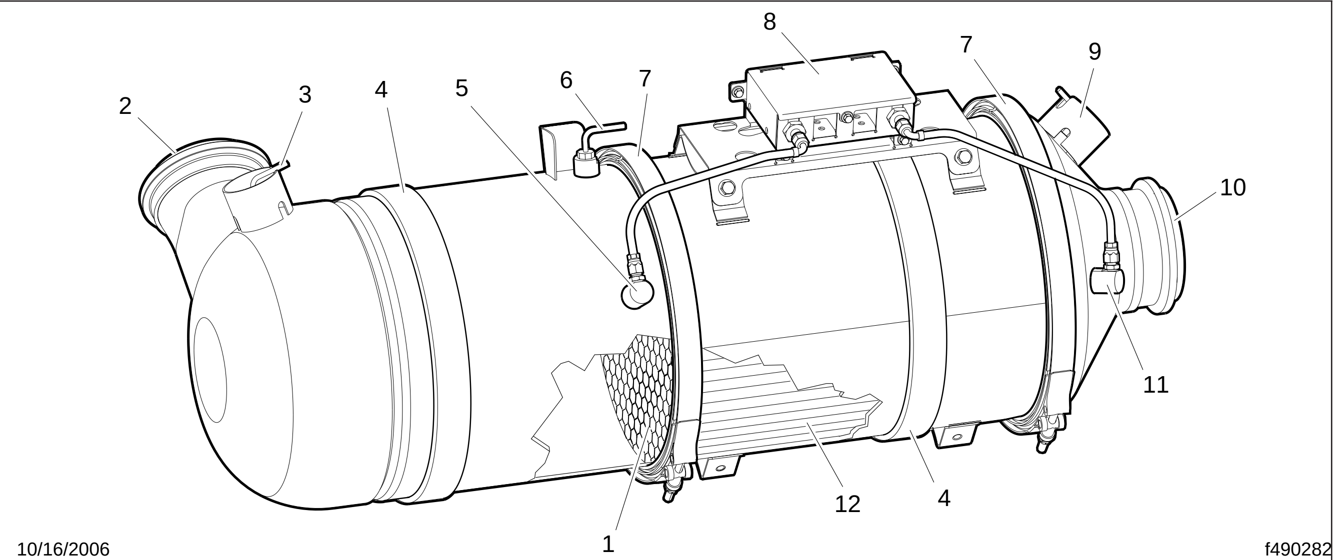
Be careful not to stress or twist the bellows as the ATD is manipulated. The bellows is not designed to support weight or withstand undue stress and can easily be damaged, requiring expensive replacement.

6. Remove the clamps from the Marmon fittings at the ATD inlet and outlet.
7. Remove the two mounting bands that hold the ATD to its mounting brackets, so that the ATD is held by the ATD handling device.

NOTE: It may be necessary to raise the vehicle, or remove heat shields or body panels, to remove the ATD.

8. Move the ATD handling device slightly, so that the ATD positioning pin (see **Fig. 4**) clears its hole in the mounting bracket. Carefully remove the ATD from the vehicle.

EPA07 Aftertreatment Device Removal and Installation



1. Diesel Particulate Filter (DPF) Front End Honeycomb
2. Marmon Fitting at Inlet from Turbocharger
3. Diesel Oxidation Catalyst (DOC) Intake Temperature Sensor
4. ATD Mounting Band
5. DPF Intake Pressure Sensor
6. DOC Outlet Temperature Sensor (connection to sensor housing not shown)
7. DPF V-Band Mounting Clamp
8. Sensor Housing
9. DPF Outlet Temperature Sensor (connection to sensor housing not shown)
10. Exhaust Outlet Marmon Fitting
11. DPF Outlet Pressure Sensor
12. DPF Ceramic Substrate

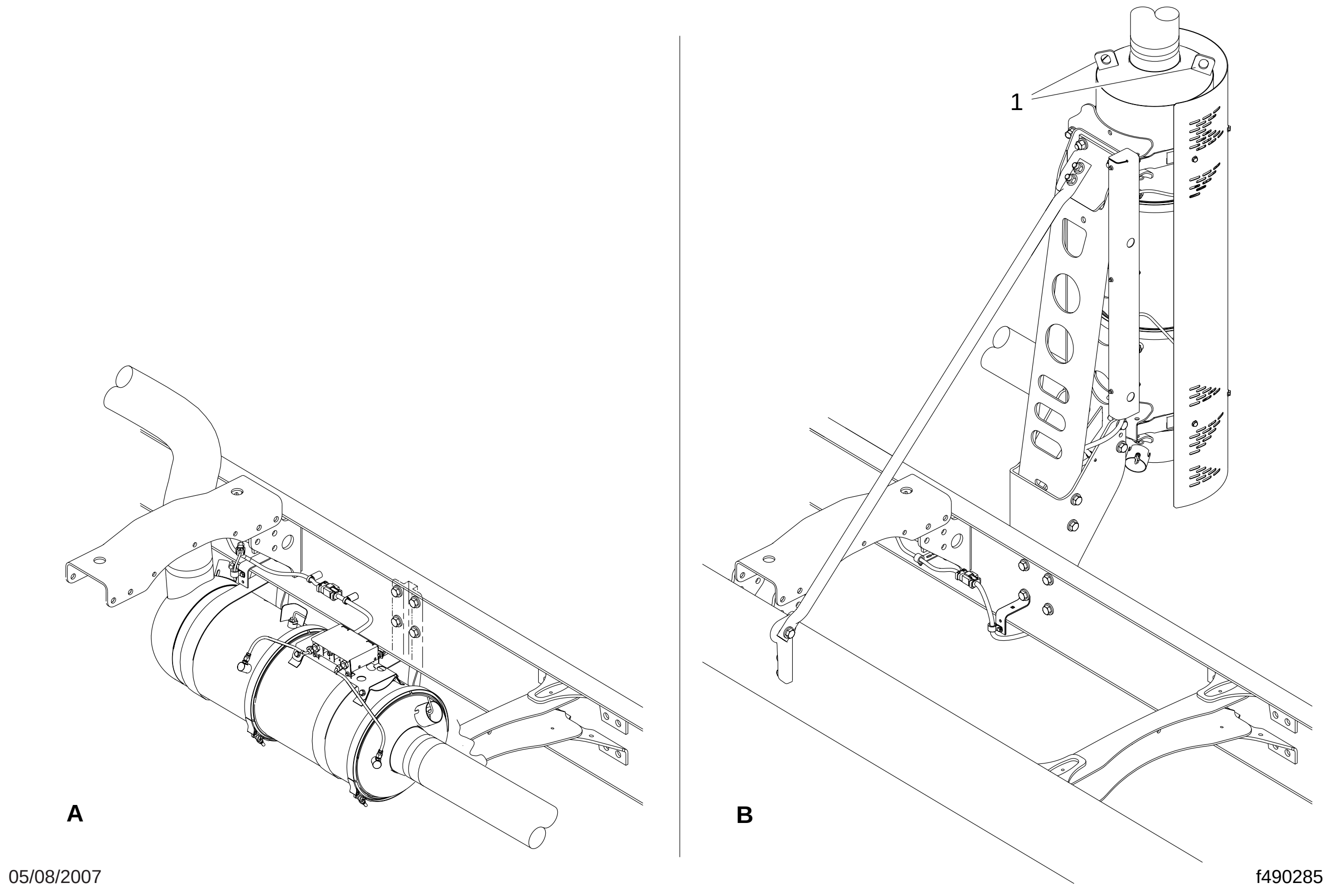
Fig. 1, Typical ATD

NOTE: ATD component service procedures, such as cleaning the DPF or servicing the sensors, are documented in the engine manufacturers' service literature.

Installation

1. Use the ATD handling device to move the ATD into position, so the inlet and exhaust align with the inlet and exhaust piping. Be sure the ATD positioning pin engages its hole in the ATD mounting bracket, or that the positioning marks align.
2. Install the ATD mounting bands, but do not tighten them yet.
3. Position the V-band clamps on the Marmon fittings and tighten them to the value shown in **Table 1**.
4. Tighten the ATD mounting bands to the value shown in **Table 1**.
5. Connect the harness to the sensor housing and the front temperature sensor.
6. Remove the ATD handling device.
7. If a support was fastened around the exhaust pipe, remove it.
8. Operate the vehicle and check for leaks.

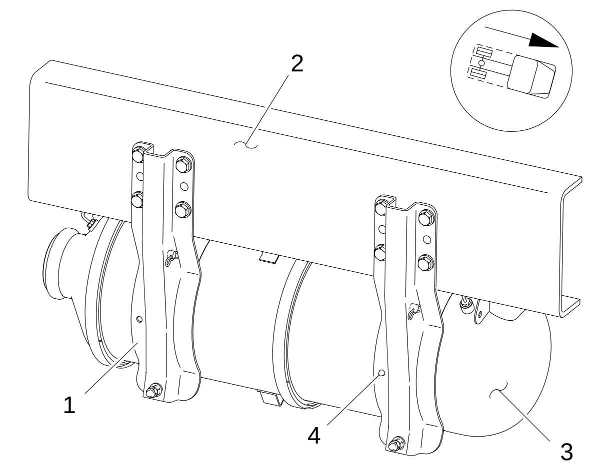
EPA07 Aftertreatment Device Removal and Installation



A. Typical Horizontal ATD Layout
B. Typical Vertical ATD Layout
1. Vertical ATD Lifting Ears

Fig. 2, ATD Mounting Options

EPA07 Aftertreatment Device Removal and Installation

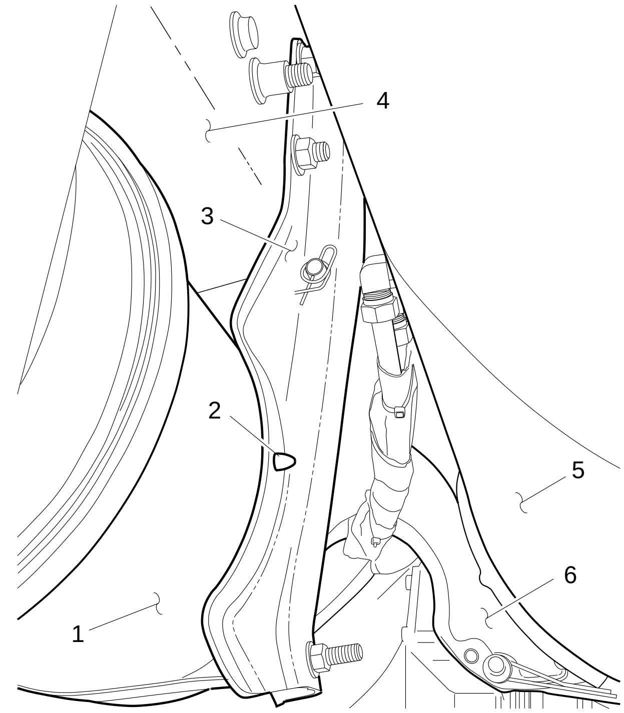


1. ATD Mounting Bracket
2. Chassis Frame Rail
3. ATD Inlet End
4. ATD Positioning Pin

Fig. 3, ATD Mounting on Frame Rail

ATD Torque Values	
Fitting	**Torque: lbf·ft (N·m)**
Mounting Bands	Initial: 15 (20) Final: 30 (41)
Temperature Sensor Nuts	26–29 (35–39)
Pressure Line Tube Nuts	11–13 (15–17)
Pressure Sensor Jam Nuts	15–18 (20–25)
Marmon V-Band Clamps	12–13 (16–17)
Compression Fittings	15–18 (20–25)
Bellows Torco Clamps	Target: 41 (56) Range: 35–48 (48–64)

Table 1, ATD Torque Values



1. ATD
2. ATD Positioning Pin
3. ATD Mounting Bracket
4. Chassis Frame Rail
5. Fuel Tank
6. Fuel Tank Mounting Bracket

Fig. 4, ATD Mounting Bracket

EPA07 Aftertreatment System Bellows Replacement

Replacement

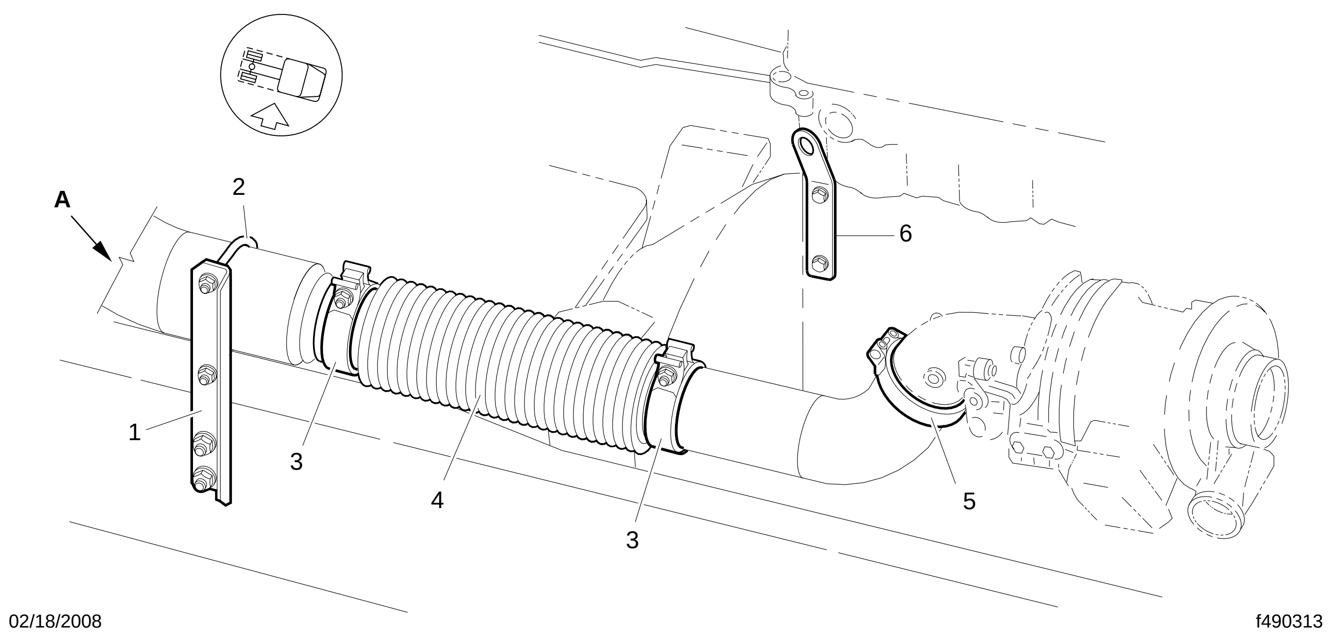
1. Open the hood.
2. Open the tool box under the passenger-side door, and remove the cover.
3. Remove the right quarter fender and mud flap. For instructions, see **Group 88.**
4. Remove the V-clamp (**Fig. 1**, Item 5) that holds the turbo outlet pipe to the turbocharger.
5. Remove the U-clamp that holds the aftertreatment device (ATD) inlet pipe to the support bracket on the frame rail (**Fig. 1**, Item 2).
6. Remove the clamp that holds the exhaust pipe to the front of the ATD, then disconnect the exhaust pipe from the ATD.
7. Remove the bellows and exhaust pipes as a unit from under the vehicle. If the vehicle is equipped with side fairings, remove the parts from the rear of the vehicle.
8. Place the assembly on a work bench. Loosen and spread the seal clamps on the ends of the bellows. Pry the ends of the bellows off the exhaust pipes, being careful not to damage the exhaust pipe ends. If it is not possible to remove the bellows this way, proceed as follows:

WARNING

Always wear a face shield and other appropriate protection when using a cutting wheel.

The cut edges of the bellows are extremely sharp, and can cause serious injury. Wear appropriate protective gear, including heavy gloves and a face shield, when removing the bellows from the exhaust pipes.

9. If you cannot remove the bellows by prying, use a cutoff wheel to cut through each end of the bellows between the exhaust pipe ends. Be careful not to cut the exhaust pipes. Discard the center section of the bellows when it is cut loose.



A. To the Aftertreatment Device (ATD)

1. Frame-rail Support Bracket
2. U-Clamp
3. Seal Clamp
4. Bellows
5. V-Clamp
6. Bellows Support Bracket

Fig. 1, Bellows Installation

EPA07 Aftertreatment System Bellows Replacement

10. Carefully remove the bellows ends and clamps from the exhaust pipes, either by prying them off, or by driving them off with a soft drift. Be careful not to damage the exhaust pipes.

IMPORTANT: Take the following measurements *before* installing the bellows.

The main section of the ATD inlet pipe is a larger diameter than the turbo outlet pipe. Make sure you measure at the **end** of the pipe, where it inserts into the bellows. The two measurements should be identical. If they are not, loosen the U-clamp nuts that hold the ATD inlet pipe to the frame-rail support bracket, and move the pipe up or down as needed.

The ends of the ATD inlet pipe and the turbo outlet pipe must be in exact vertical and horizontal alignment before installing the new bellows. If they are not aligned the bellows will be twisted, and will fail after a short time.

11. Attach the turbo outlet pipe to the turbocharger, then to the bellows support bracket. Tighten the clamps enough to hold the pipe in place.
12. Attach the ATD inlet pipe to the ATD and the frame-rail support bracket. Tighten the clamps enough to hold the pipes in place.
13. Using a ruler or tape measure, measure the vertical distance between the end of the ATD inlet pipe and the frame rail. See **Fig. 2**. Do the same for the end of the turbo outlet pipe. The two measurements must be the same. If the measurements are different, loosen the U-clamp nuts on the frame-rail support bracket, and raise or lower the ATD inlet pipe as needed. Tighten the U-clamp nuts enough to hold the pipe in place.
14. Using a ruler (or a T-square) and a tape measure, measure the distance between each pipe end and the frame rail. See **Fig. 3**. If these two measurements are different, do one or more of the following adjustments (see **Fig. 4**):
    - Check that the U-clamp on the bellows support bracket is installed correctly, and is not crooked.
    - Rotate the turbo outlet pipe at the turbocharger.
    - Support the ATD with a suitable jack, then loosen the ATD straps and rotate the ATD.
    - Rotate the ATD inlet pipe at the Marmon flange on the ATD.
15. With the two pipe ends in horizontal and vertical alignment and the bellows not installed, measure the distance between them. See **Fig. 5**.

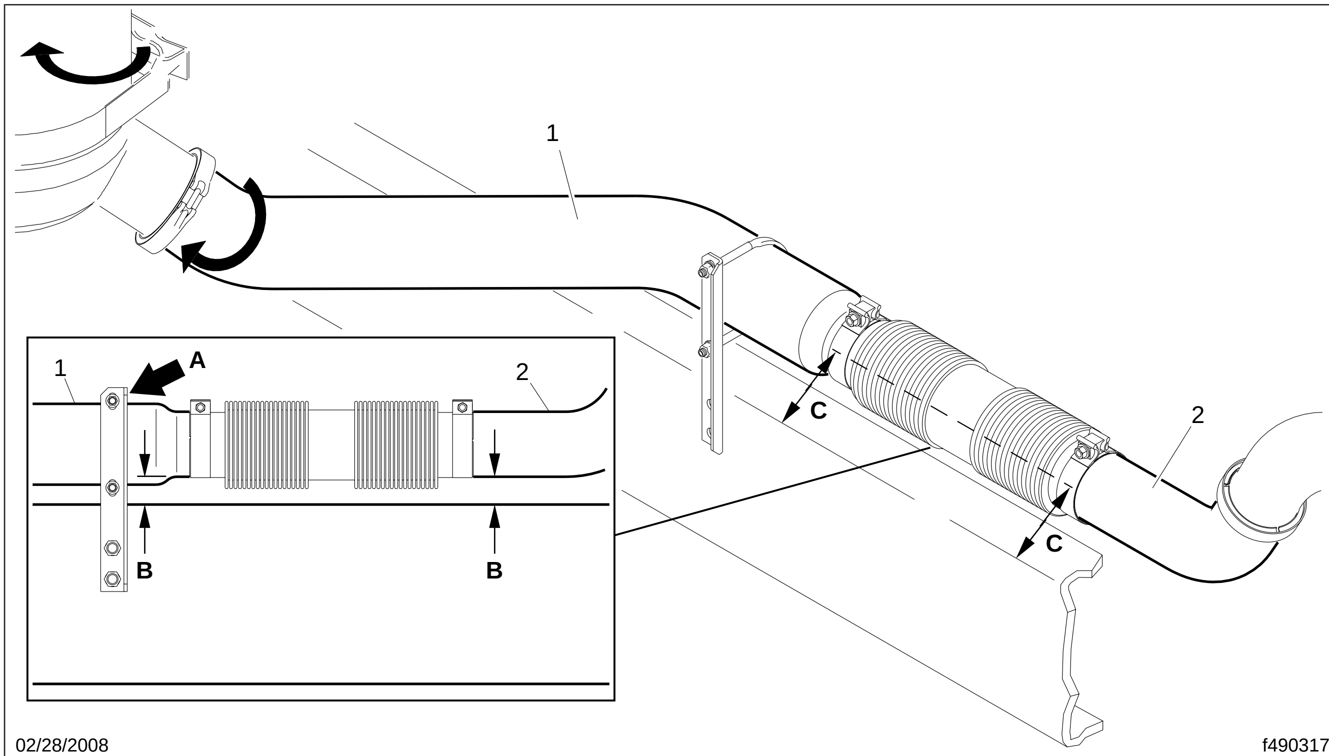
    The distance between the pipe ends is to be at least 14 inches (35.5 cm), but not more than 14-3/8 inches (36.5 cm).

    If the distance is less than the above, remove the turbo outlet pipe and the ATD inlet pipe, and cut off an equal amount from each pipe end, as needed; otherwise, go to the next step. Make sure you remove all burrs from the cut ends of the pipes.

IMPORTANT: If they were loosened, do not tighten the ATD mounting straps until the U-clamp nuts on the frame-rail support bracket are tightened to their final torque. To do otherwise will affect the alignment of the exhaust pipes.

16. When the horizontal and vertical alignment is the same for both exhaust pipes and the distances between the pipe ends is correct, tighten the U-clamp nuts on the frame-rail support bracket that holds the ATD inlet pipe in place. See **Subject 100** for torque values.
17. Tighten the V-clamp that holds the inlet pipe to the ATD. See **Subject 100** for torque values.
18. If applicable, tighten the mounting straps on the ATD, then remove the jack.
19. Remove the turbo outlet pipe from the turbocharger.
20. Remove any dirt or soot from the outer surface of the exhaust pipe ends to ease the installation of the new bellows.
21. Install the new bellows on the ATD inlet pipe, with the clamp nuts on top and facing outboard (**Fig. 2**).
22. Insert the end of the turbo outlet pipe into the bellows, then connect the pipe to the turbocharger and to the new bellows support bracket. See **Subject 100** for torque values.
23. Tighten the bellows seal clamps; see **Subject 100** for torque values.
24. Start the engine and check for leaks. Shut down the engine, and tighten any clamps as needed.

EPA07 Aftertreatment System Bellows Replacement



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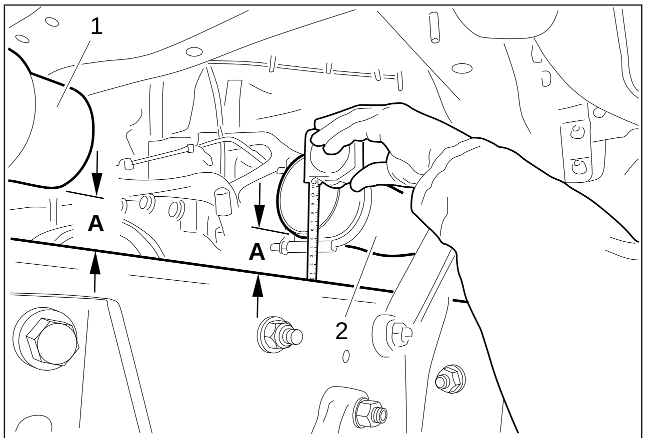
A. Up-and-down adjustment to be done at this bracket.
B. Vertical measurements to be the same.
C. Horizontal (in-and-out) measurements to be the same.

1. ATD Inlet Pipe
2. Turbo Outlet Pipe (support bracket not shown)

Fig. 2, Rotation and Adjustment Areas for Exhaust Pipe alignment (vertical ATD installation shown)

EPA07 Aftertreatment System Bellows Replacement



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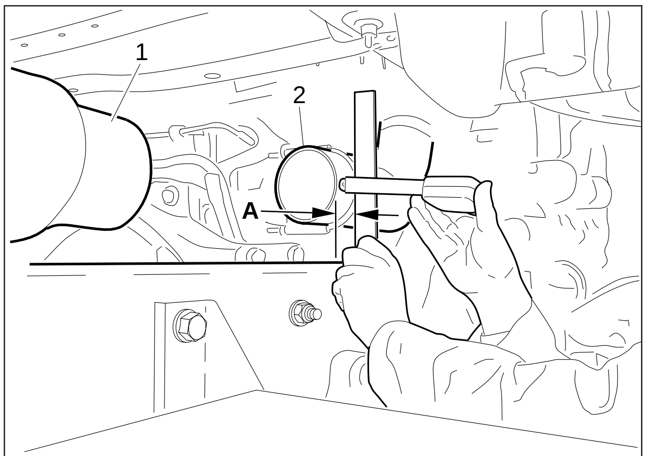
A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe
2. Turbo Outlet Pipe

Fig. 3, Measuring the Vertical Distance

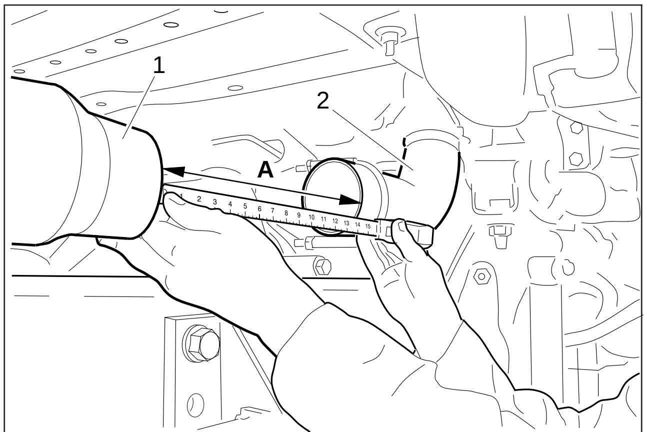


02/13/2008 f490316

A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe
2. Turbo Outlet Pipe

Fig. 4, Measuring the Horizontal Distance



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A. This distance should be a minimum of 14 inches (35.5 cm) and a maximum of 14-3/8 inches (36.5 cm).

1. ATD Inlet Pipe
2. Turbo Outlet Pipe

Fig. 5, Measuring the Distance Between Pipe Ends

General Information

The on-highway environment places severe demands on a vehicles electrical system. The following material describes the methods for repairing and sealing electrical connections that will provide the durability necessary for the automotive environment.

There are four distinct components for making a wire repair that will withstand:

- the mechanical demands of vibration, strain, and thermal cycling
- the electrical requirement of oxidation free conductivity
- the insulating properties to resist shorting to adjacent objects
- the ability to seal for corrosion protection

When troubleshooting electrical systems, consider body height and suspension travel. Interference and strain may be caused by normal frame flexing and body accessories that are not apparent when a vehicle is stationary.

Wire Repair and Splicing

Disconnect the batteries at the negative terminals before performing any repairs to the electrical system.

IMPORTANT: Before repairing or replacing any damaged electrical system components, locate and correct the cause of the damage before continuing with the repair.

Wire that is discolored or melted due to an external heat source may need to be re-routed or installation of a heat shield may be necessary. If wire length permits, a splice may be made with a single connector. Often a length of wire will need to be added and two splices are made. Carefully check damaged wire for signs of corrosion that has wicked up into the insulation and through the wire. If the wire conductor has become green or black, cut off the discolored wire and replace it with a new section.

Corrosion on battery cable terminals may be cleaned with a mild solution of baking soda and water, and scrubbed with a wire brush.

Wiring Repair Using Phillips STA-DRY® Solderless Connectors

Parts and Tools

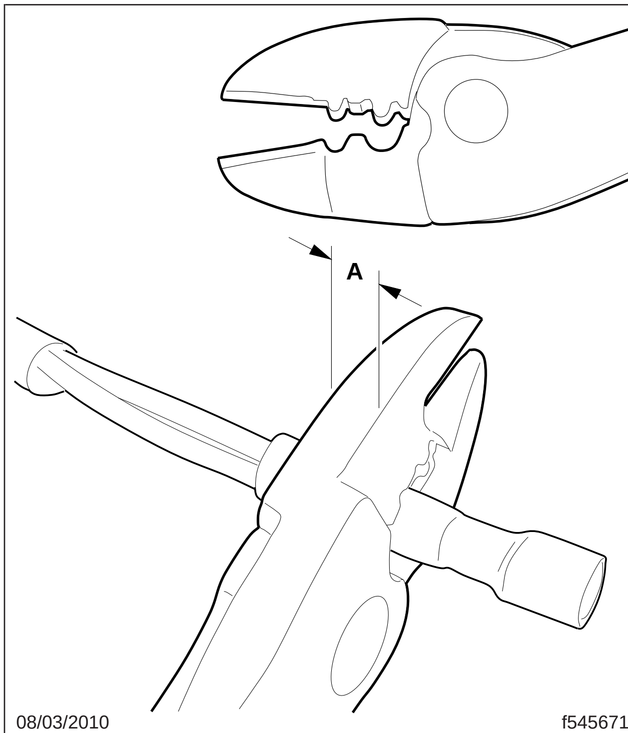
Parts are available through the Parts Distribution Centers (PDCs) in packages of 25 connectors. Use the connectors and adhesive lined shrinkable tubing shown in **Table 1** when making a wiring splice.

Tools needed for wiring repair using solderless connectors include the following.

- A dimple-type crimp tool with a minimum 3/16 inch width. See **Fig. 1** for an example of a proper crimp tool. A typical manufacturer for this tool is Thomas & Betts.
- A heat gun rated at 1000°F (538°C).

Procedure

1. Dress the wires to be spliced by stripping the insulation to expose 1/4 inch of copper. Slide a 3-inch section of adhesive coated shrink tubing onto one of the wires.
2. Crimp the splice connector onto the wires. Use the type of crimp tool that makes a dimple in the connector. The dimple must be at least 3/16 inch wide or there will be too much space inside the connector and the solder will not flow into the wire. This crimp provides the mechanical retention needed. See **Fig. 2**.
3. Pull test the wires by hand to ensure the crimp is mechanically solid.
4. A crimp tool that is too narrow will leave excessive air gaps in the crimp. The connection will not have the required amount of mechanical strength and the solder will not bond the wire to the connector. **Figure 3** shows an example of a bad crimp when the wrong tool is used.
5. Heat the properly crimped splice connector with the heat gun while slowly rotating the wire. The solder will take longer to flow than it will for the shrinkable insulation to contract. Heat until the solder band has completely melted into the connector. If the shrinkable insulation ruptures and a small amount of solder bubbles out, gently shake the splice to remove the solder. See **Fig. 4**.



A. Minimum 3/16 inch width.

Fig. 1, Dimple-Type Crimp Tool

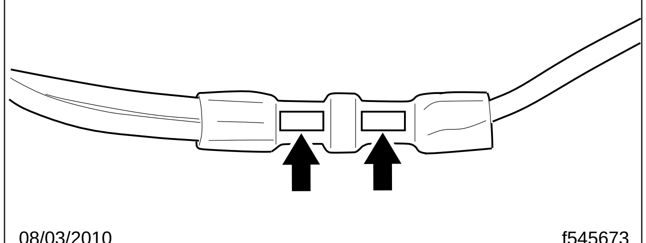


Fig. 2, Properly Crimped Splice

6. When the connector has cooled, center the shrinkable tubing over the splice and heat the tubing until it has completely sealed the splice and a small fillet of adhesive is visible at the ends of the shrink tube. See **Fig. 4**.

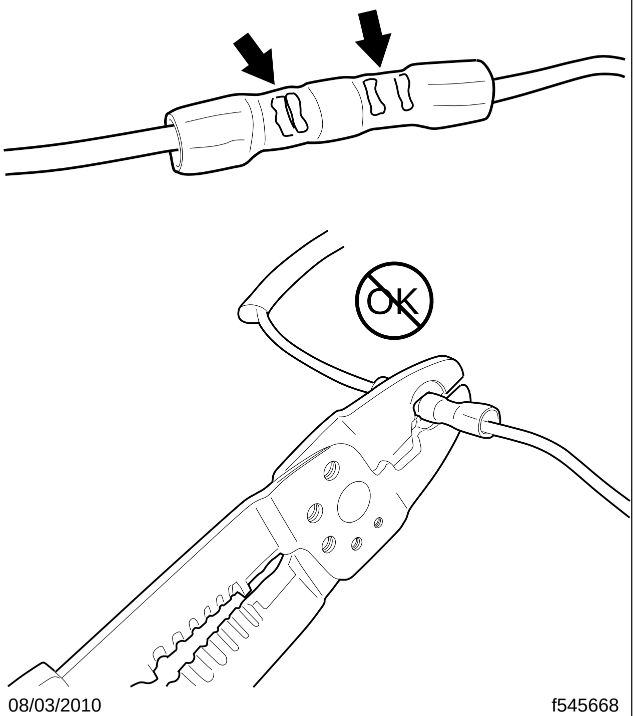
Wiring Repair Using Phillips STA-DRY® Solderless Connectors

Solderless Connector Parts		
Wire Size: gauge (mm)	Connector Part Number*	Shrinkable Tubing (Daimler Part Number)
20 to 18 (0.5 to 0.8)	PHM 1 1863	1/4 inch with internal adhesive coating (48-02461-025)
16 10 14 (1 to 2)	PHM 1 1862	1/4 inch with internal adhesive coating (48-02461-025)
12 to 10 (3 to 5)	PHM 1 1861	3/8 inch with internal adhesive coating–4 foot length (48-02461-038)
8 or larger (5 or larger)	Replace the terminal or the entire cable	Use adhesive lined red for positive cables and black for negative cables.

* Twenty-five connectors per pack.

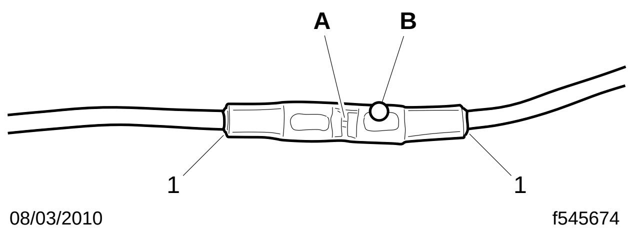
Table 1, Solderless Connector Parts

7. A three-wire tap splice can be made following the same procedure. Use a connector that is large enough to fit all the strands of the wires. See **Fig. 5** for an example of the completed splice.



NOTE: Even with two crimps, there is too much air gap; the solder will not bond.

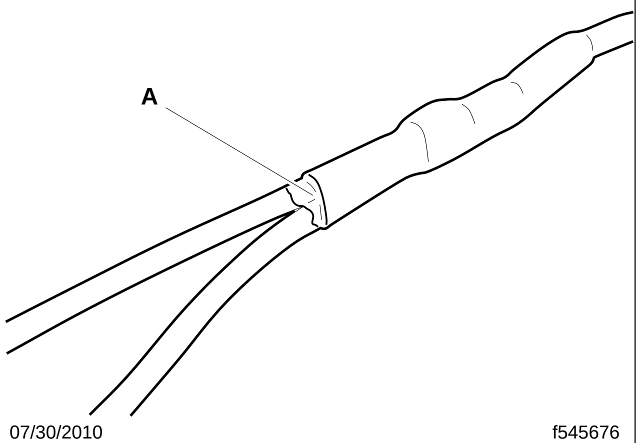
Fig. 3, Wrong Tool Being Used and a Crimp That Will Fail



A. The solder band is completely melted.
B. Insulation rupture; gently shake off the solder bead.

1. Adhesive Fillet

Fig. 4, Solder Bead Rupture



A. The fillet of adhesive at the ends of the shrink tube indicate a complete seal.

Fig. 5, Completed Three-Wire Tap Splice

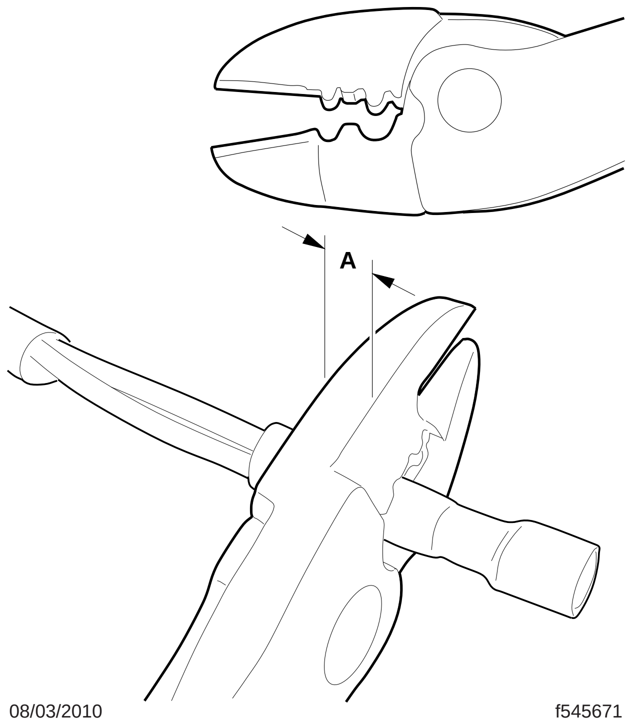
Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404

Parts and Tools

Parts are available through the Parts Distribution Centers (PDCs) in kits with material for 50 splices. This kit may be used on 16 to 14 gauge (1 to 2 mm) wire.

Tools needed for wiring repair using solderless connectors include the following.

- A dimple-type crimp tool with a minimum 3/16 inch width. See **Fig. 1** for an example of a proper crimp tool. A typical manufacturer for this tool is Thomas & Betts.
- A heat gun rated at 250°F (121°C).



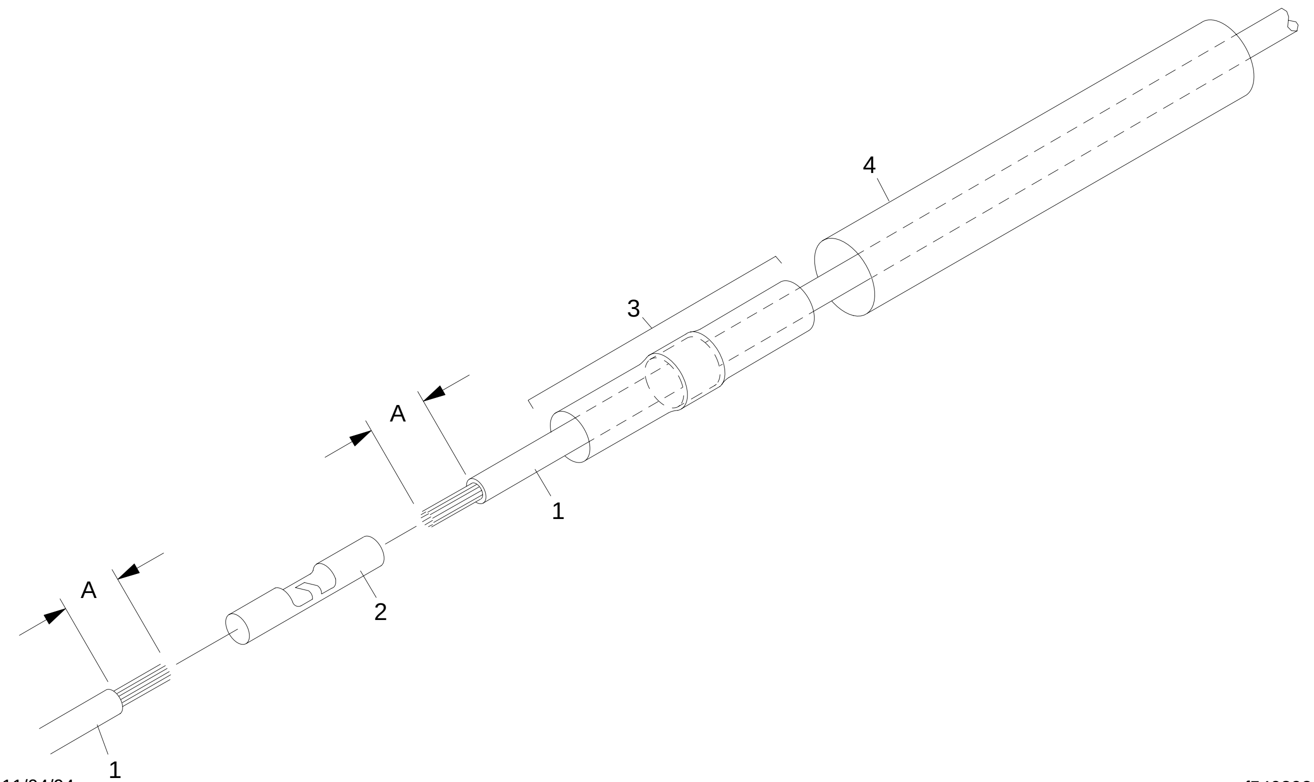
A. Minimum 3/16 inch width.

Fig. 1, Dimple-Type Crimp Tool

Procedure

1. Dress the wires to be spliced by stripping the insulation to expose 1/4 inch of copper. Slide a piece of the shrink tubing from the kit onto one of the wires.
2. Slide a shrinkable solder sleeve from the kit onto one of the wires.
3. Place the wires that will be spliced into each end of the barrel connector. See **Fig. 2** for an example of the splice.
4. Crimp each end of the barrel using a dimple-type crimp tool to secure the wires. See **Fig. 1** for an example of a proper crimp tool.
5. Pull test the wires by hand to ensure the crimp is mechanically solid.
6. Slide the shrinkable solder sleeve onto the barrel connector so the solder band is at the center of the barrel connector.
7. Heat the splice using a heat gun rated at 250°F (121°C) until the sleeve has completely shrunk against the wire and the solder flows into the barrel connector. A small fillet of adhesive may be visible at the ends of the connector. See **Fig. 3**.
8. Slide the shrinkable tubing over the splice and apply heat with a heat gun rated at 250°F (121°C) until it has completely shrunk against the wire insulation. A small fillet of adhesive should be visible at the ends of the shrinkable tubing.

Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404



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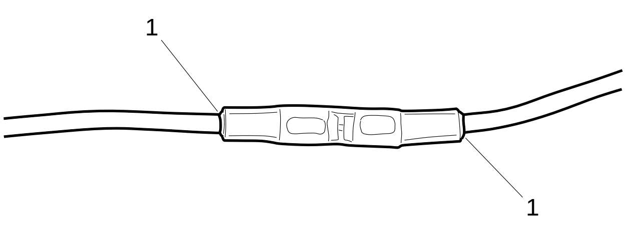
A. 1/4 inch (6.4 mm)

1. Wire End
2. Barrel Connector
3. Solder Sleeve
4. Shrink Tube

Fig. 2, Splice Prepared with Parts in Kit ESY ES66 404



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1. Adhesive Fillet

Fig. 3, Heated Solder Sleeve with Solder Band Melted into the Splice

Parts

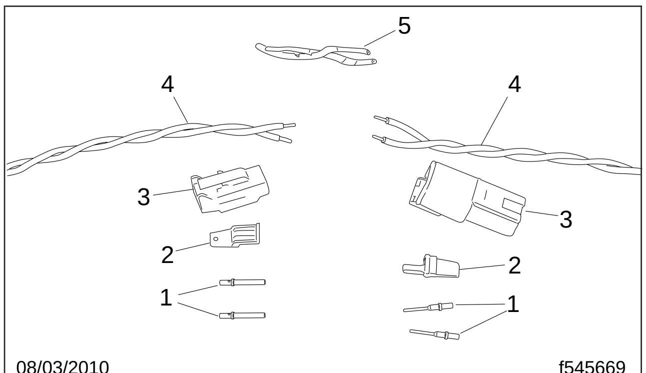
Twisted-pair datalink wires may be spliced using a mating connector set. See **Table 1** for a typical set of datalink connector parts.

Datalink Connector Parts		
Description	**Part Number**	**Quantity**
Connector Body Plug	23-13148-204	1
Terminal Lock	23-13303-015	1
Terminals	23-13210-020	2
Connector Body Receptacle	23-13148-206	1
Terminal Lock	23-13303-013	1
Terminals	23-13210-030	2

Table 1, Datalink Connector Parts

Procedure

1. Cut out any damaged section of datalink wire, keeping the lengths of the two wires equal. See **Fig. 1** for an example of a damaged section of datalink wire that has been removed and the datalink prepared for repair.



1. Terminals
2. Terminal Lock
3. Connector
4. Twisted-Pair Datalink Wires
5. Damaged Section of Datalink Wires

Fig. 1, Datalink Splice Parts

2. Crimp the terminals onto the wires using the proper crimp tool.
3. Pull test the terminals by hand to ensure the crimp is mechanically solid.
4. Insert the terminated wires into the connector body and install the terminal lock. The protocol for J1939 is for the yellow wire to be in cavity 1 and the green wire to be in cavity 2. Note that the lock is installed while holding the wires in position. Test the installation. If the wires slipped back during the lock installation, they will pull out of the connector.
5. Make certain the wires are twisted as close to the entry point of the connector as possible. Plug the two connector halves together. See **Fig. 2**.

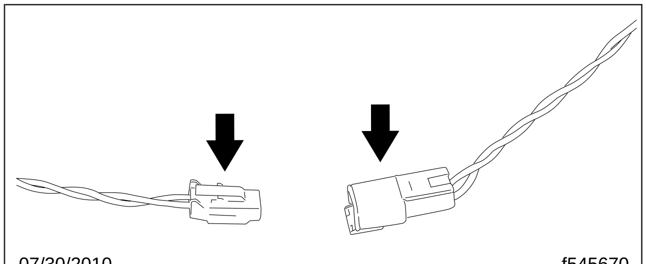


Fig. 2, Datalink Connectors

Connection Protection

Use the dielectric protectants and procedures provided here to protect electrical connections from corrosion. A list of approved dielectric protectants is shown in **Table 1**.

The components listed in **Table 2** have electrical connections that need to be protected.

When disconnecting any of these circuits, clean the connection and remove the old dielectric material. Completely cover the exposed area after assembly using the product and procedure in this bulletin. Always follow the product manufacturers recommendations for work area ventilation.

Approved Dielectric Protectants			
Material	**Type**	**Manufacturer**	**Product**
Dielectric Red Enamel	Spray On	3M®	1602 IVI
		Glyptal	1201A
	Brush On	Glyptal	1201E 2100
Dielectric Grease	Lithium Base	Fiske Brothers Lubriplate® (FLP)	DS-ES
	Synthetic	Nye	Nyogel 760G

Table 1, Approved Dielectric Protectants

Electrical Component Protection and Procedure		
Protection	**Component**	**Procedure**
Dielectric Red Enamel	Starter - All Exposed Connections	Protect connections and cable terminals.
	Magnetic Switch	Protect connections and cable terminals.
	Alternator	Protect all connections. Do not allow dielectric material to enter the alternator.
	Bolt and Stud Ground Connections (outside cab)	Cover all terminals, studs, and nuts with dielectric enamel.
	Battery Cut-Off Switch Connections	Protect connections and cable terminals.
	Exposed Battery Cable Connections (located outside of the battery box)	Protect connections and cable terminals.
	Power Distribution Modules	Protect battery power studs on chassis mounted PDMs.
	Mega Fuses (when located outside of the battery box)	Place tape across the part of the fuse with the labeling, then apply the dielectric material. Remove the tape.

Electrical Connection Protection

Electrical Component Protection and Procedure		
Protection	**Component**	**Procedure**
Dielectric Grease, Lithium Base	Tail Lamp Bulb Sockets (non LED)	Remove the bulb, apply grease to the inside of socket. Replace the bulb.
	Battery Terminals	Apply grease to battery terminals before connecting interconnect cables.
	Battery Interconnect Cable Connections	Apply grease to connection studs and pads before connecting battery cables.
	Parked HVAC Power Connections	Disconnect the two power and one ground cable where they enter the basket on the underside of the cab. Apply grease, then connect.
	Inverter Power Connections	Disconnect the power and ground feeds at the cab pass through. Apply grease, then connect.
	Mega Fuses (if located in the battery box)	Apply grease to protect exposed terminals and connections.
Dielectric Grease, Synthetic	Connections with serial data circuits or with very low voltage signals.	Apply synthetic grease to the terminals inside the connector.

Table 2, Electrical Component Protection and Procedure

General Specifications

See Table 1 for standard wiring color-coding.

See Table 2 for standard wiring circuit numbers and descriptions.

Standard Wiring Color-Coding		
Color	Abbr	Typical Usage
Black	BK	Ground, General
Black-White	BK-W	Ground, Clean or Isolated
Blue DK	DKBL	Backup/Windshield Wiper/Trailer Auxiliary
Blue LT	LTBL	HVAC/Circulation Fans/1922+
Blue LT-White	LTBL-W	Water, Oil Gauge and Indicator (Engine and Transmission)
Brown	BR	Marker, Tail and Panel Lamps
Gray	GY	Electronic Engine (or TXL Insulation)
Green DK	DKG	Turn Signal, RH/Driver’s Display/Data Record/1587+/1939–
Green DK-White	DKG-W	Starting Aids/Fuel Heaters/Material Control/Winch/Tailgate
Green LT	LTG	Headlamp/Roadlamp/DRL
Green LT-White	LTG-W	Axle Controls and Indicators/Suspension/Fifth Wheel
Orange	O	ABS/EBS/1587–
Pink	PK	Start Control/Ignition/Charging/Volt and Ammeter/1922–
Pink-White	PK-W	Fuel Control and Indicators/Shutdown/Speed Limiter
Purple	PRP	Engine Fan/PTO/Auto Lube and Oil
Purple-White	PRP-W	Utility/Spot/Ad/Interior/Emergency Lighting
Red	R	Power Distribution, Constant
Red-White	R-W	Brake/Pneumatic/Hydraulic/Retarder/Stop
Tan	T	MPH, RPM Signals/Horn/Flasher/Pyro/Turbo
Tan-White	T-W	Audio/Video/Security/Window/Computer/Seat/Mirror/Cab-Tilt
White	W	Transmission (or SXL Insulation)
Yellow	Y	Turn Signal, LH/1939+ (or GXL Insulation)
Yellow-White	Y-W	Air Bag and SPACE

Table 1, Standard Wiring Color-Coding

Circuit Numbers		
Circuit Number	Description	Modules
1	Battery Cable, Ground	156 286 291
6	Battery Cable, Positive	224 281 291 292 293 295
14	Cab Power, Main	156 224 277 281 285 286 291 292 293 295 306 320 321
15	Starter, Crank Circuit	146 155 156 157 158 286 291 320 895
16	Alternator, Main Power	124 125 286 320 836 846

Specifications

Circuit Numbers		
Circuit Number	**Description**	**Modules**
18	Air Pressure Warning	320 486 838 840 877 880 882
19	Voltmeter	286 320 836 846
20	Headlamp, Left	27D 288 304 312 320 659
21	Headlamp, Right	27D 288 304 312 320 659
22	Headlamp, Low and High Beam	27D 288 304 312 320 659
23	Tail Lamps	288 294 296 301 302 304 30A 320 335
24	Horn, Electric	288 320 321 726
25	Horn, Air	288 320 321 726
27	Road Lamp	288 313 314 320
28	Fog Lamp	288 313 314 320
29	Instrument Panel Lamps	27D 288 296 302 304 30A 312 320 335 659 732 811 81B
30	Transmission Temperature and Filter	286 320 343 345 34B 34C 353 355 863 864
31	Transmission Aux Controls and Temp	286 320 343 345 34B 34C 353 355 863 864
34	Engine Oil Pressure	165 286 320 852
35	Engine Oil Temperature	286 320 854
36	Stop Lamps	288 294 296 301 320 335 486 838 840 877 880 882
38	Turn Signal	288 294 296 298 299 300 301 320 335 811
39	Stop/Turn Combination Lamp	288 294 296 301 320 335 880
40	Fan, Windshield/Sleeper	287 320 716 718
41	Dome/Interior Lamp	271 287 294 300 302 305 311 312 314 316 318 319 31A 31B 31C 31D 31E 320 322 324 325 327 328 32B 32C 469 470
42	Axle Oil Temperature, Forward	288 320 865 866
43	Axle Oil Temperature, Rear	288 320 865 866
44	Axle Oil Temperature, Center	288 320 865 866
45	Receptacle, Trailer	173 285 296 297 303 306 307 308 309 310 320 321 331 334 335
46	Marker Lamps	288 296 302 304 30A 320 335
47	Fuel Level	288 320 844 847
48	Fuel Control and Level, Natural Gas	148 150 152 162 164 283 286 288 320 811 814 844 847 860
52	Ignition Switch	156 285 306 320 321
55	Data Recorder	283 286 320 343 810 817
57	12V Power Outlet/Lighter	284 287 320 785
58	Heater, Auxiliary	130 287 320 700 703 70A 70C 723
73	Utility Lamps	287 288 318 31J 320 327 329 57W
74	Starter Mag Switch, Solenoid	155 156 157 158 286 320 895

Circuit Numbers		
Circuit Number	Description	Modules
75	Starter Mag Switch, Ground	146 155 156 157 158 286 895
76	Mirror Heat	320 656 744 74E
78	Spot Lamp	316 320 57V
81	Ignition Switch Control Devices	156 285 304 306 320 811 814 860
82	Starter Mag Switch Power	155 156 157 158 286 320 895
86	Axle Lock Solenoid	288 320 452 874 878 87A 87B 87F 896 900
87	Axle Lock	288 320 452 865 866 874 878 87A 87B 87F 896 900
88	Lubrication System, Automatic	288 594
90	Sander, Road	288 320 329
91	Heater, Diesel Fired Auxiliary	130 132 138 140 141 154 166 286 287 288 320 467 700 703 70A 70C 723
94	Air Dryer, Heated	288 480 48A 880
95	Speaker, Radio	287 320 746 74D 750 751 753 75B 75C 79F 79G
97	Air Conditioner	130 287 320 700 703 70A 70B 723
98	Heater – A/C Motor, Blower	130 156 283 285 286 287 320 321 700 703 70A 70B 70C 723
99	Fuel Solenoid, Engine Run	148 150 152 162 164 283 286 320
102	Parking Lamps	288 296 302 304 30A 320 335
108	Door Activated Lamps Courtesy/ Footwell/Door	320 324 325 32B 675 676 677 67E 67F 811 814 860
113	Baggage Compartment Lamps	287 320 322 324 325 32C
117	Speed Sensor +	283 286 320 343 810 817
118	Speed Sensor –	283 286 320 343 810 817
119	Coolant Temperature, Engine	198 199 286 320 732 810 812 830 836 838 83A 840 841 842 843 844 845 846 847 852 854 856 858 862 864 865 866 867 868 869
120	Back-Up Lamps	288 294 320 471 721
121	Brake, Engine	128 129 164 283 286
122	Back-Up Alarm	288 294 320 471 721
123	Alternator, Voltage Regulation/ Rectifier	124 125 156 286 836
125	Park Brake Indicator/Warning	288 294 296 301 320 335 486 838 840 877 880 882
132	Alternator Charge Monitor	124 125 156 286 836
137	Alternator Indicator/Relay	124 125 156 286 836
140	Oil Pressure, Engine	286 320 852
149	Fan Manual Controls, Engine	273 276 286 320
154	Auxiliary Air Pressure	288 320 486 838 840 865 866 877 880 882
155	Axle Lift Controls	288 320 452 874 878 87A 87B 87F 896 900
157	Power Mirror Controls	320 656 744 74E

Specifications

Circuit Numbers		
Circuit Number	Description	Modules
162	Tachometer Sensor +	283 286 320 812 819
163	Tachometer Sensor –	283 286 320 812 819
166	Engine Starting Aid, Ether	132 154 286 320 467
168	Hour Meter, Engine	286 320 812 813 81A 837 852
170	Fifth Wheel Slide Lock and Controls	173 296 297 303 307 308 309 310 331 334 581 87E
171	Brakesaver, Cat	128 129 286 343 34B 34C 34W 353
172	Clock	287 320 687 738
173	Coolant Level, Engine	152 286 320 856
182	Fuel Pressure	320 841 843 845
183	Air Cleaner Restriction, Engine	329 472
193	Cab Tilt Pump	288 320 670
196	Fuel Water Separator Heater	110 127 220 288
200	PTO Controls	148 283 286 288 320 372
203	Exhaust Brake	128 129 164 283 286
204	Seat Belt Indicator/Warning	320 74F 756 760 763
208	Axle Control, Tri Axle, Steer Lock	288 320 376 452 865 866 874 876 878 87A 87B 87C 87F 896 898 900
209	Axle, Two Speed Shift Control	283 286 288 320 343 376 810 817 876 87C 898
210	Power Distribution Module, Outside Cab	224 281 285 286 291 292 293 295 306 320 321
211	Security System, Rockwell	287 320 656 787
214	Generator, Auxiliary	124 125 286 599
218	Pyrometer	286 320 858
219	Turbo Pressure	286 320 842
221	Suspension Dump Controls	288 320 87D 888 910
222	Headlamp Dimmer Controls	27D 288 304 312 320 659
223	Transmission Controls, Auto Shift	160 283 285 286 288 320 330 343 345 34B 34C 355 376 732 736 810 811 813 814 817 876 87C 898
224	Transmission Controls	286 288 320 343 345 34B 34C 353 355 376 876 87C 898
225	Air Pressure Gauge, Primary	320 486 838 840 877 880 882
226	Air Pressure Gauge, Secondary	320 486 838 840 877 880 882
227	Air Pressure Gauge, Application	320 486 838 840 877 880 882
232	Transmission Controls Power Supply	160 283 285 286 320 330 343 345 34B 34C 353 355 732 736 811 813 814
234	Engine Fan Controls	273 276 286 320
236	Transmission Neutral Indicator	286 320 343 345 34B 34C 353 355
242	Seat Controls	320 74F 756 760 763

Circuit Numbers		
Circuit Number	Description	Modules
243	Shore Power, Power Inverter	274 277 284 287 307 320 336 337 33C 785
244	Speed Limiter, Vehicle, Hewitt	150 164 283 286
246	Electric Fuel Pump	148 150 152 162 164 283 286 320
250	Predictive Cruise Control	149 283 286
253	Cab Tilt Indicator	288 320 670
254	Roof Mounted Emergency Lamp/ Strobe	264 271 275 27A 27B 27C 27E 288 31A 31B 31C 31D 31G 320 327 33A
255	Advertising/Identification Lamp	288 296 302 304 30A 319 320 335
256	Optional Power Wire	285 286 306 320 321
261	Axle Lock, Controlled Differential	288 320 865 866
262	Retarder, Allison Transmission	128 129 286 343 34B 34C 34W 353
281	Oil Filter Change Indicator	165 286 320 852
285	Suspension Electric and Air Controls	288 320 87D 888 910
286	Fuel Water Separator Indicator	122 127 288 320 80F 844 845 847
294	Air Tank Auto Drain Valve	288 480 48A 880
295	Radio, AM/FM/CB/Disc	287 320 746 748 74D 750 751 752 753 75B 75C 79F 79G
299	Air Temperature, Exterior	320 860 867
300	Radio, Audio Signal	287 320 746 74D 750 751 753 75B 75C 79F 79G
303	Low Air Pressure	322 486 838 840 877 880 882
315	Windshield Wipers and Controls	320 321 660 66B
320	Windshield Washer	320 321 660 66B
331	Diagnostic Connector Power/Tach Ext Test	160 283 286 320 32A 330 338 343 725 732 733 736 811 812 813 819 835 888
338	HVAC Controls	130 287 320 700 703 70A 70B 70C 723
339	LBCU/ICU/Gauge Power/Data	320 732 811 814 860
347	Shutter, Engine Fan	273 276 286 320
359	Headlamp On Signal, LBCU/ICU	27D 288 304 312 320 659
363	Power Windows	320 654 656 66A
364	Power Windows, Rear	320 654 656 66A
372	Receptacle # 2, Trailer 7-Way, ISO 3731	173 296 297 303 307 308 309 310 331 334 335
376	Antilock Brake Controls	160 283 285 286 296 308 320 330 331 332 333 335 343 34B 414 447 44G 44H 454 490 493 732 736 811 813 814
377	Antilock Brake Sensors	308 330 331 332 333 414 447 44G 44H 454 490 493
378	Antilock Brake Valves	160 283 285 286 308 320 330 331 332 333 343 34B 414 447 44G 44H 454 490 493 732 736 811 813 814

Specifications

Circuit Numbers		
Circuit Number	Description	Modules
379	Daytime Running Lamps (DRL)	271 27D 288 294 300 302 304 305 311 312 314 316 318 319 31A 31B 31C 31D 31E 31F 320 322 324 325 327 328 469 470 659
388	Hydraulic Brake Power/Controls	288 320 486 49A 880
399	Optional Circuit, Cab/Chassis, Customer Specified	160 283 285 286 306 320 321 329 330 343 34B 472 732 736 811 813 814 860
400	Optional Circuit, Cab/Chassis, Customer Specified	329 472
402	Engine Start/Stop System, TAS	152 156 162 283 285 286 287 320 321
406	Emergency Lamp, Alternating, Access	264 271 275 27A 27B 27C 27E 287 288 318 31A 31B 31C 31D 31G 31J 320 327 33A 57W
407	—	—
408	Emergency Vehicle Accessory and Warning Lights	264 271 275 27A 27B 27C 27E 288 31A 31B 31C 31D 31G 320 327 33A
410	Emergency Siren and Bells	288 320 321 726
416	Refrigerator/Video Power	284 287 320 737 75B 785
417	Mobile Phone Power	320 789 79C
424	Headlamp Wiper/Washer	288 304 312 320
425	PNDB/CLDS Controls	224 277 281 285 291 292 293 295 306
427	Satellite Tracking System	287 320 786 78A 79H 80D
428	Battery Isolator Protection System	124 125 156 224 277 281 285 286 291 292 293 295 306 836
430	Windshield Wiper Heater	320 321 660 66B
431	Starting Aid, Engine Preheater	132 154 286 320 467
432	Seat Controls	320 74F 756 760 763
433	Data Recorder	160 286 320 813
434	Suspension Controls, ECAS	283 286 288 320 343 810 817 87D 888 910
435	Seat Belt Indicator/Warning	320 74F 756 760 763
436	Camera, Rear and Side View	160 288 320 736
437	Instrument Control Unit/LBCU	320 486 732 811 814 838 840 860 877 880 882
439	Engine ECU and Controls	106 128 129 148 152 156 162 164 283 286 372
440	Engine ECU and Controls	106 128 129 148 149 152 156 160 162 164 273 276 283 285 286 301 320 330 343 34B 732 736 811 813 814 856 880
441	Engine ECU and Controls	106 148 164 165 283 286 320 852
442	Data Recorder/Data Logger	160 286 320 813
443	Door Locks	320 655 656 787
444	Obstacle Detection System/VORAD	160 288 320 736 73B 73C
445	Body Controls/Dump Lock	288 320 329
446	Tire Pressure Monitor System	288 320 489

Circuit Numbers		
Circuit Number	Description	Modules
447	Battery Cutoff Protection System	130 156 224 277 281 285 287 291 292 293 295 306 320 700 703 70A 70B 723
448	Tail Gate Controls	288 320 329
449	Fueling Data Recording and Transmitter	198 199 283 286 288 320 343 732 810 812 817 830 836 838 83A 840 841 842 843 844 845 846 847 852 854 856 858 862 864 865 866 867 868 869
450	Mirror Dimming Controls	320 656 744 74E
453	Optional Customer Specified Wiring	164 283 285 286 306 320 321 329 343 345 34B 34C 353 355 472
454	Inflatable Restraint and Seat Pretension	160 283 285 286 320 330 343 34B 725 732 736 811 813 814
455	Instrument Left/Right Side Selection	320
457	Dash Controls, Datalink, (BPU)	164 283 286
458	Step Deployment Unit, Passenger Side	320 675 676 677 67E 67F
459	Steering Pump Controls	539
460	Transmission-Automatic, Controls	286 320 343 345 34B 34C 353 355
461	Transmission-Automatic, Controls	286 320 343 345 34B 34C 353 355
462	Headlamps, Auxiliary	27D 288 304 312 313 314 320 659
463	Headlamps, Auxiliary Right	27D 288 304 312 313 314 320 659
464	Transmission, Smart Shift Control	286 320 343 345 34B 34C 353 355
465	Headlamp, Flashing Control	27D 288 304 312 320 659
466	Land Departure System	160 288 320 736
467	Engine Coolant Flow Systems	152 286 320 856
468	Obstacle Detection System/VORAD	160 288 320 736 73B 73C
469	Level Control, Body/Chassis	288 320 329
470	Datalink Transmit	287 320 786 78A 79H 80D
471	Datalink Receive	287 320 786 78A 79H 80D
472	Engine ECU and Controls	106 128 129 148 152 156 162 164 283 286 320 343 34B 34C 34W 353 856
473	Multifunction Stalk Switch	329 472
474	Smart Switch, Resistance Identified, MUX	329 472
475	Engine Idler Controls	152 156 162 283 286
476	Adjustable Pedal Controls	288 320 486 49A 880
477	Hazard Lights, USPS	320 327 329
478	E-Stroke Brake Monitoring System	320 486 838 840 877 880 882

Specifications

Circuit Numbers		
Circuit Number	Description	Modules
479	CB Radio Antenna Coaxial	320 748 751 752
480	Switched Auxiliary Air Pressure	288 320 486 49A 880
481	Chassis Expansion Module	160 283 285 286 320 329 330 343 34B 472 732 736 811 813 814
482	Firetruck Pump Controls	148 283 286 372
483	Engine ECU and Controls	106 148 152 156 160 162 164 283 285 286 320 330 343 34B 372 732 736 811 812 813 814 819
484	Tire Chains	288 320 452 874 878 87A 87B 87F 896 900
485	Public Address System	287 320 746 74D 750 751 753 75B 75C 79F 79G
486	Vehicle Information Center	283 286 288 320 732 74F 756 760 763 811 812 814 819 860 867 877 882
487	Engine Emissions Detection and Monitor	148 150 152 162 164 283 286 320 811 814 860
488	Brake Wear Indicator	320 486 838 840 877 880 882
490	Bus Door and Window Sensing and Warning	287 288 294 300 320 327 329 654 655 656 66A 675 676 677 67E 67F 700 703 723 787 811 814 860
491	Engine Compartment Lights/Buzzer	287 320 327 329 656 787 811 814 860
492	Engine ECU and Controls	148 150 152 162 164 283 286 320 372
493	All Wheel Drive Controls	288 320 452 874 878 87A 87B 87F 896 900
494	Transmission Shift Controls	286 320 343 345 34B 34C 353 355
495	Emergency Medical Service Accessories	264 271 275 27A 27B 27C 27E 288 31A 31B 31C 31D 31G 320 327 33A
496	Steering Wheel Controls	329 472
497	Transmission Controls	286 320 343 345 34B 34C 353 355
498	Transmission Controls	286 320 343 345 34B 34C 353 355
499	Engine ECU and Controls	164 283 286
504	Dome/Interior Lamp	287 320 322 324 325 32C
506	Aerial Equipment Systems	264 271 275 27A 27B 27C 27E 288 31A 31B 31C 31D 31G 320 327 33A
507	MUX Control, MSF/CGW	287 320 786 78A 79H 80D
508	CAN Datalink	287 320 786 78A 79H 80D
509	Firetruck Pump And Hose Controls	264 271 275 27A 27B 27C 27E 288 31A 31B 31C 31D 31G 320 327 33A
510	Firetruck Pump And Hose Controls	265 271 275 27A 27B 27C 27E 288 31A 31B 31C 31D 31G 320 327 33A
511	Bus Door and Window Sensing and Warning	146 155 156 157 158 286 895
512	Emergency Vehicle Auxilixry Switches	—
513	Emergency Vehicle Door Switches	—

Circuit Numbers		
Circuit Number	Description	Modules
514	Emergency Vehicle Lights and Alarm	288 294 320 471 721
515	Emergency Vehicle Tank Level Systems	—
518	Emergency Vehicle Ladder and Rack Systems	—
519	Emergency Vehicle Body Lighting	—
520	Emergency Vehicle Body Lighting	—
521	Emergency Vehicle Body Lighting	—
522	Emergency Vehicle Body Lighting	—
523	Emergency Vehicle Body Lighting	—
524	Emergency Vehicle Power Source	—
525	Emergency Vehicle Warning Lights	—
526	Emergency Vehicle Body Lighting	—
527	Firetruck Pump And Hose Controls	—
528	Emergency Vehicle AC Power System	—
529	Windshield Defroster Grid	287 320 716 718
532	Aftertreatment Systems, Exhaust	160 164 283 285 286 320 330 343 34B 732 736 811 813 814
533	Engine ECU and Controls, Alternative Fuel	106 148 152 164 283 286 320 856
1587	J1587/J1708 Datalink	160 283 286 320 32A 330 338 343 725 732 733 736 811 812 813 819 835 888
1922	J1922 Datalink	160 283 286 330 343
1939	J1939 CAN Datalink	160 283 286 320 330 343 725 732 736 811 813 888

Table 2, Circuit Numbers

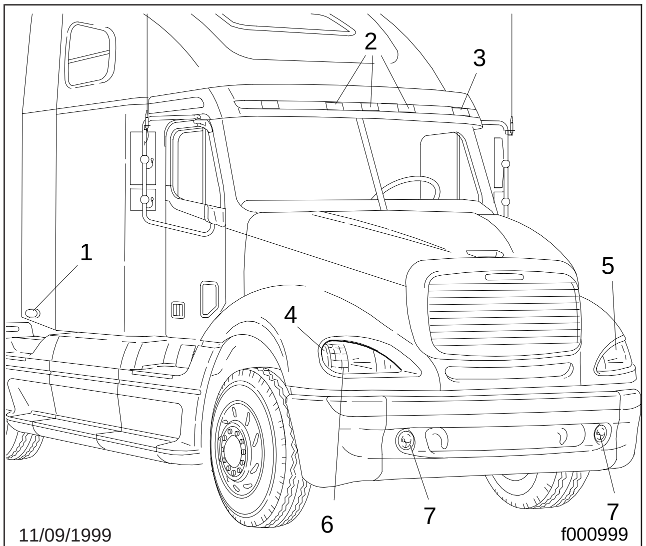
General Information

The exterior lighting system includes the following lighting circuit functions:

- Headlights
- Turn Signals (front, side, side fairing, and rear; can also be activated as 4-way flashers)
- Identification Lights
- Road Lights
- Marker Lights (front, side, and side fairing clearance)
- Taillights and Stoplights
- Back-Up Lights
- Daytime Running Lights (optional)

Each of these lighting functions illuminates one or more bulbs on the vehicle. For example, the parking light circuit illuminates the front turn signal, side marker, and taillight bulbs.

In the front of the vehicle there are headlights, front turn signals, road lights, and front marker lights. See **Fig. 1**.



1. Marker Light
2. Identification Lights
3. Clearance Lights
4. Side-Marker Lights
5. Headlights
6. Turn Signals
7. Road Lights

Fig. 1, Exterior Lights

The parking lights operate a second filament in the dual-filament bulbs located in the front turn signals, side marker lights, and taillights (red utility lights).

Optional road lights are installed in the lower-front bumper.

The front marker lights are installed on the sun visor. On vehicles with no sun visor installed, they are located on the cab roof.

On each side of the vehicle, there is a side-marker light with a dual-filament bulb. The first filament doubles as a turn signal, and the second filament is for the parking lights. In addition, there is a clearance light on the cab side, which also doubles as a turn signal.

On the rear of the vehicle, there are three utility lights. The utility lights with the red lenses have dual-filament bulbs, with one filament being a combination taillight, brake light, and rear turn signal, while the other filament is for the parking lights. The utility light with the white lens is a back-up light.

For vehicles equipped with daytime running lights, switching on the ignition and releasing the parking brakes automatically activates the daytime running light at reduced voltage. The daytime running lights share with the headlights. This light will operate as a daytime running light until the parking brakes are applied or the headlight switch is turned on.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the electrical connector at the bottom of the daytime running lights (DRL) module. See Troubleshooting 300 in this section for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

NOTE: For vehicles built to operate in the United States, the low-beam headlights must be turned on before the road lights can be turned on. The road lights will not go on if the high-beam headlights are already on, and switching from low beams to high beams will switch off the road lights.

For vehicles built to operate in Canada, the taillights and clearance lights must be on before

General Information

the road lights can be turned on. Unless the headlight switch is all the way up (headlights, taillights, clearance lights, marker lights, and panel lights on) or down (taillights, clearance lights, marker lights, and panel lights on), the road light switch will not turn on the road lights.

Inside the cab are the following lights:

- Dome lights (with map and reading lights)
- Courtesy lights in both driver's and passenger's footwells
- An instrument panel that features fully lighted gauges and panels

The steering column-mounted turn-signal switch has the headlight dimmer switch built into it.

In the bunk or sleeper are dome lights, under-bunk storage compartment lights, and reading lights. Baggage compartments may be equipped with accessory lights.

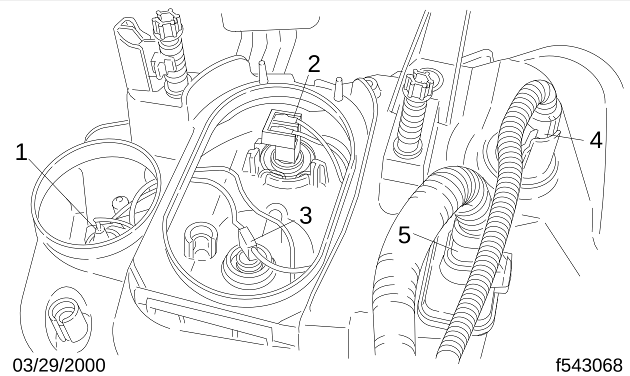
Headlight aim can be checked and adjusted most easily, using a screen or wall.

Headlight, Running Light and Turn Signal Bulb Replacement

NOTE: The headlight bucket contains the headlight, front turn signal, and the daytime running light (DRL). See **Fig. 1**. The DRL is optional, so the space allocated for the bulb may be empty.

IMPORTANT: Handle the bulb assembly only by the base. Do not touch the glass.

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.



1. Daytime Running Light Bulb Harness (if equipped)
2. Low-Beam Headlight Bulb Harness
3. High-Beam Headlight Bulb Harness
4. Turn Signal Bulb Harness
5. Power Plug

Fig. 1, Headlight Bucket (passenger-side shown)

2. Tilt the hood.
3. Remove the plastic cover on the back of the headlamp bucket, the round cover for the DRL or the oval shaped cover for high and low-beam headlights.
4. Replace the appropriate headlight bulb. See **Fig. 1**.
5. Install the plastic cover(s).
6. Return the hood to the normal operating position.

Front Headlight Bucket Replacement

1. Tilt the hood.
2. Remove the turn signal bulb harness and power plug. See **Fig. 1**.
3. Remove the head lamp and DRL bulbs.
4. Remove the nuts and washers attaching the bucket to the hood and remove the bucket. See **Fig. 2**.
5. Install the new bucket and fasten it to the hood.
6. Install the bulbs, turn signal harness, and power plug.
7. Return the hood to the normal operating position.
8. Test the headlights, turn signal, and DRL (if equipped) for proper operation.

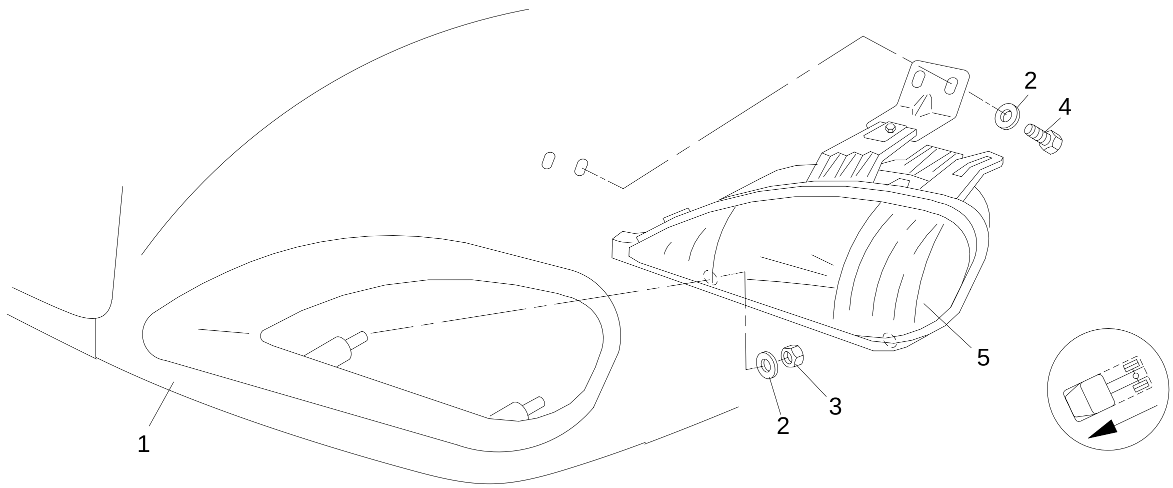
Road Lamp Bulb Replacement

1. Tilt the hood.
2. Turn the lamp bulb, with harness connected, clockwise to release it from the road lamp fixture.
3. Remove the bulb assembly from the harness. See **Fig. 3**.
4. To provide corrosion protection, coat the pins of the connector and new bulb assembly with dielectric grease. Refer to the approved electrical lubricants table in **Specifications 400**.

IMPORTANT: Handle the new bulb assembly only by the base. Do not touch the glass.

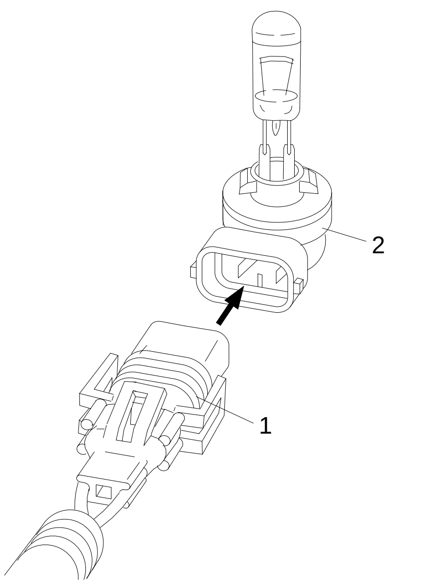
5. Plug the new bulb assembly into electrical harness.
6. Install the bulb assembly into the back of the road lamp fixture.
7. Return the hood to the normal operating position.
8. Wipe the lens with a clean cloth to remove any dirt or skin oil.
9. Test the light for proper operation.

Exterior Light Replacement



1. Hood
2. Washer
3. Nut
4. Bolt
5. Headlight Bucket

Fig. 2, Headlight Bucket Replacement



1. Road Lamp Harness
2. Bulb Assembly

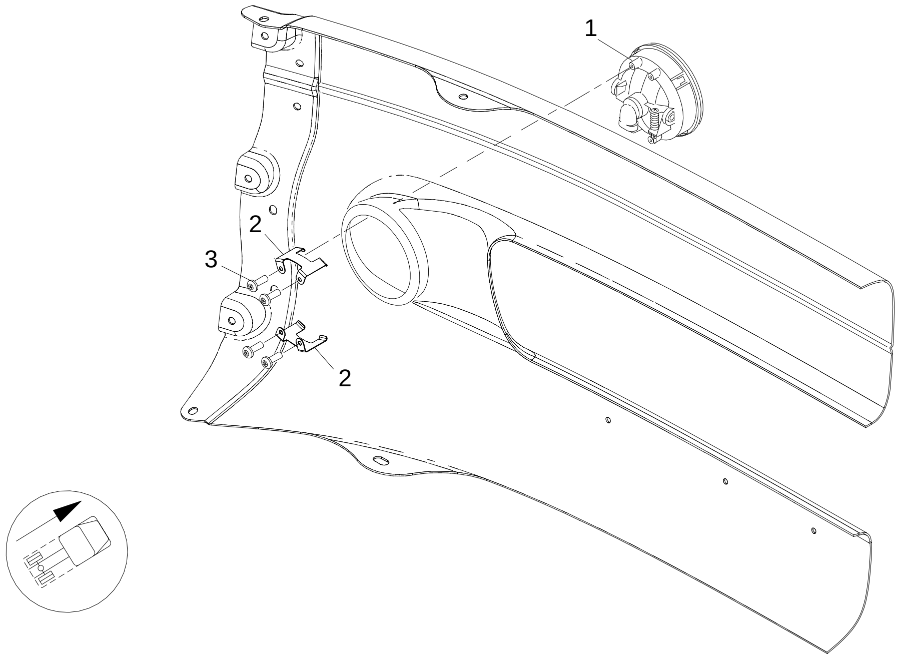
Fig. 3, Road Lamp Bulb Replacement

Road Lamp Fixture Replacement

1. Tilt the hood.

IMPORTANT: Handle the bulb assembly only by the base. Do not touch the glass.

2. Turn the lamp bulb, with harness connected, clockwise to release it from the road lamp fixture.
3. Remove the four screws from the fixture mounting brackets and remove the fixture. See **Fig. 4**.
4. Install the new fixture with the mounting brackets and four screws.
5. Install the bulb and harness assembly.
6. Return the hood to the normal operating position.
7. Test the lamp for proper operation.
8. Check the alignment of the light. Make sure the light is pointing forward and slightly toward the shoulder side of the road.



1. Road Lamp Fixture
2. Mounting Brackets
3. Mounting Screws

Fig. 4, Road Lamp Fixture Replacement

Side-Marker Bulb Replacement

(Fig. 5)

1. Amber Lens Bulb Cover
2. Exterior Cab Wall

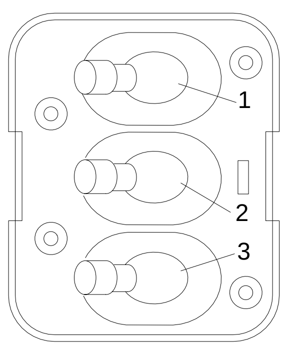
Fig. 5, Side-Marker Light

1. Remove the two Torx-head screws.
2. Remove the amber lens cover and replace the bulb.
3. Test the new bulb for proper operation.
4. Replace the amber lens cover and tighten the Torx-head screws tightly.
5. Remove the chocks.

Dome/Map Light Replacement

NOTE: On vehicles with an overhead console, the dome/map light has three lights: a diffuse dome light, a clear spotlight (reading light), and a red map light. See **Fig. 1**. On vehicles without an overhead console, the dome light has a single white light.

1. Remove the dome light lens, that snaps on to the lens holder. See **Fig. 2**.



1. Red Dome Light
2. Clear Spotlight
3. Diffuse Dome Light

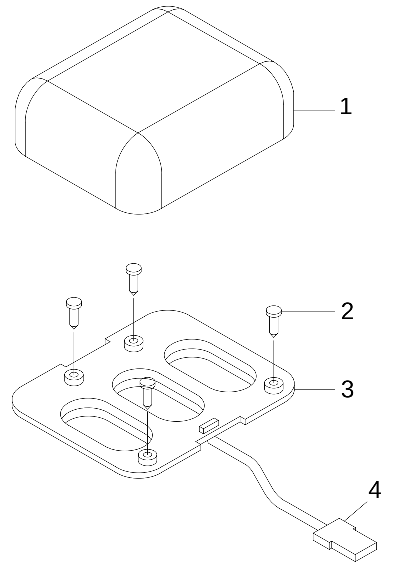
Fig. 1, Dome/Map Light Bulbs

2. Twist the bulb holder one-quarter turn clockwise to remove the bulb that needs changing.
3. Press the new bulb into its socket and check that it is firmly in place.
4. Test the light for correct operation.
5. Snap the dome light lens into place.

Courtesy Lights

DRIVER'S FLOOR COURTESY LIGHT

1. Reach in under the dash and snap the lens off the lamp base. See **Fig. 3**.
2. Replace the light bulb.
3. Snap the lens back in place on the lamp base.



1. Dome Light Lens
2. 10–14 Thread-Rolling Screw
3. Dome Light Lens Holder
4. Electrical Connector

Fig. 2, Lens Removal

PASSENGER'S FOOTWELL COURTESY LIGHT

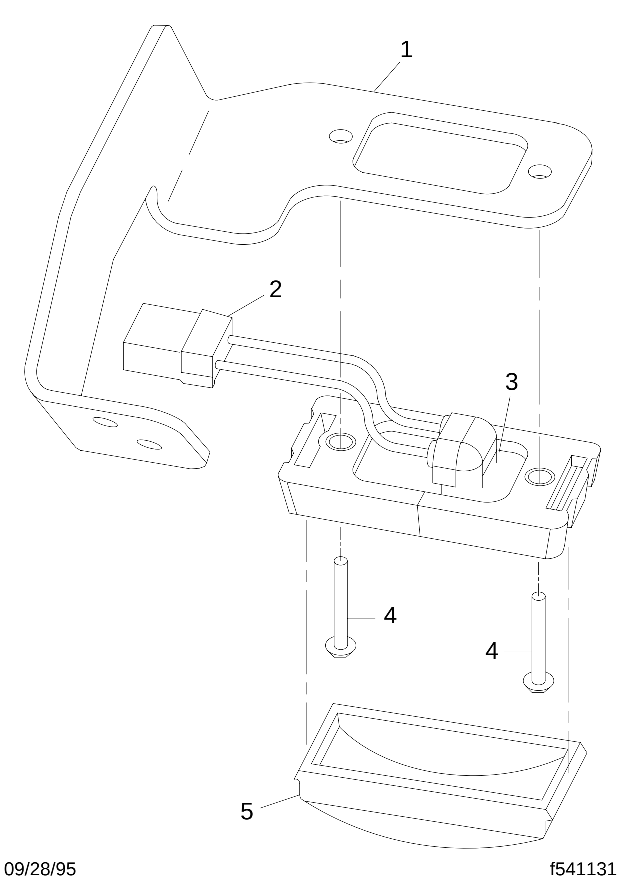
1. Reach into the recess in the HVAC cover and snap the lens off the lamp base. See **Fig. 4**.
2. Replace the bulb.
3. Snap the lens back into place on the lamp base.
4. Install the HVAC cover. For instructions, see **Section 60.08**.

Dash Panel Lights

INSTRUMENT PANEL GAUGE LIGHTS

To replace instrument panel gauge lights, see **Section 54.07**.

Interior Light Replacement



1. Steering Column Light Bracket
2. Electrical Connector
3. Lamp Base
4. 3/16-Inch Monobolt
5. Lens

Fig. 3, Driver's Floor Courtesy Light

INSTRUMENT PANEL SWITCH LIGHTS

Wiper/Washer Switch

NOTE: The wiper/washer switch is the only double-paddle switch installed on the dash.

1. Remove the auxiliary instrument panel from the dash. For procedures, see **Section 54.07**.

NOTE: In some installations, the bulb is on the side of the switch. On these switches, it is not necessary to remove the switch from the panel.

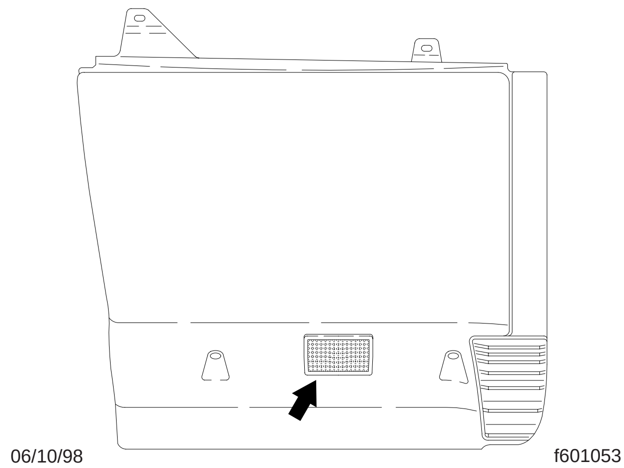
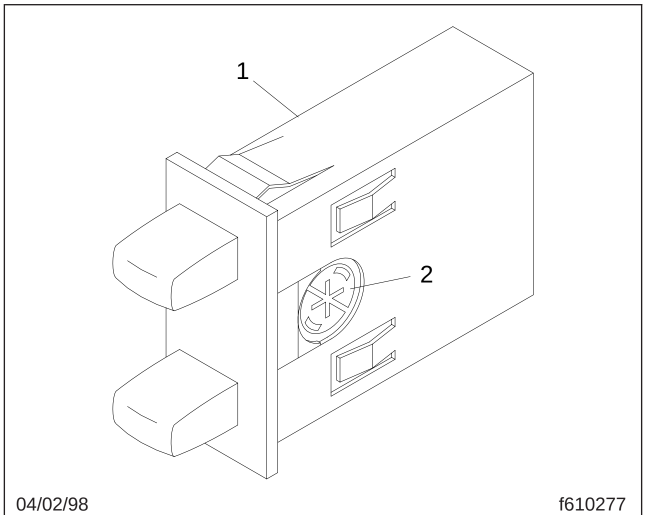


Fig. 4, Passenger's Footwell Courtesy Light

2. Remove the switch from the auxiliary instrument panel (if necessary). For procedures, see **Section 54.07**.
3. Locate the bulb base on the side of the switch. Using a small screwdriver, turn the bulb base one-quarter turn to remove it. See **Fig. 5**.

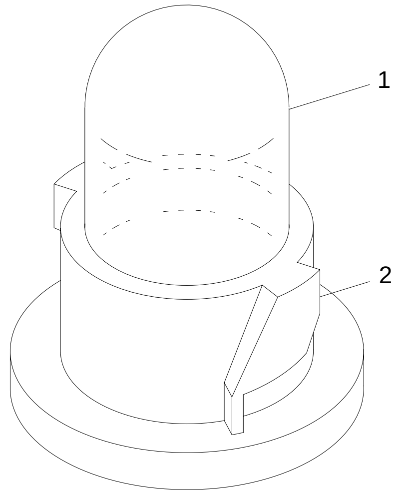


1. Switch Body
2. Bulb Base

Fig. 5, Wiper/Washer Switch Light

NOTE: The base is part of the bulb assembly and must be replaced with the bulb.

4. Install a new bulb and base assembly on the back of the valve. See **Fig. 6**.



1. Bulb 2. Base

Fig. 6, Bulb Base

5. Install the switch (if removed) in the auxiliary instrument panel. For procedures, see **Section 54.07**.

6. Install the auxiliary instrument panel. For procedures, see **Section 54.07**.

Rocker Switches

1. Turn the switch on.

2. With the switch on, slip a small screwdriver under the top end of the rocker panel and pop it off of the switch body, exposing the bulb. See **Fig. 7**.

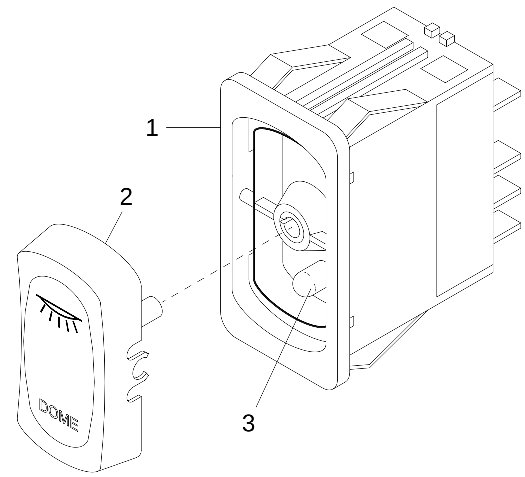
3. Using needle-nose pliers (or a small plastic tube or straw), remove the burned-out bulb.

NOTE: If using a tube or straw, rock the bulb and pull on it gently to remove it.

4. Install the new bulb in the socket.

    4.1 Push the new bulb onto the end of the small plastic tube or straw.

    NOTE: If using the bulb replacement tool located underneath the dash message center bezel, use care because the rocker switch bulbs are slightly smaller than the warning and indicator light bulbs in the dash message center.



1. Switch Body
2. Rocker Panel
3. Bulb

Fig. 7, Rocker Switch Light Bulb

    4.2 Holding the bulb on the end of the tube, insert it into the socket.

    4.3 Rotate the straw until the bulb is seated; then pull on the straw to remove it from the bulb.

5. Check that the rocker panel is right side up. Snap it back onto the switch body.

Single-Paddle Switches

1. With the switch on, slip a small screwdriver under the side of the lens and pry it off of the switch body, exposing the bulb. See **Fig. 8**.

IMPORTANT: Be careful not to scratch the switch body.

2. Using needle-nose pliers (or a small plastic tube or straw), remove the burned-out bulb.

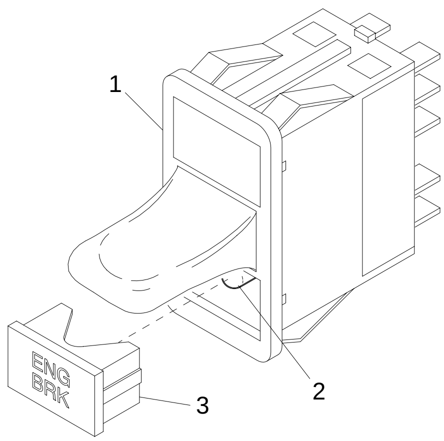
NOTE: If using a tube or straw, rock the bulb and pull on it gently to remove it.

3. Install the new bulb in the socket.

    3.1 Push the new bulb onto the end of the small plastic tube or straw.

    NOTE: If using the bulb replacement tool located underneath the dash message center bezel, use care because the rocker

Interior Light Replacement



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1. Switch Body
2. Bulb
3. Lens

Fig. 8, Single-Paddle Switch Light Bulb

switch bulbs are slightly smaller than the warning and indicator light bulbs in the dash message center.

3.2 Holding the bulb on the end of the tube, insert it into the socket.

3.3 Rotate the straw until the bulb is seated; then pull on the straw to remove it from the bulb.

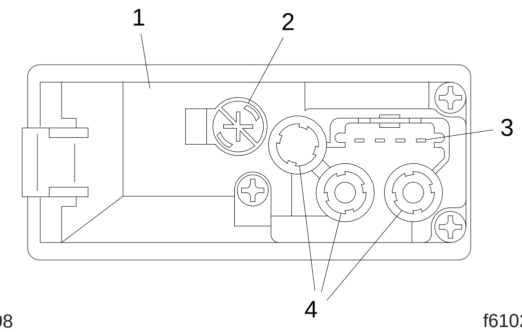
4. Check that the lens is right side up. Insert it back into the switch body.

INSTRUMENT PANEL FLIPPER VALVE LIGHTS

1. Remove the auxiliary instrument panel from the dash. For procedures, see **Section 54.07**.
2. Locate the bulb base on the back of the flipper valve. Using a small screwdriver, turn the bulb base one-quarter turn to remove it. See **Fig. 9**.

NOTE: The base is part of the bulb assembly and must be replaced with the bulb.

3. Install a new bulb and base assembly on the back of the valve. See **Fig. 6**.
4. Install the auxiliary instrument panel. For procedures, see **Section 54.07**.



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Flipper valve shown in rear view.

1. Valve Body
2. Bulb Base
3. Electrical Connector
4. Air Line Connectors

Fig. 9, Flipper Valve Light

WARNING AND INDICATOR LIGHTS

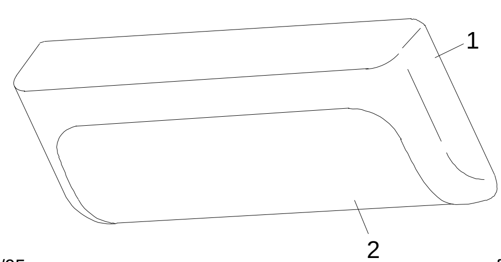
To replace warning and indicator lights, see **Section 54.07**.

Sleepercab Light Replacement

MID-ROOF DOME LIGHT

NOTE: This light is installed on sleepercabs only. See **Fig. 10**. The front overhead dome/ map light is installed on all cabs.

1. Press in on each side of the mid-roof dome light lens to release the mounting tabs. See **Fig. 11**. Remove the lens from the light receptacle.
2. Remove the bulb(s) from their socket(s).
3. Install a new bulb. See **Fig. 11**.



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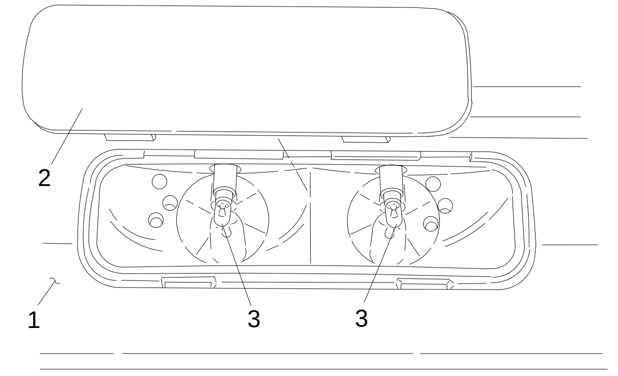
1. Dome Light
2. Dome Light Lens

Fig. 10, Mid-Roof Dome Light



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1. Cab Ceiling
2. Lens
3. Bulb

Fig. 11, Mid-Roof Dome Light Bulbs

4. Test the dome light for correct operation.
5. Press the lens onto the lens housing. Make sure the mounting tabs snap into place.

BUNK READING LIGHT

NOTE: This light is installed on sleeper cabs only.

The reading light is installed on the bunk control panel.

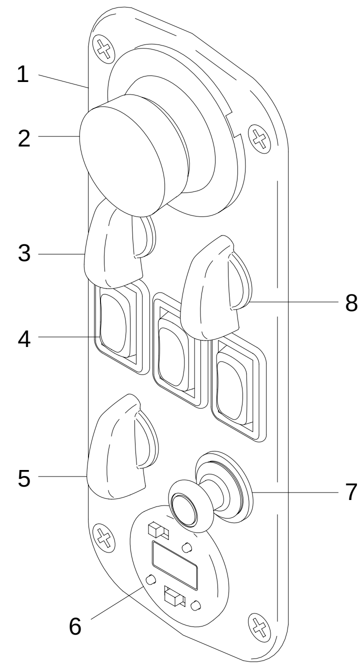
Lights Without Removable Bulbs

1. Twist the light counterclockwise and press in to free it from the panel. See **Fig. 12**.
2. Install a new reading light. Align the light with the three notches in the panel and snap into position.
3. Test the reading light for correct operation.

Lights With Removable Bulbs

1. Remove the lens and rubber guard assembly from the lamp swivel.

   Remove the burned out light bulb.
2. Install a new light bulb.
3. Snap the lens and rubber guard assembly onto the lamp swivel.



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NOTE: Number and placement of switches may vary.

1. Control Panel
2. Reading Light
3. Fan Control Knob
4. Dome and Reading Light Switches
5. Volume Control Knob
6. Clock
7. Cigarette Lighter
8. A.T.C. Control Knob

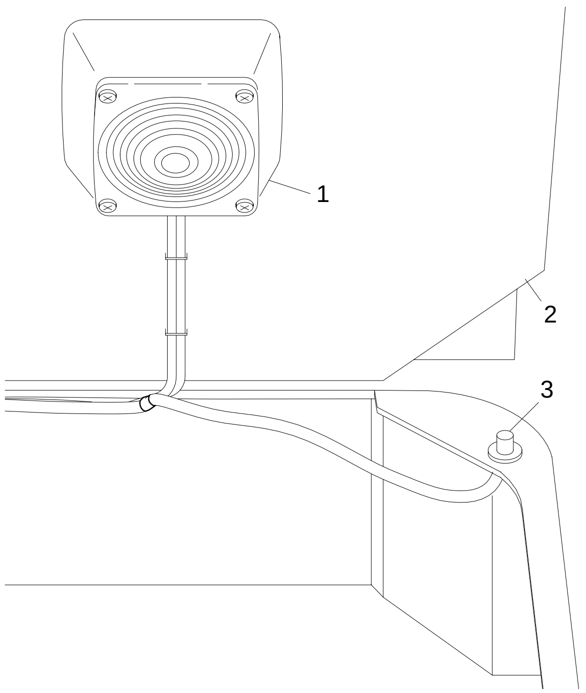
Fig. 12, Bunk Reading Light

UNDER-BUNK STORAGE COMPARTMENT LIGHT

NOTE: This light is installed on sleeper cabs only.

1. Open up the bunk to gain access to the storage compartment light and switch. See **Fig. 13**.
2. Remove the four screws from the light receptacle to expose the bulb.
3. Remove the bulb from the socket.
4. Install a new bulb.
5. Test the under-bunk light for correct operation.

Interior Light Replacement



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1. Under-Bunk Light
2. Bunk
3. Switch

Fig. 13, Under-Bunk Light

Headlight Dimmer and Turn-Signal Switch Replacement

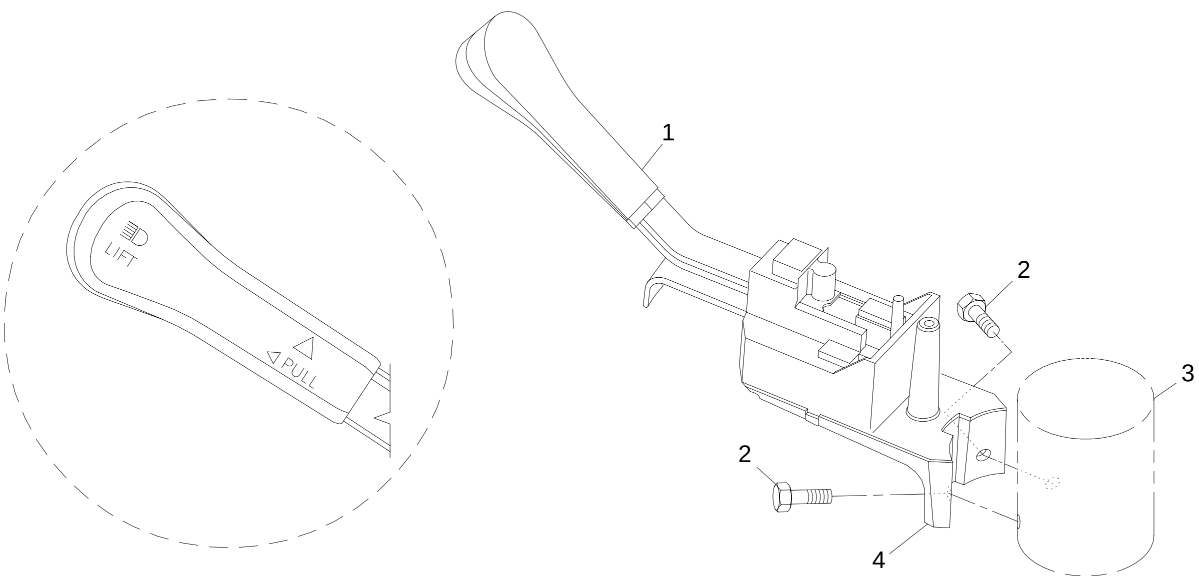
Replacement

NOTE: Before replacing the dimmer and turn-signal switch, make sure that the trouble is in the switch and not elsewhere in the circuit. Check that the circuit breaker and fuse are working, and inspect the signal light bulbs for broken filaments. Also, check the flasher relay, and replace it if necessary.

1. Remove the steering column cover (clamshell cover). For instructions, see **Section 46.02**.

NOTE: Some headlight dimmer and turn signal switches also have a horn button installed on the end of the switch.

2. Using a 7/16-inch wrench, loosen the two 1/4–28 locking capscrews attaching the headlight dimmer and turn signal switch to the steering column. Remove the turn signal switch mounting assembly from the steering column. See **Fig. 1**.
3. Unsnap the wiring connector from the turn-signal switch.
4. Connect the wiring connector to the new switch.
5. Install the turn signal switch.
   - 5.1 Position the switch on the steering column. Align the switch so that it is pointing directly to the left, toward the driver's door.
   - 5.2 Install the two locking capscrews and tighten them firmly.
6. Check the turn signals, headlight dimmer, horn (if installed), and 4-way flashers for correct operation.



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1. Switch Lever
2. 1/4–28 Locking Capscrew
3. Steering Column
4. Switch Bracket

Fig. 1, Headlight Dimmer/Turn Signal Switch

Headlight Aim Checking and Adjusting

Before checking or adjusting the headlight aim, do the following:

- Remove large amounts of mud or ice from the underside of the fenders.
- Check the springs for sagging or broken leaves.
- Check the suspension for proper functioning of the leveling mechanism. On cabs with air suspensions, make sure that the height is properly adjusted.
- Check for damage to the hood and hinge assembly. Repair as necessary.
- Clean the headlight lenses.
- With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.

Checking

1. Park the vehicle on a level surface 25 ft (7.6 m) from a screen or wall that can be used for aiming the headlights. Shut down the engine, apply the parking brake, and chock the front tires. See **Fig. 1**.

NOTE: The low-beam headlight is the top bulb in the dual-beam assembly.

2. On each headlight, find the bulb center. See **Fig. 2**.
3. Measure the distance from the ground to the center of each low-beam bulb. Note those distances.
4. On the screen or wall 25 ft (7.6 m) away, make the appropriate markings directly across from each headlight and at the same height as measured for the headlight.
5. Turn on the headlights to the low-beam setting. See **Fig. 3** for the ideal and acceptable patterns for both headlights.
   - If either or both headlights do not aim into the inner edges of the centerline, follow the adjusting procedure below.
   - If both headlights come close to the inside of each headlight centerline (as shown), no further work is needed. Turn off the headlights and remove the chocks from the front tires.

Adjusting

1. Lift the flap over the rear end of the headlight bucket to expose the two plastic adjusting knobs on each headlight. See **Fig. 4**.

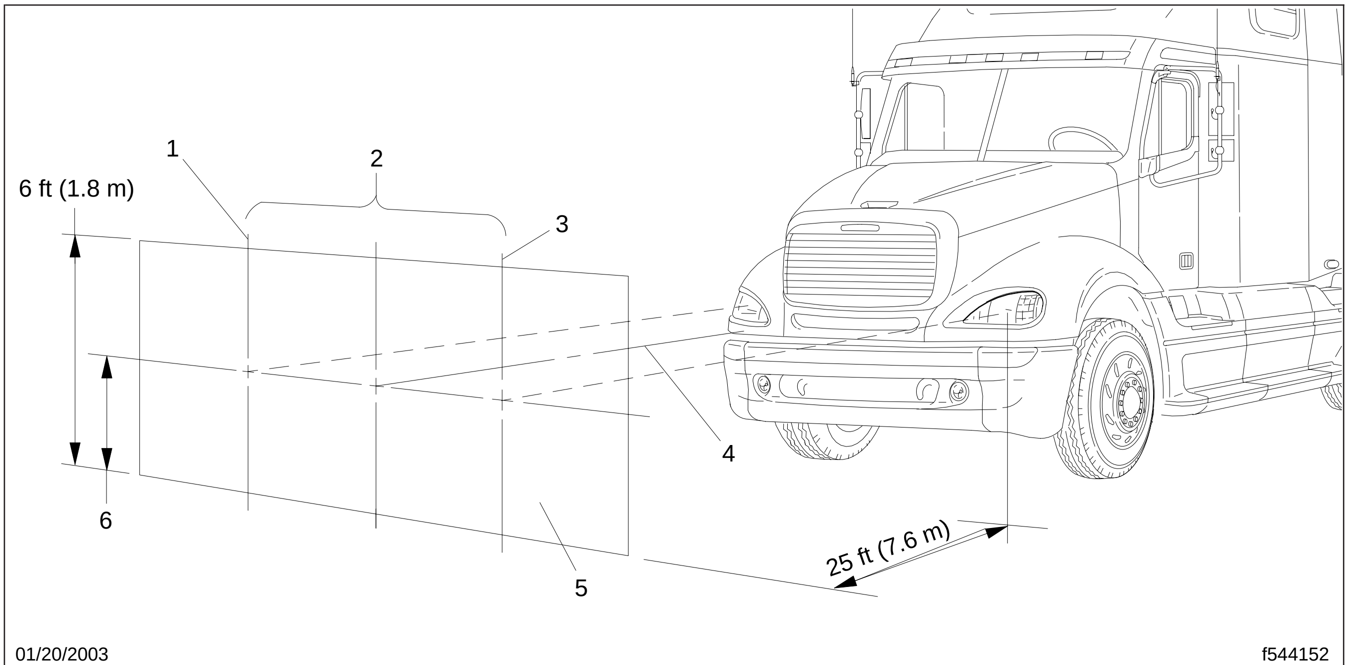
NOTE: Horizontal aim should not be adjusted in the field.

2. With the vehicle parked 25 ft (7.6 m) from the screen or wall, put the headlights on low beams, and turn both adjusting knobs the same amount, as needed to adjust the lights until the beam pattern meets the acceptable standard in **Fig. 3**.

NOTE: Blocking off each light is not necessary, but it can help to present a clearer beam pattern.

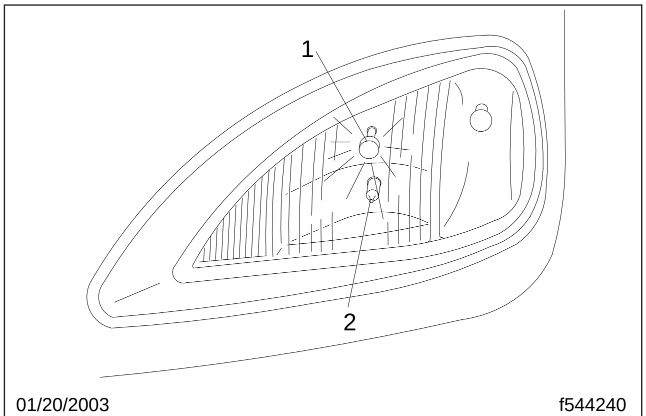
3. Remove the chocks from the front tires.

Headlight Aim Checking and Adjusting



1. Vertical Centerline of Right Headlight
2. Distance Between Headlights
3. Vertical Centerline of Left Headlight
4. Projected Vehicle Centerline
5. Screen or Wall
6. Height of Lamp Centers

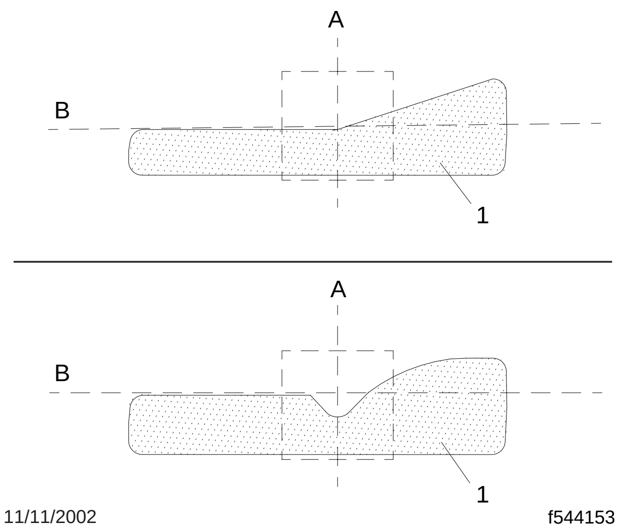
Fig. 1, Headlight Aiming Screen or Wall



Measure beam height from the ground to the center of the low-beam bulb.

1. Low-Beam Bulb and Reflector
2. High-Beam Bulb

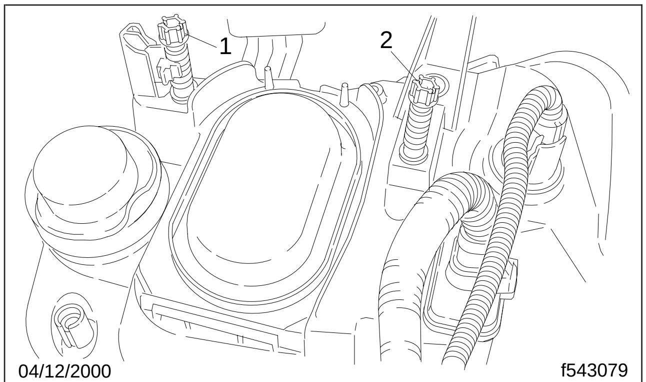
Fig. 2, Headlight Beam Height



NOTE: The top view shows the ideal beam pattern; the bottom view shows an acceptable standard.

A. Vertical Centerline
B. Horizontal Centerline
1. Bright Area

Fig. 3, Headlight Beam Patterns



NOTE: The right-hand side headlight bucket is shown. The left-hand side is opposite.

1. Inboard Adjusting Knob
2. Outboard Adjusting Knob

Fig. 4, Headlight Adjusting Knobs

Troubleshooting

DAYTIME RUNNING LIGHT TEST

Before troubleshooting the daytime running lights (DRLs), do the following test of DRL operation.

1. Be sure the ignition keyswitch, headlights and turn signals are off. Set the parking brake and be sure that the DRLs are off.
2. Turn on the ignition keyswitch. Make sure that the DRLs stay off.
3. With the air system fully charged, release the parking brake. Make sure that both DRLs turn on.

NOTE: The bulb for the DRLs is a dual-filament bulb. When the DRLs are on, the brighter filament is operating. When the marker lights are on, the other, less bright filament is operating.

4. Turn the headlight switch on. Make sure that the headlights and marker lights come on and the DRLs turn off.
5. Turn on the left and then the right turn signals and check them for proper operation. Make sure that front turn signals, side turn signals, and rear tractor and trailer turn signals (if equipped) all flash on and off at the same time.
6. Turn the headlight switch off. Check the turn signal operation again. Make sure that the front turn signals (DRLs) now flash alternately with the side turn signals, not at the same time.

   When the left turn signal is flashing, make sure that the right DRL is on.

   When the right turn signal is flashing, make sure that the left DRL is on.
7. Set the parking brake and shut down the engine. Be sure that the DRLs turn off.

DAYTIME RUNNING LIGHT TROUBLESHOOTING

If the DRLs are not operating properly, do the following steps.

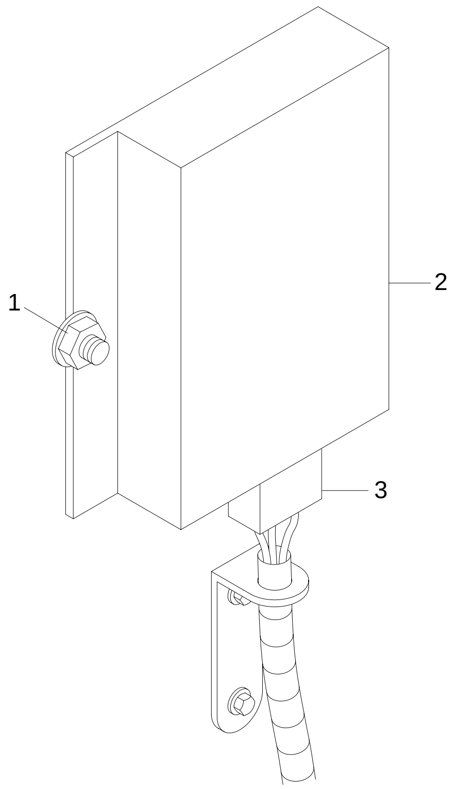
1. Check the bulbs in the DRLs. Replace any bulb that is burned out.
2. Disconnect the electrical connector to the DRL module (see **Fig. 1**) and check the pins for proper contact with the plug. Reconnect the DRL module and test again.
3. If the DRLs are still not operating, disconnect the electrical connector again and use a volt/ohmmeter (VOM) to do a voltage test on each pin (use the harness side). For the correct voltages, see **Table 1**.
4. If any voltage tested does not match the value given in **Table 1**, correct the fault and do the test again.
5. If one or both of the DRLs still do not function at this point, check the wiring to the DRLs for open circuits or circuits shorted to ground. When only one DRL is not working, the typical cause is a failure in one of these wires.
6. If the DRLs are still not working, replace the DRL module.

DRL Module Pin Voltages			
No.	**Name**	**Instructions**	**Voltage**
A	Left Output	None	0
B	Ground	None	0
C	Park Brake	Set Park Brake and connect a VOM between pins C and D	0
		Release Park Brake and connect a VOM between pins C and D	12
D	Battery	None	12
E	Right Output	None	0
F	Right Turn Signal	Right Turn Signal Off	0
		Right Turn Signal On	0/12 (alternating)
G	Ignition	Ignition Off	0
		Ignition On	12
H	Right Headlight	Headlights Off	0
		Headlights On	12
J	Left Headlight	Headlights Off	0
		Headlights On	12

Troubleshooting

DRL Module Pin Voltages			
No.	Name	Instructions	Voltage
K	Left Turn Signal	Left Turn Signal Off	0
		Left Turn Signal On	0/12 (alternating)

Table 1, Daytime Running Light Module Pin Voltages



1. Mounting Nut
2. DRL Module
3. Electrical Connector

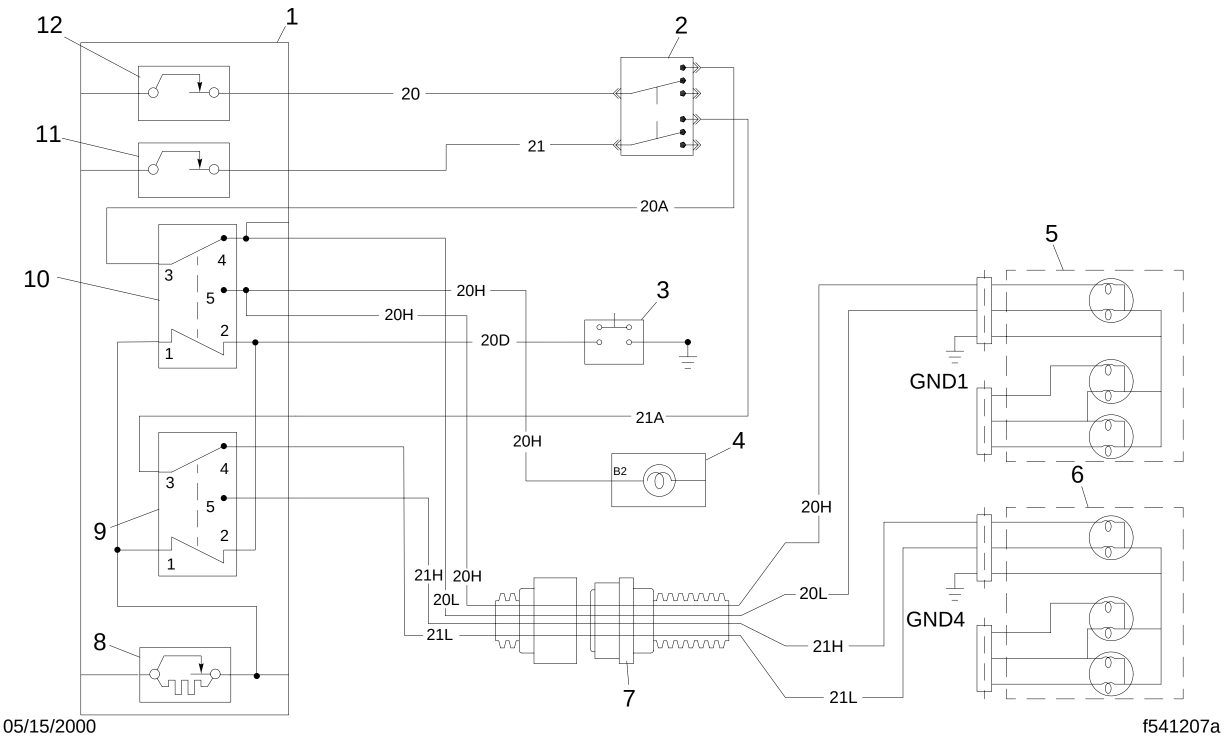
Fig. 1, Daytime Running Light (DRL) Module

Specifications

Manufacturer	Lubricant or Part Number
Shell Oil Co.	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK-77

Table 1, Approved Electrical Lubricants

For a wiring diagram of the headlight circuits, see **Fig. 1**.



1. Power Distribution Module
2. Headlight Switch
3. Dimmer Switch
4. High Beam Indicator Light
5. Left-Hand Headlight Assembly
6. Right-Hand Headlight Assembly
7. Chassis Connector
8. 15-Amp ACC Power Circuit Breaker
9. Right Headlight Micro Relay
10. Left Headlight Micro Relay
11. 15-Amp Right Headlight Circuit Breaker
12. 15-Amp Left Headlight Circuit Breaker

Fig. 1, Headlight Wiring

For a wiring diagram of the turn signal and brake light circuits, see **Fig. 2**.

For a wiring diagram of the daytime running light (DRL) circuits, see **Fig. 3**.

For a wiring diagram of the internal lighting circuits showing the bunk light wiring, see **Fig. 4**.

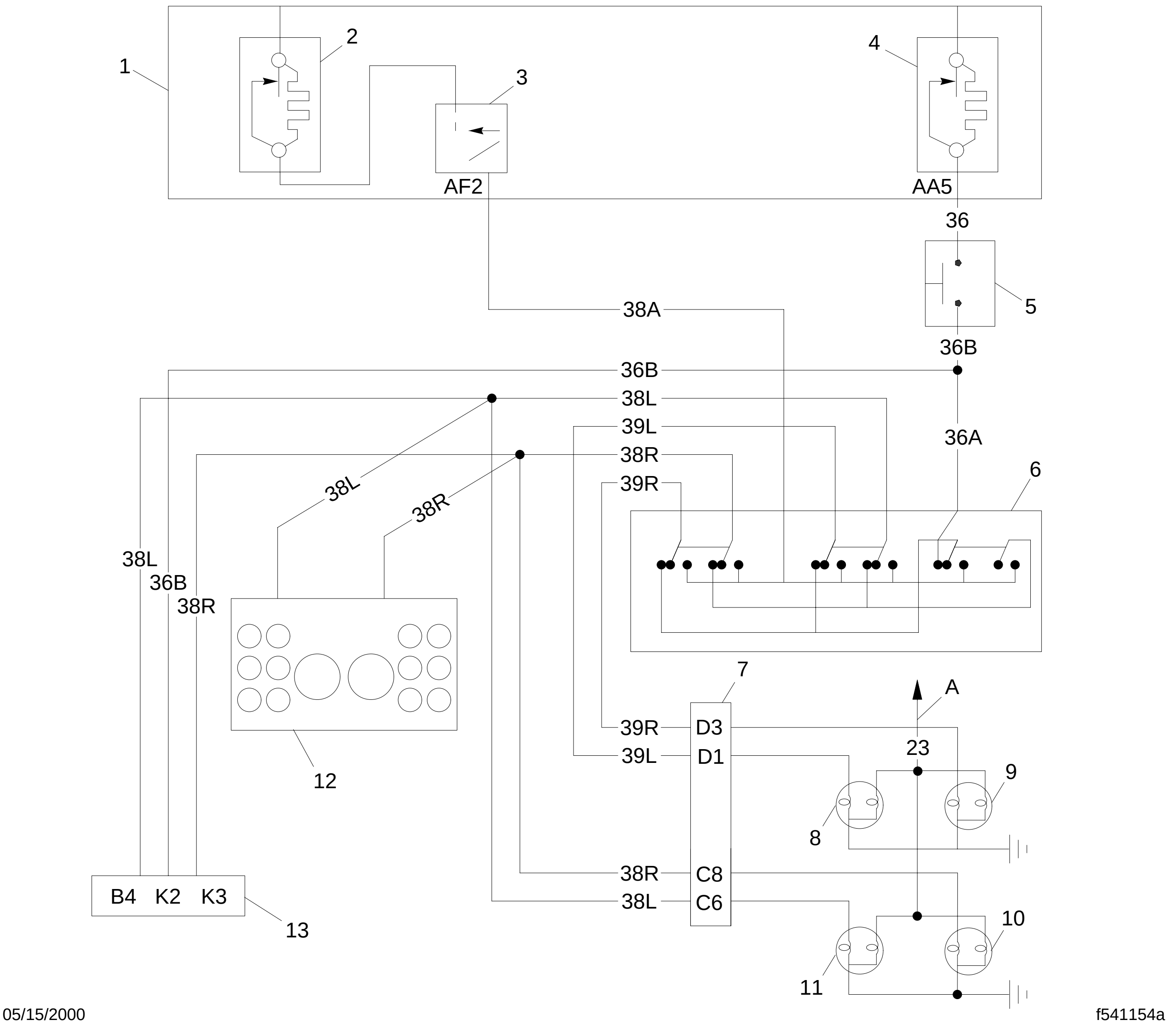
For a wiring diagram of the internal lighting circuits showing the dome light wiring for day cab and mid-roof vehicles, see **Fig. 5**.

For a wiring diagram of the internal lighting circuits showing the bunk light wiring for raised-roof sleepers with control panels on the upper and lower bunks, see **Fig. 6**.

For a wiring diagram of the internal lighting circuits showing the bunk light wiring for raised-roof sleepers with two control panels on the lower bunks, see **Fig. 7**.

For a wiring diagram of the internal lighting circuits showing the bunk light wiring for mid-roof sleepers with a control panel on the lower bunk, see **Fig. 8**.

Specifications

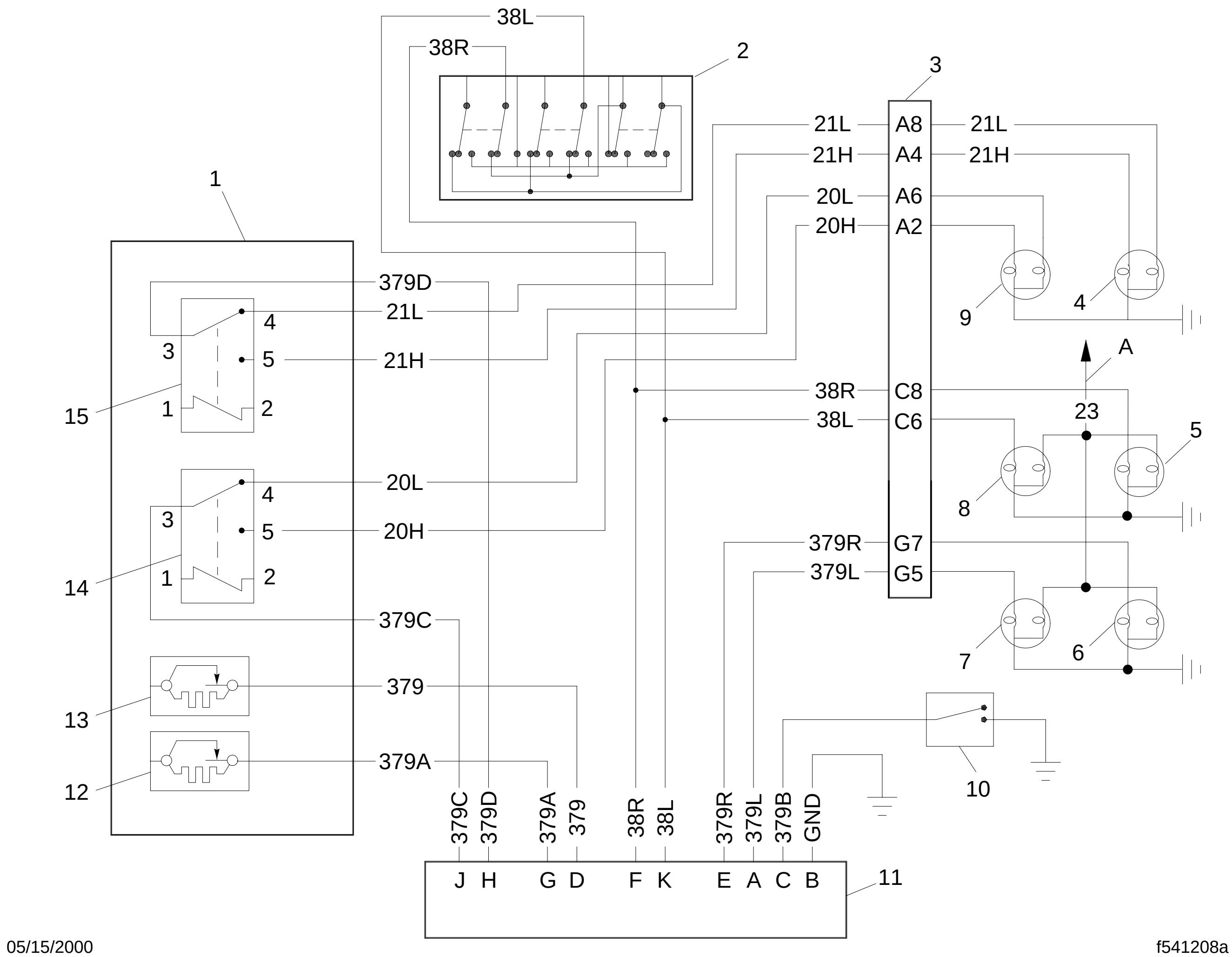


1. Power Distribution Module
2. 20-Amp Turn Signal Circuit Breaker
3. Flasher Unit
4. 25-Amp Brake Light Circuit Breaker
5. Brake Light Switch
6. Turn Signal Switch
7. Chassis Connector
8. Left-Hand Rear Turn Signal/ Brake Light
9. Right-Hand Rear Turn Signal/ Brake Light
10. Right-Hand Front Turn Signal
11. Left-Hand Front Turn Signal
12. Instrumentation Control Unit
13. 7-Way Connector

Fig. 2, Turn Signal and Brake Light Wiring

For a wiring diagram of the internal lighting circuits showing the bunk light wiring for raised-roof sleepers with a control panel on the lower bunk, see **Fig. 9**.

For a wiring diagram of the internal lighting circuits showing the overhead console wiring, see **Fig. 10**.



1. Power Distribution Module
2. Turn Signal Switch
3. Chassis Connector
4. Right Headlight
5. Right-Hand Turn Signal
6. Right-Hand DRL
7. Left-Hand DRL
8. Left-Hand Turn Signal
9. Left Headlight
10. Parking Brake Switch
11. DRL Module
12. 10-Amp Cluster Circuit Breaker
13. 10-Amp DRL Circuit Breaker
14. Left Headlight Micro Relay
15. Right Headlight Micro Relay

Fig. 3, Daytime Running Lights (DRL) Wiring

For a wiring diagram of the dash accessory circuits, see **Fig. 11**.

Specifications

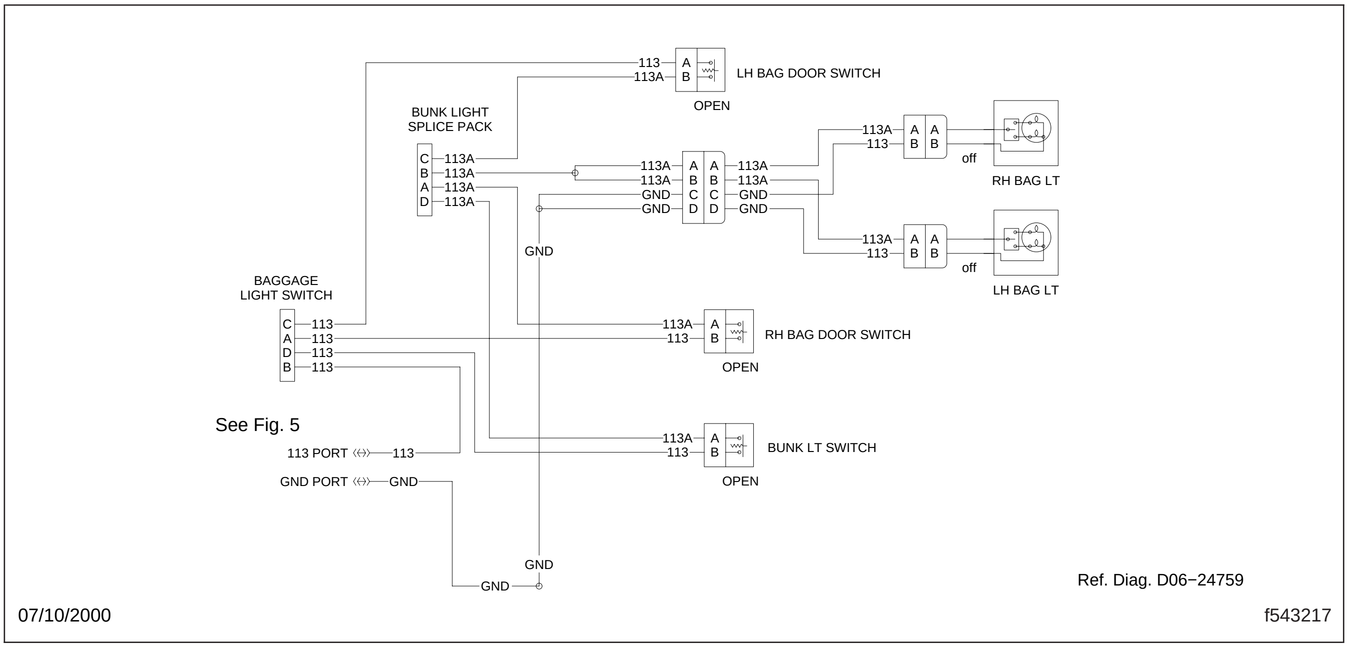
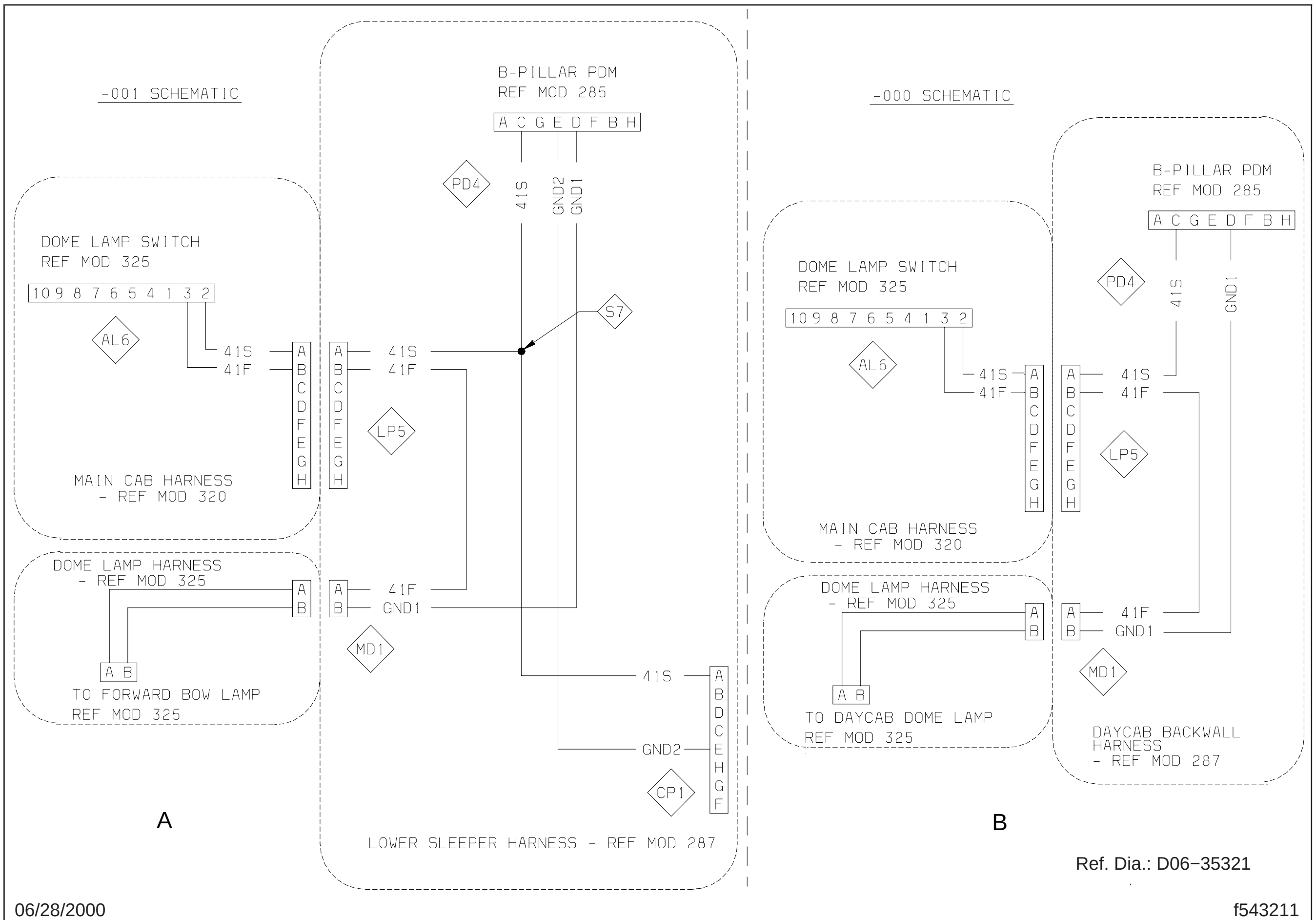


Fig. 4, Bunk Light Wiring



A. Mid-Roof Dome Light Wiring
B. Day Cab Dome Light Wiring

Fig. 5, Dome Light Wiring for Day Cab and Mid-Roof Vehicles

Specifications

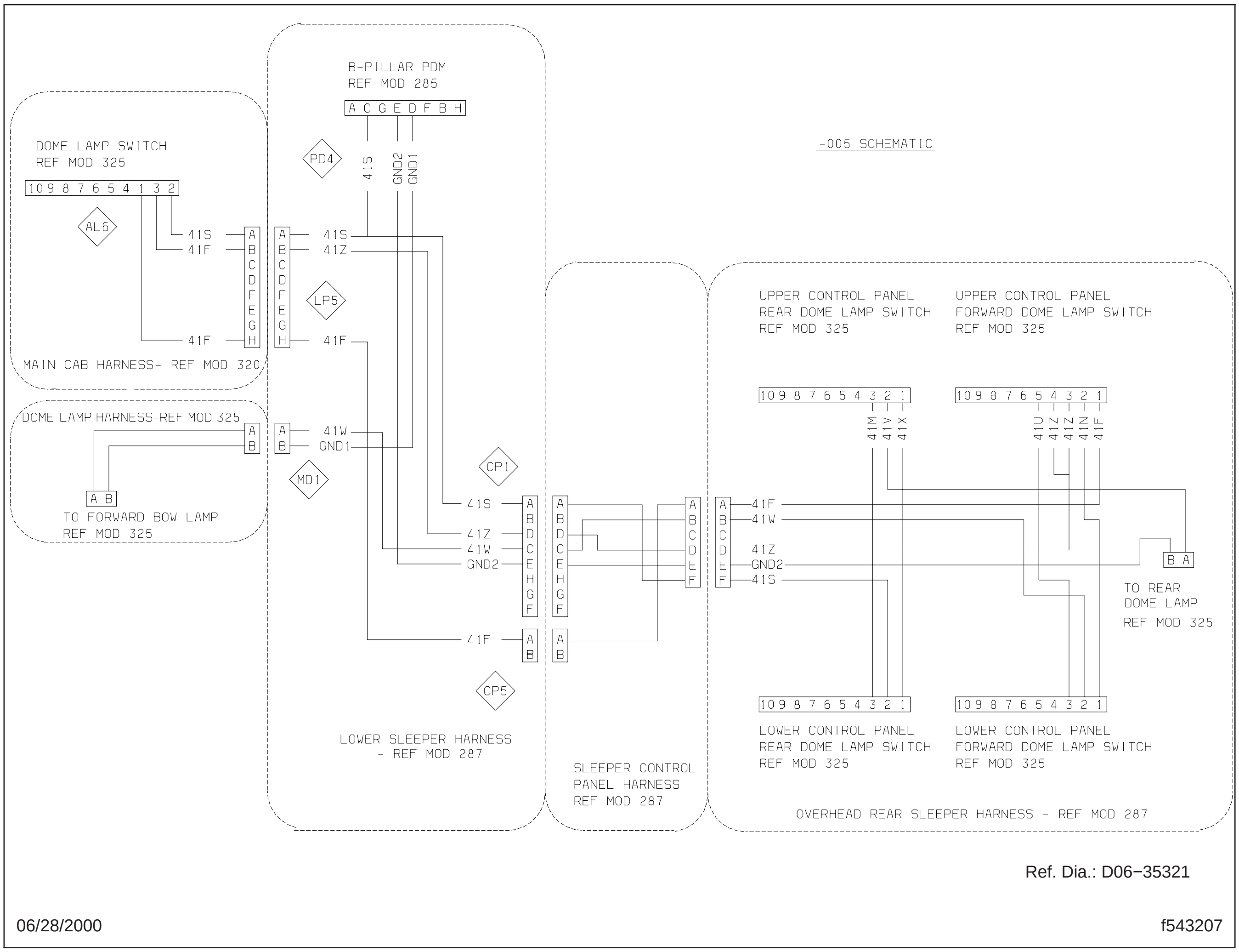


Fig. 6, Bunk Light Wiring for Raised-Roof Sleepers with Control Panels on the Upper and Lower Bunks

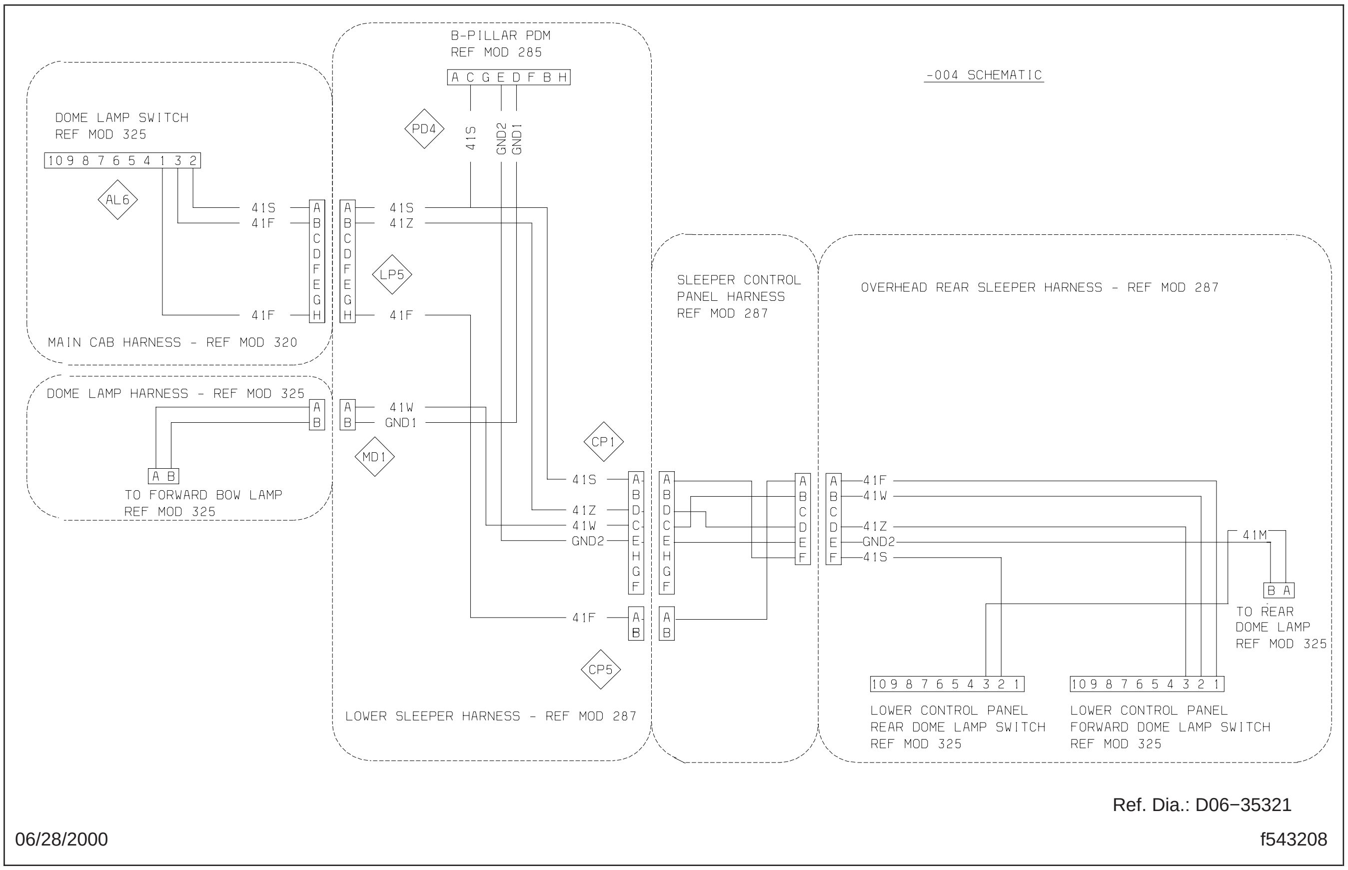


Fig. 7, Bunk Light Wiring for Raised-Roof Sleepers with Two Control Panels on the Lower Bunks

Specifications

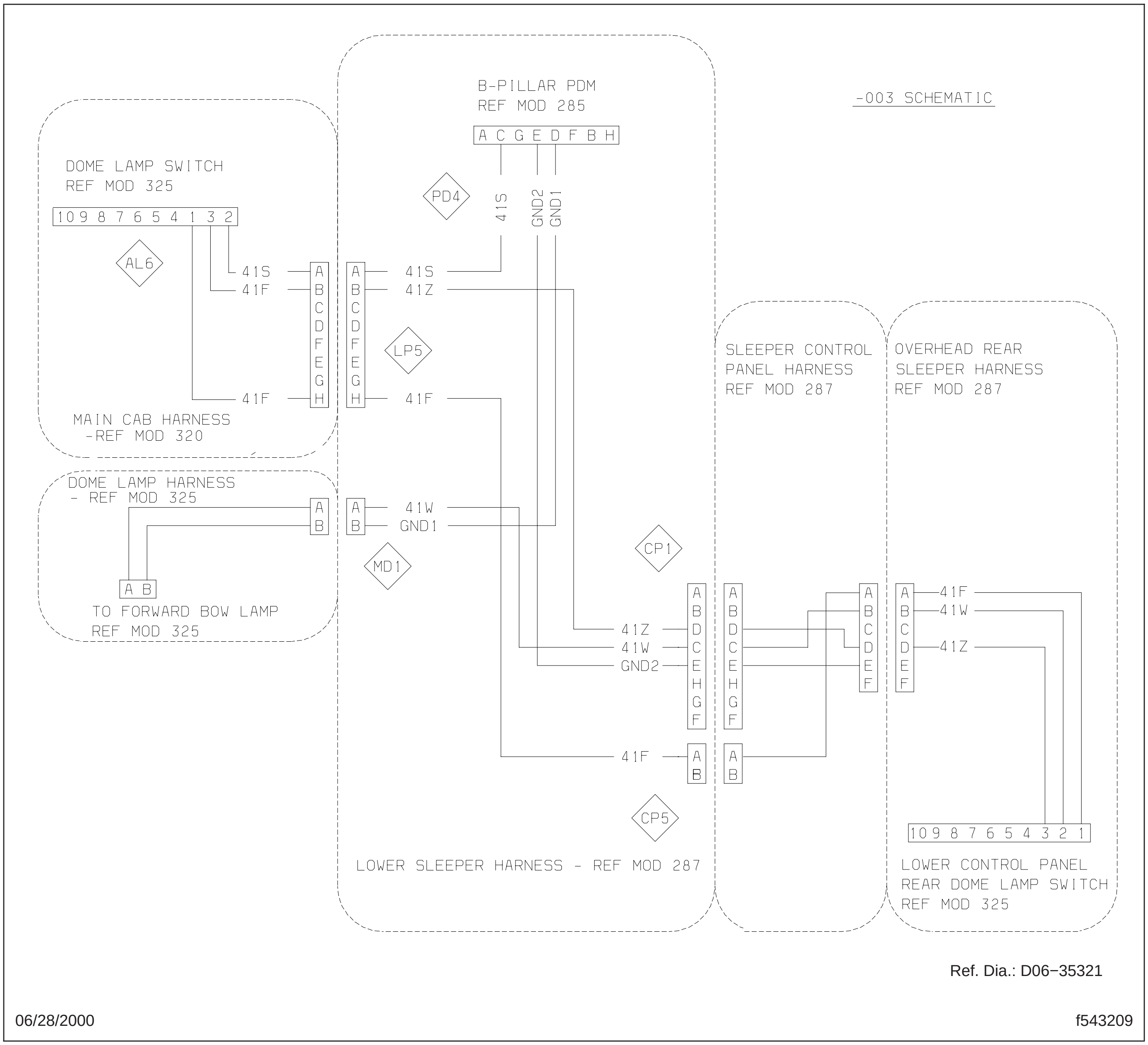


Fig. 8, Bunk Light Wiring for Mid-Roof Sleepers with a Control Panel on the Lower Bunk

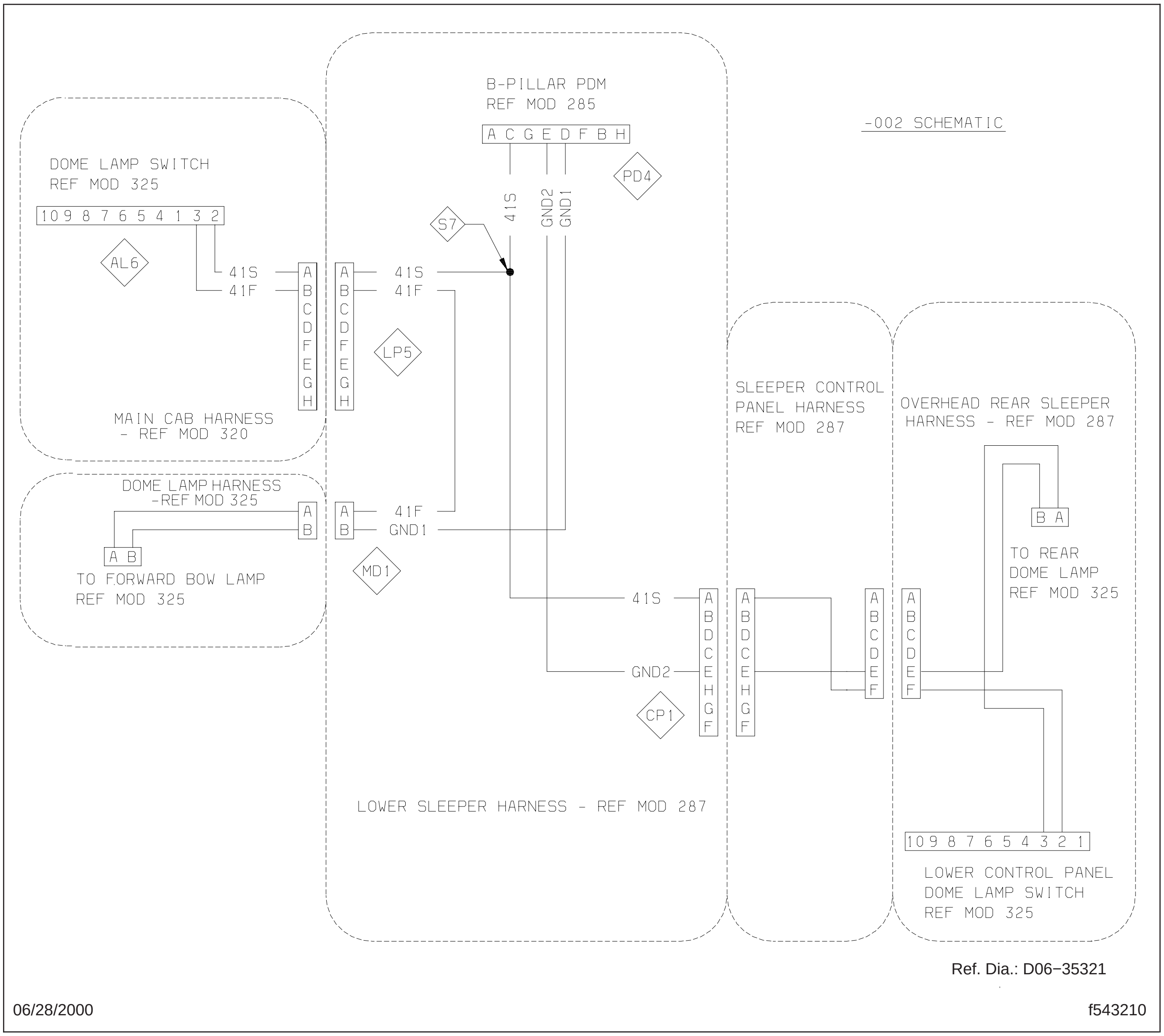


Fig. 9, Bunk Light Wiring for Raised-Roof Sleepers with a Control Panel on the Lower Bunk

Specifications

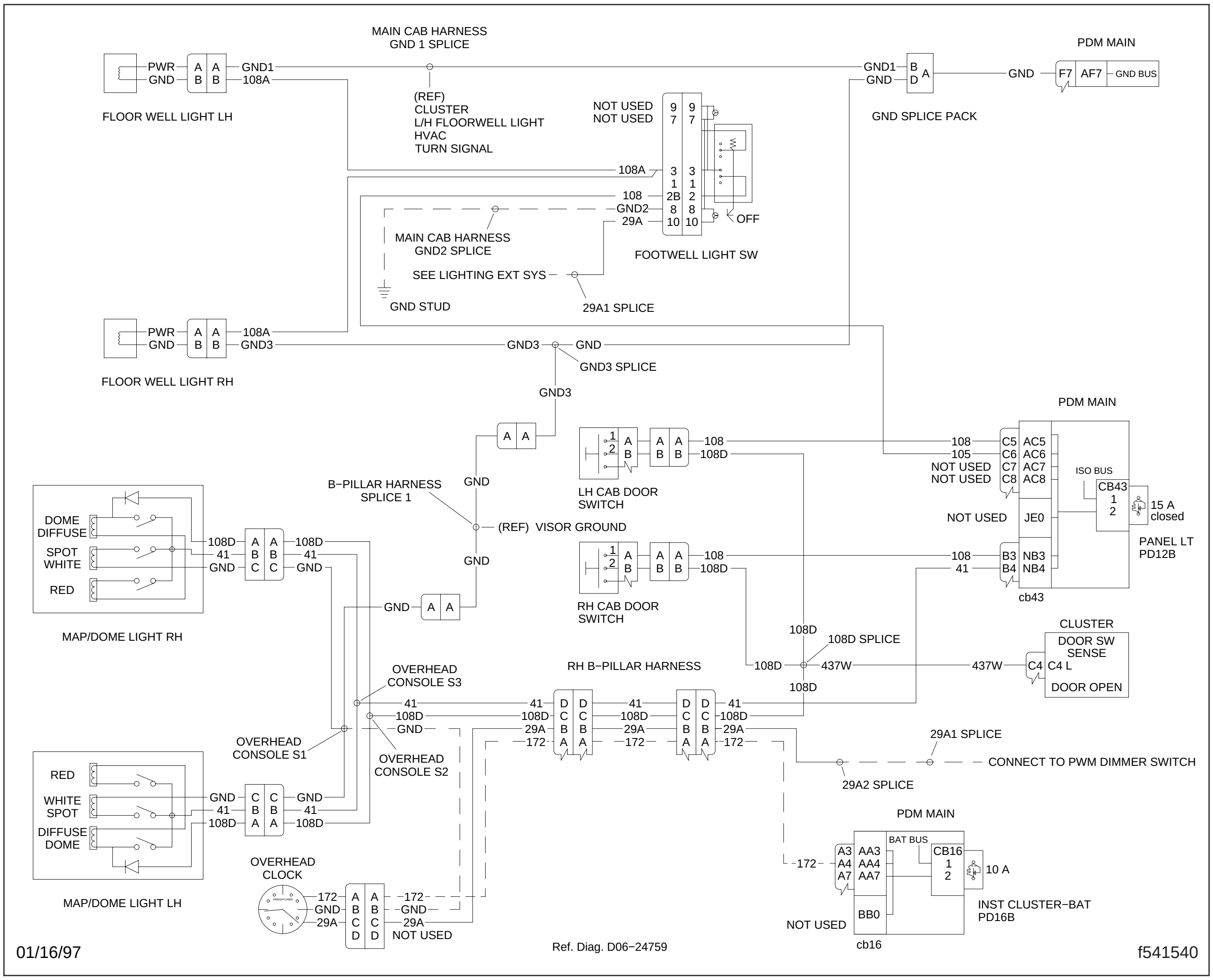


Fig. 10, Overhead Console Wiring

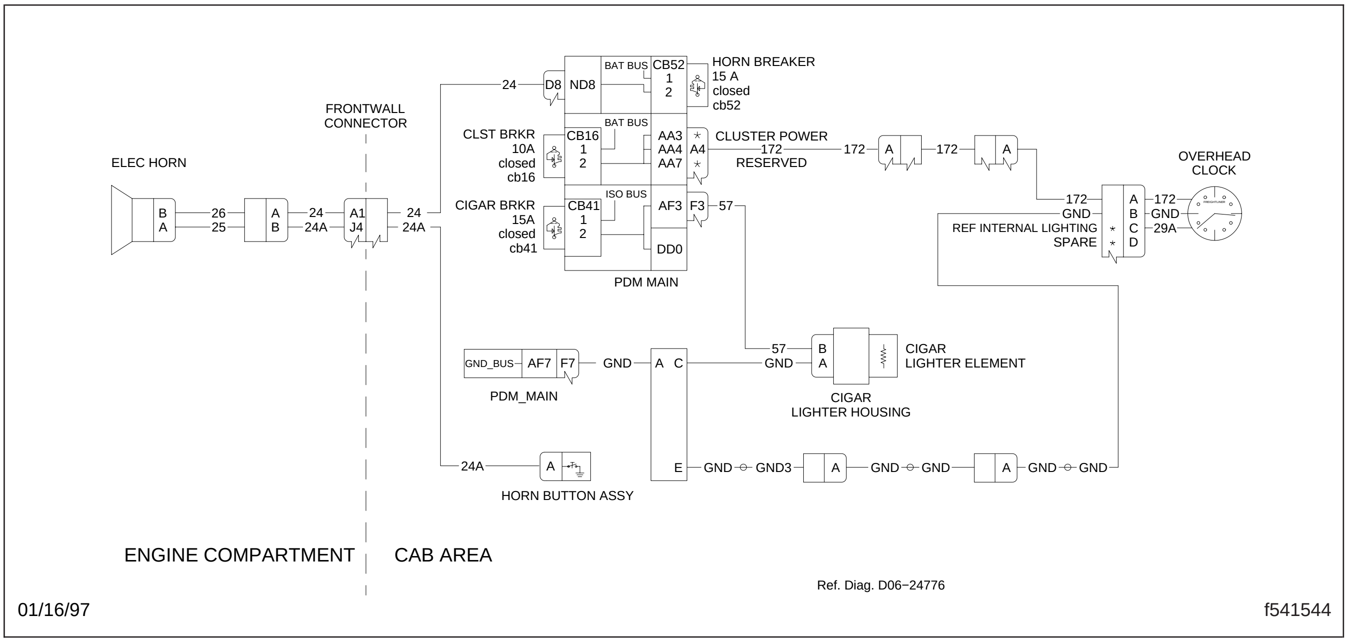


Fig. 11, Dash Accessory Wiring

General Information

Lead-Acid Batteries

Batteries are electrochemical devices that store chemical energy. When the battery is connected to an external load, such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

The battery has three functions:

- To supply power to start the engine.
- To stabilize the voltage in the electrical system. The battery filters high voltage transients and protects electronic components in the vehicle.
- To supply power when the vehicle's electrical load requirements go beyond what the charging system can supply or when the engine is not running.

All lead-acid batteries use plates made of two unlike metals held apart by separators. One of the metals becomes the positive plate, the other the negative plate. These plates are then grouped in pairs, alternating negative and positive. The groups are connected in series, and each plate group (cell) produces about two volts. Thus, a battery with six cells is a 12-volt battery.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a solution of electrolyte (dilute sulfuric acid).

Batteries may produce hydrogen gas when being charged. The vents allow the escape of gases produced in the battery.

NOTE: Liquid-electrolyte batteries must be kept in an upright position to prevent electrolyte leakage. Tipping a wet cell beyond a 45-degree angle in any direction can allow a small amount of electrolyte to leak out the vent holes.

Proper testing will indicate the battery condition. For more information, see **Troubleshooting 300**.

Absorbed Glass Mat (AGM) Batteries

Absorbed Glass Mat (AGM) batteries are lead-acid batteries in which the electrolyte is contained in a fiberglass mat. AGM batteries are physically similar to standard batteries. Carefully check the label on every battery to be certain it is AGM, and **never install AGM batteries in the same circuit with other types of batteries.**

AGM batteries are designed for high cranking amps and repeated cycle service to accommodate many of the auxiliary loads on vehicle electrical systems. They offer good protection against damage due to vibration, and are leak- and spill-proof, even if cracked or broken. Also, they self-discharge more slowly, and generate less heat when charging or discharging.

IMPORTANT: AGM batteries may be damaged or ruined by equipment designed for other types of batteries. AGM battery chargers must be regulated to a charge voltage less than 15.4 DCV; many chargers provide excessive voltage. To get full service from AGM batteries, carefully follow the battery manufacturer's instructions regarding charging rates and procedures.

Parasitic Battery Drain

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough that the starter will not be able to crank the engine.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off.

A typical parasitic drain falls into the 25 to 325 mA (0.025 to 0.325 amps) range. Multiply the drain (in amps) by the time (in hours) the batteries sit without being recharged. The result is the amount of ampere-hours consumed by the parasitic drain. The actual drain may be small, but over time the batteries grow steadily weaker.

At warm temperature of 77°F (25°C), using approximately 40 percent of the total available ampere-hours will bring fully charged batteries to a no-start condition. In colder temperatures, the batteries will reach a no-start condition sooner.

General Safety Precautions

WARNING

Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

When charging the batteries, gas forms in each cell and escapes through the vent holes. In poorly ventilated areas, the gas lingers around the battery several hours after it has been charged. The gas is explosive around sparks, flame, or other intense heat; if ignited, it could cause the battery to explode. Follow these precautions when charging the batteries.

- Wear safety glasses or a face shield when working with batteries. When many batteries are handled, wear rubber gloves and an apron to protect clothing.
- Make sure that the area is well ventilated.
- Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.
- Make sure that the charger cable leads are clean and making good connections. A poor connection could cause an electrical arc which could ignite the gas mixture and explode the battery.
- Do not break live circuits at the terminals because a spark usually occurs at the point where a live circuit is broken. Use care when connecting or disconnecting booster leads or cable clamps on chargers.
- Do not smoke near batteries that are being charged or have recently been charged. Keep the batteries away from open flames or sparks.
- If the battery is frozen, let it reach room temperature and completely thaw before trying to charge it. Check for leaks and cracks before charging the battery. Replace the battery if leaks or cracks are seen.
- Take care that tools or metal objects do not fall across the battery terminals.

WARNING

Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.

CAUTION

If a metal object connects an ungrounded battery terminal to a nearby metal part of the vehicle which is grounded, it could short out the batteries, causing sparks and possible property damage.

Battery Electrolyte Safety Precautions

WARNING

Protect skin and eyes from battery electrolyte (acid). Electrolyte is corrosive and could result in serious personal injury if splashed on your skin or in your eyes.

If electrolyte is splashed on your skin or in your eye, force the eye open, rinse it with cool, clean water for about five minutes and call a doctor immediately. Do not add eye drops or other medication unless advised by the doctor.

If electrolyte is swallowed, drink several large glasses of milk or water. Follow with milk of magnesia, a beaten raw egg, or vegetable oil. Call a doctor immediately.

Use extreme care to avoid spilling or splashing electrolyte. Electrolyte spilled or splashed on your body or clothing should be neutralized with baking soda or household ammonia, then rinsed with clean water.

Electrolyte can also damage painted or unpainted metal vehicle parts. If electrolyte is spilled or splashed on any metal surface, neutralize and rinse it with clean water.

To prevent possible skin burns, do not wear watches, rings, or other jewelry while performing maintenance work on the batteries.

Battery Safety Precautions

WARNING

Do not apply pressure to the end walls of a plastic-case battery. This could cause electrolyte to squirt from the vents, possibly resulting in serious injury to skin or eyes.

When handling plastic-case batteries, use a battery carrier. If one is not available, lift these batteries with your hands placed at opposite corners of the battery.

Emergency Starting Using Booster Cables

⚠ WARNING

Before jump-starting a vehicle, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

⚠ WARNING

Batteries release explosive gas. Do not smoke when working around batteries. Put out all flames and remove all sources of sparks or intense heat in the vicinity of the battery. Do not allow the vehicles to touch each other. Do not lean over the batteries when making connections, and keep all other persons away from the batteries. Failure to follow these precautions could lead to severe personal injury as a result of an explosion or acid burns.

NOTICE

Make sure both electrical systems are the same voltage. Electronic devices on both vehicles can be damaged when connected to a vehicle with a different operating voltage.

1. Apply the parking brakes and turn off all lights and other electrical devices. Ensure that the vehicles are not touching and both ignition switches are turned to the OFF position.

IMPORTANT: Do not attempt to jump start a damaged battery.

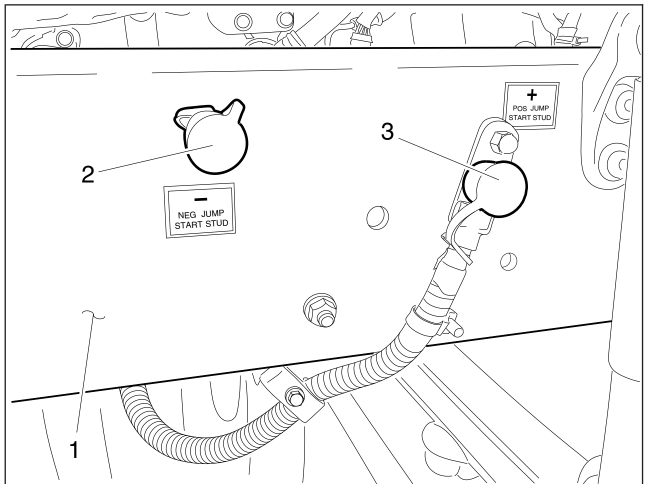
2. Remove the battery box cover.

NOTICE

Always connect the batteries and jumper cables correctly (positive-to-positive and negative-to-negative). Connecting a charging device backwards (positive-to-negative) can severely damage the vehicle electrical content and cause non-warrantable failures.

IMPORTANT: On vehicles equipped with optional jump start posts, connect to these posts instead of the battery terminals. Jump start posts may be installed in various locations on the vehicle. See **Fig. 1**.

3. Connect the positive (+) jumper cable to the positive terminal or jump start post on the discharged battery. See **Fig. 2**.



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1. Frame Rail
2. Negative Jump Start Post
3. Positive Jump Start Post

Fig. 1, Possible Jump Start Post Location (passenger-side engine compartment)

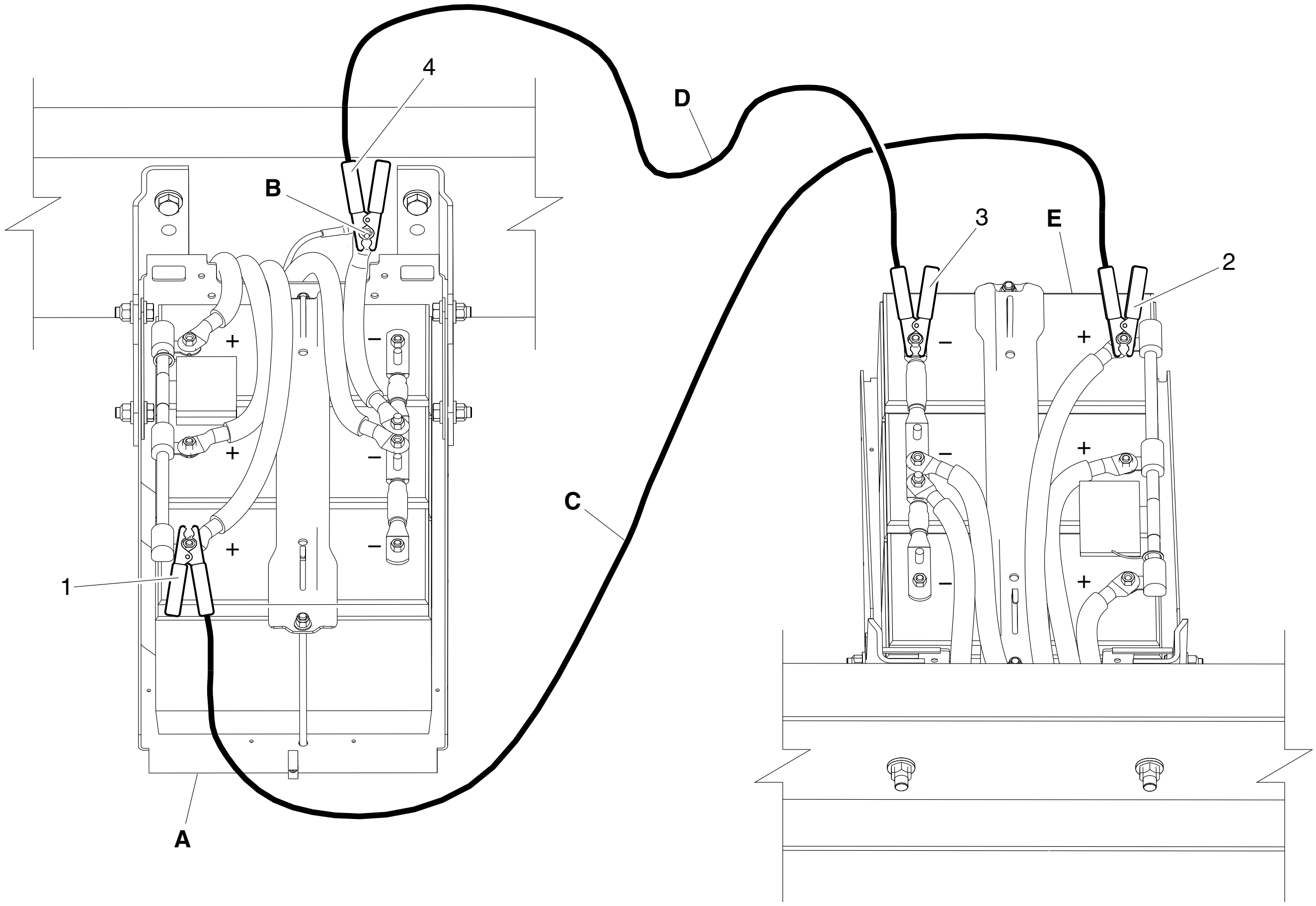
4. Connect the other end of the positive jumper cable to the positive terminal or jump start post on the booster battery providing the charge.

⚠ WARNING

Do the next step exactly as instructed and do not allow the clamps of one cable to touch the clamps of the other cable. Otherwise, a spark could occur near a battery, possibly resulting in severe personal injury from explosion and acid burns.

5. Connect the negative (-) jumper cable to the negative terminal or jump start post on the booster battery.
6. Connect the other end of the negative jumper cable to the negative ground stud on the vehicle requiring the jump start.
7. Start the engine of the vehicle providing the jump start and let the engine run a few minutes to charge the batteries of the other vehicle.

Emergency Starting Using Booster Cables



Disconnect jumper cables in the REVERSE order that they were connected.

A. Discharged Battery
B. Negative Ground Stud
C. Positive Jumper Cable
D. Negative Jumper Cable
E. Booster Battery

1. 1st Connection: Positive Jumper Cable to Discharged Battery
2. 2nd Connection: Positive Jumper Cable to Booster Battery
3. 3rd Connection: Negative Jumper Cable to Booster Battery
4. 4th Connection: Negative Jumper Cable to Negative Ground Stud (discharged battery)

Fig. 2, Jumper Connections

8. Attempt to start the engine of the vehicle receiving the jump. Do not operate the starter longer than 30 seconds, and wait at least two minutes between starting attempts to allow the starter to cool.
9. When the engine starts, let it idle a few minutes.

WARNING

Do the next step exactly as instructed and do not allow the clamps of one cable to touch the clamps of the other cable. Otherwise, a spark could occur near a battery, possibly resulting in severe personal injury from explosion and acid burns.

Emergency Starting Using Booster Cables

10. Disconnect the negative jumper cable from the negative cable stud on the jump-started vehicle.
11. Disconnect the negative jumper cable from the booster battery.
12. Disconnect the positive cable from the booster battery.
13. Disconnect the other end of the positive jumper cable from the jump-started vehicle.
14. Install the battery box cover; be sure it is positioned properly before fastening the latch.

⚠ WARNING

Before charging a battery, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

Battery Charging

AGM batteries may be charged only with a charger that is specified for AGM batteries. Many older chargers operate at a voltage that is too high for AGM batteries and will cause permanent damage. Never combine AGM and flooded batteries together for charging or for use in a vehicle.

See **Table 1** for voltage to approximate battery state of charge for flooded batteries.

Voltage to Approximate Battery State of Charge for Flooded batteries		
Voltage		State of Charge
Flooded	AGM	
12.6	12.8	100%
12.4	12.6	75%
12.2	12.3	50%
12.0	12.0	25%
11.8	11.8	0%

Table 1, Voltage to Approximate Battery State of Charge for Flooded batteries

1. If the batteries are not installed in the vehicle, install the lead adapters on the battery positive and negative posts.
2. Connect the charger to the battery following the manufacturer's instructions. Slightly rock the charger's clamps to insure a complete connection.

IMPORTANT: If the battery feels hotter than 125°F (52°C) or if rapid gassing or spewing of electrolyte occurs, lower the charging rate or stop charging the battery and allow it to cool.

3. When finished, turn the charger off.

⚠ WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

Battery Removal, Cleaning and Inspection, and Installation

WARNING

Before doing any of the following procedures, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Removal

Before working on any battery box, make sure all electrical loads (lights, ignition, accessories) are turned off.

Note what type of battery box is installed. Removal procedures for the side-rail battery boxes are similar; those for the between-rail and the above-rail boxes are completely different.

Three basic battery box installations are available. First, the standard box, long side to rail with a step and diamond plate side cover (for vehicles with one fuel tank and standard cab entry with no side fairings). See Fig. 1.

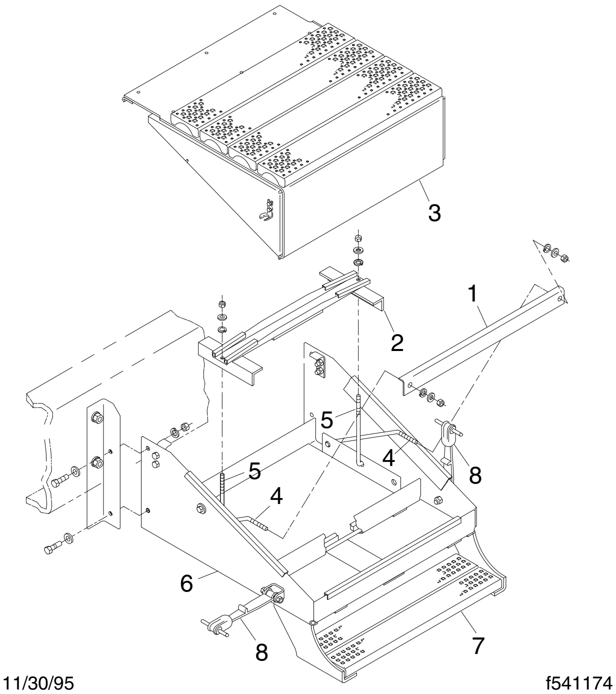
Second, an optional box, long side to rail with no step. See Fig. 2.

Third, a between-rail plastic box for vehicles with dual fuel tanks. See Fig. 3.

SIDE-RAIL BATTERY BOX

1. Remove the threaded fasteners that attach the air fairing panel (if equipped) in front of the battery box. Remove the air fairing panel. For instructions, see Section 31.04, Subject 100.

   If no air fairing panel is installed, remove the step plate.
2. Pull on the end of each hold-down latch until the end clears the cover-mounted catch. Pivot the latches out of the way, then lift off the battery box cover.
3. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components. Remove the battery cables.
4. Remove the battery retainer assembly. Remove the batteries from the carrier.



1. Hold-Down Angle
2. Retainer Assembly
3. Cover
4. Hold-Down Bolt
5. Retainer Bolt
6. Battery Box
7. Step
8. Latch

Fig. 1, Side-Rail Battery Box, Long Side to Rail, with Step and Diamond Plate Side Cover

BETWEEN-RAIL BATTERY BOX

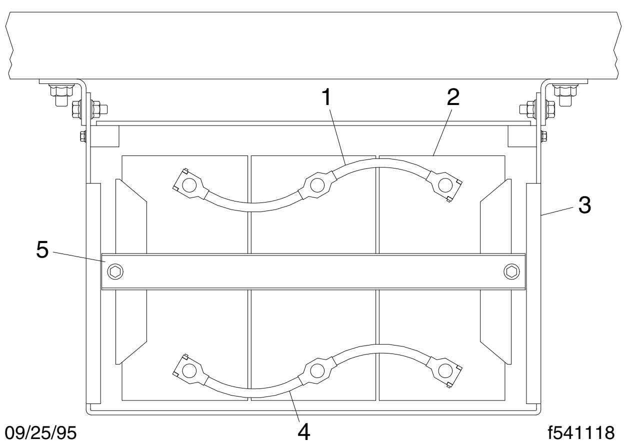
1. Remove the battery box lid. If equipped, remove the spring pin.
2. Disconnect the battery cables from the battery terminals and move the cables out of the way.
3. Remove the battery hold-downs. See Fig. 4.

   3.1 Remove the 5/16–18 hold-down locknut and washer.

   3.2 Slip the hold-down off the 5/16-inch rib-neck bolt.

   3.3 Remove the rib-neck bolt and set all hold-down hardware aside.
4. Remove the batteries from the vehicle. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components.

Battery Removal, Cleaning and Inspection, and Installation



1. Positive Cables (Red)
2. Battery
3. Battery Box
4. Negative Cables (Black)
5. Battery Retainer

Fig. 2, Side-Rail Battery Box, Long Side to Rail, with Cover Removed

5. Remove the battery box. See **Fig. 5**.
   - 5.1 From underneath the battery box, remove the 3/8–16 hexnut and flatwasher from the keeper assembly. Retain the keeper and spring.
   - 5.2 Remove the battery box from the vehicle.
6. Remove the battery box bracket from the frame rail. See **Fig. 6**.
   - 6.1 Remove the lock pin and collar from each Huck® fastener. For instructions, see **Section 31.01**, Subject 050.
   - 6.2 Remove the bracket from the frame rail. The plastic washers are attached to the bracket with pressure-sensitive adhesive and come off with the bracket.

Cleaning and Inspection

1. Inspect all battery cables and interconnectors for wear, and replace them if necessary. Remove corrosion from cables, terminals, and battery posts with a wire brush and a solution of baking soda and water. Rinse thoroughly with clean water, and dry.
2. Clean and tighten the battery ground cable at the weld stud on the frame rail. Inspect and ensure that the nut is self-locking and that a flat washer is used. Do not use a split-lock washer or star washer. Torque the nut 15 to 18 lbf·ft (20 to 24 N·m). Seal the area with red dielectric enamel.
3. Inspect the retainer assembly and battery box. Replace worn or damaged parts. Remove any corrosion with a wire brush and wash with a weak solution of baking soda and water. Rinse with clean water and dry. To prevent rusting, paint the retainer assembly if needed.
4. Be sure foreign objects, such as stones, bolts, and nuts, are removed from the battery box.

Installation

1. Be sure that the battery to be installed has a sufficient capacity to cover the electrical needs of the vehicle.

CAUTION

Using an under-capacity battery will result in poor performance and premature battery failure, resulting in damage or reduced life of the starter.

2. Be sure the battery is at full charge when installed. If the battery has been in storage for some time, or if the installation is being made in subfreezing temperatures, give the battery a boost-charge before installing it. For instructions, see **Subject 120**.

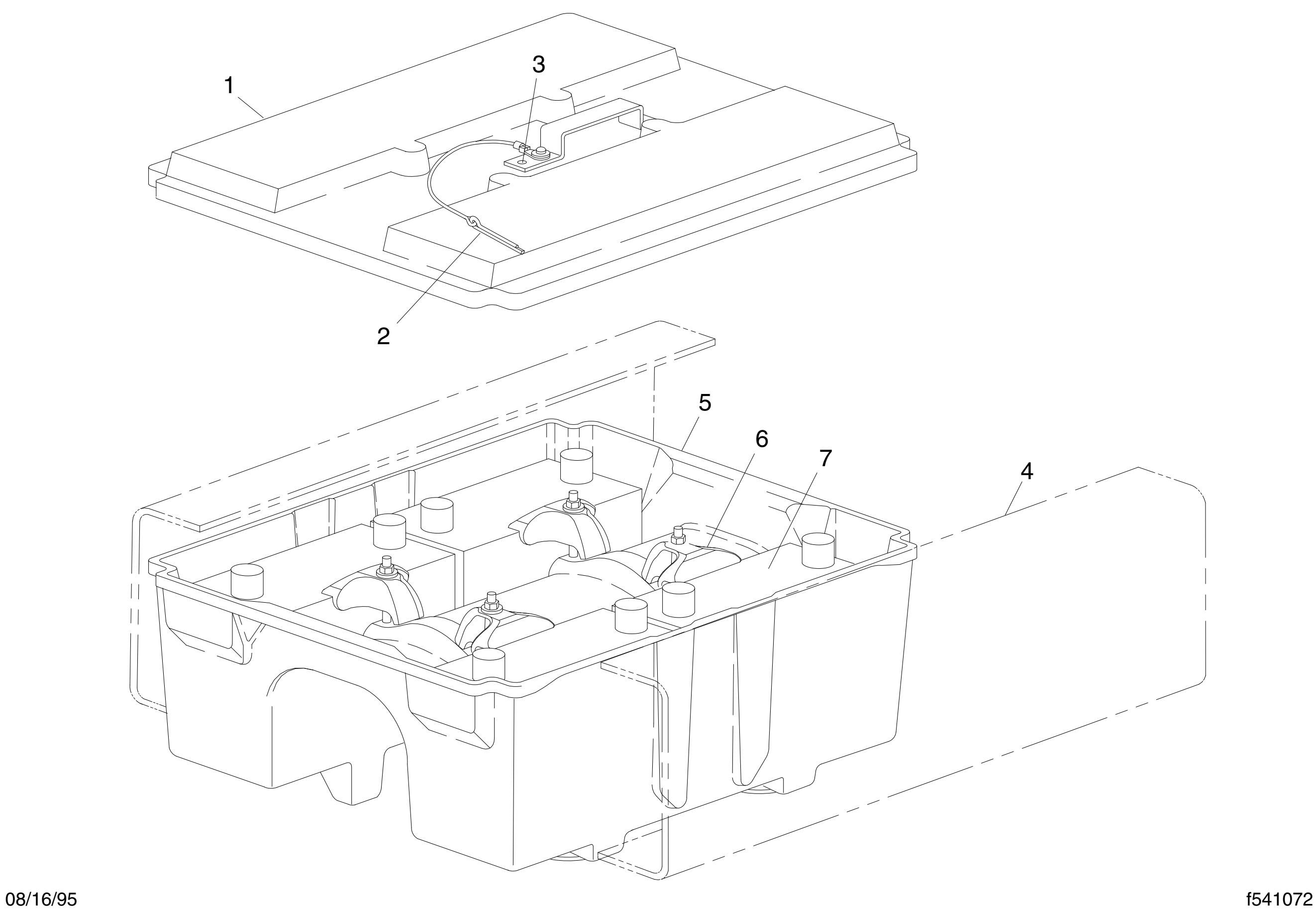
SIDE-RAIL BATTERY BOX

1. Place the batteries in the carrier with the terminals in the proper position, as referenced earlier. The batteries should rest level in the carrier.
2. Install the battery retainer assembly, and tighten it until the batteries are secure. See **Fig. 1**.

CAUTION

Do not overtighten the battery retainer assembly. Overtightening could damage the batteries.

3. Connect the battery cables to the batteries.
   - 3.1 To provide corrosion protection, apply pumpable dielectric grease (48-02349-000) liberally to the terminal pads. For a



1. Battery Box Lid
2. Spring Pin (if installed)
3. Spring Pin Insert Hole
4. Frame Rail
5. Battery Box
6. Battery Hold-Downs
7. Battery

Fig. 3, Between-Rail Battery Box

list of approved suppliers, see **Specifications 400**.

3.2 Install the battery cable interconnectors.

3.3 Tighten the battery cables to the torque specifications listed on the battery, generally 10 to 15 lbf·ft (14 to 20 N·m). Connect the ground cable last.

CAUTION

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

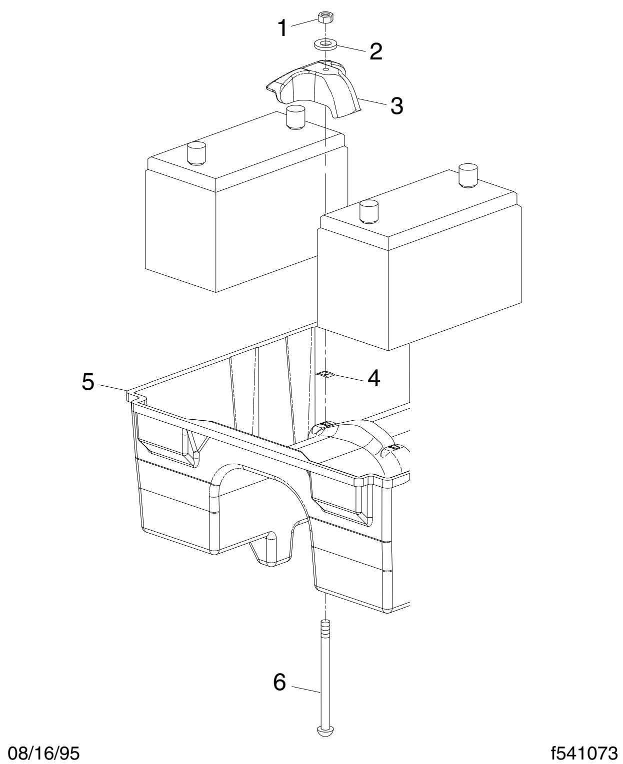
3.4 Check for correct polarity with respect to the vehicle.

4. Start the engine, and check the operation of the charging system. If needed, repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.

CAUTION

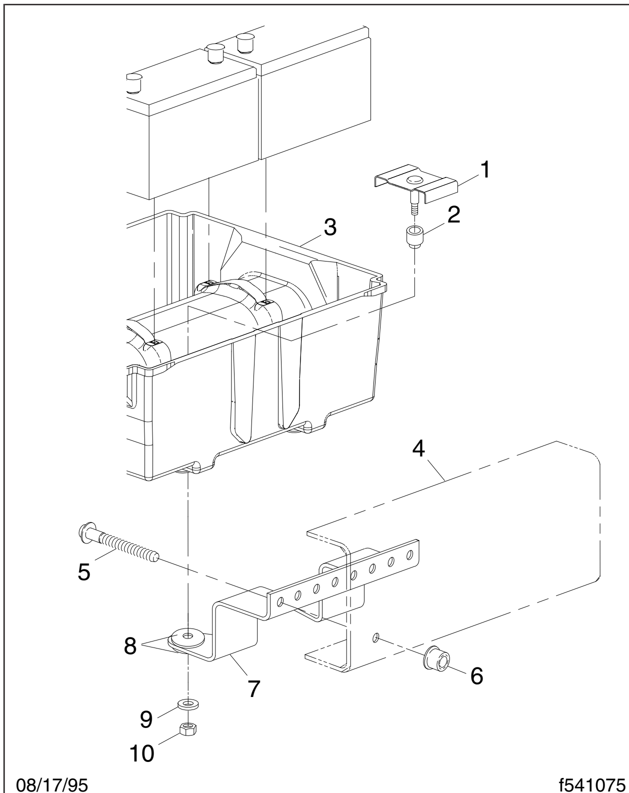
Make sure all battery posts are covered with protective caps. Failure to do so could cause the battery box cover to short across the posts.

Battery Removal, Cleaning and Inspection, and Installation



1. Hold-Down Nut, 5/16–18
2. Flatwasher
3. Hold-Down
4. Push-On Retainer
5. Battery Box
6. Rib-Neck Bolt, 5/16 in

Fig. 4, Battery Hold-Downs



1. Keeper Assembly
2. Spring
3. Battery Box
4. Frame Rail
5. Huck Lock Pin
6. Huck Spin Collar
7. Battery Box Bracket
8. Plastic Washer
9. Flatwasher
10. Hexnut, 3/8–16

Fig. 5, Battery Box Removal

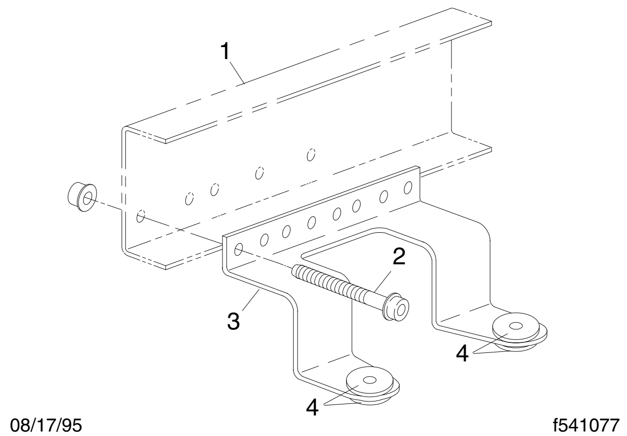
5. Install the battery box cover. Install the threaded fasteners that attach the air fairing panel (if equipped). For instructions, see **Section 31.04**, Subject 100.

   If removed, install the step plate.

BETWEEN-RAIL BATTERY BOX

1. Install the battery box brackets on the frame rail. See **Fig. 6**. Install four new 5/8D Huck lock pins and 5/8-inch spin collars on each bracket. For instructions, see **Section 31.01**, Subject 050.
2. Install the battery box. See **Fig. 5**.
   - 2.1 Line up the holes in the bottom of the battery box with the holes in each bracket.
   - 2.2 Install four keeper assemblies and springs through the holes in the battery box and brackets.
   - 2.3 From underneath the battery box, install a 3/8–16 hexnut and flatwasher on each keeper assembly. Tighten the hexnuts 18 lbf·ft (24 N·m).
3. Place the batteries in the battery box with the terminals in the proper position, as referenced earlier. Make sure the batteries rest level in the box.
4. Install the battery hold-downs. See **Fig. 4**.
   - 4.1 Install a hold-down on each battery.

Battery Removal, Cleaning and Inspection, and Installation



1. Frame Rail
2. Huck Lock Pin
3. Bracket
4. Plastic Washers

Fig. 6, Battery Box Bracket Removal

4.2 Insert a rib-neck bolt up through each hold-down and thread onto it a 5/16–18 hold-down locknut and washer.

CAUTION

Do not overtighten the battery hold-downs. Overtightening could damage the batteries.

4.3 Tighten each locknut 10 lbf·ft (14 N·m).

5. Connect the battery cables to the batteries.

5.1 To provide corrosion protection, apply pumpable dielectric grease (48-02349-000) liberally to the terminal pads. For a list of approved suppliers, see **Specifications 400**.

5.2 Install the battery cable interconnectors.

5.3 Tighten the battery cables to the torque specifications listed on the battery, generally 10 to 15 lbf·ft (14 to 20 N·m). Connect the ground cable last.

5.4 Check for correct polarity with respect to the vehicle.

CAUTION

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

6. Start the engine, and check the operation of the charging system. If needed, repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.

CAUTION

Make sure all battery posts are covered with protective caps. Failure to do so could cause the battery box cover to short across the posts.

7. Install the battery box cover. If equipped, install the spring clip.

Troubleshooting

If the batteries pass testing, check for the following causes:

1. Accessories were left on overnight.
2. A slipping alternator belt, high resistance in the wiring, or a defective alternator is causing the batteries to discharge.
3. The electrical loads are exceeding the charging system capacity.
4. Wires in the electrical system are shorted or pinched.
5. There are loose or damaged battery cable-to-terminal connections.
6. The batteries are still connected in a vehicle that has been out of service. Small current drains of accessories that are connected all the time can discharge the batteries in a few days. Batteries left in a discharged condition are subject to freezing.

Electrical Drain and Parasitic Load

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough to cause a no-start condition.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off. Some devices, such as the electronic control unit (ECU), the bulkhead module (BHM), the chassis module (CHM), the antilock braking system (ABS), and radio memory are intended to draw a very small current continuously. These draws are measured in milliamps (mA). Current draw should be less than 325 milliamps with no circuits active and the ECU, BHM, CHM, and ABS turned off.

Problem—The Batteries Are Undercharged

Problem—The Batteries Are Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt and tensioner. Refer to the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the alternator section in **Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. Refer to the troubleshooting subject in the alternator section in **Group 15** for instructions.
The batteries are undercharged.	Perform a battery test. Charge or replace batteries as needed. If the batteries were discharged, start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The alternator or battery cables are undersized.	Perform a cable load drop test.
The alternator is malfunctioning.	Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The isolator relay is not operating correctly (optional battery isolator system only).	Refer to **Group 82, Subject 300** in this manual for instructions.

Battery Troubleshooting

1. **Check battery pack voltage to determine state of charge**.

   If equipped, set Load Disconnect Switch to "Off." With the DMM probes on the positive and negative posts of the battery pack, record the voltage. Due to differences in their design and operation, flooded cell and AGM batteries have different voltages at the same state of charge.

   Batteries should be fully charged before further testing. If batteries are not fully charged, they will draw current to recharge during testing, invalidating the troubleshooting test results. Fully charged batteries ensure reliable diagnosis.

   See **Table 1** for voltage as an approximate indicator of state of charge for AGM and flooded batteries.

   If the battery pack will not charge to 100% state of charge, there may be a shorted cell. Break the pack into individual batteries and test individually using an approved tester. Go to **Check 3, Individual Battery Testing**. After batteries have been tested individually, verify pack voltage once again.

Flooded	AGM	SoC
12.6	12.8	100%
12.4	12.6	80%
12.3	12.4	60%
12.1	12.2	40%
12	12	20%
11.8	11.8	0%

Table 1, Voltage to Approximate State of Charge (SoC)

2. **Remove surface charge: HVAC blower, lights on, 5 min.**

   Surface charge refers to a higher initial charge (volts), when discharging, in recently-charged batteries. This charge is a "shallow" charge, meaning that the charging-induced chemical reaction has mostly occurred at the surface of the lead plates, and has not equalized throughout the lead. Drawing current from the batteries before testing removes the surface charge, allowing for a better assessment of the "deep charge" state of the lead plates.

   After the surface charge is removed, the batteries need to be at least 80% SoC for further testing. See **Table 1** for voltage as an approximate indicator of state of charge.

3. **Test Individual Batteries**.

   IMPORTANT: Batteries should only be tested individually.

   3.1 Remove the negative cables of the batteries first, and secure the leads out of the way before touching the positive cables. Remove the battery cables and clean the terminal pads with a wire brush. The adapters will not make sufficient contact with dirty or corroded contact pads.

   3.2 Connect the battery tester's positive and negative clamps to the lead base terminal pads at the positive and negative studs. See **Fig. 1**.

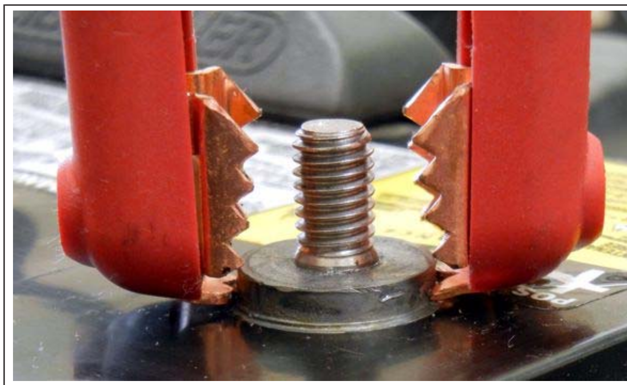

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Fig. 1, Tester Clamps Attached to the Post

The threaded portion of the battery posts are *not* the right place to clip: the steel threads won't make a good connection. The base of the post, on the lead, is the best place to clip. Taking a few extra seconds to make sure the tester, DMM, and carbon pile clips are well-connected can be the difference between a useful and a useless test.

NOTE: If the lead base is too small to clamp to, only lead stud adapters should be used, never nuts. The lead stud adapters must be screwed down tight against the cleaned lead base using a hand tool. Lead adapters are available at most tool vendors.

Refer to the battery tester instruction manual for complete testing instructions.

If the battery tester requires the CCA rating of the battery, it should be on the battery label. See **Fig. 2**.

3.3 If the battery fails, enter the battery serial number and print out the result. The sensor windows on the tester and printer must be aligned to transmit the test results to the printer.

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Fig. 2, Battery Label

Specifications

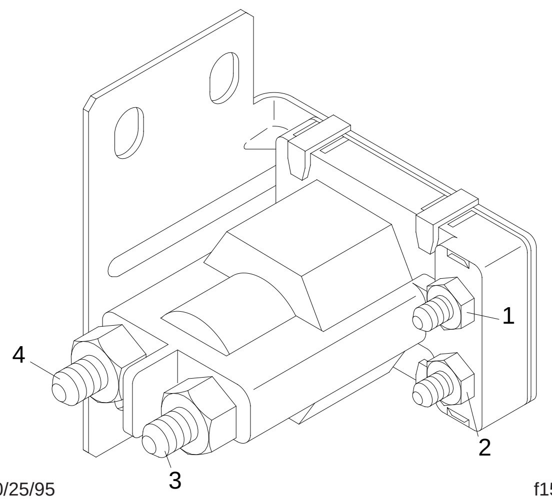
See **Table 1** for recharge times. Refer to the commercial batteries page at **www.dekabatteries.com** for more information.

Recharge Time Using a Typical Charger (hours)						
Open Circuit Voltage		State of Charge	Charger Maximum Rate			
Flooded	AGM		50 Amps	30 Amps	20 Amps	10 Amps
12.6V	12.8V	100%	Ready to Use			
12.4V	12.6V	75%	0.6	0.9	1.3	2.5
12.2V	12.3V	50%	1.2	1.9	2.7	5.1
12.0V	12.0V	25%	1.8	2.9	4.3	10.7
11.8V	11.8V	0%	2.5	4.0	5.7	10.7

Table 1, Recharge Time Using a Typical Charger

General Information

All 12-volt starting systems are equipped with a heavy duty starter relay, referred to as a magnetic switch. See **Fig. 1**. The magnetic switch is attached to the lower left-hand frontwall. When the ignition switch is held in the extreme clockwise (START) position, the magnetic switch closes, connecting electrical current to the starter motor solenoid. The starter motor solenoid engages the starter motor pinion into the engine flywheel ring gear and then energizes the starter motor.



1. Coil Terminal (to ground)
2. Coil Terminal (to ignition switch)
3. Switch Terminal (to solenoid)
4. Switch Terminal (to starter BAT terminal)

Fig. 1, Magnetic Switch

The magnetic switch consists of a winding mounted around a hollow cylinder containing a movable core (plunger) with a contact disk that is assembled onto the plunger.

When the magnetic switch winding is energized, plunger movement causes the contact disk to be held tightly against the two main switch terminals. The contact disk closes the circuit between these terminals and activates the starting motor. When the winding is de-energized, a return spring causes the plunger to return to its original position, opening the circuit to the starter motor solenoid.

Magnetic Switch Replacement

NOTE: Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do the Preliminary Checks and the Magnetic Switch Circuit Test as described in **Troubleshooting, 300**.

Replacement

The magnetic switch cannot be disassembled. If the magnetic switch does not work, replace it.

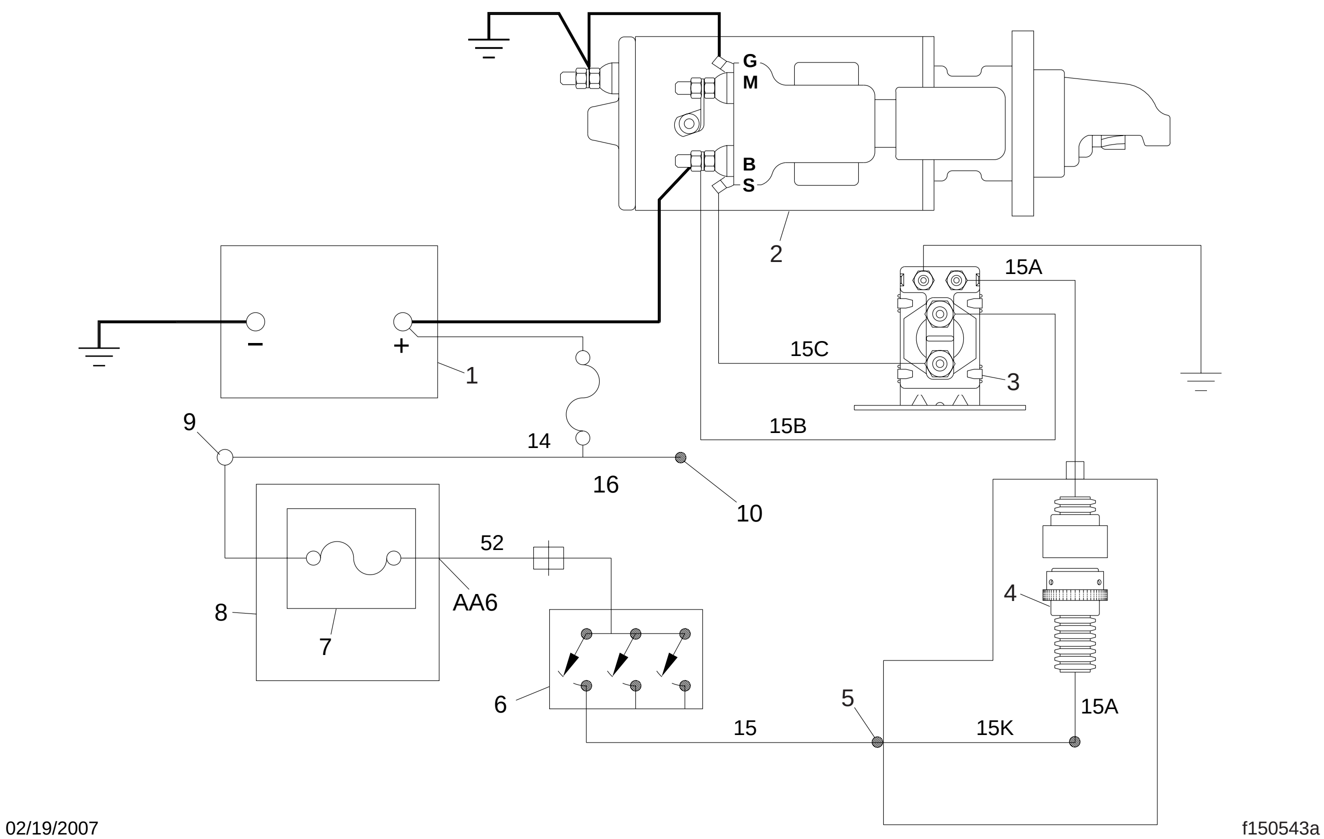
1. Apply the parking brakes and chock the rear tires.
2. Open the hood.
3. Disconnect the batteries.
4. Locate the magnetic switch on the frontwall.
5. Mark the wires for later reference, then disconnect the wires that are attached to the magnetic switch. See **Fig. 1**.
6. Remove the two mounting screws that attach the magnetic switch to the frontwall.
7. Remove the two large terminal nuts.
8. Disconnect the two-pin pigtail connector. Remove the magnetic switch.
9. Install the new magnetic switch on the frontwall.
   - 9.1 Tighten the mounting screws 84 lbf·in (940 N·cm).
   - 9.2 Connect the wires to the magnetic switch, using the marks made on removal. Tighten the terminal nuts securely.
   - 9.3 Connect the 2-pin pigtail connector.
10. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Approved Dielectric Red Enamel	
Protectant Material	**Approved Brands**
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at **www.glyptal.com** or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

11. Install the inner fender splash shield.
12. Connect the batteries and close the hood.
13. Remove the chocks from the tires.

Magnetic Switch Replacement



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (Pin E1)
5. Splice Connector
6. Ignition Switch
7. Circuit Breaker, 10-Amp
8. Power Distribution Module
9. Cab/Frontwall Power Stud
10. Engine Power Stud

Fig. 1, Magnetic Switch Wiring

Preliminary Checks

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do these Preliminary Checks and the Magnetic Switch Circuit Test.

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.02**. Subject 140. Be sure the batteries are fully charged.

NOTE: The wiring, switches, and starter motor cannot be checked if the batteries are damaged or discharged.

4. Check the starting motor, ignition switch, and starter solenoid for damage or wear. Repair or replace the component(s), as needed.
5. Make sure that the thermostat in the Delco-Remy 450 series starters has not opened because of high heat in the starter. Allow the starter one to six minutes to cool before performing the following tests.

Magnetic Switch Circuit Test

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do this test:

NOTE: If the starter motor is equipped with a thermostat switch (Over-Crank Protection, OCP), make sure that the thermostat contacts are closed before troubleshooting the starter circuit.

1. Complete the preliminary checks described above.
2. Check the wiring and the magnetic switch for wear or damage. See **Fig. 1**.
3. Check the wiring between the magnetic switch and the starter B terminal (circuit 15B) for correct voltage.

    3.1 Connect a voltmeter to the magnetic switch terminal where the circuit from the starter B terminal is connected (circuit 15B).

    3.2 If the voltmeter reading is 0 volt, check for an open circuit.

    If the voltmeter reading is less than 12.0 volts, check for corroded or loose connections. Repair or replace any damaged wires or cables.

    If the voltmeter reading is 12.0 volts or more, check the magnetic switch ground circuit as described in the next step.

4. Check the ground circuit for the magnetic switch winding.

    4.1 Connect an ohmmeter between the ground terminal for the magnetic switch winding and a known good ground.

    4.2 If the ohmmeter reading is more than 0.5 ohm, check for corroded or loose connections.

    4.3 Repair or replace any damaged wires.

5. Check the ignition wiring (circuit 15) for the magnetic switch winding for the correct voltage. Disconnect the wiring running from the starter S terminal to the magnetic switch (circuit 15C).

    NOTE: This check requires two persons.

    5.1 Have one person turn on the ignition switch and hold it in the START position.

    5.2 Have the other person connect a voltmeter between the magnetic switch winding terminal where the ignition circuit is connected (circuit 15A) and a known good ground.

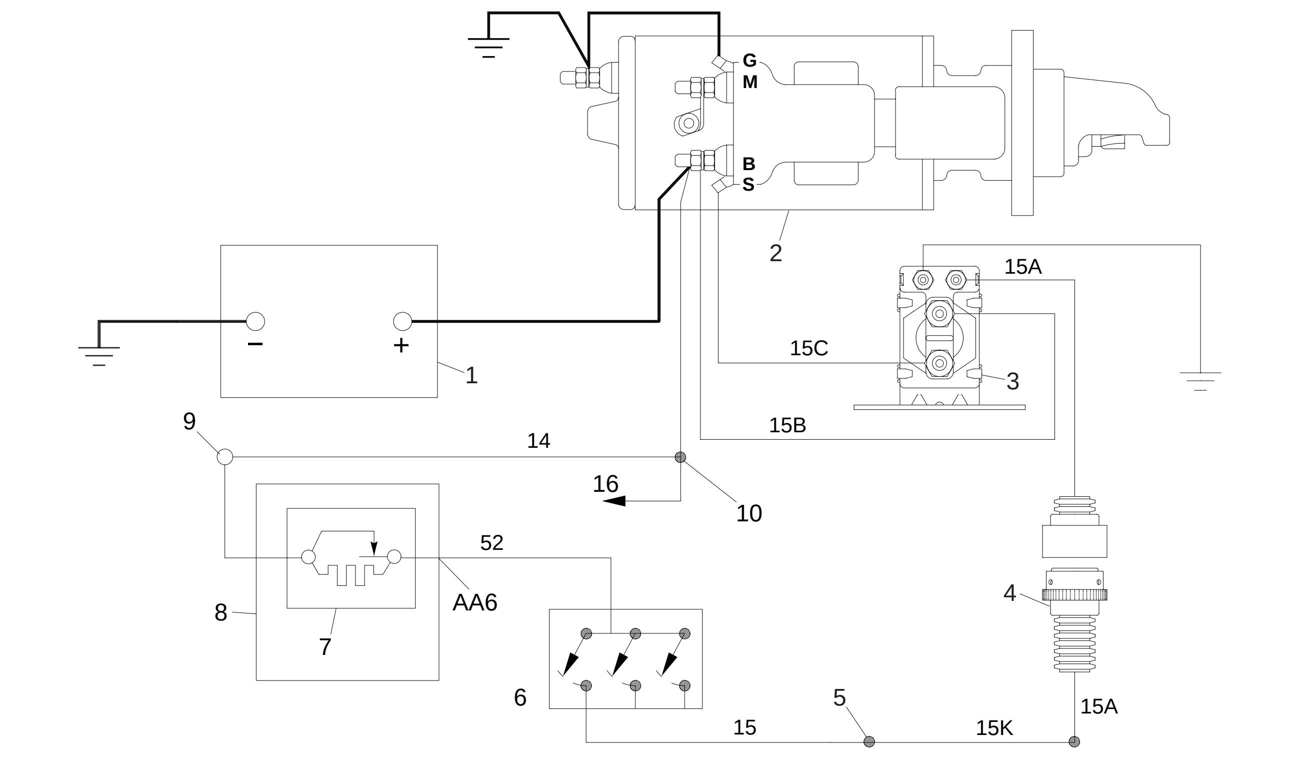
    5.3 If the voltmeter reading is 0 volt, check for an open in circuit 15A. Repair or replace any damaged wires, circuit breakers, relays, or the ignition switch.

    If the voltmeter reading is less than 11.0 volts, check for corroded or loose connections.

    If the voltmeter reading is 11.0 volts or more, go to the next step.

6. Check the magnetic switch at the terminal (circuit 15C) from the starter solenoid S for correct voltage. This tests the operation of the magnetic switch and provides a no-load test of the magnetic switch contacts.

Troubleshooting



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (pin E1)
5. Splice Connector
6. Ignition Switch
7. Circuit Breaker, 10-Amp
8. Power Distribution Module
9. Cab/Frontwall Power Stud
10. Engine Power Stud

Fig. 1, Magnetic Switch Wiring

NOTE: This check requires two persons.

6.1 With the wire from the S terminal still disconnected from the magnetic switch, have one person hold the ignition switch in the START position.

6.2 Have the other person connect a voltmeter between the magnetic switch terminal where the circuit from the starter S terminal connects (circuit 15C) and a known good ground.

6.3 If the voltmeter reading is less than 11.0 volts, replace the magnetic switch. For instructions, refer to **Subject 100**.

6.4 If the voltmeter reading is more than 11.0 volts, perform the Magnetic Switch Contactor Test as described below.

Magnetic Switch Contactor Test (Under Load)

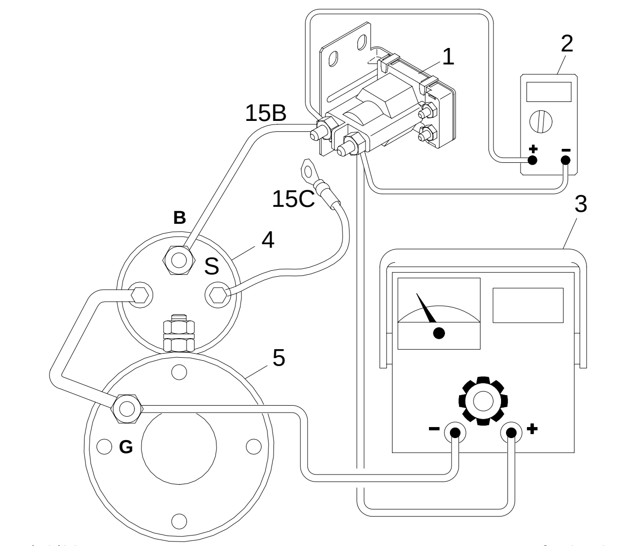
The cranking circuit includes the battery, starter solenoid, cranking motor, magnetic switch, and ignition switch.

If there is excessive voltage loss in the cranking circuit, the starter may not engage the flywheel at all, or it may release too soon when battery voltage is low. In this case, check the cranking circuit and starter solenoid for voltage loss. For instructions, refer to the appropriate section in **Group 15**.

Troubleshooting

If the magnetic switch closes during the cranking circuit test and the starter wiring test, also check the magnetic switch contactor for voltage loss when it is under a heavy electrical load.

1. Disconnect (at the magnetic switch) the wire 15C from the S (starter solenoid) terminal and connect one lead from a carbon pile tester to that magnetic switch terminal stud.
2. Connect the other lead of the carbon pile to the G (ground) terminal on the starter.
3. Set a digital voltmeter on the low scale and connect the positive lead to the magnetic switch battery terminal (15B). Connect the negative lead to the large terminal on the magnetic switch that has the carbon pile connected. See **Fig. 2**.



1. Magnetic Switch
2. Digital Voltmeter
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

Fig. 2, Magnetic Switch Contactor Test

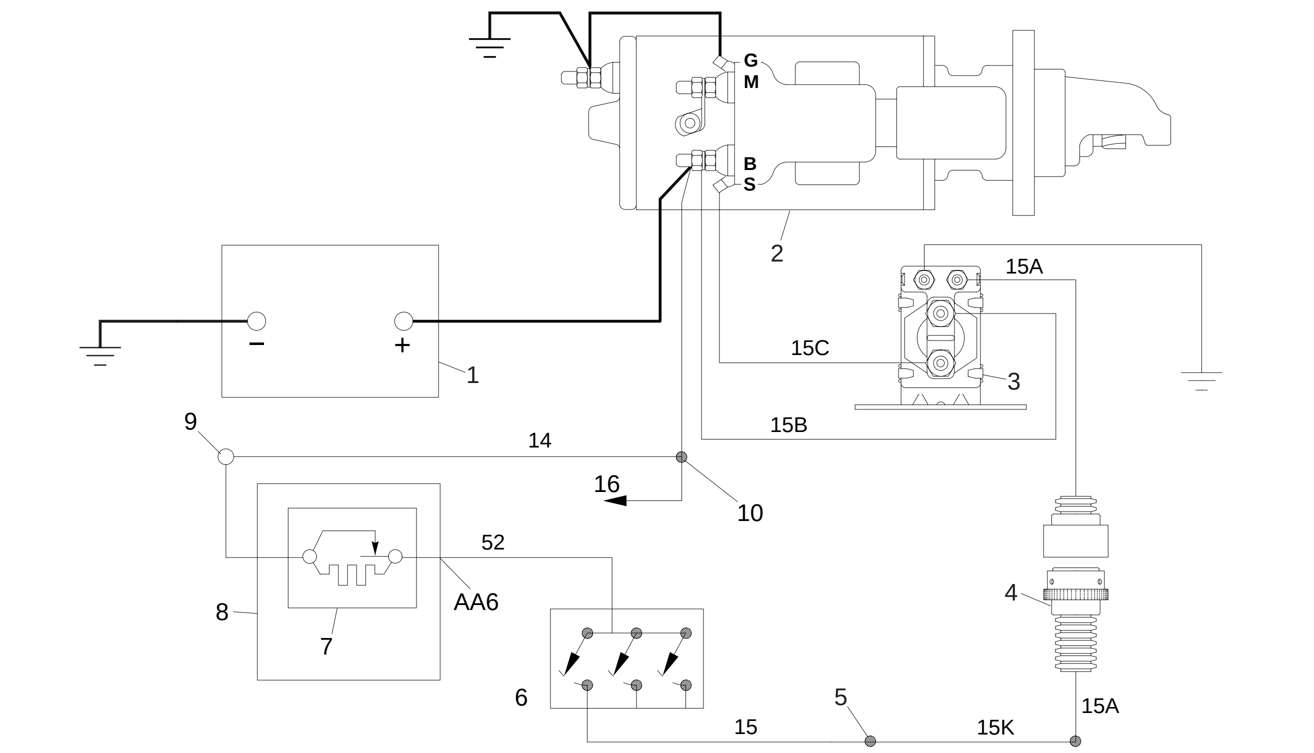
4. Hold the ignition switch in the START position and read the voltage on the voltmeter. It should read 0 volt.
5. Hold the ignition switch in the START position, turn on the carbon pile and adjust it to a 100-amp load.
6. Hold the ignition switch in the START position and again read the voltage on the voltmeter. Turn off the ignition switch and the carbon pile.

   If the voltage reading is 0.5 volt or less, the magnetic switch contactors are satisfactory.

   If the voltage reading is more than 0.5 volt, replace the magnetic switch.
7. Connect wire 15C from the starter solenoid S terminal to the magnetic switch.
8. Close the hood and remove the chocks from the tires.

Specifications

For magnetic switch wiring, see **Fig. 1**.



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Frontwall Connector (Pin E1)
5. Splice Connector
6. Ignition Switch
7. 10-Amp Circuit Breaker
8. Power Distribution Module
9. Cab/Frontwall Power Stud
10. Engine Power Stud

Fig. 1, Magnetic Switch Wiring

General Information

Circuits requiring protection are routed through circuit breakers mounted in a power distribution module. There are two power distribution modules. The main power distribution module (**Fig. 1**) is the electrical power center of the vehicle and is mounted underneath the electrical cover inside the upper dash assembly (right-hand panel).

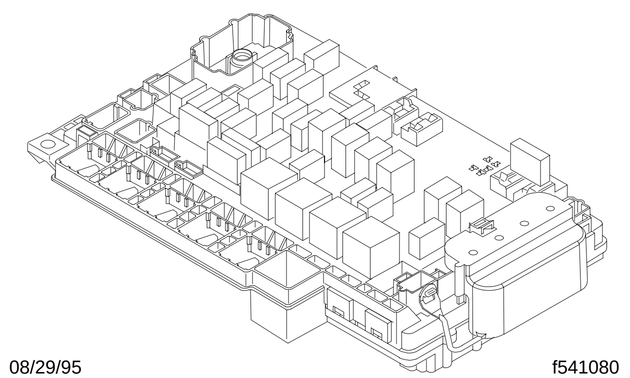


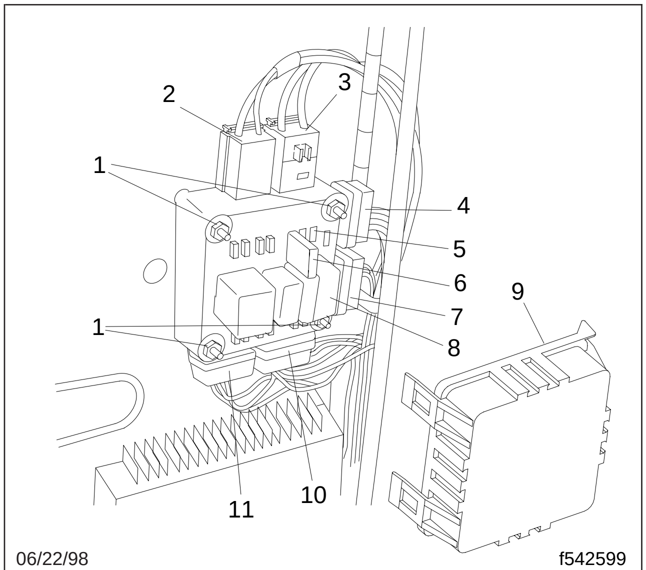
Fig. 1, Main Power Distribution Module

There is also an auxiliary power distribution module mounted on the inside of the electrical compartment door located on the B-pillar on the left-hand side behind the seat. See **Fig. 2**.

The auxiliary power module has three horizontal rows:

- The top row contains several fuses for the sleeper lighting and one sleeper HVAC circuit breaker.
- The middle row contains three relays for the sleeper HVAC.
- The bottom row contains ignition and battery power for the ABS and data logging unit (DLU).

The new auxiliary power module on the Columbia also has six plug-in connectors for easy disconnection of circuits during troubleshooting.



1. Locknut, 10–24
2. Connector P6
3. Connector P5
4. Connector P4
5. Fuse
6. Circuit Breaker
7. Connector P3
8. Relay
9. Cover
10. Connector P2
11. Connector P1

Fig. 2, Auxiliary Power Distribution Module

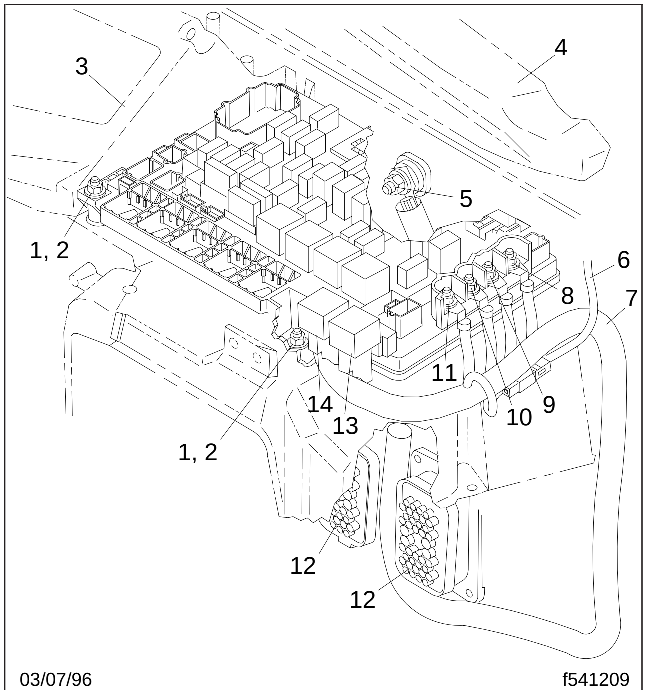
Main Power Distribution Module Removal and Installation

Removal

1. Apply the parking brakes and chock the rear tires. Disconnect the batteries.
2. Push the button to remove the electrical cover.
3. Remove the HVAC ducting.
   3.1 Remove the horizontal piece of ducting on top of the main power distribution module (PDM).
   3.2 Remove the two fasteners holding the vertical piece of ducting along the kick panel. Remove the ducting.
4. Remove the cover from the four PDM ring terminals on the right-hand side of the main PDM. Remove the ground connector from the right-hand aft corner of the PDM.
5. Remove the four ring connectors from their terminals. See **Fig. 1**. Mark with a paint pen for ease in installation.
6. Remove the PDM from the vehicle.
   6.1 Remove the two hold-down nuts and washers from the aft edge of the PDM.
   6.2 Remove the eight electrical connectors B through J from the top of the PDM by inserting a flat-blade screwdriver on the side of the plug to unfasten the clips. See **Fig. 2**. Remove the 7-mm capscrew attaching 46-pin connector A to the PDM.
   6.3 Unfasten the locking clips on the relays on the aft edge of the PDM. Push the relays through the holes in the PDM. Mark with a paint pen.
   6.4 Disconnect the accessory (ACC) and ignition (IGN) relays (the two relays fastened to the PDM with spade connectors). Then detach the clips from the PDM with care.

   IMPORTANT: Do not break the clip off the spade connector.

   6.5 Rotate the PDM to an angle of about 60° from vertical to expose the bottom of the PDM. If the PDM will not rotate that far because of binding from the electrical harness, disconnect the three main junction connectors and cut tie straps as needed to gain enough flexibility. See **Fig. 3**.



1. Hold-Down Nut, 1/4–20
2. Hold-Down Washer, 1/4"
3. Dash Panel
4. Main Defrost Duct
5. Cab Power Stud
6. Breakout from Main Dash Harness
7. PDM Power Harness
8. ACC Ring Terminal
9. IGN Ring Terminal
10. ISO Ring Terminal
11. BAT Ring Terminal
12. Cannon Plugs
13. ACC Relay
14. IGN Relay

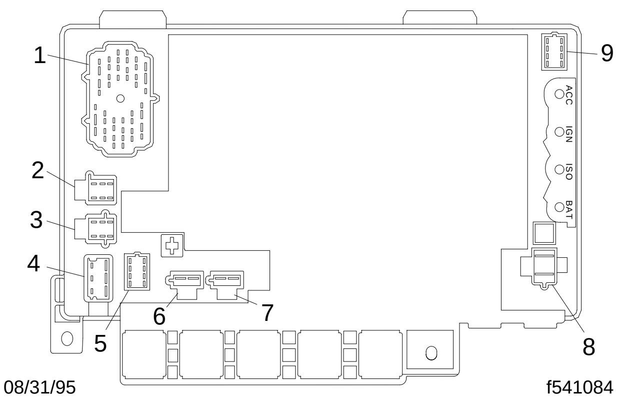
Fig. 1, Main Power Distribution Module

NOTE: To disconnect the junction connectors, first disconnect, from the engine side, the cannon plugs leading to the junction connectors. Both the cannon plugs and the junction connectors fasten with clips on their top edges.

   6.6 Remove the electrical pins and connectors from the four terminals at the bottom of the PDM, including the large 46-pin connector N. See **Fig. 4**.

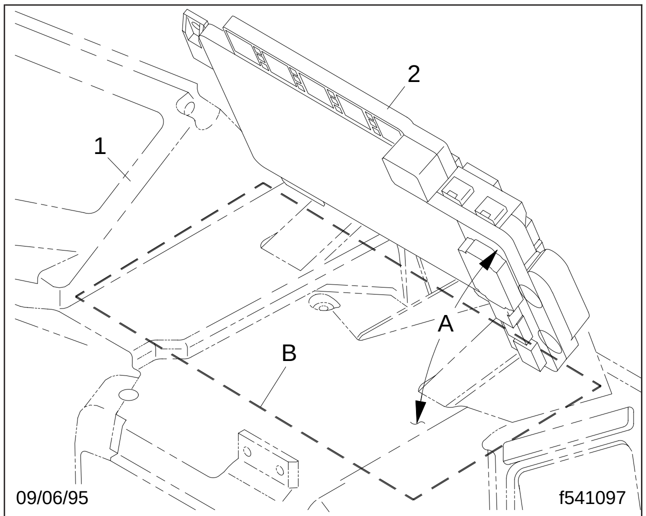
NOTE: There is a 7-mm capscrew attaching 46-pin connector N to the PDM.

Main Power Distribution Module Removal and Installation



1. 46-Pin Connector A
2. 6-Pin Connector B
3. 6-Pin Connector C
4. 6-Pin Connector D
5. 8-Pin Connector E
6. 2-Pin Connector F
7. 2-Pin Connector G
8. 2-Pin Connector H
9. 8-Pin Connector J

Fig. 2, Pin Connectors (top view)



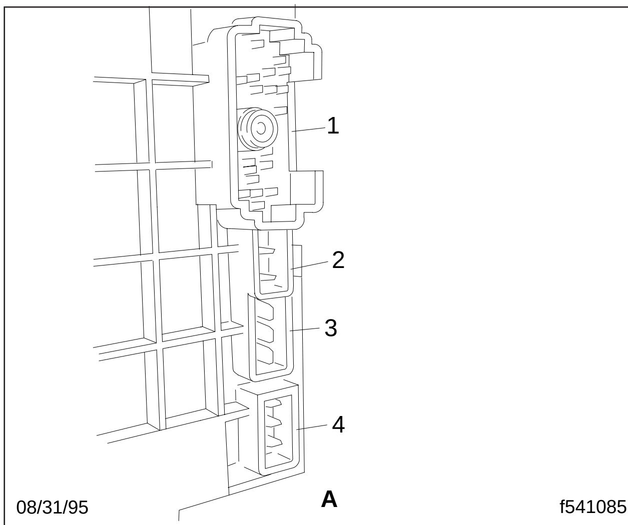
Tilt the PDM onto its forward edge. At Angle A, it can be removed from the vehicle more easily.

A. 60° angle (approximate).
B. Original position of PDM.

1. Upper Dash Panel
2. Power Distribution Module

Fig. 3, Tilting the Power Distribution Module

6.7 After all the plugs and connectors have been removed, remove the PDM from the vehicle.



A. Forward edge of PDM.

1. 46-Pin Connector N
2. 2-Pin Connector M
3. 6-Pin Connector L
4. 6-Pin Connector K

Fig. 4, Pin Connectors (bottom view)

Installation

1. With the PDM tilted upwards, install the connectors to the bottom of the PDM. Attach the 7-mm capscrew to 46-pin connector N. See **Fig. 4**.
2. Place the PDM over the two attaching studs with the holes lined up. Make sure the ground wire and all ring terminals, harnesses and electrical connectors are clear. See **Fig. 1**.
3. Install the PDM on the vehicle.

   3.1 Install the ground connector to the lower right-hand receptacle.

   3.2 Install the ring connectors using the markings made on removal. Install the attaching nuts and washers.

   3.3 Attach the 7-mm capscrew to the 46-pin connector and install it to the top of the PDM. See **Fig. 2**.

   3.4 Attach all relays and electrical connectors to the top of the PDM, using the markings made on removal. Attach all locking clips and make sure the connections are firm.

IMPORTANT: Do not break the clip off the spade connector.

Main Power Distribution Module Removal and Installation

3.5 Fasten the PDM to the cab with the hold-down nuts and washers.

4. Install the HVAC ducting on the vehicle.
   4.1 Install the vertical piece of ducting along the right-hand kick panel, using the two fasteners removed earlier.
   4.2 Install the horizontal piece of ducting over the PDM.
5. If removed, install the junction connectors on the frontwall. Attach tie straps as needed and reroute the electrical harness to its correct position.
6. Install the electrical cover.
7. Connect the batteries. Remove the chocks from the tires.

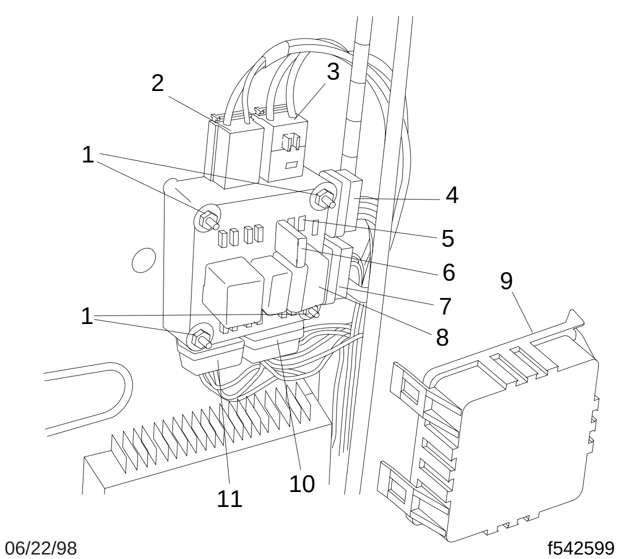
Auxiliary Power Distribution Module Removal and Installation

Removal

1. Apply the parking brakes and chock the rear tires. Disconnect the batteries.
2. Open the electrical compartment door on the left-hand B-pillar, behind the seat. The auxiliary power distribution module is installed on the inside of the door.

NOTE: For a list of individual relays and circuit breakers installed on the auxiliary power module and their plug-in positions, see **Troubleshooting, 300**.

3. Remove the auxiliary power distribution module. See **Fig. 1**.



1. Locknut, 10–24
2. Connector P6
3. Connector P5
4. Connector P4
5. Fuse
6. Circuit Breaker
7. Connector P3
8. Relay
9. Cover
10. Connector P2
11. Connector P1

Fig. 1, Auxiliary Power Distribution Module

3.1 Unplug the six electrical connectors (top, right-hand side, and bottom) and mark them for later installation.

3.2 Remove the four 10–24 locknuts and washers attaching the auxiliary power module to the B-pillar access door.

3.3 Remove the auxiliary power module from the electrical compartment door.

Installation

1. Install the auxiliary power distribution module onto the left-hand B-pillar electrical compartment door. See **Fig. 1**.

1.1 Install the four mounting locknuts and washers attaching the auxiliary power module to the B-pillar access door.

1.2 Attach the six electrical connectors, as removed.

2. Close the electrical compartment door on the left-hand B-pillar.
3. Connect the batteries. Then remove the chocks from the tires.

Main PDM

To troubleshoot malfunctioning circuit breakers (C/Bs) and relays, do the following:

1. Check the circuit breaker/relay location on the applicable figure.
2. Check the applicable table to find the breaker or relay size and note the pin (or plug) positions.
3. Replace the C/B or relay.
4. Find the pinouts (or plug-ins) on the applicable figure and check the circuit again.

For circuit breaker and relay locations on the main power distribution module (PDM), see **Fig. 1**.

For a list of standard component circuit breakers and relays installed in the main PDM, see **Table 1**. For a list of optional component circuit breakers and relays installed in the main PDM, see **Table 2**.

Troubleshooting

Fig. 1, Main PDM Circuit Breaker/Relay Locations

Circuit Breaker/Relay ID (standard components)			
Pos.	**Pin No.**	**Component**	**Description**
02	AF5	10-Amp C/B	A/C Clutch
04	AF2	Flasher	Turn Signal Flasher
08	AB8 AE6 AE7	Micro Relay	Starter Lock-Out (not used at this time)
09	MB	40-Amp Fuse	Cab Wiring
11	AF2	20-Amp C/B	Turn Signals
12	AB7 AF4 AD6	15-Amp C/B	Panel Lights

Circuit Breaker/Relay ID (standard components)			
Pos.	**Pin No.**	**Component**	**Description**
13	AB4 AB3 BD BE BF	10-Amp C/B	ICU Optional Gauges
16	AA3 AA4 AA7 BB	10-Amp C/B	ICU Battery Power
17	DE NC1 JD	15-Amp C/B	Ignition-Powered Options

Circuit Breaker/Relay ID (standard components)			
Pos.	Pin No.	Component	Description
26	AF1 AE2	10-Amp C/B	ICU Ignition Power
28	AE1	15-Amp C/B	Left Headlight
29	AD4	15-Amp C/B	Right Headlight
30	AB7 AF4 AD6	Micro Relay	Panel Lights
31	AE1 *	Micro Relay	Left Headlight
32	AD4 *	Micro Relay	Right Headlight
33	AE3 * AD3 *	Micro Relay	Tractor Tail & Marker Lights
35	AE8 * NE8 *	Micro Relay	High-Speed Wipers
36	AD8 * NB5 *	Micro Relay	Low-Speed Wipers
38	AA6	10-Amp C/B	Ignition Switch
39	AE3 * AD3 *	15-Amp C/B	Tractor Taillights
40	AA5	25-Amp C/B	Stop Lights
41	AF3 DD	15-Amp C/B	Cigar Lighter
43	AC6 *	15-Amp C/B	Dome Light
45	EC JH	15-Amp C/B	Accessory-Powered Options
48	NF5	10-Amp C/B	Back-Up Lights
49	AD5 *	15-Amp C/B	Windshield Wipers
52	ND8	15-Amp C/B	Horn
53	NF8	30-Amp C/B	Trailer Taillights
54	NA2	30-Amp C/B	Trailer Marker Lights
55	AA2 *	30-Amp C/B	HVAC
56	AA1 * NF2 * NF7 *	Mini Relay	HVAC High-Speed
57	AA2 * KA *	Mini Relay	HVAC Regular-Speed
58	NF6 *	Mini Relay	Trailer Taillights
59	NA2 *	Mini Relay	Trailer Marker Lights

* Pin assignments may vary.

Table 1, Main PDM Circuit Breaker/Relay ID (standard components)

Circuit Breaker/Relay ID (optional components)			
Pos.	Pin No.	Component	Description
01	AE5	10-Amp C/B	Engine Fan
03	BC FA GA KC	10-Amp C/B	Power Door Locks
05	LB	30-Amp C/B	Fuel Heater
06	KB	30-Amp C/B	Trailer Aux
07	LB	Mini Relay	Fuel Heater
10	MA	60-Amp Fuse	Sleeper Cab Wiring
14	ED JB	10-Amp C/B	Radio (ACC Bus)
15	AB1 BA	15-Amp C/B	Utility Lights
18	CE LA	15-Amp C/B	Right-Hand Power Window
19	JA	10-Amp C/B	Windshield Fan
20	NE7 NE6 AE4	20-Amp C/B	Road Lights
21	DF JF	10-Amp C/B	CB Radio (ACC Bus)
22	LE	10-Amp C/B	Daytime Running Lights
23	JC	10-Amp C/B	Spotlight
24	LC	30-Amp C/B	Trailer ABS
25	CC	15-Amp C/B	Left-Hand Power Window
27	CB DB LF	30-Amp C/B	IGN Accessory-Powered Options

Troubleshooting

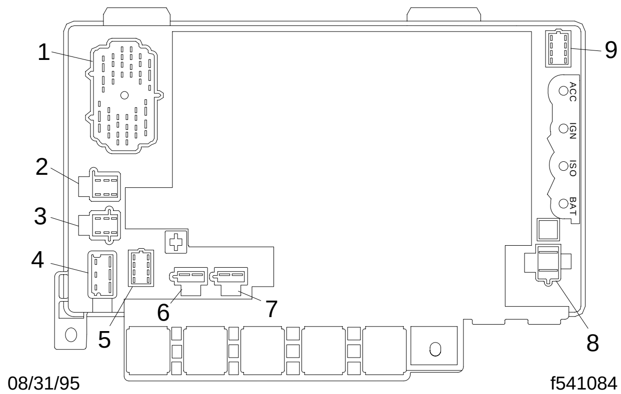
Circuit Breaker/Relay ID (optional components)			
Pos.	**Pin No.**	**Component**	**Description**
34	NE7 NE6 AE4	Micro Relay	Road Lights
37	AB2 CD	15-Amp C/B	Heated Mirror
42	AC1	10-Amp C/B	Engine ECM
44	EE LD	15-Amp C/B	Optional Switch Power (1)
46	DC	30-Amp C/B	Power Seat
47	EF JG	15-Amp C/B	Optional Switch Power (2)
50	ND6	15-Amp C/B	Air Dryer
51	FB DA	30-Amp C/B	Ignition-Powered Options
60	—	Mini Relay	Optimized Idle
61	—	Mini Relay	Optimized Idle
62	—	Mini Relay	Optimized Idle
63	—	10-Amp Fuse	Optimized Idle
64	—	10-Amp C/B	BAT Isolator (IGN Switch)
64X	—	10-Amp C/B (15-Amp with Caterpillar engines)	BAT Isolator (Engine ECM)

Table 2, Main PDM Circuit Breaker/Relay ID (optional components)

For location of pin connectors on the top of the main PDM, see **Fig. 2**. For position of individual pinouts on pin connectors A through G (main PDM—left-hand side), see **Fig. 3**. For position of individual pinouts on pin connectors H and J (main PDM—right-hand side), see **Fig. 4**.

For location of pin connectors on the bottom of the main PDM, see **Fig. 5**.

NOTE: To locate pinouts, use this key: The first letter indicates the connector in which the pin is located. The second letter indicates the row of the connector. The number indicates the number



1. 46-Pin Connector A
2. 6-Pin Connector B
3. 6-Pin Connector C
4. 6-Pin Connector D
5. 8-Pin Connector E
6. 2-Pin Connector F
7. 2-Pin Connector G
8. 2-Pin Connector H
9. 8-Pin Connector J

Fig. 2, Main PDM Pin Connectors (top view)

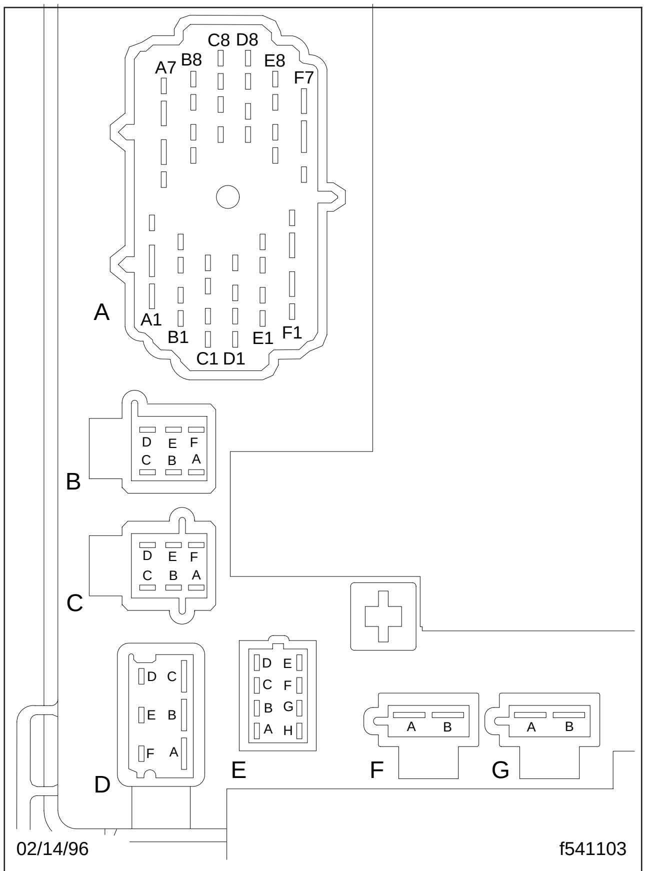


Fig. 3, Main PDM Pinout Positions (left side, top)

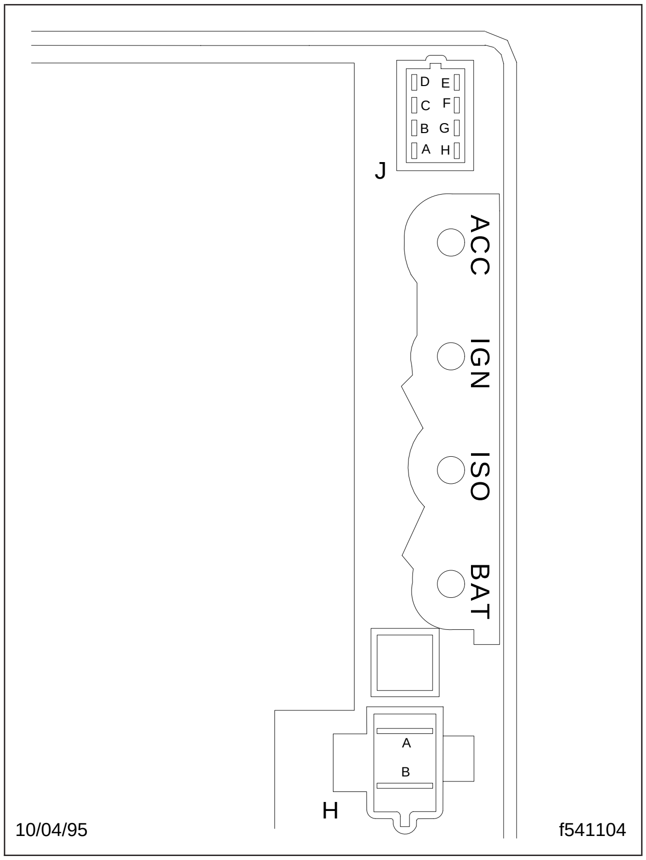
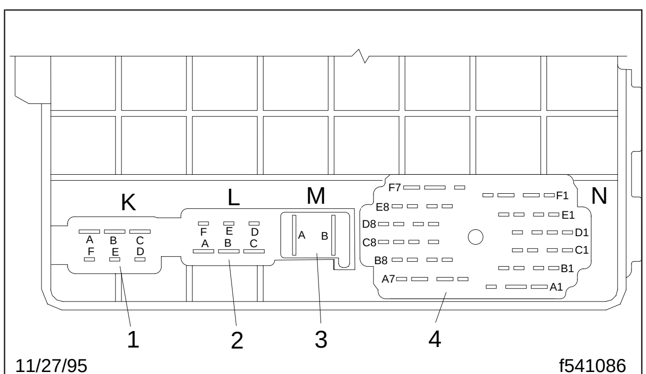


Fig. 4, Main PDM Pinout Positions (right side, top)



1. 6-Pin Connector K
2. 6-Pin Connector L
3. 2-Pin Connector M
4. 46-Pin Connector N

Fig. 5, Main PDM Pin Connectors (bottom view)

of the pin in the row, if there is more than one. If there is only one pin in a row, this number is missing.

Examples: Pin number AF5 means connector A, row F, pin 5. Pin number BC means connector B, pin C.

Auxiliary Power Module

The Columbia has an auxiliary power module with six plug-in connectors (two each on the top, right-hand side, and bottom of the module case).

On the auxiliary power module itself, there are three rows:

- Row A, the top row, contains 6 fuses and one 30-amp HVAC circuit breaker.
- Row D, the middle row, contains 3 HVAC relays.
- Row G, the bottom row, contains between 3 and 8 fuses, depending on options installed.

For circuit breaker and relay locations on the auxiliary power module, see **Fig. 6**.

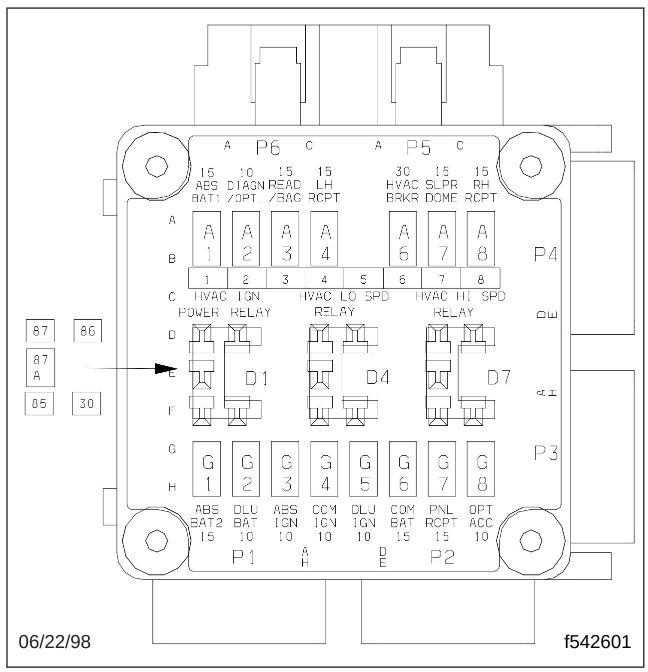


Fig. 6, Circuit Breaker/Relay Locations, Auxiliary Power Module

For lists of all component fuses (standard and optional), circuit breakers, and relays installed in the auxiliary power module, together with the connector

Troubleshooting

and pin number of each circuit, see **Table 3** for Row A, **Table 4** for Row D, and **Table 5** for Row G.

Circuit Breaker/Fuse ID (Row A), Auxiliary Power Module						
Pos.	Plug No.	Circuit	Connector	Pin No.	Component	Description
A1	A1	14E	P6	A	15-Amp Fuse	ABS BAT #1
	B1	376A	P1	F		
A2	A2	14E	P6	A	10-Amp Fuse	Diagnostic BAT
	B2	331	P1	G		
A3	A3	14S	P5	A	15-Amp Fuse	Reading/Baggage Light
	B3	41R	P4	H		
A4	A4	14S	P5	A	15-Amp Fuse	L/H Power Receptacle
	B4	57B	P4	G		
A6	A6	14S	P5	A	30-Amp C/B	Sleeper HVAC
	B6	+12V *	—	—		
A7	A7	14S	P5	A	15-Amp Fuse	Dome Light
	B7	41S	P4	C		
A8	A8	14S	P5	A	15-Amp Fuse	RH Power Receptacle
	B8	57A	P4	B		

* The +12V circuit is internal to the auxiliary power module.

Table 3, Circuit Breaker/Fuse ID (Row A), Auxiliary Power Module

Relay ID (Row D), Auxiliary Power Module						
Pos.	Plug No.	Circuit	Connector	Pin No.	Component	Description
D1	D1	+12V *	—	—	Mini Relay	Sleeper HVAC Power
	D2	GND	P5	C		
	F1	98Y	P1	E		
	F2	98S	P3	A		
D4	D4	+12V *	—	—	Mini Relay	Sleeper HVAC Low-Speed
	D5	GND	P5	C		
	E4	98R	P4	F		
	F4	97A	P1	H		
	F5	98L	P3	H		
D7	D7	+12V *	—	—	Mini Relay	Sleeper HVAC Remote High-Speed
	D8	GND	P5	C		
	F7	98Z	P2	G		
	F8	98H	P3	G		

* The +12V circuit is internal to the auxiliary power module.

Table 4, Relay ID (Row D), Auxiliary Power Module

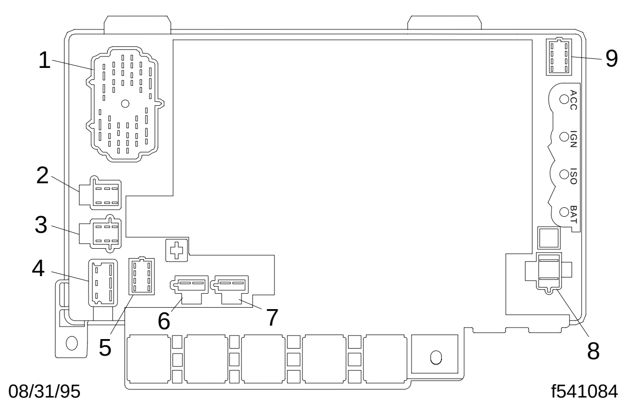
Fuse ID (Row G), Auxiliary Power Module						
Pos.	Plug No.	Circuit	Connector	Pin No.	Component	Description
G1	G1	14E	P6	A	15-Amp Fuse	ABS BAT #2
	H1	376B	P1	D		
G2	G2	14E	P6	A	10-Amp Fuse	DLU BAT Power *
	H2	442	P1	C		
G3	G3	52R	P6	C	10-Amp Fuse	ABS IGN Power
	H3	376C	P1	B		
G4	G4	52R	P6	C	10-Amp Fuse	Communications System *
	H4	434R	P1	A		
G5	G5	52R	P6	C	10-Amp Fuse	DLU IGN Power *
	H5	442A	P2	D		
G6	G6	14S	P5	A	15-Amp Fuse	Optional BAT Power *
	H6	OPT+	P2	C		
G7	G7	14S	P5	A	15-Amp Fuse	Panel Power Receptacle
	H7	57C	P3	C		
G8	G8	ACC+	P2	H	10-Amp Fuse	Optional Accessory Power *
	H8	52K	P2	A		

* Optional; not installed on all vehicles

Table 5, Fuse ID (Row G), Auxiliary Power Module

Specifications

For pin connector locations on the top of the main PDM, see **Fig. 1**.



1. 46-Pin Connector A
2. 6-Pin Connector B
3. 6-Pin Connector C
4. 6-Pin Connector D
5. 8-Pin Connector E
6. 2-Pin Connector F
7. 2-Pin Connector G
8. 2-Pin Connector H
9. 8-Pin Connector J

Fig. 1, Main PDM Pin Connectors (top view)

For positions of individual pinouts on the top of the main PDM, see **Fig. 2** for connectors A through G (left-hand side), and **Fig. 3** for connectors H and J (right-hand side).

For location of pin connectors and individual pin positions on the bottom of the PDM, see **Fig. 4**.

NOTE: To locate pinouts, use this key: The first letter indicates the connector in which the pin is located. The second letter indicates the row of the connector. The third number, if present, indicates the number of the pin in the row, if there is more than one. If there is only one pin in a row, this number is missing.

Examples: Pin number AF5 means connector A, row F, pin 5. Pin number BC means connector B, pin C.

For a list of circuit breakers and relays installed in the main and auxiliary power distribution modules, see **Troubleshooting, 300**.

For a full schematic view of the PDM wiring, see **Fig. 5**. For a detailed (partial) view of the PDM wiring schematic, see **Fig. 6** and **Fig. 7**.

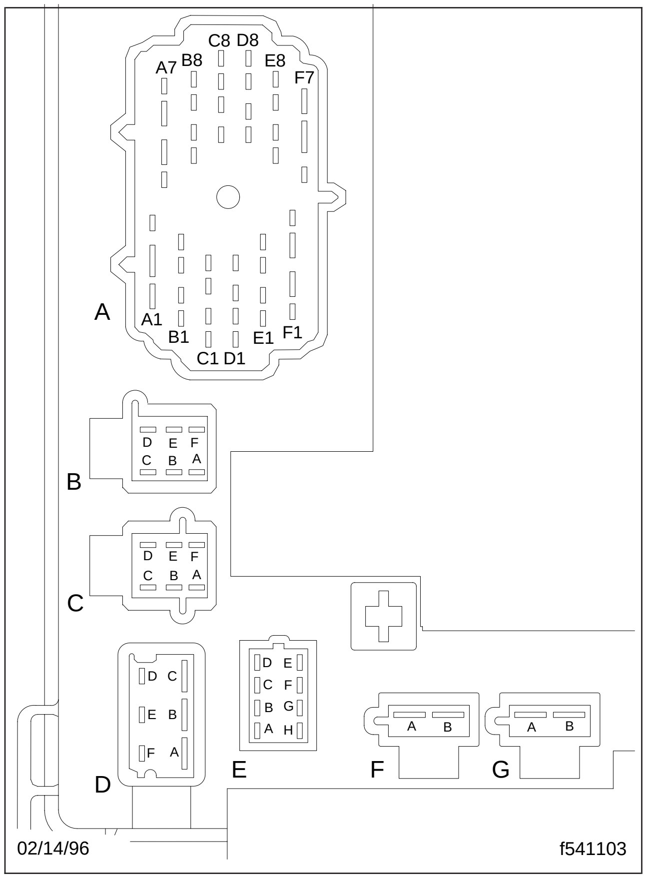


Fig. 2, Main PDM Pinout Positions (left side, top)

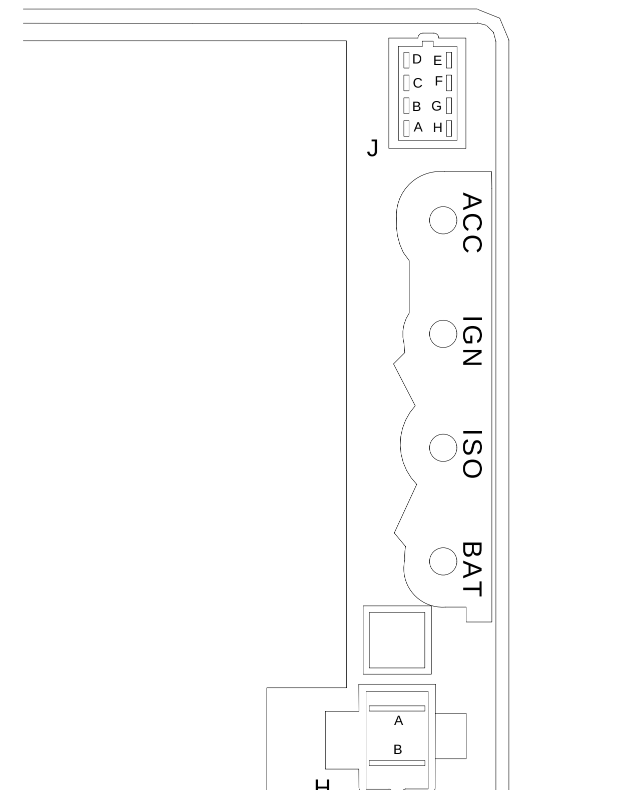
To identify relay terminals, first check the type of relay. On micro relays, the terminals are numbered 1 through 5, corresponding to the position numbers on the schematic. On all other relays, the terminals are numbered 30 through 87A, corresponding to positions 1 through 5 as shown in **Table 1**.

Mini Relay Terminal Numbers	
Position	**Terminal Number**
1	86
2	85
3	30
4	87A
5	87

Table 1, Mini Relay Terminal Numbers

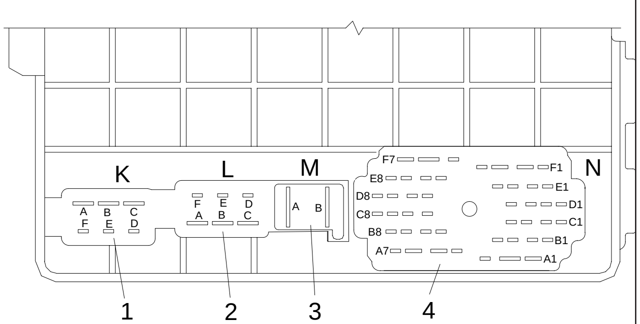
For a full schematic view of the "B" block auxiliary power module wiring, see **Fig. 8**. For a detailed (par-

Specifications



10/04/95 f541104

Fig. 3, Main PDM Pinout Positions (right side, top)



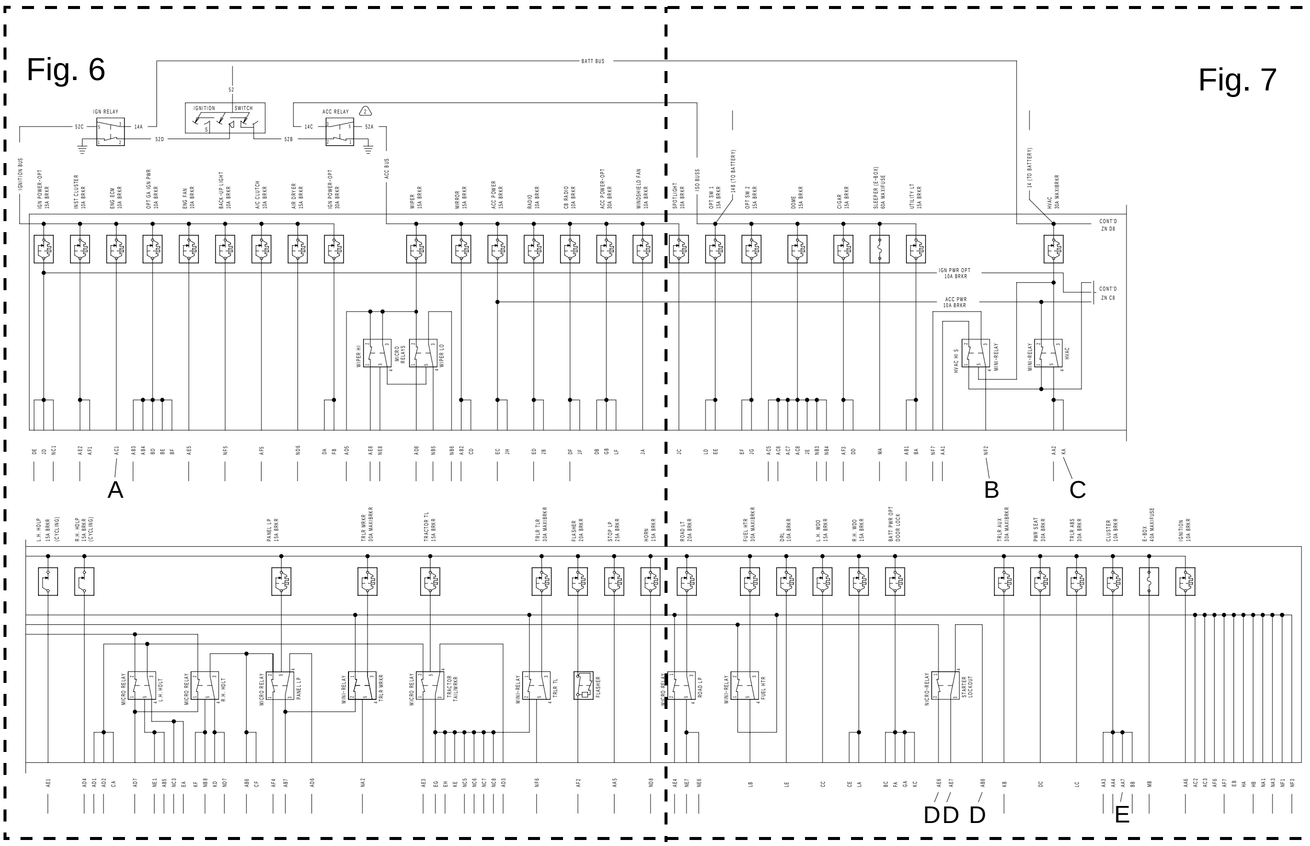
11/27/95 f541086

1. 6-Pin Connector K
2. 6-Pin Connector L
3. 2-Pin Connector M
4. 46-Pin Connector N

Fig. 4, Main PDM Pin Connectors (bottom view)

tial) view of the "B" block auxiliary power module wiring, see **Fig. 9** and **Fig. 10**.

Specifications



05/15/2000 Reference Diagram: D06−21957 Chg.Ltr. H f541242

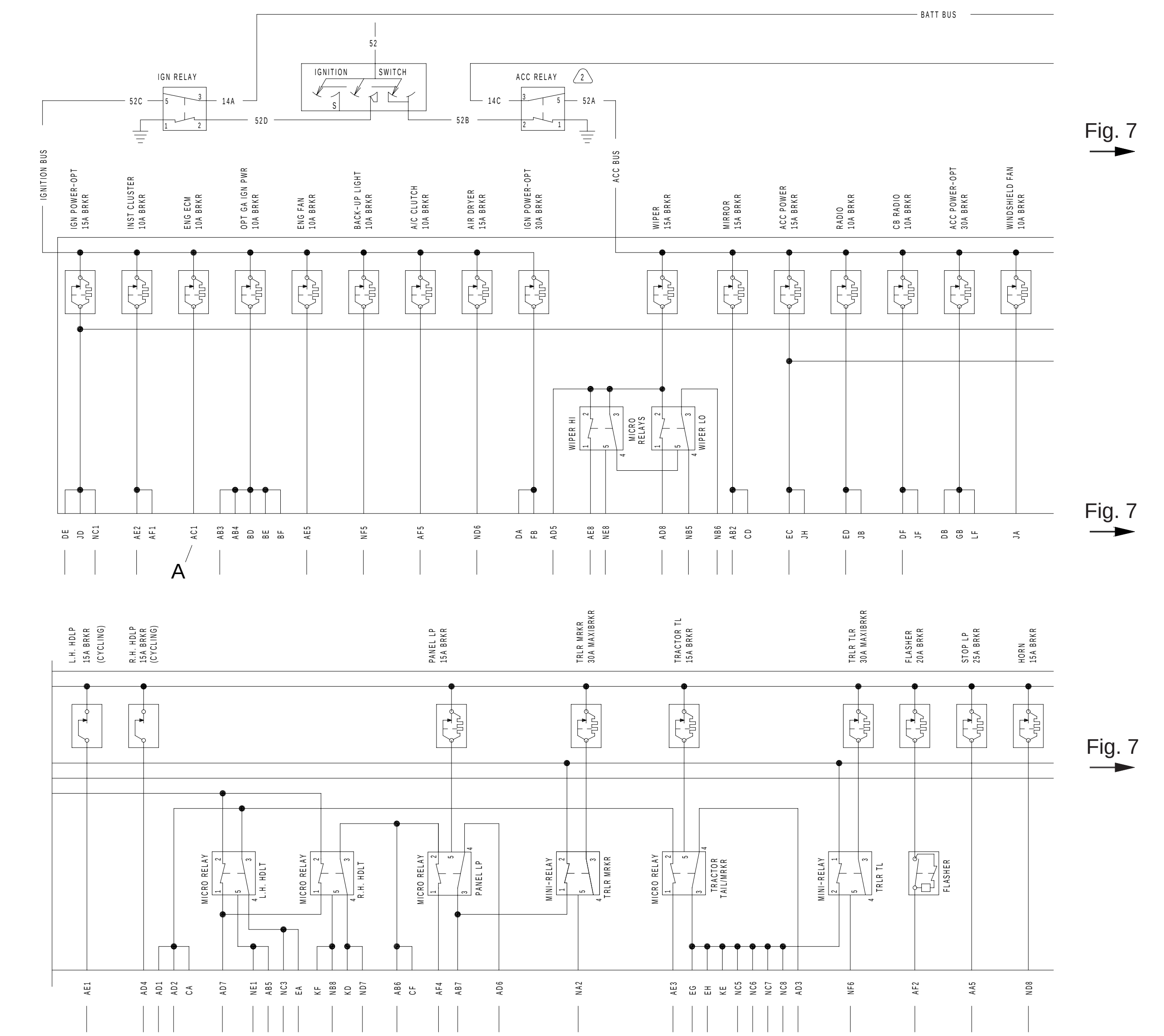
Each relay terminal has a position number. On micro relays, the terminal number corresponds exactly to the position number. On all other relays (mini relays, ignition-powered relays), see **Table 1**.

NOTE: Starter lockout circuitry not available at this time.

A. Reserved for Engine Control Module (ECM) overlays.
B. Do not use.
C. Circuit assignments to this optional pin position must be approved by Freightliner Engineering.
D. Reserved for starter lockout circuitry.
E. Reserved for ignition keyswitch courtesy light feed.

Fig. 5, Main PDM Wiring Schematic (full view)

Specifications

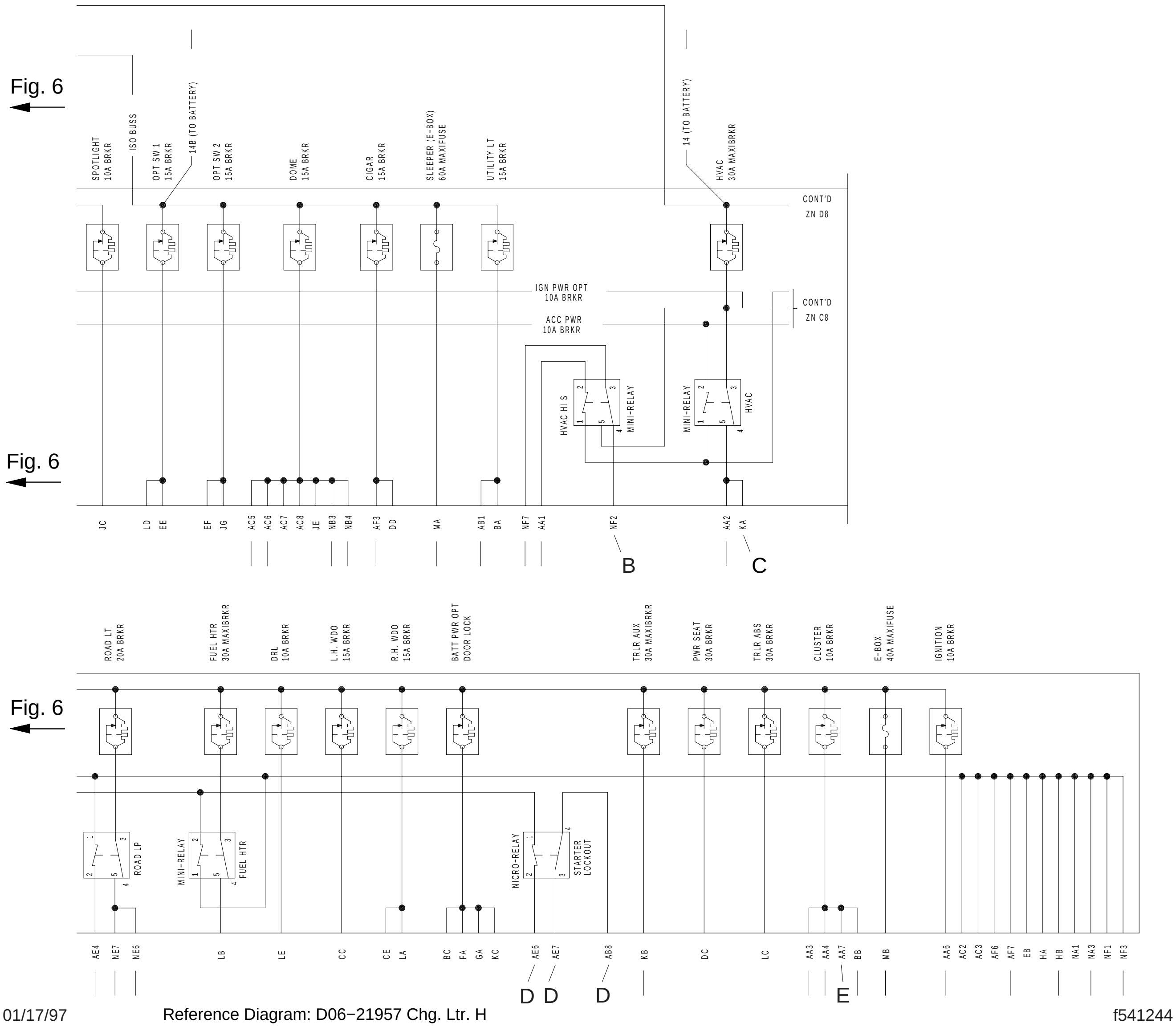


01/17/97 Reference Diagram: D06−21957 Chg. Ltr. H f541243

Each relay terminal has a position number. On micro relays, the terminal number corresponds exactly to the position number. On all other relays (mini relays, ignition-powered relays), see **Table 1**.

A. Reserved for Engine Control Module (ECM) overlays.

Fig. 6, Main PDM Wiring Schematic (partial view)



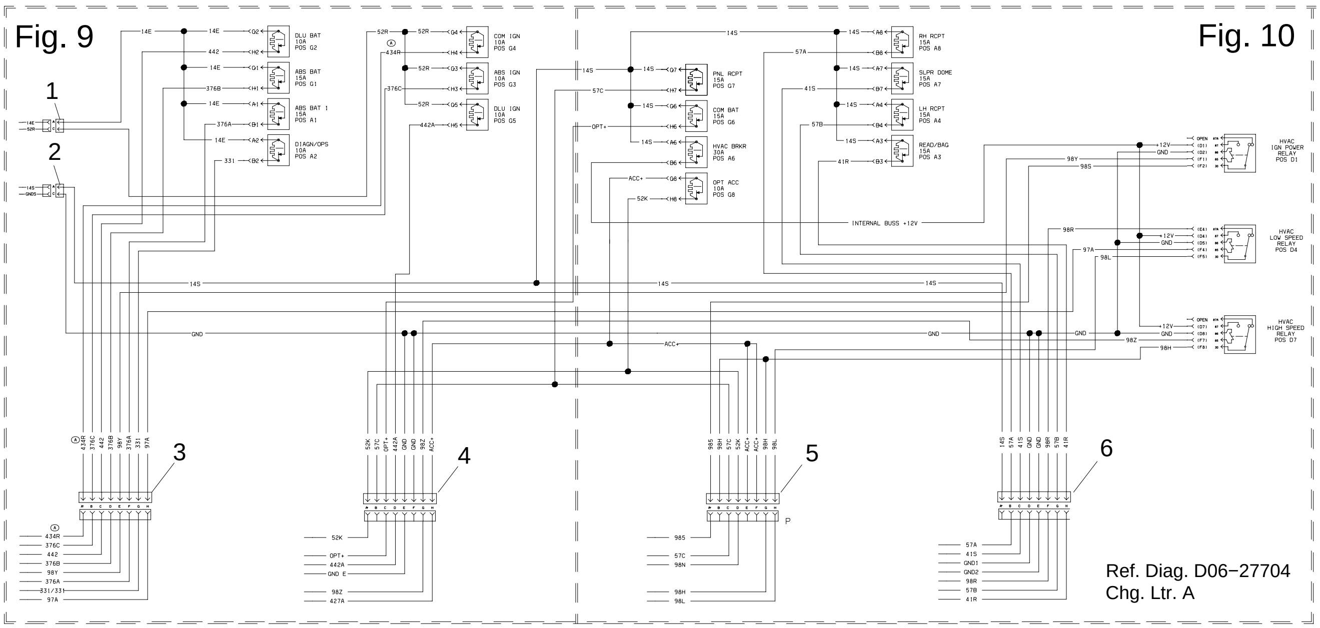
Each relay terminal has a position number. On micro relays, the terminal number corresponds exactly to the position number. On all other relays (mini relays, ignition-powered relays), see **Table 1**.

NOTE: Starter lockout circuitry not available at this time.

B. Do not use.
C. Circuit assignments to this optional pin position must be approved by Freightliner Engineering.
D. Reserved for starter lockout circuitry.
E. Reserved for ignition keyswitch courtesy light feed.

Fig. 7, Main PDM Wiring Schematic (partial view)

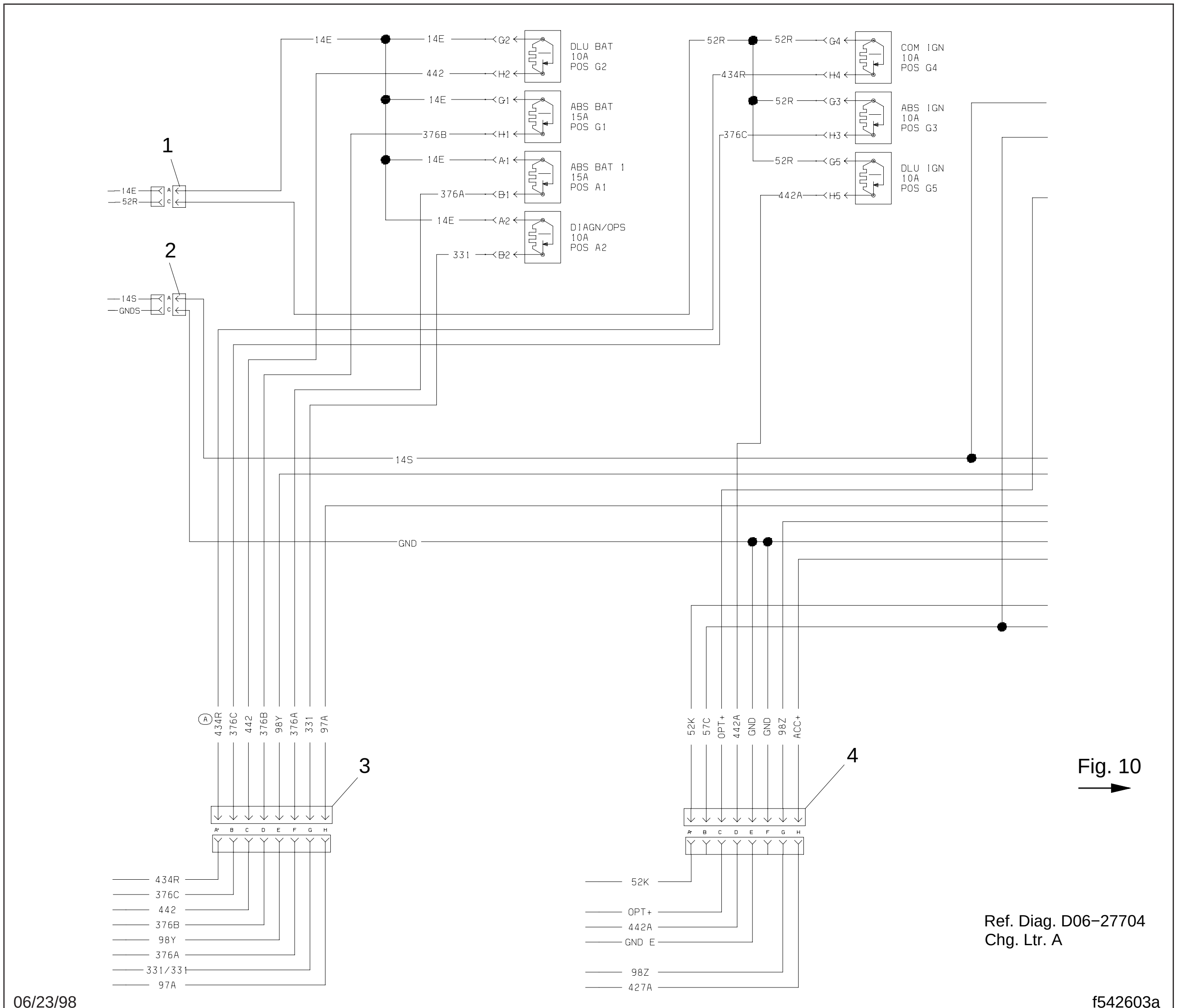
Specifications



06/23/98 f542602a

1. Connector P6
2. Connector P5
3. Connector P1
4. Connector P2
5. Connector P3
6. Connector P4

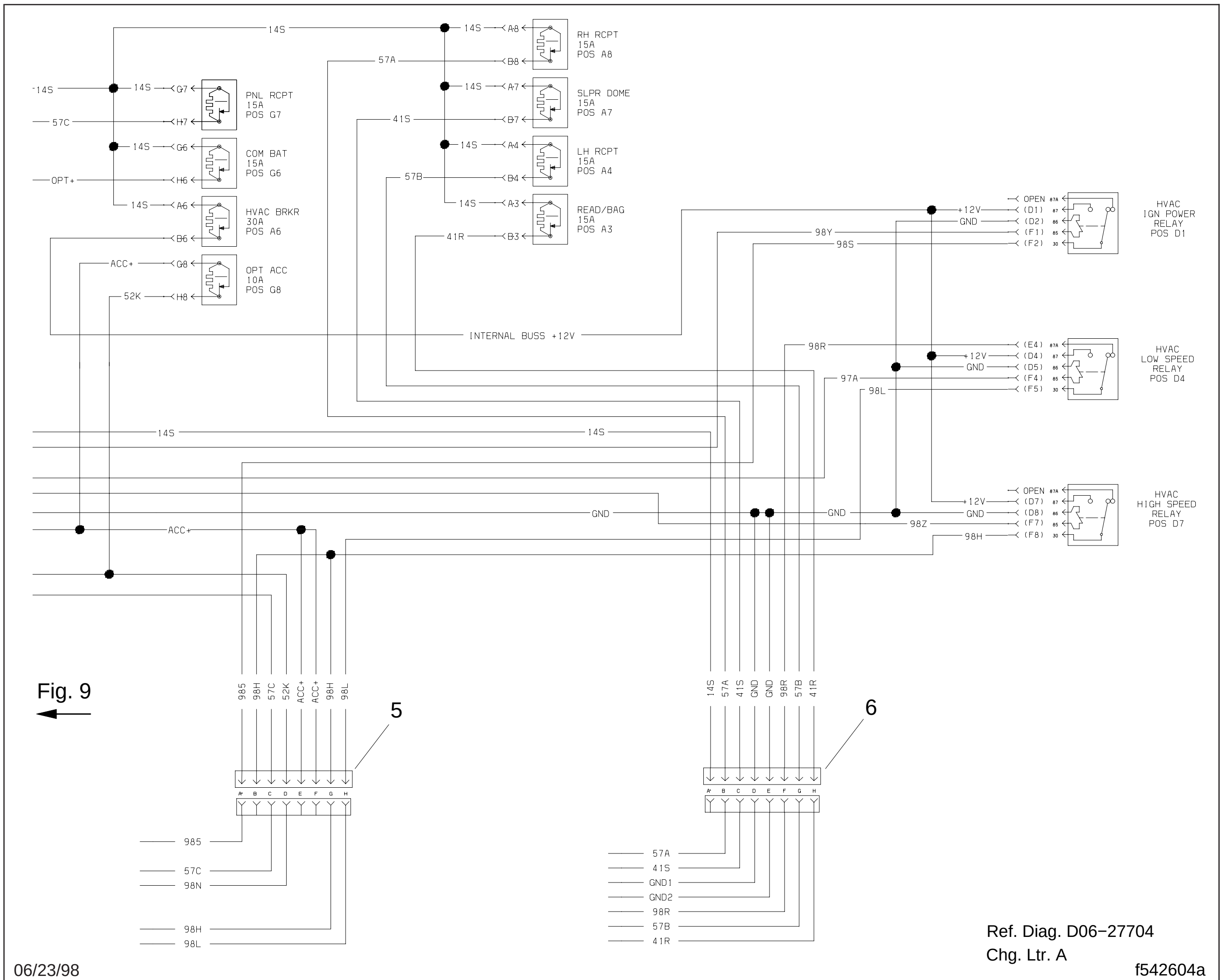
Fig. 8, Auxiliary Power Module Wiring Schematic (full view)



1. Connector P6
2. Connector P5
3. Connector P1
4. Connector P2

Fig. 9, Auxiliary Power Module Wiring Schematic (partial view)

Specifications



5. Connector P3
6. Connector P4

Fig. 10, Auxiliary Power Module Wiring Schematic (partial view)

General Information

An air restriction indicator (**Fig. 1**) or gauge indicates how much air filter capacity has been used and how much remains. It registers the actual maximum restriction of the filter element (or elements, if two air cleaners are installed) when the engine is operating at full load.

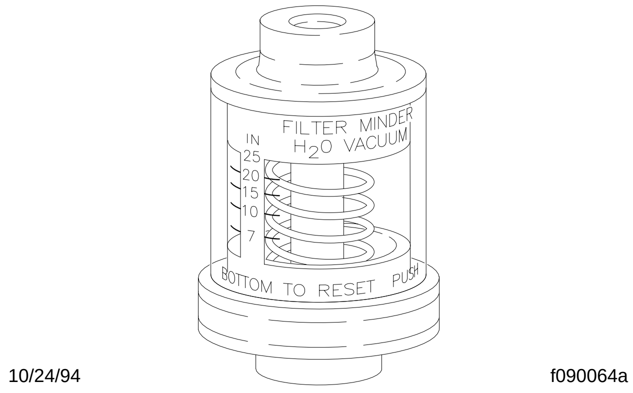


Fig. 1, Standard Air Restriction Indicator

Two types of spring-loaded air restriction indicators and one type of gauge with a pointer dial are available. The standard air restriction indicator is mounted on the air cleaner intake piping (**Fig. 2**) and has a reset button located at the end opposite the mounting fitting.

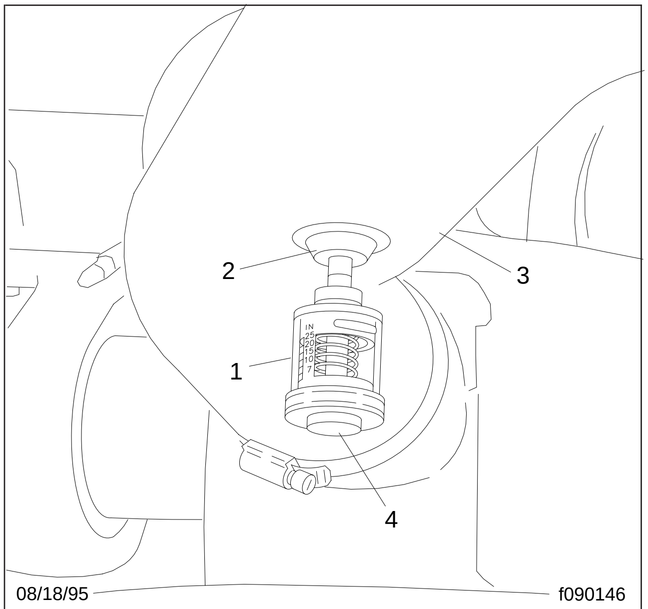
The other type of indicator is mounted on the auxiliary instrument panel (**Fig. 3**). There is a reset button on the face of the indicator.

An optional mechanical dial gauge can also be mounted in the auxiliary instrument panel (**Fig. 4**).

Inside the air restriction indicator is a yellow index marker that retains the reading so that the remaining capacity can be read even after the engine is shut down. To reset the indicator, press the reset button. The dial gauge automatically resets itself whenever the engine is shut down.

The air restriction gauge and tap fittings can sometimes become plugged from moisture or engine vapors, possibly causing an incorrect reading.

IMPORTANT: Most engine degreasers are harmful to the polycarbonate (Lexan) plastics that are used in air restriction gauges. When cleaning an engine or other components, avoid getting degreaser on these plastic parts.



1. Air Restriction Indicator
2. Mounting Fitting
3. Air Intake Piping
4. Reset Button

Fig. 2, Standard Air Restriction Indicator Mounted on the Intake Piping

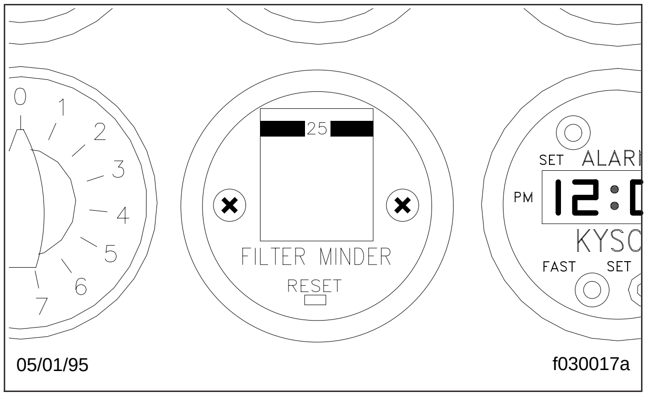


Fig. 3, Optional Air Restriction Indicator Mounted in the Auxiliary Instrument Panel

General Information

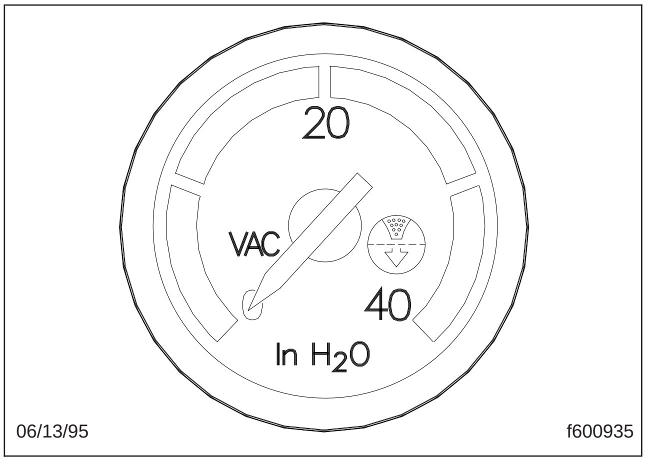


Fig. 4, Optional Air Restriction Dial Gauge Mounted in the Auxiliary Instrument Panel

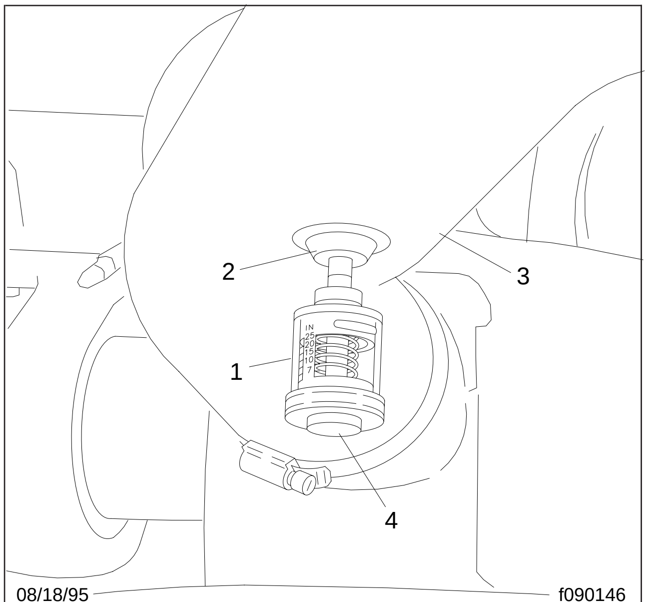
Air Restriction Indicator/Gauge Replacement

Replacement

Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires and open the hood.

AIR RESTRICTION INDICATOR (MOUNTED ON THE AIR INTAKE PIPING)

1. Using a wrench, unscrew the indicator from the air intake piping. See **Fig. 1**.



1. Air Restriction Indicator
2. Mounting Fitting
3. Air Intake Piping
4. Reset Button

Fig. 1, Standard Air Restriction Indicator

2. Install the new air restriction indicator in the fitting. Tighten it securely.

NOTE: The fitting in the intake duct is a special fitting incorporating an orifice and a filter. Be sure that the correct fitting is installed.

3. Close the hood and remove the chocks from the tires.

AIR RESTRICTION INDICATOR/ GAUGE (MOUNTED IN THE AUXILIARY INSTRUMENT PANEL)

1. Remove the auxiliary instrument panel. Pull out the panel to gain access to the back of the air restriction indicator/gauge.
2. Remove the nuts and lockwashers that attach the mounting bracket to the indicator/gauge. Disconnect the air line.
3. Replace the indicator/gauge in the auxiliary instrument panel.
4. Connect the air line. Using the mounting nuts and lockwashers, install the mounting bracket.
5. Install the auxiliary instrument panel.
6. Close the hood and remove the chocks from the tires.

Troubleshooting

Problem—No Restriction Reading

Problem—No Restriction Reading	
Possible Cause	**Remedy**
The indicator leaks.	Remove the air restriction indicator. Apply a vacuum to the indicator until the yellow index marker reaches the red line. With your thumb on the mounting fitting, close the end of the indicator airtight. Hold in the reset button. The yellow index marker will drop slightly and then not move unless the indicator has a leak. If the indicator is functioning properly, install it and press the reset button. If the yellow index marker continues to move, replace the air restriction indicator. Repeat the troubleshooting procedure to verify that the new indicator does not leak. When the indicator is functioning properly, install it and press the reset button.
The intake pipe fitting or vacuum hose is plugged (panel-mounted indicator/gauge).	Remove the air restriction indicator/gauge. Apply a vacuum to the indicator until the yellow index marker reaches the red line. Connect the indicator/gauge to the intake pipe fitting or yellow hose (as appropriate), and reset the indicator/gauge. The yellow index marker or dial will fully return to zero unless the fitting or vacuum hose is plugged. (A slow return is normal due to the safety filter in the fitting.) If the indicator/gauge is functioning properly, reset the indicator/gauge. Return the indicator/gauge to its mounting. If the yellow index marker or dial does not fully return to zero, clear the fitting or vacuum hose and repeat the procedure.
The vacuum hose leaks (panel-mounted indicator/gauge).	First, check to be sure that the indicator is not leaking (instructions above). Disconnect both ends of the vacuum hose. Apply vacuum to the indicator/gauge until the indicator reaches the red line. Connect the indicator/gauge to the vacuum hose and close the other end of the hose airtight. Reset the indicator/gauge. The yellow index marker or dial will drop slightly and then not move unless the vacuum hose has a leak. If the indicator/gauge is functioning properly, install the vacuum hose and return the indicator/gauge to the dash mounting; reset the indicator/gauge. If the yellow index marker or dial continues to move, replace the vacuum hose. Repeat the troubleshooting procedure to verify that the new hose does not also leak. When the indicator/gauge functions properly, install the vacuum hose and return the indicator/gauge to the panel mounting; reset the indicator/gauge.
Engine airflow is too low to generate a reading.	Turbocharged engines must be at full load to pull full engine airflow. Restrictions can be simulated by gradually closing off air intake. If there is still no restriction reading, check for leaks in the indicator/gauge or vacuum hose, as appropriate, and take corrective action.

Problem—High Restriction Readings

Problem—High Restriction Readings	
Possible Cause	**Remedy**
The element(s) is (are) plugged or poorly cleaned.	Ultra-fine particles are difficult to remove, and cleaning may not sufficiently lower the restriction. Carefully attempt to unplug or clean the element(s); if unsuccessful, install a new filter element or elements.
The safety filter is plugged (if equipped).	Do not clean the safety filter. Replace it with a new one.

Troubleshooting

Problem—High Restriction Readings	
Possible Cause	**Remedy**
The air cleaner(s) is (are) undersized.	The air cleaner may be too small if a larger engine has been installed. Replace the undersized unit(s) with properly-sized air cleaner(s).
The air restriction indicator is too close to the intake of an engine blower or turbo.	Under certain circumstances, air turbulence near the blower intakes may cause a high vacuum reading. Locate the indicator away from the blower intake by at least 1-1/2 times the diameter of the intake tube.
The intake screens or ducts are plugged.	Check the system upstream from the air restriction indicator and remove any debris. Check for damage or improper installation, and take any necessary corrective action.
Heavy snow or rain.	Temporary high restriction can occur during a rain or snow storm and disappear after drying out. However, the cold air may be so dense that high restriction may not reduce the engine power before the element(s) is (are) damaged. If the indicator/gauge reads maximum restriction (red line), check the element(s) for damage and replace if necessary.

General Information

IMPORTANT: The level II ICU is also known (on ServiceLink) as the ICU2L.

This section covers the instrumentation control unit, level II (level II ICU).

LEVEL II ICU (ICU2L)

The level II ICU (ICU2L) is a basic electronic dashboard that accepts input from electrical/magnetic vehicle sensors and the vehicle data bus, and converts it into digital output that can be fed to an electronic gauge. Only air gauges operate mechanically.

The level II ICU has one 16-bit microprocessor.

There can be up to 14 removable gauges (11 electronic, 1 electromechanical, and 2 mechanical) on the driver's instrument panel. The level II ICU can not drive gauges located on the auxiliary instrument panel.

DASH MESSAGE CENTER

The heart of the level II ICU is the dash message center. It has two parts: a set of 18 warning and indicator lights similar to those found on a conventional lightbar, and a dash driver display screen. The dash driver display screen is a 1-line by 6-character vacuum fluorescent display.

The information that can be provided by the message center includes:

- odometer readings
- a listing of active faults
- a "no datalink activity" alert message

Principles of Operation

IGNITION SEQUENCE

When the ignition is turned on, the level II ICU (ICU2L) runs through the ignition sequence. See **Fig. 1** for the standard level II ICU.

If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

IMPORTANT: When the ignition is first turned on, all the electronic gauges (except the voltmeter) complete a full sweep of their dials, the warning and indicator lights light up, and the buzzer sounds for three seconds.

The following indicator lights go on during the ignition sequence:

- High Coolant Temperature Warning
- Low Engine Oil Pressure Warning
- Low Air Pressure Warning
- Park Brake On Indicator
- All engine warning lights, including Engine Protection, Check Engine, and Stop Engine (Cummins only)
- All ABS warning lights, including Wheel Spin, Tractor ABS, and Trailer ABS (if installed)

NOTE: While the engine and ABS warning lights go on during the ignition sequence, they are not controlled by the level II ICU, but by their own system ECU (electronic control unit).

Once the ignition switch has been turned on, the ICU performs a self-test, looking for active faults. During the first half of the self-test, all segments of the display illuminate. During the second half of the self-test, the software revision level is displayed.

If there are no active faults, the screen displays the odometer.

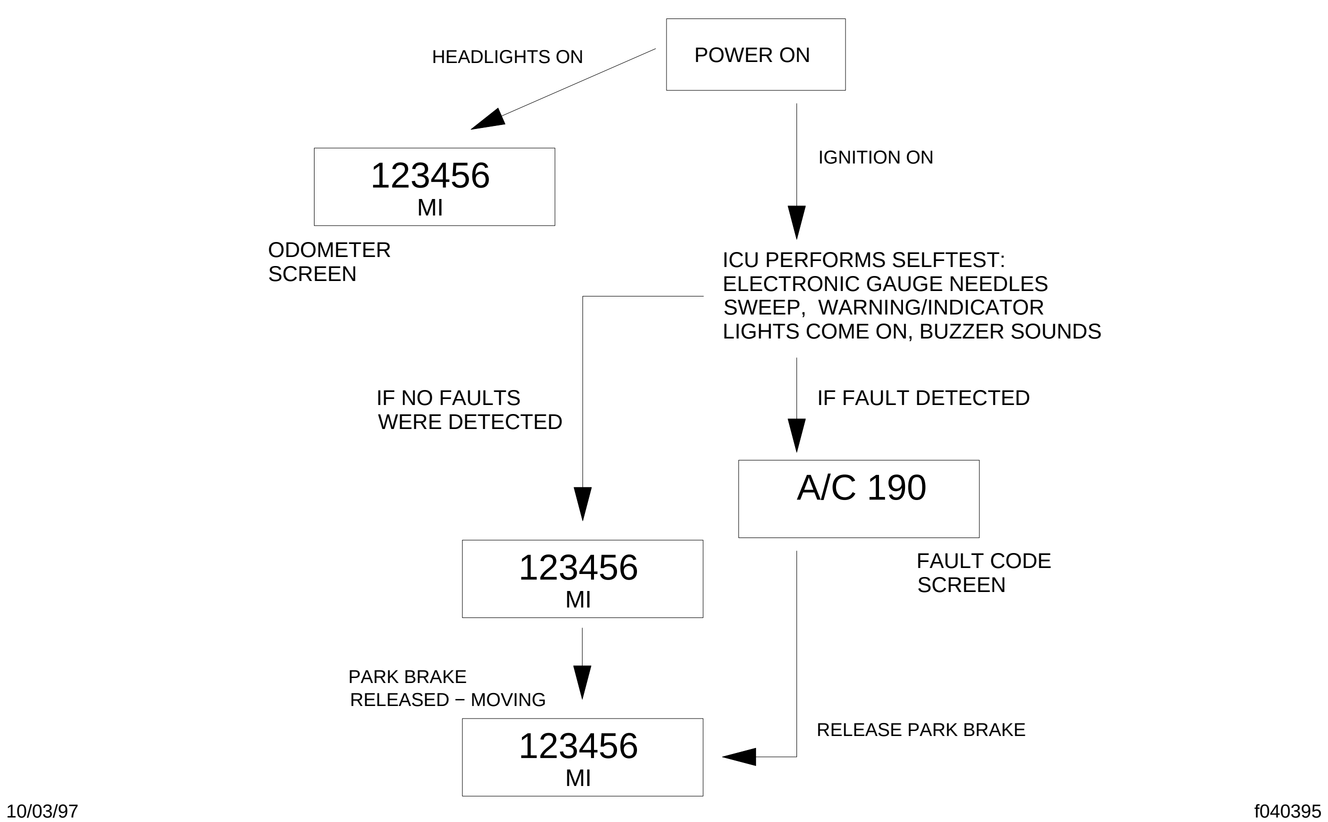
If the standard level II ICU has received active fault codes from other devices, it displays them, one after the other, until the parking brake is released, or the ignition switch is turned off.

NOTE: The screen displays a code, called the message identifier (MID), indicating the electronic control unit or system that is not functioning properly.

IMPORTANT: The ICU will report a fault for the Qualcomm or HighwayMaster communications systems when the system control unit, or ECU, is connected properly and the system is working correctly.

To troubleshoot the Qualcomm system, have an incoming test message sent to the unit in the vehicle and make sure that it is received properly.

General Information



During the first half of the self-test, all segments of the display illuminate. During the second half of the self-test, the software revision level is displayed.

NOTE: If there is more than one fault, the level II ICU displays them, one after another, changing every three seconds, until the park brake is released.

Fig. 1, Ignition Sequence, Standard Level II ICU (ICU2L)

To troubleshoot the HighwayMaster system, see **Section 54.12**, Troubleshooting, 300.

Once the parking brake is released, the level II ICU displays the odometer again.

ODOMETER

The odometer is a six-digit display with no decimal point. The odometer only displays significant figures (no leading zeros), until the vehicle has traveled one million miles or kilometers (km). At one million miles (or km), the odometer resets itself to 000000, and then continues to display leading zeros.

Example: 456 = 456 miles (or km)

000456 = 1,000,456 miles (or km)

When first installed, the odometer starts at 0 miles (or km). When the level II ICU is replaced, the odometer does not start with the engine miles (or km), but starts again from 0 and cannot be changed, either up or down.

IMPORTANT: Although the odometer uses data supplied by the engine ECM to update its count, it keeps its own mileage starting from the zero point, which marks where it was first installed.

The odometer can be set to display in either miles or kilometers. For procedures, see **Subject 110**.

ALERT SCREEN

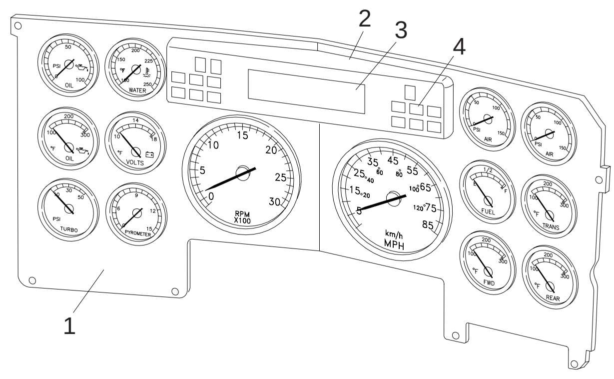
This screen displays NODATA when there is no activity on the datalink.

Level II Instrumentation Control Unit Replacement

IMPORTANT: The level II ICU is also known (on ServiceLink) as the ICU2L.

Replacement

The instrumentation control unit, level II (level II ICU) includes the driver's instrument panel, the ICU housing, and the dash message center (all installed as one unit). See **Fig. 1**.



1. Driver's Instrument Panel
2. Dash Message Center
3. Dash Driver Display Screen
4. Warning and Indicator Lights

Fig. 1, Driver's Instrument Panel

To replace one of the following components, refer to the indicated subject or topic.

- Complete level II ICU with a new set of gauges, see "ICU Replacement" (With Gauge Replacement);
- Level II ICU and reinstall the old set of gauges, see "ICU Replacement" (Without Gauge Replacement);
- Individual gauges, switches, or flipper valves, see **Subject 150**;
- Light bulbs (gauge light, or warning and indicator light), see **Subject 120**;
- Warning buzzer, see **Subject 130**;
- Dash driver display screen, see **Subject 140**.

ICU Replacement (With Gauge Replacement)

1. Remove the left-hand dash panels. Be sure the screws that attach the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08, Subject 100**.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

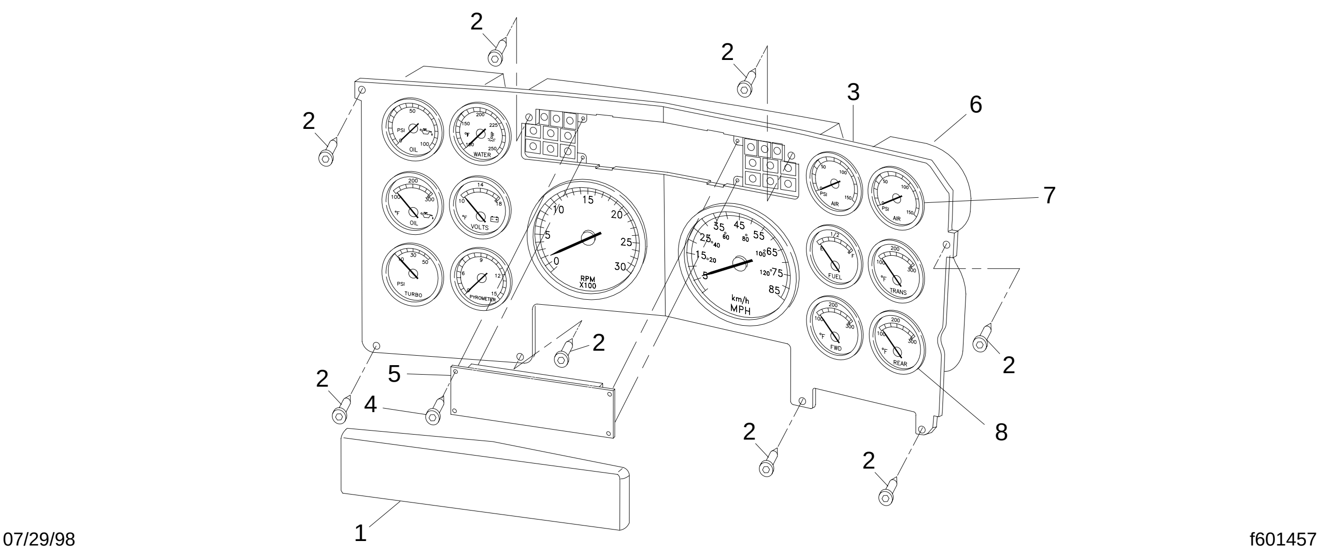
3. Remove the fasteners from the driver's instrument panel. See **Fig. 2**. Fasteners used on the level II ICU are T25 Torx® dog-point screws. See **Fig. 3**.
   - 3.1 Remove the bezel from the dash message center, exposing the two screws underneath it. For more information, see **Subject 140**.
   - 3.2 Remove the two screws underneath the dash message center bezel.
   - 3.3 Remove the four screws on the bottom of the driver's panel.
   - 3.4 Remove the two screws on the sides of the driver's panel.

CAUTION

When removing the ICU, the wiring harness may have to be loosened before the driver's panel can be pulled free of the dash. Do not forcibly pull the driver's panel from the dash. This may disconnect wires from the harness electrical connectors on the back of the ICU housing and damage them.

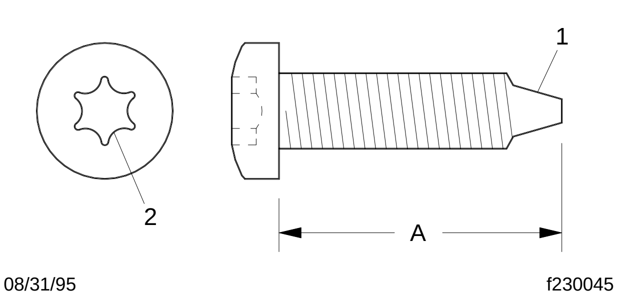
4. Pull the old ICU away from the dash.

Level II Instrumentation Control Unit Replacement



1. Message Center Bezel
2. Dog-Point Screw
3. Driver's Instrument Panel
4. Display Screen Screw
5. Dash Driver Display Screen
6. ICU Housing
7. Mechanical Gauge
8. Electronic Gauge

Fig. 2, Instrumentation Control Unit, Level II (ICU2L)



A. 3/4 Inch (19 mm)
1. Dog Point
2. Torx Head

Fig. 3, Dog-Point Screw

4.1 From behind the ICU housing, disconnect the two electrical connectors on the left-hand side.

IMPORTANT: Bleed off all air before trying to remove the air hoses.

4.2 Disconnect all air hoses. Using a paint pen, mark the hoses for ease of installation.

5. Remove the old ICU from the dash. See **Fig. 4**.

6. Remove the three screws and speed nuts that attach the dash panel trimtop to the old ICU.

7. Install the dash panel trimtop on the new level II ICU.

8. Install the ICU on the dash.

8.1 Connect the air hoses to the air gauges as marked during removal.

8.2 Connect the two electrical connectors, as removed.

8.3 Place the new level II ICU in the dash and install the fasteners. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel.

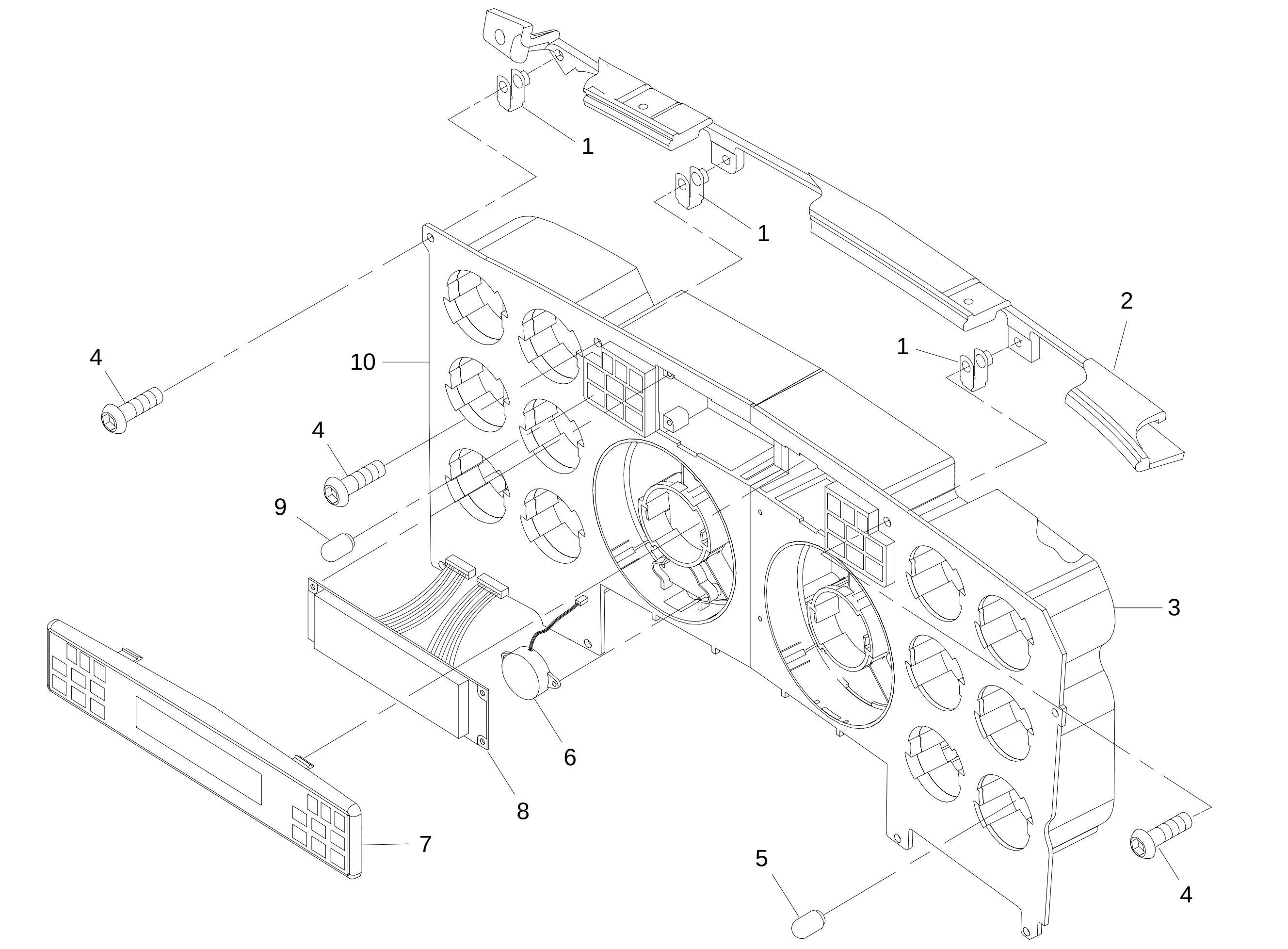
IMPORTANT: A typical warning and indicator light layout is shown in **Fig. 5**.

NOTE: See **Fig. 6** for a layout of standard gauge hole locations as described in ServiceLink.

9. Install the dash message center. See **Fig. 4**.

9.1 Remove the bezel from the dash message center on the new level II ICU.

Level II Instrumentation Control Unit Replacement



NOTE: Gauges have been removed.

1. Speed Nut
2. Dash Panel Trimtop
3. ICU Housing, RH
4. T25 Dog-Point Screw
5. Gauge Light Bulb
6. Buzzer
7. Message Center Bezel
8. Dash Display Screen
9. Warning and Indicator Light Bulb
10. ICU Housing, LH

Fig. 4, ICU Housing

CAUTION

Be careful not to scratch the new bezel when replacing the lightbar legends. Scratches on the inside of the bezel are visible from the front.

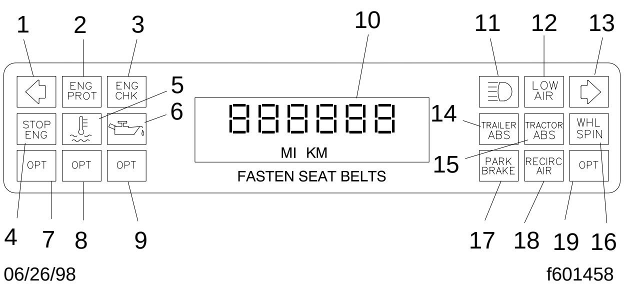
9.2 Take the bezel from the old level II ICU and, using fingers, tweezers, or a small pair of needlenose pliers, gently remove any of the optional plastic legends installed in the bezel. Install these in the new bezel, being careful not to scratch it.

9.3 Snap the bezel into place.

10. Check the gauge layout of the new unit and compare it to the old unit.

IMPORTANT: If any positions are different, replace the gauge for that position with the correct

Level II Instrumentation Control Unit Replacement



NOTE: Typical installation shown. Location and function of optional lights may vary.

1. Left Turn Indicator
2. Engine Protection Warning and Indicator
3. Check Engine Indicator
4. Stop Engine Warning (Cummins engine only)
5. High Coolant Temperature Warning (optional)
6. Low Oil Pressure Warning (optional)
7. Optional Indicator 3
8. Optional Indicator 2
9. Optional Indicator 1
10. Dash Driver Display Screen
11. High Beam Indicator
12. Low Air Warning
13. Right Turn Indicator
14. Trailer ABS Warning (optional)
15. Tractor ABS Warning
16. Wheel Spin Warning
17. Park Brake On Indicator
18. Recirc Air Warning (optional)
19. Optional Indicator 4

Fig. 5, Dash Message Center, Level II ICU (ICU2L)

gauge from the old unit. For gauge replacement procedures, see **Subject 110**.

11. Turn on the ignition and test the operation of the new level II ICU. All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

    If any gauges are not working properly, they will need to be serviced or replaced.

NOTE: Mechanical (air) gauges do not make a sweep.

ICU Replacement (Without Gauge Replacement)

1. Remove the left-hand dash panels. For instructions, see **Section 60.08, Subject 100**.
2. Remove the fasteners from the driver's instrument panel and dash panel trimtop. See **Fig. 2**. Fasteners used on the level II ICU are T25 Torx dog-point screws. See **Fig. 3**.

   2.1 Remove the bezel from the dash message center, to expose the two screws underneath it. Remove these two screws.

   2.2 Remove the four screws on the bottom of the driver's panel.

   2.3 Remove the two screws on the sides of the driver's panel.
3. Note the gauge layout for later installation and remove all the gauges. For instructions, see **Subject 110**. Set aside the gauges for later installation in the new panel.

   3.1 Remove the two large-face gauges from the center of the driver's panel. See **Fig. 7**.

   3.2 Remove the small-face gauges (six maximum) from the left-hand side of the driver's panel. See **Fig. 8**.

   3.3 Remove the small-face gauges (six maximum) from the right-hand side of the driver's panel. See **Fig. 9**.

CAUTION

Laying gauges face down for more than one day could allow the oil-dampening fluid to leak out, causing dial movement to become erratic.

4. Pull the old ICU away from the dash.

   4.1 From behind the ICU housing, disconnect the two electrical connectors on the left-hand side.

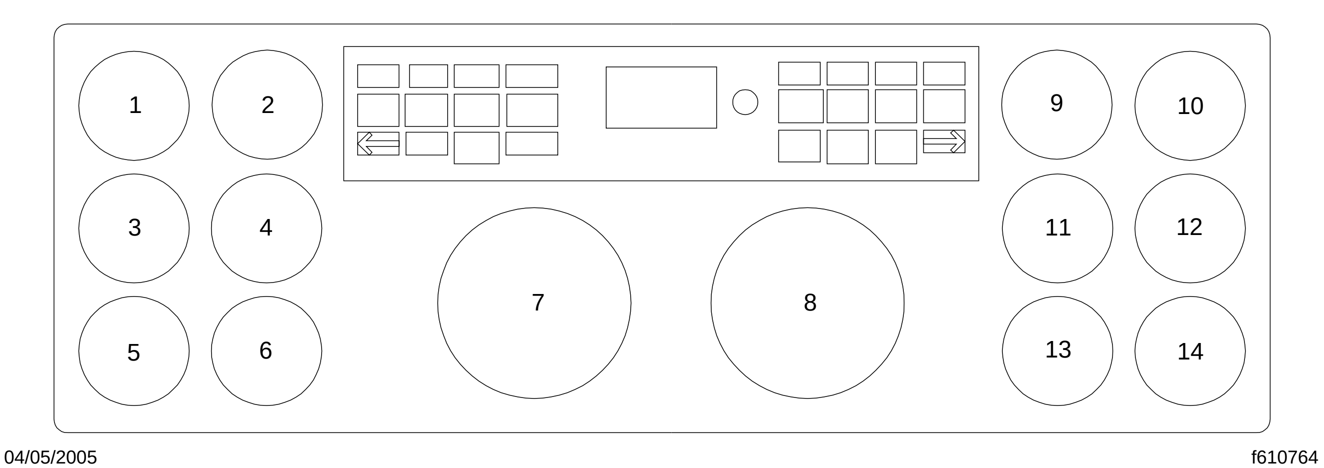
   IMPORTANT: Bleed off all air before trying to remove the air hoses.

   4.2 Disconnect all air hoses. Using a paint pen, mark the hoses for ease of installation.

CAUTION

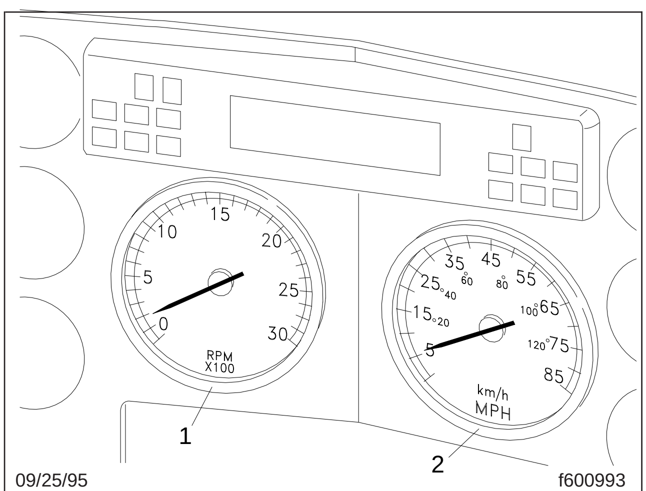
When removing the old ICU, the wiring harness may have to be loosened before the driver's panel can be pulled free of the dash. Do not forcibly pull the driver's panel from the dash. This

Level II Instrumentation Control Unit Replacement



1. Oil Pressure Gauge (DR001)
2. Water Temperature Gauge (DR002)
3. Oil Temperature Gauge (DR003)
4. Voltmeter (DR004)
5. Turbo Air Pressure Gauge (DR005)
6. Pyrometer (DR006)
7. Tachometer (DR007)
8. Speedometer (DR008)
9. Primary Air Pressure Gauge (DR009)
10. Secondary Air Pressure Gauge (DR010)
11. Fuel Gauge (DR011)
12. Transmission Fluid Temperature Gauge (DR012)
13. Forward Axle Temperature Gauge (DR013)
14. Rear Axle Temperature Gauge (DR014)

Fig. 6, Gauge Hole Position Numbers



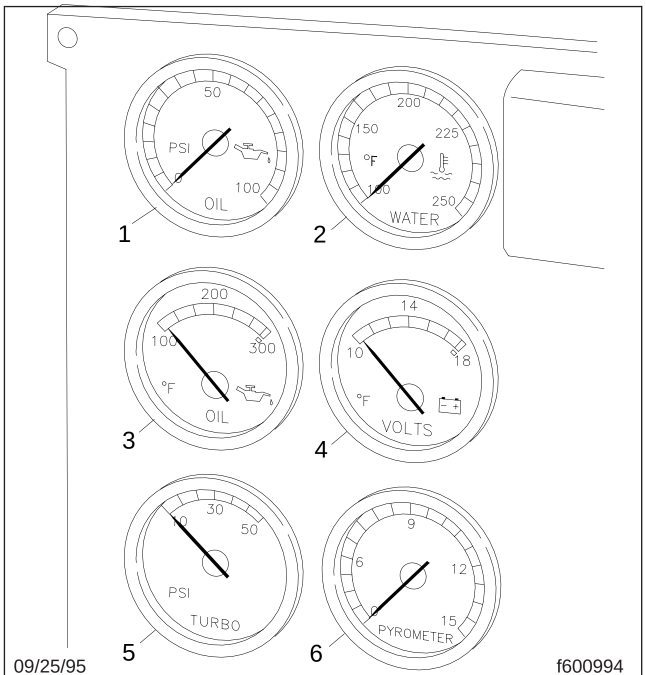
1. Tachometer
2. Speedometer

Fig. 7, Driver's Panel Gauge Layout (large-face gauges)

may disconnect wires from the harness electrical connectors on the back of the ICU housing and damage them.

5. Remove the old ICU from the dash. See **Fig. 4**.
6. Remove the three screws and speed nuts that attach the dash panel trimtop to the old ICU.
7. Install the dash panel trimtop on the new ICU.
8. Install the new ICU in the dash.
   - 8.1 Install all the fasteners as removed, including the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel.
   - 8.2 Connect the two electrical connectors, as removed.
   - 8.3 Install all gauges in the positions from which they were removed. Insert each gauge into its correct hole and twist clockwise about 1/8 turn, until seated.
9. Snap the dash message center bezel into place, using the four small tabs on the sides of the bezel.
10. Turn on the ignition and test the operation of the gauges. All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

Level II Instrumentation Control Unit Replacement

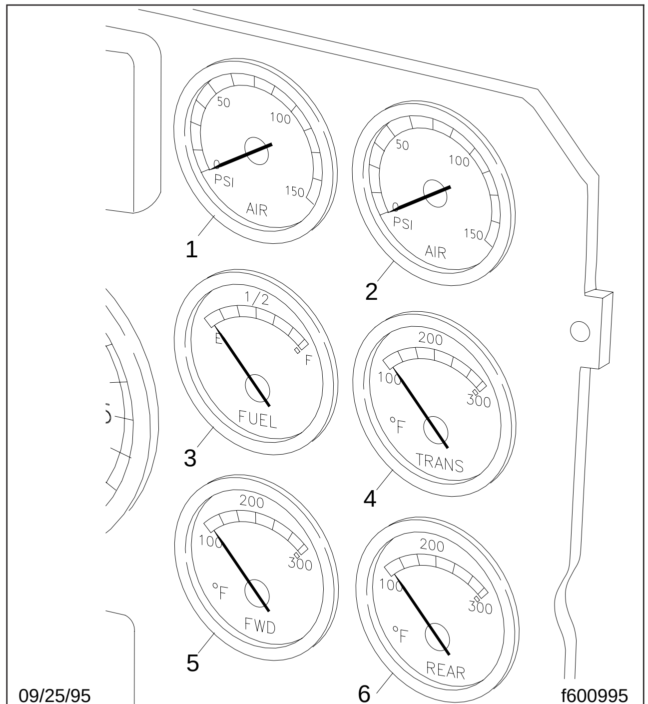


NOTE: Gauge layouts may vary. To work properly, gauges must be installed in their correct locations.

1. Oil Pressure Gauge
2. Water Temperature Gauge
3. Oil Temperature Gauge
4. Voltmeter
5. Turbo Air Pressure Gauge
6. Pyrometer

Fig. 8, Driver's Panel Gauge Layout (left-hand side)

NOTE: Mechanical (air) gauges do not make a sweep.



NOTE: Gauge layouts may vary. To work properly, gauges must be installed in their correct locations.

1. Primary Air Pressure Gauge
2. Secondary Air Pressure Gauge
3. Fuel Gauge
4. Transmission Fluid Temperature Gauge
5. Forward Axle Temperature Gauge
6. Rear Axle Temperature Gauge

Fig. 9, Driver's Panel Gauge Layout (right-hand side)

Level II Instrumentation Control Unit Display Changing

Changing

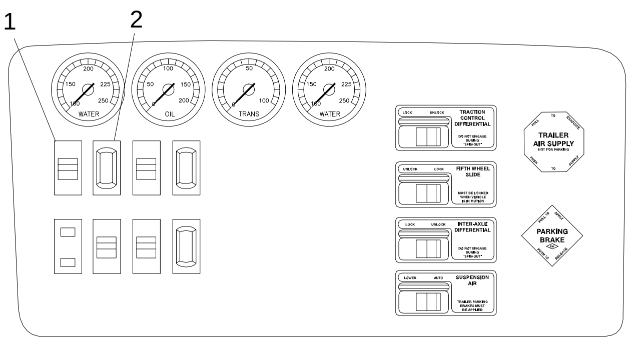
USING THE CRUISE CONTROL SWITCHES

IMPORTANT: The level II ICU is also known (on ServiceLink) as the ICU2L.

The odometer can display the distance the vehicle has traveled in either miles or kilometers. The choice of units is selectable using the cruise control switches.

To change the display, do the following steps.

1. Shut down the engine and set the parking brake.
2. Turn the ignition switch ON.
3. Turn the cruise control on (cruise control on/off switch). See **Fig. 1**.



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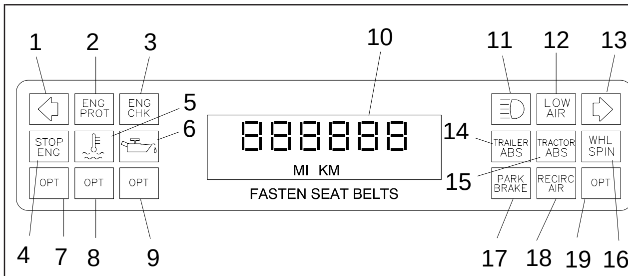
To switch from miles to kilometers, turn the cruise control on. Then press and hold down the set switch until the "MI" display starts to blink.

1. On/Off Switch
2. Set Switch

Fig. 1, Cruise Control Switches

4. With the cruise control on, press and hold down the cruise control set switch until the odometer display begins to blink. After about 5 seconds, the "MI" display at the bottom of the screen will change to "KM" (or "KM" will change to "MI," depending on what units were previously set). See **Fig. 2**.



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NOTE: Typical installation shown. Location and function of optional lights may vary.

1. Left Turn Indicator
2. Engine Protection Warning & Indicator
3. Check Engine Indicator
4. Stop Engine Warning (Cummins engine only)
5. High Coolant Temperature Warning (optional)
6. Low Oil Pressure Warning (optional)
7. Optional Indicator 3
8. Optional Indicator 2
9. Optional Indicator 1
10. Dash Driver Display Screen
11. High Beam Indicator
12. Low Air Warning
13. Right Turn Indicator
14. Trailer ABS Warning (optional)
15. Tractor ABS Warning
16. Wheel Spin Warning
17. Park Brake On Indicator
18. Recirc Air Warning (optional)
19. Optional Indicator 4

Fig. 2, Dash Message Center, Level II ICU

ICU Bulb Replacement

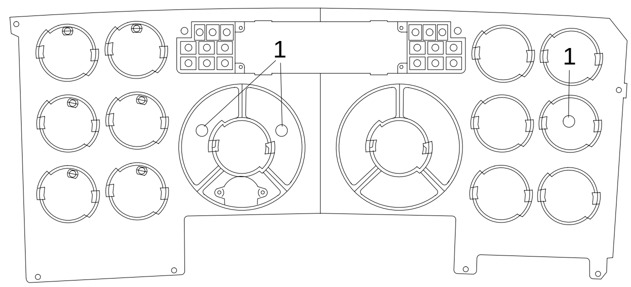
NOTE: This subject covers bulb replacement for gauges and for the warning and indicator lights.

Gauge Light Bulb Replacement

1. Remove the gauge. For instructions, see **Subject 110**.

NOTE: Small gauge bulbs are the same size as warning and indicator light bulbs. Large gauges have larger light bulbs.

2. Remove the old bulb by grasping it with the fingers and pulling until it comes out. There are two bulbs in large-face gauges, and one bulb in small-face gauges. See **Fig. 1**.



1. Bulb

Fig. 1, Gauge Light Bulb Replacement

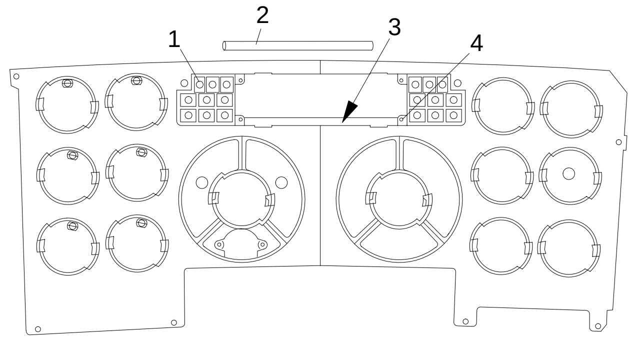
NOTE: If broken, the bulbs in the large-face gauges may be removed by twisting the bulb socket on the back of the ICU and removing the socket through the hole in back shield of the housing.

3. Install the new bulb by inserting it into the correct bulb socket and pushing it until it seats. Gently tug on the bulb to make sure it is properly seated.
4. Install the gauge. For instructions, see **Subject 110**.
5. Turn on the dash lights and check the new bulb(s) for proper operation.

Warning and Indicator Light Bulb Replacement

NOTE: Small gauge bulbs are the same size as warning and indicator light bulbs.

1. Remove the Driver Message Center bezel. For instructions, see **Subject 140**.
2. Retrieve the bulb replacement tool from its housing underneath the bezel. See **Fig. 2**.



1. Bulb
2. Bulb Replacement Tool
3. Replacement Tool Housing
4. Screw

Fig. 2, Warning and Indicator Light Bulb Replacement

3. Remove the old bulb from its socket.
   - 3.1 Gently press the tool onto the bulb until it fits snugly.
   - 3.2 Pull the tool outward to free the bulb from its socket.
   - 3.3 Remove the bulb from the tool when it is free of the socket. Hold the bulb with one hand and twist the tool with the other hand.
4. Insert the new bulb in the socket.
   - 4.1 Insert the new bulb into the end of the replacement tool.
   - 4.2 Gently push the new bulb into the socket until it seats. Gently twist while pulling outward on the tool to free it from the bulb.

ICU Bulb Replacement

5. Return the bulb replacement tool to its housing underneath the bezel. See **Fig. 2**.
6. Install the Driver Message Center bezel. For instructions, see **Subject 140**.
7. Turn on the dash lights and check the new bulb(s) for proper operation.

ICU Buzzer Replacement

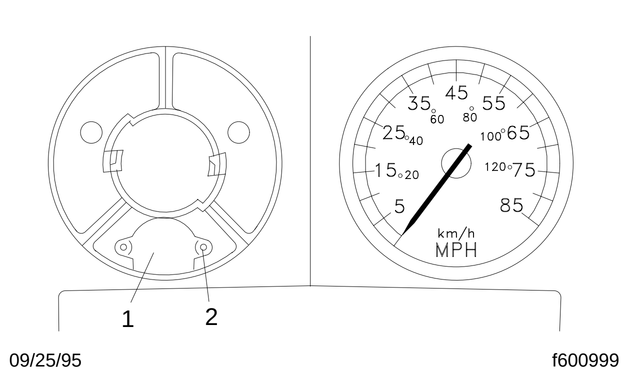
Replacement

1. Remove the tachometer from the driver's instrument panel. For procedures, see **Subject 110**.

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

2. The buzzer sits in the lower portion of the tachometer housing. Remove the old buzzer by unfastening the two mounting screws. See **Fig. 1**.



Viewed from front of driver's panel.

1. Buzzer
2. Screw

Fig. 1, Buzzer Replacement

3. Remove the electrical connector by gently pulling on the wires. If it cannot be removed by finger pressure only, use a jeweler's screwdriver or needle-nose pliers to pry it loose.
4. Insert the electrical connector into the printed circuit board.

CAUTION

Be sure that the wires are clear of the tachometer contact pins. Otherwise, the buzzer wiring may be damaged.

5. Install the new buzzer by inserting it into the tachometer housing and fastening the two screws.
6. Install the tachometer in the driver's instrument panel. For procedures, see **Subject 110**.
7. Turn on the ignition and check the new buzzer for proper operation.

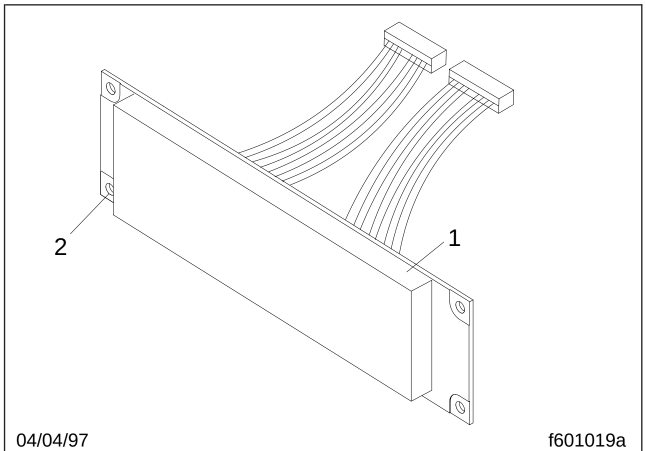
Dash Driver Display Screen Replacement

Replacement

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

1. Remove the Driver Message Center bezel. Work the four small clips on the sides of the bezel out of the slots in the instrumentation control unit (ICU) housing.
   - 1.1 Grasp the bezel with both hands approximately 3 inches from each end, fingers on the top edge and thumbs below the bottom edge.
   - 1.2 Squeeze with enough pressure to disengage the retainer hooks.
   - 1.3 Roll the top edge of the bezel outward and down to remove it from the vehicle.
2. Remove the four screws attaching the dash driver display screen to the Driver Message Center. See **Fig. 1**.



1. Dash Driver Display Screen
2. Screw Hole

Fig. 1, Dash Driver Display Screen Replacement

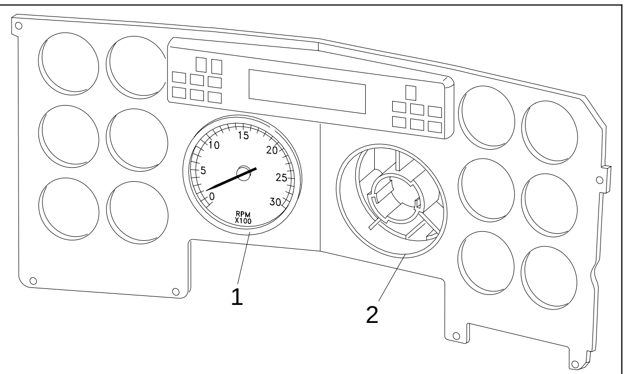
3. Carefully disconnect the two keyed electrical connectors. Note the orientation of the connectors, for correct installation.
4. Insert the two electrical connectors into the printed circuit board, as removed.
5. Replace the display screen. Fasten the four screws.
6. Install the Driver Message Center bezel. Press the four small clips on the bezel into the slots in the ICU housing.
7. Turn on the ignition and check the new display for proper operation.

Gauge Replacement

First, determine if the gauge to be replaced is an electronic or mechanical gauge. There are different procedures for electronic and mechanical gauges.

ELECTRONIC GAUGES

For large-face gauges, such as the speedometer or tachometer, and for small-face gauges located in the A-panel, see **Fig. 1**. For small-face electronic gauges located in the auxiliary panel, such as the voltmeter or fuel gauge, see **Fig. 2**.



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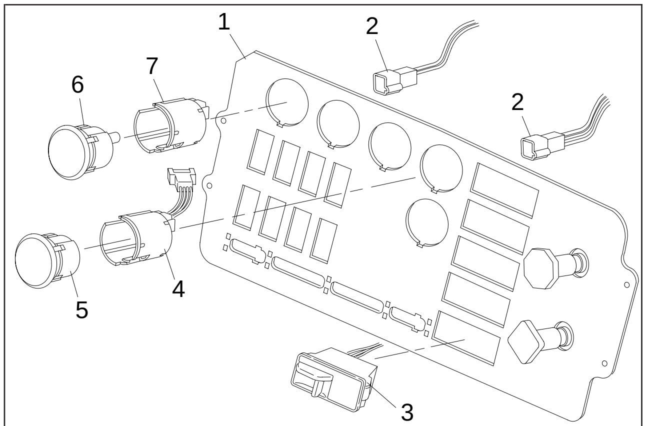
Be sure to note gauge location and gauge pigtail location before removal. Gauges will not function correctly if moved to a new location unless the gauge pigtail can be routed to the new location.

1. Large-Face Gauge
2. Large-Face Gauge Removed

Fig. 1, Large-Face Gauge Replacement

IMPORTANT: Be sure to note gauge location before removal. A-panel gauges will not function correctly if moved to a new location, unless the gauge pigtail connection can be moved to the new position. B-panel gauge locations can be changed only if the gauge housing is also moved.

1. Grasp the gauge bezel with the fingertips and twist it counterclockwise until it comes free of the panel. Pull the gauge straight out of its housing.



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Be sure to note gauge and flipper valve location before removal. Gauges and flipper valves will not function correctly if moved to a new location with changing the wire routing.

1. Auxiliary Instrument Panel
2. Main Cab Harness Connector
3. Flipper Valve
4. Electronic Gauge Housing (auxiliary panel only)
5. Electronic Front-Removable Gauge
6. Mechanical Front-Removable Gauge
7. Mechanical Gauge Housing (auxiliary panel only)

Fig. 2, Small-Face Gauge, Gauge Housing, and Flipper Valve Replacement

CAUTION

Be careful not to pinch the wires of the electrical harness. Pinched wires can cause the gauge to malfunction.

2. Disconnect the 4-wire pigtail harness from the gauge. Be careful not to pinch or kink any wires.

CAUTION

Do not lay gauges face down for long periods of time. The electronic gauges use an oil-dampening fluid that leaks out when the gauge is face down, causing dial movement to become erratic.

3. Insert the new gauge carefully into the opening in the panel. When fully inserted, grasp the bezel with fingertips and twist clockwise until the gauge clicks into position. Tug gently at the gauge to be sure it is properly seated.

Dash Gauge, Valve, and Switch Replacement

4. When finished, turn on the ignition and test the operation of the new gauge(s). All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

MECHANICAL GAUGES

IMPORTANT: Be sure to note gauge location before removal. Air gauges will not function correctly if moved to a new location unless the air hose for the gauge is also moved to the new location.

1. Grasp the gauge bezel with the fingertips and twist it counterclockwise until it comes free of the panel. Pull the gauge straight out of its housing. See **Fig. 2**.

WARNING

Remove the compressed air from the air tanks before disconnecting the hoses to the air gauges. Failure to do so could cause the hoses to move uncontrollably and cause personal injury or damage to the equipment.

2. Remove the air hose from the gauge.
   - 2.1 Carefully pull the hose out through the panel housing.
   - 2.2 While holding the gauge in the palm of one hand, press on the colored collar around the hose. Remove the hose with the free hand.
3. Install the air hose in the new gauge.
   - 3.1 Insert the hose into the colored collar. Push on it gently to seat it, being careful not to kink the hose.
   - 3.2 Tug firmly on the hose to be sure it is well gripped by the collar.
   - 3.3 Lead the hose carefully back into the panel housing, being careful not to kink it.
4. Insert the new gauge carefully into the opening in the panel. When fully inserted, grasp the bezel with fingertips and twist until the gauge clicks into position. Tug gently at the gauge to be sure it is properly seated.
5. When finished, turn on the ignition (for air gauges, turn on the air system) and test the operation of the new gauge(s).

B-PANEL GAUGE HOUSINGS

1. Remove the gauge. For procedures, see either "Electronic Gauge Replacement" or "Mechanical Gauge Replacement."
2. Remove the old front-removable gauge housing. See **Fig. 2**. From the back of the panel, unplug the main cab harness electrical connector from the gauge housing.
3. Install a new front-removable gauge housing.
   - 3.1 Install the electrical connector to the gauge housing.
   - 3.2 Place the tab on the back of the housing at 6 o’clock.
   - 3.3 Slide the housing into the panel from the front.
   - 3.4 Press in firmly until the housing snaps into position.
4. Install the gauge. For procedures, see either "Electronic Gauge Replacement" or "Mechanical Gauge Replacement."
5. When finished, turn on the ignition and test the operation of the new gauge(s). All the electronic gauges (except the voltmeter) should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

Flipper Valve Replacement

IMPORTANT: Be sure to note flipper valve location before removal. If moved to a new location, flipper valves will not function correctly without also relocating the associated hoses.

1. From the back of the valve, unplug the electrical connector. See **Fig. 2**. Hold on to the connector and avoid pulling on the wires.
2. Disconnect the air supply and distribution hoses.

WARNING

Relieve pressure in the compressed air tanks before attempting to remove any air hoses. A sudden release of air pressure can cause injury to eyes and ears. The disconnected ends of pressurized air hoses can move uncontrollably and cause personal injury or equipment damage.

2.1 If not color-coded, use a paint pen to mark the air supply and distribution ports and hoses for ease of installation.

2.2 Disconnect the air supply and distribution hoses.

2.3 Label and remove any jumper hoses.

3. To remove the old valve, press the retainer tab on the right side of the valve. While holding the retainer tab, gently roll the valve towards the left and out the front of the panel.
4. To install the new valve, align the groove on the left side of the valve with the cutout on the instrument panel and slip into place. Then roll the right side into the cutout until the valve snaps into place. Tug on the valve firmly to make sure it is properly seated.
5. Connect the air hoses and electrical connectors.

5.1 Support the valve on the front of the panel with one hand.

5.2 With the other hand, connect the air supply and distribution hoses as marked on removal. Connect any jumper hoses as marked.

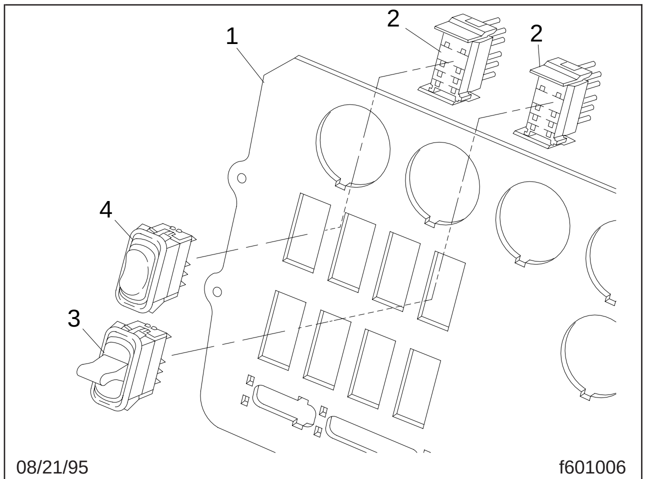
5.3 While still supporting the valve with one hand, connect the electrical connector.

6. When finished, turn on the ignition and test the new flipper valve(s) for correct operation.

Rocker and Paddle Switch Replacement

IMPORTANT: Be sure to note switch location before removal. If moved to a new location, switches will not function correctly without also relocating the associated wiring.

1. From the back of the panel, unplug the electrical connector. Avoid pulling on the wires.
2. Remove the old switch(es) from the panel. See Fig. 3 .



1. Auxiliary Instrument Panel
2. Switch Connector
3. Paddle Switch
4. Rocker Switch

Fig. 3, Rocker and Paddle Switch Replacement

2.1 If more than one switch is to be replaced, use a paint pen to mark the switch location and connector, for ease of installation.

2.2 From the back of the panel, depress the two locking clips and pull the switch out the front of the panel.

3. Install the new switch(es) in the panel.

3.1 Make sure the top of the switch is up when installed.

3.2 Press the switch into the panel from the front until it clicks into place. Tug firmly on the switch to make sure it is properly seated.

3.3 While supporting the switch with one hand, connect the electrical connector with the other. Be sure the locking tabs on the switch mesh with those on the connector.

4. When finished, turn on the ignition and test the new switch(es) for correct operation.

Troubleshooting

The instrumentation control unit (ICU) receives messages and faults transmitted by other ECUs on the J1587 datalink.

NOTE: There are also some warnings that are controlled by sensor inputs to the ICU.

The ICU presents warning information via lamps in the panel. Active fault codes are abbreviated in the driver display.

Ignition Sequence

When the ignition switch is turned ON, the ICU performs an ignition sequence. The electronically driven gauges sweep from zero to full scale and then back to zero. The parking brake, low air pressure, high coolant temperature, and low oil pressure warning/indicator lights also activate for approximately three seconds.

NOTE: The battery voltage, primary air, and secondary air gauges are not electronically driven and do not sweep.

System Fault Analysis

The ICU indicates active fault codes by displaying a three-letter code, which is an abbreviation for the system with the fault.

For lists of MIDs, PIDs, SIDs, and FMIs, see **Specifications, 400**. For more information on these code groups and how to read them, see "Fault Codes" in this subject.

To correct an active fault, see the following sources:

- Engine ECM (MID 128)—use the engine manufacturer's literature.
- ABS ECU (MID 136)—see **Section 42.00**, Subject 300, or use the antilock brake system manufacturer's literature.
- ICU (MID 140)—this section.
- DLU (MID 179)—see **Section 54.05**.

IMPORTANT: To begin troubleshooting active fault codes, do not turn the ignition switch OFF and then ON. It is not uncommon for a fault to disappear when ignition power is removed, only to return again when the vehicle has left the shop.

1. Correct the active fault.
2. To verify that the problem is corrected and that the fault code is no longer displayed as active, turn the ignition switch OFF and then ON.
3. Start the vehicle.

NOTE: In some cases, it may be necessary to drive the vehicle to confirm that a fault has been repaired.

Datalink Activity

1. If the alert message "NO DATA" is displayed, check the J1587 datalink wiring (twisted pairs).
2. Verify that all ECUs are connected.
3. Verify that the ECU J1587+ is connected to the datalink J1587+ and that ECU J1587– is connected to datalink J1587–.

Gauges

Gauge Does Not Sweep

NOTE: This section applies only to electronic gauges; the air gauges and voltmeter do not sweep.

If a particular gauge does not sweep during the ignition sequence, there is a problem either with the gauge or the ICU.

1. Turn the gauge counterclockwise and remove it from the ICU housing.
2. Install a gauge known to be good and repeat the ignition sequence.
3. If the test gauge sweeps full scale and back to zero, replace the original gauge with a new one. For replacement instructions, see **Subject 110**.
4. If the test gauge does not sweep, replace the ICU. For replacement instructions, see **Subject 100**.

NOTE: If the ICU has failed, replace the complete ICU housing. Remove all gauges, the message center bezel, and the panel. Install these parts in the new ICU housing.

Troubleshooting

Gauge Does Sweep

If a gauge malfunctions but sweeps during the ignition sequence, the ICU is not at fault.

1. Check the circuits that supply input signals to the ICU.
2. Check the engine ECM programming.

NOTE: Use the technician diagnostic routine (TDR), provided with ServicePro, to help determine the cause of the problem.

Warning/Indicator Lights

Light Does Not Illuminate

The parking brake, low air pressure, high coolant temperature, and low oil pressure warning/indicator lights should illuminate during the ignition sequence.

IMPORTANT: The following lights do not illuminate during the ignition sequence:

A. ENG PROT indicator light input WL002

B. CHK ENG indicator light input WL003

C. STOP ENG indicator light input WL007 (used on Cummins engines only)

D. TRAC ABS indicator light input WL011

If a warning/indicator light other than those listed above does not illuminate during the ignition sequence, either the light bulb is bad or the ICU is malfunctioning. Replace the light bulb with a test bulb known to be good and repeat the ignition sequence.

1. Remove the message center bezel and replace the bulb with a test bulb. Use the bulb replacement tool provided.
2. If the test bulb lights, replace the original bulb with a new one. For replacement instructions, see **Subject 120**.

   If the test bulb does not light, replace the ICU. For replacement instructions, see **Subject 100**.

Light Illuminates

If a warning/indicator light malfunctions but illuminates during the ignition sequence, the ICU is not at fault.

Check the circuits that supply input signals to the ICU. These lights are activated by either a 12-volt power input or a ground input.

NOTE: Use the technician diagnostic routine (TDR) provided with ServicePro to help determine the cause of the problem.

Buzzer

Buzzer Does Not Operate

If the buzzer does not activate during the ignition sequence, either the buzzer or the ICU is malfunctioning. The buzzer is mounted behind the tachometer.

1. Install a buzzer known to be good and repeat the ignition sequence.
2. If the test buzzer functions, replace the original buzzer with a new one. For replacement instructions, see **Subject 130**.

   If the test buzzer does not function, replace the ICU. For replacement instructions, see **Subject 100**.

Buzzer Does Operate

If the buzzer operates during the ignition sequence but does not work properly for another function, there is a problem with ICU input circuits.

1. Check the circuits that supply input signals to the ICU.
2. Check the ECU programming corresponding to the buzzer function.

Dash Driver Display Screen

Screen Does Not Activate

If the dash driver display screen does not activate during the ignition sequence, either the display screen itself or the ICU is malfunctioning. The dash driver display screen is mounted behind the message center bezel.

1. Install a dash driver display screen known to be good and repeat the ignition sequence.
2. If the test screen functions, replace the original dash driver display screen with a new one. For replacement instructions, see **Subject 140**.

If the test screen does not function, replace the ICU. For replacement instructions, see **Subject 100**.

Screen Does Activate

If the dash driver display screen operates during the ignition sequence, but the odometer does not display properly, the ICU is faulty.

ICU Small Gauges

The oil pressure, coolant temperature, oil temperature, and turbo air pressure gauges are driven electronically by the ICU using data inputs from the engine ECM. The ICU receives digital data from the engine ECM via the J1587 datalink.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be elsewhere, use ServiceLink, or the engine manufacturer's diagnostic software tool, and determine if there is an active engine ECM fault code related to the problem.
3. If an active fault code is displayed, follow the engine manufacturer's instructions to correct the problem.

   If no active fault code is displayed, check the datalink connection from the engine ECM to the ICU.
4. Check the datalink for cross-wired connections from all ECUs.

Voltmeter

The voltmeter is driven by the voltage input to the ICU. The voltmeter should function with the ignition switch in the ON position.

1. Replace a problem gauge with a test gauge known to be good and turn the ignition ON.
2. If the test gauge indicates 11 to 14 volts, replace the original gauge with a new one.

   If the test gauge indicates lower than 11 volts or higher than 14 volts, check input voltages to the ICU as follows:

   2.1 Check the 12-volt battery circuit: pin D14 and wire 437.

   2.2 Check the 12-volt ignition circuit: pin D15 and wire 437A.

   2.3 Check the ground circuit: pin D13 and wire GND1.
3. Troubleshoot and repair any of the above circuits that shows a malfunction.

   If all the circuits above are functioning, replace the ICU. For replacement instructions, see **Subject 100**.

Pyrometer

The pyrometer is electronically driven by the ICU. The pyrometer input circuit to the ICU contains a thermocouple mounted on the turbocharger exhaust port and a thermocouple amplifier module (TAM).

The thermocouple senses the exhaust temperature and sends a small voltage signal to the TAM. The TAM amplifies this voltage signal by a factor of 100 (typically 0 to 8 Vdc) and sends it on to the ICU. The ICU receives the analog voltage signal from the TAM and converts it to the digital signal that drives the pyrometer.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.
2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check for 12 Vdc of ignition power at the vehicle side connector to the TAM (circuit 218). The TAM is located just above the right-hand wheel well. Repair a malfunctioning circuit if necessary.
3. Warm up the engine fully so that the thermocouple reaches operating temperature. Then shut down the engine and turn the ignition back on.

NOTE: Do not measure voltage using chassis ground as a reference.

4. Check the voltage output signal of the TAM.

   Example: At 300°F (150°C) = 5.14 Vdc (acceptable); at 480°F (250°C) = 9.16 Vdc (unacceptable).

NOTE: To measure TAM output voltage, gain access the circuits at the right-hand wheel well or at the ICU connector pin C6 (218A+) and pin D6 (218A–).

4.1 Check between circuits 218A+ (positive lead) and 218A– (negative lead). Voltage should be 4 to 8 Vdc, depending on temperature.

4.2 If this measurement is not within the tolerances, then either the TAM or the thermocouple is malfunctioning.

NOTE: The TAM's output should be 100 times greater than the thermocouple output (TAM output = 5.14 Vdc, thermocouple output = 0.0514 Vdc).

NOTE: Do not measure voltage using chassis ground as a reference.

5. Check the voltage output signal of the thermocouple.

   Example: At 300°F (150°C) = 0.0514 Vdc (acceptable); at 480°F (250°C) = 0.0916 Vdc (unacceptable).

   NOTE: To measure thermocouple output voltage, gain access to the circuits at the right-hand wheel well.

   5.1 Check the voltage between circuits. The voltage should be between 0.04 and 0.08 Vdc.

   5.2 If this measurement is out of tolerance, the thermocouple is malfunctioning. Replace a malfunctioning thermocouple as required.

   If this measurement is within tolerance, but the measurement in the previous step was out of tolerance, the TAM is malfunctioning. Replace a malfunctioning TAM as required.

6. Check the circuits from the TAM to the ICU.

   6.1 Check for continuity between circuit 218A+ and ICU left-hand connector pin C6.

   6.2 Check for continuity between circuit 218A– and pin D6.

   6.3 Repair a malfunctioning circuit if necessary.

Transmission Temperature Gauge

The transmission temperature gauge is electronically driven by the ICU. The ICU input circuit contains a temperature sensor (thermistor) mounted in the transmission housing. The sensor causes a voltage drop across its leads corresponding to the transmission temperature. The ICU measures the voltage drop and converts it to a digital signal, which drives the electronic transmission temperature gauge.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.

2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the temperature sensor at the transmission. The resistance between the two sensor pins is typically 5250 ohms to 172 ohms. Replace the sensor if necessary.

   Examples: At 32°F (0°C) = 5250 ohms; at 77°F (25°C) = 5000 ohms.

3. Check the continuity of the sensor-to-ICU circuits on the ICU connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 30 and pin C12.

   3.2 Check for continuity between wire 30G and pin C13.

Drive Axli Temperature Gauge

The temperature gauges for the forward-rear and rearmost drive axles are electronically driven by the ICU. The input circuits to the ICU contain temperature sensors (thermistors) mounted in the drive axle housings. The sensor causes a voltage drop across its leads corresponding to the axle temperature. The ICU measures the voltage drop and converts it to a digital signal, which drives the electronic gauges.

1. To determine whether the fault lies in the ICU or the gauge input circuits, use the "Gauges" procedure above.

2. If the problem is found to be in the ICU, replace the ICU. For replacement instructions, see **Subject 100**.

   If the problem is found to be in the gauge input circuits, check the resistance of the rear axle temperature sensors. The resistance between the two sensor pins is typically 5250 ohms to 172 ohms. Replace the sensor if necessary.

   Examples: At 32°F (0°C) = 5250 ohms; at 77°F (25°C) = 5000 ohms.
3. Check the continuity of the circuits from the forward-rear drive axle sensors to the ICU connector. Repair a malfunctioning circuit if necessary.

   3.1 Check for continuity between wire 42 and pin A10.

   3.2 Check for continuity between wire 42G and pin A11.
4. Check the continuity of the circuits from the rearmost drive axle sensors to the ICU connector. Repair a malfunctioning circuit if necessary.

   4.1 Check for continuity between wire 43 and pin B2.

   4.2 Check for continuity between wire 43G and pin B4.

Fuel Level Gauge Diagnosis

The fuel level gauge is controlled by the ICU using a variable resistance input from the fuel level sending unit that is located in the fuel tank. The fuel level sending unit resistance varies linearly from 31±2Ω with a full tank to 247±3Ω when empty.

If the ICU3 is measuring a resistance greater than 284Ω between circuit 47 and ground, a fault will be set for fuel level circuit open. If the ICU3 is measuring less than 23.5Ω between circuit 47 and ground, a fault will be set for fuel level circuit shorted low. ServiceLink may be used to monitor for these faults. The gauge will read empty until the measurement from the sensor is between 284Ω and 23.5Ω. Refer to **Table 1** for the fuel level diagnostic procedure.

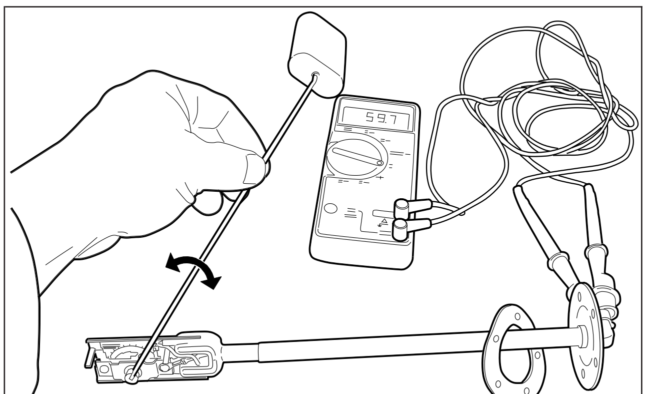
NOTE: If the fuel level sensor is below the minimum resistance (short to ground) or above the maximum (open), the fuel gauge will read empty. Shorting the fuel sensor wires will not drive the gauge to full scale.

Fuel Level Gauge Diagnosis			
Step	**Test Procedure**	**Test Result**	**Action**
1	If a 100 ohm resistor is available, disconnect the fuel level sender connector and place the resistor across circuit 47 and ground in the wiring harness connector to simulate the fuel level sending unit. Turn the ignition to the ON position and observe the fuel gauge. If, after gauge initialization, the gauge points closely to the half tank mark, then the wiring and ICU are all operating correctly. Jump to Step 4 if there is no problem with the wiring and ICU. Does the fuel level gauge stay at empty even though there is fuel in the tank or is the complaint an inaccurate and intermittent reading? Note - turn the ignition to OFF and disconnect the batteries before continuing.	Stays at Empty	Go to Step 2.
		Inaccurate or Intermittent	Go to Step 4.

Troubleshooting

Fuel Level Gauge Diagnosis			
Step	Test Procedure	Test Result	Action
2	Disconnect the connector at the fuel level sender and measure the resistance of the sender. What is the resistance of the sender?	Greater than 284Ω or Less than 23.5Ω	Go to Step 4.
		Between 284Ω and 23.5Ω	Go to Step 3.
3	Connect the fuel level sender and disconnect the connectors on the back of the ICU. Measure the resistance in the vehicle wiring between circuit 47 in connector pin D1 and the ground circuit in connector pin D2. What is the resistance of the circuit?	Greater than 284Ω	Troubleshoot and repair an open circuit on either circuit 47 or the ground between the ICU connector and the fuel level sender.
		Between 284Ω and 23.5Ω	This is the valid resistance range. If the fuel tank is full and the resistance is close to 31Ω, replace the ICU. Otherwise no problem is indicated.
		Less than 23.5Ω	Troubleshoot and repair a short to ground on circuit 47 between the ICU connector and the fuel level sender.
4	Remove the fuel sending unit from the fuel tank. Connect an ohm meter to the pins at the fuel level sender connector. Slowly move the level of the float arm from full to empty. See **Fig. 1**. Does the resistance vary linearly from 31±2Ω to 247±3Ω?	Yes	Troubleshoot and repair for corrosion or an intermittent connection in the circuitry between the ICU and the fuel level sender.
		No	Replace the fuel level sending unit.

Table 1, Fuel Level Gauge Diagnosis



Slowly move the float arm from full to empty.

Fig. 1, Testing the Fuel Level Sending Unit

Fault Codes

Since the ICU gathers information via the J1587 datalink, any error message or warning displayed by the ICU can indicate one of two things: a fault in the vehicle system or a fault in the data. If the fault lies in a particular vehicle system, see the troubleshooting subject in the appropriate section of the workshop manual.

Fault Code Screens

Fault code screens provide troubleshooting information in a brief, easy-to-read format.

NOTE: The only fault codes displayed on the Level II ICU (ICU2L) are: ENG 128, ABS 136, and ICU 140.

Specifications

IMPORTANT: The level II ICU is also known (on ServiceLink) as the ICU2L.

The instrumentation control unit, level II (level II ICU) has only one microprocessor, on the left. The two connectors are pink. Connector #1 has 24 pins, numbered A1 through A12, and B1 through B12. Connector #2 has 32 pins, numbered C1 through C16, and D1 through D16. **Table 1** and **Table 2** show the description and wire numbers of the connectors.

See **Fig. 1** for a schematic of the wiring and pinout connections for the level II ICU (ICU2L).

Table 3 lists the Message Identifiers (MIDs). Refer to **Table 4** for Parameter Identifiers (PIDs) 51 through 63. **Table 5** shows PIDs 64 through 97 and **Table 6** shows PIDs 98 through 127. **Table 7** lists PIDs 154 through 183. PIDs 184 through 253 are shown in **Table 8**.

The Engine SIDs are found in **Table 9**, **Table 10**, and **Table 11**.

The AntiLock Braking SIDs are found in **Table 12**, **Table 13**, and **Table 14**.

Table 15 shows the ACPU SIDs.

Table 16 lists the VORAD SIDs.

Generic SIDs are found in **Table 17**, **Table 18**, and **Table 19**.

Table 20 lists the Failure Mode Identifiers (FMIs).

Level II ICU Connector #1 Pin Assignments, Pins A1 Through B12		
Number	**Description**	**Wire**
A1	Panel Lights	29A
A3	Low Air Pressure	18
A4	Optional Indicator 3	GND
A5	Optional Indicator 2	GND
A6	Optional Indicator 1	GND
A7	Low Oil Pressure	GND
A8	High Coolant Temperature	GND
A10	Forward-Rear-Axle Oil Temperature Sensor (+)	42
A11	Forward-Rear-Axle Oil Temperature Sensor (–)	42G
A12	Headlights (high beams)	20H
B2	Rearmost-Axle Oil Temperature Sensor (+)	43
B3	J1587 Databus (–)	1587–C
B4	Rearmost-Axle Oil Temperature Sensor (–)	43G
B10	J1587 Databus (+)	1587+C
B11	Tractor ABS	376L

Table 1, Level II ICU Connector #1 Pin Assignments, Pins A1 through B12

Level II ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
C1	Recirculation Pressure	98K
C5	Parking Brake	125
C6	Pyrometer (+)	218A+
C8	Left Turn	38L

Specifications

Level II ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	Pin Assignment	Wire
C11	Wheel Spin	376S
C12	Transmission Fluid Temperature Gauge (–)	30G
C13	Transmission Fluid Temperature Gauge (+)	30
C14	Engine Protection (CUM only)	N16
C15	Check Engine	C799
		D419
		N25
C16	Engine Shutdown	C659
		D509
		N01
D1	Fuel Level (+)	47
D2	Fuel Level (–)	47G
D3	Panel Light Ground	GND
D4	Optional Indicator 4	GND
D6	Pyrometer (–)	218A–
D8	Right Turn	38R
D9	Buzzer Enable	437Z
D10	EMI Ground	GND
D12	Trailer ABS	376F
D13	Ground	GND
D14	Battery	437
D15	Ignition	437A
D16	Headlights	359

Table 2, Level II ICU Connector #2 Pin Assignments, Pins C1 through D16

Message Identifiers (MIDs)		
MID	Description	Text Message
128	Engine #1	ECU128
136	Anti-Lock Brakes (ABS)	AbS136
140	Instrumentation Control Unit, Left	ICU140
164	B-Panel Unit	bPU164
181	Communications Unit–Satellite	SAT181
190	Air Conditioning Protection Unit	A/C190
219	Collision Detection Radar	CdU219
231	Communications Unit–Cellular	CEL231

Message Identifiers (MIDs)		
MID	Description	Text Message
232	SPACE (Seat Belt Unit)	SbU232

Table 3, Message Identifiers (MIDs)

Parameter Identifiers (PIDs) 51 through 63		
PID	Description	Text Message
51	Throttle Position	Throttle Pos
52	Engine Intercooler Temperature	Intercool TEMP
53	Transmission Synchronizer Clutch Value	Synchro Clutch
54	Transmission Synchronizer Brake Value	Synchro Brake
55	Shift Finger Positional Status	Shift FNGR Pos
56	Transmission Range Switch Status	RANGE Switch
57	Transmission Actuator Status #2	Actuator #2
58	Shift Finger Actuator Status	Shift FNGR Act
59	Shift Finger Gear Position	Shift FNGR Gear
60	Shift Finger Rail Position	Shift FNGR Rail
61	Parking Brake Actuator Status	Park Brake Act
62	Retarder Inhibit Status	RetardrInhibit
63	Transmission Actuator Status #1	Actuator #1

Table 4, Parameter Identifiers (PIDs) 51 through 63

Parameter Identifiers (PIDs) 64 through 97		
PID	Description	Text Message
64	Direction Switch Status	Dir Switch
65	Service Brake Switch Status	Serv Brake Sw
66	Vehicle Enabling Component Status	Veh ENABLING
67	Shift Request Switch Status	Shift RQST Switch
68	Torque Limiting Factor	TORQ LimitFctr
69	Two-Speed Axle Switch Status	2 SPEEDAxl Sw
70	Parking Brake Switch	Park Brake Sw
71	Idle Shutdown Timer Status	IdleShutdwnTmr
72	Blower Bypass Valve Position	Blowr BYPASVal
73	Auxiliary Water Pump Pressure	Aux PUMP Press
74	Maximum Road Speed Limit	Max ROAD SPEED
75	Steering Axle Temperature	Str. Axle TEMP
76	Axle Lift Air Pressure	Axle Lift Pres
77	Forward-Rear Drive Axle Temperature	FR DrvAxl TEMP

Specifications

Parameter Identifiers (PIDs) 64 through 97		
PID	Description	Text Message
78	Rearmost (Rear-Rear) Drive Axle Temperature	RR DrvAxl TEMP
79	Road Surface Temperature	Road Surf TEMP
80	Washer Fluid Level	Washer Level
81	Particulate Trap Inlet Pressure	PartTRAP Press
82	Air Start Pressure	Air Start Pres
83	Road Speed Limit Status	ROAD SPEED Lim
84	Road Speed	ROAD SPEED
85	Cruise Control Status	Cruise Status
86	Cruise Control Set Speed	Cruise Set
87	Cruise Control High—Set Limit Speed	Cruise Hi Set
88	Cruise Control Low—Set Limit Speed	Cruise Lo Set
89	Power Takeoff Status	PTO Status
90	PTO Oil Temperature	PTO Oil TEMP
91	Percent Accelerator Pedal Position	Throttle Pedal
92	Percent Engine Load	% ENG LOAD
93	Output Torque	OUTPUT TORQUE
94	Fuel Delivery Pressure	Fuel DlvrPress
95	Fuel Filter Differential Pressure	Fuel Filter
96	Fuel Level	Fuel Level
97	Water in Fuel Indicator	Water In Fuel

Table 5, Parameter Identifiers (PIDs) 64 through 97

Parameter Identifiers (PIDs) 98 through 127		
PID	Description	Text Message
98	Engine Oil Level	Oil Level
99	Engine Oil Filter Differential Pressure	Oil Fltr Pres
100	Engine Oil Pressure	Oil Pressure
101	Crankcase Pressure	CrankcasePress
102	Boost Pressure	Boost Press
103	Turbo Speed	Turbo SPEED
104	Turbo Oil Pressure	TurboOilPress
105	Intake Manifold Temperature	IntakeAir TEMP
106	Air Inlet Pressure	AirInlet Press
107	Air Filter Differential Pressure	Air Filter
108	Barometric Pressure	Baro Press
109	Coolant Pressure	Coolant Press

Parameter Identifiers (PIDs) 98 through 127		
PID	Description	Text Message
110	Engine Coolant Temperature	Coolant TEMP
111	Coolant Level	Coolant Level
112	Coolant Filter Differential Pressure	CoolFltDiffPrs
113	Governor Droop	Governor DROOP
114	Net Battery Current	Battery AMPS
115	Alternator Current	Alternator AMPS
116	Brake Application Pressure	APPLI Press
117	Brake Primary Pressure	Primary Press
118	Brake Secondary Pressure	Sec. Press
119	Hydraulic Retarder Pressure	Retarder Press
120	Hydraulic Retarder Oil Temperature	Retdr Oil TEMP
121	Engine Retarder Status	Retardr Status
122	Engine Retarder Percent	% Retarder
123	Clutch Pressure	Clutch Press
124	Transmission Oil Level	Oil Level
125	Transmission Oil Level High/Low	Oil Level
126	Transmission Filter Differential Pressure	FilterDifPress
127	Transmission Oil Pressure	Oil Pressure

Table 6, Parameter Identifiers (PIDs) 98 through 127

Parameter Identifiers (PIDs) 154 through 183		
PID	Description	Text Message
154	Auxiliary Input and Output Status #2	Aux. In/Out #2
155	Auxiliary Input and Output Status #1	Aux. In/Out #1
156	Injector Timing Rail Pressure	Inj Time Press
157	Injector Metering Rail Pressure	Inj Metr Press
158	Battery Potential (voltage)—Switched	Volts (BattSw)
159	Gas Supply Pressure	Gas Press
160	Main Shaft Speed	MainShaftSPEED
161	Input Shaft Speed	In Shaft SPEED
162	Transmission Range Selected	RANGE Selected
163	Transmission Range Attained	RANGE Attained
164	Injection Control Pressure	Inj Ctrl Press
165	Compass Bearing	COMPASS Dir.
166	Rated Engine Power	Rated Power
167	Alternator Potential (voltage)	Volts (Alt)

Specifications

Parameter Identifiers (PIDs) 154 through 183		
PID	Description	Text Message
168	Battery Potential (voltage)	Volts (Batt)
169	Cargo Ambient Temperature	CARGO TEMP
170	Cab Interior Temperature	CAB TEMP
171	Ambient Air Temperature	Outside TEMP
172	Air Inlet Temperature	Air Inlet TEMP
173	Exhaust Gas Temperature	Exh Gas TEMP
174	Fuel Temperature	Fuel TEMP
175	Engine Oil Temperature	Oil TEMP
176	Turbo Oil Temperature	Turbo Oil TEMP
177	Transmission Oil Temperature	Oil TEMP
178	Front Axle Weight	Front Axle Wt.
179	Rear Axle Weight	Rear Axle Wt.
180	Trailer Weight	Trailer WEIGHT
181	Cargo Weight	CARGO WEIGHT
182	Trip Fuel	TRIP Fuel
183	Fuel Rate	Fuel Rate

Table 7, Parameter Identifiers (PIDs) 154 through 183

Parameter Identifiers (PIDs) 184 through 253		
PID	Description	Text Message
184	Instantaneous Fuel Economy	Inst Fuel Econ
185	Average Fuel Economy	AVG. Fuel Econ
186	Power Takeoff Speed	PTO SPEED
187	Power Takeoff Set Speed	PTO Set SPEED
188	Idle Engine Speed	Idle ENG SPEED
189	Rated Engine Speed	Rated SPEED
190	Engine Speed	ENGINE SPEED
191	Transmission Output Shaft Speed	OUTPUT SPEED
232	DGPS Differential Correction	DGPS Correctn
233	Power Unit Number	— *
234	Software Identification	Software ID
235	Total Idle Hours	Total Idle Hrs
236	Total Idle Fuel Used	Totl Idle Fuel
237	Vehicle Identification Number	VIN
238	Velocity Vector	VelocityVector
239	Vehicle Position	Veh. Position

Specifications

Parameter Identifiers (PIDs) 184 through 253		
PID	**Description**	**Text Message**
240	Change Reference Number	CHANGE Ref #
241	Tire Pressure	Tire Pressure
242	Tire Temperature	Tire TEMP
243	Component Identification	COMPONENT ID
244	Trip Distance	TRIP Distance
245	Total Vehicle Distance	Total Veh Dist
246	Total Vehicle Hours	Total Veh Hrs.
247	Total Engine Hours	Total ENG Hrs.
248	Total PTO Hours	Total PTO Hrs.
249	Total Engine Revolutions	Total ENG Revs
250	Total Fuel Used	Total FUELUsed
251	Clock	Clock
252	Date	Date
253	Elapsed Time	ELAPSED Time

* If there is no text message, the display area reserved for that text message will be blank. Only the PID number will display.

Table 8, Parameter Identifiers (PIDs) 184 through 253

MID 128 Engine Sub-System Identifiers 1 through 32		
SID	**Description**	**Text Message**
1	Injector Cylinder #1	Cyl #1 Injectr
2	Injector Cylinder #2	Cyl #2 Injectr
3	Injector Cylinder #3	Cyl #3 Injectr
4	Injector Cylinder #4	Cyl #4 Injectr
5	Injector Cylinder #5	Cyl #5 Injectr
6	Injector Cylinder #6	Cyl #6 Injectr
7	Injector Cylinder #7	Cyl #7 Injectr
8	Injector Cylinder #8	Cyl #8 Injectr
9	Injector Cylinder #9	Cyl #9 Injectr
10	Injector Cylinder #10	Cyl 10 Injectr
11	Injector Cylinder #11	Cyl 11 Injectr
12	Injector Cylinder #12	Cyl 12 Injectr
13	Injector Cylinder #13	Cyl 13 Injectr
14	Injector Cylinder #14	Cyl 14 Injectr
15	Injector Cylinder #15	Cyl 15 Injectr
16	Injector Cylinder #16	Cyl 16 Injectr
17	Fuel Shutoff Valve	Fuel Shutoff

Specifications

MID 128 Engine Sub-System Identifiers 1 through 32		
SID	Description	Text Message
18	Fuel Control Valve	Fuel Control
19	Throttle Bypass Valve	ThrottleBYPASS
20	Timing Actuator	TIMINGActuator
21	Engine Position Sensor	PositionSensor
22	Timing Sensor	TIMING Sensor
23	Rack Actuator	Rack Actuator
24	Rack Position Sensor	Rack Pos Sens
25	External Engine Protection Input	ExtENG Protect
26	Auxiliary Output Device Driver #1	AuxOut Driver
27	Variable Geometry Turbocharger Actuator #1	Turbo Actuator
28	Variable Geometry Turbocharger Actuator #2	TurboActuator2
29	External Fuel Command Input	Ext Fuel INPUT
30	External Speed Command Input	Ext SPEEDINPUT
31	Tachometer Signal Output	TACH OUTPUT
32	Wastegate Output Device Driver	WASTEGATE Drvr

Table 9, Engine SIDs 1 through 32

MID 128 Engine Sub-System Identifiers 33 through 64		
SID	Description	Text Message
33	Fan Clutch Output Device Driver	Fan Clutch Drv
34	Exhaust Back Pressure Sensor	Exh Press Sens
35	Exhaust Back Pressure Regulator Solenoid	Exh Press Sol
36	Glow Plug Lamp	Glow PLUG LAMP
37	Electronic Drive Unit Power Relay	Power Relay
38	Glow Plug Relay	GlowPLUG Relay
39	Engine Starter Motor Relay	Starter Relay
40	Auxiliary Output Device Driver #2	Auxout Driver2
41	ECM 8 Volts DC Supply	ECM 8VDC
42	Injection Control Pressure Regulator	Inj Press REG
43	Autoshift High Gear Actuator	HIGH Gear Act.
44	Autoshift Low Gear Actuator	Low Gear Act.
45	Autoshift Neutral Gear Actuator	Neutral Act.
46	Autoshift Common Low Side (Return)	Common
47	Injector Cylinder #17	Cyl 17 Injectr
48	Injector Cylinder #18	Cyl 18 Injectr
49	Injector Cylinder #19	Cyl 19 Injectr

MID 128 Engine Sub-System Identifiers 33 through 64		
SID	**Description**	**Text Message**
50	Injector Cylinder #20	Cyl 20 Injectr
51	Auxiliary Output Device Driver #3	Auxout Driver3
52	Auxiliary Output Device Driver #4	Auxout Driver4
53	Auxiliary Output Device Driver #5	Auxout Driver5
54	Auxiliary Output Device Driver #6	Auxout Driver6
55	Auxiliary Output Device Driver #7	Auxout Driver7
56	Auxiliary Output Device Driver #8	Auxout Driver8
57	Auxiliary PWM Driver #1	Aux PWM Drvr 1
58	Auxiliary PWM Driver #2	Aux PWM Drvr 2
59	Auxiliary PWM Driver #3	Aux PWM Drvr 3
60	Auxiliary PWM Driver #4	Aux PWM Drvr 4
61	Variable Swirl System Valve	Swirl Valve
62	Prestroke Sensor	PreStroke Snsr
63	Prestroke Actuator	PreStroke actr
64	Engine Speed Sensor #2	SPEED Sensor 2

Table 10, Engine SIDs 33 through 64

MID 128 Engine Sub-System Identifiers 65 through 78		
SID	**Description**	**Text Message**
65	Heated Oxygen Sensor	— *
66	Ignition Control Mode Signal	— *
67	Ignition Control Timing Signal	— *
68	Secondary Turbo Inlet Pressure	— *
69	ACOC (Aftercooler/Oil Cooler) Coolant F	— *
70	Inlet Air Heater Driver #1	— *
71	Inlet Air Heater Driver #2	— *
72	Injector Cylinder #21	— *
73	Injector Cylinder #22	— *
74	Injector Cylinder #23	— *
75	Injector Cylinder #24	— *
76	Knock Sensor	— *
77	Gas Metering Valve	— *
78	Fuel Supply Pump Actuator	— *

* If there is no text message, the display area reserved for that text message will be blank. Only the SID number will display.

Table 11, Engine SIDs 65 through 78

Specifications

MID 136 ABS Sub-System Identifiers 1 through 14		
SID	Description	Text Message
1	Wheel Sensor ABS Axle 1 Left	Wh Snsr Axl 1L
2	Wheel Sensor ABS Axle 1 Right	Wh Snsr Axl 1R
3	Wheel Sensor ABS Axle 2 Left	Wh Snsr Axl 2L
4	Wheel Sensor ABS Axle 2 Right	Wh Snsr Axl 2R
5	Wheel Sensor ABS Axle 3 Left	Wh Snsr Axl 3L
6	Wheel Sensor ABS Axle 3 Right	Wh Snsr Axl 3R
7	Pressure Modulation Valve ABS Axle 1 Left	Mod. Valve A1L
8	Pressure Modulation Valve ABS Axle 1 Right	Mod. Valve A1R
9	Pressure Modulation Valve ABS Axle 2 Left	Mod. Valve A2L
10	Pressure Modulation Valve ABS Axle 2 Right	Mod. Valve A2R
11	Pressure Modulation Valve ABS Axle 3 Left	Mod. Valve A3L
12	Pressure Modulation Valve ABS Axle 3 Right	Mod. Valve A3R
13	Retarder Control Relay	Rtdr Cntrl Rly
14	Relay Diagonal 1	Relay DIAG. 1

Table 12, ABS SIDs 1 through 14

MID 136 ABS Sub-System Identifiers 15 through 47		
SID	Description	Text Message
15	Relay Diagonal 2	Relay DIAG. 2
16	Mode Switch ABS	ABS Mode Swtch
17	Mode Switch ASR	ASR Mode Swtch
18	DIF 1-ASR Valve	ASR Dif1 Valve
19	DIF 2-ASR Valve	ASR Dif2 Valve
20	Pneumatic Engine Control	Pneu ENG Cntrl
21	Electronic Engine Control (Servomotor)	Elec ENG Cntrl
22	Speed Signal Input	SPEEDSIGNAL In
23	Warning Light Bulb	WarnLIGHT Bulb
24	ASR Light Bulb	ASR LIGHT Bulb
25	Wheel Sensor, ABS Axle 1 Average	Sensor AX1 AVG
26	Wheel Sensor, ABS Axle 2 Average	Sensor AX2 AVG
27	Wheel Sensor, ABS Axle 3 average	Sensor AX3 AVG
28	Pressure Modulator, Drive Axle Relay Valve	Mod, Relay Valve
29	Pressure Transducer, Drive Axle Relay Valve	Trans, Relay Vlv
30	Master Control Relay	Master Relay
31	Trailer Brake Slack Out of Adjust Frwrd Axle Left	Brake Adjust
32	Trailer Brake Slack Out of Adjust Frwrd Axle Right	Brake Adjust

MID 136 ABS Sub-System Identifiers 15 through 47		
SID	Description	Text Message
33	Trailer Brake Slack Out of Adjust Rear Axle Left	Brake Adjust
34	Trailer Brake Slack Out of Adjust Rear Axle Right	Brake Adjust
35	Tractor Brake Slack Out of Adjust Axle 1 Left	Brake Adjust
36	Tractor Brake Slack Out of Adjust Axle 1 Right	Brake Adjust
37	Tractor Brake Slack Out of Adjust Axle 2 Left	Brake Adjust
38	Tractor Brake Slack Out of Adjust Axle 2 Right	Brake Adjust
39	Tractor Brake Slack Out of Adjust Axle 3 Left	Brake Adjust
40	Tractor Brake Slack Out of Adjust Axle 3 Right	Brake Adjust
41	Ride Height Relay	—
42	Hold Modulator Valve Solenoid—Axle 1 Left	—
43	Hold Modulator Valve Solenoid—Axle 1 Right	—
44	Hold Modulator Valve Solenoid—Axle 2 Left	—
45	Hold Modulator Valve Solenoid—Axle 2 Right	—
46	Hold Modulator Valve Solenoid—Axle 3 Left	—
47	Hold Modulator Valve Solenoid—Axle 3 Right	—

Table 13, ABS SIDs 15 through 47

MID 136 ABS Sub-System Identifiers 48 through 80		
SID	Description	Text Message
48	Dump Modulator Valve Solenoid—Axle 1 Left	—
49	Dump Modulator Valve Solenoid—Axle 1 Right	—
50	Dump Modulator Valve Solenoid—Axle 2 Left	—
51	Dump Modulator Valve Solenoid—Axle 2 Right	—
52	Dump Modulator Valve Solenoid—Axle 3 Left	—
53	Dump Modulator Valve Solenoid—Axle 3 Right	—
54	Hydraulic Pump Motor	—
55	Brake Light Switch 1	—
56	Brake Light Switch 2	—
57	Electronic Pressure Control, Axle 1	—
58	Pneumatic Back-Up Pressure Control, Axle 1	—
59	Brake Pressure Sensing, Axle 1	—
60	Electronic Pressure Control, Axle 2	—
61	Pneumatic Back-Up Pressure Control, Axle 2	—
62	Brake Pressure Sensing, Axle 2	—
63	Electronic Pressure Control, Axle 3	—
64	Pneumatic Back-Up Pressure Control, Axle 3	—

Specifications

MID 136 ABS Sub-System Identifiers 48 through 80		
SID	Description	Text Message
65	Brake Pressure Sensing, Axle 3	—
66	Electronic Pressure Control, Trailer Control	—
67	Pneumatic Back-Up Pressure Control, Trailer Control	—
68	Brake Pressure Sensing, Trailer Control	—
69	Axle Load Sensor	—
70	Lining Wear Sensor, Axle 1 Left	—
71	Lining Wear Sensor, Axle 1 Right	—
72	Lining Wear Sensor, Axle 2 Left	—
73	Lining Wear Sensor, Axle 2 Right	—
74	Lining Wear Sensor, Axle 3 Left	—
75	Lining Wear Sensor, Axle 3 Right	—
76	Brake Signal Transmitter	—
77	Brake Signal Sensor 1	—
78	Brake Signal Sensor 2	—
79	Tire Dimension Supervision	—
80	Vehicle Deceleration Control	—

Table 14, ABS SIDs 48 through 80

MID 190 ACPU Sub-System Identifiers		
SID	Description	Text Message
1	Refrigerant Charge	REFRIG Pres
2	Refrigerant Moisture Level	REFRIG Moistr
3	Non-Condensable Gas in Refrigerant	Gas In REFRIGN
4	Refrigerant Flow Control Solenoid	RFRG Flow Ctrl
5	Low Pressure Switch	Low Pres SW
6	Refrigerant Clutch Circuit	Clutch Cir
7	Evaporator Thermostat Circuit	Tstat Cir

Table 15, ACPU SIDs

MID 219 VORAD Collision Avoidance Radar Sub-System Identifiers		
SID	Description	Text Message
1	Forward Antenna	—
2	Antenna Electronics	—
3	Brake Input Monitor	—
4	Speaker Monitor	—
5	Steering Sensor Monitor	—

MID 219 VORAD Collision Avoidance Radar Sub-System Identifiers		
SID	Description	Text Message
6	Speedometer Monitor	—
7	Right Turn Signal Monitor	—
8	Left Turn Signal Monitor	—
9	Control Display Unit	—
10	Right Side Sensor	—
11	Left Side Sensor	—
12	Rear Sensor	—

Table 16, VORAD Collision Avoidance Radar SIDs

Generic Sub-System Identifiers (Common to all MIDs) 151 through 153		
SID	Description	Text Message
151	System Diagnostic Code #1	—
152	System Diagnostic Code #2	—
153	System Diagnostic Code #3	—

Table 17, Generic SIDs 151 through 153

Generic Sub-System Identifiers (Common to all MIDs) 154 through 248		
SID	Description	Text Message
154	System Diagnostic Code #4	—
155	System Diagnostic Code #5	—
219	Start Signal Indicator	—
220	Electronic Tractor/Trailer Interface (ISO 11992)	—
221	Internal Sensor Voltage Supply	—
222	Protect Light	—
223	Ambient Light Sensor	—
224	Audible Alarm	—
225	Green Light	—
226	Transmission Neutral Switch	—
227	Auxiliary Analog Input #1	—
228	High Pressure Switch	HI Pres SW
229	Kickdown Switch	—
230	Idle Validation Switch	—
231	SAE J1939 Datalink	—
232	5-Volt DC Supply	—
233	Controller #2	—
234	Parking Brake ON Actuator	—

Specifications

Generic Sub-System Identifiers (Common to all MIDs) 154 through 248		
SID	Description	Text Message
235	Parking Brake OFF Actuator	—
236	Power Connect Device	—
237	Start Enable Device	—
238	Diagnostic Light—Red	—
239	Diagnostic Light—Amber	—
240	Program Memory	—
242	Cruise Control RESUME Switch	—
243	Cruise Control SET Switch	—
244	Cruise Control ENABLE Switch	—
245	Clutch Pedal Switch #1	—
246	Brake Pedal Switch #1	—
247	Brake Pedal Switch #2	—
248	Proprietary Datalink	—

Table 18, Generic SIDs 226 through 248

Generic Sub-System Identifiers (Common to all MIDs) 249 through 254		
SID	Description	Text Message
249	SAE J1922 Datalink	SAE J1922
250	SAE J1708 (J1587) Datalink	—
251	Power Supply	POWER SUPPLY
252	Calibration Module	—
253	Calibration Memory	—
254	Controller #1	Controller

Table 19, Generic SIDs 249 through 254

Failure Mode Identifiers (FMIs)		
FMI	Description and Comments	Text Message
00	Above normal operating range, for example: engine overheating (required diagnostic information)	HIGH
01	Below normal operating range, for example: engine oil pressure too low (required diagnostic information)	Low
02	Erratic, intermittent, or incorrect data	Erratic
03	Voltage above normal or shorted high	Short Hi
04	Voltage below normal or shorted low	Short Lo
05	Current below normal or open circuit	OPEN
06	Current above normal or circuit shorted to ground	Short
07	Mechanical system not responding properly	NoRESPONSE

Failure Mode Identifiers (FMIs)		
FMI	Description and Comments	Text Message
08	Abnormal frequency, pulse width, or period	SIGNAL
09	Abnormal update rate	UPDATE
10	Abnormal rate of change	Rate
11	Failure node not identifiable	Not Known
12	Bad intelligent device or component	Bad
13	Out of calibration	Calibrate
14	Special instructions	RSRVD
15	Reserved for future assignment	RSRVD

Table 20, Failure Mode Identifiers (FMIs)

Speaker Removal and Installation

Tweeter

REMOVAL

1. Shut down the engine and set the parking brake. Chock the front tires.
2. Remove the Torx®-head screw attaching the tweeter grille to the front of the arm rest cover assembly. See **Fig. 1**.
3. Remove the tweeter grille by gently prying it away from the arm rest cover assembly. Begin prying at the forward end of the grille.
4. At the mirror lower bracket cover on the outside of the vehicle, remove the access tab to uncover the bolt that passes through the door and attaches to the tweeter bracket.
5. Remove the bolt.
6. Remove the two capscrews attaching the tweeter bracket to the inner door panel.
7. Remove the front arm rest cover to access the wires attached to the tweeter. Then, disconnect the speaker wires from the wire harness.

IMPORTANT: Do not remove the heat shrink tube from the speaker wire. Disconnect the wires by pulling the tweeter away from the door, and then disconnecting the wires from the wire harness inside the door.

8. Remove the capscrew attaching the tweeter to the tweeter bracket.

INSTALLATION

1. Attach the tweeter to the tweeter bracket with one capscrew. Orient the tweeter wires so that they remain in a 6 o'clock position when the tweeter is installed.
2. Connect the tweeter wires to the speaker wiring harness inside the door.
3. Using two capscrews, attach the tweeter bracket to the door inner panel.
4. Install the front arm rest cover.
5. Install the bolt that attaches through the door to the tweeter bracket. Install the access tab on the mirror lower bracket cover.
6. Install the tweeter grille in the door panel by inserting the tab at the aft edge of the grille in the slot in the door panel.
7. Install the Torx-head screw to secure the tweeter grille to the front of the arm rest cover assembly.
8. Remove the chocks from the tires.

Midrange Speaker (5-1/4 Inch)

REMOVAL

1. Shut down the engine and set the parking brake. Chock the front tires.
2. Gently pry the midrange speaker grille away from the speaker, prying from the front edge of the grille. See **Fig. 1**.
3. Remove the four Torx-head screws attaching the speaker to the inner door panel.
4. Remove the speaker.
5. Disconnect the speaker wires from the speaker wiring harness.

INSTALLATION

1. Connect the speaker wires to the speaker wiring harness inside the inner door panel.
2. Attach the speaker to the door panel using the four Torx-head screws.
3. Install the grille by inserting the tabs on the aft edge of the grille in the slots provided. Snap the forward edge of the grille into position.
4. Remove the chocks from the tires.

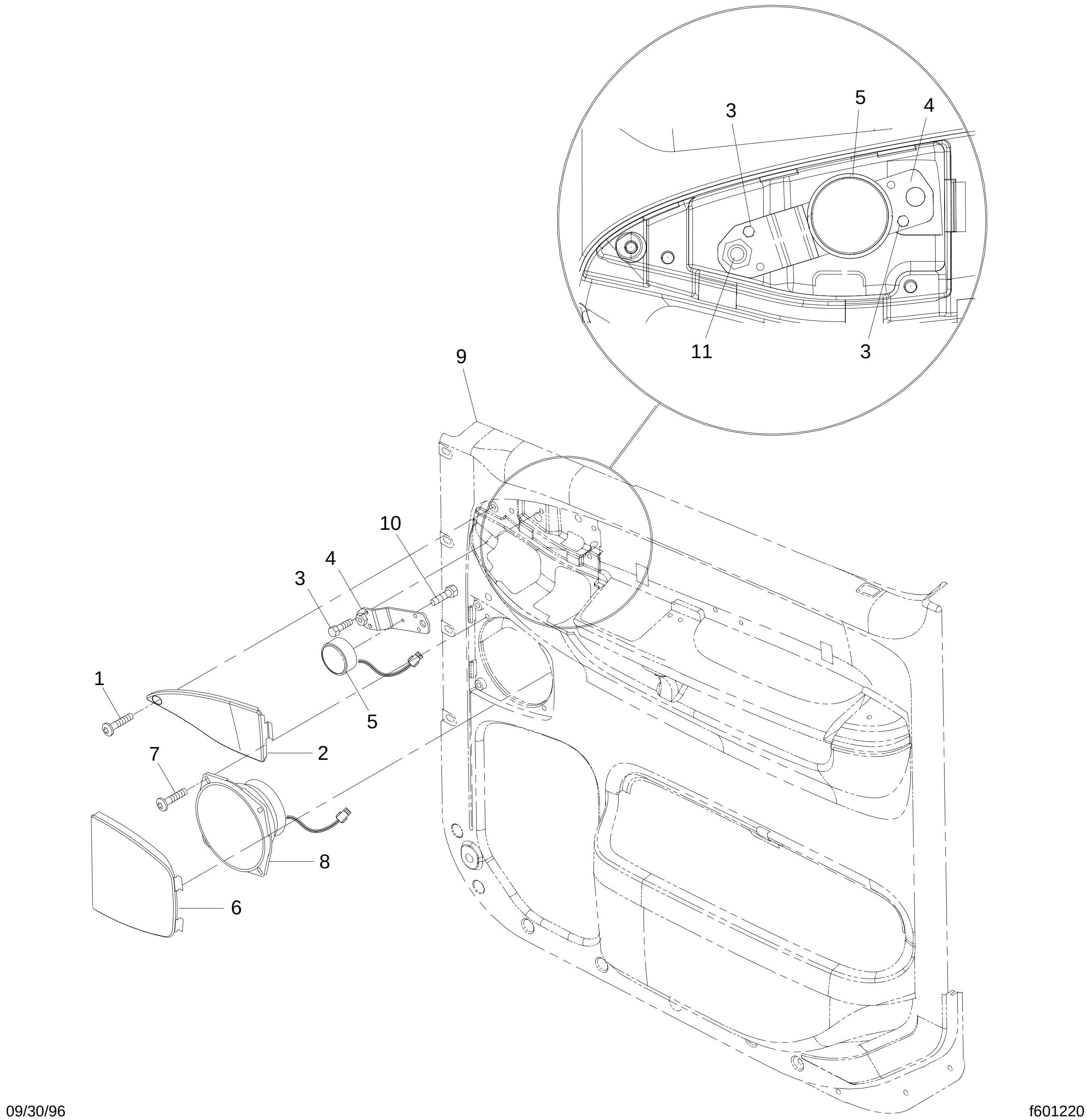
Full Range Speaker (6 by 9 Inch)

REMOVAL

The location of the full range speakers depends on the type of vehicle. In raised-roof vehicles, the speakers are mounted in the roof cap above the upper bunk. In mid-roof cab vehicles, the speakers are mounted on the underside of the rear overhead shelves in the upper rear sleeper corners.

NOTE: In mid-roof cab vehicles without the rear overhead shelves, the speakers are 5-1/4 inch

Speaker Removal and Installation



1. Torx-head Screw, Tweeter Grille
2. Tweeter Grille
3. Capscrew, Tweeter Bracket
4. Tweeter Bracket
5. Tweeter Speaker
6. Midrange Grille
7. Torx-head Screw, Midrange
8. Midrange Speaker
9. Door (inside view)
10. Capscrew, Tweeter
11. Weldnut, Door Bolt

Fig. 1, Tweeter and Midrange Speaker Installations (right-hand door)

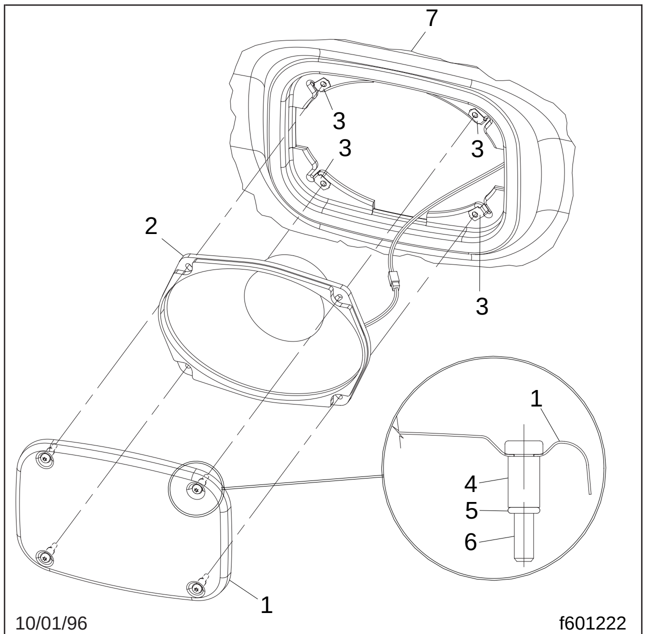
speakers, and are mounted in the upper rear sleeper corners.

1. Shut down the engine and set the parking brake. Chock the front tires.

WARNING

Be careful when removing the speaker grille and speaker. The speaker is heavy and, because the speaker is attached with the same fasteners as the speaker grille, the speaker may fall suddenly from the speaker opening during removal, resulting in personal injury or property damage.

2. Remove the four screws, spacers, and O-rings attaching the grille and the speaker to the cab interior components. Then, remove the grille and the speaker. See **Fig. 2**. Save the fasteners and O-rings for installation.



1. Speaker Grille
2. Bass Speaker
3. J-Clip
4. Spacer
5. O-ring
6. Screw
7. Cab Interior Panel

Fig. 2, Bass Speaker Assembly

3. Disconnect the speaker wires from the speaker wire harness.

INSTALLATION

1. Insert the four screws in the speaker grille mounting holes. Then, slip the spacers over the screws and secure with the O-rings. See **Fig. 2**.
2. Be sure the four J-clips are in place in the speaker cut-out area to receive the screws.
3. Connect the speaker wires to the speaker wire harness.
4. Install the speaker and speaker grille in the cab interior panel and tighten the four screws.
5. Remove the chocks from the tires.

Subwoofer

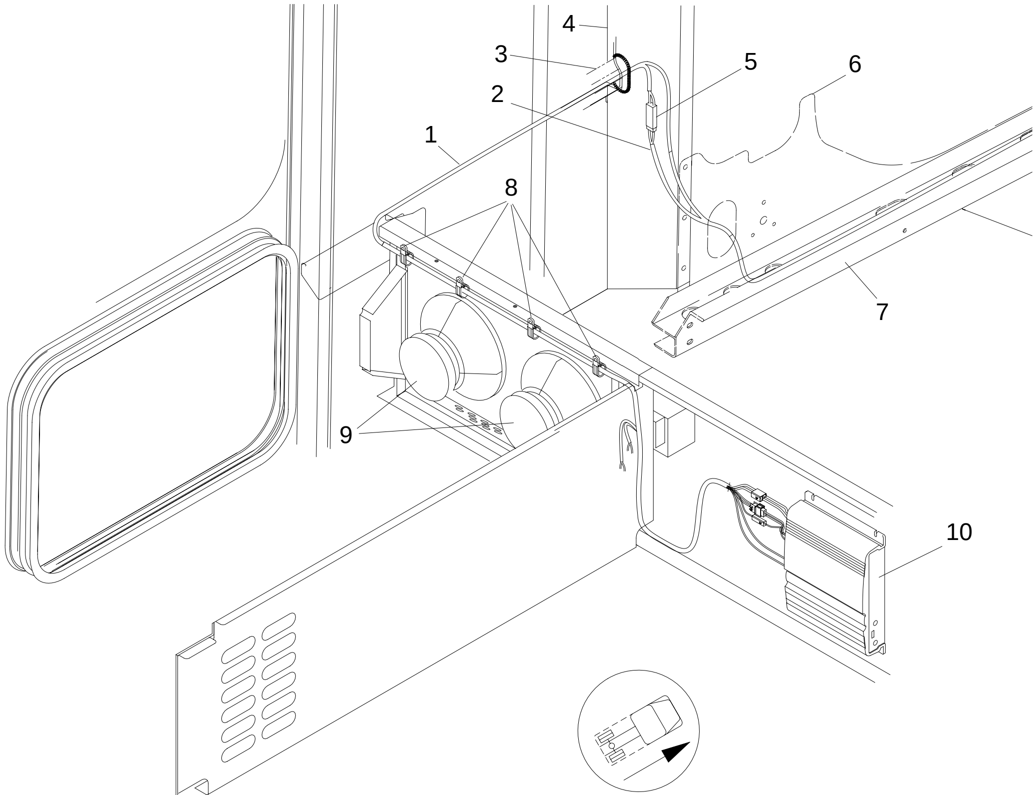
REMOVAL

1. Shut down the engine and set the parking brake. Chock the front tires.
2. Raise the bunk to access the underbunk storage area and the subwoofer assembly. See **Fig. 3**.
3. Disconnect the subwoofer wiring harness from the subwoofer power amplifier.
4. Remove the press-fit grilles from the individual speakers.
5. Remove the nylon locknuts that secure the grille retaining rings.
6. Remove the subwoofer assembly from the underbunk storage area by pulling the assembly away from the bunk partition until all eight screws are free.
7. If replacing subwoofer assembly components, disassemble the subwoofer assembly. See **Fig. 4**.
   - 7.1 Remove the speaker guard from the speaker and panel assembly.
   - 7.2 Remove the nuts and washer securing the speakers to the panel.
   - 7.3 Remove the clamps that secure the speaker wires to the back of the panel.
   - 7.4 Remove the speakers from the panel.

INSTALLATION

1. Assemble the subwoofer speaker assembly.

Speaker Removal and Installation



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1. Amplifier/Subwoofer Harness, Bunkside
2. Amplifier/Subwoofer Harness, Cabside
3. Sidewall Wire Hole
4. B-pillar
5. Harness Connector
6. B-pillar Lower Reinforcement
7. Outer Underbody Sill
8. Clip
9. Subwoofer
10. Amplifier

Fig. 3, Subwoofer/Amplifier Assembly

1.1 Install each speaker on the back (flat side) of the mounting panel with four screws. Orient the speakers with the speaker wire terminals facing down in the 6 o'clock position.

1.2 On the front of the panel, install the nuts and washers on the screws to secure the speakers to the panel. The nuts and washers should be within the inset area on the front of the panel but the screws extend beyond the face of the panel.

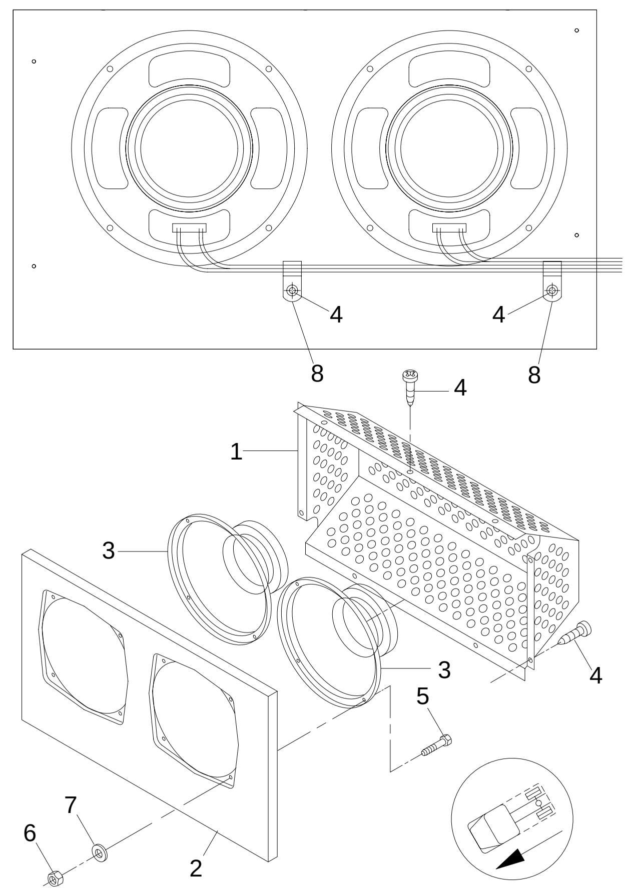
1.3 Secure the wire harness to the back of the panel with clamps as shown in **Fig. 4**.

1.4 Attach the speaker and panel assembly to the speaker guard. See **Fig. 4**.

1.5 Route the wire harness through the hole in the lower corner of the guard.

2. Position the subwoofer assembly in the under-bunk storage area as shown in **Fig. 3** so that the eight screws protruding from the forward face of the assembly fit the holes in the bunk partition and carpet.
3. Install the grille retaining rings on the screws. Secure each screw with a nylon locknut.
4. Install the press-fit grilles over the retaining rings.
5. Connect the subwoofer wiring harness to the harness from the subwoofer power amplifier.
6. Remove the chocks from the tires.

Speaker Removal and Installation



1. Speaker Guard
2. Speaker Mounting Panel
3. Subwoofer
4. Screw, 10–16 x 5/8 in
5. Screw, 10–24 x 1-3/4 in
6. Nut, 10–24
7. Washer
8. Clamp

Fig. 4, Subwoofer Assembly

Overhead Console Speaker Grille Removal and Installation

Removal and Installation

The triangular-shaped speaker grille mounted to the center bottom of the overhead console does not cover a specific speaker at this location. If a CB radio is installed in the overhead console, however, the speaker grille allows the sound from the CB radio speaker to be heard. Removing the speaker grille allows access to the center portion of the console for installation purposes.

The speaker grille has four tabs along the edge of the grille to keep it in place on the overhead console. To remove and install the speaker grille:

1. Using a slotted screwdriver, and taking care not to mark or bend the grille itself, gently pry the forward portion of the grille free of the console.
2. Install the grille by positioning it on the console and gently tapping it into place.

General Information

The HighwayMaster® mobile communications system combines phone and satellite capabilities. It includes the following components, as shown in **Fig. 1**:

- A control unit for processing all vehicle communications, mounted in the cab (**Fig. 2**)
- A cellular telephone handset and cradle, mounted on the dash console (**Fig. 3**)
- A text display unit for satellite communications, mounted on the upper dash panel (**Fig. 3**)
- A hands-free microphone, mounted on top of the display unit (**Fig. 3**)
- A speaker, mounted on the cab wall above the driver's seat (**Fig. 4**)
- A cellular antenna for telephone communications, normally mounted on the passenger's side outside cab wall or on the back of the cab (**Fig. 5**)
- A GPS (global positioning system) antenna for satellite communications, normally mounted on the back of the cab (**Fig. 6**)
- The cables necessary to connect the various components together

Each of these components can be replaced separately. See the appropriate subject for replacement procedures.

- For control unit replacement, see **Subject 100**
- For handset replacement, see **Subject 110**
- For display unit replacement, see **Subject 120**
- For microphone replacement, see **Subject 130**
- For speaker replacement, see **Subject 140**
- For cellular antenna replacement, see **Subject 150**
- For GPS antenna replacement, see **Subject 160**

Before use, the control unit must be activated to receive data through the cellular and satellite networks. Also, the system must receive an authorization from Customer Care, HighwayMaster's technical support facility, that a system module has been assigned and that the information about it has been stored in ACUS, a database maintained by AT & T.

NOTE: When replacing a control unit, make sure the new unit has been activated before turning it on for the first time.

To operate successfully, the information must be accurate, and include the following:

1. TIN (Truck Identification Number)—a number generated by HighwayMaster for billing purposes
2. CID (Customer Identification Number)—a number generated by HighwayMaster for customer reporting and tracking
3. MIN (Mobile Identification Number)—the phone number of the cellular modem, which is found on a decal on the side of the control unit
4. ESN (Electronic Serial Number)—an electronically encoded serial number in the control unit, which is also found on the decal on the side of the control unit
5. Tractor Number—the vehicle ID number
6. System Module Serial Number—the serial number of the control unit, which is also found on the decal on the side of the control unit
7. Text Display Serial Number—the serial number of the display unit, which is found on a decal on the back of the display unit
8. Handset Serial Number—the serial number of the handset, which is found on on a metal tag on the back of the handset

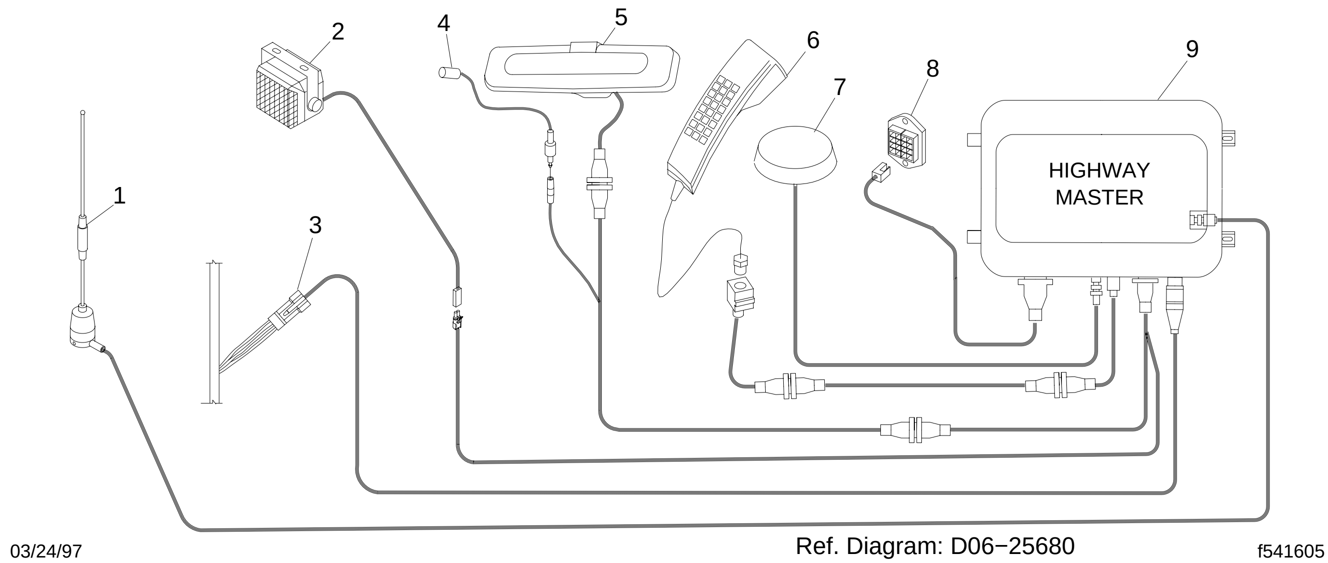
Principles of Operation

START-UP CYCLE

Each time the engine is started, the HighwayMaster system goes into its start-up cycle. When the system is functioning properly, it goes through the following steps:

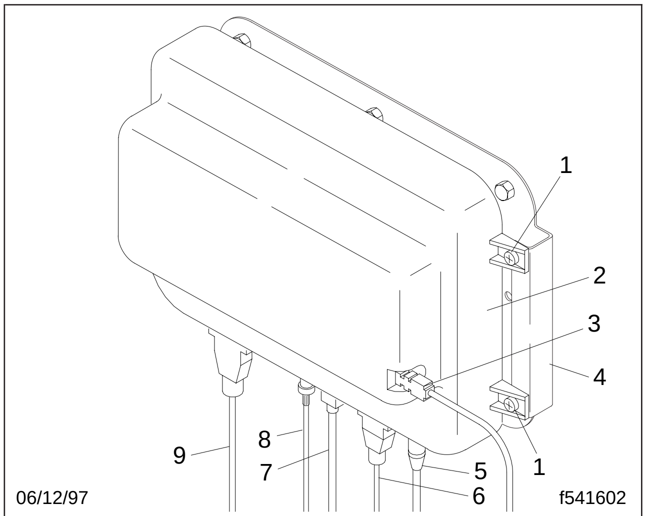
1. The display shows the underline prompt (_).
2. The display reads "Checking Cellular Service" and then changes to "Registering Unit for Service."
3. Once the unit has been registered, the display reads either "HighwayMaster Service Area" (if you are in an area where HighwayMaster pro-

General Information



1. Cellular Antenna
2. Speaker
3. Power Cable Connection
4. Microphone
5. Display Unit
6. Handset
7. GPS Antenna
8. B-Pillar Datalink Junction Block
9. Control Unit

Fig. 1, HighwayMaster System Components



1. SEM Screw
2. Control Unit
3. Cellular Antenna Cable
4. Mounting Plate
5. Power Cable
6. Display Cable
7. Phone Cable
8. GPS Antenna Cable
9. Datalink Cable

Fig. 2, Control Unit and Cables

vides cellular coverage) or "HighwayMaster" (if you are out of the coverage area).

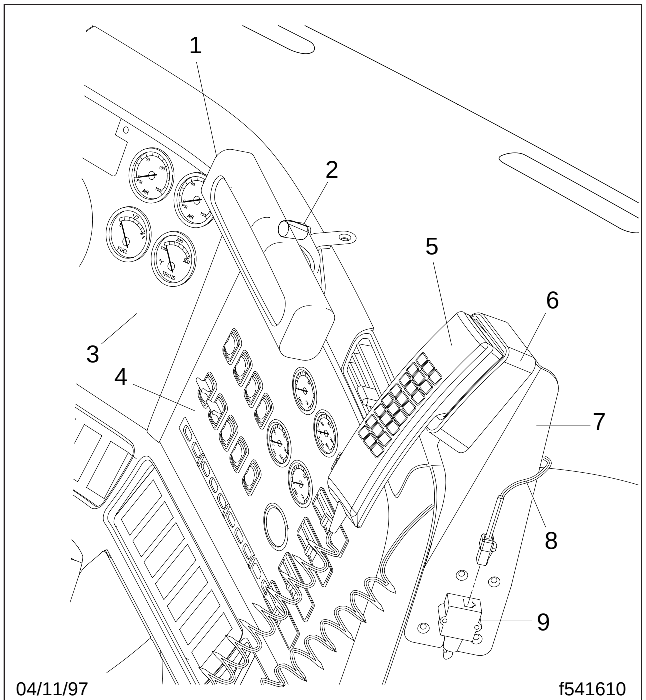
4. When fully operational, the handset is illuminated and the display shows from three to seven bars.

The screen saver timer is a feature that allows the display to go blank if the system has not been used for a programmable number of minutes. The timer can be set to anywhere from 1 to 240 minutes in 1-minute intervals.

HANDSET KEYPAD

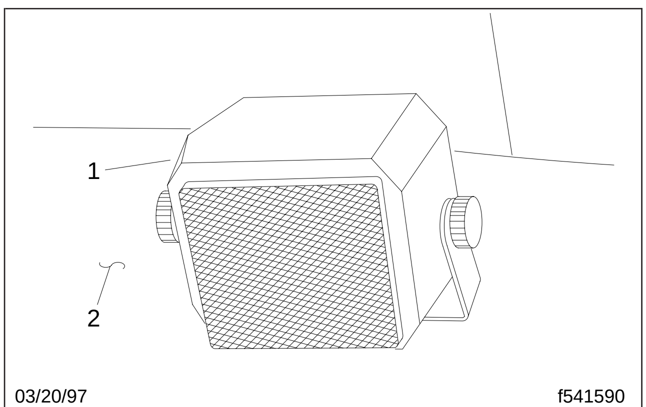
In addition to having all the features of a telephone, the handset also functions as a keypad for programming the HighwayMaster system. The function keys on the handset also allow access to the memory functions of the system. The up and down keys allow scrolling through the information stored in memory

- The SND (Send) key is used to start a call and to transmit information. Pressing SND when receiving a call activates the hands-free microphone and the voice recognition system.
- The END key is used to end a hands-free call and get the system ready to receive new information.
- The PWR (Power) key turns the system on and off.



1. Display Unit
2. Microphone
3. Driver's Instrument Panel
4. Auxiliary Instrument Panel
5. Handset
6. Cradle
7. Pedestal
8. Cord
9. Pickup

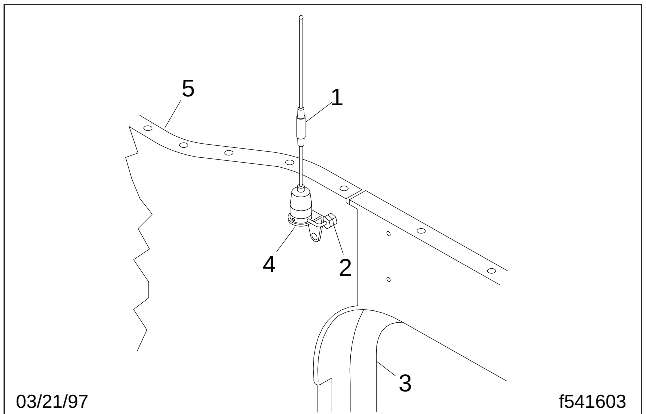
Fig. 3, HighwayMaster Dash Components



1. Speaker
2. Door Overhead Panel

Fig. 4, Speaker

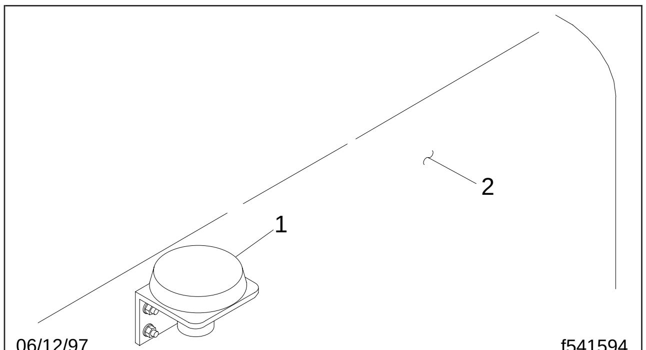
- The CHK (Check) key is used to check information, such as NAV status.



On aftermarket installations, the cellular antenna is installed on the back of the cab, like the GPS antenna.

1. Cellular Antenna
2. Cable Pass-Through Nut
3. RH Door Frame
4. Mounting Bracket
5. Cab Skin, RH Side

Fig. 5, Cellular Antenna



1. GPS Antenna
2. Back of Cab

Fig. 6, GPS Antenna

- The RCL (Recall) key is used to recall information stored in memory.
- The STO (Store) key is used to store information in memory, including telephone numbers and programming codes.
- The F (Function) key calls up the programming menu, allowing you to set functions such as the screen saver timer.
- The CLR (Clear) key is used to clear information from the display.

General Information

VOICE RECOGNITION

For greater driver convenience, the system can be operated by voice commands, using the hands-free microphone and the voice recognition system.

The control unit contains the voice recognition system which allows the speaker to respond to voice commands. To test the voice recognition system, press the END key on the handset. If the speaker says "Ready," the voice recognition system is working.

POWER OFF DELAY

Power off delay is a feature that allows the HighwayMaster system to remain in operation for a programmable number of hours after the vehicle is shut off. The delay can be set to anywhere from 0 to 12 hours in 1-hour intervals.

PERSONAL AND AUTHORIZED CALLING

The personal calling feature allows drivers, at their own expense, to use the HighwayMaster system to make personal calls, providing they have an AT & T TrueChoice SM calling card.

Both personal and authorized phone numbers can be stored in memory for easier dialing.

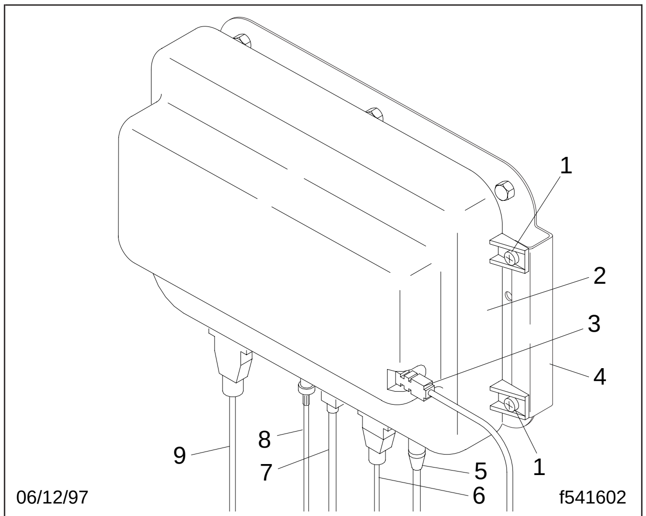
Authorized numbers are used for company business. They are stored in memory by the trucking company using special codes, allowing the driver to call dispatchers, terminals, and customers at company expense.

Replacement

The HighwayMaster® control unit is normally mounted on a mounting tray attached to the wall of the baggage compartment. On day cabs, and in other cases where space does not permit it to be mounted in this location, the control unit is mounted with its mounting plate attached directly to the cab deck.

IMPORTANT: Before attempting to install a new control unit, fax the serial number, electronic serial number, and mobile identification number of the unit to HighwayMaster at 1–800–647–6643. These numbers are found on the decal on the side of the control unit.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Gain access to the control unit. Normally it is installed under the bunk on the right-hand side of the cab.
3. Remove the cables attached to the control unit. See **Fig. 1**.



1. SEM Screw
2. Control Unit
3. Cellular Antenna Cable
4. Mounting Plate
5. Power Cable
6. Display Cable
7. Phone Cable
8. GPS Antenna Cable
9. Datalink Cable

Fig. 1, Control Unit and Cables

3.1 Remove the round 1-pin connector on the cellular antenna cable from the plug on the side of the front casing.

3.2 Remove the round 3-pin connector on the power cable from the plug on the bottom of the case.

3.3 Remove the 9-pin connector on the display cable from the plug on the bottom of the case.

3.4 Remove the connector on the phone cable from the phone plug on the bottom of the case.

3.5 Remove the round 1-pin connector on the GPS antenna cable from the plug on the bottom of the case.

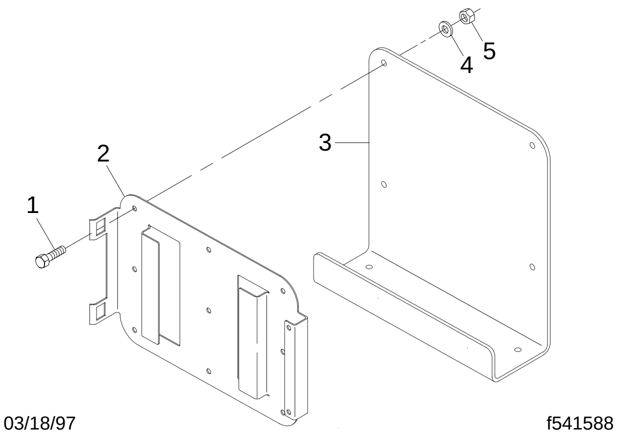
3.6 Remove the 15-pin connector on the datalink cable from the plug on the bottom of the case.

4. Remove the two SEM screws attaching the control unit to the mounting plate and lift the two lugs on the other end of the control unit out of the slots provided on the mounting plate.

NOTE: It is not necessary to remove the mounting plate to replace the control unit. Do the following step only if it is necessary to replace the mounting plate or to change the mounting of the control unit.

5. Remove the 1/4–20 capscrews (3/4-inch long), washers, and locknuts attaching the mounting plate to the mounting tray. See **Fig. 2** for installations using the mounting tray and **Fig. 3** for installations with the mounting plate attached directly to the cab deck or other cab structure.
6. If removed, attach the mounting plate to the mounting tray or cab structure, as required.
7. Insert the lugs in the control unit into the slots in the mounting plate. Install the SEM screws and tighten them until snug.
8. Connect the batteries.
9. Connect the display, phone, and both antenna cables to the control unit, as removed. Check all cables for good connections at both ends.
10. Connect the datalink cable to the control unit, as removed. Check the cable for good connections at both ends. See **Fig. 4**.

Control Unit Replacement



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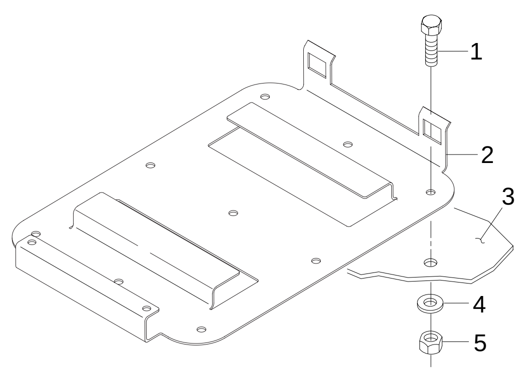
1. Capscrew, 1/4–20
2. Mounting Plate
3. Mounting Tray
4. Flatwasher, 1/4–20
5. Locknut, 1/4–20

Fig. 2, Removing the Mounting Plate from the Mounting Tray



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1. Capscrew, 1/4–20
2. Mounting Plate
3. Cab Deck
4. Flatwasher, 1/4–20
5. Locknut, 1/4–20

Fig. 3, Removing the Mounting Plate from the Cab Rear Deck

IMPORTANT: Do not connect the power cable until battery power has been restored. Before connecting power to the unit, call HighwayMaster Customer Care at 1–800–647–6693 to confirm the unit has been initialized from the host.

11. With battery power restored, connect the power cable to the control unit, as removed. Check the cable for good connections at both ends. See **Fig. 5**.

12. Initialize the control unit.

    12.1 On the handset, press the following sequence of keys:

    - "STO," "9," "9," "SND"
    - "STO," "0," "1," "SND"

    NOTE: If the display does not read "TRANSMISSION SUCCESSFUL," first press the key sequence "STO," "0," "1," "SND" again. If that does not work, call HighwayMaster Customer Care at 1–800–647–6693 and follow their instructions.

    12.2 When the display reads "TRANSMISSION SUCCESSFUL," type in this key sequence:

    - "5," "9," "8," "2," "0," "0," "CHK"

    12.3 When the display reads "GPS HAS REACHED NAV STATUS," the system is ready to operate.

    If the display does not read "GPS HAS REACHED NAV STATUS," see **Troubleshooting, 300**.

13. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.

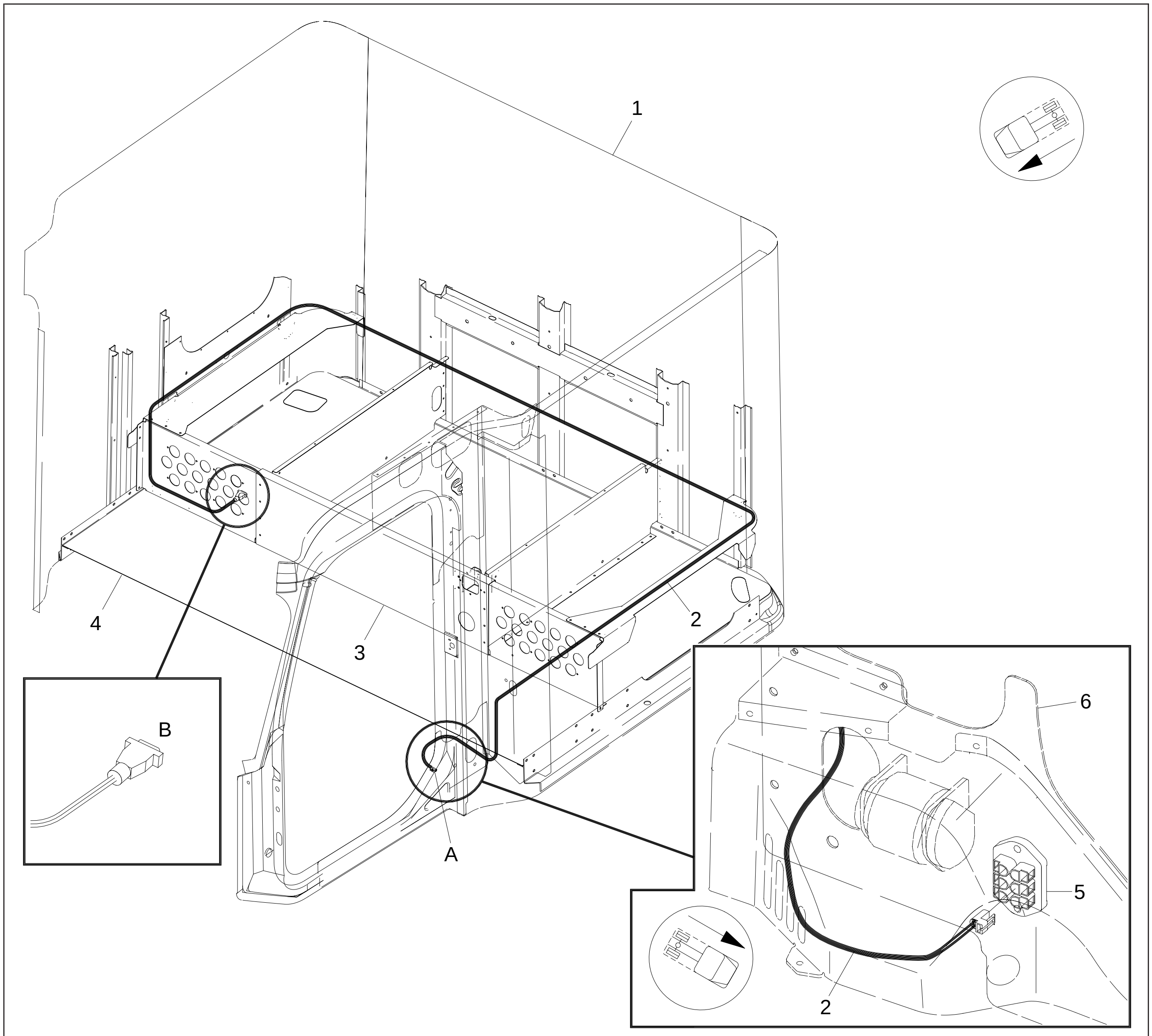
14. Ask Customer Care to issue a returned materials authorization number (RMA). Enter this number on a "Service Record/Installation Acknowledgment" form and send the form back to HighwayMaster along with the old control unit.

15. Return the old control unit to HighwayMaster, using the address label provided. Send it to the following address: HighwayMaster Repair Depot, ATTN: Roy Moultrie, 2300 Highway 79 South, Guntersville AL 35976.

16. Restore the cab to normal operating condition.

17. Remove the chocks from the tires.

Control Unit Replacement

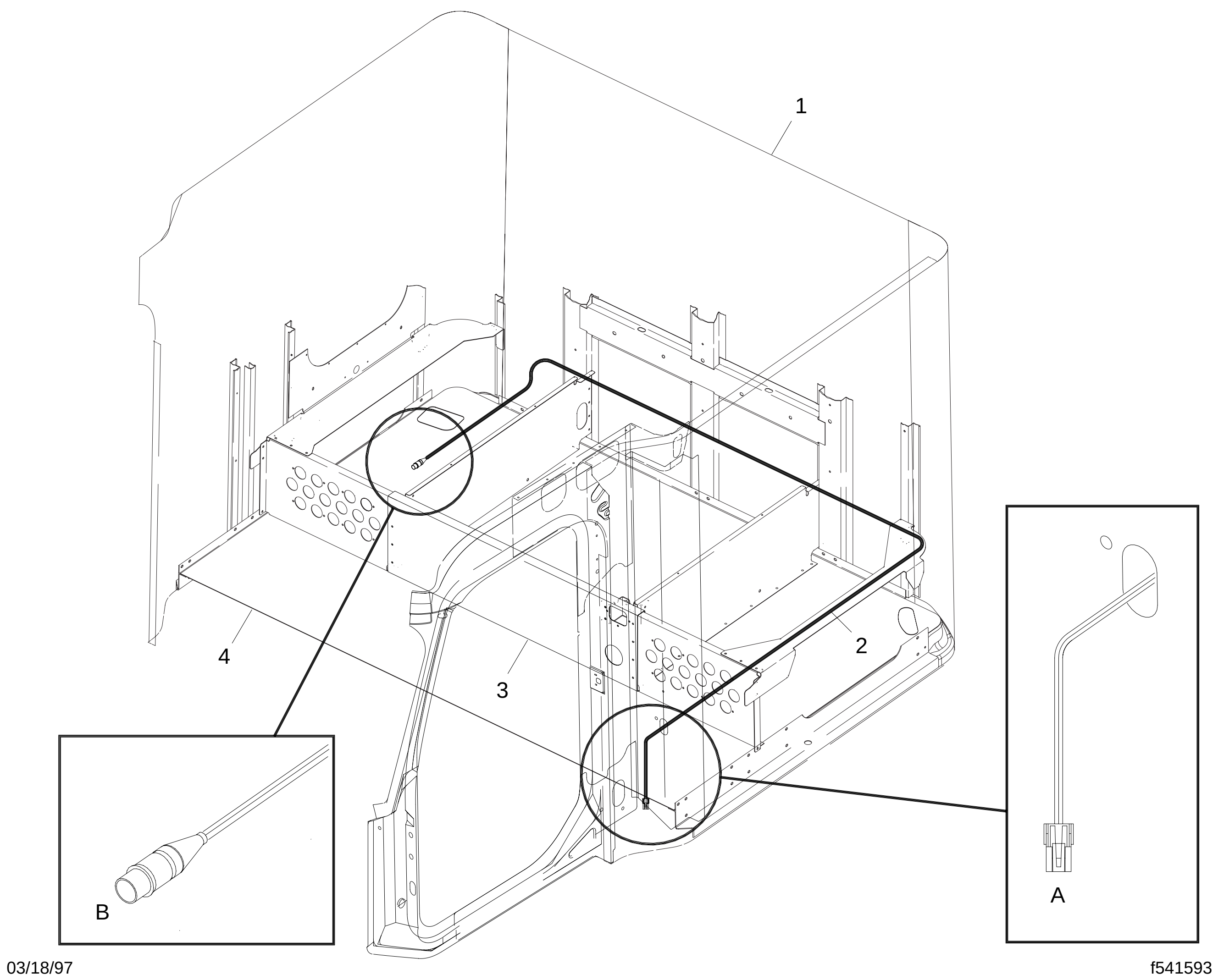


A. To B-pillar datalink junction block.
B. To control unit.

1. Cab
2. Datalink Cable
3. Forward Bunk Partition
4. Rear Deck
5. Datalink Junction Block
6. B-Pillar

Fig. 4, Datalink Cable Routing

Control Unit Replacement



A. To B-pillar auxiliary power distribution module (PDM).
B. To control unit.
1. Cab
2. Power Cable
3. Forward Bunk Partition
4. Rear Deck

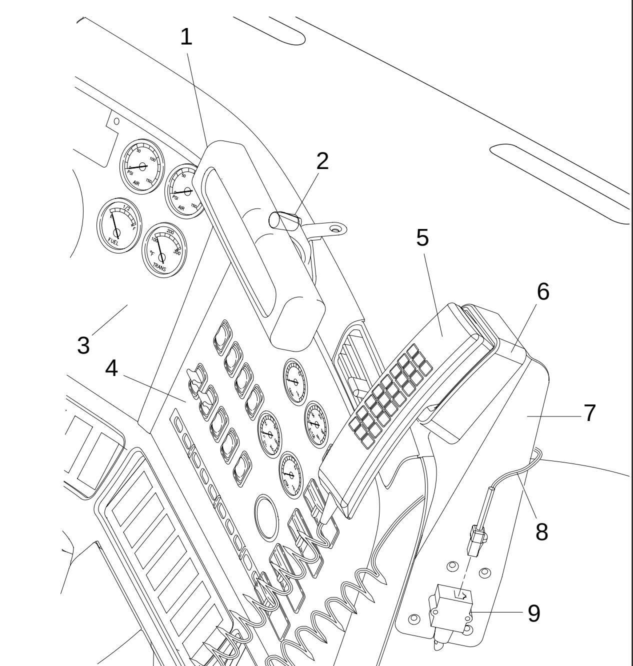
Fig. 5, Power Cable Routing

Replacement

The HighwayMaster® handset and cradle are normally mounted on a pedestal attached to the upper dash assembly (center panel).

IMPORTANT: Before attempting to install a new handset, fax the serial number of the unit to HighwayMaster at 1–800–647–6643. The serial number is found on a metal tag on the back side of the handset.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the handset cord from the pickup (mounted on the pedestal). See **Fig. 1**.



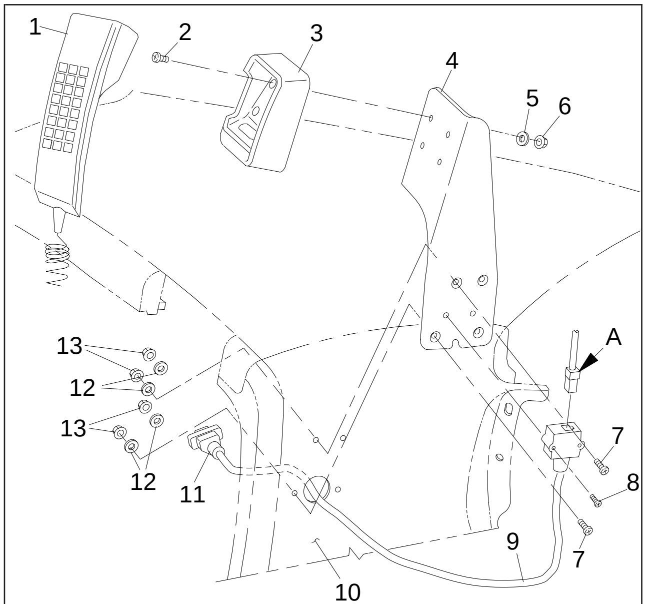
04/11/97 f541610

1. Display Unit
2. Microphone
3. Driver's Instrument Panel
4. Auxiliary Instrument Panel
5. Handset
6. Cradle
7. Pedestal
8. Cord
9. Pickup

Fig. 1, Handset and Cord

NOTE: It is not necessary to remove the pedestal to replace the handset. Do the following step only if it is necessary to replace the pedestal or to change the mounting of the handset.

3. Remove the pedestal from the upper dash assembly. See **Fig. 2**.



03/24/97 f541606

A. To Handset
1. Handset
2. Machine Screw, 6–32
3. Cradle
4. Pedestal
5. Washer, #6
6. Locknut, 6–32
7. Machine Screw, 10–24
8. Machine Screw, 4–40
9. Phone Cable (dash)
10. Upper Dash Assembly (center panel)
11. Connector
12. Washer, #10
13. Locknut, 10–32

Fig. 2, Handset, Cradle, and Pedestal (exploded view)

3.1 Remove the four 6–32 machine screws, locknuts, and #6 washers, that attach the cradle to the pedestal.

3.2 Remove the two 4–40 machine screws that attach the phone cable pickup to the pedestal.

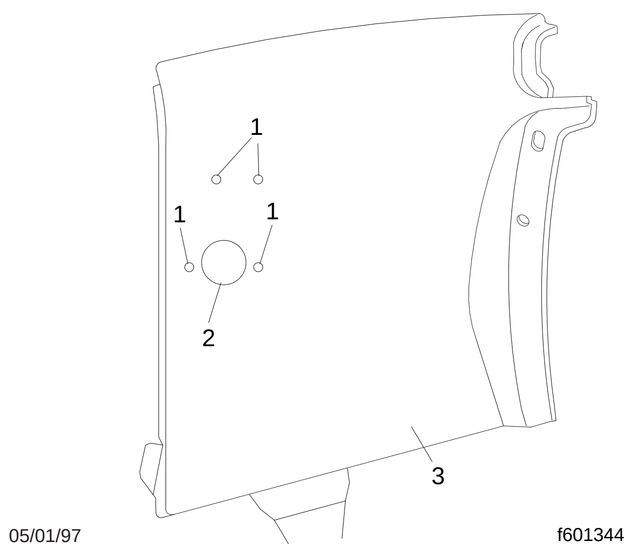
3.3 Remove the four 10–24 machine screws, 10–32 locknuts, and #10 washers that attach the pedestal to the dash.

3.4 Remove the phone cable (dash) through the 1-1/4 inch (30 mm) hole in the upper dash assembly.

Handset Replacement

3.5 Remove the round 1-pin connector on the GPS antenna cable from the plug on the bottom of the case.

4. Insert the phone cable through the 1-1/4 inch (30 mm) hole in the center panel of the upper dash assembly. Attach the pedestal to the four 1/4-inch (6 mm) holes, as removed. See **Fig. 3**.

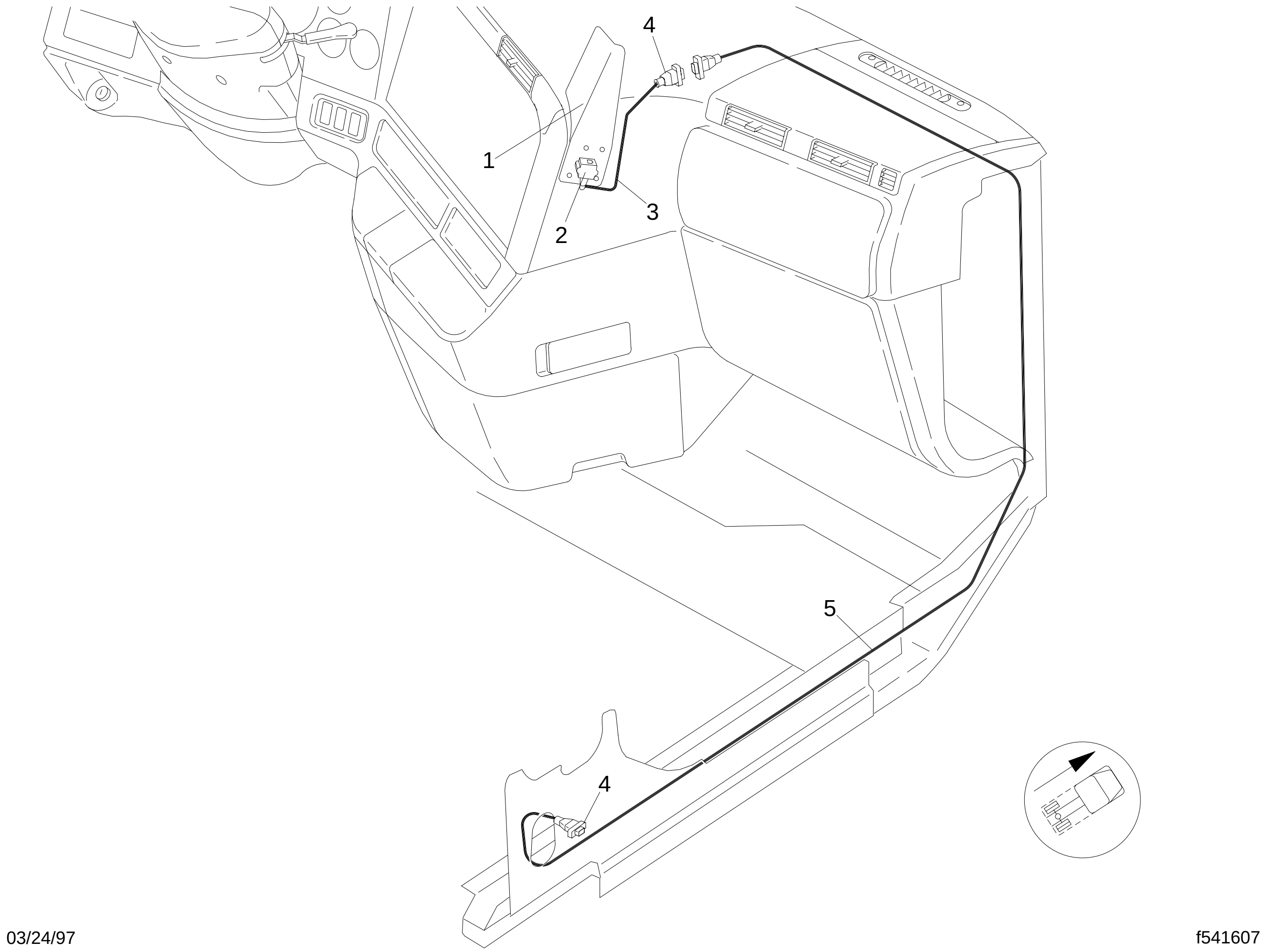


1. Hole, 1/4 in (6 mm)
2. Hole, 1-1/4 in (30 mm)
3. Upper Dash Assembly (center panel)

Fig. 3, Pedestal Mounting and Phone Cable Holes

5. If removed, attach the cradle and phone cable pickup.
6. Insert the cord of the new handset into the pickup.
7. Check all the phone cable connections, as shown in **Fig. 4** and **Fig. 5**. Check all three cables, dash, door, and cab, for good connections at both ends.
8. Connect the batteries.
9. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
10. Remove the chocks from the tires.

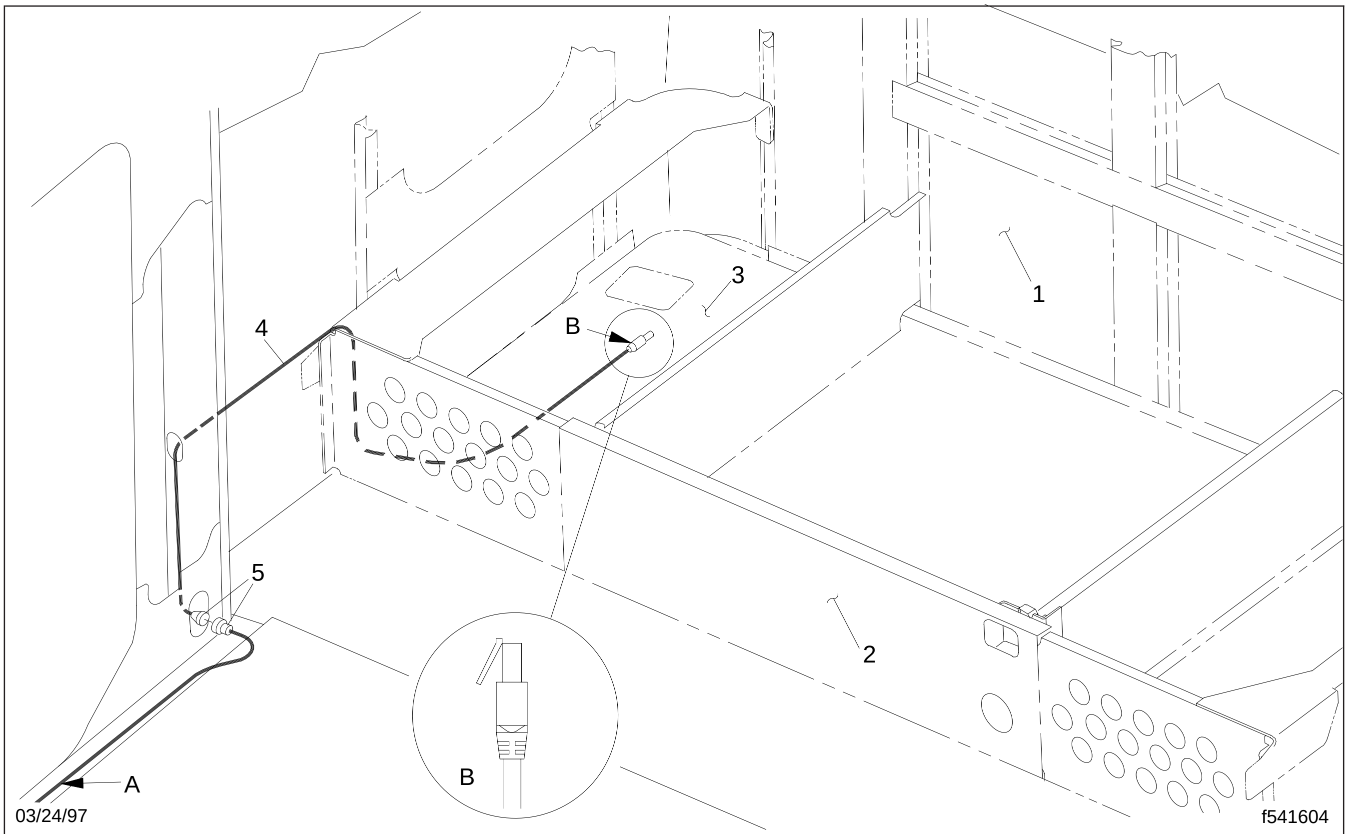
Handset Replacement



1. Pedestal
2. Pickup
3. Phone Cable (dash)
4. Connector
5. Phone Cable (door)

Fig. 4, Phone Cable Routing (dash)

Handset Replacement



A. To Handset
B. To Control Unit

1. Cab
2. Forward Bunk Partition
3. Rear Deck
4. Phone Cable (cab)
5. Connectors

Fig. 5, Phone Cable Routing (cab)

Replacement

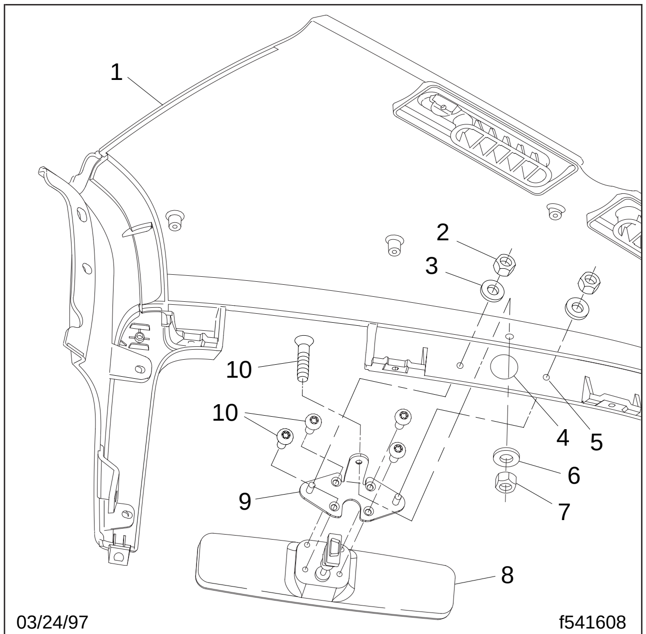
The HighwayMaster® display unit is normally mounted on the auxiliary dash panel.

IMPORTANT: Before attempting to install a new display unit, fax the serial number of the unit to HighwayMaster at 1–800–647–6643. The serial number is found on the decal on the back side of the control unit.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Unclip the microphone from the microphone bracket. If the bracket is damaged, remove the two speed clips attaching it to the upper dash assembly and replace the bracket.
3. Remove the 10–32 machine screw from the prong of the display bracket. Remove the locknuts and washers from the studs on the back of the display unit. See **Fig. 1**.
4. Remove the display bracket, with the display unit attached, from the dash. Pull the two wires (display unit and microphone) out of the dash. When the connectors are sufficiently exposed, disconnect the wires and mark them for later assembly. See **Fig. 2**.

NOTE: If necessary, reach under the dash to disconnect the display and microphone wires.

5. Remove the four 10–32 machine screws attaching the display bracket to the display unit.
6. Attach the electrical connectors to the display unit and microphone, as removed.
7. Install the new display unit on the display bracket, using the four 10–32 machine screws.
8. Position the display bracket on the upper dash assembly as shown in **Fig. 3**. Make sure the studs on the back of the display bracket pass through the fastener holes on the front of the upper dash assembly. See **Fig. 4**.
9. Attach the #10 washers and 10–24 locknuts to the studs. Attach the display bracket to the dash with 10–32 machine screw.
10. Install a new microphone bracket, if removed. Clip the microphone to the microphone bracket.



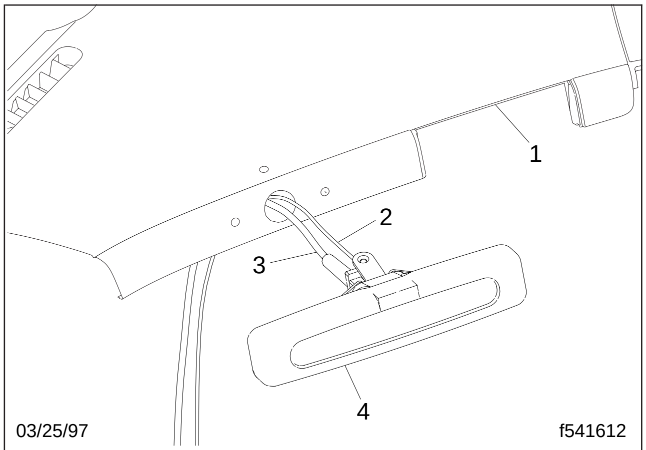
NOTE: The auxiliary dash panel has been removed for clarity.

1. Upper Dash Assembly (LH panel)
2. Locknut, 1/4–20
3. Washer, 1/4 in
4. Cable Hole, 1-1/4 in (30 mm)
5. Screw Hole, 5/16 in (8 mm)
6. Washer, #10
7. Locknut, 10–32
8. Display Unit
9. Display Bracket
10. Machine Screw, 10–32

Fig. 1, Display Unit Mounting Hardware

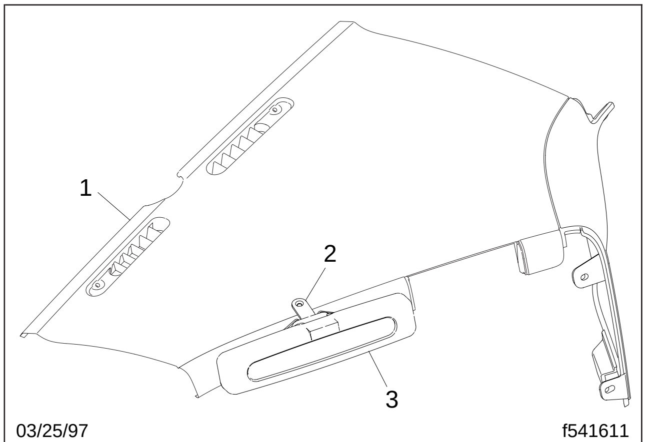
11. Check the door display cable for good connections at both ends. See **Fig. 5**.
12. Check the door display cable for good connections at both ends. See **Fig. 6**.
13. Connect the batteries and restore the cab to normal operating condition.
14. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
15. Remove the chocks from the tires.

Display Unit Replacement



1. Upper Dash Assembly (LH panel)
2. Microphone Wire
3. Display Unit Wire
4. Display Unit

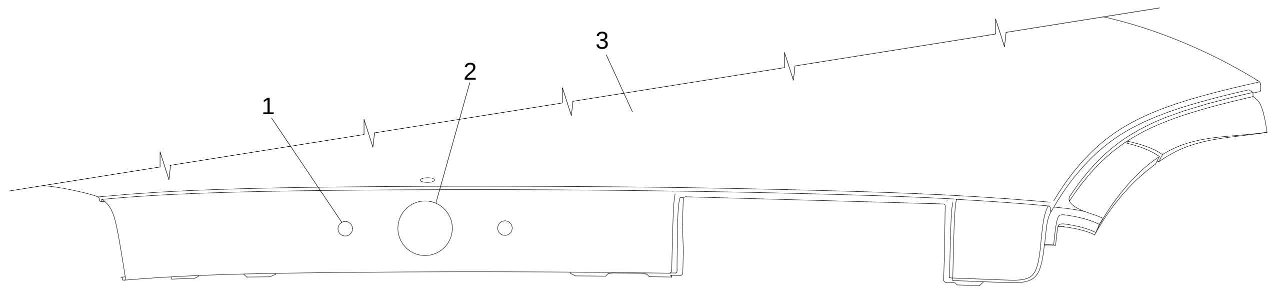
Fig. 2, Wire Removal



1. Upper Dash Assembly (LH panel)
2. Prong of Display Bracket
3. Display Unit

Fig. 3, Display Unit Positioning

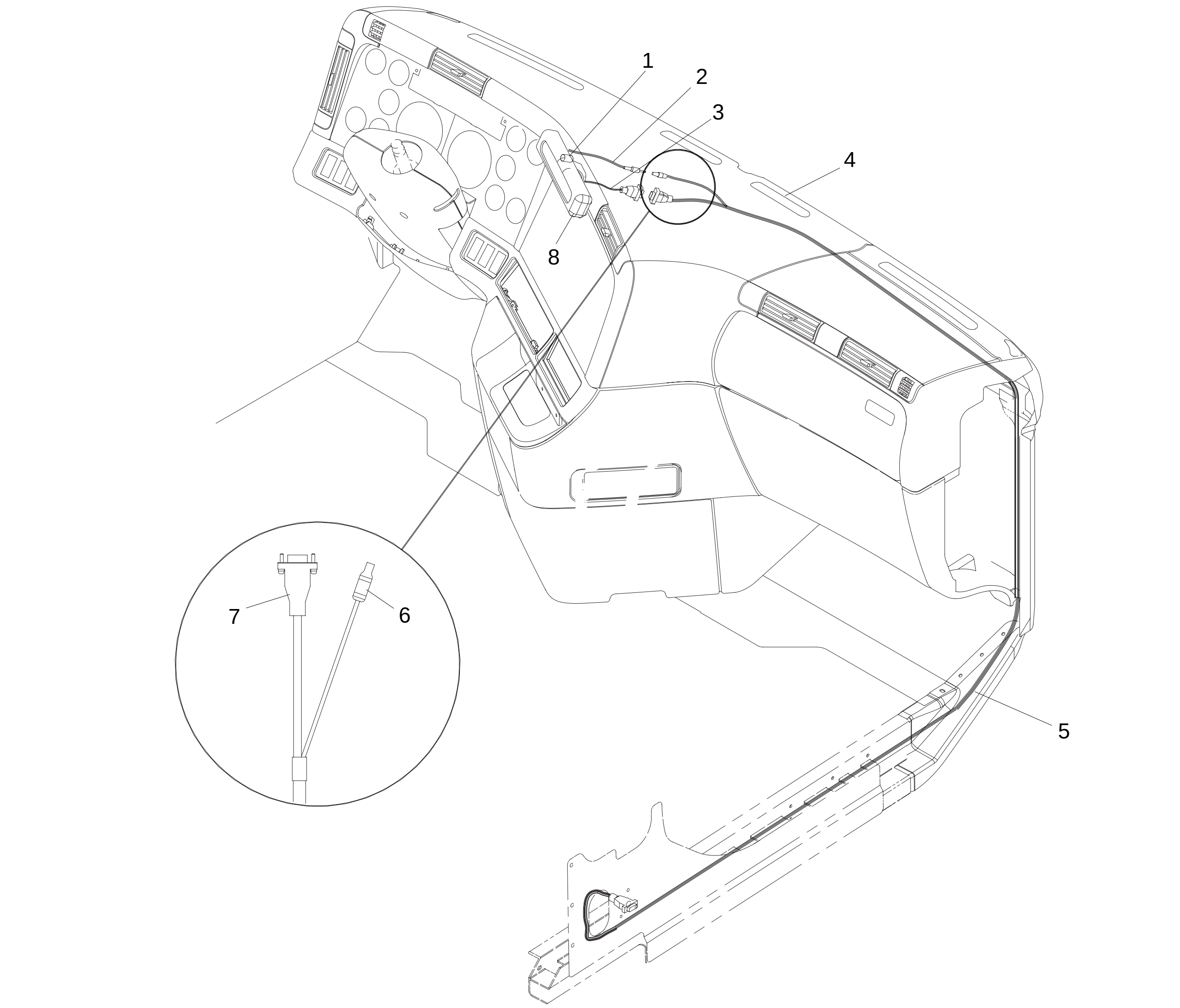
Display Unit Replacement



1. Fastener Hole, 5/16 in (8 mm)
2. Cable Hole, 1-1/4 in (30 mm)
3. Upper Dash Assembly (LH panel)

Fig. 4, Hole Location

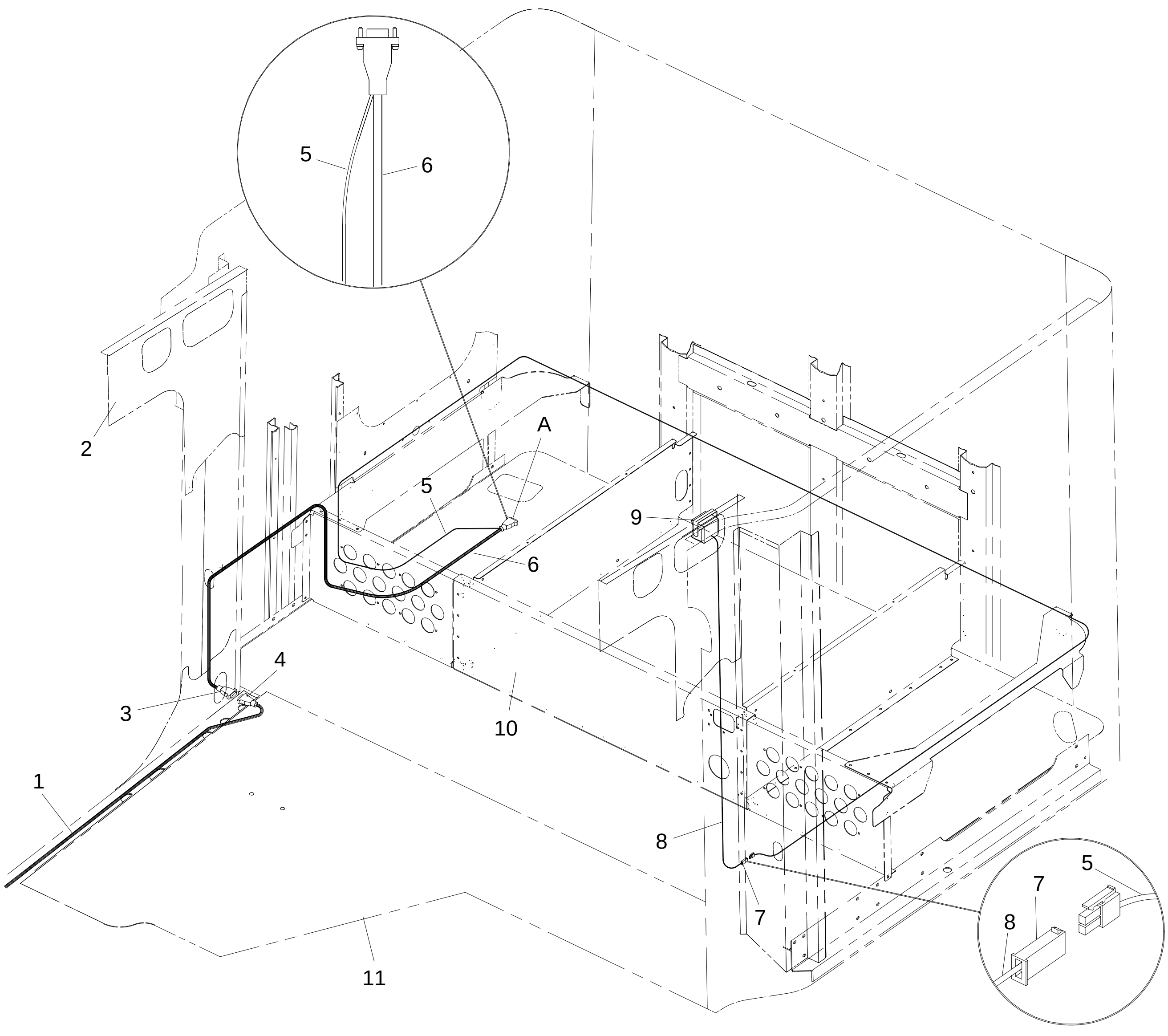
Display Unit Replacement



1. Microphone
2. Microphone Wire
3. Display Unit Wire
4. Upper Dash Assembly (LH panel)
5. Display Cable (door)
6. Display Connector
7. Microphone Connector
8. Display Unit

Fig. 5, Display and Microphone Cable Routing (dash)

Display Unit Replacement



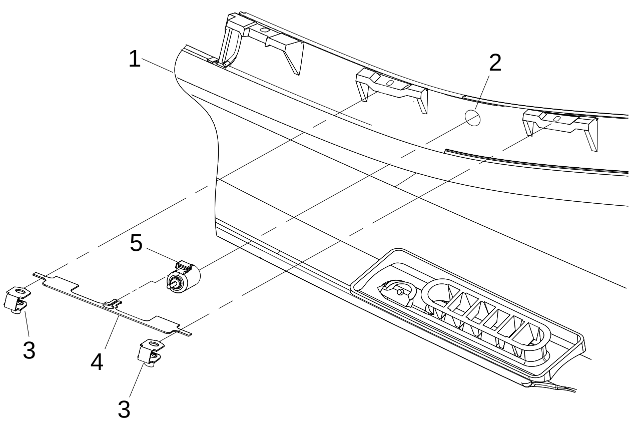
A. To Control Unit
1. Display Cable (door)
2. B-Pillar
3. Display Cable Cab Connector
4. Display Cable Door Connector
5. Speaker Cable (cab)
6. Display Cable (cab)
7. Speaker Connector
8. Speaker Cable (B-pillar)
9. Speaker
10. Forward Bunk Partition
11. Rear Deck

Fig. 6, Display and Speaker Cable Routing (cab)

Replacement

The HighwayMaster® hands-free microphone is normally clipped to a small bracket attached to the upper dash assembly.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Unclip the microphone from the microphone bracket. See **Fig. 1**.



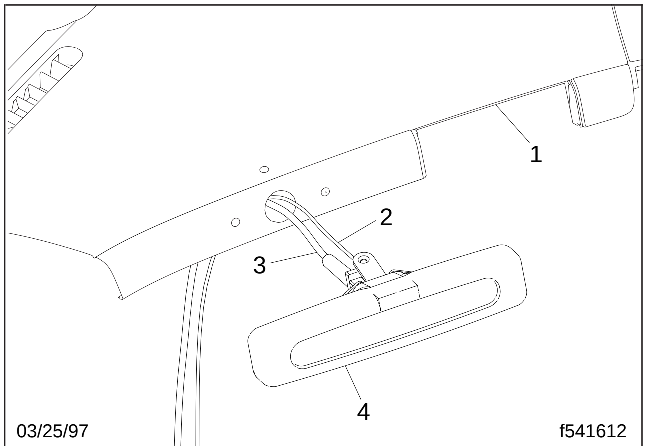
1. Upper Dash Assembly (LH panel)
2. Hole, 9/16 in (14 mm)
3. Speed Clip
4. Microphone Bracket
5. Microphone

Fig. 1, Microphone Mounting

3. Remove the 10–32 machine screw from the prong of the display bracket. For more information, see **Subject 120**.
4. Remove the display bracket, with the display unit attached, from the dash. Pull the two wires (display unit and microphone) out of the dash. When the microphone connector is sufficiently exposed, disconnect the wire. See **Fig. 2**.

NOTE: If necessary, reach under the dash to disconnect the display and microphone wires.

5. Attach the electrical connector to the new microphone, as removed.
6. Install the display bracket, using the 10–32 machine screw to fasten the prong of the bracket to the upper dash assembly.

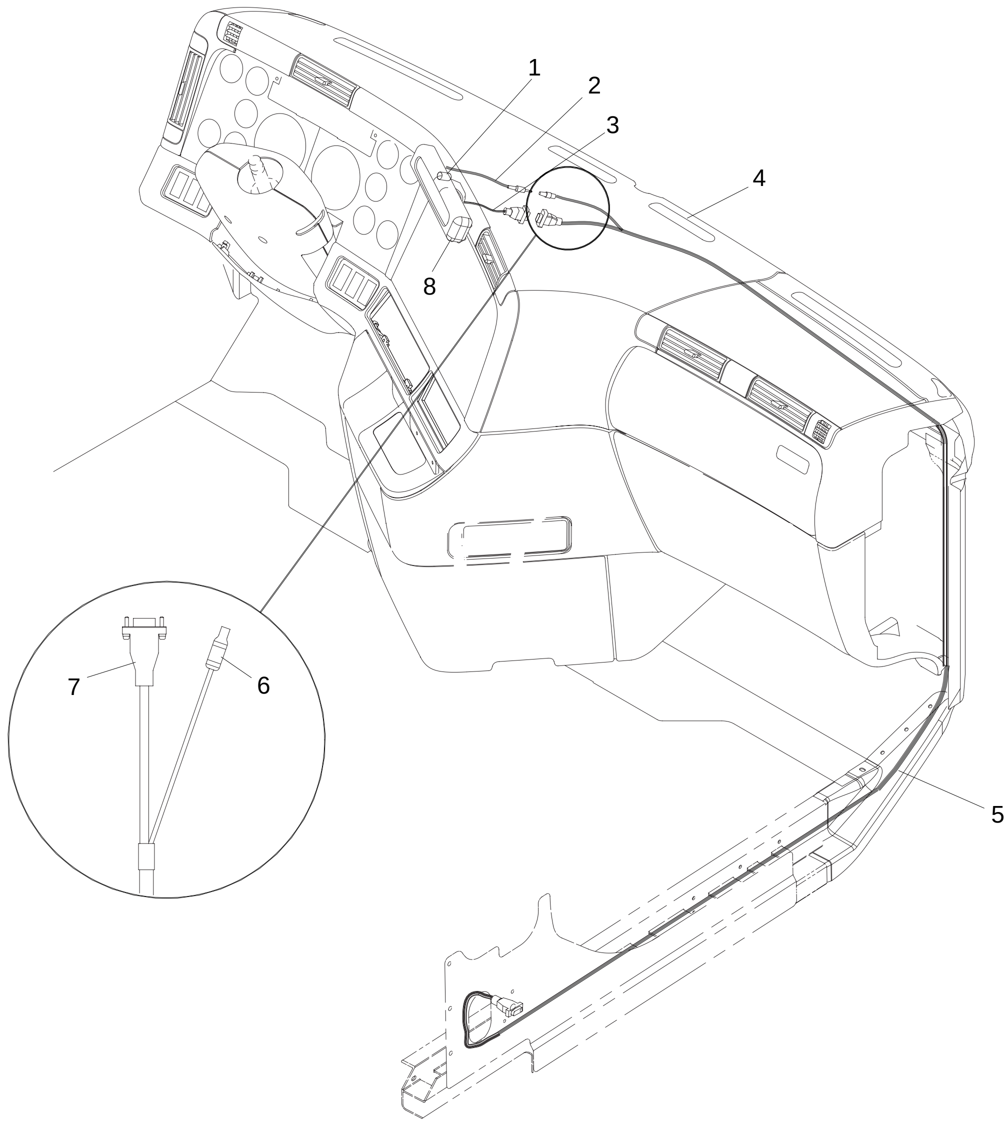


1. Upper Dash Assembly (LH panel)
2. Microphone Wire
3. Display Unit Wire
4. Display Unit

Fig. 2, Wire Removal

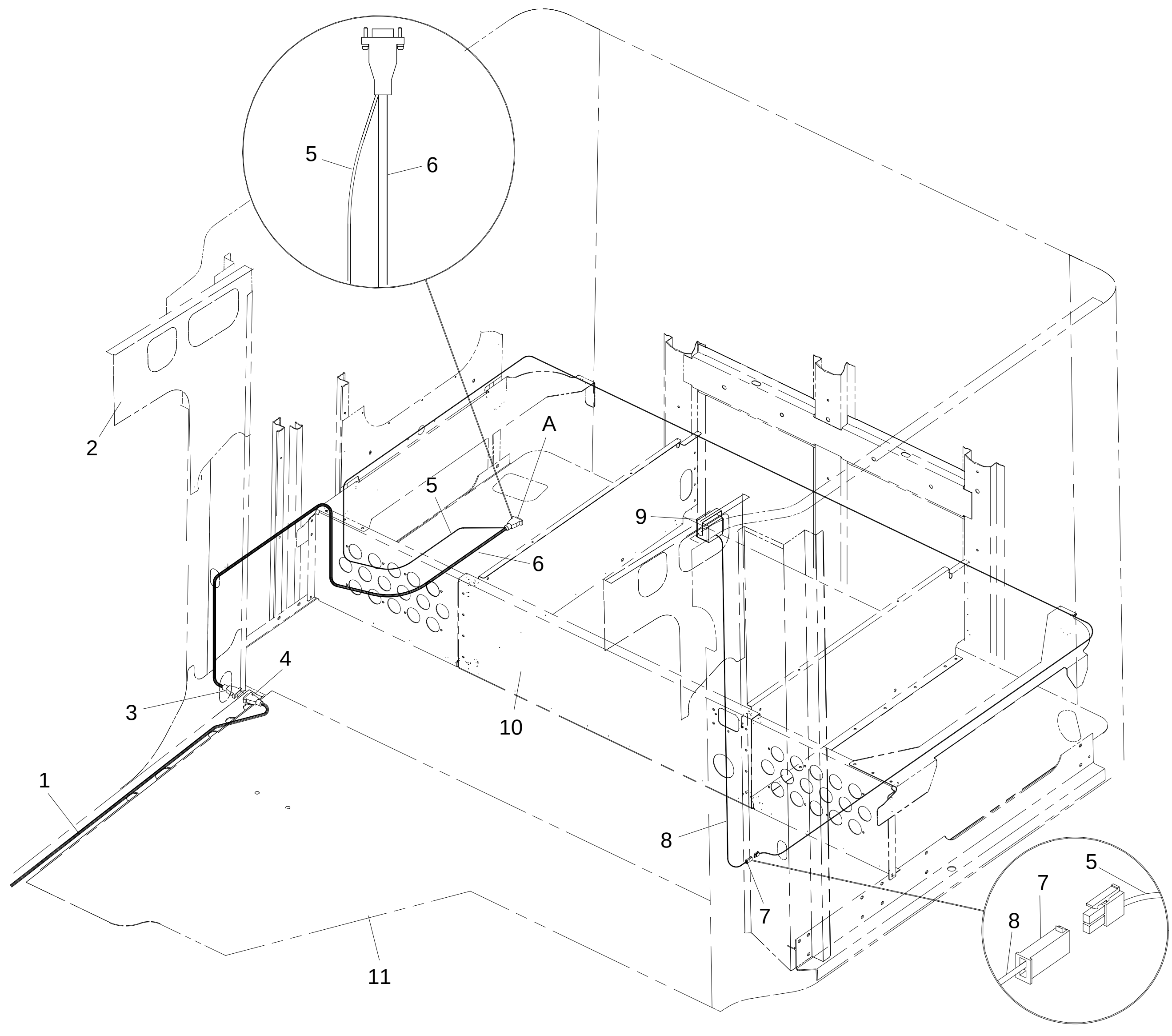
7. Clip the new microphone to the microphone bracket.
8. Check the door display cable for good connections at both ends. See **Fig. 3**.
9. Check the cab display cable for good connections at both ends. See **Fig. 4**.
10. Connect the batteries and restore the cab to normal operating condition.
11. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
12. Remove the chocks from the tires.

Microphone Replacement



1. Microphone
2. Microphone Wire
3. Display Unit Wire
4. Upper Dash Assembly (LH panel)
5. Display Cable (door)
6. Display Connector
7. Microphone Connector
8. Display Unit

Fig. 3, Display and Microphone Cable Routing (dash)



03/11/2002 f541616

A. To control unit

1. Display Cable (door)
2. B-Pillar
3. Display Cable Cab Connector
4. Display Cable Door Connector
5. Speaker Cable (cab)
6. Display Cable (cab)
7. Speaker Connector
8. Speaker Cable (B-pillar)
9. Speaker
10. Forward Bunk Partition
11. Rear Deck

Fig. 4, Display and Speaker Cable Routing (cab)

Replacement

The HighwayMaster® speaker is normally installed on the driver's side of the cab. On factory installations, it is on the B-pillar (**Fig. 1**); on aftermarket installations, it is on the cab wall above the window (**Fig. 2**).

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Open the electrical compartment door on the driver's side B-pillar, behind the seat. Disconnect the speaker electrical connector. See **Fig. 3**.
3. Remove the speaker from the speaker bracket. See **Fig. 1** for the factory installation, and **Fig. 2** for the aftermarket installation.

   3.1 Loosen the knobs on each side of the speaker and remove the speaker from the speaker bracket.

   3.2 Pull the speaker cable wire and connector out through the hole in the cab wall. If necessary, remove the upholstery panel.
4. If necessary to change the mounting or replace any of the mounting hardware, remove the speaker mounting. See **Fig. 4** for the factory installation, and **Fig. 5** for the aftermarket installation.

   4.1 Remove the two 8–32 machine screws attaching the speaker bracket to the mounting angle (or cab wall, on aftermarket installations).

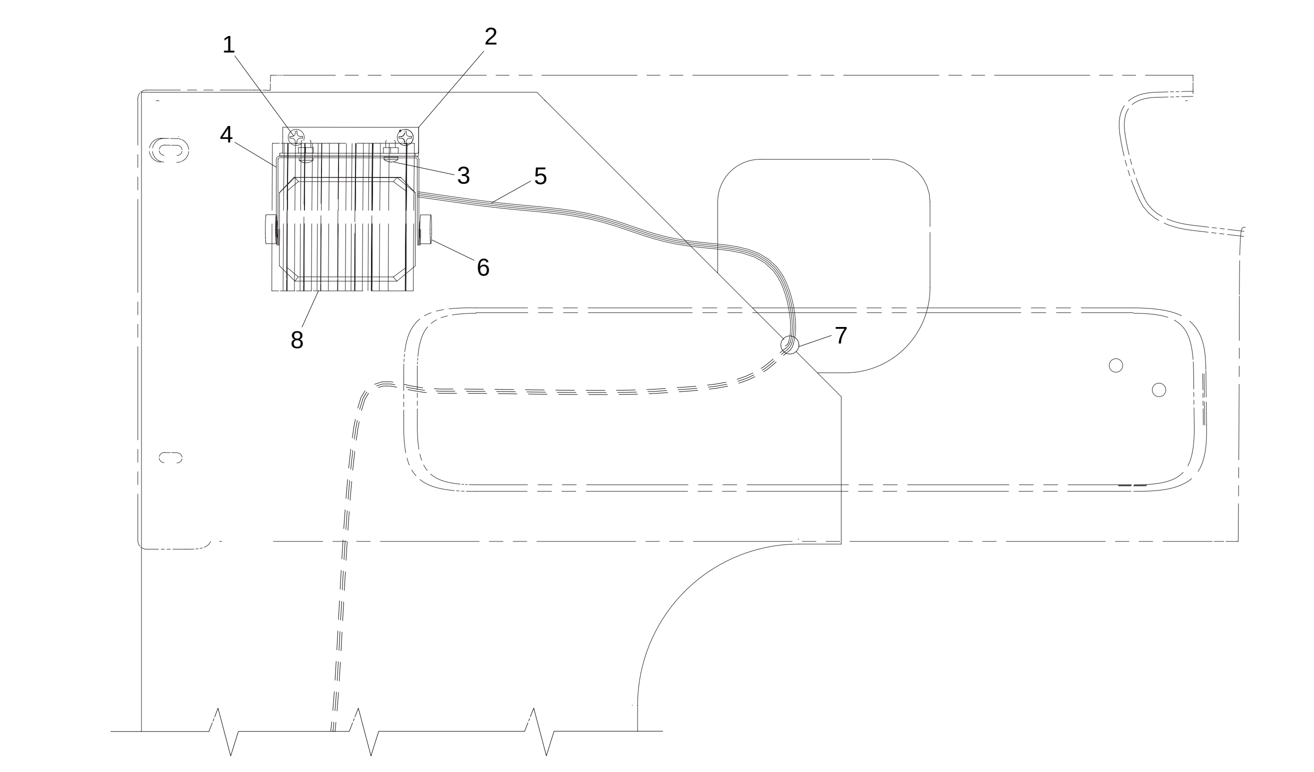
   4.2 If installed, remove the two 10–16 self-tapping screws and washers attaching the mounting angle to the cab wall.
5. If removed, install the mounting angle and speaker bracket. Use the removed fasteners.
6. Install the speaker.

   6.1 Insert the knobs on each side of the new speaker into the slots in the speaker bracket.

   6.2 Route the new speaker cable through the drill hole and connect it to the electrical connector on the end of the cab speaker cable.

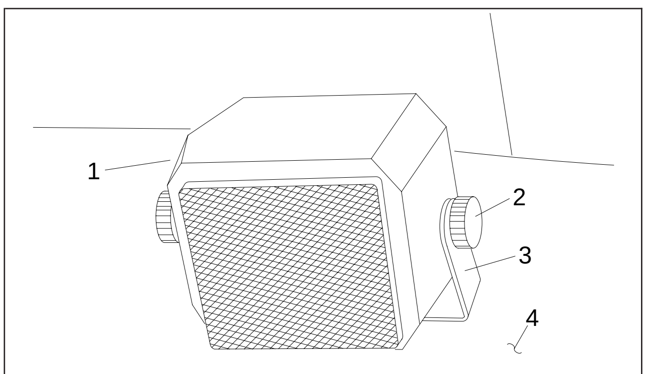
   6.3 When the cable has been properly routed and connected, tighten the knobs on the speaker until firm and tight.
7. Check the B-pillar speaker cable for good connections at both ends. See **Fig. 3**.
8. Check the cab speaker cable for good connections at both ends. See **Fig. 6**.
9. Connect the batteries and restore the cab to normal operating condition.
10. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
11. Remove the chocks from the tires.

Speaker Replacement



1. Self-Tapping Screw, 10–16
2. Mounting Angle
3. Locknut, 8–32
4. Speaker Bracket
5. Speaker Cable
6. Knob
7. Drill Hole
8. Speaker

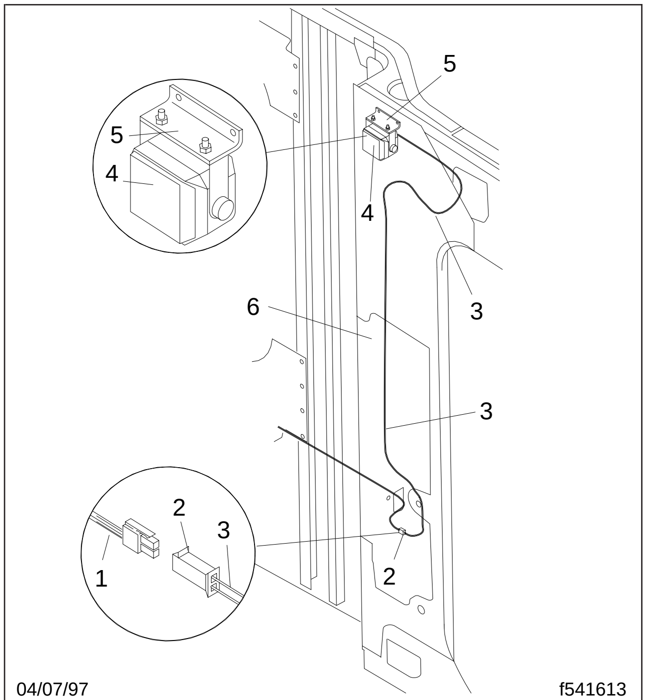
Fig. 1, Speaker (factory installation)



1. Speaker
2. Knob
3. Speaker Bracket
4. Cab Wall

Fig. 2, Speaker (aftermarket installation)

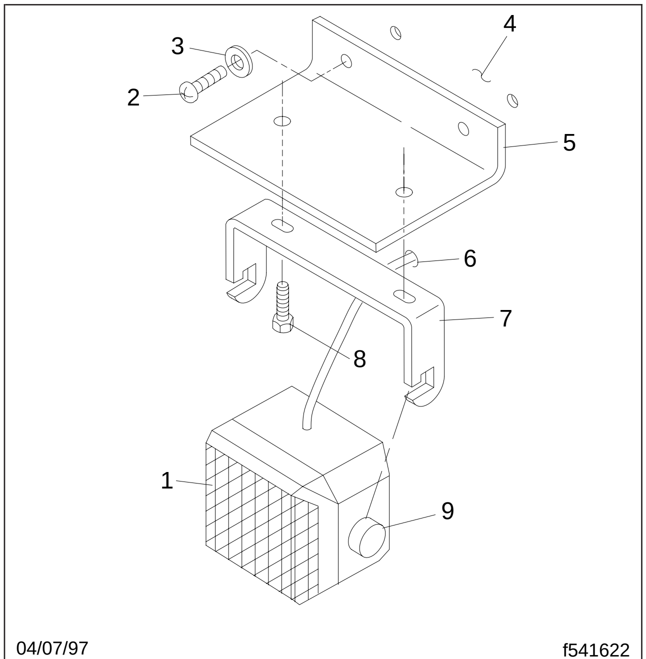
Speaker Replacement



Factory installation is shown. The aftermarket installation is similar.

1. Speaker Cable (cab)
2. Electrical Connector
3. Speaker Cable (B-pillar)
4. Speaker
5. Mounting Angle
6. B-Pillar Electrical Compartment

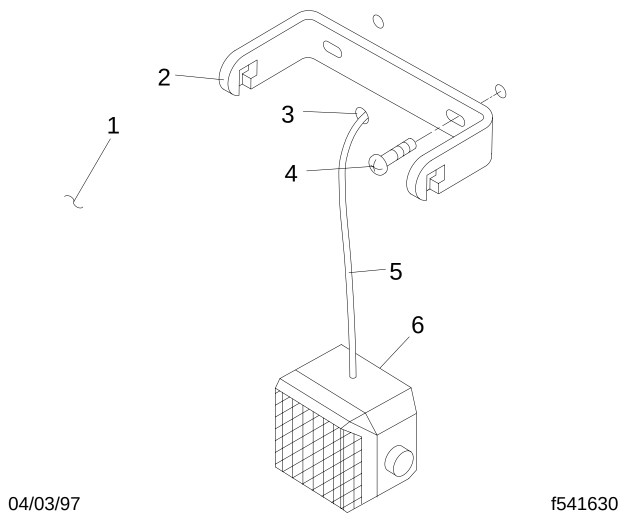
Fig. 3, Speaker Cable Routing (B-pillar)



1. Speaker
2. Self-Tapping Screw, 10–16
3. Washer
4. Cab Wall
5. Mounting Angle
6. Drill Hole
7. Speaker Bracket
8. Machine Screw, 8–32
9. Knob

Fig. 4, Speaker Mounting (factory installation)

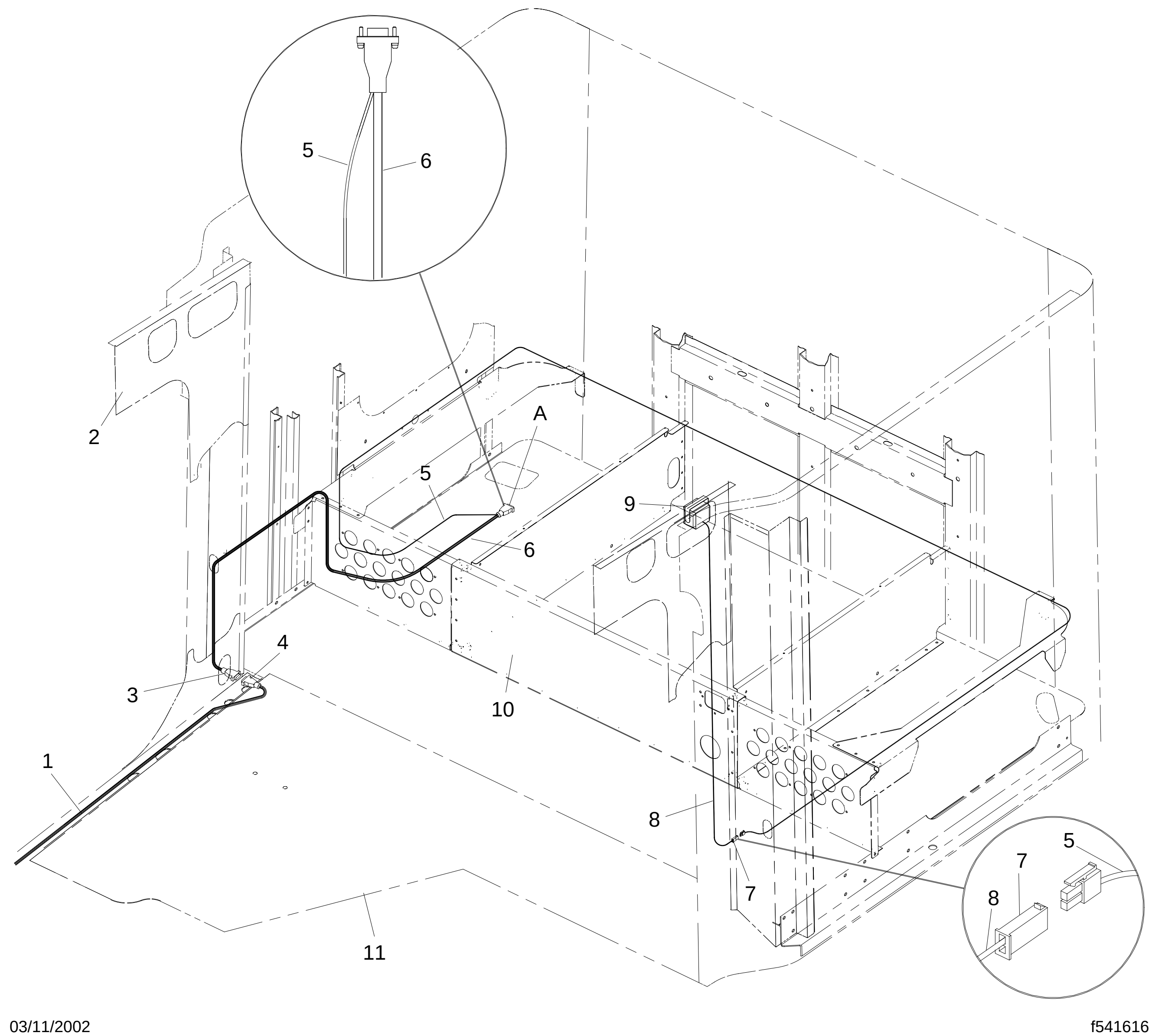
Speaker Replacement



1. Cab Wall
2. Speaker Bracket
3. Drill Hole
4. Machine Screw, 8–32
5. Speaker Cable
6. Speaker

Fig. 5, Speaker Mounting (aftermarket installation)

Speaker Replacement



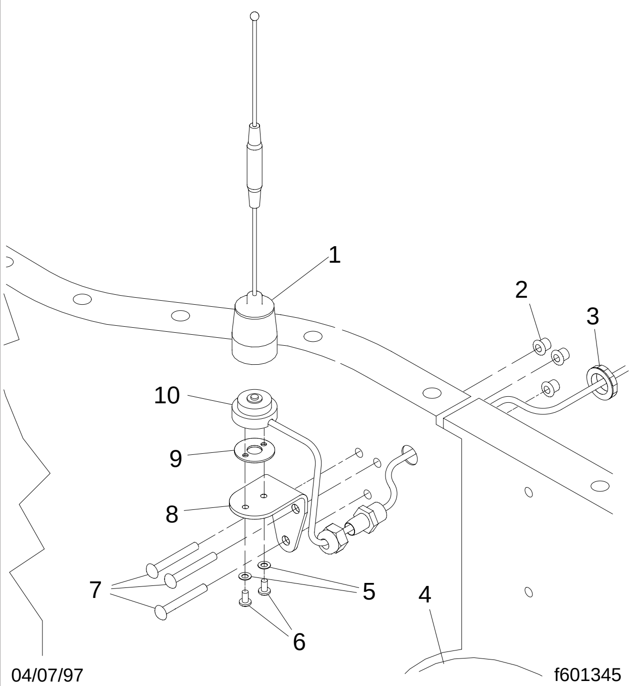
A. To Control Unit

1. Display Cable (door)
2. B-Pillar
3. Display Cable Cab Connector
4. Display Cable Door Connector
5. Speaker Cable (cab)
6. Display Cable (cab)
7. Speaker Connector
8. Speaker Cable (B-pillar)
9. Speaker
10. Forward Bunk Partition
11. Rear Deck

Fig. 6, Display and Speaker Cable Routing (cab)

Replacement

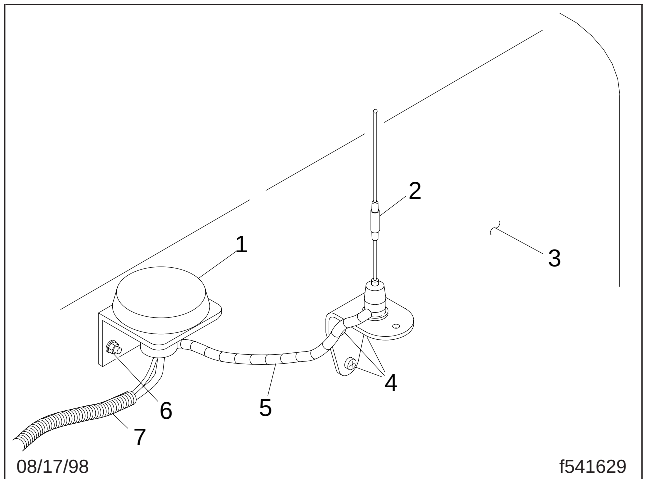
The HighwayMaster® cellular antenna is normally installed on the outside of the cab. On factory installations, it is on the cab wall on the passenger's side just above and behind the door (**Fig. 1**); on aftermarket installations, it is on the back of the cab (**Fig. 2**).



1. Cellular Antenna
2. Collar, 1/4 in
3. Cable Nut
4. Cab Skin (passenger side)
5. Washer, #10
6. Machine Screw, 10–32
7. Lockbolt, Brazier HD
8. Cellular Antenna Bracket
9. Spacer
10. Antenna Base

Fig. 1, Cellular Antenna (factory installation)

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the two 10–32 machine screws and washers from the cellular antenna bracket. Remove the antenna, base and spacer.
3. Install the new antenna, base, and spacer. Use the removed fasteners.

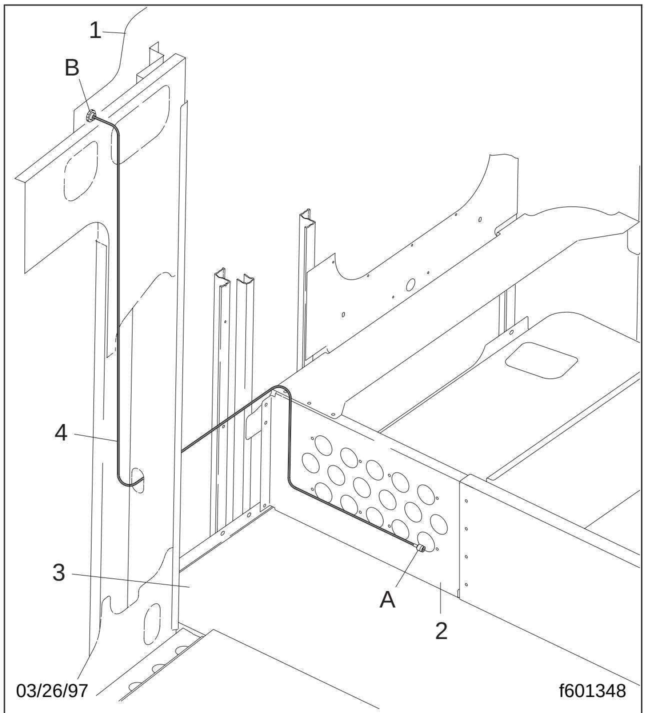


1. GPS Antenna
2. Cellular Antenna
3. Back of Cab
4. Lockbolt
5. Cellular Antenna Cable
6. Hexnut, 5/16 in
7. Dual Antenna Cable

Fig. 2, Cellular Antenna (aftermarket installation)

4. Check the cellular antenna cable for good connections at both ends. See **Fig. 3**.
5. Connect the batteries and restore the cab to normal operating condition.
6. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
7. Remove the chocks from the tires.

Cellular Antenna Replacement



NOTE: Factory installation is shown.

A. To Control Unit B. To Cellular Antenna

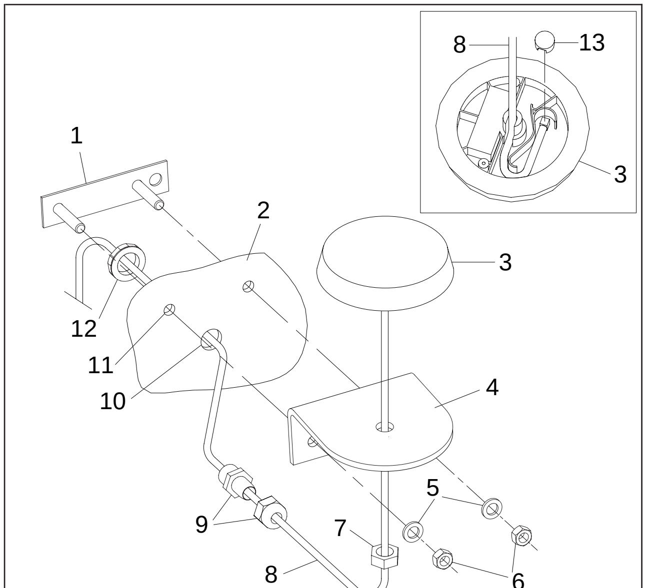
1. Cab Wall
2. Forward Bunk Partition
3. Rear Deck
4. Cellular Antenna Cable

Fig. 3, Cellular Antenna Cable Routing

Replacement

The HighwayMaster® global positioning system (GPS) antenna is normally installed on the back of the cab. On factory installations, it is on the roof cap on the passenger's side; on aftermarket installations, it is on the back of the cab.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Loosen the M12 nylon hexnut from the GPS antenna bracket. Remove the antenna. See **Fig. 1** for factory installations and **Fig. 2** for aftermarket installations.

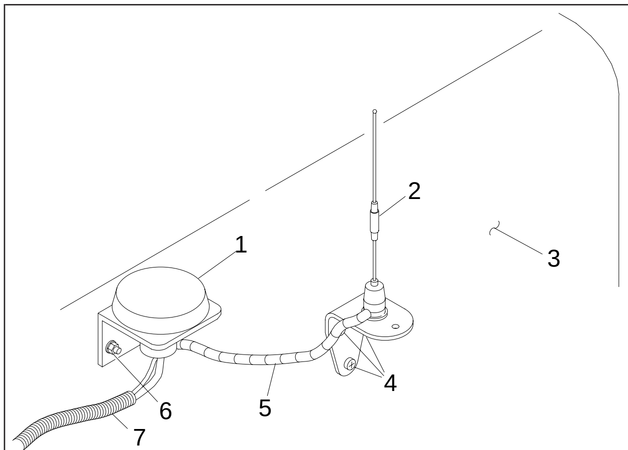


NOTE: The insert shows a bottom view of the antenna.

1. Backing Plate
2. Roof Cap
3. GPS Antenna
4. GPS Antenna Bracket
5. Washer, 5/16 in
6. Locknut, 5/16 in
7. Hexnut, M12 Nylon
8. GPS Antenna Cable
9. Through-Skin Fittings
10. Cable Hole, 21/32 in (17 mm)
11. Fastener Hole, 3/8 in (9 mm)
12. Cable Nut
13. Rubber Cable Cap

Fig. 1, GPS Antenna (factory installation)

3. Turn over the new antenna and install the rubber cable cap on end of the GPS antenna cable.
4. Install the new antenna. Make sure the M12 nylon hexnut is firm and tight.

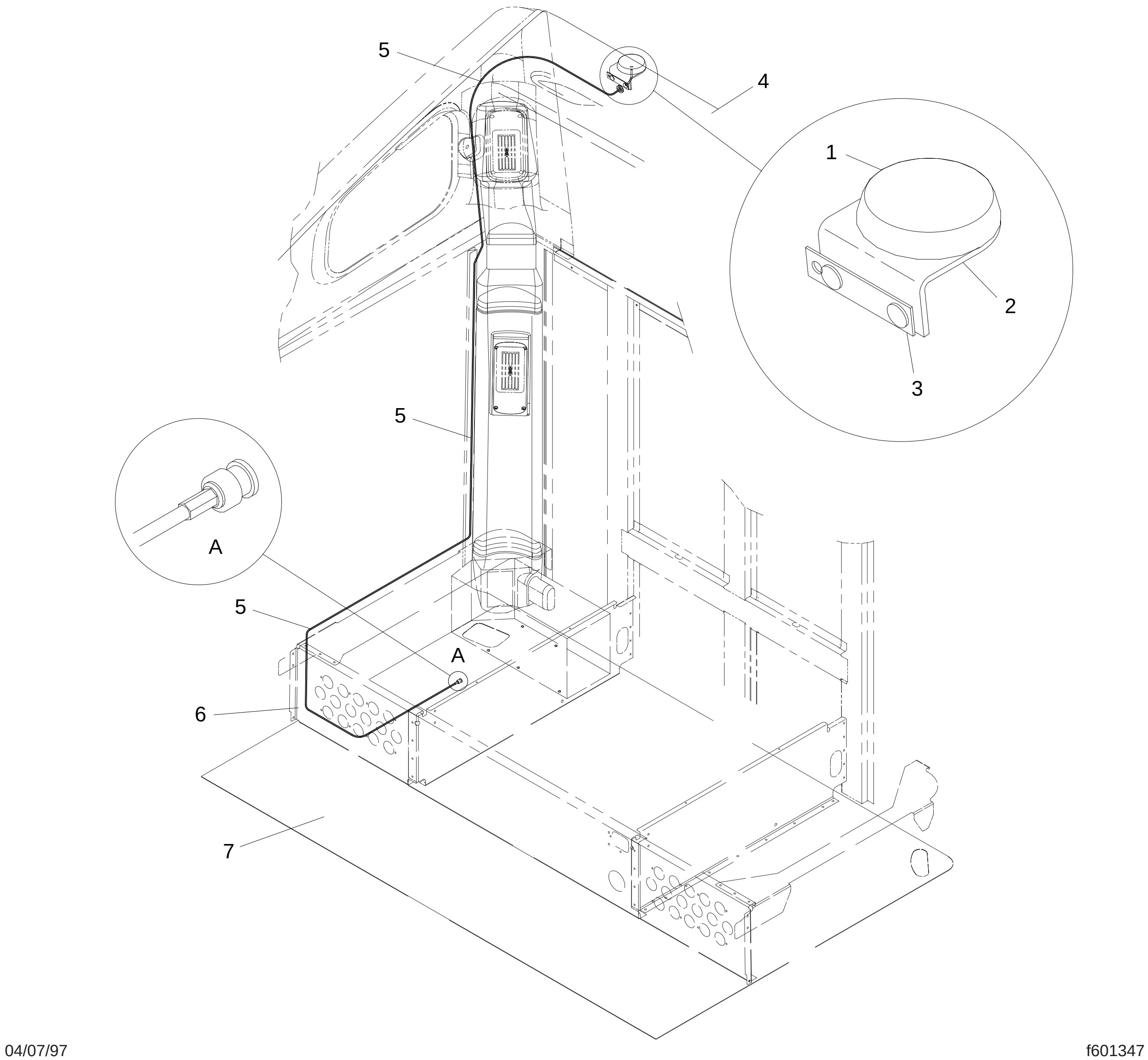


1. GPS Antenna
2. Cellular Antenna
3. Back of Cab
4. Lockbolt
5. Cellular Antenna Cable
6. Hexnut, 5/16 in
7. Dual Antenna Cable

Fig. 2, GPS Antenna (aftermarket installation)

5. Check the GPS antenna cable for good connections at both ends. See **Fig. 3**.
6. Connect the batteries and restore the cab to normal operating condition.
7. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
8. Remove the chocks from the tires.

GPS Antenna Replacement



A. To Control Unit

1. GPS Antenna
2. GPS Antenna Bracket
3. Backing Plate
4. Roof Cap
5. GPS Antenna Cable
6. Forward Bunk Partition
7. Rear Deck

Fig. 3, GPS Antenna Cable Routing

Troubleshooting

When the engine is started, the HighwayMaster system goes into its start-up cycle. When the system is functioning properly, it goes through the following steps:

1. The display shows the underline prompt (_).
2. The display reads "Checking Cellular Service" and then changes to "Registering Unit for Service."
3. Once the unit has been registered, the display reads either "HighwayMaster Service Area" (if you are in an area where HighwayMaster provides cellular coverage) or "HighwayMaster" (if you are out of the coverage area).
4. When fully operational, the handset is illuminated and the display shows from three to seven bars.

Use this cycle as a diagnostic check. If the system does not go through all of these steps, see the appropriate troubleshooting table below.

Problem—The HighwayMaster System Has No Power

Problem—The HighwayMaster System Has No Power	
Possible Cause	**Remedy**
The vehicle is not running.	With the transmission in neutral and the parking brake set, start the engine and check to see if the system goes through the complete start-up cycle.
The circuit breaker is blown or missing.	Check the 10-amp circuit breaker in position #7, Block B3, of the auxiliary power distribution module (PDM) inside the left-hand B-pillar electrical compartment. Replace any damaged components.
There are loose connections.	Carefully check all of the connections on the power, phone, display, speaker, and both antenna cables. Connect as necessary.
The power cable needs replacing.	Disconnect the power cable to the auxiliary PDM. Then disconnect the power cable from the control unit. With the power cable reconnected to the auxiliary PDM, turn the ignition switch on. Now insert the negative lead of a digital voltmeter into the right-hand cavity on the connector. Insert the positive lead into another cavity, and check for voltage. When finished, check the other end of the cable. If the voltage at either end reads less than 11 volts, or more than 13.5 volts, replace the power cable.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The HighwayMaster System Has Intermittent Power

Problem—The HighwayMaster System Has Intermittent Power	
Possible Cause	**Remedy**
The circuit breaker is loose or defective.	Check the 10-amp circuit breaker in position #7, Block B3, of the auxiliary power distribution module (PDM) inside the left-hand B-pillar electrical compartment. Replace any damaged components.
There are loose connections.	Carefully check all of the connections on the power, phone, display, speaker, and both antenna cables. Repair/replace as necessary.

Troubleshooting

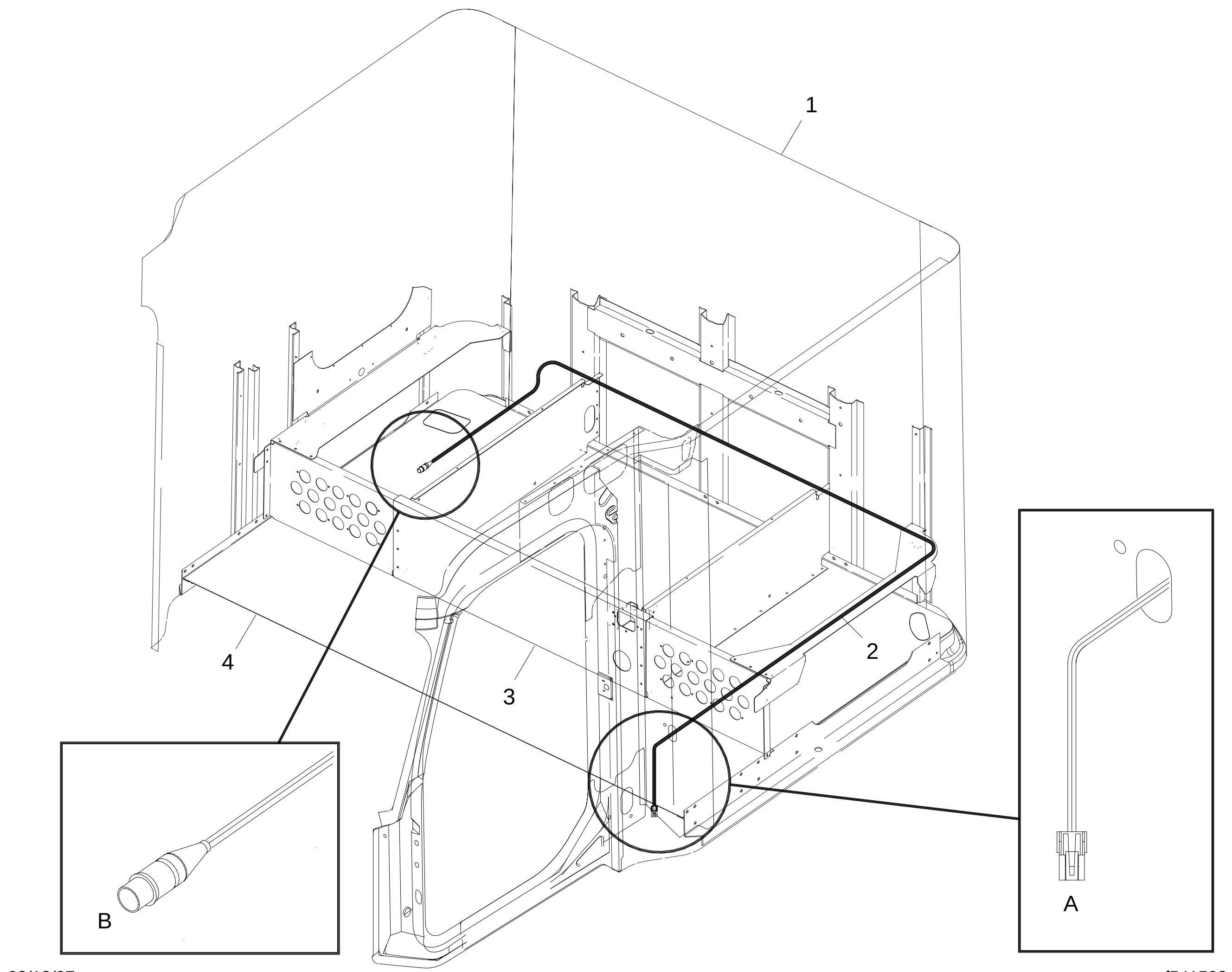
Problem—The HighwayMaster System Has Intermittent Power	
Possible Cause	**Remedy**
The power cable needs replacing.	Disconnect the power cable from the auxiliary PDM. Then disconnect the power cable from the control unit. With the power cable reconnected to the auxiliary PDM, turn the ignition switch on. See **Fig.1**. Now insert the negative lead of a digital voltmeter into the right-hand cavity on the connector. Insert the positive lead into another cavity, and check for voltage. When finished, check the other end of the cable. If the voltage at either end reads less than 11 volts, or more than 13.5 volts, replace the power cable.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—When the Ignition Switch Is Turned Off, the HighwayMaster System Also Turns Off

Problem—When the Ignition Switch Is Turned Off, the HighwayMaster System Also Turns Off	
Possible Cause	**Remedy**
The power off delay is not set or is set to 0.	Call the host operator to set the delay to the desired time, from 1 to 12 hours.
There are loose connections in the phone cables.	Disconnect the power cable from the auxiliary PDM. Now disconnect and reconnect the phone cables, making sure the connectors seat properly. See **Fig.2** and **Fig.3**. Reconnect the power cable to the auxiliary PDM.
The power plug is installed incorrectly.	Check the installation of the power plug and reposition it if necessary.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Handset Does Not Illuminate

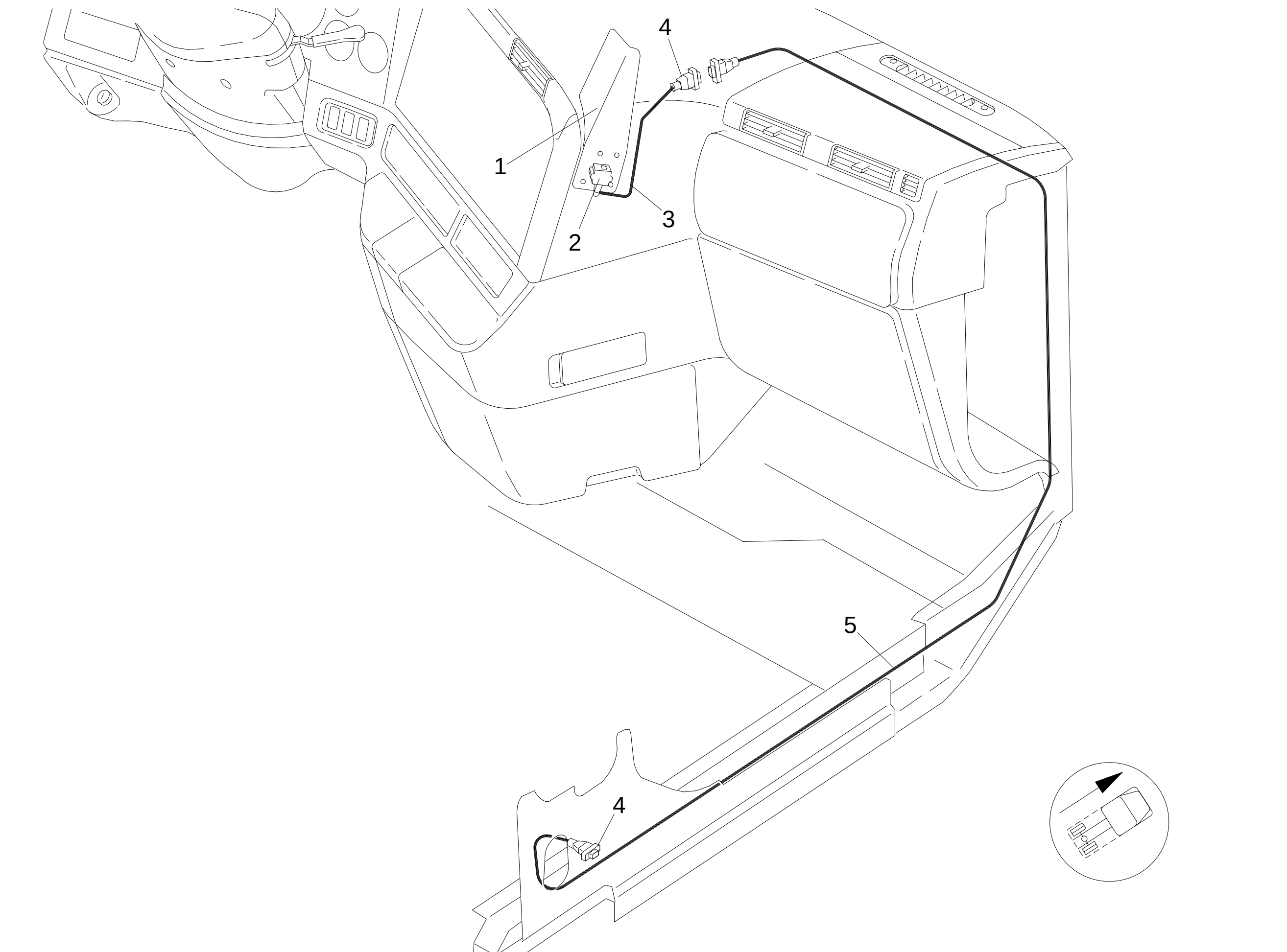
Problem—The Handset Does Not Illuminate	
Possible Cause	**Remedy**
The handset is not correctly connected to the pickup.	Turn the unit off. Check the connection of the handset cord to the pickup and turn the unit back on.
There are loose connections in the phone cables.	Disconnect the power cable from the auxiliary PDM. Now disconnect and reconnect the phone cables, making sure the connectors seat properly. See **Fig.2** and **Fig.3**. Reconnect the power cable to the auxiliary PDM.
The handset is broken.	Turn the unit off. Replace the handset with a spare handset and turn the unit back on. If the handset now illuminates, replace the handset. See **Subject 110** for detailed instructions.
The phone cable assembly needs replacing.	Disconnect the power cable from the auxiliary PDM. Now connect a spare phone cable assembly, making sure the connectors seat properly. See **Fig.2** and **Fig.3**. Reconnect the power cable to the auxiliary PDM. If the handset now illuminates, replace the phone cable assembly.



A. To B-Pillar Auxiliary Power Distribution Module (PDM)
B. To Control Unit
1. Cab
2. Power Cable
3. Forward Bunk Partition
4. Rear Deck

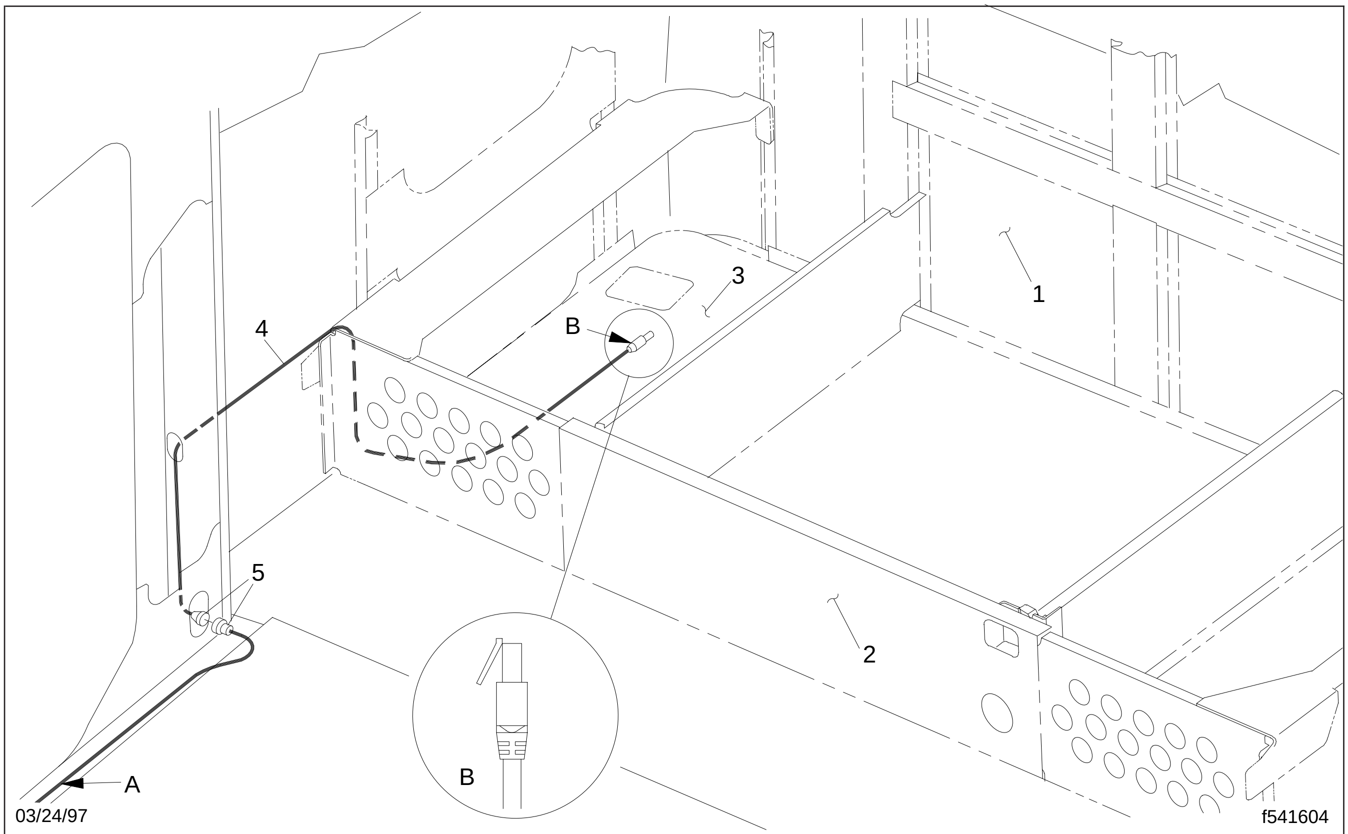
Fig. 1, Power Cable Routing

Troubleshooting



1. Pedestal
2. Pickup
3. Phone Cable (dash)
4. Connector
5. Phone Cable (door)

Fig. 2, Phone Cable Routing (dash)



A. To Handset
B. To Control Unit
1. Cab
2. Forward Bunk Partition
3. Rear Deck
4. Phone Cable (cab)
5. Connectors

Fig. 3, Phone Cable Routing (cab)

Problem—The Keypad on the Handset Does Not Function

Problem—The Keypad on the Handset Does Not Function	
Possible Cause	**Remedy**
The handset is damaged.	Check the handset for physical damage, disconnected wires, and broken seals.
There are sticky keys in the keypad.	Try several keys to see if any key responds. If some keys respond but others do not, clean the keypad. Turn the unit off. Spray on some contact cleaner and wipe off the keypad until it is dry. Turn the unit back on and check the keys again. Repeat if necessary.
The handset is broken.	Turn the power off. Replace the handset with a spare handset and turn the power back on. If the handset now illuminates, replace the handset. See **Subject 110** for detailed instructions.

Troubleshooting

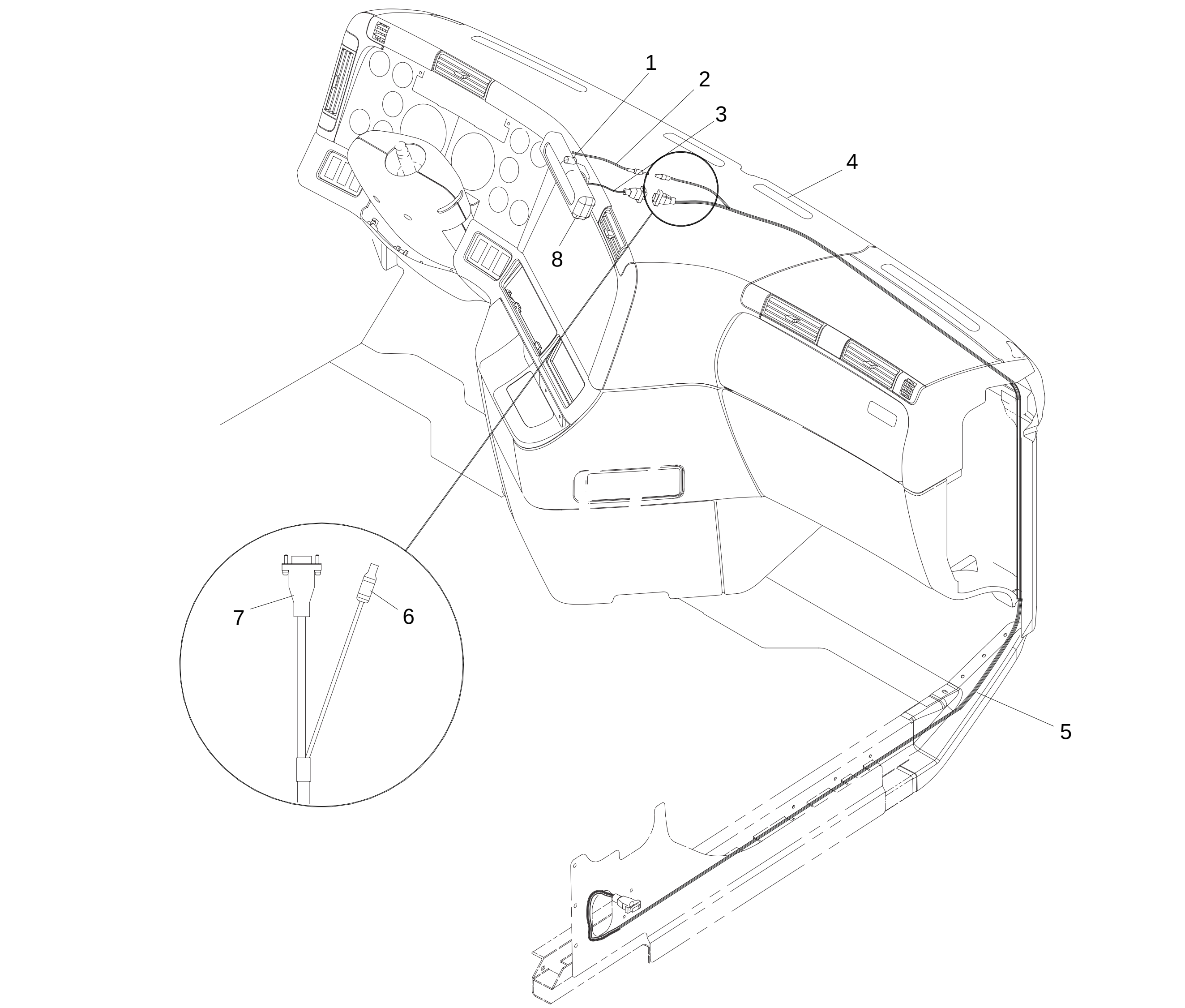
Problem—The Keypad on the Handset Does Not Function	
Possible Cause	**Remedy**
The phone cable assembly needs replacing.	Disconnect the power cable from the auxiliary PDM. Now connect a spare phone cable assembly, making sure the connectors seat properly. See **Fig.2** and **Fig.3**. Reconnect the power cable to the auxiliary PDM. If the handset now illuminates, replace the phone cable assembly.

Problem—The Display Is Blank, but the Handset and Control Unit Have Power

Problem—The Display Is Blank, but the Handset and Control Unit Have Power	
Possible Cause	**Remedy**
The screen saver is set to a short period of time.	On the handset, press "F" (function) and "Send." Use the arrow key to move down the menu to get to "Set Screen Saver Timer." Enter any number from 1 to 240 to change the number of minutes before the display goes blank.
There are loose connections in the display cables.	Disconnect the power cable from the auxiliary PDM. Now disconnect and reconnect the display cables, making sure the connectors seat properly. See **Fig.4** and **Fig.5**. Reconnect the power cable to the auxiliary PDM.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig.4** and **Fig.5**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The display unit is broken.	Replace the display unit. See **Subject 120** for detailed instructions.

Problem—The Display Shows Only the Underline Prompt (_)

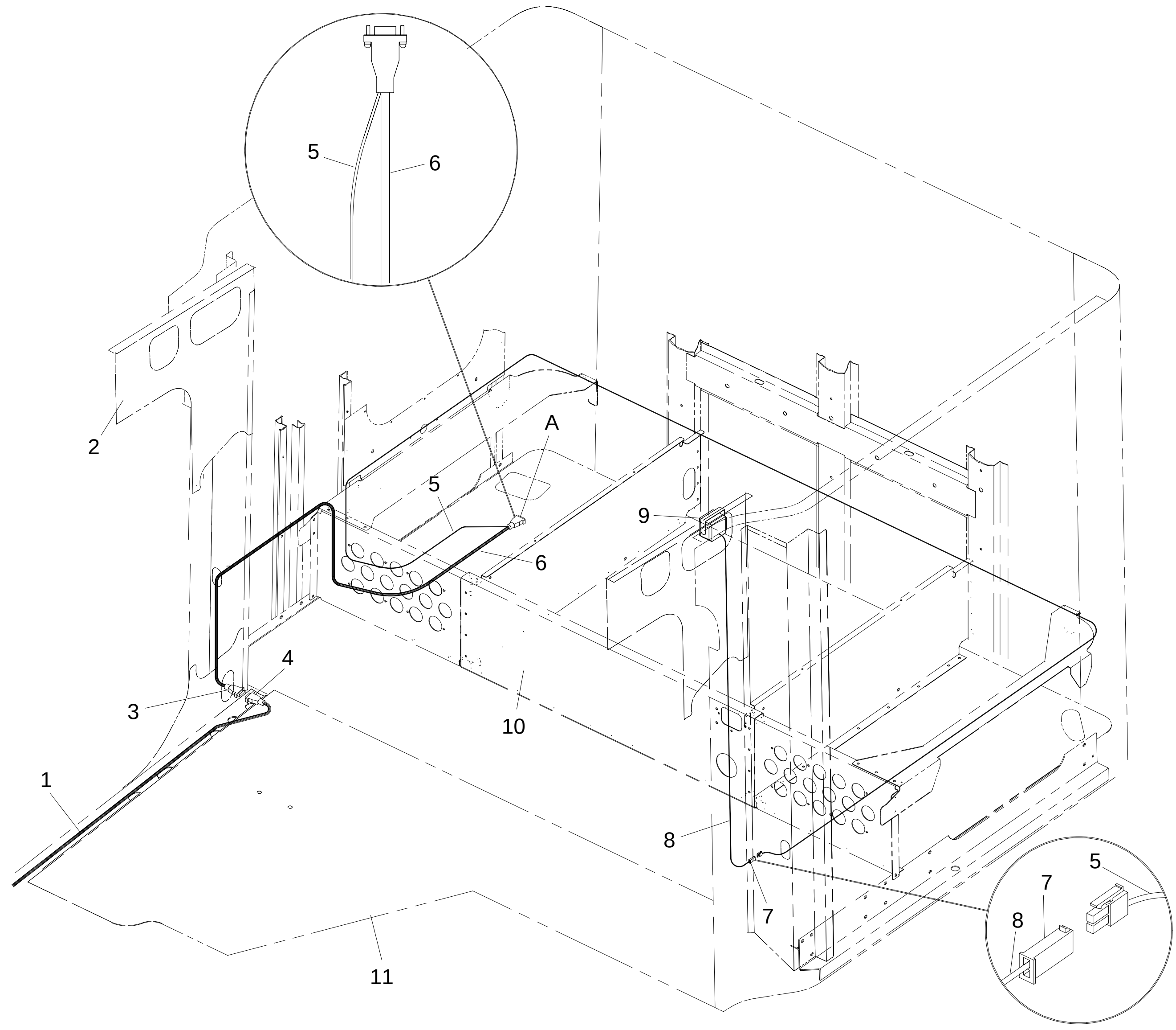
Problem—The Display Shows Only the Underline Prompt (_)	
Possible Cause	**Remedy**
The screen saver is set to a short period of time.	On the handset, press "F" (function) and "Send." Use the arrow key to move down the menu to get to "Set Screen Saver Timer." Enter any number from 1 to 240 to change the number of minutes before the display goes blank.
There are loose connections in the display cables.	Disconnect the circuit breaker. Now disconnect and reconnect the display cables, making sure the connectors seat properly. See **Fig.4** and **Fig.5**. Reconnect the circuit breaker.
The display unit is broken.	Replace the display unit. See **Subject 120** for detailed instructions.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig.4** and **Fig.5**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.



1. Microphone
2. Microphone Wire
3. Display Unit Wire
4. Upper Dash Assembly (LH panel)
5. Display Cable (door)
6. Display Connector
7. Microphone Connector
8. Display Unit

Fig. 4, Display and Microphone Cable Routing (dash)

Troubleshooting



A. To Control Unit

1. Display Cable (door)
2. B-Pillar
3. Display Cable Cab Connector
4. Display Cable Door Connector
5. Speaker Cable (cab)
6. Display Cable (cab)
7. Speaker Connector
8. Speaker Cable (B-pillar)
9. Speaker
10. Forward Bunk Partition
11. Rear Deck

Fig. 5, Display and Speaker Cable Routing (cab)

Problem—The Display Shows Only the "HighwayMaster" Message

Problem—The Display Shows Only the "HighwayMaster" Message	
Possible Cause	**Remedy**
The vehicle is outside the coverage area.	The display is functioning correctly. Move the vehicle to a covered area and the message will change to "HighwayMaster Service Area."
The cellular antenna is missing.	Replace the cellular antenna, making sure the tab is bent down enough to make contact with the antenna base. See **Subject 150** for detailed instructions.
The cellular antenna connector is broken.	Inspect the connector (at the control unit) for damage. Replace the connector, and check the display again. See **Fig.6**. If the display is still not correct, ask Customer Care (1–800–647–6693) to download a SID table.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Display Gives Scrambled Information

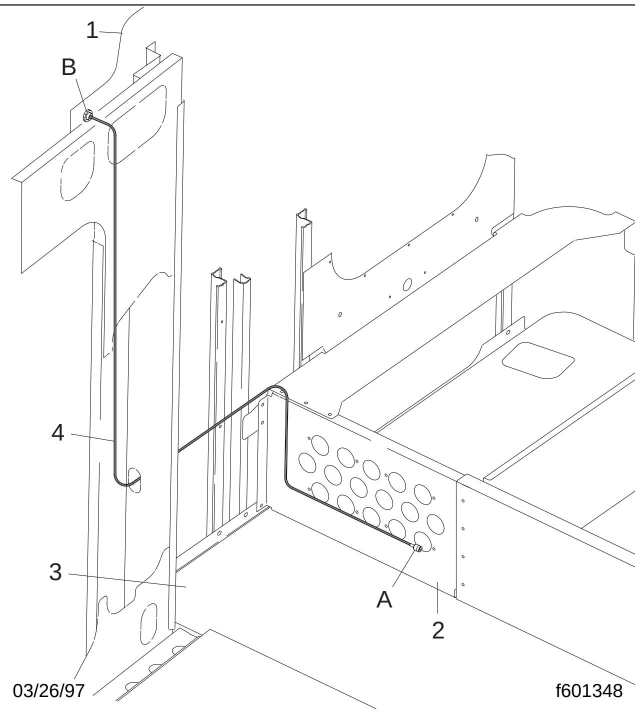
Problem—The Display Gives Scrambled Information	
Possible Cause	**Remedy**
The system needs to be restarted.	Call Customer Care at 1–800–647–6693 and request a remote restart. Remove power from the system for one minute. Reconnect the power and reinitialize the control unit. See **Subject 100** for detailed instructions.

Problem—The Microphone Does Not Work, or Broadcasts Noise

Problem—The Microphone Does Not Work, or Broadcasts Noise	
Possible Cause	**Remedy**
There is interference from wind, or other electrical sources.	Check the microphone with the window rolled up and all electrical appliances off.
The connection with the display cable is bad.	Check the connection with the display cable and make sure it is properly connected. For a more secure connection, wrap electrical tape around the connector.
The microphone wire is damaged.	Check the microphone wire for damage. Replace the microphone if any is found. See **Subject 130** for detailed instructions. Test the system again with the new microphone installed.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig.4** and **Fig.5**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Troubleshooting

Problem—The Speaker Does Not Work



Factory installation is shown.

A. To Control Unit
B. To Cellular Antenna
1. Cab Wall
2. Forward Bunk Partition
3. Rear Deck
4. Cellular Antenna Cable

Fig. 6, Cellular Antenna Cable Routing

Problem—The Speaker Does Not Work	
Possible Cause	**Remedy**
The handset is not properly seated in the cradle.	Check that the handset is seated properly. Turn the power on, and press the "End" button. If the speaker is operating, it will respond by saying "Ready."
The display unit is broken.	Disconnect the circuit breaker. Now connect a spare display unit. Reconnect the circuit breaker, and press the "End" button. If the speaker now operates, replace the display unit. See **Subject 120** for detailed instructions.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig.4** and **Fig.5**. Reconnect the circuit breaker, and press the "End" button. If the speaker now operates, replace the display cable assembly.
The voice recognition system in the control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

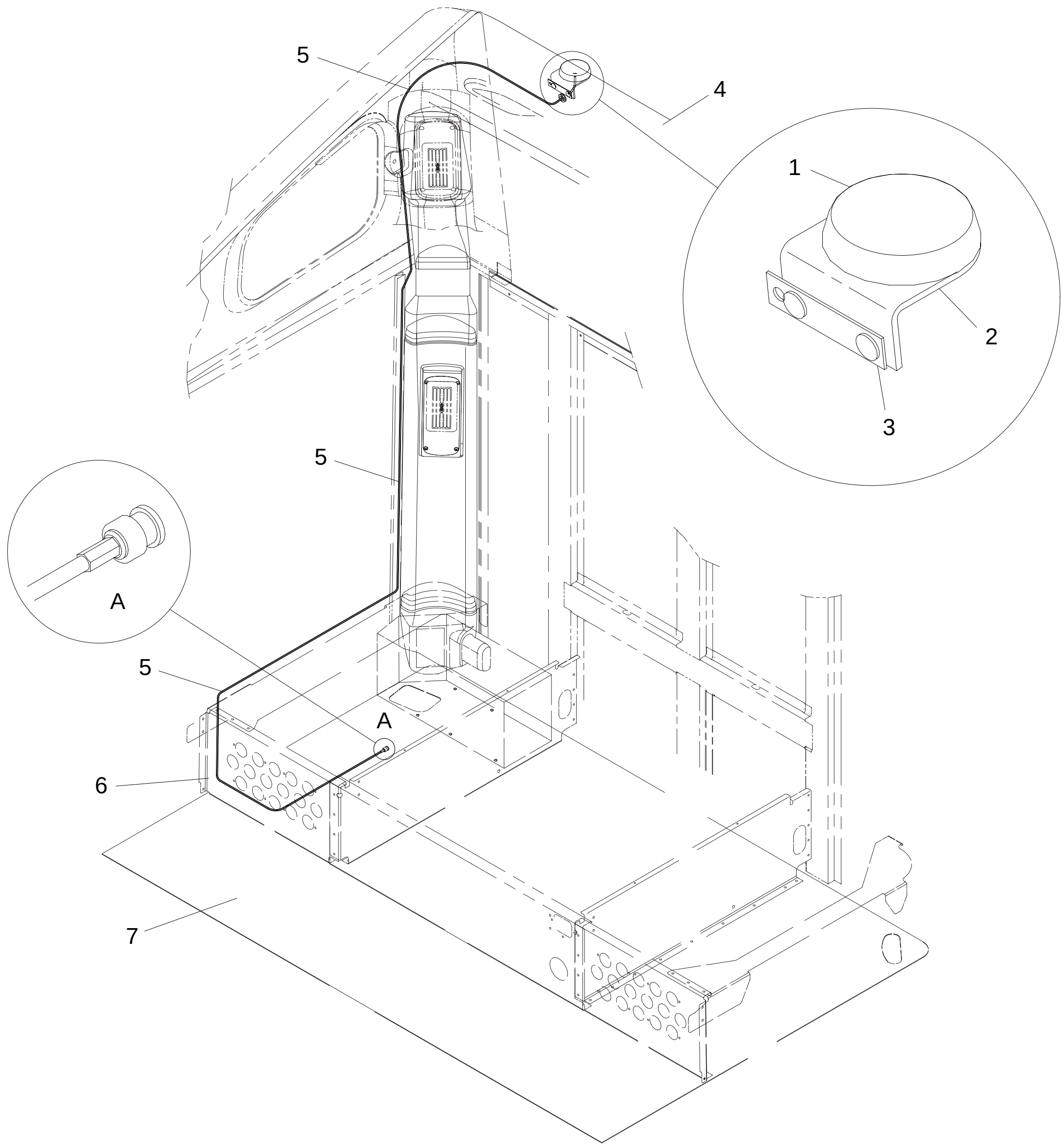
Problem—The GPS (Satellite) System Does Not Provide Actual Position Data, or Provides It Infrequently

Problem—The GPS (Satellite) System Does Not Provide Actual Position Data, or Provides It Infrequently	
Possible Cause	**Remedy**
The system has not reached "NAV" status.	On the handset keypad, enter "589200," followed by "CHK." When the display reads "GPS HAS REACHED NAV STATUS," call the host operator and ask for an actual position on the vehicle. If the operator still does not have an actual, ask for an immediate data exchange (F2) to download the data.
There are loose connections on the GPS antenna.	Check all of the antenna connections for condition. See **Fig.7**. Repair/replace as necessary.
The GPS antenna and/or cable is damaged.	Check the GPS antenna and cable for damage. Repair or replace any damaged parts as necessary. On the handset keypad, enter "589200," followed by "CHK." When the display reads "GPS Has Reached NAV Status," call the host operator and ask for an actual position on the vehicle. If the operator still does not have an actual, ask for an **immediate data exchange (F2)** to download the data.
The HighwayMaster system is not registered properly.	Call Customer Care at 1–800–647–6693 to check the registration status of the system.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The HighwayMaster System Does Not Receive Status Codes or Authorized Numbers

Problem—The HighwayMaster System Does Not Receive Status Codes or Authorized Numbers	
Possible Cause	**Remedy**
The registration codes were never entered.	On the handset keypad, enter "STO," "99," and "SEND." When the display reads "HighwayMaster Service Area," enter "STO," and "01." Keep repeating this step until the Display reads "Transmission Successful." Check the status codes by entering "STO" "01," and the up arrow (↑) to scroll through the codes. Similarly, check the authorization numbers by entering "RCL," "#," "01," and the up arrow (↑) to scroll through the numbers.
The control unit has not been initialized.	Call the host operator to request initialization and repeat the procedure above.
The HighwayMaster system is not registered properly.	Call Customer Care at 1–800–647–6693 to check the registration status of the system.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Troubleshooting



A. To Control Unit
1. GPS Antenna
2. GPS Antenna Bracket
3. Backing Plate
4. Roof Cap
5. GPS Antenna Cable
6. Forward Bunk Partition
7. Rear Deck

Fig. 7, GPS Antenna Cable Routing

Troubleshooting

Problem—The HighwayMaster System Will Not Power Off

Problem—The HighwayMaster System Will Not Power Off	
Possible Cause	**Remedy**
The power off delay has been set.	Call the host operator to reset the delay.
The electrical connections are not in the correct place.	Check all the electrical connections from the auxiliary power distribution module to the control unit. Repair/ replace as necessary.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Driver Is Unable to Call Personal Numbers

Problem—The Driver Is Unable to Call Personal Numbers	
Possible Cause	**Remedy**
The driver does not have a valid AT & T calling card.	Ask the driver to call AT & T to obtain a valid calling card.
The personal calling feature is not active.	Call Customer Care at 1–800–647–6693 and ask them to active the personal calling feature.

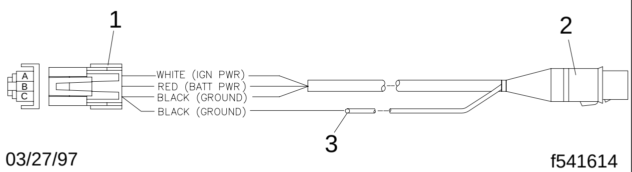
Specifications

For a drawing of the power cable, see **Fig. 1**.

For a drawing of the phone cable, see **Fig. 2**.

For a drawing of the display cable, see **Fig. 3**.

For a schematic of the HighwayMaster system wiring, see **Fig. 4**.



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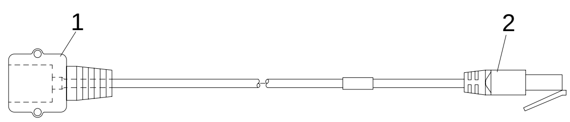
1. Auxiliary PDM Connector
2. Control Unit Connector
3. Splice Clip

Fig. 1, HighwayMaster Power Cable



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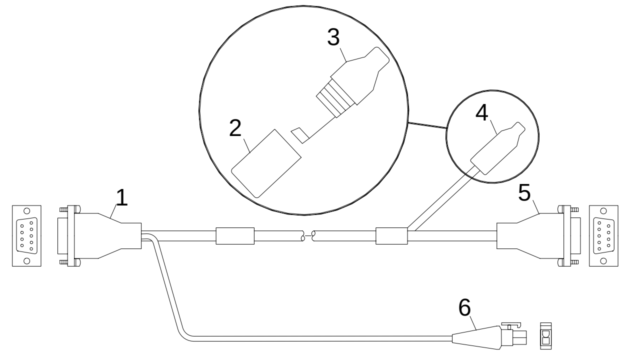
1. Pickup (to handset)
2. Control Unit Connector

Fig. 2, HighwayMaster Phone Cable



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1. Control Unit Connector
2. Sleeve
3. Sleeve Terminal
4. Microphone Connector
5. Display Unit Connector
6. Speaker Connector

Fig. 3, HighwayMaster Display Cable

Specifications

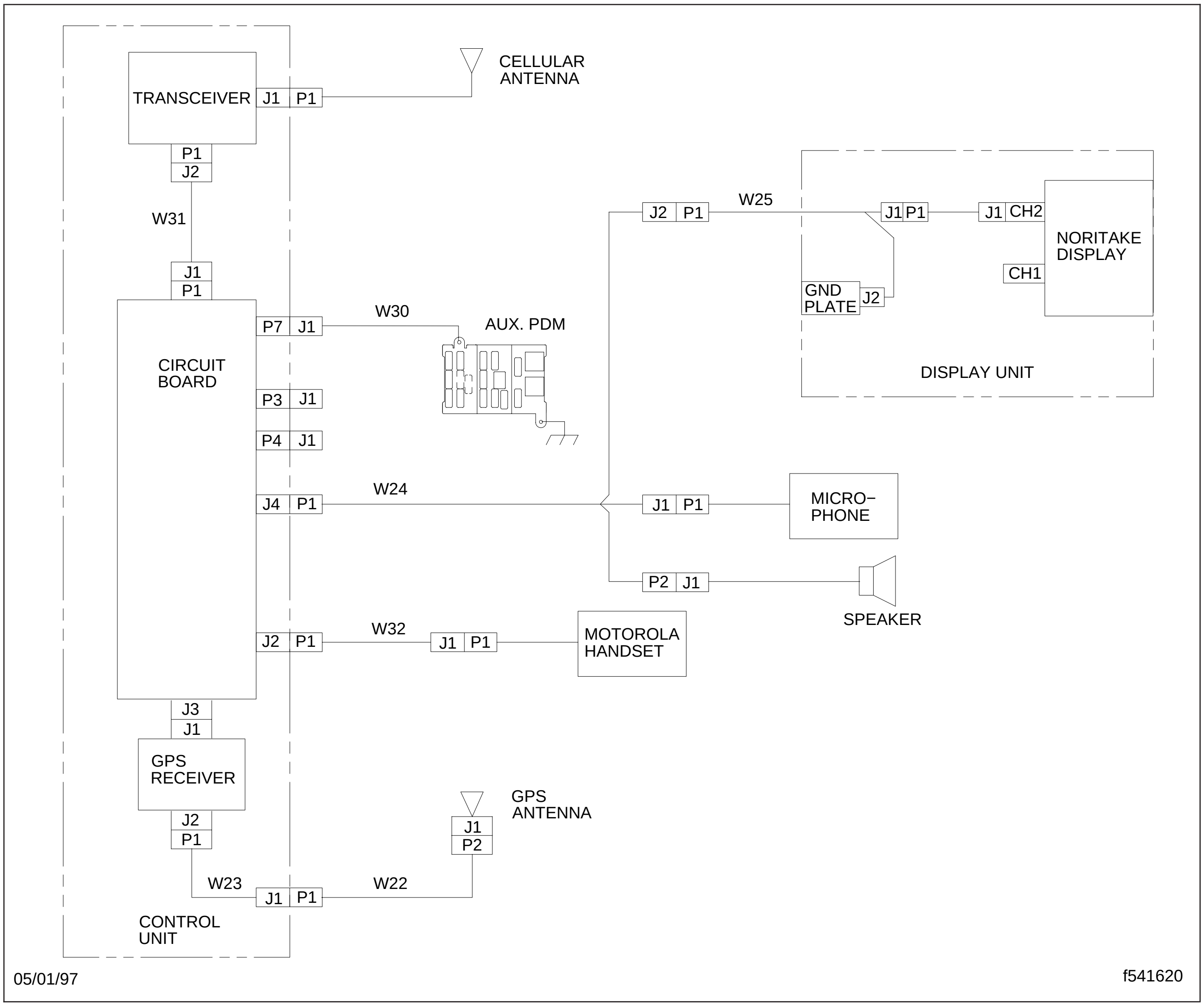


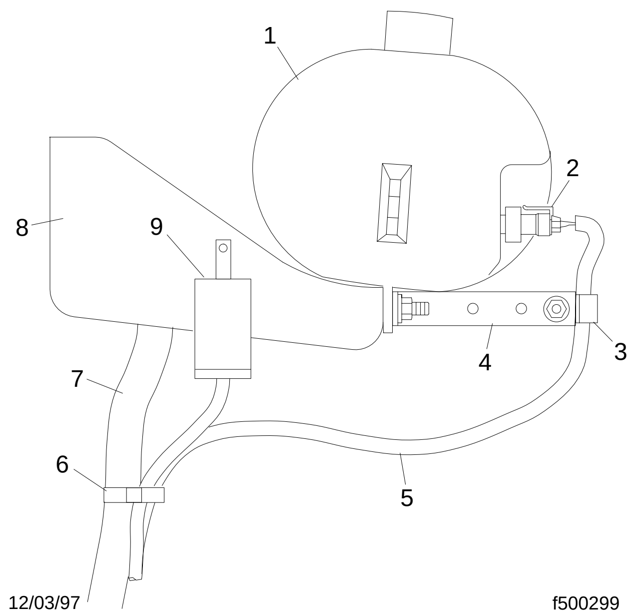
Fig. 4, HighwayMaster Wiring Schematic

General Information

The coolant level probe inserts directly into the surge tank. The connector on the probe attaches to a special low coolant level (LCL) overlay harness which connects between the electronic engine harness and the frontwall harness.

For overlay harness wiring, see **Specifications, 400** in this section. For frontwall harness wiring, see **Section 54.00**, Specifications, 400.

Vehicles with Cummins (CUM) and Caterpillar (CAT) engines have a control module installed on the side of the surge tank lower bracket. See **Fig. 1**. On these engines, an electronic engine overlay harness provides 5-volt power to the control module.

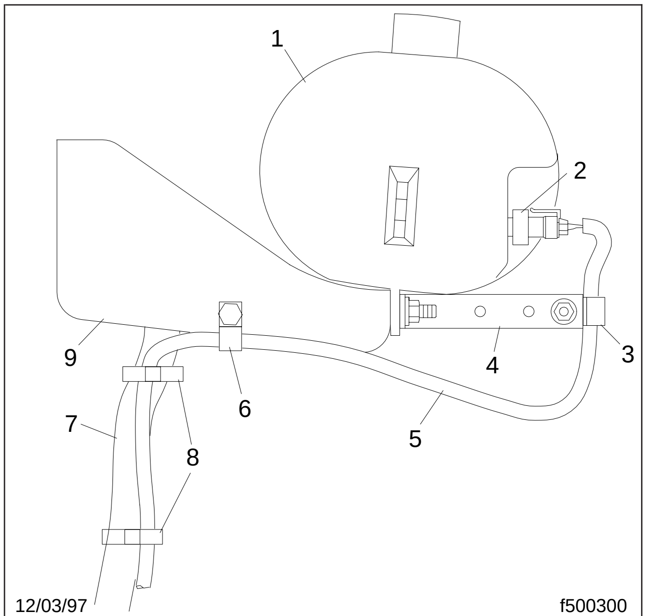


NOTE: Hoses removed for clarity.

1. Surge Tank
2. Coolant Level Probe
3. Surge Tank Clamp
4. Overlay Harness Bracket
5. LCL Overlay Harness
6. Tie Strap
7. Electronic Engine Harness
8. Surge Tank Lower Bracket
9. Control Module

Fig. 1, Probe Mounted In Surge Tank, CAT/CUM Engines

Vehicles with Detroit Diesel (DDEC) engines have no control module. See **Fig. 2**.



NOTE: Hoses removed for clarity.

1. Surge Tank
2. Coolant Level Probe
3. Surge Tank Clamp
4. Overlay Harness Bracket
5. LCL Overlay Harness
6. Surge Tank Clamp
7. Electronic Engine Harness
8. Tie Straps
9. Surge Tank Lower Bracket

Fig. 2, Probe Mounted In Surge Tank, DDEC Engines

Probe In Surge Tank

REMOVAL

1. Set the parking brake and chock the rear tires.

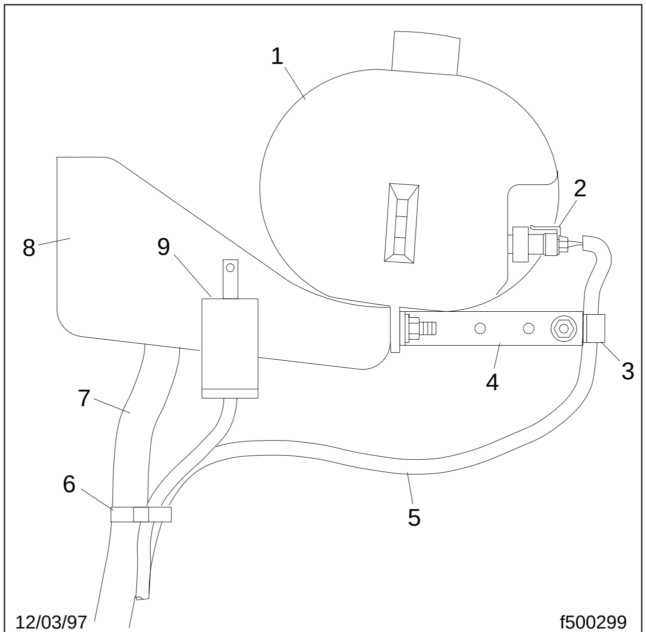
WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant out of the surge tank, at least to the level of the coolant probe. The coolant can be drained by disconnecting the clamps on the makeup line at the bottom of the surge tank and placing the hose in a suitable container.
3. Disconnect the electrical connector at the rear of the probe. See **Fig. 1** for vehicles with Caterpillar (CAT) or Cummins (CUM) engines. See **Fig. 2** for vehicles with Detroit Diesel (DDEC) engines.
4. Unscrew the coolant level probe and remove it from the surge tank.
5. Check the O-ring in the base of the probe and replace it if it is damaged or worn.

INSTALLATION

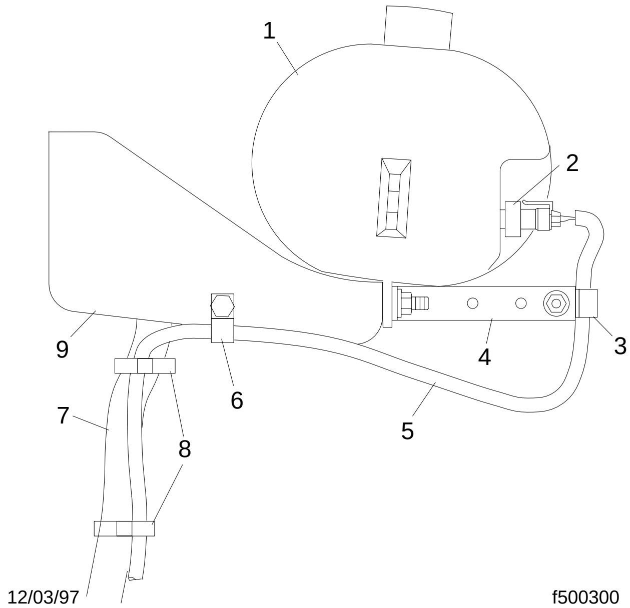
1. Screw the coolant probe into the threaded hole in the surge tank until the threads bottom out and the probe is firmly in place.
2. Attach the electrical connector to the rear of the probe.
3. Fill the surge tank with coolant. For instructions, see **Section 20.01**, Subject 100.
4. Run the engine and check for leaks around the surge tank.
5. Remove the chocks from the tires.



NOTE: Hoses removed for clarity.
1. Surge Tank
2. Coolant Level Probe
3. Surge Tank Clamp
4. Overlay Harness Bracket
5. LCL Overlay Harness
6. Tie Strap
7. Electronic Engine Harness
8. Surge Tank Lower Bracket
9. Control Module

Fig. 1, Probe In Surge Tank, CAT/CUM Engines

Coolant Probe Removal and Installation



NOTE: Hoses removed for clarity.

1. Surge Tank
2. Coolant Level Probe
3. Surge Tank Clamp
4. Overlay Harness Bracket
5. LCL Overlay Harness
6. Surge Tank Clamp
7. Electronic Engine Harness
8. Tie Straps
9. Surge Tank Lower Bracket

Fig. 2, Probe In Surge Tank, DDEC Engines

Control Module Removal and Installation

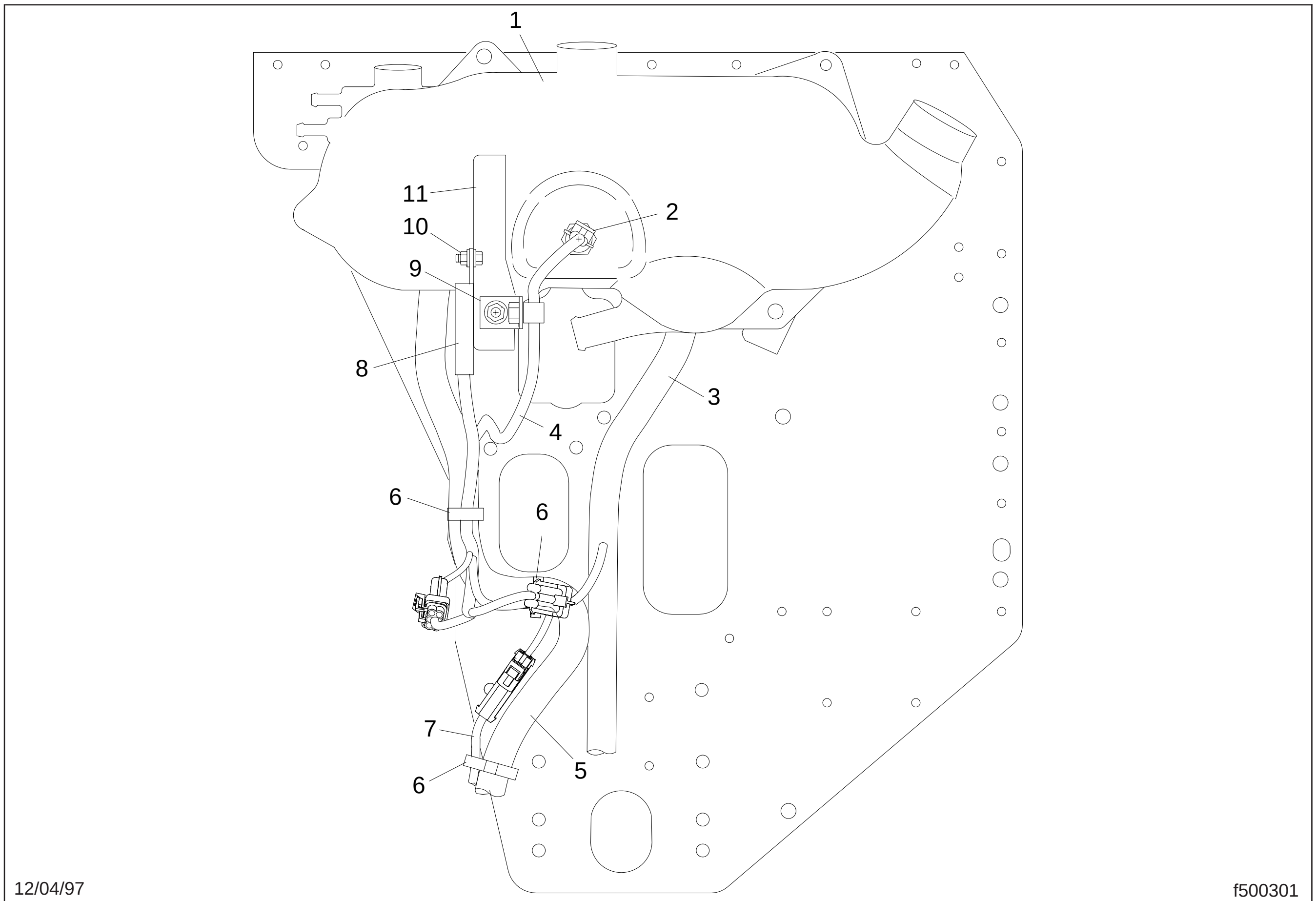
NOTE: Vehicles with Detroit Diesel engines have no control module.

Removal

1. Set the parking brake and chock the tires.
2. Disconnect the electrical connector from the bottom of the control module. See **Fig. 1**.
3. Remove the 1/4–20 locknut from the surge tank lower bracket.
4. Remove the control module from the mounting capscrew.

Installation

1. Position the control module on the mounting capscrew and tighten the locknut 84 lbf·in (940 N·cm).
2. Attach the electrical connector to the base of the module.



NOTE: Hoses removed for clarity.

1. Surge Tank
2. Coolant Level Probe
3. Frontwall Harness
4. LCL Overlay Harness
5. Electronic Engine Harness
6. Tie Strap
7. Electronic Engine Overlay Harness
8. Control Module
9. Overlay Harness Bracket
10. Locknut, 1/4–20
11. Surge Tank Lower Bracket

Fig. 1, Control Module

Control Module Removal and Installation

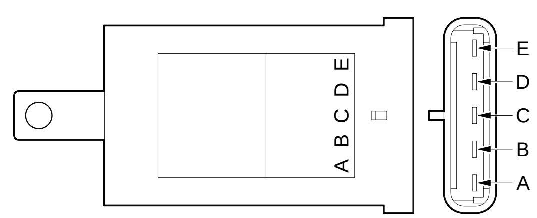
3. Run the engine and check for proper operation of the control module (no false indications of low coolant level).
4. Remove the chocks from the tires.

Coolant Level Warning System Test (Caterpillar and Cummins)

NOTE: Do this test only on vehicles with a Caterpillar or Cummins engine. Vehicles with Detroit Diesel engines do not have a low coolant level module. For these vehicles, see "Coolant Level Probe Test (Detroit Diesel)."

LOW COOLANT LEVEL MODULE

1. Disconnect the low coolant level module from the connector.
2. Connect a 5-volt power source to the unit.
3. Attach the power supply positive lead to pin E and the negative lead to pin C. See **Fig. 1**.



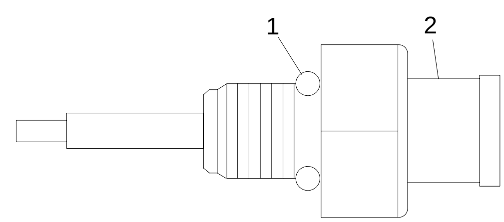
A. Circuit PROB (coolant level probe)
B. Circuit LNOR (normal level signal)
C. Circuit LGND (ground)
D. Circuit LLOW (low level signal)
E. Circuit L+5V (5-volt power)

Fig. 1, Low Coolant Level Module

4. Connect a jumper wire between pin A (probe) and pin C (ground) to simulate a normal coolant level sensor reading (probe in coolant).
   - 4.1 Use a digital multimeter to measure the voltage. The digital multimeter should read approximately 5 volts when connected to pin B (positive meter lead) and pin C (negative meter lead).
   - 4.2 The digital multimeter should read approximately 0 volt when connected to pin D (positive meter lead) and pin C (negative meter lead).
5. Disconnect the jumper wire between pin A and pin C to simulate a low coolant level sensor reading.
   - 5.1 The digital multimeter should read approximately 0 volt when connected to pin B (positive meter lead) and to pin C (negative meter lead).
   - 5.2 The digital multimeter should read approximately 5 volts when connected to pin D (positive meter lead) and to pin C (negative meter lead).

COOLANT LEVEL PROBE

1. Check for leaks around the area where the probe attaches to the surge tank. Replace the O-ring if needed. See **Fig. 2**.



1. O-Ring 2. Coolant Level Probe

Fig. 2, Coolant Level Probe

2. Disconnect the Metri-Pack® connector from the coolant level probe. Attach a 5-volt power source to the two pins on the probe. Connect the digital multimeter, set on the 20-Vdc scale, and measure the voltage across the two pins.

   If the meter shows approximately 5 volts, the coolant level probe is functioning correctly.

   If the meter shows low voltage, replace the coolant level probe.

NOTE: Disregard the minus (–) sign on negative voltages.

Coolant Level Probe Test (Detroit Diesel)

NOTE: Do this test only on vehicles with a Detroit Diesel engine. For vehicles with Caterpillar

Troubleshooting

or Cummins engines, see Coolant Level Warning System Test (Caterpillar and Cummins).

1. Check for leaks around the area where the probe attaches to the surge tank. Replace the O-ring if needed. See **Fig. 2**.
2. Disconnect the Metri-Pack connector from the coolant level probe.
3. Set a digital multimeter on the 20-Vdc scale and attach it between the cavities in the connector.

   If the meter reads approximately 5 volts, go to the next step.

   If the meter reads very little or no voltage, check circuits D115 and D953 and repair or replace, as necessary.

NOTE: Disregard the minus (–) sign on negative voltages.

4. With the Metri-Pack connector still disconnected, attach a 5-volt power source to the two pins on the probe and measure the voltage across the two pins of the probe.

   If the meter shows approximately 5 volts, the coolant level probe is functioning correctly.

   If the meter shows low voltage, replace the coolant level probe.

Specifications

The low coolant probe connects to a low coolant level (LCL) overlay harness, which connects in between the electronic engine harness and the frontwall harness. For a schematic of the LCL wiring, see **Fig. 1** for Caterpillar and Cummins electronic engines and **Fig. 2** for Detroit Diesel (DDEC) electronic engines.

For a drawing of the LCL overlay harness, see **Fig. 3** for Caterpillar and Cummins electronic engines and **Fig. 4** for DDEC electronic engines.

On Caterpillar and Cummins engines, an electronic control module draws 5-volt power through the electronic engine overlay harness. For a drawing of the electronic engine overlay harness, see **Fig. 5** for Caterpillar and **Fig. 6** Cummins electronic engines.

Specifications

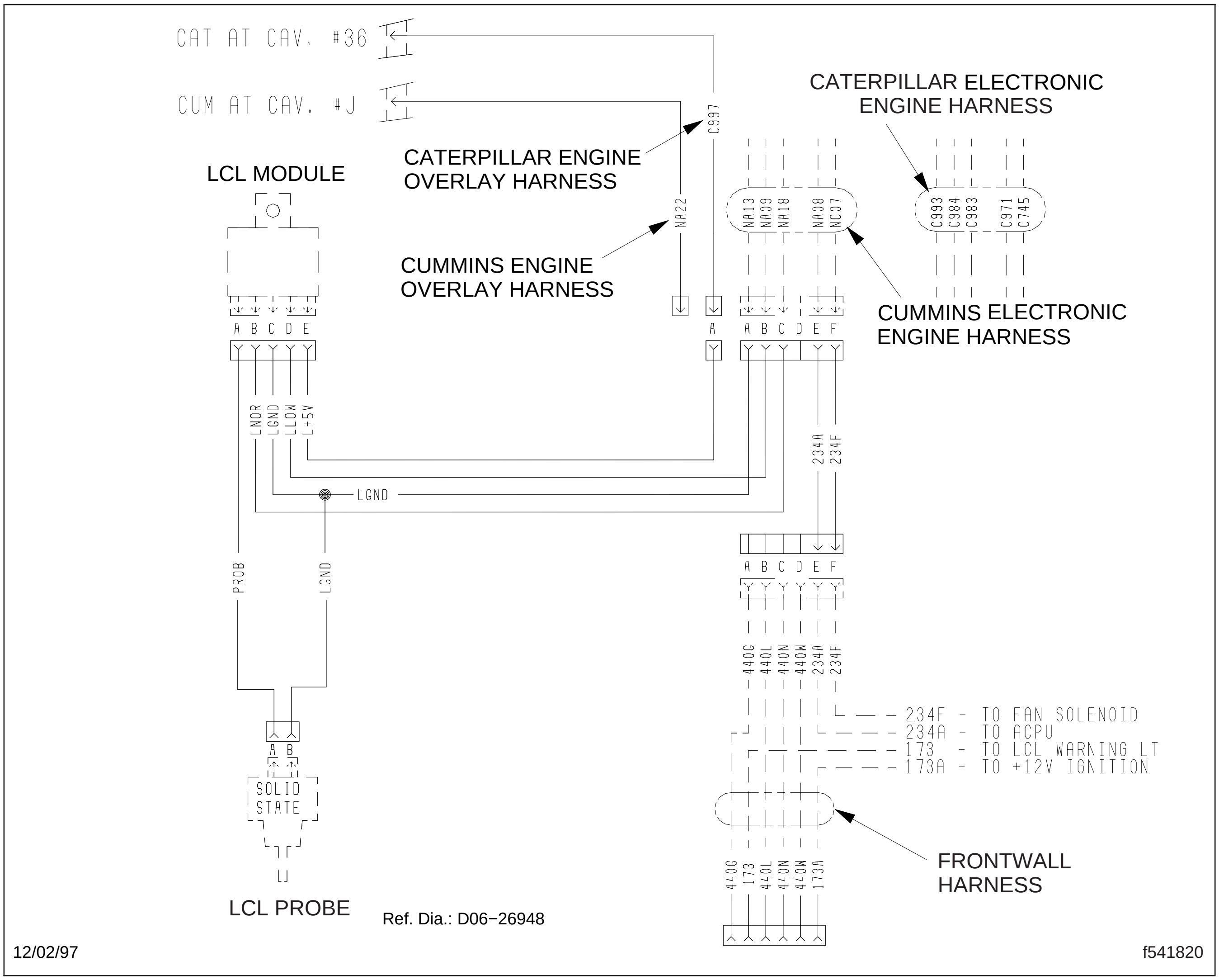


Fig. 1, LCL Wiring Schematic, Caterpillar/Cummins Engines

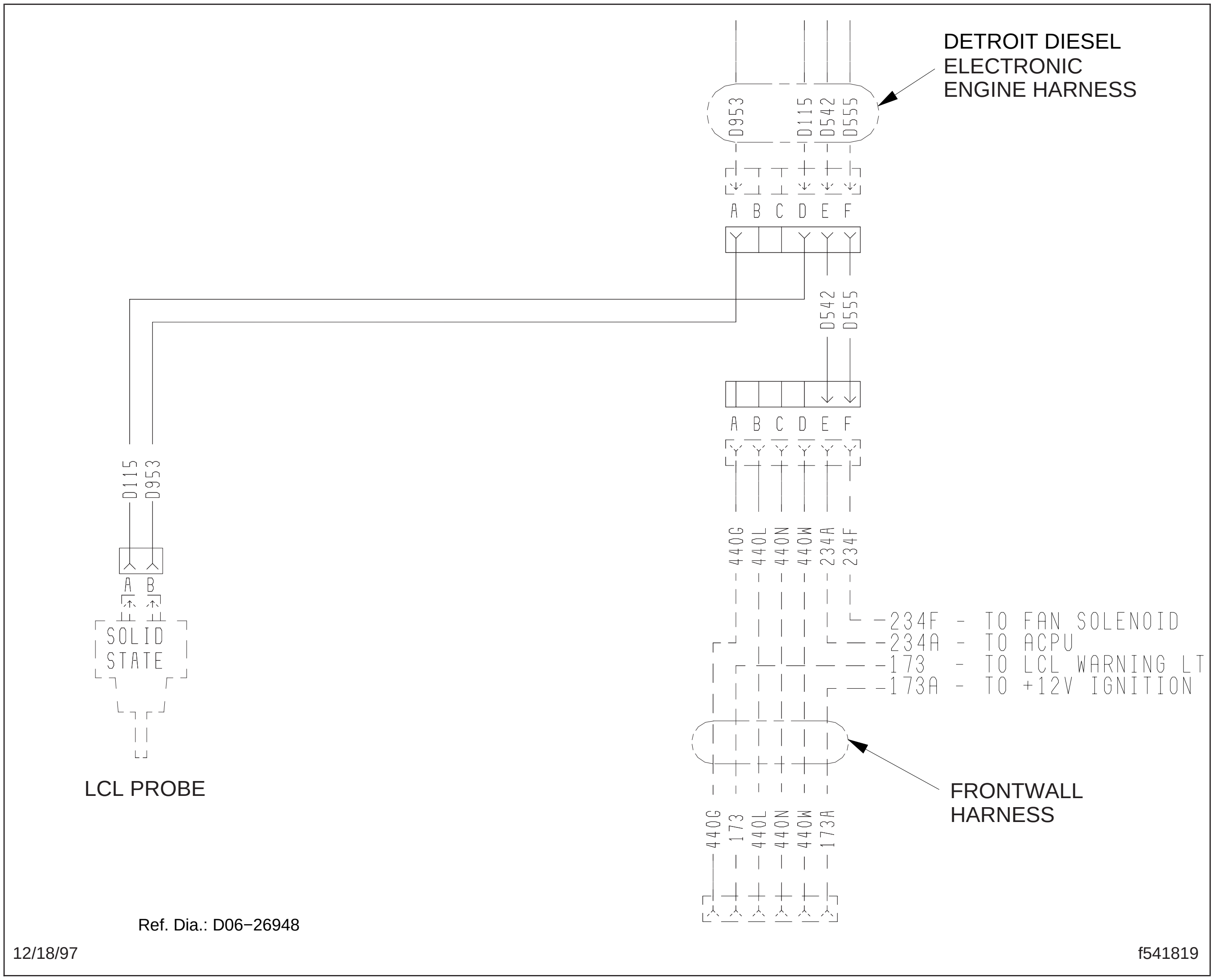
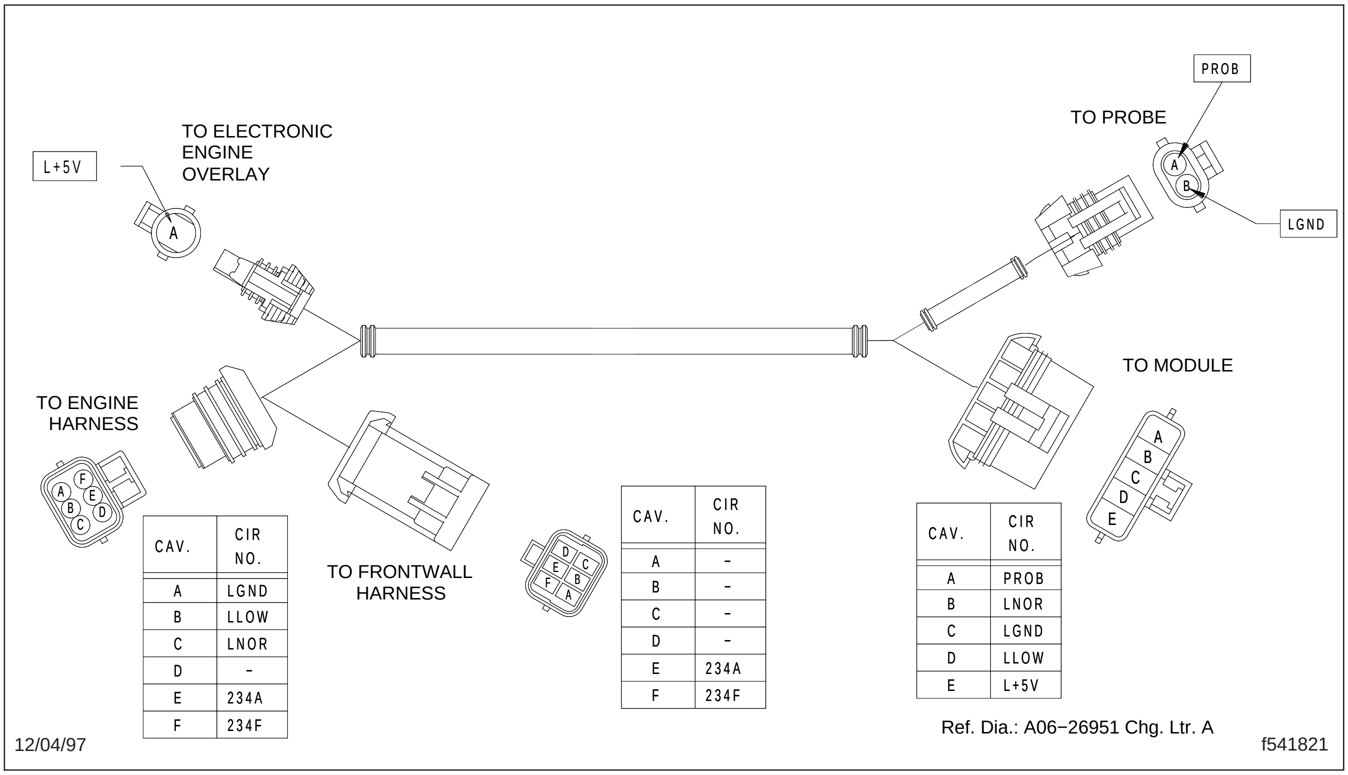


Fig. 2, LCL Wiring Schematic, DDEC Engines

Specifications

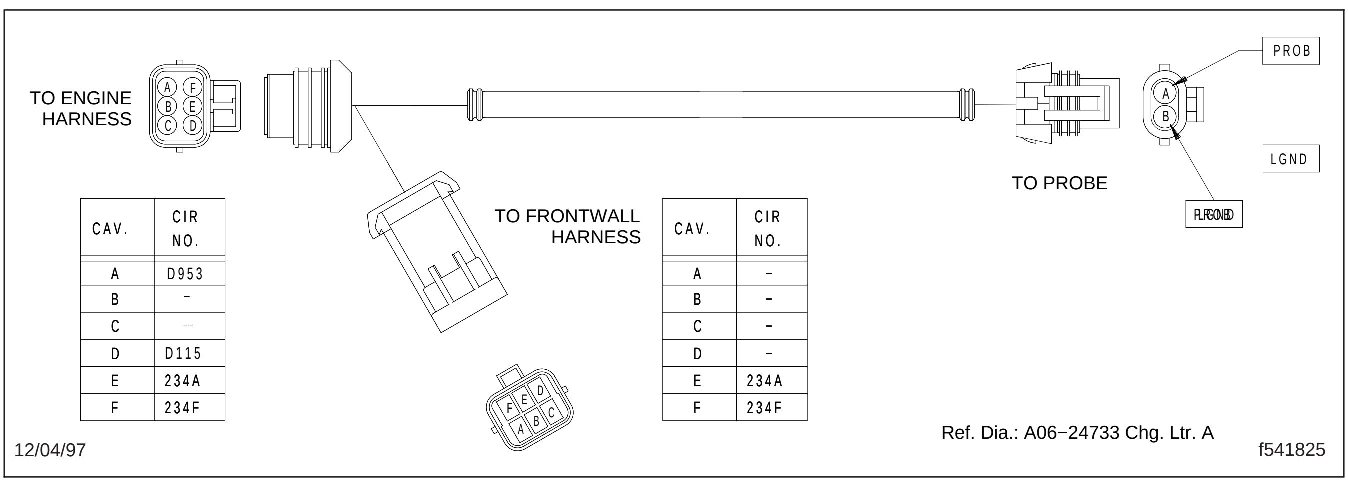


CAV.	CIR NO.
A	LGND
B	LLOW
C	LNOR
D	–
E	234A
F	234F

CAV.	CIR NO.
A	–
B	–
C	–
D	–
E	234A
F	234F

CAV.	CIR NO.
A	PROB
B	LNOR
C	LGND
D	LLOW
E	L+5V

Fig. 3, LCL Overlay Harness, Caterpillar/Cummins Engines



CAV.	CIR NO.
A	D953
B	–
C	–
D	D115
E	234A
F	234F

CAV.	CIR NO.
A	–
B	–
C	–
D	–
E	234A
F	234F

Fig. 4, LCL Overlay Harness, DDEC Engines

Specifications

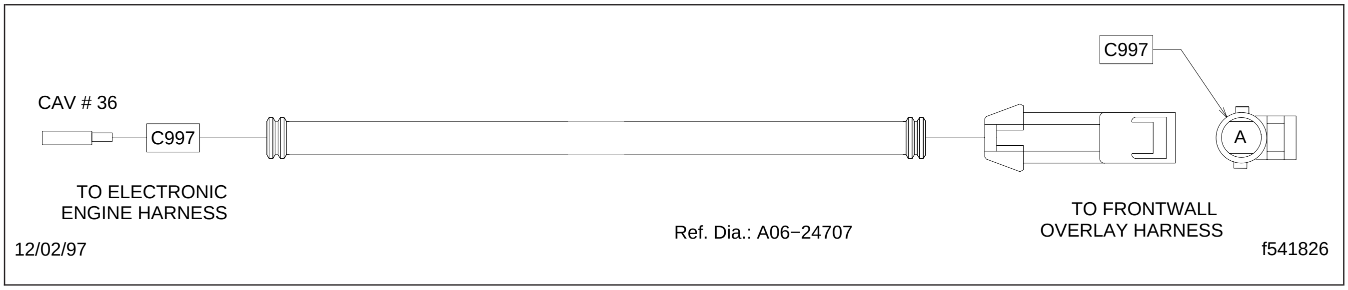


Fig. 5, Electronic Engine Overlay Harness, Caterpillar Engines

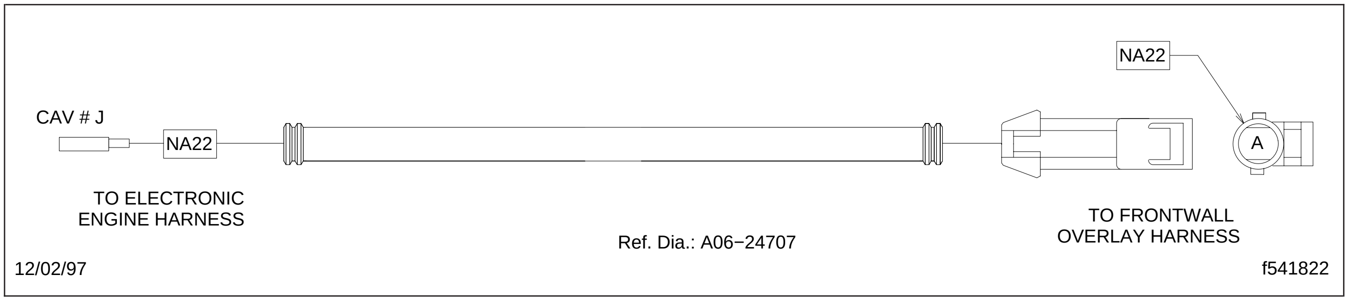


Fig. 6, Electronic Engine Overlay Harness, Cummins Engines

General Information

The low voltage disconnect (LVD) module is located on the engine tunnel plate behind the dash lower console.

The low voltage disconnect module monitors battery voltage levels. If battery voltage falls below 12.3 volts, a red LED on the LVD flashes for 1 minute. If no action is taken during the 1 minute that the LED is flashing, an alarm starts beeping slowly for 30 seconds. If no action is taken to reduce the load after 30 seconds, the alarm then beeps quickly for 30 seconds. At the end of this 30 second interval, the LVD removes power to predetermined cab and sleeper circuits and a warning light on the dash illuminates.

NOTE: If the voltage at the batteries is checked just before the LVD cuts off power, the voltage may be lower than the cut off voltage of 12.3 volts. This is normal operation since the power-off function is triggered at 12.3 volts and the load is still draining the batteries. Once these accessories are shut off, the batteries typically recover to about 12.3 volts under the power-restore threshold of 12.8 volts (nominal).

As long as the battery voltage is under the power restore threshold, these accessories will not come back on. Either the truck must be started to bring the battery voltage back up, or a battery charger must be installed.

The LVD module provides input to the power distribution module to control the following cab circuits:

- Option 1 (circuit 44S)
- Option 2 (PDM address PD 47S)
- Dome light (PDM address PD 43S)
- Cigarette lighter (PDM address PD 41S)
- Sleeper (E-box) (PDM address PD 10S)
- Utility light (PDM address PD 15S)

The LVD module provides input to the power distribution module to control the following sleeper circuits:

- Main dome light (circuit 41S)
- Power receptacles #2, and #3 (circuits 57A, 57B, and 57C)
- Read/bag light (circuit 41R)
- Optional battery power (OPT)
- HVAC breaker (circuit 98)

When the battery voltage reaches 13.1 volts, or if the vehicle is started, the LVD module automatically reconnects power to the predetermined circuits.

The LVD module has a 60-second time delay to prevent false triggering and is equipped with internal short circuit protection, over-current protection, transient-voltage suppression, and thermal protection.

The LVD module has two terminal post connections and a ten-position connector. For the LVD module wiring diagram, see **Specifications, 400**.

The two terminal post connections are V-in and V-out.

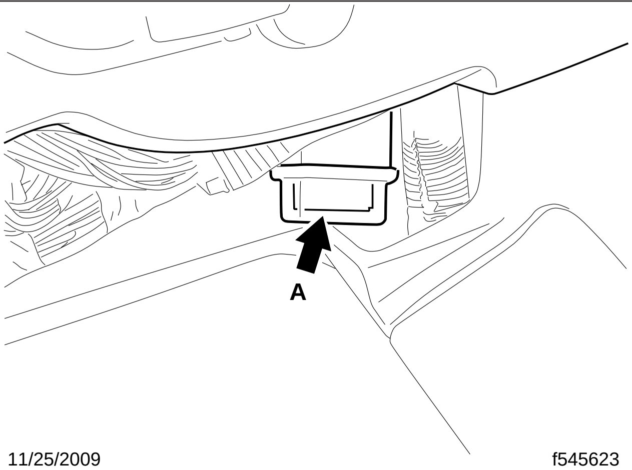
- The V-in terminal (circuit 14D) is the voltage supply input from the frontwall power stud.

  Power is supplied to the V-in terminal by a 50 amp fuse located near the passenger-side footwell. See **Fig. 1**.
- The V-out terminal (circuit 14BS) is the controlled voltage output from the LVD module to the ISO bus power input terminal of the power distribution module (predetermined cab and sleeper circuits). It also supplies power to the buzzer diode.

Three of the terminals in the 10-position connector are used for the LVD system.

- The ground terminal (circuit GND) supplies ground for the module and is connected to the main ground junction box (MGJB).
- The buzzer diode control terminal (circuit 447J) supplies ground to the buzzer diode, which sounds when the LVD module detects low voltage.
- The V-sense terminal (circuit 447B) is used by the LVD module to monitor the level of battery voltage and is connected to 5-amp fuse B in the PNDB.

General Information



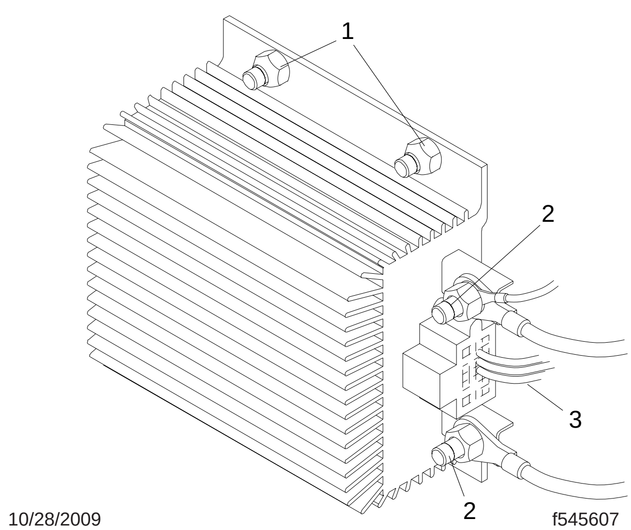
A. The 50 amp fuse is located near the passenger-side footwell.

Fig. 1, 50 Amp Fuse

Low Voltage Disconnect Module Removal and Installation

Removal

1. Park the vehicle and chock the tires.
2. Remove the dash lower console.
   2.1 Remove the nine mounting screws and pull the lower console away from the dash.
   2.2 Disconnect the connector from the passenger footwell light.
   2.3 Remove the lower console from the vehicle.
3. Remove the two battery cables. See **Fig. 1**.



1. Mounting Bolts
2. Battery Cables
3. Connector Plug

Fig. 1, Low Voltage Disconnect Installation

4. Remove the connector plug from the LVD.
5. Remove the four nuts that secure the LVD to the engine tunnel.
6. Remove the LVD.

Installation

1. Secure the new LVD to the engine tunnel plate with four nuts. Tighten the nuts securely.
2. Install the connector plug.
3. Connect the battery cables.
4. Verify the operation of the LVD.
5. Install the dash lower console.
   5.1 Position the lower console in the vehicle.
   5.2 Connect the connector to the passenger footwell light.
   5.3 Install the nine mounting screws and tighten the screws 24 to 30 lbf·in (270 to 340 N·cm).
6. Remove the chocks from the tires.

Low Voltage Disconnect Buzzer Diode Removal and Installation

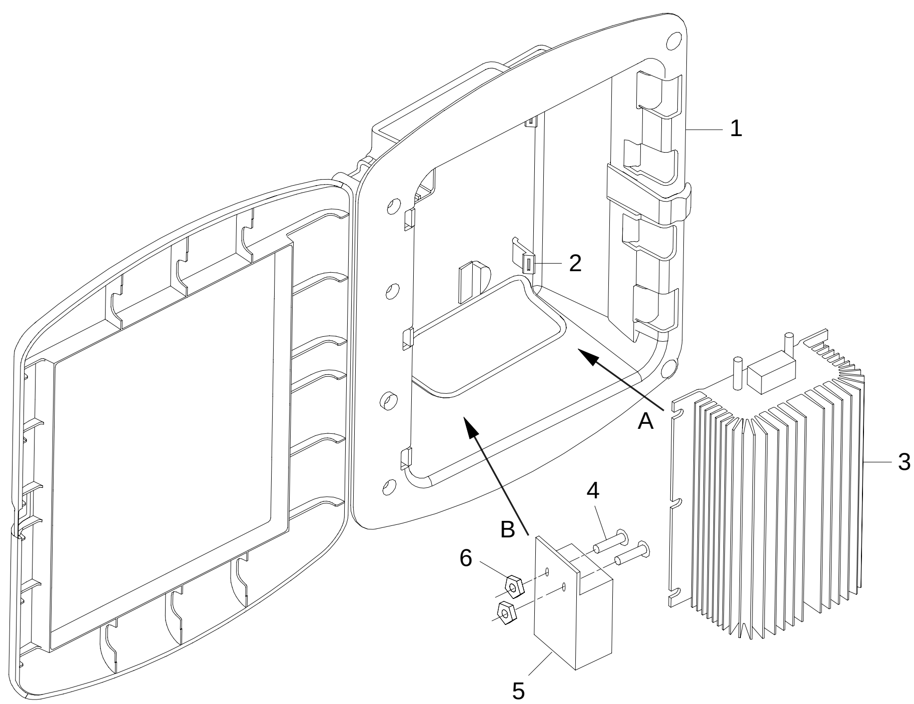
Removal

1. Apply the parking brakes and chock the tires. Disconnect the batteries.
2. Open the door on the plastic B-pillar box (standard installation) or the right-hand B-pillar door located behind the seat (alternate installation). See **Fig. 1** or **Fig. 2**. The configuration depends on other options that may be installed on the vehicle.
3. Remove the buzzer diode from the plastic B-pillar box or B-pillar door, as applicable.

    3.1 Disconnect the four-position connector on the LVD module harness from the buzzer diode.

    3.2 On standard installations, remove two 10–24 Torx®-head screws and hexnuts securing the diode to the left-hand side of the plastic box.

    On alternate installations, remove two 10–24 hexnuts from the mounting studs on the B-pillar access door.



A. The LVD module is mounted on the back of the mounting box.
B. The buzzer diode is mounted on the side of the mounting box.

1. Plastic Mounting Box
2. Mounting Clip
3. LVD Module
4. Torx-Head Screw, 10–24
5. Buzzer Diode
6. Hexnut, 10–24

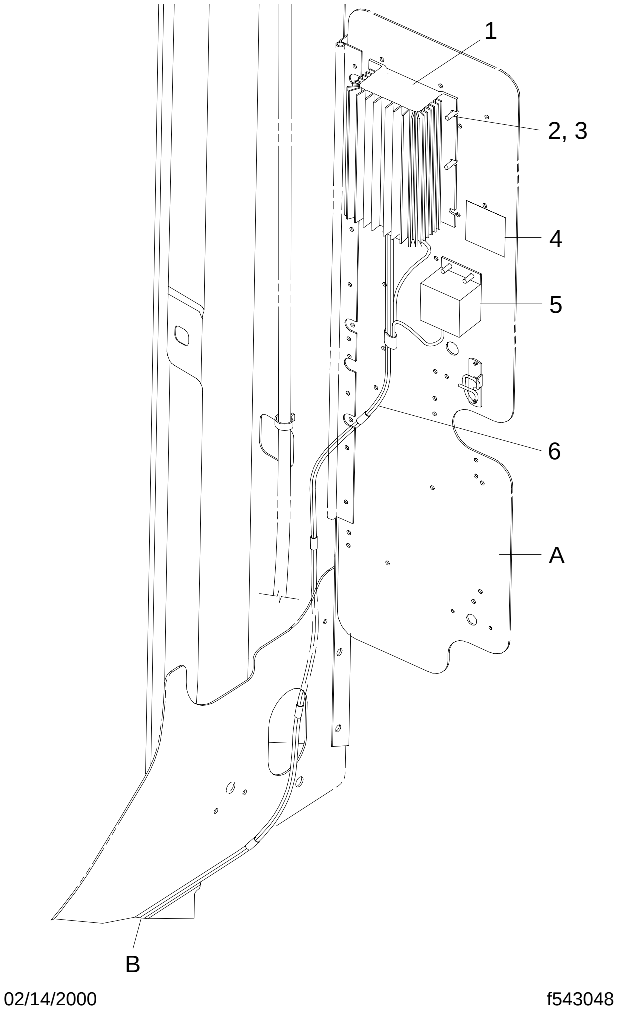
Fig. 1, Standard Buzzer Diode Installation

Installation

1. Install the buzzer diode.

    - Standard Installation—using two 10–24 Torx-head screws and hexnuts, install the buzzer diode on the left-hand side of the plastic B-pillar box. See **Fig. 1**. Tighten the hexnuts firmly.
    - Alternative Installation—place the diode on the two mounting studs attached to the

Low Voltage Disconnect Buzzer Diode Removal and Installation



A. Right-hand B-pillar door shown open.
B. To frontwall bulkhead.

1. Low Voltage Disconnect (LVD) Module
2. Mounting Stud (Torx-Head Screw, 10–24)
3. Locknut, 10–24
4. Battery Discharge Protection Label
5. Buzzer Diode
6. Harness, LVD Module

Fig. 2, Alternate Buzzer Diode Installation

B-pillar door. See **Fig. 2**. Install two 10–24 hexnuts on the studs and tighten them firmly.

2. Connect the LVD module harness to the buzzer diode.
3. Close the door on the plastic B-pillar box or electronics bay.
4. Connect the batteries and remove the chocks from the tires.

Functional Test

NOTE: If the LVD deactivates (removes power to the cab/sleeper loads), it needs to be reset prior to performing a functional test. If the batteries are discharged below 12.3 volts, charge the batteries before performing any troubleshooting procedures. The LVD can be reset by starting the engine. Once the LVD senses 13.1 volts or more, it resets automatically.

1. Shut down the engine.
2. Unplug the 10-position connector from the LVD.
3. Remove wire 447B from cavity E on the connector, and wrap a small piece of electrical tape around the exposed wire.
4. Insert the plug into the LVD with wire 447B still removed.

NOTE: The red LED indicator light on the LVD should turn ON when the connector is inserted.

5. Insert a metal conducting probe into cavity E of the connector, making sure contact is made between the metal probe and pin E on the LVD.
6. Connect a jumper wire between the terminal on wire 447B and the test probe inserted in cavity E.

NOTE: The electrical loads such as dome lights will remain OFF even though an electrical connection exists between circuit 447B and pin E. The LVD needs to be reset after removing the plug from the LVD.

7. Reset the LVD by starting the engine. The dome lights should come back ON, and the red LED indicator light on the LVD should turn OFF.
8. Shut down the engine.
9. Remove the metal test probe from cavity E.

NOTE: After removing the test probe, there will be a delay before the LVD disconnects the cab/sleeper loads. If equipped with the optional warning buzzer, it will sound for 60 seconds. After the time delay, the cab/sleeper loads (dome lights, for example) will shut OFF, and the optional warning buzzer will shut OFF.

10. Disconnect the jumper wire from 447B.
11. Remove the 10-position connector from the LVD.
12. Insert wire 447B into cavity E of the connector.
13. Insert the connector into the LVD.
14. Start the engine to reset the LVD.
15. If the LVD does not operate properly after performing the functional test, perform the troubleshooting procedures in this subject.

Troubleshooting Table

Low Voltage Disconnect System

Refer to **Table 1** to troubleshoot the low voltage disconnect system.

Refer to **Specifications, 400** for a wiring diagram of the LVD.

NOTE: The warning alarm is an option that is not present on all vehicles. Verify that the vehicle has the warning alarm option. Some LVD modules are designed to disconnect at 12.3 volts. Check the option code to find out which model is under test.

Low Voltage Disconnect System Malfunctions	
Possible Cause	**Remedy**
Voltage goes below 12.1 volts without the LVD disconnecting.	See **Table 2**.
The LVD system is always activated – no power on the ISO terminal of the Main PDM.	See **Table 3**.
No warning alarm operation when LVD activates.	See **Table 4**.
LVD system cuts power to accessories when the key is in the OFF position.	See **Table 5**.

Table 1, Low Voltage Disconnect System Malfunctions

Troubleshooting

Voltage Goes Below 12.1 Volts Without the LVD Disconnecting			
Step	**Test Procedure**	**Test Result**	**Action**
1	Test the voltage at the BATT terminal on the PDM. Is the voltage at or below 12.1 volts?	Yes	Go to step 2.
		No	Without starting the engine, turn the headlights on, and as many electrical loads as manageable, to draw the batteries down. As the voltage drops to/below 12.1 volts, go to step 2.
2	Is the LED on the LVD module illuminated steady or flashing?	Flashing	Monitor the voltage at the ISO terminal of the PDM for the next two minutes. If the LVD is also equipped with an audible alarm, it will begin to beep after the LED flashes for one minute. Go to step 3.
		Illuminated	When the light is on steady, the LVD has disconnected voltage. Measure the voltage at the ISO terminal of the PDM. If there is still battery voltage at the ISO terminal of the main PDM, replace the defective LVD module. If battery voltage is not present at the ISO terminal, the LVD has properly disconnected power. There is no problem per the reported symptom.
		Steady	The module is not recognizing a low voltage situation. If battery voltage goes below 12.0 volts with no activity from the LVD, replace the LVD.
3	The alarm beeps slowly for 30 seconds then rapidly for 30 seconds. After the LED flashes for two minutes and is at the end of the alarm cycle, the LVD disconnects the output to the ISO terminal of the PDM and the LED illuminates steadily. Measure the voltage on the ISO terminal of the PDM. Is battery voltage present?	Yes	If the LED continues to flash for more than two minutes or if it is on steady, the module is not disconnecting power. Replace the LVD.
		No	The LVD disconnects power. There is no problem per the reported symptom. Reset the system by starting the engine. When system voltage is greater than 12.8 volts, the LVD will reconnect power to the ISO circuit.

Table 2, Voltage Goes Below 12.1 Volts Without the LVD Disconnecting

LVD System Always Activated			
Step	**Test Procedure**	**Test Result**	**Action**
1	Measure the voltage at the BAT terminal on the PDM. Is the voltage at or close to 0 volts?	Yes	Go to step 3.
		No	Measure the voltage on the ISO terminal of the PDM. If the voltage is at or close to 0 volts, go to step 2. Otherwise, go to step 3.

LVD System Always Activated			
Step	Test Procedure	Test Result	Action
2	Start the engine and measure the voltage on the BAT terminal of the PDM. When the voltage is above 12.8 volts, the LVD should reconnect power to the ISO terminal. If the voltage on the BAT terminal does not go above 12.8 volts, go to step 3. Otherwise, when it does, measure the voltage on the ISO terminal. Is battery voltage present?	Yes	The LVD is reconnecting power correctly. No further action is necessary.
		No	Check the 50-amp in-line fuse located in the passenger side footwell. If the fuse is open, determine the cause of the short; it could be the LVD module, or the wiring before or after it and through the PDM. Also, check the 5-amp fuse in the PNDB that sources the sense signal to the LVD. If the fuse is open, determine the cause of the short, which may be the LVD module or circuit 447B.
3	Measure the voltage at the batteries. Is battery voltage close to 12 volts?	Yes	Locate and repair an open circuit feeding the main PDM. Check the pass-through stud on the frontwall directly below the PDM and the 175-amp fuse, F3 in the PNDB.
		No	Recharge the vehicle batteries then repeat this testing.

Table 3, LVD System Always Activated

No Warning Alarm Operation When LVD Activates			
Step	Test Procedure	Test Result	Action
1	Measure the voltage at the BAT terminal on the PDM. Is the voltage at or above 12.4 volts?	Yes	Without starting the engine, turn the headlights and as many electrical loads as manageable on to draw the batteries down. As the voltage drops to/below 12.1 volts, go to step 2.
		No	Reset the LVD by starting the engine to bring system voltage above the disconnect threshold. When power is reconnected, repeat this test.
2	When the system voltage drops to the cut off threshold, the LED on the LVD module will begin to flash. After one minute of flashing, the alarm will begin to beep slowly if the LVD is equipped with alarm option. Does the alarm beep?	Yes	The system is working normally.
		No	The alarm is internal to the LVD and is not serviceable separately. Replace the LVD module.

Table 4, No Warning Alarm Operation When LVD Activates

LVD System Cuts Power to Accessories when the Key is in the OFF Position			
Step	Test Procedure	Test Result	Action
1	Measure the voltage at the batteries. Is the voltage above 12.4 volts?	Yes	Check the wiring at the LVD. Make sure circuit 14D is connected to the LVD V_In terminal, and that circuit 14BS is connected to the V_Out terminal. If not, switch the circuits.
		No	The LVD is working properly.

Table 5, LVD System Cuts Power to Accessories when the Key is in the OFF Position

Specifications

For a wiring diagram of the low voltage disconnect system, see **Fig. 1**.

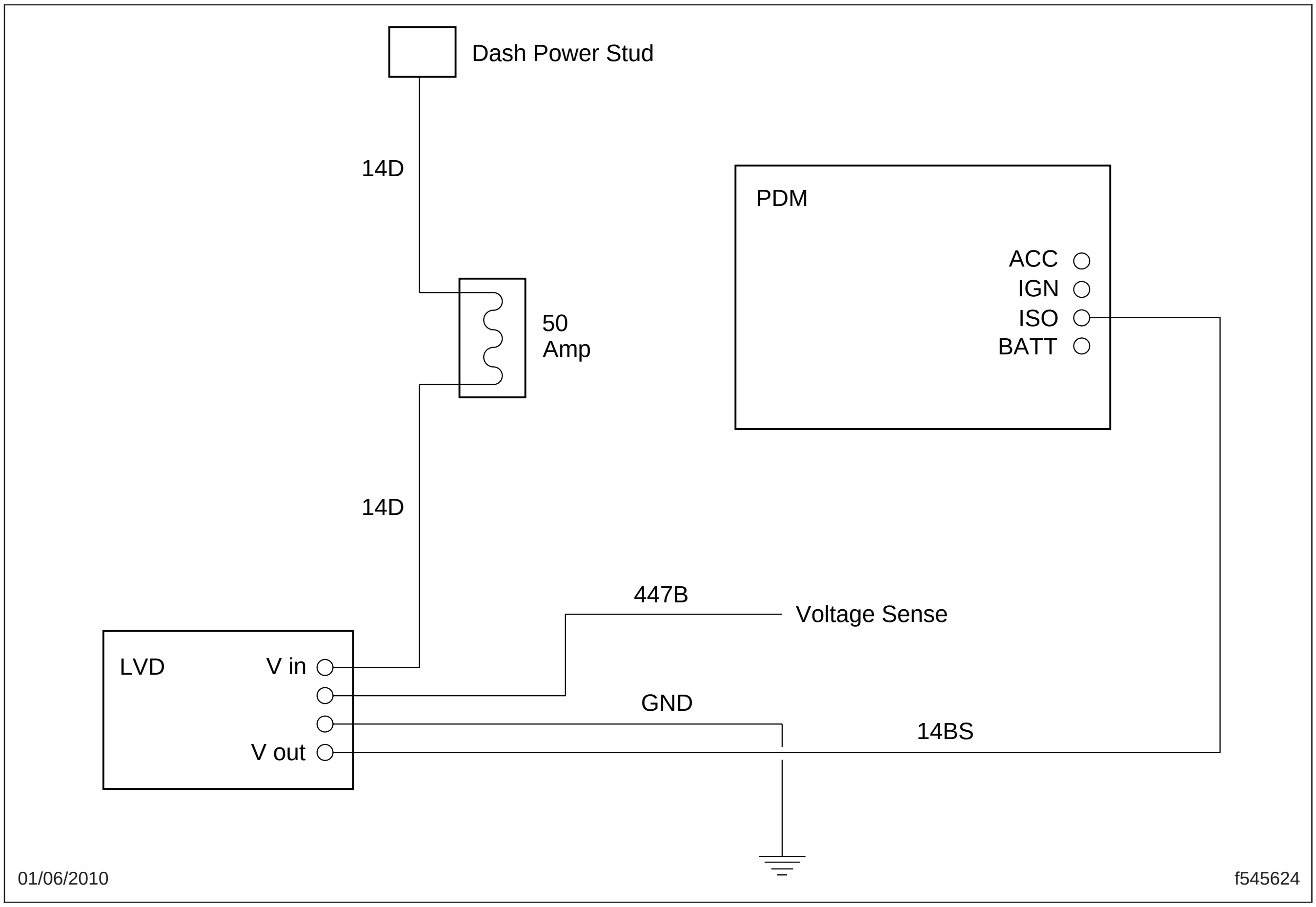


Fig. 1, Wiring Diagram, Low Voltage Disconnect System

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

General Description

This section covers the instrumentation control unit, level I (level I ICU). It is the standard ICU on the Columbia.

NOTE: For information about the level II ICU, see **Section 54.07**.

LEVEL I ICU (ICU3)

The level I ICU (ICU3) is a basic electronic dashboard that accepts input from the fuel level sensor, the transmission temperature sensor (if installed), and the J1587 datalink. The information is processed by a micro-computer and displayed on electronic gauges driven by stepper motors. Only air gauges operate mechanically.

The following gauges are standard:

- Speedometer
- Tachometer
- Engine Oil Pressure Gauge
- Coolant Temperature Gauge
- Fuel Level Gauge
- Primary Air System Pressure Gauge
- Secondary Air System Pressure Gauge

The transmission fluid temperature gauge is optional, but it is required on vehicles with automatic transmissions.

The speedometer and tachometer are large-faced electronic gauges located below the driver information center. See **Fig. 1**.

The other gauges are small-faced gauges on the driver's instrument panel, to either side of the speedometer and tachometer. The engine oil pressure, coolant temperature, transmission fluid temperature, and fuel level gauges are electronic; the two system air gauges, primary and secondary, are mechanical.

Only the air pressure gauges are replaceable in the field. The level I ICU can not drive gauges located on the auxiliary instrument panel.

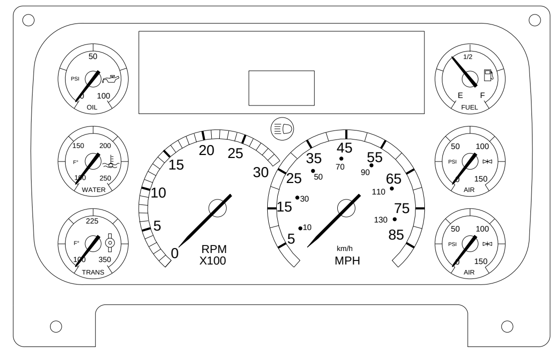


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Fig. 1, Level I ICU (ICU3)

DASH MESSAGE CENTER

The heart of the level I ICU is the dash message center. It has two parts: a set of 26 warning and indicator lights similar to those found on a conventional lightbar, and a dash driver display screen. The dash driver display screen is a 1-line by 7-character liquid crystal display (LCD) that is normally used to display the odometer reading. In addition, there is a separate voltmeter display underneath the odometer display.

The information that can be provided by the message center includes:

- odometer reading
- voltmeter reading
- trip miles
- trip hours
- mile/km screens
- alert messages
- diagnostic messages
- a listing of active faults

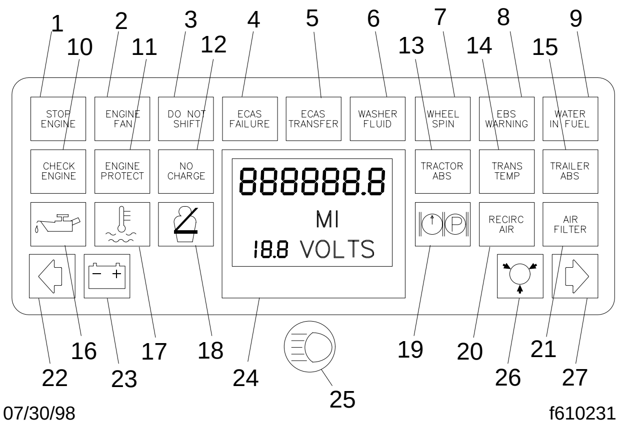
Some messages require the optional reset/mode switch.

WARNING AND INDICATOR LIGHTS

There are spaces on the level I ICU for 26 warning and indicator lights. See **Fig. 2** for a typical installation.

There are four rows of lights. The lights in the top row are all optional and may be installed in any or-

General Information



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Typical installation shown. Location of legends installed in the top row may vary, and other legends may be specified.

1. Stop Engine Warning (Cummins engine only)
2. Engine Fan On Indicator (optional)
3. Do Not Shift Indicator (optional)
4. ECAS Failure Warning (optional)
5. ECAS Transfer Indicator (optional)
6. Low Washer Fluid Indicator (optional)
7. Wheel Spin Indicator (optional)
8. EBS Warning (optional)
9. Water In Fuel Indicator (optional)
10. Check Engine Indicator
11. Engine Protection Warning (optional)
12. Alternator No Charge Indicator (optional)
13. Tractor ABS Warning
14. Transmission Temperature Warning (optional)
15. Trailer ABS Warning (optional)
16. Low Engine Oil Pressure Warning
17. High Coolant Temperature Warning
18. Fasten Seat Belt Warning
19. Parking Brake On Warning
20. Recirculated Air Indicator
21. Air Restriction Indicator
22. Left Turn Signal
23. Low Battery Voltage Warning
24. Dash Driver Display Screen
25. High Beams On Indicator
26. Low Air Pressure Warning
27. Right Turn Signal

Fig. 2, Dash Message Center, Level I ICU (ICU3)

der, except for two lights which are typically installed at a fixed position.

- Position 1: Stop Engine Warning (Red)—installed on vehicles with Cummins engines only
- Position 7: Wheel Spin Indicator (Amber)

NOTE: Positions 1 through 8 are ground-activated circuits; position 9 is power-activated.

On the other three rows, the lights are installed at fixed positions that do not vary. Some lights are optional; if an optional light is not requested, the position is blank (does not light up).

The following fixed-position lights are standard:

- Check Engine Indicator (Amber)
- Low Engine Oil Pressure Warning (Red)
- High Coolant Temperature Warning (Red)
- Fasten Seat Belt Warning (Red)
- Left Turn Signal (Green)
- Low Battery Voltage Indicator (Amber)
- Tractor ABS Indicator (Amber)
- Parking Brake On Warning (Red)
- Recirculated Air Indicator (Amber)
- Low Air Pressure Warning (Red)
- Right Turn Signal (Green)
- High Beams On Indicator (Blue)

The following fixed-position lights are optional:

- Engine Protection Warning (Red)
- Alternator No Charge Indicator (Amber)
- High Transmission Temperature Warning (Red)—installed on vehicles with automatic transmissions
- Trailer ABS Indicator (Amber)—installed on vehicles designed to be used with a trailer
- Air Restriction Indicator (Amber)

The following is a partial list of optional lights that are available for installation in the top row:

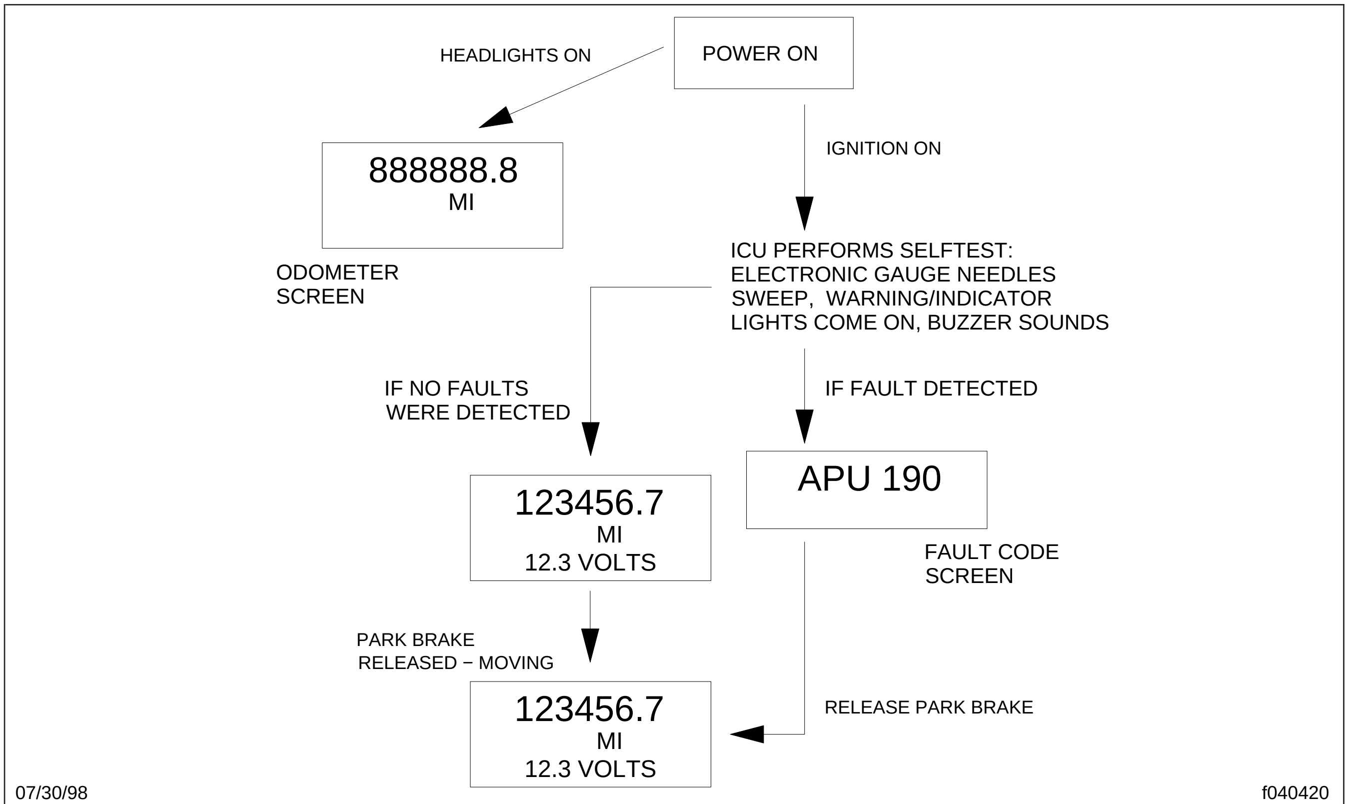
- Engine Fan On Indicator (Amber)
- Do Not Shift Indicator (Amber)
- ECAS Failure Warning (Red)
- ECAS Transfer Indicator (Amber)
- Low Washer Fluid Indicator (Amber)
- EBS (Electronic Braking System) Warning (Red)
- Water In Fuel Indicator (Amber)

All light bulbs are replaceable in the field, including gauge light bulbs and warning/indicator light bulbs.

Principles of Operation

IGNITION SEQUENCE

When the ignition switch is turned on, the level I ICU (ICU3) runs through the ignition sequence. See **Fig. 3**. If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.



During the first half of the self-test, all segments of the display illuminate. During the second half of the self-test, the software revision level is displayed.

NOTE: The parking brake must be on for faults to be displayed.

NOTE: If there is more than one fault, the level II ICU displays them, one after another, changing every 3 seconds, until the parking brake is released.

Fig. 3, Level I ICU Ignition Sequence

IMPORTANT: When the ignition switch is first turned on, all the electronic gauges complete a full sweep of their dials, the warning and indicator lights light up, and the buzzer sounds for 3 seconds.

The parking brake must be on for the faults to be displayed.

The following warning and indicator lights go on during the ignition sequence:

- Low Engine Oil Pressure Warning
- High Coolant Temperature Warning
- Low Air Pressure Warning
- Parking Brake On Warning
- Low Battery Voltage Indicator

General Information

- Fasten Seat Belt Warning
- All engine warning lights, including Engine Protection, Check Engine, and Stop Engine (on Cummins only)
- All ABS warning lights, including Wheel Spin, Tractor ABS, and Trailer ABS (if installed)

NOTE: While the engine and ABS warning lights go on during the ignition sequence, they are not controlled by the level I ICU, but by their own system ECU (electronic control unit).

Once the ignition switch has been turned on, the ICU performs a self-test, looking for active faults. During the first half of the self-test, all segments of the display illuminate as follows: "888888.8." During the second half of the self-test, the software revision level is displayed.

If there are no active faults, the screen displays the odometer.

If, however, the level I ICU has received active fault codes from other devices, it displays them, one after the other, until the parking brake is released or the ignition switch is turned off.

The screen displays a code, called the message identifier (MID), indicating the ECU or system that is not functioning properly.

Example: If the air conditioning system or air conditioning protection unit is not functioning properly, the screen displays "APU 190." For a complete list of possible screen displays, see **Specifications, 400**.

NOTE: If the level I ICU receives a message from an ECU that has not been pre-programmed into the ICU’s memory, it displays "SYS MID" instead.

Once the parking brake is released, the level I ICU displays the odometer again.

ODOMETER

The odometer is set to display in either miles or kilometers, depending on the primary scale of the speedometer. The legend, either "MI" or "KM," illuminates between the odometer and the volts display when the engine is running or the headlights are turned on.

The odometer is a seven-digit display with a decimal point, until the vehicle has traveled 999,999.9 miles or kilometers (km). At one million miles (km), the odometer resets itself to "1000000," without the decimal point, and can continue up to 9,999,999. The odometer only displays significant figures (no leading zeros).

IMPORTANT: Although the odometer uses data supplied by the engine ECM to update its count, it keeps its own mileage starting from the zero point, which marks where it was first installed.

BUZZER

The buzzer sounds during the ignition sequence and whenever one of the following conditions exists:

- The engine oil pressure falls below the preset level, which is 5 to 9 psi (35 to 60 kPa) on most engines.
- The coolant temperature rises above the preset level, which is 215°F (101°C) on Caterpillar and Detroit Diesel engines; 220°F (104°C) on Cummins engines.
- The air pressure falls below the preset level, which is 44 psi (6400 kPa).
- The parking brake is set with the vehicle moving at two or more miles per hour.

An optional ground-activated buzzer can be controlled by another ECU on the vehicle.

Level I Instrumentation Control Unit Replacement

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

Replacement

The instrumentation control unit, level I (level I ICU) is a self-contained one-piece unit, including housing, gauges, and the dash message center. For installation on the Columbia, it is attached to extender panels that are fastened to the dash. See **Fig. 1**.

2. Remove the four fasteners from the corners of the level I ICU bezel. See **Fig. 2**. Fasteners used on the level I ICU are T25 Torx®-head dog-point screws. See **Fig. 3**.

CAUTION

Do not forcibly pull the driver's panel from the dash. This may dislodge wires from the harness electrical connectors on the back of the ICU housing and damage the wires, the ICU, or the dash.

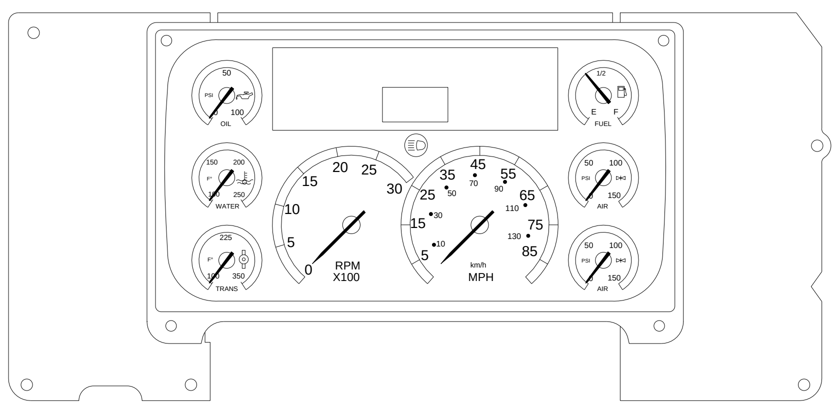


Fig. 1, Level I ICU With Extenders

Air pressure gauges and light bulbs are the only components that are replaceable in the field. For air pressure gauge replacement, see **Subject 110**. For light bulb replacement, see **Subject 120**.

IMPORTANT: Before draining the air, move the adjustable steering column to the lowest possible position.

1. Drain both primary and secondary air systems.

CAUTION

Electronic components of the ICU3 are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU3 circuitry.

3. Pull the old ICU away from the dash. When removing the old ICU, carefully work the ICU housing free of the extender panels. Pull the top of the unit towards you until the back of the housing is free, then pull up to remove the rest of the unit.

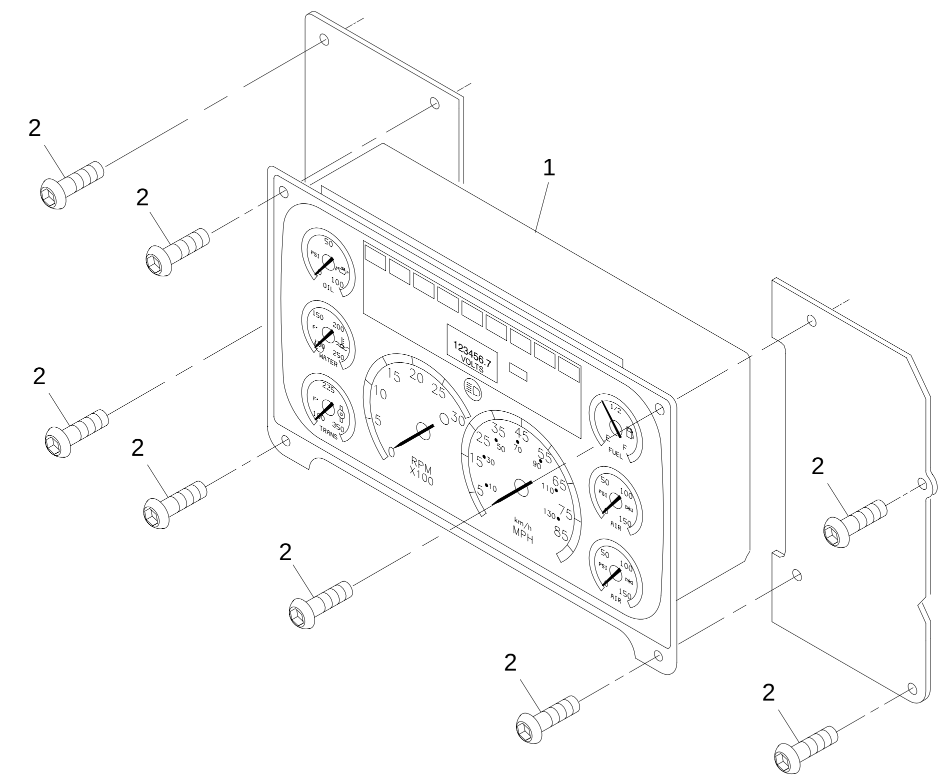
4. Remove the connectors from the back of the housing.

   4.1 From behind the ICU housing, disconnect the two electrical connectors in the center of the housing.

WARNING

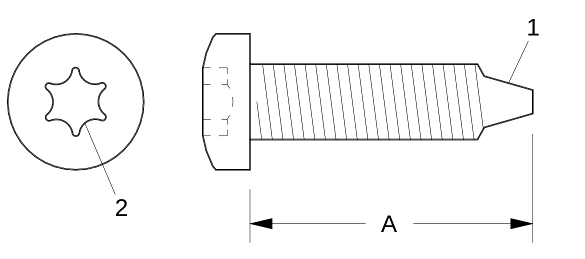
Drain all air from the compressed air tanks before trying to remove the air hoses. Failure to do so can cause the hoses to move uncontrollably

Level I Instrumentation Control Unit Replacement



1. ICU Housing
2. T25 Dog-Point Screw

Fig. 2, Level I ICU Installation



A. 3/4 Inch (19 mm)
1. Dog Point
2. Torx Head

Fig. 3, Dog-Point Screw

when disconnected, possibly causing personal injury or equipment damage.

4.2 Disconnect all air hoses. Using a paint pen, put identification marks on the hoses for ease of installation.

5. Remove the old ICU from the vehicle. See **Fig. 2**.
6. Install the level I ICU on the dash. See **Fig. 2**.

   6.1 Connect the air hoses to the air gauges as marked on removal.

   6.2 Connect the two electrical connectors, as removed.

   6.3 Place the new level I ICU in the dash and install the fasteners.

7. Turn on the ignition and test the operation of the new level I ICU. All the electronic gauges should make one complete sweep and return to their normal indicating positions. The warning and indicator lights should turn on, then off.

   If any electronic gauges are not working properly, the level I ICU will need to be serviced or replaced.

Level I Instrumentation Control Unit Replacement

NOTE: Mechanical (air) gauges do not make a sweep.

Air Pressure Gauge Replacement

Replacement

IMPORTANT: Before draining the air, move the adjustable steering column to the lowest possible position. This makes it easier to remove the ICU.

WARNING

Drain all air from the compressed air tanks before trying to remove the air hoses. Failure to do so can cause the hoses to move uncontrollably when disconnected, possibly causing personal injury or equipment damage.

1. Drain both primary and secondary air systems.

CAUTION

To avoid damaging the ICU, please read and follow the cautions in Subject 100 regarding grounding the ICU and forcibly pulling it from the dash.

2. Remove the level I ICU. See Fig. 1. For detailed instructions, see Subject 100.

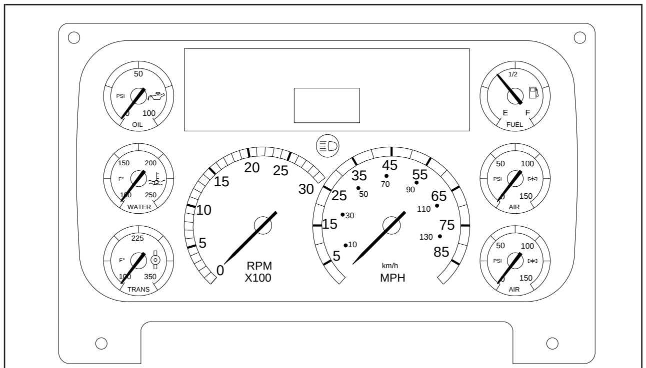


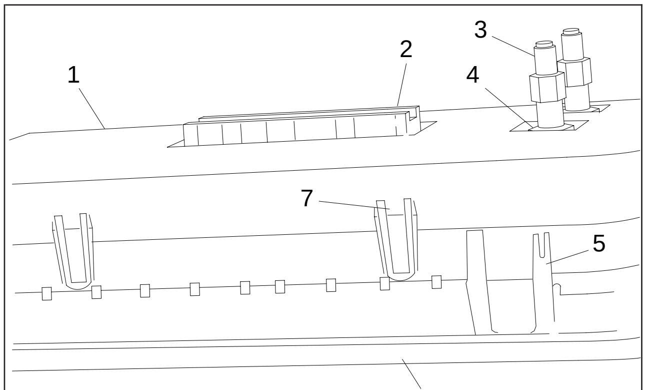
Fig. 1, Level I ICU

3. Remove the reset button, if present.

CAUTION

Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

4. Using a thin-bladed screwdriver, very carefully pry off the nine large white clips from the sides of the ICU housing. Remove the bezel from the ICU housing. See Fig. 2.



1. ICU Housing
2. Electrical Connector
3. Ferrule
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 2, Air Pressure Gauge Installation

4.1 From the back of the ICU housing, remove the ferrule from the threaded tube coming out the back of the air gauge.

4.2 Remove the nut from the threaded air tube.

5. Remove the old air gauge from the ICU.
6. Install the new air gauge.

6.1 Insert the new gauge into the hole in the ICU housing.

6.2 Tighten the nut on the threaded tube.

6.3 Wrap Teflon® tape on the ferrule threads, then install the ferrule in the threaded tube on the back of the air gauge.

7. Position the bezel on the ICU housing. Fasten the nine white clips to the sides of the ICU housing.
8. Install the reset button on the ICU, if one was removed.
9. Install the level I ICU. For detailed instructions, see Subject 100.
10. Start the engine and wait for the air pressure to build up. Test the operation of the new gauge.

Replacement

IMPORTANT: Before draining the air, move the adjustable steering column to the lowest possible position. This makes it easier to remove the ICU.

WARNING

Drain all air from the compressed air tanks before trying to remove the air hoses. Failure to do so can cause the hoses to move uncontrollably when disconnected, possibly causing personal injury or equipment damage.

1. Drain both primary and secondary air systems.

CAUTION

To avoid damaging the ICU, please read and follow the cautions in Subject 100 regarding grounding the ICU and forcibly pulling it from the dash.

2. Remove the level I ICU. See Fig. 1. For detailed instructions, see Subject 100.

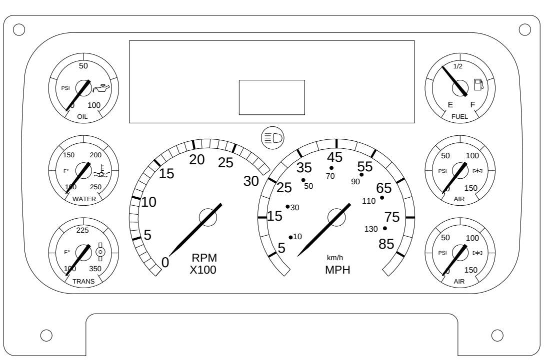


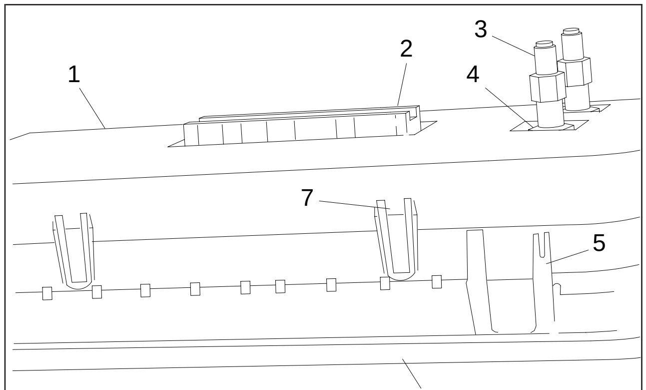
Fig. 1, Level I ICU

3. Remove two capscrews from the back cover.

CAUTION

Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

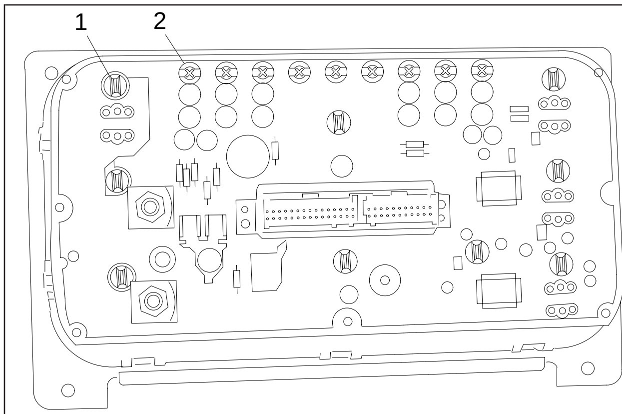
4. Pry off the five small black clips from the sides of the ICU housing. Remove the back cover from the ICU housing. See Fig. 2.



1. ICU Housing
2. Electrical Connector
3. Ferrule
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 2, Back Cover Installation

5. Remove the burned-out light bulb(s). See Fig. 3.



1. Gauge Light Bulb Holder
2. Warning and Indicator Light Bulb Base

Fig. 3, Light Bulb Installation

5.1 To remove gauge light bulbs, twist the bulb holder behind the affected gauge until the bulb comes out.

5.2 To remove warning/indicator light bulbs, use a small screwdriver to twist out the bulb base behind the affected light.

Light Bulb Replacement

6. Install the new light bulb(s).
   6.1 To install gauge light bulbs, twist the bulb holder into the slot from which the old one was removed.
   6.2 To install warning/indicator light bulbs, insert the new bulb base into the proper slot and use a small screwdriver to tighten it.
7. Position the back cover on the ICU housing. Fasten the five black clips to the sides of the ICU housing.
8. Install two capscrews on the back cover.
9. Install the level I ICU. For detailed instructions, see **Subject 100**.
10. Turn on the ignition switch. Check all bulbs for correct operation.

Fuel Level Gauge Diagnosis

The fuel level gauge is controlled by the ICU using a variable resistance input from the fuel level sending unit that is located in the fuel tank. The fuel level sending unit resistance varies linearly from 31±2Ω with a full tank to 247±3Ω when empty.

If the ICU3 is measuring a resistance greater than 284Ω between circuit 47 and ground, a fault will be set for fuel level circuit open. If the ICU3 is measuring less than 23.5Ω between circuit 47 and ground, a fault will be set for fuel level circuit shorted low. ServiceLink may be used to monitor for these faults. The gauge will read empty until the measurement from the sensor is between 284Ω and 23.5Ω. Refer to **Table 1** for the fuel level diagnostic procedure.

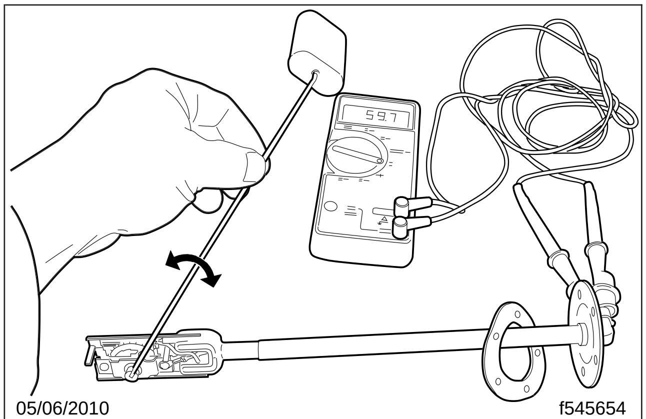
NOTE: If the fuel level sensor is below the minimum resistance (short to ground) or above the maximum (open), the fuel gauge will read empty. Shorting the fuel sensor wires will not drive the gauge to full scale.

Fuel Level Gauge Diagnosis			
Step	**Test Procedure**	**Test Result**	**Action**
1	If a 100 ohm resistor is available, disconnect the fuel level sender connector and place the resistor across circuit 47 and ground in the wiring harness connector to simulate the fuel level sending unit. Turn the ignition to the ON position and observe the fuel gauge. If, after gauge initialization, the gauge points closely to the half tank mark, then the wiring and ICU are all operating correctly. Jump to Step 4 if there is no problem with the wiring and ICU. Does the fuel level gauge stay at empty even though there is fuel in the tank or is the complaint an inaccurate and intermittent reading? Note - turn the ignition to OFF and disconnect the batteries before continuing.	Stays at Empty	Go to Step 2.
		Inaccurate or Intermittent	Go to Step 4.
2	Disconnect the connector at the fuel level sender and measure the resistance of the sender. What is the resistance of the sender?	Greater than 284Ω or Less than 23.5Ω	Go to Step 4.
		Between 284Ω and 23.5Ω	Go to Step 3.
3	Connect the fuel level sender and disconnect the connectors on the back of the ICU. Measure the resistance in the vehicle wiring between circuit 47 in connector pin D1 and the ground circuit in connector pin D2. What is the resistance of the circuit?	Greater than 284Ω	Troubleshoot and repair an open circuit on either circuit 47 or the ground between the ICU connector and the fuel level sender.
		Between 284Ω and 23.5Ω	This is the valid resistance range. If the fuel tank is full and the resistance is close to 31Ω, replace the ICU. Otherwise no problem is indicated.
		Less than 23.5Ω	Troubleshoot and repair a short to ground on circuit 47 between the ICU connector and the fuel level sender.

Troubleshooting

Fuel Level Gauge Diagnosis			
Step	**Test Procedure**	**Test Result**	**Action**
4	Remove the fuel sending unit from the fuel tank. Connect an ohm meter to the pins at the fuel level sender connector. Slowly move the level of the float arm from full to empty. See **Fig. 1**. Does the resistance vary linearly from 31±2Ω to 247±3Ω?	Yes	Troubleshoot and repair for corrosion or an intermittent connection in the circuitry between the ICU and the fuel level sender.
		No	Replace the fuel level sending unit.

Table 1, Fuel Level Gauge Diagnosis



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Slowly move the float arm from full to empty.

Fig. 1, Testing the Fuel Level Sending Unit

Specifications

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

The two connectors are pink and plug into pins located in the center of the unit, on the back. Connector #1 has 24 cavities, numbered A1 through A12, and B1 through B12. Connector #2 has 32 cavities, numbered C1 through C16, and D1 through D16.

See **Fig. 1** for a schematic of the wiring and pinout connections for the level I ICU (ICU3).

Level I ICU Connector #1 Pin Assignments, Pins A1 Through B12		
Number	**Description**	**Wire**
A1	Panel Lamp Power (+)	29A
A2	Reserved	— *
A3	Low Air Pressure	18
A4	Transmission Temperature (optional; automatic transmission)	30G
A5	Air Restriction	183A
A6	Optional Indicator 2	GND
A7	Optional Indicator 3	GND
A8	Optional Indicator 4	GND
A9	No Charge (optional)	137
A10	Reserved	— *
A11	Reserved	— *
A12	High Beam Indicator Lamp	20H
B1	Optional Indicator 5	GND
B2	Reserved	— *
B3	J1587 Datalink (–)	1587–C
B4	Reserved	— *
B5	Reserved	— *
B6	Reserved	— *
B7	Reserved	— *
B8	Optional Indicator 6	GND
B9	Reserved	— *
B10	J1587 Datalink (+)	1587+C
B11	Tractor ABS Indicator Lamp	376L
B12	Ground-Activated Buzzer (optional)	437Z

* Do not use reserved pins for testing or programming.

Table 1, Level I ICU Connector #1 Pin Assignments, Pins A1 through B12

Level I ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
C1	Optional Indicator 8	GND
C2	Reserved	— *

Specifications

Level I ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	Pin Assignment	Wire
C3	Reserved	— *
C4	Reserved	— *
C5	Parking Brake Indicator Lamp	125
C6	Reserved	— *
C7	Reserved	— *
C8	Left Turn Indicator Lamp	38L
C9	Reserved	— *
C10	Recirculated Air Indicator Lamp	98K
C11	Wheel Spin (optional indicator 7)	376S
C12	Transmission Fluid Temperature Gauge (–)	30G
C13	Transmission Fluid Temperature Gauge (+)	30
C14	Stop Engine—CUM only (optional indicator 1)	N16
C15	Check Engine Indicator Lamp	C799
		D419
		N25
C16	Engine Protection (optional; shutdown warning)	C659
		D509
		N01
D1	Fuel Level (+)	47
D2	Fuel Level (–)	47G
D3	Panel Light Ground	GND1
D4	Optional Indicator 9	286
D5	J1939 Datalink (+)	1939+C
D6	Reserved	— *
D7	Reserved	— *
D8	Right Turn Indicator Lamp	38R
D9	J1939 Datalink (–)	1939–C
D10	EMI Ground	GNDC
D11	J1939 (shield)	1939
D12	Trailer ABS (optional; trailer only)	376F
D13	PC Board Ground	GND1
D14	Battery Power	437
D15	Ignition Power	437A
D16	Headlight Power (odometer illumination)	359

* Do not use reserved pins for testing or programming.

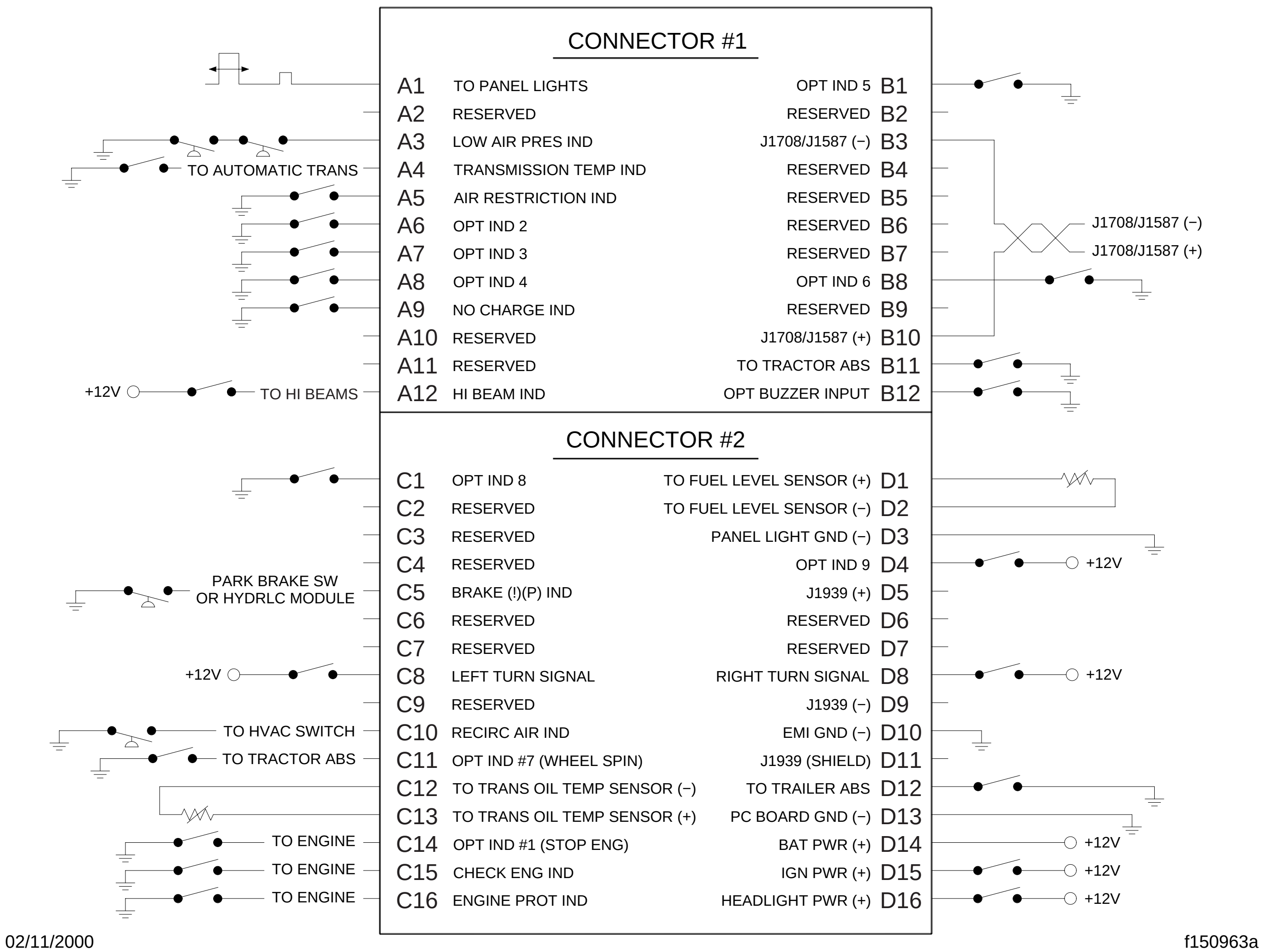
Table 2, Level I ICU Connector #2 Pin Assignments, Pins C1 through D16

Specifications

Message Identifiers (MIDs)		
MID	Description	Text Message
128	Engine Control Unit	ECU 128
130	Transmission Control Unit	tCU 130
136	Anti-Lock Brakes (ABS)	AbS 136
140	Instrumentation Control Unit	ICU 140
164	B-Panel Unit	bPU 164
181	Communications Unit—Satellite	SAT 181
190	Air Conditioning Protection Unit	APU 190
219	Collision Detection Radar	CdU 219
223	Transmission Shift Unit	tSU 223
231	Communications Unit—Cellular	CEL 231
232	SPACE (Seat Belt Unit)	SbU 232
236	Step Deployment Unit #1	SdU 236
237	Step Deployment Unit #2	SdU 237
###	Generic MID (not listed)	SYS ###

Table 3, Message Identifiers (MIDs)

Specifications



IMPORTANT: Do not use reserved pins for testing or programming.

NOTE: See **Subject 050** for warning and indicator light positions.

Fig. 1, Level I ICU Pinouts (ICU3)

Mode/Reset Switch Functions

Use the following flow charts to cycle through the Mode/Reset switch functions and screens.

See **Fig. 1**, for Mode/Reset Switch Start Sequence.

See **Fig. 2**, for Mode/Reset Switch Trip Screens.

See **Fig. 3**, for Mode/Reset Switch Engine Miles and Service Screens.

See **Fig. 4**, for Mode/Reset Switch Fault Screens.

See **Fig. 5**, for Mode/Reset Switch Service Screens.

See **Fig. 6**, for Mode/Reset Switch Oil Level Screens.

See **Fig. 7**, for Mode/Reset Switch Reset and Toggle Screens.

Service Interval Tables

For service interval miles look-up values, see **Table 1**.

For service interval hours look-up values, see **Table 2**.

Service Interval Distance Settings		
Number	**Miles**	**Kilometers**
1	1000	1610
2	1500	2415
3	2000	3220
4	2500	4025
5	3000	4830
6	3500	5635
7	4000	6440
8	4500	7245
9	5000	8050
10	5500	8855
11	6000	9660
12	6500	10465
13	7000	11270
14	7500	12075
15	8000	12880
16	8500	13685
17	9000	14490
18	9500	15295
19	10000	16100
20	11000	17710
21	12000	19320
22	13000	20930
23	14000	22540
24	15000	24150
25	16000	25760
26	17000	27370
27	18000	28980
28	19000	30590
29	20000	32200
30	21000	33810
31	22000	35420
32	23000	37030
33	24000	38640
34	25000	40250

Table 1, Service Interval Distance Settings

Mode/Reset Switch Functions

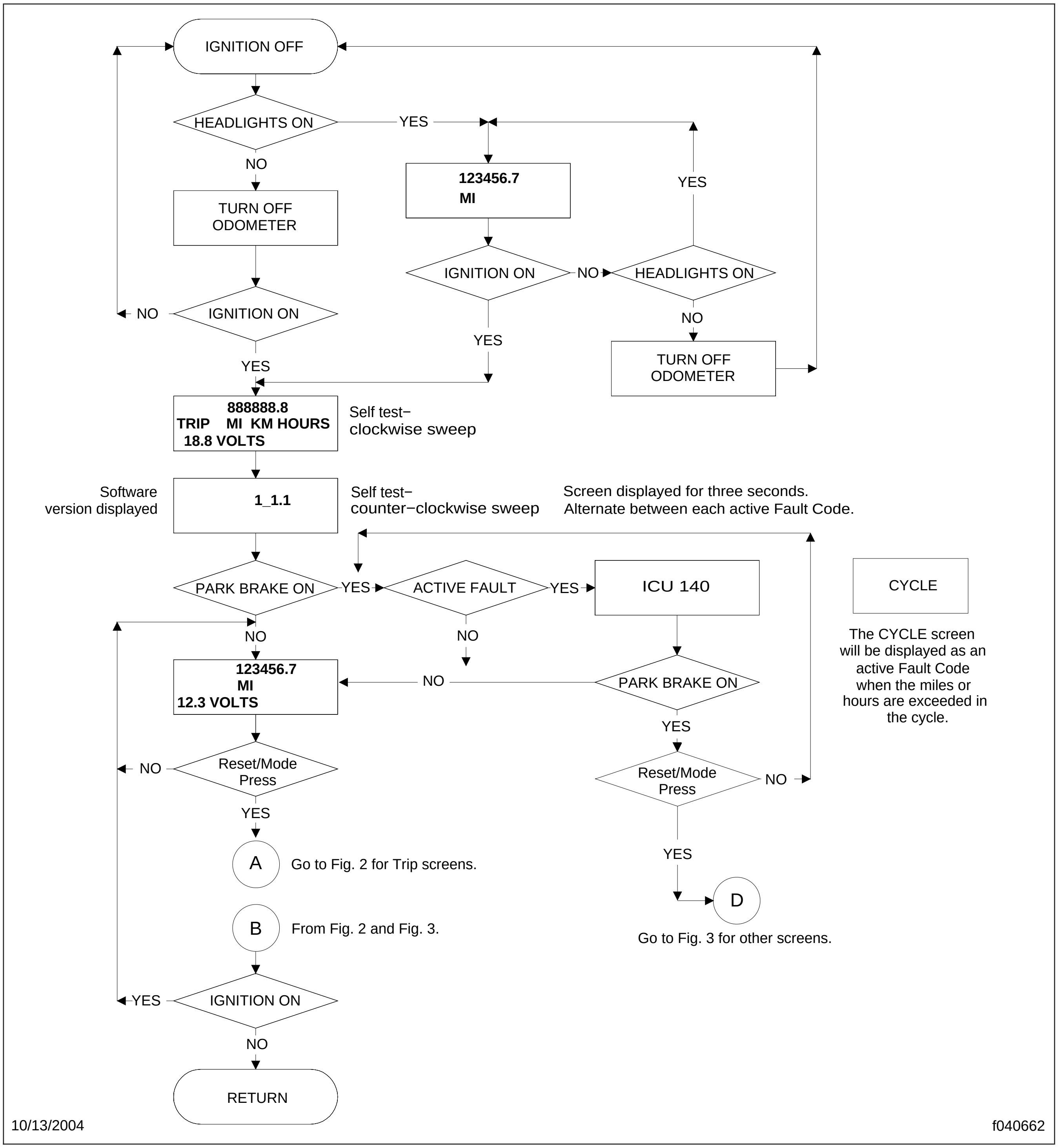


Fig. 1, Mode/Reset Switch Start Sequence

Mode/Reset Switch Functions

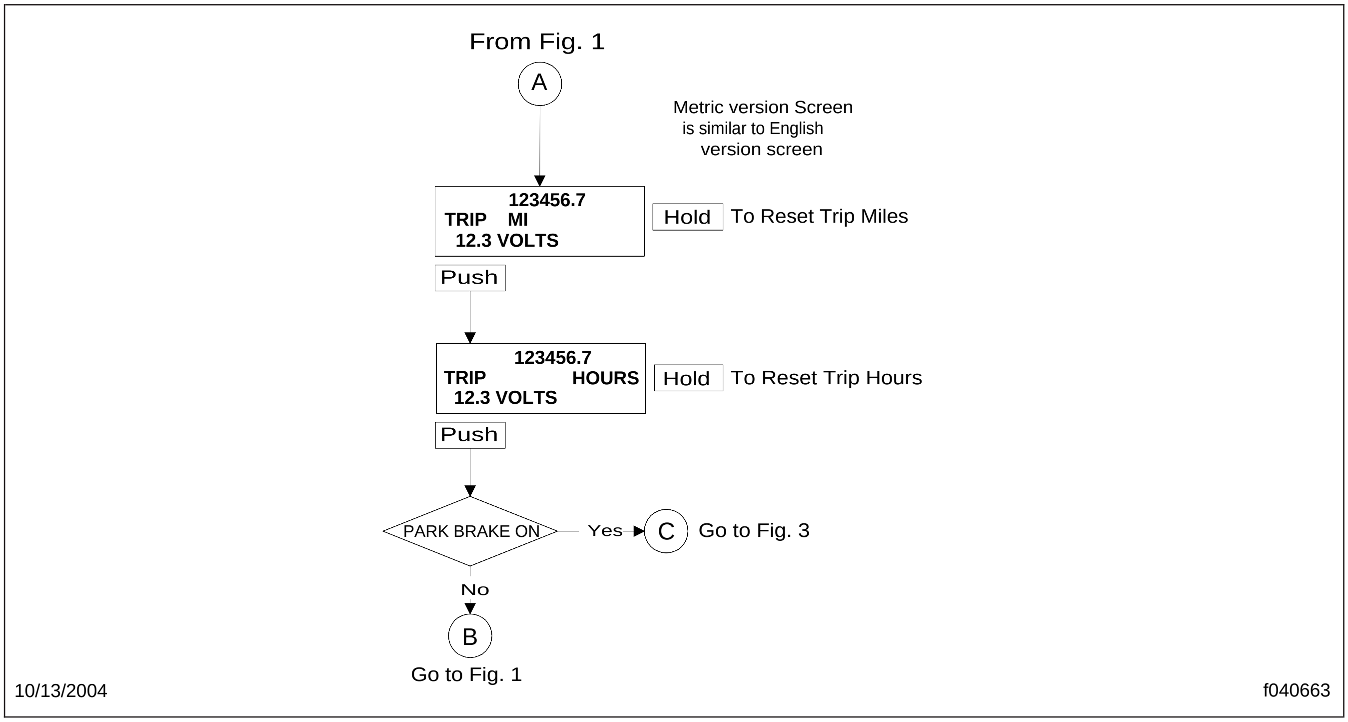


Fig. 2, Mode/Reset Switch Trip Screens

Mode/Reset Switch Functions

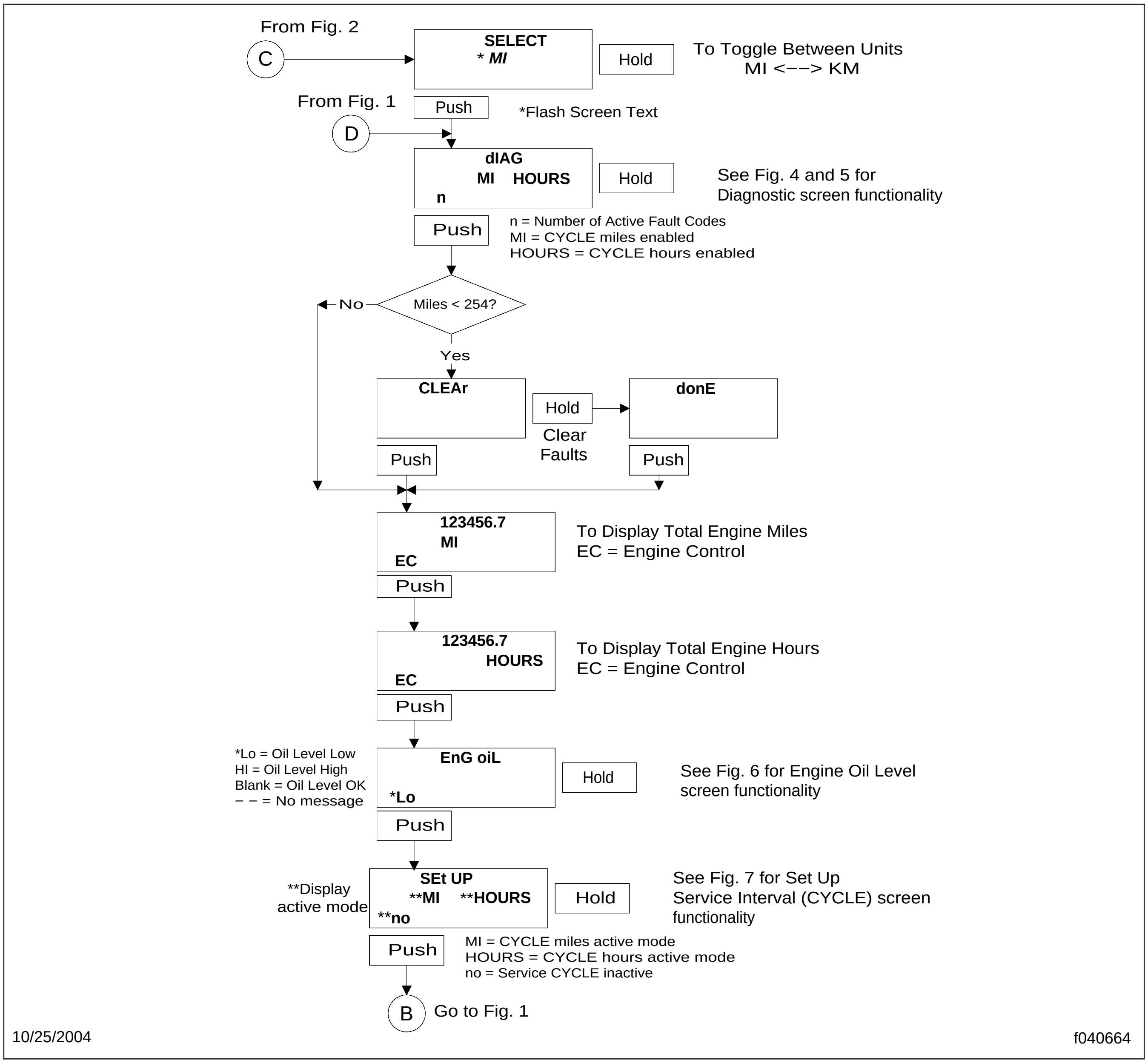


Fig. 3, Mode/Reset Switch Engine Miles and Service Screens

Mode/Reset Switch Functions

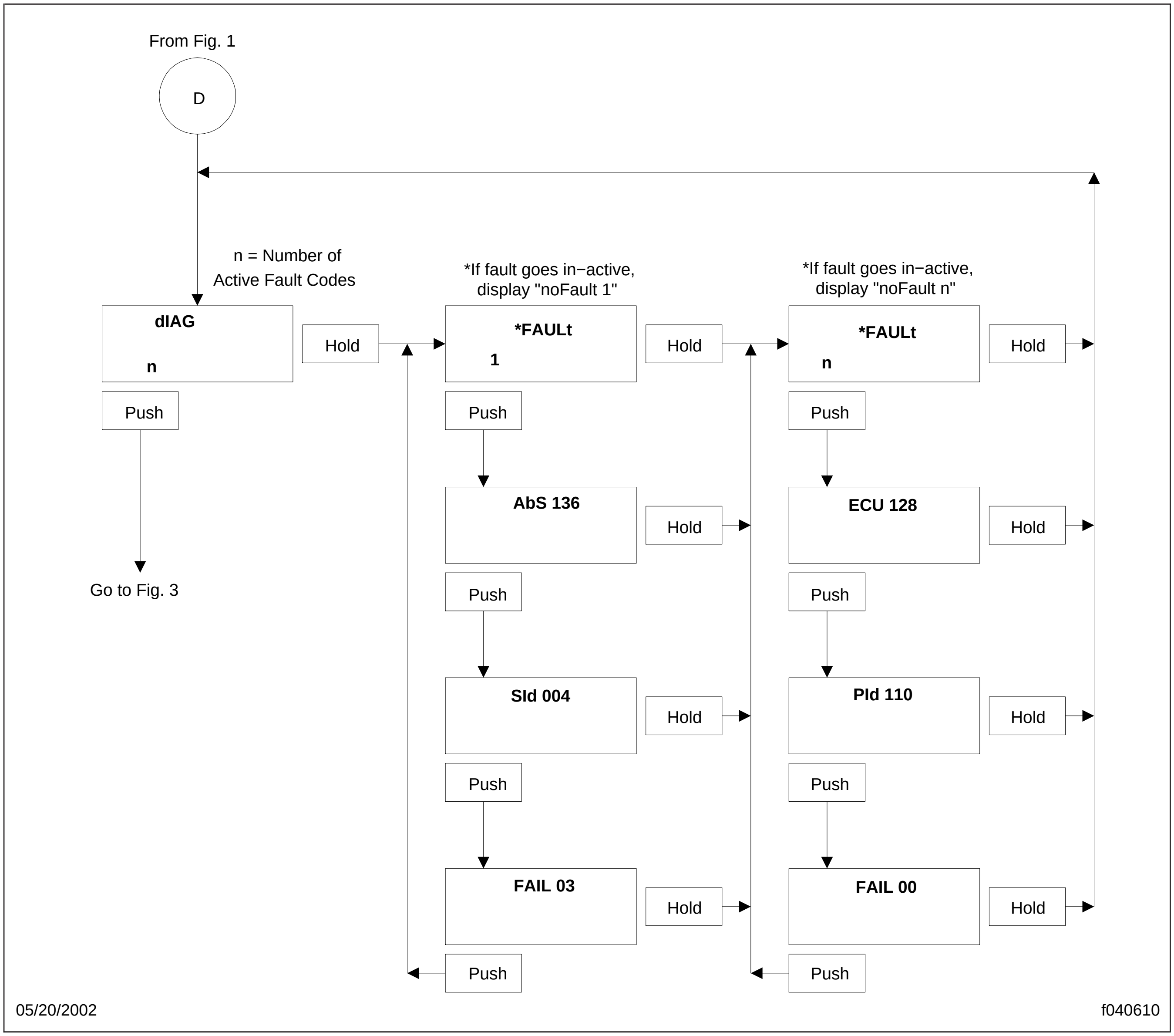


Fig. 4, Mode/Reset Switch Fault Screens

Mode/Reset Switch Functions

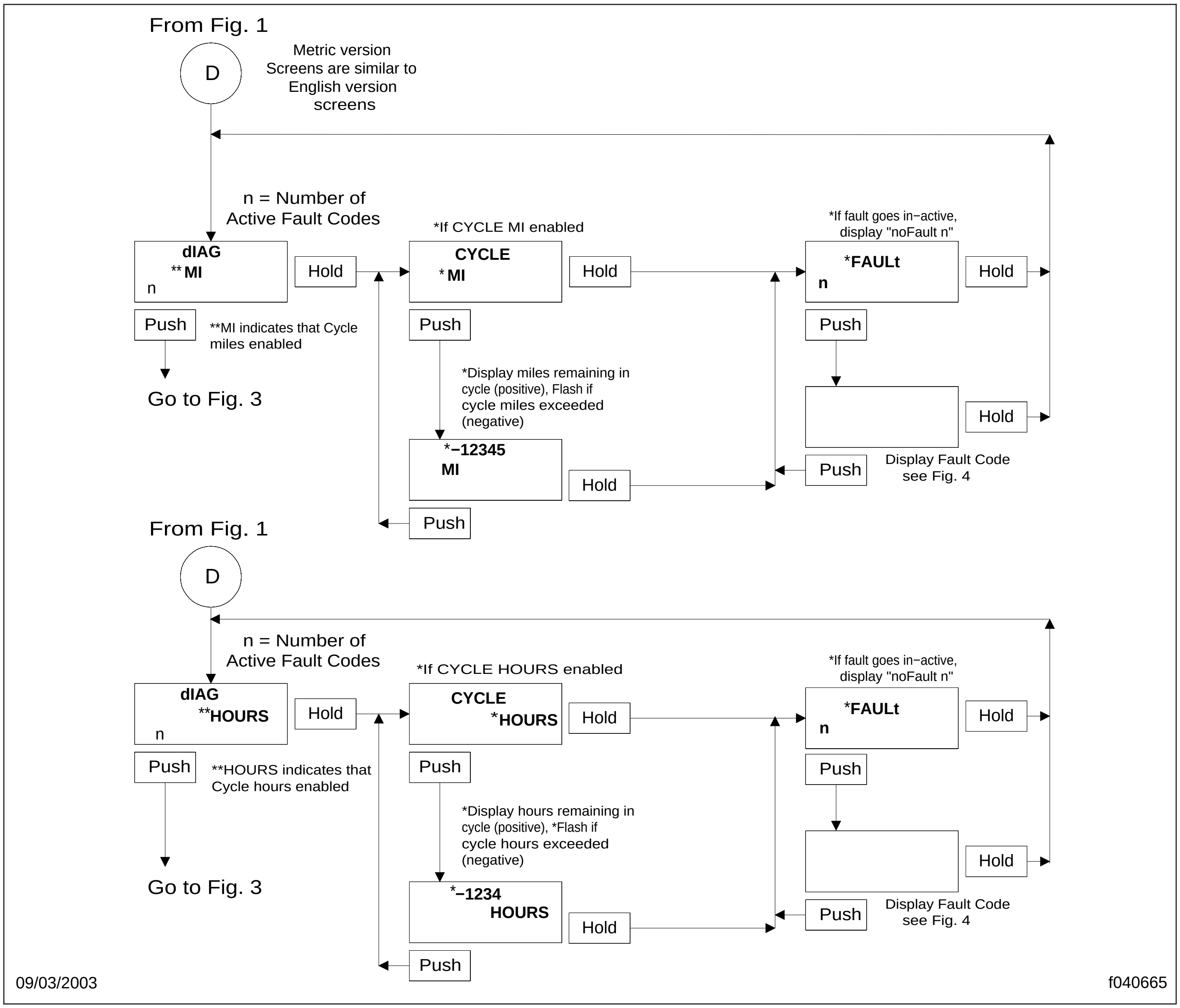


Fig. 5, Mode/Reset Switch Service Screens

Mode/Reset Switch Functions

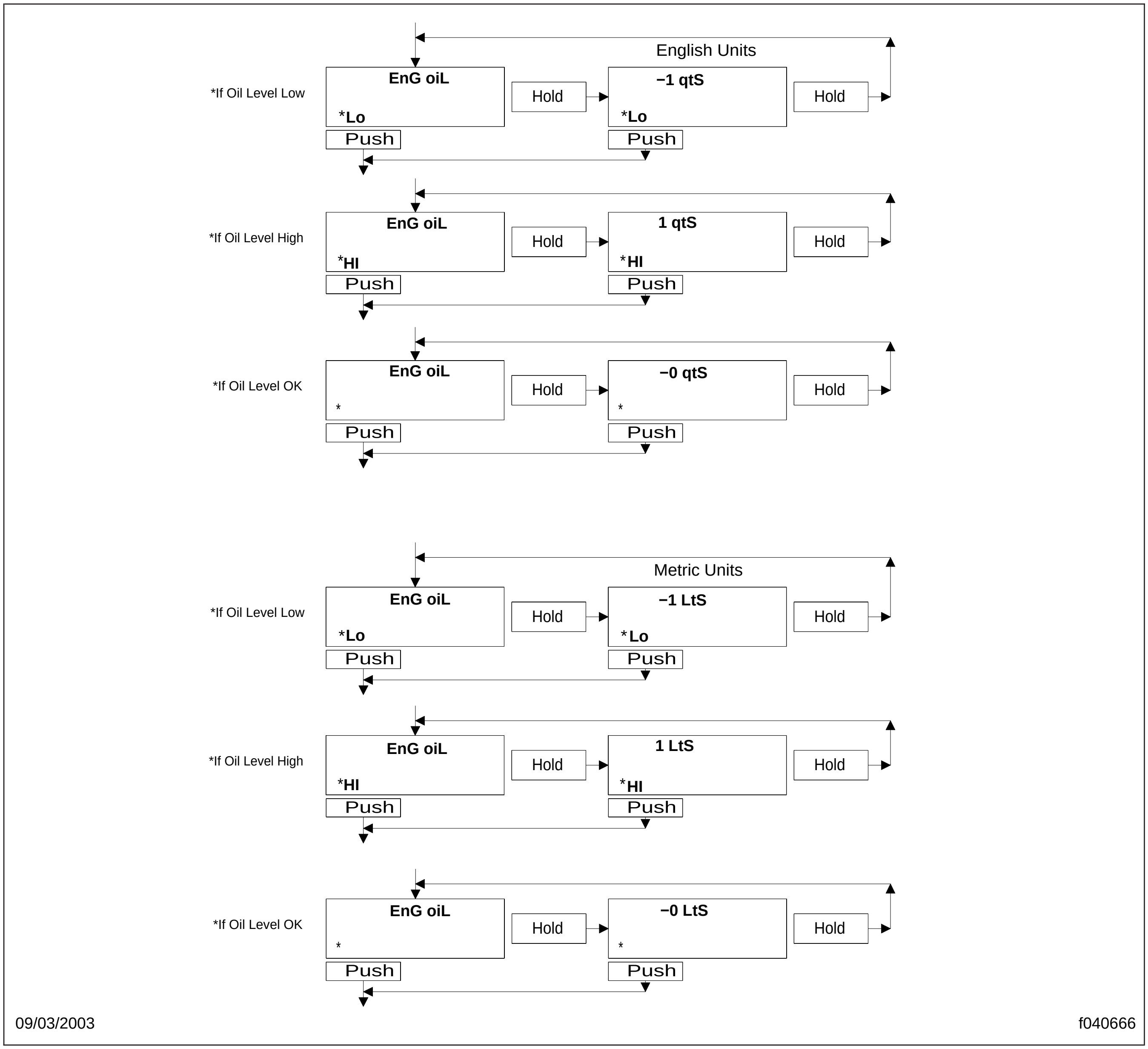


Fig. 6, Mode/Reset Switch Oil Level Screens

Mode/Reset Switch Functions

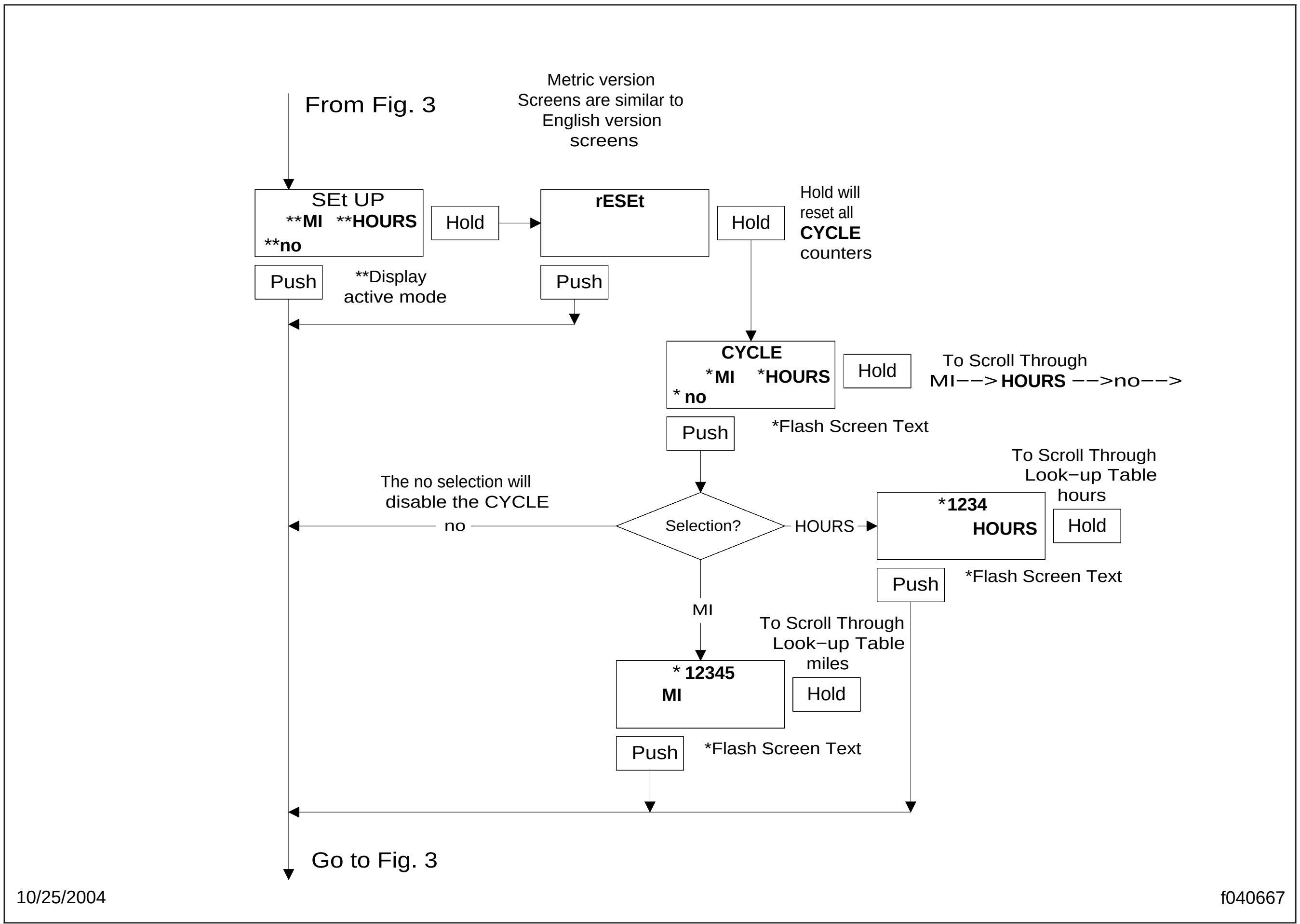


Fig. 7, Mode/Reset Switch Reset and Toggle Screens

Service Interval Hours Settings	
Number	**Hours**
1	50
2	75
3	100
4	125
5	150
6	175
7	200
8	225
9	250
10	300
11	350

Service Interval Hours Settings	
Number	**Hours**
12	400
13	450
14	500
15	550
16	600
17	650
18	700
19	750
20	800
21	850
22	900

Service Interval Hours Settings	
Number	**Hours**
23	950
24	1000

Table 2, Service Interval Hours Settings

General Information

IMPORTANT NOTIFICATION: Servicing the Eaton VORAD EVT–300 Collision Warning System (CWS) should be done only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the CWS Central Processing Unit (CPU) 32-pin connector and ground cables. See Subject 150 for instructions. Electric currents produced during electric welding can damage various electronic components on the vehicle.

The Eaton VORAD EVT–300 is a computerized collision warning system that uses front-mounted and side-mounted (optional) radar to continuously monitor vehicles ahead and to the side of your vehicle. Additional warning time, to prevent potential rear-ending of other vehicles, is provided by alerting the driver to stationary or slow moving objects in front of the vehicle or to objects toward which your vehicle is moving. The system provides three levels of alerts to indicate the interval to a vehicle ahead when travelling at normal speeds.

The system warns of potentially dangerous situations by visual and audible alerts. The system performs in fog, rain, snow, dust, smoke, and darkness. To be detected, objects must be within the radar beam's field of view and provide a surface area that can reflect back the radar beam.

Components consist of one, two, or three in-cab display units, the front-mounted antenna assembly, side sensor(s), the central processing unit (CPU), antenna mounting plate, and associated wiring harnesses.

The front-looking antenna assembly transmits radar signals to, and receives them back from, vehicles and objects ahead. This allows the determination of the distance, relative speed, and angle to the target vehicles and objects ahead. The system uses this information to warn the driver of potentially dangerous situations.

The forward-looking antenna assembly simultaneously monitors up to 20 vehicles within a 350-foot (107-meter) range. Much information processing is done by the antenna itself. A four-wire twisted pair attaches via a Deutsch connector to the rear of the antenna. The antenna wires are built into the 32-pin connector going to the CPU.

The forward-looking azimuth measurement system (monopulse technology) provides a 12° beam. It is able to track targets in a curve (up to 20 targets at one time) but reports only those within your lane. Road curvature information is provided by the CPU's yaw rate sensor, which shapes the radar detection zone to the curve.

IMPORTANT: The detection range is reduced during a sharp turn.

An optional side sensor(s), mounted on the side of the vehicle, also transmits and receives radar signals for a distance of 2 to 10 feet (0.5 to 3 meters), alongside your vehicle. It has a 15° beam angle. The side sensor can detect unseen vehicles and objects, moving and stationary, adjacent to your vehicle.

WARNING

The Eaton VORAD EVT–300 Collision Warning System (CWS) is intended solely as an aid for an alert and conscientious professional driver. It is not intended to be used or relied upon to operate a vehicle. Use the system in conjunction with rearview mirrors and other instrumentation to safely operate the vehicle. Operate this vehicle, equipped with the EVT–300 Collision Warning System, in the same safe manner as if the EVT–300 Collision Warning System were not present.

The EVT–300 Collision Warning System is not a substitute for safe, normal driving procedures, nor will it compensate for any driver impairment, such as drugs, alcohol, or fatigue.

The EVT–300 Collision Warning System may provide little or no warning of hazards such as pedestrians, animals, oncoming vehicles, or cross traffic.

Failure to drive safely and use the system properly could result in personal injury and/or death and severe property damage.

The CPU's internal gyroscope is sensitive to orientation. The CPU must be mounted with the uppermost surface within ±3° of the true horizontal and vertical planes. Be sure that the directional arrow on the

General Information

CPU points up. A separate power ground, as well as a ground strap, is provided on the CPU.

The driver display unit (DDU) contains the controls and indicators relating to system operation. See **Fig. 1**. A slot is provided at the front lower edge to insert an optional driver's identification card. An optional, configurable light and audible alarm indicate whether or not the driver's identification card has been inserted. At startup, a power-on LED test takes place and all of the lights illuminate.

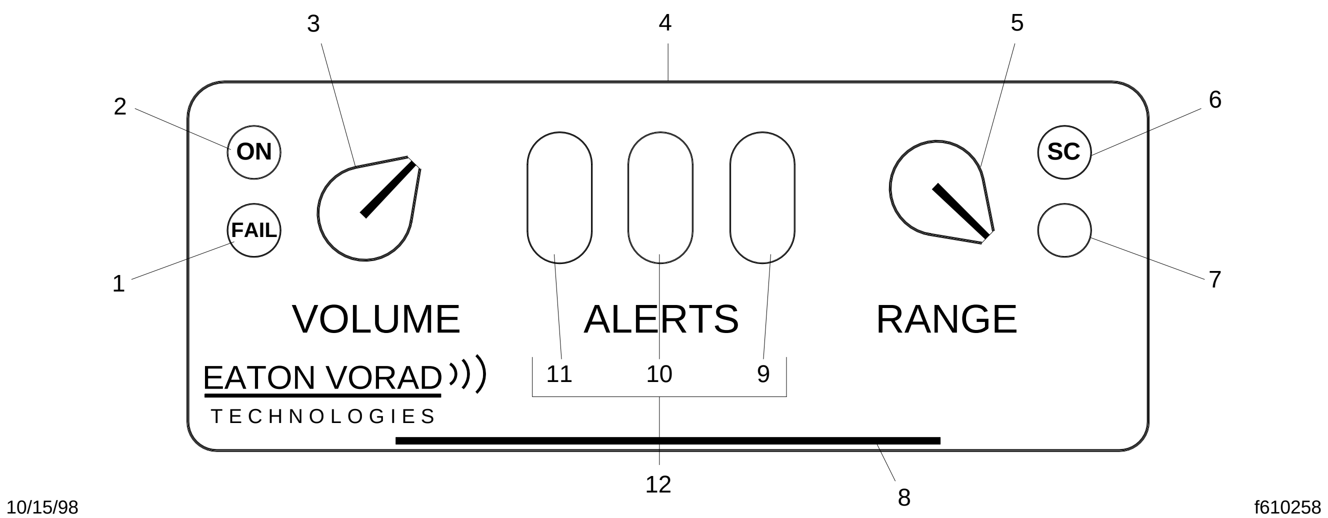
Adjust the first alert detection range to between 3 and 2-1/8 seconds by rotating the range knob left to right.

finished if the accident reconstruction data was previously stored.

The yellow alert light illuminates when an object is detected within the 350-foot (107-meter) maximum detection range. The yellow light also illuminates when the proximity alarm threshold is crossed.

NOTE: The maximum detection range on straight roads is 350 feet (107 meters). On curved roads, the range is reduced by the road's turn radius.

The orange alert light illuminates along with the yellow alert light when your vehicle is within a 3-second



1. Red, System Failure Indicator Light
2. Green, Power On/Driver's Card Status Indicator Light
3. Volume Control and Power On/Off Knob
4. Speaker (on top or unit)
5. Range Knob
6. Green, SC Indicator Light
7. Light Sensor
8. Driver's Card Slot
9. Red, Alert Light
10. Orange, Alert Light
11. Yellow, Alert Light
12. Distance/Danger Alert Lights

Fig. 1, Driver Display Unit (DDU)

NOTE: The system may be configured so that range control is not adjustable by the driver.

Push and hold the range knob for 5 seconds to save the accident reconstruction data. This saves the most recent data in half of the allocated memory.

The green SC indicator light flashes eight times when the range knob is pressed for 5 seconds to store the accident reconstruction information. It also flashes eight times after the power-on LED test is

following interval behind another vehicle in the same lane. If you are within a 2-second following interval, and narrowing the gap to the vehicle ahead, a warning tone also sounds.

The red alert light illuminates along with the yellow and orange alert lights when you are less than 1 second behind a vehicle. If the vehicle ahead is increasing the gap, no tone sounds. If you are decreasing the gap, double tones sound. If you follow with a 1/2-second or less following interval, the tones repeat twice per second.

If a stationary vehicle or object, or an object moving at least 20 percent slower than your vehicle, is detected within 220 feet (67 meters), and within 3 seconds, all three alert lights illuminate and the double tones sound. This warning overrides all others and is not affected by the range control knob setting.

If your vehicle is traveling less than 5 mph (8 km/h) and an object is detected less than 15 feet (4.5 meters) in front of your vehicle, and the closing rate is less than 2 mph (3 km/h) but more than 1/2 mph (1 km/h), the yellow alert light illuminates and a low-frequency double tone sounds.

NOTE: All warnings apply only to objects within the maximum detection range and in your lane. Proximity alert tones and 2-second following interval tones can be adjusted by changing the parameters. All tones, except the 1/2-second alert, are disabled in sharp turns or when the brakes are applied. If the configuration permits, the 3-second alert level may be adjusted with the range control knob. A low-frequency tone sounds when a system failure is detected. A medium-frequency tone sounds when the volume control level is changed.

Only if the system is configured to require a driver's identification card (optional) does the following information apply: A high-frequency tone sounds when the driver's identification card has been successfully read. A low-frequency tone sounds when the driver's card has been unsuccessfully read. The system can be configured so that if the system is on and the requested driver's card has not been inserted, no alert is given, or a visual alert only is given, or both a visual and an audible alert are given.

The side sensor is an optional part of the system. One side sensor may be mounted on one side of the vehicle, or one may be mounted on each side of the vehicle, or two may be mounted on one side to increase the monitored area on that side. The red side sensor light illuminates and stays on if a failure is detected.

The optional accident reconstruction capability provides two segments of system data, one of which can be stored in system memory. Push and hold the driver display unit (DDU) range knob for about 5 seconds to store the first segment. Within 6 seconds, the green SC indicator light will blink rapidly eight times, confirming that the data has been saved. If the range knob is pushed again, a fail tone sounds. After the first segment is saved, the second segment runs continuously, but only contains the last 10 minutes (approximately) of system data.

NOTE: If the first memory segment has been stored, then the other segment cannot be saved. Only by disconnecting the main CPU connector can the second memory segment be preserved. You must return the CPU to Eaton VORAD for downloading and interpretation of accident reconstruction data.

To activate the failure display mode, press and hold the driver display unit (DDU) volume knob (**Fig. 1**) for at least 5 seconds. The system may turn off if you release the knob before 5 seconds. After 5 seconds, the DDU FAIL light begins to blink, representing the fault codes. After an 8-second interval, additional fault codes, if present, will be displayed by a series of blinks. A code 41 is displayed if either no faults are found or when all fault codes have been displayed.

Principles of Operation

The collision warning system operates by transmitting and receiving low power, high frequency, radar (microwave) signals between the vehicle and objects in front of and to the side(s) of it. These signals determine changes in distance and speed between the vehicle and the object. This information is then used to inform the driver of a potential collision by visual and auditory alerts. To be detected, an object must be within the field of view of the antenna's radar beam. The object must also provide a surface that can reflect the radar beam back to the antenna assembly. The side sensor(s) detects objects at the side of the vehicle.

The antenna assembly compares the frequencies between the transmitted and received signals. It converts the information to a digital format and outputs it to the central processing unit (CPU) for processing. The CPU sends signals to activate the appropriate lights and alarms. The antenna is mounted to aim directly in front of your vehicle. It has a range of up to 350 feet (107 meters) for moving objects and 220 feet (67 meters) for stationary and slow-moving objects.

General Information

The side sensor detects vehicles in the adjacent lane and provides that information to the CPU for processing.

The CPU processes the information it receives from the antenna assembly, J1587 (vehicle speed), side sensor(s), brake circuit, and turn signal circuit. The CPU sends signals to the driver display unit and to the side sensor display to illuminate the alert lights. It also signals the driver display unit to sound alerts over the speaker.

The driver display unit (DDU), if so configured, controls power to the system, speaker volume, and the range threshold of alerts to objects in the road. It also controls the storage of the first 10-minute segment of accident reconstruction data onto the driver's card.

The side sensor display (SSD) contains red and yellow alert lights, indicating whether an object is detected or not. The red light indicates a detected object. The yellow light indicates no object detected. Both the side sensor display and the driver display unit have a light-intensity sensor to adjust the brightness according to the ambient light.

Driver Display Unit (DDU) Replacement

Replacement

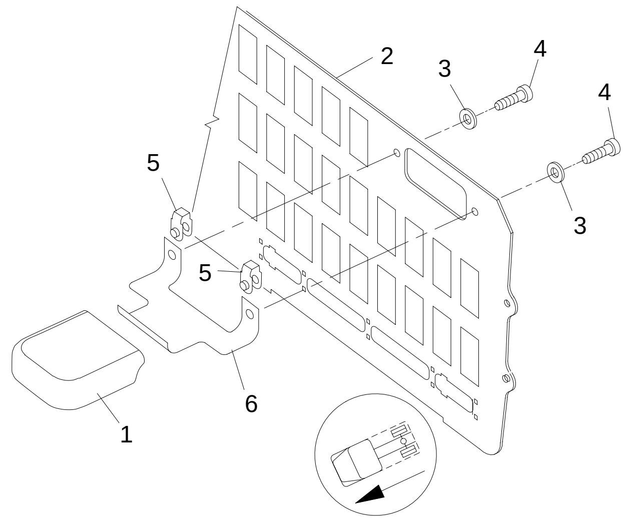
IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: Removal of the driver display unit (DDU) requires gaining access to the inside of the auxiliary instrument panel. See **Group 60** for specific procedures for removal and installation of the dash panels. See **Subject 170** for DDU test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the instrument center-panel trim, the HVAC/radio trimplate, and the right-hand dash trimcap.
3. Remove the four Torx®-head screws securing the auxiliary instrument panel to the dash assembly.
4. Gain access to the rear (forward side) of the auxiliary panel by pulling the panel toward you.
5. Remove the two Torx-head screws which attach the DDU mounting bracket to the auxiliary panel. See **Fig. 1** .
6. Withdraw the DDU, with its mounting bracket attached, and disconnect the electrical harness.

NOTE: If replacing the DDU or the bracket, carefully separate the unit from the bracket. It is attached with a two-sided adhesive. Remove all of the old adhesive. Install new adhesive and attach the DDU to the bracket.

7. To install the DDU, first connect the electrical harness.
8. Place the DDU, with bracket attached, behind the auxiliary panel and insert it into the panel.
9. Install and tighten the two bracket mounting Torx-head screws.
10. Carefully push the auxiliary panel into position, against the dashboard assembly.



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1. Driver Display Unit (DDU)
2. Auxiliary Panel (seen from the rear)
3. Washer
4. Torx-head Screw
5. J-Clip
6. DDU Mounting Bracket

Fig. 1, Driver Display Unit (DDU)

11. Install the four Torx-head screws which secure the panel to the dashboard assembly and tighten them securely.
12. Install the right-hand trimcap, the HVAC/radio trimplate, and the instrument center-panel trim.
13. Connect the batteries and remove the chocks from the tires.

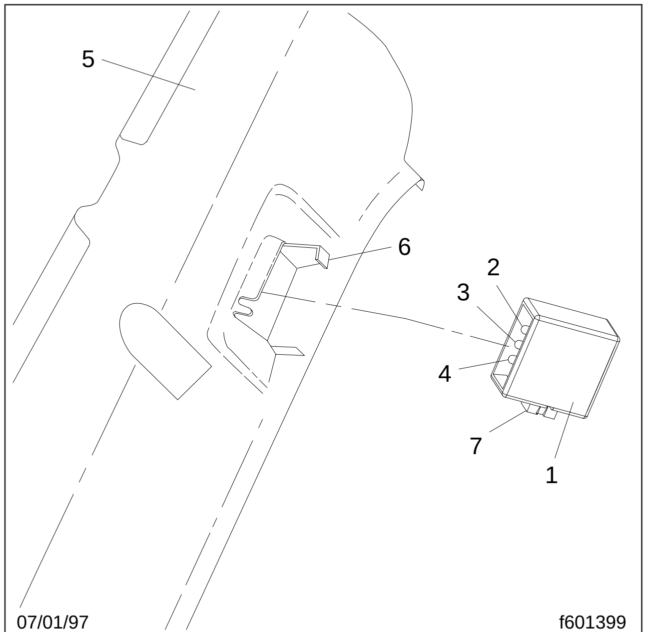
Side Sensor Display (SSD) Replacement

Replacement

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: See **Subject 170** for side sensor display (SSD) test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the two Torx®-head screws securing the passenger grab handle to the passenger side A-pillar. Remove the handle.
3. Pull the door trim edging back to expose the edge of the inner A-pillar trim cover. Remove the cover. See **Fig. 1** .
4. Release the plastic retaining clip securing the SSD to the A-pillar cover. Remove the SSD.
5. Disconnect the electrical harness.
6. To install, connect the harness to the SSD.
7. Insert the SSD into the A-pillar cover and ensure it is secured with the plastic retaining clip.
8. Put the A-pillar cover in position on the A-pillar.
9. Press the door trim edging into place.
10. Place the grab handle in position. Install and securely tighten the mounting screws.
11. Connect the batteries and remove the chocks from the tires.



1. Side Sensor Display (SSD)
2. Red Alert Light (vehicle detected)
3. Light Sensor
4. Yellow Alert Light (no vehicle detected)
5. Inner A-Pillar Trim Cover
6. SSD Retaining Clip
7. Electrical Harness Connector

Fig. 1, Side Sensor Display (SSD)

Replacement

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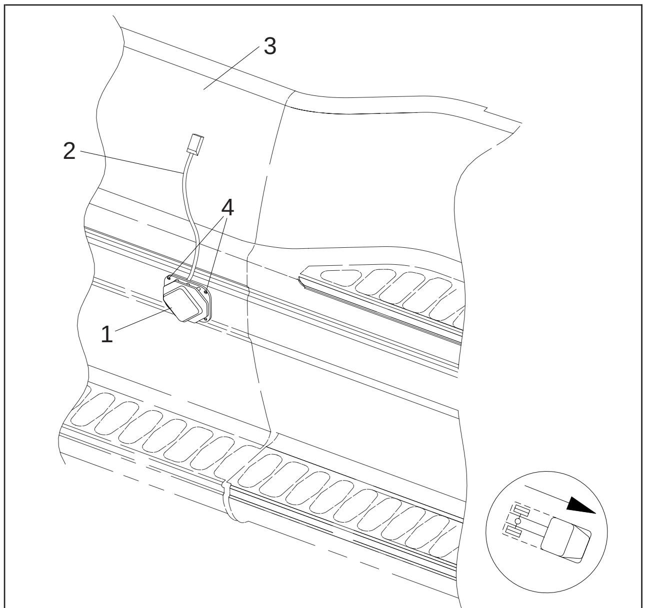
NOTE: See **Subject 170** for side sensor test procedures.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the four fasteners and nuts securing the side sensor to the center air-fairing panel. See **Fig. 1**.



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1. Side Sensor
2. Side Sensor Harness
3. Center Air-Fairing Panel
4. Mounting Fastener

Fig. 1, Side Sensor

3. Pull the sensor away from the panel.
4. Reach through the fuel access door, or up between the side-fairing and fuel tank, and locate the sensor harness. Cut any tie straps securing the sensor harness and pull the mated connectors out through the sensor mounting hole and disconnect them.
5. From the outside, feed the harness through the hole in the fairing panel.
6. To install, locate the two side sensor harness connector ends and join them together.
7. Secure the assembly to the fairing panel with the four fasteners and nuts.
8. Reach up between the side-fairing and the fuel tank and make a service loop in the excess side sensor harness. Secure the service loop to the aluminum side-fairing mounting rail with tie straps.
9. Connect the batteries and remove the chocks from the tires.

Replacement

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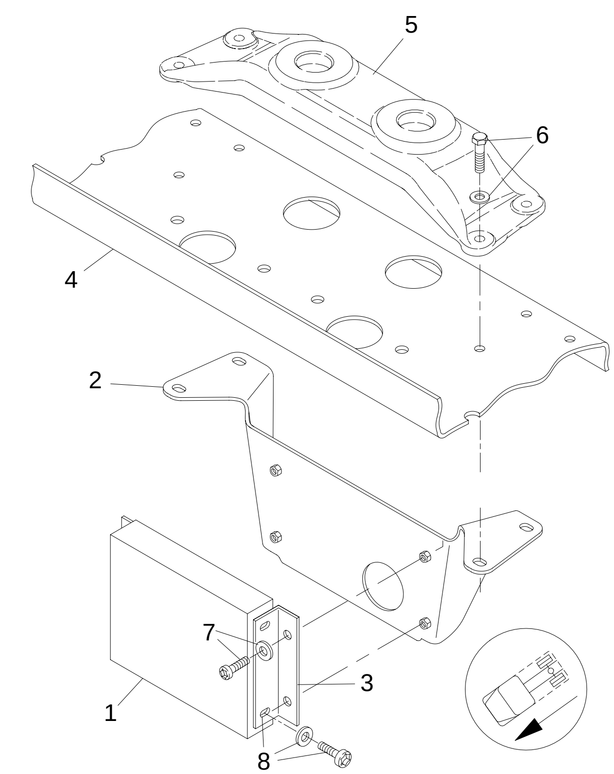
NOTE: See **Subject 170** for antenna assembly test procedures, **Subject 160** for initial adjustments, and **Subject 180** for on-road checks and final adjustments.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the four fasteners which secure the antenna assembly mounting brackets to the antenna mounting plate. See **Fig. 1** .
3. Pull the antenna assembly forward to gain access to the four-wire twisted pair and the Deutsch connector.
4. Disconnect the Deutsch connector from the rear of the antenna assembly.
5. To install the antenna assembly, connect the Deutsch connector to the rear of the antenna assembly.
6. Attach the antenna assembly to the mounting plate with the four fasteners and tighten them securely.
7. Realign the antenna.
8. Connect the batteries and remove the chocks from the tires.



1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Closing Crossmember
5. Lower Radiator Support
6. Fastener (mounting plate/radiator support)
7. Fastener (mounting plate/antenna bracket)
8. Adjusting Slot/Fastener

Fig. 1, Antenna Assembly

Replacement

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the antenna assembly. See **Subject 130** for removal instructions.
3. With the antenna assembly removed, disconnect the Deutsch connector from the rear of the antenna assembly.
4. Hold the heads of the four mounting plate/radiator support fasteners from above and remove the nuts below the mounting plate. See **Fig. 1** .
5. Remove the mounting plate from the vehicle.
6. Replace the antenna mounting plate.

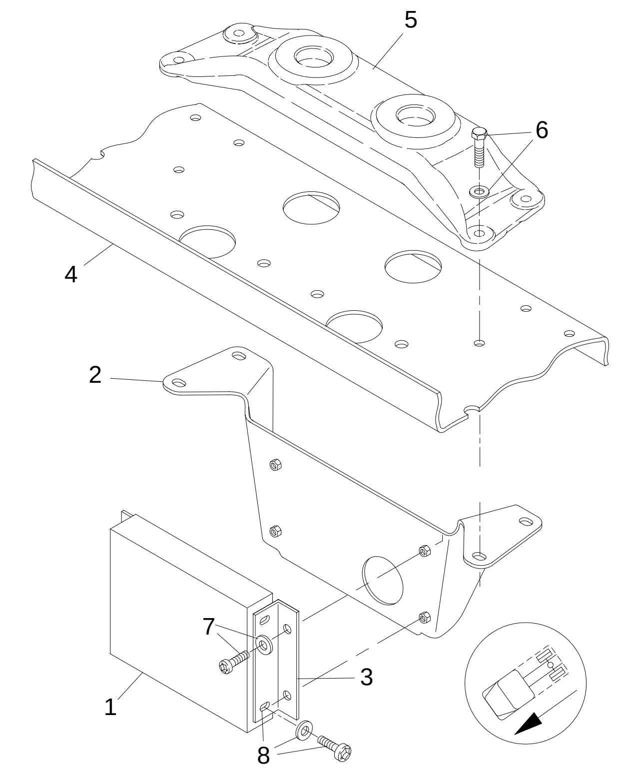
   6.1 Place the mounting plate in position under the front closing crossmember.

   6.2 Insert four 3/8–16 capscrews and washers through the holes in the lower radiator support, crossmember, and mounting plate.

   NOTE: Push the plate back against the mounting fasteners while tightening the nuts. This ensures that the plate is perpendicular to the vehicle's longitudinal axis.

   6.3 Install four washers and 3/8–16 hexnuts, and tighten the hexnuts 28 lbf·ft (38 N·m).
7. Connect the Deutsch connector to the rear of the antenna assembly, and install the antenna assembly onto the mounting plate.
8. Install the antenna assembly. See **Subject 130** for installation instructions.

NOTE: When the antenna assembly is removed from the mounting plate, even with the mounting brackets left attached, it is necessary to realign the antenna.



1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Closing Crossmember
5. Lower Radiator Support
6. Fastener (mounting plate/radiator support)
7. Fastener (mounting plate/antenna bracket)
8. Adjusting Slot/Fastener

Fig. 1, Antenna Mounting Plate (Conventional)

9. Connect the batteries and remove the chocks from the tires.

Replacement

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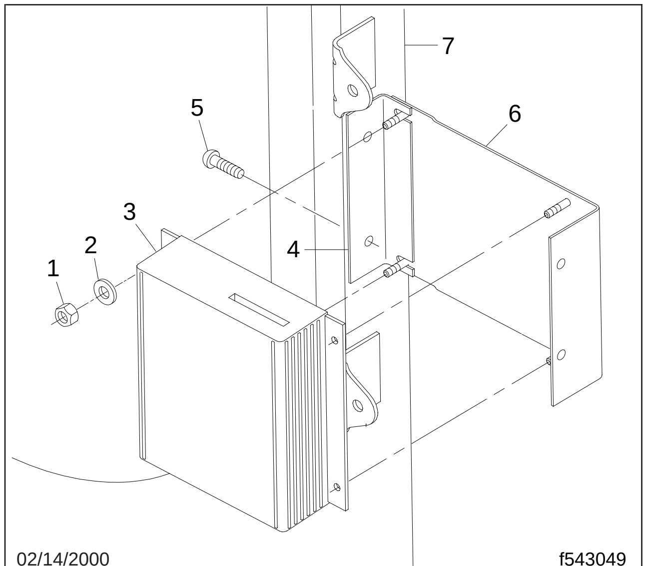
NOTE: Before replacing a central processing unit (CPU), confirm that there is a problem. Visually inspect the CPU and confirm that all connections, power and grounds, are good. Check for a blown fuse or tripped circuit breaker. Check the condition of the pins in all connectors and cavities. Examine the wiring and look for physical damage to the insulation, corrosion, or the effects of heat. Check for fault codes. See **Subject 300** for CPU fault codes and troubleshooting procedures.

IMPORTANT: If possible, view the configuration parameters of the old CPU with ProLink and record them before removing the old CPU from the system.

1. Park the vehicle on a level surface. Set the parking brake, chock the tires, and disconnect the batteries.
2. Inside the cab, turn the two camlock fasteners on the B-pillar door with a flat-bladed screwdriver and open the B-pillar door. See **Fig. 1** .
3. Remove the four locknuts attaching the CPU to the mounting studs on the inside of the B-pillar bracket. Remove the CPU from the bracket.
4. Disengage the push lock connector and carefully withdraw the 32-pin harness connector from the CPU.
5. At the bottom of the CPU, remove the nut from the ground stud and remove the ground wire from the stud.

IMPORTANT: The CPU's internal gyroscope is sensitive to orientation. The CPU must be mounted with the uppermost surface within ±3° of true horizontal and vertical planes. Also, ensure that the directional arrow on the CPU points up.



1. Locknut, 10–24 (4 places)
2. Washer, #10 (4 places)
3. Central Processing Unit (CPU)
4. Half-Bracket
5. Monobolt®, 3/16 in (4 places)
6. Mounting Bracket

Fig. 1, VORAD CPU Installation

6. To install, place the new CPU in position against the mounting studs, inside the B-pillar bracket.
7. Install the four locknuts and tighten them securely.
8. Place the ground wire ring terminal over the ground stud on the bottom of the CPU. Install and tighten the nut securely.
9. Carefully connect the 32-pin harness connector to the CPU.
10. Close the B-pillar door and secure it by turning the two camlock fasteners.

NOTE: When replacing a CPU with a new unit, it is necessary to verify the system's configuration using ProLink. Follow the steps below to verify that a new CPU is configured identically to the one it is replacing.

11. Access the ProLink SET UP menu.
12. Verify that the vehicle ID number and the odometer reading are correct.

Central Processing Unit (CPU) Replacement

13. Select H/W (hardware) CONFIGURATION from the SETUP menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
14. Select S/W (software) CONFIGURATION from the SETUP menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
15. Select TRIP PARAMETERS from the S/W (software) CONFIGURATION menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
16. Select PERFORMANCE OPTIONS from the S/W (software) CONFIGURATION menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
17. Select PRODUCT OPTIONS from the S/W (software) CONFIGURATION menu and confirm that the current parameters of the new CPU are identical to those of the CPU it is replacing.
18. After you have ensured that the new CPU is configured identically to the old one, press FUNC to return to the SETUP menu and clear all fault codes.
19. Connect the batteries and remove the chocks from the tires.

General Information

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The only component requiring an initial adjustment, after removal and installation, is the antenna assembly.

For initial adjustments to the antenna assembly, a good-quality digital level is recommended.

NOTE: Perform these initial adjustments when the antenna assembly, antenna assembly mounting brackets, or antenna mounting plate have been removed or replaced. Perform the initial adjustments before performing the on-road checks and final adjustments.

Initial Antenna Assembly Adjustment

1. Park the vehicle on a level surface. Set the parking brake, chock the rear tires, and disconnect the batteries.

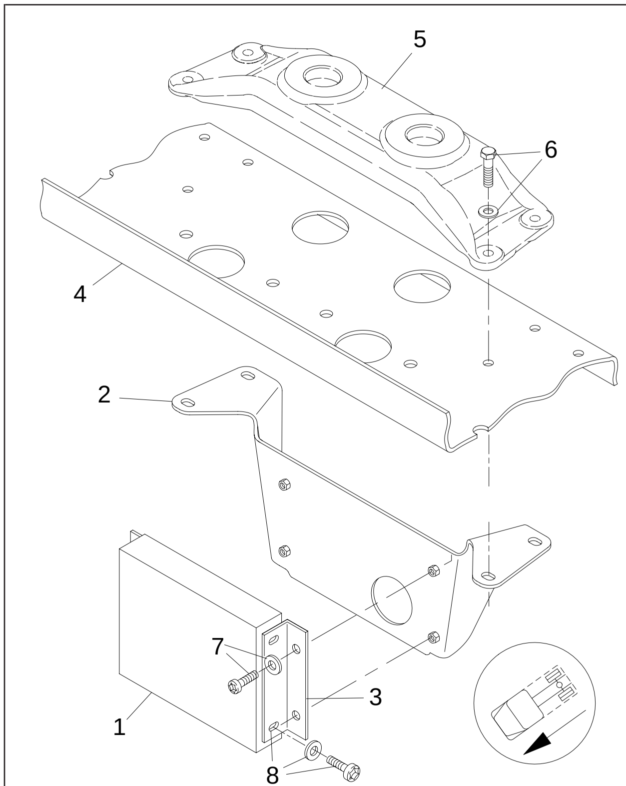
IMPORTANT: The vehicle must be parked on a level surface, with the suspension aired up to the normal ride height and ride attitude, to properly perform the initial antenna assembly adjustment procedure.

2. Place the digital level on the frame rail, behind the cab. The vehicle and the ground surface must be approximately level.

NOTE: Take note of the angle of the vehicle and/or ground surface. You must compensate for any deviation from absolute level.

3. Loosen the four adjusting setscrews (two on each antenna mounting bracket) with a 5/32-inch Allen wrench. See **Fig. 1**.

4. Push the antenna assembly all the way back in the mounting bracket adjustment slots, so that the antenna is flush with the antenna mounting plate, and only snug the setscrews.



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1. Antenna Assembly
2. Antenna Mounting Plate
3. Antenna Bracket
4. Front Closing Crossmember
5. Lower Radiator Support
6. Fastener (mounting plate/radiator support)
7. Fastener (mounting plate/antenna bracket)
8. Adjusting Slot/Fastener

Fig. 1, Antenna Assembly (Conventional)

NOTE: Push the antenna assembly back, flush with the antenna mounting plate, to do the initial antenna assembly left-to-right adjustment. This adjustment is also dependent upon the proper installation of the mounting plate. When installing the mounting plate, be sure to push the mounting plate back and hold it against the four mounting plate/radiator support fasteners as the nuts are tightened.

5. Place the digital level vertically against the face of the antenna. The initial vertical antenna setting is 1-degree down. Look for a reading of 89 degrees (or 91 degrees), depending on the level

Initial Adjustments

readout. Make sure that the top of the antenna is tilted toward the front by 1 degree.

NOTE: If the vehicle is angled down because it is not parked a level surface, add the number of degrees off from level to the 1-degree down. If the vehicle is angled up, subtract the number of degrees off from level to the 1-degree down. For example, if the vehicle is angled down 2.7 degrees the antenna angle must be 3.7-degrees down, which will produce a reading of 86.3 degrees (or 93.7 degrees), depending on the level readout.

6. Adjust the antenna out from either the top or bottom to obtain the required degree reading on the level.
7. Tighten the setscrews securely.
8. Check the vertical setting to be sure it is still set at the required degree angle.
9. If the vertical setting has changed, repeat the procedure.
10. Proceed to **Subject 180** for instructions on performing the on-road checks and final adjustments.
11. Connect the batteries and remove the chocks from the tires.

Component Checks

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

MPSI PROLINK® 9000

To properly test and diagnose problems with the Eaton VORAD EVT–300 collision warning system, an MPSI ProLink 9000 diagnostic tool equipped with an Eaton VORAD cartridge, or a multi-protocol cartridge with the Eaton applications PCMCIA card, is required. The initial or default EVT–300 diagnostic menu consists of three sub menus: setup, checkout, and error log. Verify system configuration of the central processing unit (CPU) with the setup menu. Use the checkout menu to test the functions of the various components. Display fault codes using the error log menu.

NOTE: Use only a digital ohmmeter when performing tests to avoid damaging electronic components.

COMPONENT CHECKS USING THE CHECKOUT MENU

NOTE: Before selecting CHECKOUT, select SETUP and verify system configuration. This ensures proper operation of the CHECKOUT menu during component function tests.

The various components of the collision warning system can be activated using this menu. Some checks require assistance from the technician. The technician will be asked, via the ProLink, if the expected event occurred. Use the UP and DOWN arrow keys to scroll the selection arrow. Select the CHECKOUT menu from the initial EVT–300 diagnostic menu by placing the selection arrow next to CHECKOUT and pressing ENTER.

NOTE: The following component checks are performed with the vehicle stationary.

Side Sensor Display (SSD) Test

1. Select SSD TEST from the CHECKOUT menu.
2. Place the selection arrow next to the side sensor display.

NOTE: If the vehicle has only one side sensor, there will be an N/A value displayed for the other side sensor.

3. Press ENTER to toggle the state of the side sensor display light.
4. The indicator light on the side sensor display will match the RED or YELLOW message shown on the ProLink.
5. Press FUNC to exit the SSD TEST and return to the CHECKOUT menu.

Side Sensor (SS) Test

1. Select SS TEST from the CHECKOUT menu.
2. Place the selection arrow next to the side sensor you are testing.

NOTE: If the vehicle has only one side sensor, there will be an N/A value displayed for the other side sensor.

3. Wave your hand in front of the side sensor.
4. As you wave your hand, the message displayed on the ProLink will change from NO to YES.

NOTE: The message OPEN/SHORT will appear if the side sensor power source is disconnected.

5. Press FUNC to exit the SS TEST and return to the CHECKOUT menu.

Driver Display Unit (DDU) Test

1. Select DDU TEST from the CHECKOUT menu.

NOTE: At the lamp test line, the RED, YELLOW, and ORANGE range control alert lights will toggle automatically. Each will illuminate individually on the display as the ProLink indicates their color.

2. On the DDU, rotate the left knob (volume control) left to right fully through its range. The percentage value for the LEFT KNOB on the ProLink display will change from 0 to 100 percent.
3. Then, rotate the right knob (range control) left to right fully through its range. The percentage value for the RIGHT KNOB on the ProLink display will change from 0 to 100 percent.

Component Checks

4. Push in the right knob (range control). The display will indicate PUSH.
5. Press FUNC to exit the DDU TEST and return to the CHECKOUT menu.

Speaker Test

1. Select the SPEAKER TEST from the CHECKOUT menu.
2. Place the selection arrow next to the particular sound to be tested and press ENTER.

NOTE: When performing this test, sound volume is always at maximum. Adjusting the volume knob (left knob) on the DDU will have no effect.

3. Listen for the specific sound from the DDU speaker.
4. Repeat the procedure to test each of the six different sounds.
5. Press FUNC to exit the SPEAKER TEST and return to the CHECKOUT menu.

Antenna Test

1. Select ANTENNA TEST from the CHECKOUT menu.
2. Have an assistant walk toward the front of the antenna.

NOTE: The antenna will only detect a moving object.

3. Note the RANGE reading on the ProLink.
4. Ensure that the RANGE reading is approximately correct.
5. Press FUNC to exit the ANTENNA TEST and return to the CHECKOUT menu.

Turn Signal Test

1. Select TURN SIGNAL TEST from the CHECKOUT menu.
2. Place the selection arrow next to the right-side turn signal.

NOTE: There will be an N/A value displayed for the turn signal on the left-hand side.

3. Move the turn signal lever into position to activate the turn signal for the right-hand side.
4. The ProLink display for that turn signal position will change from OFF to ON.
5. Press FUNC to exit the TURN SIGNAL TEST and return to the CHECKOUT menu.

Brake Test

1. Select BRAKE TEST from the CHECKOUT menu.
2. Depress the brake pedal when the ProLink display indicates PRESS BRAKE PEDAL.

NOTE: If the system is not configured for a brake signal BIT test, there will be an N/A value displayed.

3. The BRAKE message on the display will change from OFF to ON when the brake pedal is depressed.
4. Press FUNC to exit the BRAKE TEST and return to the CHECKOUT menu.

Antenna Assembly

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

NOTE: These procedures are intended to be performed only on an interstate highway, freeway, or similar roadway where at least two lanes in your direction are available for use. Perform these procedures only after performing the initial adjustments when an antenna assembly, antenna assembly mounting brackets, or antenna mounting plate have been removed or replaced. See **Subject 160** for instructions.

1. Drive the vehicle straight ahead at normal highway speeds of 50 to 55 mph (80 to 88 km/h).

WARNING

Only attempt these procedures where at least two lanes are available for use and traffic is light. Improperly performing these procedures could result in loss of control of the vehicle and possible physical injury and property damage.

2. Confirm that the system is monitoring only the vehicle traveling immediately ahead of your vehicle.
3. Using ProLink, select the CHECKOUT menu, then scroll to and select ANTENNA.

NOTE: The driver display unit (DDU) should display following distance information only for the vehicle traveling immediately ahead, by illuminating the number 1 or number 2 alert light. The DDU should not display following distance information for vehicles in the left or right lanes, but only ahead of the your vehicle, while your vehicle is traveling in a straight line.

4. Monitor the azimuth reading on ProLink. Look for a 0.0 reading.

NOTE: The vehicle you are tracking must be traveling directly ahead in your lane, in the same position (center) of the lane as your vehicle, and both vehicles must be traveling on a straight roadway.

When the above conditions are met and a negative value is indicated, the antenna is "seeing" the target in its own left field of view (antenna facing to the right too much). When a positive value is indicated, the antenna is "seeing" the target in its own right field of view (antenna facing to the left too much). Look for a reading that will "bounce around" 0.0 in equal values, positive to negative (equal values produced left to right).

5. To adjust the antenna assembly, first pull the vehicle off the road in a safe location and shut off the engine.
6. Loosen the two adjusting setscrews in the antenna mounting bracket only on the side you wish to adjust.
7. If negative values were read, point the antenna to the left by pulling out the (driver's) right side of the antenna.
8. If positive values were read, point the antenna to the right by pulling out the (driver's) left side of the antenna.
9. Tighten the antenna-adjusting setscrews securely.
10. Drive the vehicle again and monitor the azimuth reading on ProLink. Look for a 0.0 reading.
11. If necessary, repeat the procedure from the beginning until the reading "bounces around" 0.0 in equal values, positive to negative (equal values produced left to right).

Troubleshooting

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

Component Troubleshooting

When an active fault is detected by the system, the red failure light on the driver display unit (DDU) illuminates until the cause of the condition is corrected. It is possible to read fault codes either on the DDU, by placing it in failure display mode, or with a Pro-Link® 9000 diagnostic tool.

NOTE: Vehicles equipped with an instrument cluster with a message center (ICU-2M only), will automatically display MID, SID, and FMI codes when a CWS fault is detected. An abbreviated text description of the fault, in English, will also display. The Eaton-VORAD assigned fault code numbers (10 through 94) will not display.

Active and inactive fault codes may be blinked out over the DDU when the system is placed in failure display mode. Press and hold the DDU volume knob for at least 5 seconds. The system may turn off if you release the knob before 5 seconds. After 5 seconds, the DDU red failure light will begin blinking out fault codes. After an 8-second interval additional fault codes, if present, will be blinked out. A code 10 will be displayed if either no faults are found or when all fault codes have been displayed. Display active codes by turning the range knob to the left of center. Display inactive codes by turning the knob to the right of center. The failure light will blink as many times as the first digit of the fault code number, pause approximately 3/4 of a second, and then blink as many times as the second digit. After all of the active or inactive fault codes have been displayed, the sequence repeats. This process continues until the system is turned off. To clear all fault codes from system memory while in failure display mode, press and hold the range knob for approximately 30 seconds.

Make the various basic checks below before proceeding to the more detailed troubleshooting procedures in the following tables.

NOTE: Certain tests, as noted in the following table require the use of a ProLink 9000 diagnostic tool, equipped with an Eaton VORAD cartridge or a multi-protocol cartridge with the Eaton applications PCMCIA card.

1. Confirm that there is a problem.
2. Before replacing any component, make continuity checks with a DVOM (digital volt/ohm meter).
3. Confirm that all connections, power and grounds, to either the vehicle or components, are good.
4. Check for a blown fuse or tripped circuit breaker.
5. Check the condition of pins in all connectors and cavities.
6. Examine the wiring of the suspect component. Look for physical damage to the insulation, corrosion, and the effects of heat.
7. Examine the external components (antenna assembly, wire harness, side sensor) for damage or corrosion.

Component Troubleshooting		
Symptom	**Cause/Source**	**Remedy**
DDU green ON light blinks continuously.	Driver ID card not inserted/driver ID card.	1. — Verify that the card alarm is correctly configured in the CPU. * 2. — Insert a new driver identification card.
DDU green SC light blinks eight times at power up.	An event is stored in the CPU's memory.	NOTE: When the system is turned on, the SC light will blink eight times after the self-test has been completed, if an event has been saved. Return the CPU to the factory to have the event uploaded and/or cleared.

Troubleshooting

Component Troubleshooting		
Symptom	**Cause/Source**	**Remedy**
Red FAIL light on side sensor display illuminates continuously.	CPU not receiving side sensor information/side sensor.	1. — Confirm that the vehicle has a side sensor. If not, verify in the H/W configuration menu that the RSS, LSS, and 2SS 1SSD setting is NO. * 2. — Check the connection and for damage to the side sensor wiring harness to the CPU. 3. — While performing the SS test, wave your hand in front of the side sensor and verify that the correct signal is received. * 4. — Verify a 5-volt output at the side sensor signal wire at the side sensor connector, using a DVOM (digital volt/ohm meter) with a target present. 5. — Disconnect the three-pin side sensor, pigtail, and CPU connectors. Check for corrosion or a recessed pin. 6. — Replace the side sensor.
No warning tones audible.	Speaker not functioning, incorrect brake signal, gyro malfunction, speed input signal inoperative/ DDU, brake input or configuration setting, CPU, speed input or source.	1. — Verify that the volume control knob is turned all the way to the right. 2. — Turn the system off and back on. Turn the volume control knob and listen for a tone. 3. — Verify that the DDU connection is good. 4. — Perform the speaker test and verify that an audible tone is heard from the DDU speaker. 5. — Verify that the CPU is oriented and mounted correctly for its type. 6. — Verify speed input. 7. — Perform the brake test and verify that the correct signal is received when the brake pedal is depressed. *
Warning tones audible when brakes applied.	Incorrect input signal/ brake input.	NOTE: The forward following distance warning tones are disabled when the brake pedal is depressed. Creep (proximity) and side sensor alerts are not disabled when the brake pedal is depressed. 1. — Perform the brake test and confirm receipt of the correct signal when the brake pedal is depressed. * 2. — Verify that the brake mode setting is correctly configured in the CPU. * 3. — Verify that the brake logic is correctly configured in the CPU. *
Side sensor warning tone audible when brakes are applied.	Incorrect input signal/ turn signal input.	1. — Verify that a tone is not audible when you wave your hand in front of the side sensor, with only the brake pedal depressed (turn signal not activated). 2. — Verify that the turn signal setting is correctly configured in the CPU. * 3. — Perform the turn signal test and confirm receipt of the correct signal when the turn signal is applied. *
No system ON/OFF capability.	Software/system configuration.	NOTE: System parameters may be configured to enable or disable the on/off capability. This requires use of a ProLink 9000 diagnostic tool.

Component Troubleshooting		
Symptom	**Cause/Source**	**Remedy**
The volume knob does not reduce the volume.	System configuration/ DDU.	NOTE: System parameters can be configured to limit volume to a minimum level, but only with a ProLink diagnostic tool. If the owner or fleet manager allows full adjustment of the volume level, follow the procedure below. 1. — Verify that the MIN VOL setting is zero. * 2. — Perform the DDU test and confirm proper operation of the volume knob. * 3. — Check that the DDU is properly connected and not damaged. 4. — Check that the main harness to the CPU is properly connected and not damaged.
The range knob does not change the alert levels.	Software configuration/ DDU.	NOTE: System parameters do not always allow the operator to reduce the range threshold level. This configuration can only be changed with a ProLink diagnostic tool. If the owner or fleet manager allows adjustment of the range level, follow the procedure below. 1. — Verify that the RANGE ENABLE configuration is ON. * 2. — Perform the DDU test and confirm proper operation of the range knob. * 3. — Check that the DDU is properly connected and not damaged. 4. — Check that the main harness to the CPU is properly connected and not damaged.
Front antenna detects vehicles in an adjacent lane with no vehicle in front of your vehicle.	Antenna misaligned/ antenna assembly.	1. — Walk a measured path in front of the vehicle and cross from side to side in front of the antenna. Verify that the reported target distance and azimuth angle are correct. * 2. — Confirm that the antenna face angle is properly adjusted to 1 degree down. 3. — Adjust the antenna in the direction opposite the detected side lane. Then, confirm that the antenna azimuth angle is correct left to right.
Front antenna detects vehicles in both left and right adjacent lanes, with no vehicle in front of your vehicle.	Radar side lobes extended/antenna assembly.	1. — Confirm that the antenna assembly is mounted at the minimum height, or above. 2. — Confirm that the antenna assembly is mounted securely. 3. — Confirm that the antenna beam's path is unobstructed and that no movement of surrounding body panels is being detected. 4. — Walk a measured path in front of the vehicle and cross from side to side in front of the antenna. Verify that the reported target distance and azimuth angle are correct. * 5. — Confirm that the antenna face angle is properly adjusted to 1 degree down. NOTE: Contact Eaton VORAD at (800) 840–7970 for additional assistance.

Troubleshooting

Component Troubleshooting		
Symptom	**Cause/Source**	**Remedy**
Front antenna loses or ignores detected vehicles within 100 feet (30 meters) in front of your vehicle.	Tracking module error/ antenna assembly.	1. — Confirm that the antenna assembly is correctly aligned. 2. — Check the antenna harness connection to the CPU and the antenna assembly. 3. — Inspect the antenna assembly, the harness, and the CPU for corrosion or damage. 4. — Confirm that the antenna assembly is mounted at the minimum height or above. 5. — Confirm that the antenna assembly is securely mounted. 6. — Confirm that the antenna beam's path is unobstructed and that no movement of surrounding body panels is being detected. 7. — Walk a measured path in front of the vehicle and cross from side to side in front of the antenna. Verify that the reported target distance and azimuth angle are correct. * 8. — Confirm that the antenna face angle is properly adjusted to 1 degree down. NOTE: If the component listed in the Cause/Source column has been replaced, perform a road test afterward to confirm that the condition has been resolved.
Side sensor display does not indicate power, or a detected object.	Side sensor display, wiring, CPU/side sensor display, wire harness, CPU.	1. — Check the side sensor display with ProLink and verify its operation. * 2. — Check that the side sensor display wire harness is properly connected and not damaged. 3. — Check for correct continuity and supplied voltage readings at the connector. 4. — Replace the side sensor display, then check its operation. 5. — Replace the CPU, reconfigure settings, then check its operation. *

* A ProLink 9000 diagnostic tool, equipped with an Eaton VORAD cartridge or a multi-protocol cartridge with the Eaton applications PCMCIA card, is required to perform checkout and configuration procedures.

Table 1, Component Troubleshooting

Fault Code Troubleshooting Using the Error Menu

1. Select ERROR LOG from the initial EVT–300 diagnostic menu.

NOTE: ERROR LOG provides a list of all the fault codes detected by the system. A BIT (Built-In Test) is performed every 15 seconds by the system to determine the condition of the components and internal processes. Faults that occur are logged as fault codes in the system's memory. The first line of the ERROR LOG menu displays the code number and the code status, either active or inactive.

2. Place the selection arrow next to the first line of the ERROR LOG menu. The first fault code in the error log is displayed.

NOTE: The second line of the ERROR LOG menu displays the name of the current fault. The third line (CLR CT/MIN) displays the number of occurrences of the current fault and the total number of minutes it has been continuously occurring. The fourth and fifth lines of the menu indicate the date and time of the first and last occurrences, respectively, of the fault.

3. Return the display arrow to the active or inactive code line.
4. Press ENTER and the next fault code with its information is displayed.
5. Continue to press ENTER to display all logged fault codes with their information.

NOTE: It may be helpful in diagnosing or solving a problem to know if some action will remove a fault. Clear the count on a particular fault by following the steps below.

6. Select the fault code for which the count is to be cleared as in steps 2 and 3 above.
7. Place the display arrow on the CLR CT/MIN line.
8. Press ENTER to clear the fault's count.

NOTE: To get to the Eaton VORAD main menu, press FUNC in the initial EVT–300 diagnostic menu. The EVT–300 diagnostic menu is the default menu and comes on initially. Once at the Eaton VORAD main menu screen, you may select active or inactive faults. The name, FMI code, and count for active and inactive faults are displayed here. Failure Mode Identifiers (FMI) numbers describe a specific type of failure detected in a specific system.

9. Press the left or up arrow key to display the previous active or inactive fault.
10. Press the right or down arrow key to display the next active or inactive fault.
11. Press FUNC to return to the Eaton VORAD main menu.

NOTE: At the CLEAR FAULT CODES line, accessed from the Eaton VORAD main menu, you can clear all fault codes from system memory. Be sure this is what you want to do as all BIT data will be reinitialized when all fault codes are cleared.

12. Press ENTER if you want to clear all fault codes and then select DIAGNOSTICS from the Eaton VORAD main menu to return to the EVT–300 diagnostic menu.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
11/CONTROLLER	Controller/CPU.	254	12	CPU cruise control input error. Cannot be repaired in the field. †
12/CONTROLLER	Controller/CPU.	254	4	CPU NVRAM memory error. Cannot be repaired in the field. †
13/CONTROLLER	Controller/CPU.	254	4	CPU NVRAM internal battery voltage low. Cannot be repaired in the field. †
14/CONTROLLER	Controller/CPU.	254	12	CPU EEPROM error. Unable to write to memory storage device. Cannot be repaired in the field. †
15/CONTROLLER	Controller/ CyberCard.	254	12	1. — The system is unable to read the CyberCard or the card slot is damaged. Ensure that the card slot is clean and that no dirt, dust, or debris is present. 2. — CPU internal component failure. Cannot be repaired in the field. †

Troubleshooting

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
21/BRAKE	Vehicle brake input connection not detected/brake input.	3	2	1. — Confirm that the brake source is correctly configured in the CPU. ‡ 2. — Confirm that the exterior brake light bulbs are good. 3. — Confirm that the brake switch operates correctly. 4. — Perform the brake test and confirm that the correct signal is received when the pedal is depressed. ‡ 5. — Confirm that the brake logic is correctly configured in the CPU. ‡ 6. — Confirm that the brake input wire is connected to the proper source. 7. — Ensure that the main harness to CPU connection is good and that the harness is not damaged. 8. — Verify that pin number 9, on the top row of the main harness connector, receives 12 volts when the brake is applied.
22/SPEED MONITOR	Speed input is not detected/speed input, configuration setting.	6	2	1. — Confirm that the SPEEDO BIT setting is correctly configured in the CPU. ‡ 2. — Confirm that the speed mode is correctly configured. ‡ 3. — Perform the speedometer test to confirm the speedometer's accuracy against the vehicle speed. ‡ 4. — Check the main harness to the CPU connection and for damage to the main harness.
23/RIGHT TURN SIGNAL	Right turn signal input not detected/ turn signal input, configuration setting.	7	2	1. — Confirm that the vehicle has a right side sensor. If not, confirm that the right turn signal setting, in the H/W configuration menu, is NO. ‡ 2. — Confirm that the exterior turn signal bulbs are good. 3. — Confirm that the turn signal switch operates properly. 4. — Confirm that the right turn signal input is connected to the right turn signal lead. 5. — Perform the turn signal test to confirm that the correct input is received when the right turn signal is activated. ‡ 6. — Verify that pin number 15, on the top row of the main harness connector, receives 12 volts when the right turn signal is activated. 7. — Check the main harness to the CPU connection and for damage to the main harness.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
24/RIGHT SIDE SENSOR	Right side sensor not communicating with CPU/right side sensor.	10	2	1. — Confirm that the vehicle has a right side sensor. If not, verify in the H/W configuration menu that the RSS setting is NO. ‡ 2. — Check the connection and for damage to the right side sensor wiring harness to the CPU. 3. — While performing the SS test, wave your hand in front of the right side sensor and verify that the correct signal is received. ‡ 4. — Disconnect the three-pin right side sensor, CPU pigtail, and CPU connectors. Check for corrosion or a recessed pin.
25/LEFT TURN SIGNAL	Left turn signal input not detected/ turn signal input, configuration setting.	8	2	1. — Confirm that the vehicle has a left side sensor. If not, confirm that the left turn signal setting is NO. ‡ 2. — Confirm that the exterior turn signal bulbs are good. 3. — Confirm that the turn signal switch operates properly. 4. — Confirm that the left turn signal input is connected to the left turn signal lead. 5. — Perform the turn signal test to confirm that the correct input is received when the left turn signal is activated. ‡ 6. — Verify that pin number 15, on the bottom row of the main harness connector, receives 12 volts when the left turn signal is activated. 7. — Check the main harness to the CPU connection and for damage to the main harness.
26/LEFT SIDE SENSOR	Left side sensor not communicating with CPU/left side sensor.	11	2	1. — Confirm that the vehicle has a left side sensor. If not, verify in the H/W configuration menu that the LSS setting is NO. ‡ 2. — Check the connection and for damage to the left side sensor wiring harness to the CPU. 3. — While performing the SS test, wave your hand in front of the left side sensor and verify that the correct signal is received. ‡ 4. — Disconnect the three-pin left side sensor, CPU pigtail, and CPU connectors. Check for corrosion or a recessed pin.
31/CONTROLLER	Controller/CPU.	254	12	CPU real time clock error. Cannot be repaired in the field. †
32/CONTROLLER	CPU gyroscope error/CPU.	254	12	1. — Confirm that the CPU is oriented and mounted correctly for its type. 2. — While performing the GYRO test, confirm that the voltage is stable when the vehicle is stationary, but begins to vary when a turn is simulated by tilting the CPU left to right. ‡ 3. — CPU internal component failure. Cannot be repaired in the field. †
33/CONTROLLER	VBUS communications reception/wire integrity, connectors.	254	12	1. — Check the main harness to CPU connection and for damage to the pins and harness. 2. — Check the connection of the J1587 wires and for damage to the pins and wires.

Troubleshooting

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
34/CONTROLLER	VBUS communications transmission/wire integrity, connectors.	254	12	1. — Check the main harness to CPU connection and for damage to the pins and harness. 2. — Check the connection of the J1587 wires and for damage to the pins and wires.
41/CONTROLLER	J1587 communications reception/CPU, wire integrity, connectors.	254	12	1. — In the S/W configuration menu, confirm that J1587 is correctly configured and enabled. ‡ 2. — Check the connection of the J1587 wires to the vehicle harness and for damage to the wires. 3. — Check the connection of the J1587 wires at pin number 7 positive and pin number 8 negative, on the top row of the CPU connector.
42/CONTROLLER	J1587 communications transmission/CPU, wire integrity, connectors.	254	12	1. — In the S/W configuration menu, confirm that J1587 is correctly configured and enabled. ‡ 2. — Check the connection of the J1587 wires to the vehicle harness and for damage to the wires. 3. — Check the connection of the J1587 wires at pin number 7 positive and pin number 8 negative, on the top row of the CPU connector.
43/CONTROLLER	J1939 H/W communications/ CPU, wire integrity, connectors.	254	12	1. — In the S/W configuration or product options menu, confirm that J1939 is activated through SPEED mode or BRAKE mode. ‡ 2. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 3. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. NOTE: Special instructions are necessary to clear this error. Contact Eaton VORAD at (800) 840–7970.
44/CONTROLLER	J1939 address communications/ CPU, wire integrity, connectors.	254	12	1. — In the S/W configuration or product options menu, confirm that J1939 is activated through SPEED mode or BRAKE mode. ‡ 2. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 3. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. NOTE: Special instructions are necessary to clear this error. Contact Eaton VORAD at (800) 840–7970.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
45/CONTROLLER	J1939 ERC 1 communications/ wire integrity, connectors, engine retarder, engine retarder switch.	254	12	1. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 2. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. 3. — Confirm that the engine retarder and the engine retarder switch function properly. NOTE: Special instructions are necessary to clear this error. Contact Eaton VORAD at (800) 840–7970.
46/CONTROLLER	J1939 EEC 1 communications/ wire integrity, connectors, engine ECM software.	254	12	1. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 2. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. 3. — Confirm that the engine ECM software is compatible with EVT–300.
47/CONTROLLER	J1939 ETC2 communications/ wire integrity, connectors, transmission, transmission software.	254	12	1. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 2. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. 3. — Confirm that the transmission and/or transmission software is compatible with EVT–300. NOTE: Contact Eaton VORAD at (800) 840–7970 for additional assistance.
48/CONTROLLER	J1939 CCVS communications/ wire integrity, connectors, cruise control switch(es).	254	12	1. — Check the connection of the J1939 harness to the vehicle J1939 backbone and for damage to the harness. 2. — Check the connection of the J1939 wires at pin number 7 positive, pin number 8 negative, and pin number 9 shield on the bottom row of the CPU connector. 3. — Confirm that the cruise control switch(es) operates properly. NOTE: Contact Eaton VORAD at (800) 840–7970 for additional assistance.
51/CONTROL DISPLAY UNIT	No DDU power message/DDU, wire integrity, connectors.	9	12	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 3. — Check the J1587 wire connections and for damage to the wires.

Troubleshooting

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
52/CONTROL DISPLAY UNIT	No DDU ID message/DDU, wire integrity, connectors, driver ID card.	9	12	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 3. — Check the J1587 wire connections and for damage to the wires. 4. — Insert the driver ID card and confirm that it is identified.
53/CONTROL DISPLAY UNIT	DDU reset message error/DDU, wire integrity, connectors.	9	12	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 3. — Check the J1587 wire connections and for damage to the wires.
54/CONTROL DISPLAY UNIT DDU VBUS TIMEOUT	No VBUS communications/ wire integrity, connectors.	9	12	1. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 2. — Check the J1587 wire connections and for damage to the wires.
61/CONTROL DISPLAY UNIT DDU VBUS	No VBUS communications/ wire integrity, connectors.	9	12	1. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires. 2. — Check the J1587 wire connections and for damage to the wires.
62/CONTROL DISPLAY UNIT	DDU volume input error/DDU, wire integrity, connectors.	9	5	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires.
63/CONTROL DISPLAY UNIT	DDU range input error/DDU, wire integrity, connector.	9	5	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires.
64/CONTROL DISPLAY UNIT	DDU speaker error/ DDU, wire integrity, connector.	4	5	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires.
65/CONTROL DISPLAY UNIT DDU SPEAKER DRIVER	No DDU speaker output/DDU, wire integrity, connector.	4	5	1. — Confirm that the DDU indicator lights, speaker, and knobs function properly. ‡ 2. — Check the connection of the DDU wires in the main harness to the CPU and for damage to the wires.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
71/FORWARD ANTENNA NO FE POWER MESSAGE	No FE power message/antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
72/FORWARD ANTENNA NO FE ID MESSAGE	No FE ID message/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
73/FORWARD ANTENNA FE RESET MESSAGE	FE reset message/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
74/FORWARD ANTENNA FE VBUS TIMEOUT	FE VBUS time-out/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
81/FORWARD ANTENNA FE ADC INTERRUPT	FE ADC interrupt/ antenna assembly, wire integrity, connector.	2	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
83/FORWARD ANTENNA FE NOISE FLOOR	FE noise floor/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.

Troubleshooting

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
84/FORWARD ANTENNA FE MODULATION	FE modulation/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
85/FORWARD ANTENNA FE FREQUENCY INJECTION	FE frequency injection/antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
86/FORWARD ANTENNA FE PROGRAM CRC	FE program CRC/ antenna assembly, wire integrity, connector.	1	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
87/FORWARD ANTENNA	Forward antenna communications/ antenna assembly, wire integrity, connector.	2	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
88/FORWARD ANTENNA	Forward antenna communications/ antenna assembly, wire integrity, connector.	2	12	1. — Walk in front of the antenna and verify that the reported target distance and azimuth angle are correct. ‡ 2. — Check the connection of the antenna assembly wires in the main harness to the CPU and for damage to the wires and connector pins. 3. — Check the condition of the J1587 wires and for damage to the wires.
91/VEHICLE BATTERY	Vehicle battery/ vehicle battery problem.	0	0	1. — Inspect the vehicle batteries and determine the problem. 2. — Charge or replace the vehicle batteries.

Fault Code Troubleshooting				
Fault Code *	**Cause/Source**	**SID**	**FMI**	**Remedy**
92/HEAVY RAIN	Heavy rain/side sensor, wire integrity, connectors.	0	0	1. — In heavy rain conditions, this is not an error. 2. — Confirm that the vehicle has a side sensor. 3. — Check the side sensor to CPU connection and for damage to the wire harness. 4. — While performing the SS test, wave your hand in front of the side sensor and confirm that the correct signal is received. ‡ 5. — Disconnect the three-pin side sensor and CPU connectors. Check for corrosion or a recessed pin.
93/SOFTWARE	Software error/ software, CPU, antenna assembly, DDU, side sensor.	0	0	1. — The software detects a J1587 transmit or receive buffer overflow. 2. — Internal component failure. Cannot be repaired in the field. †
94/VBUS Q	VBUS queue error/ software.	0	0	1. — The software detects a VBUS transmit or receive buffer overflow. 2. — Internal component failure. Cannot be repaired in the field. †
10/END	No faults found, or end of fault codes.	0	0	1. — No faults found. 2. — End of fault codes.

* MID (message identifier) # 219 applies to all the fault codes in this table. This MID has been assigned to collision avoidance radar.

† Return the CPU to the manufacturer for repair and/or replace it.

‡ A ProLink 9000 diagnostic tool, equipped with an Eaton VORAD cartridge or a multi-protocol cartridge with the Eaton applications PCMCIA card, is required to perform checkout and configuration procedures.

Table 2, Fault Code Troubleshooting

IMPORTANT NOTIFICATION: Servicing of the Eaton VORAD Collision Warning System should be undertaken only by qualified technicians. Special skills and equipment are required to perform these procedures. For assistance, contact Eaton VORAD at (800) 840–7970.

The Columbia Collision Warning System overlay harness is similar to the Century Class harness. A schematic of the Century Class overlay harness is included for reference only. See **Fig. 1**.

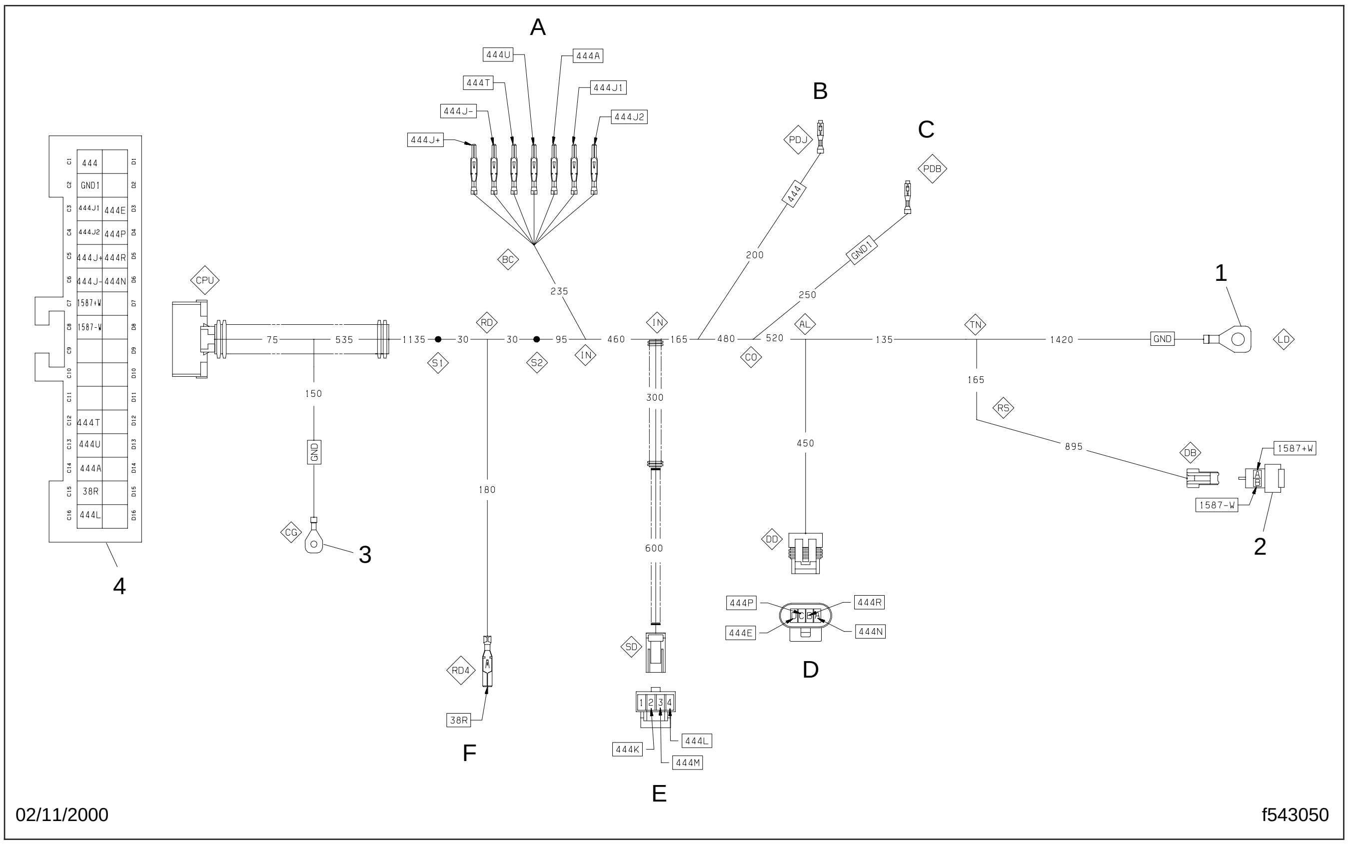


Fig. 1, Harness Assembly (Century Class, for reference only)

Torque Specifications		
Description	**lbf·ft**	**N·m**
Antenna Mounting Plate Capscrews and Locknuts	28	38

Table 1, Torque Specifications

Specifications

Component Specifications			
Description	**Inches**	**Millimeters**	**Degrees**
Antenna Assembly Azimuth Setting	—	—	0
Antenna Assembly Vertical Angle	—	—	1 Down (89 or 91)

Table 2, Component Specifications

General Description

The ICU4 instrument cluster is an individual-gauge cluster with an intelligent light bar that houses the integrated warning and indicator lights on the dash message center (light bar faceplate). See **Fig. 1**. It looks very similar to the ICU2L instrument cluster except for two differences:

- ICU4 gauges sweep 270 degrees
- the ICU4 has a mode/reset switch on the light-bar display to the right of the message display screen
- the ICU4 has an LCD display

NOTE: The ICU4 component that houses the dash message center is called the light bar in this manual. The dash message center is also referred to as the light bar faceplate.

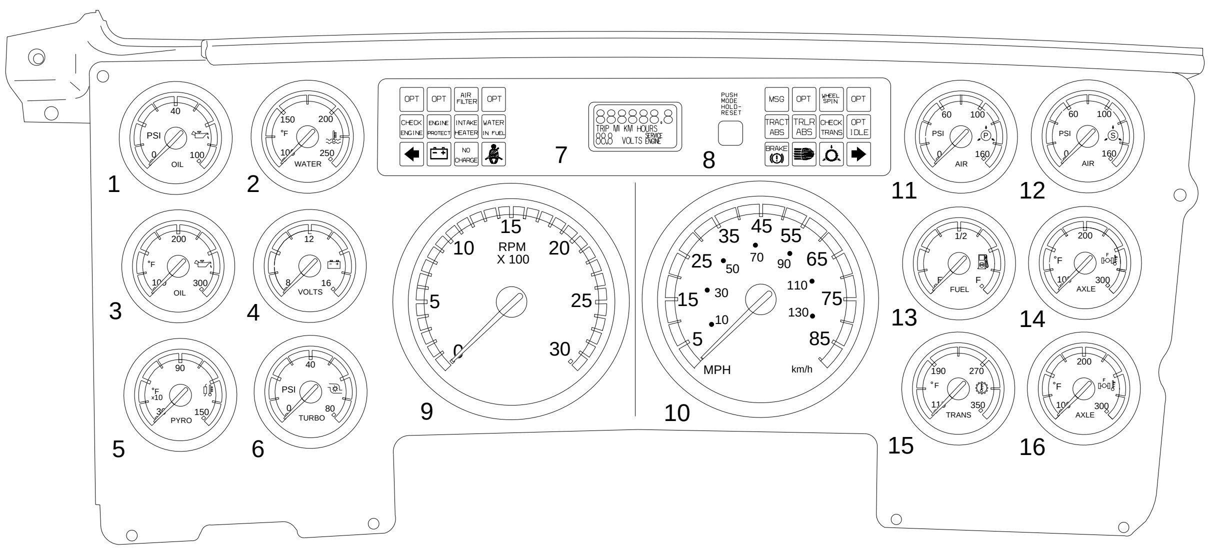
There can be up to 14 removable gauges on the driver's instrument panel. The ICU4 can also drive gauges located on the auxiliary instrument panel.

The ICU4 dash message center includes a set of 24 warning and indicator lights, and a message display screen in the center. See **Fig. 2**.

Standard gauges are:

- speedometer
- engine coolant temperature
- engine oil pressure
- battery voltmeter
- fuel level

NOTE: Some vehicles may be equipped with a digital display voltmeter integrated into the mes-



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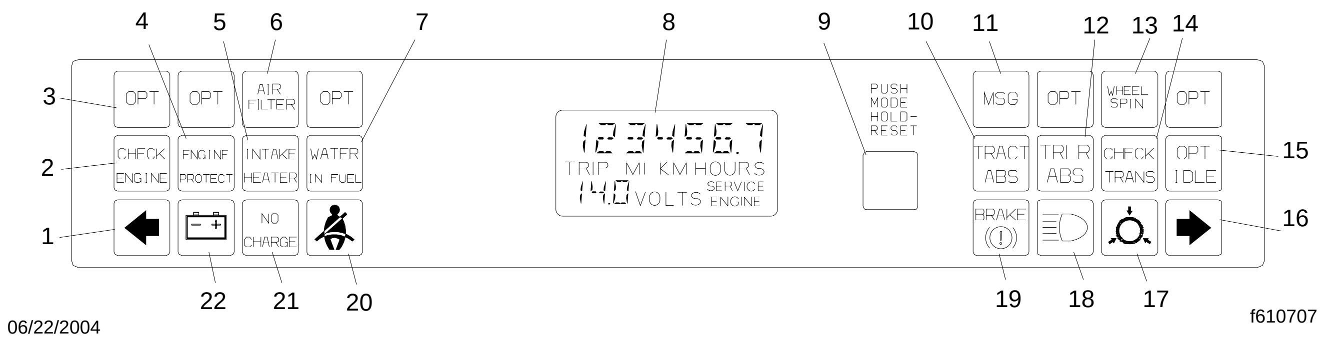
1. Engine Oil Pressure Gauge
2. Engine Coolant Temperature Gauge
3. Engine Oil Temperature Gauge
4. Battery Voltage Gauge
5. Pyrometer
6. Turbo Boost Air Pressure Gauge
7. Dash Message Center (light bar faceplate)
8. Mode/Reset Switch
9. Tachometer
10. Speedometer
11. Primary Air Pressure Gauge
12. Secondary Air Pressure Gauge
13. Fuel Level Gauge
14. Axle Temperature Gauge
15. Transmission Oil Temperature Gauge
16. Axle Temperature Gauge

Fig. 1, ICU4 Instrument Cluster (typical)

General Information



1. Left Turn Signal
2. Check Engine Indicator
3. Optional Indicator
4. Engine Protection Warning
5. Intake Heater Indicator
6. Air Filter Indicator
7. Water in Fuel Indicator
8. Message Display Screen
9. Mode/Reset Switch
10. Tractor ABS Indicator
11. Message Indicator
12. Trailer ABS Indicator
13. Wheel Spin Indicator
14. Check Transmission Indicator
15. Optimized Idle Indicator
16. Right Turn Signal
17. Low Air System Pressure Warning
18. High Beam Indicator
19. Parking/Emergency Brake Warning
20. Fasten Seat Belt Warning
21. No Charge Indicator (alternator)
22. Low Vehicle Battery Voltage

Fig. 2, ICU4 Dash Message Center (typical)

sage display screen instead of a battery voltage gauge. See **Fig. 3**.

Gauges with an integrated warning light on the gauge are listed below with an indication of how the warning light is activated:

- engine coolant temperature (high)
- engine oil pressure (low)
- fuel level (low)
- transmission oil temperature (high)

Other available gauges include:

- tachometer

Fig. 3, Message Display Screen with Integrated Digital Voltmeter

- engine oil temperature
- transmission oil temperature
- axle temperature; forward-rear, and rear-rear
- ammeter
- air pressure; primary, secondary, application, and suspension
- pyrometer
- turbo boost

Warning and Indicator Lights

Up to 24 warning and indicator lights can be installed in the ICU4; the bottom two rows (16 total) are fixed, and the eight positions in the top row are optional. There may also be up to four gauges with a warning light integrated on the gauge.

The red engine protection (ENGINE PROTECT) light comes on to indicate that the protection system available for the engine has been activated. If the engine coolant temperature, the coolant level, the engine oil pressure, or on some engines, the engine oil temperature or the intake air temperature reach preset levels, the engine will begin a warning and shutdown

General Information

process. The engine ECU will begin to reduce the maximum engine torque and speed and, if the condition does not improve, will shut down the engine within 30 seconds of the light illuminating. The driver must safely bring the vehicle to a stop on the side of the road and shut down the engine as soon as the red light is seen. If the engine shuts down while the vehicle is in a hazardous location, the engine can be restarted after turning the key to the OFF position for a few seconds.

The standard warning and indicator lights operate as follows:

- The green right-turn and left-turn signal lights flash on and off whenever the outside turn signal lights are flashing.
- The blue high-beam indicator light comes on when the headlights are on high beam.
- The yellow CHECK ENGINE indicator comes on when an engine fault is detected or recorded. The check engine light is controlled by the engine ECM. See the engine manufacturer's manuals for troubleshooting.
- The red low air pressure warning light (a circle with arrows symbol) and buzzer activate whenever air pressure in the primary or secondary air reservoir falls below 64 to 76 psi (440 to 525 kPa).
- The red high coolant temperature warning light (located on the engine coolant temperature gauge) and buzzer activate whenever the coolant temperature goes above a maximum level whenever the cluster receives a high coolant fault message from the engine (MID 128, PID 110, and FMI 00).
- The red low engine oil pressure warning light (located on the engine oil pressure gauge) and buzzer activate whenever the engine oil pressure goes below a minimum level whenever the cluster receives a low oil pressure fault message from the engine (MID 128, PID 100, and FMI 01).
- The yellow high transmission oil temperature indicator (located on the optional transmission oil temperature gauge) activates when the transmission fluid temperature goes above a maximum level specified by the transmission manufacturer. This telltale is directly controlled by the transmission via hard wire input to the cluster.
- The red parking/emergency brake (BRAKE!) warning light activates whenever the parking brake is engaged. A buzzer also activates when the vehicle is moving at least 2 mph (3 km/h) with the parking brake set.
- The yellow low fuel indicator (located on the fuel gauge) activates when the fuel tank is less than 1/8 full.
- The red fasten seat belt warning symbol illuminates for 15 seconds when the ignition key is turned to the ON position.
- The yellow INTAKE HEATER indicator illuminates to indicate that the intake air heater is active. This telltale is directly controlled by the engine via hard wire input to the cluster.
- The yellow WATER IN FUEL indicator illuminates to indicate that the fuel could contain water. This telltale is directly controlled by the engine via hard wire input to the cluster.
- The yellow tractor ABS (TRACT ABS) indicator illuminates when a problem with the ABS system is detected. This telltale is directly controlled by the ABS via hard wire input to the cluster.
- The yellow check transmission (CHECK TRANS) indicator illuminates when a problem with the electronic transmission is detected. This telltale is directly controlled by the transmission via hard wire input to the cluster.
- The yellow Optimized Idle (OPT IDLE) indicator illuminates on vehicles equipped with a Detroit Diesel engine and the Optimized Idle system when Optimized Idle is active and controlling the engine start and stop functions. This system operates only when the vehicle is stopped and the parking brake is on. This telltale is directly controlled by the engine via hard wire input to the cluster.
- The red low vehicle battery voltage warning light (battery symbol) illuminates when the battery voltage is 11.9 volts or less. This telltale is controlled by the cluster by monitoring the voltage message from the engine.
- The yellow alternator NO CHARGE indicator illuminates to indicate an alternator charge output failure. This telltale is directly controlled by the alternator via hard wire input to the cluster.

General Information

The yellow trailer ABS (TRLR ABS) indicator operates as follows when a compatible trailer is properly connected to a tractor before the engine is started (PLC trailers only):

- With the ignition key in the ON position, the trailer ABS lamp illuminates momentarily, then turns off.
- If the lamp comes on momentarily during vehicle operation, then shuts off, a fault was detected and corrected.
- If the lamp comes on and stays on during vehicle operation, there is a fault with the trailer ABS. Repair the trailer ABS system immediately to ensure full antilock braking capability.

The trailer ABS lamp will not illuminate unless a compatible trailer is connected to the tractor.

NOTE: When connected to a PLC-equipped trailer, this telltale is directly controlled by the **tractor** ABS ECU via hard wire input to the cluster.

On non-PLC-equipped trailers, this telltale is directly controlled by the **trailer** ABS ECU via hard wire input to the cluster.

The eight warning and indicator light positions on the top row of the light bar are optional. Available optional indicator lights include: low washer fluid, automatic transmission overheat warning, wheel spin warning, impaired air filter warning, ECAS (electronic suspension) transfer indicator, and ECAS failure warning.

Buzzer and Chime

The buzzer sounds for 3 seconds during the self-test at start-up, and when the following conditions exist:

- low air pressure
- low oil pressure
- high coolant temperature
- the parking brake is applied and the vehicle is moving at a speed of at least 2 mph (3 km/h)

A friendly chime sounds when the parking brake is off and the door is open, or when the headlights are on and the door is open.

Ignition Sequence

When the ignition key is turned on, the ICU4 begins a self-test. During this process all gauges controlled by the cluster sweep to full scale and return, the buzzer sounds for 3 seconds, the fasten seat belt warning light illuminates for 15 seconds, and the following warning lights illuminate then turn off: battery voltage, low air pressure, parking brake, low oil pressure, high coolant temperature, high transmission temperature, and low fuel level. Then the software revision level of the ICU4 is displayed, followed by active faults, if any, then the odometer display.

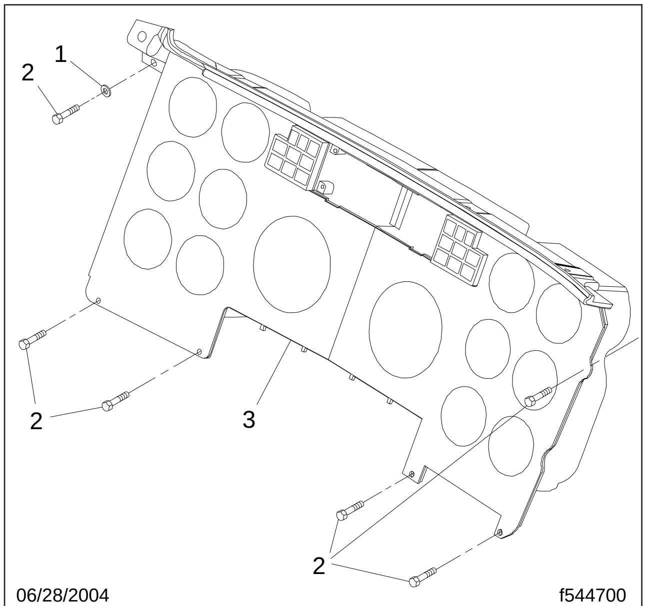
Replacement

To replace the following components, refer to the indicated subject.

- Individual gauges, see **Subject 110**
- Light bar, see **Subject 120**
- Light bulbs or telltales, see **Subject 130**

ICU4

1. Remove the left-hand dash panels. Be sure the screws attaching the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08**, Subject 100.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.
3. Remove the fasteners that secure the driver's instrument panel. Fasteners used on the ICU4 are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.



1. #10 Stainless Steel Flat Washer, 1/2" O.D.
2. 7/8" Dog-Point Torx Mounting Capscrew
3. ICU4 Cluster

Fig. 1, ICU4 Dash Panel Installation

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

4. Disconnect the electrical harness connectors from the back of the light bar. These include the 32-pin light bar connector, the 24-pin light bar connector, and the two 6-pin gauge databus connectors. Also disconnect the 3-pin auxiliary input connector, if so equipped. See **Fig. 2**.

IMPORTANT: Bleed off all air before trying to remove the air hoses.

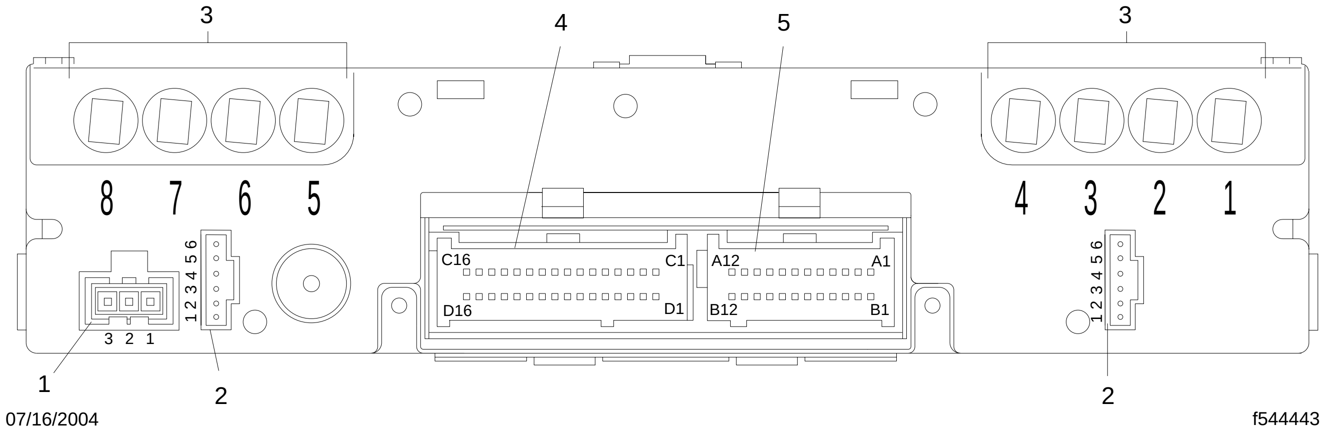
5. Using a paint pen, mark the air hoses for ease of installation. After bleeding all air from the system, disconnect all air gauge hoses.
6. Remove the light bar faceplate by placing a small flat blade under each end near the center and carefully pry it forward to release the locking tabs.
7. When all fasteners and connections between the cluster and the dash have been disconnected, remove the old ICU from the dash. See **Fig. 3**.
8. Remove the light bar from the back by removing its four Torx mounting capscrews from the front of the ICU4. The top two mounting capscrews also secure the trimtop to the cluster housing.
9. Disconnect each gauge from the others by disconnecting the daisy chain harness connectors.

NOTE: Record the location of each gauge before removing them if the same configuration is desired for reinstallation. Gauges must be installed in the appropriate size panel opening, and they must all be connected to each other in daisy-chain fashion in order to work, but a specific location for each gauge is not necessary.

10. Remove all gauges. See **Fig. 4**.

    10.1 To remove the speedometer and tachometer, remove the two Torx mounting cap-

ICU4 Replacement



1. 3-Pin Auxiliary Input Connector
2. 6-Pin Gauge Databus Connector
3. Optional Telltale Bulbs
4. 32-Pin Light Bar Connector
5. 24-Pin Light Bar Connector

Fig. 2, Light Bar Connector Pin Locations (rear view)

screws that secure the mounting bracket and the gauge to the cluster.

10.2 For small gauges, push in and twist the black plastic gauge mounting collar counterclockwise slightly until the collar unlocks from the gauge. Remove the gauge through the front of the opening and the collar and wave ring from the back.

11. Remove the remaining screw that attaches the dash panel trimtop to the old ICU.

12. Attach the dash panel trimtop to the replacement ICU cluster housing.

13. Install the gauges in their appropriate openings. See **Fig. 4**.

13.1 For the speedometer and tachometer, orient the gauge and place it through the opening from the front. Then place the mounting bracket on the back of the gauge and install the two Torx mounting capscrews.

13.2 For small gauges, orient the gauge and place it through the front of the opening, and place the collar and wave ring from the back. Push the gauge mounting collar against the wave ring and twist the collar clockwise until the collar locks in place.

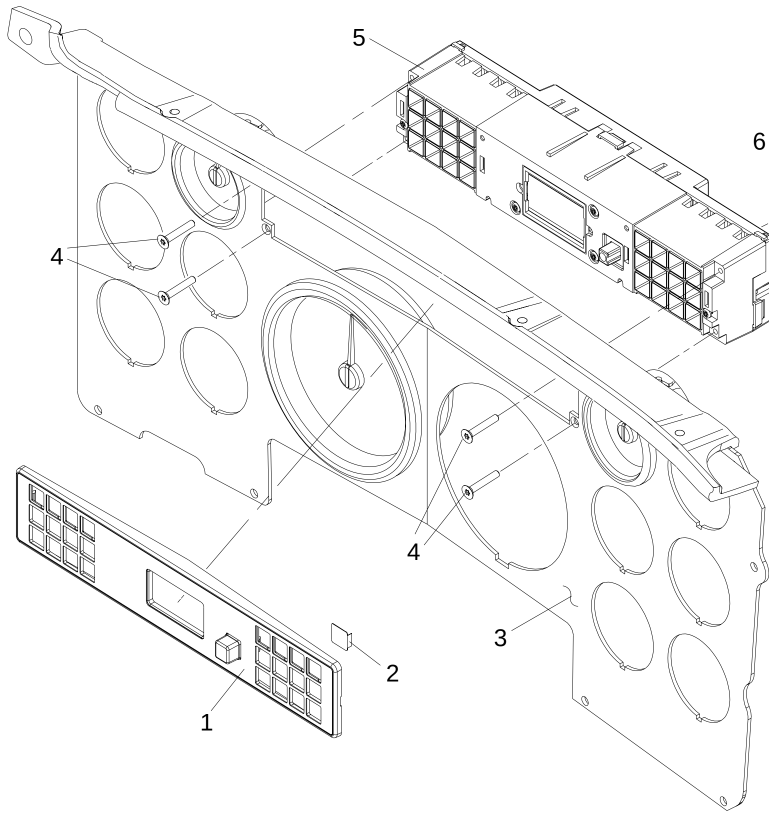
14. Install the light bar. Place it into the opening from the back and install its four Torx mounting capscrews from the front of the ICU4. The top two mounting capscrews also secure the trimtop to the cluster housing. Hold the triptop so its mounting tabs are flush to the cluster, then secure the light bar. See **Fig. 3**.

15. Install the light bar faceplate by placing it over the front of the light bar, then carefully press it on until its end tabs lock in place.

16. Connect each gauge to the others on each side of the cluster by connecting the harnesses in a daisy-chain fashion.

16.1 Start by connecting the inside harness of one of the two large gauges to the closest 6-pin connector on the light bar. Then connect the harness on the outside of the gauge to the nearest plug at the top of the column of small gauges next to it. Connect the other harness from the small gauge to the one below it. Continue working down, then across the bottom to the column of gauges next to it, then up the column. The final gauge in the chain will connect only to the gauge immediately below it.

16.2 Connect the gauges on the other side of the cluster in similar fashion. Start with the other large gauge, connect it to the nearest 6-pin connector on the light bar, then connect the other harness from the large gauge to the small gauge nearest on the



1. Light Bar Faceplate
2. Telltale
3. ICU4 Cluster
4. Light Bar Mounting Capscrews
5. Light Bar
6. Light Bulb

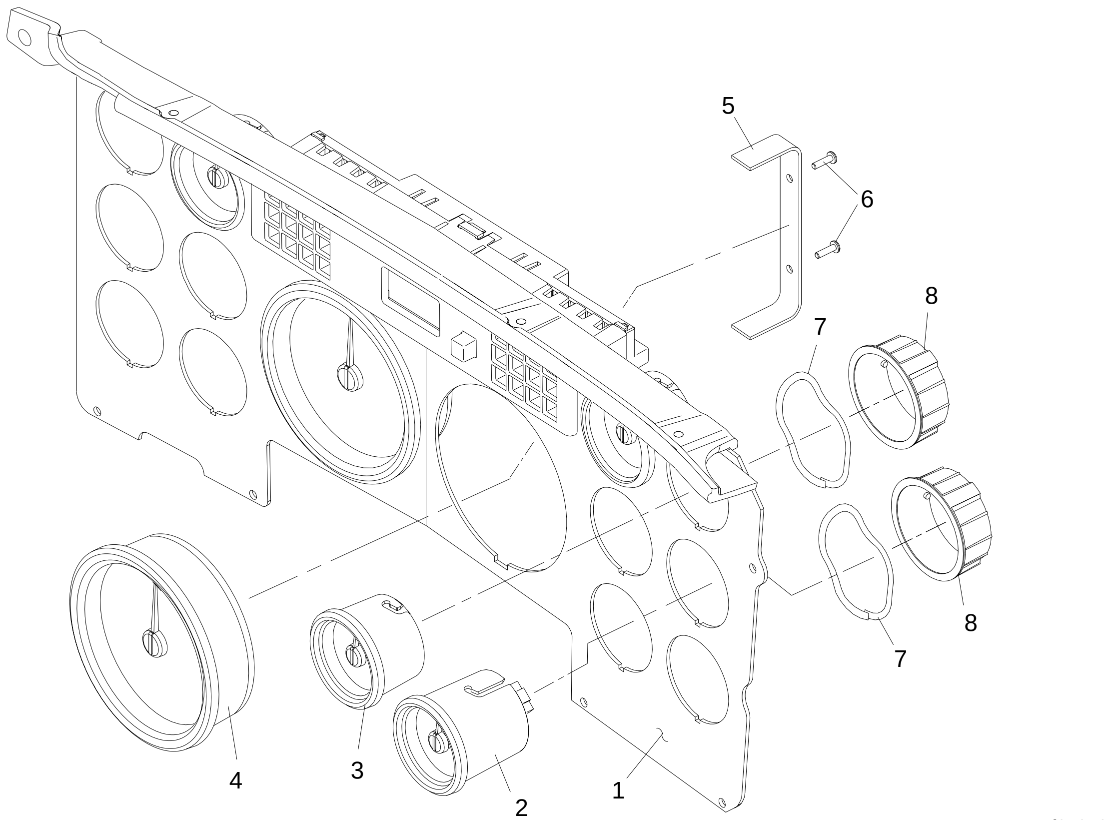
Fig. 3, Light Bar Replacement

top inside column and work similarly down the inside column and up the outside column around so all gauges are connected in the chain.

17. Place the ICU4 cluster close to its dash opening and connect the air hoses to the air gauges as marked on removal.
18. Connect all remaining electrical harnesses to the back of the light bar. These include the 32-pin light bar harness connector, the 24-pin light bar harness connector, and the 3-pin auxiliary input harness connector, if so equipped. See **Fig. 2**.
19. Install the fasteners that secure the cluster to the dash. Fasteners used on the ICU4 are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.
20. Install all remaining dash panels. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel. For instructions, see **Section 60.08**, Subject 100.
21. Turn on the ignition and test the operation of the ICU. All gauges controlled by the cluster sweep to full scale and return, the buzzer sounds for 3 seconds, the fasten seat belt warning light illuminates for 15 seconds, and the battery voltage, low air pressure and parking brake warning lights illuminate then turn off.

    If any gauges are not working properly, see **Subject 300** for troubleshooting information.

ICU4 Replacement



1. ICU4 Cluster Housing
2. Air Pressure Gauge
3. Small Gauge
4. Large Gauge (Speedometer or Tachometer)
5. Large Gauge Mounting Bracket
6. Large Gauge Mounting Capscrews
7. Wave Ring
8. Small Gauge Mounting Collar

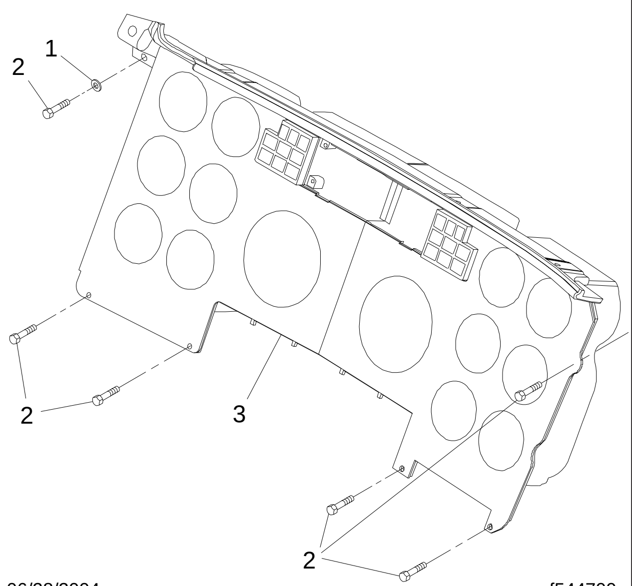
Fig. 4, ICU4 Gauge Installation

Gauge Replacement

Use the instructions for removing the dash panels that follow to access the back to the ICU4. Then go to the appropriate instructions to replace each type of gauge. Then use the instructions at the end of the subject for installing the dash panels.

Removing the Dash Panels

1. Remove the left-hand dash panels. Be sure the screws attaching the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08**, Subject 100.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.
3. Remove the fasteners that secure the driver's instrument panel. Fasteners used on the ICU4 are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.



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1. #10 Stainless Steel Flat Washer, 1/2" O.D.
2. 7/8" Dog-Point Torx Mounting Capscrew
3. ICU4 Cluster

Fig. 1, ICU4 Dash Panel Installation

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

4. Carefully pull the dash panel forward to gain access to the gauges from behind the panel.

Speedometer and Tachometer

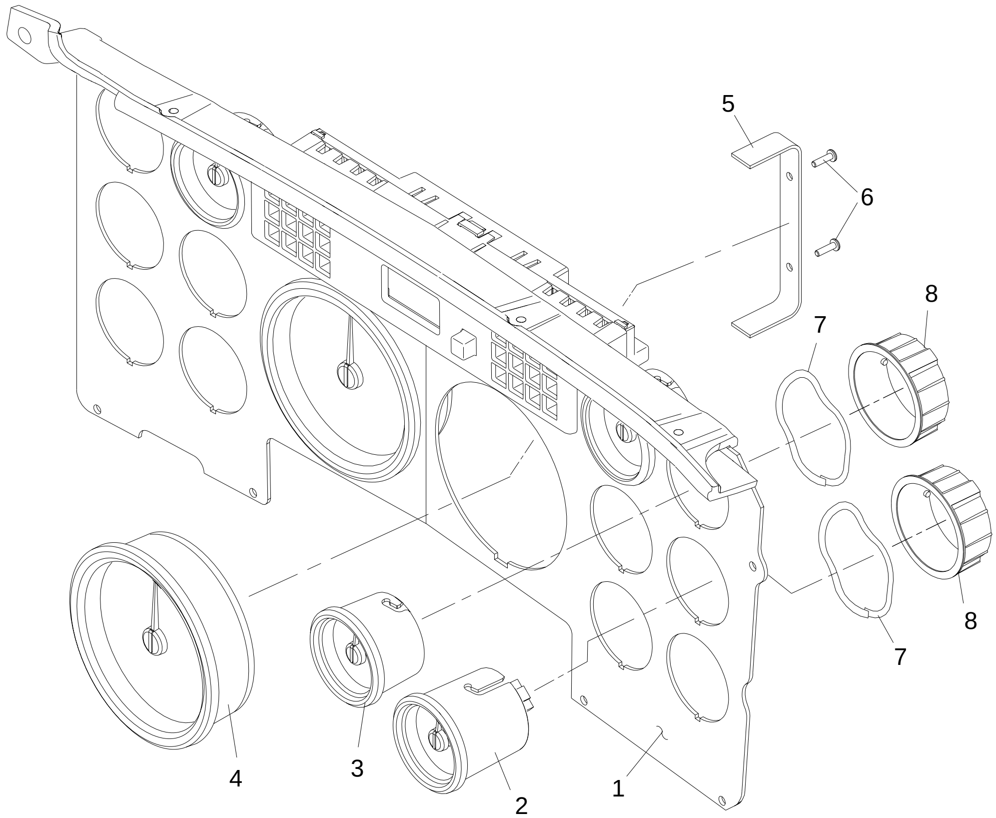
1. Disconnect the electrical harness connectors from the back of the gauge.
2. Remove the two Torx mounting capscrews that secure the mounting bracket and the gauge to the cluster. See **Fig. 2**.
3. Orient the replacement gauge and place it through the opening from the front. Then place the mounting bracket on the back of the gauge and install the two Torx mounting capscrews.
4. Connect both wire harnesses to the back of the gauge.
5. See the instructions that follow to install the dash panels.

Air Pressure Gauges

IMPORTANT: Bleed off all air before trying to remove the air hoses.

1. Using a paint pen, mark the air hoses for ease of installation. After bleeding all air from the system, disconnect the air gauge hoses.
2. Unplug both wire harnesses from the back of the gauge.
3. Note the location of each gauge before removing them if multiple gauges are being replaced. To remove the gauge, push in and twist the black plastic gauge mounting collar counterclockwise slightly until the collar unlocks from the gauge. Remove the gauge through the front of the opening and the collar and wave ring from the back. See **Fig. 2**.
4. Orient the replacement gauge and place it through the front of the opening, and place the collar and wave ring from the back. Push the

Gauge Replacement



1. ICU4 Cluster Housing
2. Air Pressure Gauge
3. Small Gauge
4. Large Gauge (Speedometer or Tachometer)
5. Large Gauge Mounting Bracket
6. Large Gauge Mounting Capscrews
7. Wave Ring
8. Small Gauge Mounting Collar

Fig. 2, ICU4 Gauge Installation

gauge mounting collar against the wave ring and twist the collar clockwise until the collar locks in place.

5. Connect both wire harnesses to the back of the gauge.
6. Connect the air gauge hoses.
7. See the instructions that follow to install the dash panels.

All Other Gauges

1. Unplug both wire harnesses from the back of the gauge.
2. Note the location of each gauge before removing them if multiple gauges are being replaced. To remove the gauge, push in and twist the black plastic gauge mounting collar counterclockwise slightly until the collar unlocks from the gauge. Remove the gauge through the front of the opening, and the collar and wave ring from the back. See **Fig. 2**.
3. Orient the replacement gauge and place it through the front of the opening, and place the collar and wave ring from the back. Push the gauge mounting collar against the wave ring and twist the collar clockwise until the collar locks in place.
4. Connect both wire harnesses to the back of the gauge.

5. See the instructions that follow to install the dash panels.

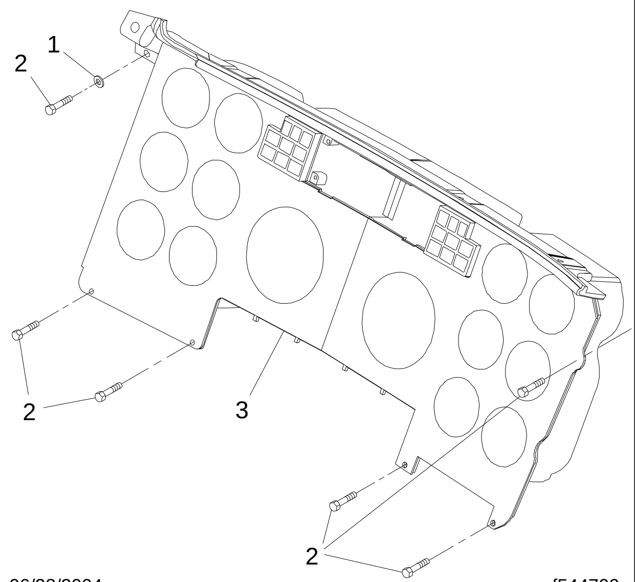
Installing the Dash Panels

1. Install the fasteners that secure the cluster to the dash. Fasteners used on the ICU4 are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.
2. Install all remaining dash panels. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel. For instructions, see **Section 60.08**, Subject 100.
3. Turn on the ignition and test the operation of the ICU. All gauges controlled by the cluster sweep to full scale and return, the buzzer sounds for 3 seconds, the fasten seat belt warning light illuminates for 15 seconds, and the battery voltage, low air pressure and parking brake warning lights illuminate then turn off.

   If any gauges are not working properly, see **Subject 300** for troubleshooting information.

Light Bar Replacement

1. Remove the left-hand dash panels. Be sure the screws attaching the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08**, Subject 100.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.
3. Remove the fasteners that secure the driver's instrument panel. Fasteners used on the ICU4 are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.



1. #10 Stainless Steel Flat Washer, 1/2" O.D.
2. 7/8" Dog-Point Torx Mounting Capscrew
3. ICU4 Cluster

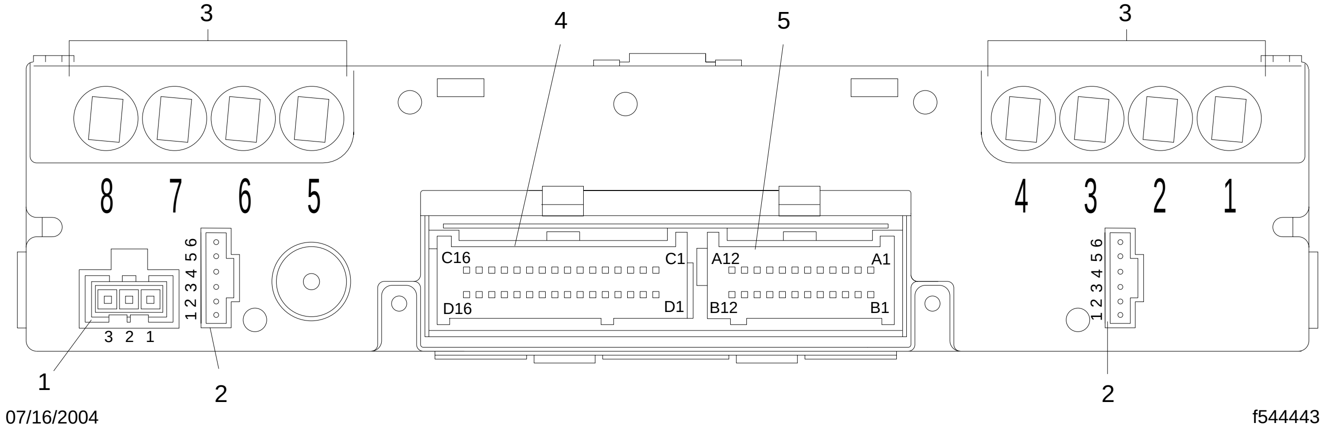
Fig. 1, ICU4 Dash Panel Installation

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

4. Disconnect the electrical harness connectors from the back of the light bar. These include the 32-pin light bar connector, the 24-pin light bar connector, and the two 6-pin gauge databus connectors. Also disconnect the 3-pin auxiliary input connector, if so equipped. See **Fig. 2**.
5. Remove the light bar faceplate by placing a small flat blade under each end near the center and carefully pry it forward to release the locking tabs.
6. Remove the light bar from the back by removing its four Torx mounting capscrews from the front of the ICU4. The top two mounting capscrews also secure the trimtop to the cluster housing. See **Fig. 3**.
7. Install the replacement light bar. Place it into the opening from the back and install its four Torx mounting capscrews from the front of the ICU4. The top two mounting capscrews also secure the trimtop to the cluster housing. Hold the trimtop so its mounting tabs are flush to the cluster, then secure the light bar. See **Fig. 3**.
8. Install the light bar faceplate by placing it over the front of the light bar, then carefully press it on until its end tabs lock in place.
9. Connect the electrical harnesses to the back of the light bar; the 32-pin harness connector, the 24-pin harness connector, the two 6-pin databus harness connectors from the speedometer and tachometer, and the 3-pin auxiliary input harness connector, if so equipped. See **Fig. 2**.
10. Install the fasteners that secure the cluster to the dash. Fasteners used on the ICU4 are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.
11. Install all remaining dash panels. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel. For instructions, see **Section 60.08**, Subject 100.
12. Turn on the ignition and test the operation of the ICU. All gauges controlled by the cluster sweep to full scale and return, the buzzer sounds for 3 seconds, the fasten seat belt warning light illuminates for 15 seconds, and the battery voltage, low air pressure and parking brake warning lights illuminate then turn off.

Light Bar Replacement

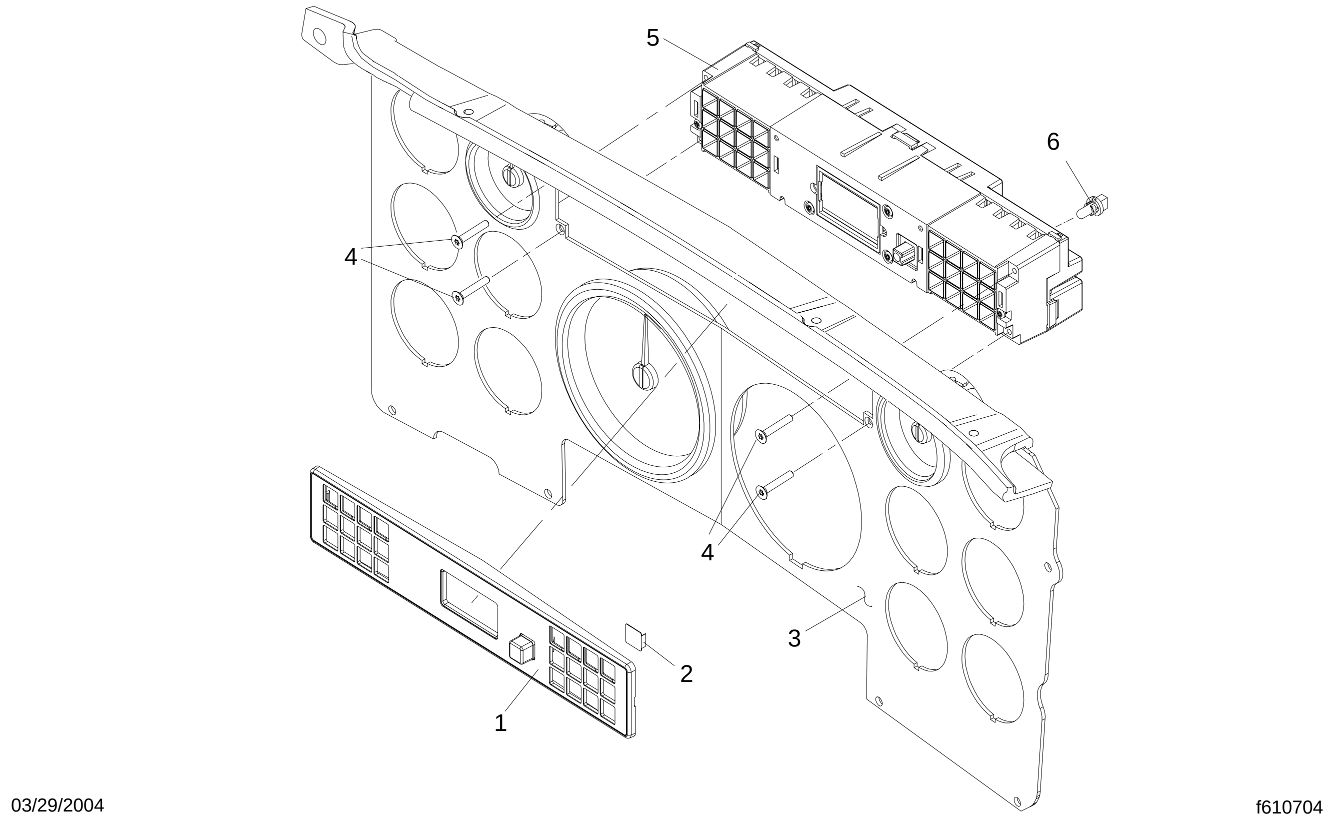


1. 3-Pin Auxiliary Input Connector
2. 6-Pin Gauge Databus Connector
3. Optional Telltale Bulbs
4. 32-Pin Light Bar Connector
5. 24-Pin Light Bar Connector

Fig. 2, Light Bar Connector Pin Locations (rear view)

If any gauges are not working properly, see **Subject 300** for troubleshooting information.

Light Bar Replacement



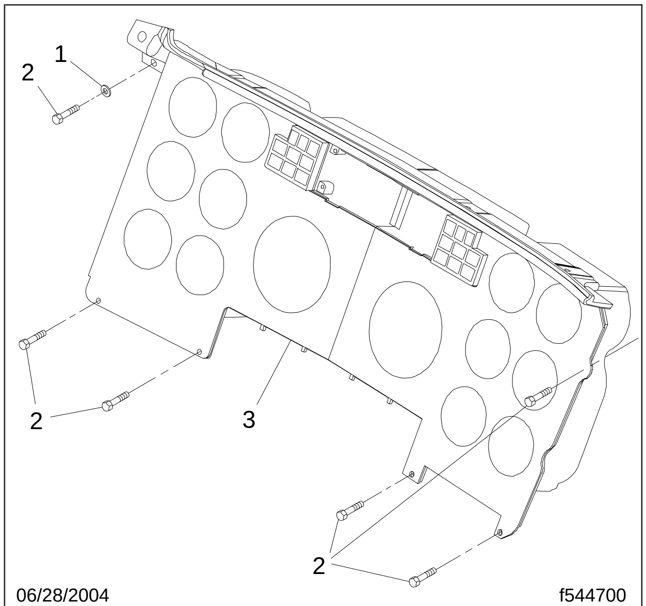
1. Light Bar Faceplate
2. Telltale
3. ICU4 Cluster
4. Light Bar Mounting Capscrews
5. Light Bar
6. Light Bulb

Fig. 3, Light Bar Replacement

Light Bulb Replacement

NOTE: Only the top row of warning and indicator lights have replaceable bulbs. The replaceable bulbs are incandescent. All lights in this row are optional, so not all positions may be in use. See the troubleshooting procedures in **Subject 300** to diagnose warning and indicator light problems and solutions.

1. Remove the left-hand dash panels. Be sure the screws attaching the dash panel trimtop to the upper dash assembly have been removed. For instructions, see **Section 60.08**, Subject 100.
2. Remove the screw that attaches the dash panel trimtop to the lower dash panel. This screw is located on the far left of the trimtop.
3. Remove the fasteners that secure the driver's instrument panel. Fasteners used on the ICU4 are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.



1. #10 Stainless Steel Flat Washer, 1/2" O.D.
2. 7/8" Dog-Point Torx Mounting Capscrew
3. ICU4 Cluster

Fig. 1, ICU4 Dash Panel Installation

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

4. Carefully pull the dash panel forward to gain access to the light bar from behind the panel.
5. Twist the burned-out bulb about 1/8-turn counterclockwise and pull it out from the back of the light bar. See **Fig. 2**.
6. Insert a new bulb into the opening on the back of the light bar and twist it about 1/8-turn clockwise until it is securely in place.
7. Install the fasteners that secure the cluster to the dash. Fasteners used on the ICU4 are 7/8" Torx pan-head dog-point screws. See **Fig. 1**.
8. Install all remaining dash panels. Be sure to install the fasteners that attach the dash panel trimtop to the upper dash assembly and lower dash panel. For instructions, see **Section 60.08**, Subject 100.
9. Turn on the ignition and test the operation of the ICU. All gauges controlled by the cluster sweep to full scale and return, the buzzer sounds for 3 seconds, the fasten seat belt warning light illuminates for 15 seconds, and the battery voltage, low air pressure and parking brake warning lights illuminate then turn off.

   If any gauges are not working properly, see **Subject 300** for troubleshooting information.

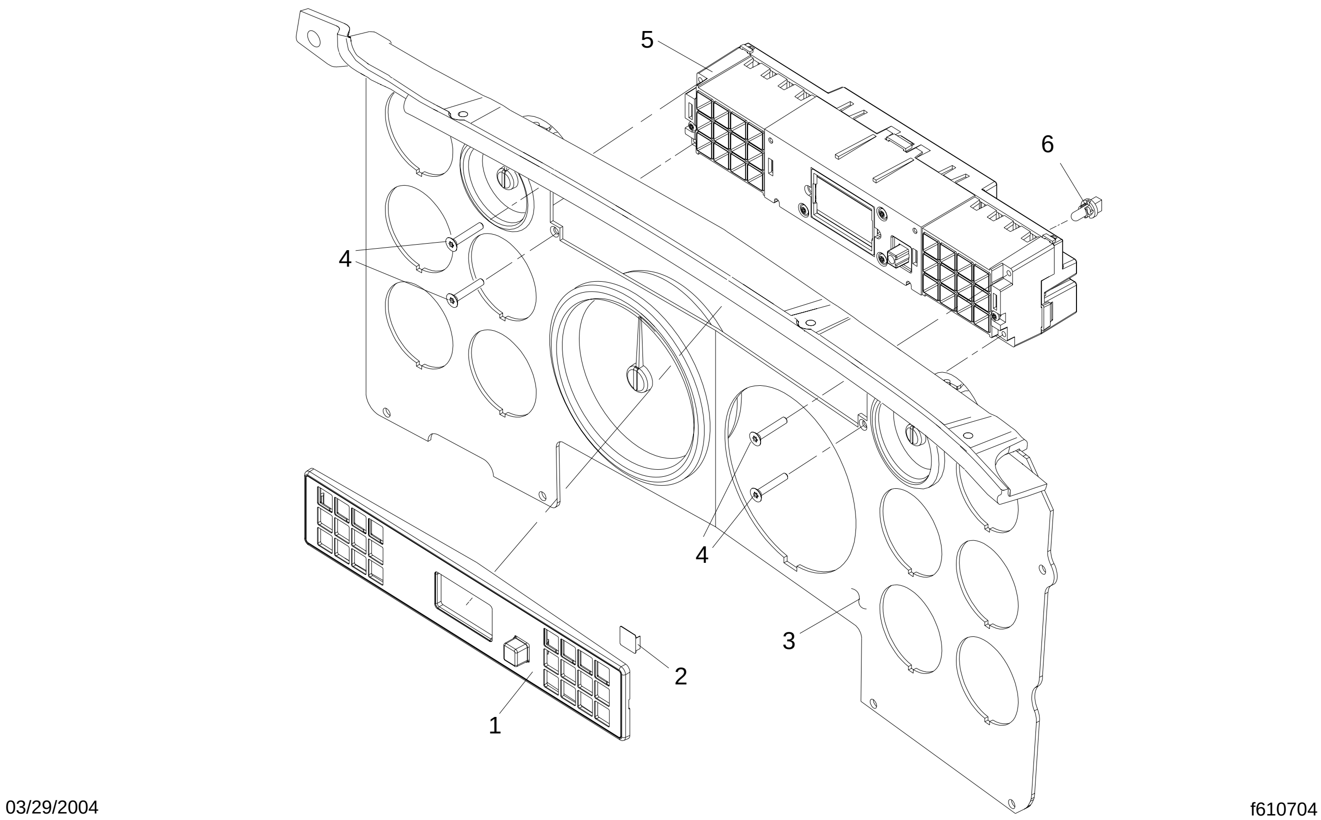
Telltale Replacement

The term "telltale" refers to the small plastic lens in the top row of the light bar faceplate (dash message center) with a warning or indicator message printed on it. These are replaceable.

CAUTION

Electronic components of the ICU are vulnerable to damage from static electricity. If available,

Light Bulb/Telltale Replacement



1. Light Bar Faceplate
2. Telltale
3. ICU4 Cluster
4. Light Bar Mounting Capscrews
5. Light Bar
6. Light Bulb

Fig. 2, ICU4 Light Bar Installation

wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU circuitry.

1. Place a flat blade under each end of the light bar faceplate and carefully pry it off the light bar.
2. Using a pair of needlenose pliers or a similar tool, grab the exposed tab along the side of the telltale slot and carefully slide the telltale out from the slot.
3. Place the replacement telltale in its correct slot the same way it was removed. Properly orient the telltale so the text is readable from the front, then slide the telltale into its slot.

Turn on the ignition keyswitch. Check all bulbs and telltales for correct operation.

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General Information

The Ametek ICU4 replaced the Pollak ICU2L in production on June 7, 2004. The ICU4 consists of individual gauges, a light bar control unit, and a daisy-chain databus. See **Fig. 1**. The light bar is the brain of the system. It contains the warning lamps as well as an LCD display. The light bar controls all of the individual gauges except the air pressure gauges. The light bar has two input types to drive the gauges: J1587 data from the engine ECM to control the databus-driven gauges, and direct-wired sensor input to control the other gauges. Each gauge has a unique address that the light bar communicates with.

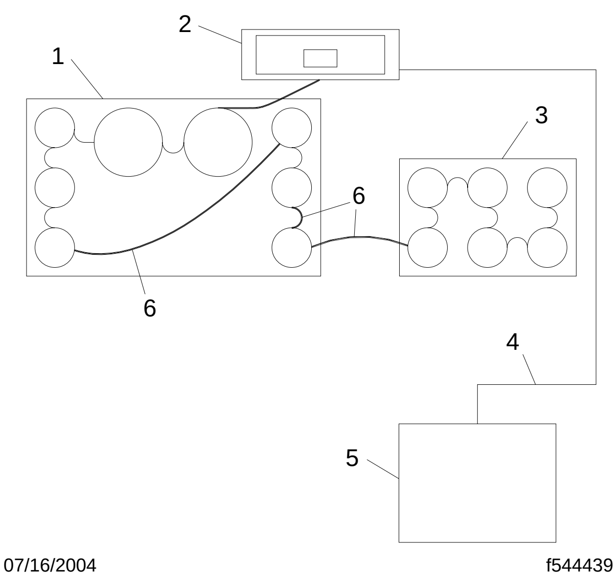
J1587-driven gauges are the:

- speedometer
- tachometer
- oil pressure gauge
- coolant temperature gauge
- oil temperature gauge
- turbo boost pressure gauge
- voltmeter

Other gauges are the:

- fuel level gauge
- primary air pressure gauge
- secondary air pressure gauge
- application air pressure gauge
- transmission temperature gauge

- forward-rear axle temperature gauge
- rear-rear axle temperature gauge
- pyrometer
- ammeter
- transmission gear display
- cruise control set speed display



1. A-Panel Gauges
2. Light Bar Control Unit (LBCU)
3. B-Panel Gauges
4. J1587 Databus
5. Engine
6. Cluster Databus (jumper wires or daisy chain)

Fig. 1, Light Bar Control Unit Block Diagram

General Troubleshooting Procedure

For gauge problems do the following:

1. Check for ICU fault codes (MID 140) and address these first. See **Table 1** for MID 140 fault code definitions and troubleshooting information. If this solves the problem, no further action is necessary. If the problem is still present, go to the next step.
2. Determine whether a single gauge or multiple gauges are malfunctioning. For a single gauge malfunction, see **Table 2**. For multiple gauges malfunctioning, see **Table 3**.

For gauge accuracy problems, see **Table 4**.

For air pressure gauge problems, see **Table 5**.

For light bar warning lamp problems, see **Table 8**.

For in-gauge warning lamp problems, see **Table 9**.

For backlighting problems, see **Table 10**.

For a list of possible light bar LCD displayed roll call and power on messages, see **Table 11** and **Table 12**.

Fault Code Troubleshooting

This section defines fault codes that originate from the instrument cluster light bar (MID 140). Use **Table 1** to diagnose all MID 140 fault codes.

J1587 Fault Code Troubleshooting				
MID	**PID/SID**	**FMI**	**Fault Code Description**	**Action**
140	p168	1	Light bar voltage too low (less than 10.5 volts)	Check voltage supply to light bar. Repair as necessary.
140	s240	12	Light bar program memory failure	Replace the light bar.
140	s254	12	Light bar controller failure	Replace the light bar.

Table 1, J1587 Fault Code Troubleshooting

Gauge Troubleshooting

The tables in this section detail specific troubleshooting procedures for gauge problems. Use **Table 2** for diagnosing a single gauge that does not work. For multiple gauge failures, use **Table 3**. For gauge inaccuracy problems, use **Table 4**. Use **Table 5** to troubleshoot air pressure gauges.

Diagnosis for a Single Gauge Not Working			
Test No.	**Test Description**	**Test Result**	**Action**
1	Does the gauge sweep when the ignition is turned on?	Yes	Go to Test 4.
		No	Go to Test 2.
2	Is this particular gauge the last one in the chain from the light bar? (If so, it will be one of the gauges that has only one jumper wire connected to it.)	Yes	Go to Test 3.
		No	Replace the gauge.
3	Remove the jumper wire to this gauge and install a known good wire. Does the gauge now work?	Yes	Replace the jumper wire.
		No	Replace the gauge.
4	Is the gauge driven by direct sensor input to the light bar? (See **Table 7** for gauge control strategy.)	Yes	If the gauge is just inaccurate, the sensor may be defective. See **Table 4** for diagnosis. If the gauge is not working, check the sender and sender wiring to the light bar. Refer to **Specifications 400** for sender specifications. If no problem is found with the sender or sender wiring, the light bar may be defective.
		No	Go to Test 5.
5	Connect ServiceLink to vehicle and open the Ametek ICU4 Instrument Cluster Datalink Monitor template. Does the gauge work on the template?	Yes	Replace the light bar.
		No	Check the sensor that drives gauge. It will usually be an input to the engine ECM. Repair as necessary.

Table 2, Diagnosis for a Single Gauge Not Working

Diagnosis for Multiple Gauges Not Working (databus-driven gauges)			
Test No.	**Test Description**	**Test Result**	**Action**
1	Do the affected gauges sweep when the ignition is turned on?	Yes	Go to Test 2.
		No	Go to Test 8.
2	Are the only affected gauges sensor driven by direct input to the light bar (gauges not J1587 databus driven)? See **Table 7** for gauge control strategy.	Yes	If the affected gauges are one or more of the following: transmission temp, ammeter, and axle temp #3, then check the common sensor ground that connects to pin C12. If okay, the light bar is probably faulty. If the gauges above are not affected, then the light bar is probably faulty. Repair as necessary.
		No	Go to Test 3.
3	Are only J1587 driven gauges affected? See **Table 7** for gauge control strategy.	Yes	Go to Test 4.
		No	Replace the light bar.
4	Connect PC to vehicle and start Servicelink. Will Servicelink connect?	Yes	Go to Test 5.
		No	Assuming Servicelink and the vehicle adapter are working correctly, the most likely cause is something taking the entire J1587 databus down (short, etc.). Repair as necessary.

Troubleshooting

Diagnosis for Multiple Gauges Not Working (databus-driven gauges)			
Test No.	Test Description	Test Result	Action
5	In Servicelink, does the ICU4 show up in the ECU list (MID 140)?	Yes	Go to Test 6.
		No	Check the J1587 databus to the ICU. If okay, the light bar is probably faulty. Repair as necessary.
6	In Servicelink, does the engine ECM show up in the ECU list (MID 128)?	Yes	Go to Test 7.
		No	Check the J1587 databus to the engine ECM. If okay, the engine ECM is probably faulty. Repair as necessary.
7	In Servicelink, open the Ametek ICU4 Instrument Cluster Datalink Monitor template. Do the affected gauges work on the template?	Yes	Replace the light bar.
		No	The engine ECM sensor wiring or the engine ECM itself is probably faulty. Repair as necessary.
8	Do any of the gauges sweep when the ignition is turned on?	Yes	Go to Test 9.
		No	Check power and ground to the light bar. If okay, the light bar is probably faulty. Repair as necessary.
9	Are all of the affected gauges in sequence with one another on the daisy chain?	Yes	Go to Test 10.
		No	Replace the light bar.
10	Locate the faulty gauge that is closest to the light bar in the daisy chain. Replace the jumper wire between this gauge and the next gauge closest to the light bar that works (or the light bar itself). Do the gauges now work?	Yes	Replace the jumper wire.
		No	Replace the light bar.

Table 3, Diagnosis for Multiple Gauges Not Working (databus-driven gauges)

Diagnosis for Inaccurate Gauges			
Test No.	Test Description	Test Result	Action
1	Is the gauge controlled by the J1587 databus? See Table 7 to determine gauge control strategy.	Yes	Go to Test 2.
		No	Go to Test 3.
2	Using the Ametek ICU4 Instrument Cluster Datalink Monitor template within Servicelink, check if the template gauge reads the same as the cluster gauge. Does the template gauge read the same as the cluster gauge?	Yes	The gauge is okay. The sensor connected to the engine ECM may be faulty. See engine manufacturer's literature for troubleshooting information.
		No	Try a known good gauge. If this does not correct the problem, replace the light bar.

Diagnosis for Inaccurate Gauges			
Test No.	**Test Description**	**Test Result**	**Action**
3	For sensor driven gauges, check if gauge sensor resistance or (voltage for ammeter, and early production pyrometers) matches the specified values for a given temperature (or amperage for ammeter). Refer to **Specifications 400** for sender specifications. NOTE: An accurate thermometer or ammeter will have to be used to determine appropriate sensor values. Does the sensor resistance (or voltage for the ammeter, and early production pyrometers) match the published values?	Yes	Go to Test 4.
		No	Replace the sensor.
4	Repeat Test 3, except take the readings at the light bar connector (disconnect the connector). Refer to **Specifications 400** for sender specifications. Does the sensor resistance (or voltage for the ammeter, and early production pyrometers) match the published values?	Yes	Try a known good gauge. If this does not correct the problem, replace the light bar.
		No	Repair sensor wiring as necessary.

Table 4, Diagnosis for Inaccurate Gauges

Air Pressure Gauge Diagnosis			
Test No.	**Test Description**	**Test Result**	**Action**
1	Which air pressure gauge is not functioning correctly?	Primary or secondary	Go to Test 2.
		Application	Go to Test 3.
		Suspension	Go to Test 4.
2	Drain the air tanks. Connect an accurate pressure gauge to the primary or secondary air tank (whichever one corresponds with the problem gauge). Start the engine and build air pressure until the compressor cuts out. Is the air pressure gauge in the cluster within 6 psi (41 kPa) of the test gauge?	Yes	No problem found.
		No	Check for kinked air lines to the gauge. If OK, replace the gauge.
3	Connect an accurate pressure gauge to a delivery port on the foot valve. Make a 90 psi (620 kPa) brake application while observing the application air pressure gauge in the cluster and the test gauge. Is the air pressure gauge in the cluster within 3 psi (21 kPa) of the test gauge?	Yes	No problem found.
		No	Check for kinked air lines to the gauge. If OK, replace the gauge.

Troubleshooting

Air Pressure Gauge Diagnosis			
Test No.	Test Description	Test Result	Action
4	Connect an accurate pressure gauge to the air suspension. Is the air pressure gauge in the cluster within 3 psi (21 kPa) of the test gauge?	Yes	No problem found.
		No	Check for kinked air lines to the gauge.. If OK, replace the gauge.

Table 5, Air Pressure Gauge Diagnosis

Fuel Level Gauge Diagnosis

The fuel level gauge is controlled by the ICU using a variable resistance input from the fuel level sending unit that is located in the fuel tank. The fuel level sending unit resistance varies linearly from 31±2Ω with a full tank to 247±3Ω when empty.

If the ICU3 is measuring a resistance greater than 284Ω between circuit 47 and ground, a fault will be set for fuel level circuit open. If the ICU3 is measuring less than 23.5Ω between circuit 47 and ground, a fault will be set for fuel level circuit shorted low. ServiceLink may be used to monitor for these faults. The gauge will read empty until the measurement from the sensor is between 284Ω and 23.5Ω. Refer to **Table 6** for the fuel level diagnostic procedure.

NOTE: If the fuel level sensor is below the minimum resistance (short to ground) or above the maximum (open), the fuel gauge will read empty. Shorting the fuel sensor wires will not drive the gauge to full scale.

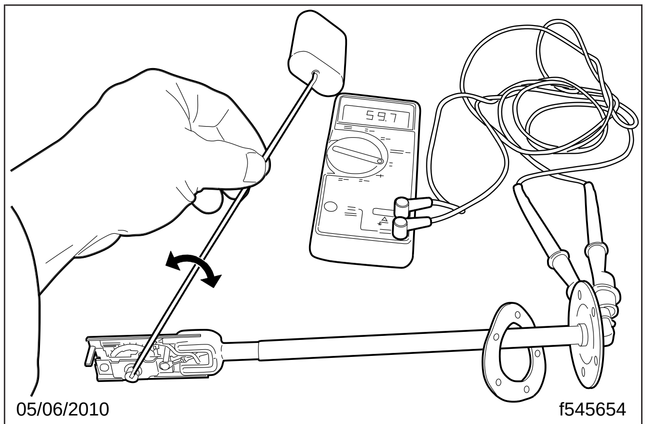
Fuel Level Gauge Diagnosis			
Step	Test Procedure	Test Result	Action
1	If a 100 ohm resistor is available, disconnect the fuel level sender connector and place the resistor across circuit 47 and ground in the wiring harness connector to simulate the fuel level sending unit. Turn the ignition to the ON position and observe the fuel gauge. If, after gauge initialization, the gauge points closely to the half tank mark, then the wiring and ICU are all operating correctly. Jump to Step 4 if there is no problem with the wiring and ICU. Does the fuel level gauge stay at empty even though there is fuel in the tank or is the complaint an inaccurate and intermittent reading? Note - turn the ignition to OFF and disconnect the batteries before continuing.	Stays at Empty	Go to Step 2.
		Inaccurate or Intermittent	Go to Step 4.
2	Disconnect the connector at the fuel level sender and measure the resistance of the sender. What is the resistance of the sender?	Greater than 284Ω or Less than 23.5Ω	Go to Step 4.
		Between 284Ω and 23.5Ω	Go to Step 3.

Fuel Level Gauge Diagnosis			
Step	**Test Procedure**	**Test Result**	**Action**
3	Connect the fuel level sender and disconnect the connectors on the back of the ICU. Measure the resistance in the vehicle wiring between circuit 47 in connector pin D1 and the ground circuit in connector pin D2. What is the resistance of the circuit?	Greater than 284Ω	Troubleshoot and repair an open circuit on either circuit 47 or the ground between the ICU connector and the fuel level sender.
		Between 284Ω and 23.5Ω	This is the valid resistance range. If the fuel tank is full and the resistance is close to 31Ω, replace the ICU. Otherwise no problem is indicated.
		Less than 23.5Ω	Troubleshoot and repair a short to ground on circuit 47 between the ICU connector and the fuel level sender.
4	Remove the fuel sending unit from the fuel tank. Connect an ohm meter to the pins at the fuel level sender connector. Slowly move the level of the float arm from full to empty. See **Fig. 2**. Does the resistance vary linearly from 31±2Ω to 247±3Ω?	Yes	Troubleshoot and repair for corrosion or an intermittent connection in the circuitry between the ICU and the fuel level sender.
		No	Replace the fuel level sending unit.

Table 6, Fuel Level Gauge Diagnosis

Gauge Control Strategy

This section defines how each individual gauge, standard or optional, is controlled. Some gauges are J1587 databus-driven, meaning the information is sent to the instrument cluster from the engine ECM. Other gauges are controlled by a sensor wired directly to the instrument cluster light bar. **Table 7** identifies each standard and optional gauge, and its method of control.



Slowly move the float arm from full to empty.

Fig. 2, Testing the Fuel Level Sending Unit

Standard and Optional Gauges—Input Types		
Gauge	**Input Type to Light Bar to Drive Gauge**	**Standard/Optional**
Speedometer	J1587 databus—from engine (MID 128)	Standard
Engine Coolant Temperature	J1587 databus—from engine (MID 128)	Standard
Engine Oil Pressure	J1587 databus—from engine (MID 128)	Standard
Fuel Level	Sensor input	Standard
Tachometer	J1587 databus—from engine (MID 128)	Standard
Voltmeter	J1587 databus—from engine (MID 128)	Standard

Troubleshooting

Standard and Optional Gauges—Input Types		
Gauge	**Input Type to Light Bar to Drive Gauge**	**Standard/Optional**
Primary Air System Pressure	NA—air line is connected directly to gauge	Standard
Secondary Air System Pressure	NA—air line is connected directly to gauge	Standard
Transmission Oil Temperature	Manual, Eaton, and AGS - sensor connected to ICU Allison - data from transmission ECU	Optional
Forward Rear Axle Temp	Sensor input	Optional
Rear Rear Axle Temp	Sensor input	Optional
Engine Oil Temperature	J1587 databus—from engine (MID 128)	Optional
Turbo Boost Pressure	J1587 databus—from engine (MID 128)	Optional
Pyrometer	Sensor input*	Optional
Application Air Pressure	NA—air line is connected directly to gauge	Optional
Suspension Air Pressure	NA—air line is connected directly to gauge	Optional
Ammeter	Sensor input	Optional

* Pyrometer sensors used in initial production use a voltage amplifier and supply a voltage input to the light bar.

Table 7, Standard and Optional Gauges—Input Types

Warning Lamp Troubleshooting

Use **Table 8** to diagnose light bar warning lamp problems, and **Table 9** for in-gauge warning lamp problems.

Diagnosis for Warning Lamps in the Light Bar			
Test No.	**Test Description**	**Test Result**	**Action**
1	What is the problem with the warning lamp?	Stays on	Go to Test 8.
		Does not turn on	Go to Test 2.
2	Is the warning lamp one of the following? • Park Brake/Brake Warning • Low Air Pressure • Low Battery Voltage • Fasten Seatbelt	Yes	Go to Test 3.
		No	Go to Test 4.
3	Does the warning lamp turn on when the ignition is turned on?	Yes	No problem found.
		No	Replace the light bar.

Diagnosis for Warning Lamps in the Light Bar			
Test No.	Test Description	Test Result	Action
4	Is the warning lamp activated by a ground input or +12V input? See **Table 13**.	12V activated	Go to Test 5.
		Ground activated	Go to Test 6.
5	Disconnect the light bar connector that contains the circuit for the warning lamp that is not working (see **Fig. 3**, and **Table 15** and **Table 16**). Turn the ignition on and activate the circuit that controls the warning lamp (for example, turn on the left turn signal for the left turn warning lamp). See **Fig. 3**, and **Table 15** and **Table 16**. Check for voltage at the light bar connector pin that corresponds to that warning lamp. What is the voltage? NOTE: For turn signal circuits, the voltage will alternate between 12V and 0V.	12V	Replace the light bar.
		0V	Check circuit that controls warning lamp and repair as necessary.
6	Is the warning lamp one of the optional warning lamps (top row of light bar)?	Yes	Check the bulb and replace if necessary. If the bulb is okay, go to Test 7.
		No	Go to Test 7.
7	Locate the light bar connector and circuit that controls the warning lamp (see **Fig. 3**, and **Table 15** and **Table 16**). Using a jumper to ground, backprobe the pin that corresponds to the problem warning lamp. Does the warning lamp turn on?	Yes	Problem is in the circuit that controls the warning lamp, repair as necessary.
		No	Replace the light bar.
8	Is the warning lamp that stays on the Low Air Pressure warning lamp?	Yes	Go to Test 11.
		No	Go to Test 9.
9	Is the problem with the Low Battery Voltage warning lamp?	Yes	Within Servicelink, open the Ametek ICU4 Instrument Cluster Datalink Monitor template and start the engine. Check the voltmeter voltage on the template. If the voltage is below 11.9V, check and repair the vehicle charging system or power and ground circuits to the engine ECM. If the voltage is above 11.9V, replace the light bar.
		No	Go to Test 10.
10	Is the problem with the Fasten Seatbelt warning lamp?	Yes	If the Fasten Seatbelt warning lamp does not turn off approximately 15 seconds after the ignition is turned ON, then replace the light bar.
		No	Go to Test 12.

Troubleshooting

Diagnosis for Warning Lamps in the Light Bar			
Test No.	**Test Description**	**Test Result**	**Action**
11	Turn the ignition ON. Using a jumper to ground, backprobe pin A3 of the 24-pin light bar connector. Does the Low Air Pressure warning lamp turn off?	Yes	Either the air brake system pressure is too low or the problem is in the low air pressure warning circuit that controls the warning lamp. Repair as necessary.
		No	Replace the light bar.
12	Is the warning lamp activated by a ground input or +12V input? See **Table 13**.	12V activated	Go to Test 13.
		Ground activated	Go to Test 14.
13	Disconnect the connector that contains the circuit for the warning lamp that stays on (see **Fig. 3**, and **Table 15** and **Table 16**). Turn the ignition ON. Check for voltage at the light bar connector pin that corresponds to the warning lamp. What is the voltage?	12V	The problem is not with the light bar. Check the system that controls the warning lamp for faults (the light may be on for a reason other than a faulty warning lamp circuit). Otherwise, check warning lamp circuit for short to power and repair as necessary.
		0V	Replace the light bar.
14	Disconnect the connector that contains the circuit for the warning lamp that stays on (see **Fig. 3**, and **Table 15** and **Table 16**). Turn the ignition ON. Check for voltage at the light bar connector pin that corresponds to the warning lamp by connecting the positive meter lead to battery (+) and the negative lead to the connector pin that corresponds to the warning lamp. What is the voltage?	12V	The problem is not with the light bar. Check the system that controls the warning lamp for faults (the light may be on for a reason other than a faulty warning lamp circuit). Otherwise, check warning lamp circuit for short to ground and repair as necessary.
		0V	Replace the light bar.

Table 8, Diagnosis for Warning Lamps in the Light Bar

Diagnosis for In-Gauge Warning Lamps			
Test No.	**Test Description**	**Test Result**	**Action**
1	Does the warning lamp illuminate during the ignition on gauge sweep?	Yes	Go to Test 2.
		No	Replace the gauge.
2	Is the problem with either one of the following gauge warning lamps? • Low Oil Pressure • High Coolant Temperature	Yes	Go to Test 3.
		No	Go to Test 5.

<table>
<tr><th colspan="4">Diagnosis for In-Gauge Warning Lamps</th></tr>
<tr><th>Test No.</th><th>Test Description</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Is the problem that the warning lamp stays on?</td><td>Yes</td><td>Go to Test 4.</td></tr>
<tr><td>No</td><td>The warning lamp is probably not illuminating because it is not receiving an active fault code from the engine ECM:
128 p100 01 (oil pressure too low)
128 p110 00 (coolant temp too high)
If the appropriate code is active and the warning lamp does not work, then the light bar is probably faulty.</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Check for either of the following engine fault codes:
128 p100 01 (oil pressure too low)
128 p110 00 (coolant temp too high)
Are either of these faults active?</td><td>Yes</td><td>Check for a problem in the engine's lubrication or cooling system. Repair as necessary.</td></tr>
<tr><td>No</td><td>Replace the light bar.</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Is the problem with the High Transmission Temperature warning lamp?</td><td>Yes</td><td>Go to Test 6.</td></tr>
<tr><td>No</td><td>Go to Test 9.</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Is the problem that the warning lamp stays on?</td><td>Yes</td><td>Go to Test 8.</td></tr>
<tr><td>No</td><td>Go to Test 7.</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Using a jumper to ground, backprobe pin A4 of the 24-pin connector.
Does the High Transmission Temperature warning lamp turn on?</td><td>Yes</td><td>The problem is in the circuit that controls the warning lamp. Repair as necessary.</td></tr>
<tr><td>No</td><td>Replace the light bar.</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">Disconnect the 24-pin light bar connector.
Turn the ignition ON.
Check for voltage at the 24-pin light bar connector pin A4 by connecting the positive meter lead to battery (+) and the negative lead to pin A4.</td><td>12V</td><td>The problem is not with the light bar. Check the transmission for faults (the light may be on for a reason other than a faulty warning lamp circuit). Otherwise, check warning lamp circuit for short to ground and repair as necessary.</td></tr>
<tr><td>0V</td><td>Replace the light bar.</td></tr>
<tr><td rowspan="2">9</td><td rowspan="2">Is the problem that the Low Fuel Level warning lamp stays on?</td><td>Yes</td><td>Go to Test 10.</td></tr>
<tr><td>No</td><td>Go to Test 11.</td></tr>
<tr><td rowspan="2">10</td><td rowspan="2">Does the fuel gauge read below 1/8?</td><td>Yes</td><td>Normal condition; no further action is necessary.</td></tr>
<tr><td>No</td><td>Replace the light bar.</td></tr>
<tr><td rowspan="2">11</td><td rowspan="2">Does the fuel gauge read below 1/8?</td><td>Yes</td><td>Replace the light bar.</td></tr>
<tr><td>No</td><td>The warning lamp should not turn on until the fuel level is 1/8 or less for at least 60 seconds. No problem found.</td></tr>
</table>

Table 9, Diagnosis for In-Gauge Warning Lamps

Troubleshooting

Backlighting Troubleshooting

For backlighting problems, see **Table 10**.

NOTE: The backlighting signal to the light bar is a pulse-width-modulated (PWM) signal at approximately 320 Hz.

Backlighting Troubleshooting (gauges and light bar)			
Test No.	**Test Description**	**Test Result**	**Action**
1	Does any of the backlighting work (i.e. panel switches, etc.)?	Yes	Go to Test 2.
		No	Check the panel lamp dimmer switch, and panel lighting circuit. Repair as necessary.
2	Is all the cluster backlighting dead (light bar LCD and all gauges)?	Yes	Go to Test 3.
		No	Go to Test 5.
3	Disconnect the light bar 24-pin connector (see **Fig. 3**). Turn the headlamps ON, and the panel lamp dimmer switch to full bright. Measure the voltage at connector pin A1; it should be approximately +12V. What is the voltage?	12V	Go to Test 4.
		0V	Check backlighting circuit 29A for open between the instrument cluster and splice to other dash components. Repair as necessary.
4	Disconnect both the light bar 24-pin and 32-pin connectors (see **Fig. 3**). Turn the headlamps ON, and the panel lamp dimmer switch to full bright. Measure the voltage between pin A1 (24-pin connector) and pin D3 (32-pin connector). What is the voltage?	12V	Replace the light bar.
		0V	Check panel lamp ground circuit. Repair as necessary.
5	Is the light bar LCD backlighting the only thing with dead backlighting?	Yes	Replace the light bar.
		No	Go to Test 6.
6	Is only one gauge backlight dead?	Yes	Go to Test 7.
		No	Go to Test 8.
7	Is the gauge with dead backlighting the last gauge in the daisy chain (farthest from the light bar)?	Yes	Try a known good jumper wire to the gauge. If backlight now works on this gauge, this solved the problem. If the backlighting still does not work, replace the gauge.
		No	Replace the gauge.
8	Are all the gauges with dead backlighting in sequence with one another in the daisy-chain?	Yes	Try a known good jumper wire between the gauge with dead backlighting that is closest to the light bar and the next good gauge (one closer to light bar). If all backlighting now works, the jumper solved the problem. If not, replace all gauges with dead backlighting.
		No	Go to Test 9.

Backlighting Troubleshooting (gauges and light bar)			
Test No.	**Test Description**	**Test Result**	**Action**
9	Is one of the dead gauges the last gauge in the daisy-chain (farthest from the light bar)?	Yes	Try a known good jumper to the last gauge. If the last gauge now works, the jumper solved the problem to this gauge. Replace all other gauges with dead backlighting. If the jumper did not correct the backlighting to the last gauge in the daisy-chain, replace all gauges with dead backlighting.
		No	Replace all gauges with dead backlighting.

Table 10, Backlighting Troubleshooting (gauges and light bar)

Light Bar LCD Display Fault Messages

This section defines possible fault messages displayed on the light bar LCD display. **Table 11** lists possible roll call faults and **Table 12** lists possible power on fault messages. Roll call faults are ECUs that do not respond during power up.

Roll Call Faults (displayed on the LCD display)	
Displayed Message	**Description**
NO ENG	The ICU is unable to communicate with the engine ECM on the J1587 databus. Check databus wiring, repair as necessary.
NO ABS	The ICU is unable to communicate with the ABS on the J1587 databus. Check databus wiring, repair as necessary.
NO DATA	The light bar is not communicating with the J1587 databus.

Table 11, Roll Call Faults (displayed on the LCD display)

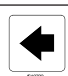
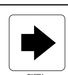
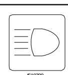
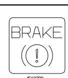
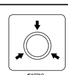
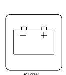
Display Messages After Power-On Sweep			
Message	**System With Active Fault**	**Message**	**System With Active Fault**
ICU 140	Instrumentation Control Unit (ICU4)	TCU 130	Transmission Control Unit
AC 146	Air Conditioning system (front unit)	TSU 223	Transmission Shift Unit
ECU 128	Engine Control Unit (engine ECM)	AC 200	Air Conditioning system (rear unit)
ABS 136	Anti-lock Brake System	SBU 232	Seat Belt Unit (SPACE/Airbag system)
CDU 219	Collision Detection Unit (VORAD)	SYS ###	Generic—system not defined in this table.
SAT 181	Satellite communications (Qualcomm)	—	—

Table 12, Display Messages After Power-On Sweep

Warning Lamp Control Strategy

This section defines how each individual warning is controlled. Not all warning lamps are standard. Some in-gauge warning lamps are J1587 databus-driven, meaning the information is sent to the instrument cluster from the engine ECM (see **Table 14**). The light bar warning lamps are controlled directly by a hardwire to the instrument cluster light bar (see **Table 13**). Other warning lamps are controlled by decisions made by the light bar (see **Table 13** and **Table 14**).

NOTE: In **Table 13**, the warning lamps that are indicated as having a bulb check after the ignition is turned on are controlled by the light bar. Other direct-wired warning lamps may have a bulb check that is controlled by the device they are connected to (e.g. the engine ECM). These externally controlled bulb checks are not indicated in **Table 13**.

Light Bar Warning Lamp Control						
Warning Lamp	**Legend**	**Bulb Check**	**Buzzer Operation**	**Power Source**	**Warning Lamp Operation/ Control**	**Control Pin**
Left Turn Signal		—	—	12V external	12V (activates)	C8
Right Turn Signal		—	—	12V external	12V (activates)	D8
Highbeam		—	—	12V external	12V (activates)	A12
Park Brake/ Brake System Warning		Yes	When vehicle is moving over 2 mph with brake set.	12V Ign (internal)	Ground (activates)	C5
Low Air Pressure		Yes	Coincides with operation of this warning lamp	12V Ign (internal)	Ground (deactivates)	A3
Low Battery Voltage		Yes	—	Internal	Controlled by light bar. If light bar receives battery voltage message from the engine less than 11.9V, the warning lamp will illuminate.	NA
Fasten Seat Belt		Yes	—	Internal	Controlled by light bar. On for approximately 15 sec after ignition is turned on.	NA
Check Engine		No*	—	12V Ign (internal)	Ground (activates)	C15
Engine Protection		No*	—	12V Ign (internal)	Ground (activates)	C16
Tractor ABS		No*	—	12V Ign (internal)	Ground (activates)	B11

Light Bar Warning Lamp Control						
Warning Lamp	**Legend**	**Bulb Check**	**Buzzer Operation**	**Power Source**	**Warning Lamp Operation/ Control**	**Control Pin**
Trailer ABS	TRLR ABS	No*	—	12V Ign (internal)	Ground (activates)	D12
Check Trans	CHECK TRANS	No*	—	12V Ign (internal)	Ground (activates)	D10
Water in Fuel	WATER IN FUEL	No*	—	12V Ign (internal)	Ground (activates)	C10
Intake Heater	INTAKE HEATER	No*	—	12V Ign (internal)	Ground (activates)	A5
No Charge	NO CHARGE	No	—	12V Ign (internal)	Ground (activates)	A9
Optimized Idle	OPT IDLE	No	—	12V Ign (internal)	Ground (activates)	C1
Opt. #1 (Stop Engine)	STOP ENGINE	No*	—	12V Ign (internal)	Ground (activates)	C14
Opt. #2	—	No	—	12V Batt (internal)	Ground (activates)	A6
Opt. #3	—	No	—	12V Ign (internal)	Ground (activates)	A7
Opt. #4	—	No	—	12V Ign (internal)	Ground (activates)	A8
Opt. #5	—	No	—	12V Ign (internal)	Ground (activates)	B1
Opt. #6	—	No	—	12V Ign (internal)	Ground (activates)	A2
Opt. #7	—	No	—	12V Ign (internal)	Ground (activates)	C11
Opt. #8	—	No	—	12V (external)	12V (activates)	D4

* Bulb check is not controlled by the lightbar. The controlling device (engine, ABS, transmission, etc.) may perform a bulb check.

Table 13, Light Bar Warning Lamp Control

Gauge Warning Lamp Control (warning lamps in gauge)				
Gauge Warning Lamp	**Gauge**	**Bulb Check**	**Warning Lamp/Buzzer Operation**	**Warning Lamp/Buzzer Control**
Low Oil Pressure	Oil Pressure	Yes	Warning lamp and buzzer will remain on for a minimum of 30 seconds and will stay on as long as the fault remains active.	Light bar controls this gauge warning lamp when the engine sends low oil pressure fault MID 128, PID 100, FMI 01.
High Coolant Temperature	Engine Coolant Temperature	Yes	Warning lamp and buzzer will remain on for a minimum of 30 seconds and will stay on as long as the fault remains active.	Light bar controls this gauge warning lamp when the engine sends high coolant temperature fault MID 128, PID 110, FMI 00.

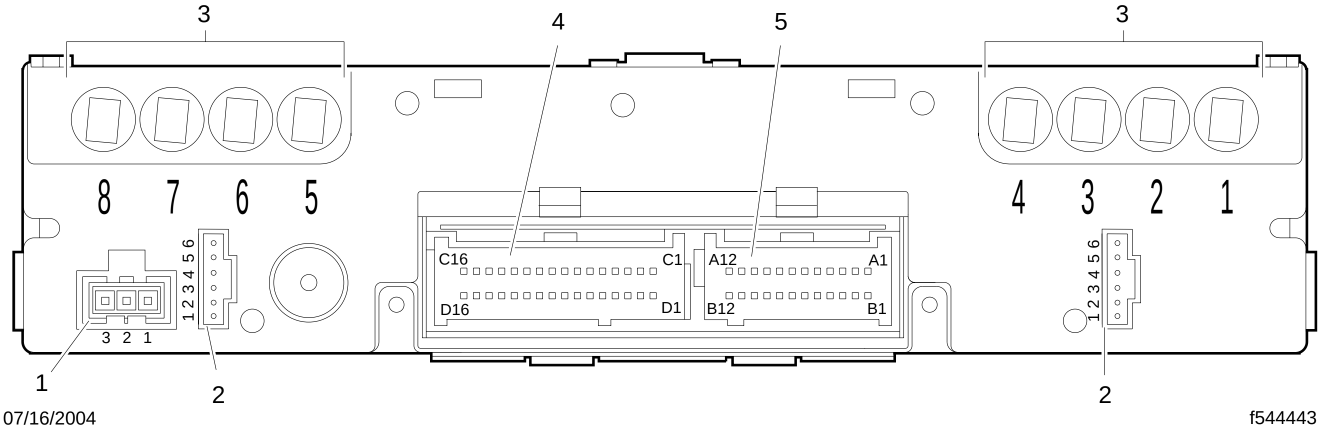
Troubleshooting

Gauge Warning Lamp Control (warning lamps in gauge)				
Gauge Warning Lamp	**Gauge**	**Bulb Check**	**Warning Lamp/Buzzer Operation**	**Warning Lamp/Buzzer Control**
High Transmission Temperature	Transmission Temperature	Yes	On when input to light bar is grounded.	Ground activated from hard wire input to light bar pin A4.
Low Fuel Level	Fuel Level	Yes	The light bar turns this warning lamp on if the fuel level is less than 1/8 of a tank for at least 60 seconds.	Light bar compares fuel level sensor input to programmed resistance values to determine when to illuminate this warning lamp.

Table 14, Gauge Warning Lamp Control (warning lamps in gauge)

Pin and Circuit Descriptions

See **Fig. 3** for a rear view of the light bar, showing connector pin locations. See **Table 15** for 24-pin connector pin descriptions, **Table 16** for 32-pin connector pin descriptions, **Table 17** for 6-pin gauge databus connector pin descriptions, and **Table 18** for 3-pin light bar auxiliary input connector pin descriptions.



1. 3-Pin Auxiliary Input Connector
2. 6-Pin Gauge Databus Connector
3. Optional Telltale Bulbs
4. 32-Pin Light Bar Connector
5. 24-Pin Light Bar Connector

Fig. 3, Light Bar Connector Pin Locations (rear view)

24-Pin Light Bar Connector Pin Descriptions			
Pin	**Description**	**Pin**	**Description**
A1	(+) Panel Backlight Power (PWM)*	B1	Optional Warning Lamp # 5—ground activated
A2	Optional Warning Lamp # 6—ground activated	B2	(+) Rear Rear Axle Temp Sensor

24-Pin Light Bar Connector Pin Descriptions			
Pin	Description	Pin	Description
A3	Low Air Pressure Warning Lamp—ground activated	B3	J1587 databus (–)
A4	High Trans Temp Warning Lamp—ground activated	B4	(–) Rear Rear Axle Temp Sensor
A5	Intake Heater Warning Lamp—ground activated	B5	—
A6	Optional Warning Lamp #2—ground activated	B6	—
A7	Optional Warning Lamp #3—ground activated	B7	—
A8	Optional Warning Lamp #4—ground activated	B8	—
A9	No Charge Warning Lamp—ground activated	B9	—
A10	(+) Forward Rear Axle Temp Sensor	B10	J1587 databus (+)
A11	(–) Forward Rear Axle Temp Sensor	B11	Tractor ABS Warning Lamp—ground activated
A12	High Beam Warning Lamp—12V activated	B12	Optional Buzzer Input—ground activated

* PWM = Pulse Width Modulation

Table 15, 24-Pin Light Bar Connector Pin Descriptions

32-Pin Light Bar Connector Pin Descriptions			
Pin	Description	Pin	Description
C1	Optimized Idle Warning Lamp—ground activated	D1	(+) Fuel level Sensor
C2	Opt. Low Current Output (gnd)—Starter Lockout	D2	(–) Fuel level Sensor
C3	Opt. Low Current Output (gnd)—Key Illumination	D3	(–) Panel Backlight Ground
C4	Opt. 12V Input (Door Open)*	D4	Optional Warning Lamp # 8—12V activated
C5	Park Brake Warning Lamp—ground activated	D5	—
C6	(+) Pyrometer	D6	(–) Pyrometer
C7	—	D7	—
C8	Left Turn Warning Lamp—12V activated	D8	Right Turn Warning Lamp—12V activated
C9	—	D9	—
C10	Water In Fuel Warning Lamp—ground activated	D10	Check Trans Warning Lamp—ground activated
C11	Optional Warning Lamp #7—ground activated	D11	—
C12	(–) Sensor common (trans temp, axle #3 temp, ammeter)	D12	Trailer ABS Warning Lamp—ground activated
C13	(+) Transmission Oil Temp	D13	Ground
C14	Optional Warning Lamp #1—ground activated	D14	(+) Battery Power
C15	Check Engine Warning Lamp—ground activated	D15	(+) Ignition Power
C16	Engine Protection Warning Lamp—ground activated	D16	(+) Headlamp Power Input 12V—used to control LCD brightness

* Pin C4 (door open input) is used for the Door Open/Park Brake Not Set chime. If the park brake is off, and the door is open, then the light bar will sound a chime.

Table 16, 32-Pin Light Bar Connector Pin Descriptions

Troubleshooting

6-Pin Gauge Databus Connector Pin Descriptions		
Pin	Description	Jumper Wire Color
1	(+) Gauge Power	Blue
2	(–) Gauge Ground	Green
3	Gauge Databus (+)	Black
4	Gauge Databus (–)	Violet
5	Gauge Backlighting (–)	Red
6	Gauge Backlighting (+)	Yellow

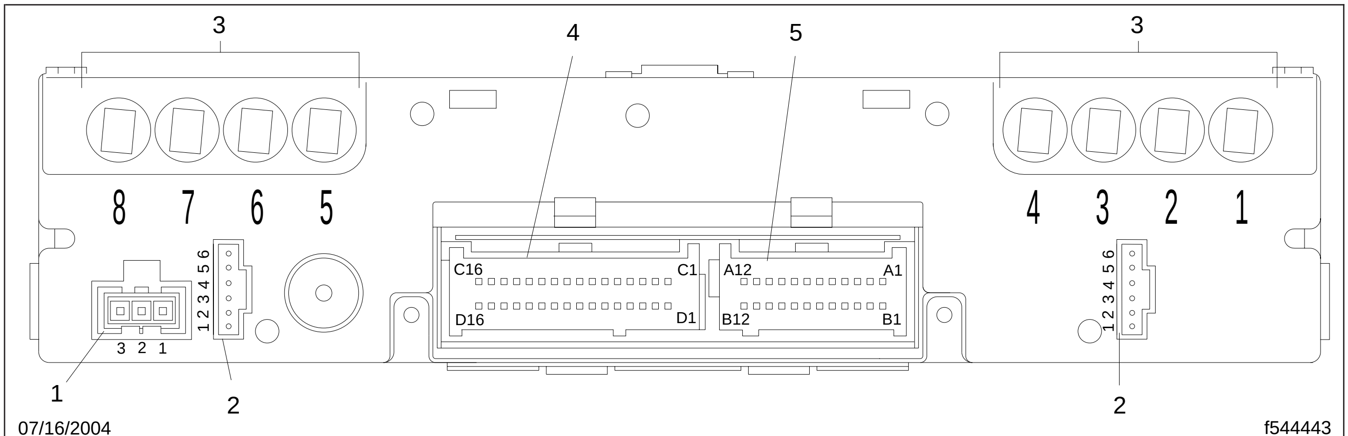
Table 17, 6-Pin Gauge Databus Connector Pin Descriptions

3-Pin Light Bar Auxiliary Input Connector Pin Descriptions	
Pin	Description
1	(+) Ammeter Input, 0.5 to 4.5V from ammeter sender
2	(+) Axle #3 Temperature Input
3	—

Table 18, 3-Pin Light Bar Auxiliary Input Connector Pin Descriptions

Pin and Circuit Descriptions

See **Fig. 1** for a rear view of the light bar, showing connector pin locations. See **Table 1** for 24-pin connector pin descriptions, **Table 2** for 32-pin connector pin descriptions, **Table 3** for 6-pin gauge databus connector pin descriptions, and **Table 4** for 3-pin light bar auxiliary input connector pin descriptions.



1. 3-Pin Auxiliary Input Connector
2. 6-Pin Gauge Databus Connector
3. Optional Telltale Bulbs
4. 32-Pin Light Bar Connector
5. 24-Pin Light Bar Connector

Fig. 1, Light Bar Connector Pin Locations (rear view)

24-Pin Light Bar Connector Pin Descriptions			
Pin	**Description**	**Pin**	**Description**
A1	(+) Panel Backlight Power (PWM)*	B1	Optional Warning Lamp # 5—ground activated
A2	Optional Warning Lamp # 6—ground activated	B2	(+) Rear Rear Axle Temp Sensor
A3	Low Air Pressure Warning Lamp—ground activated	B3	J1587 databus (–)
A4	High Trans Temp Warning Lamp—ground activated	B4	(–) Rear Rear Axle Temp Sensor
A5	Intake Heater Warning Lamp—ground activated	B5	—
A6	Optional Warning Lamp #2—ground activated	B6	—
A7	Optional Warning Lamp #3—ground activated	B7	—
A8	Optional Warning Lamp #4—ground activated	B8	—
A9	No Charge Warning Lamp—ground activated	B9	—
A10	(+) Forward Rear Axle Temp Sensor	B10	J1587 databus (+)
A11	(–) Forward Rear Axle Temp Sensor	B11	Tractor ABS Warning Lamp—ground activated

Specifications

24-Pin Light Bar Connector Pin Descriptions			
Pin	Description	Pin	Description
A12	High Beam Warning Lamp—12V activated	B12	Optional Buzzer Input—ground activated

* PWM = Pulse Width Modulation

Table 1, 24-Pin Light Bar Connector Pin Descriptions

32-Pin Light Bar Connector Pin Descriptions			
Pin	Description	Pin	Description
C1	Optimized Idle Warning Lamp—ground activated	D1	(+) Fuel level Sensor
C2	Opt. Low Current Output (gnd)—Starter Lockout	D2	(–) Fuel level Sensor
C3	Opt. Low Current Output (gnd)—Key Illumination	D3	(–) Panel Backlight Ground
C4	Opt. 12V Input (Door Open)*	D4	Optional Warning Lamp # 8—12V activated
C5	Park Brake Warning Lamp—ground activated	D5	—
C6	(+) Pyrometer	D6	(–) Pyrometer
C7	—	D7	—
C8	Left Turn Warning Lamp—12V activated	D8	Right Turn Warning Lamp—12V activated
C9	—	D9	—
C10	Water In Fuel Warning Lamp—ground activated	D10	Check Trans Warning Lamp—ground activated
C11	Optional Warning Lamp #7—ground activated	D11	—
C12	(–) Sensor common (trans temp, axle #3 temp, ammeter)	D12	Trailer ABS Warning Lamp—ground activated
C13	(+) Transmission Oil Temp	D13	Ground
C14	Optional Warning Lamp #1—ground activated	D14	(+) Battery Power
C15	Check Engine Warning Lamp—ground activated	D15	(+) Ignition Power
C16	Engine Protection Warning Lamp—ground activated	D16	(+) Headlamp Power Input 12V—used to control LCD brightness

* Pin C4 (door open input) is used for the Door Open/Park Brake Not Set chime. If the park brake is off, and the door is open, then the light bar will sound a chime.

Table 2, 32-Pin Light Bar Connector Pin Descriptions

6-Pin Gauge Databus Connector Pin Descriptions		
Pin	Description	Jumper Wire Color
1	(+) Gauge Power	Blue
2	(–) Gauge Ground	Green
3	Gauge Databus (+)	Black
4	Gauge Databus (–)	Violet
5	Gauge Backlighting (–)	Red
6	Gauge Backlighting (+)	Yellow

Table 3, 6-Pin Gauge Databus Connector Pin Descriptions

Specifications

3-Pin Light Bar Auxiliary Input Connector Pin Descriptions	
Pin	**Description**
1	(+) Ammeter Input, 0.5 to 4.5V from ammeter sender
2	(+) Axle #3 Temperature Input
3	—

Table 4, 3-Pin Light Bar Auxiliary Input Connector Pin Descriptions

General Information

The mode/reset switch controls the display of the odometer, trip miles and hours, engine miles and hours, service cycle screens, fault code screens, and oil level screens (on some Mercedes engines; if equipped and enabled).

Push the switch to scroll through mode selections, and hold the switch to reset trip miles or hours while they are displayed. See **Fig. 1**. With the parking brake released, only the odometer, trip miles, and trip hours can be accessed. Park the vehicle and set the parking brake to access additional screen functions. See **Fig. 2** and **Fig. 3**.

Trip Miles, Trip Hours

When the odometer is displayed, push the mode/reset switch once to display trip distance. Push it again to display trip hours. Both numbers are calculated from the last time the value was reset. Hold the switch when each number is displayed to reset trip miles or hours to zero.

Diagnostic Screens

During vehicle start-up, with the parking brake on, the ICU4 displays any active fault codes for three seconds each until the parking brake is released. With active fault codes on display, push the mode/reset switch once to display the initial diagnostic screen (DIAG) and the total number of active faults. If service cycle screens are enabled, and service distance or time has been exceeded, the text SERVICE will be displayed with the other fault messages. This will inform the vehicle operator that the service interval has been exceeded and vehicle service is required.

Specific fault code information can be displayed only with the vehicle parked and the parking brake set. If the odometer screen is displayed, push the mode/reset switch until the DIAG screen is displayed, then hold the switch to enter the fault code screen sequence. Once the initial fault code is displayed, push the switch to cycle through additional diagnostic codes relating to the first fault. Hold the switch to display additional faults or return to the DIAG screen. If service cycle screens are enabled, service interval information is displayed before fault code information is displayed.

If the word SERVICE appears on the DIAG message display screen, service cycle screens are enabled. Hold the mode/reset switch at the DIAG screen to display miles or hours remaining until the next scheduled service. If MI appears on the DIAG screen, service miles are enabled; if HOURS appears on the screen, service hours are enabled. Either service miles or hours can be enabled, but not both. If service miles or hours has been exceeded, the number flashes to indicate service is overdue.

Engine Screens

Push the mode/reset switch once following the DIAG screen and the word ENGINE is displayed in the lower right corner of the digital display. Hold the switch to display total engine miles. Hold it again to display total engine hours. If OIL LVL is displayed earlier with ENGINE (on Mercedes vehicles only; if equipped and enabled) hold the switch again to access oil level screens.

Oil Level Screens (optional)

If OIL LVL is displayed with ENGINE, hold the switch twice to display total engine miles and total engine hours, respectively, then hold again to access oil level screens.

The display will read OIL OK, or it will display OIL LVL and indicate in the lower left hand corner of the display whether the level is high (HI) or low (Lo). Hold the switch again to display the amount, in quarts (QTS) or liters (LTS), by which the oil level is high or low. If the oil level is low or OK the amount will be displayed with a minus sign in front of it (–). If the oil level is high the amount will be displayed as a whole number. If the oil level is OK, the level will display -0 QTS (quarts) or -0 LTS (liters).

The maximum range of quarts or liters too low or high is from –9 to 9.

Hold the button again to return to the OIL LVL/ENGINE screen, or push the button to go to the SETUP screen.

If the engine oil level message is not received from the engine for 25 seconds, the text Lo, HI, or blank displays as hyphens (- -) while the OIL LVL text appears on the display. The hyphens indicate that the engine oil level message communication was received at one time, but now has a problem. The en-

Mode/Reset Switch Functions

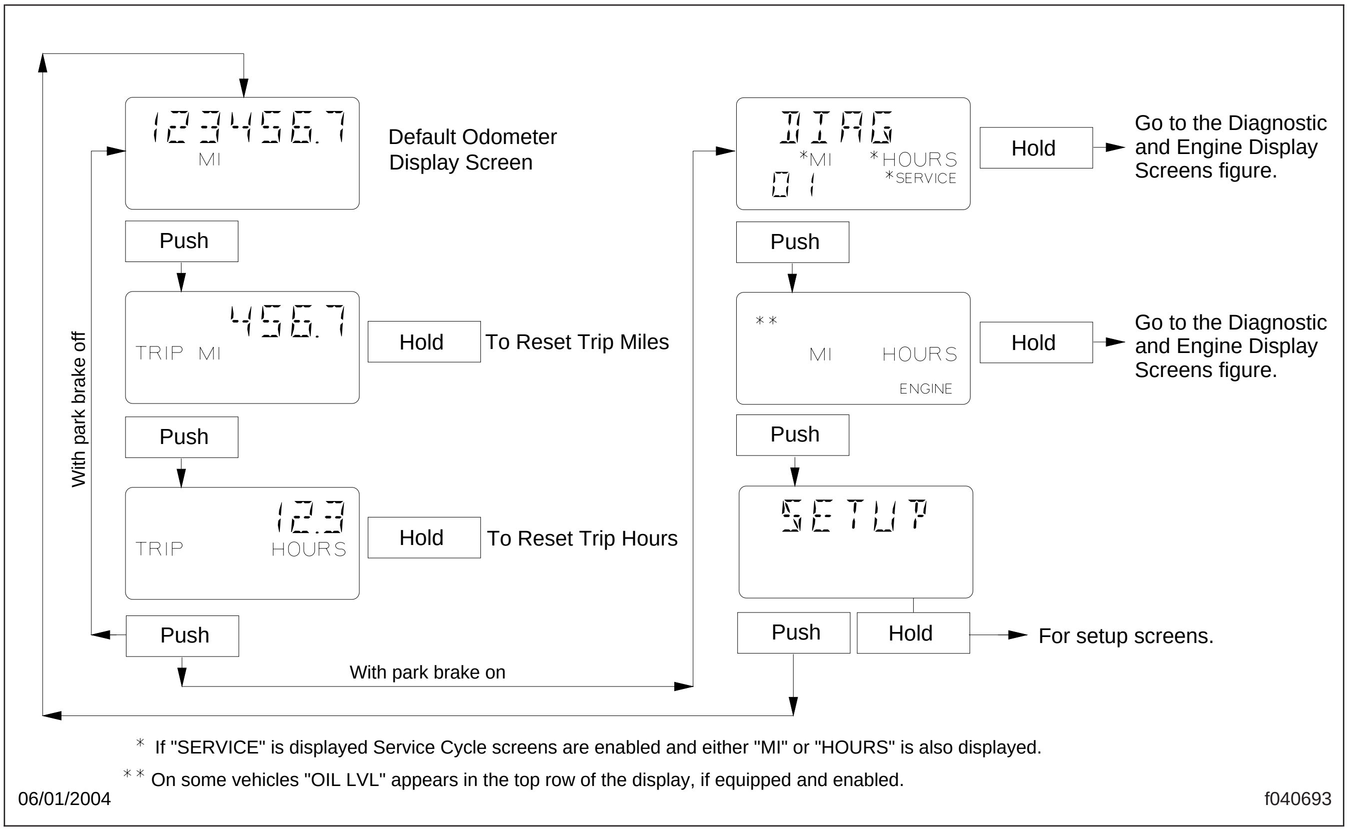


Fig. 1, Mode/Reset Switch Basic Functions

gine oil amount screen will not be displayed if the oil level message is not received.

To change units of measure between quarts and liters, go to the the SETUP display screen, hold the switch to advance to the SELECT screen, then hold again to toggle between MI (miles) and KM (kilometers). When set to miles the oil level amount screens will display the unit of measure in quarts (U.S. customary). When set to kilometers the amount screens will display liters (metric).

Setup Screens

Setup screens allow the technician to:

- Change between U.S. customary and metric units
- Turn the LCD display lamp on and off
- Set a service interval to miles or hours, or turn it off
- Reset service interval counters
- Set service interval values

See **Fig. 3** for a flowchart of the setup screens.

Service Interval Tables

For service interval miles look-up values, see **Table 1**.

For service interval hours look-up values, see **Table 2**.

Mode/Reset Switch Functions

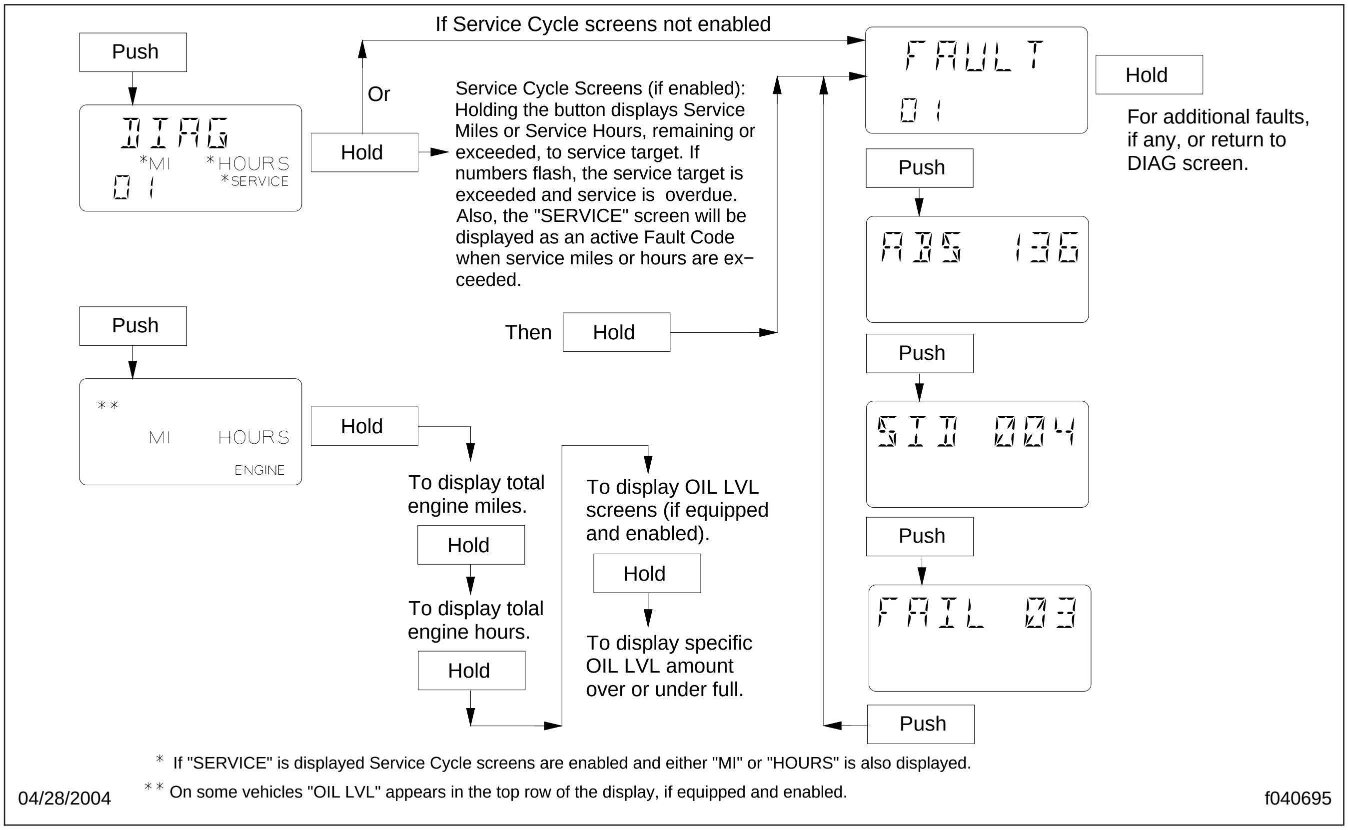


Fig. 2, Mode/Reset Switch Diagnostic and Engine Display Screens

Service Interval Distance Settings		
Number	**Miles**	**Kilometers**
1	1000	1610
2	1500	2415
3	2000	3220
4	2500	4025
5	3000	4830
6	3500	5635
7	4000	6440
8	4500	7245
9	5000	8050
10	5500	8855
11	6000	9660
12	6500	10465
13	7000	11270
14	7500	12075

Service Interval Distance Settings		
Number	**Miles**	**Kilometers**
15	8000	12880
16	8500	13685
17	9000	14490
18	9500	15295
19	10000	16100
20	11000	17710
21	12000	19320
22	13000	20930
23	14000	22540
24	15000	24150
25	16000	25760
26	17000	27370
27	18000	28980
28	19000	30590

Mode/Reset Switch Functions

Service Interval Distance Settings		
Number	Miles	Kilometers
29	20000	32200
30	21000	33810
31	22000	35420
32	23000	37030
33	24000	38640
34	25000	40250

Table 1, Service Interval Distance Settings

Service Interval Hours Settings	
Number	Hours
1	50
2	75
3	100
4	125
5	150
6	175
7	200
8	225
9	250
10	300
11	350
12	400
13	450
14	500
15	550
16	600
17	650
18	700
19	750
20	800
21	850
22	900
23	950
24	1000

Table 2, Service Interval Hours Settings

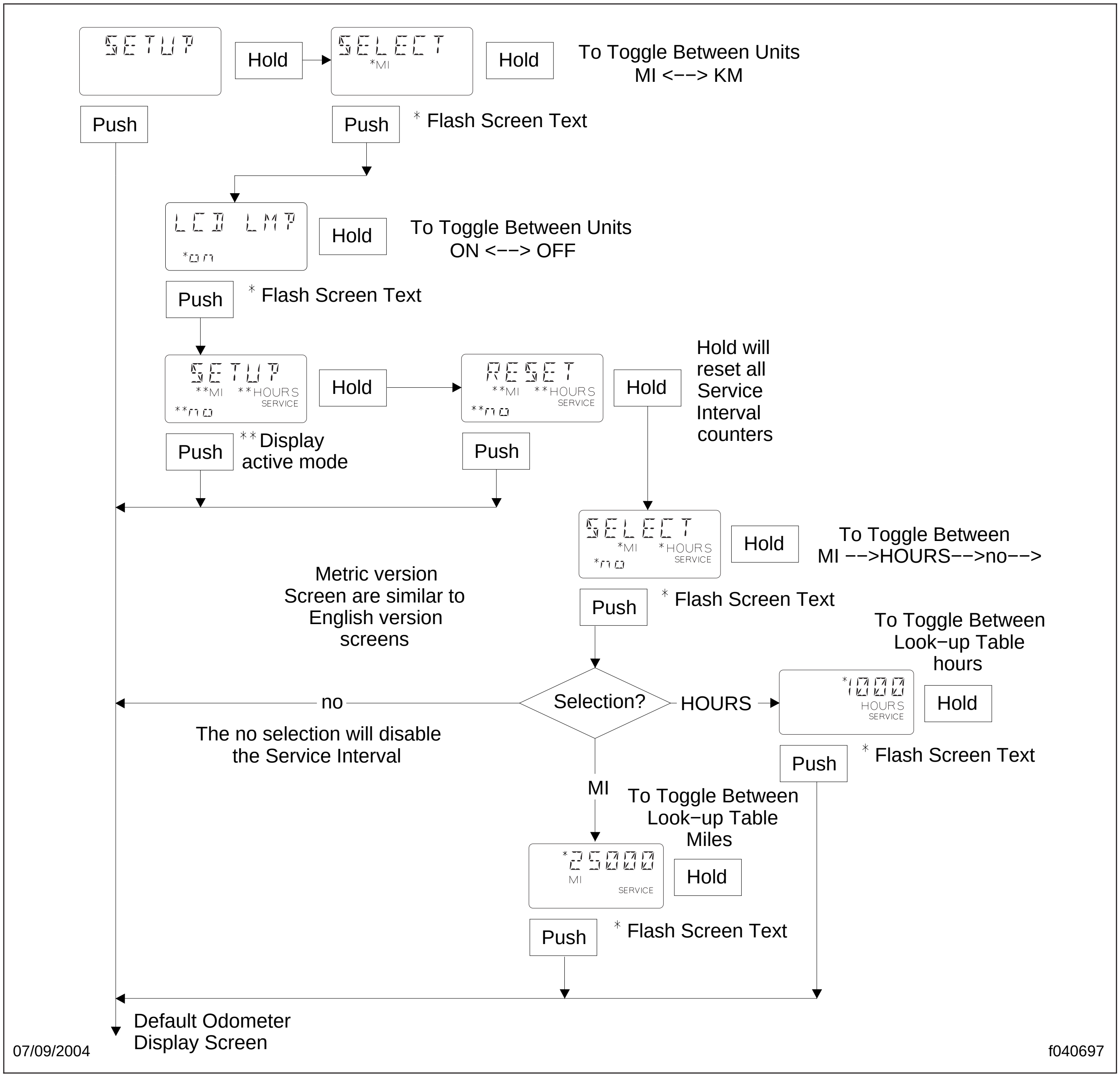


Fig. 3, Mode/Reset Switch Setup Screens

General Information

A "datalink" is an electrical network that connects two or more computers to exchange data. The simplest datalink is a pair of wires between two computers. Freightliner uses datalinks to connect the Electronic Control Units (ECUs) for the electronically controlled vehicle systems with each other and with the Instrumentation Control Unit (ICU). A personal computer using Freightliner's ServiceLink diagnostic software can also be connected to the network via a datalink.

Datalink Systems

Different types of datalinks are used to connect certain ECUs. The vehicle may have any of the following datalinks:

J1587/J1708

J1587/J1708 is a low speed vehicle datalink that communicates information between the ECUs on the vehicle. The J1587 datalink is also referred to as J1708. See **Fig. 1**. J1708 refers to the SAE standard for the physical part of the datalink, such as the wiring and the electronic components. J1587 refers to the SAE standard for the messaging protocol that communicates on the J1708 network. In the context of vehicle repair, the terms J1708 and J1587 are used interchangeably.

The J1587 datalink uses a twisted pair of wires to reduce interference from digital messages being sent on the wires. Wire colors for the J1587 datalink are:

- Orange **J1587 Low**
- Green **J1587 High**

J1939

J1939 is a high-speed vehicle datalink that communicates information between ECUs on the vehicle. See **Fig. 2**.

Unlike the J1587 datalink, the J1939 datalink allows an ECU to broadcast requests as well as information. Examples of information that can be communicated on the J1939 datalink are:

- engine rotational speed;
- road speed;
- transmission tailshaft speed;
- engine retarder deactivation request;
- engine torque reduction request.

The J1939 datalink uses a twisted pair of wires to reduce interference from digital messages being sent on the wires. Wire colors for the J1939 datalink are:

- Yellow **J1939 High**
- Green **J1939 Low**

The backbone of the J1939 datalink is the section of the datalink that is between two terminating resistors. An ECU can be connected anywhere along the length of the backbone in between the terminating resistors. The wiring between the ECU and the J1939 backbone is called a circuit. The maximum distance of the terminating resistor is 3 feet from the last ECU or diagnostic connector.

The purpose of the terminating resistors is to minimize the reflection of data on the datalink which can cause J1939 messages to become partially or completely lost. Terminating resistors prevent this from occurring. Each terminating resistor is 120 Ohms, but the equivalent of two 120 Ohms resistors in parallel is 60 Ohms. With both resistors installed in the circuit, there should be 60 Ohms measured at any two points between **J1939 High** and **J1939 Low** in the circuit.

Each ECU is generally connected to the J1939 backbone using a tee connector or splice. See **Fig. 3**.

Making the Pinout Measurements Easier to See

The pins on the diagnostic connector may be difficult to see when testing. If the pins are difficult to see, use a Y-cable as an extension to the diagnostic connector to make test measurements easier. See **Fig. 4** for a drawing of the connector at the end of the Y-cable and the corresponding 9-pin diagnostic connector pins.

NOTE: Be sure to attach a meter with a proper jumper kit to prevent unintentional shorting to other pins and possible damage to ECUs.

The Roll Call

To check the readiness of the ECUs on the datalink, the ICU sends a signal to other ECUs and expects a response from each. This "Roll Call" procedure tells the ICU which ECUs are functioning correctly. When

General Information

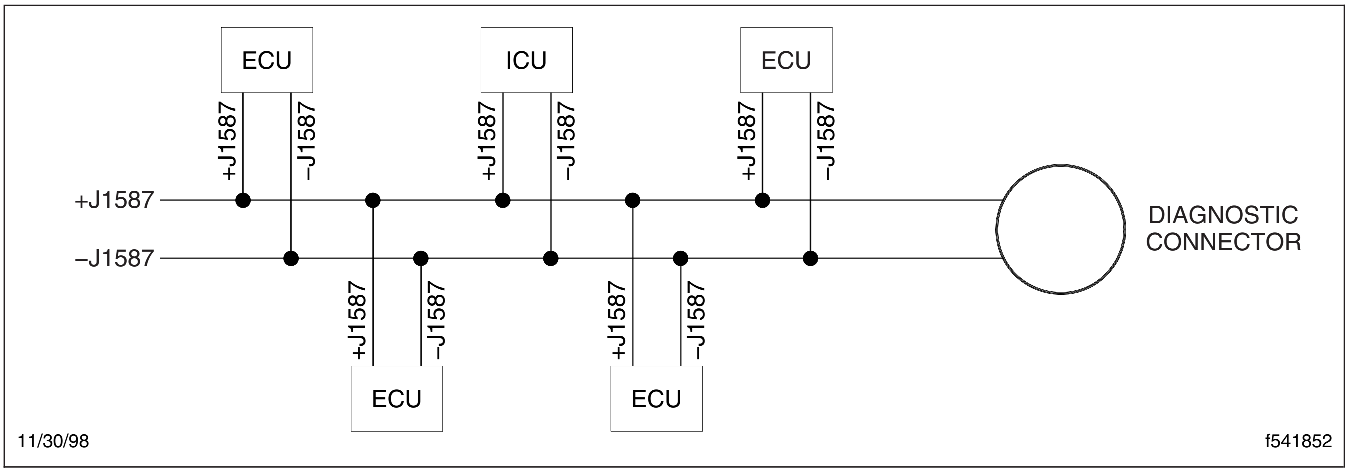


Fig. 1, J1587 Datalink

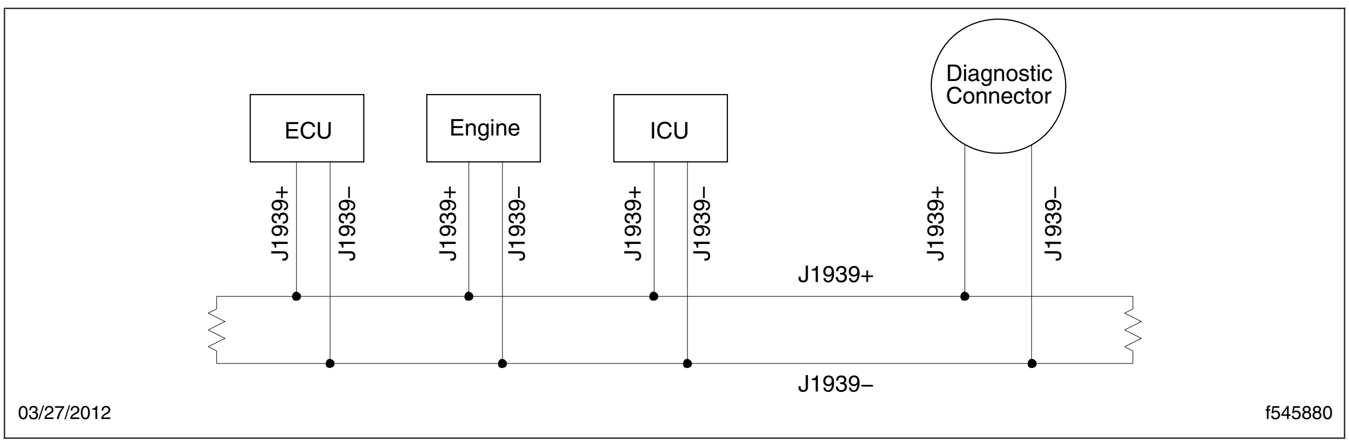
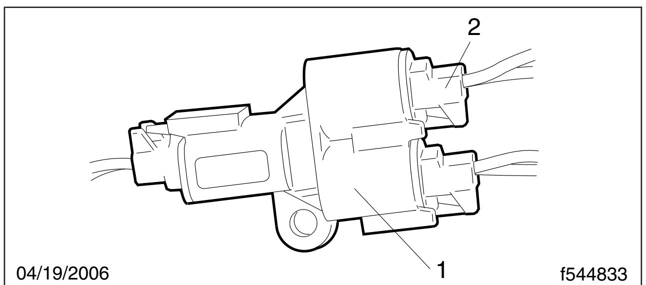


Fig. 2, J1939 Datalink



1. Branch to Backbone
2. Branch to ECU

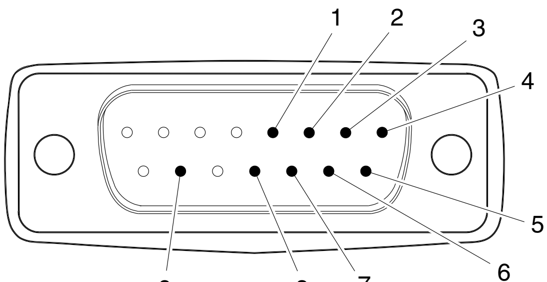
Fig. 3, J1939 Tee Connector

the list of functioning ECUs is compared against the parameter list of factory-installed ECUs that are supposed to respond, the technician can determine which ECUs or datalinks are bad.

The roll call procedure was not included in the software of the ICU2L. The list of ECUs that are polled can be changed using Freightliner ServiceLink software for ICU2M only. The following ICUs will conduct a roll call when the ignition is first turned on:

- ICU2M (any ECU, subject to parameter settings)
- ICU3 (limited to engine ECU and ABS ECU)
- ICU2L (limited to engine ECU and ABS ECU)

If the ICU does not receive a signal on the datalink from one or more of the active ECUs, it displays a roll call fault. The roll call fault is displayed *only* on the dash driver display screen. It is not broadcast on the datalink; therefore, it cannot be read by ServiceLink. However, Servicelink can be used to determine if an ECU is not responding because it polls all



1. Pin H (Diagnostic CAN High)
2. Pin A
3. Pin E
4. Pin B
5. Pin F
6. Pin G
7. Pin C (J1939 High)
8. Pin D (J1939 Low)
9. Pin J (Diagnostic CAN Low)

Fig. 4, Y-Cable Pinouts

ECUs on the datalink when it first connects to the vehicle datalink.

Datalink Junction Blocks

For the J1587 datalink, the wires routed through the vehicle cab have two datalink junction blocks and two datalink connections. The ICU3 uses only one connection to the ICU.

Locating J1939 Wiring Diagrams

The J1939 wiring diagram can be found in module 160. Other modules may also contain datalink wiring information. See **Table 1**.

Use PartsPro® to obtain drawing numbers for installation drawings, harness assembly drawings, and wiring diagrams applicable to the vehicle being worked on.

Component Module Locations	
Component	**Module Number**
General J1939 harness drawings, schematics, and installation drawings	160
Engine harness and installation drawings	283 and 286
Transmission harness and installation drawings	34A and 343
ABS harness and installation drawings	330, 332, and 333

Table 1, Component Module Locations

Datalink Repairs

J1587 Repairs

Use the same methods of repair for the twisted-pair datalink wiring as are used for the other wires on the vehicle. However, the datalink wires must be twisted at a rate of a minimum one turn per inch (25 mm) of length.

J1939 Repairs

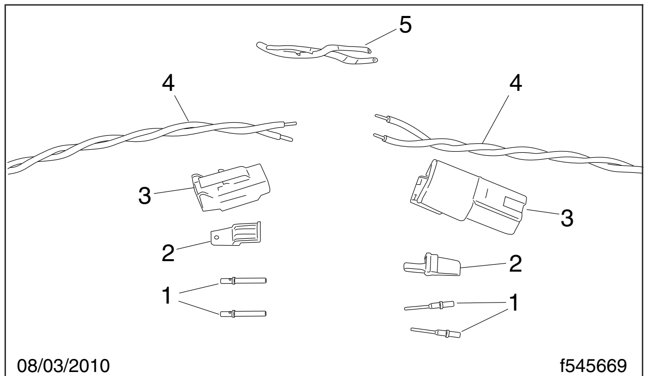
A special cable must be used for repairs to the J1939 datalink wiring. The two types of J1939 cable ("heavy" and "lite") can be spliced together as long as the pass-through connectors are the "heavy" type. The "lite" cable (because of its lower cost) is recommended for repairs on both types of J1939 cable. Refer to Appendix C of SAE J1939-11 for the special procedures for repairing the "heavy" J1939 datalink.

Parts

Twisted-pair datalink wires may be spliced using a mating connector set. See **Table 1** for a typical set of datalink connector parts.

Procedure

1. Cut out any damaged section of datalink wire, keeping the lengths of the two wires equal. See **Fig. 1** for an example of a damaged section of datalink wire that has been removed and the datalink prepared for repair.
2. Crimp the terminals onto the wires using the proper crimp tool.
3. Pull test the terminals by hand to ensure the crimp is mechanically solid.
4. Insert the terminated wires into the connector body and install the terminal lock. The protocol for J1939 is for the yellow wire to be in cavity 1 and the green wire to be in cavity 2. Note that the lock is installed while holding the wires in position. Test the installation. If the wires slipped back during the lock installation, they will pull out of the connector.
5. Make certain the wires are twisted as close to the entry point of the connector as possible. Plug the two connector halves together. See **Fig. 2**.



1. Terminals
2. Terminal Lock
3. Connector
4. Twisted-Pair Datalink Wires
5. Damaged Section of Datalink Wires

Fig. 1, Datalink Splice Parts

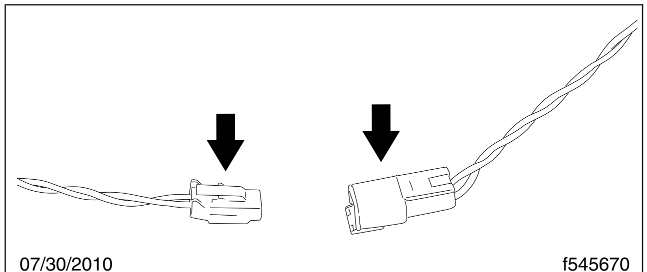


Fig. 2, Datalink Connectors

Datalink Repairs

Datalink Connector Parts		
Description	**Part Number**	**Quantity**
Connector Body Plug	23-13148-204	1
Terminal Lock	23-13303-015	1
Terminals	23-13210-020	2
Connector Body Receptacle	23-13148-206	1
Terminal Lock	23-13303-013	1
Terminals	23-13210-030	2

Table 1, Datalink Connector Parts

General Information

This Troubleshooting subject has three main parts:

- Troubleshooting Tables

  Use the Troubleshooting Tables to get ideas on what could be causing the problem and the possible remedies to that problem.

- Troubleshooting Procedures

  Follow the Troubleshooting Procedures section to isolate the areas that have faults and to know which tests to perform.

- Testing Procedures

  The Testing Procedures section has the individual tests and specifications needed to determine whether a part must be repaired or replaced.

NOTE: Be sure to attach a meter with a proper jumper kit to prevent unintentional shorting to other pins and possible damage to ECUs.

Troubleshooting Tables

Use the following troubleshooting tables to find remedies to possible causes of datalink problems.

Problem—Power-On Roll Call Reports Fault

Problem—Power-On Roll Call Reports Fault	
Possible Cause	**Remedy**
The ECU does not support roll call function (ICU1/2M only).	Reset the ECU parameter to disable roll call.
The datalink wiring has a fault.	Repair or replace the wiring.
Wrong power supply voltage or ground to ECU.	Replace the fuse or circuit breaker, charge the battery, the check connections.
The connector has a fault - (Pass-through, Branch, Diagnostic)	Repair or replace the wiring.
The ECU has a fault.	Replace the ECU.
The ICU has a fault.	Replace the ICU.
The terminating resistor for J1939 datalink is missing or has a fault.	Replace the terminating resistor.
The branch length is too long on J1939 datalink.	Shorten "lite" branch to less than 10 feet (3 m).
The battery is discharged or is bad.	Charge or replace the battery.

Problem—ServiceLink Will Not Connect

Problem—ServiceLink Will Not Connect	
Possible Cause	**Remedy**
ICU is older series that does not support roll call.	Use ICU for display of active fault codes only.
One or more ECUs has a fault.	Remove suspected ECUs one at a time until the Service Tool can be connected.
The service tool computer is not configured or connected correctly.	Check the computer settings, communication adaptor and cabling between the computer, communication adaptor, and diagnostic connector.
Connector types are different.	The J1939 datalink and new J1587 datalinks have 9-pin connectors. Connect an adapter or use the ICU for the diagnostics information display.

Troubleshooting

Problem—ServiceLink Will Not Connect	
Possible Cause	**Remedy**
Battery is discharged, has a bad connection, or has a fault.	Charge, clean terminals, or replace battery.

Problem—Missing Data on Datalink-Driven Gauges

Problem—Missing Data on Datalink-Driven Gauges *	
Possible Cause	**Remedy**
ICU or engine ECU is not communicating on datalink.	Test wiring and ICU or engine ECU.
Datalink wiring has a fault.	Test and repair wiring.
Connector or junction block has a fault.	Repair or replace connector.
Incorrect voltage to ECUs	Test datalink and vehicle wiring.

* Datalink-driven gauges include: engine oil pressure, coolant temperature, engine oil temperature, turbo air pressure, tachometer, speedometer

Troubleshooting Procedures

To find the part of the datalink system that is causing a problem, follow the Troubleshooting Procedures and refer to the appropriate Troubleshooting Tests for the test points and specifications. Perform the steps of the Troubleshooting Procedures in sequence until you locate the fault.

The seven steps to diagnosing a datalink problem are:

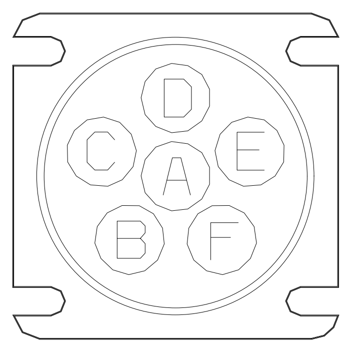
1. Determine which types of datalink are installed on the vehicle.

    1.1 Check the diagnostic connector. A 6-pin connector (or a 9-pin connector without pins C and D installed) is used for J1587 datalinks. See **Fig. 1** and **Fig. 2**. J1939 datalinks have pins C and D installed in the 9-pin diagnostics connector.

    1.2 Check the wires. J1939 cable has a heavy jacket. Note that some non-Freightliner ECUs have their J1587 wires inside a jacket as well. If all the wiring has a jacket, the datalink is a J1939 datalink.

    If the J1939 cable has a drain wire inside the shielding, it is a "heavy" cable. The J1939 "lite" cable (with no drain wire) can be spliced into a section of "heavy" cable.

    1.3 Determine whether a Cummins IS Series, Caterpillar CFE, or a Mercedes-Benz engine is installed with an ABS system that has traction control. These systems use a J1939 datalink.



11/30/98 f542751

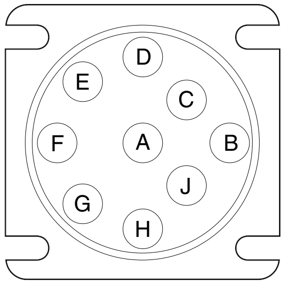
1. Pin A (J1587 High)
2. Pin B (J1587 Low)
3. Pin C (12V+)
4. Pin D (Reserved)
5. Pin E (Ground)
6. Pin F (Reserved)

Fig. 1, J1587 6-Pin Diagnostics Connector

    1.4 A J1939 datalink is used when an Eaton® Fuller® AutoShift transmission is installed. The WABCO EBS (brake-by-wire) system and certain Eaton VORAD EVT-300 systems also require J1939 datalinks. Certain other ECUs may require a J1939 datalink.

2. Determine which ECUs are not communicating with the service tool.

    2.1 Connect to the vehicle with ServiceLink



NOTE: Pins C and D are not installed in the J1587 diagnostics connector.

1. Pin A Battery (Low)
2. Pin B Battery (High)
3. Pin C (J1939 High)
4. Pin D (J1939 Low)
5. Pin E (Shield)
6. Pin F (J1587 High)
7. Pin G (J1587 Low)
8. Pin H (Diagnostic CAN High)
9. Pin J (Diagnostic CAN LOW)

Fig. 2, J1939/J1587 9-Pin Diagnostics Connector

2.2 Compare the ICU roll call list with ECU list.

Note: Some ECUs cannot communicate with the ICU, but will appear on the diagnostic tool parameter list. The ICU2L and ICU3 rollcall function is limited to the engine ECU and the ABS ECU.

2.3 If an ECU is not communicating on the datalink, disconnect all the generic ECUs, one at a time, until no faults are displayed on the ICU screen or until ServiceLink connects to the system. The last ECU to be disconnected before the successful ServiceLink connection is the one causing the problem.

3. Check the suspected ECU.

3.1 Check the resistance and voltage at the ECU connectors. See **Testing the ECUs** in the datalink testing procedures section of this subject.

3.2 Temporarily replace the ECU with an ECU known to be good. If the ICU (or ServiceLink) now lists that ECU, install a new ECU.

4. Check the wires and connectors from the ICU at the connector for the suspected faulty ECU. See **Testing the J1587 Datalink** or **Testing the J1939 Datalink** in the datalink testing procedures section of this subject.

4.1 Check the power supply voltage.

4.2 Check the data signal voltage.

4.3 Check the continuity and resistance to ground. If the readings are outside the acceptable range and are found at several test points, suspect that the datalink has a fault.

5. Determine which branch includes the suspected faulty ECU. Find the connectors and junction blocks that are in series with the suspected faulty ECU.

6. Check the wiring between the branch connector and the ECU and the wiring from the ICU to the branch connector. See **Testing the J1587 Datalink** or **Testing the J1939 Datalink** in the datalink testing procedures section of this subject.

6.1 Check power supply voltage.

6.2 Check the data signal voltage.

6.3 Check the continuity and resistance to ground.

7. Check the ICU. See **Testing the ICU** in the datalink testing procedures section of this subject.

7.1 Check the voltages at the junction block to the ICU.

7.2 Replace the ICU with an ICU known to be good.

Datalink Testing Procedures

The following procedures give the test points and specifications for checking the various types of datalinks, connectors, ECUs and ICUs. Refer to the datalink troubleshooting tables, and the datalink troubleshooting procedures, above, for information on when to test the particular parts of the datalink system.

Testing at the ECUs

1. Make sure that the vehicle battery is charged and the fuses and circuit breakers are good before testing the ECU connectors.
2. The keyswitch must be in the OFF position. Disconnect the ECU datalink circuit at the connector closest to the ECU. Turn the keyswitch to the ON

position and check the voltage at the ECU harness connector. See Table 1 for the acceptable results.

3. Connect the ECU to the datalink connector when the keyswitch is in the OFF position. Turn the keyswitch to the ON position for this test. Touch the probes of the digital multimeter (on the DC voltmeter scale) to the metal terminals of the ECU connector as shown in Table 1 to test the ECU. Use the AC scale for the voltage tests if the multimeter will not display the rapidly changing DC voltage using the DC scale. If the test results are not within the range shown, replace the ECU and test again.

NOTE: Voltages in Table 1 will be varying.

ECU Harness Voltage Tests		
J1587 aDatalink		
Meter (High) Probe	**Meter (Low) Probe**	**Acceptable Meter Reading (VDC)**
ECU Datalink High Terminal	ECU Datalink Low Terminal	1 to 4 VDC (1 to 3V on the AC Scale)
Battery Positive Post	ECU Datalink High Terminal	6 to 11 VDC *
	ECU Datalink – Terminal	9 to 13.5 VDC *
J1939 Datalink		
Diagnostics Pin C (J1939 High)	Diagnostics Pin D (J1939 Low)	.2 to 5 VDC (.1 to 4V on the AC Scale)
Diagnostics Pin B (BAT High)	Diagnostics Pin C	6 to 11 VDC*
	Diagnostics Pin D	9 to 13.5 VDC*

* If datalink wire connections are reversed, the results are reversed.

Table 1, ECU Harness Voltage Tests

Testing the J1587 Twisted-Pair Datalink

1. Make sure that all fuses and circuit breakers are in good condition.
2. Turn the keyswitch to the OFF position before disconnecting or connecting any part of the datalink system. Disconnect the J1587 connector for the datalink section you are testing.

IMPORTANT: Do NOT disconnect the datalink by disconnecting the engine, frontwall or chassis electrical connectors.

IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1587 resistance tests. Failure to do so may result in inconclusive resistance measurements. The J1939 datalink is not completely inactive with only the ignition off. It may be active even if there appears to be no voltage on the datalink.

3. Turn the keyswitch to the OFF position. Test the continuity of a J1587 twisted-wire pair by touching the red (positive) probe of a digital multimeter (set to the ohmmeter mode) to the **J1587 High** terminal of the connector. Connect the black (negative) probe to the J1587– wire terminal. See Table 2 for the results.

   Check the datalink isolation to the vehicle ground by holding one ohmmeter probe on the **J1587 Low** wire and the other probe to a good ground. Perform this test again with the ohmmeter leads reversed. Table 2 shows the acceptable resistances for these tests.

J1587 Resistance Tests		
Meter (High) Probe	**Meter (Low) Probe**	**Acceptable Meter Reading (Ohms)**
High	Low	1k to 30k Ohms
High	Vehicle Ground	More than 1k Ohms

J1587 Resistance Tests		
Meter (High) Probe	Meter (Low) Probe	Acceptable Meter Reading (Ohms)
Low	Vehicle Ground	More than 1k Ohms

Table 2, J1587 Resistance Tests

4. Test the signal voltage on the J1587 twisted pair as shown in **Table 1**. The keyswitch must be in the ON position for the voltage tests. Use the AC scale for the voltage tests if your multimeter will not display the rapidly changing DC voltage using the DC scale.

NOTE: If any voltage reading is a steady 0 VDC or a steady 12 VDC, the ECU or datalink wiring has a fault.

Testing the J1939 Datalink

Use the following five basic steps in the order given to successfully locate J1939 datalink problems. Do not skip steps or tests unless directed to do so.

J1939 Resistance Test

This test checks whether or not both terminating resistors are installed, and ensures that there is a complete circuit from the diagnostic connector through the backbone loop. It does not ensure that branch circuits to each ECU are OK.

Tests in this subject are performed using a digital multimeter set to read ohms.

IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1939 resistance tests. Failure to do so may result in inconclusive resistance measurements. The J1939 datalink is not completely inactive with only the ignition off. It may be active even if there appears to be no voltage on the the datalink.

1. Turn the ignition OFF and disconnect the batteries.
2. Connect the meter leads of a digital multimeter set to read ohms to pins C and D of the 9-pin diagnostic connector and measure the resistance.
3. Reconnect the batteries after the test is completed.

See **Table 3** for test results and possible causes.

J1939 Resistance Test	
Result	Possible Cause
$60\Omega \pm 6\Omega$	The J1939 datalink backbone is intact and both terminating resistors are installed. Go to step 2.
$120\Omega \pm 12\Omega$	Any of the following: • One of the terminating resistors is missing. • One of the terminating resistors is open. • The circuit may be open anywhere between the terminating resistors.
$40\Omega \pm 4\Omega$	Three terminating resistors have been installed; one must be removed. There must be one terminating resistor at each end of the backbone for a total of two.
0Ω to 5Ω	**J1939 High** and **J1939 Low** have shorted together somewhere in the system.
Greater than 1000Ω	The most likely cause is an open circuit between the diagnostic connector and the J1939 backbone. It may also be that both terminating resistors are missing or open.

J1939 Resistance Test	
Result	**Possible Cause**
Any other readings	Any of the following: • Incorrect terminating resistor resistance. • Poor or corroded connections. • Short circuit to ground or an open circuit somewhere on the datalink. Go to step 2 to pinpoint the problem.

Table 3, J1939 Resistance Test

ECU Communication Test

The following series of tests check for communication with each ECU connected to the J1939 datalink. If one fails to communicate, pinpoint whether the problem is wiring or an ECU. If all ECUs communicate as they should, J1939 is probably not the problem.

1. **Check whether each ECU connected to the J1939 datalink responds.**

   1.1 Connect the computer to the diagnostic connector.

   1.2 Start the J1939 Datalink Monitor template.

   NOTE: The template contains instructions on its use.

   1.3 Check whether each ECU that is supposed to be connected to the datalink responds. See **Table 4** for test results and possible causes.

Check whether each ECU connected to the J1939 datalink responds	
Result	**Possible Cause**
All ECUs respond	The J1939 datalink is probably not the problem.
One ECU fails to respond.	Go to step 2.
No ECUs respond	Possible explanations are: • The **J1939 High** and **J1939 Low** pinouts may be reversed at the diagnostic connector, or at any other connector in the system. Check their polarity. • There may be a problem with the PC to vehicle interface. • The entire datalink may be down due to a short to power or short to ground. Go to Step 3 to pinpoint the problem.

Table 4, Check Whether Each ECU Connected to the J1939 Datalink Responds

2. **Check the J1939 datalink wiring to the ECU that does not respond.**

   IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1939 resistance tests.

   2.1 Turn the ignition OFF and disconnect the batteries.

   2.2 Locate the connector at the ECU in Step 2, Test 1 that did not respond and disconnect it.

   2.3 Locate the pins for **J1939 High** and **J1939 Low**. Refer to Freightliner or component supplier literature or wiring diagrams for the specific component.

2.4 Check to make sure that **J1939 High** and **J1939 Low** polarity is correct at the component before proceeding. If not, this is the most likely problem.

2.5 Using a digital multimeter set to read ohms, measure the resistance across the two J1939 datalink pins at the connector to the suspect ECU.

2.6 Reconnect the batteries after the test is completed. See **Table 5** for test results and possible causes.

Check the J1939 datalink wiring to the ECU that does not respond	
Result	**Possible Cause**
60Ω ± 6Ω	The datalink itself is probably not the problem. Make sure that any changeable J1939 parameters for this ECU are set correctly before proceeding. Also, make sure that there is power and ground to the suspect ECU. Go to **step 3** once the following have been confirmed: • J1939 parameters for the ECU (if they can be changed) are correct. • There is power and ground to the suspect ECU.
Not 60Ω ± 6Ω	There is a problem with the J1939 wiring between the ECU connector and its connection to the J1939 backbone. Repair as necessary.

Table 5, Check the J1939 Datalink Wiring to the ECU That Does Not Respond

3. **Install a test ECU to confirm the problem.**

3.1 Install a test ECU and make sure that all J1939 parameters (if changeable) are set correctly.

3.2 Using the J1939 Datalink Monitor template, check to see if every ECU that is supposed to be connected to the datalink responds. See **Table 6** for test results and possible causes.

Install a test ECU to confirm the problem	
Result	**Possible Cause**
All ECUs respond	The ECU was faulty and the test ECU confirmed this. Replace the ECU.
The ECU still does not respond.	The problem has not been confirmed. Carefully repeat all the diagnostics. If the ECU still does not respond, contact your District Service Manager or the ECU supplier directly for assistance.

Table 6, Install a Test ECU to Confirm the Problem

Test J1939 Voltage for Circuit Faults (Shorts to Power and Ground)

These tests check for shorts to power and shorts to ground on the J1939 datalink.

NOTE: All tests are performed using a digital multimeter set to read voltage.

NOTE: Before proceeding, verify that battery voltage (approximately +12 VDC) is available at pin B of the diagnostic connector. With the ignition ON, use a digital multimeter to test for voltage at pin B by placing the red (+) lead on pin B and the black (-) lead on a good chassis ground.

1. **Test J1939 High for shorts to power and ground.**

1.1 Turn the ignition ON.

1.2 Touch the red (+) lead to pin B (+12 VDC) and the black (-) lead to pin C (**J1939 High**) of the diagnostic connector. See **Table 7** for test results and possible causes.

Troubleshooting

Shorts to Power and Ground (J1939 High)	
Result	**Possible Cause**
0 VDC	**J1939 High** is shorted to power. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink."
12 VDC (battery voltage)	**J1939 High** is shorted to ground. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink."
Any other reading	**J1939 High** is not shorted to power or ground. Go to step 2.

Table 7, Shorts to Power and Ground (J1939 High)

2. **Test J1939 Low for shorts to power and ground.**
   2.1 Turn the ignition ON.
   2.2 Touch the red (+) lead to pin B (+12 VDC) and the black (-) lead to pin D (**J1939 Low**) of the diagnostic connector. See Table 8 for test results and possible causes.

Shorts to Power and Ground (J1939 Low)	
Result	**Possible Cause**
0 VDC	**J1939 Low** is shorted to power. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink."
12 VDC (battery voltage)	**J1939 Low** is shorted to ground. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink."
Any other reading	**J1939 Low** is not shorted to power or ground. There may be a problem with the vehicle to computer interface. The datalink itself appears to be OK.

Table 8, Shorts to Power and Ground (J1939 Low)

Databus Quick Test

NOTE: All voltages in **Table 1**, except for BAT + and BAT – will be varying.

Databus Quick Test				
No.	**Test**	**Red Lead/Black Lead**	**Specification**	**Result**
Battery Connected – Ignition ON				
1	Bat+ to Bat-	Pin B to Pin A	Source Voltage (> 12.4)	
2	J1587+ to J1587–	Pin F to Pin G	1 – 5 VDC (0 – 4 VAC)	
3	Bat+ to J1587+	Pin B to Pin F	6 – 11 VDC	
4	Bat+ to J1587–	Pin B to Pin G	9 – 13.5 VDC	
5	J1939+ to J1939–	Pin C to Pin D	.2 – 5 VDC (.1 – 4 VAC)	
6	Bat+ to J1939+	Pin B to Pin C	6 – 11 VDC	
7	Bat+ to J1939–	Pin B to Pin D	9 – 13.5 VDC	
Ignition OFF – Battery Disconnected at Batteries – NOT Cab Load Disconnect Switch				
8	J1587+ to J1587–	Pin F to Pin G	1k – 30k Ohms	
9	J1587+ to Bat–	Pin F to Pin A	> 1k Ohms	
10	J1587- to Bat–	Pin G to Pin A	> 1k Ohms	
11	J1939+ to J1939–	Pin C to Pin D	55 – 65 Ohms	
12	J1939+ to Bat–	Pin C to Pin A	> 1k Ohms	
13	J1939- to Bat–	Pin D to Pin A	> 1k Ohms	
14	Terminating Resistors	—	110 – 130 ohms	

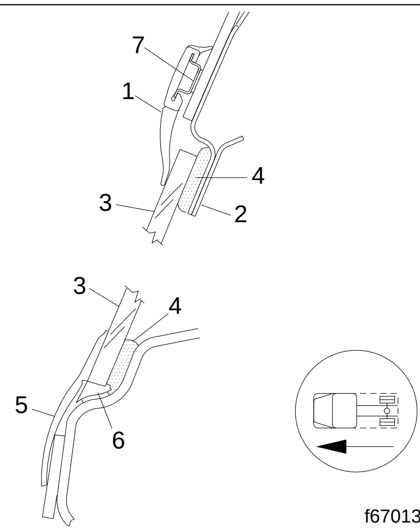
Table 1, Databus Quick Tests

NOTE: J1939 tests can also be performed on Diagnostic CAN High – Pin H, and Diagnostic CAN Low – Pin J for similar results.

General Information

The windshield is either a one-piece or a two-piece installation. The windshield glass is held in place on the windshield mask by a bead of urethane adhesive/sealant. Rubber molding strips are installed at the top and bottom edges of the glass. Two-piece windshields have an additional molding strip on the center post, between the right and left glass panes.

The windshield is installed in a manner similar to automobile windshields, in that the urethane sealant holds the windshield in place and seals out moisture; see **Fig. 1**. The molding strips are installed mainly for appearance.



NOTE: Installation with a top molding retainer strip is shown.

1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Bottom Molding Strip
6. Positioning Block
7. Retainer Strip

Fig. 1, Windshield Installation, Cross-Sectional View

See **Specifications 400** for special tools and materials needed to replace a windshield.

Replacement

NOTE: Freightliner recommends Sika Ultrafast, Dow U-400HV, or Bostik® 70-08A adhesive for windshield replacement.

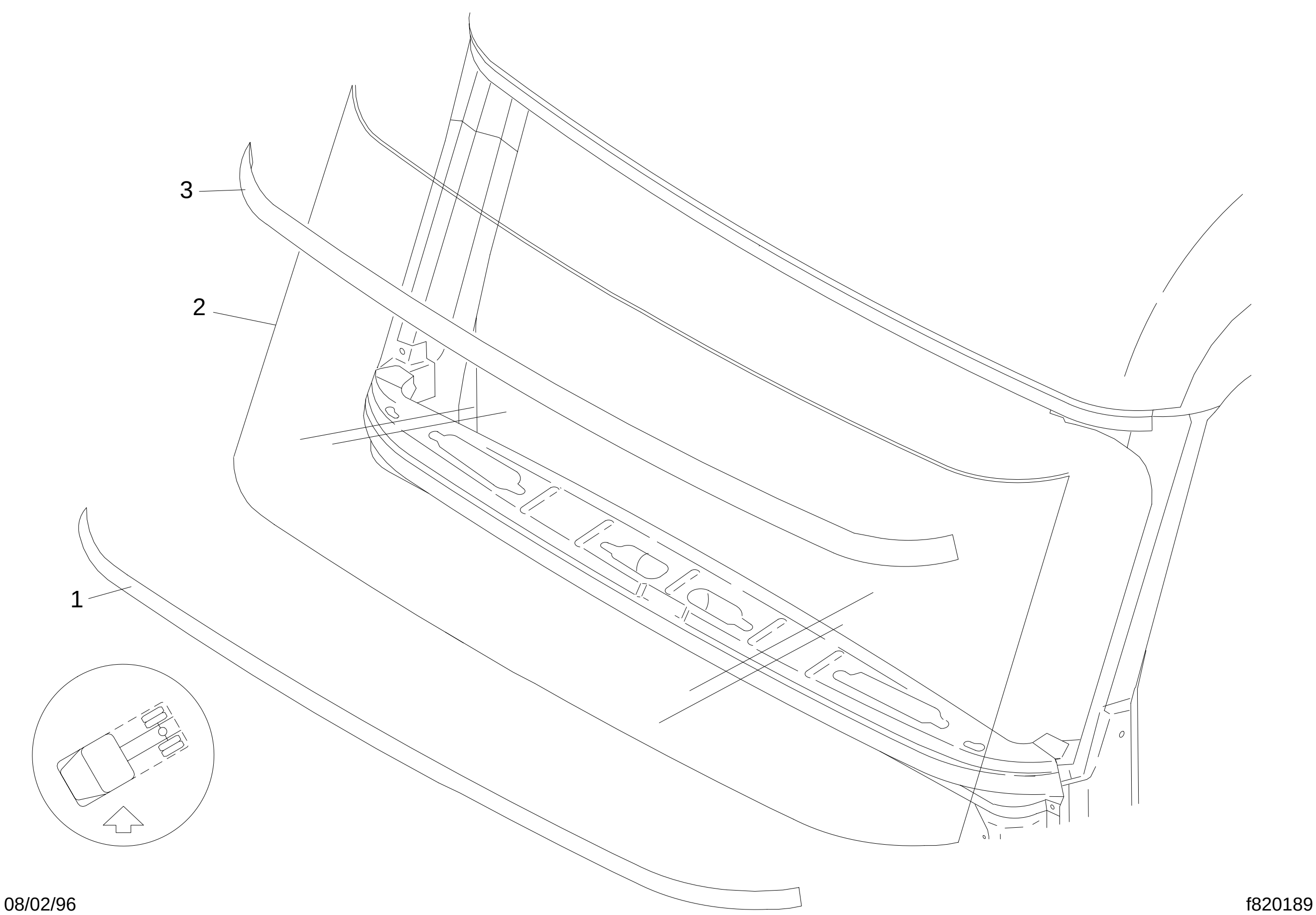
The procedure below specifies Dow adhesives and primers, though other manufacturers' systems can be used. Regardless of the system used, adhere to the adhesive manufacturer's instructions, and use that manufacturer's recommended primers and glass prep solutions for the entire procedure.

See **Fig. 1** for a one-piece windshield installation.

If the windshield is cracked, carefully inspect the glass, urethane sealant, and the windshield mask to determine the cause. Correct the problem before installing a new windshield. If the underlying cause for the crack is not corrected, the replacement windshield may crack when exposed to high winds, pressure, temperature extremes, or vehicle motion.

NOTE: At least two people are needed to replace a windshield.

1. Apply the parking brakes and chock the tires.
2. Open the windows. Shutting the doors with the windows closed could pressurize the cab and create gaps in the uncured adhesive.

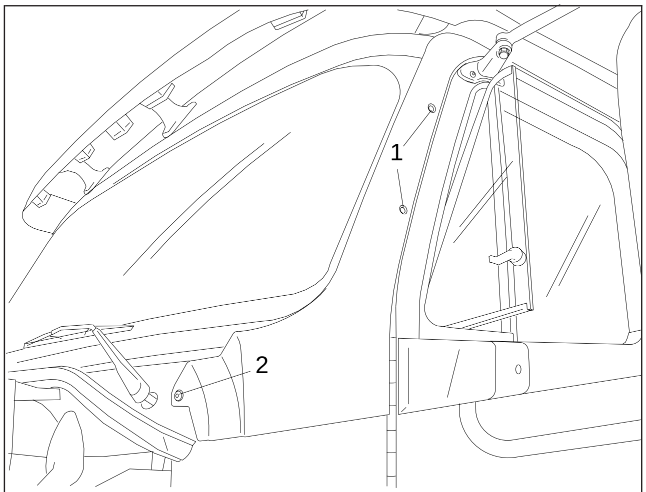


1. Bottom Molding Strip 2. Windshield Glass 3. Top Molding Strip

Fig. 1, One-Piece Windshield Installation

One-Piece Windshield Replacement

3. Open the hood.
4. Remove the windshield wiper arms; see **Section 82.00, Subject 100**.
5. Protect the paint finish and instrument panel by taping paper around the inside and outside of the windshield opening.
6. Remove the lower capscrew from the exterior A-pillar panel; see **Fig. 2**.



1. Middle A-Pillar Fasteners (Columbia 120 only)
2. Lower A-Pillar Fastener

Fig. 2, A-Pillar Exterior Panel Fasteners

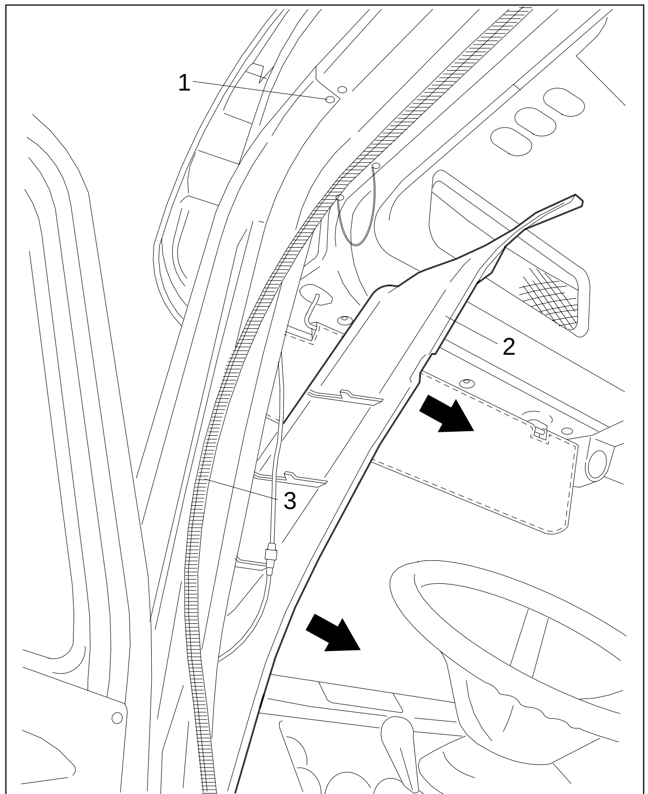
7. If the vehicle is a Columbia 120, remove the two fasteners that attach the middle span of the panel to the A-pillar.

   If the vehicle is a Columbia 112, the exterior panel mounting is concealed under the A-pillar interior trim. Remove the mounting nuts, as follows.

   7.1 Remove the grab handle from the right-hand A-pillar.

   7.2 On both sides of the vehicle, loosen the door trim, then remove the A-pillar interior trim; see **Fig. 3**.

   7.3 If the vehicle is equipped with an Eaton® VORAD® collision warning system, disconnect the sensor located on the inside of the right-hand A-pillar.



1. Capscrew
2. A-Pillar Interior Trim
3. Door Trim

Fig. 3, Removing A-Pillar Interior Trim

   7.4 Through the access holes on each A-pillar, remove the three nuts that attach the exterior panel to the A-pillar; see **Fig. 4**.

8. Remove the capscrew that attaches the exterior A-pillar panel to the top of the door frame; see **Fig. 3**. Remove the panel.
9. Remove the Torx® screw and bushing at each end of the top molding strip; see **Fig. 5**.
10. Slide the top molding strip off the retainer strip.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; remove the top molding strip by pulling it loose from the gap between the windshield glass and the windshield mask.

11. Remove the bottom molding strip.

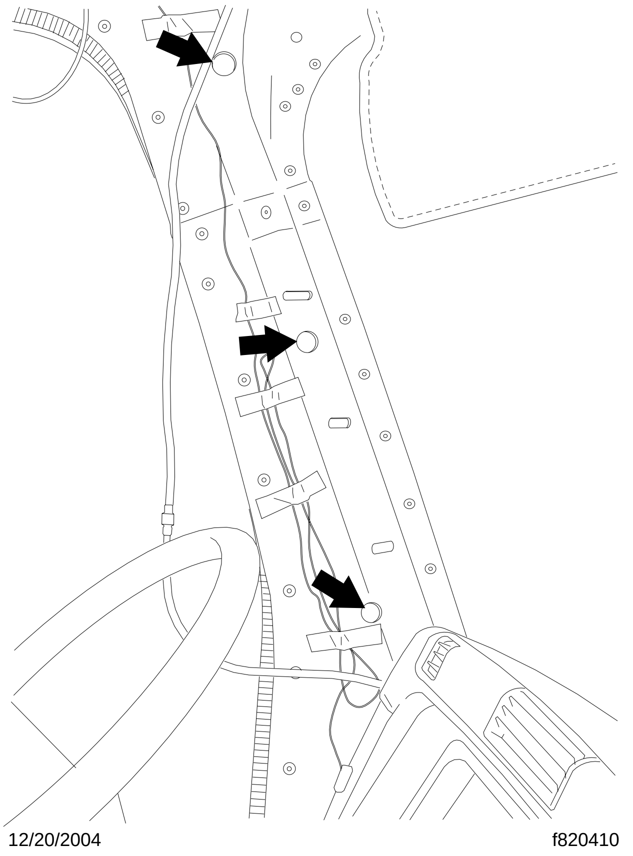


Fig. 4, A-Pillar Fastener Access Holes

12. Using a pneumatic cutting tool (**Fig. 6**), a piano wire (**Fig. 7**), or a pull knife (**Fig. 8**), cut through the urethane sealant all around the edges of the windshield glass.

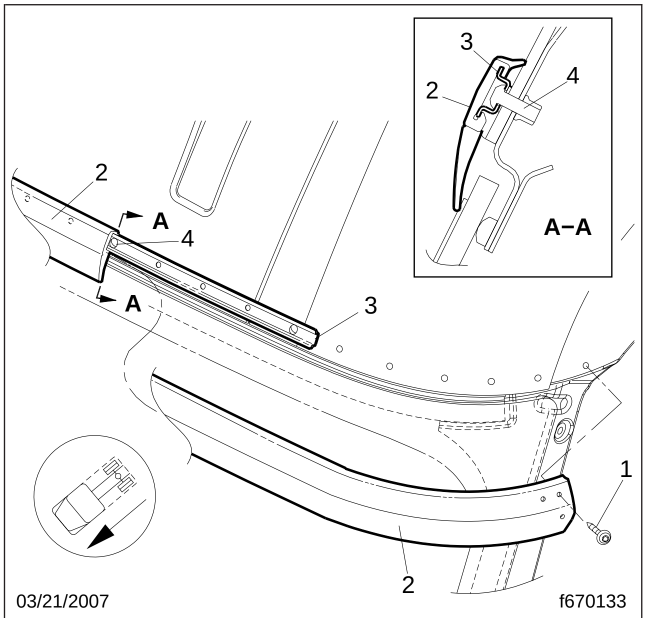
NOTE: To order a BTB pneumatic cutting tool, see **Specifications 400**.

⚠ WARNING

Wear protective gloves and safety glasses when replacing windshield glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.

13. Carefully remove the damaged windshield glass.

14. Remove the four rubber positioning blocks from the lower windshield mask; see **Fig. 9**. Discard them.



1. Screw and Bushing
2. Top Molding Strip
3. Retainer Strip
4. Lockbolt

Fig. 5, Top Molding Strip Installation

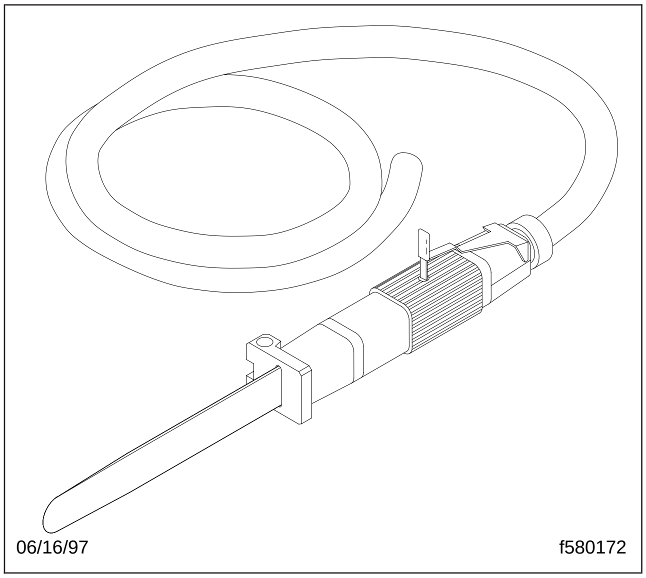
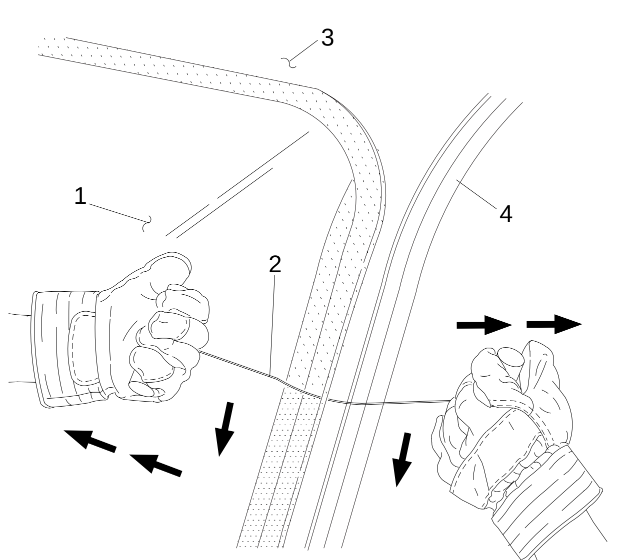


Fig. 6, BTB Pneumatic Cutting Tool

15. Using a BTB pneumatic cutting tool or a sharp knife, trim down the old urethane sealant to a thickness of about 1/16 inch (1 to 2 mm). Make sure any remaining adhesive has a smooth and even surface.

One-Piece Windshield Replacement



1. Windshield Glass
2. Piano Wire
3. Roof
4. Door Frame

Fig. 7, Windshield Glass Removal with Piano Wire

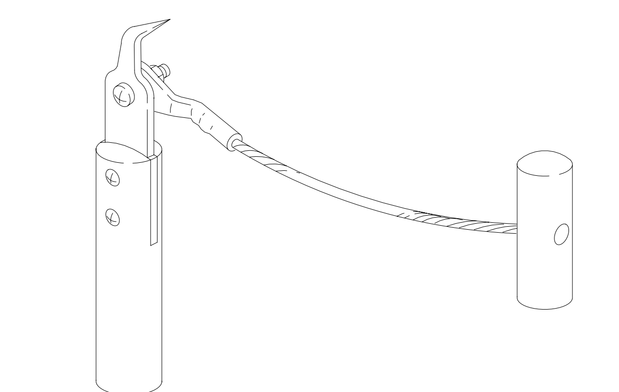
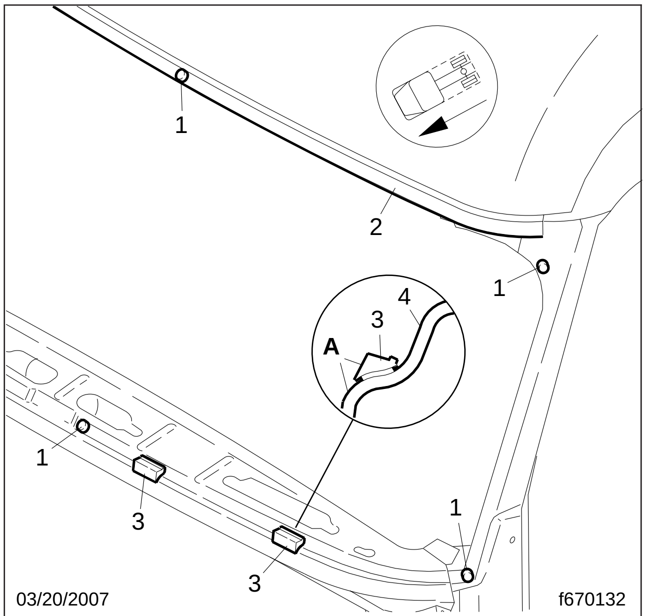


Fig. 8, Typical Pull Knife

16. Brush the remaining adhesive and debris from the windshield-seating cavity.
17. Check the windshield mask. Apply Betaprime® 5404A Pinchweld and Encapsulation Primer to any bare metal. Allow to dry for a minimum of 6 minutes.



A. These two surfaces are to be flush.

1. Spacer Button
2. Windshield Mask (upper)
3. Positioning Block
4. Windshield Mask (lower)

Fig. 9, Cab Area for Windshield Installation

NOTE: Exposed bare metal areas larger than 1/2 inch x 1/2 inch (13 mm x 13 mm) require the use of Betaprime 5201TF Bare Metal Etch Primer.

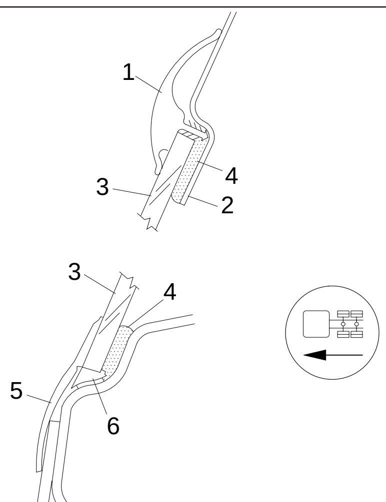
18. Install eight spacer buttons on the windshield mask; see **Fig. 9**.
19. Install four new rubber positioning blocks in the cavity; see **Fig. 9**.
20. Put the new windshield glass on a suitable stand or fixture, with the inside surface of the glass facing up.
21. Clean the bonding surface of the glass with Betaclean GC-800.
22. Apply Betaprime 5500 1-Step Glass/Frit Primer all the way around the edge of the glass to a width of about 1 inch (25 mm). *Do not get any of the primer on the black dot pattern of the glass.* Allow a minimum of six minutes for the primer to dry.
23. Holding the sealant applicator at a 90-degree angle to the windshield mask on the cab, apply a

uniform and continuous bead of Betaseal U-400HV Adhesive all the way around the edges of the windshield mask. The bead should be a minimum of 3/8 inch (10 mm) thick.

Keep the spiked edge of the applicator tip against the edge of the mask, and overlap the bead slightly.

IMPORTANT: Do not apply the urethane adhesive/sealant to the windshield glass. Aligning a windshield with adhesive on the glass is very difficult to do without getting the adhesive/sealant on the painted cab surface outside the windshield mask.

24. Attach a suction device to the outside of the windshield. Lift and install the windshield. Make sure the glass is centered on the windshield mask, and that the bottom edge of the glass seats onto the positioning blocks correctly; see **Fig. 10** or **Fig. 11**.



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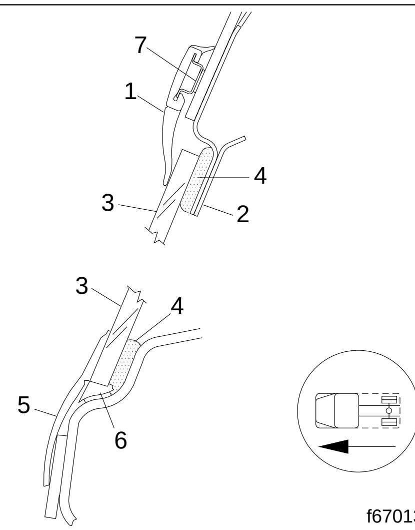
1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Sealant
5. Bottom Molding Strip
6. Positioning Block

Fig. 10, Cross-Section View (vehicles built before July 21, 2000)

25. Gently press down on the glass all the way around the bead line to firmly seat the windshield.

26. With a spatula or a paddle, smooth the adhesive flat along the edge of the windshield.



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1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Bottom Molding Strip
6. Positioning Block
7. Retaining Strip

Fig. 11, Cross-Section View (vehicles built from July 21, 2000)

27. Install the bottom rubber molding strip, using Betaseal U-418 primerless auto glass urethane adhesive. Do not use a silicone hot glue.

28. Slide the top molding strip onto the retainer strip, if so equipped. Fasten each end of the strip to the A-pillar with a Torx screw and bushing; see **Fig. 5**.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip. Attach the molding strip using Betaseal U-418 primerless auto glass urethane adhesive.

29. Attach each A-pillar exterior panel to the top of the door frame with a capscrew; see **Fig. 3**.

30. If the vehicle is a Columbia 120, install the two fasteners that attach the middle span of the panel to the A-pillar; see **Fig. 2**.

    If the vehicle is a Columbia 112, install the A-pillar exterior panel mounting nuts and interior trim, as follows.

    30.1 Through the access holes on each A-pillar, install the three nuts that attach the exterior panel to the A-pillar; see **Fig. 4**.

One-Piece Windshield Replacement

30.2 If the vehicle is equipped with an Eaton® VORAD® collision warning system, connect the sensor located on the inside of the right-hand A-pillar.

30.3 On both sides of the vehicle, install the A-pillar interior trim, then secure the door trim; see **Fig. 3**.

30.4 Attach the grab handle to the right-hand A-pillar.

31. Secure the lower end of the A-pillar exterior panel with a capscrew; see **Fig. 2**.
32. Install the wiper arms; see **Section 82.00, Subject 100**.
33. Clean both sides of the new windshield glass.
34. Remove the protective coverings from the dash.
35. Close the hood.
36. See the adhesive manufacturer's documentation for cure and drive-away times.

Replacement

NOTE: Freightliner recommends Sika Ultrafast, Dow U-400HV, or Bostik® 70-08A adhesive for windshield replacement.

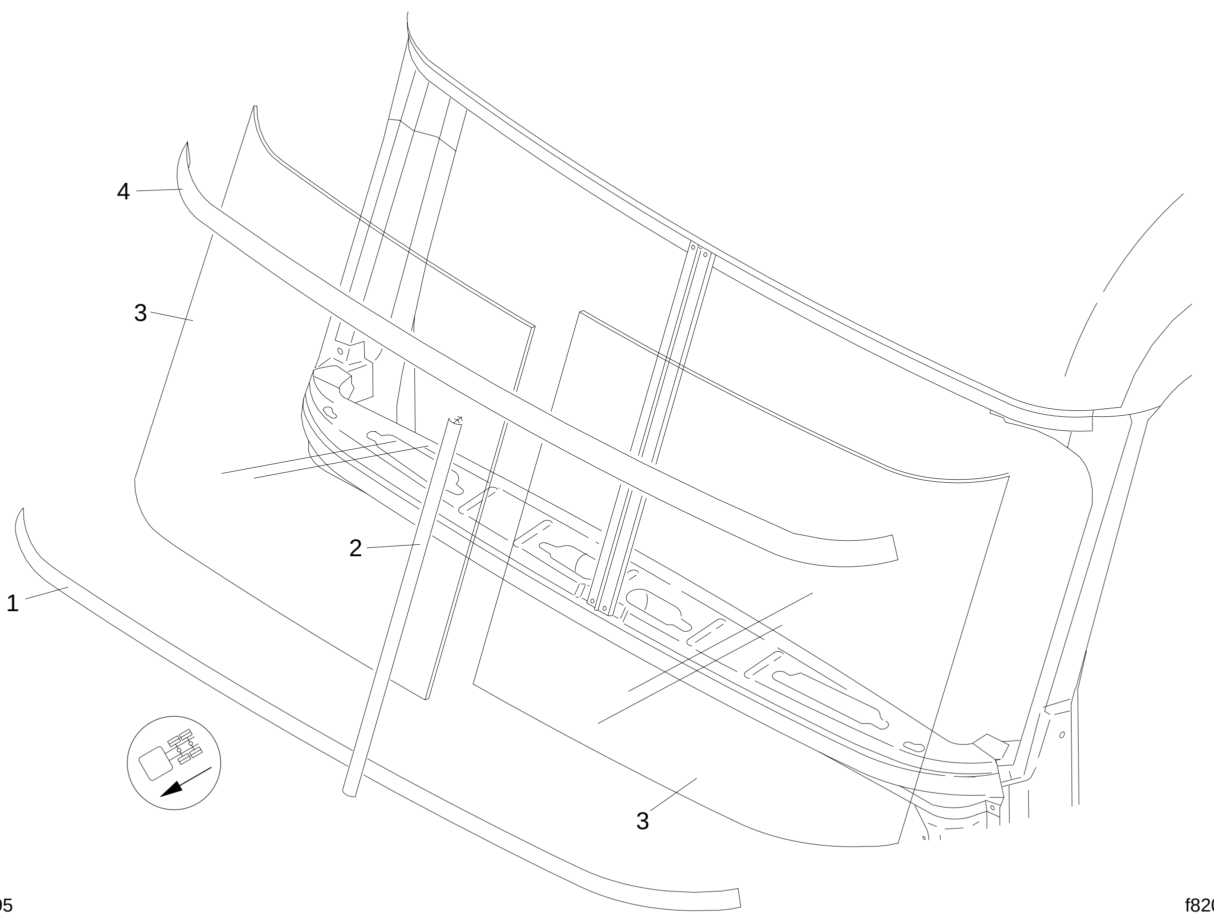
The procedure below specifies Dow adhesives and primers, though other manufacturers' systems can be used. Regardless of the system used, adhere to the adhesive manufacturer's instructions, and use that manufacturer's recommended primers and glass prep solutions for the entire procedure.

See **Fig. 1** for a two-piece windshield installation.

If the windshield is cracked, carefully inspect the glass, urethane sealant, and the windshield mask to determine the cause. Correct the problem before installing a new windshield. If the underlying cause for the crack is not corrected, the replacement windshield may crack when exposed to high winds, pressure, temperature extremes, or vehicle motion.

NOTE: At least two people are needed to replace a windshield.

1. Apply the parking brakes and chock the tires.

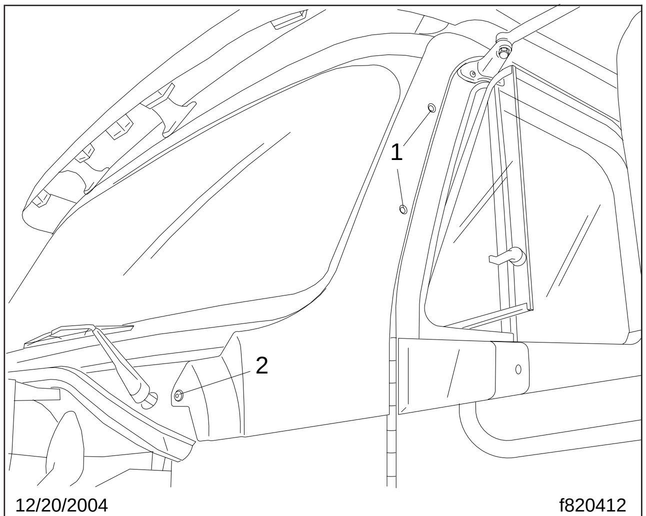


1. Bottom Molding Strip
2. Center Molding Strip
3. Windshield Glass
4. Top Molding Strip

Fig. 1, Two-Piece Windshield Installation

Two-Piece Windshield Replacement

2. Open the windows. Shutting the doors with the windows closed could pressurize the cab and create gaps in the uncured adhesive.
3. Open the hood.
4. Remove the windshield wiper arm(s); see **Section 82.00, Subject 100**.
5. Remove the exterior sun visor.
6. Protect the paint finish and instrument panel by taping paper around the inside and outside of the windshield opening.
7. Remove the lower capscrew from the exterior A-pillar panel; see **Fig. 2**.



1. Middle A-Pillar Fasteners (Columbia 120 only)
2. Lower A-Pillar Fastener

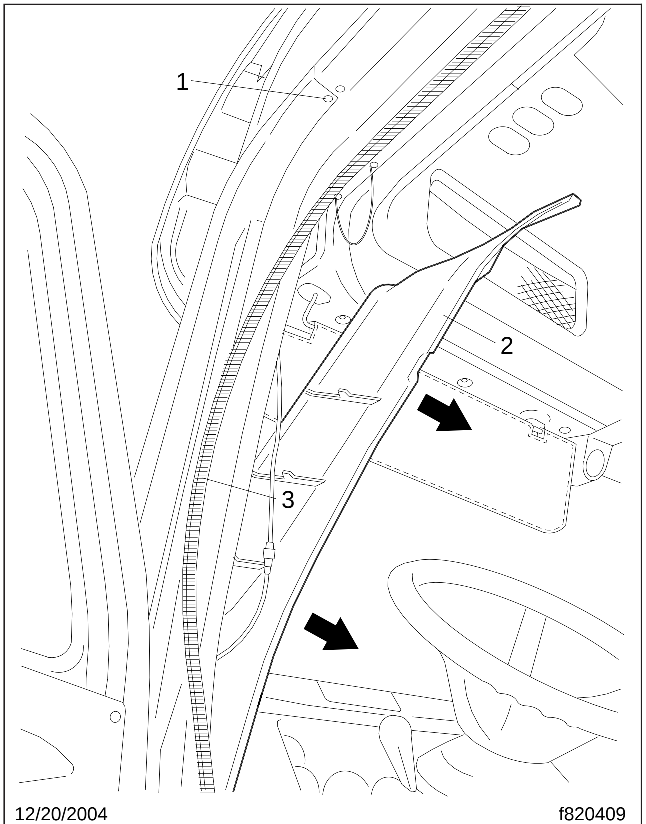
Fig. 2, A-Pillar Exterior Panel Fasteners

8. If the vehicle is a Columbia 120, remove the two fasteners that attach the middle span of the panel to the A-pillar.

   If the vehicle is a Columbia 112, the exterior panel mounting is concealed under the A-pillar interior trim. Remove the mounting nuts, as follows.

   8.1 If applicable, remove the grab handle from the right-hand A-pillar.

   8.2 Loosen the door trim, then remove the A-pillar interior trim; see **Fig. 3**.



1. Capscrew
2. A-Pillar Interior Trim
3. Door Trim

Fig. 3, Removing A-Pillar Interior Trim

   8.3 If applicable, disconnect the sensor for the Eaton® VORAD® collision warning system, located on the inside of the right-hand A-pillar.

   8.4 Through the access holes on the A-pillar, remove the three nuts that attach the exterior panel to the A-pillar; see **Fig. 4**.

9. Remove the capscrew that attaches the exterior A-pillar panel to the top of the door frame; see **Fig. 3**. Remove the panel.
10. Remove the center molding strip from the windshield center post; see **Fig. 1**.
11. Remove the Torx® screw and bushing at each end of the top molding strip; see **Fig. 5**.
12. Slide the top molding strip off the retainer strip.

Two-Piece Windshield Replacement

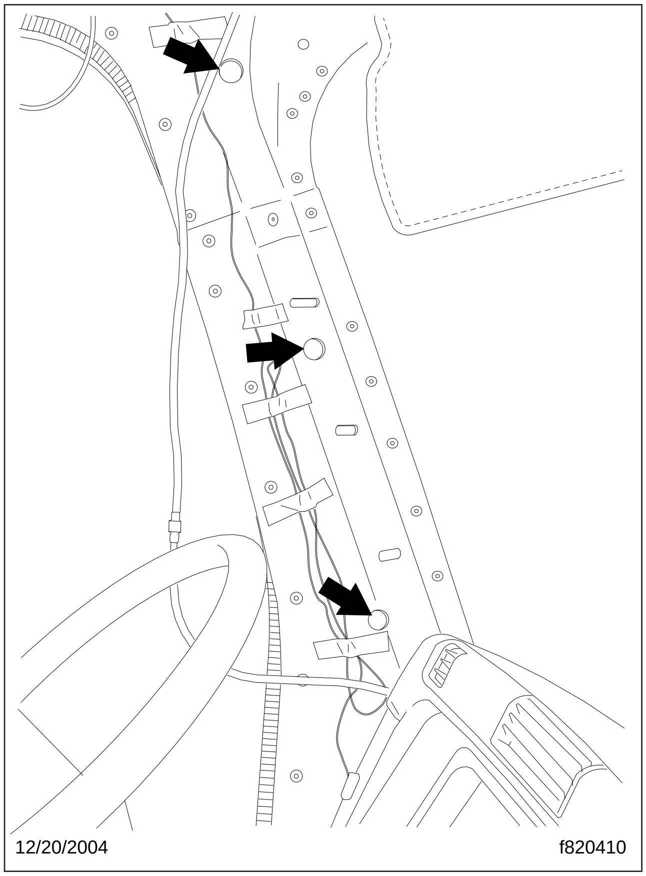


Fig. 4, A-Pillar Fastener Access Holes

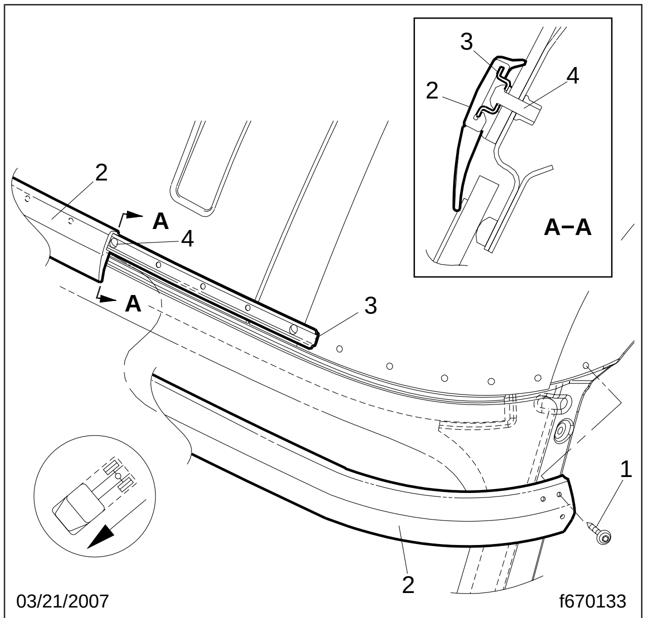
NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip; remove the top molding strip by pulling it loose from the gap between the windshield glass and the windshield mask.

13. Remove the bottom molding strip.
14. Using a pneumatic cutting tool (**Fig. 6**), a piano wire (**Fig. 7**), or a pull knife (**Fig. 8**), cut through the urethane sealant all around the edges of the windshield glass.

NOTE: To order a BTB pneumatic cutting tool, see **Specifications 400**.

WARNING

Wear protective gloves and safety glasses when replacing windshield glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.



1. Screw and Bushing
2. Top Molding Strip
3. Retainer Strip
4. Lockbolt

Fig. 5, Top Molding Strip Installation

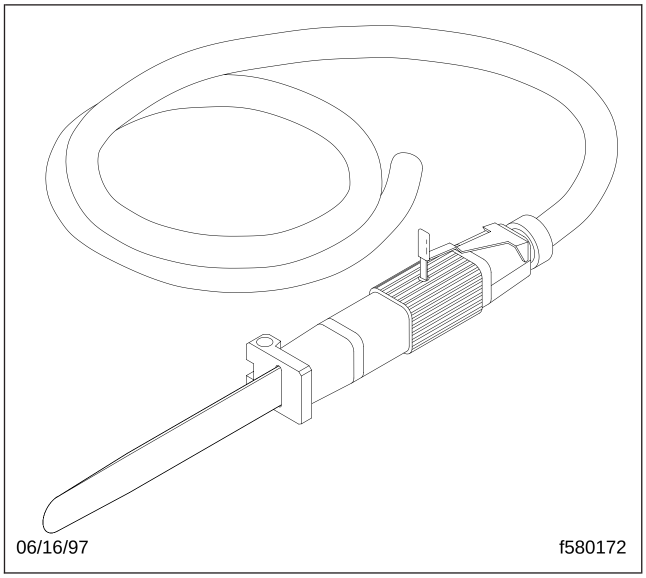
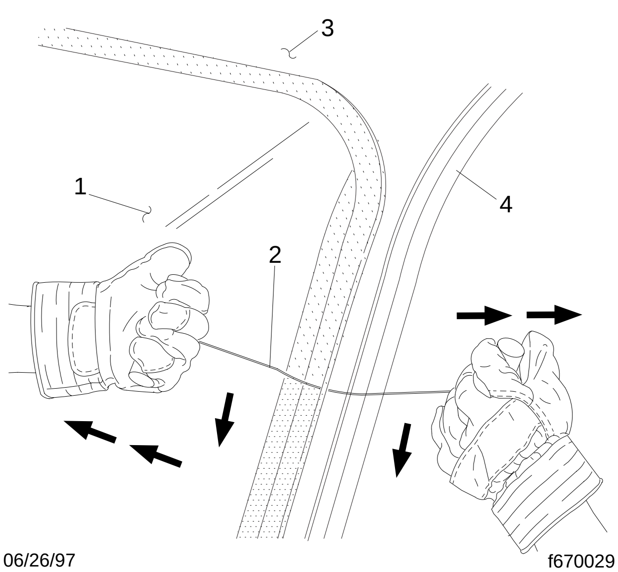


Fig. 6, BTB Pneumatic Cutting Tool

15. Carefully remove the damaged windshield glass.

Two-Piece Windshield Replacement



1. Windshield Glass
2. Piano Wire
3. Door Frame
4. Roof

Fig. 7, Windshield Glass Removal with Piano Wire

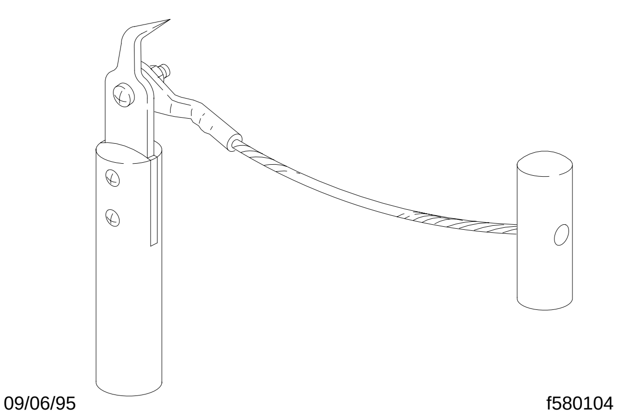
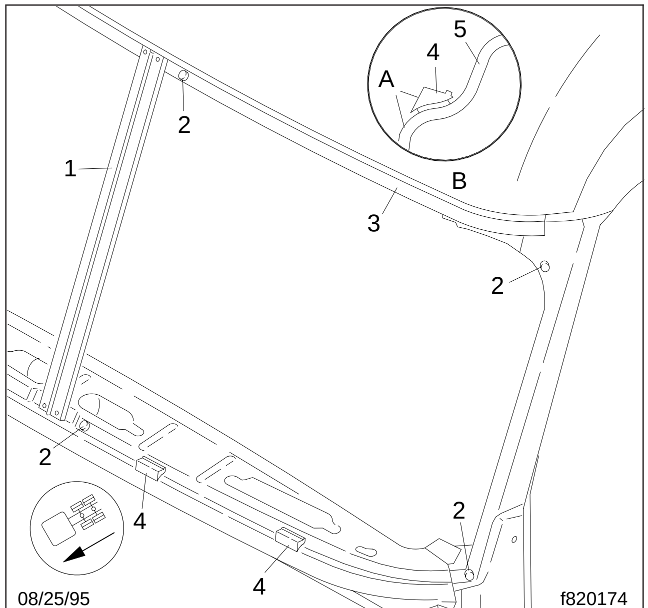


Fig. 8, Typical Pull Knife

16. Remove the rubber positioning blocks from the lower windshield mask; see **Fig. 9**. Discard them.
17. Using a BTB pneumatic cutting tool or a sharp knife, trim down the old urethane sealant to a thickness of about 1/16 inch (1 to 2 mm). Make sure any remaining adhesive has a smooth and even surface.



A. These two surfaces are to be flush.
B. Cross-Section View

1. Center Post
2. Spacer Button
3. Windshield Mask (upper)
4. Positioning Block
5. Windshield Mask (lower)

Fig. 9, Cab Area for Windshield Installation

18. Check the windshield mask. Apply Betaprime® 5404A Pinchweld and Encapsulation Primer to any bare metal. Allow to dry for a minimum of 6 minutes.

NOTE: Exposed bare metal areas larger than 1/2 inch x 1/2 inch (13 mm x 13 mm) require the use of Betaprime 5201TF Bare Metal Etch Primer.

19. Install a spacer button in each corner of the windshield mask; see **Fig. 9**.
20. Install new positioning blocks at the bottom of the windshield mask. Make sure the front edge of each block is flush with the front edge of the windshield mask; see **Fig. 9**.
21. Put the new windshield glass on a suitable stand or fixture, with the inside surface of the glass facing up.
22. Clean the bonding surface of the glass with Betaclean GC-800.

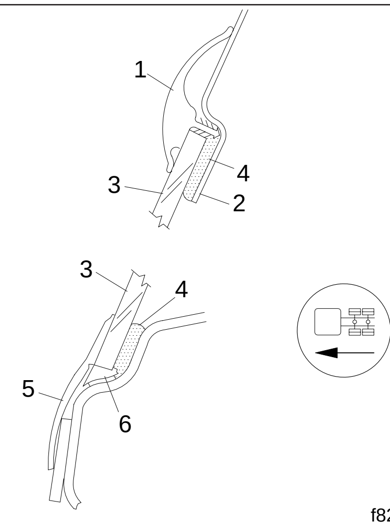
23. Apply Betaprime 5500 1-Step Glass/Frit Primer all the way around the edge of the glass to a width of about 1 inch (25 mm). *Do not get any of the primer on the black dot pattern of the glass.* Allow a minimum of six minutes for the primer to dry.
24. Holding the sealant applicator at a 90-degree angle to the windshield mask on the cab, apply a uniform and continuous bead of Betaseal U-400HV Adhesive all the way around the edges of the windshield mask. The bead should be a minimum of 3/8 inch (10 mm) thick.

    Keep the spiked edge of the applicator tip against the edge of the mask, and overlap the bead slightly.

IMPORTANT: Do not apply the urethane adhesive/sealant to the windshield glass. Aligning a windshield with adhesive on the glass is very difficult to do without getting the adhesive/sealant on the painted cab surface outside the windshield mask.

25. Using suction cups, carefully install the new windshield onto the windshield mask. Make sure the alignment marks on the glass are lined up with the center of the bolts holding the rain tray in place, and that the bottom edge of the windshield seats onto the positioning blocks correctly; see **Fig. 10** or **Fig. 11**.
26. Gently press down on the glass all the way around the bead line to firmly seat the windshield.
27. With a spatula or a paddle, smooth the adhesive flat along the edge of the windshield.
28. Install the center molding strip into the windshield center post, using Betaseal U-418 primerless auto glass urethane adhesive. Do not use a silicone hot glue.
29. Install the bottom rubber molding strip, using Betaseal U-418 primerless auto glass urethane adhesive.
30. Slide the top molding strip onto the retainer strip, if so equipped. Fasten each end of the strip to the A-pillar with a Torx screw and bushing; see **Fig. 5**.

NOTE: Vehicles built before July 21, 2000 are not equipped with a retainer strip. Attach the



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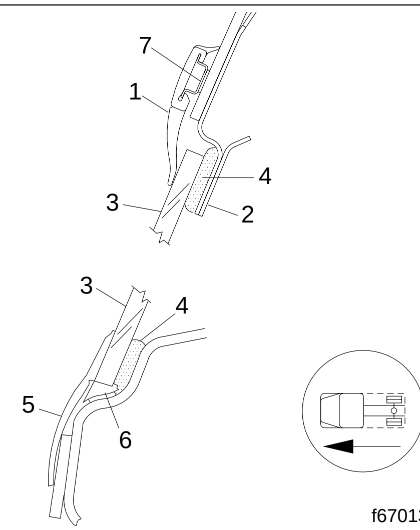
1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Sealant
5. Bottom Molding Strip
6. Positioning Block

Fig. 10, Cross-Section View (vehicles built before July 21, 2000)



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1. Top Molding Strip
2. Windshield Mask
3. Windshield Glass
4. Urethane Adhesive/ Sealant
5. Bottom Molding Strip
6. Positioning Block
7. Retaining Strip

Fig. 11, Cross-Section View (vehicles built from July 21, 2000)

Two-Piece Windshield Replacement

molding strip using Betaseal U-418 primerless auto glass urethane adhesive.

31. Attach the A-pillar exterior panel to the top of the door frame with a capscrew; see **Fig. 3**.
32. If the vehicle is a Columbia 120, install the two fasteners that attach the middle span of the panel to the A-pillar; see **Fig. 2**.

    If the vehicle is a Columbia 112, install the A-pillar exterior panel mounting nuts and interior trim, as follows.

    32.1 Through the access holes on the A-pillar, install the three nuts that attach the exterior panel to the A-pillar; see **Fig. 4**.

    32.2 If applicable, connect the sensor for the Eaton® VORAD® collision warning system, located on the inside of the right-hand A-pillar.

    32.3 Install the A-pillar interior trim, then secure the door trim; see **Fig. 3**.

    32.4 If applicable, attach the grab handle to the right-hand A-pillar.
33. Secure the lower end of the A-pillar exterior panel with a capscrew; see **Fig. 2**.
34. Install the wiper arm(s); see **Section 82.00, Subject 100**.
35. Clean both sides of the new windshield glass.
36. Remove the protective coverings from the dash.
37. Install the exterior sun visor.
38. Close the hood.
39. See the adhesive manufacturer's documentation for cure and drive-away times.

See **Table 1** for the materials needed for windshield installation using Dow U-400HV urethane adhesive. The items in **Table 1** are available from your local Dow/Essex dealer.

If using another adhesive, refer to the adhesive manufacturer's instructions for applicable cleaners and primers.

Materials and Tools Needed for Windshield Installation	
Material or Tool	**Part Number**
Betapclean® Glass Cleaner	GC-800
Betaprime® Glass Primer	5500
Betaprime Body Primer	5404A
Betaseal® Adhesive	U-400HV
Betaseal Primerless Auto Glass Adhesive	U-418

Table 1, Materials and Tools Needed for Windshield Installation

See **Fig. 1** and **Fig. 2** for the special tools needed for windshield removal.

To obtain the BTB pneumatic cutting tool (J–43029) contact:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
1-800-328-6657

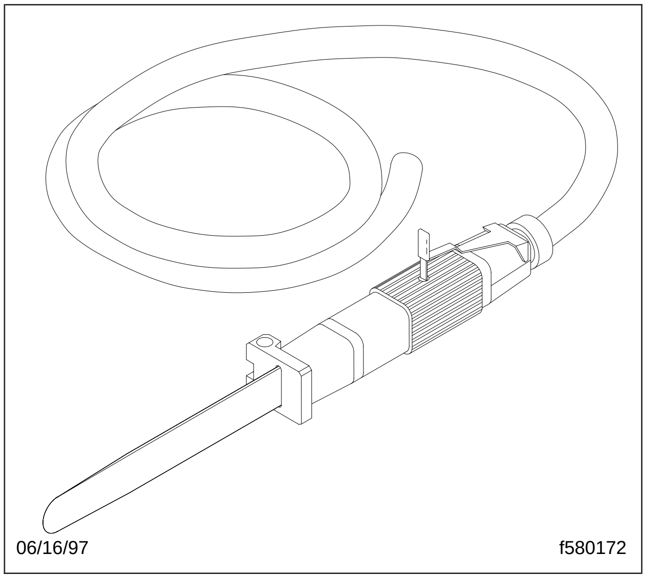


Fig. 1, BTB Pneumatic Cutting Tool

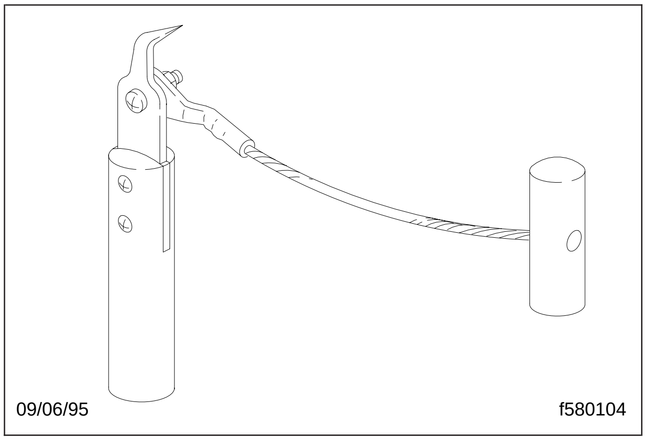
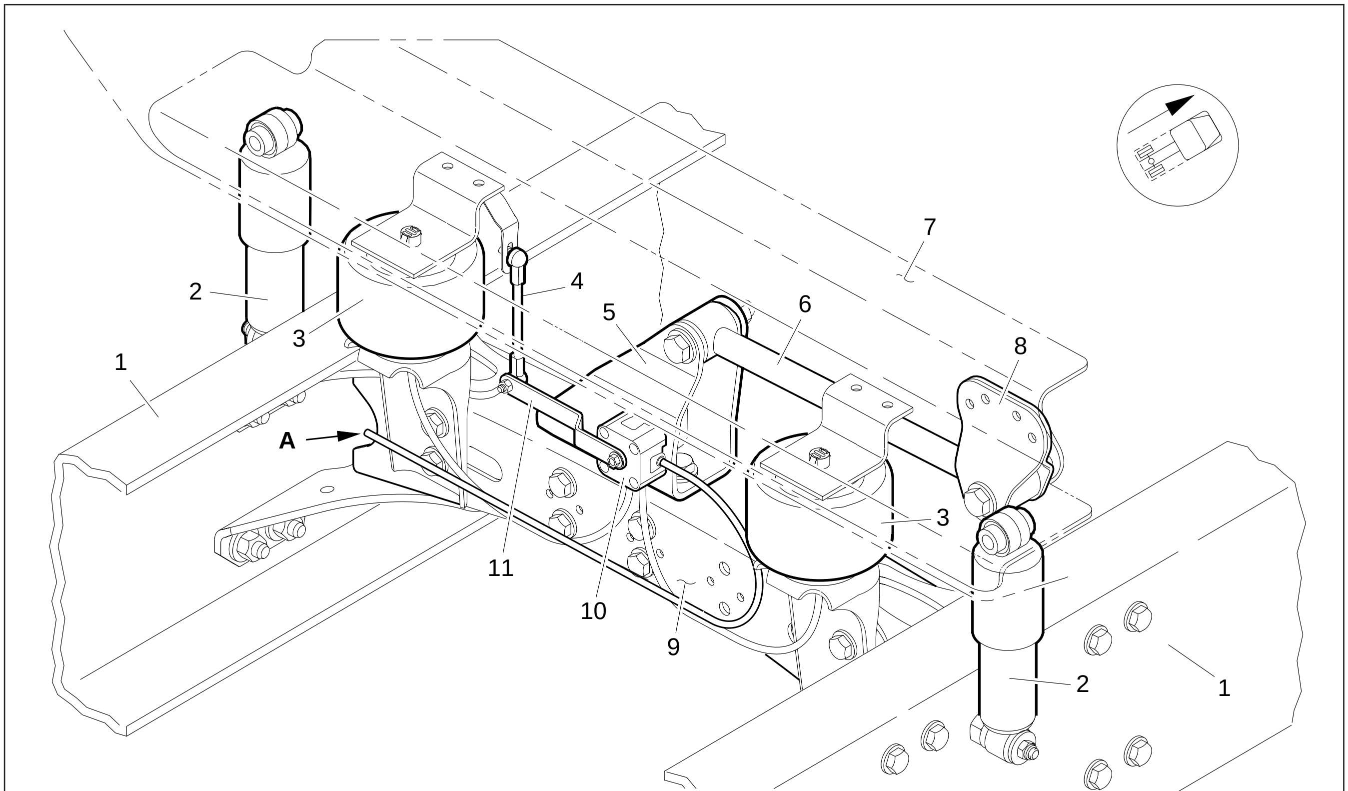


Fig. 2, Typical Pull Knife

General Information

Cab air-suspension systems consist of two air springs, a height-control valve, a lateral control rod, two shock absorbers, and a vertical linkage; see **Fig. 1** and **Fig. 2**.

The cab rear air-suspension system absorbs road shocks better than a solid-mount system, and thus provides a smoother ride for cab occupants and cab-mounted equipment.



A. From secondary air tank

1. Frame Rail
2. Shock Absorber
3. Air Spring
4. Vertical Linkage Rod
5. Mounting Bracket
6. Lateral Control Rod
7. Cab Underbody
8. Outboard Control Rod Bracket
9. Frame Crossmember
10. Height-Control Valve
11. Horizontal Control Lever

Fig. 1, Cab Rear Air-Suspension Installation, SleeperCab

Air Springs

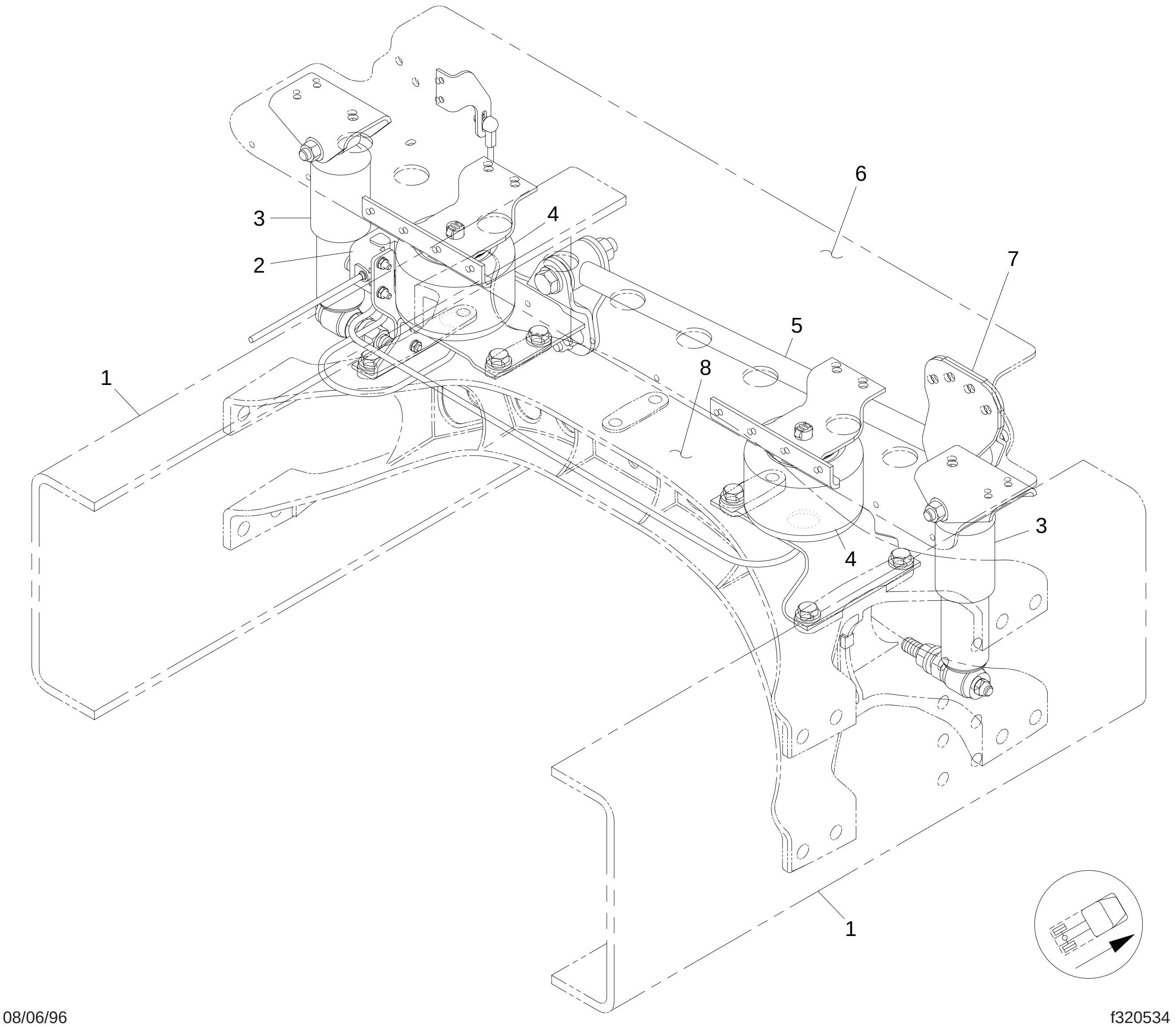
The top of the air spring is mounted to a bracket on the cab underbody, and the bottom is mounted to a bracket on a frame rail crossmember. Together with the height-control valve, the air springs compensate for changes in cab load by maintaining the correct cab height at the rear of the cab.

Height-Control Valve

NOTE: If a leak occurs in the cab air-suspension system, a pressure protection valve (located at the secondary air tank, which supplies the air to the height-control valve) will maintain a minimum pressure of about 65 psi (450 kPa) in the vehicle secondary air system.

All of the air in the cab air-suspension system is admitted through or exhausted from the height-control

General Information



1. Frame Rail
2. Height-Control Valve
3. Shock Absorber
4. Air Spring
5. Lateral Control Rod
6. Cab Underbody
7. Outboard Control Rod Bracket
8. Frame Crossmember

Fig. 2, Cab Rear Air-Suspension Installation, Day Cab

valve. It mounts on the control rod bracket, which is attached to the frame rail. The height-control valve has a horizontal control lever, the outboard end of which is connected to a vertical linkage. The upper end of the vertical linkage is attached to the cab underbody.

When the load on the cab increases, the dimension between the cab and the crossmember decreases, causing the vertical linkage to push downward on the end of the horizontal control lever. This turns the height-control valve shaft, which activates the height-control valve. Air flows through the valve and into the air springs until the pressure in the springs raises the cab to the correct height. At this height, the control lever and the control shaft are returned to their neutral positions, closing the intake air supply.

When the load on the cab decreases, the rear of the cab rises, causing the vertical linkage to pull up on the end of the horizontal control lever. Turning the height-control valve shaft in this direction activates an exhaust port in the valve. This allows air pressure in the air springs to decrease until the cab is lowered to the correct height. Again, the control lever and control shaft are returned to their neutral positions, and air flow is stopped.

When the vehicle is in motion, small and abrupt movements of the cab will occur, resulting in small or abrupt movements of the control lever. These movements of the control lever do not activate the height-control valve to correct the cab ride height.

Changes in load that occur when occupants or heavy items are added to or removed from the cab will activate the height-control valve to correct the cab ride height. Also, when the vehicle is moving forward at high speed or in a high headwind, a major change in load occurs from the downforce applied to an optional air shield or air fairing. When these changes in load occur, the cab air-suspension system will correct the cab ride height at the rear of the cab.

Lateral Control Rod

The lateral control rod limits the side-to-side motion of the rear of the cab. The inboard end of the control rod is mounted on the crossmember bracket that the height-control valve is mounted to, and the outboard end is attached to a bracket on the cab underbody.

Shock Absorbers

The shock absorbers control the air spring and cab suspension movement, and dampen oscillation in the cab suspension system. They are attached to the rear of the cab and to the outboard edge of each frame rail.

Cab Height Adjustment

If it is necessary to remove a Barksdale height-control valve from a mounting bracket, note the following.

CAUTION

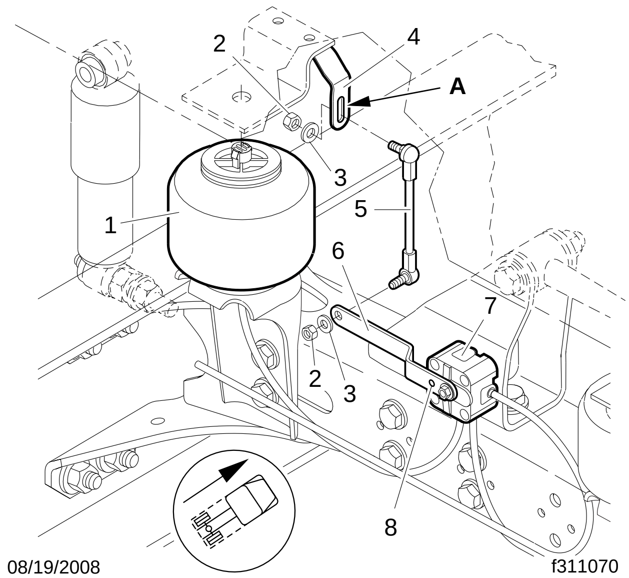
When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Height Adjustment

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.
3. Disconnect the vertical linkage from the slotted hole in the bracket under the cab deck; see **Fig. 1**.

NOTE: On a day cab air suspension, the height-control valve is mounted outboard of the left-side air spring; see **Fig. 2**.

4. Raise the control lever on the height-control valve to exhaust the air from the air springs.
5. Lower the control lever on the height-control valve to fill the air springs. Raise the cab until the distance from the rear cab underbody flange to the lower shock absorber bolt is 9-1/16 to 9-7/16 inches (231 to 240 mm); see **Fig. 3** and **Fig. 4**.
6. Lock the height-control valve in the neutral position by inserting a 5/32-inch (4-mm) pin or drill bit in the neutral-position hole in the height-control valve and the horizontal control lever.
7. With the height-control valve locked in the neutral position, connect the upper end of the vertical linkage to the bracket under the cab deck. The vertically slotted hole in the bracket allows for the height adjustment. Tighten the nut 96 lbf·in (1080 N·cm).
8. Remove the pin or drill bit previously inserted in the height-control valve.
9. Check the cab height again. The distance from the rear cab underbody flange to the lower shock absorber bolt should be 9-1/16 to 9-7/16 inches (231 to 240 mm). If the height is not correct, repeat the entire procedure.

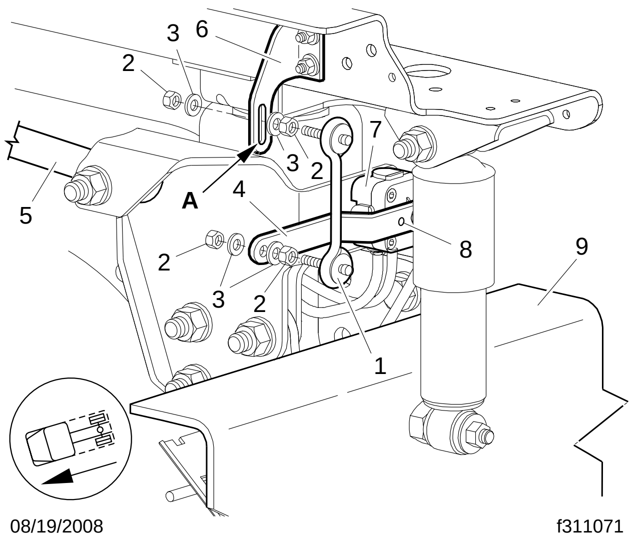


A. Slotted hole allows for height adjustment.

1. Air Spring
2. 1/4–20 Locknut
3. Washer
4. Vertical Linkage Bracket
5. Vertical Linkage
6. Horizontal Control Lever
7. Height-Control Valve
8. Hole for Installing Locking Pin

Fig. 1, Vertical Linkage Installation, SleeperCab

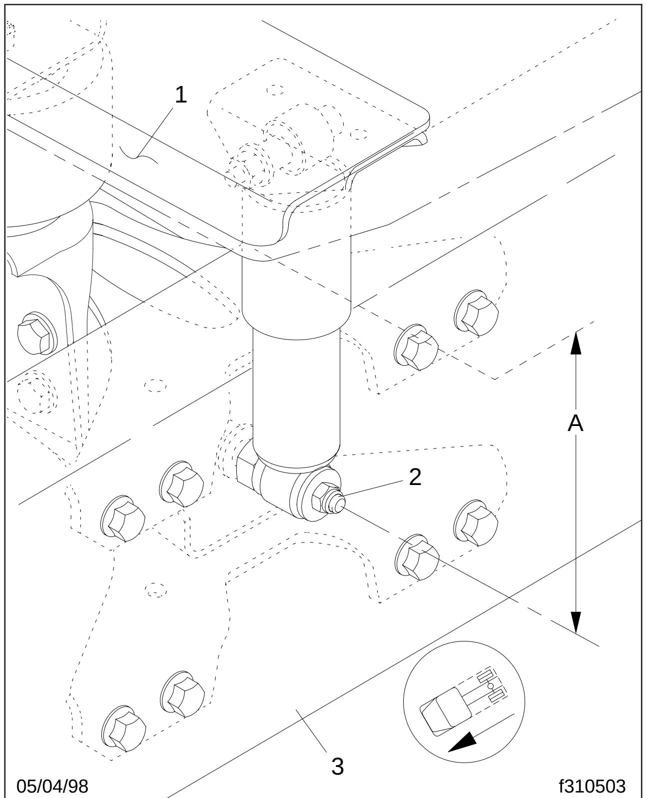
Cab Height Adjustment



A. Slotted hole allows for height adjustment.

1. Vertical Linkage
2. Locknut
3. Washer
4. Horizontal Control Lever
5. Lateral Control Rod
6. Vertical Linkage Bracket
7. Height-Control Valve
8. Hole for Installing Locking Pin
9. Frame Rail

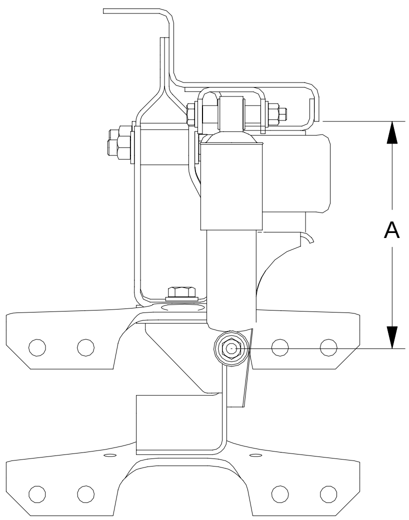
Fig. 2, Vertical Linkage Installation, Day Cab



A. 9-1/16 to 9-7/16 inches (231 to 240 mm)

1. Rear Cab Underbody Flange
2. Lower Shock Absorber Bolt
3. Frame Rail

Fig. 3, Cab Height Measurement



A. 9-1/16 to 9-7/16 inches (231 to 240 mm)

Fig. 4, Cab Height Measurement (side view)

Height-Control Valve Checking

It is normal to hear air leaking from the height-control valve for as much as five minutes after getting out of the vehicle. This air leakage is just the height-control valve exhausting air from the cab suspension air spring to reach the neutral position.

The height-control valves used on the Columbia are Barksdale valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Checking the Height-Control Valve Without Using a Test Kit

WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

1. With the vehicle parked on a level surface, run the engine to build vehicle air pressure to at least 100 psi (690 kPa), then shut off the engine, apply the parking brakes, and chock the tires.
2. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve. This air leakage is the height-control valve exhausting air due to a decreased load on the cab suspension.

WARNING

Do not disconnect the vertical linkage in the cab suspension system without first blocking the cab securely. If the cab is not securely blocked, moving the control lever could cause the cab to drop abruptly, possibly resulting in serious injury.

3. Disconnect the vertical linkage from the horizontal control lever.
4. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is okay.
5. Return the control lever to the neutral position.
6. Push the control lever down about 45 degrees for 6 to 8 seconds. If the air spring inflates, that section of the valve is okay.
7. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.

Height-Control Valve Checking

8. If the valve works as stated in all of the above steps, no further checking is needed. Connect the vertical linkage to the control lever, then tighten the linkage nut. If needed, adjust the cab ride height; see **Subject 100**.

   If the height-control valve does not work properly, replace it; see **Subject 120**.

NOTE: If the valve leaks, go to "Checking the Height-Control Valve Using a Test Kit." Barksdale valves have an acceptable leakage rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Check the rubber exhaust flapper at the back of the valve housing for leaks. Use a soapy solution.
5. Disconnect the vertical linkage from the control lever.
6. Rotate and hold the control lever up at about 45 degrees to exhaust air from the air springs.
7. Disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 1**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 1**.
10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.

    11.1 Rotate the valve control lever down 45 degrees from the horizontal to the fill position.

    11.2 Press the reset button on the test gauge.

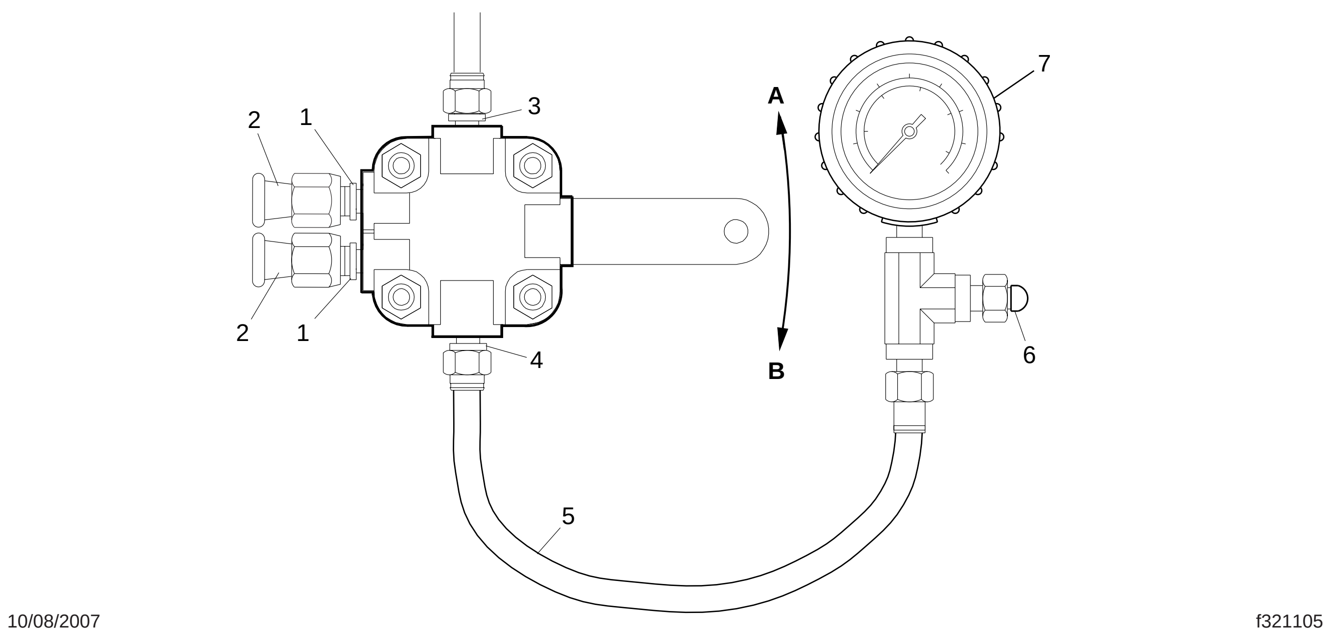
    11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 2** for the maximum allowable exhaust pressure change versus inlet pressure.

    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.



A. Exhaust
B. Fill

1. Air Spring Port
2. Parker Plug
3. Air Intake Port
4. Exhaust Port Test Fitting
5. Air Line
6. Reset Button
7. Test Gauge Assembly

Fig. 1, Test Connections

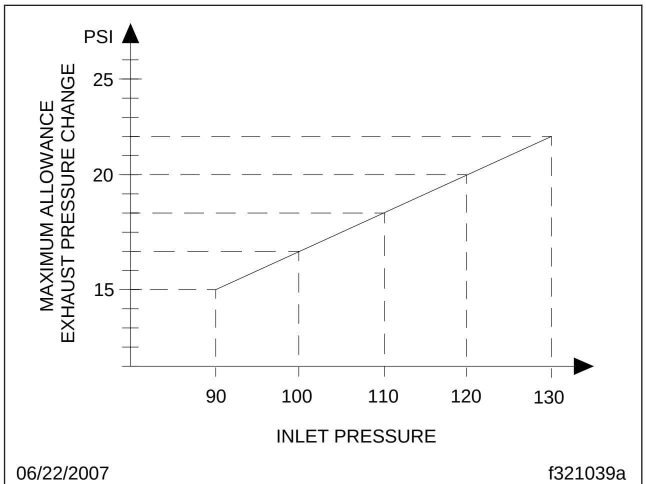


Fig. 2, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

12.1 Rotate the valve control lever up 45 degrees from the horizontal to the exhaust position.

12.2 Press the reset button on the test gauge.

12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 2** for the maximum allowable exhaust pressure change versus inlet pressure.

The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see **Subject 120**.
15. Install the flapper on the exhaust port by pressing it into place.

Height-Control Valve Checking

16. Remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

Replacement

IMPORTANT: Before replacing the height-control valve, do the steps in **Subject 110** to see if the valve is actually damaged or just out of adjustment.

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Block the cab at normal ride height by placing a wooden block between the cab underbody and the top of the frame crossmember.
3. Drain all air from the air tanks.

WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

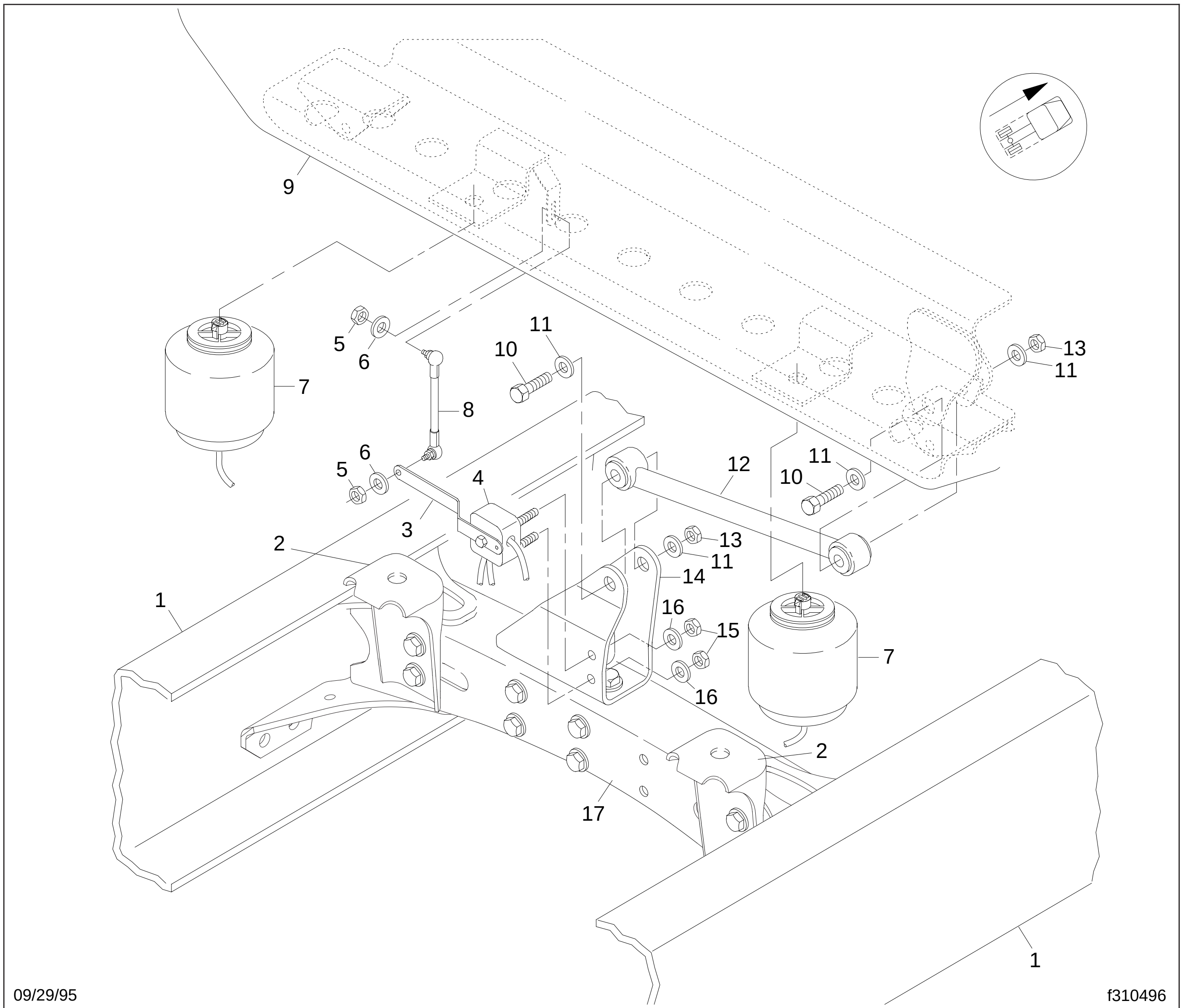
4. Disconnect the height-control valve vertical linkage from the horizontal control lever; see **Fig. 1**. Push the lever down, and hold it there until all air is exhausted from the air springs.
5. Mark the air lines to the height-control valve for later reference, then disconnect them.

CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

6. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
7. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.
8. Connect the air lines to the height-control valve. Install the air lines into the fittings until they seat completely. Tug on the lines to make sure they are completely seated.
9. Connect the vertical linkage to the horizontal control lever.
10. Close the drain cocks on all air reservoirs. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
11. Check all air lines and connections for leaks; eliminate all leaks.
12. Check the operation of the new height-control valve; see **Subject 110**.
13. Adjust the height-control valve, if needed; see **Subject 100**.
14. Remove the cab supports.

Height-Control Valve Replacement

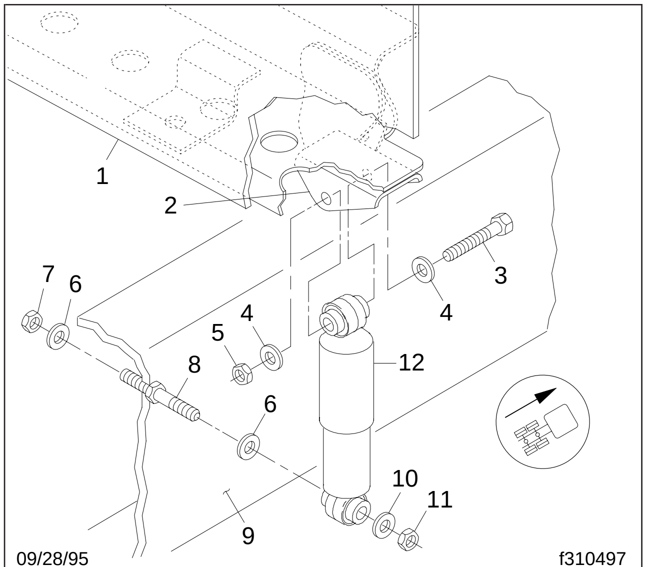


1. Frame Rail
2. Air Spring Mounting Bracket
3. Horizontal Control Lever
4. Height-Control Valve
5. 1/4–20 Hexnut
6. Flatwasher
7. Air Spring
8. Vertical Linkage
9. Rear of Cab
10. 5/8–11 Hexbolt
11. Flatwasher
12. Lateral Control Rod
13. 5/8–11 Hexnut
14. Mounting Bracket
15. 1/4–20 Hexnut
16. Flatwasher
17. Crossmember

Fig. 1, Cab Rear Air-Suspension Installation, SleeperCab

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the shock is removed.
3. Remove the 7/16–20 hexnut and washer from the lower mounting stud; see **Fig. 1**.



1. Rear of Cab
2. Shock Absorber Upper Mounting Bracket
3. 1/2–13 Hexbolt
4. Flatwasher
5. 1/2–13 Hexnut
6. 5/8" Flatwasher
7. 5/8–11 Hexnut
8. Shock Absorber Lower Mounting Stud
9. Frame Rail
10. 7/16" Washer
11. 7/16–20 Hexnut
12. Shock Absorber

Fig. 1, Shock Absorber

4. Remove the upper hexbolt, hexnut, and washers that attach the shock absorber to the bracket on the cab underbody. Remove the shock absorber.
5. Install the new shock absorber on the mounting stud on the frame rail, using the hexnut and washers. Do not tighten the hexnut yet.
6. Position the upper end of the shock absorber in the upper bracket, and install the hexbolt, washers, and hexnut. The hexbolt head should be facing toward the front of the vehicle.
7. Tighten the upper hexnut 45 lbf·ft (61 N·m). Tighten the lower hexnut 22 to 32 lbf·ft (30 to 44 N·m).
8. Remove the cab supports.

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

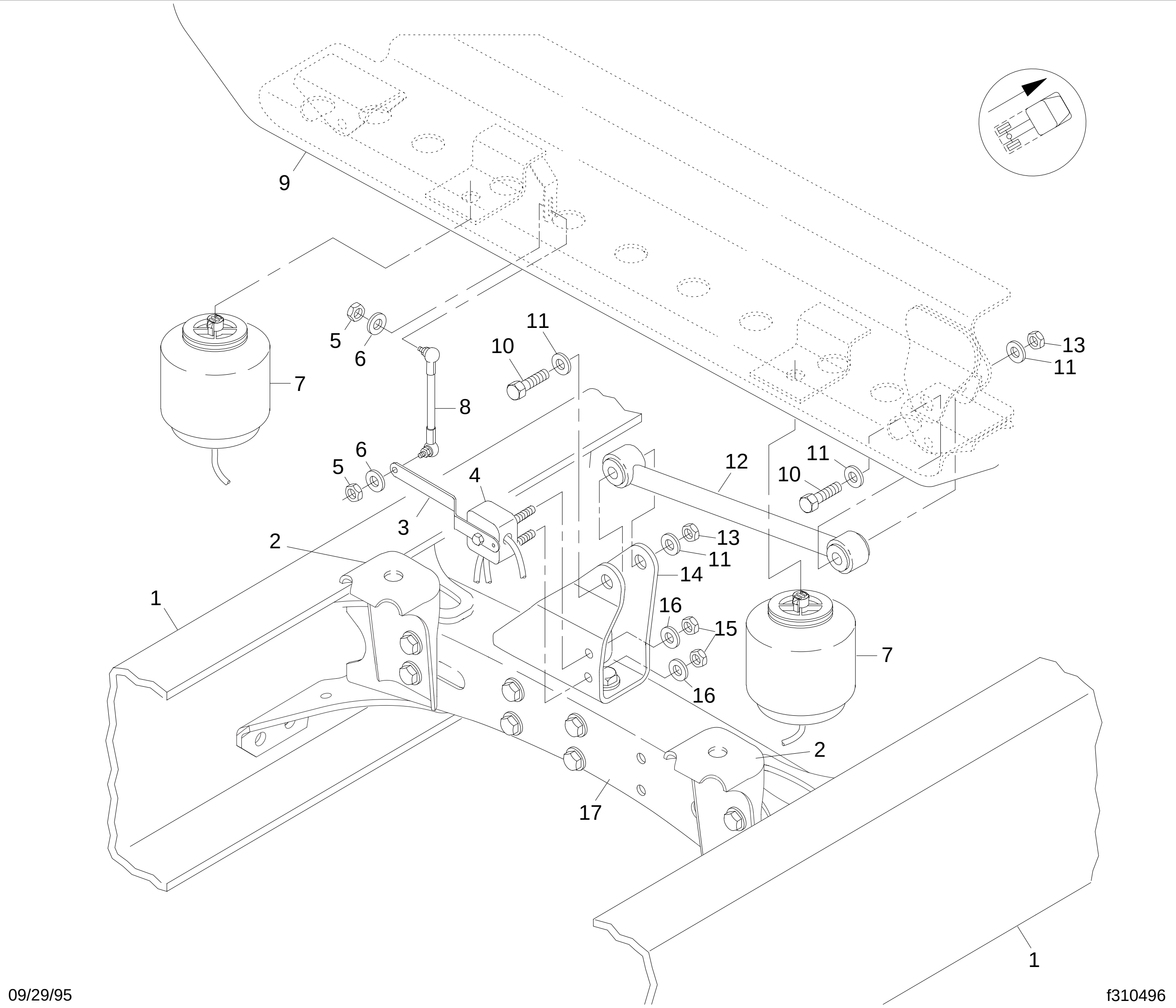
2. Jack up the cab, and block it at about 1 inch (25 mm) higher than its normal ride height. Block the cab between the frame rail crossmember and the cab underbody.
3. Drain all air from the air tanks.

WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Disconnect the supply air line from the bottom of the air spring to be replaced. Push in the brass ring at the connection, then pull the air line straight out. Cover the open end of the air line to prevent dirt or other foreign material from entering.
6. Using a screwdriver, depress the tangs at the top of the air spring, then pop it out of the upper bracket. Repeat the procedure for the bottom of the air spring; then remove the air spring.
7. Install the new air spring by snapping it in to the top bracket first, then the bottom bracket.
8. Remove the cover from the air line, then connect it by pushing it into the fitting on the bottom of the air spring. Push the air line all the way in. If it is not pushed all the way in, the connection will leak air. Tug on the air line to seat it completely.
9. Connect the vertical linkage to the horizontal control lever.
10. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air springs and at the height-control valve. Tighten the fittings or replace the parts, as needed.
11. Jack up the cab, and remove the block.

Air Spring Replacement



1. Frame Rail
2. Air Spring Mounting Bracket
3. Horizontal Control Lever
4. Height-Control Valve
5. 1/4–20 Hexnut
6. Flatwasher
7. Air Spring
8. Vertical Linkage
9. Rear of Cab
10. 5/8–11 Hexbolt
11. Flatwasher
12. Control Rod
13. 5/8–11 Hexnut
14. Mounting Bracket
15. 1/4–20 Hexnut
16. Flatwasher
17. Crossmember

Fig. 1, Cab Rear Air-Suspension Installation

Troubleshooting Tables

Problem—Both Air Springs Are Flat

Problem—Both Air Springs Are Flat	
Possible Cause	**Remedy**
Low air pressure in the secondary air system.	Check the air pressure gauge on the instrument panel. If secondary air pressure is low, run the engine until at least 70 psi (482 kPa) is indicated.
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the height-control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts.
The height-control valve is out of adjustment.	Adjust the height-control valve; see **Subject 100**.
The height-control valve is inoperative.	If upward movement of the lever on a properly adjusted valve fails to inflate the air springs, replace the height-control valve; see **Subject 120**.
The height-control valve linkage is damaged.	Check for damage to the height-control valve linkage and the lever. Repair or replace damaged linkage parts.

Problem—Air Springs Deflate Rapidly When the Engine Is Not Running

Problem—Air Springs Deflate Rapidly When the Engine Is Not Running	
Possible Cause	**Remedy**
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the height-control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts.

Problem—Rear of Cab Rides Too High or Too Low

Problem—Rear of Cab Rides Too High or Too Low	
Possible Cause	**Remedy**
The height-control valve is out of adjustment.	Adjust the height-control valve; see **Subject 100**.

Problem—Collapsed Air Spring

Problem—Collapsed Air Spring	
Possible Cause	**Remedy**
An air spring is punctured.	Locate leaks by listening for escaping air, or by applying a soap and water solution to the air spring and watching for bubbles. Repair punctures and cuts that are less than 1/8 inch (3 mm). Replace the air spring if damage is greater. Check the area around the damaged air spring for contact with other components. Correct the problem areas as needed.
The air spring is continually or repeatedly over-extended.	Check the suspension height. Make sure the correct height is maintained. Adjust if needed; see **Subject 100** for the correct height and adjustment procedures. Check for a broken shock absorber or shock bracket; replace if broken.

Troubleshooting

Checking the Cab Height-Control System for Air Leaks

WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.

   NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal and does not indicate a damaged valve.
3. Apply a soap-and-water solution to the outside of the air fittings on the height-control valve and on the suspension air springs. Look for bubbles indicating an air leak.
4. If bubbles are seen, check that the air tubing is installed correctly into the fitting.

   If no bubbles are seen, check the height-control valve for air leaks; see **Subject 110**.

Diagnostics and Testing

Air Spring

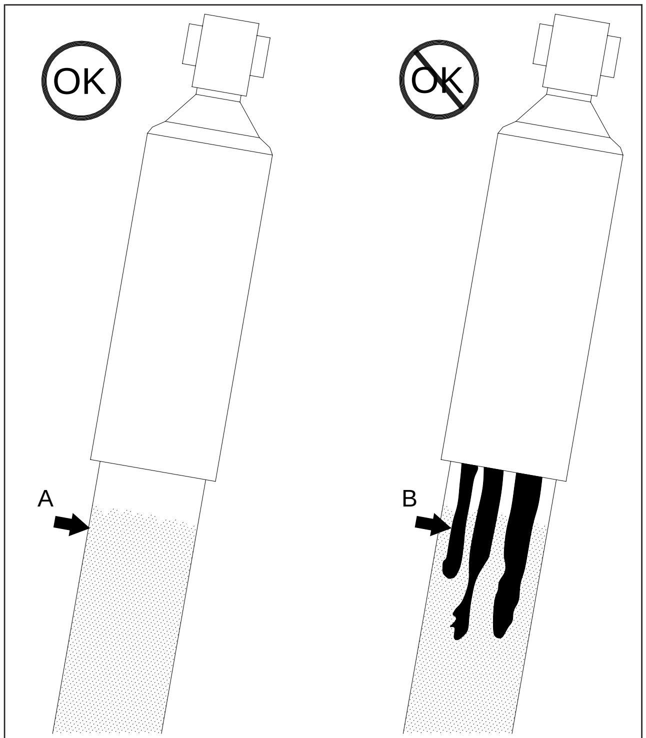
Inspect the exterior surfaces of the air spring, looking for wear. With the air spring fully inflated, check to see if there is sufficient clearance around the air spring to prevent lines or objects from rubbing against the air spring. Air tubing or cab components that rub against the air spring will cause damage to the air spring. If the air spring is not capable of lifting the cab to its proper ride height, check to see if the shock absorber is damaged. A binding shock absorber will limit the air spring's ability to extend. To clean the air spring, use soap and water.

NOTE: Do not use organic solvents, abrasives, or pressurized steam cleaners to clean the air spring.

Shock Absorber

Inspect the shock body for damage such as bends or dents in the piston. Bends or dents in the shock body will negatively affect the operation of the shock. Inspect the shock body for signs of leaking fluid. Normal operation of the shock will result in some misting of the hydraulic fluid onto the exterior shock body. Large streams of fluid indicate a leak and the shock should be replaced; see **Fig. 1**. To test the operation of a shock absorber, hold the shock in an upright position and cycle the piston at least five times by pushing the piston up and down. The piston should move evenly throughout each section of the cycle. If the shock does not move evenly when pushed down or pulled up, the shock should be replaced. Noises such as squeaks, which may be intermittent, may be caused by the valves used to regulate the internal hydraulic fluid. This problem is not repairable and the shock will need to be replaced. Noises from the shock, such as knocking or rattling, may be due to movement between the bushings and mounting brackets. Inspect the bushings or mounting brackets for wear. Repair worn components as necessary. Check the torque of the shock absorber mounting nuts and tighten if necessary.

NOTE: The shock absorber bushings do not require any type of lubrication. Do not attempt to stop bushing noise by lubricating them; grease and mineral-oil-base lubricants will deteriorate the bushing rubber.



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A. Dust covered mist (normal).
B. Hydraulic fluid streaks indicating an actual leak.

Fig. 1, Differences Between Misting and Leaking

Torque Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.04**.

Description	Size	Torque*	
		lbf·ft (N·m)	lbf·in (N·cm)
Height-Control Valve Housing Bolts†	1/4–20	—	45 (500)
Height-Control Valve Mounting Locknuts†	1/4–20	—	95 (1100)
Lower Shock Absorber Hexnuts	7/16–20	22–32 (30–44)	—
Upper Shock Absorber Hexnuts	1/2–13	45 (61)	—
Lateral Control Rod Fasteners	1/2–13	45 (61)	—
Control Rod Bracket Fasteners	5/8–11	150 (203)	—
Lower Air-Spring Bracket Fasteners	1/2–13	75 (102)	—

* Grade 8 bolts with phosphate- and oil-coated threads, and cadmium-plated, wax-coated Grade C hexnuts; both used with hardened washers.

† See the cautionary statements below.

Table 1, Torque Values

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

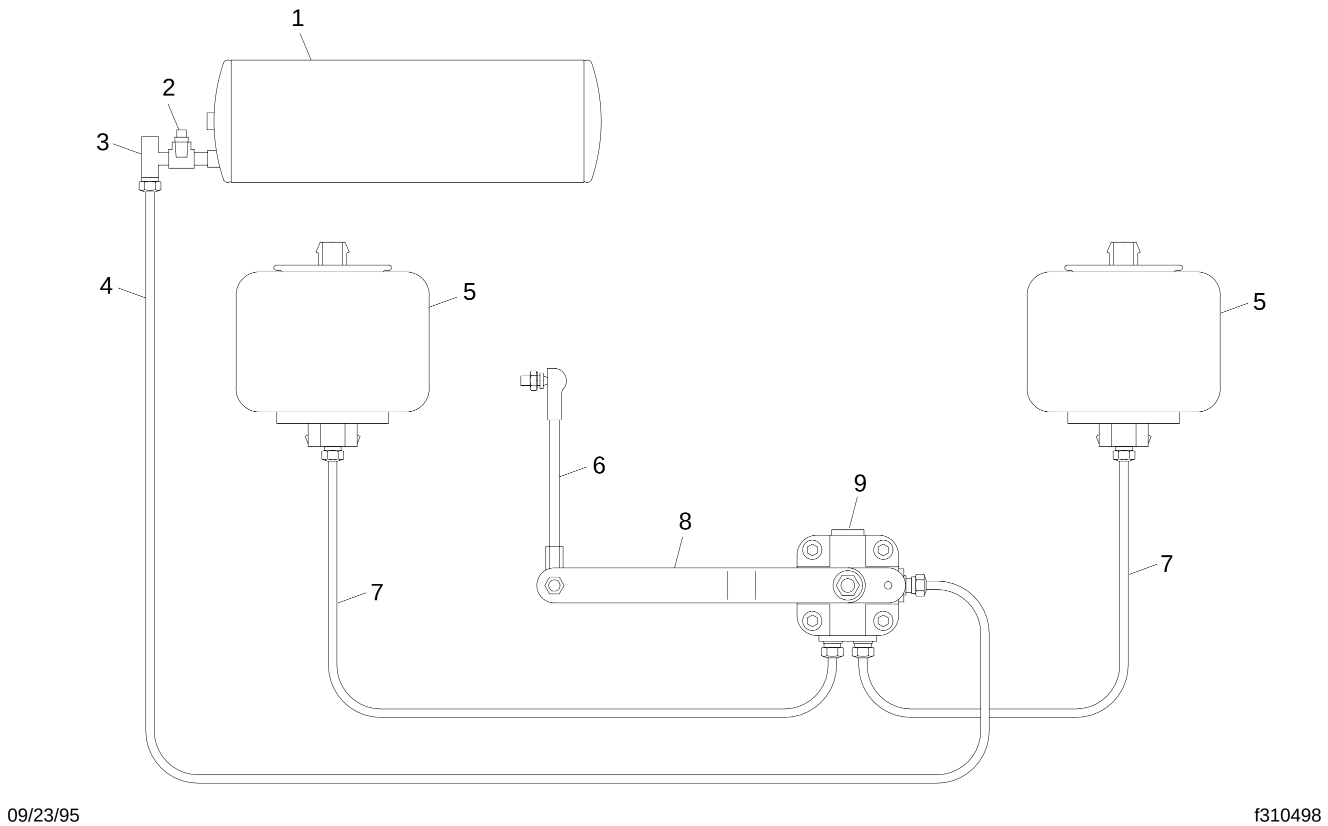
Plumbing Diagram

For the cab air suspension plumbing diagram, see **Fig. 1**.

Special Tools

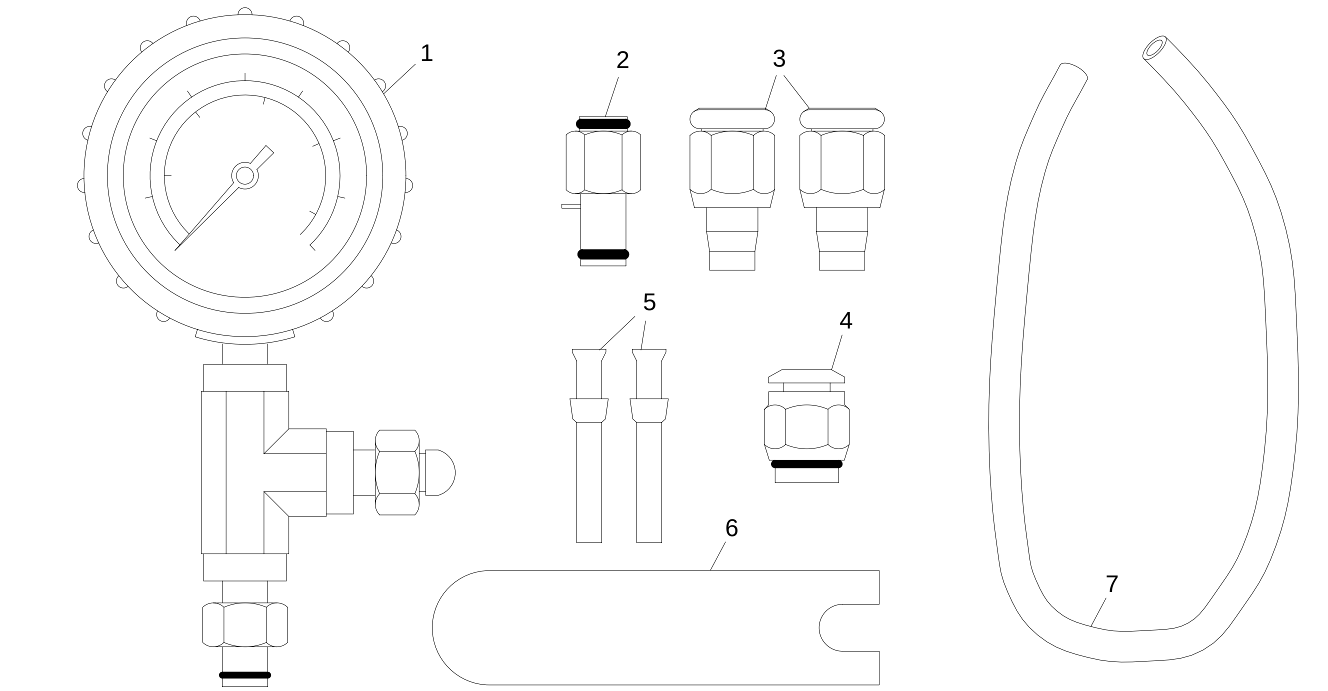
Use the kit shown in **Fig. 2** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in paragon.

Specifications



1. Secondary Air Tank
2. Pressure Protection Valve
3. Tee
4. Air Supply Line (nylon tubing)
5. Air Spring
6. Vertical Linkage
7. Air Spring Supply Line (nylon tubing)
8. Horizontal Control Lever
9. Height-Control Valve

Fig. 1, Cab Air Suspension Plumbing Diagram



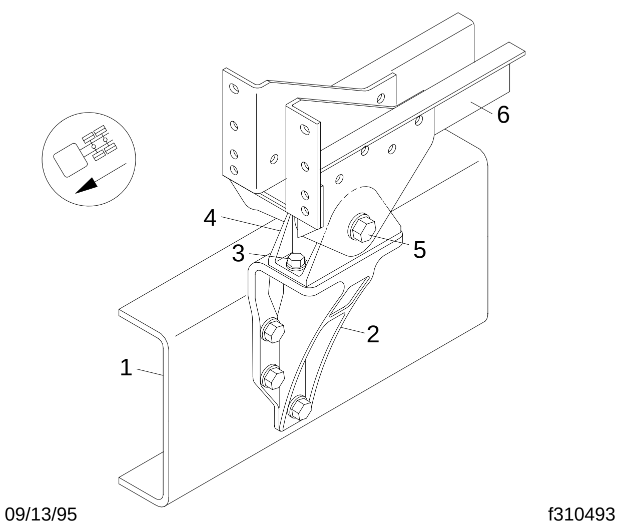
1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 2, Barksdale Height-Control Valve Test Kit KD2264

General Information

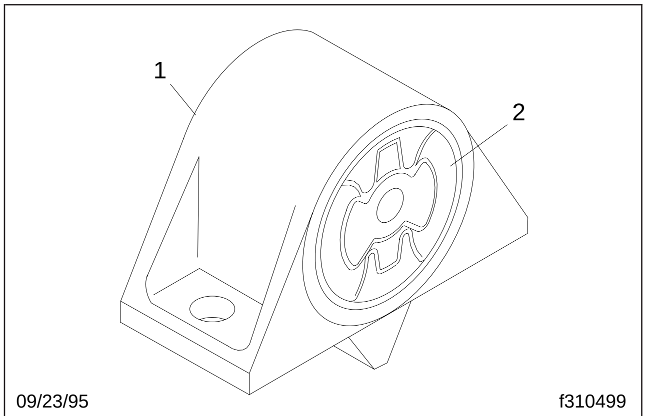
The forward part of the cab is attached to the frame rails by means of two cab mount assemblies. See **Fig. 1.** Each forward cab mount assembly consists of a hard rubber islolator surrounded by a steel bracket. See **Fig. 2.** The assembly is attached to a frame rail bracket and the cab underbody.

Cab mounts are replaced only as complete units. See **Fig. 2.**



1. Left Frame Rail
2. Frame Rail Bracket
3. Mounting Fasteners
4. Cab Mount Assembly
5. Isolator Hexbolt
6. Cab Underbody

Fig. 1, Left Forward Cab Mount Installation



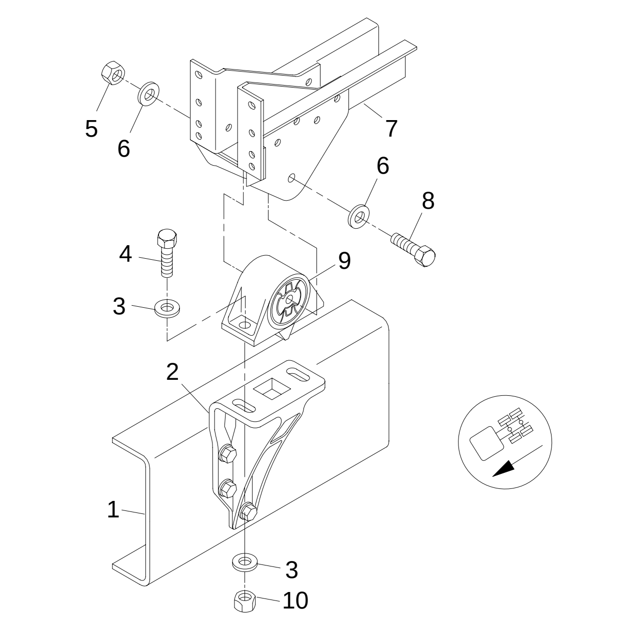
1. Cab-Mount Bracket
2. Isolator

Fig. 2, Forward Cab Mount Assembly

Forward Cab Mount Replacement

Replacement

1. Park the vehicle, apply the parking brakes, then chock the tires.
2. Jack up the front of the cab to take the weight off of the forward cab mount. Support the cab with jackstands.
3. Remove the 1/2–13 fasteners holding the cab mount assembly to the frame rail brackets. See **Fig. 1.**



1. Frame Rail
2. Frame Rail Bracket
3. Flatwasher
4. 1/2–13 Hexbolt
5. 5/8–11 Hexnut
6. Flatwasher
7. Cab Framework
8. 5/8–11 Isolator Hexbolt
9. Cab Mount Assembly
10. 1/2–13 Hexnut

Fig. 1, Forward Cab Mount Fasteners

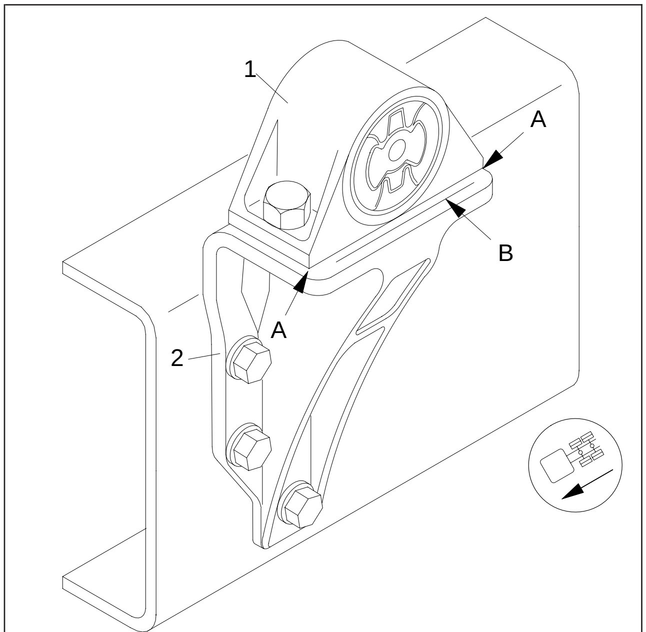
4. Remove the 5/8–11 fasteners that hold the cab mount assembly to the cab underbody bracket.
5. If needed, raise the cab so the tab on the bottom of the cab mount assembly clears the hole on the frame rail bracket; then remove the cab mount assembly.
6. Install a new cab mount assembly.

6.1 Put the cab mount assembly between the ears of the cab underbody bracket; then install the 5/8–11 isolator hexbolt, washers and nut. Make sure the bolt head is facing outboard.

6.2 Hand tighten the nut.

6.3 Carefully lower the cab, making sure the tab at the bottom of the cab mount assembly lines up with the square hole in the frame rail bracket.

Make sure the outboard edge of the cab mount assembly is parallel with the grooves machined into the top surface of the frame rail mounting bracket. See **Fig. 2.** Also make sure that the same number of grooves is showing on both sides of the vehicle.



A. The edge of the cab mount assembly is to be parallel to the grooves on the bracket.
B. The same number of grooves is to be showing on both sides of the vehicle.
1. Cab Mount Assembly
2. Frame Rail Bracket

Fig. 2, Forward Cab Mount Installation

6.4 Install the 1/2–13 hexbolts, washers and nuts through the cab mount assembly and the frame rail bracket, with the bolt

Forward Cab Mount Replacement

heads facing up. Tighten the nuts 68 lbf·ft (92 N·m).

6.5 Tighten the nut on the isolator hexbolt 136 lbf·ft (184 N·m).

7. Remove the chocks from the tires.

Lower Bunk Structure Removal and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Disconnect the batteries.

⚠ WARNING

Support the bunk assembly before removing the gas springs. If not supported, the bunk could fall on you, which could result in personal injury.

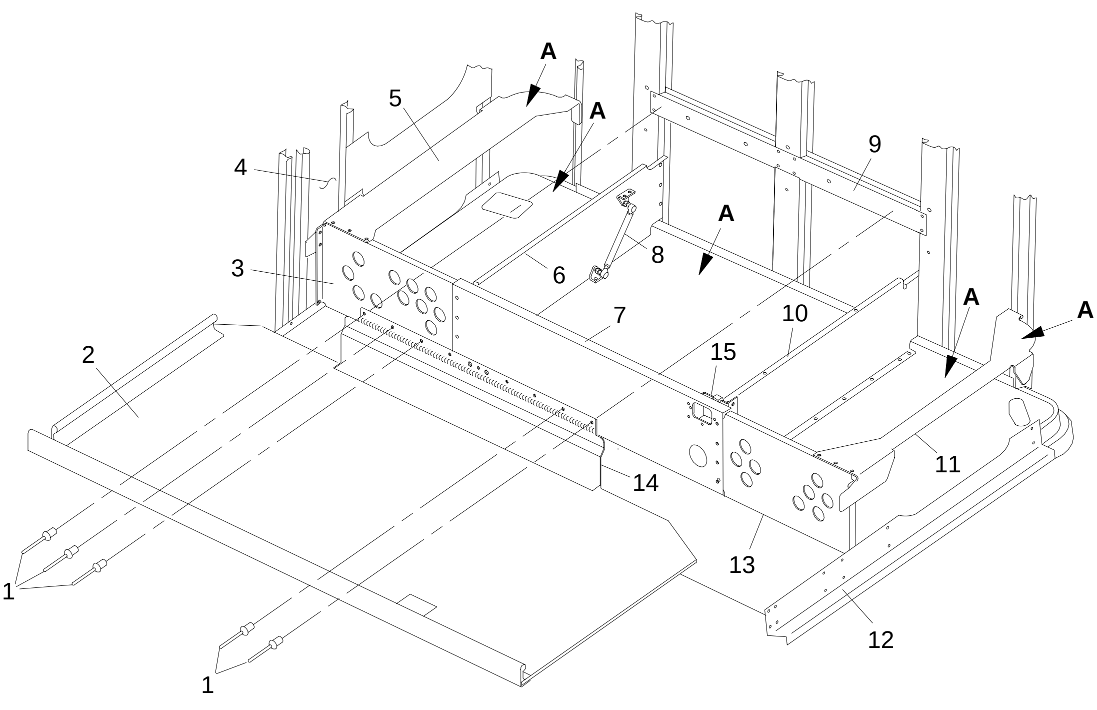
3. Remove the bunk. See **Fig. 1.**

3.1 Remove the mattress pad; then raise the bunk.

3.2 Disconnect the wiring from the lights on the bottom surface of the bunk.

3.3 Support the bunk to keep it from falling; then disconnect the two gas springs from the bunk and the bunk side partitions. Disconnect them by first pulling out the end cap, then removing the gas spring from the ball stud. See **Fig. 2.**

3.4 Lower the bunk; then remove the bunk hinge assembly from the sleeper back wall. See **Fig. 1.**



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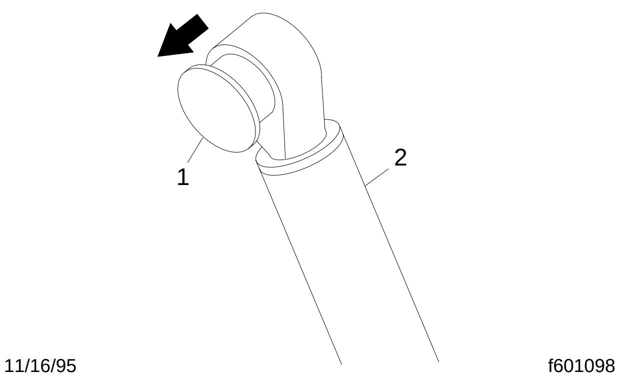
NOTE: Not all parts are shown.

A. Remove upholstery from here.

1. Blind Rivets
2. Bunk Assembly
3. Right Front Bunk Partition
4. Sleeper Right Side Wall
5. Right Bunk Support Angle
6. Right-Hand Side Bunk Partition
7. Front Center Bunk Partition
8. Right Gas Spring
9. Sleeper Back Wall
10. Left-Hand Side Bunk Partition
11. Left Bunk Support Angle
12. Sleeper Deck
13. Left Front Bunk Partition
14. Bunk Hinge Assembly
15. Bunk Latch Mounting Bracket

Fig. 1, Bunk Structure

Lower Bunk Structure Removal and Installation



1. End Cap (shown pulled out)
2. Gas Spring

Fig. 2, Disconnecting the Gas Spring

3.5 Remove the bunk assembly from the vehicle.

4. Remove the upholstery, floor mats, and carpeting from inside the bunk partition area and the tops of the bunk partitions and supports.

NOTE: Some vehicles have a slot built into the under bunk structure. This area may be used for a cooler. See **Fig. 3.**

5. Disconnect the wiring from the auxiliary HVAC; then move the wiring harness up forward by the "B" pillar, and out of the way.

6. Disconnect, then remove the auxiliary HVAC ducting.

7. Remove the bunk support angles and partitions. See **Fig. 1.**

   7.1 Remove the fasteners holding the bunk latch mounting bracket in place; then remove it.

   7.2 Remove the fasteners holding the support angles in place; then remove them.

   7.3 Remove the fasteners holding the front center bunk partition in place; then remove it.

   7.4 Remove the fasteners holding the right and left front bunk partitions in place; then remove them.

   7.5 Remove the fasteners holding the right-hand and left-hand side bunk partitions in place; then remove them.

Installation

1. Using 1/4-inch Magnabulb fasteners, install the bunk partitions and support angles. See **Fig. 1.**

   1.1 Attach the front center bunk partition to the sleeper deck.

   1.2 Install the right and left front bunk partitions on the sleeper deck; then the center front bunk partition and the side partitions.

   1.3 Install the side support angles on the Z-strips on the back wall, the side walls, and the tops of the right and left front bunk partitions.

   1.4 Install the left-hand and right-hand side bunk partitions on the sleeper deck, the back wall, and the front partitions.

   1.5 Install the bunk latch mounting bracket on the center bunk partition and on the left-hand side bunk partition.

2. Install the HVAC ducting.

3. Route the wiring harness along the sleeper back wall, and inside the bunk partitions; then connect the wiring to the auxiliary HVAC unit.

4. Install the floor mats and carpeting inside the bunk partition.

5. Install the HVAC ducting.

6. Install the bunk.

   6.1 If not already done, install the hinge assembly on the rear edge of the bunk.

   6.2 Using 1/4-inch Magnabulb fasteners, install the bunk and hinge assembly on the back wall of the sleeper.

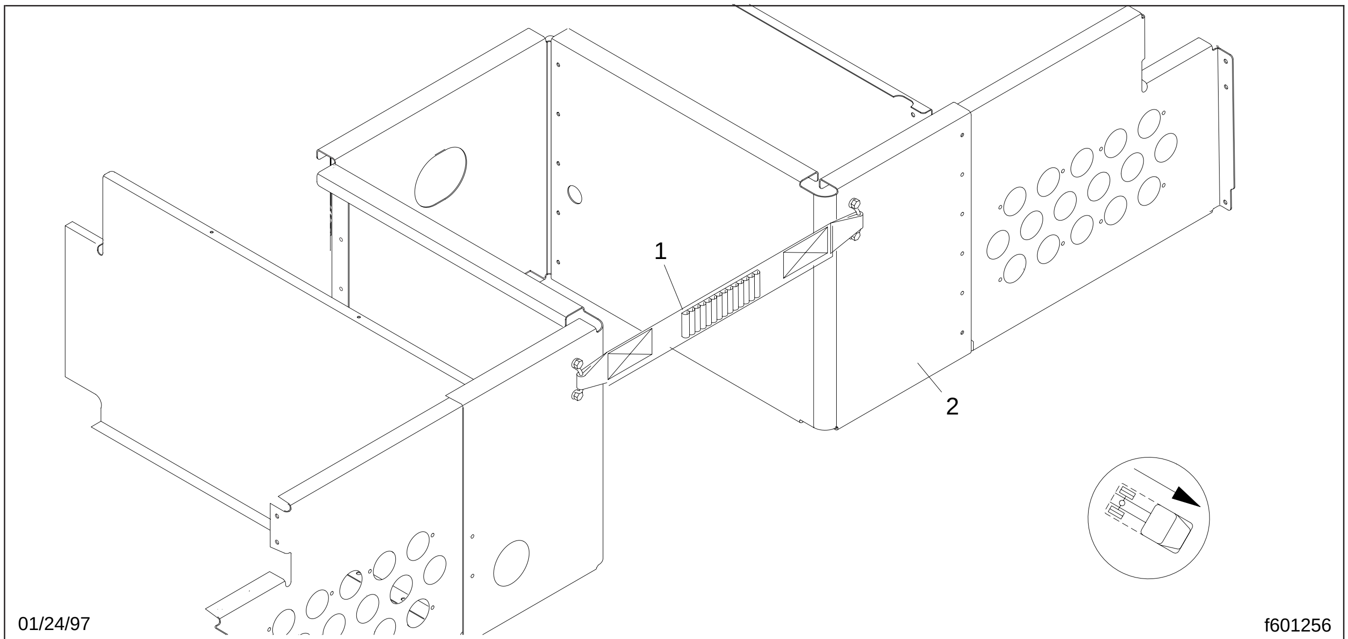
   6.3 Install the gas springs on the bunk and bunk side partitions.

   6.4 Connect the wiring to the lights on the bottom surface of the bunk.

7. Close the bunk, then install the mattress pad.

8. Remove the chocks from the tires.

Lower Bunk Structure Removal and Installation



1. Strap
2. Bunk Partition

Fig. 3, Under Bunk Slot

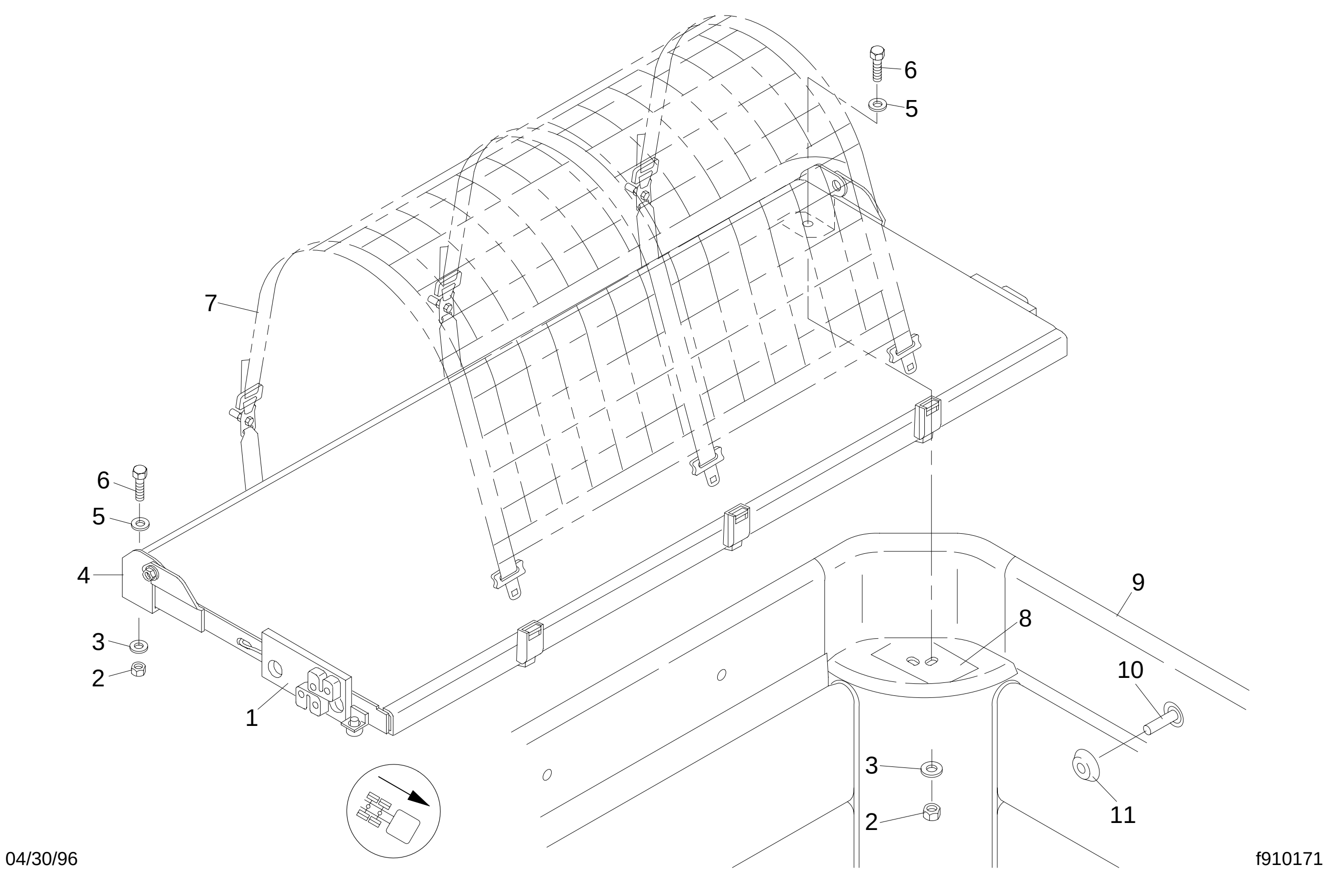
Dymetrol Upper Bunk Removal and Installation

Removal

1. Park the vehicle and apply the parking brake.
2. Chock the rear tires.
3. Remove the bunk. See **Fig. 1.**

WARNING

Support the bunk assembly before removing the mounting bolts. If not supported, the bunk could fall on you, which could result in personal injury.



1. Latch Mounting Bracket
2. Nut
3. Washer
4. Bunk Assembly
5. Washer
6. Bolt
7. Bunk Restraint
8. Bunk Mount
9. Cab Sidewall
10. Striker Pin
11. Trim Washer

Fig. 1, Upper Bunk Structure

3.1 Raise the bunk and make sure it is securely latched.

3.2 Remove the two bunk mounting bracket covers.

3.3 Support the bunk assembly, then remove the nut, bolt, and washers from each of the two bunk mounts.

3.4 With the aid of a helper, remove the bunk assembly from the vehicle.

Dymetrol Upper Bunk Removal and Installation

Installation

1. Install the bunk. See **Fig. 1.**
   - 1.1 With the aid of a helper, set the bunk in its raised position onto the mounts. Support the bunk securely.

WARNING

Support the bunk assembly while installing the mounting bolts. If not supported, the bunk could fall on you, which could result in personal injury.

   - 1.2 Carefully lower the bunk and secure the latches to the striker pins.
   - 1.3 On each side, install the mounting bolt and washers and tighten the nut.
   - 1.4 Place the two mounting bracket covers in position over the bunk mounting brackets.
   - 1.5 Secure each cover with two Christmas-tree fasteners.
2. Remove the chocks from the tires.

General Information

Although the raised roof cap exterior panels and the interior panels are made of different materials, they are closely related in manufacture and repair procedures.

EXTERIOR PANEL MANUFACTURE

Raised roof cap panels are made of glass fiber reinforced plastic (FRP) materials. FRP panels are manufactured using both male and female molds. The steel molds are maintained at temperatures ranging between 120° and 150°F (49° and 66°C).

Initially, the mold halves are coated with a release agent to permit part removal after the resin hardens. Next, the glass reinforcing fabric is attached to the female mold half. Now the resin is catalyzed and poured into the female mold half. The mold halves are then nested together, but with a gap between them in order to produce the specified thickness in the finished panel.

The resin is allowed to harden in the mold. After the resin hardens, the mold is separated and the part removed. This process produces parts with uniform wall thickness and smooth inner and outer walls.

ROOF CAP CONSTRUCTION

The roof cap is assembled in the following manner:

1. After the parts are molded, any holes or cutouts that were not molded are added.
2. All parts are cleaned and then sanded.
3. A two-part urethane adhesive is applied to the mating surfaces.
4. The exterior cap panels are assembled in a fixture. The fixture includes heated clamping blocks that clamp the outer panels at the bond lines to speed the cure process.
5. The outer panel assembly is inverted in another fixture. The front interior panels and the rear interior panels have urethane adhesive applied to their bonding surfaces and are then bonded to the exterior cap subassembly.
6. Finally, the rear interior panel subassemblies are bonded to the exterior cap, completing the roof cap assembly. After assembly, the interior panels provide structural reinforcement to the exterior cap panels.

If it is damaged, the cap can be repaired by following the procedures specified in **Subject 100**. If the cap is so badly damaged that the major subassemblies described above need to be replaced, remove the entire roof cap and replace it with a service cap available through the Daimler Trucks North America Parts Distribution Centers.

INTERIOR PANEL MANUFACTURE

The interior panels are made of RIM polyurethane. Because it is a different material than fiberglass, the repair and replacement of the RIM components varies from the repair of the exterior panels of the raised roof components.

The RIM components are manufactured using a closed-mold process, in which a male and a female mold are brought together to form a part.

The mold, or cavity, is textured, which gives the part its final surface texture. Just prior to closing the mold, the mold is painted with the final surface finish.

A mixture of two liquid compounds is then injected into the closed molds. This, coupled with the mold temperature, initiates a chemical reaction that will eventually yield the finished part after the liquid mixture is allowed to harden in the mold.

The mold is separated, and the part is removed. This process produces parts with uniform wall thickness and surfaces of any given texture and color.

If damaged, the cabinets can be repaired by following the procedures specified in **Subject 110**.

Repair Safety Precautions

Before performing any polyurethane repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing polyurethane are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to resin, epoxy, or other repair material. Also, don't allow the hardener to contact your skin; the hardener can be a skin irritant.

IMPORTANT: In case the hardener or resin contacts your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water for 15 minutes, and call a doctor.

3. When working with these materials, wear old clothing, since the resin may damage the cloth. Wash the clothing before wearing it again.
4. Most of the liquids involved in repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well ventilated.

WARNING

Ensure that polyurethane repairs are done in a safe workshop area with adequate ventilation. Failure to do so could result in severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding polyurethane surfaces, wear goggles or other protective eye shields, and also an air-purifying respirator, either a throw-away type or one with a replaceable particulate filter(s). Don't breathe grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fiber slivers off your clothing.
7. Because dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).
8. Unless repairs are done on a regular (daily) basis, don't save leftover liquids. If liquids must be saved, store them in cool, dark areas, away from direct sunlight.

Surface Damage Repair—Exterior and Interior Panels

WARNING

Before doing any work, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved could lead to serious personal injury.

Surface damage refers to scratches, chips, or nicks on the exterior roof cap panels or roof cap panels. See **Fig. 1**. To repair surface damage, do the following steps:

1. Locate the damaged area. If there are cracks, see if they go all the way through the panel. If they do, refer to "Structural Damage Repair" for instructions.
2. Clean the area with xylene or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint around the damaged area to a distance of about 1-1/2 inches (4 cm). See **Fig. 2**.
4. Using an air nozzle, blow off all dust.
5. Wipe filler (Ashland Pliogrip 7775L) over the non-coated area and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of filler, slightly higher than the painted surface.
6. After the filler dries (about 50 minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB–11 black conductive primer. See **Group 98** for spot-painting instructions.

Structural Damage Repair

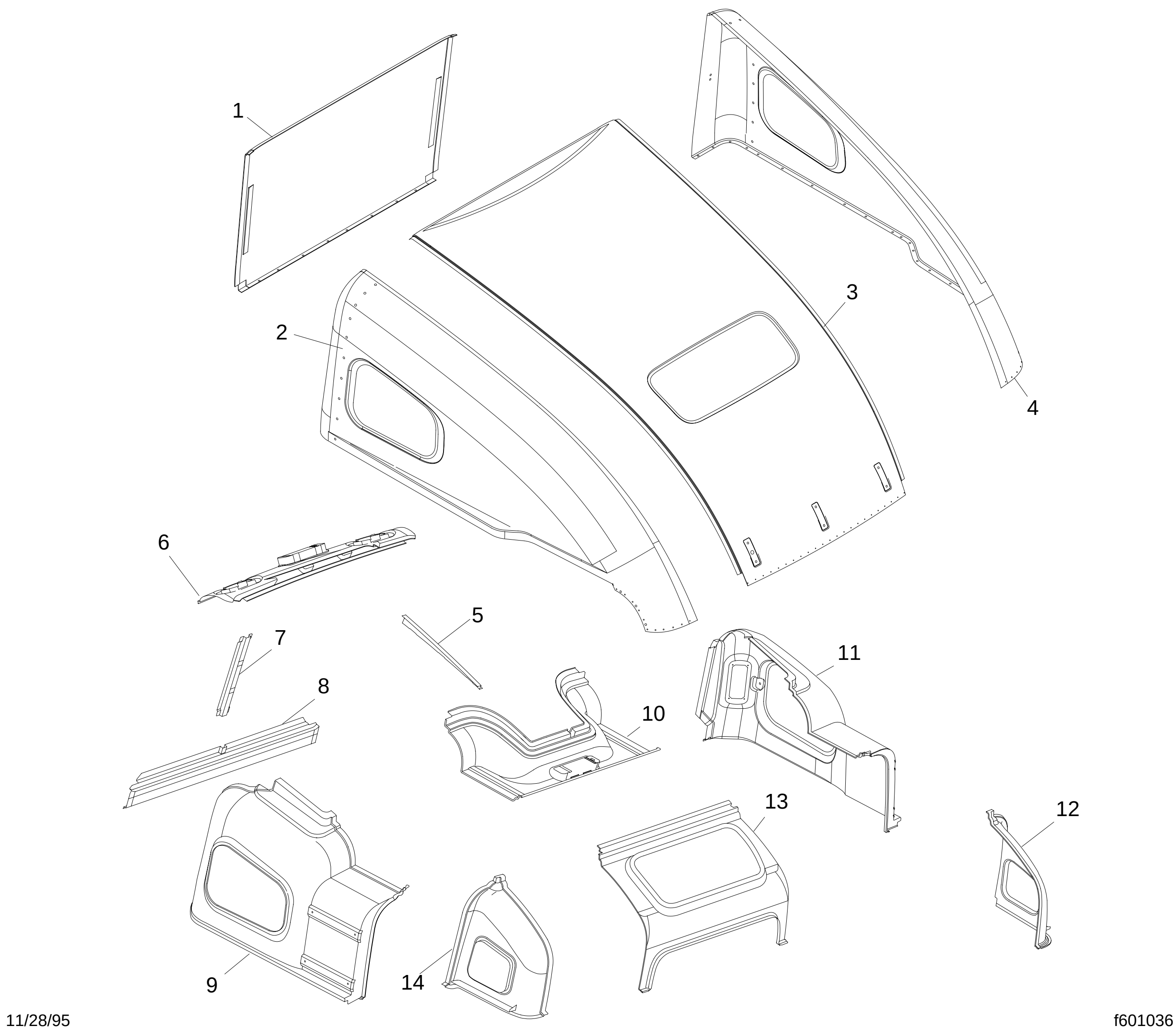
CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the laminate requires repair with a fiberglass reinforced patch. This repair is valid for panels 1 through 4, **Fig. 1**.

1. Examine the damage to the roof cap assembly. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch diameter bit to drill a hole completely through the uncracked laminate 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 3**
5. On the inner surface of the panel, use a router bit (on a grinder or a drill) to grind away a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward from all sides of the damage. Taper the outside edge of the ground area. See **Fig. 4**.

   If repairing a crack, grind outward to the drilled hole at the end of the crack, but not beyond. See **Fig. 5**, Ref. A.
6. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) away from the fracture on all sides. Be sure to scuff thoroughly, since this will give the patch a surface to which it can stick. See **Fig. 5**, Ref. B.
7. Blow the dust away with compressed air and wipe the area with a clean cloth.
8. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.
9. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (19 mm). See **Fig. 5**, Ref. C.

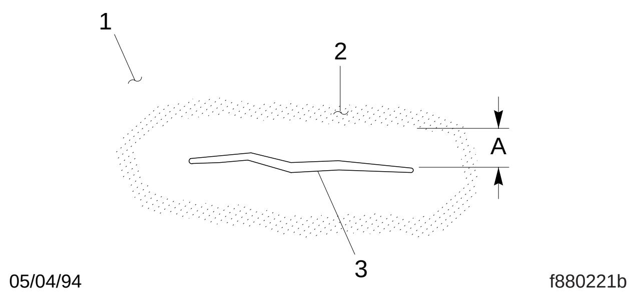
Raised Roof Cap Repairs



1. Center Rear Skin
2. Right-Hand Side Skin
3. Center Front Skin
4. Left-Hand Side Skin
5. Upper Roof Trim Reinforcement
6. Upper Rear Panel
7. Center Rear Vertical Reinforcement
8. Lower Rear Reinforcement, Horizontal Center Rear Halo Support
9. Right-Hand Window Surround Panel
10. Upper Panel Assembly
11. Left-Hand Window Surround Panel
12. Front Overhead Assembly, Left-Hand Side
13. Front Storage Panel Halo
14. Front Overhead Assembly, Right-Hand Side

Fig. 1, Roof Cap Assembly Components (SleeperCab shown)

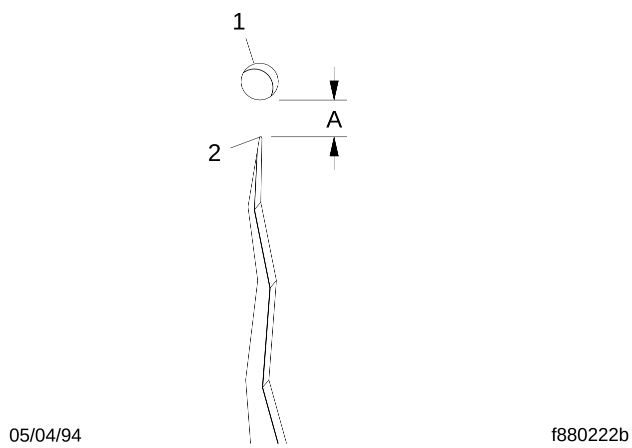
Raised Roof Cap Repairs



A. Remove paint and primer 1-1/2 inches (4 cm) around the damaged area. Use 220-grit or finer sandpaper.

1. Paint
2. Primer
3. Scratch

Fig. 2, Damaged Area With Paint Removed



A. Drill a 1/8-inch hole, 1/8 inch (3 mm) away from the end of a crack.

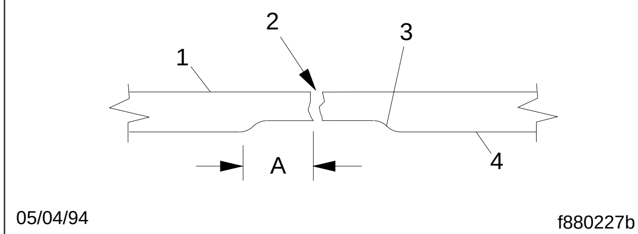
1. 1/8-Inch Hole
2. End of Crack

Fig. 3, Crack Prevention

10. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip® 7775 urethane adhesive.

    When using Ashland Pliogrip 7775: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

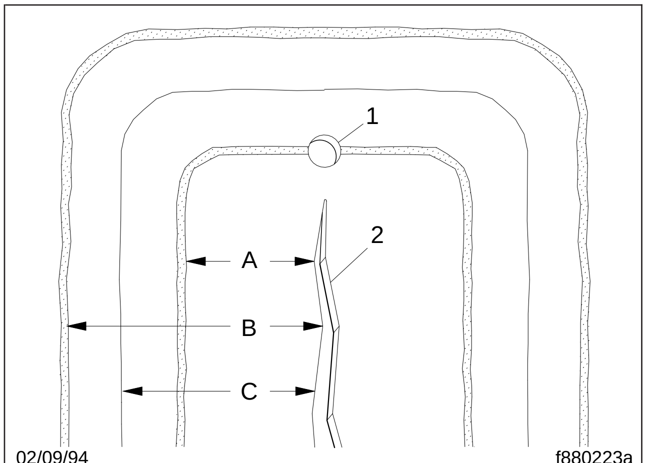
11. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.



A. Grind a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Roof Panel
2. Crack
3. Slight Taper
4. Underside of Panel

Fig. 4, Recessed Area (cross-sectional view)



A. Use a router to grind away a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward from the damage. If repairing a crack, don't grind past the hole drilled at the end of the crack.
B. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
C. Cut the fiberglass cloth to fully cover the damage, and overlay about 3/4 inch (19 mm).

1. Hole
2. Crack

Fig. 5, Preparing the Damaged Area on the Inner Side of the Roof Panel

12. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.

Raised Roof Cap Repairs

13. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.
14. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within five minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after 15 minutes when the agent has set.

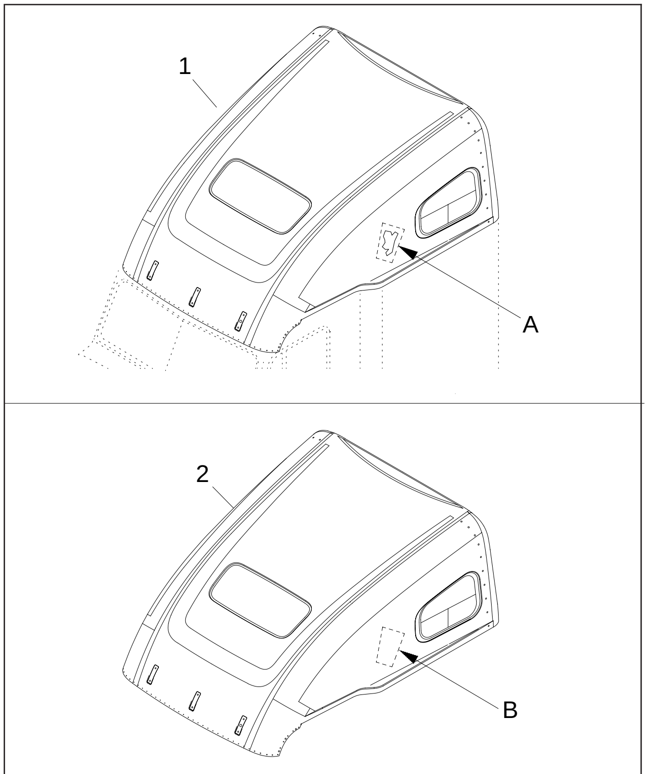
15. The patch should be hard enough in 50 minutes to allow sanding to a smooth flat surface if required.
16. Repair the damage on the outside surface of the panel and paint the surface on both sides, using the instructions in "Surface Damage Repair."

PUNCTURE AND LARGE FRACTURE REPAIR (SECTION REPLACEMENT)

On very large damaged areas (for example, structural damage on the roof cap covering an area of a square foot or more) it may be easier to do a section replacement rather than make a patch. Panels and roof reinforcements may be used in section replacements. Also, another damaged roof with the needed section intact may be available as scrap.

IMPORTANT: Do not use interior panel sections as replacement for damaged outer skin panels. The interior panels have no reinforcement, and cannot be sanded and refinished.

1. Push in on the area immediately surrounding and underneath the damaged area to determine the extent of the damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. Using a saber saw, cut out a large, straight-sided panel containing the damaged area. See the example in **Fig. 6**, Ref. A. If the damage extends to a joint where the part is bonded to another, first separate the bonded portion of the damaged section with a heat gun and putty knife before cutting.



A. Remove this area.
B. Use as a section replacement for damaged roof skin or panel.
1. Damaged Roof
2. Scrap Roof

Fig. 6, Section Replacement of a Damaged Fiberglass Roof

⚠ WARNING

Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to

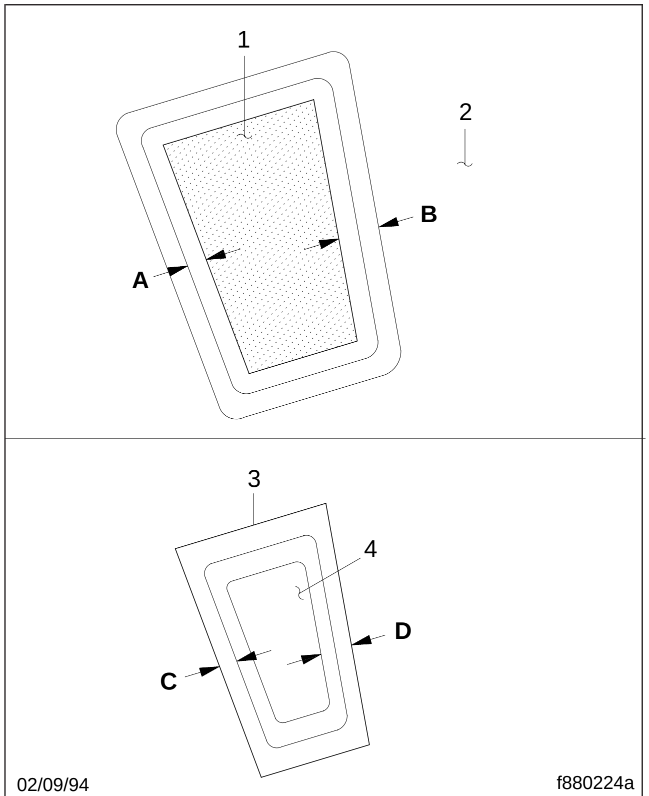
your eyes and, if inhaled, could cause throat or lung irritation.

CAUTION

Do not use a heat gun on the interior panels. The interior roof cap panels are made with a urethane based material that has the same melting properties as the urethane adhesive used to manufacture the cap. Heat will destroy the interior panel before the glue debonds.

5. From the scrap roof panel or new part, cut a section replacement panel from the same area, only slightly larger than the original cutout. See the example in **Fig. 6**, Ref. B. Then, trim the section replacement to fit both the size and contour of the original cutout.
6. After the trimming is completed, sand the edges to allow a 1/16- to 1/8-inch (about 2- to 3-mm) gap around the cutout.
7. On the inner side of the panel, use a router bit (on a grinder or drill) to grind away a shallow recess one-quarter the depth of the roof panel, 1/2 inch (13 mm) outward from all sides of the cutout area. See **Fig. 7**, Ref. A. Also, grind 1/2 inch (13 mm) inward from all sides of the section replacement. See **Fig. 7**, Ref. C. Slightly taper the outside edge of the ground area on the roof panel and the inside edge of the ground area on the section replacement. See **Fig. 8**.
8. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) out from all sides of the cutout area. See **Fig. 7**, Ref. B.

   Also, scuff at least 1 inch (25 mm) in from all sides of the section replacement. See **Fig. 7**, Ref. D. Be sure to scuff thoroughly, since this will give the section replacement a surface to which it can stick. Be sure to completely sand off any undercoating sprayed on these areas.
9. On the outer sides of both the cutout and the section replacement, bevel the edges about 45 degrees. See **Fig. 9**.
10. Gently feather the outer painted surfaces back about 1/2 inch (13 mm) beyond the edges of the repair areas (on both the cutout and the section replacement), using 220-grit or finer sandpaper.
11. Blow the dust away with compressed air and wipe the area with a clean cloth.



A, C. Use a router to grind away a shallow recess one-quarter the depth of the roof panel, and 1/2 inch (13 mm) away from the edge.
B, D. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.

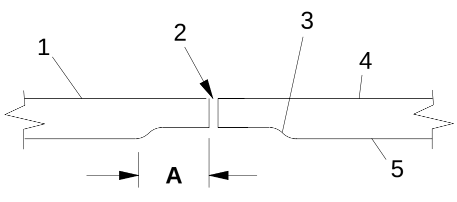
1. Cutout Hole
2. Underside of Roof
3. Section Replacement
4. Underside of Section Replacement

Fig. 7, Preparing the Section Replacement and Roof Panel Cutout on the Unexposed Side

12. If the section replacement is close enough to an edge, use clamps to temporarily secure it during the repair. If the replacement is too far from an edge to use clamps, use bond strips as shown in **Fig. 10**.

    12.1 Cut some scrap FRP into strips. Make enough strips to hold the section replacement in position, about one every six inches (15 cm). If the surface of the replacement panel is contoured or curved, use many small bond strips. Larger strips could deform the curves.

Raised Roof Cap Repairs



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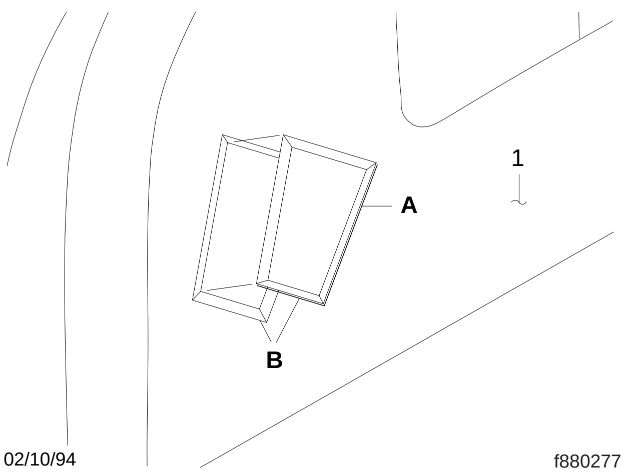
A. Grind a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Section Replacement
2. Gap
3. Slight Taper
4. Roof Panel
5. Underside of Roof

Fig. 8, Cutout Area (cross-sectional view)



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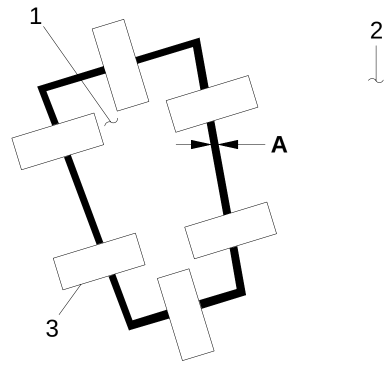
A. Insert section replacement.
B. Bevel outer surface edges on all sides.
1. Exposed Side of Roof

Fig. 9, Areas to be Beveled

12.2 On the inner side of the repair, use 80- to 220-grit sandpaper to scuff sand the areas on the roof and section replacement panels where you plan to bond the strips.

12.3 If a joint between parts was separated for the repair, rebond the joint. Refer to "Roof Cap Assembly Rebonding" for instructions.

12.4 Holding the section replacement in position, bond the strips to both roof and replacement panels in the area already



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A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)

1. Section Replacement
2. Underside of Roof
3. Bond Strip

Fig. 10, Securing the Section Replacement to the Roof Panel Using Bond Strips

scuffed. Use Ashland Pliogrip 7773 to bond the strips.

12.5 The Pliogrip 7773 adhesive will set in 10 minutes, and will be sandable in 30 minutes. Cure times may be shortened by using a heat gun. Do not expose the adhesive to temperatures in excess of 180°F (82°C).

12.6 After the bonding agent has hardened, use 80- to 220-grit sandpaper to scuff the bond strips.

12.7 Blow the dust away with compressed air and wipe the area with a clean cloth.

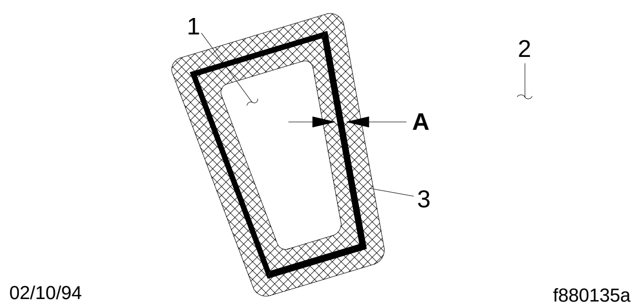
13. With a razor-blade knife, cut sections of woven fiberglass cloth to fully cover the gap between the cutout and the section replacement, all the way around the damaged area. The cloth should overlay about 3/4 inch (19 mm) on both sides of the gap. See **Fig. 11**.

14. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

    When using Ashland Pliogrip 7775L: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

15. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.

Raised Roof Cap Repairs



NOTE: The fiberglass cloth should overlay about 3/4 inch (19 mm) on both sides of the gap.

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)
1. Section Replacement
2. Underside of Roof
3. Fiberglass Cloth

Fig. 11, Fiberglass Cloth Overlay

16. Lay the cut sections of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.
17. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.
18. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within five minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after fifteen minutes when the bonding agent has set.

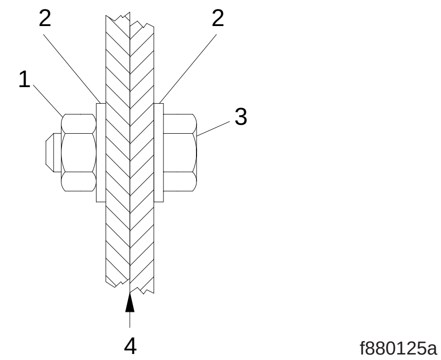
19. Repair the damage on both inner and outer surfaces of the roof, and paint the surface on both sides, using the instructions in "Surface Damage Repair." Surfaces on the inside of the roof cap that will be covered with insulation and upholstery panels do not require paint.

ROOF CAP ASSEMBLY REBONDING

1. If rebonding a joint that has separated, or if replacing a damaged part, completely separate each part. The outer FRP panels are separated using a heat gun and putty knife. Remove as much of the old adhesive as possible. The heat gun will soften the adhesive and allow it to be peeled off the FRP roof cap subassemblies. The inner RIM panels must be separated mechanically. Work folded medium-grit sandpaper or a section of a steel hacksaw blade between the two surfaces to remove the old adhesive.
2. Scuff the surfaces of the outer FRP panels with with 80- to 220-grit sandpaper. Do not sand or scratch the interior RIM panels.
3. Clean the surfaces to be bonded with Ashland 6036 primer or methylene chloride. Inspect the area closely to be sure all of the old adhesive, dirt, water, grease, and oils are removed.
4. If replacing a large part, such as an outer panel, align the part on the roof cap assembly and clamp it in place. Drill holes through the bonding surfaces and install clamping bolts in the holes. Use two washers, one on each side of the joint. See Fig. 12. There should be enough clamping bolts to hold the panel in place and keep the bonding surfaces together, or at least one bolt every 12 to 18 inches (30 to 45 cm). Remove the part for application of bonding agent. If RIM panels will be drilled, use a fluted or a parabolic drill bit. Do not use standard 180-degree ground drill bits.
5. Use the Pliogrip urethane cartridge materials 7773 or 7779 or equivalents to bond panels together.

   When using Ashland Pliogrip 7773 or 7779: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.
6. Within four minutes after applying the bead, align the part on the roof assembly and clamp it firmly in place. If it is a large part, install the clamping bolts. Tighten the clamps or clamping bolts just enough to ensure that a uniform amount of pressure is applied along the seam. Ideally, the bonding agent should be compressed to form a bond

Raised Roof Cap Repairs



1. Nut
2. Washer
3. Bolt
4. Bond Joint

Fig. 12, Clamping Bolt at Bond Joint

line one inch (25 mm) wide and 0.030 inch (0.76 mm) thick. This thickness can be ensured by sprinkling 0.030 inch glass beads into the bonding agent before mating the parts.

7. Before it cures, within seven to 10 minutes, remove any excess bonding agent that squeezes out the edges of the bond.
8. If a heat gun is used, remove the clamps when the bonded FRP parts are cool to the touch; in about one hour. If no heat is applied, leave the bonded parts clamped together for twenty-four hours.

NOTE: Do not use a heat gun in excess of 180°F (82°C) when working with Ashland Pliogrip adhesive.

9. If holes were drilled for clamping bolts, repair them using the instructions under "Crack or Small Hole Repair."
10. If necessary, prime and paint the repair area using the instructions under "Surface Damage Repair."

WARNING

Before doing any work, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved could lead to serious personal injury.

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks in the outer surface of the interior panels. To repair surface damage, do the following steps:

1. Locate the damaged area. If there are cracks, see if they go all the way through the component. If they do, refer to "Structural Damage Repair" for instructions.
2. Clean the area with xylene or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Depending on the depth and extent of the damage, simply retouching the affected areas with paint may be sufficient. If the damage is significant, follow the next steps.
4. Using an air nozzle, blow off all dust.
5. Wipe filler (Akemi AP–3030) over the non-coated area and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of filler, slightly higher than the painted surface.
6. After the filler dries (about five minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB–11 black conductive primer. See **Group 98** for spot-painting instructions.

Structural Damage Repair

The interior panels are bonded together with a structural bonding agent.

If there is damage at any joint between two parts, the damage is not repairable. For example, if the panel is damaged so badly that the roof panel is also damaged, replace the panel.

If a joint between two parts has separated and there is no damage at the joint area, the parts can be rebonded. Or, if a part is damaged and its adjoining parts are not damaged, the damaged part can be separated from the roof and new or used parts can be bonded in place. A section of a part can be replaced as long as the section does not include a joint between two parts. Panels are available as replacement parts or for use in section replacements.

CAUTION

As noted above, the panels serve as structural reinforcement for the outer panels. Removing the larger interior panels may cause the outer panels to deform, making reassembly impossible.

If the damage is such that the parts cannot be replaced, or a section replacement cannot be done, replace the entire roof cap assembly.

For damage in the form of a small crack or hole, refer to "Crack or Small Hole Repair."

For larger damaged areas, see **Subject 100**.

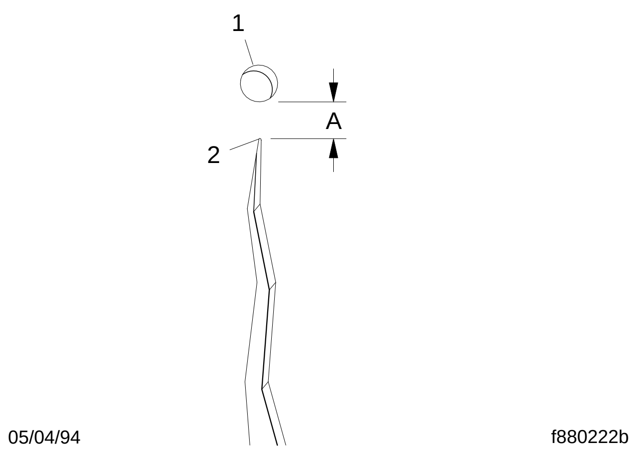
For replacing or rebonding parts, see **Subject 100**.

CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the polyurethane may require repair with a fiberglass reinforced patch, depending on the size and the extent of the fracture.

1. Examine the damage to the assembly. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch diameter bit to drill a hole completely through the uncracked polyurethane 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 1**.

Interior Panel Repairs



A. Drill a 1/8-inch hole, 1/8 inch (3 mm) away from the end of a crack.
1. 1/8-Inch Hole 2. End of Crack

Fig. 1, Drilling for Repair

5. On the outer surface (at the surface between the interior panels and the exterior panel skins), use 80- to 220-grit sandpaper to scuff an area at least 1 to 2 inches (25 to 51 mm) surrounding the damaged area. This will give the patch a surface to stick to.
6. Blow the dust away with compressed air and wipe the area with a clean cloth.
7. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.
8. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (19 mm).
9. To bond the fiberglass cloth to the damaged panel, choose one of the following bonding agents:
    - Magnolia Magnabond 58 epoxy resin
    - Ashland Pliogrip® 7773 polyurethane adhesive

IMPORTANT: Do not mix epoxy and polyurethane.

When using Magnolia Magnabond 58: Measuring the volumes with a spoon, and using a wooden stir stick, mix equal parts of Magnolia Magnabond 58 A and B epoxy resins on a clean sheet of glass, metal, or a section of scrap laminate. Mix for fifteen seconds to ensure a good blend.

IMPORTANT: With Magnolia Magnabond 58, it is critical to measure the A:B ratio accurately. Also, make sure the two components are adequately mixed.

When using Ashland Pliogrip 7773: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

10. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.
11. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.
12. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.
13. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the parts to be bonded within one to four minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after fifteen minutes when the agent has set.

14. The patch should be hard enough in fifteen minutes to allow sanding to a smooth flat surface if required.
15. Repair the damage on the outside surface of the panel and paint the surface on both sides, using the instructions in "Surface Damage Repair."

Cab Removal and Installation

When removing the cab, make sure you have equipment that is suitable for lifting the entire weight of the cab. For the frontwall disconnections, work first on one side of the vehicle, then the other.

Removal

1. Park the vehicle, set the parking brakes, then chock the tires
2. Support the rear of the cab with blocks.
3. Disconnect the batteries at the negative terminal.
4. Drain the air system tanks.
5. Open the hood, and support it on a padded table or bench.
6. Remove the roof fairing and side extenders, if equipped.
7. Remove the chassis side fairings. See the applicable section in **Group 31** for instructions.
8. Drain the radiator.

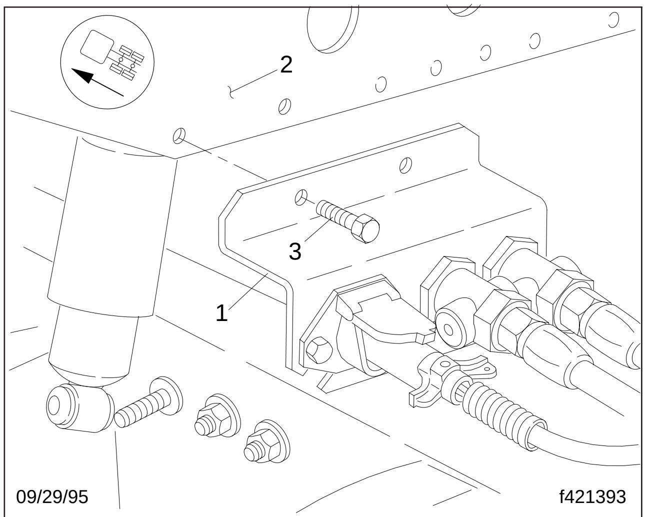
NOTE: The following steps are done on the left side of the vehicle.

9. Remove the windshield washer reservoir.
10. Disconnect the left-side radiator strut from the frontwall.
11. Mark the upper end of the steering column connection, then disconnect it from the lower end of the steering column.
12. Disconnect the lower steering column from the steering gear and the upper steering column. See the applicable section in **Group 46** for instructions.
13. Mark, then disconnect all the electrical wiring from the left side of the frontwall.
14. Disconnect the clutch linkage. See the applicable section in **Group 25** for instructions.
15. Mark, then disconnect all the air lines at their quick-disconnects.
16. Mark, then disconnect all the lines from the air/oil junction block.
17. Remove the left-side mudflap and bracket assembly.
18. Find the ground wire coming from under the cab, below the forward cab-mount bracket. Disconnect it from the frame rail.
19. Disconnect the engine block heater wiring from the chassis, if equipped.
20. Remove fasteners holding the forward cab-mount assemblies to the frame rail mounting brackets.
21. Disconnect the air line from the air horn, which is mounted underneath the cab deck, below the driver's seat.
22. If so equipped, disconnect the front-axle ABS harness from the underside of the cab deck, in back of the driver's seat area.
23. Go to the right side of the frontwall.
24. Disconnect the right radiator strut from the frontwall.
25. Remove the air cleaner and the heat shield below it.
26. Mark, then disconnect all the electrical wiring from the right side of the frontwall.
27. Evacuate the air conditioning system. See the applicable section in **Group 83** for instructions.
28. Mark, then disconnect the lines from the HVAC receiver-drier. Cover the lines to keep out contaminants.
29. Mark, then disconnect the cab heater supply and return hoses.
30. Disconnect the auxiliary (sleeper) heater hose from the large supply hose coming from the radiator.
31. Put a container under the engine, then disconnect the auxiliary heater supply hose from the engine block.
32. Disconnect the lines from the HVAC expansion valve on the right side of the frontwall.
33. Remove the right-side mud flap and bracket assembly
34. Remove the transmission shift lever.
    - 34.1 From inside the cab, remove the metal bezel from the cab deck, then slide the rubber boot up the shift lever
    - 34.2 Disconnect the splitter airline and the cruise control wiring, if so equipped.

Cab Removal and Installation

34.3 Using a 5/32-inch Allen wrench, and a 1/2-inch crescent wrench, disconnect the shift lever from the shift tower.

35. Remove the fasteners holding the right-side forward cab-mount bracket to the frame rail mounting bracket.
36. At the back of the cab, disconnect the cab rear air suspension.
37. Remove the mufflers and heat shields. See the applicable section in **Group 47** for instructions.
38. Remove the bracket for the trailer air connections from the back wall of the cab. See **Fig. 1.**



1. Bracket
2. Back Wall of Cab
3. Hexbolt (2 qty.)

Fig. 1, Trailer Air-Connection Bracket

WARNING

Before lifting the cab from the chassis, make sure the cab is correctly balanced, that it is supported in at least four places, and that the hoist is strong enough to support the cab. Failure to do so could result in the cab falling, which could cause serious personal injury and damage to the cab.

39. Using a suitable hoist, and attaching straps at four points on the cab (two forward, and two rear), lift the cab off the chassis.

CAUTION

Do not try to lift the cab by the door frames unless you install a special door lifting insert into each door frame. The door frames are not strong enough to support the full weight of the cab, and damage to the cab could result if it is lifted without the use of lifting inserts. Using the inserts also ensures that the cab will be correctly balanced in the lifting straps.

39.1 Open the doors; then install a lifting insert into each door frame, and clamp it in place, using padded clamps. See **Fig. 2.**

Right and left lifting door insert assemblies are available through Daimler Trucks North America Parts Distribution Centers. The part numbers are A22-45473-000 (left-side), and A22-45473-001 (right-side).

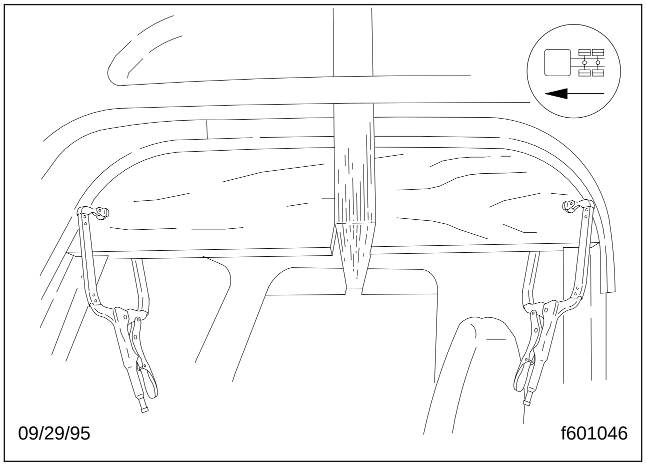


Fig. 2, Door Lifting Insert Installed and Lifting Strap in Place

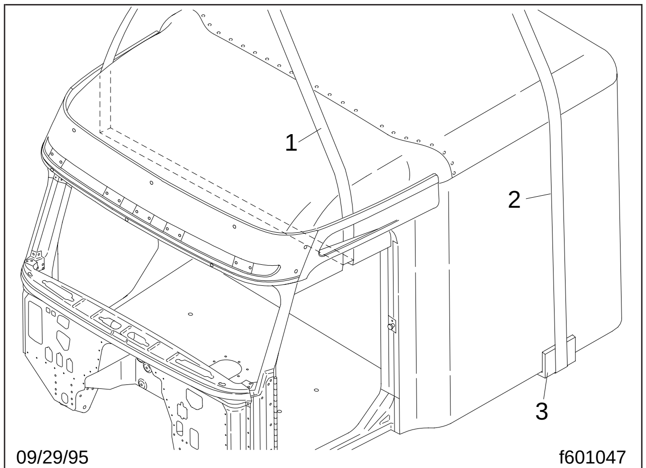
39.2 Attach the forward lifting strap. Make sure it fits into the groove of each lifting insert.

39.3 Attach lifting straps to the rear of the right and left side walls, using suitable padded clamps. See **Fig. 3.**

39.4 Lift the cab slightly to make sure it is balanced, and that nothing is holding it to the chassis. If needed, lower the cab and adjust the placement of the rear straps.

39.5 Lift the cab clear of the chassis.

Cab Removal and Installation



1. Forward Lifting Strap
2. Rear Lifting Strap
3. Padded Clamp

Fig. 3, Lifting the Cab

Installation

1. Lower the cab onto the chassis. Make sure the forward cab mounts line up with the frame rail mounting brackets, both fore and aft, and side to side.
2. Attach the forward cab mounts to the frame rail mounting brackets. See the applicable section in this group for instructions.
3. Connect the rear cab air suspension.
4. Install the bracket for the trailer air connections to the left side of the cab back wall.
5. Install the mufflers and heat shields. See the applicable section in **Group 47** for instructions.
6. From inside the cab, connect the transmission shift lever to the shift tower. Install the rubber boot to the cab deck.
7. On the right side of the frontwall, connect the lines to the HVAC expansion valve.
8. Connect the lines to the HVAC receiver-drier.
9. Connect the auxiliary (sleeper) heater supply hose to the engine block.
10. Connect the other auxiliary heater hose to the large supply hose coming from the radiator.
11. Connect the cab heater hoses as previously marked.
12. As previously marked, connect all the wiring on the right side of the frontwall.
13. Install the air cleaner and the heat shield.
14. Attach the right radiator strut to the frontwall.
15. On the left side of the vehicle, connect the front-axle ABS wiring harness to the underside of the cab deck, at the rear of the driver's seat.
16. Connect the air line to the air horn.
17. If so equipped, connect the engine block heater wiring.
18. Connect the ground wire coming from under the cab deck.
19. As previously marked, connect the lines to the air/oil junction block.
20. As previously marked, connect all the air lines.
21. As previously marked, connect all the electrical wiring on the left side of the frontwall.
22. Connect the clutch linkage. See the applicable section in **Group 25** for instructions.
23. Connect the lower steering column to the steering gear and the upper steering column. Make sure you use a new pinch bolt at the steering gear connection. See the applicable section in **Group 46** for instructions.
24. Attach the right radiator strut to the frontwall.
25. Install the windshield washer reservoir.
26. Install the right- and left-side mudflaps and brackets to the chassis.
27. If so equipped, install the chassis side fairings. See the applicable section in **Group 31** for instructions.
28. If so equipped, install the roof fairing and side extenders.
29. Fill the radiator with coolant.
30. Connect the batteries.
31. Charge the HVAC system. See the applicable section in **Group 83** for instructions.
32. Start the engine and check all the coolant and heater hoses for leaks. Check all the electrical systems and gauges.

Cab Removal and Installation

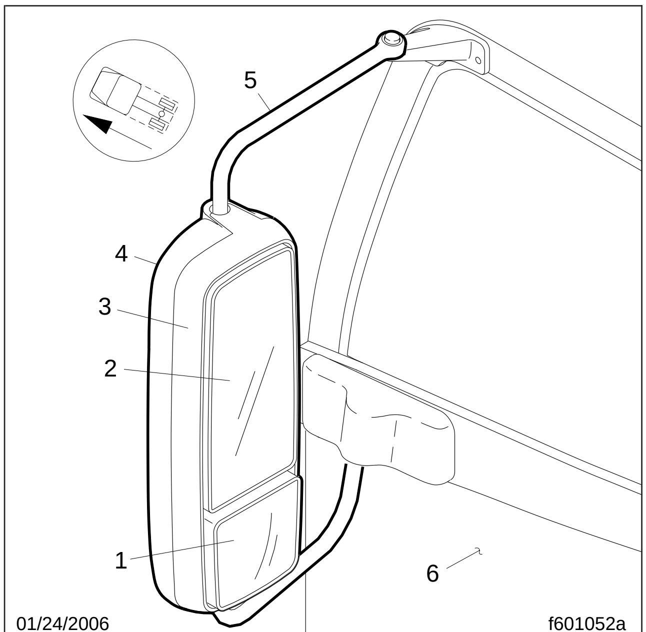
33. Build the air pressure to 110 psi.
34. Adjust the cab height.
35. Close the hood.
36. Remove the chocks from the tires.

General Information

The Lang-Mekra and Truck-Lite mirrors are electrically heated, remote-controlled mirrors. The mirror unit consists of an upper rectangular main (flat) mirror, and a lower square (convex) mirror. The mirror is mounted in a housing, and the entire mirror head assembly is mounted to the door by a fold-away tubular support loop. See **Fig. 1** and **Fig. 2**.

The main mirror can be actuated remotely, or moved manually in case of an electrical problem. The convex mirror is not remotely actuated, but can be adjusted manually. An indicator light on the dash alerts the driver that the heating element in the mirror is on.

Dual electric motors (one for vertical movement, and one for horizontal movement) are mounted inside the mirror housing, and are equipped with a clutch to prevent damage in case of binding. All the wiring is hidden within the support loop and the mirror housing.



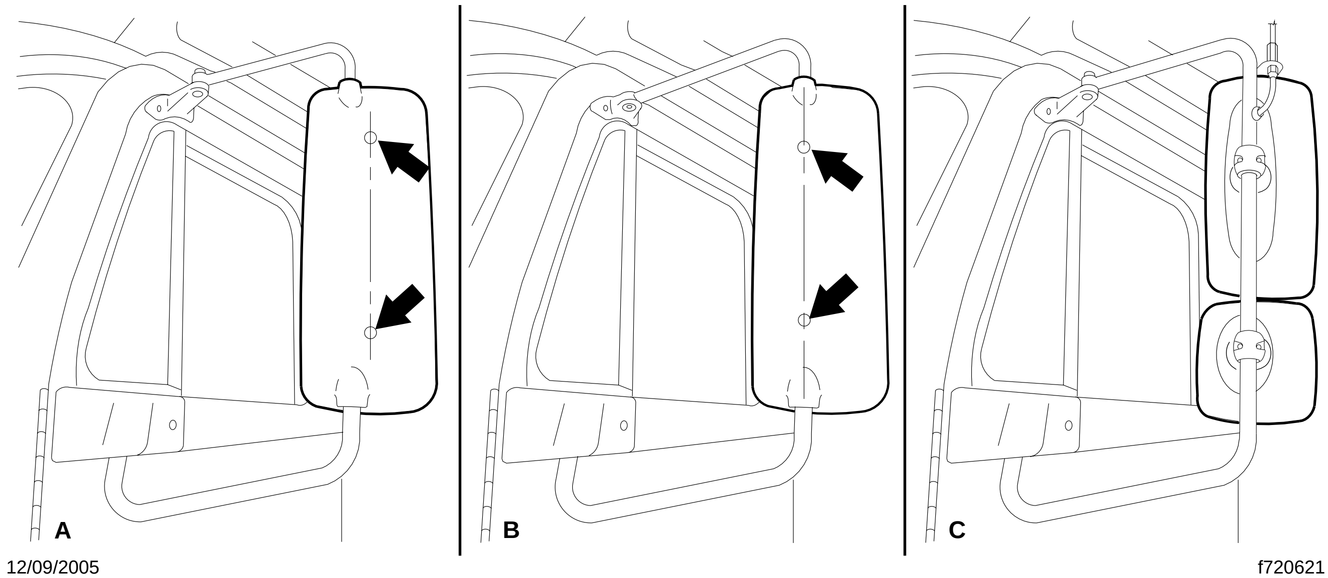
1. Square, Convex Mirror
2. Rectangular, Flat Main Mirror
3. Housing
4. Back Cover
5. Fold-Away Support Loop
6. Door (left side)

Fig. 1, Mirror Assembly (Lang-Mekra Aero Shown)

Aero-style mirrors can be identified as Lang-Mekra Aero or Truck-Lite by the placement of the two screws that attach the back cover to the mirror housing assembly. On the Truck-Lite mirror they are in line with the support loop, while on the Lang-Mekra they are offset, outboard from the support loop. See **Fig. 2**. There are also differences in the upper mounting bracket and pivot joint.

The Lang-Mekra West Coast style mirror consists of two components, the main and convex mirrors, each individually attached to the support loop. See **Fig. 2**.

General Information



A. Lang-Mekra Aero (cover screws outboard of support loop)
B. Truck-Lite (cover screws in line with support loop)
C. Lang-Mekra West Coast

Fig. 2, Mirror Identification

Mirror Assembly Removal and Installation

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Lang-Mekra West Coast
- Truck-Lite

The procedure is the same for all mirrors.

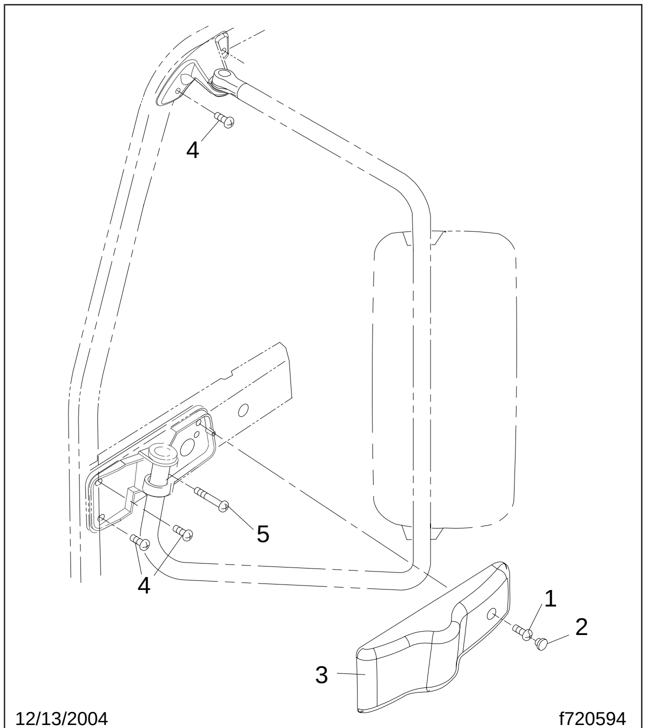
NOTE: Many parts of the mirror can be serviced without removing the entire mirror assembly from the vehicle. If the entire mirror assembly need not be replaced, see the appropriate procedure for the component to be serviced.

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the lower mirror-bracket cover. See **Fig. 1**.
   - 2.1 Remove the screw cover cap from the lower mirror-bracket cover.
   - 2.2 Remove the screw that attaches the cover to the mirror bracket.
   - 2.3 Remove the cover by pulling the rear of the cover away from the bracket while sliding the front of the cover towards the front of the vehicle.
3. Disconnect the cables at the lower bracket.
4. Remove the three screws that attach the lower bracket to the door.
5. While supporting the mirror, remove the two screws that attach the upper bracket to the door. Remove the mirror assembly from the door.

Installation

1. Position the mirror assembly on the door.
2. Attach the upper bracket to the door with the two screws. Torque the screws 11 lbf·ft (15 N·m).
3. Attach the lower bracket to the door with the three screws. Torque the screws 11 lbf·ft (15 N·m).
4. Connect the cables at the lower bracket.



1. Bracket Cover Mounting Screw
2. Screw Cover Cap
3. Lower Bracket Cover
4. Bracket Screws
5. Hexbolt

Fig. 1, Mirror Assembly Mounting

5. Install the lower mirror-bracket cover.
   - 5.1 Slide the front of the cover onto the lower bracket and push the rear of the cover onto the bracket.
   - 5.2 Install the screw that attaches the cover to the bracket.
   - 5.3 Install the screw cover cap.
6. Remove the chocks from the tires.

Mirror Support Loop Folding Repair

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Lang-Mekra West Coast
- Truck-Lite

The procedure is the same for all mirrors.

Folding Repair

Mirrors are designed to fold away if they contact an immovable object. In some cases, however, the mirror support loop may pivot too easily.

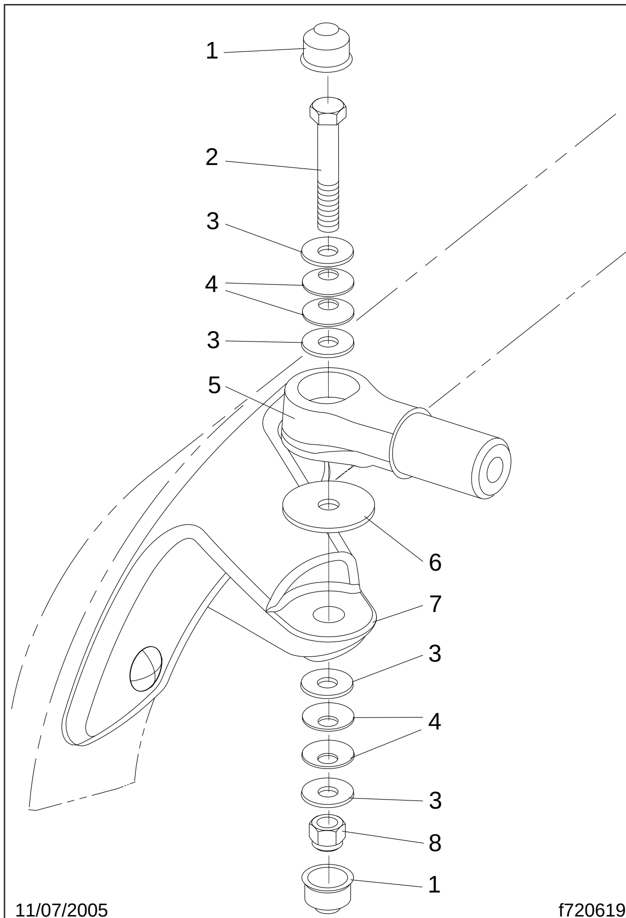
During manufacture, the upper pivot-point fasteners are torqued 31 to 35 lbf·ft (42 to 48 N·m).

If a mirror support loop moves due to high wind loads or slamming the door, retorque the upper pivot-point fasteners after removing the two protective caps from the hexbolt and locknut. See **Fig. 1**. Check the fastener torque to confirm that it is 31 to 35 lbf·ft (42 to 48 N·m).

If the torque is correct and the support loop continues to move too easily, disassemble the pivots, remove any grease, replace the hexbolt with a 3/8–24 x 2 bolt, and then assemble the pivots.

An upper pivot-point fastener kit is available for Lang-Mekra mirrors. See **Subject 210** for instructions on replacing the upper pivot-point fasteners.

NOTE: The upper pivot-point fastener kit is not serviceable on Truck-Lite mirrors.



1. Protective Cap
2. Hexbolt
3. Steel Washer
4. Belleville Washers
5. Support Loop
6. Brass Disk
7. Upper Mounting Bracket
8. Locknut

Fig. 1, Upper Pivot-Point Fasteners (Lang-Mekra)

Mirror Back Cover Removal and Installation

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Truck-Lite

The only mirrors that have removable back covers are the Aero-style mirrors. The procedure is slightly different between the Lang-Mekra Aero and Truck-Lite mirrors.

Lang-Mekra Aero

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the two screw covers on the back of the mirror.
4. Remove the two screws that attach the back cover to the mirror head.
5. Pull the bottom of the cover away from the mirror head, and carefully lift the cover up over the antenna base.

Installation

1. Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.
2. Install the two screws that attach the cover to the mirror head. Torque the screws 36 lbf·in (400 N·cm).
3. Install the two screw covers.
4. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
5. Remove the chocks from the tires.

Truck-Lite

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the two screw covers on the back of the mirror.
4. Remove the two screws that attach the back cover to the mirror housing.
5. Pull the bottom of the cover away from the mirror housing, and carefully lift the cover up over the antenna base.

Installation

1. Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.

IMPORTANT: Ensure that the mirror back cover is properly seated in the mirror housing. The gap around the edge should be uniform, and the tabs at the top and bottom should seat securely in their respective grooves.

2. Install the two screws that attach the cover to the mirror housing. Torque the screws 31 lbf·in (340 N·cm).
3. Install the two screw covers.
4. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
5. Remove the chocks from the tires.

Mirror Head Assembly Removal and Installation

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Lang-Mekra West Coast
- Truck-Lite

The Lang-Mekra mirrors are attached to the support loop with clamps, while the Truck-Lite is attached to the support loop with the actuator and pivot assembly screws, requiring the removal of the mirror plate.

On the Lang-Mekra West Coast mirror, the main and the convex mirrors are attached to the support loop separately, and can be removed independently.

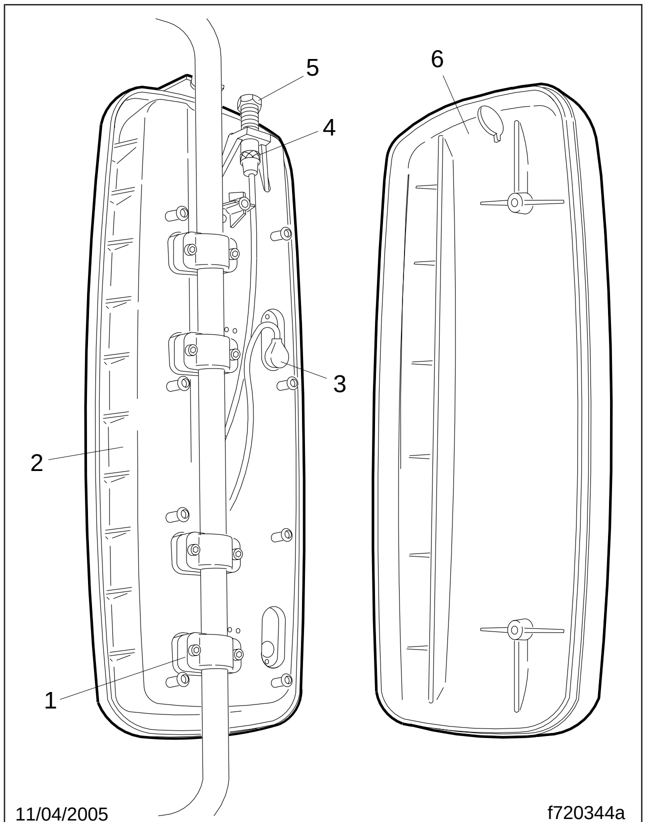
Lang-Mekra Aero

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the mirror back cover.
   - 3.1 Remove the two screw cover caps on the back of the mirror.
   - 3.2 Remove the two screws that attach the back cover to the mirror housing.
   - 3.3 Pull the bottom of the cover away from the mirror housing, and carefully lift the cover up over the antenna base.
4. Disconnect the CB and control cables from the mirror head. See **Fig. 1**.
5. While holding the mirror head, remove the screws on the four mounting clamps. Remove the mirror head from the support loop.

Installation

1. Position the mirror head assembly on the support loop.
2. Attach the mirror head assembly to the support loop by placing the four mounting clamps over the support loop and attaching them to the mirror head using the screws.



1. Mounting Clamp
2. Mirror Housing
3. Control Cable
4. CB Antenna Cable
5. Antenna Hexnut
6. Back Cover

Fig. 1, Mirror Head Installation, Lang-Mekra Aero

3. Adjust the angle of the mirror head on the support loop as needed. The angle of the mirror glass to the window glass should be 55 degrees on the driver's side, and 45 degrees on the passenger's side. Tighten the screws 53 lbf·in (600 N·cm).
4. Attach the CB cable and the control cable to the mirror head.
5. Install the mirror back cover.
   - 5.1 Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror housing.
   - 5.2 Install the two screws that attach the cover to the mirror housing. Torque the screws 36 lbf·in (400 N·cm).

Mirror Head Assembly Removal and Installation

5.3 Install the two screw cover caps.

6. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
7. Remove the chocks from the tires.

Lang-Mekra West Coast

Removal

NOTE: The main mirror and convex mirrors are attached to the support loop separately, and can be removed independently.

NOTE: On some Lang-Mekra West Coast mirrors, the electrical connector is located on the outside of the mirror. If so, it is not necessary to remove the mirror plate.

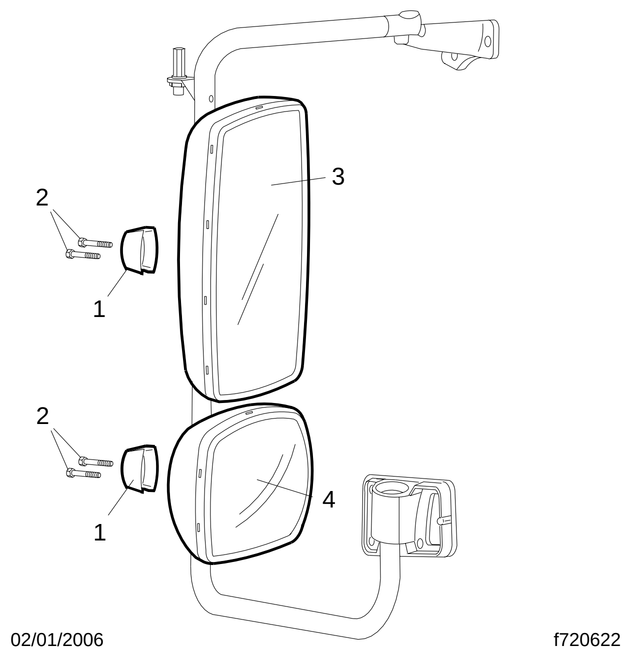
1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the applicable mirror plate, if the electrical connector is inside the mirror head. See **Subject 150** (main mirror) or **Subject 160** (convex mirror), as applicable, for instructions.

IMPORTANT: Do not pull or cut the wires when disconnecting them. Disconnect the wires by pulling on the wire terminal covers only. Connect the wires by pushing on the wire terminal covers only.

4. Disconnect the control cable (on motorized mirrors). Disconnect the mirror heat wiring (on heated mirrors), by pulling them loose by the wire terminal covers only.
5. While holding the mirror head, remove the two clamp screws and the clamp. See **Fig. 2**.
6. Remove the mirror from the support loop.

Installation

1. Position the mirror head on the support loop.



1. Clamp
2. Screw
3. Main Mirror
4. Convex Mirror

Fig. 2, Mirror Head Installation, Lang-Mekra West Coast

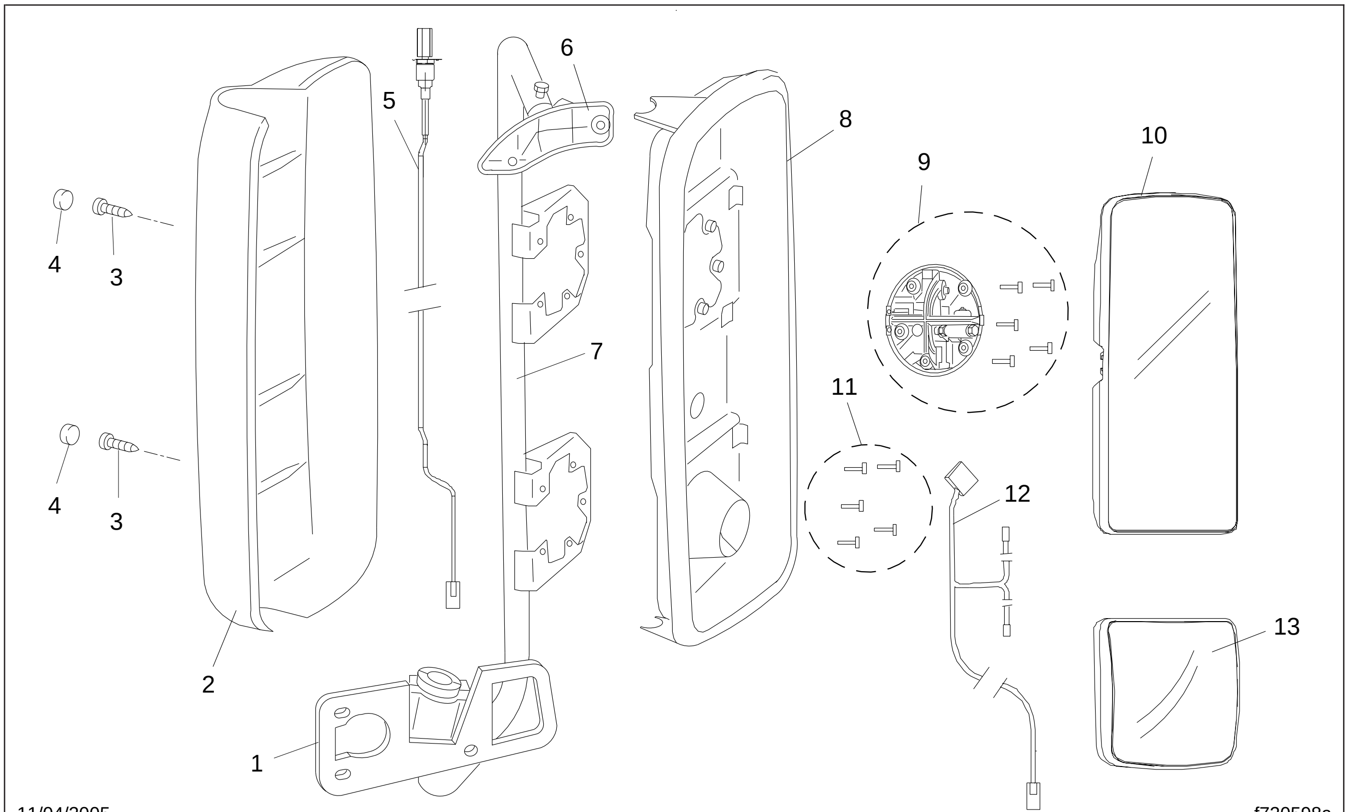
2. While holding the mirror head, attach it to the support loop with the clamp and two screws. Torque the screws 9 lbf·ft (13 N·m). See **Fig. 2**.
3. Connect the control cable (on motorized mirrors) to the mirror head. Connect the mirror heat wiring (on heated mirrors), by pushing them in by the wire terminal covers only.
4. Install the mirror plate. See **Subject 150** (main mirror) or **Subject 160** (convex mirror), as applicable, for instructions.
5. Check the viewing angle of the mirror. If necessary, reposition the mirror head by holding it in place, loosening the clamps, adjusting its position, and tightening the clamp screws 9 lbf·ft (13 N·m).
6. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
7. Remove the chocks from the tires.

Mirror Head Assembly Removal and Installation

Truck-Lite

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the mirror back cover. See **Fig. 3**.
   - 3.1 Remove the two screw covers on the back of the mirror.
   - 3.2 Remove the two screws that attach the back cover to the mirror head.
   - 3.3 Pull the bottom of the cover away from the mirror head, and carefully lift the cover up over the antenna base.
4. Remove the main mirror plate. See **Subject 150** for instructions.
5. Remove the convex mirror plate. See **Subject 160** for instructions.
6. Remove the actuator assembly. See **Subject 170** for instructions.

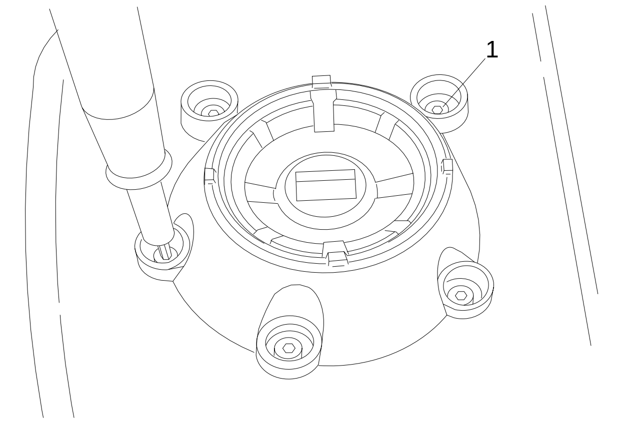


1. Lower Mounting Bracket
2. Back Cover
3. Screw
4. Screw Cover Cap
5. CB Coax Assembly
6. Upper Mounting Bracket
7. Support Loop
8. Mirror Housing
9. Actuator Assembly
10. Flat Mirror
11. Pivot Assembly Screws
12. Heater Wiring Harness
13. Convex Mirror

Fig. 3, Truck-Lite Mirror Assembly

Mirror Head Assembly Removal and Installation

7. Remove the five screws that attach the convex glass pivot assembly to the support loop. See Fig. 4. Remove the mirror head from the support loop.



1. Pivot Assembly Mounting Screw

Fig. 4, Convex Glass Pivot Assembly

Installation

1. Position the mirror head on the support loop.
2. Attach the convex glass pivot assembly to the support loop with the five screws.
3. Install the actuator assembly. See **Subject 170** for instructions.
4. Install the convex mirror plate. See **Subject 160** for instructions.
5. Install the main mirror plate. See **Subject 150** for instructions.
6. Install the mirror back cover.

   6.1 Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.

   IMPORTANT: Ensure that the mirror back cover is properly seated in the mirror housing. The gap around the edge should be uniform, and the tabs at the top and bottom should seat securely in their respective grooves.

   6.2 Install the two screws that attach the cover to the mirror head. Torque the screws 31 lbf·in (340 N·cm).

   6.3 Install the two screw covers.

7. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
8. Remove the chocks from the tires.

Support Loop Replacement

This procedure applies to the following mirrors:

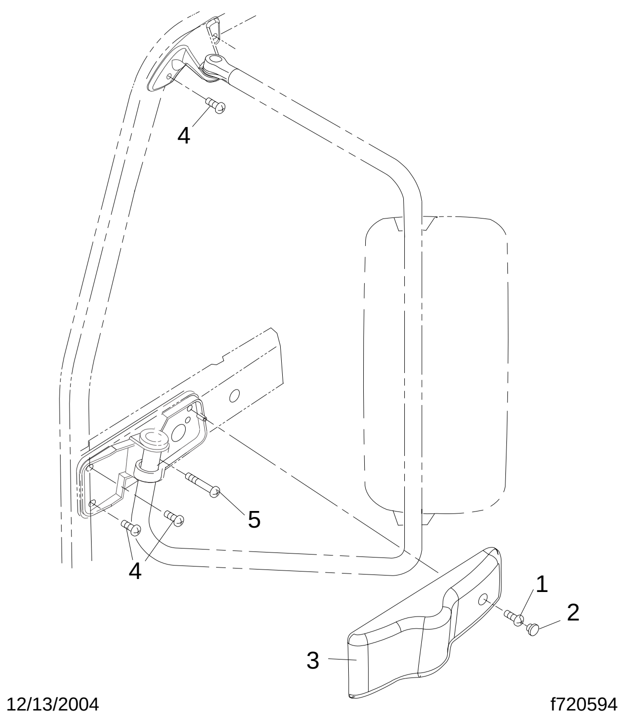
- Lang-Mekra Aero
- Lang-Mekra West Coast
- Truck-Lite

The Lang-Mekra and Truck-Lite support loops are slightly different, but the replacement procedure is similar, with the exception of the removal and installation of the mirror head.

Replacement

NOTE: The lower bracket and the wiring harness are not serviceable. If there is a problem with either one, replace the whole support loop assembly.

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the lower mirror-bracket cover. See **Fig. 1**.
   - 2.1 Remove the screw cover cap from the lower mirror-bracket cover.
   - 2.2 Remove the screw that attaches the cover to the mirror bracket.
   - 2.3 Remove the cover by pulling the rear of the cover away from the bracket while sliding the front of the cover towards the front of the vehicle.
3. Remove the mirror head assembly from the support loop. The procedure is different for each mirror. See **Subject 130** for applicable instructions.
4. Disconnect the cables at the lower bracket.
5. Remove the three screws that attach the lower bracket to the door.
6. While supporting the support loop, remove the two screws that attach the upper bracket to the door. Remove the support loop from the door.
7. Position the new support loop on the door.
8. Attach the upper bracket to the door using the two screws. Torque the screws 11 lbf·ft (15 N·m).
9. Attach the lower bracket to the door using the three screws. Torque the screws 11 lbf·ft (15 N·m).



1. Bracket Cover Mounting Screw
2. Screw Cover Cap
3. Lower Bracket Cover
4. Bracket Screws
5. Hexbolt

Fig. 1, Mirror Assembly Mounting

10. Connect the cables at the lower bracket.
11. Install the mirror head on the support loop. The procedure is different for each mirror. See **Subject 130** for applicable instructions.
12. Install the lower mirror-bracket cover.
    - 12.1 Slide the front of the cover onto the lower bracket and push the rear of the cover onto the bracket.
    - 12.2 Install the screw that attaches the cover to the bracket.
    - 12.3 Install the screw cover cap.
13. Remove the chocks from the tires.

Main Mirror Plate Removal and Installation

This procedure applies to the following mirrors:

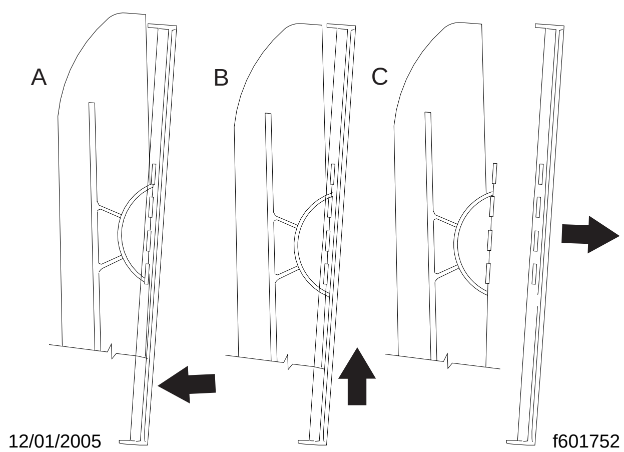
- Lang-Mekra Aero
- Lang-Mekra West Coast
- Truck-Lite

The procedure is different for each mirror.

Lang-Mekra Aero

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Move the mirror plate in at the bottom, either manually or by remote actuation. See **Fig. 1**.



A. Actuate the mirror down.
B. Slide the mirror plate up.
C. Pull the mirror plate out.

Fig. 1, Mirror Plate Removal

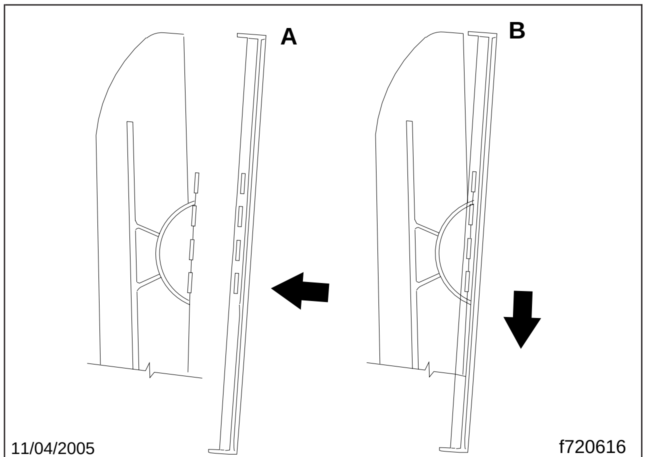
3. Slide the mirror plate up.
4. When the mirror plate is disengaged, carefully lift it to expose the heater wires.

IMPORTANT: Do not pull or cut the wires when disconnecting them. Disconnect the wires by pulling on the wire terminal covers only. Connect the wires by pushing on the wire terminal covers only.

5. Disconnect the heater wires by pulling on the wire terminal covers.
6. Remove the mirror plate.

Installation

1. Attach the wire terminals to the back of the mirror plate.
2. Position the mirror plate against the structure plate, using care not to pinch the heater wires between the socket plate and the mirror plate.
3. Slide the mirror plate down to engage the locking tabs. See **Fig. 2**.



A. Position the mirror plate against the structure plate.
B. Slide the mirror plate down.

Fig. 2, Mirror Plate Installation

4. Pull on the mirror to ensure that the plate is properly locked.
5. Remove the chocks from the tires.

Lang-Mekra West Coast

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

IMPORTANT: Do not use a screwdriver to pry the mirror plate loose. Doing so could damage the mirror.

2. Using a small flat-tip screwdriver, push in the locking tabs through the access slots along the mirror housing. Start by pushing in the tabs near

Main Mirror Plate Removal and Installation

a corner of the mirror, then continue around the mirror while pulling the mirror plate away from the housing. See Fig. 3.

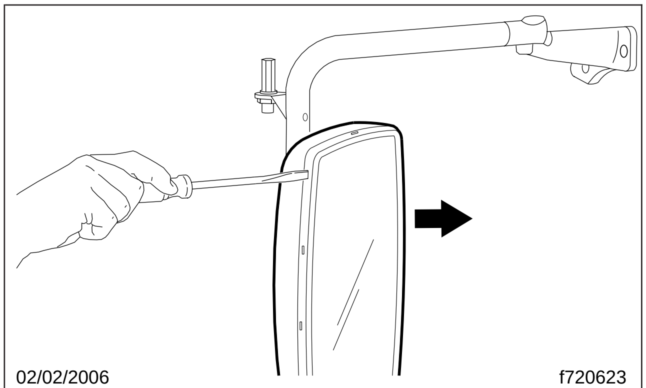


Fig. 3, Pushing in Locking Tabs Through Access Slots

3. While holding the mirror plate away from the housing, disconnect the mirror heater wires from the mirror plate.
4. Remove the mirror plate.

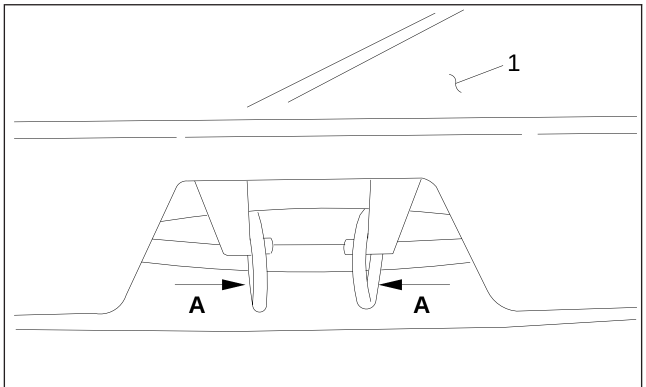
Installation

1. Connect the mirror heater wires to the mirror plate.
2. Position the mirror plate in the mirror housing, and check the alignment of the locking tabs. All tabs should be inside the housing.
3. Press the mirror plate firmly into the housing to lock the tabs.
4. Pull on the mirror to ensure that the plate is properly locked.
5. Remove the chocks from the tires.

Truck-Lite

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Manually adjust the mirror plate to the fully outboard position to allow access to the plastic retainer hooks.
3. Using your fingers or a pair of needlenose pliers, unlatch the wire loops from the plastic retainer hooks by squeezing the ends of the two loops together. See Fig. 4.



A. Pinch the wire loops until they are disengaged from the plastic retainer hooks.
1. Mirror Glass

Fig. 4, Mirror Plate Brackets

NOTE: It is only necessary to disengage the wire loops on one side of the mirror.

4. When disengaged, carefully lift the mirror plate from the actuator to expose the heater wires.
5. Slide the mirror plate connector off the mirror housing support tab, and disconnect it from the mirror wiring harness.
6. Remove the mirror plate from the mirror assembly.

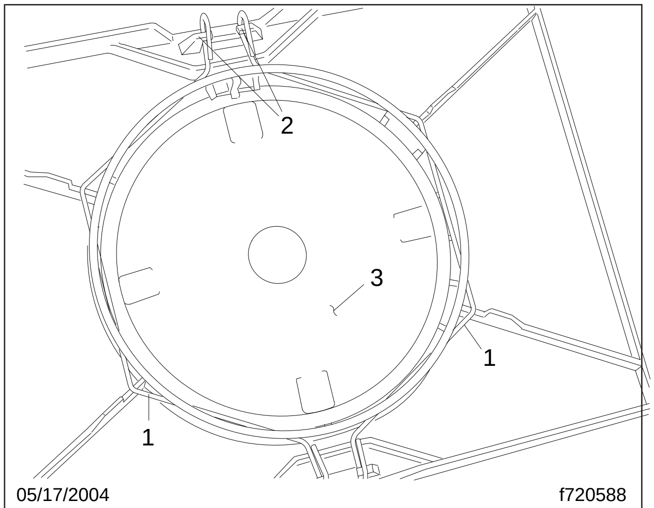
Installation

1. Install the wire loops on the back of the mirror plate. Engage the ends of the wire loops on the plastic retainer hooks. See Fig. 5.
2. Connect the mirror plate connector to the mirror wiring harness, and slide the connector onto the mirror housing support tab.

NOTE: Keep the wires free of the socket plate. Do not pinch the wires between the socket plate and the mirror plate.

3. Position the mirror plate over the actuator and press it securely in place.

Main Mirror Plate Removal and Installation



1. Wire Loops
2. Plastic Hooks
3. Actuator

Fig. 5, Wire Loop Installation

4. Actuate the glass in all directions, and gently pull on the outer edges to ensure proper assembly.
5. Remove the chocks from the tires.

Convex Mirror Plate Removal and Installation

This procedure applies to the following mirrors:

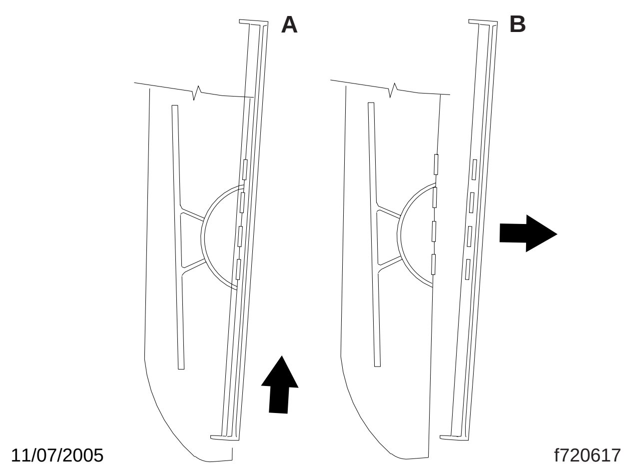
- Lang-Mekra Aero
- Lang-Mekra West Coast
- Truck-Lite

The procedure is different for each mirror. In order to remove the convex mirror plate on the Lang-Mekra Aero mirror, it is necessary to remove the main mirror plate first. On the Truck-Lite mirror, it is necessary to remove the back cover first.

Lang-Mekra Aero

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the main mirror plate. See **Subject 150** for instructions.
3. Slide the convex mirror plate up. See **Fig. 1**.



A. Slide the mirror plate up.
C. Pull the mirror plate out.

Fig. 1, Mirror Plate Removal

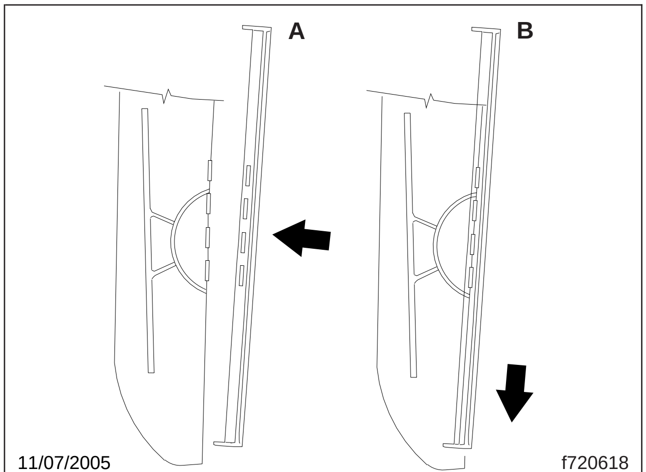
4. When the mirror plate is disengaged, carefully pull it out to expose the heater wires.

IMPORTANT: Do not pull or cut the wires when disconnecting them. Disconnect the wires by pulling on the wire terminal covers only. Connect the wires by pushing on the wire terminal covers only.

5. Disconnect the heater wires by pulling on the wire terminal covers.
6. Remove the mirror plate.

Installation

1. Attach the wire terminals to the back of the convex mirror plate.
2. Position the convex mirror plate against the structure plate, using care not to pinch the heater wires between the socket plate and the mirror plate.
3. Slide the convex mirror plate down to engage the locking tabs. See **Fig. 2**.



A. Position the mirror plate against the structure plate.
B. Slide the mirror plate down.

Fig. 2, Mirror Plate Installation

4. Pull on the mirror to ensure that the plate is properly locked.
5. Install the main mirror plate. See **Subject 150** for instructions.
6. Remove the chocks from the tires.

Convex Mirror Plate Removal and Installation

Lang-Mekra West Coast

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

IMPORTANT: Do not use a screwdriver to pry the mirror plate loose. Doing so could damage the mirror.

2. Using a small flat-tip screwdriver, push in the locking tabs through the access slots along the mirror housing, and pull the mirror plate away from the housing. See **Fig. 3**.

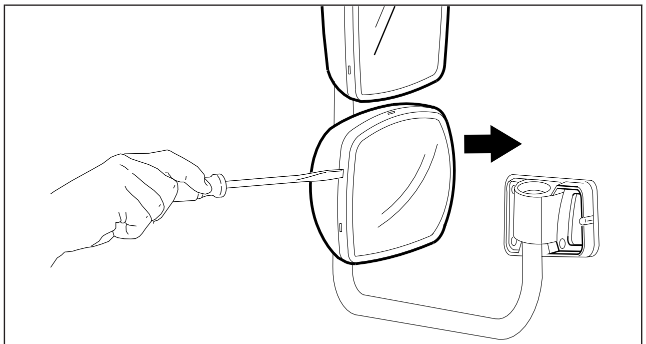


Fig. 3, Pushing in Locking Tabs Through Access Slots

3. While holding the mirror plate away from the housing, disconnect the mirror heater wires from the mirror plate.
4. Remove the mirror plate.

Installation

1. Connect the mirror heater wires to the mirror plate.
2. Position the mirror plate in the mirror housing, and check the alignment of the locking tabs. The tabs should be inside the housing.
3. Press the mirror plate firmly into the housing to lock the tabs.
4. Pull on the mirror to ensure that the plate is properly locked.
5. Remove the chocks from the tires.

Truck-Lite

Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the mirror back cover.
   - 2.1 Remove the two screw covers on the back of the mirror.
   - 2.2 Remove the two screws that attach the back cover to the mirror head.
   - 2.3 Pull the bottom of the cover away from the mirror head, and carefully lift the cover up over the antenna base.
3. Using a pair of needlenose pliers, pull and twist the white tab on the back of the convex mirror plate one quarter turn to align with the slot. See **Fig. 4**.

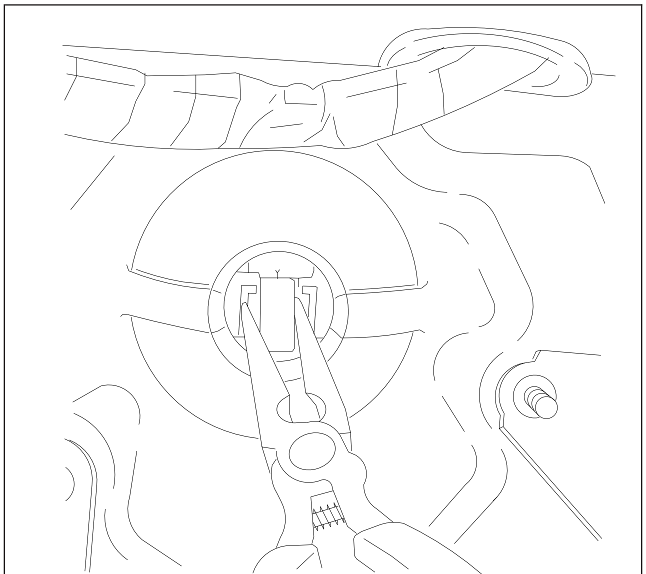


Fig. 4, Turning the White Tab to Align with the Slot

4. Disconnect the electrical connector from the mirror heater.
5. Remove the convex mirror plate from the mirror housing.

Installation

1. Connect the electrical connector to the mirror heater.
2. Position the convex mirror plate in the mirror housing. Twist the white tab on the back of the convex mirror one quarter turn until it locks.
3. Install the mirror back cover.
   3.1 Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.

   IMPORTANT: Ensure that the mirror back cover is properly seated in the mirror housing. The gap around the edge should be uniform, and the tabs at the top and bottom should seat securely in their respective grooves.

   3.2 Install the two screws that attach the cover to the mirror housing. Torque the screws 31 lbf·in (340 N·cm).

   3.3 Install the two screw covers.
4. Remove the chocks from the tires.

Mirror Actuator Replacement

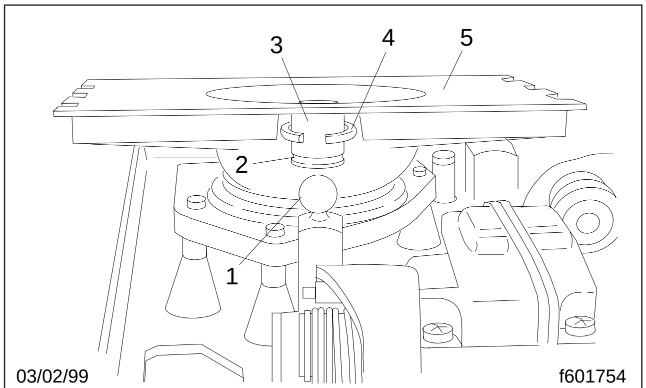
This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Lang-Mekra West Coast
- Truck-Lite

The procedure is different for each mirror.

Lang-Mekra Aero

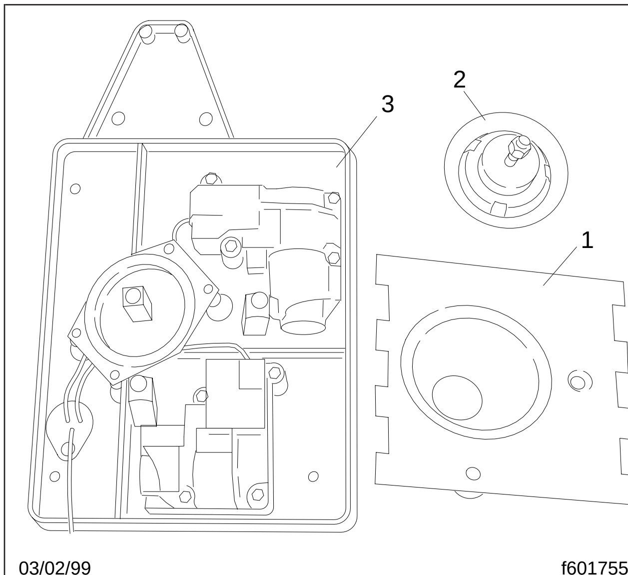
1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Disconnect the batteries.
3. Remove the main mirror plate. See **Subject 150** for instructions.
4. Disassemble the two ball-and-socket joints. See **Fig. 1**.
   4.1 On one of the split socket tubes, slide the split ring out of the retaining groove and away from the motor.
   4.2 Firmly press down on the opposite side of the socket plate to detach the ball-and-socket joint.
   4.3 Repeat the disassembly steps for the other ball-and-socket joint.



1. Ball
2. Retaining Groove
3. Split Socket Tube
4. Split Ring
5. Socket Plate

Fig. 1, Ball-and-Socket Joint

5. Remove the socket plate by removing the center pivot screw. See **Fig. 2**. Note the order of the center pivot components.



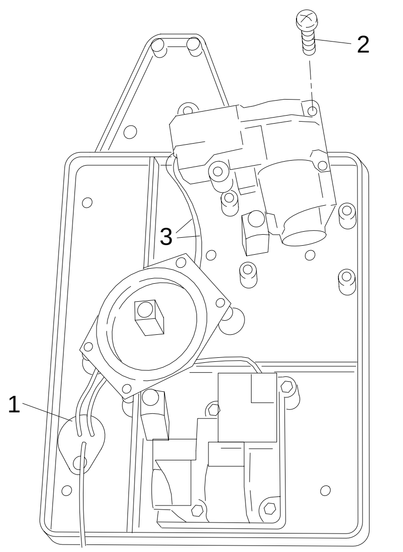
1. Socket Plate
2. Center Pivot Assembly
3. Structure Plate

Fig. 2, Socket Plate Assembly

IMPORTANT: Use care not to damage the socket flange connections when cutting the actuator wires.

6. Cut the two wires (Ref. 3 in **Fig. 3**) to the actuator, leaving at least 2-1/2 inches (60 mm) of wire for the socket.
7. Remove the four screws that attach the actuator to the structure plate. Remove the actuator. See **Fig. 3**.
8. Place the new actuator in position and attach it to the structure plate using the four screws. See **Fig. 3**. Tighten the screws 13 lbf·in (150 N·cm).
9. Connect the wires from the new actuator to the wires leading from the socket. Use butt splice connectors, or solder and shrink wrap.
10. Place the socket plate in position. Install the center pivot components and screw, in reverse order of removal. Tighten the screw 44 lbf·in (500 N·cm).
11. Assemble the two ball-and-socket joints. See **Fig. 1**.

Mirror Actuator Replacement



1. Socket Flange Connections
2. Actuator Screws
3. Actuator Wires

Fig. 3, Actuator Wiring Harness

11.1 Push the split ring up one of the split socket tubes, away from the motor assembly.

11.2 Actuate the motor towards the split socket tube.

11.3 Align the motor arm into the split socket tube.

11.4 Push firmly on the socket plate to snap the ball into the split socket tube.

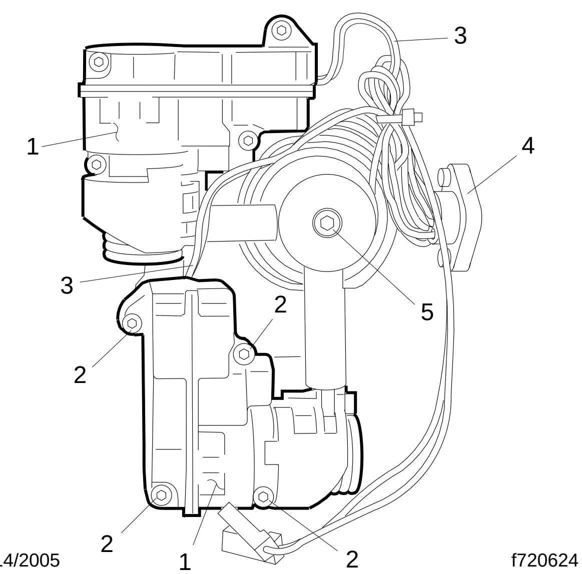
11.5 Slide the split ring into the retaining groove on the split socket tube.

11.6 Repeat the assembly steps for the other ball-and-socket joint.

12. Install the main mirror plate. See **Subject 150** for instructions.
13. Connect the batteries.
14. Remove the chocks from the tires.

Lang-Mekra West Coast

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Disconnect the batteries.
3. Remove the main mirror plate. See **Subject 150** for instructions.
4. Cut the two wires to the actuator, leaving at least 2-1/2 inches (60 mm) of wire for the socket.
5. Remove the four screws that attach the actuator to the mirror head. Remove the actuator. See **Fig. 4**.



1. Actuator
2. Retaining Screws
3. Actuator Wiring
4. Socket Flange
5. Center Pivot Screw

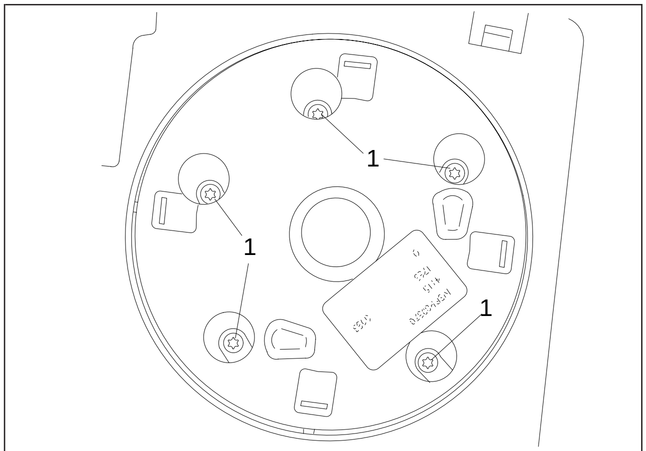
Fig. 4, Actuator Installation (Lang-Mekra West Coast)

6. Place the new actuator in position and attach it to the mirror head using the four screws. See **Fig. 4**. Tighten the screws 13 lbf·in (150 N·cm).
7. Connect the wires from the new actuator to the wires leading from the socket. Use butt splice connectors, or solder and shrink wrap.
8. Install the main mirror plate. See **Subject 150** for instructions.

9. Connect the batteries.
10. Remove the chocks from the tires.

Truck-Lite

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Disconnect the batteries.
3. Remove the main mirror plate. See **Subject 150** for instructions.
4. Remove the five Torx® screws that attach the actuator to the mirror housing. See **Fig. 5**.



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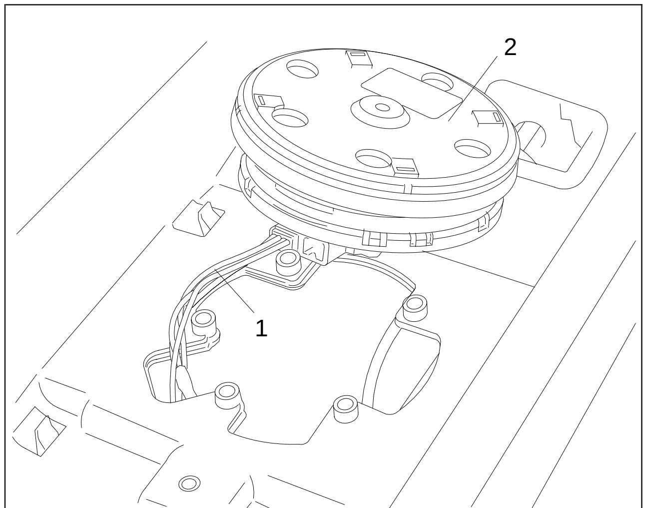
1. Torx Screws

Fig. 5, Actuator Retaining Screws

5. Lift the actuator out of the mirror housing and disconnect the electrical wires. See **Fig. 6**.

NOTE: The electrical connections are labeled A and B to prevent incorrect installation.

6. Connect the electrical wires to the new actuator. See **Fig. 6**.
7. Position the actuator in the mirror housing and install the five Torx screws. Tighten the screws 35 to 40 lbf·in (400 to 460 N·cm).
8. Install the main mirror plate. See **Subject 150** for instructions.
9. Connect the batteries.
10. Remove the chocks from the tires.



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1. Electrical Wires
2. Actuator

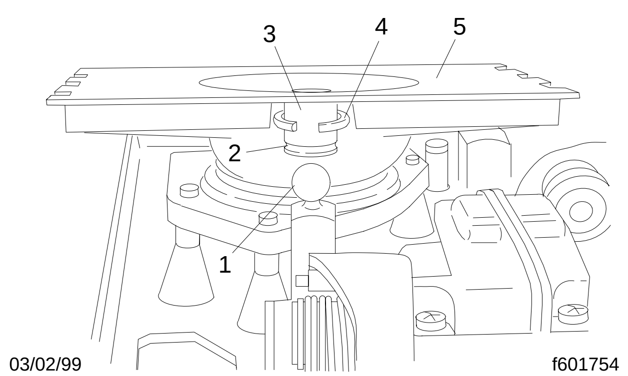
Fig. 6, Actuator Electrical Wires

This procedure applies to the following mirror only:

- Lang-Mekra Aero

Disassembly

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Disconnect the batteries.
3. Remove the main mirror plate. See **Subject 150** for instructions.
4. Slide the split ring out of the retaining groove and away from the motor. See **Fig. 1**.



1. Ball
2. Retaining Groove
3. Split Socket Tube
4. Split Ring
5. Socket Plate

Fig. 1, Ball-and-Socket Joint

5. Firmly press down on the opposite side of the socket plate to disengage the ball-and-socket joint.

Assembly

1. Push the split ring up the split socket tube, away from the motor assembly. See **Fig. 1**.
2. Actuate the motor towards the split socket tube.
3. Align the motor arm into the split socket tube.
4. Push firmly on the socket plate to snap the ball into the split socket tube.
5. Slide the split ring into the retaining groove on the split socket tube.
6. Install the main mirror plate. See **Subject 150** for instructions.
7. Connect the batteries.
8. Remove the chocks from the tires.

Structure Plate Assembly Replacement

This procedure applies to the following mirror only:

- Lang-Mekra Aero

Replacement

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the mirror head assembly from the support loop. See **Subject 130** for instructions.
3. Remove the applicable mirror plate from the mirror housing. See **Subject 150** for instructions.
4. If replacing the main mirror structure plate assembly, remove the CB antenna mount from the structure plate.
5. Disconnect the electrical wiring from the structure plate.
6. Remove the screws that attach the structure plate to the mirror housing. See **Fig. 1**.

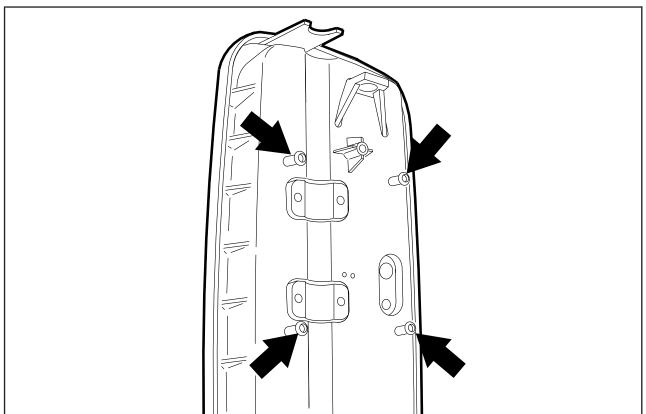
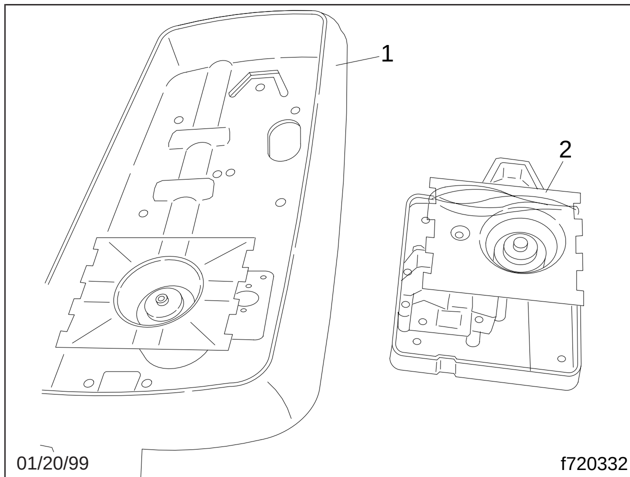


Fig. 1, Main Mirror Structure Plate Screws

7. Remove the structure plate from the mirror housing. See **Fig. 2**.
8. Position the new structure plate in the mirror housing.
9. Install the screws that attach the structure plate to the mirror housing. See **Fig. 1**.
10. Connect the electrical wiring to the structure plate.



1. Mirror Housing
2. Main Mirror Structure Plate Assembly

Fig. 2, Mirror Housing with Main Mirror Structure Plate Removed

11. Install the CB antenna mount on the main mirror structure plate, if applicable.
12. Install the mirror plate in the mirror housing. See **Subject 150** for instructions.
13. Attach the mirror head to the support loop. See **Subject 130** for instructions.
14. Remove the chocks from the tires.

Mirror Housing Replacement

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Lang-Mekra West Coast
- Truck-Lite

The procedure is different for each mirror.

Lang-Mekra Aero

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the mirror head assembly from the support loop. See **Subject 130** for instructions.
3. Remove the main mirror plate from the mirror housing. See **Subject 150** for instructions.
4. Remove the convex mirror plate from the mirror housing. See **Subject 160** for instructions.
5. Remove the CB antenna mount from the main mirror structure plate.
6. Disconnect the electrical connections from the main and convex mirror structure plates.
7. Remove the screws that attach the main mirror structure plate to the mirror housing. See **Fig. 1**. Remove the main mirror structure plate from the mirror housing.

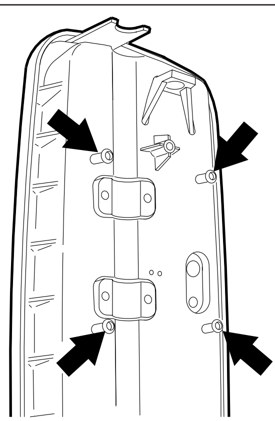


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Fig. 1, Main Mirror Structure Plate Screws

8. Remove the screws that attach the convex mirror structure plate to the mirror housing. Remove the convex mirror structure plate from the mirror housing.
9. Position the convex mirror structure plate in the new mirror housing.
10. Install the screws that attach the convex mirror structure plate to the mirror housing.
11. Position the main mirror structure plate in the new mirror housing.
12. Install the screws that attach the main mirror structure plate to the mirror housing. See **Fig. 1**.
13. Connect the electrical connections to both structure plates.
14. Install the CB antenna mount on the main mirror structure plate.
15. Install the convex mirror plate in the mirror housing. See **Subject 160** for instructions.
16. Install the main mirror plate in the mirror housing. See **Subject 150** for instructions.
17. Attach the mirror head to the support loop. See **Subject 130** for instructions.
18. Remove the chocks from the tires.

Lang-Mekra West Coast

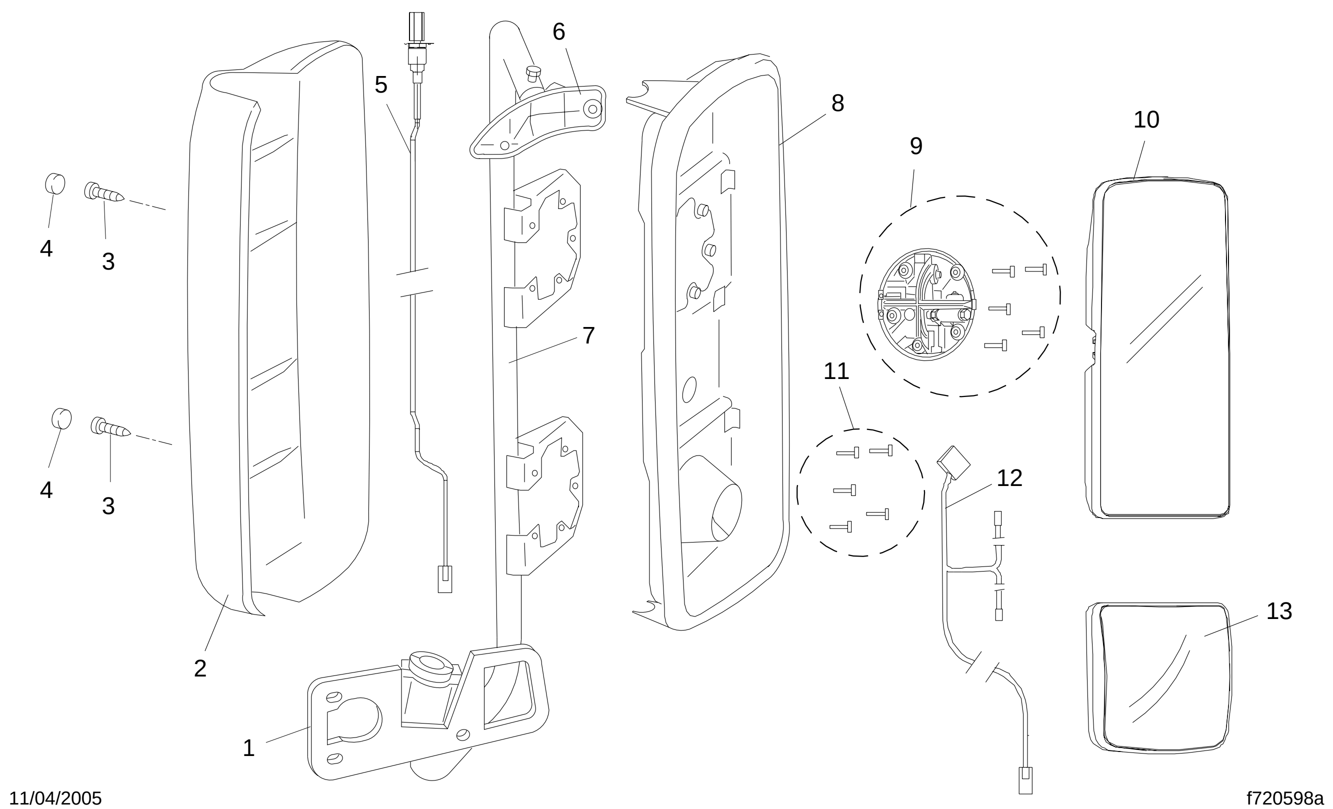
1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the mirror head assembly from the support loop. See **Subject 130** for instructions.
3. Remove the actuators from the mirror housing. See **Subject 170** for instructions.
4. Install the actuators in the new mirror housing. See **Subject 170** for instructions.
5. Install the mirror head assembly on the support loop. See **Subject 130** for instructions.

Truck-Lite

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.

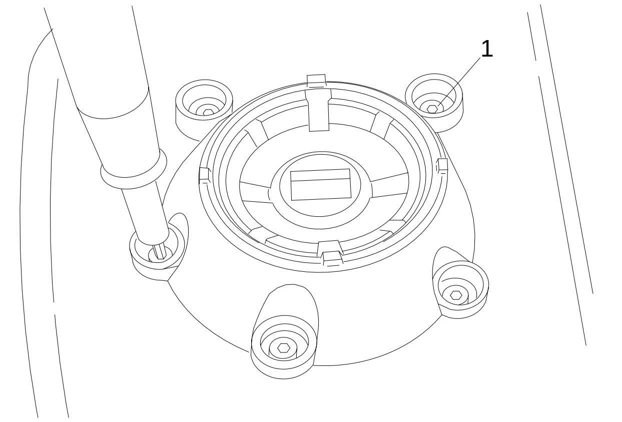
Mirror Housing Replacement

2. Remove the CB antenna from the mirror head, using a wrench to keep the antenna base from loosening.
3. Remove the mirror back cover. See **Fig. 2**.
    3.1 Remove the two screw covers on the back of the mirror.
    3.2 Remove the two screws that attach the back cover to the mirror head.
    3.3 Pull the bottom of the cover away from the mirror head, and carefully lift the cover up over the antenna base.
4. Remove the main mirror plate from the mirror housing. See **Subject 150** for instructions.
5. Remove the convex mirror plate from the mirror housing. See **Subject 160** for instructions.
6. Remove the actuator assembly from the mirror head. See **Subject 170** for instructions.
7. Remove the five screws that attach the convex glass pivot assembly to the support loop. See **Fig. 3**. Remove the mirror housing from the support loop.
8. Position the new mirror housing on the support loop.
9. Attach the convex glass pivot assembly to the support loop with the five screws. See **Fig. 3**.



1. Lower Mounting Bracket
2. Back Cover
3. Screw
4. Screw Cover Cap
5. CB Coax Assembly
6. Upper Mounting Bracket
7. Support Loop
8. Mirror Housing
9. Actuator Assembly
10. Flat Mirror
11. Pivot Assembly Screws
12. Heater Wiring Harness
13. Convex Mirror

Fig. 2, Truck-Lite Mirror Assembly



1. Pivot Assembly Mounting Screw

Fig. 3, Convex Glass Pivot Assembly

10. Install the actuator assembly. See **Subject 170** for instructions.
11. Install the convex mirror plate. See **Subject 160** for instructions.
12. Install the main mirror plate. See **Subject 150** for instructions.
13. Install the mirror back cover.

    13.1 Position the top of the cover over the antenna base, and push the bottom of the cover into place against the mirror head.

    IMPORTANT: Ensure that the mirror back cover is properly seated in the mirror housing. The gap around the edge should be uniform, and the tabs at the top and bottom should seat securely in their respective grooves.

    13.2 Install the two screws that attach the cover to the mirror head. Torque the screws 31 lbf·ft (340 N·m).

    13.3 Install the two screw covers.
14. Install the CB antenna on the mirror head assembly. Tighten the antenna hexnut 85 lbf·in (960 N·cm).
15. Remove the chocks from the tires.

Upper Pivot-Point Fastener Kit Replacement

This procedure applies to the following mirrors:

- Lang-Mekra Aero
- Lang-Mekra West Coast

NOTE: The upper pivot-point fastener kit is not serviceable on Truck-Lite mirrors.

Replacement

CAUTION

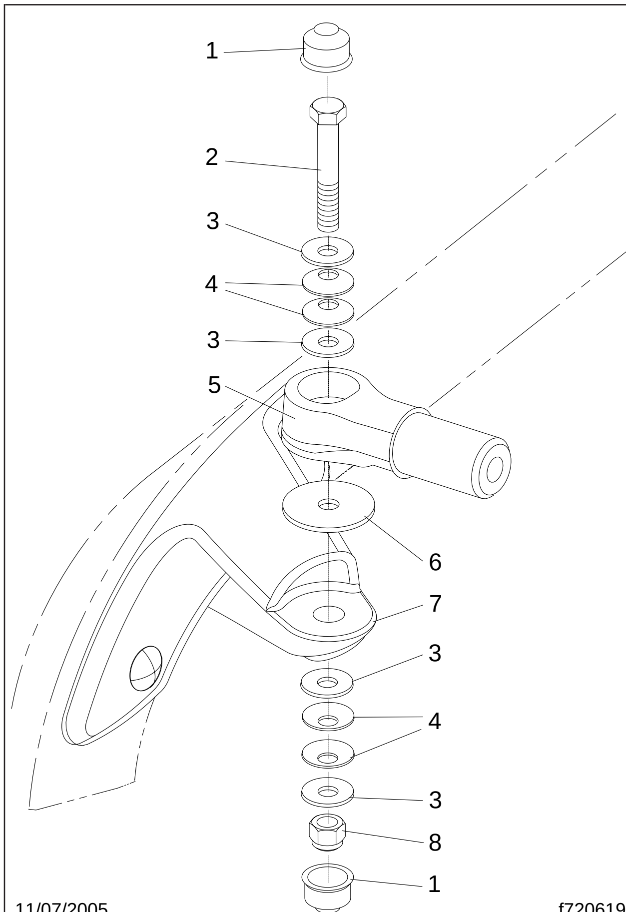
If any fasteners in the kit are over-torqued, the entire fastener kit must be replaced.

1. Remove the two protective fastener caps from the nut and bolt. See **Fig. 1**.
2. Remove the nut and bolt from the upper mounting bracket. If reinstalling the fasteners, note the order of the washers.
3. Lightly grease both sides of the brass disk.

CAUTION

When assembling the fastener kit, make sure that all components are installed in the correct order, and that the Belleville washers are oriented with the concave sides facing the upper mounting bracket and support loop. Incorrect installation may damage the fastener kit and cause the support loop pivot to bind or move too easily.

4. Place the brass disk between the upper mounting bracket and the upper arm of the support loop. See **Fig. 1**.
5. Insert the bolt through, in this order, a steel washer, two Belleville washers with concave sides towards the end of the bolt, and a permaglide steel washer with the lubricated side towards the end of the bolt.
6. Insert the assembled bolt and washers through the support loop, the brass disk, and the upper mounting bracket.
7. Install, in this order, a permaglide washer with the lubricated side towards the upper support bracket, two Belleville washers with the concave sides towards the upper support bracket, and a steel washer on the bolt.



1. Protective Cap
2. Hexbolt
3. Steel Washer
4. Belleville Washers
5. Support Loop
6. Brass Disk
7. Upper Mounting Bracket
8. Locknut

Fig. 1, Fastener Kit Installation

8. Install the locknut on the bolt. Torque the nut 31 to 35 lbf·ft (42 to 48 N·m).
9. Install the two protective caps on the nut and bolt.

Troubleshooting Tables

Problem—Mirror Support Loop Does Not Fold Back

Problem—Mirror Support Loop Does Not Fold Back	
Possible Cause	**Remedy**
An incorrect adjustment of the upper mirror-pivot bolt.	Adjust the upper mirror-pivot bolt. See **Subject 110** for instructions.

Problem—Mirror Support Loop Folds Back Too Easily or Vibrates

Problem—Mirror Support Loop Folds Back Too Easily or Vibrates	
Possible Cause	**Remedy**
The upper mirror-pivot bolt is loose.	Adjust the upper mirror-pivot bolt. See **Subject 110** for instructions.
The upper mirror-pivot bolt has been over-torqued (Lang-Mekra).	Replace the upper mirror-pivot bolt, bushing, and hexnut. See **Subject 210** for instructions.
The attachments to the door are loose.	Secure the brackets to the door. See **Subject 100** for instructions.

Problem—Remote-Controlled Mirror Will Not Adjust

Problem—Remote-Controlled Mirror Will Not Adjust	
Possible Cause	**Remedy**
Loose or damaged cables.	Connect any loose cables. Check all cables for damage and replace as needed.
Detached ball and socket joint (Lang-Mekra Aero).	Push the split ring up the split socket tube, away from the actuator. Direct the actuator towards the split socket tube, then align the actuator arm into the tube. Push firmly on the socket plate to snap the ball into the split socket tube. Slide the split ring back into the retaining groove. See **Subject 180** for instructions.
Broken rivet or socket at ball and socket joint (Lang-Mekra Aero).	Replace the socket plate. See **Subject 180** for instructions.
Broken actuator arm (Lang-Mekra Aero).	Replace the failed actuator. See **Subject 170** for instructions.
Faulty control cable (Lang-Mekra Aero).	Replace the control cable. See **Subject 130** for instructions.
Failed actuator.	Replace the failed actuator. See **Subject 170** for instructions.
No continuity from socket flange (Lang-Mekra Aero).	Replace the structure plate assembly, including the actuators. See **Subject 190** for instructions.
No continuity from socket flange (Lang-Mekra West Coast).	Replace the actuator(s) or the mirror housing. Check the actuators for function. Cut the wires to the appropriate actuator 2-1/2 inches (60 mm) from the socket flange. See **Subject 170** for details. Attach the actuator to a power source. If the actuator does not function, replace it. If the actuators function, the socket flange is faulty. Replace the mirror housing. See **Subject 200** for instructions.

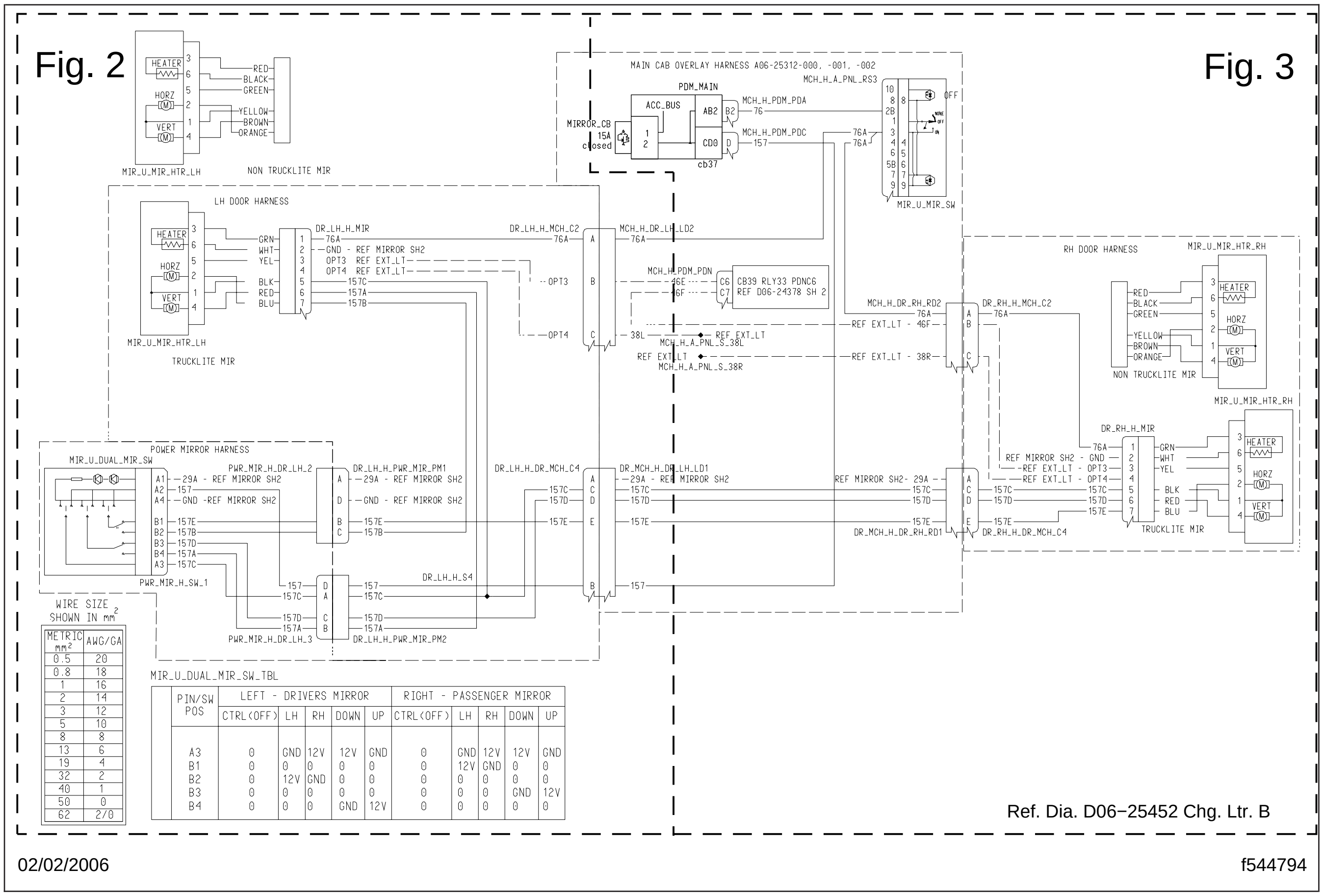
Troubleshooting

Problem—Mirror Plate Will Not Heat

Problem—Mirror Plate Will Not Heat	
Possible Cause	**Remedy**
Loose or damaged cables.	Connect any loose cables. Check all cables for damage and replace as needed.
Detached heater wires.	Attach the heater wires. See **Subject 150** (main mirror), or **Subject 160** (convex mirror) for instructions.
Loose or damaged heater spades.	Replace the mirror plate assembly. See **Subject 150** (main mirror), or **Subject 160** (convex mirror) for instructions.
Faulty control cable.	Replace the control cable. See **Subject 130** for instructions.
Faulty glass plate assembly.	Replace the mirror plate assembly. See **Subject 150** (main mirror), or **Subject 160** (convex mirror) for instructions.
No continuity from socket flange (Lang-Mekra Aero).	Replace the structure plate assembly. See **Subject 190** for instructions.
No continuity from socket flange (Lang-Mekra West Coast).	Replace the actuator(s) or the mirror housing. Check the actuators for function. Cut the wires to the appropriate actuator 2-1/2 inches (60 mm) from the socket flange. See **Subject 170** for details. Attach the actuator to a power source. If the actuator does not function, replace it. If the actuators function, the socket flange is faulty. Replace the mirror housing. See **Subject 200** for instructions.

Specifications

See **Fig. 1**, **Fig. 2**, and **Fig. 3** for the wiring diagram for a motorized and/or heated mirror.

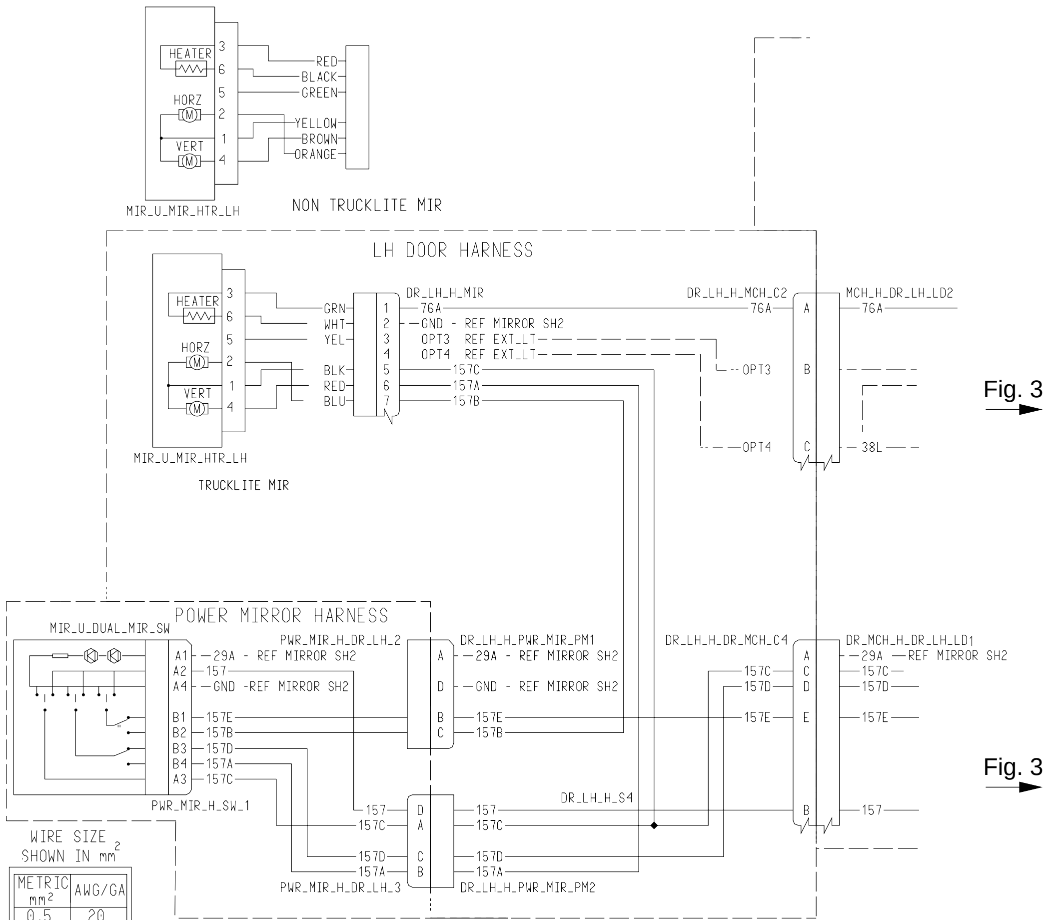


METRIC mm²	AWG/GA
0.5	20
0.8	18
1	16
2	14
3	12
5	10
8	8
13	6
19	4
32	2
40	1
50	0
62	2/0

PIN/SW POS	LEFT - DRIVERS MIRROR					RIGHT - PASSENGER MIRROR				
	CTRL(OFF)	LH	RH	DOWN	UP	CTRL(OFF)	LH	RH	DOWN	UP
A3	0	GND	12V	12V	GND	0	GND	12V	12V	GND
B1	0	0	0	0	0	0	12V	GND	0	0
B2	0	12V	GND	0	0	0	0	0	0	0
B3	0	0	0	0	0	0	0	0	GND	12V
B4	0	0	0	GND	12V	0	0	0	0	0

Fig. 1, Mirror Wiring Diagram

Specifications



WIRE SIZE SHOWN IN mm²

METRIC mm²	AWG/GA
0.5	20
0.8	18
1	16
2	14
3	12
5	10
8	8
13	6
19	4
32	2
40	1
50	0
62	2/0

MIR_U_DUAL_MIR_SW_TBL

PIN/SW POS	LEFT - DRIVERS MIRROR					RIGHT - PASSENGER MIRROR				
	CTRL(OFF)	LH	RH	DOWN	UP	CTRL(OFF)	LH	RH	DOWN	UP
A3	0	GND	12V	12V	GND	0	GND	12V	12V	GND
B1	0	0	0	0	0	0	12V	GND	0	0
B2	0	12V	GND	0	0	0	0	0	0	0
B3	0	0	0	0	0	0	0	0	GND	12V
B4	0	0	0	GND	12V	0	0	0	0	0

Ref. Dia. D06−25452 Chg. Ltr. B

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Fig. 2, Mirror Wiring Diagram (detailed view)

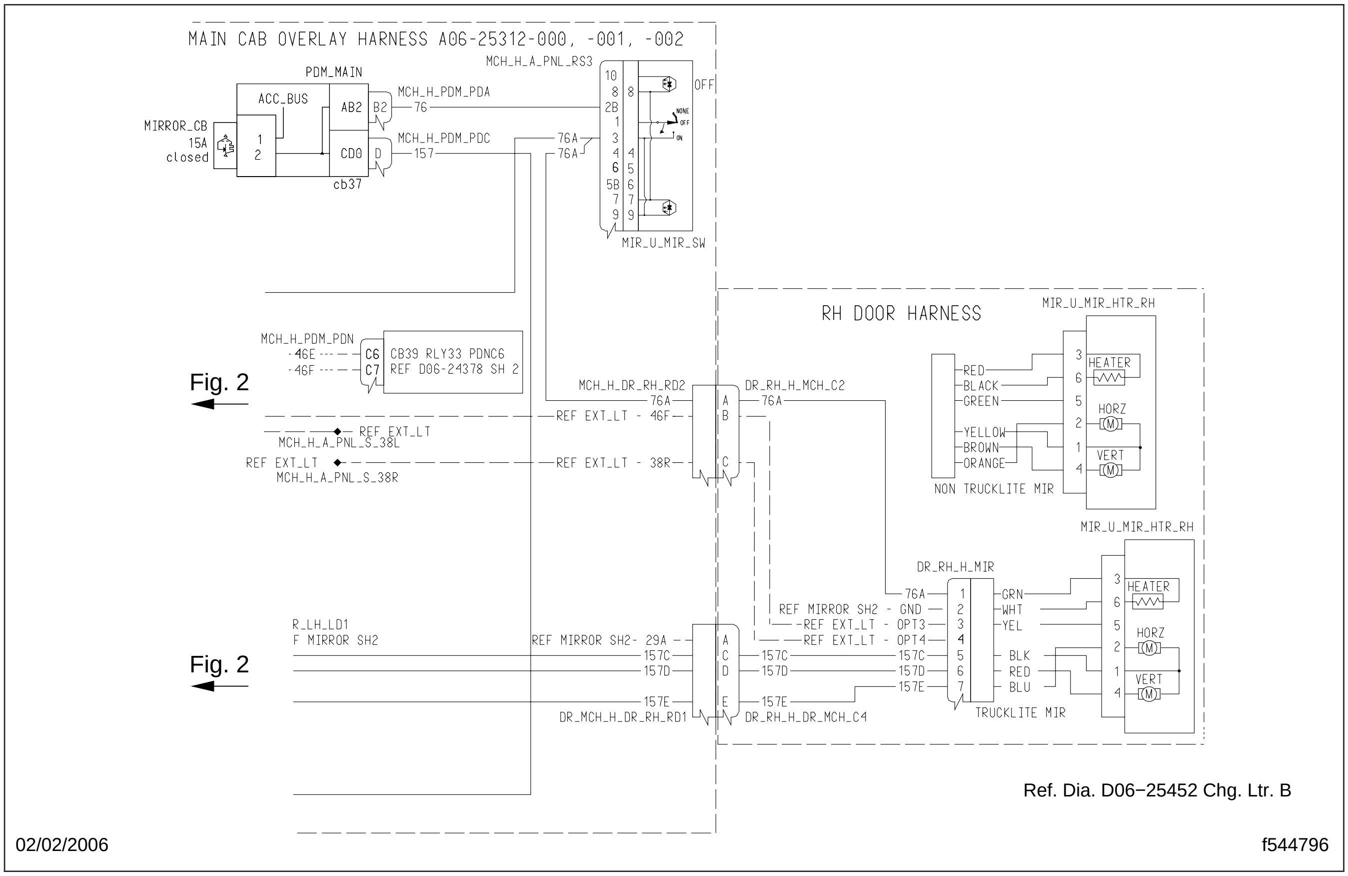


Fig. 3, Mirror Wiring Diagram (detailed view)

General Information

The aluminum cab is a semi-monocoque design, which means that the outer skin panels are load-bearing as is the internal framework. This type of construction requires less framework than standard cab construction, and results in a very strong, yet lightweight cab. See **Fig. 1**.

There are three basic cab configurations: non-sleeper cab, mid-roof SleeperCab, and raised-roof SleeperCab. Non-sleeper cabs are 48-inch lengths. The mid-roof SleeperCabs are 48-inch, 58-inch, or 70-inch lengths. Raised-roof SleeperCabs are 58-inch or 70-inch lengths.

The major cab parts are the front-wall assembly, right and left door-frame assemblies, right and left side-wall assemblies, back-wall assembly, front and rear roof cap assemblies (for mid-roof SleeperCabs), and the cab deck assembly. See **Fig. 2**. Non-sleeper cabs have one roof-cap assembly. Raised-roof SleeperCabs have one SMC fiberglass roof assembly.

The side-wall skins are bonded to the frame instead of riveted. The roof cap assemblies are attached to the cab side walls and the back wall by means of a coach joint. The coach joint is held together with 5/16–18 Torx®-head screws. Foam sealant tape is installed between the roof caps and the side walls and back wall.

The cab deck consists of a framework of longitudinal sills and transverse crossmembers, with forward and rear deck plates fastened to them. Non-SleeperCabs have one deck plate.

The cab front-wall assembly is a complete unit attached to the front of the door frame assemblies. It can be replaced as an entire unit, or in parts.

The cab parts are held together with a variety of fasteners. See **Subject 100** for more information on cab fasteners.

When any repairs are done to the cab, it is necessary to check the frame rails for correct alignment and squaring. Then the cab must be leveled and squared. If the cab is repaired without straightening the frame rails, undue stress could be put on the cab, which could weaken it. Also, it may be impossible to square up the cab.

General Information

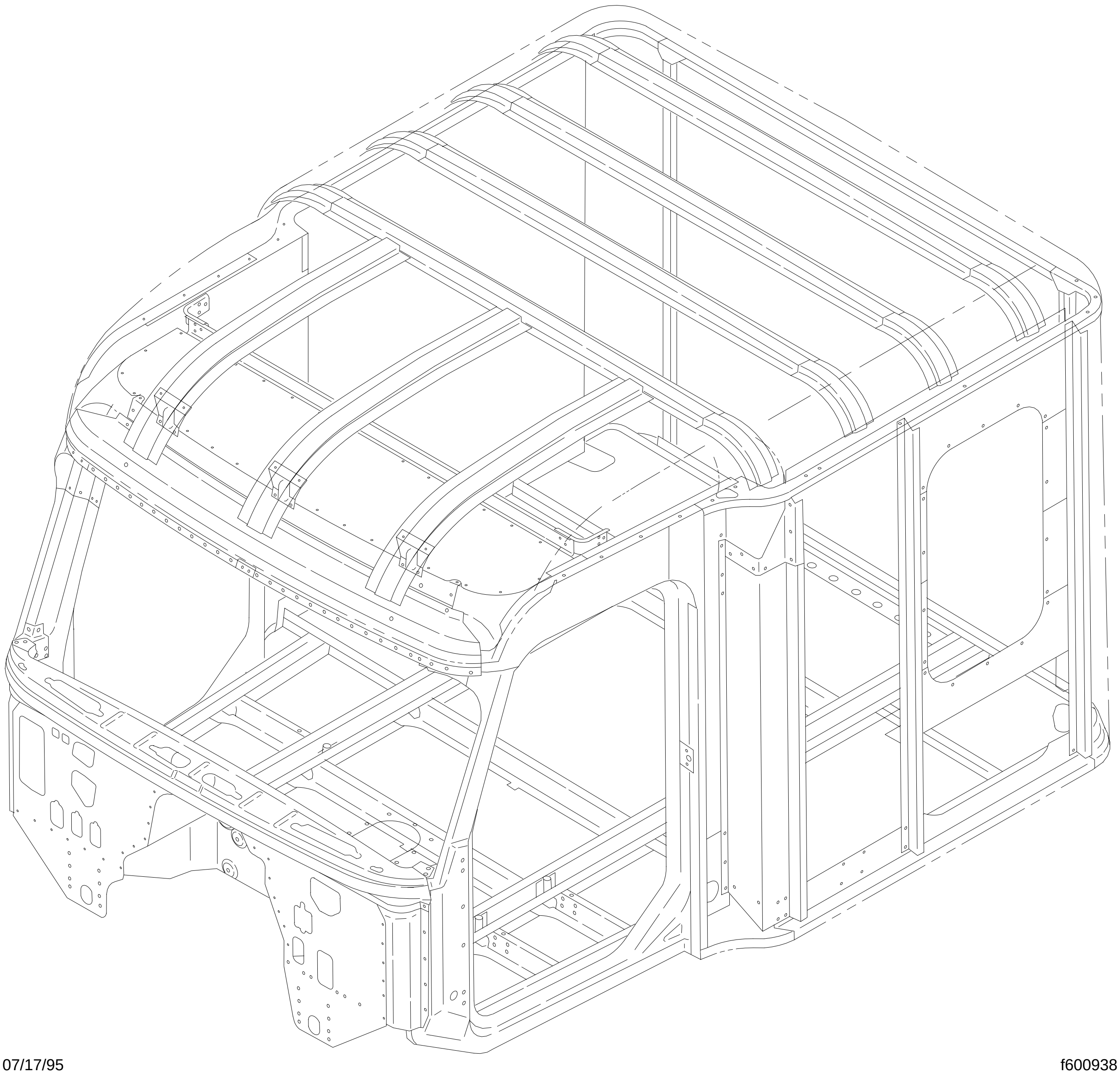
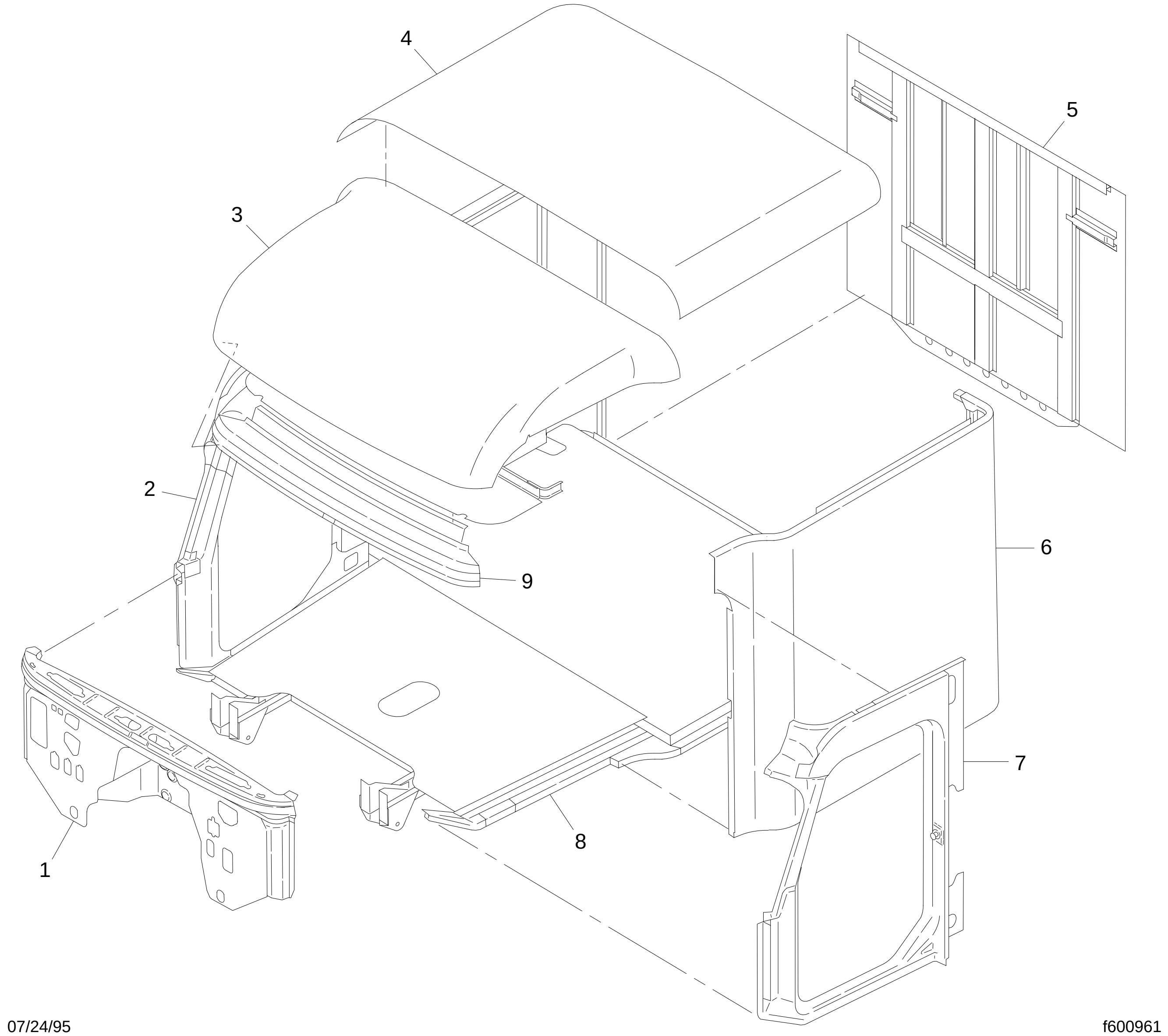


Fig. 1, Cab Structure (48-inch SleeperCab shown)

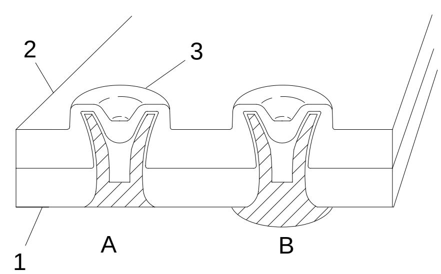


1. Front-wall Assembly
2. Right Door Frame Assembly
3. Front Roof-Cap Assembly
4. Rear Roof-Cap Assembly
5. Back-Wall Assembly
6. Left Side-Wall Assembly
7. Left Door Frame Assembly
8. Cab Deck Assembly
9. Windshield Header Assembly

Fig. 2, Major Cab Parts, Typical 48-Inch SleeperCab

General Information

Different types of fasteners are used to hold the cab together. In addition to Huck® bolts and blind rivets, steel Henrob® rivets are used extensively. These differ from other fasteners, in that they are installed without drilling holes in the material. Specialized equipment punches them directly through the metal, then extrudes a bulb on the opposite metal surface. No bucking bar is used. Henrob rivets have hollow shanks, and either brazier or countersunk heads. See **Fig. 1.** They are replaced with either Huck fasteners, aluminum bucked rivets, or blind rivets, such as Magnabulb® or Monobolt® fasteners.



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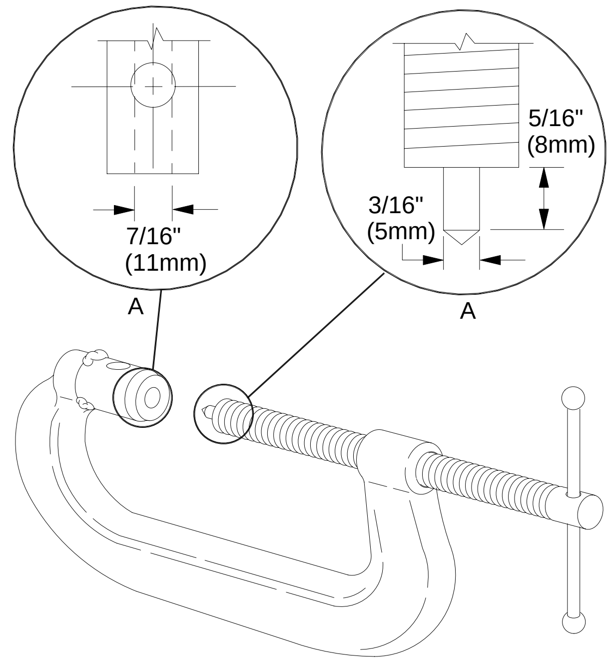
A. Countersunk Head
B. Brazier Head
1. Outer Skin
3. Extruded Bulb
2. Inner Skin

Fig. 1, Henrob Rivet Types

Remove Huck fasteners by chiseling off the collars. Remove a blind rivet by either grinding off the head, then punching out the center, or by drilling out the center, and then removing the fastener.

Remove Henrob rivets by drilling them out or pushing them out. To drill them out, use a 3/16-inch cobalt drill on low speed. When you have drilled completely through the material, remove the rivet head using a cold chisel or a punch. To push out Henrob rivets, a special tool can be made from a C-clamp. See **Fig. 2.** Grind down the extruded bulb on the back surface of the metal until it is flush. Put the special C-clamp, with the cylinder end over the head of the rivet, then line up the peg on the other end of the C-clamp with the depresssion of the shank. Tighten the C-clamp until the Henrob rivet is pushed out the front surface, and into the C-clamp cylinder.



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A. Top View

Fig. 2, C-Clamp Specially Adapted for Removing Henrob Rivets

Leveling and Squaring the Cab

IMPORTANT: Before any repairs can be made to a damaged cab, the vehicle frame rails must be level and squared. If this is not done, the cab sections will not fit together correctly. Level the frame rails using jackstands. For instructions on squaring the frame rails, see the applicable section in **Group 31**.

There are several methods for correctly squaring the cab. This subject will cover only one technique, using a specially made squaring tool. The tool can be used for measuring squareness, and can be lengthened or shortened to bring the cab parts into correct alignment. The measurements given in this procedure are also applicable for any other method of cab squaring. All measurements are to be taken from inside the cab, and with all the interior contents, and the roof cap(s) and doors removed.

1. With the cab empty, and using a 4- to 5-foot (122 to 152 cm) long straight-edge of suitable material, make sure the cab deck is level.

    1.1 Place the straight-edge cross-wise on the cab deck at the front of the cab, then the middle, then at the rear. At each place, check that the deck plates are parallel and flush with the straight-edge.

    1.2 Place the straight-edge lengthwise on the cab deck on the right side, the middle, then the left side. At each place, check that the deck plates are parallel and flush with the straight-edge.

    1.3 If the cab deck surface is not flush and parallel with the straight-edge everywhere, level the deck, using jackstands or a suitable fixture.

NOTE: The following procedure for squaring the cab involves using a special squaring tool that can be fabricated from suitable metal stock. See **Specifications, 400** for the configuration and measurements of this tool.

2. Measure the cab for squareness, starting at the front, and moving to the rear. See **Fig. 1**. Each measurement is diagonal, and taken from both the left and right sides of the cab, in an "X" configuration. For example, if you measure from the top right side to the bottom left side of the cab, you then need to take the identical measurement from the top left side to the bottom right side of the cab.

    Install a door plug into each door frame before beginning the squaring procedure. See **Specifications, 400** for measurements and materials needed to construct the door plugs.

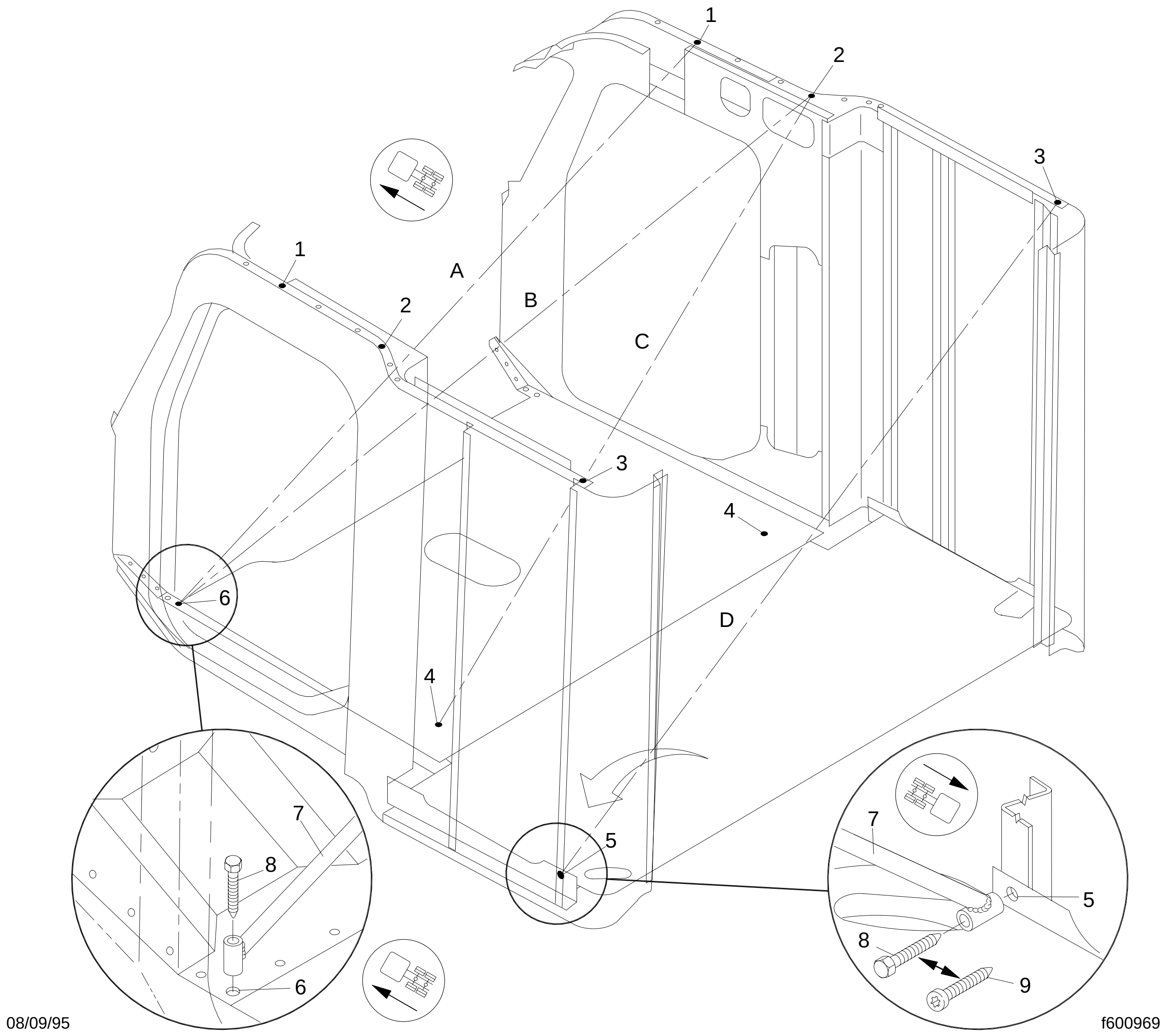
    2.1 Find the outboard, forward clinch-nut hole on the left-side cab deck (Ref. 6). Remove the fastener (if present) from the hole. (The clinch nut itself is underneath the cab deck). Install the lower end of the squaring tool into the hole, using a 5/16–18 hexbolt or screw. Then, on the right side-wall top flange, find the second fastener hole from the front (Ref. 1). Install the top end of the squaring tool into the hole, using a 5/16–18 hexbolt or screw and hexnut. Use the turnbuckle on the tool to lengthen or shorten the tool as needed. Measure the distance between the two holes (Ref. A). It should be 97-5/16 inches (2488 mm). If it is not, shorten or lengthen the squaring tool as needed, to push or pull the side walls into alignment.

    Repeat the procedure on the other side of the cab, measuring from the right-side cab deck to the left-side top of the side wall.

    2.2 On the right side-wall top flange, find the first fastener hole (Ref. 2) at the start of the sleeper transition bracket. For a non-SleeperCab, find the last hole in the side wall top flange before the corner radius. Install the top end of the squaring tool into the hole, using a 5/16–18 hexbolt or screw and hexnut. Install the other end of the squaring tool into the outboard, most forward clinch nut hole on the right side of the cab deck (Ref. 6). Measure the distance between the two holes (Ref. B). It should be 104-7/16 inches (2653 mm). If it is not, lengthen or shorten the squaring tool as needed.

    Repeat the procedure on the other side of the cab, measuring from the right-side cab deck to the left-side top of the side wall.

Leveling and Squaring the Cab



A. 97-5/16 inches (2488 mm)
B. 104-7/16 inches (2653 mm)
C. 94-5/16 inches (2396 mm)
D. 108-3/16 inches (2748 mm)

1. Outboard, Most Forward Clinch-Nut Hole
2. First Fastener Hole at the Beginning of the Sleeper Transition Bracket
3. Rearmost Fastener Hole in Side-Wall Top Flange
4. Outboard Seat Belt Anchor Hole
5. Bottom Clinch-Nut Hole on Rearmost Z-Strip
6. Outboard Forward Clinch-Nut Hole
7. Squaring Tool
8. 5/16–18 Hexbolt
9. 5/16–18 Torx-Head Screw

Fig. 1, Squaring Measurements and Location Holes, Front and Back Walls Not Shown

2.3 Find the same fastener hole (Ref. 2) in the side-wall top flange that was used in the previous substep, and install the top end of the squaring tool into it. Install the other end of the squaring tool into the threaded hole on the cab deck that is used to anchor the right outboard seat belt (Ref. 4). Measure the distance between the two holes (Ref. C). It should be 94-5/16 inches (2396 mm). If it’s not, lengthen or shorten the tool as needed.

Repeat the procedure on the other side of the cab, measuring from the right-side cab deck to the left-side top of the side wall.

For a non-SleeperCab, the procedure is complete. If the cab is a SleeperCab, go to the next substep.

2.4 For a SleeperCab, find the bottom clinch nut hole on the last Z-strip before the corner of the right side wall (Ref.5). Install the bottom end of the squaring tool, using a 5/16–18 hexbolt or screw. Then find the rearmost fastener hole on the left side-wall top flange (Ref. 3). Install the top end of the special squaring tool, using a 5/16–18 hexbolt or screw, and hexnut to hold the tool in the upper hole. Measure the distance between the two holes (Ref. D). It should be 108-3/16 inches (2748 mm). Lengthen or shorten the squaring tool as needed.

Repeat the procedure on the other side of the cab, measuring from the bottom of the left side wall to the top of the right side wall.

Side-Wall Assembly Replacement

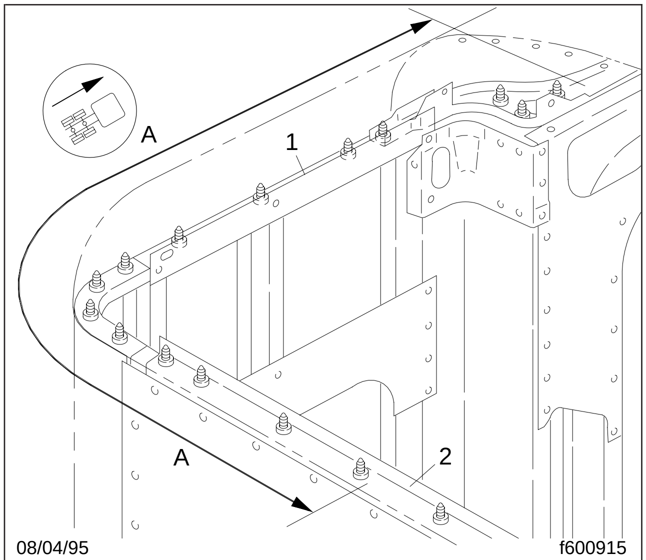
Removal

CAUTION

Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

IMPORTANT: Prior to any work being performed on the sidewall assembly, the vehicle must be prepared. See the applicable groups and sections in this manual for instructions.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Level the chassis, using jack stands.
3. Remove the seats, the bunk(s), the upholstery panels, the cabinets, the floor mats, and the carpeting from the cab interior. If so equipped, remove the auxiliary HVAC unit.
4. Move the wiring harness and all wiring located in or near the sidewall assembly out of the way.
5. Remove the door from the affected side of the vehicle. See **Group 72** for instructions.
6. Cover the remaining interior components of the cab to protect them during the replacement work.
7. Install a door plug in the open door frame. See **Specifications, 400** for the measurements and materials needed to construct door plugs.
8. Remove the brackets attaching the sun visor to the side of the cab above the door frame.
9. Remove the eight Torx®-head screws that attach the side extender and extender brackets to the rear wall assembly. Remove the side extender.
10. From inside the cab, remove the Torx-head screws holding the roof cap assembly to the upper edge of the damaged sidewall. Remove the screws from along the sidewall, around the rear wall, and as far forward on the opposite sidewall as the door frame. See **Fig. 1**.
11. Raise and block up the rear roof cap enough to allow removal of the monobolts at the top of the roof transition bracket.
12. Remove the fasteners attaching the upper B-pillar to the upper B-pillar reinforcement assembly.
13. Remove the fasteners that attach the upper and lower assembly to the sidewall. See **Fig. 2**. There is no need to remove the fasteners that attach the door plates to the door frame assembly.

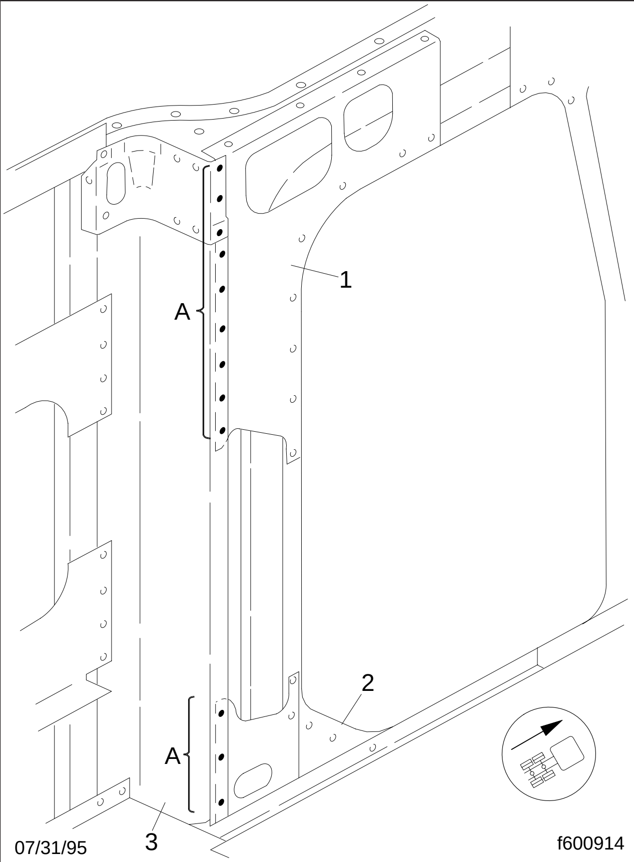


A. Remove all of these Torx-head screws.
1. Sidewall Assembly
2. Rear Wall Assembly

Fig. 1, Rear Roof Cap Fasteners, SleeperCab

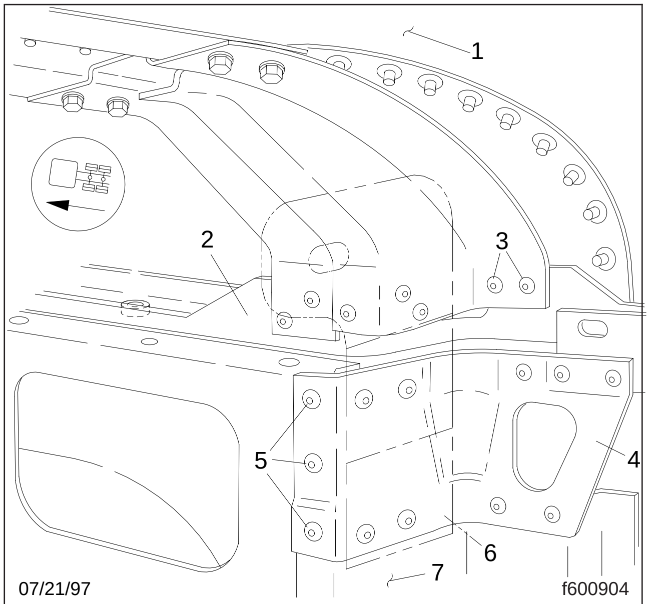
14. Remove the three monobolts that attach the roof transition bracket to the sidewall. See **Fig. 3**.
15. Remove the fasteners that attach the sidewall transition bracket to the door frame. See **Fig. 3**.
16. Remove the Torx-head screws that attach the lower ends of the Z-strips to the cab deck sill. Make sure to also remove those screws that are underneath the cab deck. See **Fig. 4**.
17. From outside the cab, remove the monobolts that attach the drip rail to the door frame.
18. Remove the nine Henrob rivets and three monobolts that attach the forward edge of the sidewall skin to the door frame. See **Fig. 5**.

Side-Wall Assembly Replacement



A. Remove these fasteners.
1. Upper B-pillar Reinforcement Assembly
2. Lower B-pillar Reinforcement Assembly
3. B-pillar

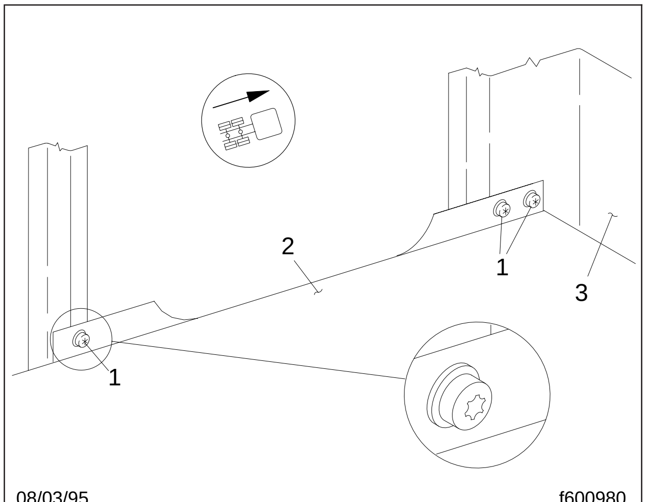
Fig. 2, Left Side, Inside View



1. Roof Cap
2. Sidewall Transition Reinforcement
3. Roof Transition Mounting Bracket Fasteners
4. Upper B-pillar
5. Sidewall Transition Mounting Bracket Monobolts
6. Upper B-pillar Reinforcement (mid-roof only)
7. Sidewall (interior wall)

Fig. 3, Transition Brackets, Right Side

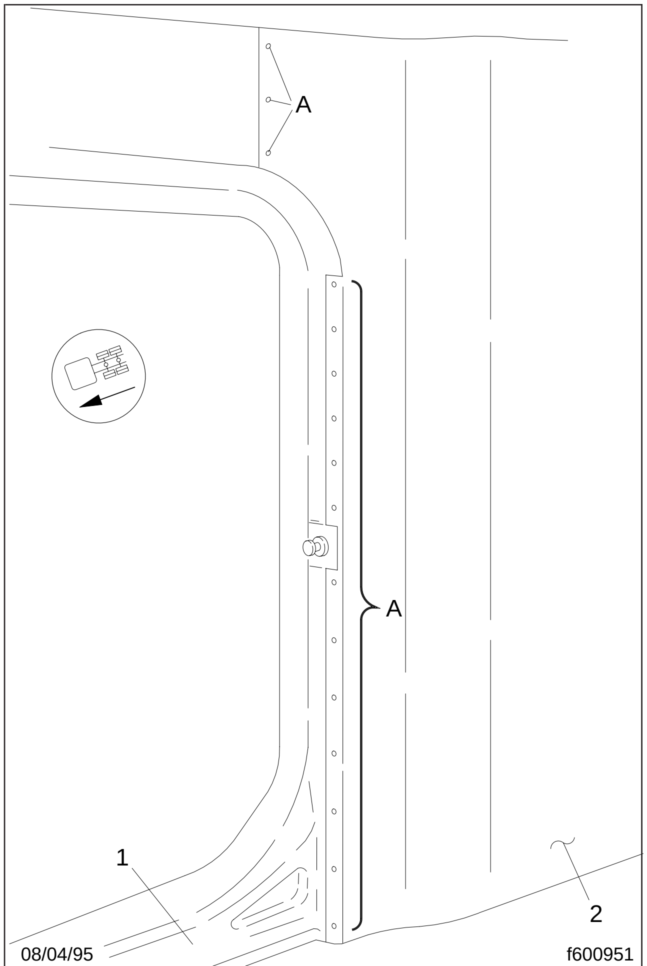
19. Remove the Henrob rivets that attach the lower edge of the sidewall skin to the bottom of the deck sill. See **Fig. 6**.
20. Remove the fasteners that join the rear edge of the sidewall skin to the rear wall. See **Fig. 6**. Carefully pry up the skin to loosen the adhesive-tape bond.
21. Remove the two outer fasteners that attach the top side extender bracket to the rear wall.
22. Check to be sure that all wiring is routed or taped out of the way.
23. Support the sidewall assembly.



1. Torx-head Screws
2. Cab Deck Sill
3. Sidewall Transition Area

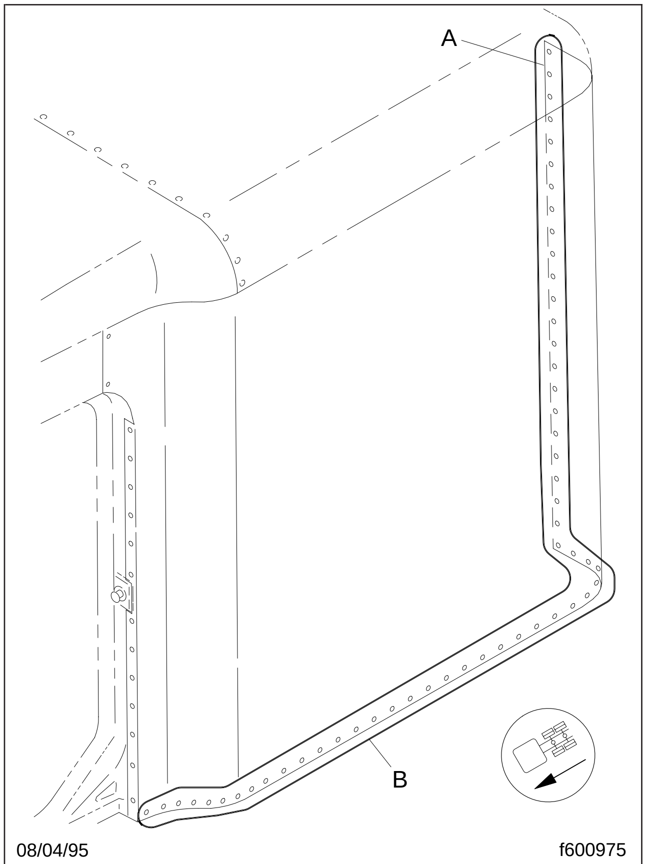
Fig. 4, Left Side, Interior View

Side-Wall Assembly Replacement



A. Remove these fasteners (lower three are monobolts).
1. Left Door-Frame Assembly
2. Left Sidewall Assembly

Fig. 5, Sidewall-to-Door Frame Henrob Rivets



A. This edge attaches to the rear wall.
B. Remove these fasteners.

Fig. 6, Sidewall Fasteners to the Cab Deck and Rear Wall

CAUTION

Do not overheat the sidewall skin. Aluminum will melt or change shape under extreme heat, and overheating can damage the side skin.

24. Using a suitable heat source, such as a heat gun or a propane torch, and working on the cab exterior, heat the forward edge of the sidewall skin at the door frame to release the glue bond. The glue bond will soften at about 275°F (135°C). Pry up the edge to prevent the glue from rebonding.

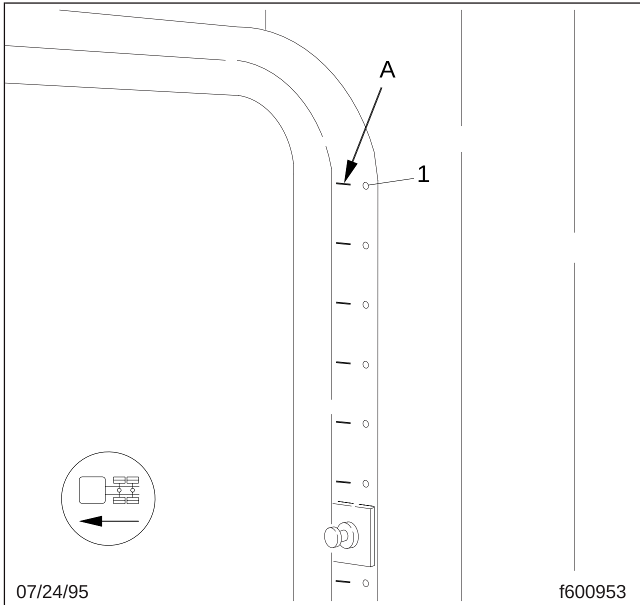
25. Remove the sidewall assembly from the cab.

Installation

1. With the door plug in place, make sure the cab is square and level. See **Subject 110** for instructions.
2. Using a putty knife, then fine sandpaper or a grinding disk, remove any adhesive residue from the surface of the door frame. Sand down to bare metal.
3. Clean the surface of the metal with a cloth.
4. Clean the exposed, bottom edge of the roof cap assembly.

Side-Wall Assembly Replacement

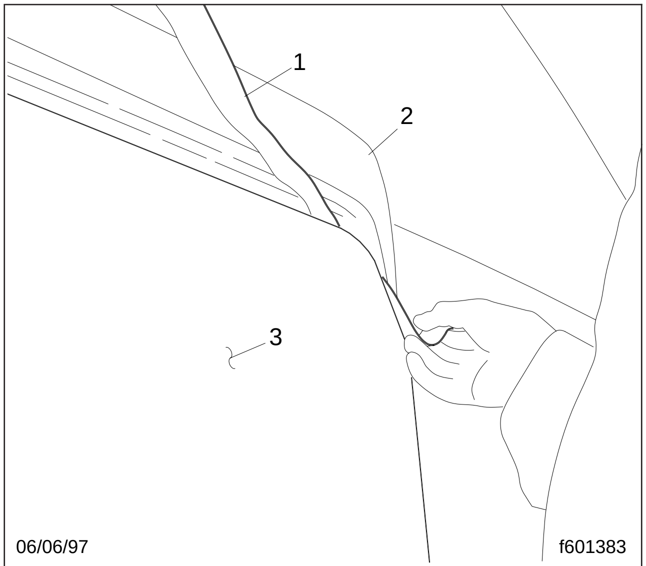
5. On the inboard edge of the rear door frame, mark the location of the existing holes that were used to attach the forward edge of the sidewall skin to the door frame. Make sure the marks are far enough inboard so they won't be covered up by the forward edge of the new sidewall skin. See **Fig. 7**.



A. Put marks here.
1. Existing B-Pillar Hole

Fig. 7, Marking the Existing Holes in the B-Pillar

6. Install new foam seal tape along the rear edge of the sidewall skin (where it joins the edge of the rear wall skin).
7. Apply foam seal tape along the entire upper edge of the sidewall assembly, where it will be attached to the roof cap assembly. See **Fig. 8**.
8. Using a knife, remove the portions of foam seal tape from the areas of the upper edge of the sidewall assembly where the Torx-head screws will be installed.
9. Clean with Scotchbrite® the forward edge of the new sideskin that joins the door frame.
10. Position the new sidewall assembly in place, making sure the holes in the bottom of the Z-strips line up with those in the deck sill, and the holes at the top hem line up with those in the clinch nuts in the roof cap hem. Also, make sure the forward edge of the sidewall skin is flush against the door frame.



1. Foam Seal Tape
2. Roof Cap
3. Sidewall Skin

Fig. 8, Applying Foam Seal Tape

11. Attach enough fasteners to keep the sidewall assembly in position during the installation procedure.
12. Apply a 1/8 inch (3 mm) bead of Magnolia 112–448 A & B two-part adhesive to the surface of the door frame between the frame surface and the sidewall skin. Apply the adhesive from the top of the door to the bottom. Follow the manufacturer's directions and safety information when using the adhesive.
13. Make sure the sidewall assembly is in position, then clamp the forward edge of the sidewall skin to the door frame, using the special clamping bar and modified C-clamps. See **Fig. 9**.
14. Allow the adhesive to cure for at least 40 minutes. Complete curing takes 24 hours. Remove any excess adhesive that is squeezed out.
15. Using 5/16–18 Torx-head screws, attach the front edge of the sidewall assembly to the forward edge of the roof cap. Don't tighten the screws all the way.

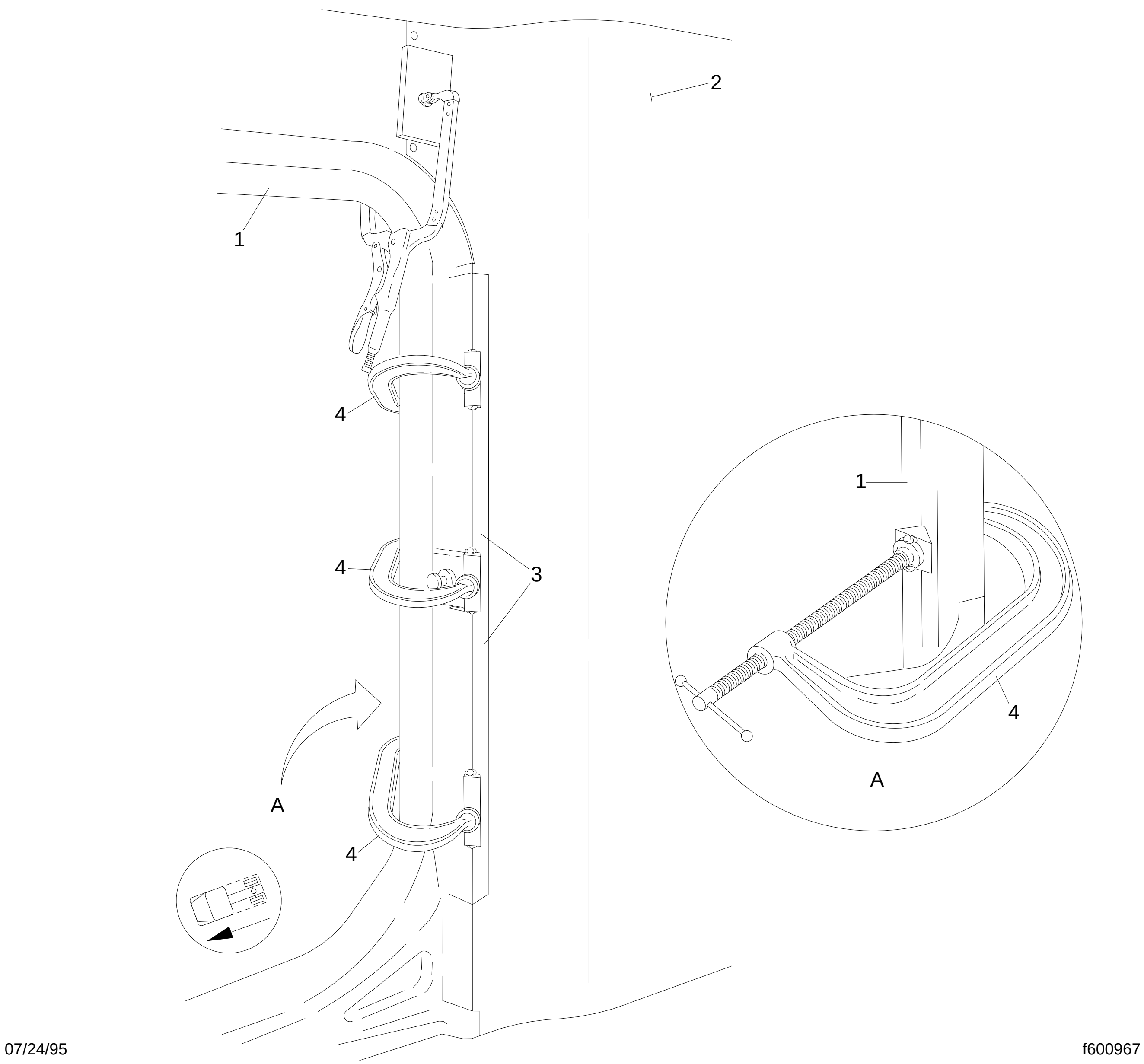
Side-Wall Assembly Replacement

16. Attach the upper B-pillar bracket to the upper B-pillar reinforcement assembly.
17. Attach the sidewall transition bracket to the door frame.
18. Attach the sidewall to the upper B-pillar and lower B-pillar reinforcement assembly.
19. Using the marks on the door frame as a guide for locating existing holes, use a #11 drill bit and drill 12 new holes through the new sidewall skin and the door frame.
20. Using a 5/16-inch counterbore, countersink from the top the nine holes and install countersunk bucked rivets that have a 5/16-inch head and a 3/16-inch shank into these nine holes. Then, install 3/16-inch monobolts in the bottom three holes.
21. Drill out along the bottom edge of the sidewall assembly the holes for fastening the sidewall skin to the cab deck. From underneath the cab, use the existing holes as a guide for drilling through the sidewall skin.
22. Remove the burrs from the drilled holes in the exterior sidewall skin.

IMPORTANT: Perform the next steps in the procedure as listed so that the sidewall skin is fastened forward-to-aft. This allows the metal to more or less remain tight against the cab structure from the door frame to where the skin joins to the rear wall. Otherwise, gaps may appear between the fasteners.

23. Using an air-powered crimping tool (see **Fig. 10**) or a buck-riveter, install 3/16 inch aluminum brazier-head bucked rivets along the bottom edge of the sidewall assembly.
24. Install the remaining 5/16–18 Torx-head screws in the upper sidewall and rear roof cap. Tighten 15 lbf·ft (20 N·m). See **Fig. 11**.
25. Using 3/16-inch aluminum brazier-head Huck® bolts (p/n lockbolt, 23-12209-000; collar, 23-11037-603), and adding a special patch of sealant on the underside of each bolt head, attach the sidewall skin to the rear wall skin. Install the bolts with the heads outside. Be sure the side extender tapping plate, if the vehicle is so equipped, is installed with this row of fasteners.
26. Install the side extender brackets and side extender.
27. Install the drip rail. Then, install the sun visor and its rear mounting bracket.
28. Prime and paint the new sidewall assembly.
29. Remove the protective coverings from the interior of the cab.
30. Remove the door plug and install the door. See **Group 72** for instructions.
31. Route the wiring harness as needed. If so equipped, install the auxiliary HVAC unit. Install the seats, the bunk(s), the upholstery panels, the cabinets, the floor mats, and the carpeting in the cab. See the applicable groups and sections for instructions.
32. Remove the jack stands from the chassis.
33. Remove the chocks from the tires.

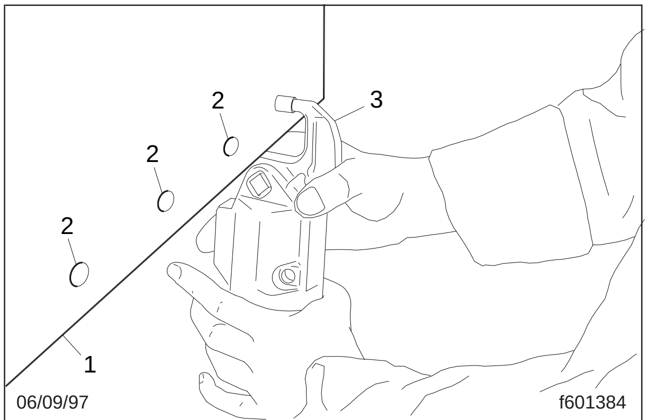
Side-Wall Assembly Replacement



A. Inside View

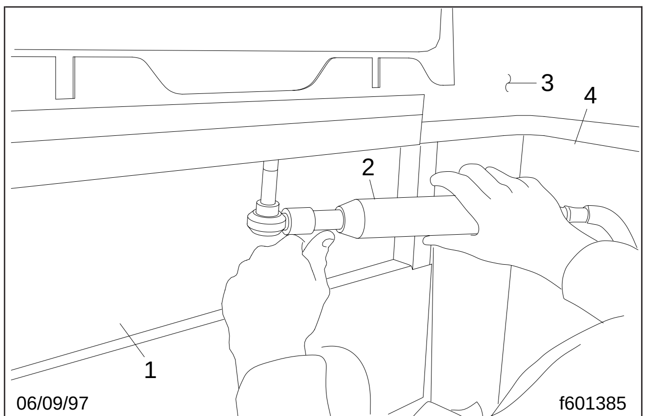
1. Door Frame Assembly
2. Sidewall Assembly
3. Special Clamping Bar
4. Modified C-Clamp

Fig. 9, Special Clamp for Door Frame



1. Sidewall Skin
2. Rivet
3. Crimping Tool

Fig. 10, Installing Rivets Along the Bottom Edge (with a crimping tool)



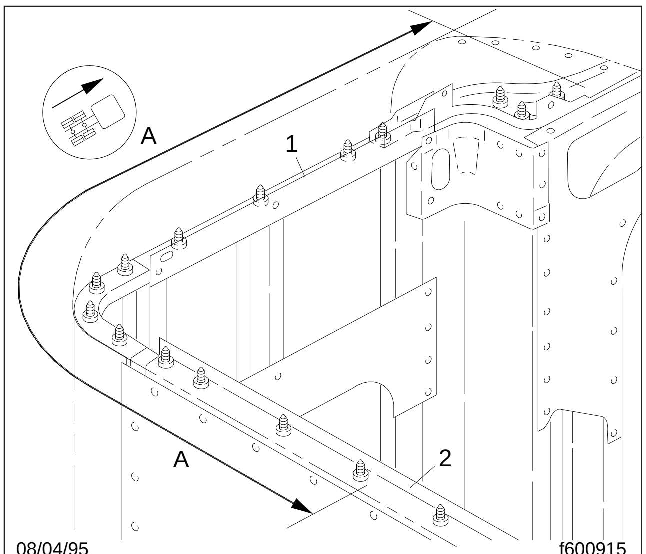
1. Sidewall Skin
2. Air-Powered Rachet
3. Roof Cap
4. Rear Wall

Fig. 11, Install the Roof Cap Screws

Back-Wall Assembly Removal and Installation

Removal

1. Park the vehicle, apply the parking brakes, then chock the tires.
2. If not already done, remove the seats, the bunk(s), the upholstery panels, the cabinets, the floor mats, and the carpeting from the cab. Put the electrical harness to one side. See the applicable sections is this group for instructions.
3. From inside the cab, remove the Torx®-head screws holding the roof cap assembly to the upper edge of the back wall and the left and right side walls. See **Fig. 1.**
4. Remove the fasteners that attach the back-wall hat sections to the cab deck. See **Fig. 2.**



A. Remove these Torx-head screws.
1. Side-Wall Assembly
2. Back-Wall Assembly

Fig. 1, Rear Roof Cap Fasteners

5. Remove the fasteners that hold the bottom of the back wall to the deck sill.
   - 5.1 Remove the two rows of fasteners that attach the reinforcement plate and the bottom of the back wall to the deck sill and the cab suspension mounting bracket. See **Fig. 3.**
   - 5.2 Remove the fasteners that attach the outboard edges of the back-wall bottom to the deck sill and the rear outboard edge of the side wall skin.
   - 5.3 Pry up the skin to loosen the sealant tape adhesive bond.
6. Support the back-wall assembly.
7. Lift up the rear roof cap assembly, and support it.
8. Using a putty knife, remove the foam sealant tape between the underside of the roof cap assembly and the chair section at the top of the back wall.
9. On each outboard side, pull the upper part of the back wall out of the corner bracket. See **Fig. 4.** (These are slip-joints.)
10. Remove the back-wall assembly from the cab.

Installation

CAUTION

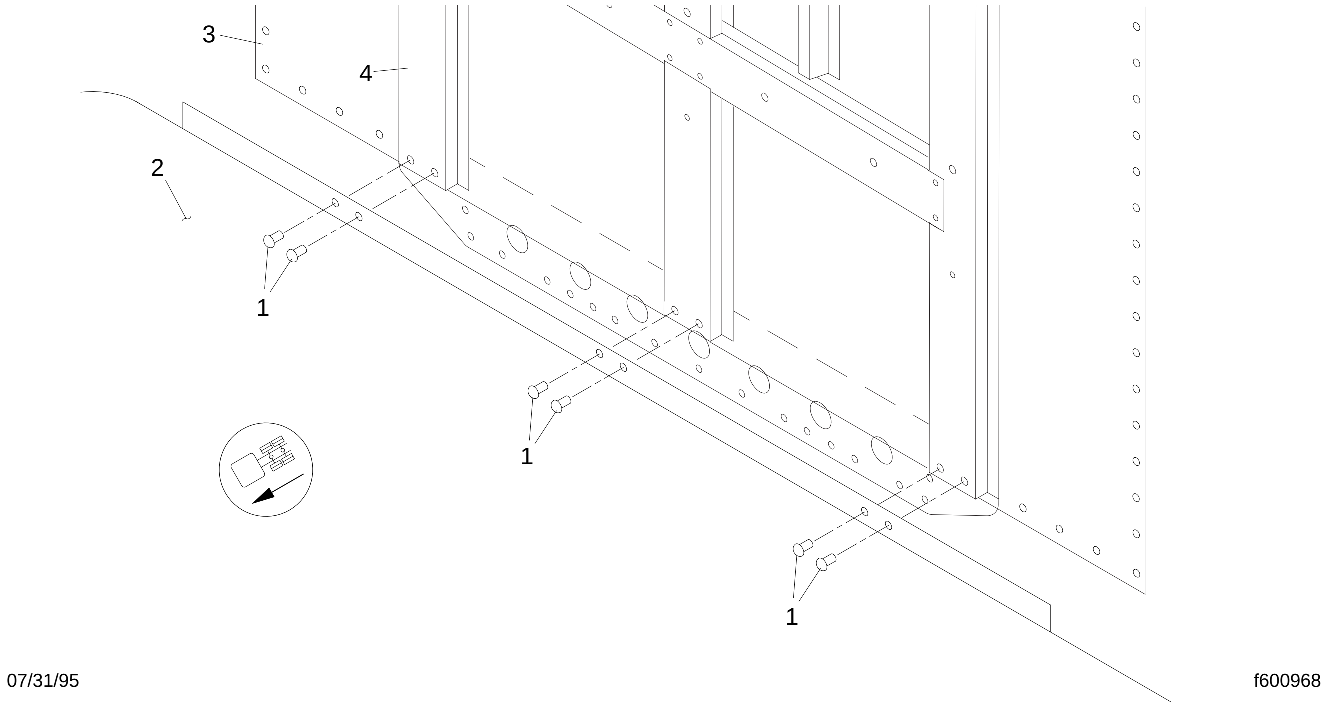
Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Remove any traces of adhesive or foam sealant tape from the bottom surfaces of the rear roof cap assembly and the side wall Z-strips.
3. Make sure the cab is square and level. See **Subject 110** for instructions.
4. Install new foam sealant tape on the bottom surface of the rear roof cap hem and the outer surface of the rearmost side wall Z-strips.
5. Place the new back-wall assembly against the rear of the cab with the upper part tilted in under the roof cap hem..
6. On each side, put the upper framework into the corner bracket slip joint.
7. Line up the back-wall assembly, top and bottom, and left and right.
8. Clamp the back-wall assembly in place.

Back-Wall Assembly Removal and Installation

9. From inside the cab, and using a #11 drill bit, backdrill through the existing holes in the rear-most side-wall Z-strip, side-wall skin, and the new back-wall skin. Do this on both sides of the back wall.
10. Install the special 3/16-inch diameter aluminum Huckbolts (with the sealant patch on the under-side of the heads) through the side wall Z-strips, the side wall skin, and the new back-wall skin. Install the Huckbolts with the heads on the out-side of the cab.
11. Install 3/16-inch diameter aluminum bucked riv-ets with countersunk heads along the outer edges of the bottom of the back wall and the deck sill.
12. Attach the back-wall reinforcement plate to the deck sill and the cab suspension mounting bracket, using #13 Magnabulb® rivets.
13. Install Monobolt® rivets in the upper corners of the back wall.
14. Prime and paint the new back-wall assembly.
15. Install the cab upholstery panels, bunk(s), cabi-nets, carpeting, floor mats, and seats. For in-structions, refer to the applicable sections in this group of the service manual.
16. Remove the jackstands from the chassis
17. Remove the chocks from the tires.

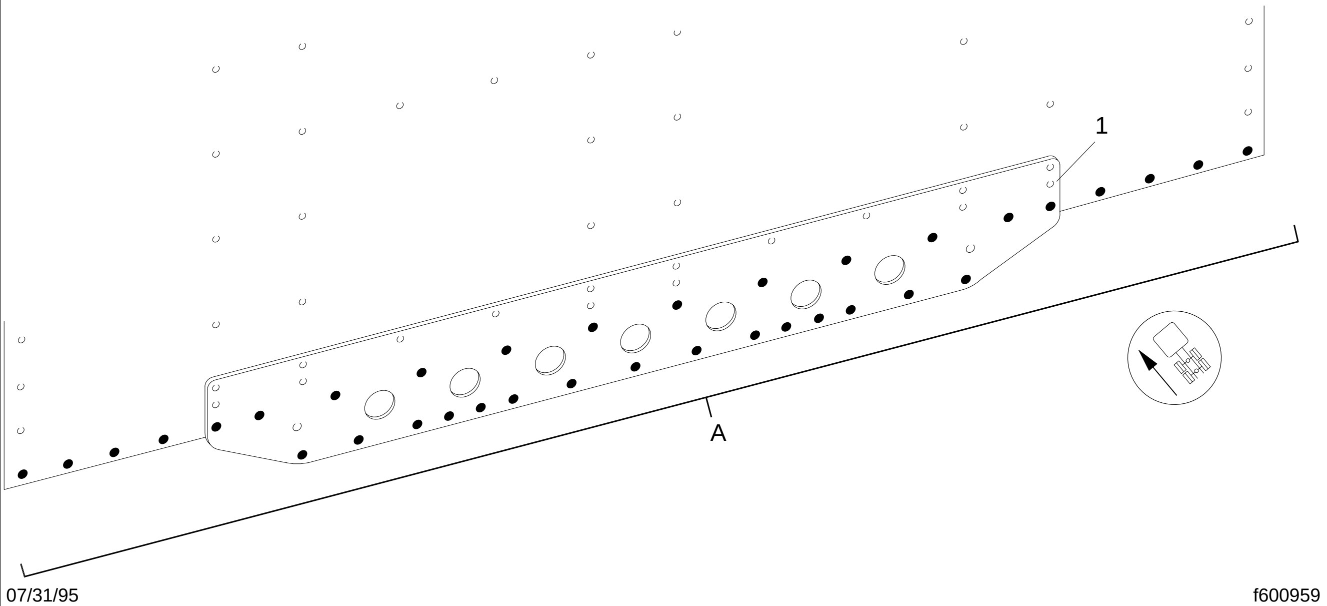
Back-Wall Assembly Removal and Installation



1. Torx-Head Screws
2. Cab Deck Assembly
3. Back-Wall Assembly
4. Hat Section

Fig. 2, Inside Back-Wall-to Cab Deck Fasteners

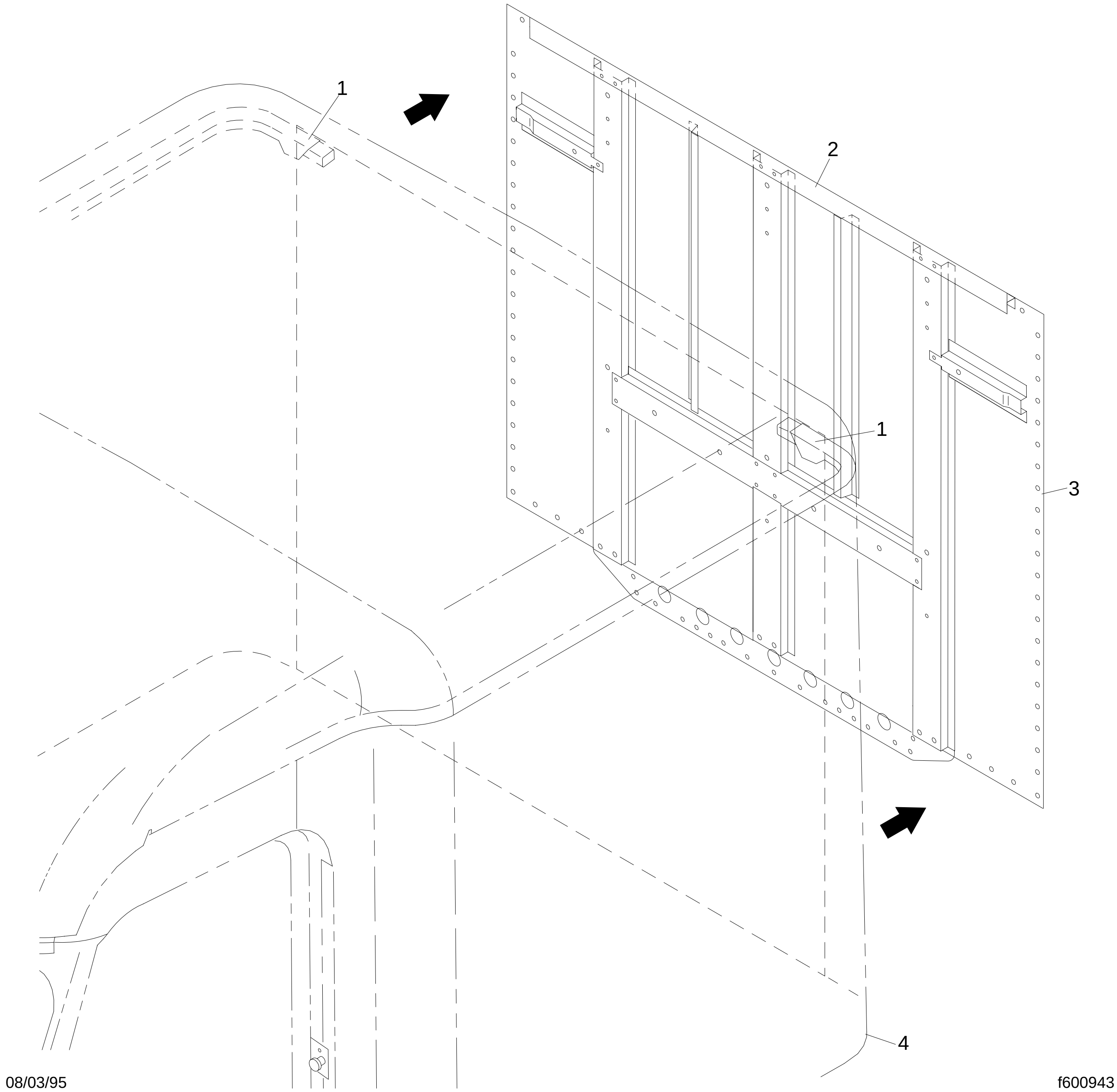
Back-Wall Assembly Removal and Installation



A. Remove these fasteners.
1. Reinforcement Plate

Fig. 3, Outside Back-Wall Fasteners

Back-Wall Assembly Removal and Installation



1. Corner Brackets
2. Back-Wall Chair Section
3. Back-Wall Outboard Edge
4. Side-Wall Assembly

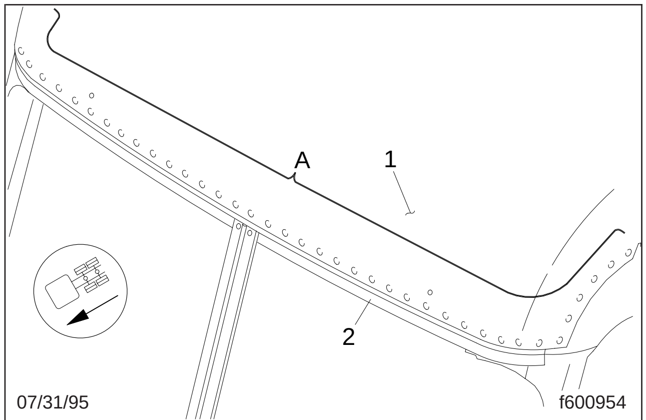
Fig. 4, Back Wall Assembly Removed from the Cab Deck and Side Walls

Front Roof-Cap Assembly Removal and Installation

Removal

NOTE: Use both this subject and **Subject 150** to replace the roof cap on a non-SleeperCab.

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. Remove the exterior sun visor and its mounting brackets from the front of the roof cap and the top of the door frame.
   - 2.1 Mark, then disconnect the wiring from the marker lights.
   - 2.2 Remove the fasteners that attach the sun visor brackets to the roof cap; then remove the exterior sunvisor and its mounting brackets.
   - 2.3 If the exterior sun visor is undamaged, set it aside.
3. If not already done, remove the seats, the upholstery panels, cabinets, carpeting, the floor mats, and the wiring harness from the cab. See the applicable sections is this group for instructions.
4. From inside the cab, grind down the extruded bulb on the back side of each Henrob rivet holding the windshield header to the front edge of the roof cap.
5. From outside the cab, and using a 7/32-inch cobalt drill on low speed, drill out and remove the Henrob rivets that attach the front edge of the roof cap to the windshield header. See **Fig. 1**. See **Subject 100** for information on removing Henrob rivets
6. Remove the fasteners from the front corners of the roof cap.
7. Remove the Huckbolts® that attach the front and rear roof caps to the curtain bow roof support. See **Fig. 2**.
8. From inside the cab, loosen the Torx®-head screws that hold the front roof cap assembly to the top of the door frames.
9. Remove the Magnabulb® rivets that attach the three forward brackets on the longitudinal roof bows to the edge of the front storage console. See **Fig. 3**.
10. Pry up the front roof cap assembly; then remove it from the cab.



A. Remove these fasteners.
1. Front Roof-Cap Assembly
2. Windshield Header

Fig. 1, Front Roof Cap Assembly Fasteners

11. If the front storage console is damaged, remove it. See **Fig. 4.**
    - 11.1 Remove the bolts from the L-brackets that attach the sides of the front storage console to the door frames.
    - 11.2 Remove the fasteners that attach the forward edge of the front storage console to the windshield header.
    - 11.3 Remove the front storage console.
12. If the windshield header is damaged, remove it. See **Subject 170** for instructions.

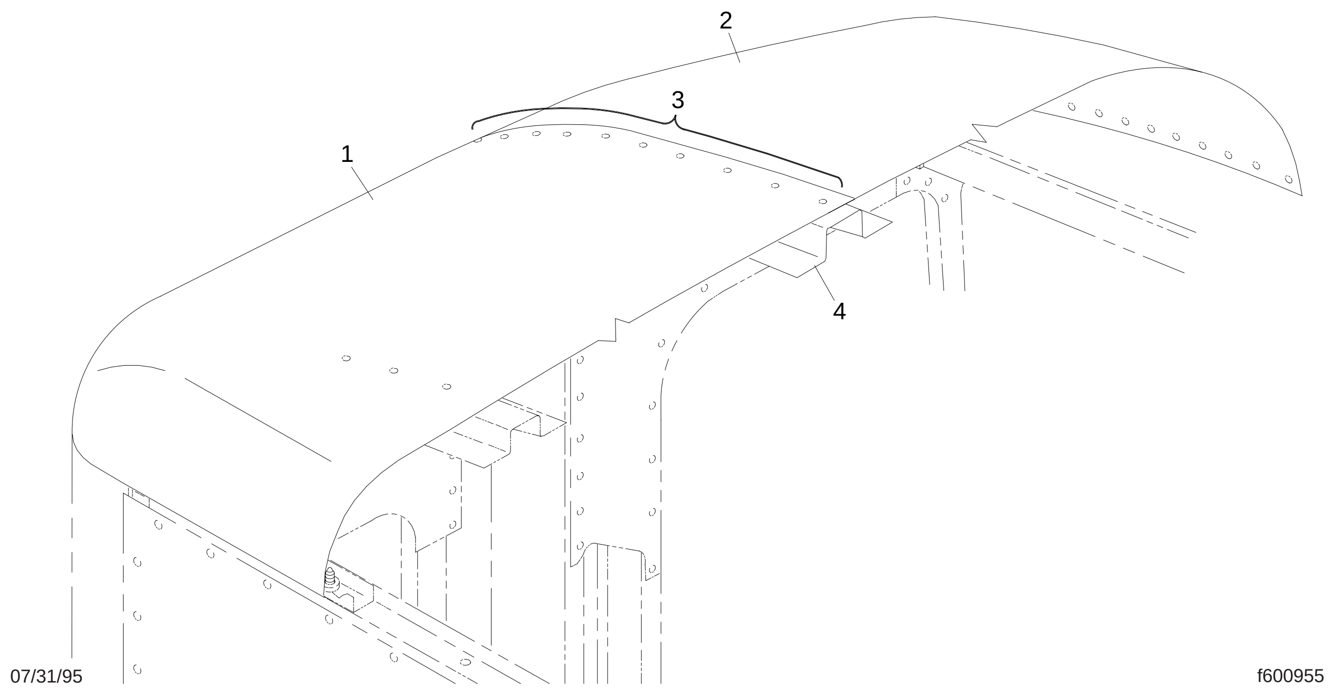
Installation

CAUTION

Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Make sure the cab is level and square. See **Subject 110** for instructions.
3. If the front storage console is being replaced, install a new one. See **Fig. 4**.

Front Roof-Cap Assembly Removal and Installation



1. Rear Roof Cap
2. Front Roof Cap
3. Huckbolts
4. Curtain Bow Roof Support

Fig. 2, Rear View, 48-Inch SleeperCab

3.1 Install the fasteners that attach the front storage console to the windshield header.

3.2 Attach the existing L-brackets to the new front storage console.

3.3 Attach the L-brackets to the door frames. Tighten the Torx-head screws 15 lbf·ft (20 N·m).

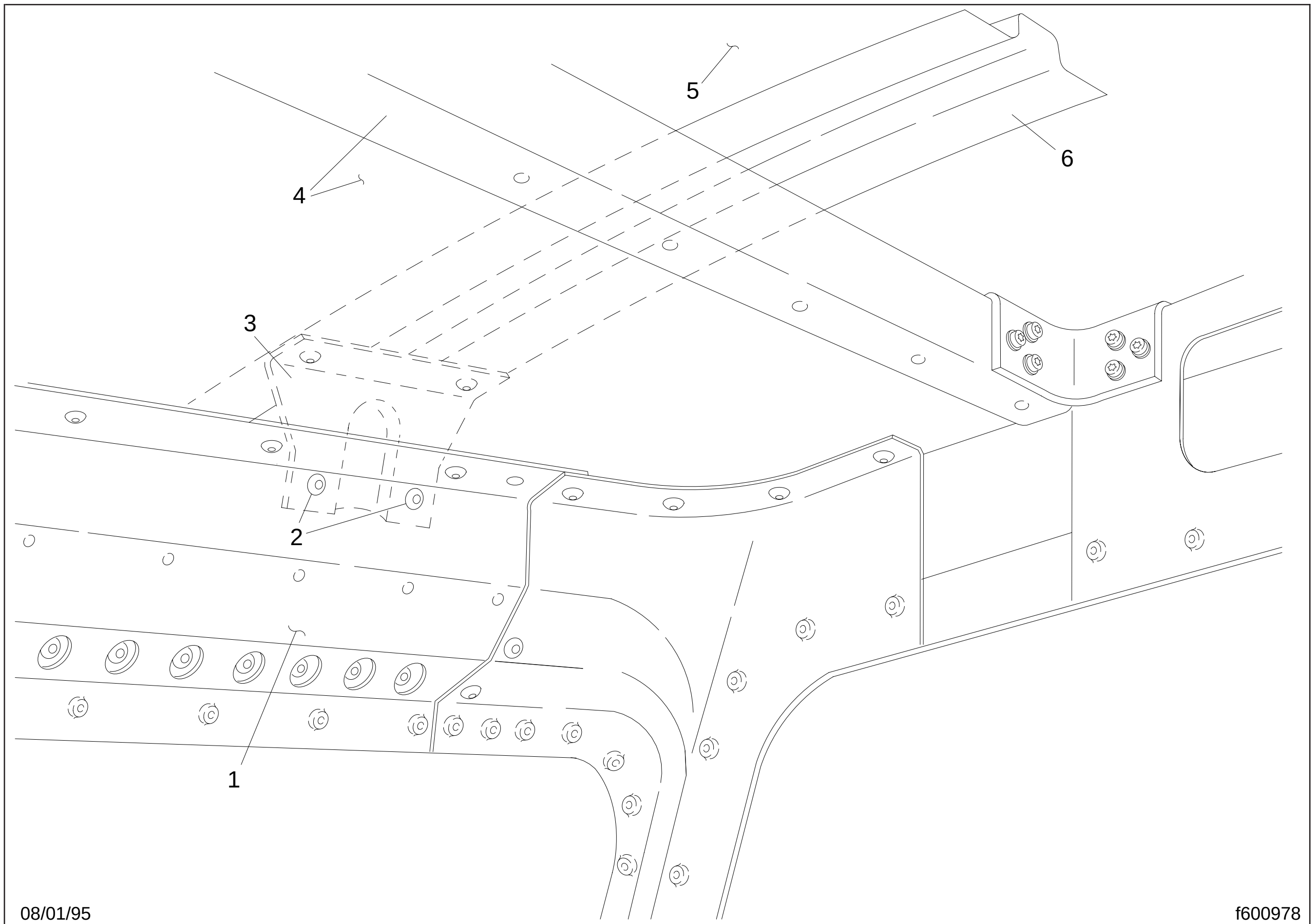
4. Clean the top surface of the door frames. Make sure all traces of foam tape and adhesive are removed.
5. Apply new foam sealant tape to the top of the door frames.
6. Apply Uniseal® 116.15 sealant along the top edge of the windshield header, where the edge of the roof cap was.
7. Put the new forward roof cap assembly in place, making sure it is centered and fits flush against the windshield header. Clamp it in place.
8. Attach the forward edge of the roof cap to the windshield header, using 3/16-inch countersunk aluminum Huck bolts or countersunk bucked rivets.

   8.1 Using the existing holes in the windshield header, backdrill through the roof-cap skin.

   8.2 Counterbore the holes, using a 5/16-inch counterbore.

   8.3 Install 3/16-inch aluminum bucked rivets with countersunk heads, or countersunk aluminum Huck fasteners. Install the fasteners in an alternating sequence. See Fig. 5.
9. Line up the sides of the roof cap with the door frame
10. Make sure the holes in the roof-cap align with those of the clinch nuts in the door frames and forward part of the side walls.

Front Roof-Cap Assembly Removal and Installation

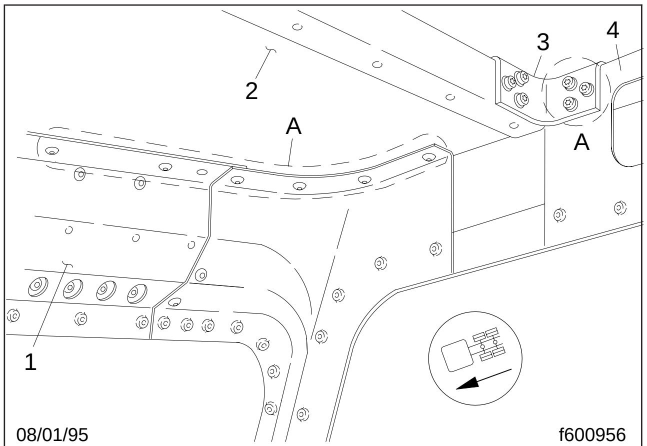


1. Windshield Header
2. Magnabulb Rivets
3. Forward Bracket (3 qty.)
4. Front Storage Console
5. Front Roof Cap
6. Longitudinal Roof Bow (3 qty.)

Fig. 3, Right Side, Interior View

11. Install the Torx-head screws. Tighten them 15 lbf·ft (20 N·m.)
12. Using 3/16-inch diameter Monobolts® rivets, attach the three forward roof-bow brackets to the windshield header.
13. Using 3/16-diameter special seal Huck bolts, attach the front roof-cap skin to the rear roof-cap skin and the curtain bow roof support.
    13.1 Clamp the front roof-cap skin in place, underneath the rear roof-cap skin.
    13.2 Using a #11 drill bit, and the existing holes in the rear roof-cap skin, drill through the new front roof-cap skin.
    13.3 Install 3/16-inch diameter Huck bolts, with the heads facing out.
14. Prime and paint the new roof cap assembly .
15. Install the cab upholstery panels, cabinets, seats, floor mats, carpeting, and the wiring harness. See the applicable groups and sections in this manual for instructions.
16. Remove the jackstands from the chassis.
17. Remove the chocks from the tires.

Front Roof-Cap Assembly Removal and Installation



A. Remove these fasteners.
1. Windshield Header
2. Front Storage Console
3. L-Bracket
4. Door Frame

Fig. 4, Front Console Fasteners

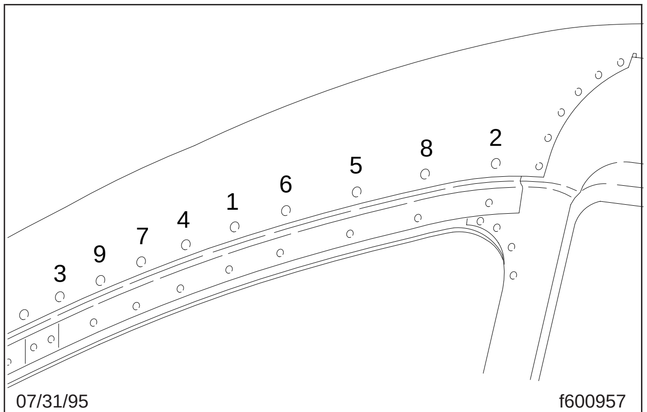


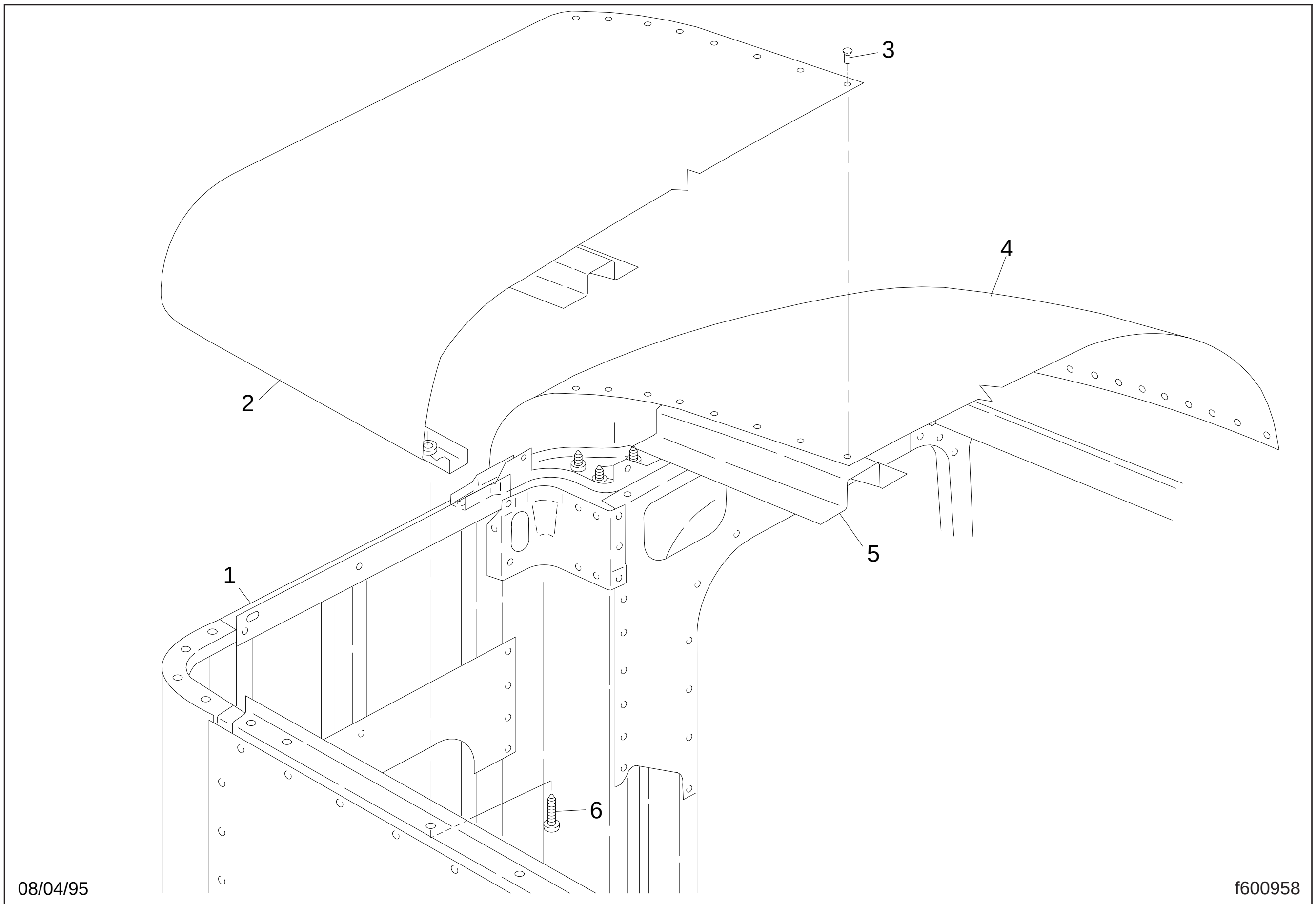
Fig. 5, Installation Sequence for Front Roof Cap Fasteners (left side)

Rear Roof-Cap Assembly Removal and Installation

Removal

NOTE: Use both this subject and **Subject 140** to replace the roof cap on a non-SleeperCab®.

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. If not already done, remove the seats, the bunk(s), all the upholstery panels, the floor mats, the carpeting, and the wiring harness from the cab. See the applicable groups and sections in this manual for instructions.
3. Remove the 5/16–18 Torx®-head screws that attach the roof cap assembly to the back wall and the side walls. See **Fig. 1**.
4. For a SleeperCab, remove the Huck® bolts that attach the forward edge of the rear roof cap to the curtain bow roof support and the front roof cap assembly.
5. Pry up the roof cap section from the back wall and the side walls to release the foam sealant tape.
6. Remove the rear roof cap assembly.



1. Side-Wall Assembly
2. Rear Roof-Cap Assembly
3. Huck Bolt
4. Front Roof-Cap Assembly
5. Curtain Bow Roof Support
6. Torx-Head Screw

Fig. 1, 48-Inch SleeperCab Shown

Rear Roof-Cap Assembly Removal and Installation

Installation

CAUTION

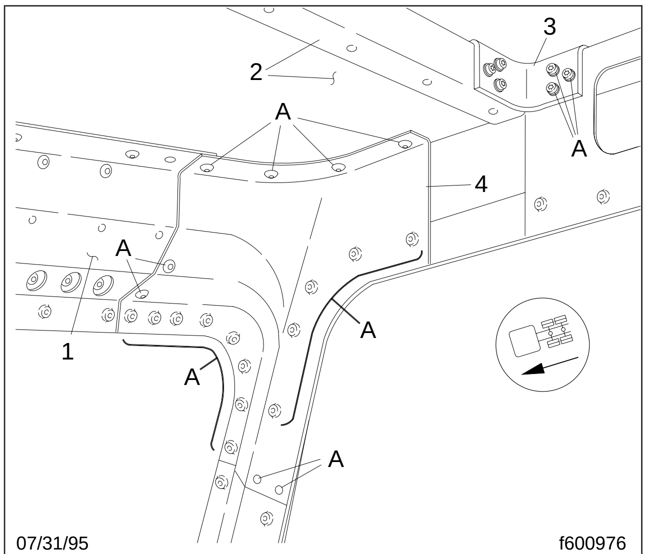
Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Make sure the cab is level and square. See **Subject 110** for instructions.
3. Clean the top edge of the side walls and the back wall. Remove all adhesive and foam sealant tape.
4. Install new foam sealant tape all the way around the top of the side walls.
5. Put the new rear roof cap assembly in place, making sure the holes in the hem line up with those in the clinch nuts in the back wall and side walls.
6. Install the 5/16–18 Torx-head screws holding the roof cap assembly to the side walls and back wall.
   6.1 Install the two front screws on both sides loosely.
   6.2 Push the edges of the roof cap in or out to line up the holes in the roof cap and the side walls; then install the screws, working your way back toward the back wall.
   6.3 Install the screws that attach the roof-cap assembly to the back wall.
   6.4 Tighten all the Torx-head screws 15 lbf·ft (20 N·m).
7. Using 3/16-diameter special seal Huck bolts, attach the front roof-cap skin to the rear roof-cap skin and the curtain bow roof support.
   7.1 Clamp the front roof-cap skin in place, underneath the rear roof-cap skin.
   7.2 Using a #11 drill bit, and the existing holes in the rear roof-cap skin, drill through the new front roof-cap skin.
   7.3 Install 3/16-inch diameter Huckbolts, with the heads facing out.
8. Prime and paint the new back wall.
9. Install the seats, upholstery panels, bunk(s), cabinets, floor mats, and carpeting. See the applicable groups and sections in this manual for instructions.
10. Remove the jackstands from the chassis.
11. Remove the chocks from the tires.

Door-Frame Assembly Removal and Installation

Removal

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. If not already done, remove the seats, the side upholstery panels, the dash panels, cabinets, carpeting, and the floor mats from the cab. See the applicable sections in this group for instructions.
3. Remove the door. See the applicable section in **Group 72** for instructions.
4. If not already done, remove the windshield. See the windshield section in this group for instructions.
5. From inside the cab, remove the fasteners holding the door header plate to the door frame and the windshield header; then remove the door header. See **Fig. 1**.

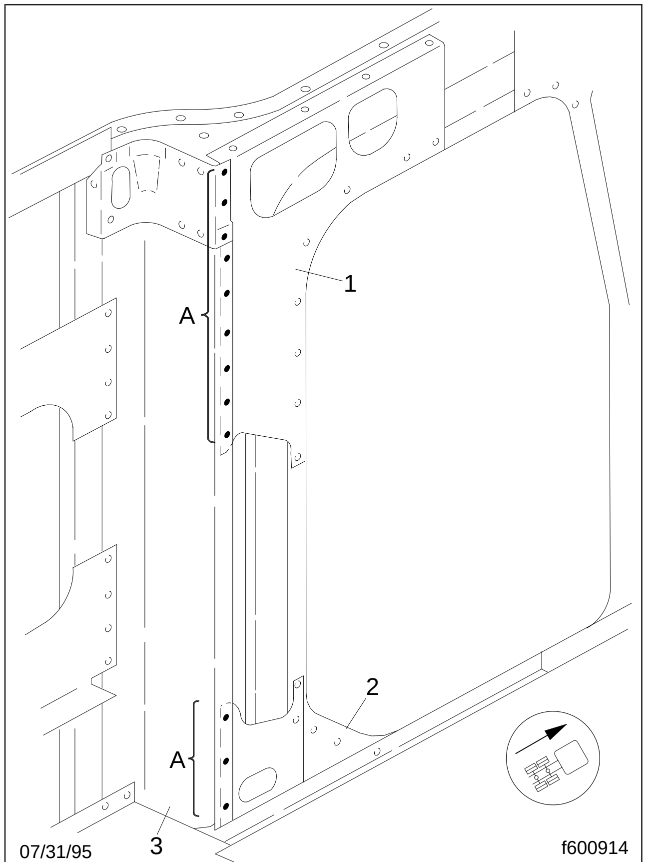


A. Remove these fasteners.

1. Windshield Header
2. Front Storage Console
3. L-Bracket
4. Door Header

Fig. 1, Right Side, Inside View

6. Remove the bolts that attach the front console L-bracket to the top of the door-frame assembly. See **Fig. 1**.
7. Remove the fasteners that hold the upper and lower rear door plates to the side-wall assembly. See **Fig. 2**.



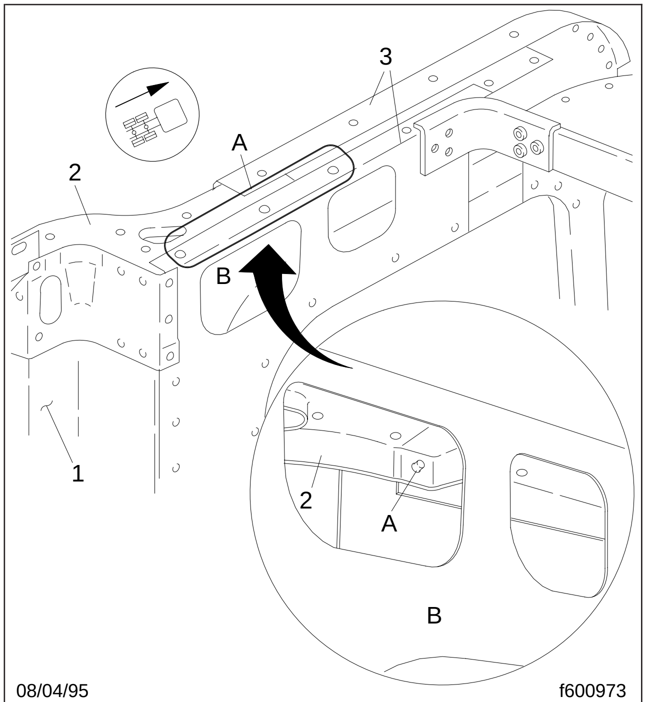
A. Remove these fasteners.

1. Upper Rear Door Plate
2. Lower Rear Door Plate
3. Side-Wall Assembly

Fig. 2, Door Plate Fasteners, Inside View

8. Remove the fasteners that hold the transition bracket to the door frame. See **Fig. 3**.
9. From outside the cab, remove the two rows of Henrob® rivets that hold the bottom of the door frame to the cab deck. See **Fig. 4**. See **Subject 100** for information on removing Henrob rivets.
10. Remove the fasteners that attach the front corner of the roof-cap skin and the windshield header to the top of the door frame assembly. See **Fig. 5**.

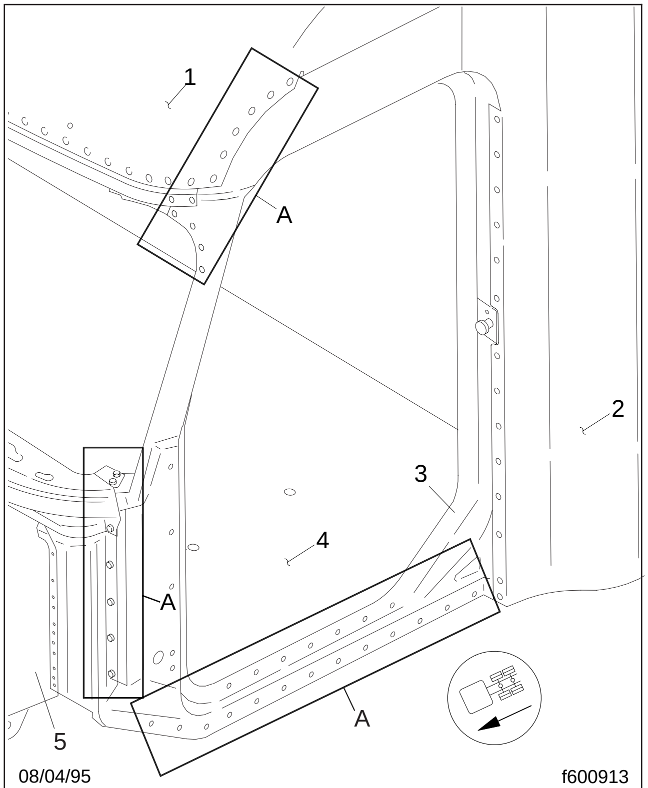
Door-Frame Assembly Removal and Installation



A. Remove these fasteners.
1. Side Wall
2. Transition Bracket
3. Door-Frame Assembly

Fig. 3, Transition Bracket Fasteners

11. Remove the bolts that hold the front of the door frame assembly to the front wall assembly. See **Fig. 3**.
12. Remove the Henrob rivets that attach the side-wall skin to the door frame. See **Fig. 6**.
13. Using a suitable heat source, such as a heat gun or a propane torch, heat the forward edge of the side-wall skin to release the glue bond at the door frame. The glue bond will soften at about 275°F (135°C). Pry up the edge to prevent the glue from rebonding.
14. Pull the rear end of the door frame out of the slip joint at the sidewall.
15. Remove the door frame from the vehicle.



A. Remove these fasteners.
1. Front Roof-Cap Assembly
2. Side-Wall Assembly
3. Door-Frame Assembly
4. Cab Deck
5. Front-Wall Assembly

Fig. 4, Door Frame Fasteners

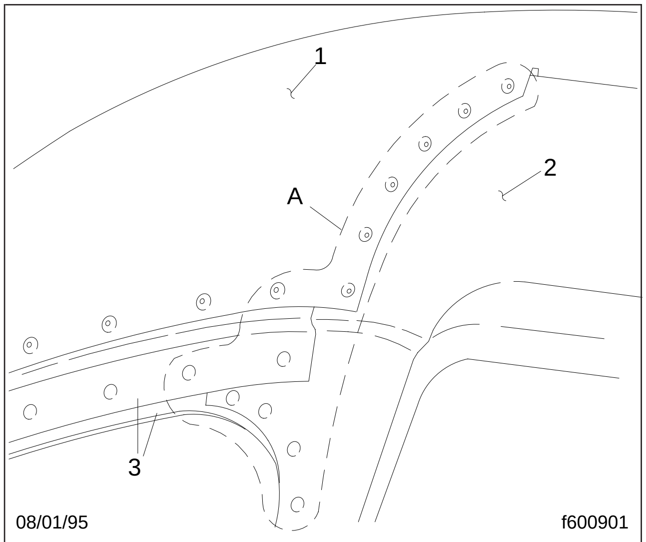
Installation

CAUTION

Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jack stands.
2. Make sure the cab is level and square. See **Subject 110** for instructions.

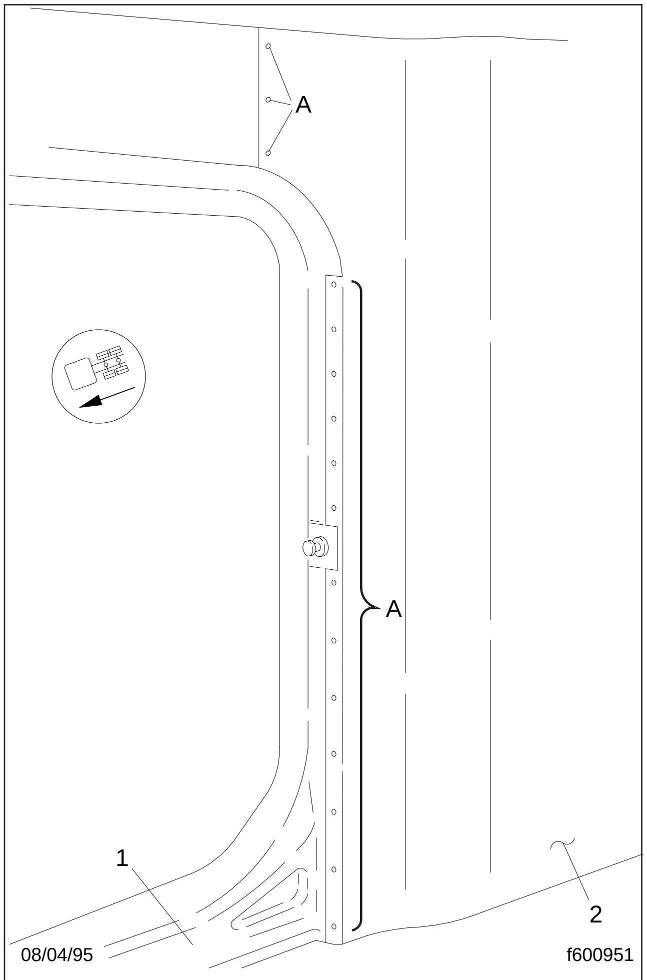
Door-Frame Assembly Removal and Installation



A. Remove these fasteners.
1. Roof Cap Assembly
2. Door Frame Assembly
3. Windshield Header Assembly

Fig. 5, Fasteners Attaching Door Frame to Windshield Header and Roof Cap

3. Put the new door frame in place up against the front wall, with the top of the door frame inside of the windshield header.
4. Attach the new door frame assembly to the front wall, using the Torx-head bolts previously removed.
5. From inside the cab, attach the front console L-brackets to the door frame assembly, using the previously removed Torx-head bolts.
6. Attach the upper plate of the door frame to the side wall.
7. Attach the lower plate of the door frame to the lower part of the side wall.
8. Install the transition bracket into the upper part of the door frame.
9. Clamp the bottom of the door frame to the cab deck sill.
10. Using the existing holes in the cab sill, backdrill into the new door frame with a #11 drill bit. On the outside of the door frame, counterbore the holes with a 5/16-inch counterbore.

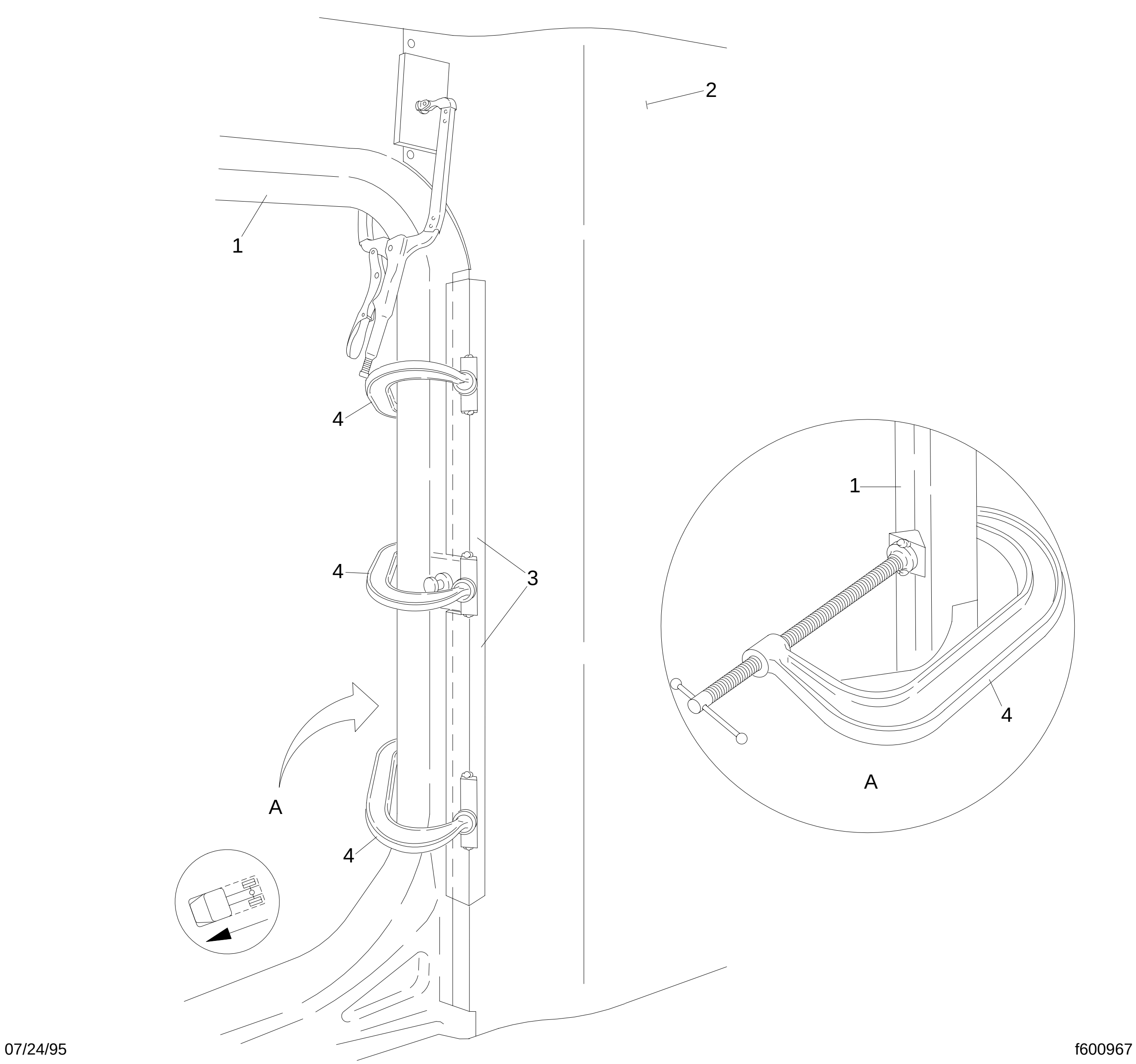


A. Remove these fasteners.
1. Left Door-Frame Assembly
2. Left Side-Wall Assembly

Fig. 6, Side-Wall to Door Frame Henrob® Rivets

11. Install 3/16-inch-diameter countersunk-head aluminum Huck bolts in the bottom row of holes.
12. Install 3/16-inch-diameter aluminum bucked rivets in the top row of holes.
13. Using a caulking gun, apply a 1/8-inch (3-mm) bead of Magnolia MPI 6155 A & B two-part adhesive to the surface of the door frame. Follow the manufacturer's directions and safety information when using the adhesive.
14. Clamp the forward edge of the side-wall skin to the door frame, using the special clamping bar and modified C-clamps. See **Fig. 7**.

Door-Frame Assembly Removal and Installation



A. Inside View
1. Door Frame Assembly
2. Side-Wall Assembly
3. Special Clamping Bar
4. Modified C-Clamp

Fig. 7, Special Clamp for Door Frame

15. Remove any excess adhesive that is squeezed out. Let the adhesive cure for at least 40 minutes. Complete curing takes 24 hours.

16. Using a #11 drill bit, and the existing holes in the side-wall skin, drill holes through the new door frame.

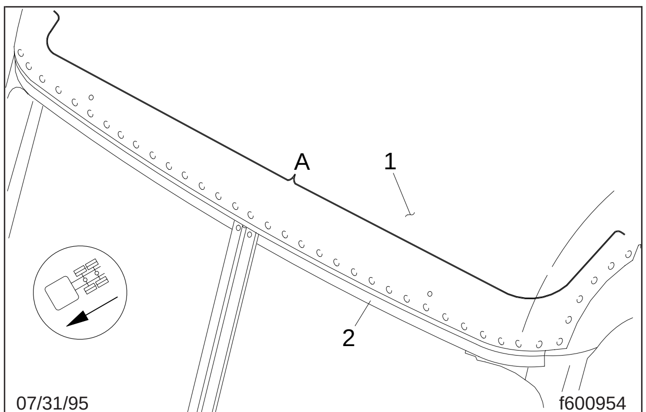
Door-Frame Assembly Removal and Installation

17. Using a 5/16-inch counterbore, countersink each hole, then install countersunk aluminum bucked rivets that have a 5/16-inch head and a 3/16-inch shank.
18. Prime and paint the new door assembly.
19. Install the windshield. See the windshield section in this group for instructions.
20. Install the side upholstery panels, cabinets, dash panels, seats, floor mats, and carpeting. See the applicable groups and sections in this manual for instructions.
21. Remove the jack stands from the chassis.
22. Remove the chocks from the tires.

Windshield Header Removal and Installation

Removal

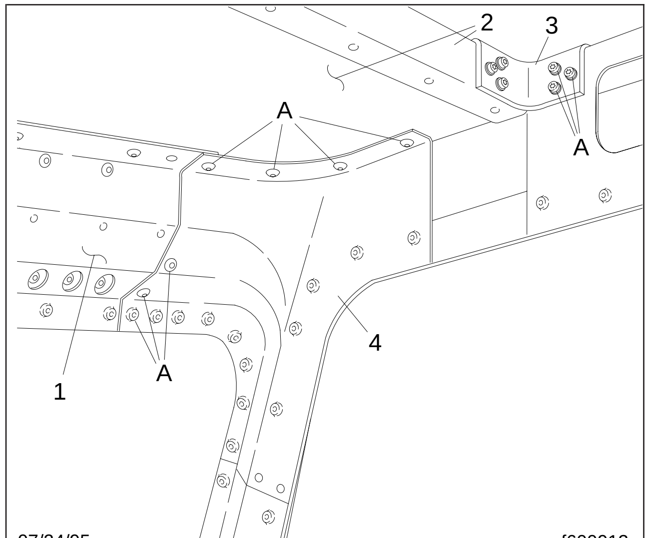
1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. If not already done, remove all the windshield glass. See the windshield section for instructions.
3. If not already done, remove the seats, the bunk(s), the upholstery panels, the dash panels, the floor mats, the carpeting, and the doors from the cab. See the applicable groups and sections is this manual for instructions.
4. If the front roof cap assembly is damaged, remove it. See **Subject 140** for instructions.
5. If the front roof cap assembly is not being removed, remove the Henrob® rivets that attach it to the windshield header assembly. See **Fig. 1.** See **Subject 100** for information on removal of Henrob rivets.



A. Remove these fasteners.
1. Front Roof Cap
2. Windshield Header

Fig. 1, Fasteners Holding Roof Cap to Windshield Header

6. From inside the cab, remove the fasteners that attach the right and left door headers to the windshield header. See **Fig. 2.**
7. Remove the bolts that hold the front storage console L-brackets to the door frame assemblies. See **Fig. 2.**
8. Remove the Magnabulb® rivets that hold the three roof-bow brackets to the windshield header. See **Fig. 3.**



A. Remove these fasteners.
1. Windshield Header
2. Front Storage Console
3. L-Bracket
4. Door Header

Fig. 2, Passenger-Side, Interior View

9. Remove the windshield center post, if present. See **Fig. 4.**
10. Remove the windshield header assembly and the front storage console assembly from the cab.
11. Remove the front storage console from the windshield header. Save it if it is undamaged.

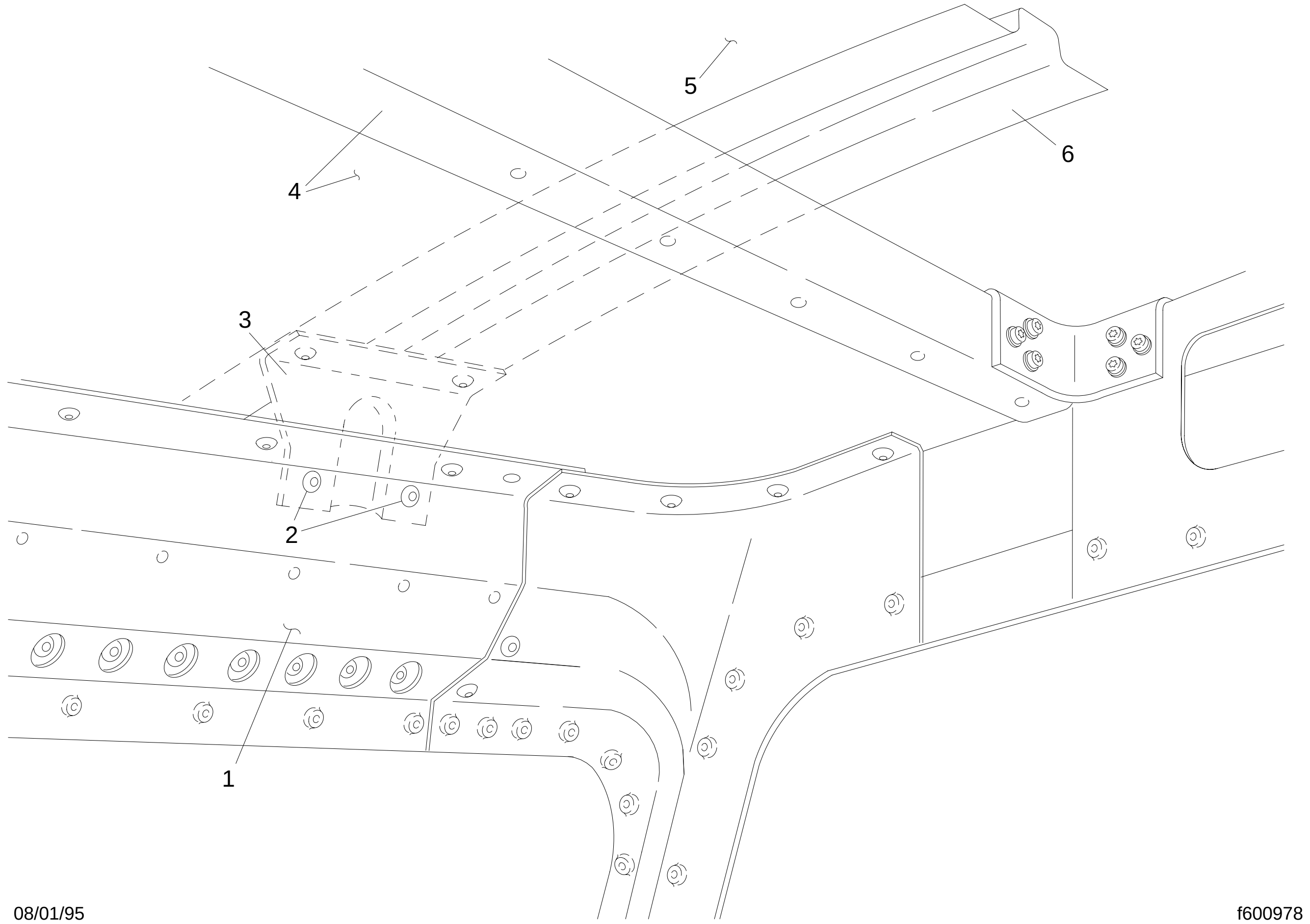
Installation

CAUTION

Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Make sure the cab is level and square. See **Subject 110** for instructions.
3. Attach the front storage console assembly to the new windshield header. Use 3/16-inch diameter Monobolt® blind rivets. If holes are not present,

Windshield Header Removal and Installation



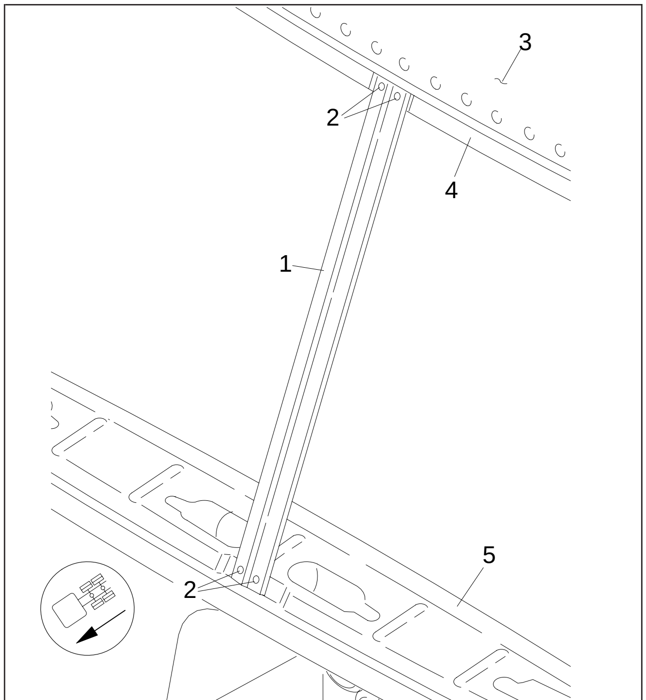
1. Windshield Header
2. Magnabulb Rivets
3. Forward Bracket (3 qty.)
4. Front Storage Console
5. Front Roof Cap
6. Longitudinal Roof Bow (3 qty.)

Fig. 3, Right Side, Interior View

drill them, using a #11 drill bit. Install the Monobolts with the heads on the bottom surface of the windshield header.

4. Put the windshield header and the front storage console assembly in place.
5. Attach the windshield header to the door headers.
   - 5.1 Using 3/16-inch diameter aluminum rivets with countersunk heads, attach each corner of the windshield header to the top of each door header.
   - 5.2 Install 3/16-inch Monobolt rivets in the remaining existing door header holes
6. From outside the cab, install the roof cap onto the windshield header.
   - 6.1 Put the roof cap in place over the new windshield header
   - 6.2 Using the existing holes in the roof cap, drill through the new windshield header.
   - 6.3 Counterbore the holes, using a 5/16-inch counterbore.
   - 6.4 Install 3/16-inch flush-head countersunk aluminum bucked rivets or countersunk aluminum Huck bolts. Install them in an alternate sequence. See **Fig. 5.**

Windshield Header Removal and Installation



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1. Windshield Post
2. Fasteners
3. Roof Cap
4. Windshield Header
5. Front Wall Assembly

Fig. 4, Windshield Post Fasteners

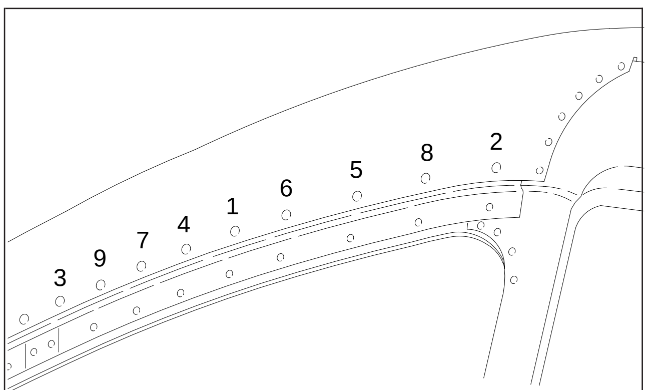

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Fig. 5, Installation Sequence for Roof Cap Rivets

7. If equipped with a two-piece windshield, install the windshield post, using two #15 Magnabulb rivets at the top and bottom of the windshield post. See **Fig. 4.**
8. Prime and paint the new windshield header.
9. Install the windshield glass. See the windshield section for instructions.
10. Install the dash panels, upholstery panels, bunk(s), cabinets, seats, floor mats, and carpeting. See the applicable groups and sections in this manual for instructions
11. Remove the jackstands from the chassis.
12. Remove the chocks from the tires.

Cab Deck Repair

Removal

IMPORTANT: Depending on the amount and severity of damage, you may need to remove the cab from the chassis to correctly repair the cab deck.

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the tires.
2. If not already done, remove the seats, the bunk(s), the upholstery panels, dash panels, cabinets, the floor mats, and the carpeting from the cab. See the applicable groups and sections is this manual for instructions.
3. Remove the doors. See **Group 72** for instructions.
4. If necessary, remove the cab from the chassis. See the applicable section in this group for instructions.
5. Remove all the fasteners that attach the deck plate to the framework. See **Fig. 1.** Remove only the deck plate needed.
6. Remove the damaged section of framework.
   - 6.1 Remove the necessary cab structures to expose the damaged area. For example, if you need to replace an outboard longitudinal sill, you will need to remove the side-wall assembly. See the applicable subject in this section for instructions.
   - 6.2 Remove the Huck® fasteners and brackets needed.

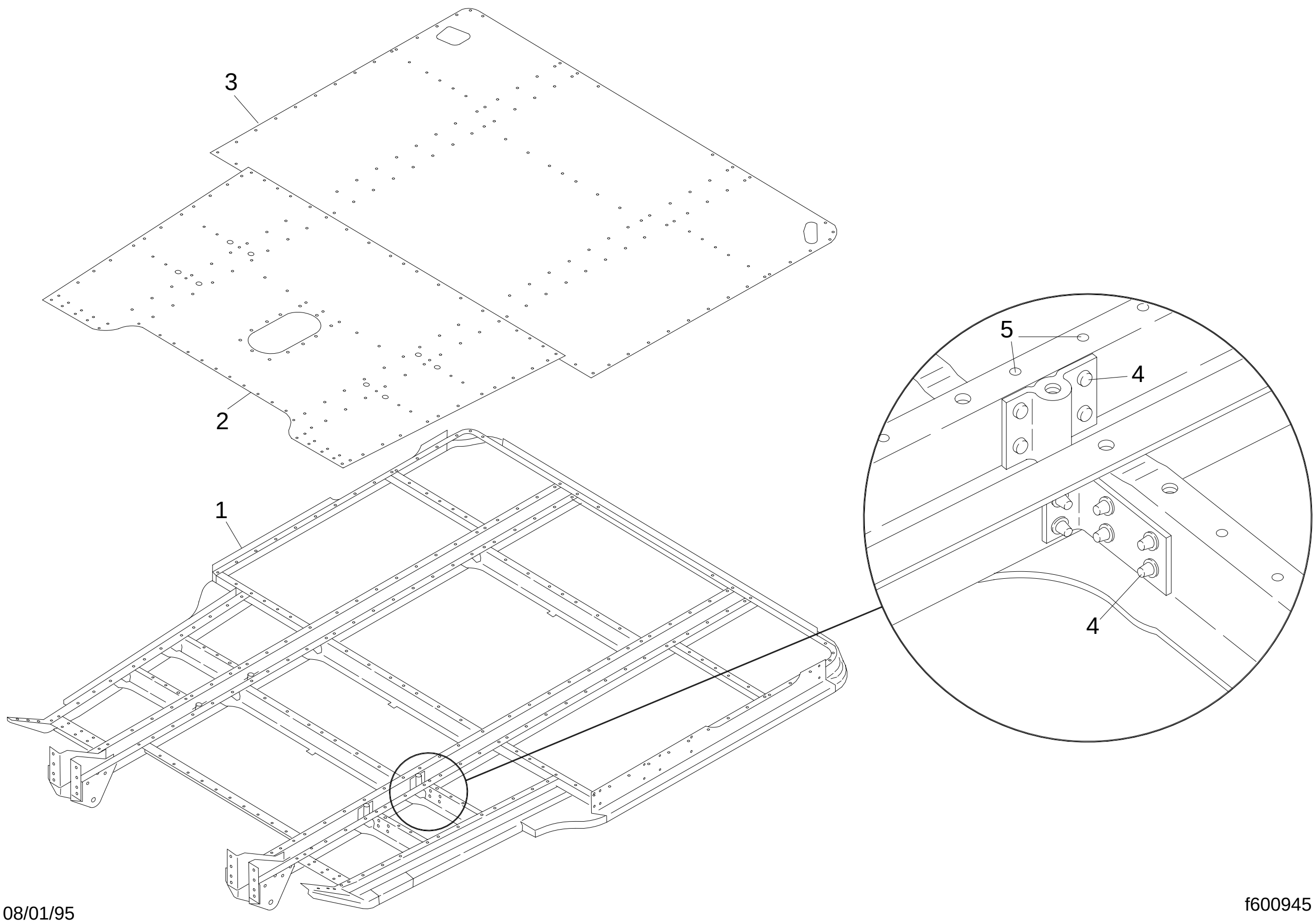
Installation

CAUTION

Check the vehicle chassis for correct alignment before making repairs to the cab. Failure to repair and align the chassis before repairing the cab could prevent you from correctly squaring the cab, and cause undue stress on the cab structure.

1. Level the chassis, using jackstands.
2. Install the new replacement part, using Huck bolts. Make sure that the fasteners match those that were removed, especially on the top surface of the frameworks. These must be flush, so that you can install the deck plate.
3. Install the deck plate, using the same kind of fasteners that were removed.
4. Make sure the cab deck is level and square. See **Subject 110** for instructions.
5. Install any cab structures that were removed, then make sure the cab is square. See **Subject 110** for instructions.
6. If the cab was removed from the chassis, install it on the chassis. See the applicable section in this group for instructions.
7. Install the bunk(s), cabinets, seats, dash panels, upholstery panels, floor mats, and carpeting. See the applicable groups and sections in this manual for instructions.
8. Install the cab doors. See **Group 72** for instructions.
9. Remove the jackstands from the chassis.
10. Remove the chocks from the tires.

Cab Deck Repair



1. Cab Deck Framework
2. Forward Deck Plate
3. Rear Deck Plate
4. Huck Bolt
5. Countersunk (flush) Fasteners

Fig. 1, Cab Deck Parts

Cab Water-Leak Detection

Use the following procedure to locate areas where water may intrude into the cab.

1. Park the vehicle, apply the parking brakes, and chock the front and rear tires.
2. Prepare a wash solution of at least one-quarter cup of soap to one gallon of water in a spray bottle.
3. Place tape over the cab exhausters.
4. Close all doors, windows, and vents.
5. With the HVAC system in "Fresh Air" mode, turn the fan blower motor on high.

NOTE: Perform the leak detection test with the HVAC system in the "Fresh Air" mode only. Do not set the system in the "Recirculation" mode.

6. Spray the cab, and sleeper if so equipped, with the wash solution, and look for bubbles. See **Fig. 1**. Inspect all applicable areas listed below:
    - windshield center post
    - windshield perimeter (especially the lower outboard corners)
    - upper windshield molding retainer strip
    - visor brackets (outboard more likely than center)
    - air horns and marker lights
    - roof deflector mounts (if so equipped)
    - coach joint
    - cab roof seams (especially raised-roof cap fore-aft seams)
    - sleeper roof seams (if present)
    - sleeper roof side windows (if present)
    - skylight window
7. Mark areas of suspected leaks.

NOTE: This method of leak detection may also identify areas that will not leak water, even though those areas produce bubbles. Bubbles around door seals, baggage doors, and along the vehicle side walls will likely not cause water intrusion issues.

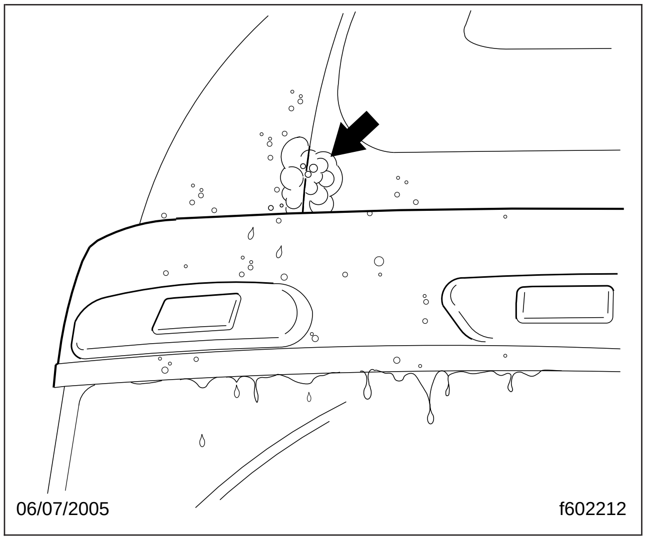


Fig. 1, Cab Water-Leak Detection with Wash Solution

If small bubbles are found in an area that is not suspected to leak, a repair may not be necessary.

8. Rinse the wash solution off the vehicle with water.
9. Turn off the fan blower motor.
10. Remove the tape from the cab exhausters.
11. Remove the chocks from the tires.

Cab Water-Leak Repair

If a leak is found, the repair method will depend on the area and type of leak. It may be necessary to remove some components, though most leaks should be repairable by sealing the area of the leak with silicone sealant.

Leaks in the Windshield or Skylight Sealant

Repair leaks in the windshield or skylight sealant using the approved method and adhesive. Refer to **Section 60.00** for instructions on windshield repair.

Leaks Caused by Structural Damage to a Roof Cap

Repair leaks caused by structural damage to a roof cap by using the procedures outlined in the applicable sections in this manual. Use the repair method appropriate to the material used in the roof cap construction.

To repair small leaks, clean with shop air and a clean rag, then seal with a silicone sealant.

Leaks in the Coach Joint Area

Repair leaks in the coach joint area without removing the roof cap, if possible. Seal the leak with silicone or a similar sealant.

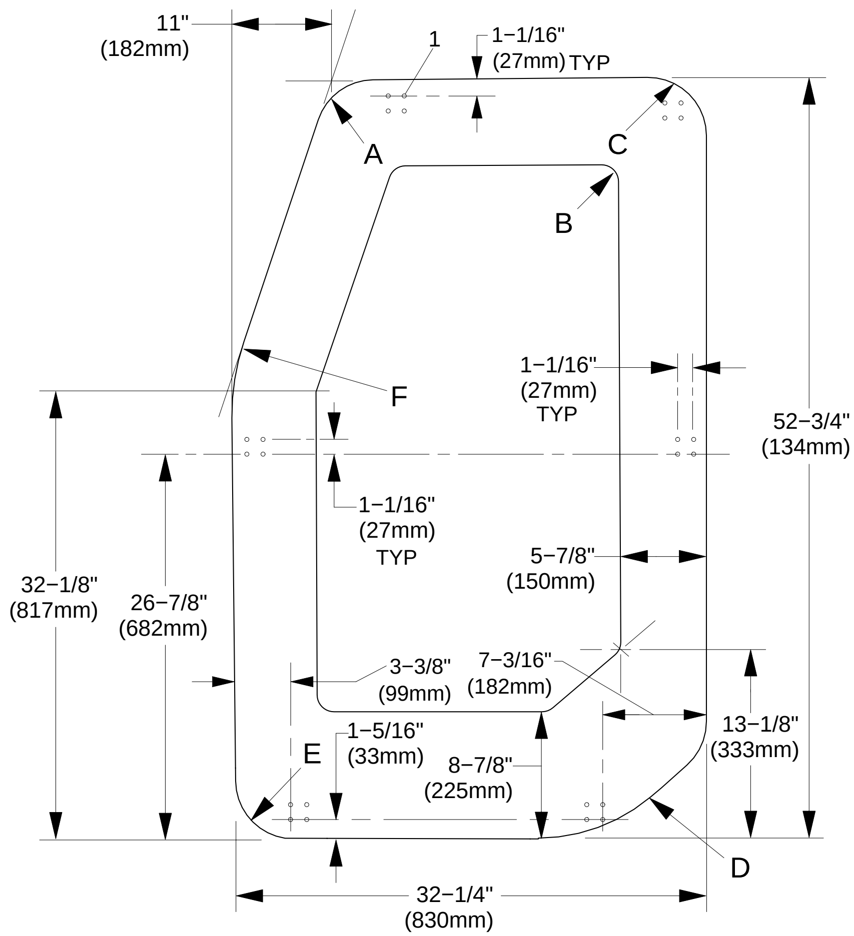
Specifications

See **Fig. 1** and **Fig. 2** for information and measurements to fabricate door plug assemblies.

See **Fig. 3** for information and measurements to fabricate the cab squaring tool.

See **Fig. 4** for information and measurements to fabricate door frame clamps.

See **Fig. 5** for information to modify C-clamps for use with door frame clamps.

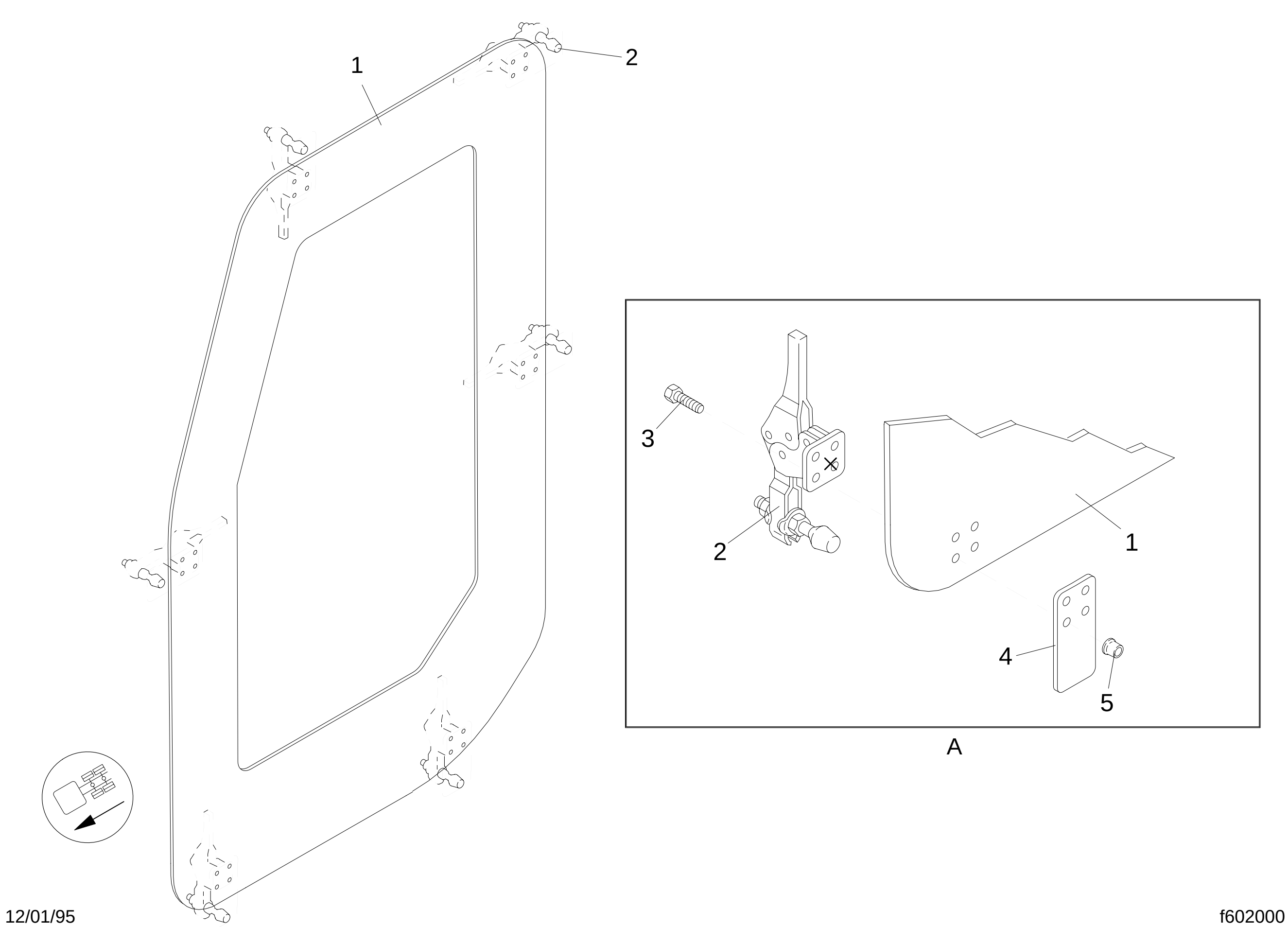


NOTE: Door plug material is to be 1/4-inch thick aluminum plate.

A. 4-inch (102-mm) Radius
B. 1-inch (25-mm) Radius
C. 4-inch (102-mm) Radius
D. 12-inch (305-mm) Radius
E. 4-inch (102-mm) Radius
F. 20-inch (508-mm) Radius
1. 1/4-Inch Diameter Hole

Fig. 1, Door Plug Specifications for Left Side of Vehicle

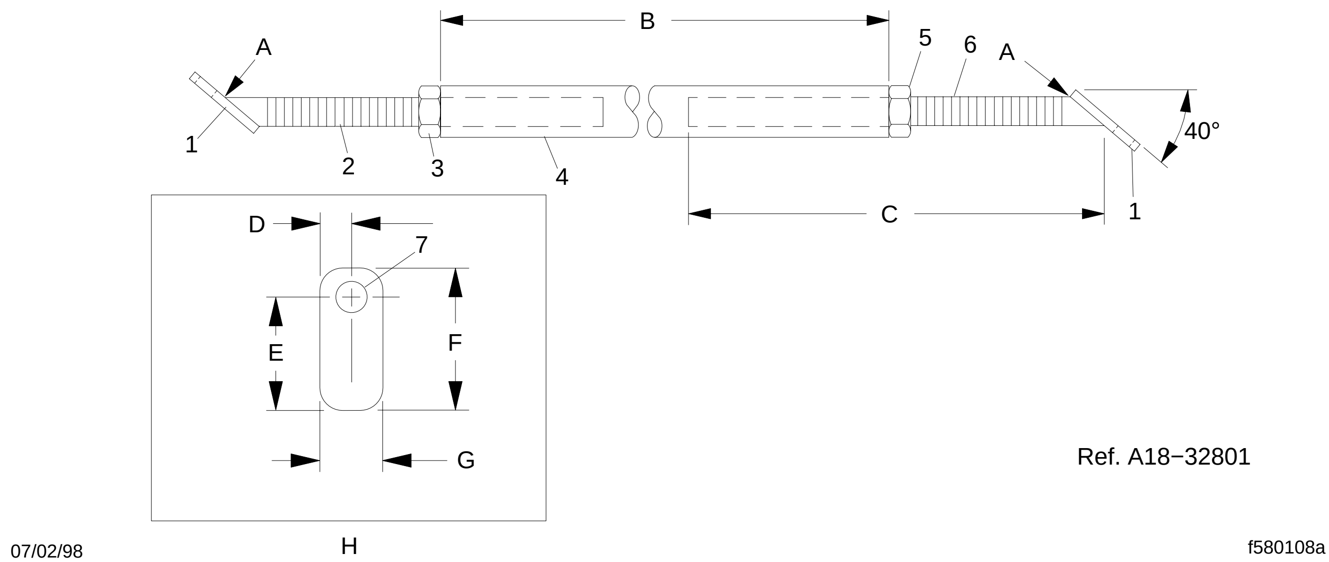
Specifications



A. Detail of Clamp Installation
1. Door Plug, 1/8-inch Thick Aluminum Plate
2. Special Clamp
3. 1/4-inch Huck® Bolt (4 qty.)
4. 1/8-Inch Thick Aluminum Plate, 1-3/4" (44 mm) x 3-7/8" (99 mm)
5. Huck Collar (4 qty.)

Fig. 2, Door Plug Clamp Installation

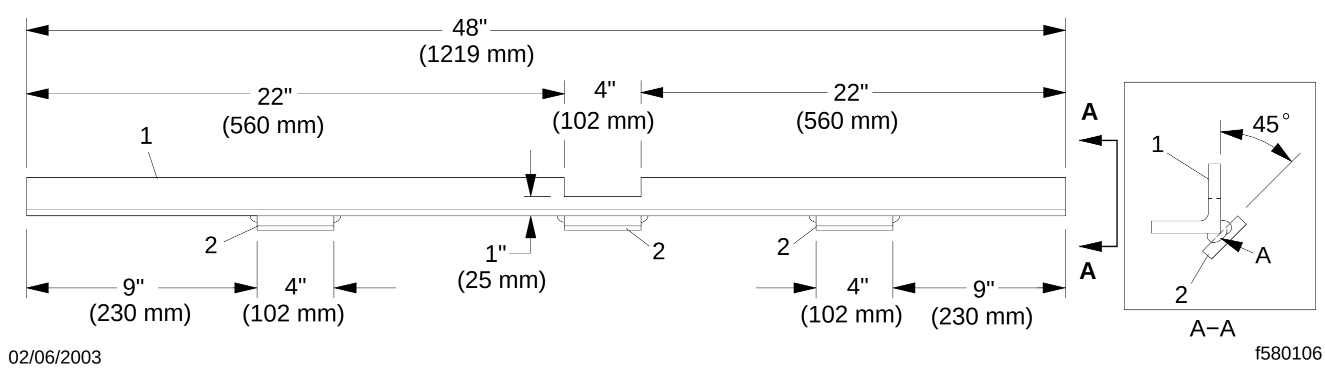
Specifications



A. Instruction: Fillet weld all the way around.
B. Measurement: 74-7/16 inches (1890 mm) [2] and 64-7/16 inches (1638 mm) [2]
C. Measurement: 20-1/16 inches (510 mm)
D. Measurement: 5/16 inches (8 mm)
E. Measurement: 1-1/8 inches (30 mm)
F. Measurement: 1-1/2 inches (38 mm)
G. Measurement: 5/8 inches (16 mm)
H. Plate Dimensions

1. 1/4-inch Thick Steel Plate
2. Threaded Rod, 1/2–13, Left-Hand Thread
3. Hexnut, 1/2–13, Left-Hand Thread (welded to pipe)
4. Steel Pipe, 1/2-Inch Diameter
5. Hexnut, 1/2–13, Right-Hand Thread (welded to pipe)
6. Threaded Rod, 1/2–13, Right-Hand Thread
7. Hole, 5/16" Diameter

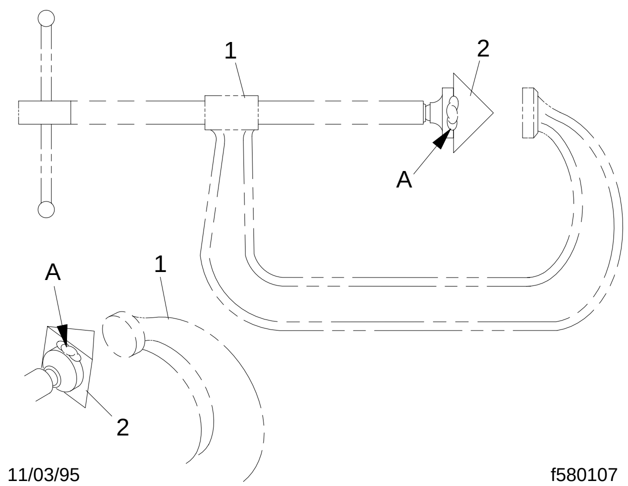
Fig. 3, Cab Squaring Tool



A. Fillet weld here.
1. 2" x 2" x 1/4" Aluminum Angle
2. Aluminum Plate, 1/4-Inch Thick, 4" x 1" (100 mm x 25 mm)

Fig. 4, Special Clamp for Door Frame, Left Side Shown

Specifications



A. Fillet weld here.
1. C-Clamp
2. Steel Wedge, 90-Degree Angle

Fig. 5, Modified C-Clamp for Use with Door Frame Clamp

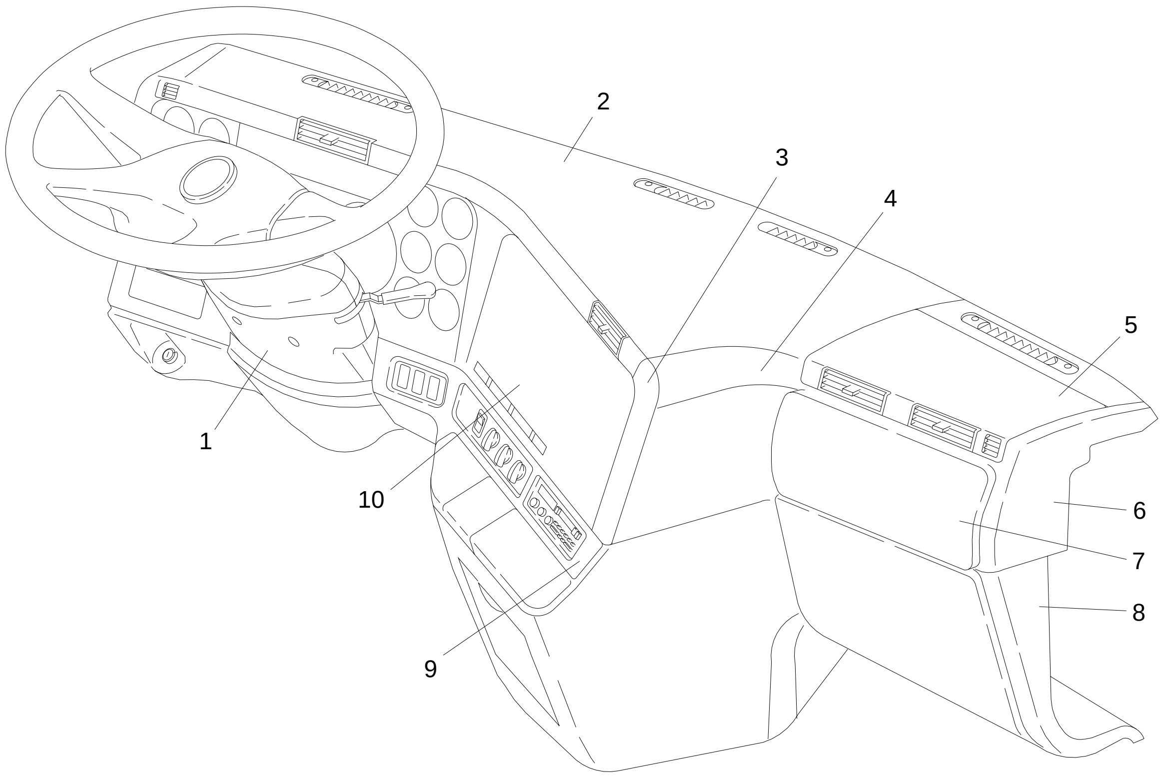
Dash Panels Removal and Installation

Removal

NOTE: When the dash is completely assembled (see Fig. 1), all dash fasteners are hidden from view.

Removing the upper dash assembly allows access to the following components: the face and defrost ducts, cab wiring, and the rear of the instrument panel.

Removing the lower dash panels allows access to the following components: the steering column cover, the keyswitch housing, waste bin slides, and the driver's console support.



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1. Steering Column Cover
2. Upper Dash Assembly (left-hand panel)
3. Right-Hand Dash Trimcap
4. Upper Dash Assembly (center panel)
5. Electrical Cover
6. Upper Dash Assembly (right-hand panel)
7. Right-Hand Upper Dash Cover
8. HVAC Cover
9. HVAC/Radio Trimplate
10. Auxiliary Instrument Panel

Fig. 1, Fully Installed Dash Panel

Removing the right-hand dash panels allows access to the following components: blower motor, resistor module, thermostat, heater core, evaporator core, and power distribution module.

Removing the left-hand dash panels allows access to the following components: the instrumentation control unit and auxiliary instrument panel.

Right-Hand Dash Panels

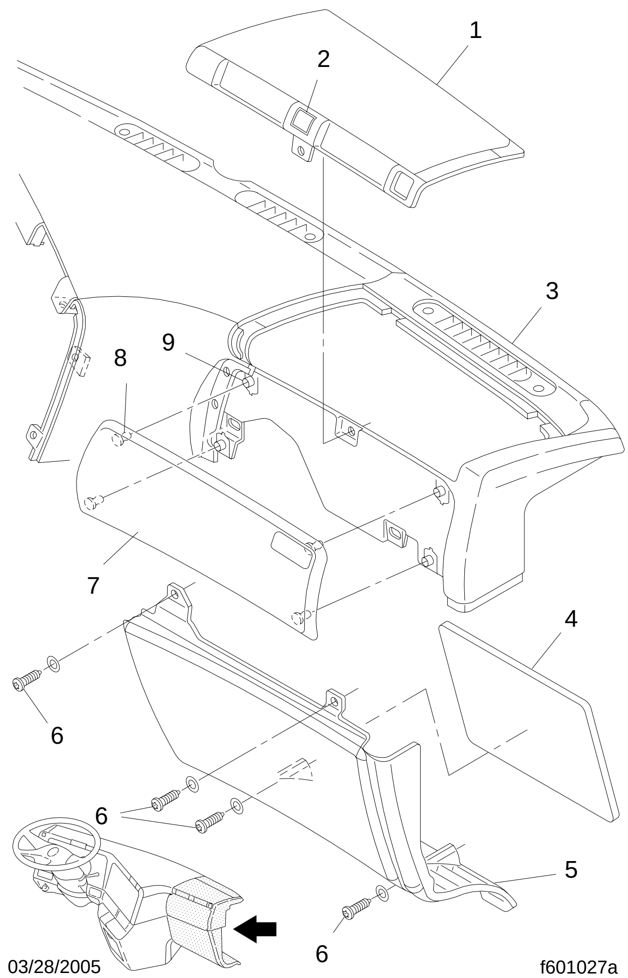
CAUTION

If the right-hand upper dash cover is difficult to remove, pry gently with a small screwdriver against the edge of the cover, using the slots

Dash Panels Removal and Installation

provided. Be careful to protect the underlying dash panel and not damage its finish.

1. Remove the right-hand upper dash cover by pulling gently aftward on the corners to disengage the four speed clips. This will expose the two screws that attach the top of the HVAC cover to the HVAC unit. See **Fig. 2**.

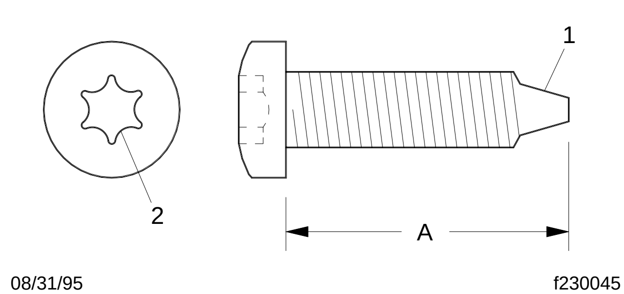


1. Electrical Cover
2. Push Button
3. Upper Dash Assembly
4. Cover Seal
5. HVAC Cover
6. Dog-Point Screws and Washers
7. Right-Hand Upper Dash Cover
8. Speed Clip
9. Speed Nut

Fig. 2, Right-Hand Dash Panels

NOTE: All screws used in the dash installation, unless otherwise called out, are T25 Torx® dog-point screws. See **Fig. 3**.

2. Remove the HVAC cover and footwell light (see **Fig. 4**).



A. 7/8 inch (22 mm)
1. Dog Point
2. T25 Torx

Fig. 3, Dog-Point Screw

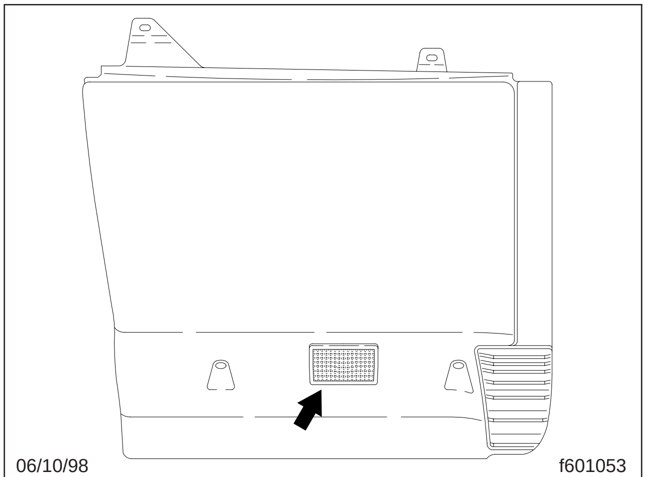


Fig. 4, Footwell Light

2.1 Remove the two screws at the top of the HVAC cover.

2.2 Remove the two screws at the bottom of the HVAC cover. Remove the HVAC cover from the dash.

2.3 Disconnect the electrical connector on the footwell light.

2.4 If needed, pry out the footwell light lens and replace the bulb.

Dash Panels Removal and Installation

3. Remove the electrical cover from the dash by pushing the push-button release that attaches the electrical cover to the upper dash assembly.
4. Remove the waste bin.
   4.1 Slide the waste bin out as far as it will go.
   4.2 Reach inside the waste bin and push the release tab.
   4.3 Remove the waste bin from the dash assembly.
5. Remove the cup holder by pulling up on the cup holder to unseat the two speed clips.
6. Remove the ashtray assembly.
   6.1 Open the ashtray.
   6.2 Press on the metal tab and pull the ashtray out.
   6.3 Remove the two 1-inch (25-mm) Torx screws that hold the ashtray housing to the left-hand console cover.
   6.4 Remove the ashtray housing.
7. Remove the right-hand console cover.
   7.1 Remove the two screws that attach the cover to the lower left-hand console cover.
   7.2 Remove the screw that attaches the cover to the lower left-hand console cover.
   7.3 Remove the screw at the back of the cover in the passenger footwell.
   7.4 Remove the screw that attaches the cover to the HVAC unit.
   7.5 Pull the bottom of the cover out to clear the tabs at the top of the lower right-hand console cover from the upper dash assembly.
   7.6 Remove the console cover.

Left-Hand Dash Panels

1. Remove the left-hand dash trim panels. See **Fig. 5**.

   NOTE: Removing the left-hand dash trim allows access to the left-hand and right-hand accessory switch panels.

   1.1 Rotate the driver's cupholder up and out of the way to expose two T25 dog-point screws that attach the HVAC/radio trimplate to the upper dash panel. Remove these screws.
   1.2 Remove the four speed clips that attach the HVAC/radio trimplate to the upper dash panel. Remove the HVAC/radio trimplate from the dash.
   1.3 Remove the two speed clips that attach the keyswitch trimplate to the keyswitch housing. Remove the keyswitch trimplate from the dash.
   1.4 Remove the screw and the speed clip that attaches the right-hand dash trimcap to the upper dash panel. Remove the right-hand dash trimcap from the dash.
2. Remove the instrument panel trim. See **Fig. 6**.

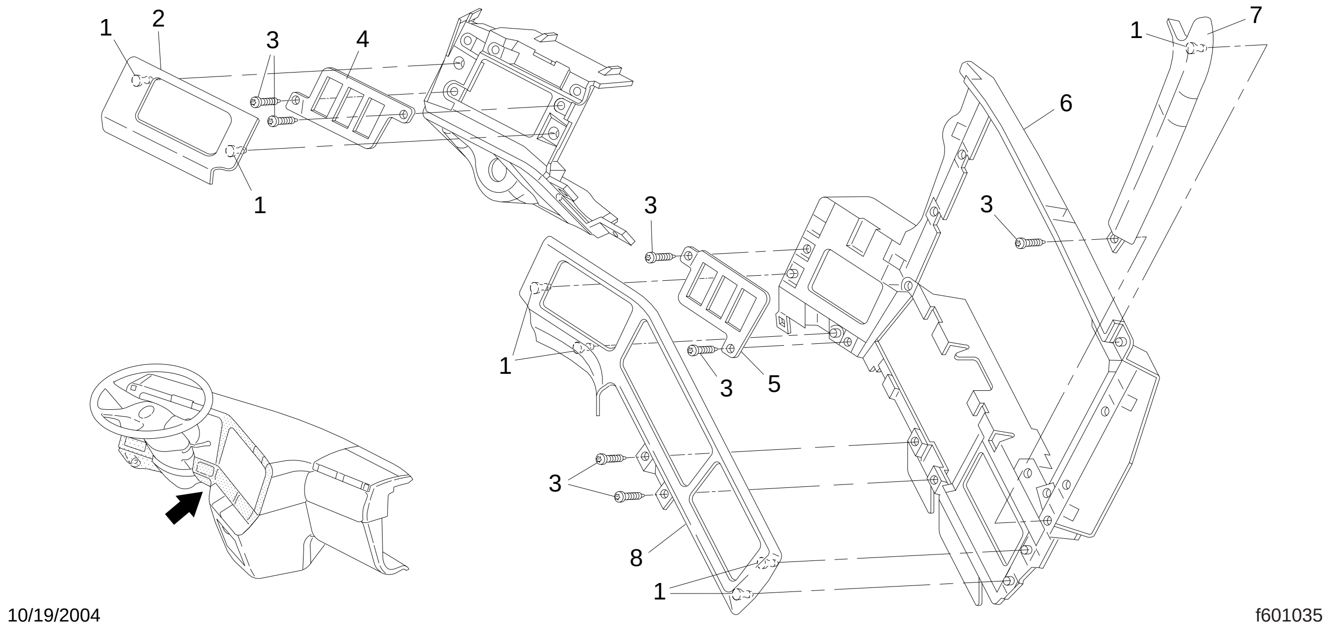
   NOTE: Removing the instrument panel trim allows access to the instrumentation control unit and auxiliary instrument panels.

   2.1 Remove the screw that attaches the left-hand dash endcap to the keyswitch housing. Remove the speed clip that attaches the left-hand dash endcap to the dash panel trimtop. Remove the left-hand dash endcap from the dash.
   2.2 Remove the dash message center bezel.
   2.3 Remove the two screws that attach the dash panel trimtop to the upper dash assembly. Leave the dash panel trimtop attached to the instrumentation control unit (ICU).
   2.4 If necessary to gain access, remove the steering column cover (clamshell cover).
   2.5 Work the bottom part of the instrument panel center trim out of the slot in the upper dash panel. Pull down on the center trim piece to free it from the mating surface on the upper dash assembly. Remove the center trim from the dash.

Upper Dash Assembly

1. Remove the electrical cover and right-hand upper dash cover using the instructions in "Right-Hand Dash Panels."

Dash Panels Removal and Installation



1. Speed Clip
2. Keyswitch Trimplate
3. T25 Dog-Point Screw
4. Left-Hand Accessory Switch Panel
5. Right-Hand Accessory Switch Panel
6. Upper Dash Panel
7. Right-Hand Dash Trimcap
8. HVAC/Radio Trimplate

Fig. 5, Left-Hand Dash Trim Panels

2. Remove the keyswitch trimplate and left-hand dash endcap, using the instructions in "Left-Hand Dash Panels."
3. Remove the upper dash assembly. See **Fig. 7**.

3.1 Remove the three 1-1/4 inch (3 cm) screws that attach the upper dash panel to the inserts along the underside of the upper dash assembly (left-hand panel).

3.2 Remove the three 1-1/4 inch (3 cm) screws that attach the upper dash assembly to the dash panel trim top.

3.3 Remove the plug in the lower right-hand console cover.

3.4 Remove the screw that attaches the dash brace to the upper dash assembly (center panel).

3.5 Remove the two screws that attach the upper dash assembly (right-hand panel) to the HVAC unit.

3.6 Remove the six screws located in the recessed areas around the louvers along the edge of the windshield.

3.7 Remove the two screws that attach the upper dash assembly to the upper dash panel.

3.8 Remove the upper dash assembly from the vehicle.

Lower Dash Panels

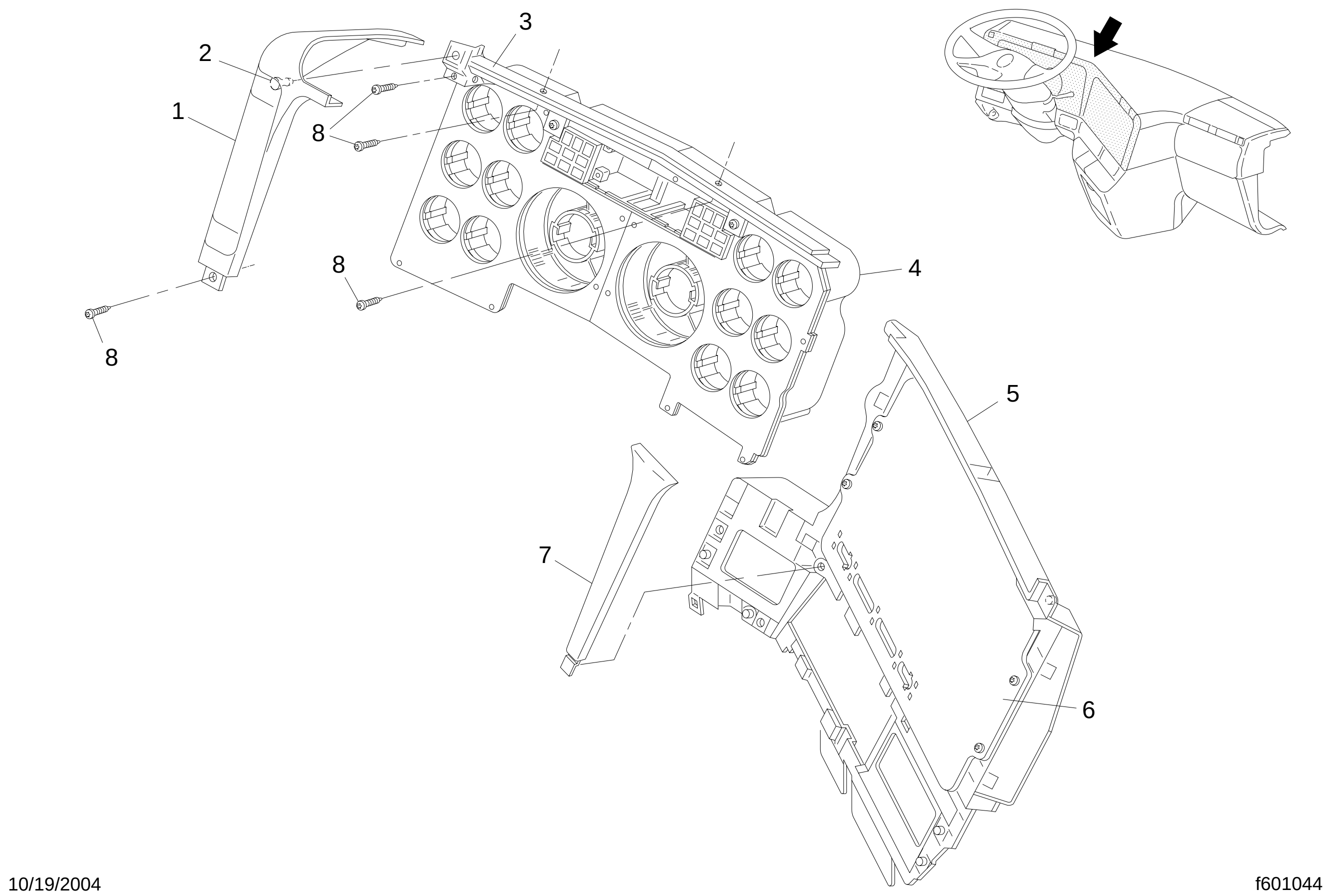
1. Remove the driver's knee bolster. See **Fig. 8**.

NOTE: Removing the driver's knee bolster allows access to the steering column cover (clamshell cover).

1.1 Remove the two speed clips that attach the lower part of the bolster to the keyswitch housing and the steering column bracket.

1.2 Unhook the knee bolster from the slots in the keyswitch housing and upper dash panel.

Dash Panels Removal and Installation



1. Left-Hand Dash Endcap
2. Speed Clip
3. Dash Panel Trimtop
4. Instrumentation Control Unit Housing
5. Upper Dash Panel
6. Auxiliary Instrument Panel
7. Instrument Panel Center Trim
8. T25 Dog-Point Screw

Fig. 6, Instrument Panel Trim

1.3 Remove the driver's knee bolster from the dash.

2. Remove the cup holder by pulling up on the cup holder to unseat the two speed clips.
3. Remove the HVAC/radio trimplate.

   3.1 Remove the two screws and washers that attach the trimplate to the upper dash panel.

   3.2 Pull up on the trimplate to disengage the four speed clips.
4. Remove the ashtray assembly.

   4.1 Open the ashtray.

   4.2 Press on the metal tab.

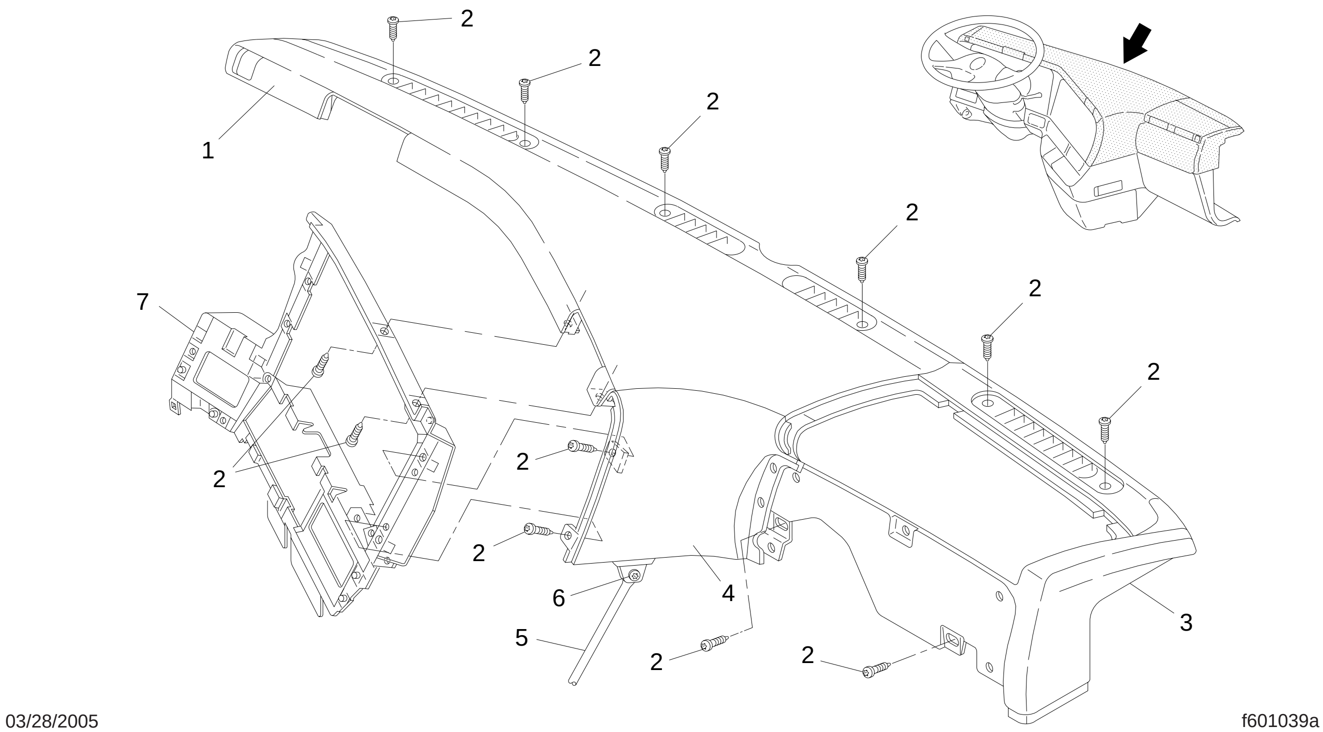
   4.3 Pull the ashtray out.

   4.4 Remove the two 1-inch (25-mm) Torx screws that hold the ashtray housing to the left-hand console cover.

   4.5 Pull the housing out.
5. Remove the waste bin.

   5.1 Slide the waste bin out as far as it will go.

Dash Panels Removal and Installation



1. Upper Dash Assembly (left-hand panel)
2. T25 Dog-Point Screw
3. Upper Dash Assembly (right-hand panel)
4. Upper Dash Assembly (center panel)
5. Dash Brace
6. Dash Brace Screw
7. Upper Dash Panel

Fig. 7, Upper Dash Assembly

5.2 Reach in the waste bin and push up on the tab at the top of the waste bin compartment.

5.3 Remove the waste bin.

6. Remove the left-hand console cover.

6.1 Remove the screw located behind the cover along the driver-side footwell edge.

6.2 Remove the screw and washer that attaches the cover to the steering column bracket.

6.3 Remove the three screws that attach the cover to the upper dash panel.

6.4 Remove the two screws that hold the cover to the lower right-hand console cover located through the ashtray and waste bin openings.

6.5 Remove the two 1-1/4 inch (30 mm) Torx screws that hold the cover to the engine tunnel cover.

6.6 Pull the cover out and reach behind to disconnect the cigarette lighter connector.

6.7 Remove the cover.

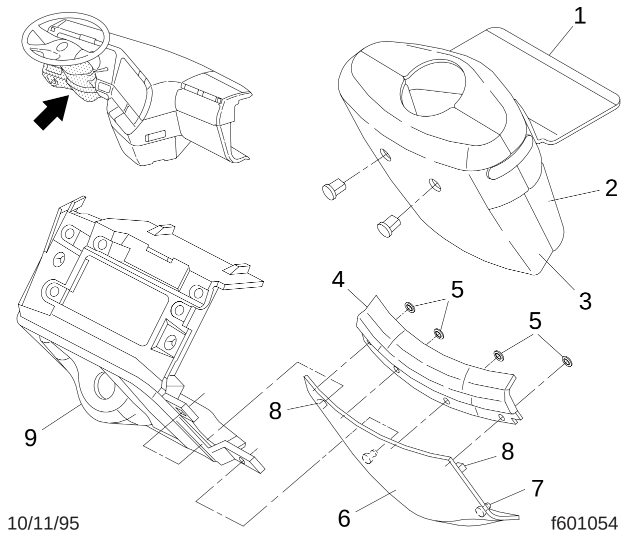
Installation

Lower Dash Panels

1. Install the left-hand console cover.

1.1 Connect the cigarette lighter connector to the cigarette lighter housing.

1.2 Install the two Torx screws that hold the cover to the engine tunnel cover.



1. Steering Column Upper Cover Seal
2. Upper Steering Column Cover
3. Lower Steering Column Cover
4. Steering Column Lower Cover Seal
5. Push-On Retainer
6. Driver's Knee Bolster
7. Speed Clip
8. Hook
9. Keyswitch Housing

Fig. 8, Driver's Knee Bolster

1.3 Install the two screws that hold the left-hand console cover to the lower right-hand console cover located through the ashtray and waste bin opening.

1.4 Remove the three screws that attach the cover to the upper dash panel.

1.5 Install the screw and washer that attaches the cover to the steering column bracket.

1.6 Install the screw located behind the cover along the driver side foot-well edge.

2. Install the ashtray assembly.

 2.1 Install the ashtray housing into the left-hand console cover.

 2.2 Install the two Torx screws that hold the housing to the left-hand console cover.

 2.3 Slide the ashtray in the ashtray housing and close the ashtray.

3. Slide the waste bin into the left-hand console cover.

4. Install the HVAC/radio trim plate.

 4.1 Position the speed clips over the holes in the upper dash panel.

 4.2 Install the two screws and washers that attach the trimplate to the upper dash panel.

5. Align the speed clips on the cup holder with the holes in the left-hand console cover and push the cupholder down into position.

6. Install the driver's knee bolster. See **Fig. 8**.

 6.1 Install the hooks on the top of the driver's knee bolster into the slots in the keyswitch housing and the upper dash panel.

 6.2 Install the speed clips that attach the knee bolster to the keyswitch housing and the steering column bracket.

 6.3 Press firmly against all four corners of the knee bolster to be sure all hooks and clips are firmly seated.

Upper Dash Assembly

1. Install the upper dash assembly. See **Fig. 7**.

 1.1 Fit the dash assembly into place along the edge of the windshield and over the top of the instrument panels.

 1.2 Install the six T25 dog-point screws in the recessed areas around the louvers along the edge of the windshield.

 1.3 Install the two screws that attach the upper dash assembly to the upper dash panel.

 1.4 Install the screw that attaches the dash brace to the upper dash assembly (center panel).

 1.5 Install the plug in the lower right-hand console cover.

 1.6 Install the three screws that attach the upper dash panel to the underside of the upper dash assembly.

 1.7 Install the three screws that attach the upper dash panel to the dash panel trim top.

Dash Panels Removal and Installation

1.8 Install the two screws that attach the upper dash assembly (right-hand panel) to the HVAC unit.

2. Install the electrical cover and right-hand upper dash cover using the instructions in "Right-Hand Dash Panels."
3. Install the keyswitch trimplate and left-hand dash endcap, using the instructions in "Left-Hand Dash Panels."

Left-Hand Dash Panels

1. Install the instrument panel trim. See **Fig. 6**.

   1.1 Insert the top edge of the instrument panel trim into its mating surface on the upper dash assembly. Insert the bottom edge of the instrument panel center trim down into the slot in the upper dash panel until it snaps into place.

   1.2 If removed, install the steering column cover (clamshell cover).

   1.3 Install the two screws that attach the dash panel trimtop to the upper dash assembly (left-hand panel).

   1.4 Snap the dash message center bezel into place.

   1.5 Install the speed clip that attaches the left-hand dash endcap to the dash panel upper trimtop. Install the screw that attaches the left-hand dash endcap to the key-switch housing.

2. Install the left-hand dash trim panels. See **Fig. 3**.

   2.1 Install the screw and the speed clip that attaches the right-hand dash trimcap to the upper dash panel.

   2.2 Install the two speed clips that attach the keyswitch trimplate to the keyswitch housing. If needed, replace the left-hand accessory/switch panel.

   2.3 Install the four speed clips and two screws that attach the HVAC/radio trimplate to the upper dash panel.

   2.4 Rotate the driver's cupholder down and into place, covering the screws on the HVAC/radio trimplate.

Right-Hand Dash Panels

1. Install the right-hand console cover.

   1.1 Slide the tabs at the top of the cover into the slots in the upper dash panel assembly.

   1.2 Install the screw that attaches the cover to the HVAC unit.

   1.3 Install the screw at the back of the cover in the passenger footwell area.

   1.4 Install the screw that attaches the cover to the left-hand console cover located in the cup holder area.

   1.5 Install the two screws that attach the cover to the left-hand console cover located through the ashtray and waste bin openings.

2. Install the HVAC cover (see **Fig. 2**) and footwell light.

   2.1 Connect the electrical connector on the footwell light.

   2.2 Place the HVAC cover into position over the upper dash assembly and install the two screws into the holes at the top of the HVAC cover.

   2.3 Install the two screws at the bottom of the HVAC cover.

3. Install the electrical cover on the dash.
4. Attach the four speed clips on the right-hand upper dash cover to the HVAC cover. See **Fig. 2**.
5. Align the speed clips on the cup holder with the holes in the left-hand console cover and push the cup holder into position.
6. Slide the waste bin into the left-hand console cover.
7. Install the ashtray assembly.

   7.1 Place the ashtray housing into the left-hand console cover.

   7.2 Install the two Torx screws that attach the ashtray housing to the left-hand console cover.

   7.3 Slide the ashtray into the ashtray housing and close the ashtray.

Exterior Sun Visor Removal and Installation

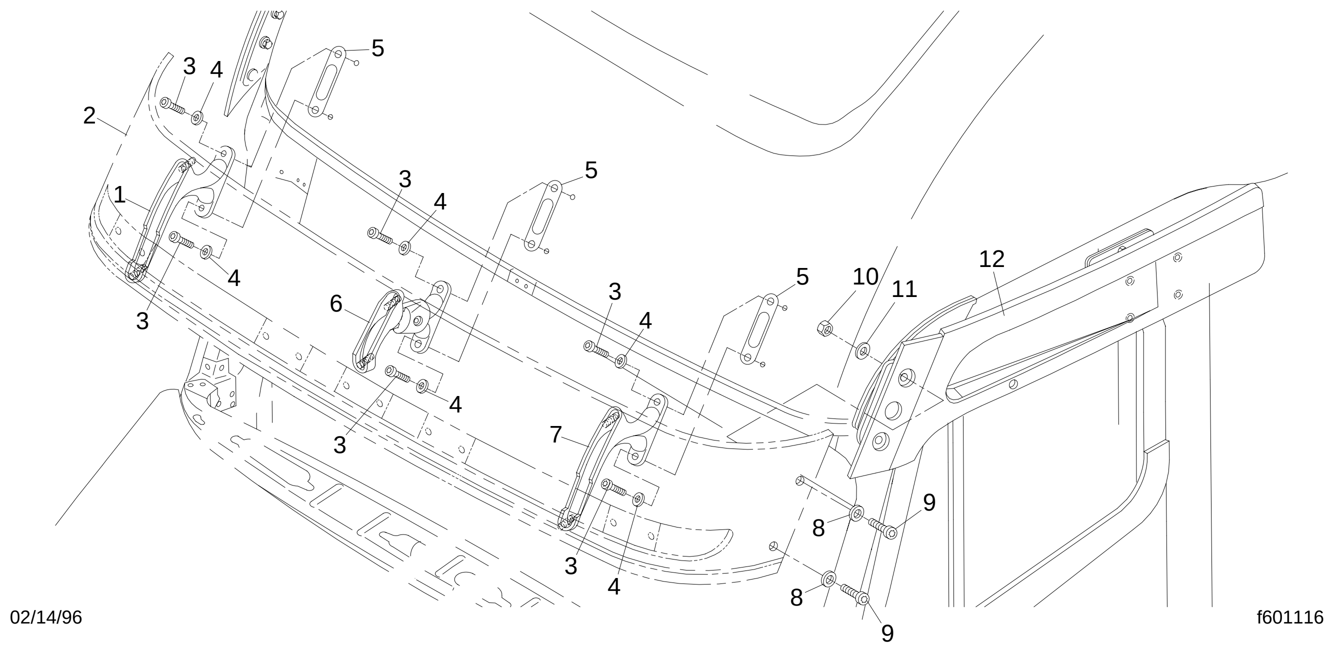
Sun Visor Removal

1. Park the vehicle, apply the parking brakes, then chock the rear tires.
2. Remove the front sun visor. See **Fig. 1** and **Fig. 2**.
   - 2.1 Remove the two 5/16–18 Torx®-head screws that hold both ends of the front sun visor to the side sun visors.
   - 2.2 Remove the 5/16–18 Torx-head screws and washers holding the front sun visor mounting brackets to the cab.
   - 2.3 Pull out the surplus wiring from the cab (where the right-front mounting bracket was installed); then disconnect it.
   - 2.4 Remove the front sun visor, mounting brackets, and seals.
   - 2.5 If replacing the sun visor itself, remove the 5/16–18 hexnuts and washers that hold the three mounting brackets to the visor; then remove the brackets.
3. If replacing the marker lights, remove the wiring harness cover from the back of the sunvisor; then remove the two screws holding each marker light in place and remove the marker light.
4. Remove the side sun visors. See **Fig. 3**.
   - 4.1 Remove the remaining 5/16–18 hexnut and washer holding the left-side sun visor to the forward outer mounting bracket.
   - 4.2 Remove the four 5/16–18 hexnuts and washers holding the left-side sun visor to the rear outer mounting bracket.
   - 4.3 Remove the left-side sun visor.
   - 4.4 Repeat the procedure for the right-side sun visor.
5. If needed, remove the side sun visor mounting brackets. See **Fig. 4**.
   - 5.1 Remove the Torx-head screws and washers from the forward and rear outer mounting brackets.
   - 5.2 Remove the brackets and their seals from the side of the cab.

Sun Visor Installation

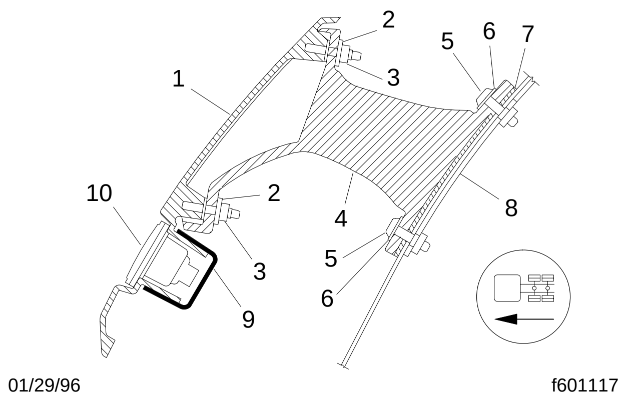
1. Install the side sun visors.
   - 1.1 If they were removed, install the forward and rear outer mounting brackets and their seals above the door frames.
   - 1.2 Align the left-side sun visor with the forward and rear mounting brackets. Install the 5/16–18 hexnuts and washers. Tighten them firmly.
   - 1.3 Repeat the procedure for the right-side sun visor.
2. Install the front sun visor.
   - 2.1 If they were removed, install the marker lights into the front sun visor. Install the wiring harness cover onto the back of the sun visor.
   - 2.2 If they were removed, install the three mounting brackets onto the front sun visor, using the 5/16–18 hexnuts and washers. Tighten the nuts firmly.
   - 2.3 Feed the wiring harness through the right mounting bracket
   - 2.4 Connect the marker light wiring to the cab harness, then push the extra length of wiring into the cab.
   - 2.5 Align the three mounting brackets with the holes in the cab roof. Make sure the holes on the ends of the front sun visor line up with those of the two side sun visors.
   - 2.6 Attach the front sun visor and mounting brackets to the cab roof, using 5/16–18 Torx-head screws. Tighten the screws firmly.
   - 2.7 Attach the ends of the front sun visor to the side sun visors, using the 5/16–18 Torx-head screws, hexnuts, and washers. Tighten the fasteners firmly.
3. Remove the chocks from the tires.

Exterior Sun Visor Removal and Installation



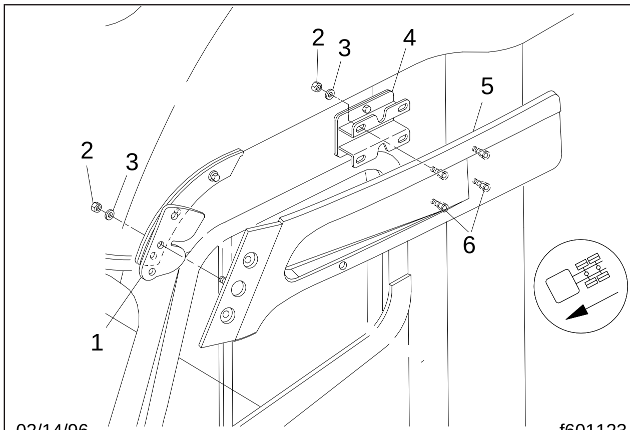
1. Side Mounting Bracket, Right
2. Front Sun Visor
3. 5/16–18 Torx®-Head Screw
4. Flatwasher
5. Seal
6. Center Mounting Bracket
7. Side Mounting Bracket, Left
8. Washer
9. Torx-Head Screw
10. Hexnut
11. Flatwasher
12. Side Sun Visor

Fig. 1, Front Exterior Sun Visor Installation



1. Front Sun Visor
2. Flatwasher
3. 5/16–18 Hexnut
4. Mounting Bracket
5. Torx-Head Screw
6. Washer
7. Seal
8. Cab Skin
9. Wiring Harness Cover
10. Parking Light

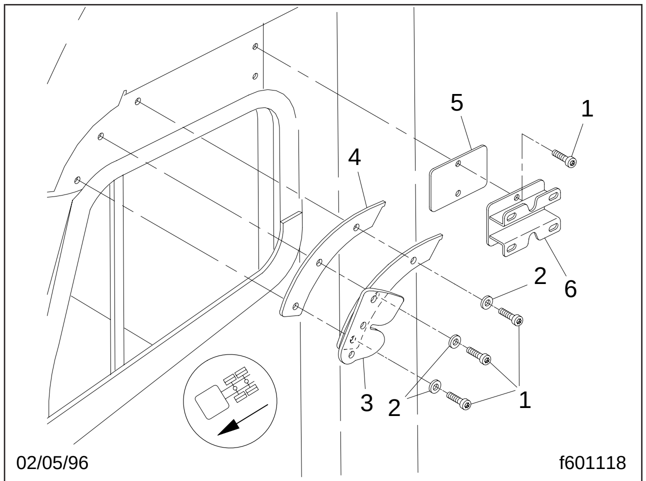
Fig. 2, Cross Section View



1. Front Outer Mounting Bracket
2. 5/16–18 Hexnut (4 qty.)
3. Flatwasher (4 qty.)
4. Rear Outer Mounting Bracket
5. Left-Side Sun Visor
6. Threaded Stud (4 qty.)

Fig. 3, Side Sun Visor Installation

Exterior Sun Visor Removal and Installation



1. Torx-Head Screw
2. Washers
3. Front Outer Mounting Bracket
4. Seal
5. Seal
6. Rear Outer Mounting Bracket

Fig. 4, Side Sun Visor Mounting Brackets

Wrap-Around Side Storage Cabinets (See Fig. 1)

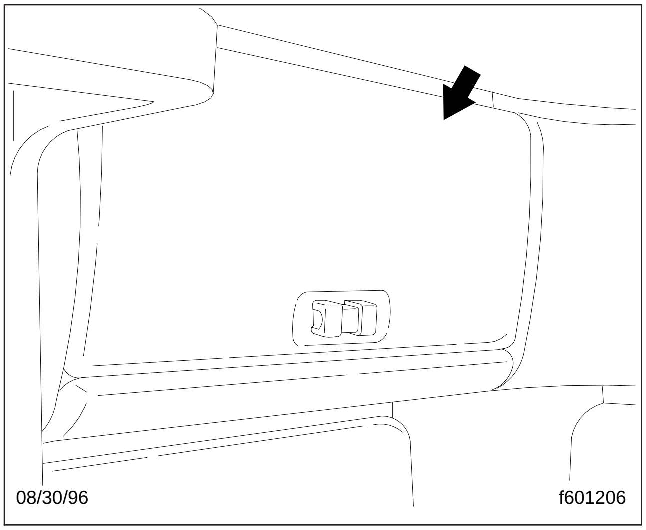


Fig. 1, Wrap-Around Storage Side Cabinet

IMPORTANT: Interior components are varied and optional. The following generalized information is intended for broad use, and should not be considered as a guide for a specific vehicle.

SIDE CABINET REMOVAL

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.

IMPORTANT: The rear center cabinet must be removed before the side cabinets can be removed. When installing the cabinets, the side cabinets must be installed before the rear center cabinet is installed.

2. Remove the Torx®-head screws holding the storage cabinet to the roof.

NOTE: The number of fasteners varies according to the type and style of interior components.

3. Lift up the rear of the cabinet so that the cabinet clears the edge of the side upholstery panel, then slide it out.
4. Disconnect the speaker wires inside the cabinet.
5. Repeat the procedure on the cabinet on the other side of the vehicle.

SIDE CABINET INSTALLATION

NOTE: When installing the side wrap-around cabinets, tip them in at the bottom so that the lips on the rear edge of the cabinets hook over the mounting channel behind the upholstery panels.

IMPORTANT: The rear center cabinet must be removed before the side cabinets can be removed. When installing the cabinets, the side cabinets must be installed before the rear center cabinet is installed.

1. Slide the side cabinet into position, taking care to clear the side panel. Make sure the cabinet fully seats into the mounting channel.
2. Connect the speaker wires inside the cabinet.
3. Attach the cabinet to the side wall upholstery.
4. Remove the chocks from the tires.

Wrap-Around Rear Center Storage Cabinet (See Fig. 2)

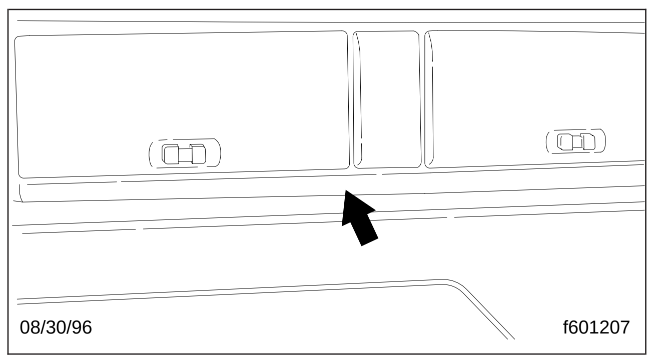


Fig. 2, Wrap-Around Rear Center Storage Cabinet

REAR CENTER CABINET REMOVAL

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.

IMPORTANT: The rear center cabinet must be removed before the side cabinets can be removed. When installing the cabinets, the side cabinets must be installed before the rear center cabinet is installed.

Removal and Installation

2. Remove the Torx-head screws attaching the storage cabinet to the rear headliner.

NOTE: The number of fasteners varies according to the type and style of interior components.

3. Maneuver the bottom of the storage cabinet to clear the rail above the rear wall upholstery panel. Allow the cabinet to drop down at the forward edge, and then lift the rear of the cabinet.
4. Remove the storage cabinet from the vehicle.

REAR CENTER CABINET INSTALLATION

NOTE: When installing the rear center wraparound cabinet, tip it in at the bottom so that the lips on the rear edge of the cabinet hooks over the mounting channel behind the upholstery panels. Make sure the cabinet fully seats into the rearwall extrusion.

IMPORTANT: The rear center cabinet must be removed before the side cabinets can be removed. When installing the cabinets, the side cabinets must be installed before the rear center cabinet is installed.

1. Lift the storage cabinet into position.
2. Attach the cabinet into place using the Torx-head screws.

NOTE: The number of fasteners varies according to the type and style of interior components.

3. Remove the chocks from the tires.

Upper Forward Side Storage Cabinet (See Fig. 3)

REMOVAL

NOTE: If the interior configuration features a driver's-side upper cabinet separate from the lower side cabinet, and a passenger-side upper cabinet sits directly on top of the lower side cabinet, use the following instructions for removal and installation.

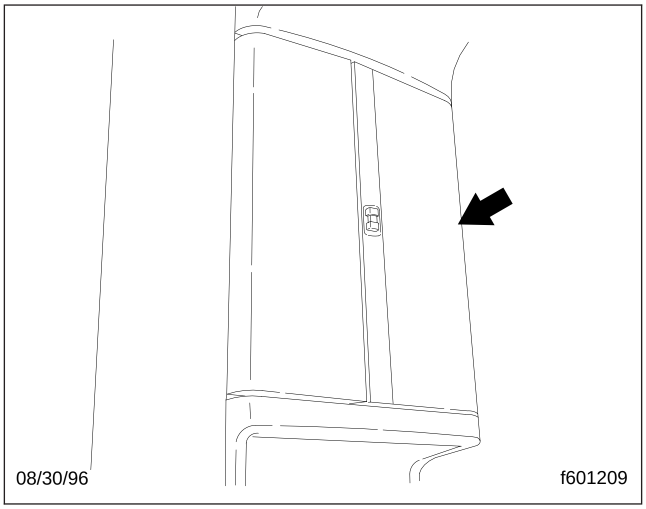


Fig. 3, Upper Forward Side Storage Cabinet

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. On the driver side, remove the two fasteners that attach the storage cabinet to the headliner and the roof.
3. Remove the fasteners that attach the storage cabinet to the side wall.

NOTE: The number of fasteners varies according to the type and style of interior components.

4. Remove the storage cabinet.
5. Repeat the procedure for the passenger side cabinet.

INSTALLATION

1. Position the side storage cabinet.
2. Attach the side storage cabinet to the side wall using the fasteners.
3. Attach the side storage cabinet to the headliner and roof using the fasteners.
4. Remove the chocks from the tires.

Front Overhead Side Consoles

(See Fig. 4)

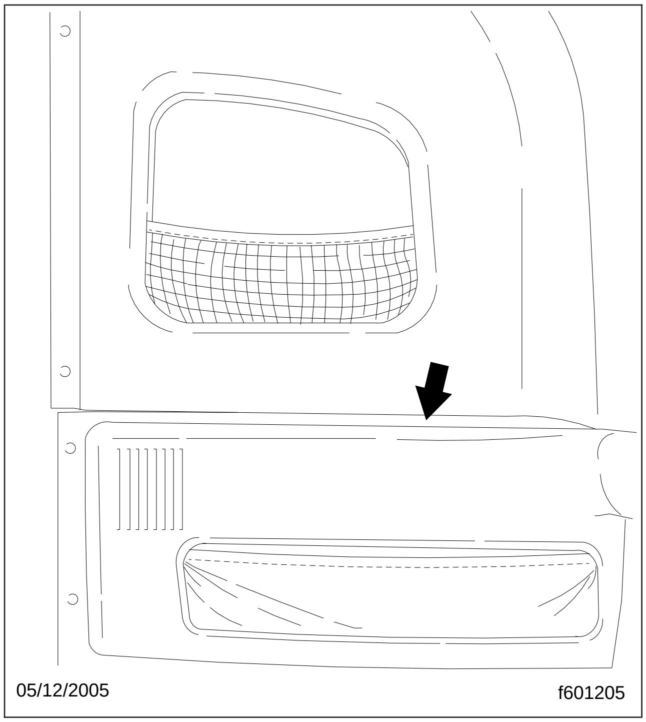


Fig. 4, Front Overhead Side Console

REMOVAL

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the privacy curtain and the curtain rail from the forward headliner. The fasteners are in the top track.
3. Remove the four fasteners attaching the side console in place.
4. Repeat the procedure for the other side console.

INSTALLATION

1. Position the side console into place.
2. Attach with the four fasteners.
3. Install the privacy curtain rail and the privacy curtain.
4. Remove the chocks from the tires.

Front Overhead Center Storage Console (See Fig. 5)

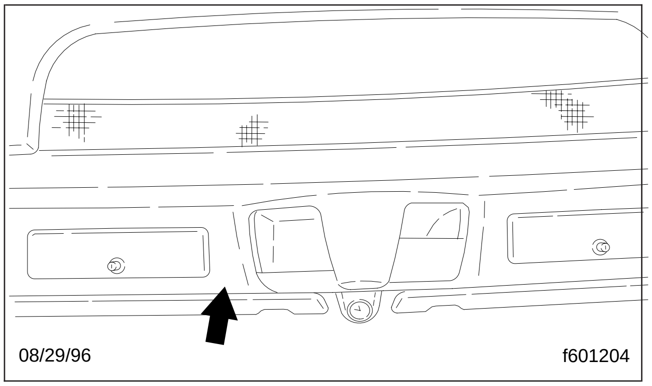


Fig. 5, Front Overhead Center Storage Console

REMOVAL

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the A-pillar inner covers.
3. Remove the grab handle on the passenger side.
4. Remove the privacy curtain and the curtain rail.
5. Remove the front overhead side consoles.
6. Remove the six fasteners that attach the center console to the windshield header.
7. Lower the center overhead console, then disconnect the wiring harness at the right-hand A-pillar.

INSTALLATION

1. Connect the wiring harness at the right-hand A-pillar.
2. Lift the center overhead console into position.
3. Attach the console with the six fasteners.
4. Install the front overhead side consoles.
5. Install the privacy curtain rail and the privacy curtain.
6. Install the upholstery panels on the A-pillar.
7. Install the grab handle on the passenger side.
8. Remove the chocks from the tires.

Removal and Installation

Side Wall Upholstery Panel

(See Fig. 6)

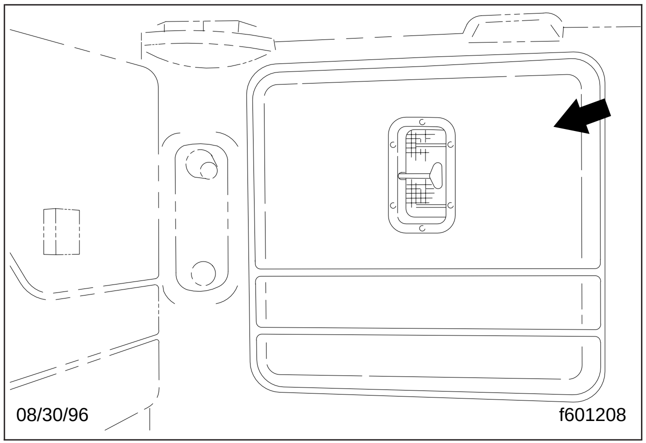


Fig. 6, Side Wall Upholstery Panel

REMOVAL

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the upper and lower forward side storage cabinets.
3. Remove the upper rear side (wrap-around) storage cabinets.
4. Remove the trim from the sleeper vent.
5. On the left side, remove the HVAC control panel, and disconnect the wiring.
6. Remove the side panels with care to keep the Christmas tree-type fasteners attached to the panel.

INSTALLATION

1. Attach the side panels with the Christmas tree-type fasteners.
2. Connect the wiring and install the HVAC control panel.
3. Install the sleeper vent trim.
4. Install the upper rear side (wrap-around) storage cabinets.
5. Install the upper and lower forward side storage cabinets.
6. Remove the chocks from the tires.

Rear Headliner

REMOVAL

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the side storage (wrap-around) cabinets. Then, remove the rear upper center cabinets.
3. Remove the upper forward side storage cabinets.
4. Remove the dome light by popping off the lens, removing the screw, and disconnecting the wiring.
5. Remove the moldings along the front edge of the headliner.
6. Remove the four Christmas tree-type fasteners, and then pry free the headliner.

INSTALLATION

1. Install the headliner with the Christmas tree-type fasteners.
2. Install the dome light.
3. Install the upper forward side storage cabinets.
4. Install the rear upper side storage cabinets, and then the rear upper center (wrap-around) cabinets.
5. Install the moldings along the front edge of the headliner.
6. Remove the chocks from the tires.

Forward Headliner

REMOVAL

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove the privacy curtain and the privacy curtain rail.
3. Remove the sleeper curtain and the sleeper curtain rail.

4. Remove the dome light by popping off the lens, removing the screw, and disconnecting the wiring.
5. Remove the four Christmas tree-type fasteners and pry free the forward headliner.

INSTALLATION

1. Install the forward headliner using the four Christmas tree-type fasteners.
2. Install the dome light.
3. Install the privacy curtain rail and the privacy curtain.
4. Install the sleeper curtain rail and the sleeper curtain.
5. Remove the chocks from the tires.

Back Wall Upholstery Panel

(See Fig. 7)

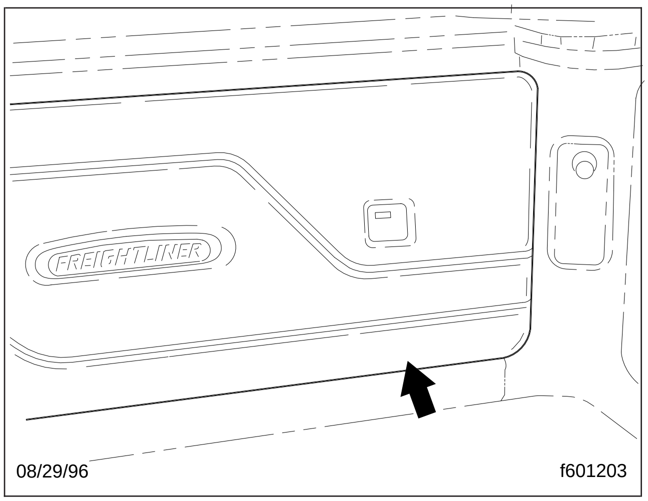


Fig. 7, Back Wall Upholstery Panel

REMOVAL

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Remove all of the upper (wrap-around) storage cabinets, beginning with the side storage cabinets.
3. Carefully pry free the Christmas tree-type fasteners at back wall upholstery panel.
4. Remove the back wall panel.

INSTALLATION

1. Position the back wall panel into place.
2. Install the back wall panel using the Christmas tree-type fasteners.
3. Install the upper (wrap-around) storage cabinets.
4. Remove the chocks from the tires.

General Description

BAGGAGE DOORS

On vehicles with sleeper compartments, baggage doors allow access to the storage compartments under the sleeper bunk.

The baggage doors have rounded corners, single-panel construction, a piano-style hinge, and a one-piece extruded aluminum door frame. A neoprene sponge bulb seal is set into the door frame. A door check cable limits opening the door beyond approximately 105 degrees.

Baggage doors have a keyed lock cylinder and a paddle handle. The same key used for the cab doors and the ignition is used for the baggage doors.

ACCESS DOOR

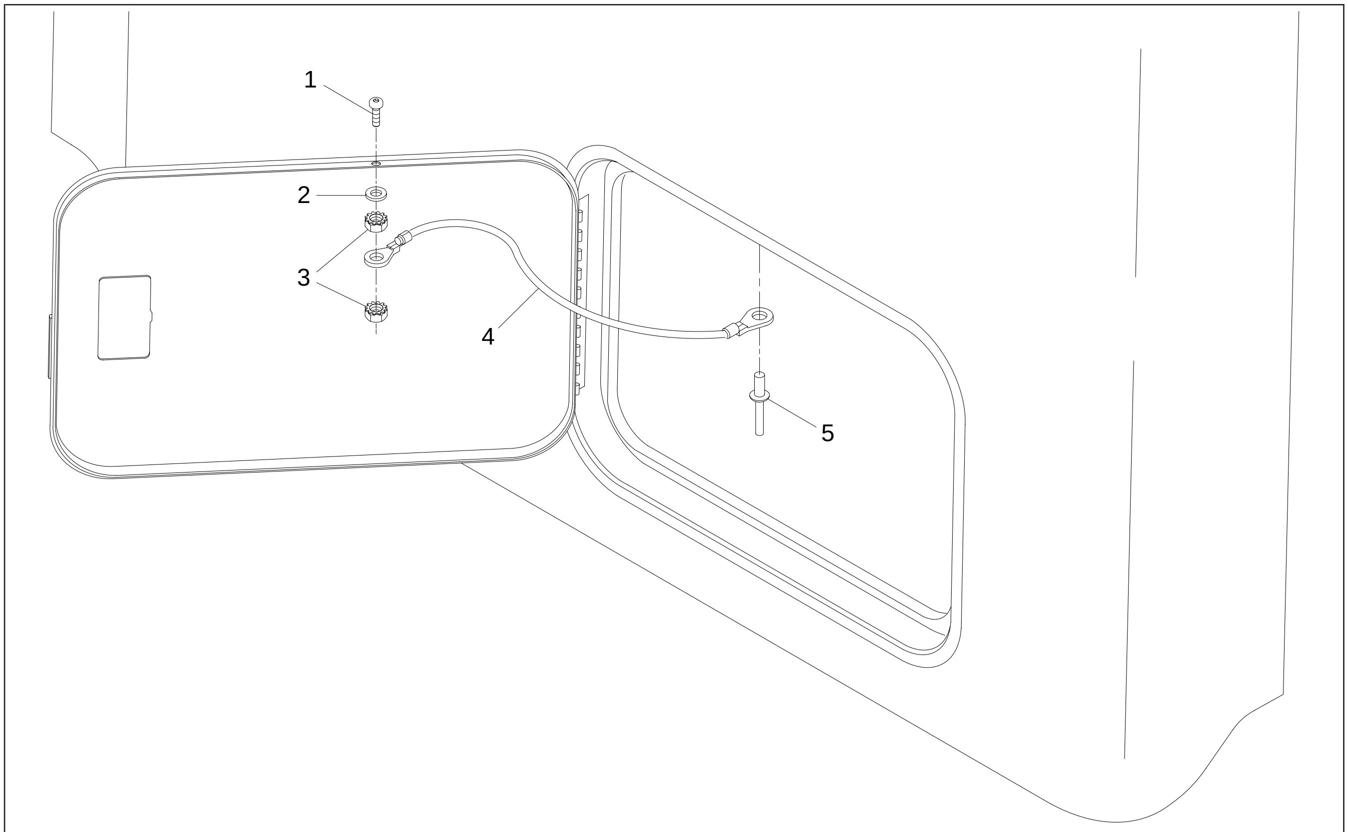
Access to sleeper compartments is provided by an access door, in addition to the walk-through opening at the back of the cab. The access door is on the passenger side of the vehicle. The access door is a rounded-corner, bulkhead-style door.

The door is flush with the outermost edge of the drip molding. A neoprene bulb seal fits into the inner flange of the door opening. There is a gas spring door check to prevent the door from opening too far.

An optional lever handle releases the access door from inside the sleeper compartment.

Replacement

1. Park the vehicle on a flat surface. Shut down the engine. Set the parking brake. Chock the tires.
2. Open the baggage door.
3. Disconnect the door check cable. See **Fig. 1**.
4. Partially remove the baggage liner upholstery.
5. Drill out the rivets attaching the door hinge to the door.
6. Remove the door from the vehicle.
7. Position the door to the vehicle.
8. Install the baggage door to the door hinge with fasteners, then buck rivet the door into place, removing the fasteners.
9. Attach the door check cable.
10. Install the baggage liner upholstery.
11. Remove the chocks from the tires.



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1. Bolt
2. Washer
3. Locknuts
4. Door Check
5. Monobolt

Fig. 1, Baggage Door

Baggage Door Seal Replacement

Replacement

1. At the seal seam located at the center of the bottom of the door frame, pull the entire length of the seal out of the door frame. See **Fig. 1**.
2. Clean and dry the seal area of the door frame. Remove any grease or dirt from the surface.
3. If not already done, cut a length of new door seal that is slightly longer than the total perimeter of the baggage door.
4. Using a soap-and-water solution, and beginning with one (squared off) end of the seal at the center of the bottom inside edge of the door frame, install the door seal, making sure that the contour of the seal is fitted to the curved lip of the door panel all the way around its perimeter. To avoid pulling the seal away from the corners of the door frame, do not stretch the seal.
5. Just prior to complete seating of the door seal, cut off (square) the excess length of the seal so that the two ends will form a hairline seam (butt joint) at the center of the bottom of the door panel. Press the seal ends together.
6. Test the door for ease of opening and closing.

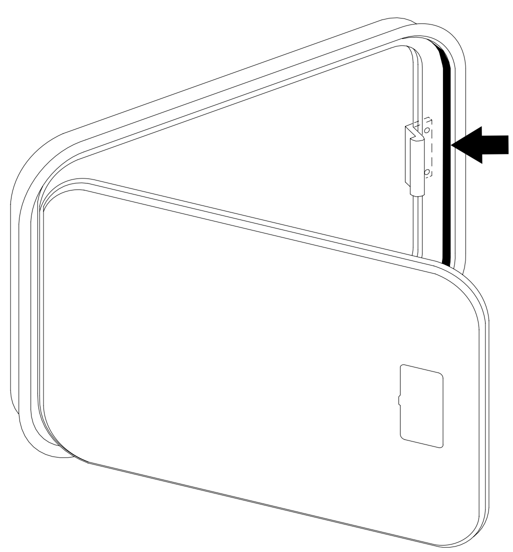
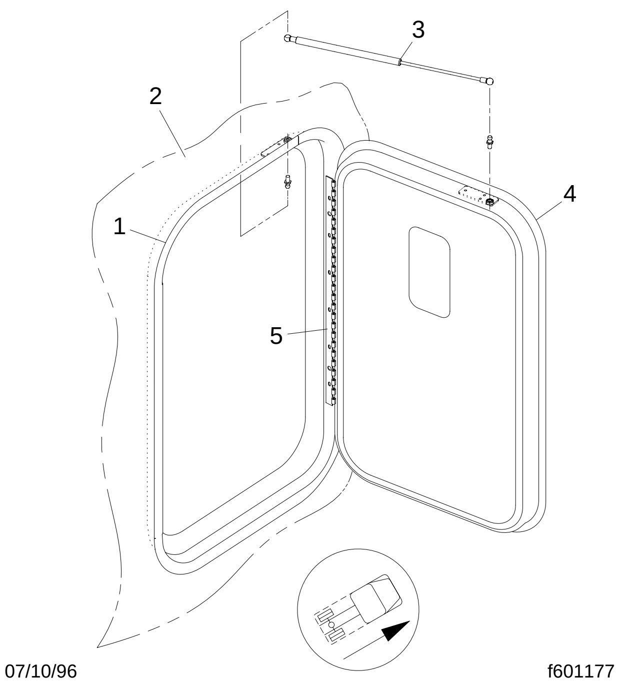


Fig. 1, Baggage Door Seal

Replacement

1. Park the vehicle on a flat surface. Shut down the engine. Set the parking brake. Chock the tires.
2. Disconnect the door check strut at the top of the door by removing the clip cover that attaches the strut end to the door. See Fig. 1.



1. Door Frame
2. Cab Wall
3. Door Check Strut
4. Access Door
5. Hinge

Fig. 1, Access Door

3. Remove the interior cab trim for access to the fasteners that attach the door hinge to the cab.
4. Remove the door by removing the rivets holding the door in place.
5. To install the door, position the door into place on the door frame, then rivet into place.
6. Attach the clip cover connecting the door strut to the top of the door.
7. Close the door, and test for proper closing.
8. Install the interior cab trim.
9. Remove the chocks from the tires.

Access Door Seal Replacement

Replacement

1. Gripping the end of the door seal, pull the entire length of the seal away from the inner door frame.
2. Remove any grease or dirt from the seal flange.
3. Using a soap-and-water solution, install the new seal onto the inner door frame so the bulb-portion of the seal is facing the door when the door is open. The ends of the seal should be located at the bottom of the door frame. To avoid pulling the seal away from the corners of the inner door frame, do not stretch the seal.
4. Just prior to complete seating of the door seal, cut off (square) any excess length of the seal so that the two ends will form a hairline seam (butt joint).
5. Test the door for ease of opening and closing.

Specifications

Description	Torque lbf·in (N·m)
Sleeper Box Access Door Striker Pin	50 (68)

Table 1, Torque Values

Air Horn Valve Removal and Installation

Removal

1. Park the vehicle. Set the parking brake. Shut down the engine and chock the tires.
2. Drain the air supply, and disconnect the batteries.
3. Remove the overhead console. See **Section 60.13** for instruction.
4. Disconnect the air hoses from the air horn valve. Mark the hoses for later reference.
5. Remove the fasteners that attach the air horn valve to the mounting bracket.
6. Disconnect the air horn control cable from the air horn valve.
7. Remove the air horn valve.

Installation

1. Position the air horn valve.
2. Connect the control cable to the air horn valve.
3. Mount the valve on its brackets and secure it with the fasteners.
4. Connect the air hoses to the air horn valve.

CAUTION

Do not overtighten the air hose fittings. Hand-tighten the fittings 1/2-turn after tightening begins. Overtightening the fittings could cause the hoses to leak, to malfunction, and to affect the vehicle air system.

5. Install the overhead console. See **Section 60.13** for instruction.
6. Connect the batteries.
7. Remove the chocks from the tires. Start the engine, and refill the air supply.
8. Test the horn.

Overhead Console Removal and Installation, Columbia

Removal

1. Park the vehicle. Set the parking brake. Shut down the engine and chock the tires.
2. Drain the air supply, and disconnect the batteries.
3. Remove the curtains from the curtain rails.
4. Remove the Torq-head fasteners attaching the curtain rails to the underside of the overhead console. Then, remove the curtain rails.
5. Remove all items from the overhead console compartments.
6. Peel the door moldings from the inner door frames.
7. Remove the grab handle from the right A-pillar cover. Then, remove both A-pillar covers. Do so by pulling back on the pillar cover, which is held in place by three tabs.
8. Set aside the VORAD sensor device (if equipped) from the right A-pillar.
9. Remove the fasteners attaching the side front console panels above the driver and passenger seats. Remove the panels.
10. Remove the six fasteners holding the overhead console in place.
11. Remove the overhead console by pulling it out and then swinging it downward.
12. Disconnect the electrical wiring connectors.
13. Remove the overhead console from the vehicle.

Installation

1. Position and then slide the overhead console into place.
2. Connect the electrical wiring connectors.
3. Install the six fasteners that attach the console to the cab structure.
4. Attach the side front console panels.
5. Attach the VORAD sensor to the right A-pillar cover, if it was removed.
6. Install the A-pillar covers by snapping them into place.
7. Install the grab handle on the right side A-pillar.
8. Attach the door moldings to the inner door frames.
9. Install both curtain rails.
10. Attach each curtain to the curtain rails.
11. Connect the batteries.
12. Remove the chocks from the tires.

Safety Precautions

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cable, and any electronic control units or similar devices installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, which could result in malfunction of the components.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake, and chock the front and rear tires.
2. Tilt the hood.
3. Disconnect the batteries. Attach the welding ground strap as close to the work being done as safely possible.
4. Disconnect the following ECUs and other electronic devices:

ENGINE ELECTRONIC CONTROL UNIT (ECU)

The location of the engine ECU differs with the engine manufacturer. See **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**.

INSTRUMENT CLUSTER UNIT (ICU)

The ICU includes the driver's instrument panel, the ICU housing, and the dash message center (all installed as one unit). To disconnect the ICU, see **Section 54.03** in this manual.

DATA LOGGING UNIT (DLU)

The DLU is one of several electronic modules mounted inside a compartment on the lefthand B-pillar, behind the driver's seat. See **Fig. 5**. The data logging unit is the top unit, and is mounted above the auxiliary power distribution module. Disconnect the electrical connector from the bottom of the unit.

AIR CONDITIONING PROTECTION UNIT (ACPU)

The ACPU connector is located near the bottom of the righthand side of the firewall in the engine compartment.

ANTILOCK BRAKE SYSTEM (ABS)

The ABS ECU is mounted in the B-pillar compartment. See **Fig. 5**.

AUXILIARY POWER DISTRIBUTION MODULE (APD)

The APD module is mounted in the B-pillar compartment. See **Fig. 5**.

VORAD SYSTEM

The ECU for the VORAD system is mounted in a small compartment on the righthand B-pillar, behind the driver's seat.

DAYTIME RUNNING LIGHTS

The ECU for the Daytime Running Lights is located in a small compartment on the righthand B-pillar, behind the driver's seat.

RADIO

Disconnect the electrical connection to the radio.

ALTERNATOR

Disconnect the ground strap, as previously mentioned, and this should serve to remove any chance for damage to the alternator.

WINDOW EXPRESS MODULE

The Window Express module is located beneath the driver's step threshold plate. Remove the plate to disconnect the module connection.

VEHICLE SECURITY SYSTEM

The vehicle's security system ECU is mounted in the righthand B-pillar compartment.

SPACE SYSTEM

If the vehicle is so equipped, the SPACE system's ECU is disconnected by unplugging the wiring at-

Safety Precautions

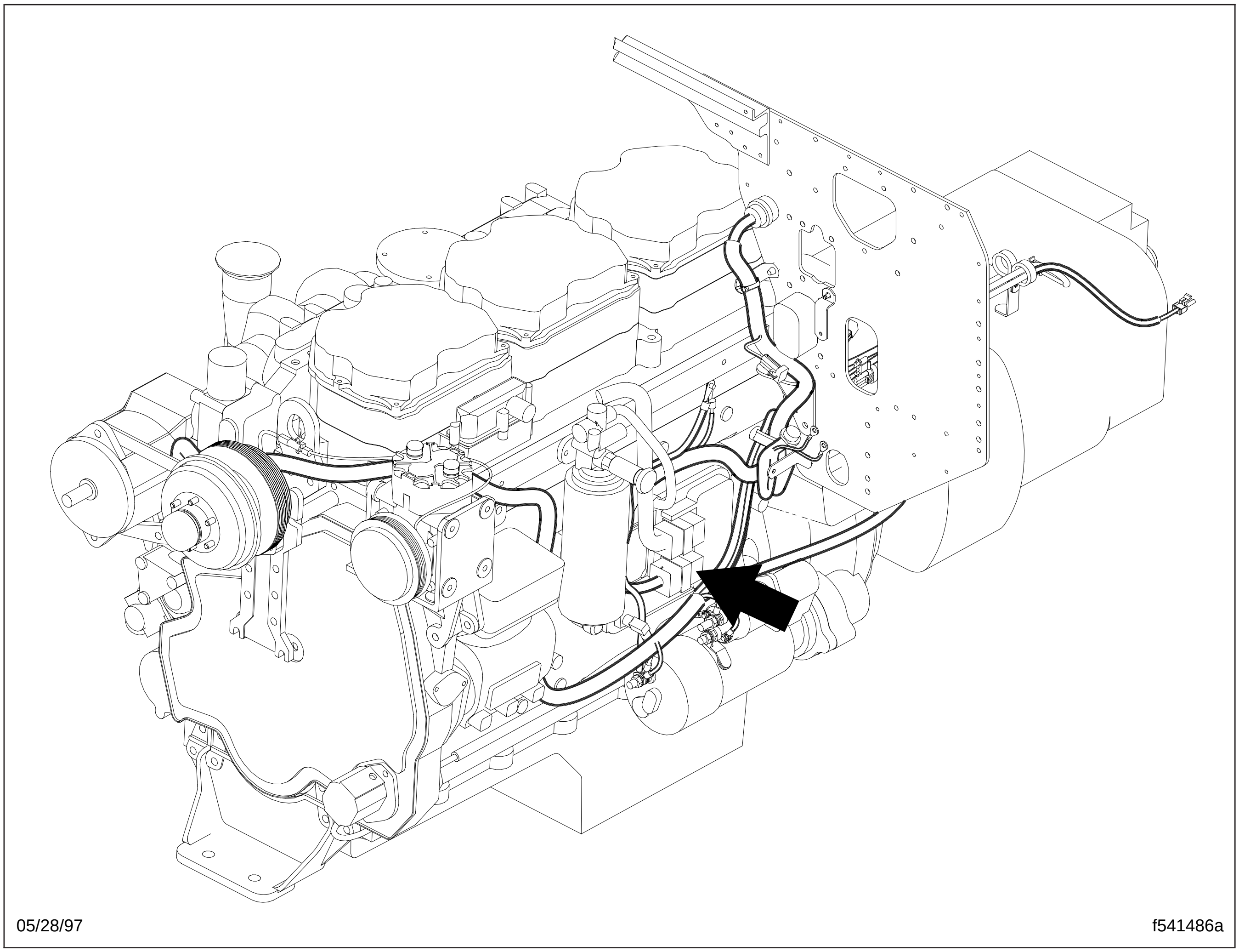


Fig. 1, Caterpillar C-10/C-12/3176 Engine ECU Location

tached to the SPACE device mounted behind the operator's seat.

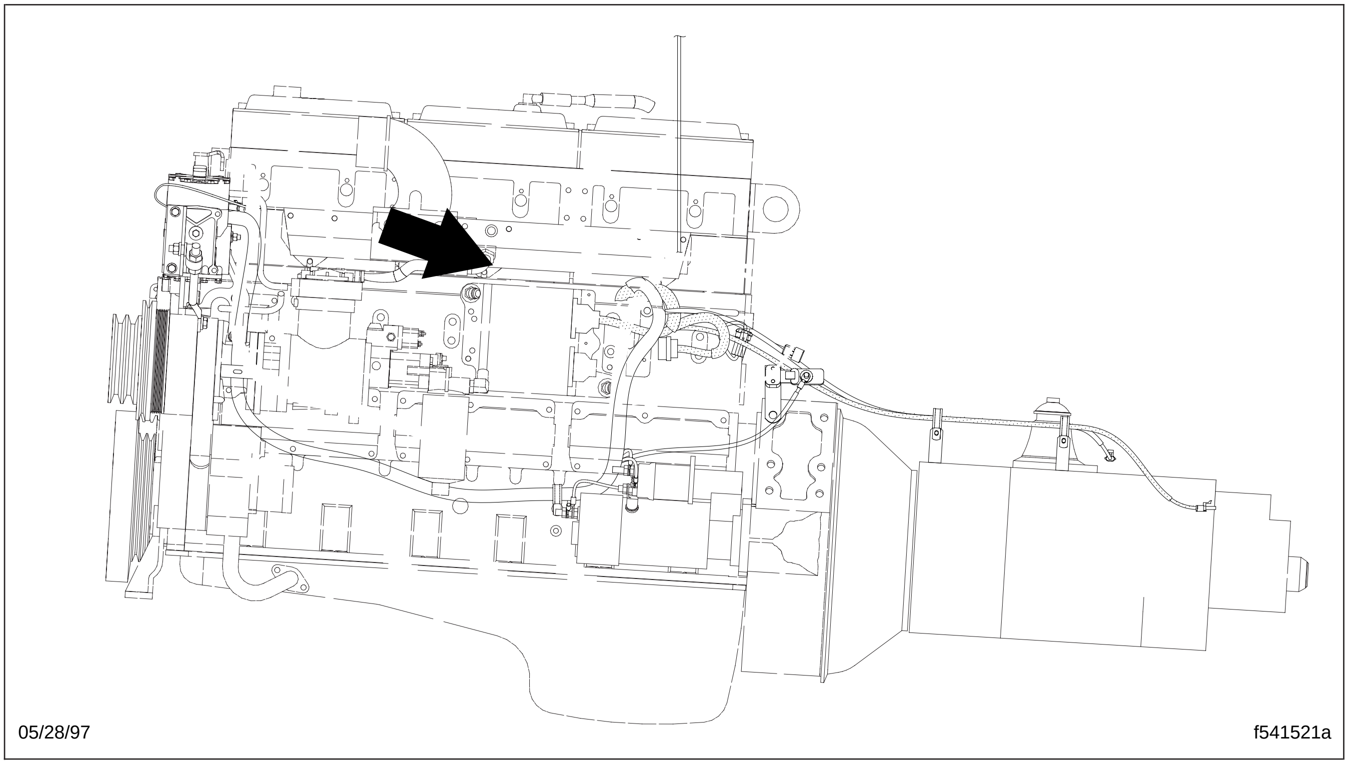


Fig. 2, Cummins N14 Engine ECU Location

Safety Precautions

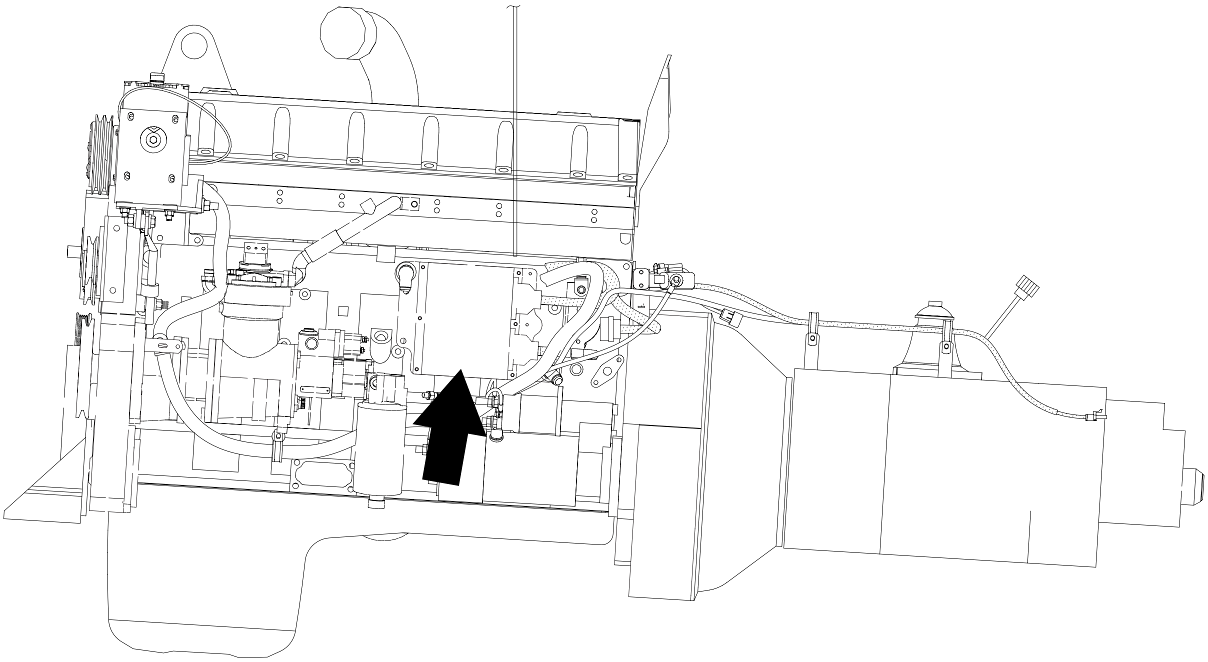


Fig. 3, Cummins M11 Engine ECU Location

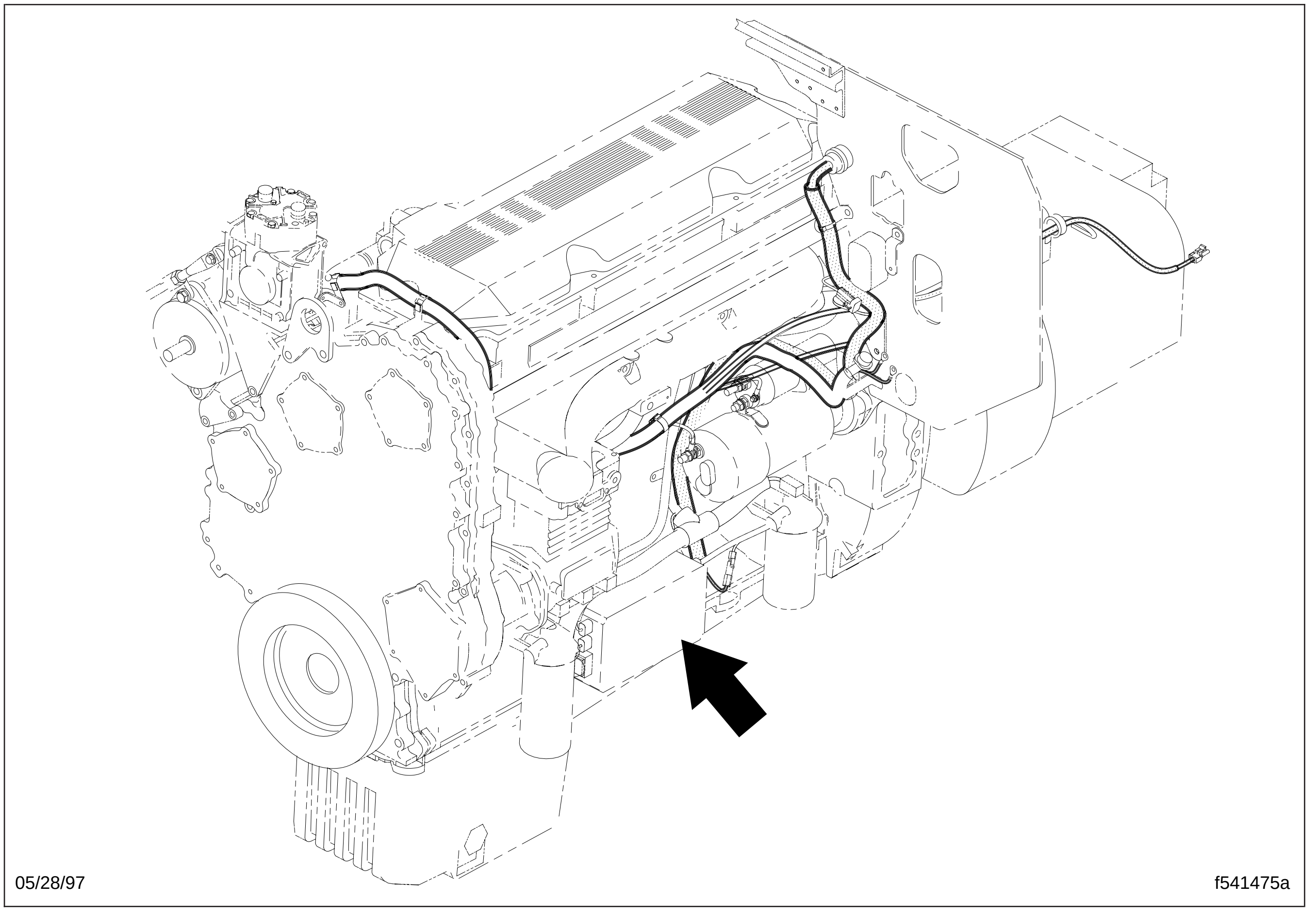
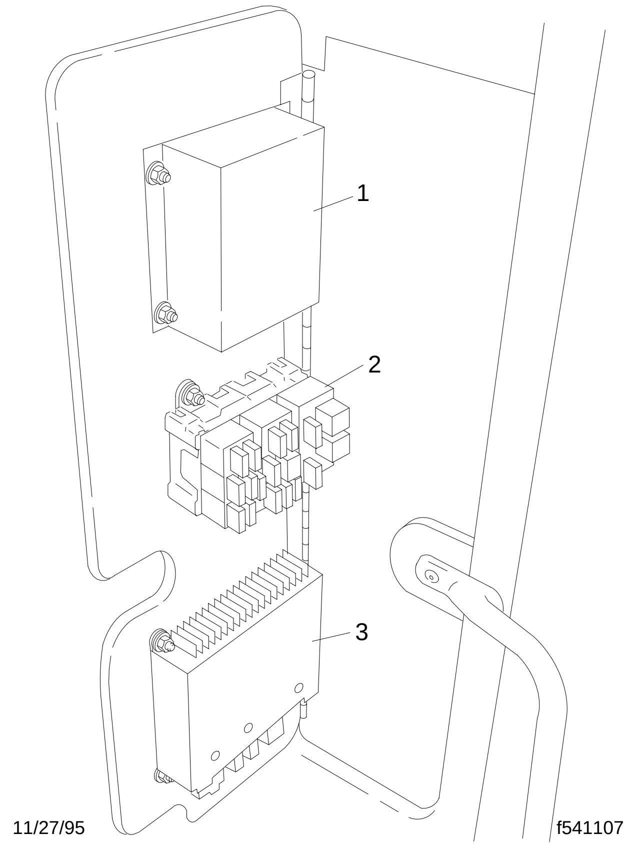


Fig. 4, Detroit Diesel Series 60 Engine ECU Location

Safety Precautions



1. Data Logging Unit
2. Auxiliary Power Distribution Module
3. ABS ECU

Fig. 5, Left-hand B-Pillar Electrical Compartment

Driver's Lounge Under-Bunk Storage Bin

REMOVAL

NOTE: The Driver's Lounge consists of the driver's lounge lower bunk, the fold-down table, the under-bunk storage bin, and the side cushion chairs. See **Fig. 1** and **Fig. 2**.

1. Park the vehicle, shut down the engine, apply the parking brake, and chock the rear tires.
2. With the driver's lounge table in the stowed position (latched to the underside of the lower bunk) raise and latch the lower bunk in its vertical position. See **Fig. 1**.
3. Press the push-button latch on the storage bin (**Fig. 2**, Ref. 2) and pull forward to gain access to the storage area.
4. Remove the shoulder bolt (Ref. 3) at each end of the storage bin and remove the bin.

INSTALLATION

1. With the driver's lounge table in the stowed position, raise and latch the lower bunk in its vertical position.
2. Place the storage bin into position between the side cushion chairs.
3. Install and tighten the passenger-side shoulder bolt and then the driver's side shoulder bolt.

NOTE: The shoulder bolts thread into mating clinch nuts in the seat box assemblies at each side.

4. Open and close the storage bin to ensure proper alignment of the bin and proper latch engagement.
5. Remove the chocks from the tires.

Driver's Lounge Table

REMOVAL

1. Park the vehicle, shut down the engine, apply the parking brake, and chock the rear tires.
2. With the driver's lounge table in the stowed position, raise and latch the lower bunk in its vertical position. See **Fig. 1**.

NOTE: The next step is best performed with the aid of an assistant. Take note of the positions of the nylon bushing and flatwasher (Refs. 13 and 14) before removing them.

3. Have the assistant hold the table in position and remove the table link-to-table mounting bolts (Ref. 3) on both sides of the table.

NOTE: When the bolts are removed, the table will drop slightly as the table pins and nylon spacers (Ref. 12) come to rest in the bottoms of the table support casting (Ref. 9) guides.

4. Have the assistant hold the table. Then unlatch and place the table leg into position to support the table.

NOTE: Doing this will unlatch the table from the striker (Ref. 7) on the underside of the bunk, if it is still engaged.

5. Carefully lift and maneuver the table away from the bunk. Use care to disengage the table pins and nylon spacers from the table support casting guides at the same time.

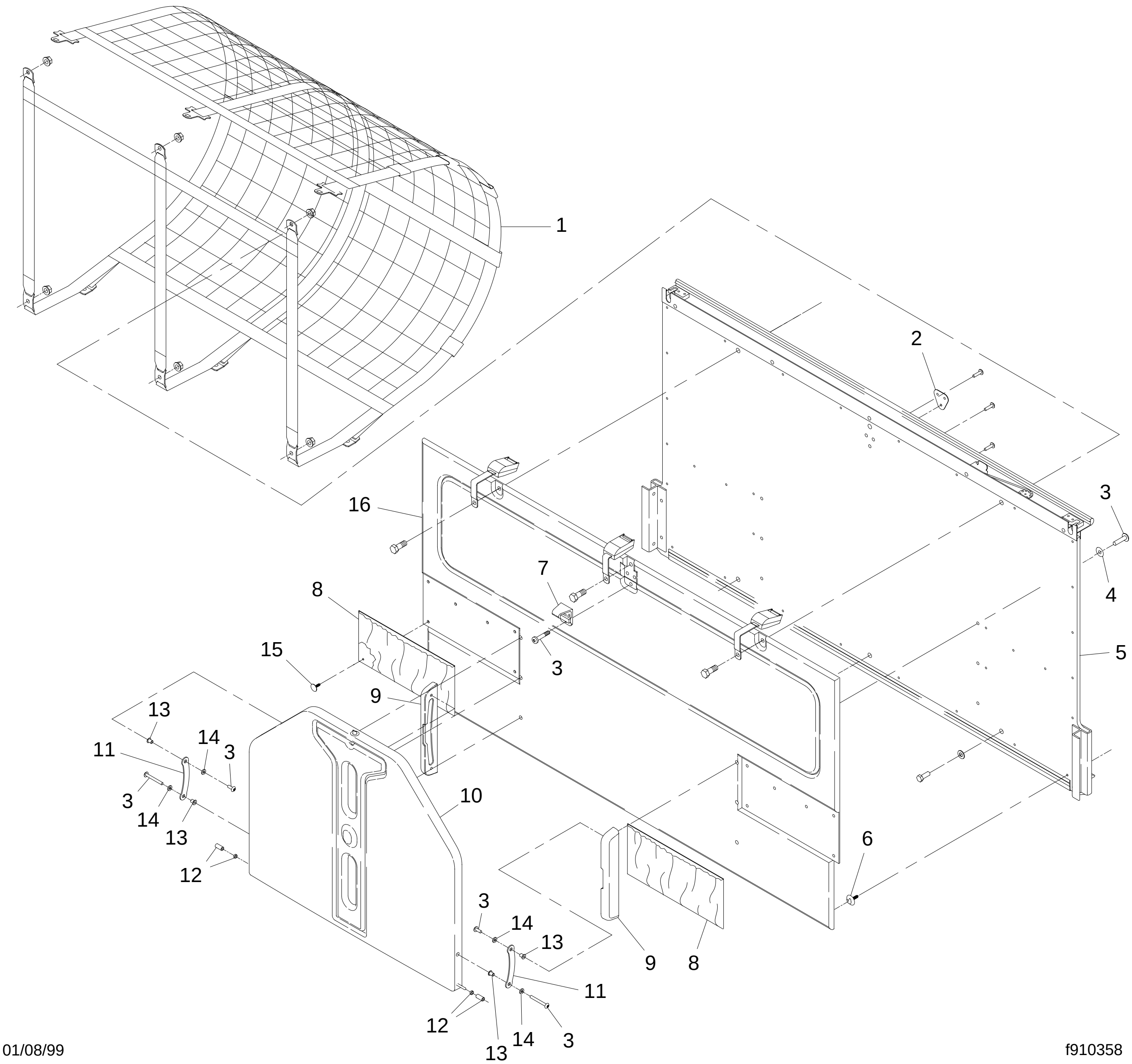
INSTALLATION

1. With the driver's lounge table in the stowed position, raise and latch the lower bunk in its vertical position.

NOTE: The next step is best performed with the aid of an assistant.

2. Carefully lift and maneuver the table (Ref. 10) into position. Use care to engage the table pins and nylon spacers into the table support casting guides at the same time. As the table pins and spacers enter the guides, carefully lower the table to allow the pins to rest in the bottoms of the guides.
3. Carefully raise one lower corner of the table and align the table link (Ref. 11) with its mounting hole in the table.
4. Ensure that the nylon bushing and flatwasher (Refs. 13 and 14) are in the same position as when removed. Then, install the mounting bolt

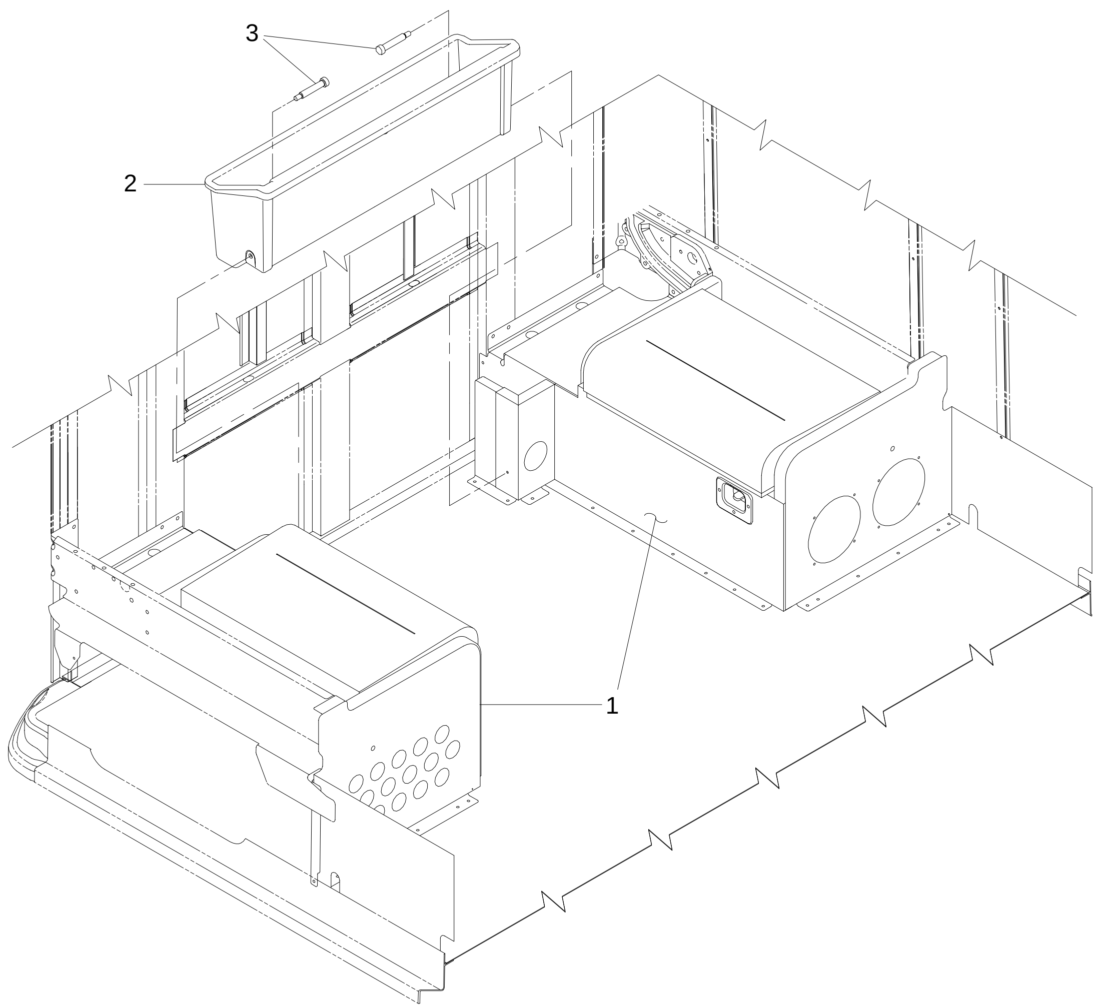
Removal and Installation



1. Bunk Restraint
2. Table Striker Mounting Plate
3. Mounting Bolt
4. Washer
5. Lower Bunk Assembly
6. 1/4-Turn Plastic Fastener
7. Table Striker Assembly
8. Pocket Assembly
9. Table Support Casting
10. Fold-Down Table
11. Table Link
12. Nylon Spacer
13. Nylon Bushing
14. Nylon Flatwasher
15. Plastic Christmas-Tree Fastener
16. Bunk Upholstery

Fig. 1, Driver's Lounge Table and Lower Bunk

Removal and Installation



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1. Seat Box Assembly
2. Under-Bunk Storage Bin
3. Shoulder Bolt

Fig. 2, Driver's Lounge Under-Bunk Storage Bin and Chairs

through the flatwasher, table link, and bushing, into the table mounting hole.

5. On the opposite side, install the mounting bolt through the flatwasher, table link, and bushing, into the table mounting hole. Tighten both bolts securely.
6. While holding the table, unlatch and place the table leg into position to support the table.
7. Push the top of the table fully against the bunk striker and lower and latch the table leg to latch the table to the striker on the underside of the bunk.
8. Place the table in position for use and then in the stowed position several times to confirm proper operation.
9. Remove the chocks from the tires.

General Information

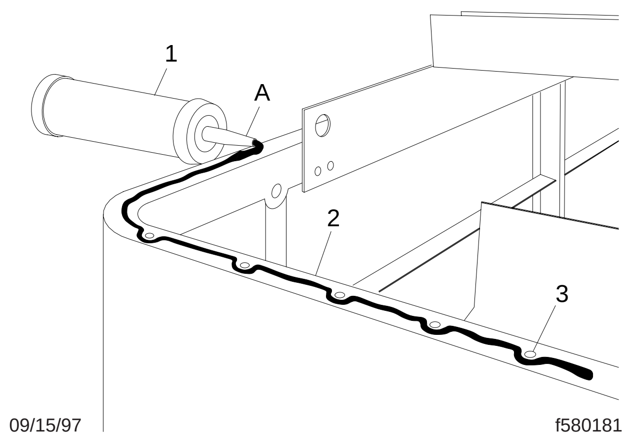
The installation of the coach joint and the roof cap changed in production on March 21, 2002. The revisions to the installation are as follows:

- The 58-inch and 70-inch raised roof assemblies are now bonded to the cabs.
- The quantity of roof cap joint fasteners is reduced from 46 to 20 (70-inch raised roof) and from 44 to 18 (58-inch raised roof).
- Seven 0.08-inch thick aluminum shims are removed.
- 19 countersunk rivets are removed.
- Four 18-gauge steel (adhesive backed) shims are removed.
- The roof cap near the corner headers and transition headers are removed.
- Side and rear roof cap headers are replaced with revised headers.
- The existing foam seating tape (.250-inch x .375-inch) is replaced with (0.188-inch by .312-inch) tape.
- The adhesive is replaced with blind rivets for attaching the window surround flange to the side headers.

Bonded Roof Cap Installation

Installation

1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Remove the roof cap. Refer to Section 60.07 of the *Columbia Workshop Manual* for instructions.
3. Fill the transitions around the top of the cab with Sika® 252 adhesive (48-25136-008) and smooth it out with a putty knife.
4. Use a glove and a lint-free rag to apply Sika Aktivator (48-25529-000). Use a quick single pass that fully wets the surface.
5. Apply a line of foam around the rim of the cab roof. See **Fig. 1**.



A. Apply adhesive around the top of the cab.
1. Adhesive Applicator
2. Cab Roof Rim
3. Fastener Hole

Fig. 1, Foam Application

NOTE: Apply adhesive 10 minutes after applying the foam, and no more than two hours after applying the Sika Aktivator.

6. Using the foam dam as a guide, apply Sika 252 adhesive. The bead should be 0.31-inch (8-mm) wide by 0.12-inch (3-mm) high.

NOTE: The adhesive should be inboard of the foam and should not spill over the top. If excess adhesive is applied, use a popsicle stick to spread it out.

7. Use bolts to align the back wall flanges.

IMPORTANT: The roof must be placed within 30 minutes after the adhesive bead is applied.

8. Install the roof cap. Refer to Section 60.07 of the *Century Class Trucks Workshop Manual* for instructions.
9. Make sure that the trim tabs and side extenders do not space out of the cap or the cab.

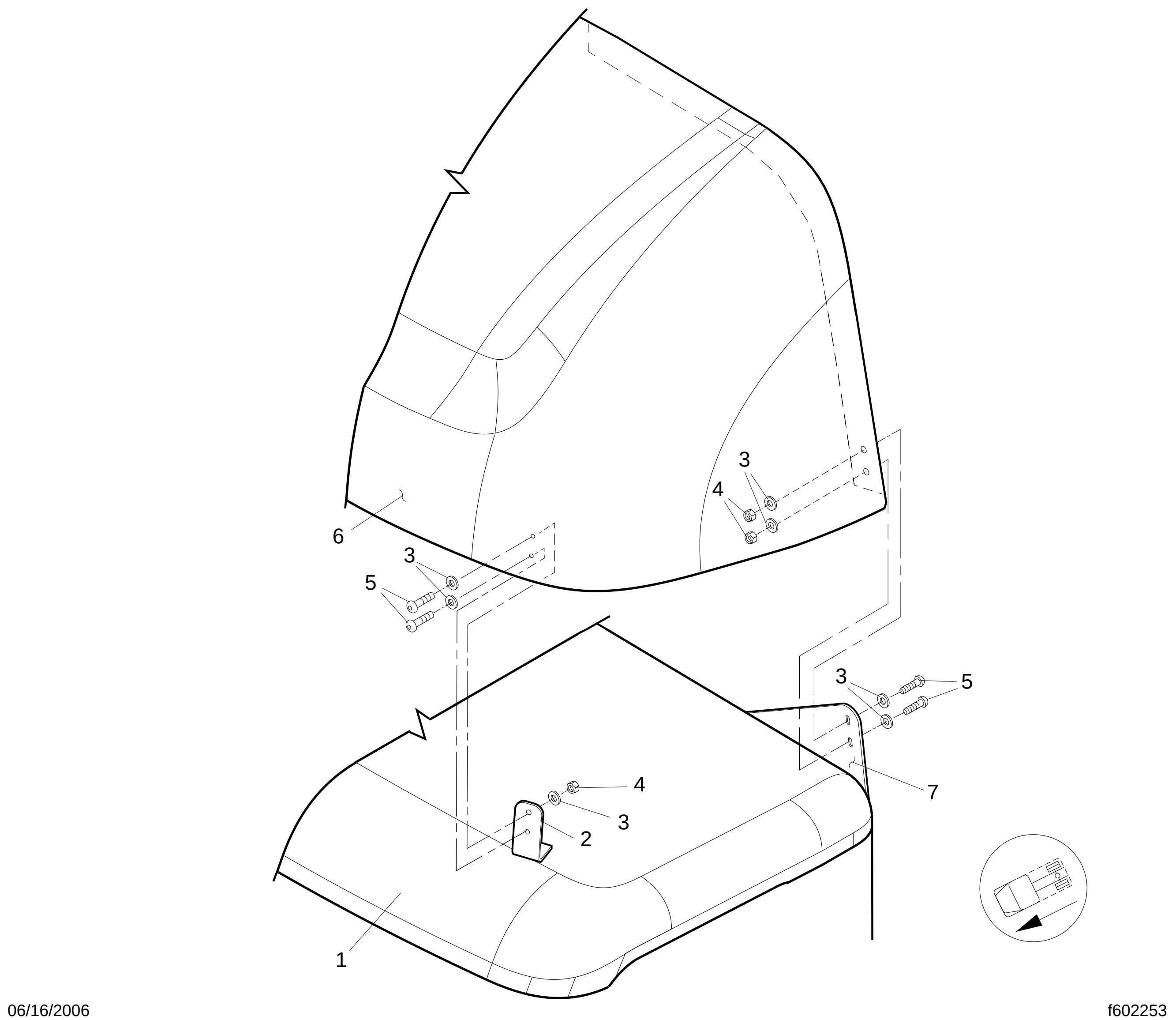
NOTE: Tighten the extenders only after the roof cap is bolted down.

10. Tighten the side extenders.
11. Before fully tightening all fasteners, inspect the toof cap to cab fit.
12. Remove the chocks from the tires.

Roof Fairing Removal and Installation

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Place some padding, such as a blanket, on the roof to avoid damaging the surface.
3. Remove the bolts, nuts, and washers that attach the fairing to the fairing front brackets. See **Fig. 1**. Lower the front of the fairing onto the padding.
4. Remove the bolts, nuts, and washers that attach the roof fairing to the back-of-cab brackets.



1. Cab Roof
2. Front Bracket
3. Washer
4. Nut
5. Bolt
6. Roof Fairing
7. Back-of-Cab Bracket

Fig. 1, Roof Fairing Installation

Roof Fairing Removal and Installation

5. Remove the fairing and the padding.

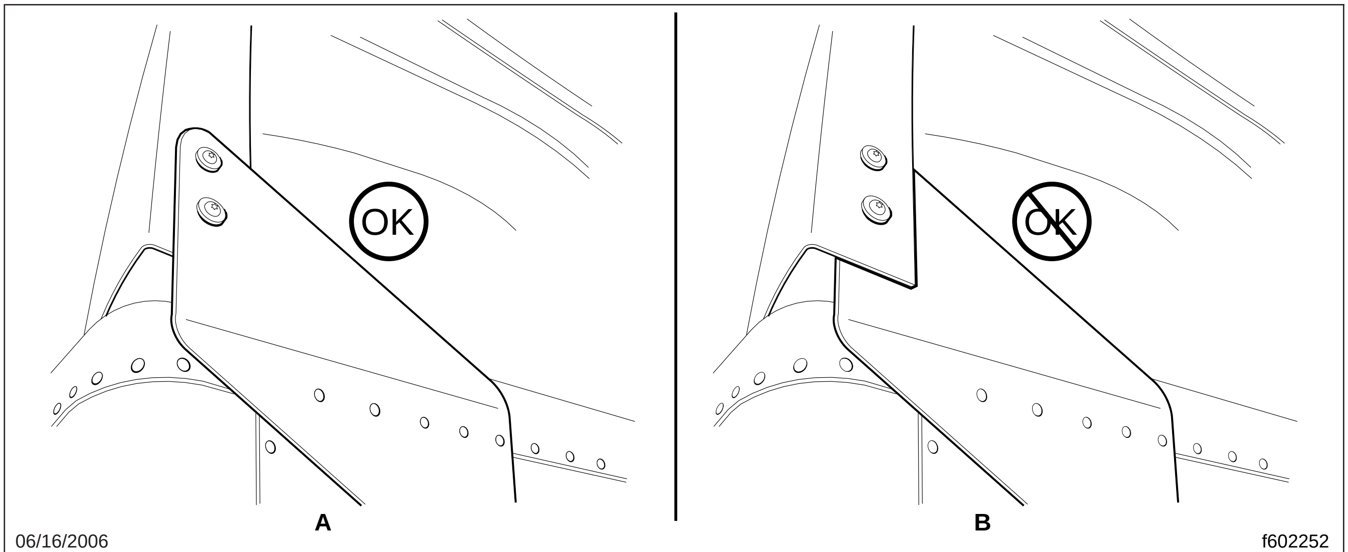
Installation

1. With the tires chocked, place some padding, such as a blanket, on the roof to avoid damaging the surface.
2. Place the fairing on the padding, taking care not to damage the roof surface. Position the fairing forward of both the front and back-of-cab brackets. See **Fig. 2**.

CAUTION

Do not attach a roof fairing to the rearward sides of the back-of-cab brackets. Roof fairings should always be attached to the forward sides of the back-of-cab brackets. Attaching a roof fairing to the rearward sides of the brackets can result in damage to the fairing.

3. Start two bolts with washers through the back-of-cab brackets and the fairing. See **Fig. 1**.
4. While supporting the front of the fairing, remove the padding from the roof, and start two bolts with washers through the fairing into each of the fairing front brackets.
5. Install a washer and nut on each bolt that attaches the fairing to the brackets. Do not tighten the nuts.
6. Check the alignment of the fairing, adjusting it if necessary.
7. Tighten all the bolts.
8. Remove the chocks from the tires.



A. Correct

B. Incorrect

Fig. 2, Fairing Back-of-Cab Installation

General Description

The bulkhead-style cab door is an aluminum extrusion upper frame and a stamp-formed lower section with two aluminum billets inserted into the extrusion and lower section. The cab seal is mounted on the door.

The "bulkhead" description refers to the manner in which the door, when closed, seats inside the door opening; the outer panel surface of the door is then flush with the outermost edge of the stamped door opening frame.

The door opening frame has a small drip molding riveted to the cab skin above the door. Both the door opening and the drip molding are painted the predominant color of the cab exterior.

The door frame is the foundation of the door assembly (**Fig. 1**), serving as:

- the mount for the outer panel of the door
- the channel support for the window glass
- the hinge support
- the wing window mount
- the door latch mount

A cable-driven window regulator assembly raises and lowers the window on standard door assemblies. Some vehicles feature optional electric windows.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the window express module harness connectors behind the inner door panels. See Subject 110 in this section. Electric currents produced during electric welding can damage various electronic components on the vehicle.

The wiring harness for the turn signals, heated mirrors, and CB/radio antenna is routed inside the mirror support, and is not visible with the door closed.

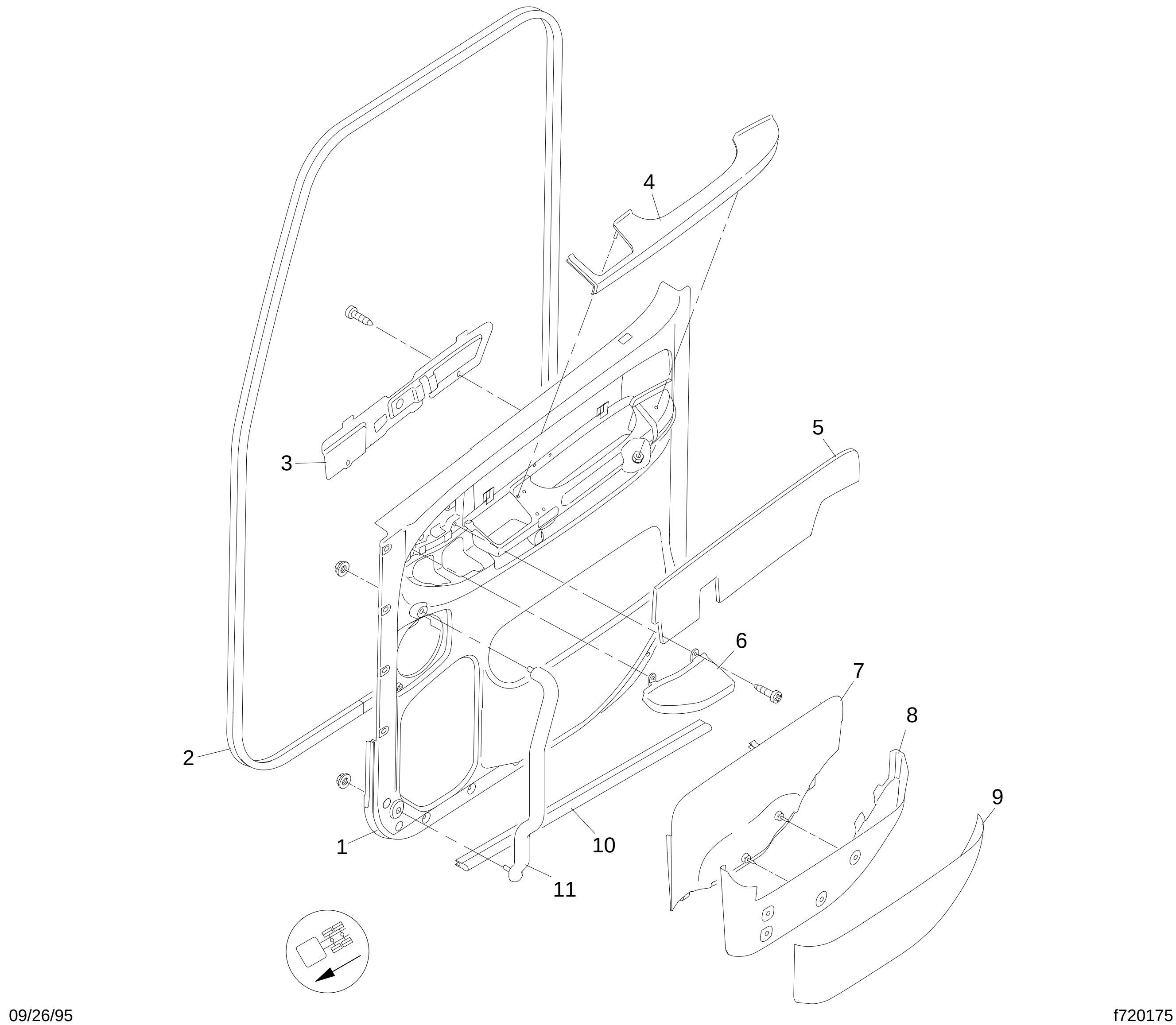
Most of the door parts are replaceable, with the exception of the outer panel (the exterior door skin). The outer panel is crimped to and bonded with structural adhesive to the door frame flange. If damaged, the outer panel and door frame assembly must be replaced as one assembly.

CAUTION

Do not attempt to replace the outer panel if it is structurally damaged. The entire portion of the panel that is crimped around the door frame is also bonded with a high-strength structural adhesive. In order to weaken this adhesive, a temperature of 400°F (204°C) is needed. If the aluminum door frame is heated to temperatures approaching 400°F (204°C), the door frame can crack or warp; accelerated aging of the metal may also occur.

Unless otherwise noted, all service operations can be done with the door attached to the vehicle. To reduce work time, don’t remove the door unless told to do so.

General Information



1. Inner Door Panel
2. Door Mounted Seal
3. Closure Panel
4. Arm Rest
5. Upholstery
6. Window Control Panel
7. Lower Door Trim Panel
8. Door Pocket Liner
9. Carpet
10. Weatherstrip
11. Grab Handle

Fig. 1, Cab Door Assembly, Exploded View

Removal

1. Apply the parking brakes, and chock the tires.
2. Lower the window.
3. Disconnect the batteries.
4. Disconnect the wiring connectors and harness leads.

IMPORTANT: As a safety precaution, bundle the loose wires, then temporarily tape them to the door.

5. Remove the door check, taking care to ensure the door does not swing out and damage the vehicle or the door. Also, do not allow the portion of the door check assembly mounted to the door opening to drop into the A-pillar.
6. Remove the inner A-pillar cover, the outer upper A-pillar cover, and the outer lower cowl A-pillar cover to provide access to the cabside of the door.

WARNING

Do not attempt to lift the door. The door weighs approximately 110 pounds (50 kg). Lifting or dropping the door could result in personal injury or damage to the door assembly and other components.

7. Using a door support or another person, support the door frame from its bottom to prevent it from falling or tipping during removal. With the door open and supported, loosen the allen-bolts and hex head fasteners that attach the door hinge to the cab.

Installation

1. If the door seal has been damaged or is weathered, replace it. For instructions, refer to **Subject 190**.

WARNING

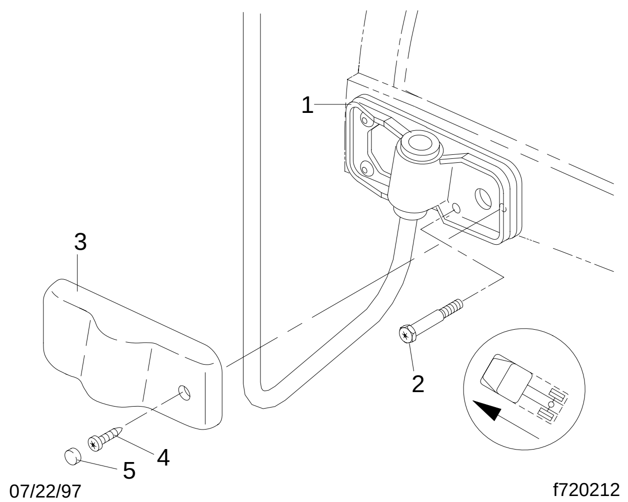
Do not attempt to lift the door. The door weighs approximately 110 pounds (50 kg). Lifting or dropping the door could result in personal injury or damage to the door assembly and other components.

2. Using a door support or another person, support the door from its bottom to prevent it from falling or tipping during installation.
3. Insert and tighten the allen-bolts and hex head fasteners that attach the door hinge to the cab.
4. Unfasten the previously tied and bundled wires. Thread the wires through the bottom portion of the door opening frame and into the cab.
5. Install the door check, again taking care to keep the part mounted inside of the door opening from falling into the A-pillar.
6. As marked earlier, connect all electrical wiring to the door. The wires should be connected at the butt splices located just inside the cab, near the door opening frame.
7. Connect the batteries.
8. Check to be sure the door electrical components are operating correctly.
9. Install the outer lower cowl A-pillar cover, the outer upper A-pillar cover, and the inner A-pillar cover.
10. Remove the chocks from the tires.

Inner Door Panel Removal and Installation

Removal

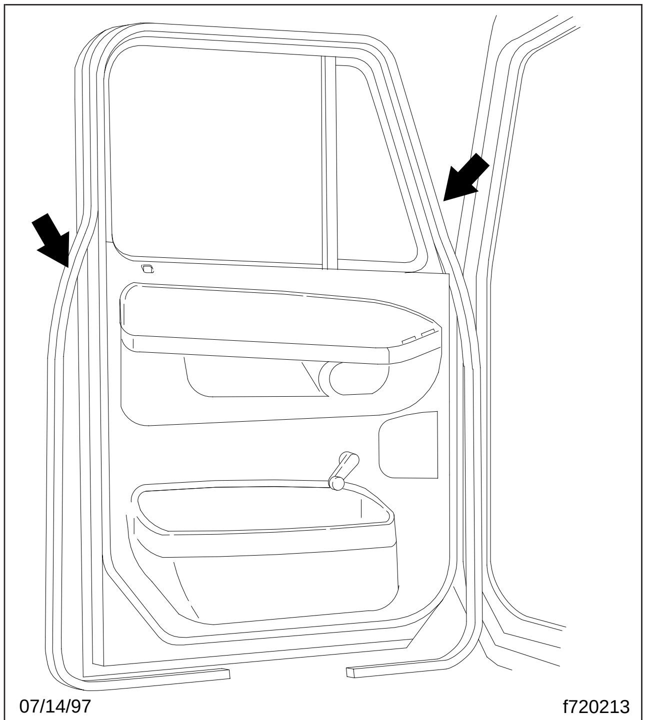
1. Apply the parking brakes and chock the tires.
2. Remove the mirror lower bracket cover. Using a T40 Torx® screwdriver, remove the 2-3/4 inch door-panel retainer bolt through the mirror bracket from the outside of the cab; see Fig. 1. For detailed information, see Section 60.06, Subject 110.



1. Lower Mirror Bracket
2. Door-Panel Retainer Bolt
3. Mirror Bracket Cover
4. Bracket Mounting Screw
5. Plastic Plug

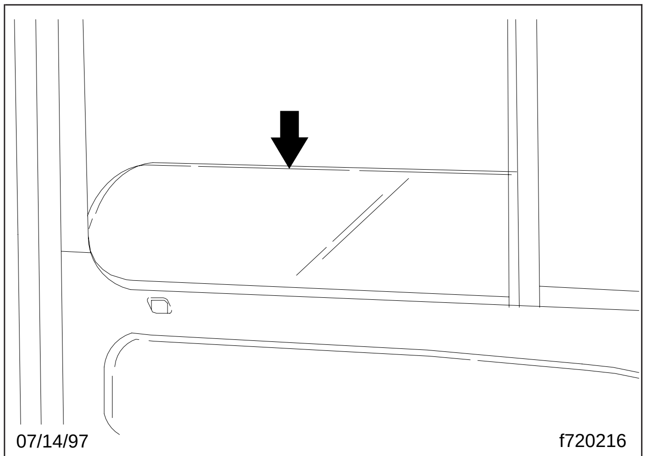
Fig. 1, Door-Panel Retainer Bolt Removal

3. Starting at the bottom, partially remove the door seal to a point higher than the top of the inner panel. Leave the ends of the seal hanging down; see Fig. 2. Take care not to bend the seal in a tight radius.
4. Remove the window crank, if installed (manual windows only).
5. Remove the lower door trim panel (door pocket panel).
6. Roll down the window part way to expose the two window lift channel nuts through the opening in the inner door panel; see Fig. 3.
7. Support the window glass.



On both sides of the door, remove the seal to a point higher than the top of the inner door panel.

Fig. 2, Door Seal Partially Removed



Lower the window glass about 2/3 of the way down; enough to expose the window lift channel nuts through the door pocket.

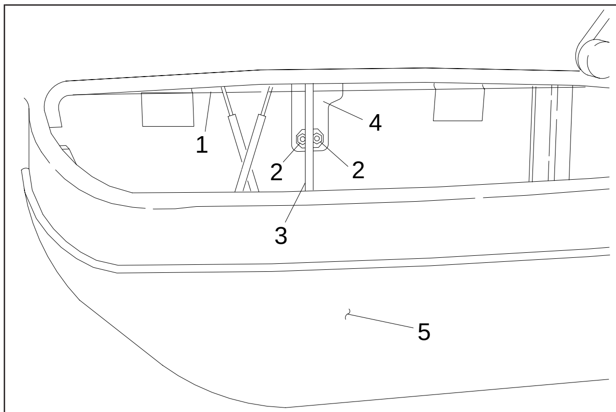
Fig. 3, Window Glass Lowered

Inner Door Panel Removal and Installation

CAUTION

To avoid damaging the window glass, make sure the window is rolled down and the window glass is supported from underneath.

8. Remove the two 1/4–20 window lift channel nuts; see **Fig. 4**.



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1. Window Glass
2. Lift Channel Nut
3. Regulator Shaft
4. Window Lift Channel
5. Inner Door Panel

Fig. 4, Lift Channel Nuts

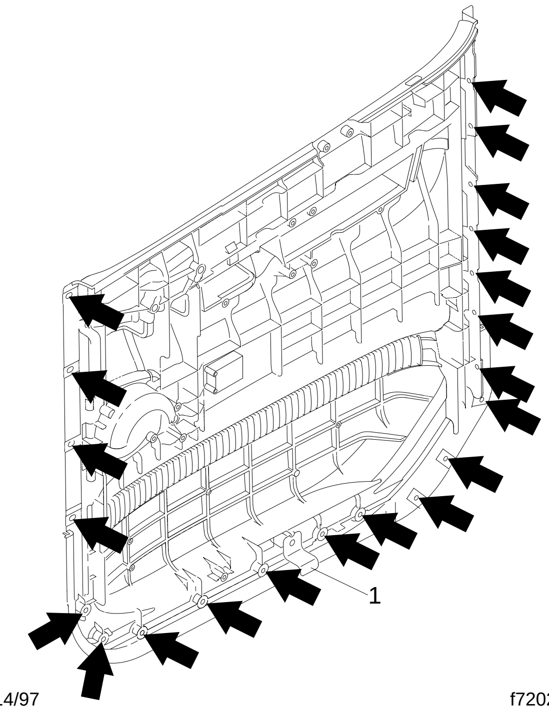
NOTE: Save all fasteners, plugs, and covers for later installation, when removing the inner door panel. Note that the screws are not all the same length. For ease of installation, keep the screws and other fasteners in a line in order of removal, so that each one can be installed in the correct hole.

9. Remove the inner door panel with the regulator and window glass installed, as follows; see **Fig. 5**.

   9.1 Remove the four plastic plugs on the rear door edge. Remove the four T25 screws, with washers, one underneath each plug; see **Fig. 6**.

   9.2 Remove the T40 Torx screw that holds the plastic cover on the rear door edge. Remove the T25 screw, with washer, underneath it.

   9.3 Remove the two exposed T25 Torx machine screws located on the door edge.



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The arrows indicate the location of T25 Torx screws (there are 21 in all).

1. Zee Bracket

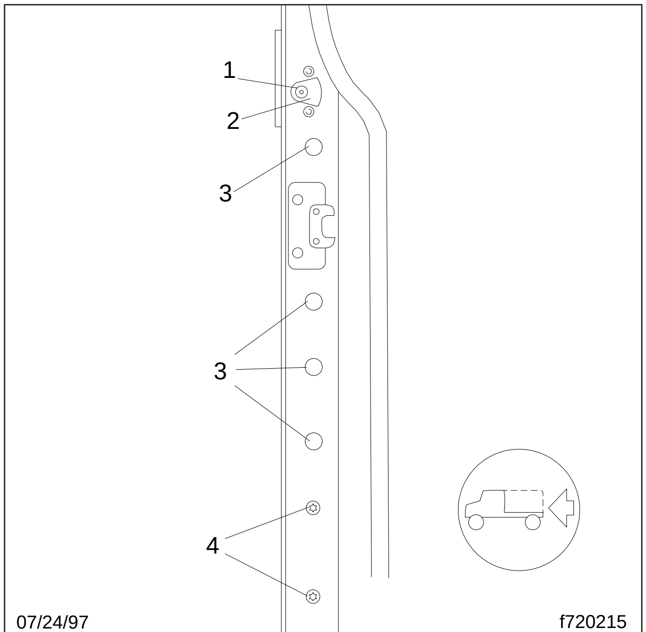
Fig. 5, Inner Door Panel Fasteners

   9.4 Remove all exposed screws on the front and rear of the door.

10. Lift the inner door panel up and over the door-lock button. Rest the panel on the edge of the door frame, using the zee bracket at the bottom of the panel.
11. Disconnect the door handle assembly. On manual door locks, tie the interior handle rod up and out of the way; see **Fig. 7**.
12. Disconnect the door electrical connectors (door harness, speakers, mirror switch harness, as installed). Loosen cables as necessary; see **Fig. 8**.
13. Lift the inner door panel out and remove it from the door.

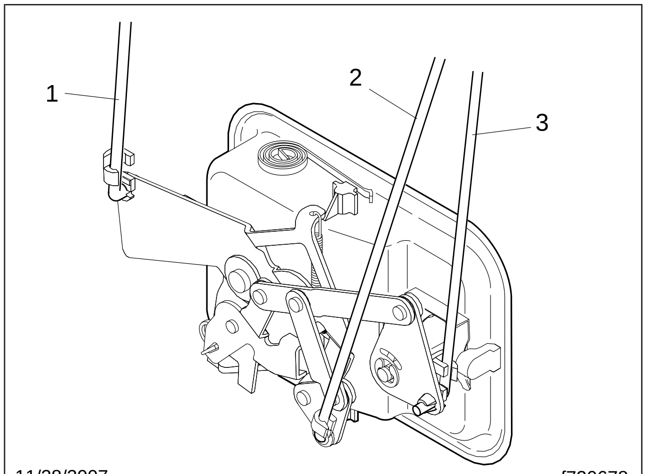
Installation

IMPORTANT: Make sure the interior handle rod, if installed, is up and out of the way.



1. T40 Cover Screw
2. Plastic Cover
3. Plastic Plug
4. T25 Machine Screws

Fig. 6, Fasteners on Aft Edge of Door

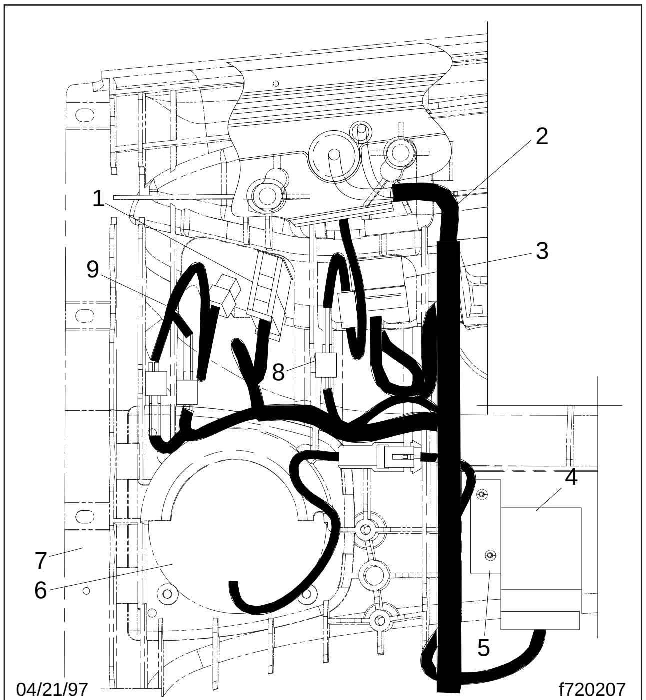


NOTE: Typical door handle shown; others are similar.

1. Latch Actuator Rod
2. Interior Handle Rod
3. Door Lock Rod

Fig. 7, Door Handle (inside view)

1. With the vehicle tires chocked, rest the inner door panel on the door frame, using the zee bracket on the bottom of the panel.



1. Door Lock Switch
2. Door Harness
3. Window Switches
4. Express Module
5. Mounting Bracket
6. Mid-Range Speaker
7. Inner Door Panel
8. Tweeter Speaker
9. Mirror Switch Harness

Fig. 8, Door Electrical Wiring (typical)

2. Connect the door handle assembly.
3. Attach all electrical connectors, as removed.
   - 3.1 Wrap tape on exposed connectors as needed.
   - 3.2 Feed any loosened cables into the door panel.
   - 3.3 Pack no-rattle foam into any empty spaces around the connectors.

CAUTION

It is possible to pinch fingers when moving the power window up and down.

   - 3.4 Briefly press down the window switch and check that the window moves up and down easily, with no binding or slippage.
4. Install the inner door panel on the door, as follows.

Inner Door Panel Removal and Installation

4.1 Attach two machine screws finger-tight, to loosely attach the inner door panel.

4.2 Check the panel all the way around the door for good seating and proper alignment.

NOTE: It may be helpful to use a magnetic screwdriver bit when installing these screws.

4.3 Install the five recessed machine screws on the door edge.

4.4 Install the rest of the machine screws and washers, as removed.

4.5 Tighten all machine screws 60 lbf·in (680 N·cm).

4.6 Install the plastic plugs and cover, as removed.

5. Install the lift channel nuts on the studs on the window lift channel. Tighten them 70 lbf·in (800 N·cm).
6. Install the window crank, if equipped with manual windows. Tighten the window crank screw 60 lbf·in (680 N·cm).
7. Install the door seal, as removed; see **Subject 190**.
8. Install the lower door trim panel (door pocket panel). Make sure it is firmly attached and not loose on either side.
9. Install the long door-panel retainer bolt through the mirror bracket from the outside of the cab. Tighten it 15 lbf·ft (20 N·m). Install the mirror bracket cover; see **Section 60.06, Subject 110**.
10. Remove the chocks.

Adjustment

When a door assembly is newly installed on a vehicle, it must be adjusted for correct up-and-down, fore-and-aft, and in-and-out positioning, relative to the door opening frame. The door assembly should also be adjusted whenever one or more of the following conditions exist (providing the door seal is correctly installed and is in good condition:

- wind or water leaks at the door opening frame
- premature wear of the door seal
- hard closing or opening of the door

The cab portion of the hinge has oversized holes, and when the bolts that attach the hinge to the cab are loosened, the door can be adjusted forward or aft, and up and down within the door opening frame. The slotted holes along the door portion of the hinge area allow for in and out adjustment of the door.

Up-and-Down, Fore-and-Aft Adjustment

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. From outside the cab, check the alignment of the door with the cab door-opening frame. See if the spaces around the top of the door are uniform. If adjustment is needed, follow the steps below.
3. Remove the outer upper A-pillar cover and the outer lower cowl A-pillar cover to provide access to the cabside of the door hinge.
4. Mark both the vertical and horizontal positions of the latch striker pin and the hinge before loosening them for adjustment. This will greatly simplify the procedure.
5. Loosen the striker pin, then tighten it finger-tight.
6. Loosen the bolts that attach the hinge to the cab door-opening frame, but keep them tight enough to prevent unintentional hinge movement.
7. Carefully close the door, then raise or lower it until the space across the top of it is uniform, and the gap is about 3/8 inch (10 mm), and is within 5/16 inch (8 mm) at both the front and rear vertical edges of the door.
8. Without disturbing the positions of the hinges or striker pin, tighten the hinge bolts.
9. Open the door and securely tighten the striker pin. From outside the cab, partially close the door until the latch jaws are about 1 to 2 inches (25 to 50 mm) from the striker pin. Be sure the striker pin will be centered in the latch jaw when the door is closed. If needed, reposition the striker pin.
10. Tighten the striker pin 18 to 32 lbf·ft (24 to 43 N·m), then close the door and recheck door alignment.
11. Install the outer lower cowl A-pillar cover and the outer upper A-pillar cover.

In-and-Out Adjustment

Poor in-and-out adjustment of the door is often indicated by hard closing of the door, wind and water leaks around the edge of the door, or premature wear of the door seal.

1. With the tires chocked, check the in-and-out adjustment of the door. The outer surface of the door should be flush, within ±5/64 inch (±2 mm), with the surface of the cab skin at *both* its front and rear edges. If adjustment is needed, follow the steps below.
2. If only the rear edge of the door needs adjusting, go to the step that begins "If the rear edge . . ."

   If the front edge of the door needs adjusting, mark the vertical and horizontal positions of the hinge before loosening them for adjustment. This will greatly simplify the procedure.
3. Loosen the bolts that attach the hinge to the door frame, but keep them tight enough to prevent unintentional hinge movement.
4. Carefully close the door, then move the front edge of the door in or out until its outer surface is flush, within ±5/64 inch (±2 mm), with the surface of the cab skin. Be careful not to disturb the up-and-down adjustment.
5. Without disturbing the positions of the hinges, carefully open and support the door, then tighten the hinge bolts.
6. If the rear edge of the door needs adjusting, mark the vertical and horizontal positions of the latch striker pin before loosening it for adjustment.
7. Loosen the striker pin, then tighten it finger-tight.

Door Adjustment

8. Carefully close the door, then move the rear edge of the door in or out until its outer surface is flush, within ±5/64 inch (±2 mm), with the surface of the cab skin. Be careful not to disturb the up-and-down adjustment.
9. Without disturbing the position of the striker pin, carefully open the door, then tighten the striker pin 18 to 32 lbf·ft (24 to 43 N·m).
10. Close the door and recheck door alignment.

Striker Pin Adjustment

1. With the tires chocked, watch to see if the door-latch striker pin is centered in relation to the latch jaws, as the door closes. The door should not move up or down when the door latch jaws engage the striker pin. Only the center of the pin must contact the latch jaws; the head of the pin should not contact any part of the latch.

   If needed, add shims between the coned washer and the door opening frame. Add only enough shims to allow correct engagement of the latch jaws around the striker pin's outer sleeve; too many shims will cause interference between the striker pin and the backing plate of the latch assembly.
2. From outside the cab, partially close the door until the latch jaws are about 1 to 2 inches (25 to 50 mm) from the striker pin. See **Fig. 1**.
3. See if the latch jaws will just clear the striker pin's head (shown in **Fig. 2**) when the door is closed. If necessary, reposition the striker pin after loosening it with a no. 50 Torx® recess driver, shown in **Fig. 3**.
4. Repeat the previous two steps above. If the striker pin appears to be correctly positioned, tighten it 18 to 32 lbf·ft (24 to 43 N·m).
5. Carefully close the door to the fully latched position (second click). From outside the cab, check the in-and-out, fore-and-aft, and up-and-down positioning of the door.
6. Remove the chocks from the tires.

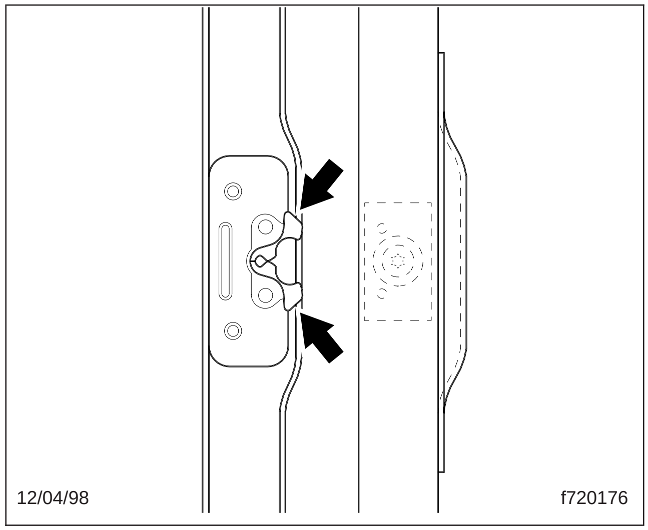
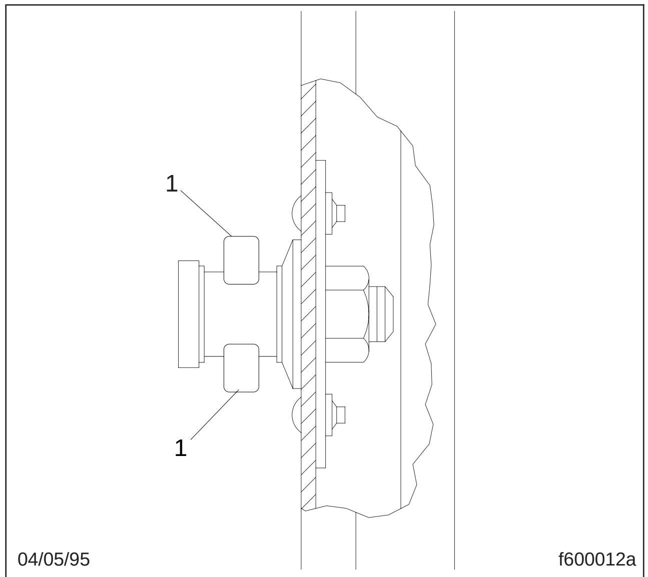
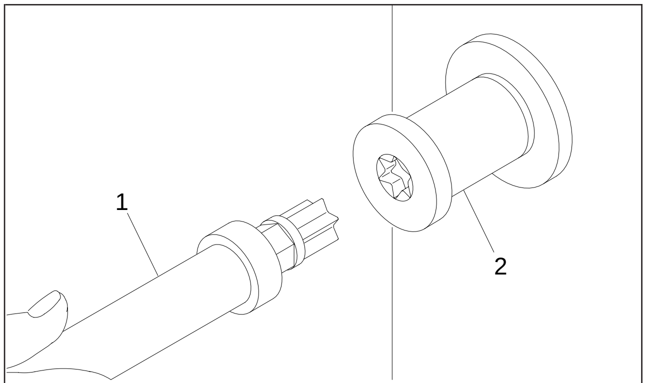


Fig. 1, Door Latch



1. Latch Jaws

Fig. 2, Door Latch Jaws on Striker Pin



1. No. 50 Torx Recess Driver
2. Striker Pin

Fig. 3, Striker Pin Tool

Door Window Removal and Installation

Removal

WARNING

Use care when working around or handling glass. Wear protective gloves and protective eyewear to eliminate the possibility of personal injury resulting from accidentally breaking or splintering the glass.

1. Apply the parking brakes. Lower the window glass.
2. For hand crank windows, remove the crank arm from the regulator assembly mounting spindle by removing the screw and carefully pulling the crank straight off the shaft.
3. Remove the inner door panel. See **Fig. 1**. For instructions, see **Subject 110**.
4. Remove the lower glass guide by removing two screws at the base of the guide and a bolt at the top.

IMPORTANT: Wear rubber gripper gloves during the removal of the window glass to ensure a secure grip on the glass.

5. If the window glass is not shattered, carefully remove the window glass and window lift channel assembly.

   Lean the window glass so that it is outside the window channel of the wing window mounting bracket, then carefully lift out the window glass assembly. If the window is broken, go to the next step.
6. Wearing protective gloves, remove all accessible shattered glass. Then, remove the window lift channel.

   Using a narrow extension accessory, vacuum out small glass fragments that may have fallen to the bottom of the door frame through the space behind the exterior door handle access cover attached to the inner panel. Failure to remove the glass fragments could cause plugged drain holes at the bottom of the door frame.
7. If necessary, remove the window glass-run channels. If the window glass was shattered, inspect the glass-run channels for cuts. Replace the glass-run channels, if damaged.
8. If the wing window assembly must be replaced, remove the fasteners that attach the window assembly to the door frame. Remove the window glass-run channel from the wing window.Remove the wing window assembly.

Installation

IMPORTANT: If the wing window assembly has been removed, carefully follow the first two steps below. Proper installation of the wing window seal will prevent water leaks from occurring when the vehicle is later placed in service.

If the wing window assembly has not been removed, skip the first two steps below.

1. Seat the wing window assembly in the door frame. Tilt the lower wing window guide toward the hinge. Make sure that the bottom seal flap on the outside of the door overlaps the belt rail (**Fig. 2**). The flap does not go under the belt rail.
2. Make sure that the flaps of the wing window side seal overlap onto the outside and inside surfaces of the door frame. If the seal flaps come between the door frame and the ventilator window mounting bracket, the holes for the panhead screws will not line up.

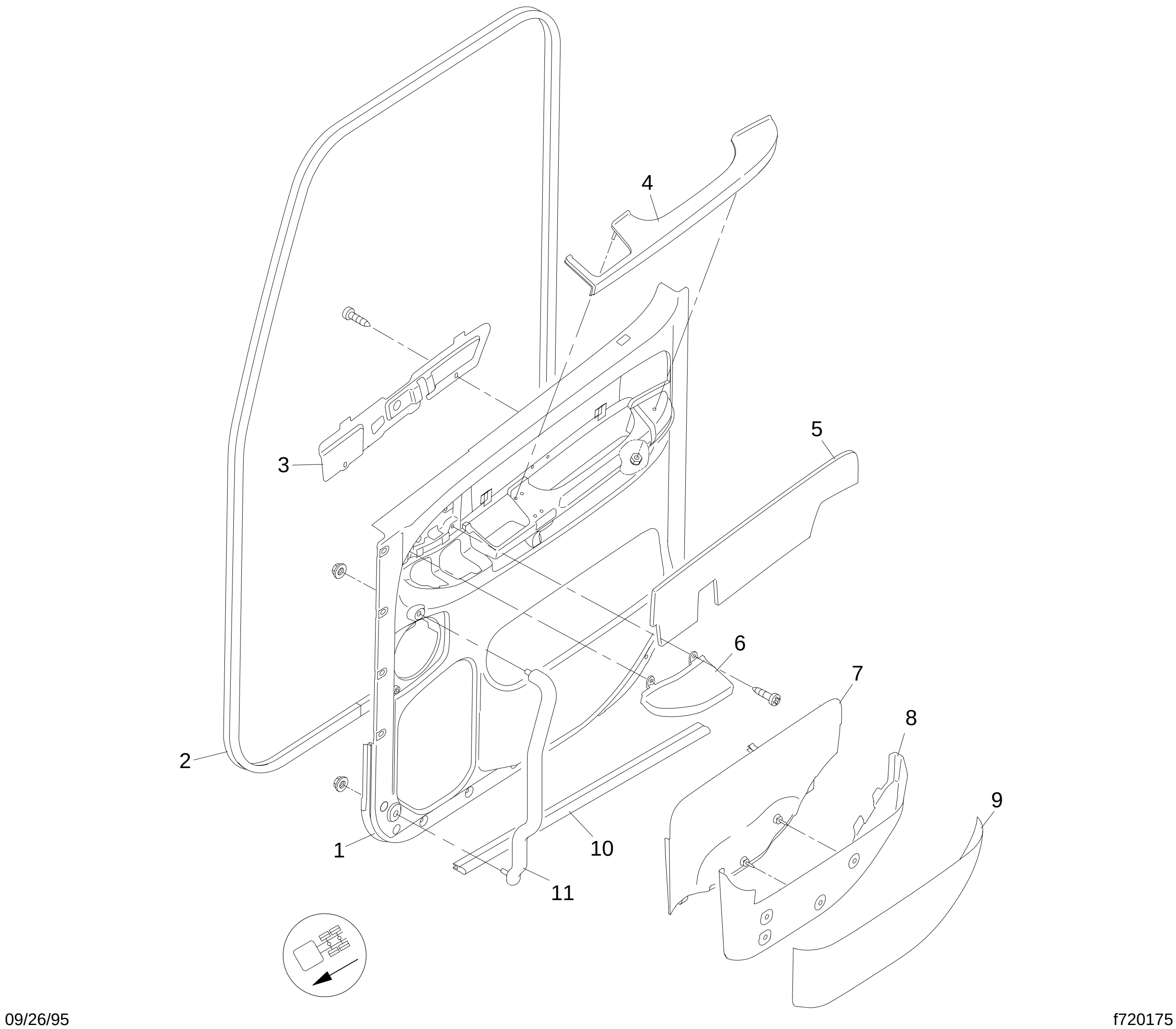
   Check the position (squareness) of the wing window in the door frame. The window channels should be parallel to one another, or binding of the window glass will occur as the window is raised. If necessary, adjust the position of the wing window. Tighten the panhead screws securely.
3. Carefully place the window glass assembly inside the door.

CAUTION

Failure to wear rubber gripper gloves while installing the window glass in the door could result in the glass slipping out of your hands and breaking.

IMPORTANT: Wear rubber gripper gloves when installing the window glass. Usually, service operations performed on the door will be done while the door is in a vertical position (that is,

Door Window Removal and Installation



1. Inner Door Panel
2. Door Mounted Seal
3. Closure Panel
4. Arm Rest
5. Upholstery
6. Window Control Panel
7. Lower Door Trim Panel
8. Door Pocket Liner
9. Carpet
10. Weatherstrip
11. Grab Handle

Fig. 1, Cab Door Assembly, Exploded View

attached to the vehicle). Because of this, you will need a secure grip when handling the glass.

4. Install the window glass assembly in the window channel as follows:

4.1 Position the bottom (hinge side) corner of the window glass on the window stop block.

4.2 Position the top (hinge side) area of the window glass so that it is inside the win-

Door Window Removal and Installation

dow channel of the wing window mounting bracket. See **Fig. 2.**

4.3 Pull up on the top (latch side) corner of the window glass. As the top edge of the window is pulled up into a horizontal position, the bottom (latch side) corner of the window lift assembly will seat in the channel. See **Fig. 3**.

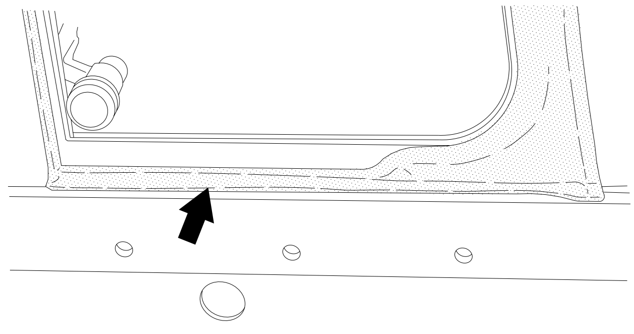
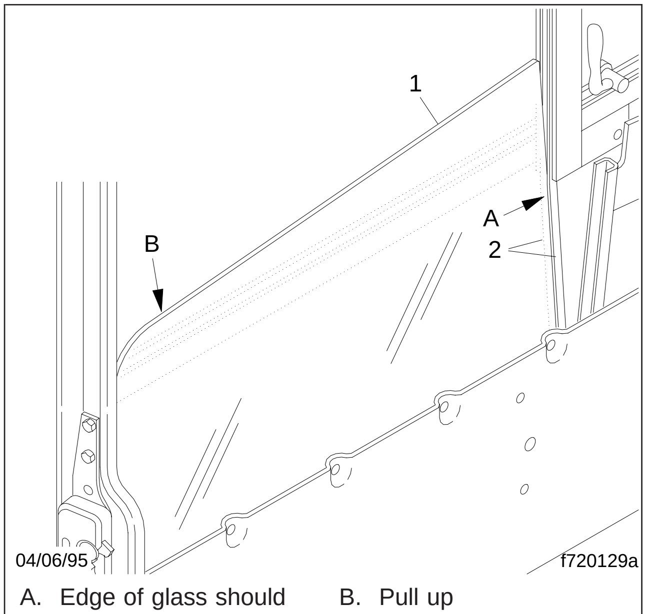


Fig. 2, Bottom Seal of the Wing Window Assembly



A. Edge of glass should be in channel
B. Pull up
1. Window Glass
2. Glass Run Channel

Fig. 3, Window Glass Installation

4.4 Tilt the lower wing window guide back to the vertical position. *Make sure that the guide remains in the vertical position.*

5. Install the lower glass guide by installing the two screws at the base and the bolt at the top.
6. Install the inner door panel. See **Fig. 1**. For instructions, see **Subject 110**.
7. Attach the crank arm to the regulator assembly mounting spindle. Test the window for up-and-down movement. Hard rolling usually means the window glass-run channels are not seated properly. Inspect the glass-run channels for seating.

Power Window Regulator

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the interior door panel, with the regulator and window glass installed; see **Subject 110**.
3. Disconnect the door harness from the pigtail connector on the regulator motor; see **Fig. 1**.
4. Remove the cable clip from the pigtail connector.
5. Remove the two 10–24 machine screws from the upper mounting bracket.
6. Remove the regulator from the interior door panel, taking care not to bend the regulator shaft.

Installation

IMPORTANT: Before attempting to install the regulator, make sure the window glass is still supported from underneath and the window is rolled down.

1. With the vehicle tires chocked, position the regulator body, the regulator shaft, and upper mounting bracket on the interior door panel; see **Fig. 1**. Make sure all the fastener holes line up properly. Take care not to bend the regulator shaft.

IMPORTANT: Make sure the interior handle rod, if installed, is up and out of the way, and between the trim panel and the regulator shaft.

2. Install the upper mounting bracket on the inner door panel, using the two 10–24 machine screws, as removed.
3. Connect the door harness to the pigtail connector on the regulator motor.
4. Attach the cable clip to the pigtail connector.
5. Install the interior door panel, with the regulator and window glass, on the door; see **Subject 110**.
6. Remove the chocks.

Manual Window Regulator

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the interior door panel, with the regulator and window glass installed; see **Subject 110**.
3. Remove the two 10–24 machine screws from the face plate on the window crank; see **Fig. 2**.
4. Remove the spring clip from the regulator body.
5. Remove the two 10–24 machine screws from the upper mounting bracket.
6. Remove the regulator from the interior door panel, taking care not to bend the regulator shaft.

Installation

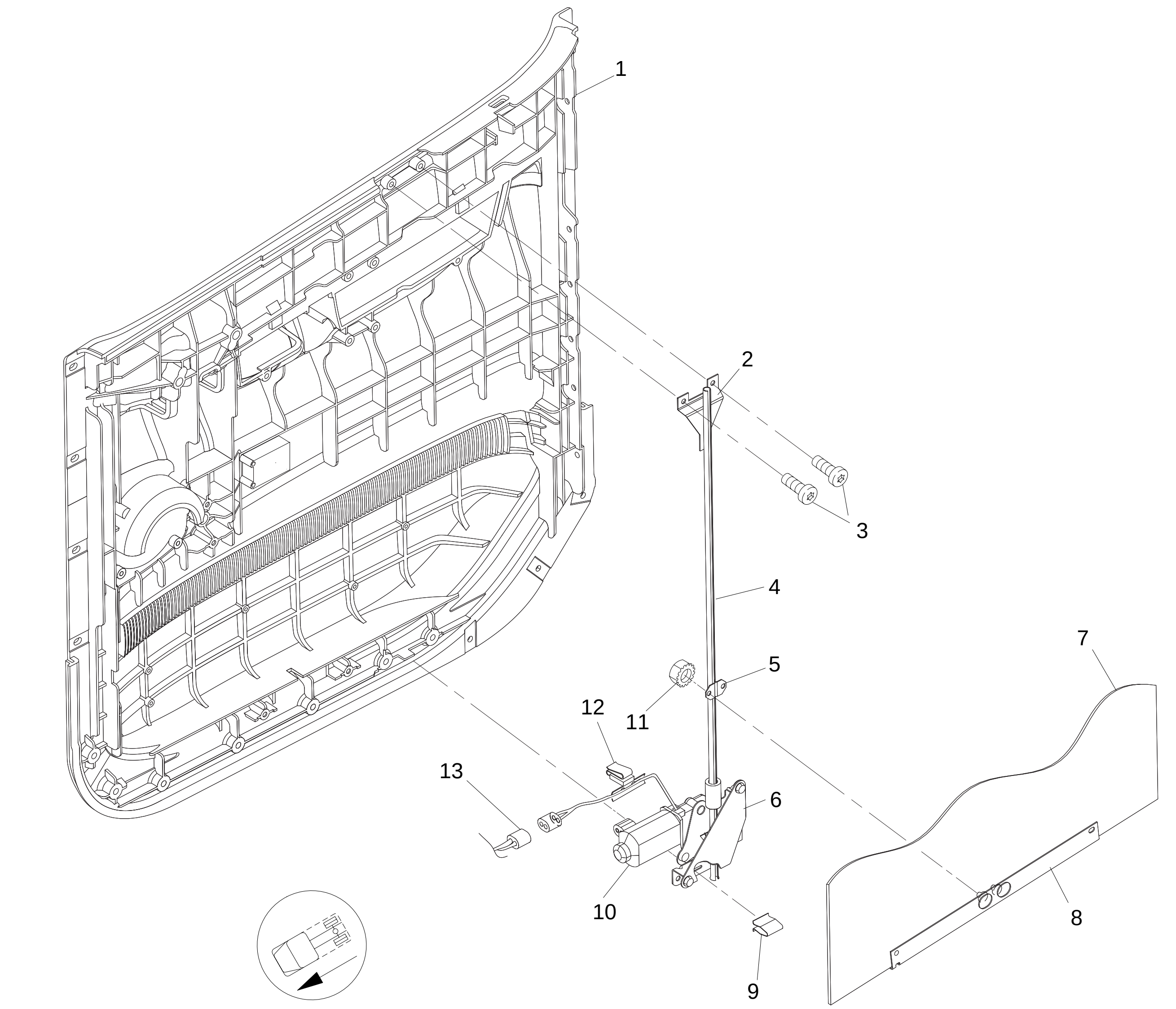
IMPORTANT: Before attempting to install the regulator, make sure the window glass is still supported from underneath and the window is rolled down.

1. With the vehicle tires chocked, position the regulator body, regulator shaft, upper mounting bracket, worm gear, and face plate on the interior door panel; see **Fig. 2**. Make sure all the fastener holes line up properly. Take care not to bend the regulator shaft.

IMPORTANT: Make sure the interior release rod, if installed, is up and out of the way.

2. Install the spring clip on the regulator body.
3. Install the face plate on the interior door panel using the two 10–24 machine screws, as removed.
4. Install the upper mounting bracket on the interior door panel using the two 10–24 machine screws, as removed.
5. Install the interior door panel, with the regulator and window glass, on the door; see **Subject 110**.
6. Install the window crank and check that the window moves up and down easily, without binding or slippage.
7. Remove the chocks.

Window Regulator Removal and Installation

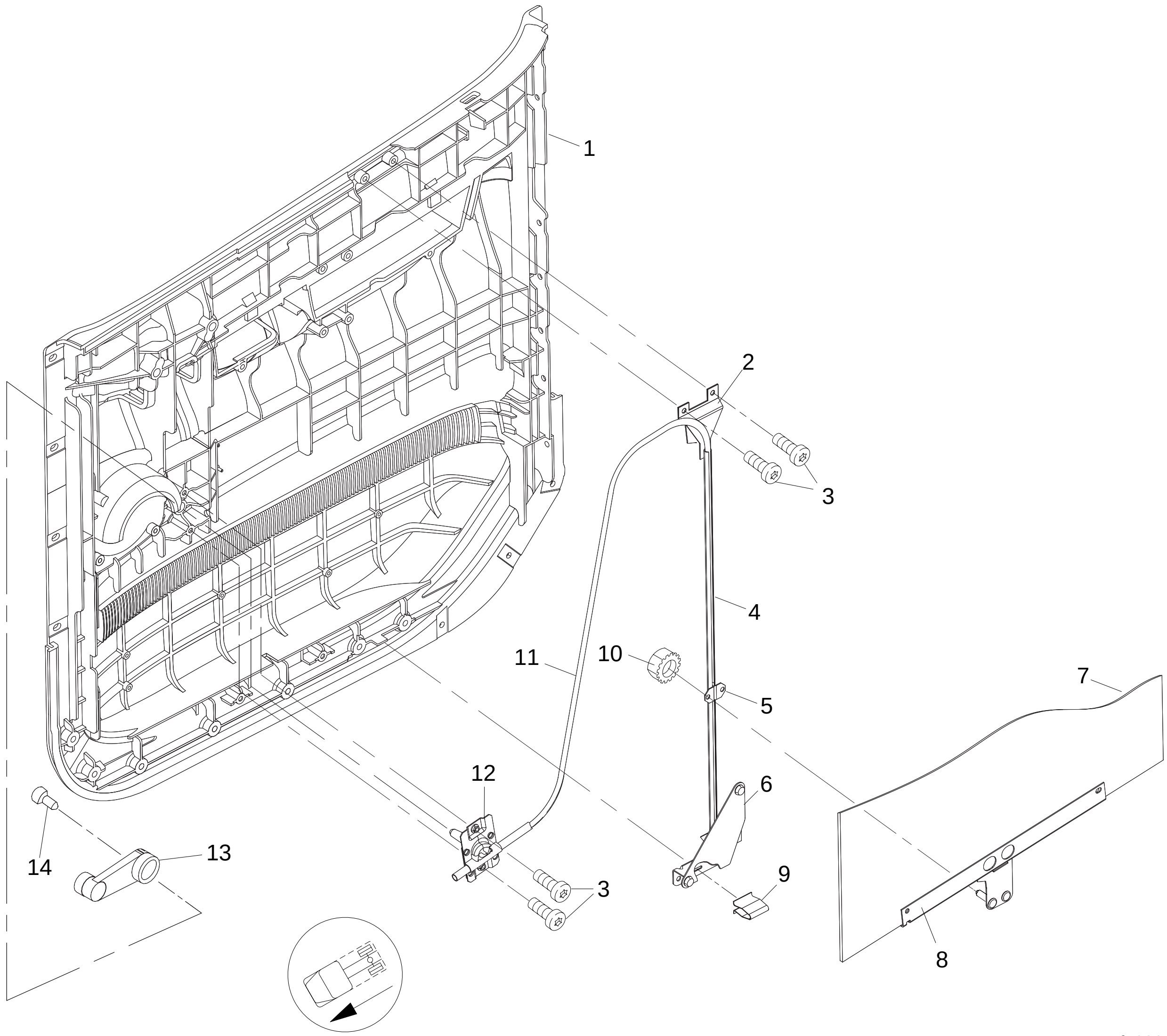


NOTE: Right-hand door is shown; left-hand door is similar.

1. Interior Door Panel
2. Upper Mounting Bracket
3. Machine Screws, 10–24
4. Regulator Shaft
5. Lift Cursor
6. Regulator Body
7. Window Glass
8. Window Lift Channel
9. Spring Clip
10. Regulator Motor
11. Window Lift Nut, 1/4–20
12. Cable Clip
13. Door Harness

Fig. 1, Power Window Regulator

Window Regulator Removal and Installation



Right-hand door is shown; left-hand door is similar.

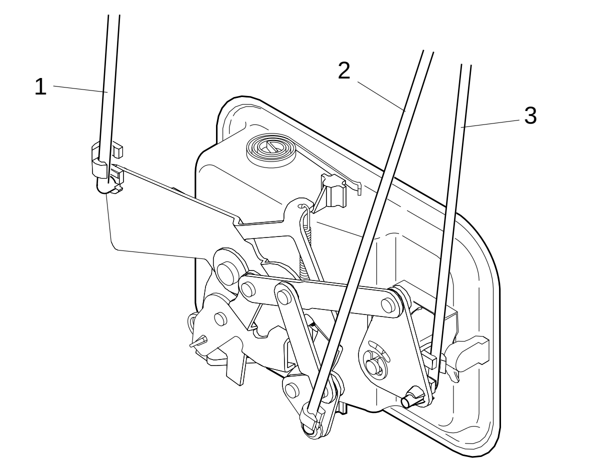
1. Interior Door Panel
2. Upper Mounting Bracket
3. Machine Screws, 10–24
4. Regulator Shaft
5. Lift Cursor
6. Regulator Body
7. Window Glass
8. Window Lift Channel
9. Spring Clip
10. Window Lift Nut, 1/4–20
11. Drive Shaft
12. Face Plate
13. Window Crank
14. Window Crank Screw, 10–24

Fig. 2, Manual Window Regulator

Exterior Door Handle and Rods Replacement

Handle Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the window crank, if so equipped.
3. Remove the interior door panel; see **Subject 110**.
4. Reference the interior handle rod, latch actuator rod, and door lock rod attached to the door handle assembly. Release the lower ends of the rods from the clips on the door handle assembly; see **Fig. 1**.



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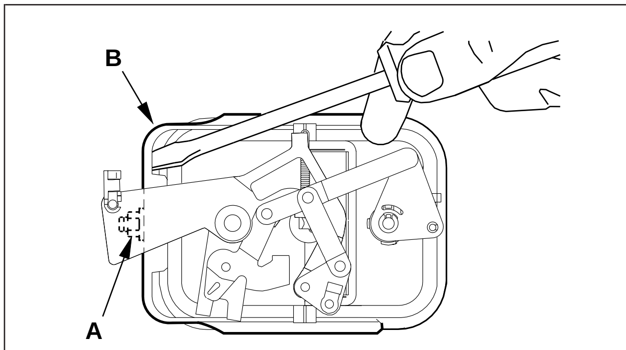
NOTE: Typical door handle shown; others are similar.

1. Latch Actuator Rod
2. Interior Handle Rod
3. Door Lock Rod

Fig. 1, Door Handle (inside view)

5. Remove the retaining nut that secures the fastening clip to the door handle assembly; see **Fig. 2**.
6. Using a pry tool, such as a screwdriver, push the fastening clip to the side until it clears the door handle bolt; see **Fig. 2**. Be careful not to let the door handle assembly drop as the fastening clip is pushed out of place. Remove the door handle assembly. It may be necessary to remove the lock cylinder (two clips) to fit the handle assembly through the door cutout.
7. Position the new door handle assembly in the door, then slide the fastening clip in place (reverse the procedure used to remove it).
8. Install the lock cylinder, if necessary.



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NOTE: Typical door handle shown; others are similar.

A. Remove retaining nut from bolt.
B. Push the fastening clip free.

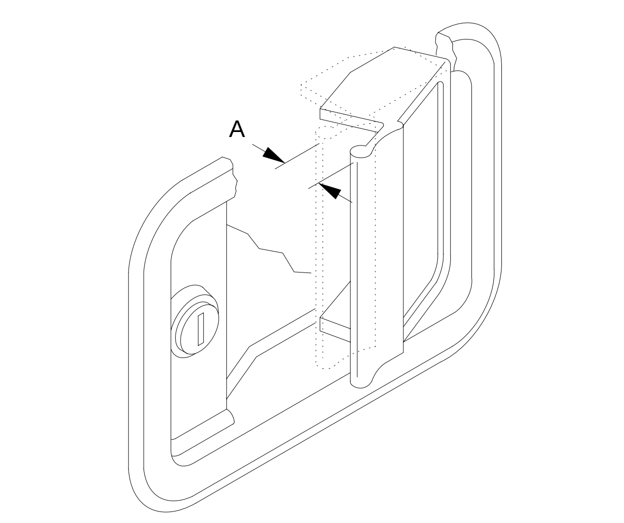
Fig. 2, Removing Exterior Door Handle Fastening Clip

9. Install the retaining nut that secures the fastening clip to the door handle assembly; see **Fig. 2**. Tighten the nut securely.
10. As referenced earlier, attach the lower ends of the interior handle rod, latch actuator rod, and door lock rod to the door handle assembly. Make sure the clips are locked in place.
11. With the cab door closed and unlocked, gradually pull on the paddle of the exterior door handle while measuring its travel. The paddle should move at least 3/8 inch (10 mm) before the door latch opens; see **Fig. 3**.
12. Make sure that the rod has been correctly installed by doing the following tests: Close the latch jaws until they lock in place. Depress the lock button on the interior side of the door. Attempt to open the locked jaws using the exterior door handle. The jaws should not open. Attempt to open the locked jaws using the interior door handle. The jaws should open and the lock button should release. If adjustment is necessary, see **Subject 200**.
13. Attach the interior door panel; see **Subject 110**.
14. Install the window crank, if so equipped. Tighten the screw 60 lbf·in (680 N·cm).
15. Remove the chocks.

Door Lock Rod Replacement

1. Apply the parking brakes and chock the tires.

Exterior Door Handle and Rods Replacement



A. Measurement: 3/8 inch (10 mm)

Fig. 3, Measurement of Paddle Travel

2. Remove the window crank, if so equipped.
3. Remove the interior door panel; see **Subject 110**.
4. Release the lower end of the door lock rod from the clip on the door handle assembly; see **Fig. 1**.
5. Remove the lock rod from the door panel by pulling the bottom end down and out through the button hole, together with the door lock button, which is attached at the top end.
6. Install the door lock button on the new lock rod.
7. Install the lock rod in the interior door panel by inserting the end of the lock rod with the door lock button through the hole in the top of the interior door panel.
8. Attach the door lock rod to the door handle assembly; see **Fig. 1**. Make sure the clip is locked in place.
9. Install the interior door panel; see **Subject 110**.
10. Install the window crank, if so equipped. Tighten the screw 60 lbf·in (680 N·cm).
11. Remove the chocks.

Interior Handle Rod and Latch Actuator Rod Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the window crank, if so equipped.
3. Remove the interior door panel; see **Subject 110**.
4. Remove the lower end of the interior handle rod by releasing the lower end from the clip on the door handle assembly; see **Fig. 1**. Remove the upper end from the clip on the bellcrank arm.
5. Remove the lower end of the latch actuator rod by releasing the lower end from the clip on the door handle assembly. Remove the upper end from the clip on the door latch.
6. Connect the upper end of the new latch actuator rod to the clip on the door latch, and the lower end to the clip on the door handle assembly; see **Fig. 1**.
7. Position the new interior handle rod between the door panel and the window regulator shaft. Connect the upper end of the rod to the clip on the bellcrank arm, and the lower end to the clip on the door handle assembly. Make sure that the clips are securely snapped on the the rod.
8. Install the interior door panel; see **Subject 110**.
9. Install the window crank, if so equipped. Tighten the screw 60 lbf·in (680 N·cm).
10. Remove the chocks.

Door Hinge Removal and Installation

Removal

1. Remove the door from the vehicle. For instructions, see **Subject 100**.
2. Remove the hinge from the door assembly.

Installation

1. Attach the hinge to the door assembly.
2. Install the door on the vehicle. For instructions, see **Subject 100**.
3. Adjust the door. For instructions, see **Subject 120**.
4. Some types of door hinges should not be lubricated. See **Group 72** of the *Columbia® Maintenance Manual* to determine whether the hinge should be lubricated.

Replacement

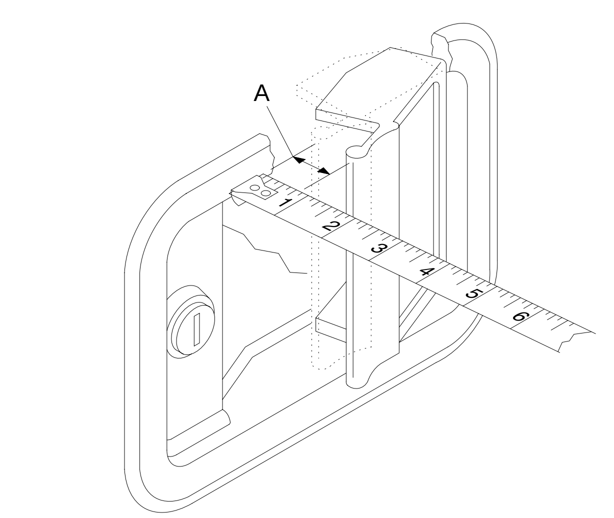
1. Remove the entire length of the seal from the channel that surrounds the upper door structure, as well as from the outer edge of the inner door panel.
2. Install the new door seal by pushing it firmly onto the channel, with the ends of the seal meeting at the bottom of the door, toward the front. Trim the seal to length as needed. Make sure the seal is pushed completely onto the channel all around the door. If necessary, use a rubber hammer to tap the seal into place. There should be no creases or buckles on the sealing surface.

NOTE: Do not stretch the door seal during installation. To do so may reduce its sealing ability, which could result in water leaks.

Exterior Door Release Adjustment

1. Apply the parking brakes and chock the tires.
2. From outside the cab (with the cab entry door closed), place a tape measure or scale on the paddle handle chrome surround. Slowly pull the paddle handle. The horizontal measurement from the handle surround ridge to the inner finger-hold ridge on the inside of the paddle handle must be 3/8 to 13/16 inch (10 to 20 mm); see **Fig. 1**.

   If the movement of the exterior paddle handle is less than 3/8 inch (10 mm) before the door opens, the primary door latch releases too easily. If the measurement is more than 13/16 inch (20 mm), the primary door latch will be difficult to release from outside the cab. If the measurements are not within the specifications, adjust the linkage for the exterior release handle, as follows.



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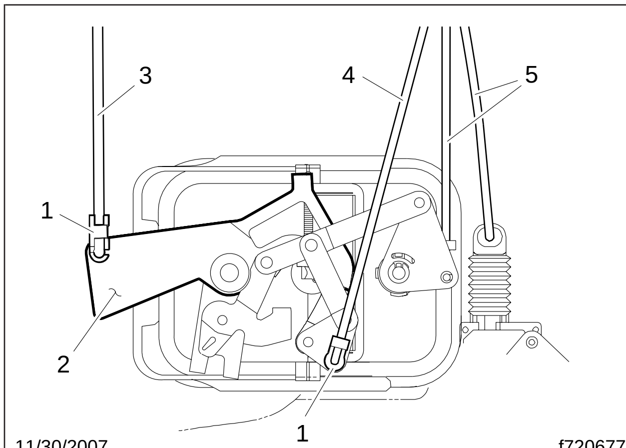
A. Door must open when handle is opened 3/8 to 13/16 inch (10 to 20 mm).

Fig. 1, Exterior Release Handle Measurement

3. Remove the interior door panel; see **Subject 110**.
4. Release the plastic clip and pull the latch actuator rod from the plastic bushing in the paddle arm of the exterior release handle; see **Fig. 2** or **Fig. 3**. Allow the latch actuator rod to hang freely near the paddle arm.



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1. Plastic Bushing with Clip
2. Paddle Arm
3. Latch Actuator Rod
4. Interior Handle Rod
5. Door Lock Rod

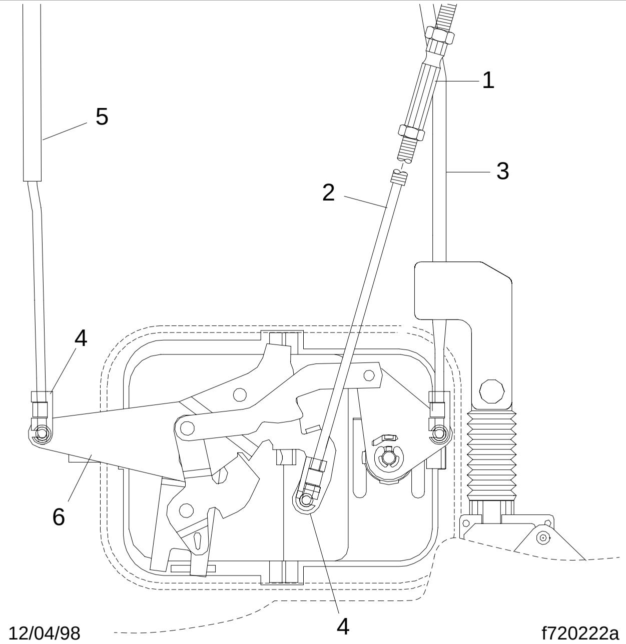
Fig. 2, Exterior Door Release Mechanism (vehicles with a non-adjustable interior door release)

5. The end of the latch actuator rod must be slightly below the hole in the plastic bushing in the paddle arm. Bend or straighten the latch actuator rod until the end is 1/8 inch (3 mm) below the hole. Make sure that the rod is aligned so that the door structure or the inner panel cannot interfere with the operation of the latch actuator rod.
6. Insert the latch actuator rod into the plastic bushing and rotate the plastic bushing to snap the clip onto the rod.
7. Make sure that the cab door opens correctly when the exterior paddle handle is pulled.
8. Install the interior door panel; see **Subject 110**.
9. Check that the rod does not rub or rattle against the inner door panel or door structure.

Interior Door Release Adjustment

NOTE: The following procedure applies to pre-2002 vehicles that are equipped with an adjustable interior release rod. If the interior release

Door Handle Adjustment



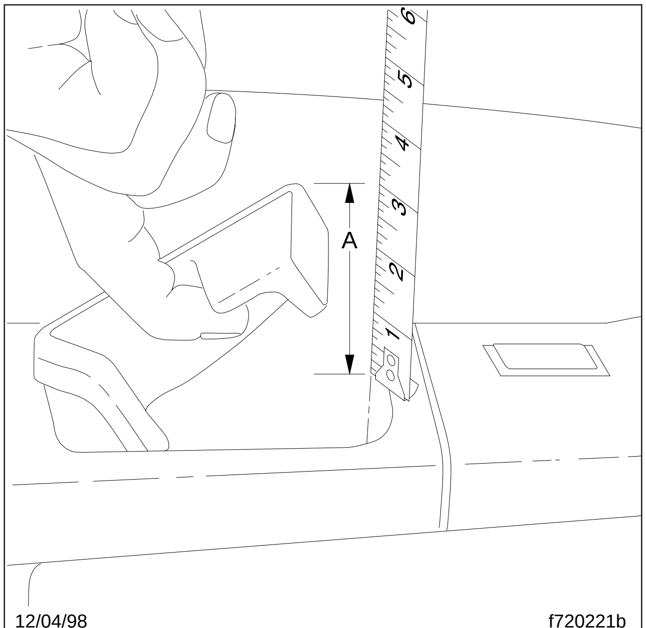
1. Threaded Coupler with Jam Nuts
2. Interior Handle Rod
3. Door Lock Rod
4. Plastic Bushing with Clip
5. Latch Actuator Rod
6. Paddle Arm

Fig. 3, Exterior Door Release Mechanism (vehicles with an adjustable interior door release)

rod does not have a threaded coupler, it is not adjustable; see **Fig. 2** (non-adjustable interior release rod) and **Fig. 3** (adjustable interior release rod).

IMPORTANT: Before checking the interior release handle adjustment, make sure that the exterior handle releases within the specified range, as described in the above procedure.

1. Apply the parking brakes and chock the tires.
2. With the cab entry door open, manually close the striker jaws to a fully closed position.
3. Place a tape measure vertically on the armrest, just forward of the interior release handle. Slowly pull up on the interior handle. The vertical measurement from the surface of the armrest to the top of the handle forward edge radius should be between 1-1/2 and 3 inches (38 and 76 mm) when the striker jaws snap open; see **Fig. 4**.
4. If the striker jaws open with less than 1-1/2 inches (38 mm) of interior handle movement, the primary door latch releases too easily. If the measurement is more than 3 inches (76 mm), the primary latch will be difficult to release from inside the cab. This maladjustment could also cause the door lock to unlock if there is an impact to the outside of the door. Adjust the linkage for the interior release handle as follows if the measurements are not within the specifications.



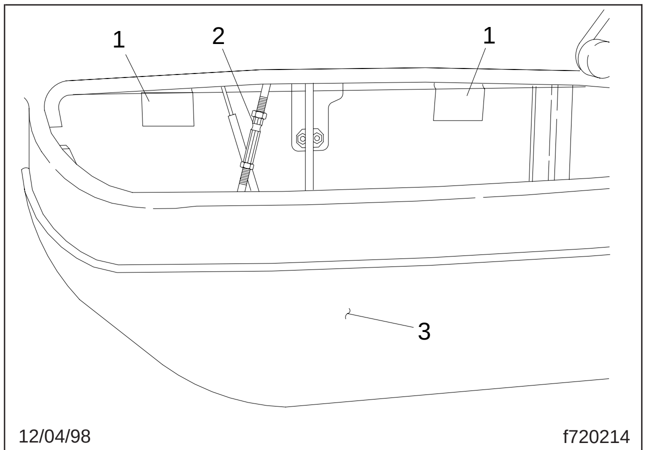
A. Door must open when handle is lifted 1-1/2 to 3 inches (38 to 76 mm).

Fig. 4, Interior Release Handle Measurement

5. If the interior release mechanism is out of adjustment, open the door and remove the cover located on the inner surface of the map pocket. This cover is retained by Velcro pads and can be removed by pulling at the top edge of the cover.
6. Lift the interior release handle and place a wood block under it, so that the handle is held up at the height specified in **Fig. 4**.
7. Loosen the two jam nuts on the threaded coupler for the interior release rod; see **Fig. 5**. Note that the lower jam nut has left-hand threads.
8. Close the latch striker jaws with your fingers; see **Fig. 6**. If the striker jaws will not stay closed with the wood block in place, turn the threaded cou-

Door Handle Adjustment

pler clockwise (looking from the top) to lengthen the rod. Manually close the latch jaws.



1. Velcro Fasteners for Trim Cover
2. Threaded Coupler
3. Inner Door Panel

Fig. 5, Threaded Coupler for Interior Handle Adjustment

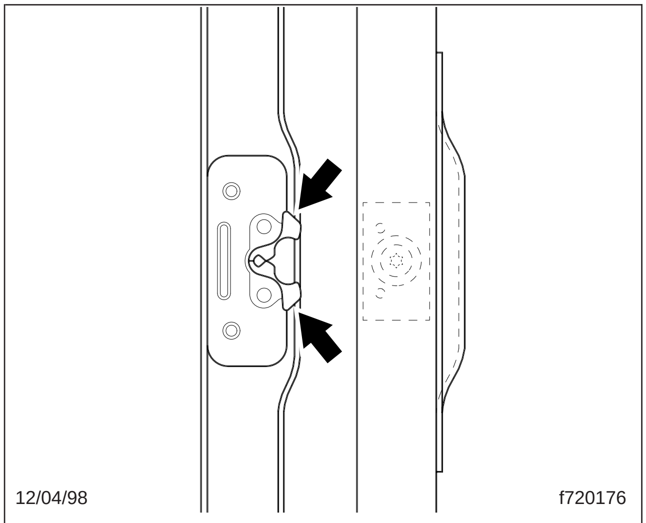


Fig. 6, Latch Striker Jaws

9. Turn the threaded coupler counterclockwise (looking from the top) until the striker jaws just open. Use your fingers to tighten the jam nuts with the threaded coupler in this position.
10. Tighten the jam nuts on the threaded coupler to 35 lbf·in (400 N·cm). Remove the wood block from underneath the interior handle, then check that the door releases when the handle is lifted between 1-1/2 and 3 inches (38 and 76 mm).
11. Install the trim cover in the map pocket of the door.

Replacement

NOTE: The wing window glass can be replaced without disassembling the wing window mounting assembly.

IMPORTANT: Replacing the wing window mounting assembly requires the disassembly of most of the door assembly and mechanisms. See **Subject 120** for instructions.

1. Unlatch and open the wing window. See **Fig. 1.**

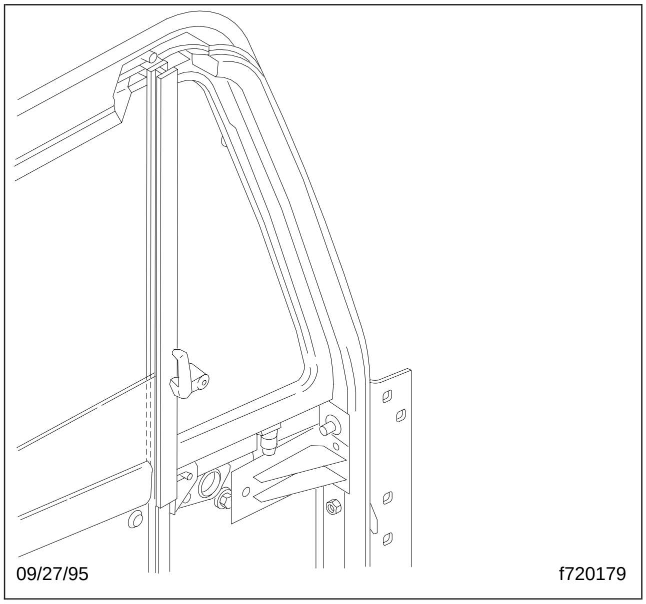


Fig. 1, Wing Window

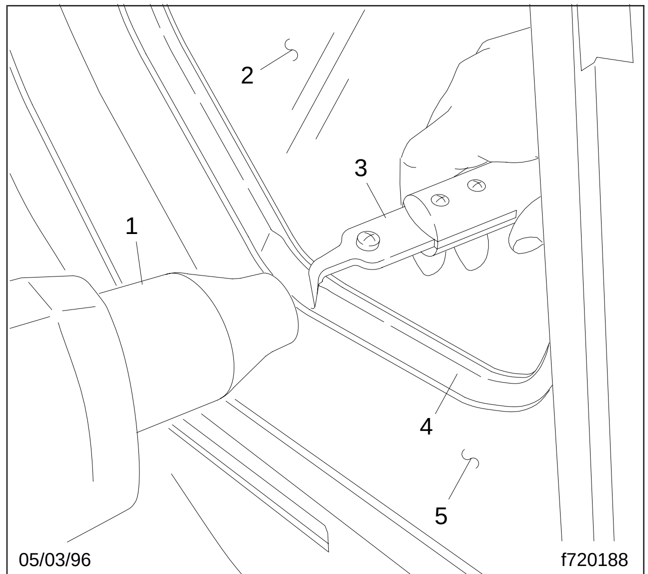
2. Remove the window glass from the wing window assembly that is located inside of the wing window bracket.
3. Remove the window latch mounted to the glass by removing the roll pin, and then removing the nut.
4. Mount the window latch to the replacement glass.
5. Seat the window glass in the glass-run channel with rubber extrusion and adhesive.
6. Close the wing window and relatch.

Replacement

⚠ WARNING

Use care when working around or handling glass. Wear protective gloves to eliminate the possibility of personal injury resulting from accidentally breaking or splintering the glass.

1. Park the vehicle on a flat surface. Shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Remove the inner door panel. See "Inner Door Panel Removal and Installation" in **Subject 110** for instructions.
4. Loosen the window guide, if necessary.
5. Disconnect and move aside all electrical connections.
6. Remove the window (rubber) trim edge from between the window glass and the outer door panel.
7. Using a pull knife and a hand-held heat gun, loosen the window glass adhesive. From the inside of the door, heat the adhesive attaching the window glass to the inside of the outer door panel while simultaneously loosening the adhesive with the pull knife. See **Fig. 1**.
8. Remove the window glass.
9. Clean the surfaces of the window glass and the window opening in the door.
10. Mount double-sided tape to the edges of the replacement window glass.
11. Position the glass correctly, remove the tape covering, and then press the glass firmly around the edges to "set" the tape.
12. Insert the window (rubber) trim edge between the window and the door.
13. Connect all electrical connections, if necessary.
14. Install the inner door panel. See "Inner Door Panel Removal and Installation" in **Subject 110** for instructions.
15. Connect the batteries.



1. Heat Gun
2. Window Glass
3. Pull Knife
4. Adhesive
5. Door

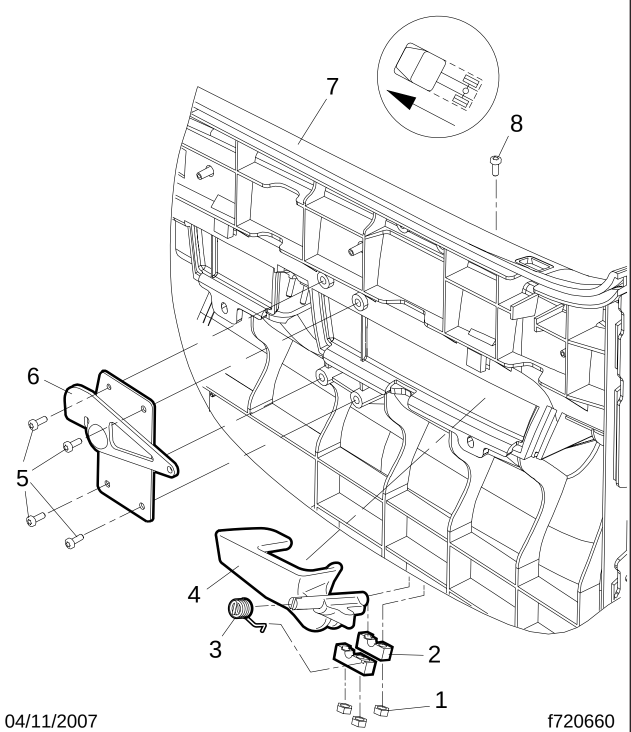
Fig. 1, Heating Adhesive for Removal with Pull Knife

16. Remove the chocks from the tires.

Replacement

NOTE: Tighten all fasteners 35 lbf·in (400 N·cm).

1. Apply the parking brakes and chock the tires.
2. Remove the interior door panel; see **Subject 110**.
3. Lay the door panel on a clean, smooth work surface, with the inner side up.
4. Remove the four screws that secure the bell crank assembly to the interior door panel; see **Fig. 1**. Remove the bell crank assembly and interior release rod.
5. Remove the three interior door handle nuts; see **Fig. 2**.



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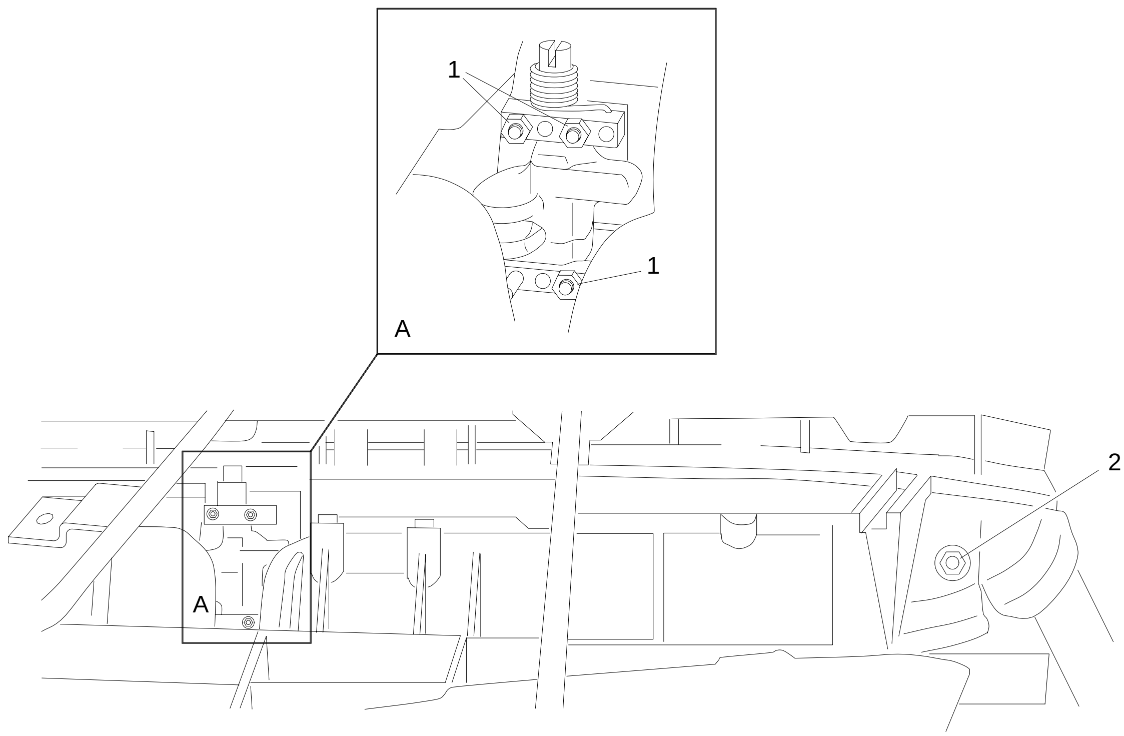
1. Nut
2. Handle Retainers
3. Door Handle Return Spring
4. Inner Door Handle
5. Screws
6. Bell Crank Assembly
7. Inner Door Panel
8. Retainer Screw

Fig. 1, Bell Crank Assembly and Inner Door Handle Installation

6. Remove the armrest support nut. Remove the arm rest.
7. Remove the interior door handle return spring.
8. From the outer side of the panel, remove the Torx® screw that secures the handle to the door panel; see **Fig. 3**. Remove the door handle.
9. Position a new handle on the door panel, and install the Torx screw on the outer side of the door panel; see **Fig. 3**.
10. Install the interior door handle return spring.
11. Install the armrest support nut; see **Fig. 2**. Install the armrest.
12. Install the interior door handle nuts.
13. Install the four screws that secure the bell crank assembly to the interior door panel; see **Fig. 1**. Install the bell crank assembly and interior release rod.
14. Install the door panel; see **Subject 110**.
15. Remove the chocks.

Inner Door Handle Replacement



1. Interior Door Handle Nuts
2. Armrest Support Nut

Fig. 2, Door Handle and Armrest Fasteners

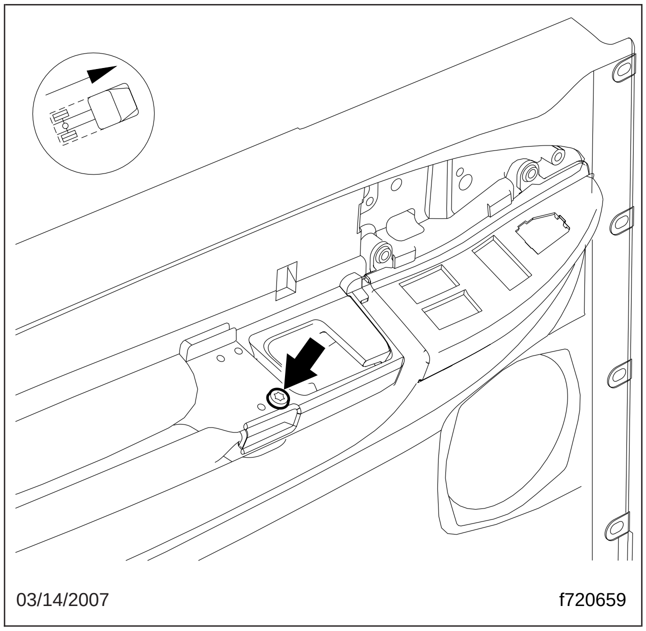


Fig. 3, Inner Door Handle Retainer Screw

For fastener torque values, see **Table 1**.

For a schematic of the power door locks, see **Fig. 1**.

For a drawing of the main cab overlay harness, see **Fig. 2**.

For a drawing of the left-hand door harness, see **Fig. 3**.

For a drawing of the right-hand door harness, see **Fig. 4**.

Torque Values			
Description	**Grade**	**Size**	**Torque**
Allen-Head Capscrews	—	1/4–20	60 lbf·in (680 N·cm)
Door-Latch Hexhead Capscrews	5	1/4–20	60-84 lbf·in (680-940 N·cm)
	8	1/4–28	120 lbf·in (1360 N·cm)
Door-Panel Retainer Bolt	5	5/16–18	15 lbf·ft (20 N·m)
Hinge/Door-Frame Hexhead Capscrews	5	1/4–20	60-84 lbf·in (680-940 N·cm)
	8	1/4–28	120 lbf·in (1360 N·cm)
Hinge Self-Tapping Screws	8	1/4–20	120 lbf·in (1360 N·cm)
Inner Door Panel Machine Screws	—	10–24	60 lbf·in (680 N·cm)
Window Lift Channel Nuts	—	1/4–20	70 lbf·in (800 N·cm)
Sheet Metal Screws: Inner Panel to Door Frame	—	Type A, No. 10	30 lbf·in (340 N·cm)
Striker Pin	8	7/16–14	18-32 lbf·ft (24-43 N·m)
Window Crank Screw	—	10–24	60 lbf·in (680 N·cm)
Interior Handle Rod Threaded Coupler Nuts	—	—	35 lbf·in (400 N·cm)
Interior Door Handle Nuts	—	—	35 lbf·in (400 N·cm)
Armrest Support Nut	—	—	35 lbf·in (400 N·cm)
Inner Door Handle Retainer Screw	—	—	35 lbf·in (400 N·cm)

Table 1, Torque Values

Specifications

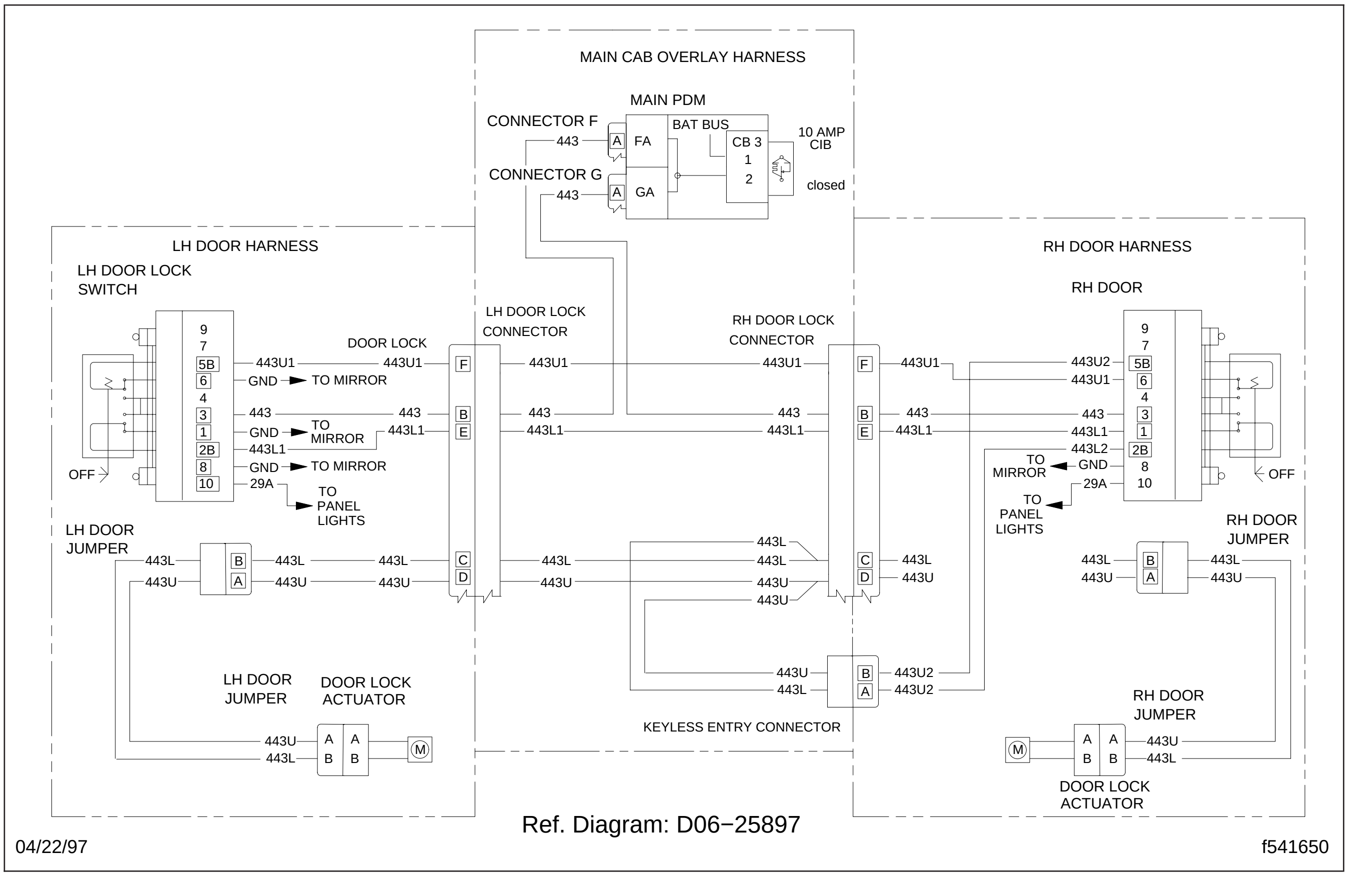


Fig. 1, Schematic, Power Door Locks

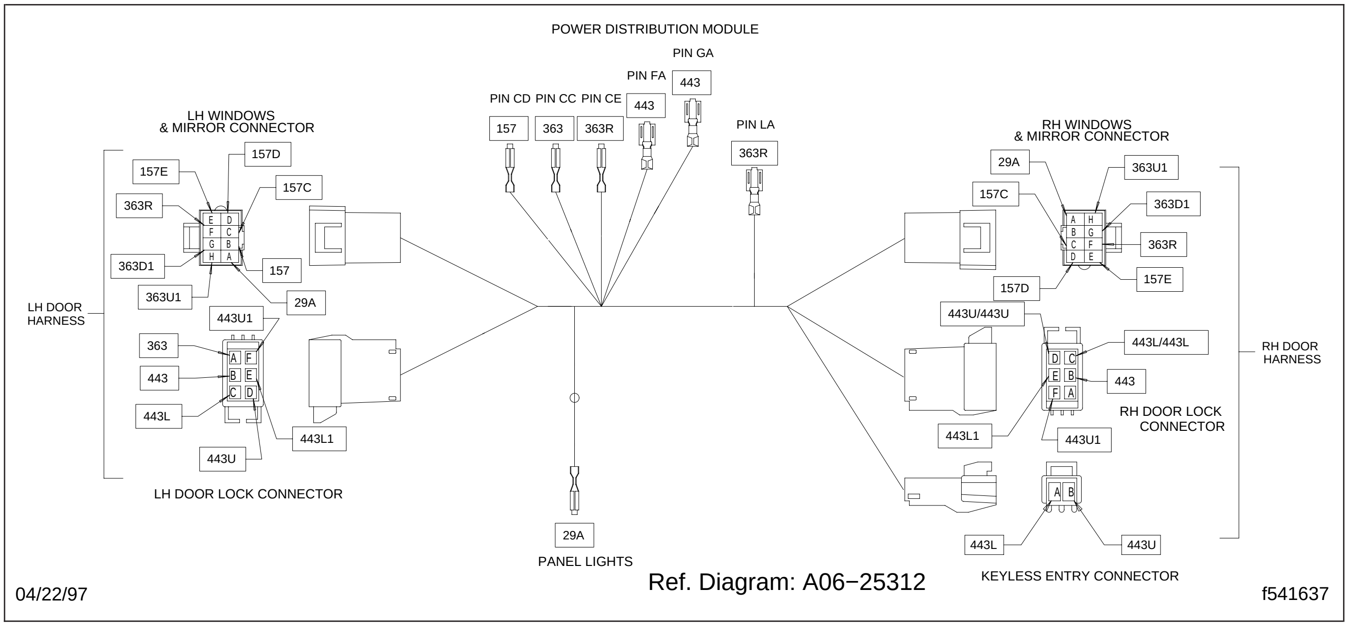


Fig. 2, Main Cab Overlay Harness

Specifications

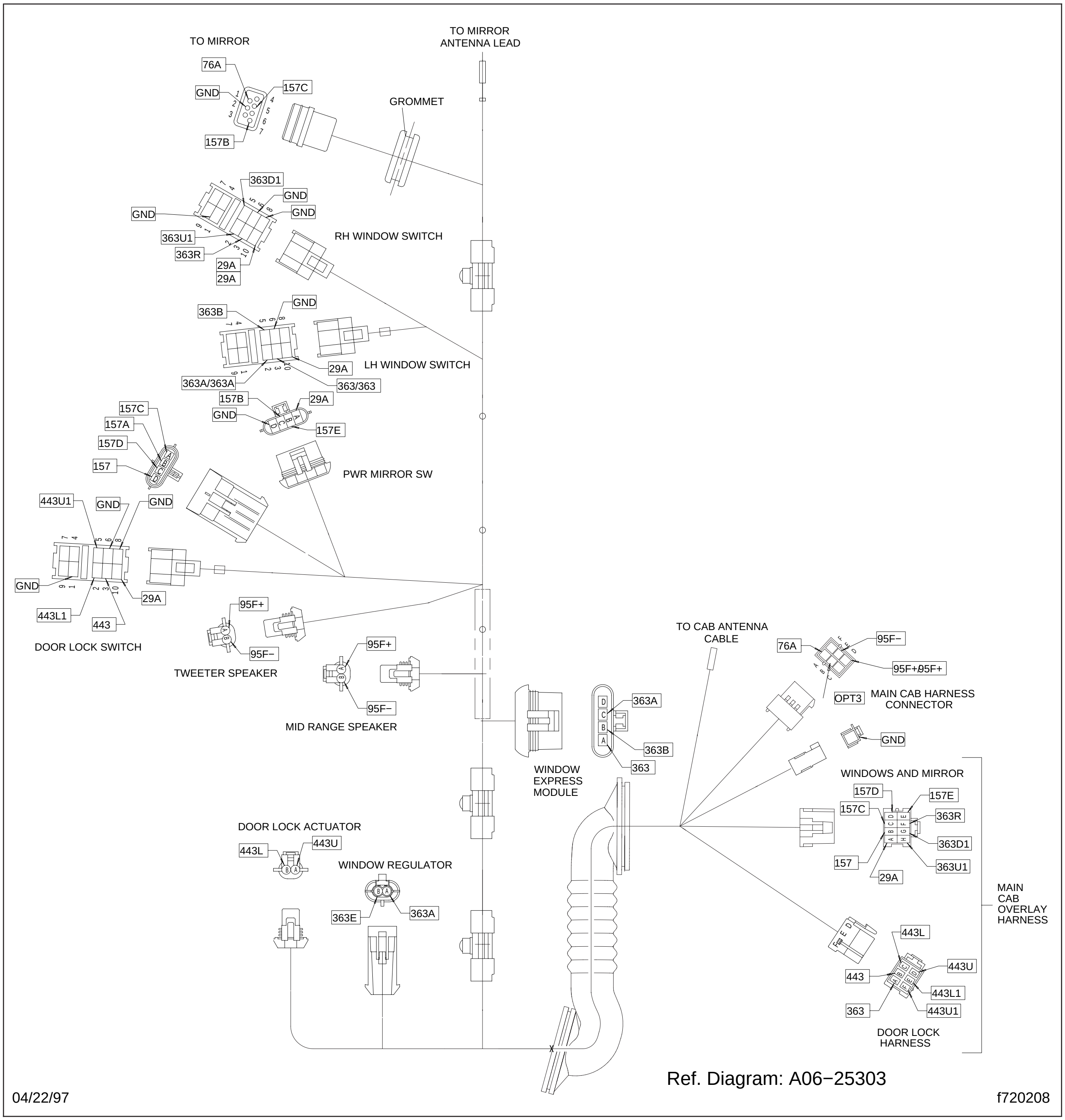


Fig. 3, Left-Hand Door Harness

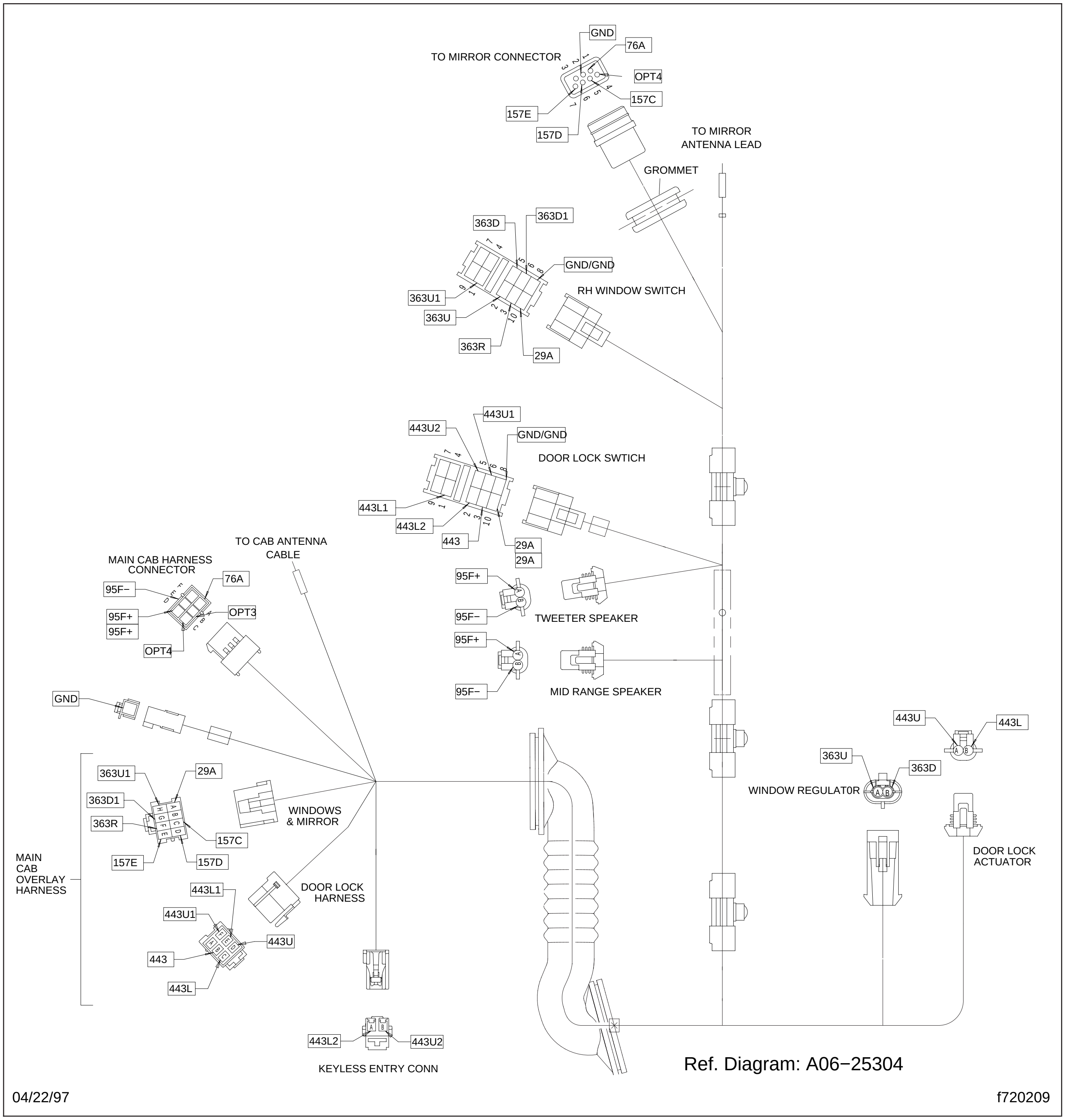
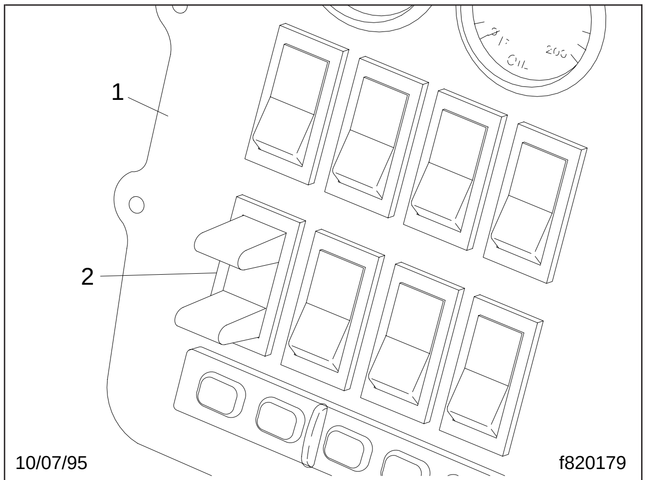


Fig. 4, Right-Hand Door Harness

General Information

The windshield wipers and washers are operated by a double-paddle switch mounted on the auxiliary instrument panel. See **Fig. 1**. Each paddle can be pushed in, up, or down, for three different functions. For wiper switch functions and operation, see **Fig. 2**.



1. Auxiliary Instrument Panel
2. Wiper/Washer Switch

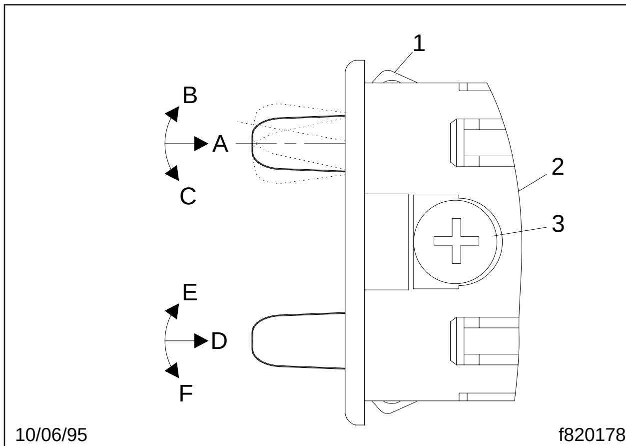
Fig. 1, Wiper/Washer Switch

The wipers have five cycles: fast, slow, mist, wash, and delay. There are six delay intervals, 3 seconds, 5 seconds (default fast), 8 seconds, 12 seconds, 17 seconds (default slow), and 23 seconds.

The top paddle, when pushed in, turns the wipers on (if they are off) or off (if they are on). When pushed up, the top paddle switches the wipers to high speed; when pushed down, it switches them to low speed.

The bottom paddle, when pushed in momentarily (for less than 1/2 second), turns the wipers on mist (one dry cycle at low speed). When pushed in and held in (for at least 1/2 second), the bottom paddle turns on the washers for a minimum of three cycles after release. For more wash cycles, hold the bottom paddle in longer (but it will always cycle three more times after release).

Pushing **the bottom paddle** up or down controls the delay cycle of the intermittent wipers. If the wipers are not in delay, push up for default fast delay (5 seconds) or down for default slow delay (17 seconds). If the wipers are already in delay, push up for the next faster delay or push down for the next slower delay.



A. Push in to turn wipers on (low speed) or off.
B. Push up for high speed.
C. Push down for low speed.
D. Push in momentarily for mist cycle. Push in and hold in for wash cycle.
E. Push up for fast delay. If already in delay, push up for the next faster delay.
F. Push down for slow delay. If already in delay, push down for the next slower delay.

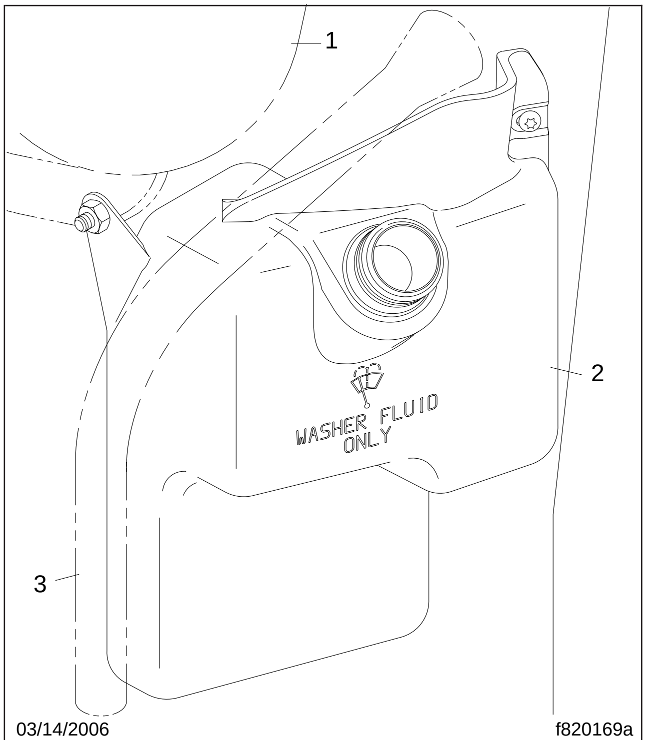
1. Locking Clip
2. Wiper/Washer Switch
3. Light Bulb Screw

Fig. 2, Wiper/Washer Switch Operation

A single wiper motor powers both wipers. It is mounted in the top center area of the cab front wall (behind the surge tank on vehicles with a front-wall mounted surge tank). The electric wiper motor is a sealed unit packaged together with a weather seal and drive crank. It is not serviceable. If a wiper motor does not work because of internal problems, replace it.

The windshield washer reservoir (**Fig. 3**) is located on the left-hand side of the cab front wall. A pump located in a recess in the bottom of the reservoir supplies washer fluid to each wiper arm. A purge mechanism empties the lines after use to prevent fluid from freezing in the lines during cold weather.

General Information



1. Surge Tank
2. Washer Reservoir
3. Drain

Fig. 3, Windshield Washer Reservoir (vehicle with front-wall mounted surge tank shown)

The service procedure for vehicles with radiator-mounted surge tanks is different from the service procedure for vehicles with cab front-wall mounted surge tanks. If the surge tank is mounted on the cab front wall, the tank has to be removed to access the wiper linkage.

Vehicles with Radiator-Mounted Surge Tanks

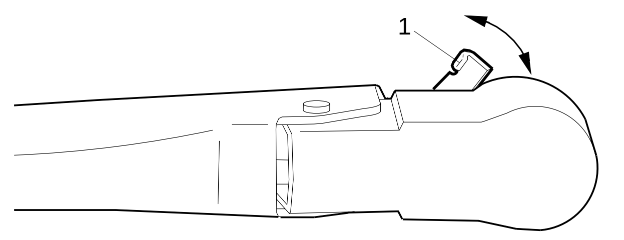
Removal

1. Apply the parking brakes and chock the tires.
2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Open the hood.
4. Disconnect the wiper motor electrical connector.

WARNING

Disconnect the wiper motor electrical connector before working on the wiper linkage. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage drive-shaft is forced out of the parked position, which could result in personal injury.

5. Remove each wiper arm and disconnect the washer hoses, as follows.
   - 5.1 Disconnect the windshield washer hose from the rain tray.
   - 5.2 With the wiper blade pulled away from the windshield, pull up the locking tab near the pivot end of the wiper arm; see **Fig. 1**. Remove the wiper arm from the wiper shaft.
6. Remove the nut and washer that attach the fan switch mounting bracket to the washer reservoir mounting stud; see **Fig. 2**. Remove the fan switch mounting bracket.
7. Detach any wiring and hoses from the bottom of the rain tray.
8. Remove the outboard drain tube from the rain tray. Remove the fastener that attaches the in-board drain tube to the rain tray, but leave the inboard drain tube in place.



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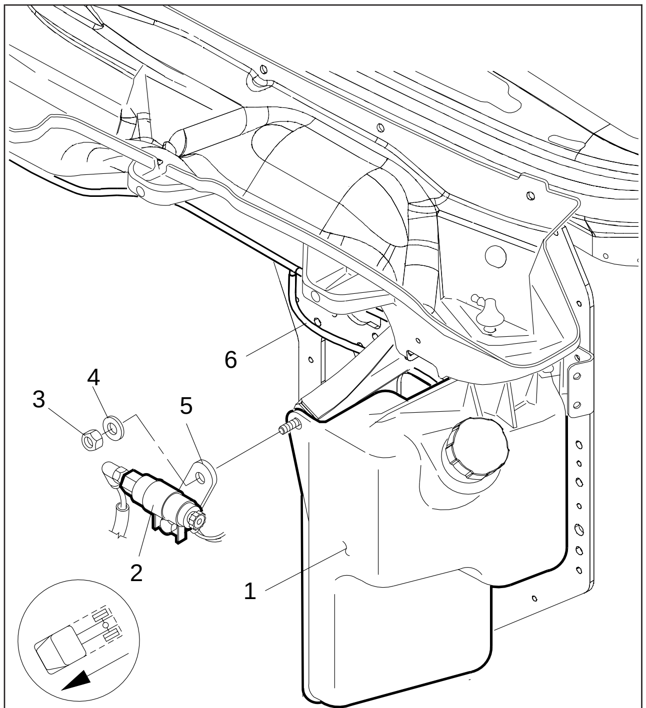
1. Locking Tab

Fig. 1, Wiper Arm Lock



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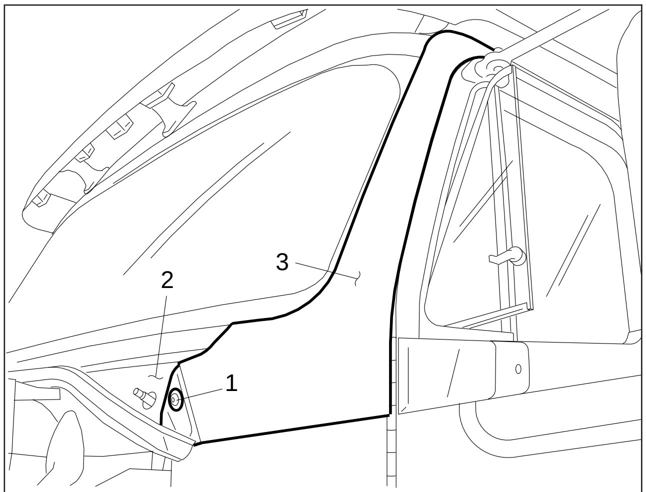
1. Washer Reservoir
2. Fan Switch
3. Nut
4. Washer
5. Fan Switch Mounting Bracket
6. Washer Fluid Line

Fig. 2, Fan Switch Installation

9. Remove the T27 Torx® screws that attach the rain tray to the A-pillar covers on both sides of the vehicle; see **Fig. 3**.
10. On the driver side only, remove the exterior covers from the upper A-pillar and the side cowl.

Wiper Linkage Removal and Installation



1. Torx Screw
2. Rain Tray
3. A-Pillar Cover

Fig. 3, A-Pillar Cover/Rain Tray Installation

11. Remove the T40 Torx capscrews that attach the rain tray to the cab front wall. Remove the rain tray.
12. Remove any hoses or wires that are attached to the wiper linkage assembly.
13. Remove the wiper linkage assembly from the cab front wall as follows; see **Fig. 4**.
    - 13.1 On the left side of the vehicle, remove the nut and washer that attach the wiper linkage mounting bracket to the front wall.
    - 13.2 On the right side of the vehicle, remove the capscrew and washer that attach the wiper linkage mounting bracket to the front wall.
    - 13.3 Remove the nut and washer that attach the wiper motor mounting bracket to the front wall. Remove the wiper linkage assembly.

Installation

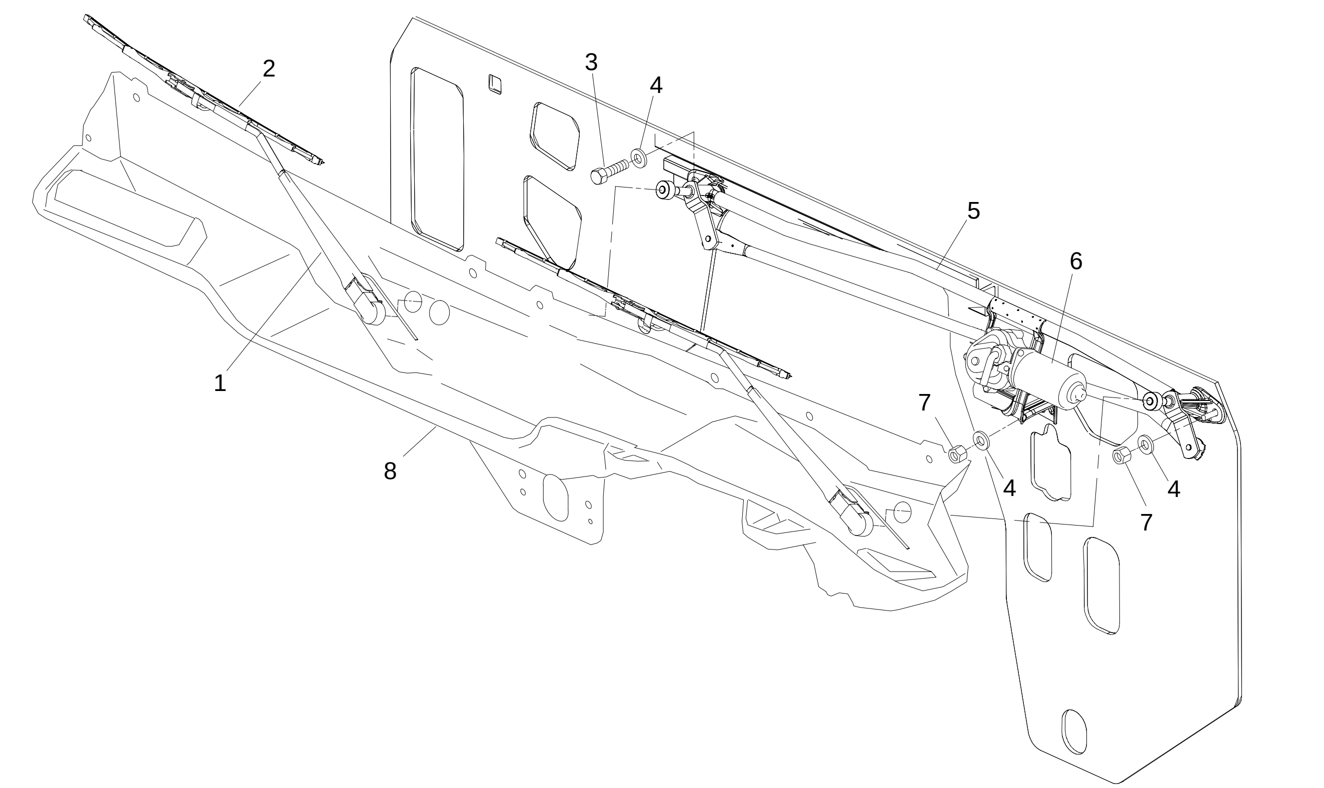
1. Install the wiper linkage assembly on the cab front wall as follows; see **Fig. 4**.
    - 1.1 Using a nut and washer, attach the left-side mounting bracket of the wiper linkage assembly to the front wall.
    - 1.2 Using a capscrew and washer, attach the right-side mounting bracket of the wiper linkage assembly to the front wall.
    - 1.3 Using a nut and washer, attach the wiper motor bracket to the front wall.
2. Attach any hoses or wires that were disconnected from the wiper linkage assembly.
3. Using six T40 Torx capscrews, attach the rain tray to the cab front wall.
4. Attach any wiring or hoses that were detached from the bottom of the rain tray.
5. Install the outboard drain tube; hook the bottom of the drain tube on the washer reservoir. Install the fastener for the inboard drain tube.
6. Install the driver-side upper A-pillar exterior cover and the side cowl exterior cover.
7. Using T27 Torx screws, attach the rain tray to the A-pillar covers on both sides of the vehicle; see **Fig. 3**.
8. Using a nut and washer, attach the fan switch mounting bracket to the upper washer reservoir mounting stud; see **Fig. 2**.
9. Install each wiper arm as follows. For the correct wiper park position, see **Fig. 5**.
    - 9.1 Install the wiper arm on the wiper driveshaft, then hold it in place while pulling the wiper blade away from the windshield. The locking tab will snap into the locked position.
    - 9.2 Check that the wiper arm is securely attached by pulling gently on it.
    - 9.3 Connect the washer hose to the rain tray.
10. Connect the wiper motor electrical connector.
11. Test the wiper motor and washers. Operate the wipers at low speed and check that the blades do not slap against the mask around the edge of the window.

Vehicles with Cab Front-Wall Mounted Surge Tanks

Removal

1. Apply the parking brakes and chock the tires.

Wiper Linkage Removal and Installation



1. Wiper Arm
2. Wiper Blade
3. Capscrew
4. Washer
5. Wiper Linkage
6. Wiper Motor
7. Nut
8. Rain Tray

Fig. 4, Wiper Linkage Installation

2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Open the hood.
4. Disconnect the wiper motor electrical connector.

WARNING

Disconnect the wiper motor electrical connector before working on the wiper linkage. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

5. Remove each wiper arm and disconnect the washer hoses as follows.

   5.1 Disconnect the windshield washer hose from the rain tray.

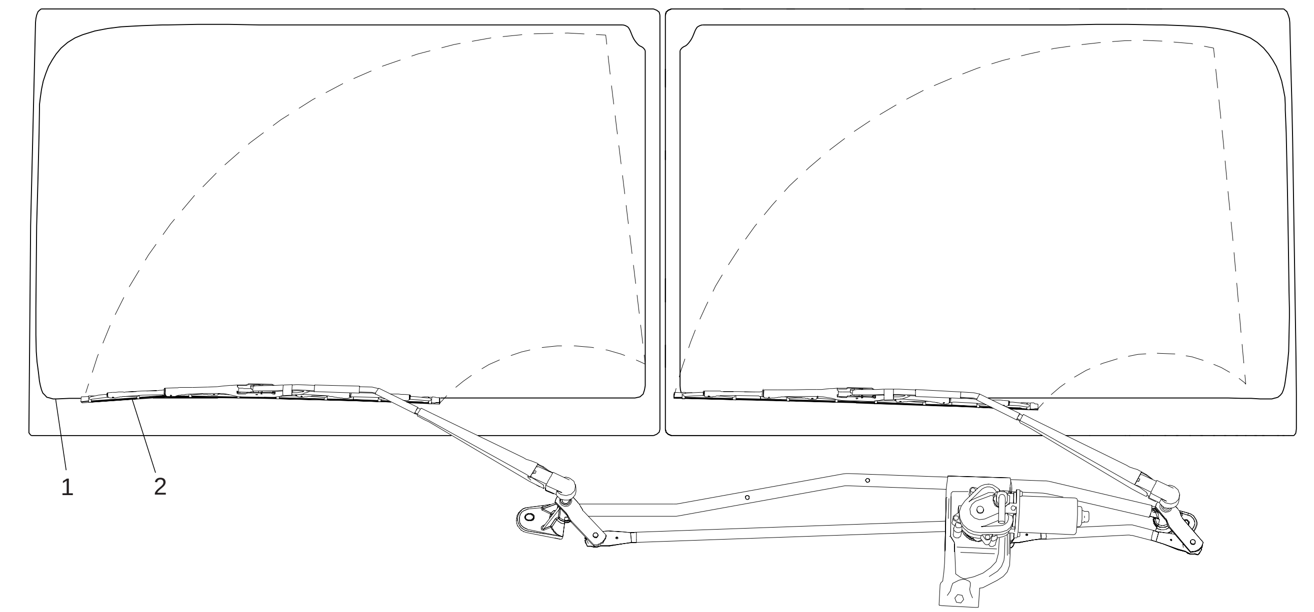
   5.2 With the wiper blade pulled away from the windshield, pull up the locking tab near the pivot end of the wiper arm; see **Fig. 1**. Remove the wiper arm from the wiper shaft.

6. On vehicles with a hood guide mounted above the washer reservoir, remove the hood guide as follows; see **Fig. 6**.

   6.1 Remove the four T40 Torx capscrews and washers that attach the hood guide to the mounting brackets.

   6.2 Remove the bolt, nut, and washers that attach the hood guide to the rain tray.

Wiper Linkage Removal and Installation



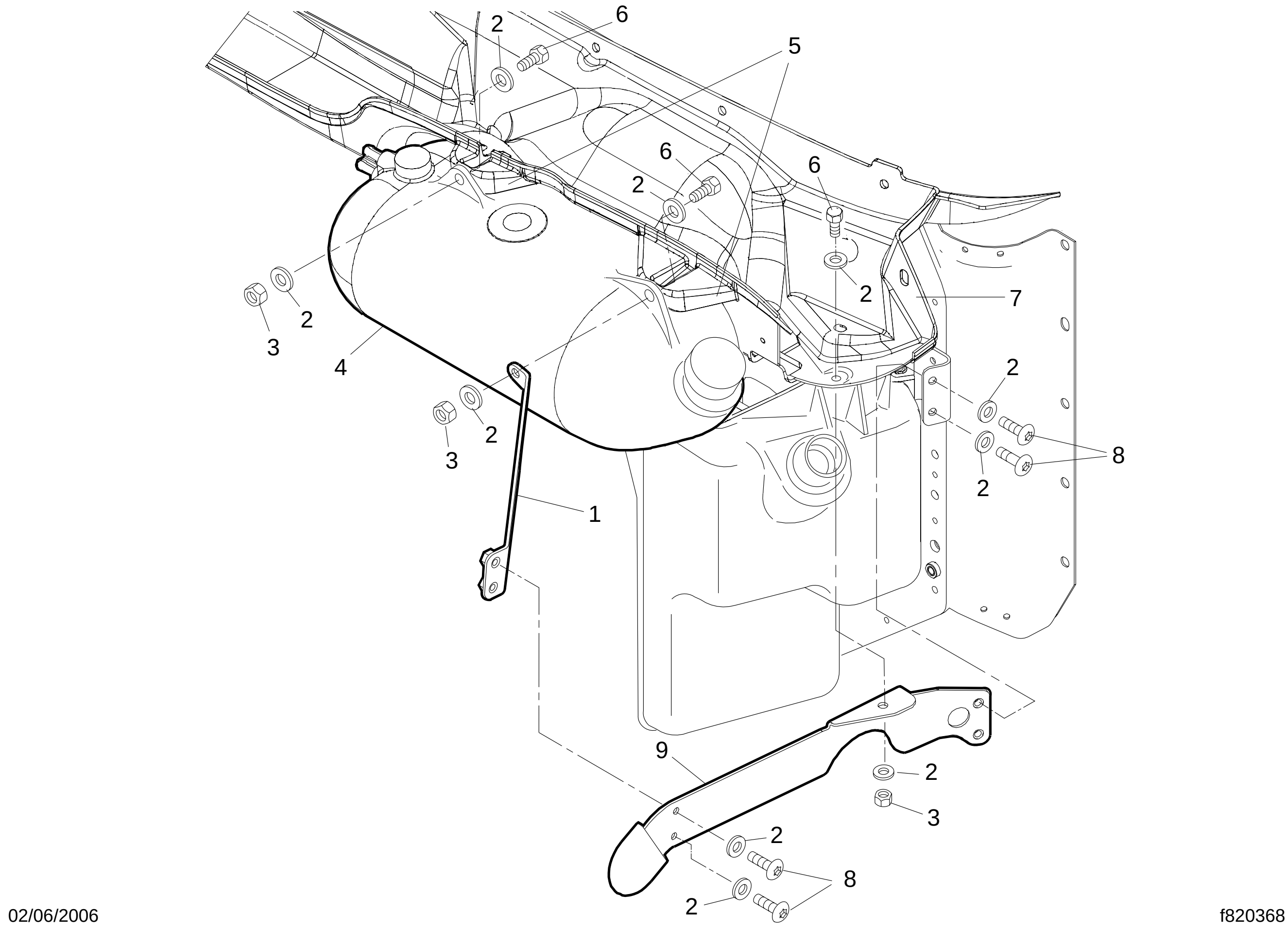
Park the blades within one spline's width of the edge of the dark band.

1. Edge of Dark Band
2. Wiper Blade

Fig. 5, Windshield Wiper Park Position

7. Remove the surge tank and the fan switch as follows.
   7.1 Remove the bolts, nuts, and washers that attach the surge tank and the hood guide mounting bracket (if so equipped) to the surge tank upper mounting brackets; see **Fig. 6**.
   7.2 Remove the nut that attaches the hose clamp to the surge tank lower mounting stud; see **Fig. 7**. Remove the hose clamp. Remove the second nut and washer that attach the surge tank to the same mounting stud.
   7.3 Remove the nut and washer that attach the fan switch mounting bracket to the surge tank lower left-side mounting stud; see **Fig. 7**. Remove the fan switch mounting bracket.
   7.4 Remove the surge tank.
8. Detach any wiring and hoses from the bottom of the rain tray.
9. Remove the outboard drain tube from the rain tray. Remove the fastener that attaches the inboard drain tube to the rain tray, but leave the inboard drain tube in place.
10. Remove the T27 Torx screws that attach the rain tray to the A-pillar covers on both sides of the vehicle; see **Fig. 3**.
11. On the driver side only, remove the exterior covers from the upper A-pillar and the side cowl.
12. Remove the T40 Torx capscrews that attach the rain tray to the cab front wall. Remove the rain tray.
13. Remove any hoses or wires that are attached to the wiper linkage assembly.
14. Remove the wiper linkage assembly from the cab front wall as follows; see **Fig. 4**.
    14.1 On the left side of the vehicle, remove the nut and washer that attach the wiper linkage mounting bracket to the cab front wall.

Wiper Linkage Removal and Installation



1. Hood Guide Mounting Bracket
2. Washer
3. Nut
4. Surge Tank
5. Surge Tank Mounting Brackets
6. Bolt
7. Rain Tray
8. T40 Torx Capscrew
9. Hood Guide

Fig. 6, Hood Guide Installation

14.2 On the right side of the vehicle, remove the capscrew and washer that attach the wiper linkage mounting bracket to the cab front wall.

14.3 Remove the nut and washer that attach the wiper motor mounting bracket to the cab front wall. Remove the wiper linkage assembly.

Installation

1. Install the wiper linkage assembly on the cab front wall as follows; see **Fig. 4**.

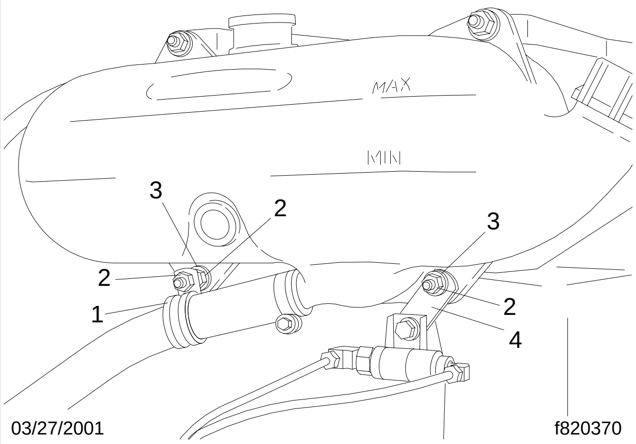
   1.1 Using a nut and washer, attach the left-side mounting bracket of the wiper linkage assembly to the cab front wall.

   1.2 Using a capscrew and washer, attach the right-side mounting bracket of the wiper linkage assembly to the cab front wall.

   1.3 Using a nut and washer, attach the wiper motor bracket to the cab front wall.

2. Attach any hoses or wires that were disconnected from the wiper linkage assembly.

Wiper Linkage Removal and Installation



1. Hose Clamp
2. Nut
3. Washer
4. Fan Switch Mounting Bracket

Fig. 7, Surge Tank Installation

3. Using six T40 Torx capscrews, attach the rain tray to the cab front wall.
4. Attach any wiring or hoses that were detached from the bottom of the rain tray.
5. Install the outboard drain tube; hook the bottom of the drain tube on the washer reservoir. Install the fastener for the inboard drain tube.
6. Install the driver-side upper A-pillar exterior cover and the side cowl exterior cover.
7. Using T27 Torx screws, attach the rain tray to the A-pillar covers on both sides of the vehicle; see **Fig. 3**.
8. Install the surge tank and the fan switch as follows.

   8.1 Position the surge tank on the mounting brackets and studs. Using a bolt, nut, and washer, install the hood guide mounting bracket (if so equipped) on the left-side upper mounting bracket; see **Fig. 6**.

   8.2 Using a bolt, nut, and washer, secure the surge tank to the right-side upper mounting bracket.

   8.3 Using a nut and washer, secure the surge tank to the lower right-side mounting stud. Install the hose clamp on the same mounting stud and secure the hose clamp with a nut; see **Fig. 7**.

   8.4 Using a nut and washer, attach the fan switch mounting bracket to the lower left-side mounting stud.
9. On vehicles with a hood guide mounted above the washer reservoir, install the hood guide as follows; see **Fig. 6**.

   9.1 Using a bolt, nut, and washer, attach the hood guide to the rain tray.

   9.2 Using four T40 Torx capscrews, attach the hood guide to the mounting brackets.
10. Install each wiper arm as follows. For the correct wiper park position, see **Fig. 5**.

    10.1 Install the wiper arm on the wiper driveshaft, then hold it in place while pulling the wiper blade away from the windshield. The locking tab will snap into the locked position.

    10.2 Check that the wiper arm is securely attached by pulling gently on it.

    10.3 Connect the washer hose to the rain tray.
11. Connect the wiper motor electrical connector.
12. Test the wiper motor and washers. Operate the wipers at low speed and check that the blades do not slap against the mask around the edge of the window.

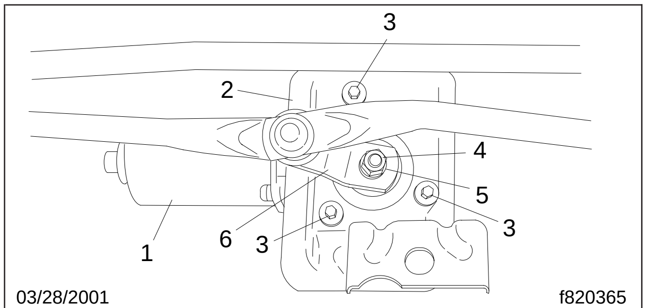
Replacement

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Check that the wiper blades are parked. If necessary, park them by turning the wipers on and then off.
3. Open the hood.
4. Disconnect the wiper motor electrical connector.

WARNING

Disconnect the wiper motor electrical connector before working on the wiper linkage. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

5. Remove the wiper linkage assembly. For instructions, see **Subject 100**.
6. Remove the nut and lockwasher that attach the motor lever to the drive shaft. See **Fig. 1**.



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1. Wiper Motor
2. Mounting Bracket
3. Capscrew
4. Nut
5. Lockwasher
6. Motor Lever

Fig. 1, Wiper Motor Assembly

7. Remove the three capscrews that attach the motor to the mounting bracket.
8. Using three capscrews, attach a new motor to the mounting bracket.
9. Using a nut and lockwasher, attach the motor lever to the drive shaft.
10. Install the wiper linkage assembly. For instructions, see **Subject 100**.
11. Connect the wiper motor electrical connector.
12. Test the wiper motor and washers. Operate the wipers at low speed and check that the blades do not slap against the mask around the edge of the window.
13. Close and latch the hood.
14. Remove the chocks.

The service procedure for vehicles with radiator-mounted surge tanks is different from the service procedure for vehicles with cab front-wall mounted surge tanks. If the surge tank is mounted on the cab front wall, the tank has to be removed to replace the washer reservoir.

Vehicles with Radiator-Mounted Surge Tanks

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood. TEXT HERE
3. Remove the nut and washer that attach the fan switch mounting bracket and washer reservoir to the mounting stud. See **Fig. 1**. Remove the fan switch mounting bracket.
4. Remove the outboard drain tube from the rain tray.
5. Disconnect the electrical connector from the washer pump.
6. Disconnect the washer fluid hose from the washer pump.

NOTE: Washer fluid will flow out of the washer pump outlet if the reservoir contains washer fluid.

7. Remove the two T40 Torx capscrews and washers that attach the washer reservoir to the mounting bracket and front wall. See **Fig. 1**. Remove the washer reservoir.

Installation

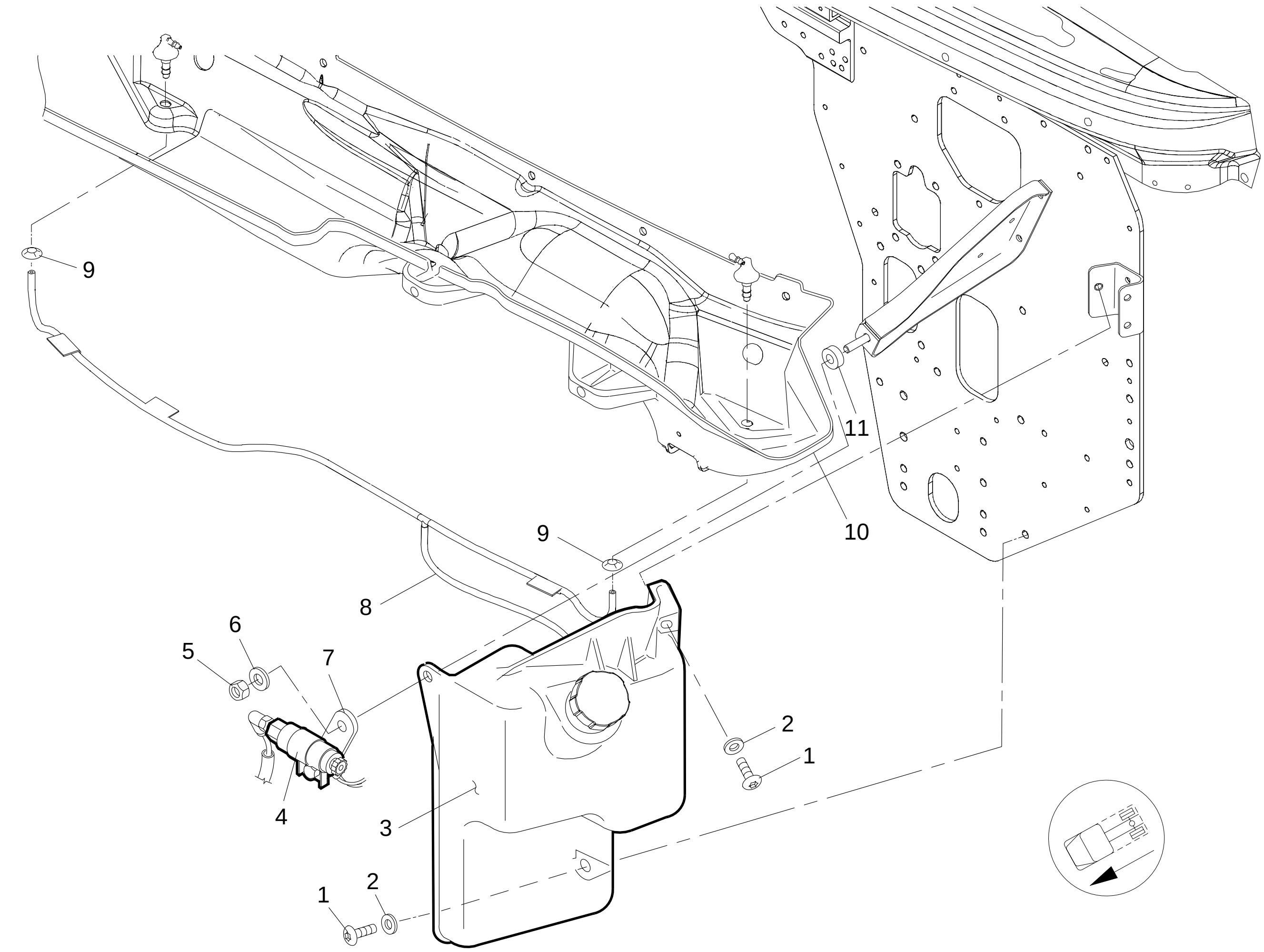
1. With the tires chocked, using two T40 Torx capscrews and washers, attach the washer reservoir to the mounting bracket and front wall. See **Fig. 1**.
2. Attach the washer fluid hose to the washer pump.
3. Attach the electrical connector to the washer pump.
4. Install the washer reservoir and the fan switch mounting bracket on the mounting stud. Using a nut and washer, secure both components to the mounting stud.
5. Install the outboard drain tube on the rain tray; hook the drain tube on the washer reservoir.
6. Close and latch the hood.
7. Remove the chocks.

Vehicles with Cab Front-Wall Mounted Surge Tanks

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. On vehicles with a hood guide mounted above the washer reservoir, remove the hood guide, as follows. See **Fig. 2**.
   - 3.1 Remove the four T40 Torx capscrews and washers that attach the hood guide to the mounting brackets.
   - 3.2 Remove the bolt, nut, and washers that attach the hood guide to the rain tray.
4. Remove the surge tank and the fan switch, as follows.
   - 4.1 Remove the bolts, nuts, and washers that attach the surge tank and the hood guide mounting bracket (if so equipped) to the upper surge tank mounting brackets. See **Fig. 2**.
   - 4.2 Remove the nut that attaches the hose clamp to the lower surge tank mounting stud. See **Fig. 3**. Remove the hose clamp. Remove the second nut and washer that attach the surge tank to the same mounting stud.
   - 4.3 Remove the nut and washer that attach the fan switch mounting bracket to the lower surge tank mounting stud. See **Fig. 3**. Remove the fan switch mounting bracket.
   - 4.4 Remove the surge tank from the mounting studs.
5. Remove the outboard drain tube from the rain tray.
6. Disconnect the electrical connector from the washer pump.

Washer Reservoir Removal and Installation



1. T40 Torx Capscrew
2. Washer
3. Washer Reservoir
4. Fan Switch
5. Nut
6. Washer
7. Fan Switch Bracket
8. Washer Fluid Hose
9. Pushnut
10. Rain Tray
11. Spacer

Fig. 1, Washer Reservoir Installation (vehicles with radiator-mounted surge tank)

7. Disconnect the washer fluid hose from the washer pump.

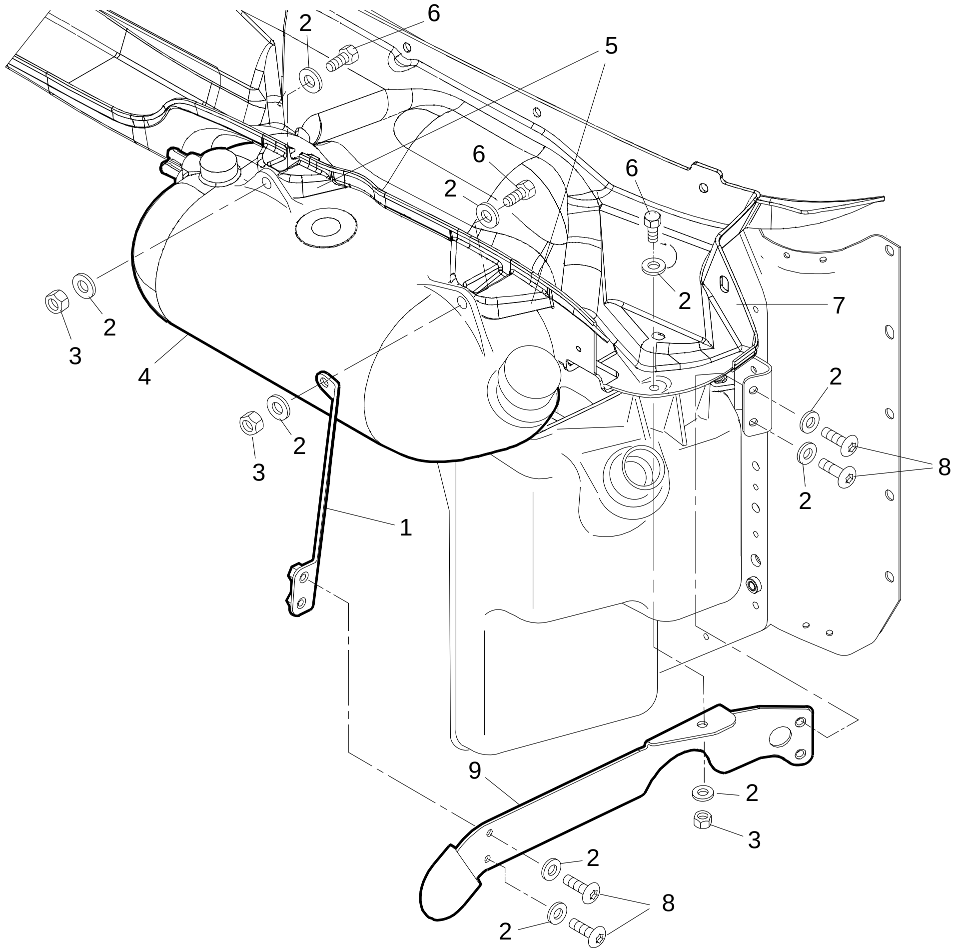
NOTE: Washer fluid will flow out of the washer pump outlet if the reservoir contains washer fluid.

8. Move the surge tank off of the lower mounting stud and upper mounting brackets.
9. Remove the two T40 Torx capscrews and washers that attach the washer reservoir to the mounting bracket and front wall. See **Fig. 4**.
10. Remove the washer reservoir from the mounting stud.

Installation

1. With the tires chocked, position the washer reservoir in place on the mounting stud. Using two

Washer Reservoir Removal and Installation



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1. Hood Guide Mounting Bracket
2. Washer
3. Nut
4. Surge Tank
5. Surge Tank Mounting Brackets
6. Bolt
7. Rain Tray
8. T40 Torx Capscrew
9. Hood Guide

Fig. 2, Hood Guide Installation

T40 Torx capscrews and washers, attach the reservoir to the mounting bracket and front wall. See **Fig. 4**.

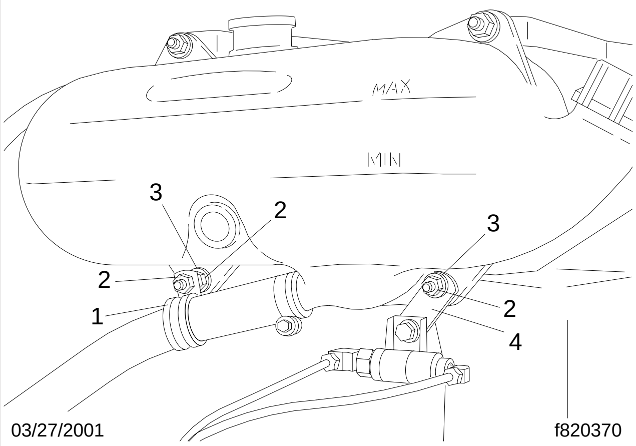
2. Attach the washer fluid hose to the washer pump.
3. Attach the electrical connector to the washer pump.
4. Install the surge tank and the fan switch, as follows.

   4.1 Position the surge tank on the mounting brackets and studs. Using a bolt, nut, and washer, install the hood guide mounting bracket (if so equipped) on the upper right-side mounting bracket. See **Fig. 2**.

   4.2 Using a bolt, nut, and washer, secure the surge tank to the upper left-side mounting bracket.

   4.3 Using a nut and washer, secure the surge tank to the lower right-side mounting stud. Install the hose clamp on the same mounting stud and secure the hose clamp with a nut. See **Fig. 3**.

Washer Reservoir Removal and Installation



1. Hose Clamp
2. Nut
3. Washer
4. Fan Switch Mounting Bracket

Fig. 3, Surge Tank Installation

4.4 Using a nut and washer, attach the fan switch mounting bracket to the left-side mounting stud.

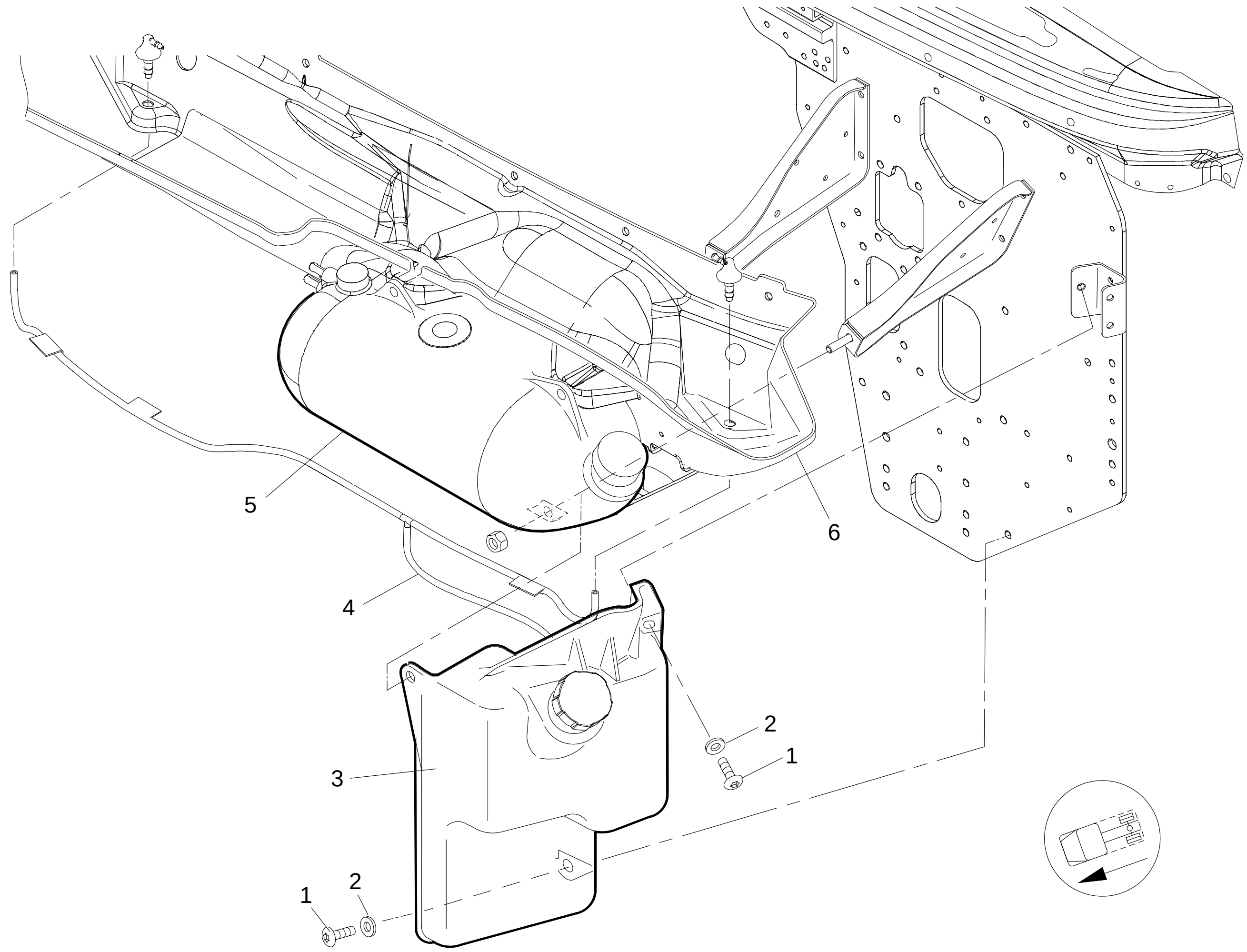
5. On vehicles with a hood guide mounted above the washer reservoir, install the hood guide, as follows. See **Fig. 2**.

   5.1 Using a bolt, nut, and washer, attach the hood guide to the rain tray.

   5.2 Using four T40 Torx capscrews, attach the hood guide to the mounting brackets.

6. Install the outboard drain tube; hook the bottom of the drain tube on the washer reservoir. Install the fastener for the inboard drain tube.
7. Close and latch the hood.
8. Remove the chocks.

Washer Reservoir Removal and Installation



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1. T40 Torx Capscrew
2. Washer
3. Washer Reservoir
4. Washer Fluid Hose
5. Surge Tank
6. Rain Tray

Fig. 4, Washer Reservoir Installation (vehicles with front-wall mounted surge tank)

Troubleshooting

WARNING

Use caution when working on or near the wiper linkage, arms, and motor. An intermittent wiper system may swipe without warning, posing a risk of personal injury.

NOTICE

Make sure the ignition switch is off before disconnecting any wiper/washer harness connectors. Removing connectors with the ignition switch on may cause electrical arcing, which will damage the pins.

Preliminary Checks

Before beginning the troubleshooting procedures, verify the driver's complaint by checking the system components, and operating the wiper and washer to duplicate the problem.

1. Check the wiper arms, blades, and linkage for wear and damage.
2. Check the washer fluid level in the reservoir.
3. Turn the ignition switch to the ON position without starting the engine.
4. Test the wipers on low speed, high speed, and several intermittent speeds.
5. Test the windshield washers.
6. Turn the ignition switch to the OFF position.
7. Check the washer hoses for leaks and damage.

Diagnostic Procedures

Symptoms

The diagnostic procedures listed in **Table 1** are described in detail in the succeeding tables. When performing the diagnostic procedures, refer to the wiring diagram (**Fig. 1**) and the tables in this subject.

NOTICE

Use caution when backprobing sealed connectors. If the seal is damaged, water could intrude into the connection, resulting in corrosion and electrical failure.

IMPORTANT: The following wiper and washer diagnostic procedures are performed with the ignition switch in the ON position, and the engine NOT running.

Troubleshooting Procedures	
Symptom	**Table Number**
Wipers are inoperative in all modes.	**Table 2**
High-speed mode only is inoperative.	**Table 3**
Low-speed and all intermittent speed modes are inoperative, high-speed mode is OK.	**Table 4**
Wipers do not park in the proper position.	**Table 5**
Wipers stay on until ignition is turned off.	**Table 6**
Washers are inoperative.	**Table 7**
Washer spray does not correctly cover wipe area.	**Table 8**

Table 1, Troubleshooting Procedures

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—

Troubleshooting

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and C to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Verify that pin A of the wiper motor connector is at ground potential; see **Table 9**. Is pin A at ground potential?	Yes	Go to **step 4**.
		No	Repair the ground circuit.
4	Access the wiper switch (**Fig. 2**) connector, and backprobe pin 1 to measure the voltage, with the connector remaining connected to the module; see **Table 10**. Is battery voltage present on pin 1?	Yes	Go to **step 5**.
		Low or at zero	Check circuit breaker CB49 in the PDM. If the circuit breaker is open, determine if there is a shorted wire or component on circuit 315 that is drawing excess current.
5	With the ignition set to the ON position and the wipers switched to low speed, measure the voltage on pin 3 of the wiper switch connector. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through the speed switching relays R35 and R36. Troubleshoot circuits 315L and 315H from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 2, Wipers Are Inoperative In All Modes

High-Speed Mode Only Is Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to high speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and B to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Access the wiper switch (**Fig. 2**) connector, and backprobe pin 4 to measure the voltage, with the connector remaining connected to the module, the ignition switch in the ON position, and the wipers set to high speed; see **Table 10**. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through relay R35 and its interconnecting wiring, including circuit 315H from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 3, High-Speed Mode Only Is Inoperative

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
2	With the connector remaining connected, backprobe the wiper motor connector on pins A and C to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 110**.
		Low or at zero	Go to **step 3**.
3	Verify the voltage at pin A of the wiper motor connector. Is it at ground potential?	Yes	Go to **step 4**.
		No	Repair the ground circuit 320.
4	With the wiper switch (**Fig. 2**) remaining connected to the connector, the ignition switch in the ON position, and the wipers set to low speed, backprobe the wiper switch connector on pin 3 to measure for battery voltage; see **Table 10**. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through the speed switching relays R35 and R36, and the interconnected wiring. Troubleshoot circuit 315L from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 4, Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	Turn the wiper switch off when the wipers are in mid-swipe. Do the wipers stop immediately, or continue traveling, then stop?	Immediately	Go to **step 3**.
		Continue traveling, then stop	Note the stopped position. Repeat the test to make sure that the wipers always stop in the same position. If the wipers always stop in the same position, regardless of where the switch was turned off, the linkage is improperly adjusted. Turn the ignition switch to OFF, disconnect the batteries, then adjust the wiper linkage to the correct position.
3	With the ignition switch in the ON position and the wipers switched off, measure the voltage on pin D of the wiper motor connector; see **Table 9**. Is battery voltage present?	Yes	Go to **step 4**.
		No	Locate and repair the open circuit on circuit 315C between the wiper motor and the PDM.
4	With the ignition in the ON position and the wipers switched to low speed, measure the voltage on pin F of the wiper motor connector; see **Table 9**. Battery voltage should be present except when the wipers travel through the park position and the circuit is momentarily at ground. Is battery voltage present?	Yes	Go to **step 5**.
		No	Replace the wiper motor; see **Subject 110**.

Troubleshooting

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
5	With the wipers switched on, measure the voltage at terminal 87A of relay R36. Is battery voltage present?	Yes	Test for an open R36 relay.
		No	Locate and repair the open circuit between relay R36 and the wiper motor in circuit 315P.

Table 5, Wipers Do Not Park in Proper Position

Wipers Stay On Until Ignition Is Turned Off			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position. Leave the wiper switch in the OFF position. Do the wipers stay on at high speed or low speed?	High speed	Troubleshoot for circuit 315B shorted to ground, and for relay R35 shorted between terminals 87 and 30.
		Low speed	Go to **step 2**.
2	Backprobe pin F of the wiper motor connector to check the voltage through the wiper motor’s internal park switch; see **Table 9**. When the wipers travel through the park position, pin F should be momentarily at ground. Most voltmeters respond quickly enough to show this momentary voltage transition. Is the momentary voltage transition to ground present?	Yes	Troubleshoot and repair for circuit 315B shorted to ground, and for relay R36 shorted between terminals 87 and 30.
		No	The wiper motor internal park switch is not working. Replace the wiper motor; see **Subject 110**.

Table 6, Wipers Stay On Until Ignition Is Turned Off

Washers Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed. Do the wipers work?	Yes	Turn the wipers off. Go to **step 2**.
		No	Follow the troubleshooting procedure under "Wipers Are Inoperative In All Modes"; see **Table 2**.
2	Check the washer reservoir fluid level. Add fluid if needed, then test the washer operation. Hold the washer switch on for at least 5 seconds in case the hoses are leaking, or the system has lost its prime. Is the pump running?	Yes	Check the system for leaks. Also follow the troubleshooting procedure under "Washer Spray Does Not Correctly Cover Wipe Area"; see **Table 8**.
		No	Go to **step 3**.
3	If the system is not leaking, backprobe the connections at the washer pump, and test for battery voltage when the washer switch is activated; see **Table 11**. Is battery voltage present?	Yes	Replace the washer pump.
		No	Go to **step 4**.

Washers Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
4	With the wiper switch (**Fig. 2**) remaining connected to the connector, and the ignition switch in the ON position, backprobe pin 5 of the wiper switch to measure voltage; see **Table 10**. When the washers are activated, is the measured voltage at or within a few tenths of a volt to ground?	Yes	Troubleshoot for a wiring fault on circuit 320 between the wiper switch and the washer pump. Also troubleshoot circuit 315C to the washer pump.
		No	Replace the wiper switch.

Table 7, Washers Are Inoperative

Washer Spray Does Not Correctly Cover Wipe Area			
Step	**Test Procedure**	**Test Result**	**Action**
1	Make sure that the fluid level in the washer fluid reservoir is adequate. If needed, add fluid.	—	—
2	Test the washer operation. Hold the washer switch in the ON position for at least 5 seconds. Is the fluid flow adequate?	Yes	Troubleshooting is completed.
		No	Check the nozzles for damage, plugging, or improper installation. Check the hoses for kinks, or wire ties that may be too tight. Make sure that there are no breaks or disconnected fittings. Go to **step 3**.
3	Test the washer operation. Does the washer work properly?	Yes	Troubleshooting is completed.
		No	Replace the washer pump.

Table 8, Washer Spray Does Not Correctly Cover Wipe Area

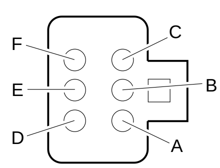
Terminal Identification of the Wiper Motor Harness Connector			
Wiper Motor Harness Connector	**Pin**	**Circuit Number**	**Circuit Description**
 f545385	A	GND	Ground
	B	315H	Wiper Motor High Speed
	C	315L	Wiper Motor Low Speed
	D	315C	Ignition Power
	E	—	Not used
	F	315P	Park Switch Signal

Table 9, Terminal Identification of the Wiper Motor Harness Connector

Troubleshooting

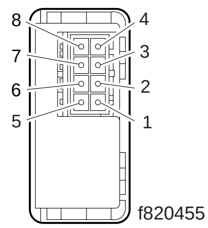
Terminal Identification of the Wiper/Washer Switch Connector			
Washer/Wiper Switch Connector	**Pin**	**Circuit Number**	**Circuit Description**
	1	315	Ignition Power
	2	29A	Backlighting
	3	315A	Wiper Motor Low Speed
	4	315B	Wiper Motor High Speed
	5	320	Washer Pump
	6	GND	Ground
	7	—	Not used
	8	—	Not used

Table 10, Terminal Identification of the Wiper/Washer Switch Connector

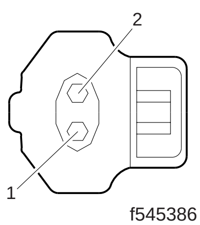
Terminal Identification of the Washer Pump Connector			
Washer Pump Connector	**Terminal**	**Circuit Number**	**Circuit Description**
	1	320	Washer Ground
	2	315C	Washer Power

Table 11, Terminal Identification of the Washer Pump Connector

Troubleshooting

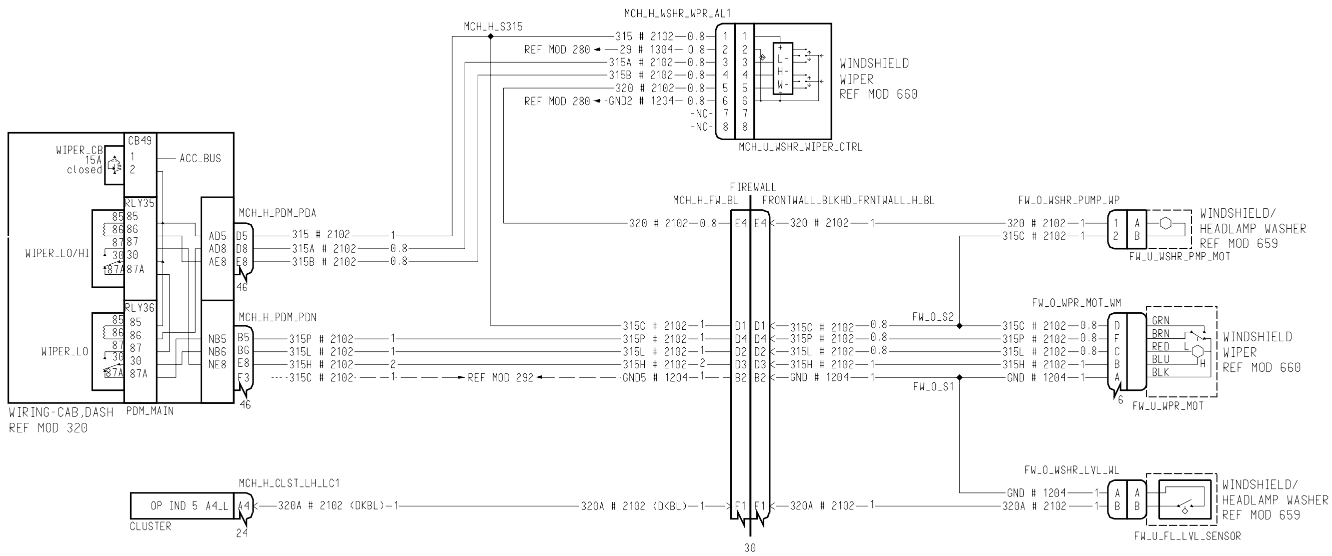
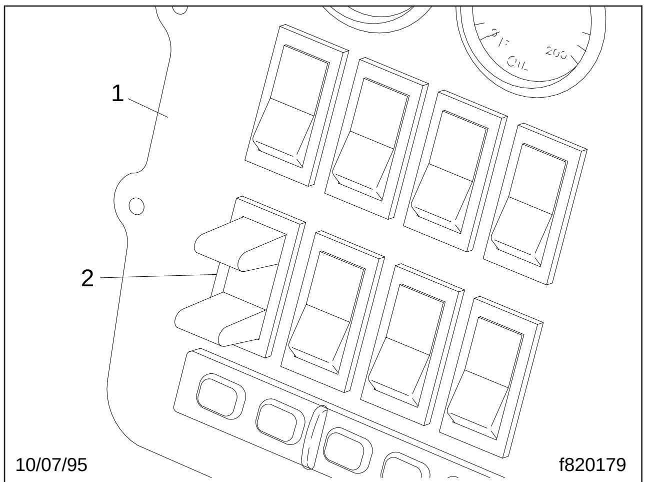


Fig. 1, Wiring Diagram, Wiper/Washer With a Dash-Mounted Switch



1. Auxiliary Instrument Panel
2. Wiper/Washer Switch

Fig. 2, Location of Dash-Mounted Wiper/Washer Switch

General Information

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioner system.

The Climate Control compressor is a two-piston design. The pistons are driven by a crankshaft and connecting rods.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyol ester (POE) refrigerant oil or polyalkylene glycol (PAG) refrigerant oil is used in the compressor. When handling refrigerant oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the A/C system or the oil container to air for long periods of time. Refrigerant oil absorbs moisture quickly.
- Use care when handling refrigerant oil. Spilled oil could damage painted surfaces, plastic parts, and other components, such as drive belts.
- Never mix POE refrigerant oil with PAG refrigerant oil.

Pre-Service Checks

WARNING

Before doing any work, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Some special tools are needed for doing repair work on the compressor. See the special tools table in **Specifications 400**. Tool kits can be bought from the distributor listed under the special tools table in **Specifications 400**.

NOTE: Compressor problems usually show in one of four ways: abnormal noise; seizure; leakage; or low suction and discharge pressures. Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. See the drive belt section in **Group 01** for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the torque specifications table under **Specifications 400**. Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt. See the drive belt section in **Group 01** for instructions.
   - 2.4 Check the compressor oil level. See **Subject 130** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system; for instructions, see **Section 83.02**, Subject 240.
6. Check the valve plate and cylinder gasket (**Subject 160**), and the shaft seal (**Subject 150**) for damage. Replace as needed.

NOTE: For other possible causes of air conditioner problems, see the heater and air conditioner section in this group and the applicable fan clutch section in **Group 20**.

Refrigerant Compressor Removal and Installation

Removal

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 240.
4. Disconnect the discharge and suction lines from the compressor. Quickly cap the discharge and suction ports and plug the fittings.

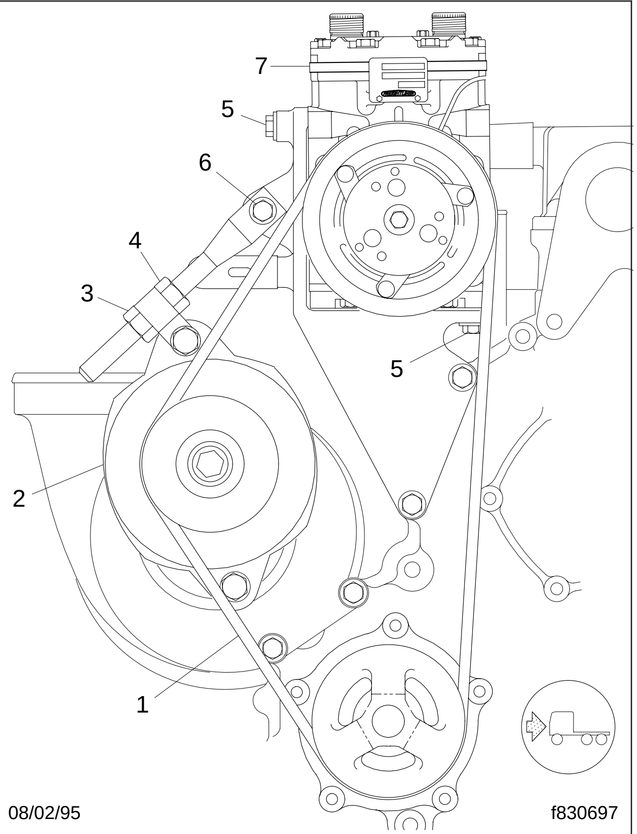
IMPORTANT: Do not leave the ports on the compressor uncapped or the fittings unplugged for longer than a total time of 5 minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Disconnect the clutch cable connector.
6. On vehicles with a V-belt, remove the V-belt. If equipped with a serpentine belt, see the next step.

    6.1 On vehicles with Detroit Diesel Series 60 engines, loosen the adjusting rod jam nut, back off the adjustment nut, and loosen the compressor mounting bolts. See **Fig. 1**. Move the compressor towards the alternator until the belt can be removed from the compressor.

    6.2 On vehicles with Cummins and Caterpillar engines, loosen the compressor pivot bolt. See **Fig. 2** and **Fig. 3**. Loosen the adjusting rod jam nut, then back off the adjustment nut until the belt can be removed.

    6.3 Remove the V-belt. Don't pry or roll it off of the pulleys.



1. V-Belt
2. Alternator
3. Jam Nut
4. Adjustment Nut
5. Compressor Mounting Bolt
6. Adjusting Rod Attachment Bolt
7. Refrigerant Compressor

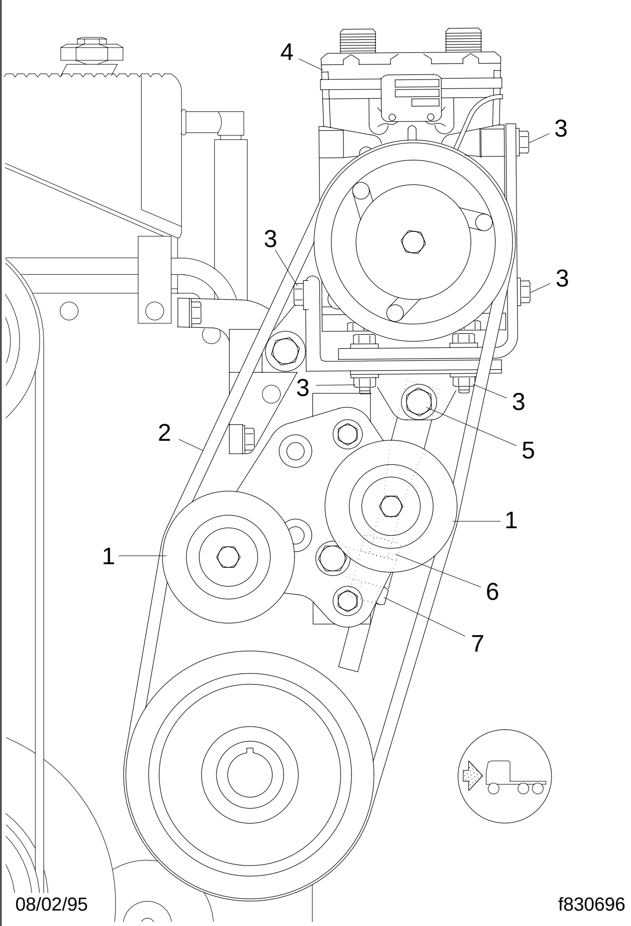
Fig. 1, Compressor Mounted on a Detroit Diesel Series 60 Engine

7. On vehicles with a serpentine belt, remove the belt by using a 1/2" breaker bar and rotating the automatic belt tensioner clockwise.
8. Remove the compressor.

    8.1 On vehicles with Detroit Diesel Series 60 engines, remove the adjusting rod attachment bolt. Remove the compressor mounting bolts and the compressor.

    8.2 On vehicles with Cummins and Caterpillar engines, pivot the compressor mounting bracket as needed to access the com-

Refrigerant Compressor Removal and Installation



1. Idler Pulley
2. V-Belt
3. Compressor Mounting Bolt and Nut
4. Refrigerant Compressor
5. Pivot Bolt
6. Adjustment Nut
7. Jam Nut

Fig. 2, Compressor Mounted on a Cummins ISM/M11 Engine

pressor mounting bolts. Remove the compressor mounting bolts and the compressor.

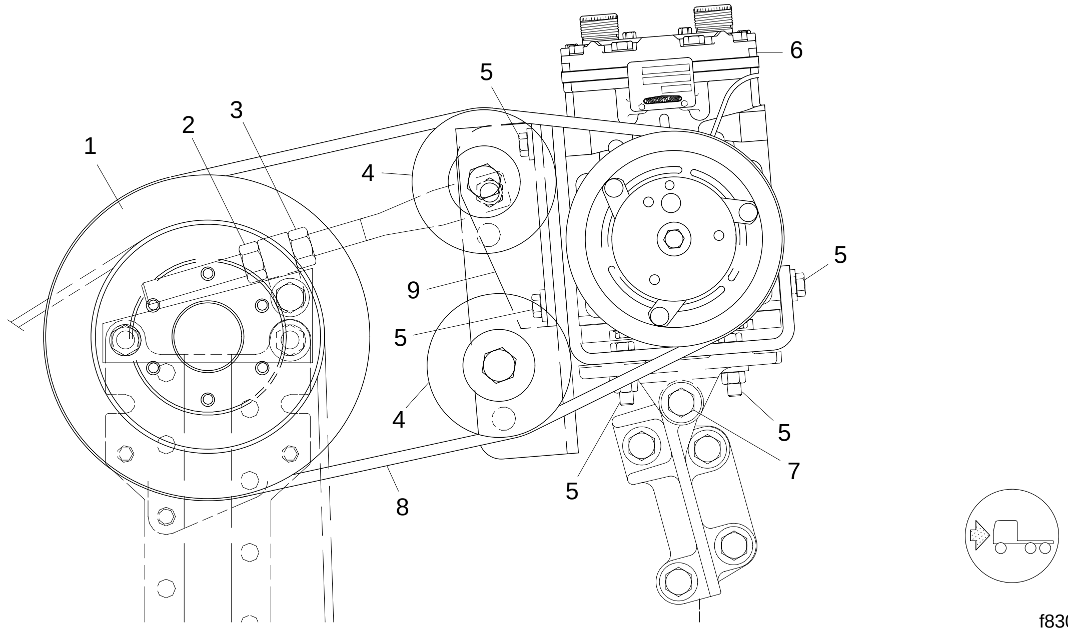
Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. The quantity is printed on a label attached to the compressor. When installing a new compressor on the vehicle, perform all of the steps below. If installing a used compressor, skip the first step.

1. Prepare a new compressor.
   1.1 Gently release the nitrogen gas from the discharge side of the compressor. Be careful not to let the oil flow out.
   1.2 Turn the compressor shaft several times by hand to distribute oil which has settled in the cylinder.
2. Place the compressor on the mounting bracket. Loosely install the mounting bolts to hold the compressor in place. On Detroit Diesel Series 60 engines, install the adjusting rod attachment bolt.
3. Install the V-belt or the serpentine belt. See **Group 01** for V-belt installation and adjustment procedures.
   3.1 On vehicles with Detroit Diesel Series 60 engines, tighten the bottom mounting bolts 20 to 25 lbf·ft (27 to 34 N·m). Then, tighten the side mounting bolts 20 to 25 lbf·ft (27 to 34 N·m). Tighten the adjusting rod attachment bolt 20 to 25 lbf·ft (27 to 34 N·m).
   3.2 On vehicles with Cummins and Caterpillar engines, tighten the mounting bolts 20 to 25 lbf·ft (27 to 34 N·m). Tighten the pivot bolt 68 lbf·ft (92 N·m). Tighten the adjusting rod jam nut 155 lbf·ft (210 N·m).
4. Uncap the discharge and suction ports. Unplug the fittings. Check the fittings and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
5. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

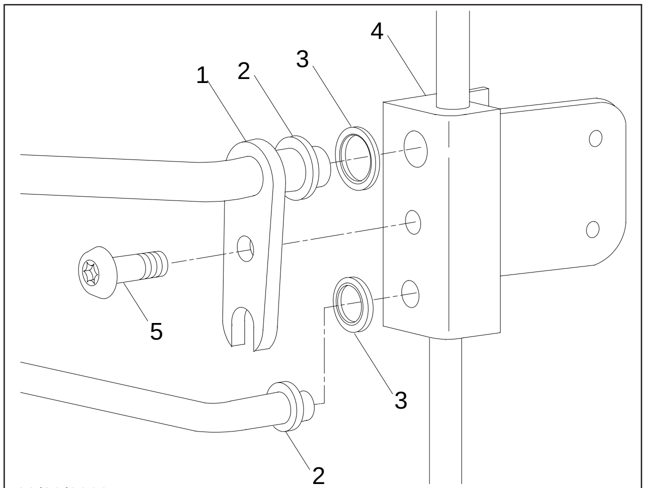
   On hose connections that have a SlimLine seal assembly (**Fig. 4**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.
6. Connect the refrigerant hoses to the compressor.

   On hose connections that have threaded fittings, torque the fittings 21 to 27 lbf·ft (28 to 37 N·m).



1. Fan Drive
2. Jam Nut
3. Adjustment Nut
4. Idler Pulley
5. Compressor Mounting Bolt
6. Refrigerant Compressor
7. Pivot Bolt
8. V-Belt
9. Adjustment Link Bracket

Fig. 3, Compressor Mounted on a Caterpillar Engine (typical installation)



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 4, A Typical SlimLine Seal Assembly

On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

7. Connect the clutch cable connector to the clutch.
8. Replace the receiver-drier. For instructions, see **Section 83.02**, Subject 200.
9. Check the oil in the compressor, as specified in **Subject 130**.
10. Evacuate, charge, and leak test the refrigerant system. For instructions, see **Section 83.02**, Subject 240.
11. Lower the hood.
12. Remove the chocks from the tires.

Oil Check and Adding Oil to the Refrigerant Compressor

General Information

IMPORTANT: On R–134a air conditioning systems, new compressors are factory-charged with about 14 fl oz (414 mL) of refrigerant oil. Some refrigerant oil is circulated through the system with the refrigerant, and cannot leave the system except through a leak, when the system is discharged or recovered, or when a system part is replaced.

Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. See the applicable refrigerant oils table in **Specifications 400** for recommended oils. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

IMPORTANT: Add the same amount of oil that is removed when the system is discharged or recovered, or when a system part is replaced. The list below provides approximate refill amounts for the R–134a air conditioning system.

A. Oil charge—the entire system should have *about* 14 fl oz (414 mL) of refrigerant oil. There should be 10 fl oz (296 mL) in the compressor. Each major component has *about* 2.0 fl oz (59 mL) of oil (this amount has been rounded off for ease of adding oil to the compressor). Therefore, additional oil must be added to the compressor when a major component is replaced.

NOTE: As an example, if the condenser and the receiver-drier are to be replaced, first check the oil level of the compressor. The compressor should have 10 fl oz (296 mL). Add oil if needed. Then, after replacing the condenser and the receiver-drier, add an additional 4.0 fl oz (118 mL) of oil to the compressor. The entire system should then have about 14 fl oz (414 mL).

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Don't mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs moisture when exposed to the air for any period of time. After use, quickly seal the oil container.

IMPORTANT: Replacing only the amount of oil that is removed during evacuation may result in the wrong oil charge because the oil charge may have been incorrect prior to evacuation. The only way to ensure the proper oil charge is to check the oil level of the compressor with a dipstick.

B. Receiver-drier—when the receiver-drier is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

IMPORTANT: A new receiver-drier does not contain any refrigerant oil.

C. Condenser—when the condenser is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

D. Evaporator coil—when the evaporator coil is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

IMPORTANT: Check the compressor oil level whenever the system has been opened.

WARNING

Don't remove the oil fill plug without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Recover the refrigerant from the air conditioner system. For instructions, see **Section 83.02**, Subject 240.
2. Remove the oil fill plug and O-ring.
3. Check the oil level with the dipstick. When the compressor is mounted vertically, use either plug; when mounted in any other orientation, use the upper plug. **Figure 1** shows the oil level with the refrigerant compressor mounted at 22 degrees. **Figure 2** shows the oil level with the refrigerant compressor mounted at 45 degrees.

   If the dipstick bottoms out before going in more than 3 inches (75 mm), it is hitting the compressor crankshaft. Rotate the drive plate by hand and insert the dipstick again until it contacts the

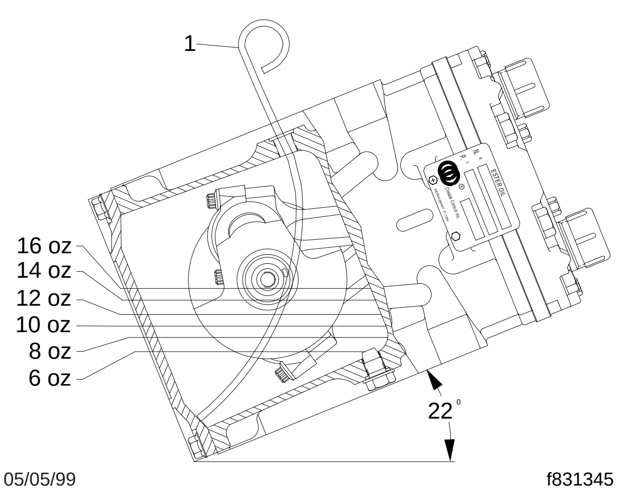
Oil Check and Adding Oil to the Refrigerant Compressor

bottom of the sump. See **Table 1** to determine the oil quantity. Add or remove oil from the compressor so that the oil charge is 10 fl oz (296 mL).

Oil Quantity at Various Dipstick Depths				
Dipstick Depth				Oil Quantity fl oz (mL)
0-Degree Mount (horizontal) inches (mm)	22-Degree Mount inches (mm)	45-Degree Mount inches (mm)	90-Degree Mount (vertical) inches (mm)	
13/16 (20.6)	1-3/4 (44.5)	1-5/8 (41.3)	7/8 (22.2)	6 (177)
1 (25.4)	2-1/16 (52.4)	1-13/16 (46)	1 (25.4)	8 (237)
1-13/16 (30.2)	2-5/16 (58.7)	2 (50.8)	1-1/8 (28.6)	10 (296)
1-5/8 (41.3)	2-9/16 (65.1)	2-1/4 (57.2)	1-7/16 (36.5)	12 (355)
1-13/16 (46)	2-7/8 (73)	2-7/16 (61.9)	1-11/16 (43)	14 (414)
1-15/16 (49.2)	3-1/8 (79.4)	2-5/8 (66.7)	1-7/8 (47.6)	16 (473)

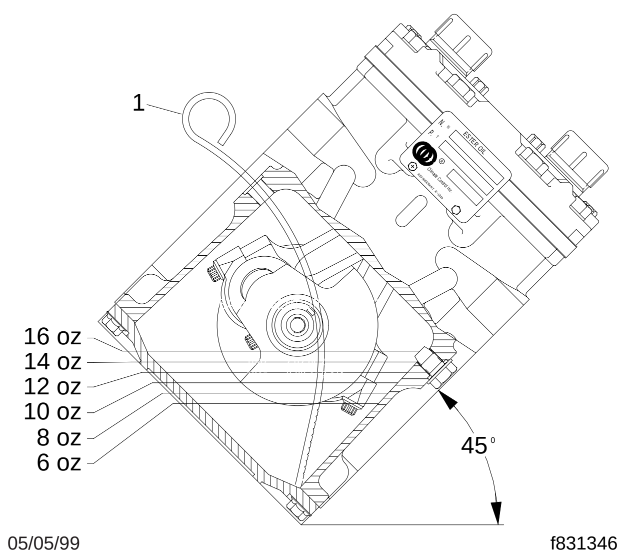
Table 1, Oil Quantity at Various Dipstick Depths

NOTE: A dipstick can be made locally or purchased from a special tools supplier. See the special tools table in **Specifications 400**. If made locally, it can be formed from 1/8-inch diameter by 8-5/16 inch long stock. See **Fig. 3**. Use a nonferrous material that is not subject to corrosion. Notching the end makes it easier to see the oil depth.



1. Dipstick

Fig. 1, Oil Level With Refrigerant Compressor Mounted at 22 Degrees



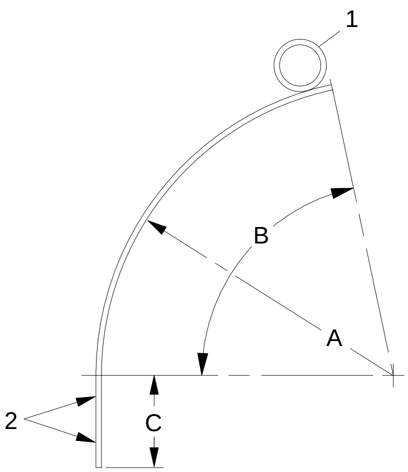
1. Dipstick

Fig. 2, Oil Level With Refrigerant Compressor Mounted at 45 Degrees

4. Being careful not to twist the O-ring, slip it over the oil fill plug threads. Insert the plug in the oil fill opening and tighten it until snug. If the plug leaks, don't attempt to stop the leak by overtightening. Leaks may be caused by dirt under the O-ring, dirt on the seat, a broken O-ring, or a

Oil Check and Adding Oil to the Refrigerant Compressor

damaged seat on the oil fill plug or opening. Correct the problem and install a new O-ring.



NOTE: Left-Hand Mounting: Check oil when shaft key is down. Right-Hand Mounting: Check oil when shaft key is up.

A. 4-3/4-inches (121-mm) Radius
B. 78 Degrees
C. 1-1/2 inches (38 mm)

1. Finger Ring
2. 12 Notches, 1/8 inch (3.2 mm) Apart

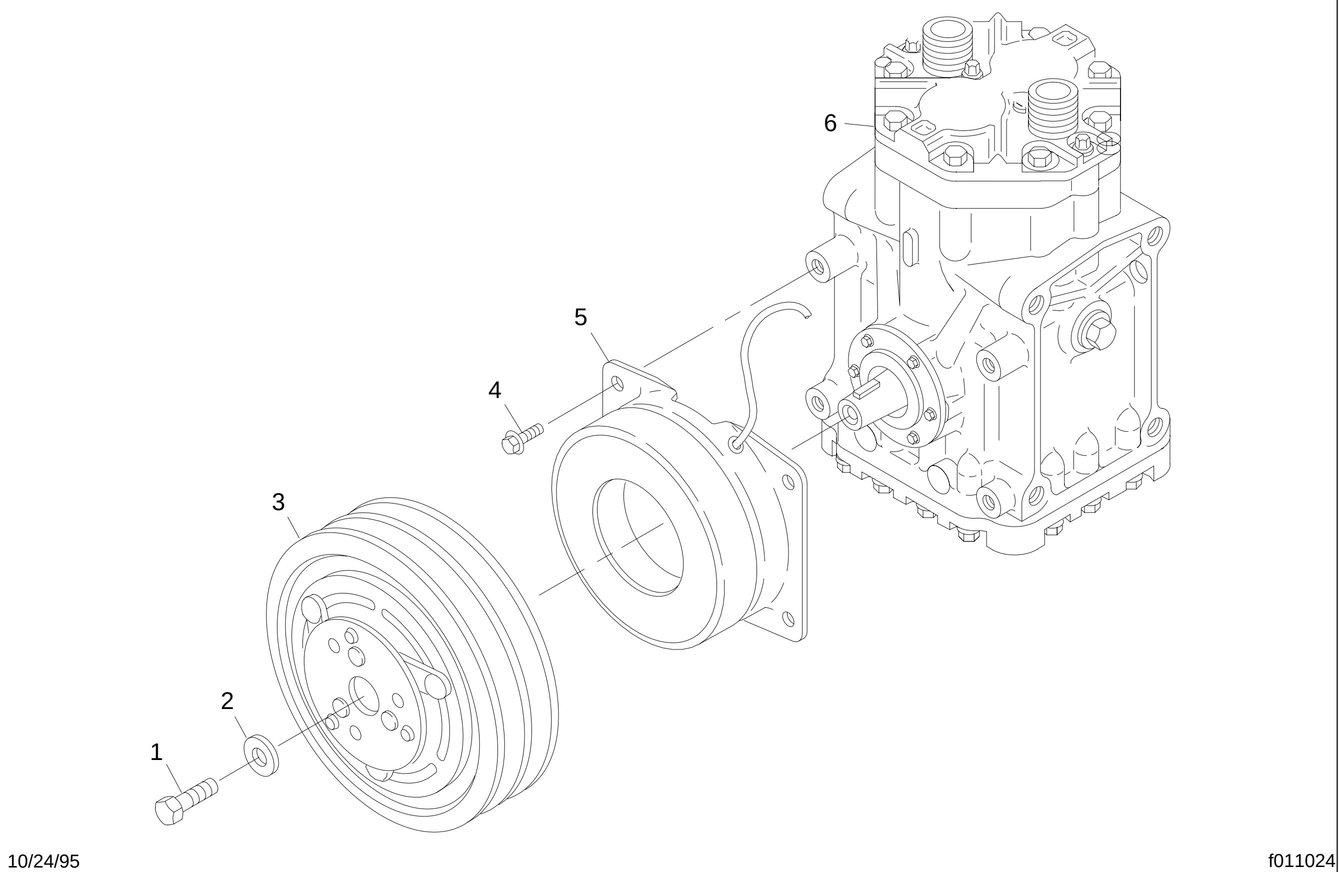
Fig. 3, Dipstick Specifications

5. Evacuate, charge, and leak test the refrigerant system. For instructions, see **Section 83.02**, Subject 240.

Refrigerant Compressor Magnetic Clutch Assembly Removal, Inspection, and Installation

Removal (See Fig. 1)

1. Remove the 5/16-inch pulley rotor retaining bolt from the center of the pulley rotor.



1. Pulley Rotor Retaining Bolt
2. Washer
3. Pulley Rotor Assembly
4. Capscrew
5. Field Coil Assembly
6. Compressor

Fig. 1, Pulley Rotor and Field Coil Assemblies

2. Install a 5/8–11 capscrew in the hub of the pulley rotor assembly.
3. Tighten the screw to pull the pulley rotor assembly off the compressor shaft.

CAUTION

Do not try to remove the pulley rotor assembly by prying or hammering. This can damage the assembly.

4. Disconnect the field coil electrical lead wire.
5. Remove the four 1/4–20 capscrews holding the field coil assembly to the compressor housing.
6. Remove the field coil assembly.

Inspection

1. Inspect the drive plate. If the friction surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.
2. Check the appearance of the pulley assembly. If the frictional surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the friction surfaces of the pulley assembly before installing it.

Refrigerant Compressor Magnetic Clutch Assembly Removal, Inspection, and Installation

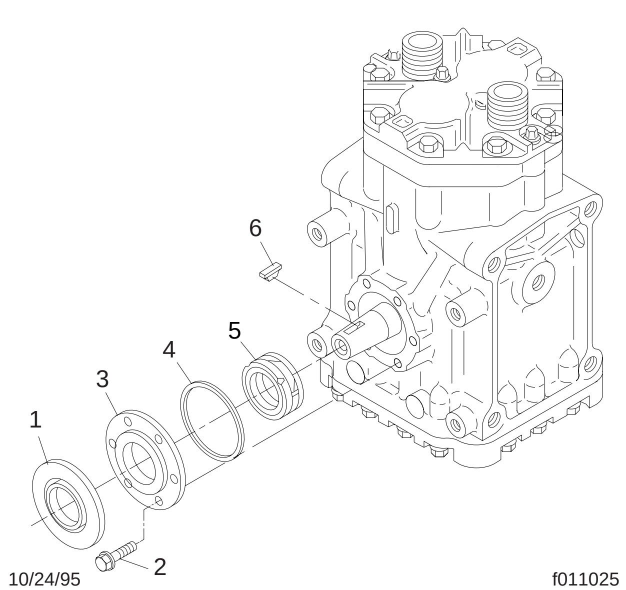
3. Check the coil for a loose connector and for cracked insulation. Replace it, if necessary.

Installation

1. Position the field coil assembly on the compressor housing with the four screw mounting holes aligned with the bosses on the housing.
2. Apply Loctite® 262 or 680 to the four 1/4–20 capscrews (on those threads that do not already have dry Loctite on them).
3. Install the capscrews and gradually tighten them to align the coil assembly. Final torque should be 15 lbf·ft (20 N·m).
4. Taking care to properly align and seat the shaft and hub keyways, attach the pulley rotor assembly to the compressor shaft.
5. Install the 5/16–24 center bolt and washer. Tighten the bolt about 20 lbf·ft (27 N·m).
6. Turn the pulley rotor assembly by hand to make sure it moves freely without interference with the field coil assembly.
7. Connect the lead wire from the field coil to the vehicle electrical circuit.
8. Engage and disengage the clutch several times to check for correct operation.

Refrigerant Compressor Shaft Seal Replacement

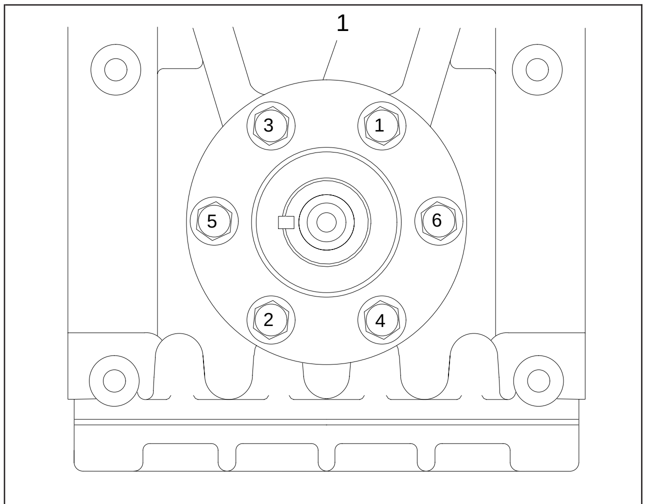
Replacement (See Fig. 1)



1. Dust Cover
2. Capscrew
3. Seal Cover Plate
4. O-Ring
5. Seal Gland
6. Shaft Key

Fig. 1, Shaft Seal Replacement

1. Remove the compressor from the vehicle. For instructions see **Subject 120**.
2. Using the clutch center jacking bolt, remove the clutch.
3. Remove the dust cover if present.
4. Remove the seal cover plate. Using the seal puller, pull out and discard the seal gland. Do not use a screwdriver to pry the seal gland from the compressor shaft; this could damage the shaft. Discard all seal parts including the O-ring.
5. Clean the shaft and seal cavity with a clean lint-free cloth.
6. Dip the new seal gland in mineral oil.
7. Push the seal assembly (**Fig. 1**), minus the carbon ring (inside the seal gland), over the end of the shaft with the carbon ring retainer facing out. Use the seal installer tool to move the seal assembly into position on the shaft.
8. Place the carbon ring in the ring retainer so the lapped surface is facing out. The notches in the outside edge of the carbon ring must engage the driving lugs and be firmly seated in the retainer.
9. Coat a new O-ring with mineral oil so it will stick; then, install it in the seal cover plate groove.
10. Install the seal cover plate so there is equal clearance around the shaft. Install the capscrews, and tighten them 60 to 84 lbf·in (680 to 940 N·cm) in sequence. See **Fig. 2**.



1. Shaft Seal Plate

Fig. 2, Tightening Sequence

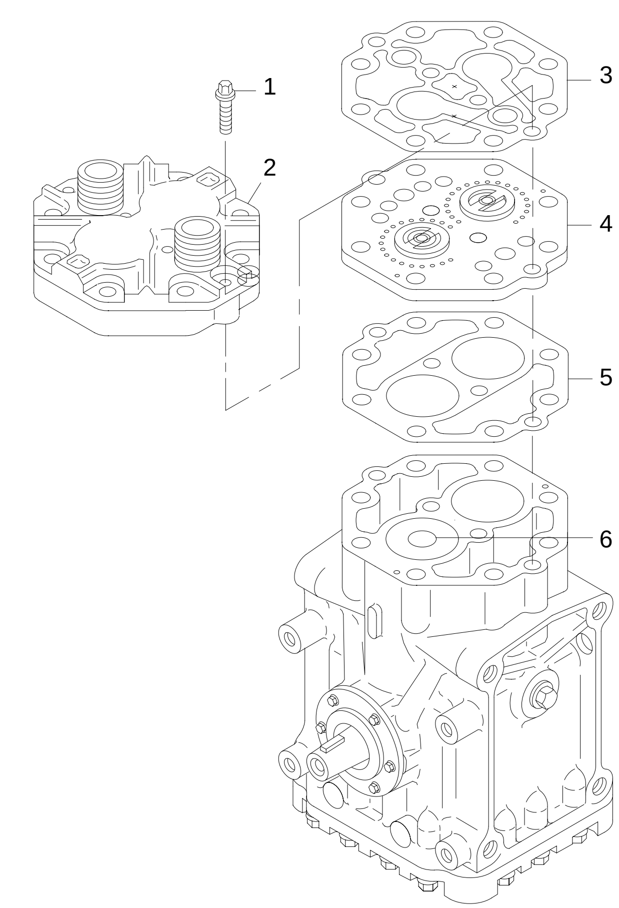
11. Place the dust cover on the shaft before inserting the shaft key. As the clutch bolt is tightened, the dust cover will be drawn into the proper position.

Refrigerant Compressor Head and Valve Plate Removal and Installation

Removal

NOTE: Before doing any work on the head and valve plate, open both service valves to release any gas pressure in the compressor. The cylinder head is made of aluminum; be careful when removing it not to damage the sealing surfaces.

1. Remove the screws from the cylinder head. See **Fig. 1**.



1. Capscrew
2. Cylinder Head
3. Cylinder Head Gasket
4. Valve Plate
5. Cylinder Gasket
6. Piston

Fig. 1, Head and Valve Plate Removal

2. Remove the valve plate and head from the cylinder by prying or tapping under the ears extending from the valve plate. If the head and valve plate adhere, hold the head and tap the valve plate ears away from the head with a soft hammer.

CAUTION

Do not hit or tap the head to separate it from the valve plate. Damage to the head may result.

3. Being careful not to scratch or nick the machined sealing surfaces, remove all gasket material adhering to the head, valve plate, or cylinder.

Installation

NOTE: Valves and valve plates are furnished only as a complete assembly.

1. Apply a thin film of clean mineral oil to the area of the crankcase to be covered by the cylinder gasket. Place the cylinder gasket in position on the cylinder so that the dowel pins in the crankcase pass through the dowel pin holes in the cylinder gasket.
2. Apply a thin film of clean mineral oil to the top and bottom valve plate areas to be covered by gaskets. Place the valve plate in position on the cylinder gasket so that the discharge valve assemblies are facing up and the locating dowel pins go through the dowel pin holes in the valve plate. The discharge valve assemblies are the smaller diameter ones with the retainer over the valve reed.
3. Place the head gasket in position on the valve plate so that the dowel pins go through the dowel pin holes in the gasket.
4. Apply a light film of clean mineral oil to the machined surface of the cylinder head which contacts the head gasket. Place the head on the cylinder head gasket so that the dowel pins go into the dowel pin holes in the head.
5. Insert the head screws and tighten all the screws until the heads make contact.
6. Tighten the head screws 17 to 25 lbf·ft (23 to 34 N·m) in sequence. See **Fig. 2**.

Refrigerant Compressor Head and Valve Plate Removal and Installation

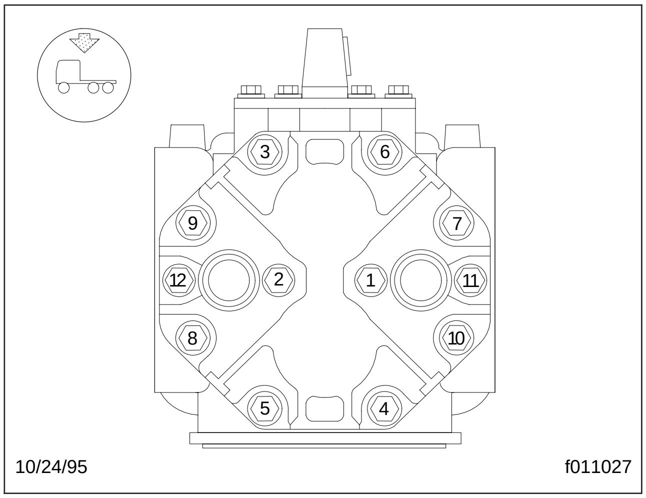


Fig. 2, Head and Service Valve Screws Tightening Sequence

Refrigerant Compressor Pistons, Connecting Rods, Crankshaft, and Bearing Removal and Installation

Piston and Connecting Rod Removal

The pistons and connecting rods are easily accessible after removing the head, valve plate assembly, and base plate. If the connecting rods will be reused, mark the rod, cap and crankshaft throw so the rod can be installed in exactly the same position on the crank pin.

Crankshaft and Bearing Removal

NOTE: When replacing the crankshaft, both the front (seal end) and rear main bearings should also be replaced since they may be damaged during removal.

1. Remove the four screws from the rear bearing cover plate.
2. Remove the cover plate by gently prying it loose from the crankcase, being careful that the housing is pulled parallel to the bearing surface.
3. Remove all components down to the crankcase, crankshaft, and seal end main bearing assembly.
4. Wash this assembly in a solvent, that meets or exceeds OSHA guidelines, to remove all traces of oil and grease. Allow it to dry.
5. Heat the assembly in an oven set to 300°F (150°C).

CAUTION

Heat the complete assembly evenly in an oven. Localized heating may crack the crankcase.

6. Remove the crankshaft and ball bearing assembly from the crankcase.
7. If the crankshaft is reusable, remove the ball bearing assembly. Hold the crankshaft vertically in a vise with the flywheel end up, gripping the shaft at the unmachined center throw. Using two large screwdrivers as a pry under the bearing race, force the bearing upward and remove it from the shaft.

Crankshaft and Bearing Installation

1. Press the rear ball bearing onto the crankshaft by exerting pressure on the bearing inner race.
2. Make sure that the shaft, bearing, and recess in the crankcase are clean and free of burrs.
3. Heat the crankcase in an oven set to 300°F (150°C).

CAUTION

Heat the complete assembly evenly in an oven. Localized heating may crack the crankcase.

4. Using the opening in the bottom of the crankcase as a point of entry, place the seal end bearing in the recess. If necessary, apply force to the outer race to be sure that it is seated in the bottom of the recess.
5. Allow the crankcase to cool. Install the crankshaft through the rear bearing cover plate opening, and guide the flywheel end through the inner race of the ball bearing.
6. Place the crankcase so that it is completely supported on the ball bearing inner race. Then, press the shaft into place until the shaft boss contacts the inner bearing race.

CAUTION

If the housing is not completely supported by the inner bearing race, the bearing may be destroyed.

7. Install the rear bearing cover plate with the O-ring in the crankcase. A slight force may be required due to the small clearances between the outer race of the ball bearing and the bearing cover plate recess.
8. Install the four capscrews and tighten them 10 to 16 lbf·ft (14 to 22 N·m) in sequence. See **Fig. 1**.

Piston and Connecting Rod Installation

NOTE: When installing either the original or a new piston and connecting rod assembly, coat

Refrigerant Compressor Pistons, Connecting Rods, Crankshaft, and Bearing Removal and Installation

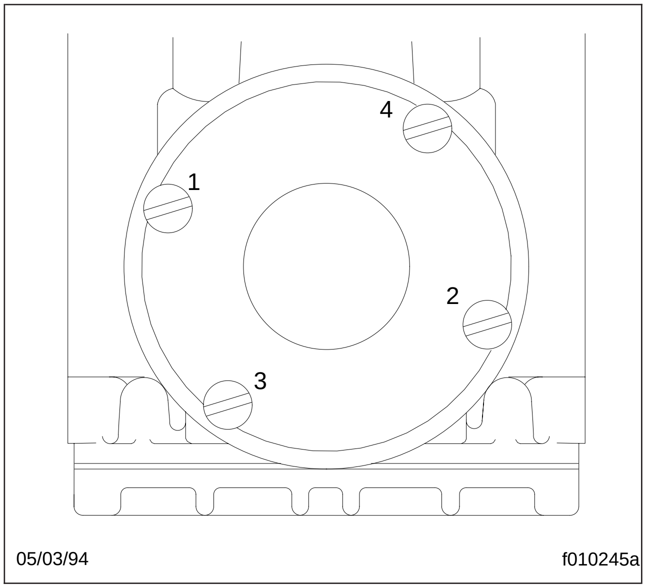


Fig. 1, Rear Bearing Cover Plate Capscrew Tightening Sequence

all bearing surfaces with clean oil of the same brand used in the crankcase.

When installing the assembly into the cylinder, the wrist pin roll pin must be positioned toward the center of the compressor. If positioned toward the outside, the roll pin may hit the crankshaft when the piston is at bottom dead center.

When installing a used connecting rod, match up the marks made during removal. When installing a new connecting rod, the dowel pins in the bearing cap must be positioned to enter the holes in the rod.

1. Install the piston and connecting rod assemblies.
2. Install the connecting rod capscrews and tighten them 12 to 16 lbf·ft (16 to 22 N·m).
3. Wipe all parts with a lint free cloth to make sure they are clean.
4. Install the base plate. Tighten the capscrews 10 to 16 lbf·ft (14 to 22 N·m) in sequence. See **Fig. 2**.
5. Install the head and valve plate assembly. For instructions, see **Subject 160**.
6. Fill the crankcase with the recommended oil. See the refrigerant oil table in **Specifications 400**.

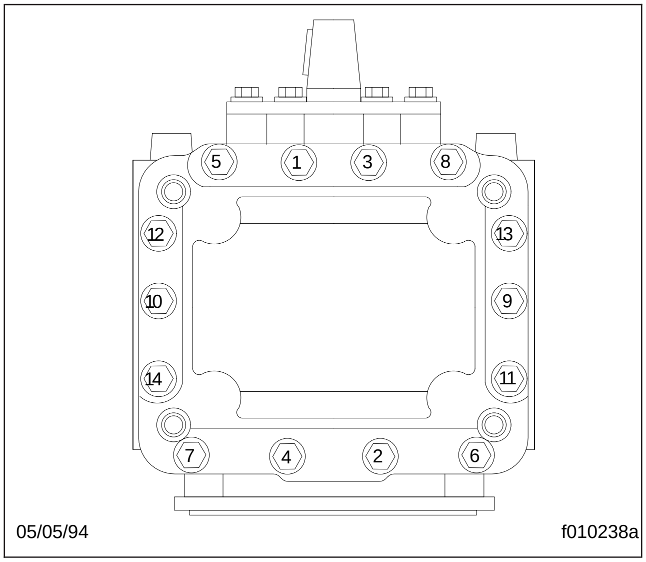


Fig. 2, Baseplate Capscrew Tightening Sequence

7. Close all openings to prevent the entrance of foreign material.

Specifications

Special tools can be ordered from your local tool supplier.

Torque Specifications				
Location	Thread	Head Type	Torque	
			lbf·ft (N·m)	lbf·in (N·cm)
Base Plate	1/4–20	Hex	10–16 (14–22)	—
Connecting Rod	1/4–20	12-point	12–16 (16–22)	—
Rear Bearing Cover Plate	1/4–20	Flat	10–16 (14–22)	—
Cylinder Head	5/16–18	Hex	17–25 (23–34)	—
Seal Plate	10–24	Hex	—	60–84 (680–940)
Tube-O Valve	1–14	Hex	35–40 (47–54)	—
Mounting Screw	3/8–16	Hex	35 (47)	—
Oil Fill Plug	3/8–24	Hex	—	60–120 (680–1360)
Clutch Bolt	5/16–24	Hex	20 (27)	—

Table 1, Torque Specifications

SlimLine Seal Assembly Torque Specifications	
HVAC Component	Torque
A/C Compressor	11–15 lbf·ft (15–20 N·m)
Condenser	11–15 lbf·ft (15–20 N·m)
Receiver-Drier	11–15 lbf·ft (15–20 N·m)
Thermal Expansion Valve	11–15 lbf·ft (15–20 N·m)
Evaporator	11–15 lbf·ft (15–20 N·m)
Junction Block	11–15 lbf·ft (15–20 N·m)

Table 2, SlimLine Seal Assembly Torque Specifications

O-Ring Fitting Torque Specifications	
Hose Size	Torque
#6	20–25 lbf·ft (27–34 N·m)
#8	30–35 lbf·ft (41–47 N·m)
#10/12	35–40 lbf·ft (47–54 N·m)
One-Inch Fittings on Compressor	21–27 lbf·ft (28–37 N·m)

Table 3, O-Ring Fitting Torque Specifications

Specifications

Recommended Refrigerant Oils, R-134a Systems*		
Description	**Part Number**	**Compressor Manufacture Date**
Polyalkylene Glycol (PAG)	ABP N83 326055	Prior to May 5, 1995, and from July 2002
Polyol Ester (POE)	ABP N83 326008	May 5, 1995, through July 2002

* Look at the identification tag on the refrigerant compressor to determine the type of refrigerant oil that should be used in the air conditioning system. If the type of oil is not specified on the identification tag, use the compressor manufacture date to determine the type of oil to use.

Table 4, Recommended Refrigerant Oils, R-134a Systems

General Information

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioning system.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following:

- keep the oil free of contaminants
- do not expose the air conditioning system or the PAG oil container to air for long periods of time; PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use
- use care when handling: spilled oil could damage painted surfaces, plastic parts, and other components (drive belts)
- never mix PAG oil with other types of refrigerant oil

Pre-Service Checks

WARNING

Before doing any work, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Some special tools are needed for doing repair work on the compressor. See the special tools table in **Specifications 400**. Tool kits can be bought from the distributor listed under the special tools table in **Specifications 400**.

NOTE: Compressor problems usually show in one of four ways: abnormal noise, seizure, leakage, or low suction and discharge pressures. Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Make the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

IMPORTANT: The Air Conditioning Protection Unit (APADS™) registers fault codes that warn of existing or impending problems with the compressor and the air conditioning system. For further information on system fault codes, see the section in **Group 54** that discusses the Instrument Cluster Unit.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. See the drive belt section in **Group 01** for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the torque specifications table under **Specifications 400**. Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt. See the drive belt section in **Group 01** for instructions.
   - 2.4 Check the compressor oil level. See **Subject 130** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system; for instructions, see the section on the cab heater and air conditioner system in this group.
6. Check the valve plate and cylinder gasket (**Subject 160**), and the shaft seal (**Subject 150**) for damage. Replace as needed.

NOTE: For other possible causes of air conditioner problems, see the heater and air conditioner section in this group and the applicable fan clutch section in **Group 20**.

Compressor Removal and Installation

Removal

1. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 240.
2. Loosen the drive belt.
3. Remove the fastener from the junction block assembly. Move the junction block assembly out of the way. Quickly cap the discharge and suction ports and plug the hoses.
4. Cut any tie straps that secure wiring. Disconnect the wiring.
5. Remove the four mounting fasteners, then remove the compressor.

Installation

IMPORTANT: A new compressor is filled with nitrogen gas and refrigerant oil. When installing a new compressor on the vehicle, perform all of the steps below. If installing a used compressor, skip the first step and proceed with the installation:

1. Prepare a new compressor.
   1.1 Slowly release the nitrogen from the discharge side of the compressor. Be careful not to let the oil flow out.
   1.2 Turn the compressor shaft several times by hand to distribute oil which has settled in the cylinders.
2. Position the compressor on the mounting block.
3. Install the four mounting fasteners and tighten them 20 to 25 lbf·ft (27 to 34 N·m).
4. Uncap the suction and discharge ports on the compressor. Unplug the hose connections. Check the hose connections and the surface of the suction and discharge ports. They must be clean and free of nicks, gasket residue, and other foreign material.

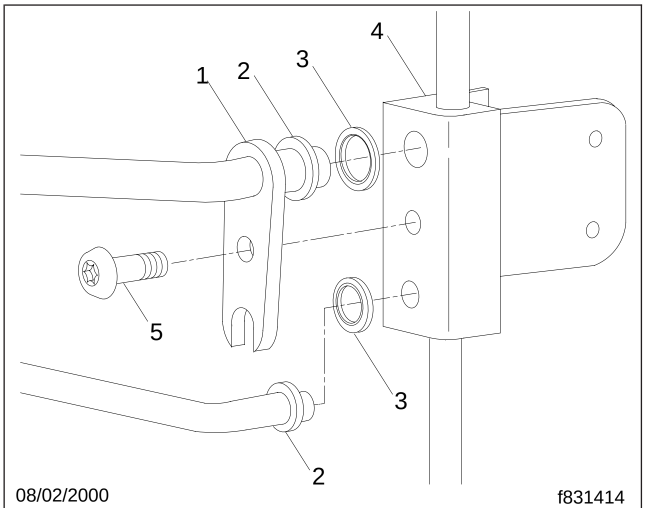
IMPORTANT: Do not leave the compressor ports uncapped or the hoses unplugged for longer than a total time of 5 minutes.

5. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 1**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.
6. Install the refrigerant lines on the compressor.

   On hose connections that have threaded fittings, torque the fittings 21 to 27 lbf·ft (28 to 37 N·m).

   On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal block and plate assembly 11 to 15 lbf·ft (15 to 20 N·m).



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 1, A Typical SlimLine Seal Assembly

7. Install the drive belt over the pulley.
8. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Section 83.02**, Subject 240.

Oil Check and Adding Oil to the Compressor

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

General Information

Compressors are charged with 10 fl oz (296 mL) of refrigerant oil. When the air conditioning system is operating, some refrigerant oil leaves the compressor and is circulated through the system with the refrigerant, but the refrigerant oil cannot leave the system except when there is a leak, when the refrigerant is recovered, or when a system part is replaced.

It is important that the air conditioning system has the correct amount of refrigerant oil for proper operation. Too little oil will result in compressor failure. Too much oil will degrade the performance of the air conditioner and may cause damage to the compressor.

IMPORTANT: Whenever the air conditioning system is discharged or recovered, the recovered oil, from the charging machine, must be measured in order to know how much oil must be returned to the system. When a system component is replaced, a quantity of new oil equal to the recovered oil plus the oil coating the inside of the component must be returned to the system. New oil must be from a container that has not been opened or that has been tightly sealed since its last use.

Order Sanden PAG oil SKI 7803 1997 (type SP–20) for an 8.45-ounce (250-mL) can of refrigerant oil from your local Freightliner parts distribution center. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

Checking and Adding Refrigerant Oil

⚠ WARNING

Do not remove the oil fill plug on the refrigerant compressor without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Before beginning the refrigerant recovery process, make sure that the oil accumulator and oil drain bottle on the recovery/recycle machine are emptied of oil from previous repairs.
2. Recover all of the refrigerant from the system. See **Section 83.04, Subject 220** for instructions.
3. Drain the recovered oil into the calibrated drain bottle of the recovery/recycle machine. Record the amount of oil recovered.
4. Inspect the refrigerant oil. If the oil has any of the following characteristics, flush and charge the system with 10 fl oz (296 mL) of oil.
    - silver or black oil—indicates metal in the air conditioning system due to compressor wear
    - milky oil—may indicate moisture in the system
    - grit or debris in the oil
5. Properly dispose of the recovered oil.
6. After repairs are finished, refer to **Table 1** and use the following equation to determine the quantity of refrigerant oil that needs to be added to the system.

    [Quantity Recovered] + [Quantity for All Replaced Components] = [Quantity to add to the System]

    Table 1 provides the quantities of oil that need to be added to the system for each component that was replaced. Add the quantities listed in the table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.

Oil Check and Adding Oil to the Compressor

Refrigerant Oil Quantities for Replaced Components	
Add the quantities listed in this table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.	
Component	**Quantity: oz (mL)**
High Pressure Line (main A/C)	1 (30)
Low Pressure Line (main A/C)	2 (59)
High Pressure Line (auxiliary A/C)	1 (30)
Low Pressure Line (auxiliary A/C)	3 (89)
Condenser	1 (30)
Evaporator (main A/C)	3 (89)
Evaporator (auxiliary A/C)	2 (59)
Receiver-Drier	3 (89)
Minor Leak at Connector Only	0.5 (15)
Major Leak at Connector Only	2 (59)

Table 1, Refrigerant Oil Quantities for Replaced Components

7. Remove the oil fill plug on the refrigerant compressor and add the refrigerant oil. Never add more than 8 fl oz (237 mL) to the system unless the system has been flushed.
8. Evacuate, charge, and leak test the refrigerant system. See **Section 83.04, Subject 220** for instructions.

Adjusting the Refrigerant Oil Level in a New Compressor

Sanden refrigerant compressors are charged with 10 fl oz (296 mL) of refrigerant oil. If the air conditioning system has been flushed, the compressor will need a 10-ounce charge. If the system has not been flushed, use the following procedure to adjust the oil level in the compressor.

Use the "Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor" shown in **Fig. 1** to adjust the refrigerant oil level in a new compressor.

Oil Check and Adding Oil to the Compressor

Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

1. Drain the oil from the old compressor.
   1.1 Remove the oil plug and drain as much oil as possible into a clean, calibrated container.
   1.2 If there are caps on the suction and discharge ports, remove them.
   1.3 Drain the oil from the suction and discharge ports into the container while turning the shaft clockwise using a socket wrench on the armature retaining nut.
   1.4 Enter the amount of oil that was drained from the compressor. 1. ☐
2. See Table 1 of this subject to determine the total amount of refrigerant oil that is needed for each component that was replaced. Enter the amount, up to 6 fl oz (177 mL), here. 2. ☐
3. Add the amounts from steps 1 and 2 and enter the total. 3. ☐
4. Subtract the total in step 3 from 10 and enter that number. For example, if the total in line 3 was six, the calculation would be 10 − 6 = 4. 4. ☐
5. Refer to the table below for the amount of oil that must be drained from the new compressor.

If the number in step 4 is:	Drain this amount from the new compressor:
a negative number(−)	2 fl oz (59 mL)
0	2 fl oz (59 mL)
1	2 fl oz (59 mL)
2	2 fl oz (59 mL)
3	3 fl oz (89 mL)
4	4 fl oz (118 mL)
5	4 fl oz (118 mL)
6	4 fl oz (118 mL)
7	4 fl oz (118 mL)
8	4 fl oz (118 mL)
9	4 fl oz (118 mL)
10	4 fl oz (118 mL)

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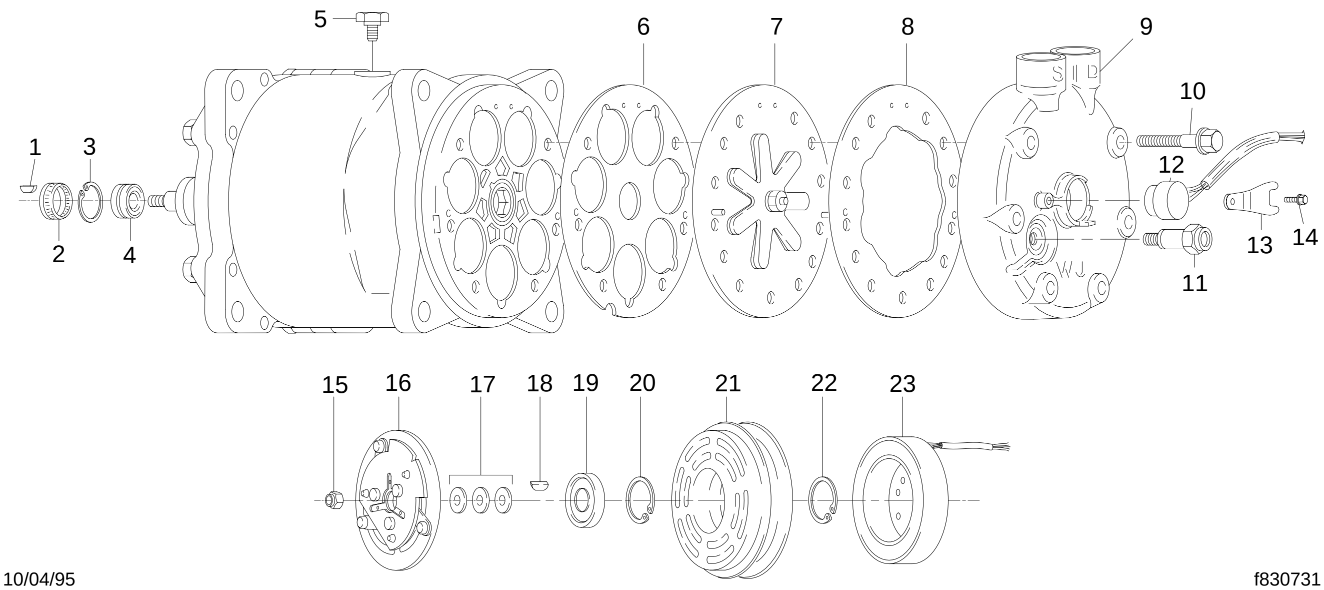
Fig. 1, Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

Clutch Assembly Removal, Inspection, and Installation

Removal (See Fig. 1)

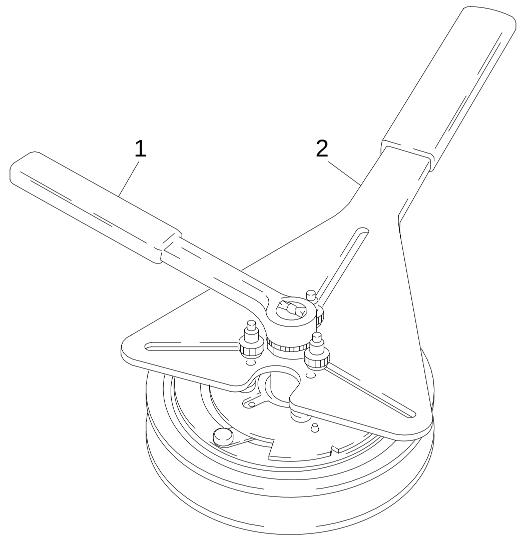


1. Shaft Key
2. Felt Ring
3. Shaft Seal Snap Ring
4. Shaft Seal (with O-ring)
5. Oil Plug
6. Block Gasket
7. Valve Plate Assembly
8. Head Gasket
9. Cylinder Head
10. Cylinder Head Bolt
11. Pressure Relief Valve
12. Thermal Protector Switch, TPS (optional)
13. TPS Clip (optional)
14. TPS Screw (optional)
15. Shaft Nut
16. Drive Plate
17. Clutch Shims
18. Shaft Key
19. Pulley Bearing Dust Cover
20. Pulley Snap Ring
21. Pulley Assembly
22. Field Coil Assembly Snap Ring
23. Field Coil Assembly

Fig. 1, Refrigerant Compressor (exploded view)

1. Remove the compressor from the vehicle. For instructions, see **Subject 120**.
2. Remove the six bolts that attach the drive plate cover and remove the cover.
3. Insert the pins of the drive plate spanner into the threaded holes of the drive plate. Hold the drive plate securely while removing the retaining nut. See **Fig. 2** .
4. Using the drive-plate puller, thread the three puller bolts into the drive plate. Turn the center screw clockwise to loosen and remove the drive plate. See **Fig. 3**.
5. Remove the pulley bearing dust cover (if equipped), the shaft key, and the clutch shims. Use a slotted screwdriver and hammer to tap the shaft key loose. See **Fig. 4** .
6. Using external snap-ring pliers, remove the pulley assembly snap ring.
7. Remove the pulley assembly.
   - 7.1 Insert the lip of the pulley puller jaws into the snap ring groove. See **Fig. 5**.
   - 7.2 Place the puller shaft protector over the exposed shaft.
   - 7.3 Align the thumb screws with the puller jaws. Tighten the screws finger tight.
   - 7.4 Using a socket wrench, turn the puller center bolt clockwise and remove the pulley.
8. Remove the coil assembly.
   - 8.1 Remove the coil's lead wire from the wire holder on the compressor.

Clutch Assembly Removal, Inspection, and Installation



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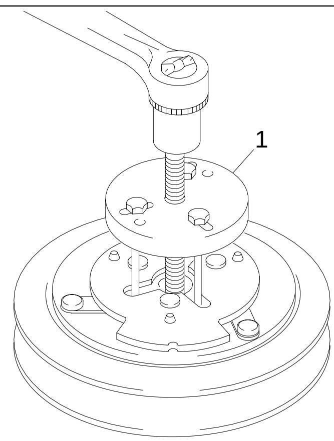
1. Socket Wrench
2. Drive Plate Spanner

Fig. 2, Remove the Retaining Nut



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1. Puller

Fig. 3, Remove the Drive Plate

8.2 Disconnect the wiring harness.

8.3 Remove the snap ring (**Fig. 6**); then, remove the coil assembly.

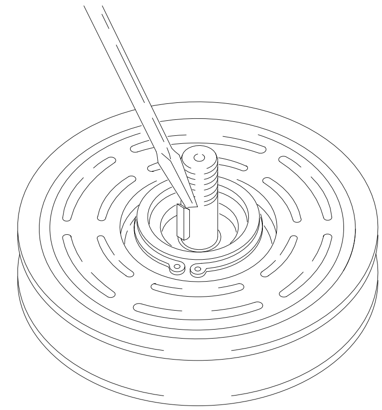

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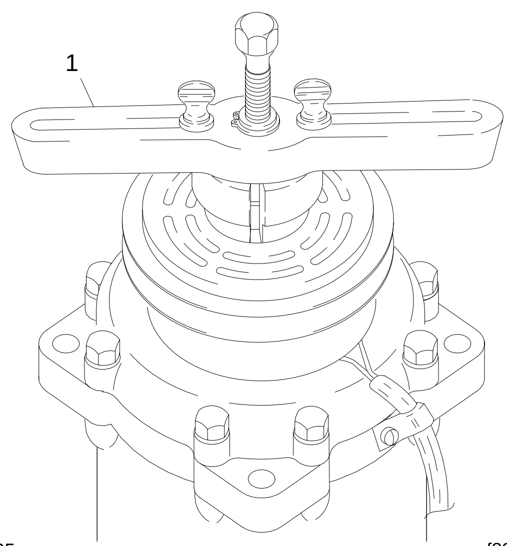
Fig. 4, Remove the Shaft Key



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1. Pulley Puller

Fig. 5, Position the Pulley Puller Jaws

Inspection

1. Inspect the drive plate. If the frictional surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.
2. Check the appearance of the pulley assembly. If the friction surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the friction surfaces of the pulley assembly before installing it.

Clutch Assembly Removal, Inspection, and Installation

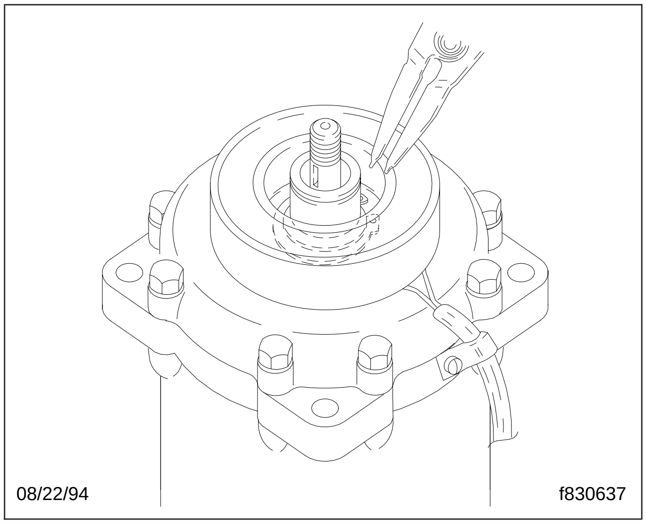


Fig. 6, Remove the Snap Ring

3. Check the coil for a loose connector and for cracked insulation. Replace it if necessary.

Installation

NOTE: When supporting the compressor in a vise, clamp only on the mounting ears, never on the body of the compressor.

1. Install the coil assembly.
   1.1 Position the coil assembly on the compressor.
   1.2 Install the snap ring.
   1.3 Attach the coil's lead wire to the wire holder on the compressor.
   1.4 Connect the wiring harness.
2. Install the pulley assembly.
   2.1 Position the pulley over the boss of the front housing.
   2.2 Place the pulley installer ring into the bearing bore. Make sure that the edge rests only on the inner race of the bearing, not on the seal, pulley, or outer race of the bearing.
   2.3 Place the driver into the ring. Using a hammer or arbor press, drive the pulley down against the front housing step. See **Fig. 7**.

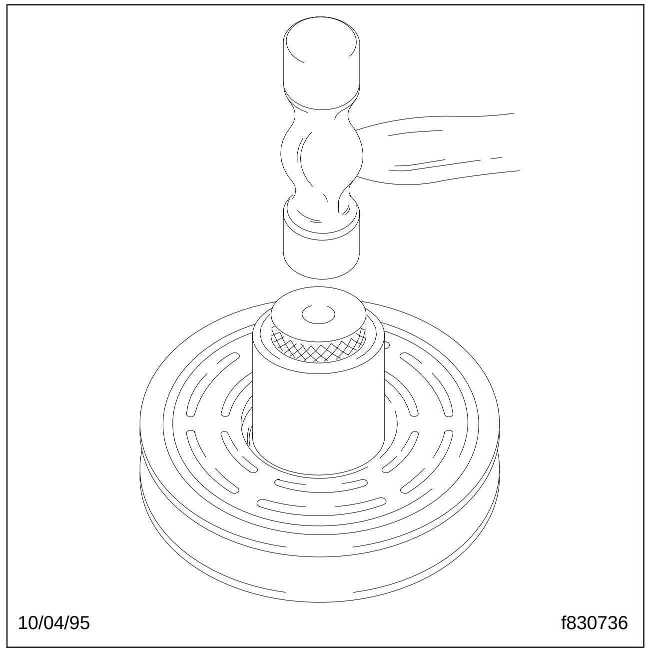


Fig. 7, Drive the Pulley Down Against the Front Housing Step.

   2.4 Using internal snap ring pliers, install the pulley bearing snap ring.
   2.5 Using external snap ring pliers, install the pulley snap ring. If a bevel is present on the snap ring, make sure that it is facing up (away from the body of the compressor).
   2.6 Install the pulley bearing dust cover by gently tapping it into place.
3. Install the drive plate assembly.
   3.1 Using pliers, install the shaft key. See **Fig. 8**.
   3.2 Install the shims.
   3.3 Align the keyway in the drive plate assembly with the shaft key. Using a driver, and a hammer or an arbor press, drive the assembly down over the shaft until it bottoms on the shims. See **Fig. 9**.
   3.4 Install the retaining nut. Tighten the nut to the torque in **Specifications 400**.
4. Using a feeler gauge, check that the clutch clearance is 0.02 to 0.03 inch (0.4 to 0.8 mm). See **Fig. 10**. Adjust the clearance by gently tapping

Clutch Assembly Removal, Inspection, and Installation

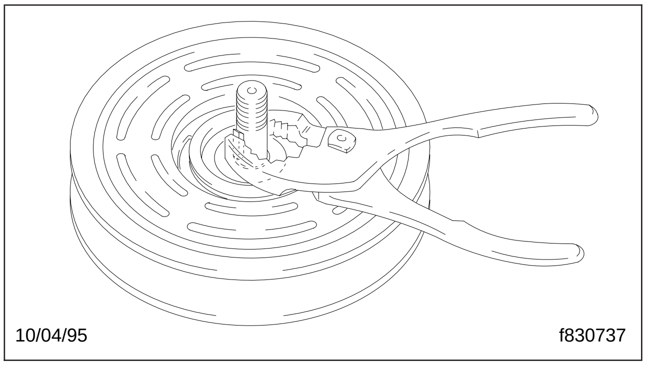


Fig. 8, Install the Shaft Key

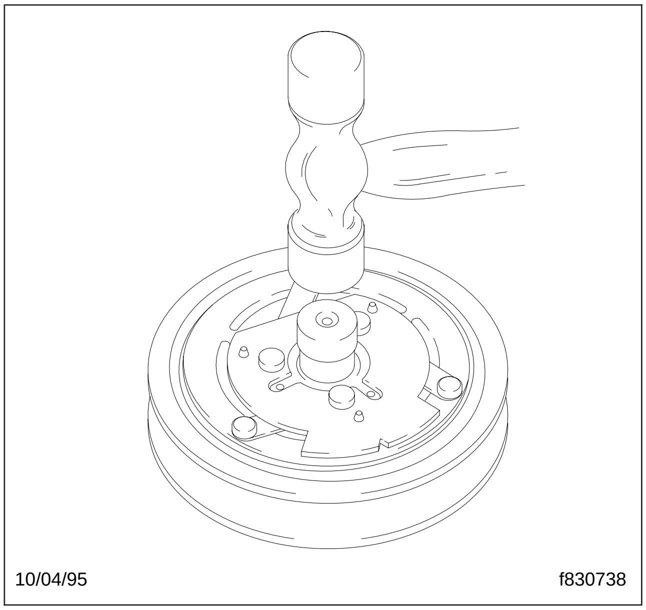


Fig. 9, Install the Drive Plate Assembly

down on the front plate at the high spots, or gently prying up at the low spots.

5. Install the drive plate dust cover. Tighten the bolts to the torque in **Specifications 400**.
6. Install the compressor on the vehicle. For instructions, see **Subject 120**.

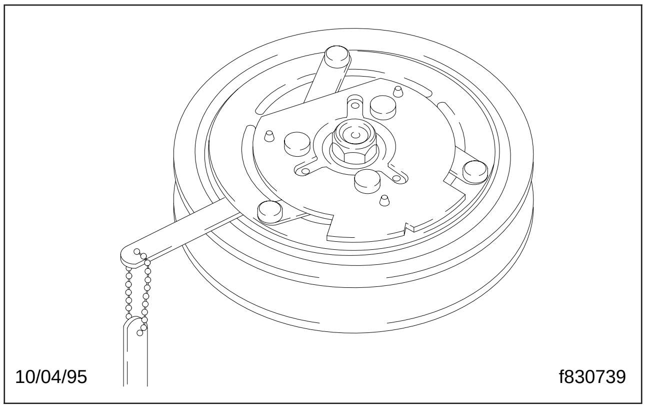


Fig. 10, Check the Clutch Clearance

Replacement

1. Remove the drive plate and pulley assemblies. For instructions, see **Subject 140**.
2. Using snap ring pliers, remove the felt ring retainer. See **Fig. 1**. Then remove the felt ring.

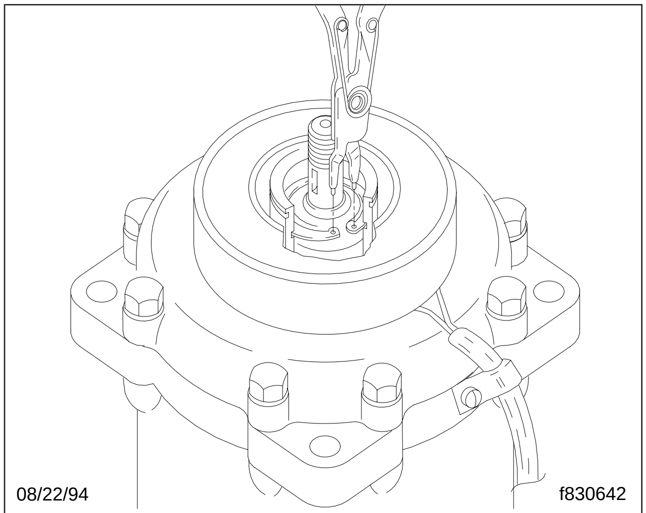
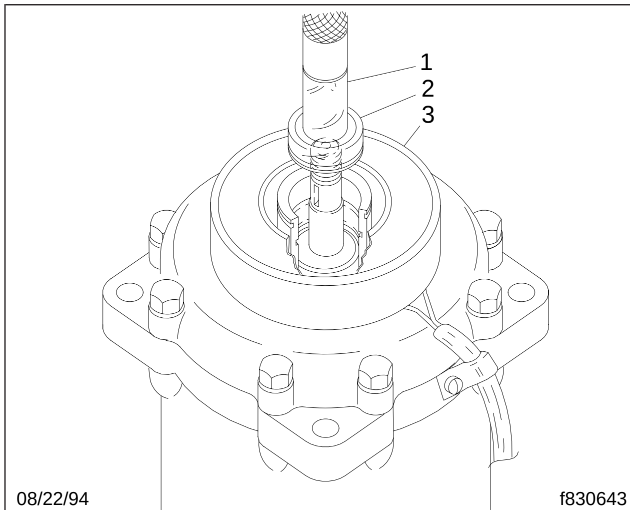


Fig. 1, Remove the Felt Ring Retainer and the Felt Ring

3. Using snap ring pliers, remove the shaft seal snap ring.
4. Position the shaft seal removal and installation tool on the shaft seal. Twist the tool until the hooks on the tool engage the slots in the shaft seal housing, then pull the seal out with a twisting motion. See **Fig. 2**.

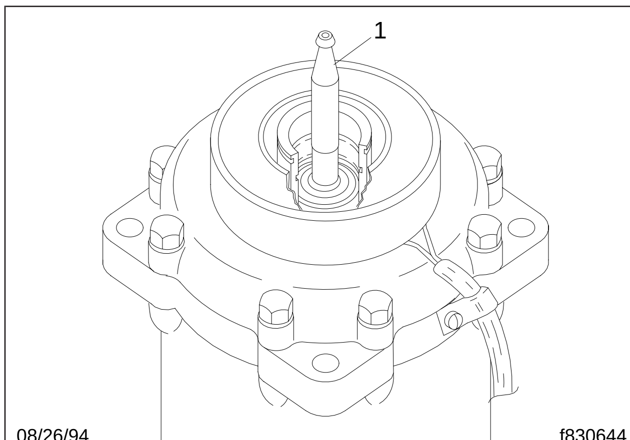
NOTE: The shaft seal and felt ring should not be reused. Always use a new seal kit. Be very careful that the lip of the shaft seal to be installed is not scratched or damaged in any way. Make sure the shaft seal is free of lint and dirt, which could damage the shaft seal surface.

5. Using a non-petroleum based solvent and a lint-free cloth, clean the shaft seal cavity. Then, use dry compressed air to blow out the shaft seal cavity.
6. Position the shaft seal protective sleeve over the compressor shaft. See **Fig. 3** . Make sure that the sleeve has no scratches so that the shaft seal will not be damaged. Also, make sure that there is no gap between the end of the sleeve and the seal surface of the shaft.



1. Shaft Seal Removal and Installation Tool
2. Shaft Seal
3. Coil Assembly

Fig. 2, Remove the Shaft Seal



1. Protective Sleeve

Fig. 3, Position the Shaft Seal Protective Sleeve

7. Position the shaft seal removal and installation tool until the hooks on the tool engage the slots in the new shaft seal housing.
8. Place the entire assembly into clean 5GS refrigerant oil. See **Fig. 4**.
9. Insert the shaft seal over the protective sleeve, then press it down as far as possible. Twist the

Shaft Seal Replacement

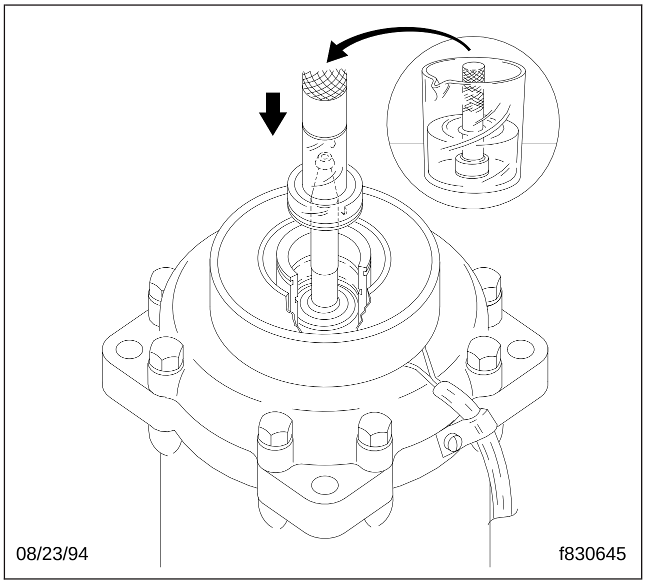


Fig. 4, Place the Shaft Seal Assembly into Clean Refrigerant Oil

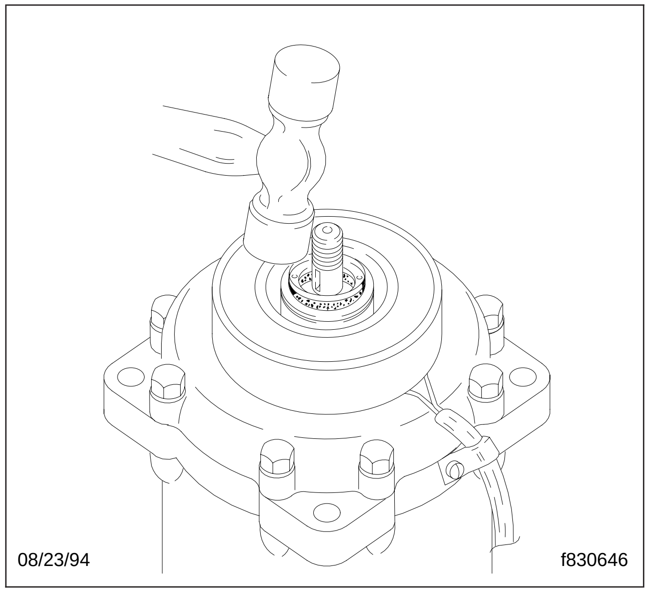


Fig. 5, Tap the New Felt Ring in Place

removal and installation tool to remove it from the seal. Remove the tool and the protective sleeve.

10. Using internal snap-ring pliers, install the snap ring. See **Fig. 1**. If needed, gently tap the snap ring to ensure that it is seated in the groove.

NOTE: When installing the snap ring, the beveled end of the snap ring must face away from the compressor body.

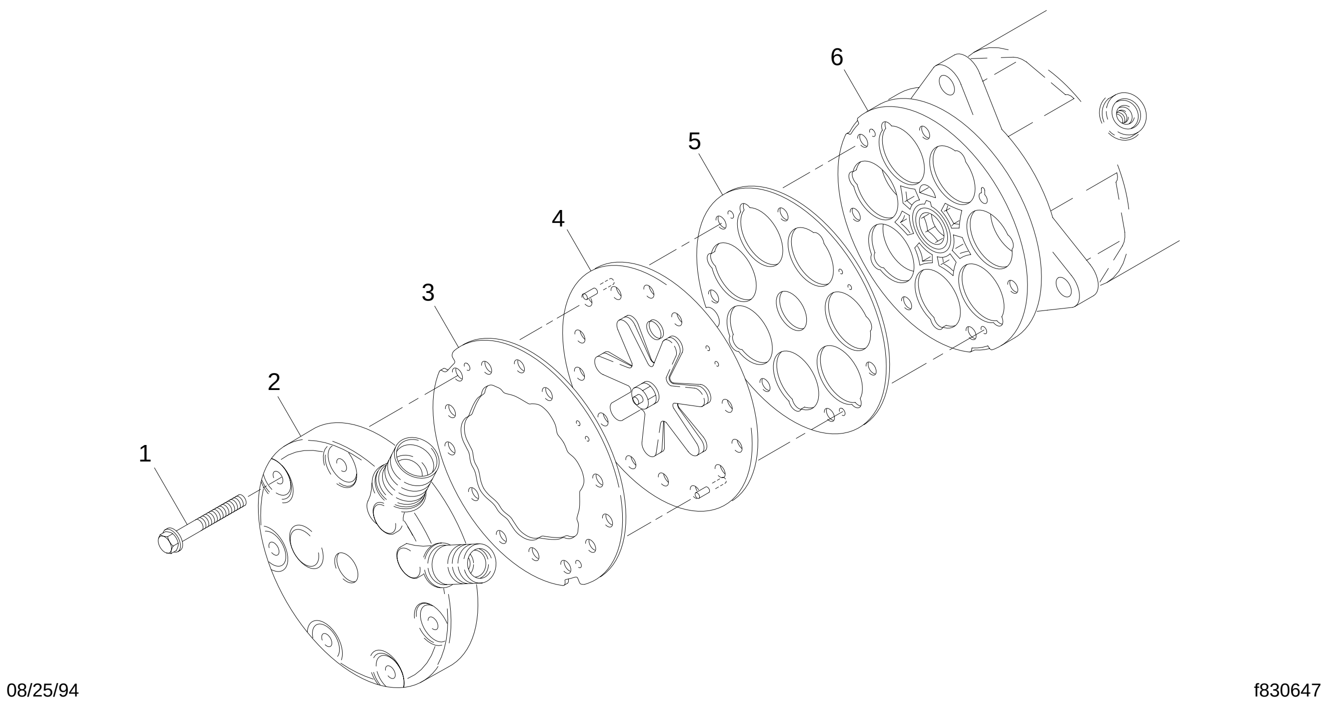
11. Gently tap the new felt ring in place. See **Fig. 5**.
12. Install the drive plate and pulley assemblies. For instructions, see **Subject 140**.

Head and Valve Plate Removal and Installation

Removal

NOTE: Before doing any work on the head and valve plate, open both service valves to release any gas pressure in the compressor.

1. Remove the bolts from the cylinder head. See **Fig. 1**.



1. Cylinder Head Bolt
2. Cylinder Head
3. Head Gasket
4. Valve Plate Assembly
5. Block Gasket
6. Compressor Body

Fig. 1, Head and Valve Plate Assembly

2. Remove the valve plate assembly and the cylinder head from the compressor. Use a gasket scraper to separate the cylinder head from the valve plate. See **Fig. 2**. Use care not to scratch the gasket surface of the cylinder head.

CAUTION

Do not hit or tap the head to separate it from the valve plate. Damage to the head may result.

NOTE: It is recommended that the head gasket (located between the cylinder head and the valve plate) and the block gasket (located between the valve plate and the cylinder block) be replaced any time the cylinder head is removed.

3. Being careful not to scratch or nick the machined sealing surfaces, remove all gasket material adhering to the head, valve plate, or compressor block.

Installation

1. Apply a thin film of clean 5GS refrigerant oil to the new block gasket. Place the block gasket in position on the compressor so that the pin holes in the compressor block line up with the pin holes in the block gasket.
2. Place the valve plate assembly in position on the block gasket so that the discharge valve, retainer, and the nut are facing up (away from the cylinder block). Make sure that the locating pins on the valve plate go through the pin holes in the gasket.

Head and Valve Plate Removal and Installation

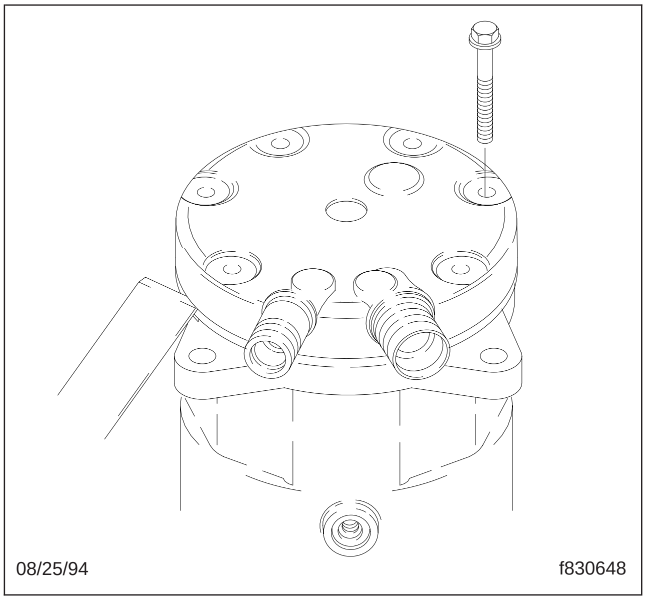


Fig. 2, Separate the Cylinder Head from the Valve Plate

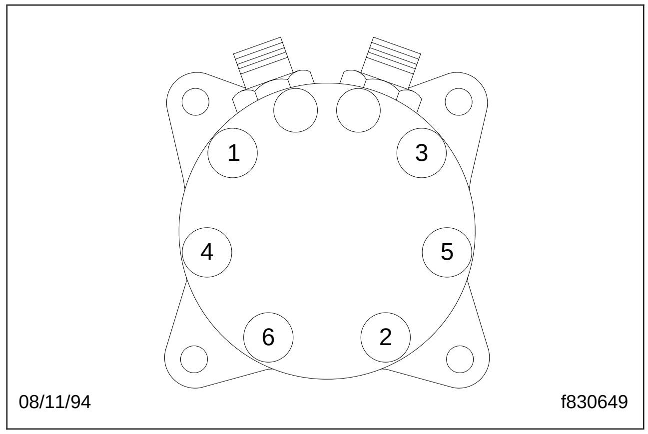


Fig. 3, Tightening Sequence

3. Remove all residual oil from each bolt hole on the cylinder block.
4. Apply a thin film of clean 5GS refrigerant oil to the new head gasket. Place the gasket in position over the valve plate locating pins. Make sure that the locating pins on the valve plate go through the pin holes in the gasket.
5. Place the head on the cylinder head gasket so that the dowel pins go into the dowel pin holes in the head.
6. Install the head bolts. Tighten the bolts in sequence to the values given in **Specifications 400**. See **Fig. 3** for the tightening sequence.

Specifications

Special tools can be purchased from the following independent suppliers:

Classic Tool Design
31 Walnut St.
New Windsor, NY 12550(914) 562–8700

Mastercool USA Inc.
216 Route 10, Bldg. 3
Randolph, NJ 07869(201) 366–1101

Torque Values		
Description	Torque	
	lbf·in (N·cm)	lbf·ft (N·m)
Adjusting Rod Jam Nut	—	140 (190)
Compressor Mounting Fasteners	—	20 to 25 (27 to 34)
Clutch Retaining Nut (1/2")	—	22 (30)
Clutch Retaining Nut (M8)	—	13 (18)
Oil Drain Plug	—	15 (20)
Cylinder Head Bolts, M6	—	10 (14)
Cylinder Head Bolts, M8	—	25 (34)
Pressure Relief Valve	11 (120)	—
Dust Cover Screws, M5	78 (880)	—
Clutch Lead Wire Clamp Screw	132 (1500)	—
Rotalock Valve	—	27 (37)

Table 1, Torque Values

SlimLine Seal Assembly Bolt Torques	
HVAC Component	Torque
A/C Compressor	11 to 15 lbf·ft (15 to 20 N·m)
Condenser	11 to 15 lbf·ft (15 to 20 N·m)
Receiver-Drier	11 to 15 lbf·ft (15 to 20 N·m)
Thermal Expansion Valve	11 to 15 lbf·ft (15 to 20 N·m)
Evaporator	11 to 15 lbf·ft (15 to 20 N·m)
Junction Block	11 to 15 lbf·ft (15 to 20 N·m)

Table 2, SlimLine Seal Assembly Bolt Torques

O-Ring Fitting Torques	
Hose Size	Torque
#6	20–25 lbf·ft (27–34 N·m)
#8	30–35 lbf·ft (41–47 N·m)
#10/12	35–40 lbf·ft (47–54 N·m)

Specifications

O-Ring Fitting Torques	
Hose Size	**Torque**
One-Inch Fittings on Compressor	21–27 lbf·ft (28–37 N·m)

Table 3, O-Ring Fitting Torques

General Information

The heating and air conditioning unit is mounted behind the dash. It consists of a heater core, evaporator, blower motor, control valves, and air ducts. The system is controlled by a climate control panel. See Fig. 1. The panel controls the heating, air conditioning, defrosting, and ventilatilation of the cab. By controlling the coolant flow through the heater core, or refrigerant flow through the evaporator, an even cab temperature is maintained. See the *Columbia® Driver's Manual* for heater/air conditioner operating instructions.

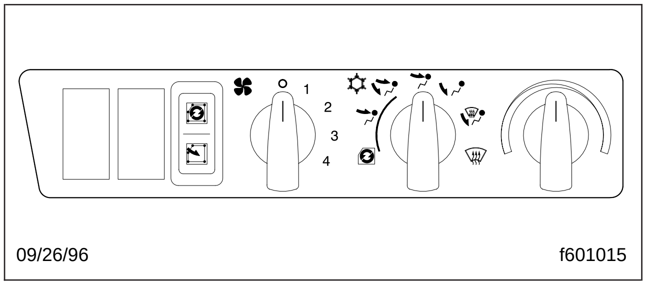


Fig. 1, Climate Control Panel

Thermodynamic Principles

Air conditioning is the cooling or refrigeration of the air in the passenger compartment. Refrigeration is accomplished by making practical use of three thermodynamic principles. These principles and their practical application are described below.

Heat Transfer

If two objects of different temperatures are placed near each other, the heat in the warmer object will always travel to the cooler object, until both are of equal temperature.

For example, a block of ice in a cooler does not transfer its coldness to a nearby warm container. Rather, the heat in the warm container flows to the ice.

The British Thermal Unit (BTU) is used to determine the amount of heat transferred from one object to another. One BTU is the amount of heat required to raise the temperature of 1 pound (0.45 kg) of water 1°F (0.55°C).

For example, to raise the temperature of 1 pound (0.45 kg) of water from 32°F to 212°F (0°C to 100°C), one BTU of heat must be added for 1°F (0.55°C) rise in temperature or a total of 180 BTUs of heat. Conversely, in order to lower the temperature of 1 pound (0.45 kg) of water from 212°F to 32°F (100°C to 0°C), 180 BTUs of heat must be removed from the water.

Latent Heat of Vaporization

When a liquid boils, it absorbs heat without raising the temperature of the resulting gas. When the gas condenses (changes back to a liquid), it gives off heat without lowering the temperature of the resulting liquid.

For example, when 1 pound (0.45 kg) of water at 32°F (0°C) is placed in a container over a flame, the temperature of the water rises 1°F (0.55°C) with each BTU of heat that the water absorbs from the flame. Thus, after it has absorbed 180 BTUs of heat, the water reaches a temperature of 212°F (100°C).

Even though the flame continues to give its heat to the water, the temperature of the water remains at 212°F (100°C). The water however starts to boil or change from a liquid to a gaseous state. It continues to boil until the water has passed off into the atmosphere as vapor. If this vapor were checked with a thermometer, it also would show a temperature of 212°F (100°C).

In other words, there was a rise of only 180°F (from 32°F to 212°F or 0°C to 100°C) in the water and vapor temperature even though the flame applied many more than 180 BTUs of heat. In this case, the heat is absorbed by the liquid in the process of boiling and disappears in the vapor. If the vapor were brought in contact with cool air, the hidden heat would flow into the cooler air and the vapor would condense back to water. Scientists refer to this principle as the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 212°F (100°C). This means that 1 pound (0.45 kg) of water at 212°F (100°C), will absorb 970 BTUs of heat when changing to vapor at 212°F (100°C). Conversely, the vapor will give off 970 BTUs of heat when condensing back to water at 212°F (100°C).

This heat transfer, occurring when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigerant systems.

General Information

For a liquid to be a refrigerant, it must also have a low boiling point. That is, the temperature at which it boils must be lower than the temperature of the substance to be cooled.

R–134a is a non-CFC refrigerant. Its temperature/pressure relationship makes it suitable for mobile air conditioning systems.

Effect of Pressure on Boiling or Condensation

As refrigerant passes through an air conditioning system, it flows under high-pressure conditions, first as a high-pressure vapor between the refrigerant compressor and the condenser, then as a high-pressure liquid between the condenser and the evaporator orifice. It expands to a low-pressure vapor between the evaporator orifice and the refrigerant return port in the refrigerant compressor. As pressures in the closed refrigerant circuit vary, temperatures will also vary. As pressure increases, temperatures also increase; as the pressure decreases, temperatures also decrease. See **Fig. 2** for a diagram of the refrigerant flow.

Description of Components

Blower Motor Resistor Block Assembly

The blower motor draws air over the evaporator and forces it through the heater core and into the cab. The resistor block assembly controls the speed of the blower motor by reducing the voltage to the motor, and has a thermal cutout which shuts off current to the blower motor if the circuit overheats.

Condenser

A condenser turns hot refrigerant gas, coming from the compressor, into liquid. Mounted in front of the radiator, it is made up of a coiled tube and a series of fins. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan and by air that is forced into the engine compartment as the vehicle moves forward.

Evaporator

Because the evaporator is an area of low pressure in the system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins of the coils. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the evaporator and drains off as water. The air becomes dehumidified.

Expansion Valve

The expansion valve is a dividing point between the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the receiver-drier passes through the expansion valve and moves into the low-pressure area of the evaporator. See **Fig. 3** and **Fig. 4**.

The expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator decreases, the temperature of the gas going to the compressor rises. This causes a sensor tube in the expansion valve to react to the temperature changes, which causes an orifice in the valve to open or close. See **Fig. 4**. Through the orifice, liquid refrigerant is metered into the evaporator.

Heater Core

The heater core is a series of fins through which tubing is routed. When the water valve is open, engine coolant flows through the heater core tubes, heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Receiver-Drier

The receiver-drier is a reservoir and filter for liquid refrigerant. It also removes water and acids from the refrigerant. The water-absorbing material (desiccant) in the unit helps stop blockages caused by moisture forming in the expansion valve and other parts of the system.

Refrigerant

Refrigerant is a substance that is used to absorb heat from the air in the cab and release it to the air outside the cab.

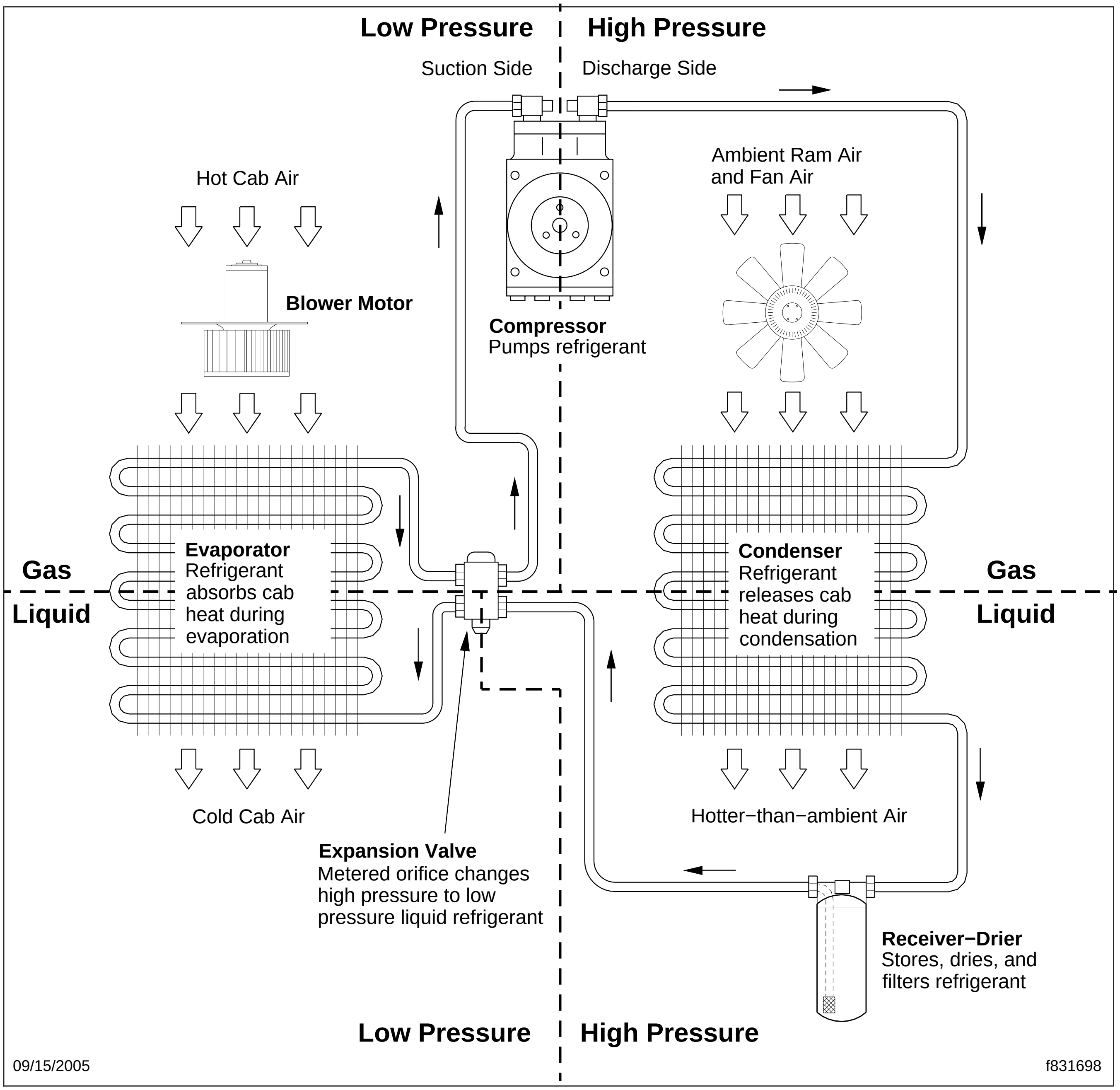
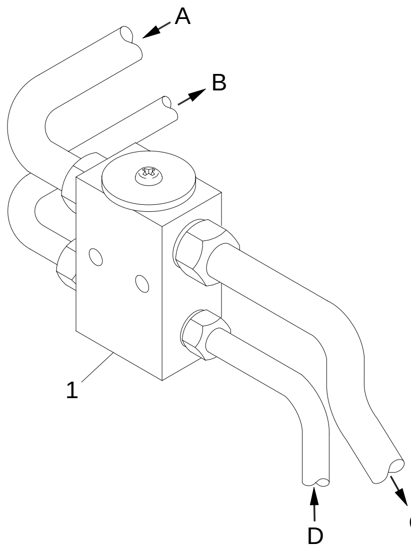


Fig. 2, Refrigerant Flow Diagram

During compressor operation, refrigerant constantly changes from a gas to a liquid then back to a gas, depending on whether it is absorbing heat (boiling) in the low-pressure evaporator, or releasing absorbed heat in the high-pressure condenser.

Refrigerant Compressor

"Heat" in the low-pressure gas of the evaporator is not heat that can be noticed by touch, because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By



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A. From the evaporator
B. To the evaporator
C. To the refrigerant compressor
D. From the receiver-drier

1. Expansion Valve

Fig. 3, Expansion Valve Refrigerant Lines

touch, the "heated" gas in the evaporator is very cold. As a result, there is the problem of how to remove heat from subfreezing gas using outside air that may be higher than 100°F (38°C).

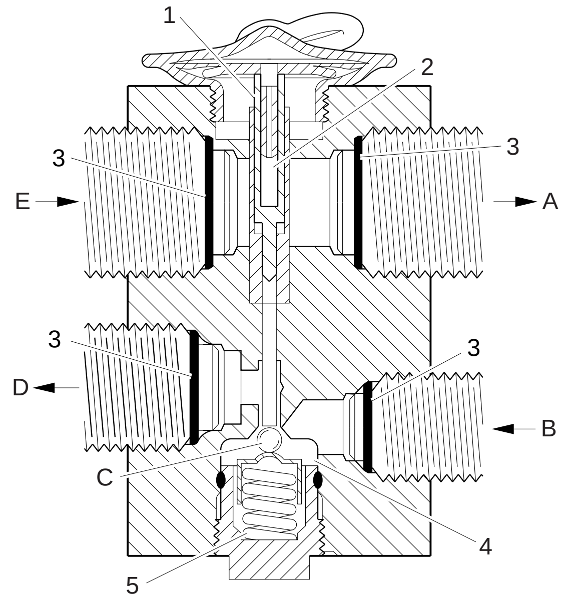
With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air without adding heat.

If system pressure rises above 550 ± 50 psi (3792 ± 345 kPa), a pressure relief valve will vent, disengaging the compressor clutch until the pressure drops to 400 psi (2758 kPa).

A secondary purpose of the compressor is to move refrigerant through the system.

Water Regulating Valve

The water regulating valve is controlled by a temperature control knob on the dash panel. A cable from the rack and pinion opens and closes the valve, regulating the amount of engine coolant flowing through the heater core.



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A. To the compressor
B. From the receiver-drier
C. Bleed at the ball seat
D. To the evaporator
E. From the evaporator

1. Internal Equalization Passage
2. Temperature Sensor
3. O-Rings
4. Metering Orifice
5. Ball and Spring

Fig. 4, Expansion Valve

Definition of Terms

Refer to the following terms for a better understanding of the heater/air conditioning system.

Air Conditioner A device used to control the temperature, humidity, and movement of air in the cab.

Air Cylinder Air-operated device used to open or close vents through which air is pushed into the cab by the blower.

Ambient Air Temperature The temperature of air around an object, or the outside temperature.

Blower Motor A blower motor forces air through the HVAC assembly and through the duct work.

Blower Resistor Block Assembly Inline resistors that control the amount of voltage going to the blower motor. By controlling the voltage, you can control the fan speed.

General Information

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Charge A specific amount of refrigerant or oil by volume or weight. Also the act of placing an amount of refrigerant or oil in the air conditioning system.

Clutch Cycling Switch (Thermostatic Switch) Engages or disengages the compressor depending on changes in evaporator temperature.

Condensate Water taken from the air, which forms on the outer surface of the evaporator.

Condenser A heat exchanger that is used to remove heat from refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid. Typically the condenser is mounted in front of the radiator.

Condensing Pressure Pressure as read from the gauge at the discharge service valve. Pressure from the discharge side of the compressor into the condenser.

Contaminants Anything other than refrigerant or refrigerant oil in the system. Usually means water, dirt, or air in the system.

Dehumidify To remove water from the air at the evaporator.

Dehydrate To remove all traces of moisture from the refrigerant system. This process occurs during evacuation.

Desiccant A drying agent used in the receiver-drier to remove moisture and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure High-side pressure or condensing pressure being discharged from the compressor.

Discharge Service Valve A device that allows high-side pressure to be checked and other service operations to be performed. This valve is located between the receiver-drier and the expansion valve.

Drive Pulley A pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Duct A passageway for the transfer of air from one point to another.

Evacuate To place a high vacuum in the refrigerant system to remove air and dehydrate or remove traces of moisture.

Evaporate A change of state from a liquid to a gas.

Evaporator A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. It also removes some moisture from the cab air.

Expansion Valve A device that causes a pressure-drop of the refrigerant and also regulates its flow.

Flooding A condition caused by too much liquid refrigerant going into the evaporator. Usually caused by an expansion valve that is stuck open.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator.

Heater Core A part of the heating system in which hot engine coolant flows to provide heat to the cab or to adjust the temperature produced by the air conditioner.

High-Side Service Valve A device located on the liquid line before the expansion device. It allows high-side pressure to be checked and other service operations to be performed.

High-Pressure Switch Located on the discharge side of the refrigerant compressor, the high-pressure switch signals the fan on and the refrigerant compressor off in the event of a high-pressure condition.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Liquid Line High pressure liquid refrigerant is carried back to the evaporator from the condenser by the liquid line to repeat the evaporation/condensation cycle.

Liquid Pressure Pressure of refrigerant in the liquid line from the condenser to the expansion device.

Low Head Pressure High-side pressure that is lower than normal due to a system problem.

Low-Pressure Switch Located on the suction side of the refrigerant compressor, the low pressure switch

General Information

signals the clutch to cycle or shut down in extremely cold temperatures, or if there is a loss of charge.

Low Suction Pressure Low-side pressure that is lower than normal due to a system problem.

Magnetic Clutch An electrical coupling device used to engage or disengage the compressor.

Manifold A device to control refrigerant flow for system test purposes. It is used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

Manifold Gauge Set A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

Micron A metric unit of length equal to one-millionth of a meter. The unit of measure is used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Nitrogen A colorless, odorless, dry, inert gas.

Opacity A condition that is used to describe contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

Polyalkylene Glycol (PAG) A highly refined, synthetic oil that is used in R–134a air conditioning systems.

Polyol Ester (POE) A highly refined, synthetic oil that is used in R–134a air conditioning systems.

psia Pounds per square inch, absolute pressure. Pressure exerted by the air at sea level. Atmospheric pressure is usually measured with a mercury barometer.

psig Pounds per square inch, gauge pressure. Any pressure above normal atmospheric pressure (14.7 psi) is referred to as gauge pressure.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Recovery Removal of the refrigerant from the air conditioning system.

Recycling Removal of contaminants and moisture from R–134a using a recovery and recycling station.

Refrigerant–134a (R–134a) The cooling agent used in automotive air conditioning systems. The chemical name for R–134a is tetrafluoroethane.

Refrigerant Compressor A device used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. A second purpose of the compressor is to move refrigerant through the system.

Refrigeration Cycle The complete circulation of refrigerant through an air conditioning system, accompanied by changes in temperature and pressure.

Relative Humidity The actual water content of the air in relation to the total water the air can hold at a given temperature.

Resistor A voltage-dropping device, usually wire wound, for controlling fan speed.

Sensor A temperature- or pressure-sensing unit that is used to sense air temperatures or pressures, and provide a control voltage for operation of automatic temperature control units.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure or the system's low-side pressure.

Suction Service Valve A device that allows low-side pressure to be checked and other service operations to be performed. This valve is located between the evaporator and the compressor.

Suction Side The low-pressure area of the system, extending from the expansion valve to the compressor inlet.

Thermistor A vacuum pressure sensor that is used to measure, in microns of mercury, the internal system vacuum level after evacuation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron of mercury with scales reading from 25,000 microns to 1 micron of mercury.

Thermostatic Switch A temperature-sensitive switch used to control system temperature and prevent evaporator freeze-up. It does this by controlling the compressor's clutch operation.

Undercharge A system low on refrigerant resulting in lack of cooling and possible compressor damage.

Vacuum Refers to pressure that is less than atmospheric pressure.

Vacuum Pump A mechanical device used to evacuate and create a high vacuum in the refrigerant system.

Vacuum Pump Oil Water soluble oil used in some vacuum pumps to absorb moisture from the refrigerant system.

Vapor The gaseous state of a material.

Water Regulating Valve A valve, mechanically operated, for controlling the flow of coolant to the heater core.

Principles of Operation

Air Conditioner

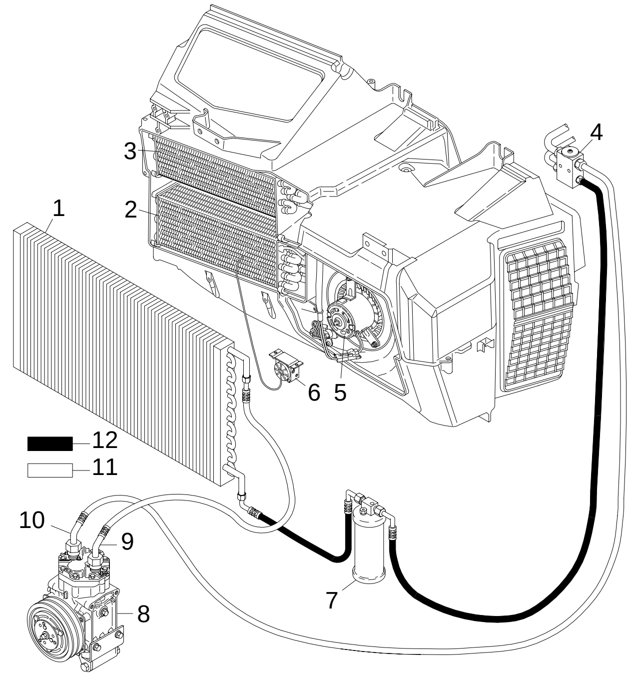
The refrigerant compressor crankshaft actuates the pistons, drawing in and compressing the low-pressure refrigerant gas into a high-pressure, high-temperature gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid.

After it is compressed, refrigerant gas moves out of the discharge port of the compressor and on to the condenser. At the condenser, air passing over the coil fins absorbs heat from the hot refrigerant gas and causes it to change into a liquid. The liquid moves to the receiver-drier, which filters it and removes traces of moisture and acids, then stores the refrigerant until it is needed by the system.

From the receiver-drier, liquid refrigerant moves to the expansion valve, which meters the flow into the evaporator and acts as a boundary between the high- and low-pressure sides of the system. The metered release of the expansion valve greatly drops the liquid's pressure causing it to expand. The pressure drop lowers the boiling point of the refrigerant, and causes it to evaporate quickly as it absorbs heat from air passing over the coil. The resulting cool air is forced into the cab by the blower. The heated refrigerant gas is drawn back into the compressor, where the cycle is repeated. See **Fig. 5**.

Heater

Turning the temperature control knob from COOL to WARM opens the water regulating valve, which allows engine-heated coolant to flow through the heater core. Air heated by passing over the heater core fins is forced through ducts, into the cab.



1. Condenser
2. Evaporator
3. Heater Core
4. Expansion Valve
5. Blower Motor
6. Thermostatic Switch
7. Receiver-Drier
8. Refrigerant Compressor
9. Discharge Side
10. Suction Side
11. Vapor
12. Liquid

Fig. 5, Air Conditioning Refrigerant Plumbing

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG), or polyol ester (POE) oil is used in the compressor. When handling these oils, observe the following:

- keep the oil free of contaminants
- do not expose the a/c system or the oil container to air for long periods of time; PAG and POE oils absorb moisture quickly
- use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if the oil is spilled on them
- never mix the oils with other types of refrigerant oil

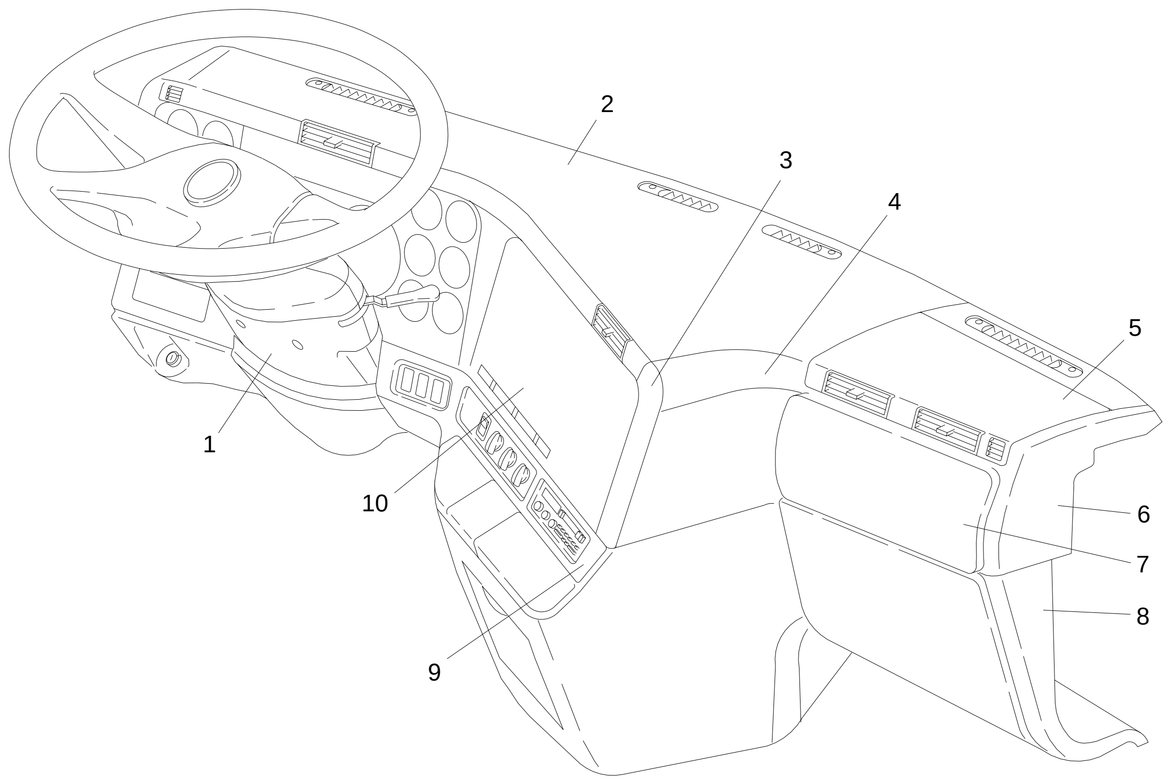
Heater and Air Conditioner Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**.

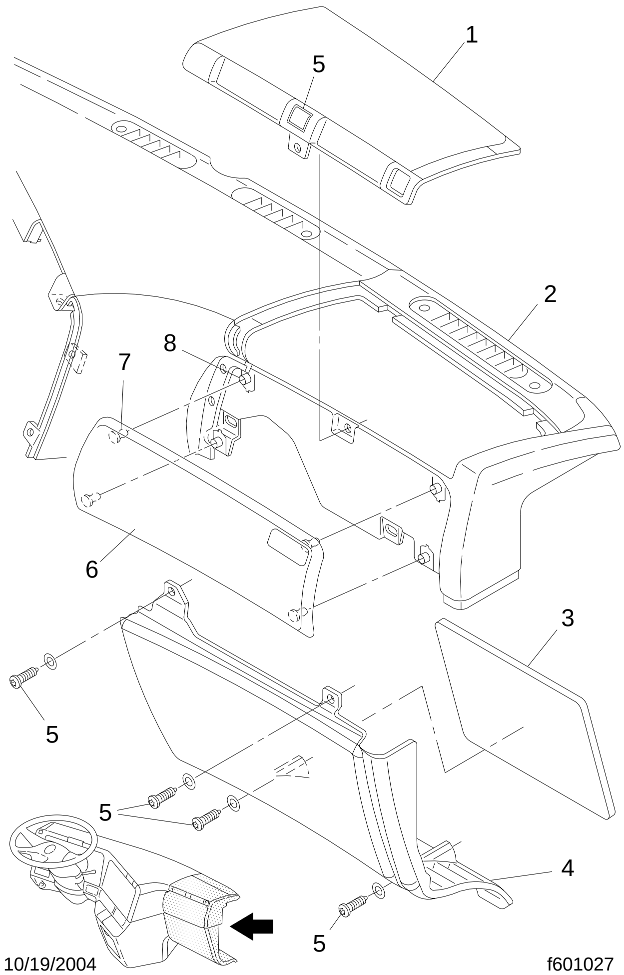
3. Remove the right-hand dash panels, the left-hand dash panels as needed, and the upper dash panels to access the heater and air conditioner assembly. See **Fig. 2** and **Fig. 3**. For instructions, see **Group 60**.
4. At the climate control panel, disconnect the air lines and unplug the electrical connector.
5. Remove the air distribution duct that runs across the top of the power distribution module.
6. Remove the two fasteners holding the vertical air duct that is located along the kick panel. Remove the duct.
7. Remove the power distribution module. For instructions, see **Group 54**.
8. Remove the air distribution duct located on top of the heater and air conditioner assembly.



1. Steering Column Cover
2. Upper Dash Assembly, Left-Hand Panel
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels

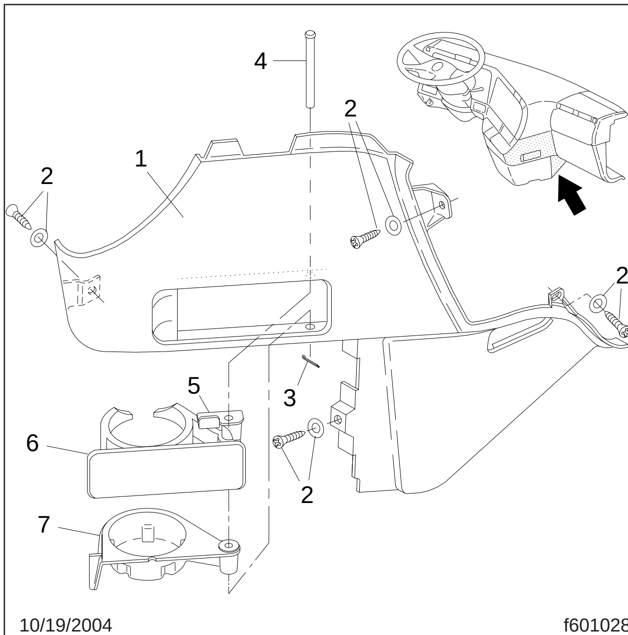
Heater and Air Conditioner Removal and Installation



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 2, Right-Hand Dash Panels

9. Remove the rain gutter and the air intake duct in the engine compartment.
10. Remove the air cleaner. For instructions, see **Group 09**.
11. At the frontwall (just above the expansion valve), disconnect the heater core supply and return lines. Clamp off the lines to prevent coolant loss.



1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

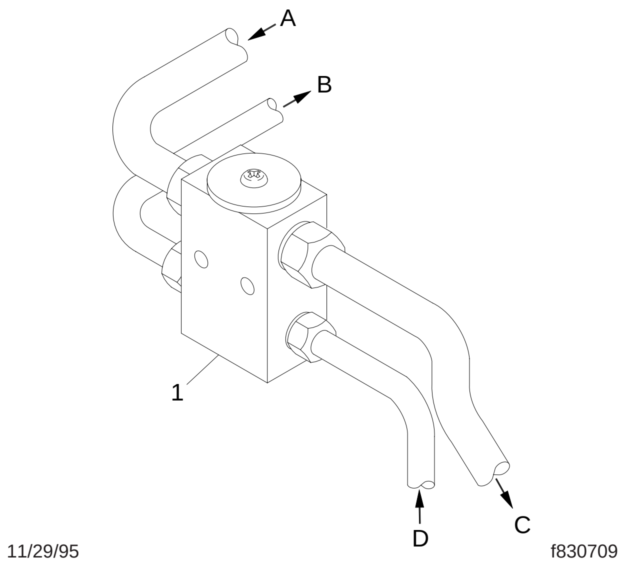
Fig. 3, Right-Hand Console Cover

12. Remove the mastic insulating tape from around the expansion valve.
13. Remove the refrigerant from the air conditioning system. For instructions, see **Subject 240**.
14. At the expansion valve, disconnect the refrigerant lines that are routed to the junction block (then on to the receiver-drier and the refrigerant compressor). See **Fig. 4**. Quickly cap the expansion valve ports, and plug the fittings.

IMPORTANT: Do not leave the expansion valve ports uncapped or the fittings unplugged for longer than a total time of 5 minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

15. Remove the drain tubes that pass through the frontwall.

Heater and Air Conditioner Removal and Installation



A. From the evaporator coil
B. To the evaporator coil
C. To the refrigerant compressor
D. From the receiver-drier
1. Expansion Valve

Fig. 4, Expansion Valve Refrigerant Lines

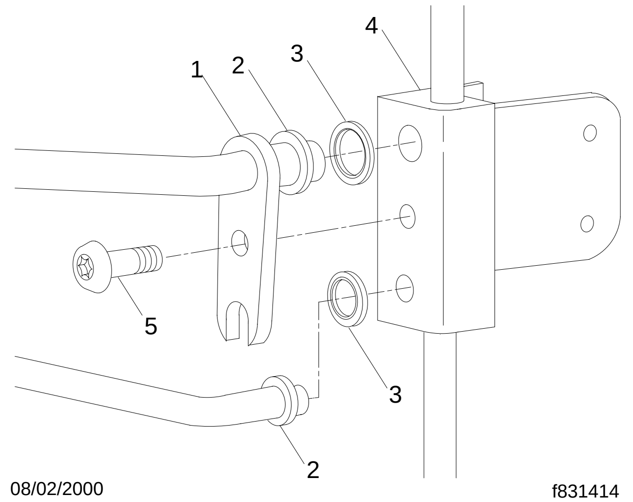
16. Remove the two capscrews and the four nuts that hold the heater and air-conditioner unit in place. Remove the heater and air conditioner.

NOTE: Pull out the lower right-hand side of the heater and air conditioner first.

Installation

1. Align the left side of the heater and air conditioner in the cab. Make sure that the ducts on the left side mate with their respective cavities in the dash structure.
2. Check that the left-hand heat duct slides into position and that all gaskets are flush against the frontwall.
3. Install the capscrews and nuts that secure the heater and air conditioner. Tighten them 16 lbf·ft (22 N·m).
4. Feed the drain tubes through the frontwall.
5. Uncap the expansion valve ports, and unplug the fittings. Check the fittings and the ports. They must be clean and free of nicks, gasket residue, and other foreign material.
6. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly, replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly. See **Fig. 5**.



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 5, A Typical SlimLine Seal Assembly

7. Install the refrigerant lines to the expansion valve.

   On hose connections that have threaded fittings, torque the large line 35 to 40 lbf·ft (47 to 54 N·m). Torque the small line 20 to 25 lbf·ft (27 to 34 N·m).

   On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).
8. Evacuate and charge the system with refrigerant. See **Subject 240** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged. For instructions, see the applicable refrigerant compressor section in this group.

Heater and Air Conditioner Removal and Installation

9. Cover the expansion valve with mastic insulating tape.
10. Connect the heater inlet and outlet hoses to the heater core pipe elbows. Tighten the clamps securely.
11. Install the air intake duct and the rain gutter in the engine compartment. Tighten the fasteners securely.
12. Install the air cleaner. For instructions, see **Group 09**.
13. Install the power distribution module. For instructions, see **Group 54**.
14. Install the vertical air duct along the right-hand side kick panel using the two fasteners removed earlier.
15. Install the air distribution duct across the top of the power distribution module.
16. Securely fasten the unit to the windshield support bracket (near the center of the windshield).
17. Connect the electrical connector to the climate control panel. Install the air lines.
18. Install the dash panels. For instructions, see **Group 60**.
19. Connect the batteries.
20. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.
21. Remove the chocks from the tires.

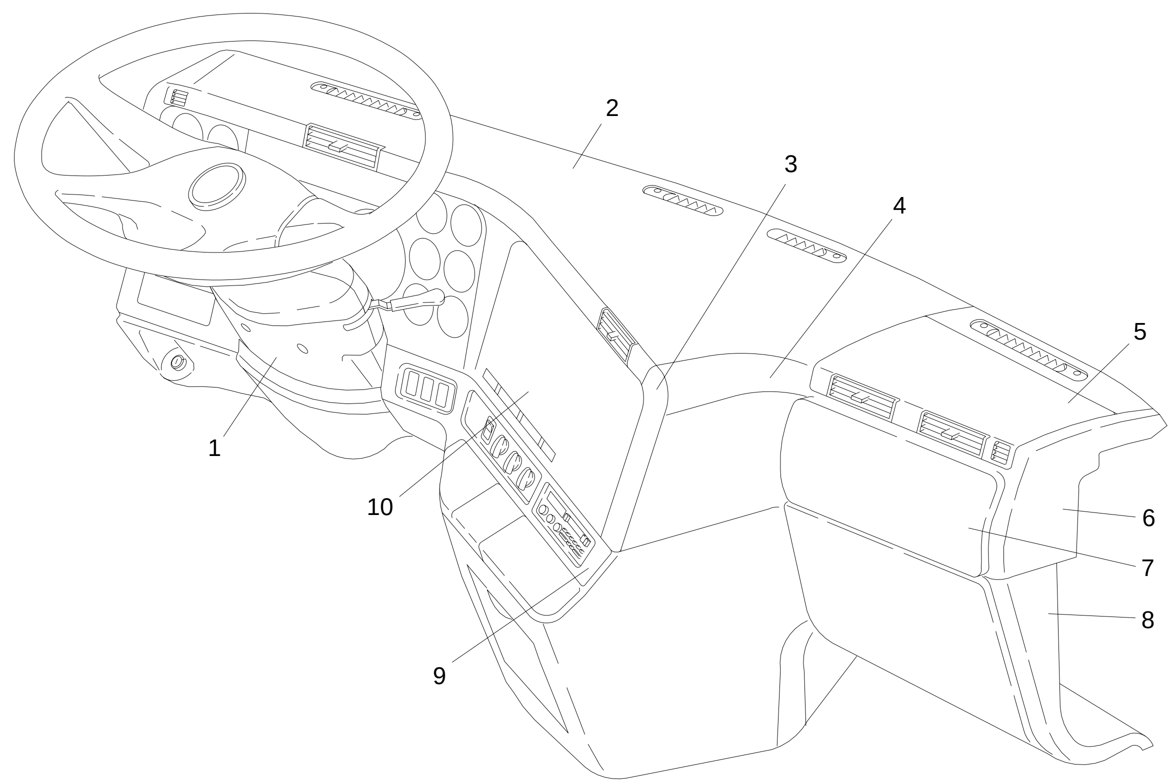
Heater Core Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**.

3. Remove the right-hand dash panels as needed to access the heater core. See **Fig. 2** and **Fig. 3**. For instructions, see **Group 60**.
4. Remove the air duct that runs across the top of the power distribution module.
5. Disconnect the harness from the thermostatic switch. See **Fig. 4**.
6. Remove the two screws attaching the thermostatic switch to the heater core and evaporator coil cover. Remove the switch and the sensor tube.
7. Remove the air duct located just above the thermostatic switch and sensor tube.
8. Remove the fasteners from the heater core and evaporator coil cover. See **Fig. 5**.
9. Open the hood and remove the air cleaner. For instructions, see **Group 09**.



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1. Steering Column Cover
2. Upper Dash Assembly, Left-Hand Panel
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
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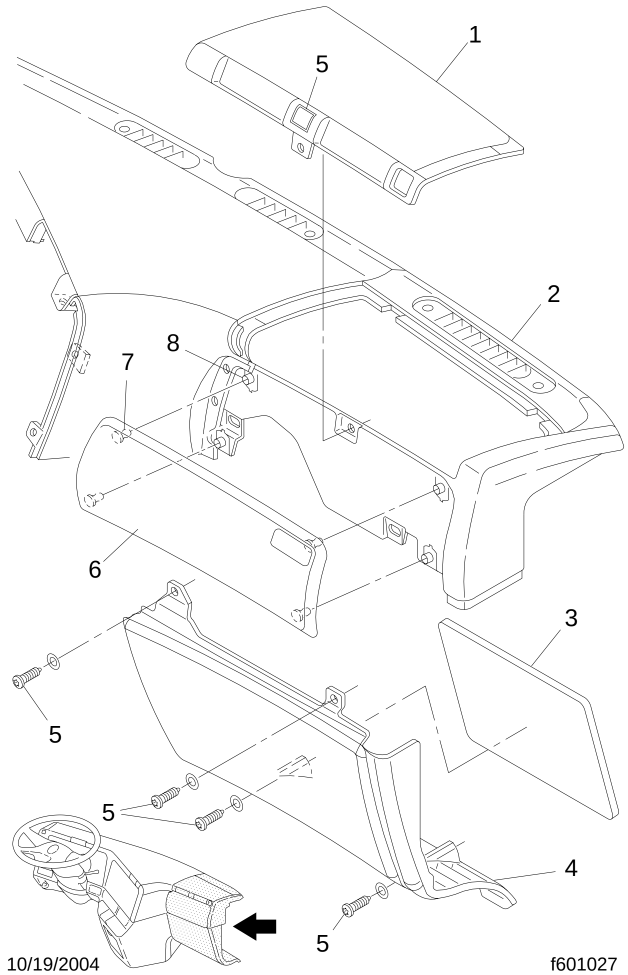
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels

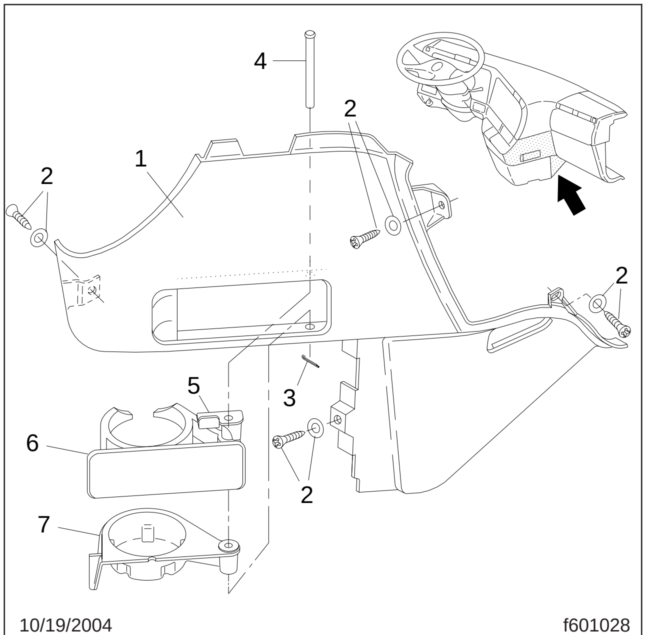
Heater Core Removal and Installation



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 2, Right-Hand Dash Panels

10. At the frontwall (just above the expansion valve), disconnect the heater core supply and return lines. Clamp off the lines to prevent coolant loss.



1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

Fig. 3, Right-Hand Console Cover

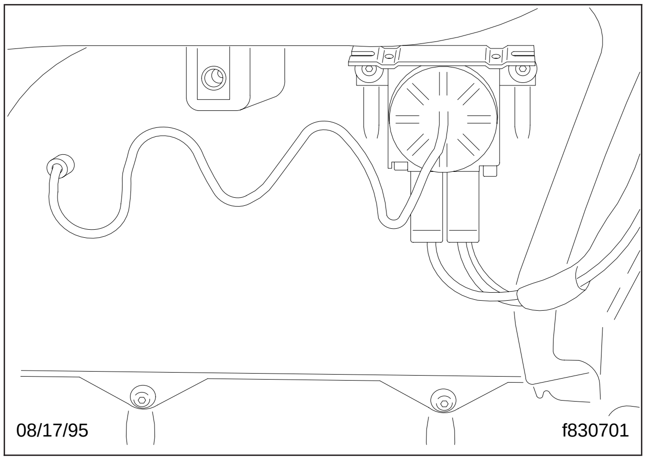


Fig. 4, Thermostatic Switch Mounting

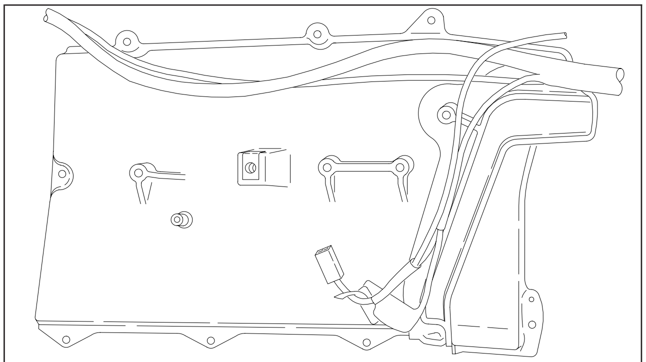


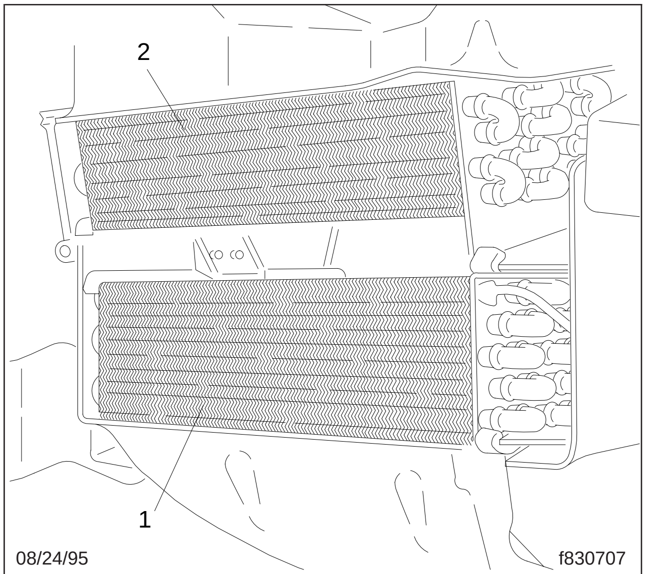
Fig. 5, Heater Core and Evaporator Coil Cover

WARNING

Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the heater core fins.

IMPORTANT: A small amount of antifreeze may be present in the heater core. Protect the interior of the vehicle to prevent any damage from antifreeze spillage.

11. Wearing protective gloves, slide the heater core out of the housing. See Fig. 6.



1. Evaporator Coil
2. Heater Core

Fig. 6, Remove the Heater Core

Installation

1. Wearing protective gloves, slide the new heater core into the housing. Make sure that the heater core gasket is flush against the frontwall. Connect the heater inlet and outlet hoses to the heater core pipe elbows. Tighten the clamps securely.
2. Install the air cleaner. For instructions, see Group 09.
3. Install the heater core and evaporator coil cover.

CAUTION

Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

4. Carefully insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with an evaporator coil fin and be inserted at least 6 inches (15 cm) into the evaporator coil.
5. Using the two screws removed previously, install the thermostatic switch.
6. Connect the wire harness to the thermostatic switch.
7. Install the air duct above the thermostatic switch.
8. Install the right-hand dash panels. For instructions, see Group 60.
9. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.
10. Lower the hood.
11. Remove the chocks from the tires.

Blower Motor Removal and Installation

Removal

WARNING

Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

1. Turn off the engine, apply the parking brakes, and chock the tires.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**.

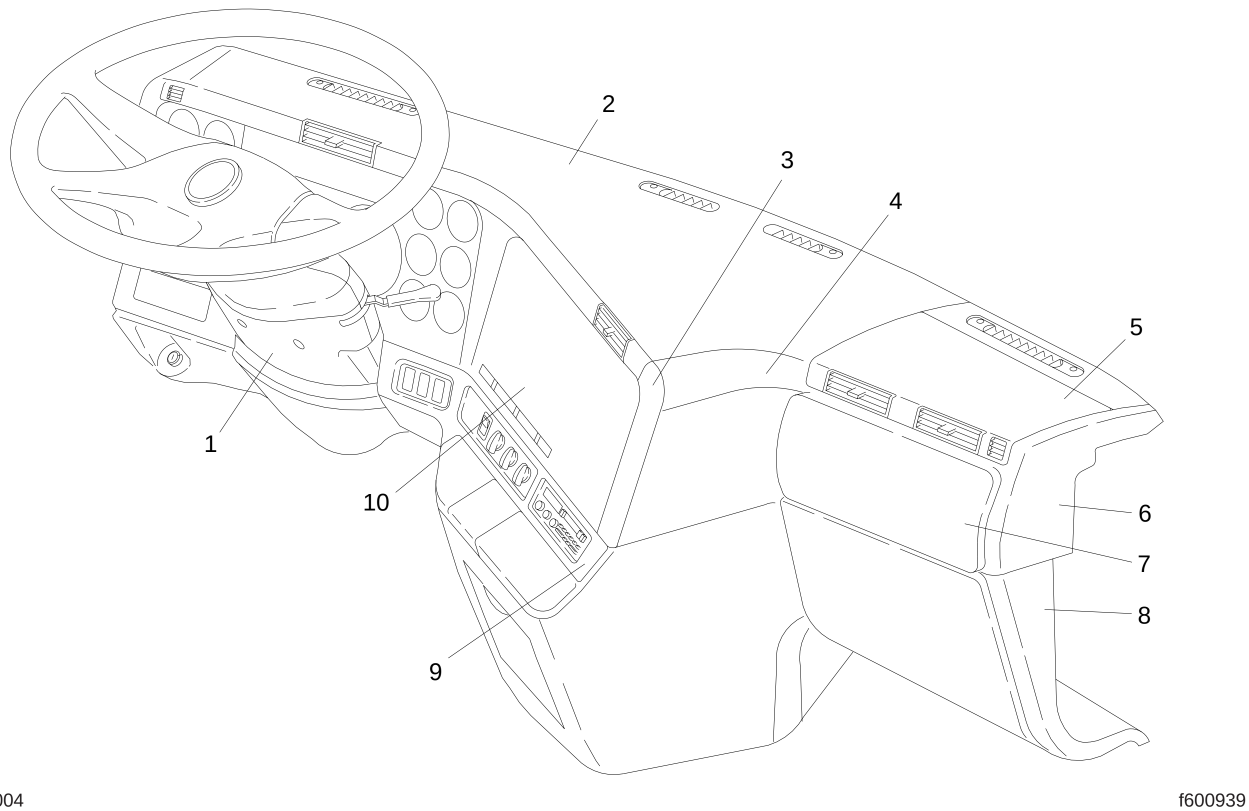
2. Remove the right-hand dash panels as needed to access the blower motor. See **Fig. 2**. For instructions, see **Group 60**.
3. Disconnect the blower motor wires. See **Fig. 3**.
4. Remove the three screws from the blower motor bracket, then lift the blower motor out of the housing.

Installation

IMPORTANT: Make sure that the wiring exiting the motor is positioned at 4 o'clock to prevent excess slack in the harness.

1. Position the blower motor on the mounting bracket in the housing. Install the screws and tighten them securely.
2. Connect the blower motor wires.
3. Install the right-hand dash panels. For instructions, see **Group 60**.
4. Turn on the ignition key and test the blower motor.
5. Remove the chocks from the tires.

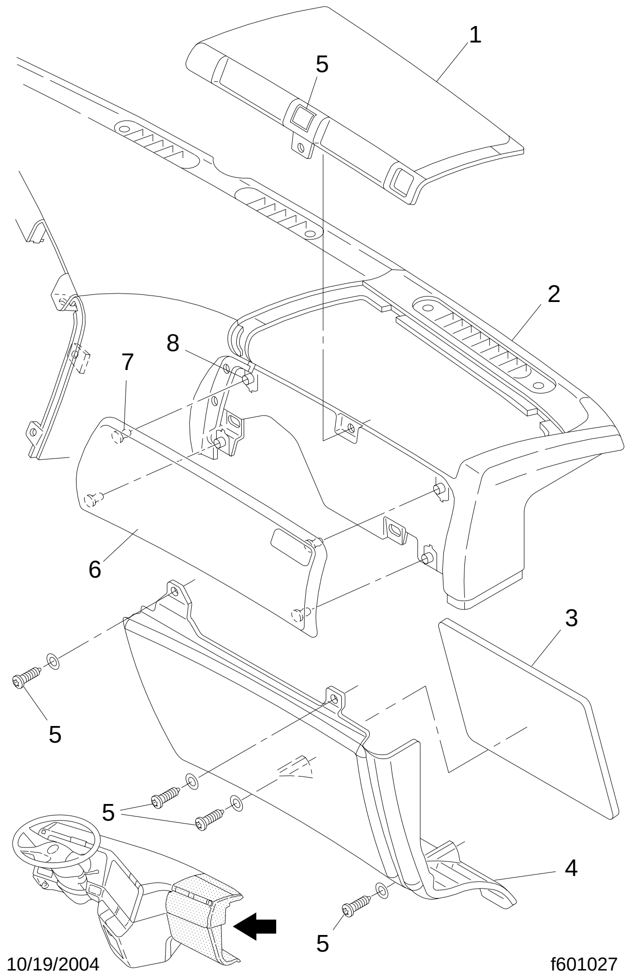
Blower Motor Removal and Installation



1. Steering Column Cover
2. Upper Dash Assembly, Left-Hand Panel
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Blower Motor Removal and Installation



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 2, Right-Hand Dash Panels

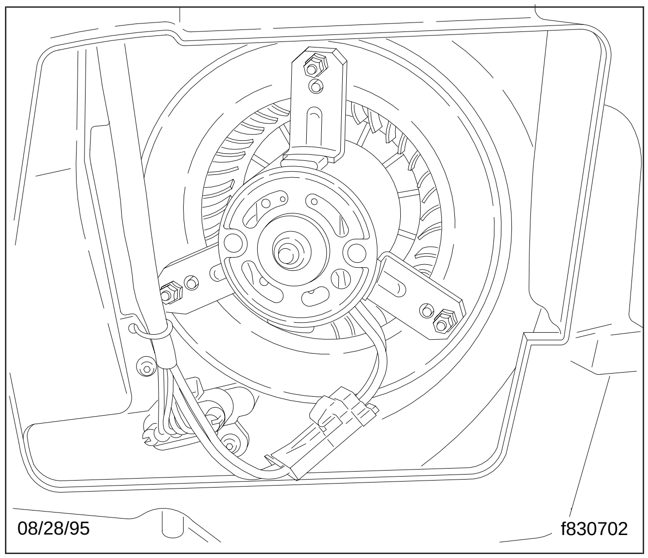


Fig. 3, Blower Motor Mounting and Electrical Connector

Resistor Block Replacement

Replacement

CAUTION

Never try to bypass the fuse in the blower motor resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater and air-conditioning system.

WARNING

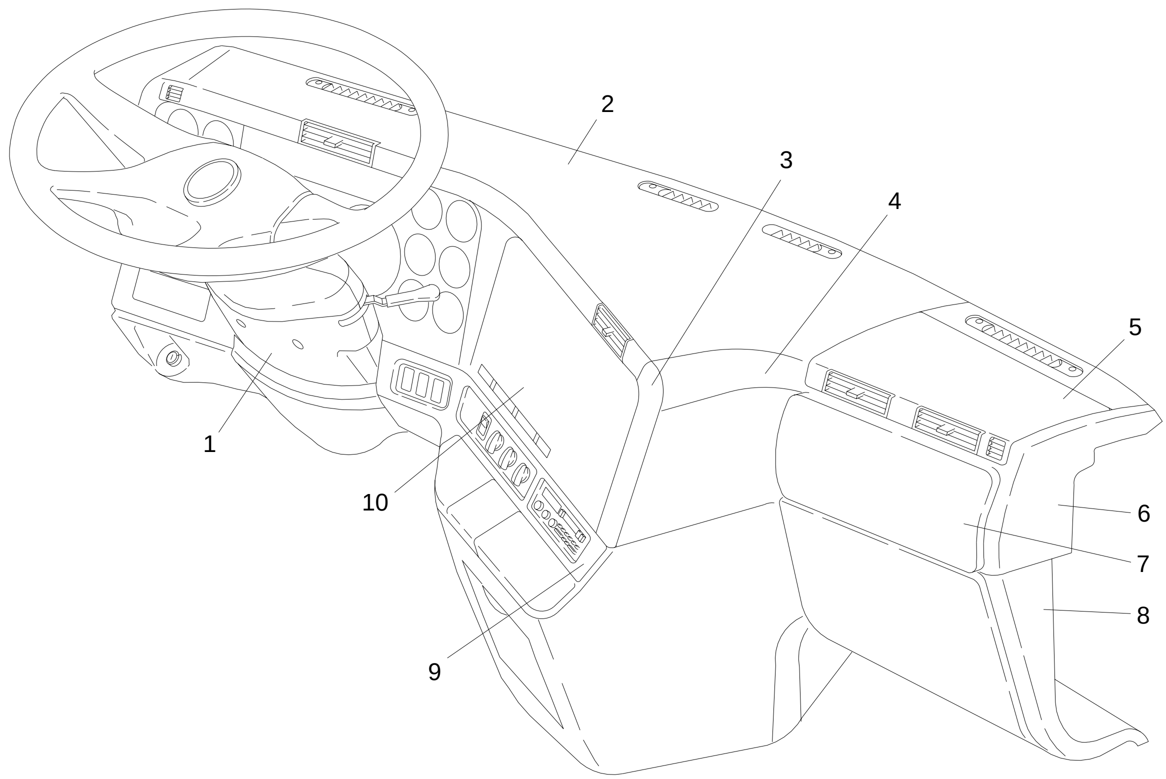
Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

1. Turn off the engine, apply the parking brakes, and chock the tires.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**.

2. Remove the right-hand dash panels as needed to access the resistor block. See **Fig. 2**. For instructions, see **Group 60**.
3. Disconnect the harness from the resistor block. See **Fig. 3**.
4. Remove the two screws and lift out the resistor block.
5. Position the new resistor block and install the mounting screws firmly.
6. Connect the wire harness.
7. Turn on the ignition key and test the blower motor.
8. Install the right-hand dash covers. For instructions, see **Group 60**.
9. Remove the chocks from the tires.

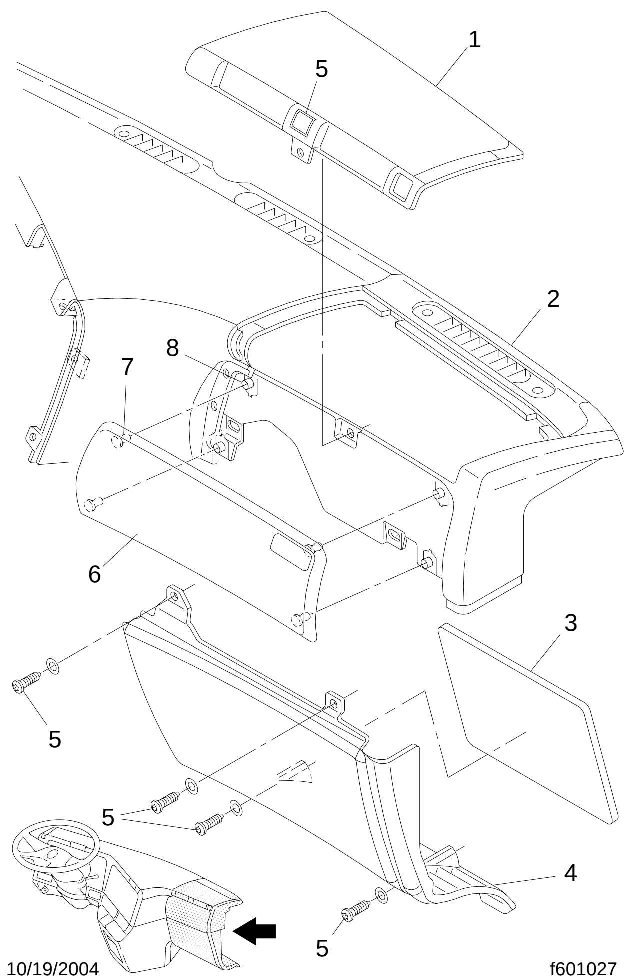
Resistor Block Replacement



1. Steering Column Cover
2. Upper Dash Assembly, Left-Hand Panel
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Resistor Block Replacement



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 2, Right-Hand Dash Panels

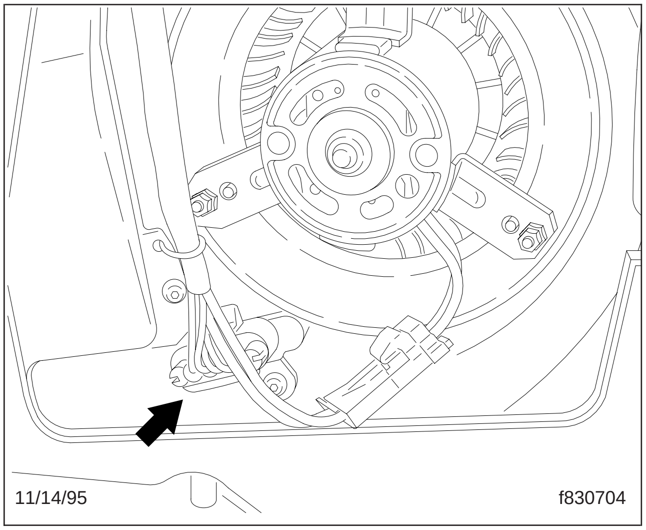


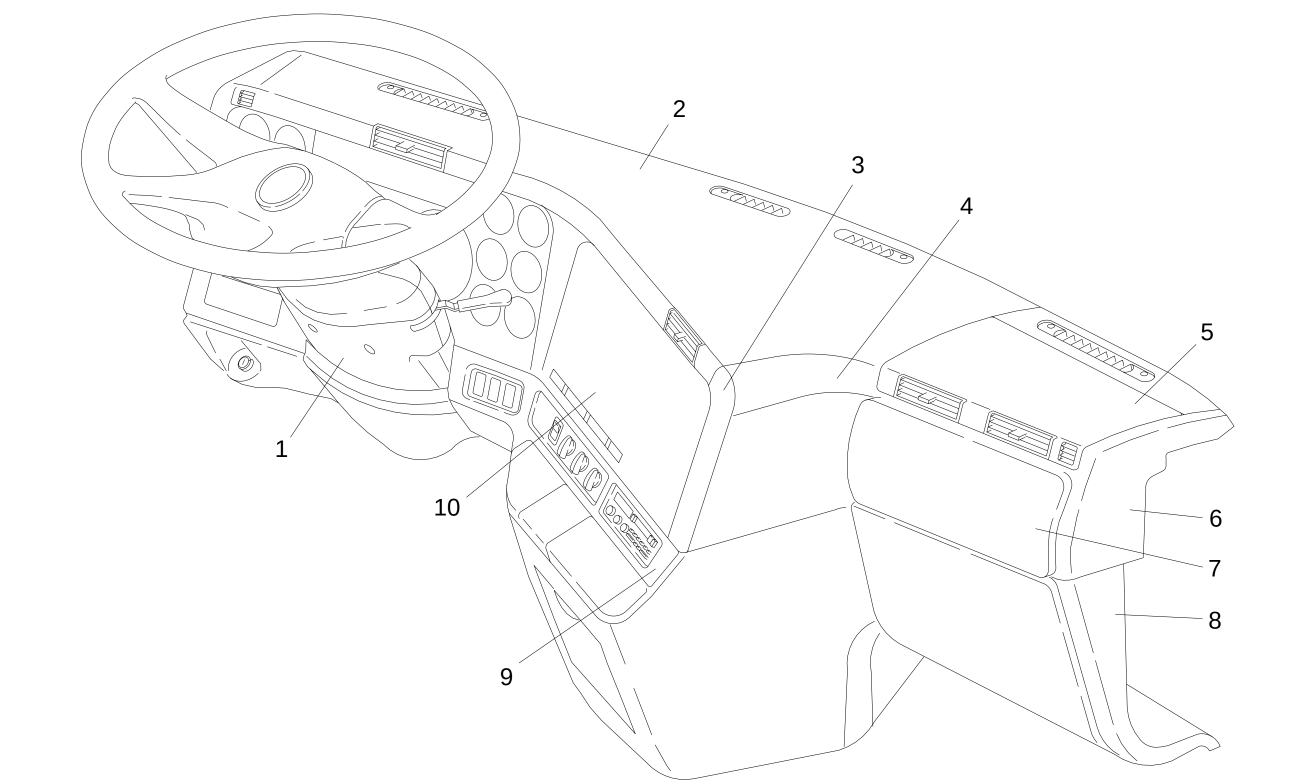
Fig. 3, Resistor Block

Replacement

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**.

3. Remove the attachment clips, then remove the air cylinder.

NOTE: During installation, use a socket to ensure even pressure on the clips.



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1. Steering Column Cover
2. Upper Dash Assembly, Left-Hand Panel
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Inlet Air Cylinder

1. Remove the right-hand dash panels as needed to access the air cylinder. See **Fig. 2**. For instructions, see **Group 60**.
2. Disconnect the air line from the cylinder by pushing in the collar and pulling out the air line. See **Fig. 3**.
3. Using new attachment clips, install the new air cylinder.
4. Install the right-hand dash panels. For instructions, see **Group 60**.

Air Cylinder Replacement

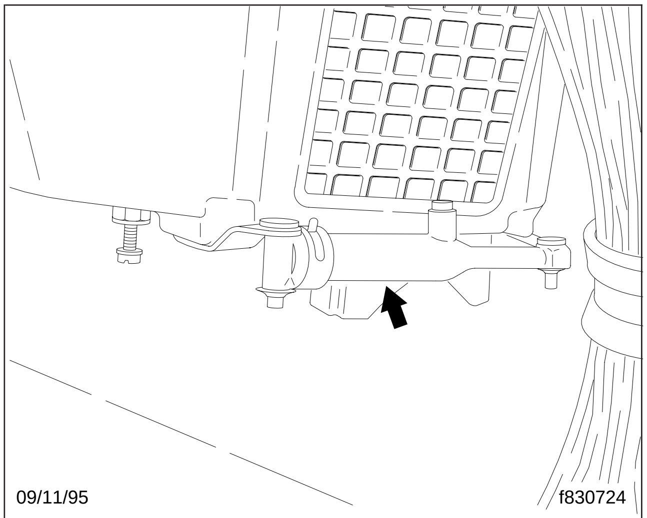
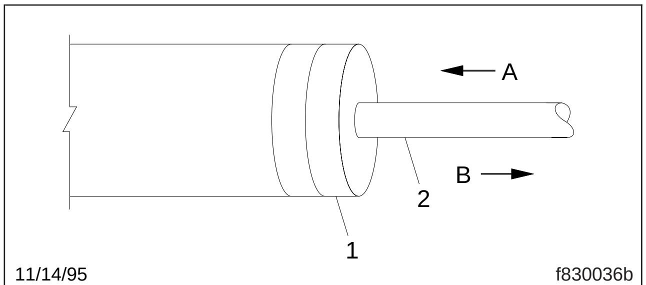


Fig. 2, Inlet Air Cylinder (located under the blower motor)



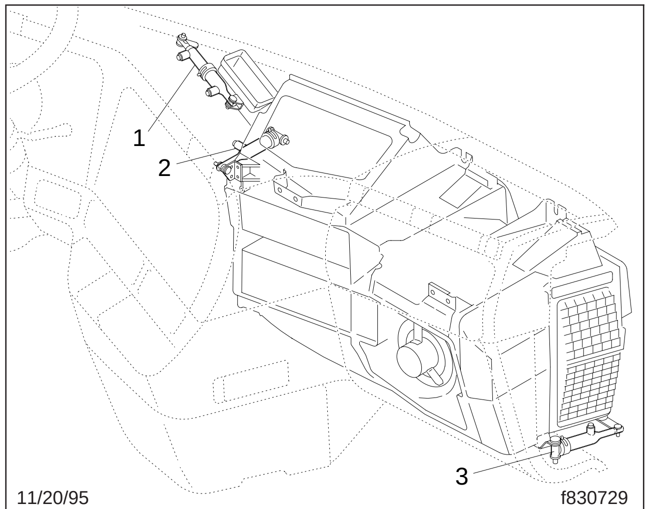
A. Push
B. Pull
1. Collar
2. Air Line

Fig. 3, Air Line

Face and Heat/Defrost Air Cylinder

NOTE: The face and heat/defrost air cylinder is located near the center of the dash assembly. See **Fig. 4**.

1. Remove the right-hand dash panels, left-hand dash panels, and upper dash panels as needed to access the air cylinder. See **Fig. 5**, **Fig. 6**, and **Fig. 7**. For instructions, see **Group 60**.
2. Move the wiring harness trough out of the way.
3. Disconnect the air lines from the cylinder by pushing in the collar and pulling out the air line. See **Fig. 3**.



1. Heat/Defrost Air Cylinder
2. Face and Heat/Defrost Air Cylinder
3. Inlet Air Cylinder

Fig. 4, Air Cylinder Locations

4. Remove the attachment clips, then remove the air cylinder.

NOTE: During installation, use a socket to ensure even pressure on the clips.

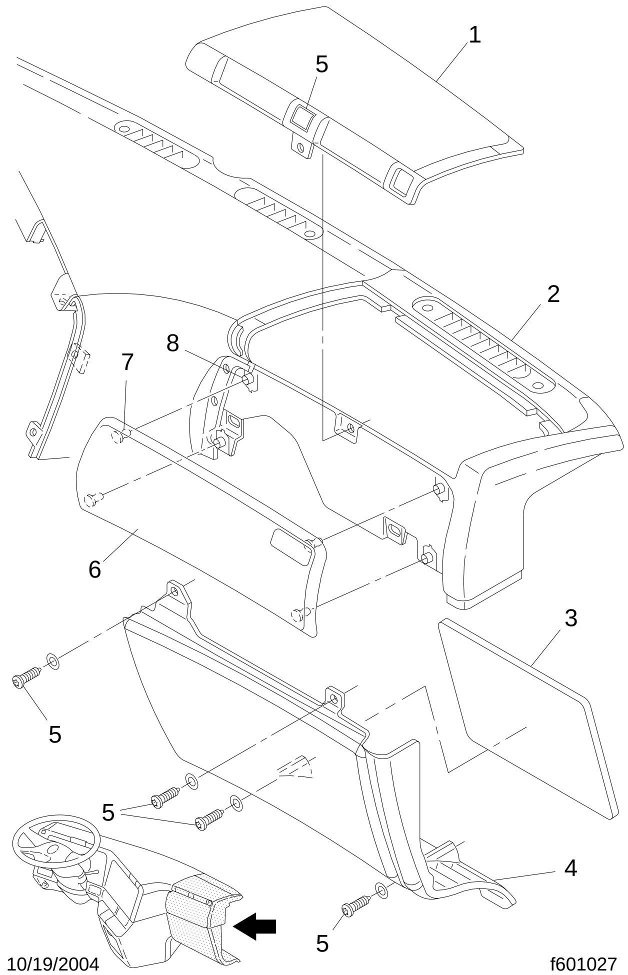
5. Using new attachment clips, install the new air cylinder.
6. Move the wiring harness trough into position in the dash.
7. Install the dash panels. For instructions, see **Group 60**.

Heat/Defrost Air Cylinder

NOTE: The heat/defrost air cylinder is located under the upper dash panels near the center of the windshield. See **Fig. 4**.

1. Remove the right-hand dash panels, left-hand dash panels, and upper dash panels as needed to access the air cylinder. See **Fig. 5**, **Fig. 6**, and **Fig. 7**. For instructions, see **Group 60**.
2. Disconnect the air lines from the cylinder by pushing in the collar and pulling out the air line. See **Fig. 3**.
3. Remove the attachment clips, then remove the air cylinder.

Air Cylinder Replacement



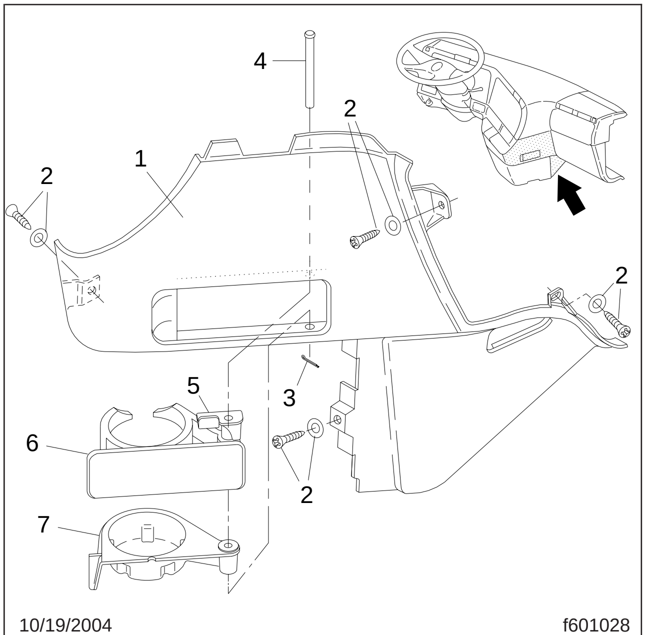
1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 5, Right-Hand Dash Panels

NOTE: During installation, use a socket to ensure even pressure on the clips.

4. Using new attachment clips, install the new air cylinder.

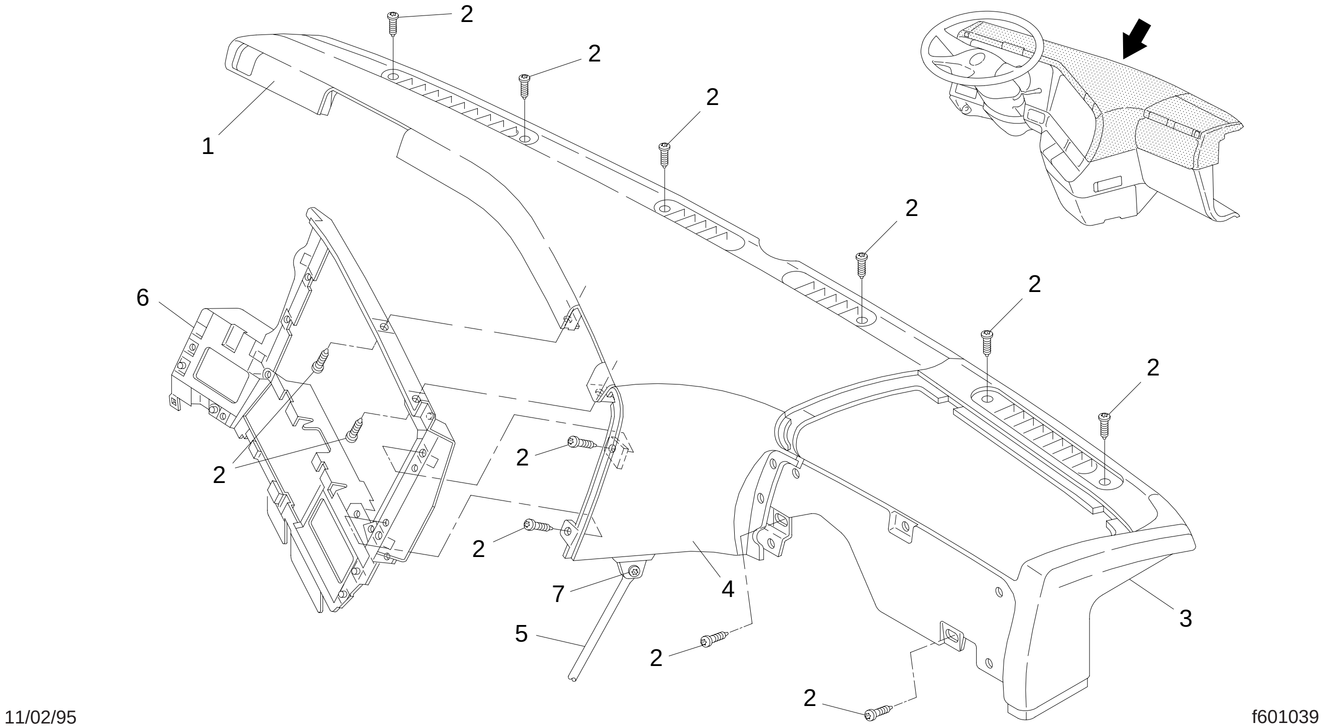
5. Install the dash panels. For instructions, see **Group 60**.



1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

Fig. 6, Right-Hand Console Cover

Air Cylinder Replacement

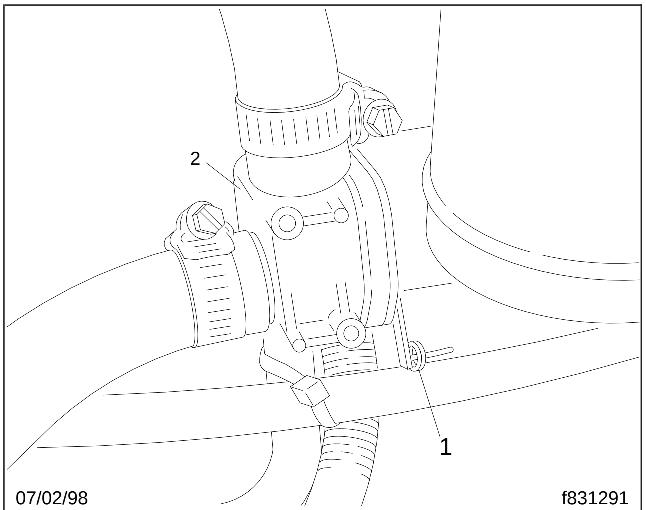


1. Upper Dash Assembly, Left-Hand
2. T25 Dog-Point Screw
3. Upper Dash Assembly, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Dash Brace
6. Upper Dash Panel
7. Dash Brace Screw

Fig. 7, Upper Dash Panels

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Remove the air cleaner. For instructions, see **Group 09**.
4. Clamp off the heater hoses to prevent coolant loss.
5. Remove the hoses from the water regulating valve. See **Fig. 1**.



1. Control Cable
2. Water Regulating Valve

Fig. 1, Water Regulating Valve

6. Slip the control cable off the end of the rod. See **Fig. 1**. Remove the control cable from the cable bracket.
7. Remove the nuts and washers that attach the water regulating valve mounting bracket to the frontwall. Remove the valve and mounting bracket.
8. Remove the water regulating valve from the valve mounting bracket. See **Fig. 2**.
9. Place a new water regulating valve on the valve bracket.
10. Place the water regulating valve and mounting bracket on the frontwall. Install the washers and nuts that attach the valve and mounting bracket to the frontwall. Tighten the nuts securely.

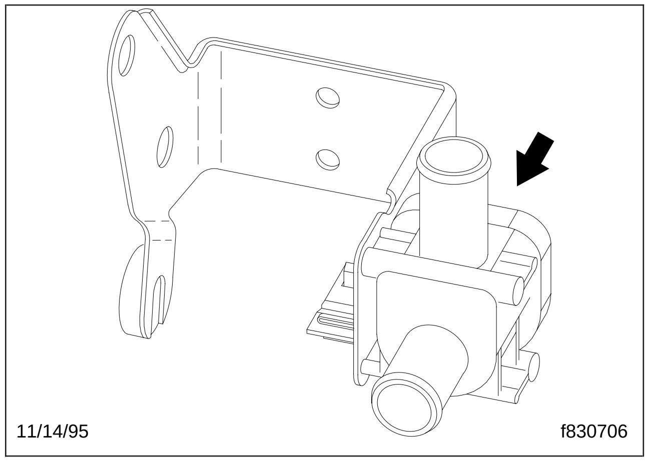


Fig. 2, Water Regulating Valve and Bracket

11. Place the control cable through the valve mounting bracket, and slip the end of the control cable over the valve rod.
12. Connect the heater hoses to the water regulating valve. Tighten the hose clamps securely.
13. Move the temperature control knob to COOL. The water regulating valve should close completely. Move the control knob to WARM. The valve should open. The travel of the knob should be smooth. If it isn't, adjust the turnbuckle following the instructions in **Subject 170**.
14. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.
15. Check for leaks around the water regulating valve and correct the cause.
16. Install the air cleaner. For instructions, see **Group 09**.
17. Lower the hood.
18. Remove the chocks from the tires.

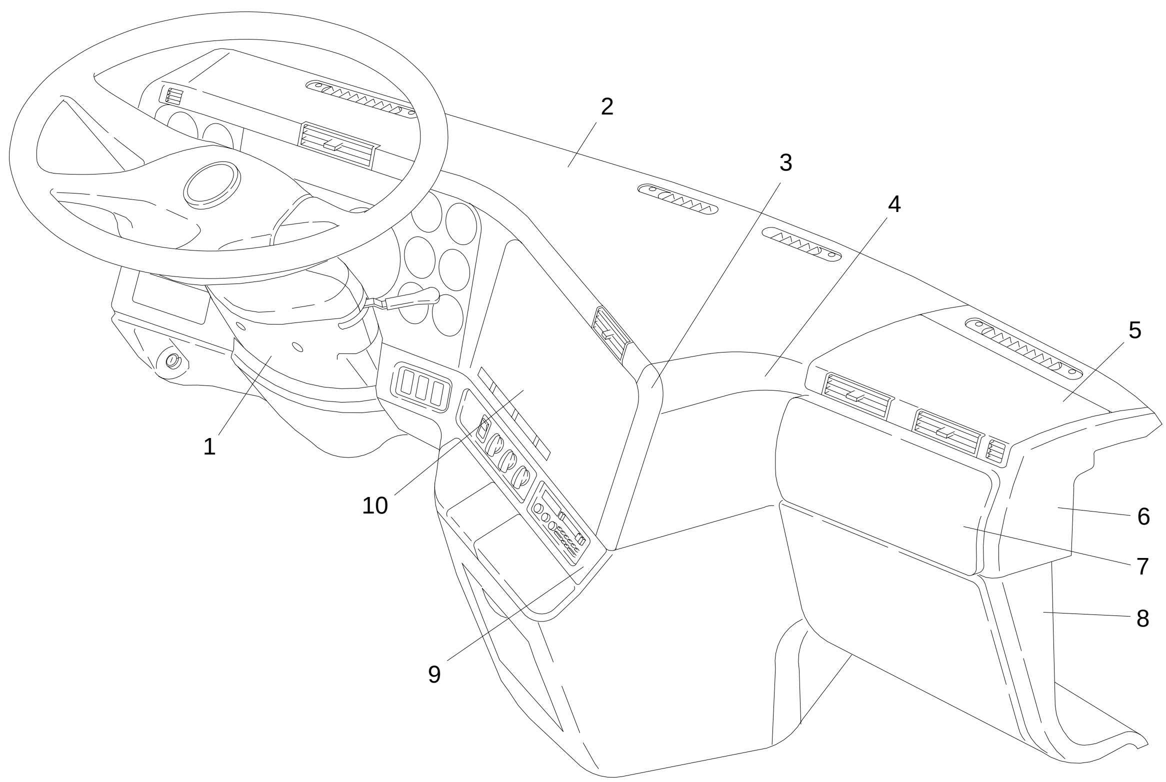
Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**.

2. Remove the right-hand dash panels as needed to replace the water regulating valve cable. See **Fig. 2** and **Fig. 3**. For instructions, see **Group 60**.

4. Cut the tie strap that secures the cable to the dash brace.
5. Open the hood and remove the air cleaner. For instructions, see **Group 09**.
6. Access the water regulating valve.
7. Slip the control cable off the end of the rod on the water regulating valve. See **Fig. 4**. Remove the cable from the cable bracket.
8. Inside the cab, pull the cable out of the engine compartment.



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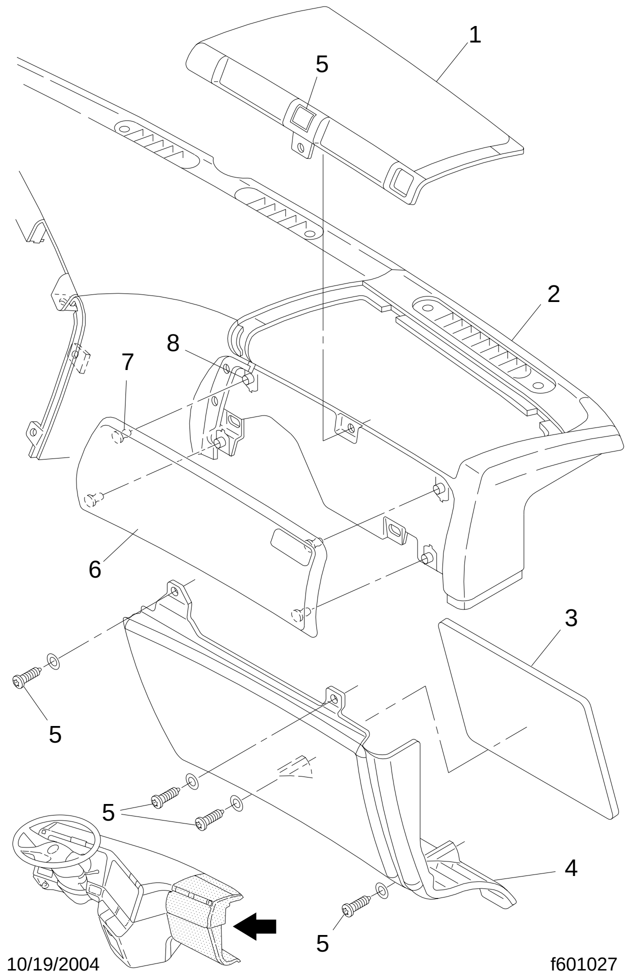
1. Steering Column Cover
2. Upper Dash Assembly, Left-Hand Panel
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels

3. Unhook the water regulator valve cable from the temperature control switch assembly.

9. Inside the cab, feed the replacement cable through the frontwall and through the clamp. Slip

Water Regulating Valve Cable Replacement

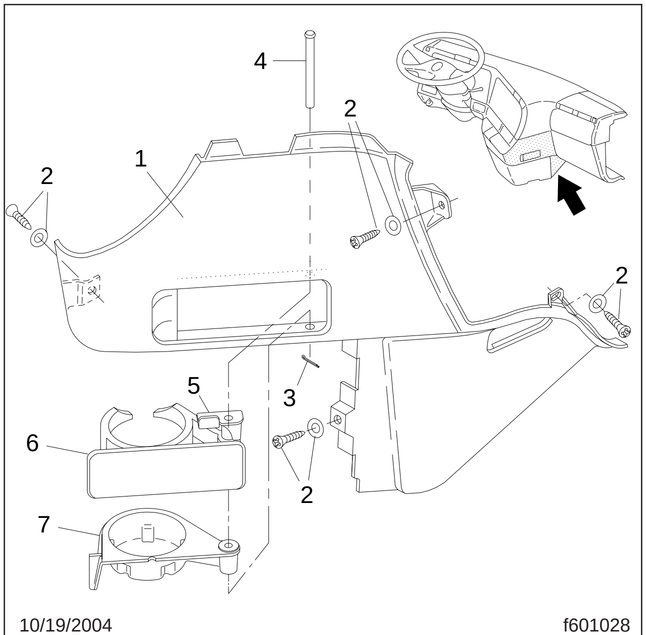


1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 2, Right-Hand Dash Panels

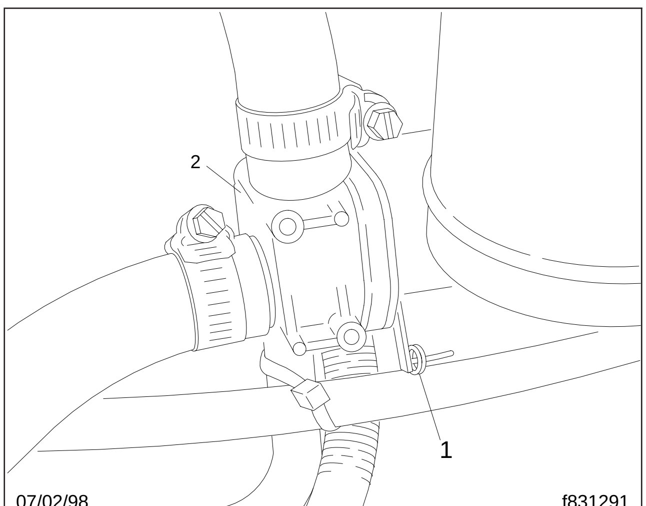
the end of the cable over the water regulating valve rod. Place the cable in the cable bracket and secure it to the valve mounting bracket.

10. At the other end of the cable, feed the end of the cable through the cable clamp and hook the end on the temperature control switch.
11. Tie strap the cable to the dash brace.



1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

Fig. 3, Right-Hand Console Cover



1. Control Cable
2. Water Regulating Valve

Fig. 4, Water Regulating Valve

Water Regulating Valve Cable Replacement

12. Install the air cleaner. For instructions, see **Group 09**.
13. Position the control panel on the dash.
14. Adjust the cable.

    The temperature control knob should spring back from the full-hot and full-cold positions. The amount of spring back should be equal at each of these positions. If it isn’t, turn the adjustment turnbuckle as needed to correct.
15. Lower the hood.
16. Install the dash panels. For instructions, see **Group 60**.
17. Remove the chocks from the tires.

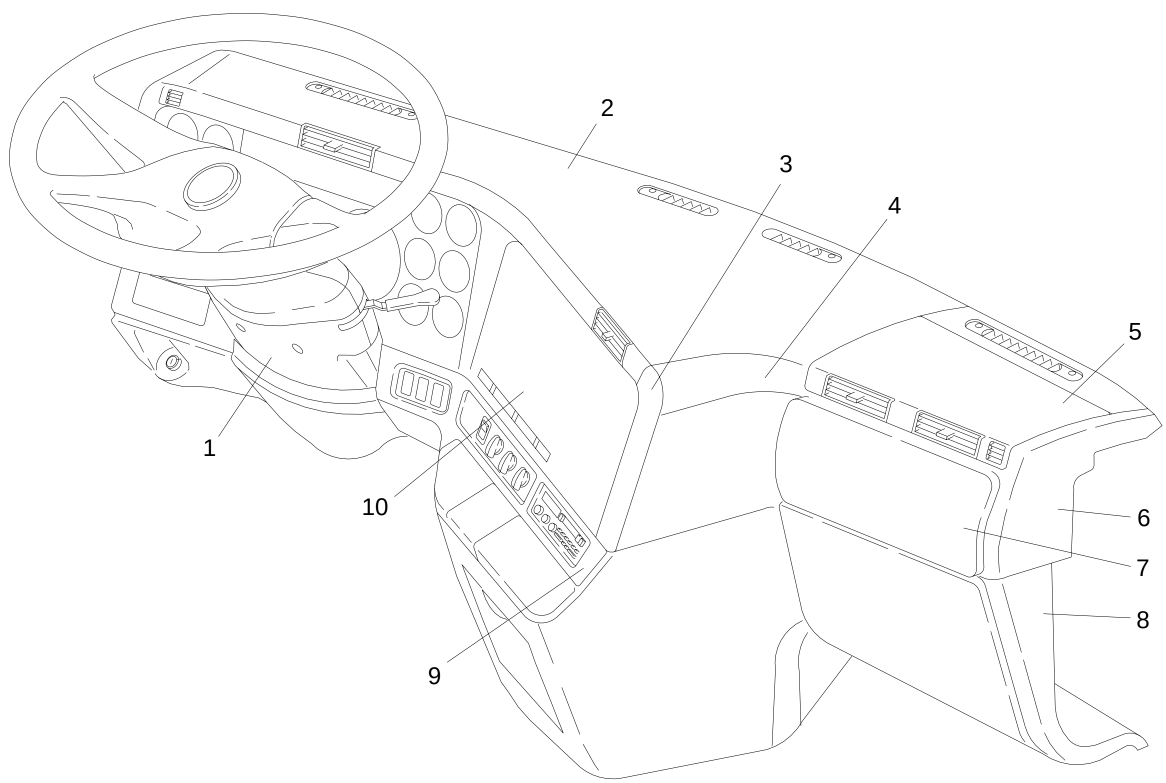
Evaporator Coil Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**.

3. Remove the right-hand dash panels as needed to access the evaporator coil. See **Fig. 2** and **Fig. 3**. For instructions, see **Group 60**.

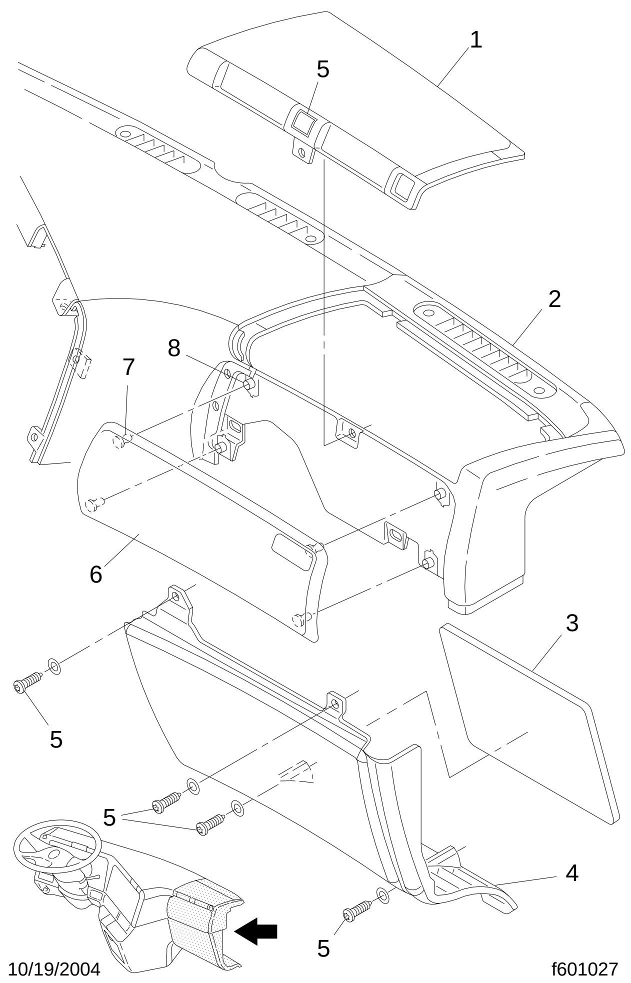


1. Steering Column Cover
2. Upper Dash Assembly, Left-Hand Panel
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels

4. Remove the air duct that is located on top of the power distribution module.
5. Disconnect the harness from the thermostatic switch. See **Fig. 4**.
6. Remove the two screws attaching the thermostatic switch to the heater core and evaporator coil cover. Remove the switch and the sensor tube.
7. Remove the fasteners from the heater core and evaporator coil cover. See **Fig. 5**.
8. Open the hood and remove the air cleaner. For instructions, see **Group 09**.
9. Remove the mastic insulating tape from around the expansion valve.

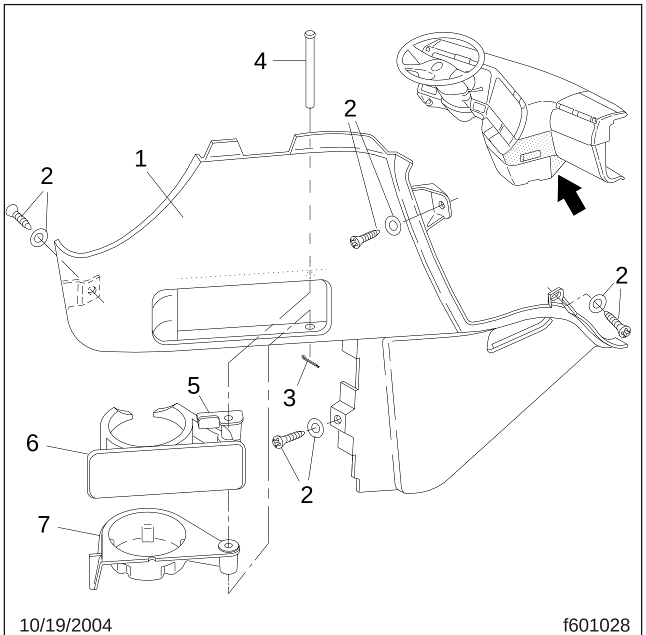
Evaporator Coil Removal and Installation



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 2, Right-Hand Dash Panels

10. Remove the refrigerant from the air conditioning system. For instructions, see **Subject 240**.
11. At the expansion valve, disconnect the refrigerant lines that are routed to the junction block (then on to the receiver-drier and the refrigerant compressor). See **Fig. 6**. Quickly cap the expansion valve ports, and plug the fittings



1. Right-Hand Console Cover
2. T25 Dog-Point Screw
3. Cotter Pin
4. Hinge Pin
5. Pivot Stop
6. Passenger's Cup Holder (upper)
7. Passenger's Cup Holder (lower)

Fig. 3, Right-Hand Console Cover

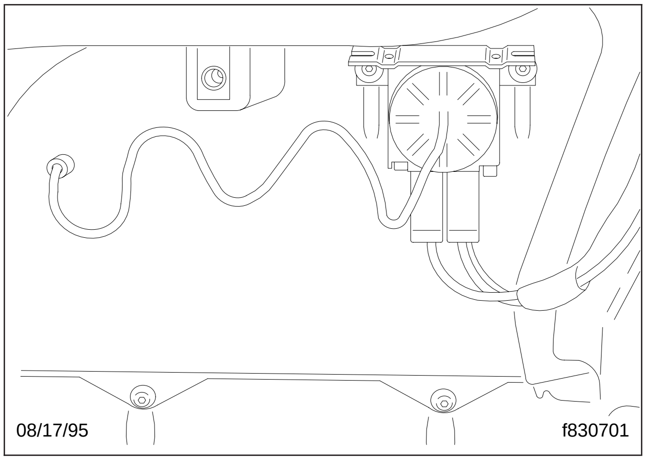


Fig. 4, Thermostatic Switch Mounting

IMPORTANT: Do not leave the expansion valve ports uncapped or the fittings unplugged for longer than a total time of five minutes. Water

Evaporator Coil Removal and Installation

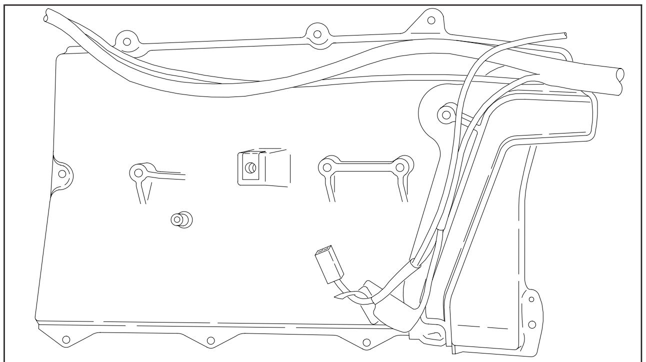
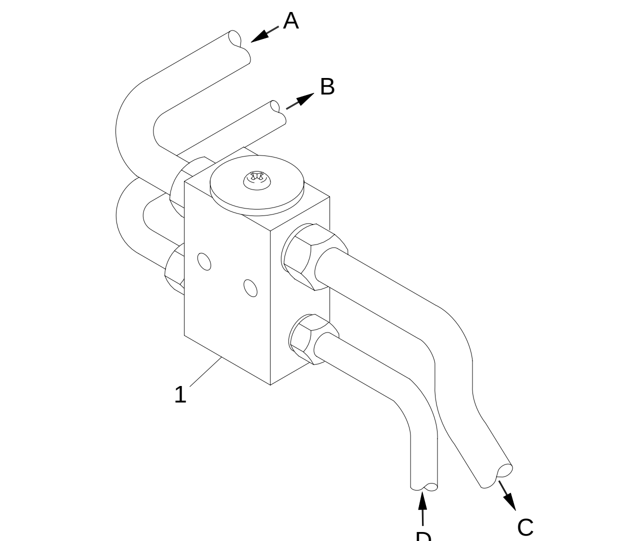


Fig. 5, Heater Core and Evaporator Coil Cover



A. From the evaporator coil
B. To the evaporator coil
C. To the refrigerant compressor
D. From the receiver-drier
1. Expansion Valve

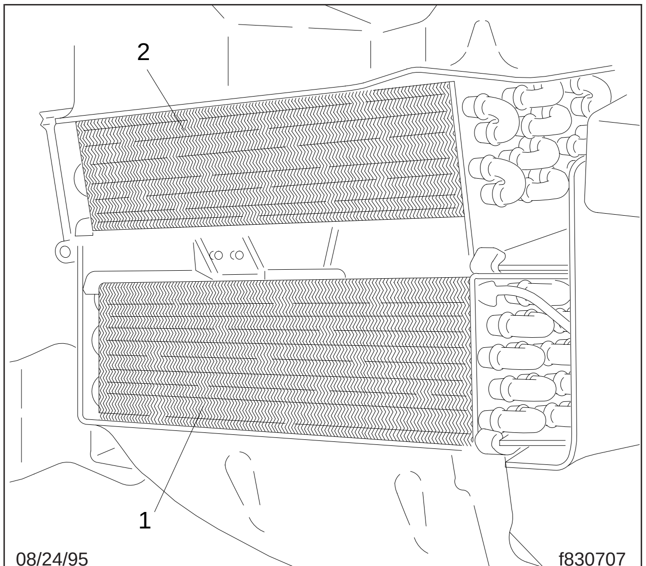
Fig. 6, Expansion Valve Refrigerant Lines

and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

WARNING

Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the evaporator coil fins.

12. Wearing protective gloves, slide the evaporator coil out of the housing. See **Fig. 7**.



1. Evaporator Coil
2. Heater Core

Fig. 7, Remove the Evaporator Coil

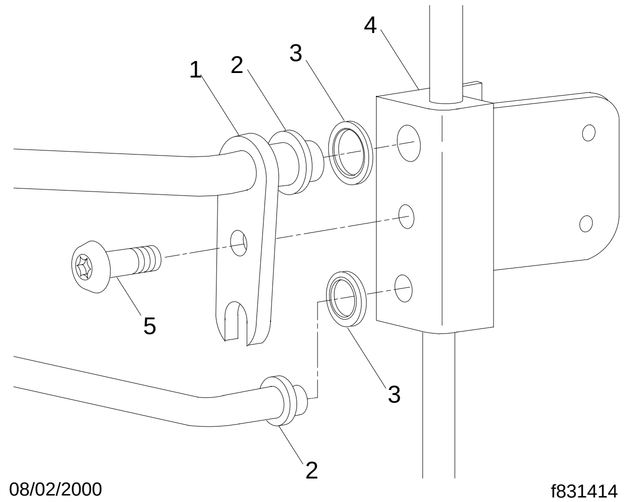
Installation

1. Wearing protective gloves, slide the evaporator coil into the housing.
2. Uncap the expansion valve ports, and unplug the fittings. Check the fittings and the ports. They must be clean and free of nicks, gasket residue, and other foreign material.
3. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 8**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.
4. Connect the refrigerant lines to the expansion valve.

   On hose connections that have threaded fittings, torque the large line 35 to 40 lbf·ft (47 to 54 N·m) Torque the small line 20 to 25 lbf·ft (27 to 34 N·m).

Evaporator Coil Removal and Installation



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 8, A Typical SlimLine Seal Assembly

On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

5. Evacuate and charge the system with refrigerant. See **Subject 240** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged. See the applicable refrigerant compressor section in this group.
6. Wipe the expansion valve and refrigerant line connections clean, and wrap them with mastic insulating tape.
7. Install the air cleaner. For instructions, see **Group 09**.
8. Install the heater core and evaporator coil cover.

CAUTION

Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

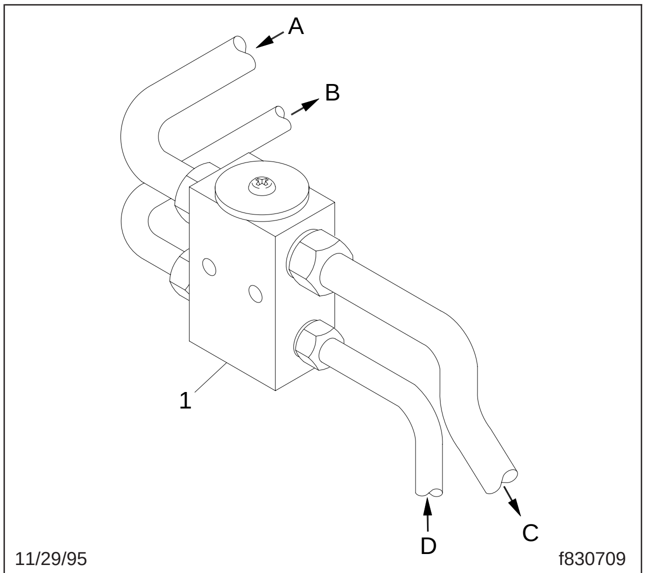
9. Carefully insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with an evaporator coil fin and be inserted at least 6 inches (15 cm) into the evaporator coil.
10. Using the two screws removed previously, install the thermostatic switch.
11. Connect the wire harness to the thermostatic switch.
12. Install the air duct on top of the power distribution module.
13. Install the right-hand dash panels. For instructions, see **Group 60**.
14. Connect the batteries.
15. Lower the hood.
16. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Remove the refrigerant from the air conditioning system. For instructions, see **Subject 240**.
4. Remove the air cleaner. For instructions, see **Group 09**.
5. Remove the mastic insulating tape from around the expansion valve.
6. Disconnect the four lines from the expansion valve. See **Fig. 1**. Quickly cap the expansion valve ports, and plug the fittings.

IMPORTANT: Do not leave the expansion valve ports uncapped or the fittings unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

7. Remove the expansion valve.

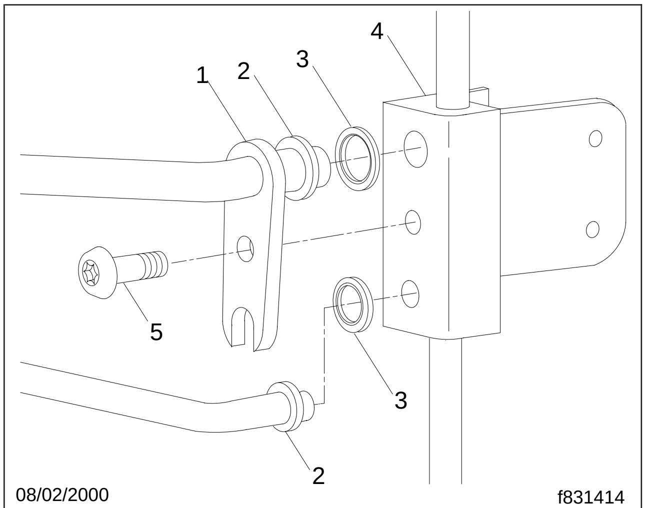


A. From the evaporator coil
B. To the evaporator coil
C. To the refrigerant compressor
D. From the receiver-drier
1. Expansion Valve

Fig. 1, Expansion Valve

8. Install a new expansion valve.
9. Uncap the inlet and outlet ports on the expansion valve. Unplug the fittings. Check the fittings, and the inlet and outlet ports. They must be clean and free of nicks, gasket residue, and other foreign material.
10. On hose connections that have a SlimLine seal assembly (**Fig. 2**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.

    On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 2, A Typical SlimLine Seal Assembly

11. Attach the four lines to the expansion valve.

    On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

    On hose connections that have threaded fittings, tighten the fittings to the following specs. See **Fig. 1**.

    - A. 35 to 40 lbf·ft (47 to 54 N·m)
    - B. 30 to 35 lbf·ft (41 to 47 N·m)
    - C. 35 to 40 lbf·ft (47 to 54 N·m)

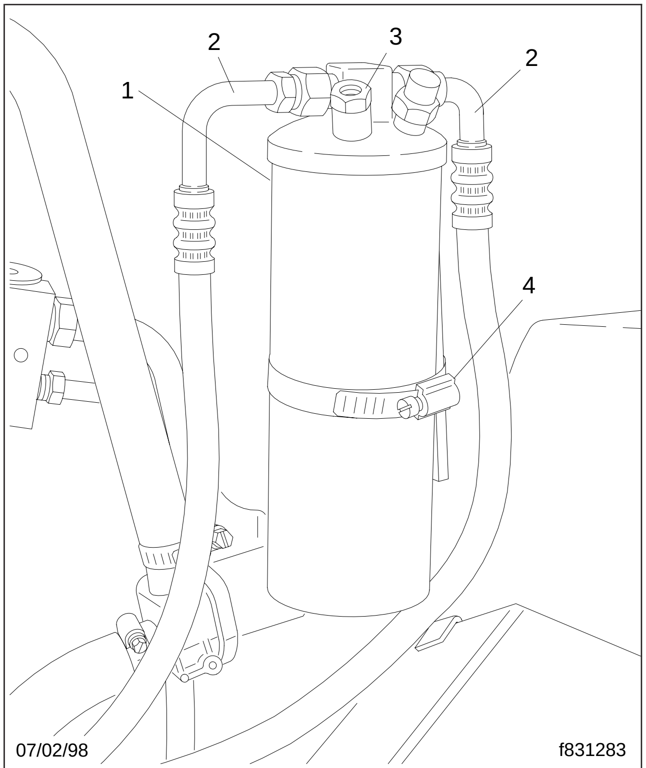
Expansion Valve Replacement

- D. 20 to 25 lbf·ft (27 to 34 N·m)

12. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 240**.
13. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged. See the applicable refrigerant compressor section in this group.
14. Wipe the expansion valve and refrigerant line connections clean, and wrap them with mastic insulating tape.
15. Install the air cleaner. For instructions, see **Group 09**.
16. Lower the hood.
17. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Remove the refrigerant from the air conditioning system. For instructions, see **Subject 240**.
4. Disconnect the refrigerant lines from the receiver-drier. See **Fig. 1**. Quickly plug the fittings.



1. Receiver-Drier
2. Refrigerant Line
3. Moisture Indicator
4. Clamp

Fig. 1, Receiver-Drier

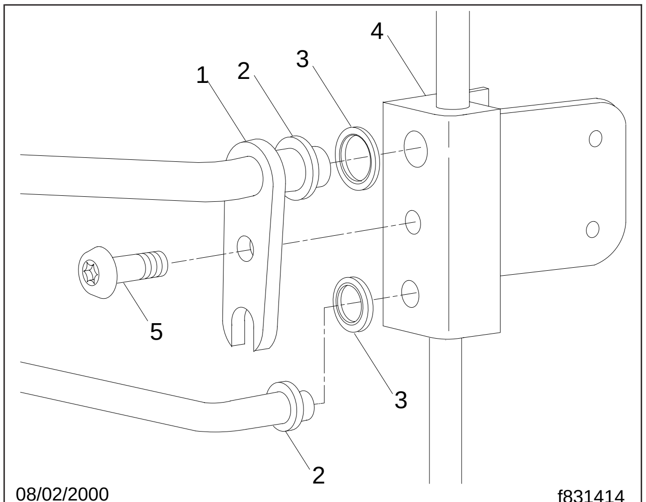
IMPORTANT: Do not leave the fittings unplugged for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Loosen the clamp that attaches the receiver-drier to the mounting bracket. Remove the receiver-drier.

IMPORTANT: If the desiccant cartridge inside the receiver-drier has fallen apart, evacuate the system and replace the expansion valve and the refrigerant compressor (desiccant matter can't be removed from these parts). A cartridge may fall apart from too much moisture in the system, because of poor evacuation of the system, or lack of maintenance.

6. Place a new receiver-drier on the mounting bracket, and tighten the clamp securely.
7. Unplug the fittings.
8. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 2**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 2, A Typical SlimLine Seal Assembly

9. Connect the refrigerant lines to the receiver-drier.
10. Tighten the fittings to the torque specifications in **Table 1**.

Receiver-Drier Replacement

A/C Fitting Torque Specifications *	
Hose Size	**Torque: lbf·ft (N·m)**
#6	20 to 25 (27 to 34)
#8	30 to 35 (41 to 47)
#10 and #12	35 to 40 (47 to 54)

* One-inch fittings on the A/C compressor need to be torqued 21 to 27 lbf·ft (28 to 37 N·m) regardless of hose size.

Table 1, A/C Fitting Torque Specifications

11. Charge the system with refrigerant. See **Subject 240** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. See the applicable refrigerant compressor section in this manual.
12. Lower the hood.
13. Remove the chocks from the tires.

Condenser Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the A/C system. For instructions, refer to **Subject 240**.
4. Disconnect the refrigerant lines from the condenser. Quickly cap the condenser inlet and outlet ports if the condenser will be reinstalled, and plug the fittings.

IMPORTANT: Do not leave the ports uncapped or the fittings unplugged for longer than a total time of five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Remove the fasteners that attach the condenser to the radiator, and remove the condenser.

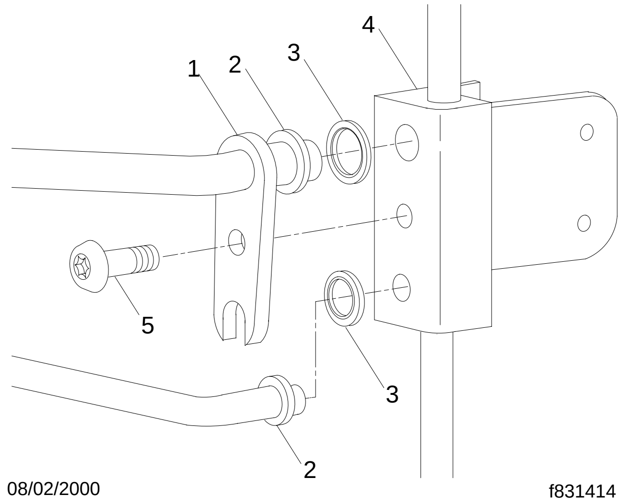
Installation

1. Place the condenser on the radiator. Install and tighten the fasteners 108 lbf·in (1220 N·cm).
2. Uncap the inlet and outlet ports on the condenser. Unplug the fittings.
3. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 1**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.
4. Install the refrigerant lines on the condenser.

   On hose connections that have threaded fittings, tighten the fittings to the torque specifications in **Table 1**.

   On hose connections that have a SlimLine seal assembly, tighten the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 1, Typical SlimLine Seal Assembly

A/C Threaded Fitting Torque Specifications*	
Hose Size	**Torque: lbf·ft (N·m)**
#6	20–25 (27–34)
#8	30–35 (41–47)
#10 and #12	35–40 (47–54)

* One-inch fittings on the A/C compressor need to be tightened 21 to 27 lbf·ft (28 to 37 N·m) regardless of hose size.

Table 1, A/C Threaded Fitting Torque Specifications

5. If needed, add refrigerant oil to the compressor to replace that which is lost in the old condenser. For instructions, see the applicable refrigerant compressor section in this manual.
6. Evacuate and charge the refrigerant system. For instructions, refer to **Subject 240**.

Thermostatic Switch Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.

WARNING

Failure to turn off the ignition switch could result in personal injury or electrical shock.

2. Turn off the ignition switch.

NOTE: When the dash is completely assembled, all dash fasteners are hidden from view. See **Fig. 1**.

3. Remove the right-hand dash panels as needed to access the thermostatic switch. See **Fig. 2**. For instructions, see **Group 60**.
4. Disconnect the harness from the thermostatic switch. See **Fig. 3**.
5. Remove the two screws attaching the thermostatic switch to the heater core and evaporator coil cover. Remove the switch and the sensor tube.

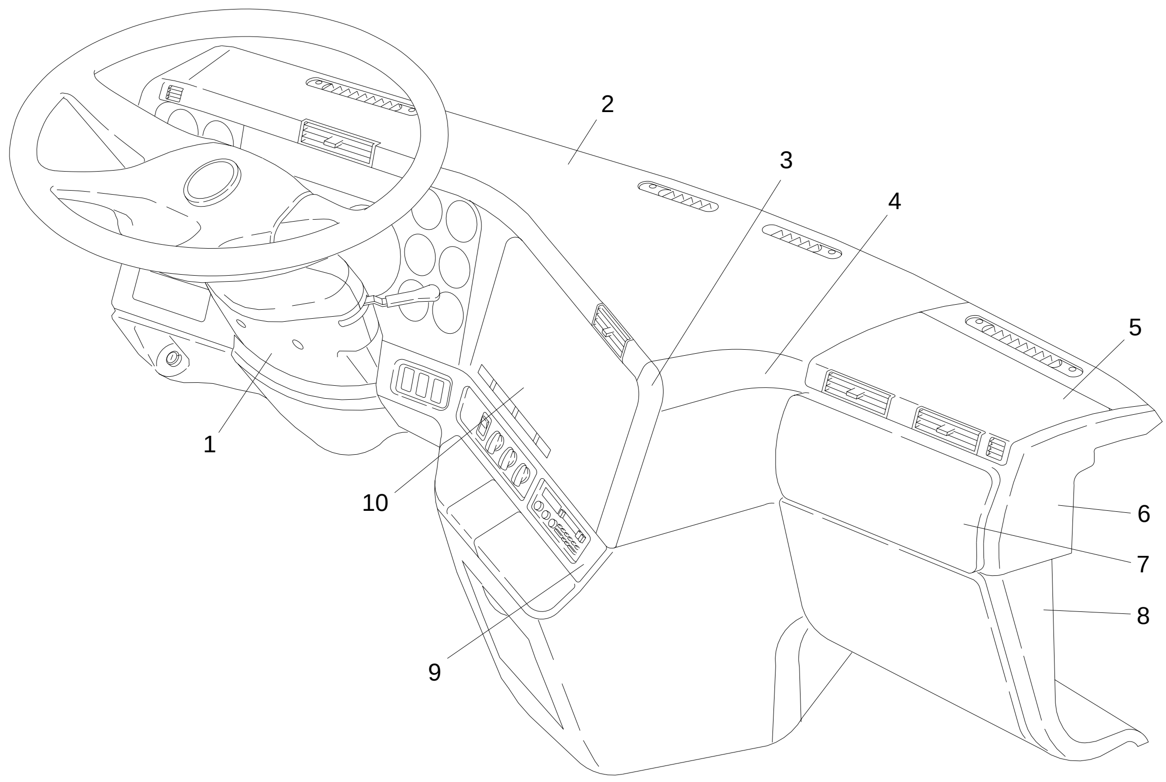
Installation

CAUTION

Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

1. Carefully insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with an evaporator coil fin and be inserted at least 6 inches (15 cm) into the evaporator.
2. Using the two screws removed previously, install the new thermostatic switch.
3. Connect the wire harness to the thermostatic switch.
4. Install the right-hand dash covers. For instructions, see **Group 60**.
5. Remove the chocks from the tires.

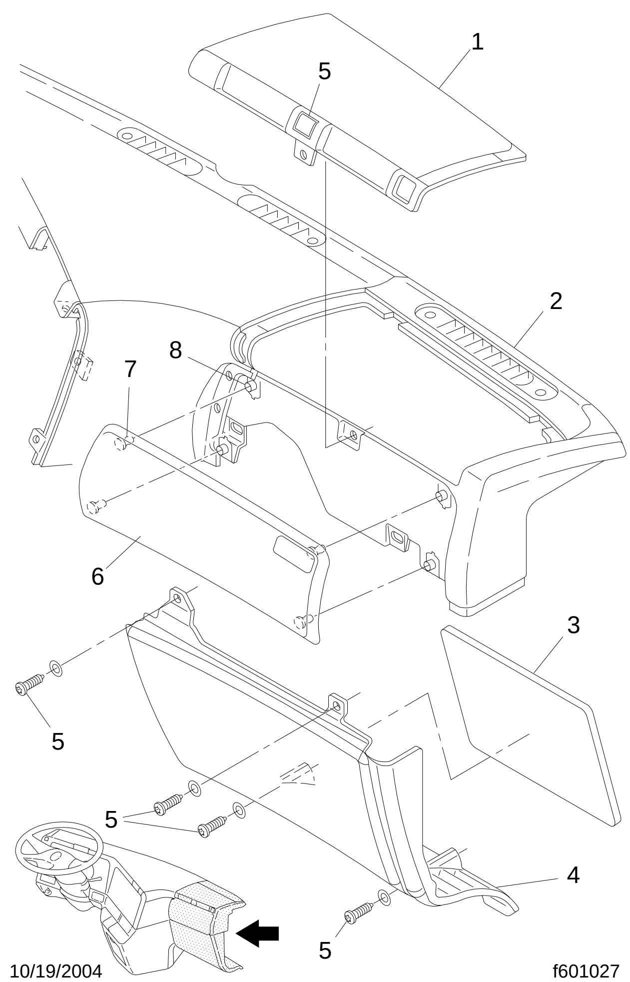
Thermostatic Switch Removal and Installation



1. Steering Column Cover
2. Upper Dash Assembly, Left-Hand Panel
3. Dash Trim Cap, Right-Hand
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Upper Dash Assembly, Right-Hand
7. Upper Dash Cover, Right-Hand
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover, Right-Hand
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Thermostatic Switch Removal and Installation



1. Electrical Cover
2. Upper Dash Assembly, Right-Hand
3. Cover Seal
4. Heater and Air Conditioner Cover
5. T25 Dog-Point Screw
6. Upper Dash Cover, Right-Hand
7. Speed Clip
8. Speed Nut

Fig. 2, Right-Hand Dash Panels

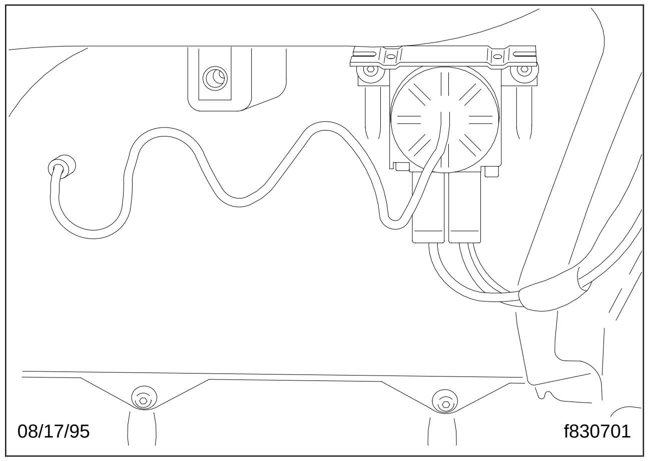


Fig. 3, Thermostatic Switch Mounting

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the heater and air conditioner/radio trim plate from the dash.
4. Remove the fasteners that attach the climate control panel to the dash. See **Fig. 1**.

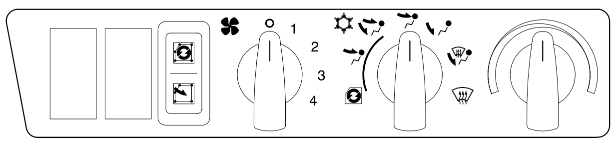


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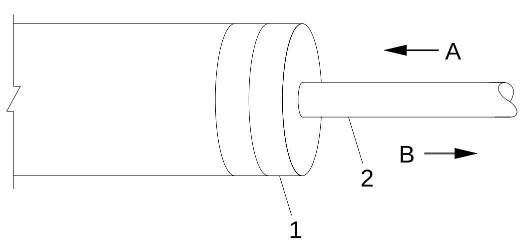
Fig. 1, Climate Control Panel

5. Move the control panel away from the dash enough to service it.
6. Disconnect the pigtail connectors from the rear of the control panel. Disconnect the electrical connectors from the control panel harness.
7. Unhook the water regulator valve cable from the temperature control switch assembly.
8. Disconnect the air lines from the control panel by pushing in the cover ring and pulling out the air line. See **Fig. 2**.



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A. Push
B. Pull
1. Collar
2. Air Line

Fig. 2, Air Line

9. Remove the panel from the dash.
10. Position the new panel and connect the air lines by pushing them into the fittings as far as they will go. Then, give the air line a slight tug so the line will lock into place.

NOTE: The color of the air lines should match the colored collar at the back of the control panel.

11. Insert the panel and connect the pig-tail connectors at the back of the panel.
12. Connect the electrical connectors to the control panel harness.
13. Hook the end of the water regulating valve control cable onto the temperature control switch assembly.

    Check the cable adjustment. For instructions, see **Subject 170**.
14. Position the control panel and install the fasteners that attach it to the dash.
15. Connect the batteries.
16. Turn on the ignition switch and test the blower motor.
17. Install the heater and air conditioner/radio trim plate.
18. Remove the chocks from the tires.

Refrigerant Service Operations

Required Equipment

You will need a machine, or machines, to identify the refrigerant and to recover, evacuate, flush, and charge the refrigerant system. Ideally, the machine will perform all the following functions:

- Identification—The machine must be able to verify the purity of the refrigerant in the refrigerant system and check for the presence of hydrocarbon-based refrigerants or other unapproved refrigerants.
- Recovery—The machine must be able to fully recover the refrigerant from the refrigerant system.
- Evacuation—Ideally, the machine should have a vacuum pump rated at 6 cfm (170 liters per minute) and be maintenance-free. A machine that requires maintenance is acceptable, as long as it has been properly maintained.
- Charging—The scale used to measure the charge should be accurate to within ±1 ounce (30 mL).
- Flushing—Adaptors for the compressor(s), expansion device(s), and receiver-drier should be purchased or fabricated, to flush the system with refrigerant.

Refrigerant Identification

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT: Identify the refrigerant in the refrigerant system, if you suspect one of the following conditions:

- Excess noncondensable gas, such as nitrogen or air, is in the system.
- Unapproved refrigerant is in the system.
- The history of refrigerant system repairs is unknown.

1. Using a high-quality refrigerant identifier and the manufacturer's instructions, attach the identifier to the vehicle and perform the test.
2. If the refrigerant passes the test, it is safe to recover.
3. If the vehicle failed the test due to an excessive amount of noncondensable gas, recover the refrigerant system, then purge the recovery tank of the noncondensable gas.
4. If the vehicle failed the test due to the presence of a hydrocarbon-based refrigerant or a refrigerant other than R-134a, **do not recover the refrigerant into the general-use machine.** To change the refrigerant, remove the existing refrigerant into a separate container. **Refrigerant must be recycled by a qualified recycling center.** It is best to refer the customer to the place where the vehicle was last serviced.

Recovery

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

The recovery process removes most of the refrigerant charge in the system.

1. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Remove the caps from the suction and discharge service valves.
3. If the history of refrigerant system repairs is unknown, or if you suspect that the system is charged with an unapproved refrigerant, identify the refrigerant using the "Refrigerant Identification" procedures.
4. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses to the valves.

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

Refrigerant Service Operations

5. Follow the refrigerant recovery and charging machine manufacturer's instructions and recover all of the refrigerant from the refrigerant system.

IMPORTANT: Always comply with all federal and local regulations regarding refrigerant recovery and disposal. You may be subject to substantial penalties for improper disposal of refrigerant.

6. Measure the oil recovered during the recovery process. The refrigerant system will have to be filled with the same quantity of new refrigerant oil. If the system is contaminated with moisture, all of the compressor oil must be replaced with clean oil. If the system is heavily contaminated with desiccant or grit, replace the compressor, expansion valve, and receiver-drier, and flush the condenser and evaporator(s). After the system is charged, perform a performance check to ensure that the heat exchangers are not plugged.

Refrigerant Identification

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT: Identify the refrigerant in the refrigerant system if you suspect one of the following conditions:

- an excess noncondensable gas, such as nitrogen or air, is in the system.
- an unapproved refrigerant is in the system.
- the history of refrigerant system repairs is unknown.

1. Using a high-quality refrigerant identifier and the manufacturer's instructions, attach the identifier to the vehicle and perform the test.
2. If the vehicle passed the test, it is safe to recover the refrigerant.
3. If the vehicle failed the test due to an excessive amount of noncondensable gas, recover the refrigerant system, then purge the recovery tank of the noncondensable gas.
4. If the vehicle failed the test due to the presence of a hydrocarbon-based refrigerant or a refrigerant other than R-134a, **do not recover the refrigerant into the general-use machine.** To change the refrigerant, remove the existing refrigerant into a separate container. **Refrigerant must be recycled by a qualified recycling center.** It is best to refer the customer to the place where the vehicle was last serviced.

Flushing

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Flushing removes moisture-laden oil and some contamination, such as dirty oil and some particles. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to flush or replace a part depends on how much contamination there is, as previously described.

Normally, the system always has pressure in it. Some loss of refrigerant from one season to the next is normal, and does not mean that the system is dirty. If refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, flush all sections of the system. Then change the oil in the compressor, and replace the receiver-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier, expansion valve(s), and inspect the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Flush the system in the opposite direction of refrigerant flow.

Flushing parts with refrigerant, requires a refrigerant recovery and charging machine.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new receiver-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done, since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new receiver-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Oil Balancing

General Information

Compressors require refrigerant oil to function. When the air conditioning system is operating, some of the oil leaves the compressor and is circulated through the system with the refrigerant. The refrigerant oil cannot leave the system except when there is a leak, the refrigerant is recovered, or when a system part is replaced. It is important that the air conditioning system has the correct amount of refrigerant oil for proper operation. Too little oil will result in compressor failure. Too much oil will degrade the performance of the air conditioner, and cause damage to the compressor.

IMPORTANT: Whenever the air conditioning system is discharged or recovered, the recovered oil, from the charging machine, must be measured in order to know how much oil must be returned to the system. When a system component is replaced, a quantity of new oil equal to the recovered oil plus the oil coating the inside of the component must be returned to the system.

IMPORTANT: Refrigerant oil is hygroscopic (attracts moisture from its surroundings), and must not be exposed to the moisture that is present

Refrigerant Service Operations

in the air. New oil must be from a container that has not been opened or that has been tightly sealed since its last use.

Tubing, funnels, or other equipment used to transfer the oil must be very clean and dry. When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

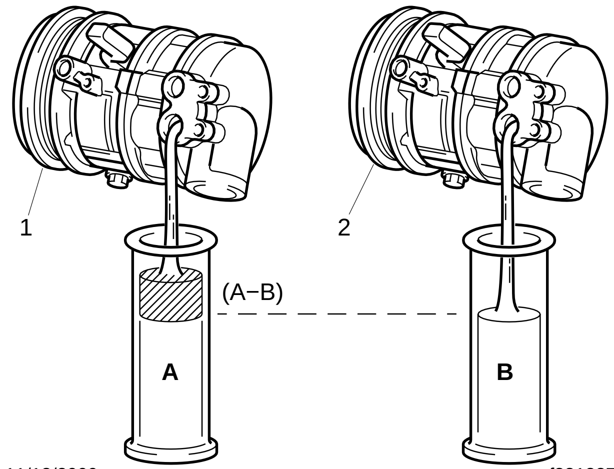
Compressor Oil Balancing

Replacement refrigerant compressors are supplied with some refrigerant oil. If the air conditioning system has been flushed, the system will need a complete new charge of oil. If the system has not been flushed, use the following procedures to adjust the oil level, when a new compressor or other system component has been installed. The type of oil required depends on the brand of compressor used on the system. See the refrigerant compressor section for details about how the total system volume is determined for the compressor being serviced. See PartsPro MOD 700 to determine the oil type and vehicle specific oil quantities.

1. Drain the remaining oil from the compressor into a clean graduated container, and note the amount. See **Fig. 1**.
2. Make note of the total volume of oil recovered.
3. Drain the oil from new compressor into a clean calibrated container, and compare the two quantities of oil.
4. Add only the amount of oil removed during recovery and from the old compressor to the system.
5. Add the new compressor oil as described in the supplier specific compressor service section of the workshop manual.

System Oil Balancing

After repairs are finished, refer to **Table 1** and use the following equation to determine the quantity of refrigerant oil that needs to be added to the system.



1. New Compressor 2 Old Compressor

Fig. 1, Oil Balancing

[Quantity Recovered] + [Quantity for All Replaced Components] = [Quantity Added to the System]

Table 1 provides the quantities of oil that need to be added to the system for each component that was replaced. Add the quantities listed in the table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less. Inject the calculated oil volume at the high-side pressure port during the refrigerant charging process.

Refrigerant Oil Quantities for Replaced Components	
Add the quantities listed in this table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.	
Component	**Quantity oz (mL)**
High Pressure Line (main A/C)	1 (30)
Low Pressure Line (main A/C)	2 (59)
High Pressure Line (auxiliary A/C)	1 (30)
Low Pressure Line (auxiliary A/C)	3 (89)
Condenser	1 (30)
Evaporator (main A/C)	3 (89)
Evaporator (auxiliary A/C)	2 (59)
Receiver-Drier	3 (89)
Minor Leak at Connector Only	0.5 (15)

Refrigerant Oil Quantities for Replaced Components	
Add the quantities listed in this table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.	
Component	**Quantity oz (mL)**
Major Leak at Connector Only	2 (59)

Table 1, Refrigerant Oil Quantities for Replaced Components

Charging

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

NOTE: Before charging, the system must be recovered and evacuated, with the recovery and charging machine connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. To determine the amount of refrigerant needed to fully charge the system, read the Air Conditioner label on the vehicle, or see **Specifications 400**.
2. Charge the system on the high side, following the refrigerant recovery and charging machine manufacturer's instructions.
3. While the compressor is engaged, check the duct temperature and operating pressures at the suction and discharge ports. Compare the temperature and pressures to those in **Specifications 400**. If the operating pressures are not acceptable, see **Subject 300** for troubleshooting procedures.
4. Disconnect the hoses.
5. Shut down the engine.
6. Recover the refrigerant that is in the hoses.

Leak Testing Methods

General Information

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to take precautions against the dangers involved when working with refrigerant, could lead to serious personal injury.

Refrigerant is nearly odorless. As a result, all of it may leak away and its loss may not be noticed until the system stops cooling. All vehicle refrigerant systems lose some refrigerant. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections, and at the various fittings and joints in the system. If unapproved replacement hoses are installed, refrigerant can leak through the hose itself.

There are two leak testing methods that can be used to detect leaks in the refrigerant system: UV (ultraviolet) dye leak detection, and electronic leak detection. Freightliner Trucks recommends using the UV dye leak detection method whenever possible, even though there are some limitations to using this method. A leak on the front seal of the compressor **must** be verified using a heated diode leak detector, and the instructions under the heading, "Electronic Leak Detection," in this subject. Visible dye on the front of the compressor clutch **does not** verify that there is a repairable leak at the front seal. Evaporator leaks may not show up with dye, and must be checked using a heated diode leak detector, if dye is not present at the condensate drain.

UV Dye Leak Detection

IMPORTANT: When using the UV dye leak detection method, always wear protective eyewear that blocks UV rays and enhances the appearance of the dye. Always wear nonleather gloves and protective eyewear when servicing the air conditioning system.

1. Inspect the refrigerant system for leaks using a UV lamp.
   1.1 Inspect the entire refrigerant system under low lighting using a UV lamp. Low lighting

Refrigerant Service Operations

will increase the apparent brightness of the UV dye at leak sights.

1.2 Move the UV lamp along the entire refrigerant system, looking for signs of damage or corrosion on the fittings, hose-to-line crimps, switch ports, service ports with caps installed (dye inside the port is not an indication of a leak), brazed or welded areas, and around all connections. Check for evaporator leaks by illuminating the condensate drain tube or hole using the UV lamp.

1.3 Move the UV lamp along the refrigerant system, following a continuous path so that no potential leak sites are missed. If a leak is found, continue to check the remainder of the system, since other leaks may be present.

2. After repairing a leak, remove all UV dye residue remaining on the outside of the refrigerant system using the cleaner provided by the dye manufacturer, or a comparable cleaner. Use a spray bottle of cleaner, a toothbrush, and a spray bottle of clean water for hard-to-reach areas.

NOTE: Minor UV dye residue, or residue that is impossible to reach, will lose its fluorescence over time.

3. See **Table 2** for a list of products that have been tested and approved for use by Freightliner dealers.
4. Close the hood and remove the chocks from the tires.

Approved Products for UV Dye Leak Detection

Type of Refrigerant Oil	Product Description	Vendor Part Number	Freightliner Part Number	Website Address
PAG	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9741CS	ABP N83 327911	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9760-0004CS	ABP N83 327961	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9760-0108	ABP N83 327951	
POE/ universal	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9742CS	ABP N83 327910	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9770-0004CS	ABP N83 327950	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9770-108	ABP N83 327960	
—	Tracerline Optimax UV Lamp	TP-8680	ABP N83 327985	www.tracerline.com
—	Bright Solutions UV Lamp	BSL760	ABP N83 327967	www.brightsol.com
—	Service Valve Cap	—	PH 660412	—

Table 2, Approved Products for UV Dye Leak Detection

Electronic Leak Detection

NOTE: Do not try to use a leak tester immediately after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely indicate a leak. Always verify that there is a leak by blowing shop air in to the area of the suspected leak, and checking the area again.

When checking for leaks, move the probe all the way around the fitting or suspected leak.

Freightliner Trucks recommends using only certain makes of the heated diode and infrared (IR) types of electronic leak detectors. Recommended electronic heated diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the corona discharge type, is specifically **not recommended**.

Use the following procedures to locate refrigerant system refrigerant gas leaks using an electronic leak detector.

1. Operate the electronic leak detector in accordance with the manufacturer's instructions. Occasionally use a leak reference bottle of R-134a to ensure that the detector is working properly.
2. Leak test with the engine turned off.
3. Charge the air conditioning system with sufficient refrigerant to indicate a gauge pressure of at least 50 psi (345 kPa), with the system not operating. Typically, one-half pound (0.22 kg) of refrigerant is sufficient to create 50 psi (345 kPa) of pressure. It may not be possible to produce this amount of pressure and measure leakage, if the ambient temperature is less than 59°F (15°C).

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK, D-Tek Select, and TekMate	Leybold Inficon 2 Technology Place East Syracuse, NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Bacharach Inc. c/o Yokogawa Corp. of America 2 Dart Road Newnan, GA 30265 (800) 258–2552	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren, MI 48092–3499 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 3, Electronic Leak Detectors

4. Be careful not to contaminate the detector probe tip, if the part being tested is not clean. Wipe the part off with a dry shop towel, or blow it off with shop air. Do not use cleaners or solvents, as many detectors are sensitive to their chemical ingredients.
5. Visually inspect the entire refrigerant system. Look for air conditioning lubricant leakage, and corrosion of, or damage to lines, hoses, and all other components. Inspect each questionable location carefully with the detector probe. Check all fittings, couplings, refrigerant controls, service ports (with caps installed), brazed or welded

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areas, and areas around attachment points and hold-downs.

6. Follow the path of the refrigerant system methodically, so that no leaks are missed. If a leak is found, continue to test the rest of the system.
7. Inspect an area of possible leakage slowly and close to the part, moving completely around the part. Move the probe no faster than one to two inches (25 to 50 mm) per second and no farther away than 1/4 inch (6.4 mm) from the part.
8. If a large leak is present in either the system being serviced or the service equipment, the surrounding air will be saturated with refrigerant gas. In this situation the leak detector operates erratically, and will indicate leakage, without being near a leak source. Place a large fan so that a light breeze blows through the work area. Verify a leak by blowing shop air into the area and repeating the inspection. Pinpoint a large leak by blowing out the area often.
9. You may test the evaporator core while it is in its housing. Turn on the blower motor for at least 15 seconds. Shut off the blower and wait for refrigerant gas to accumulate in the housing. Wait for the time specified in the detector instructions, for the gas to accumulate. Insert the detector probe into the blower resistor block, or condensate drain tube if no water is present. If this is not possible, insert the probe into the closest opening to the evaporator, such as a heater or vent duct.

NOTE: Insert the eraser end of a pencil into the end of the condensate drain tube, to determine whether there is any water present. Inserting the pencil breaks the surface tension of any water near the opening of the drain tube, and allows the water to drain out before inserting the probe tip. It is only necessary to break the plane of the drain tube with the probe tip; it does not need to be inserted far into the tube.

10. Leak test the front seal area of the compressor. Blow shop air into the cavities in and around the clutch for at least 15 seconds, to clear out any residual gas. Let the compressor stand for one minute, then test for leakage. Inspect axial-type compressors (Sanden or Sel-Tec) by placing the probe near the holes at the front of the clutch. See **Fig. 2**. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor. See **Fig. 3**.

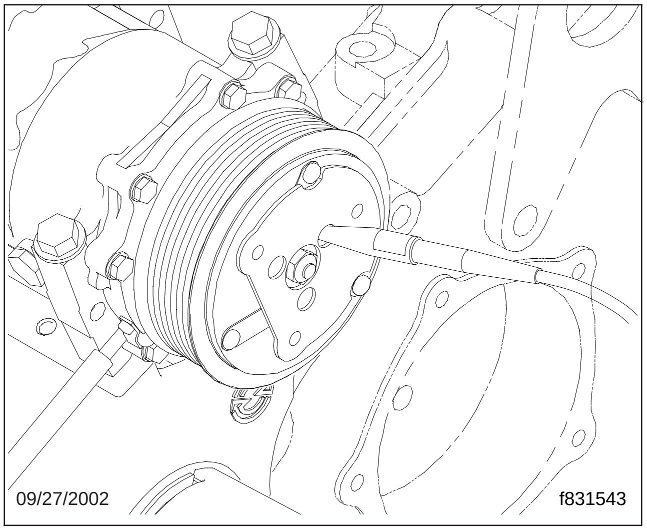


Fig. 2, Axial Type Compressor

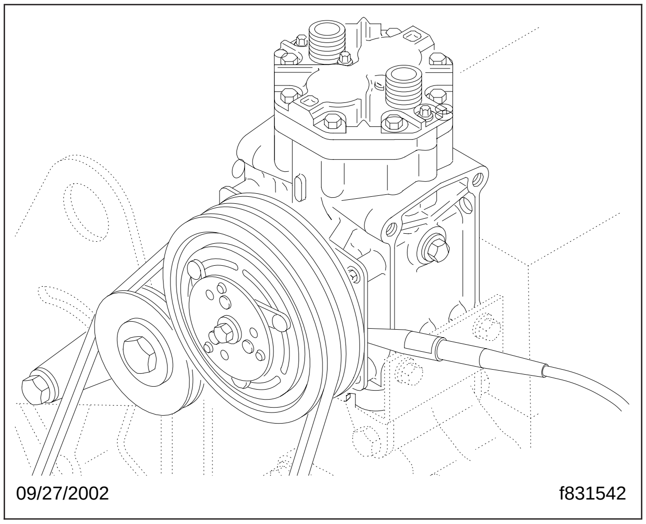


Fig. 3, Two-Cylinder Reciprocating Compressor

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

Binary Switch Replacement

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Open the hood.
4. Access the binary switch.

NOTE: The binary switch is located under the hood on the right-hand side of the frontwall.

5. Disconnect the wiring harness from the binary switch.
6. Remove the binary switch.
7. Install a new binary switch and tighten 20 to 25 lbf·ft (27 to 34 N·m).
8. Connect the wiring harness to the binary switch.
9. Connect the batteries.
10. Lower the hood.
11. Remove the chocks from the tires.

Preliminary Checks

Before testing the operation of the air conditioning system, make the following checks:

1. Make sure the drive belt on the refrigerant compressor is not damaged and is correctly tensioned. Also check the compressor mountings for tightness. For instructions and other information, see the applicable refrigerant compressor section in this group.
2. Using a feeler gauge, check for correct refrigerant compressor clutch clearance. For instructions, see the applicable refrigerant compressor section in this group.
3. Check for broken, burst, or cut hoses. Also check for loose fittings on all parts.
4. Check for road debris buildup on the condenser coil fins. Using air pressure and a whiskbroom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
5. Check the color of the moisture indicator sight glass. If the color is a deep cobalt blue, the refrigerant charge is dry. If the indicator is *not* blue, the system is contaminated with moisture. Recover the refrigerant, evacuate the system, replace the receiver-drier, and add a full refrigerant charge.
6. If there is not enough airflow, make sure that leaves or other debris have not entered the fresh air ports under the windshield. If debris have entered, it could clog the fins of the evaporator core, and block airflow.

   Also, be sure that all ducts are connected to the dash louvers and that the air-control flaps in the heater housing are moving properly.

Performance Tests

Following is a brief description of symptoms or conditions that could exist if something goes wrong with a refrigerant part.

Cooling Check

When outside temperature and humidity are high, it will take longer to cool the cab, especially if the fresh air vents are left open.

To determine if the air conditioner is cooling enough:

1. Set the engine speed at 1500 rpm. The engine fan should be on.
2. Open the hood and open the cab doors.
3. Turn on the cab air conditioner. Set the controls at air conditioning (not max AC), fresh air (not recirculated air), and maximum blower speed. The compressor must be engaged during this test.
4. In the sleeper (if equipped), turn the temperature control knob all the way counterclockwise to COOL. Turn the fan control knob to position 3 (high).
5. Allow the system to run for at least 10 minutes (longer on hot and humid days).
6. In the cab, place a thermometer inside the center dash outlet. In the sleeper, place a thermometer inside the lower outlet. Make sure the controls are set so that air flows out of the duct being tested.
7. Record the temperatures and take pressure readings at the service valves. Record the readings again after 3 minutes. If the temperature readings have not stabilized, run the system for an additional three minutes and record the readings again.
8. Compare the measured temperature readings to the readings in the temperature/pressure tables in **Specifications 400**. If the duct's air temperature is higher than normal readings, the system isn't cooling enough. For possible causes, see the troubleshooting chart.

Receiver-Drier

The receiver-drier is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cool spots exist, replace the receiver-drier.

A blockage at the inlet of the unit will cause high head pressures. Outlet blockages will cause low head pressures and little or no cooling.

If the moisture indicator is pink or white (showing that the system is wet), the receiver-drier is saturated with moisture and must be replaced.

Troubleshooting

Cooling System

Although they are not physically connected, there is a close tie between a vehicle's air conditioner and its cooling system. Poor air conditioner cooling can be the result of a problem in the cooling system.

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other underhood parts, and maybe make its way into the cab. The added heat makes it necessary for the air conditioner to work harder and, at the same time, it reduces the air conditioner's ability to cool down the air in the cab. Also, if the water regulating valve isn't closing all the way, heat will enter the cab, giving the impression that the air conditioning system is not working.

See **Group 20** for cooling system troubleshooting and the engine manufacturer's service manual for other details about cooling system problems.

Expansion Valve

Problems that start in the expansion valve show up as follows: when stuck closed, the evaporator coil and the expansion valve will be at outside temperature; when stuck open, both the coil and the valve will be extremely cold with frost or ice buildup.

Because the expansion valve channels are very small, blockages in the system tend to be found here (the valve is very sensitive to contamination). Usually, the contaminant is water; less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts, and the valve operates again, only to freeze-up when the moisture returns.

On-and-off operation of the expansion valve means that the receiver-drier is not removing moisture from the system. These contaminants should cause the moisture indicator's element to turn white and then pink.

Refrigerant Compressor

Compressor problems usually show in one of four ways: abnormal noise, seizure, leakage, or low suction and discharge pressures.

Resonant compressor noises are not causes for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

Evaporator

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockages will cause low suction pressure as well as little or no cooling.

If a leak exists in the system, and it cannot be traced to other parts or fittings, suspect damage to one of the evaporator coils.

Condenser

The condenser is usually trouble-free. Normally, the temperature of the condenser outlet line is noticeably cooler than the inlet line. However, when road debris, such as leaves or dirt, build up, airflow over the condenser fins is blocked. Air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pressures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution. Be careful not to bend the fins.

High head pressures will also occur if the condenser's tubing is abnormally bent, blocking the flow of refrigerant. Frost will appear at the point where the flow is restricted.

Less common internal blockages (bits of foreign material or metallic grit buildup) will stop the flow of refrigerant.

A quick test to check that poor system performance is caused by the condenser is to direct a spray of water onto the condenser while the system is running. If the air conditioner cools better because of the assist provided by the water, it is a sign that the condenser is not working.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the radiator transferring high levels of heat to the condenser. See **Group 20** of this manual for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

Thermostatic Switch

IMPORTANT: Before troubleshooting the thermostatic switch, be sure there is a full charge of refrigerant in the system. The compressor will not operate, or will cycle too often, if there is not enough refrigerant in the system.

Quick or delayed cycling of the compressor may be caused by a thermostatic switch that is working, but is out of adjustment. If, after doing the tests below, the switch seems to be out of adjustment, replace it (the thermostatic switch cannot be recalibrated).

1. Be sure the compressor clutch is operating correctly. See the applicable refrigerant compressor section in this group.
2. Expose the evaporator coil. See **Subject 180** for instructions.
3. Start the engine. Place the air conditioner control at its coldest setting. Turn on the air conditioner and the fan.
4. Place an accurate thermometer in contact with a tube on the evaporator coil. Be sure the thermometer is in good contact with the tube, or you will get a wrong reading.

   When the temperature drops below 31° to 36°F (–1° to 2°C), the compressor clutch should disengage and remain this way until the temperature rises to 39° to 44°F (4° to 7°C).
5. If the compressor did not engage when the temperature was above the accepted high range, do the following test:

   5.1 Connect a voltmeter or a test light from one of the terminals on the thermostatic switch to ground. Repeat this test with the other terminal on the switch.

   5.2 With the engine running and the air conditioner and blower on, both terminals will show voltage when the compressor should be engaged. One terminal will show voltage when the compressor should be disengaged.

   If there is no voltage, there is a problem in the electrical system from the batteries to the thermostatic switch. Check all circuits for the cause, and repair or replace the wiring or parts.

   In all other cases where the compressor is not engaging and disengaging properly, the thermostatic switch is the cause. Replace it with a new switch.
6. Shut down the engine and, to prevent accidental electric shock or shorting during dash assembling, disconnect the batteries.
7. Assemble the dash. See **Subject 180** for instructions.

Line Restrictions

A restricted suction line causes low suction pressure at the compressor and little or no cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge and low suction pressure, and insufficient cooling.

Usually, areas of ice or frost buildup mean a blockage. Parts that often freeze-up are probably corroded or inoperative and should be replaced. Parts (such as the expansion valve) that freeze-up once in a while may do so because of moisture in the system, which will cause the moisture indicator's element to turn white or pink. If this happens, recover the refrigerant charge, evacuate/recycle the system refrigerant, replace the receiver-drier, and install a new charge.

System Troubleshooting Tables

Troubleshooting

Problem—Little or No Airflow

Problem—Little or No Airflow	
Possible Cause	**Remedy**
The blower is not operating.	Check for an open circuit breaker. An open circuit indicates a short in the electrical system, which must be located and repaired.
	Check the air conditioner relays for operation. Replace, as necessary.
	Make sure the blower motor switch is working. Replace, if necessary.
	Check the wiring to the blower motor. If any connections are loose, securely tighten them. Make sure the wiring conforms to the applicable diagram under **Specifications, 400**.
	Check the blower motor for operation. Replace if sticking or otherwise inoperative.
	Check the resistor block. Replace, if necessary. **CAUTION** **Never try to bypass the fuse in the resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/air-conditioning system.**
There are restrictions or leaks in the air ducts.	Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Warm Airflow When the Air Conditioner Is On

Problem—Warm Airflow When the Air Conditioner Is On	
Possible Cause	**Remedy**
There is no refrigerant charge in the system.	Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant.
Moisture in the system.	If moisture is in the system, ice crystals may form at the expansion valve, blocking the flow of refrigerant (off and on). Recover the refrigerant charge, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant.
The refrigerant compressor is not operating.	If the refrigerant charge is low, charge and leak test the system. Repair any leaks.
	The refrigerant compressor clutch or drive belt needs repair or replacement. For instructions, see the applicable refrigerant compressor section elsewhere in this group.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Troubleshooting

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)	
Possible Cause	**Remedy**
The expansion valve is not working.	Replace the expansion valve.
There are restrictions in the line to the expansion valve.	Remove the line restrictions.
There is an insufficient refrigerant charge in the system.	Locate the leak. Recover the charge, replace the receiver-drier, and add a full refrigerant charge.

Problem—High Compressor Discharge Pressure

Problem—High Compressor Discharge Pressure	
Possible Cause	**Remedy**
The shutters are not opening.	Replace the shutter solenoid valve, Air Conditioning Protection Unit high pressure switch, or both.
Airflow through the condenser is restricted.	Remove the debris from the condenser.
There is an internal restriction in the condenser. (Ice buildup on the condenser or a cool spot on the line from the condenser to the receiver-drier.	Replace the condenser.
Air is present in the system.	Perform a leak test. Repair any leaks, evacuate the system, and add a full charge of refrigerant.
Heavy frosting on the suction line suggests that the evaporator coil is flooded.	Defrost the evaporator coil before resuming operation of the air conditioner.
The engine is overheated.	See the engine manufacturer’s operations manual for corrective measures.
Restriction in the compressor discharge line.	Repair or replace the line.

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops	
Possible Cause	**Remedy**
There are leaks in the system.	Leak test the system.
The expansion valve setting is too low.	Replace the expansion valve. Add a full charge of refrigerant.
Too much oil is in the system. An indication of this is clutch or belt slippage at governed engine speed.	Check and remove excess refrigerant oil. For instructions, see the applicable refrigerant compressor section elsewhere in this group.

Problem—Compressor Operates Too Often or Continuously

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
There is too little refrigerant in the system.	Perform a leak test. Repair any leaks, and add a full charge of refrigerant.

Troubleshooting

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Check the operation of the thermostatic switch, and replace as necessary.
There is a restriction in the refrigerant system.	Remove the restriction from the line.
Dirt and debris are clogging the condenser fins.	Remove all dirt and debris from the condenser fins.
The thermostatic switch isn't working.	Replace the thermostatic switch.

Problem—Quick or Delayed Cycling of the Compressor

Problem—Quick or Delayed Cycling of the Compressor	
Possible Cause	**Remedy**
The thermostatic switch operates, but is out of adjustment.	Replace the thermostatic switch. Do not attempt to adjust it.
Loss of refrigerant is causing a delayed cycling of the compressor.	Leak test and add a full charge of refrigerant.

Problem—Temperature in the Cab Too Low or No Heat

Problem—Temperature in the Cab Too Low or No Heat	
Possible Cause	**Remedy**
The water regulating valve is not opened.	Move the temperature control knob toward "warm."
The water regulating valve is not opening all the way.	Adjust the water regulating valve cable.
The water regulating valve isn't working.	Replace the water regulating valve.
A heater hose is pinched or twisted.	Repair or replace the heater hose.
Coolant is leaking from the system.	Check for leakage at the heater core, and at all hose connections from the heater core to the engine. Check the radiator coolant level, as instructed in the vehicle driver's manual, and add coolant, if necessary. Check and repair any leaks at the radiator.
Dust or dirt is clogging the heater core fins.	Remove and clean the heater core.

Problem—Condensed Water Is Leaking from the Air Conditioner

Problem—Condensed Water Is Leaking from the Air Conditioner	
Possible Cause	**Remedy**
The drain tubes are plugged.	Clean the drain holes and drain tubes.

See **Fig. 1** for a fault analysis flow chart.

Troubleshooting

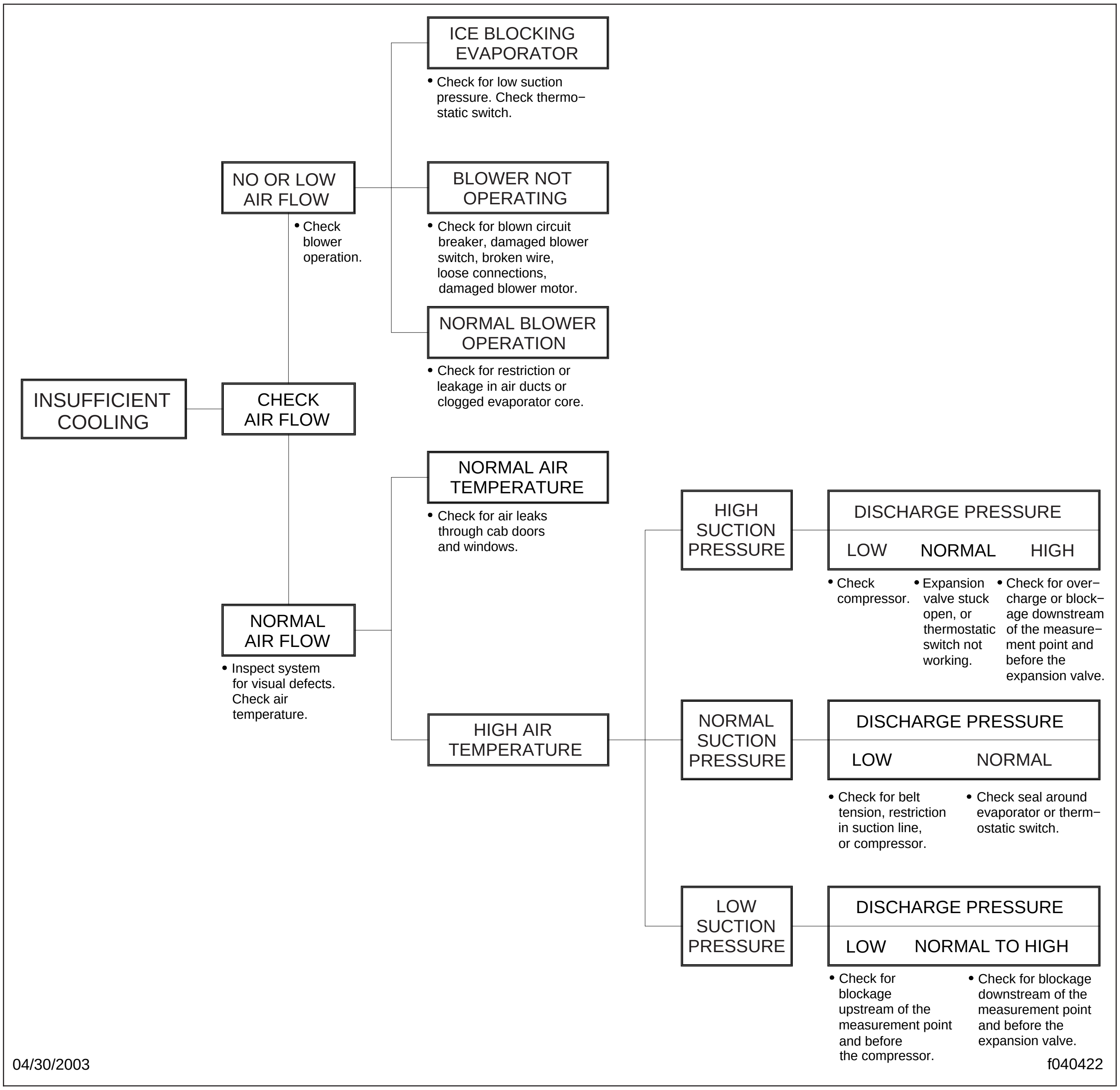


Fig. 1, Fault Analysis Flow Chart

See **Fig. 1** for heater-A/C system components. See **Fig. 2** for the wiring schematic of the heater and A/C unit. See **Fig. 3** for the heater-A/C plumbing diagram.

A/C O-Ring Fitting Torque Specifications*	
Hose Size	**Torque lbf·ft (N·m)**
#6	20 to 25 (27 to 34)
#8	30 to 35 (41 to 47)
#10 and #12	35 to 40 (47 to 54)

* One-inch fittings on the A/C compressor need to be torqued 21 to 27 lbf·ft (28 to 37 N·m) regardless of hose size.

Table 1, A/C O-Ring Fitting Torque Specifications

3/4- and 5/8-Inch Heater Hose Clamp Torque Values	
Description	**Torque lbf·in (N·cm)**
Standard Hose Clamp	40 (452)
Worm-Gear Hose Clamp	40 (452)
Breeze Constant-Torque Hose Clamp	40 (452)
Oetiker Constant-Torque Hose Clamp	18 (203)

Table 2, 3/4- and 5/8-Inch Heater Hose Clamp Torque Values

System Full-Charge Refrigerant Capacity Specifications			
Build Date	**Air Conditioner Installation**	**With Sleeper A/C**	**Refrigerant Capacity oz (kg)**
Built before April 3, 1998	Conventional	No	39 (1.10)
		Yes	46 (1.30)
Built from April 3, 1998	Conventional	No	46 (1.30)
		Yes	55 (1.56)

Table 3, System Full-Charge Refrigerant Capacity Specifications

Temperature/Pressure Specifications for Vehicles Without Sleepers				
Relative Humidity	**Outside Air Temperature °F (°C)**	**Maximum Center Dash Outlet Temperature °F (°C)**	**With Compressor Running**	
			Low Pressure psi (kPa)	**High Pressure psi (kPa)**
Low to Medium (30–60%)	70 (21)	48 (9)*	10 to 18 (69 to 124)	135 (931)
	80 (27)	52 (11)*	10 to 20 (69 to 138)	165 (1138)
	90 (32)	52 (11)	10 to 27 (69 to 186)	200 (1379)
	100 (38)	60 (16)	10 to 32 (69 to 221)	230 (1586)
	110 (43)	65 (18)	10 to 35 (69 to 241)	245 (1689)

Specifications

Temperature/Pressure Specifications for Vehicles Without Sleepers				
Relative Humidity	Outside Air Temperature °F (°C)	Maximum Center Dash Outlet Temperature °F (°C)	With Compressor Running	
			Low Pressure psi (kPa)	High Pressure psi (kPa)
High (90%)	70 (21)	50 (10)*	10 to 18 (69 to 124)	135 (931)
	80 (27)	52 (11)	10 to 20 (69 to 138)	165 (1138)
	90 (32)	60 (16)	10 to 27 (69 to 186)	200 (1379)
	100 (38)	68 (20)	10 to 32 (69 to 221)	230 (1586)
	110 (43)	74 (23)	10 to 35 (69 to 241)	245 (1689)

* The thermostatic switch may cause the compressor to cycle. In these situations, the high-side pressure will vary when the reading is taken and the dash outlet temperature will be higher than normal. If this occurs, use the lowest high-side pressure readings (after the compressor has been running for a time).

Table 4, Temperature/Pressure Specifications for Vehicles Without Sleepers

Temperature/Pressure Specifications for Vehicles With Sleepers					
Relative Humidity	Outside Air Temperature °F (°C)	Maximum Center Dash Outlet Temperature °F (°C)	Maximum Sleeper Outlet Temperature °F (°C)	With Compressor Running	
				Low Pressure psi (kPa)	High Pressure psi (kPa)
Low to Medium (30–60%)	70 (21)	48 (9)	49 (9)	10 to 25 (69 to 172)	140 (965)
	80 (27)	51 (11)	55 (13)	10 to 32 (69 to 221)	185 (1276)
	90 (32)	59 (15)	63 (17)	10 to 40 (69 to 276)	220 (1517)
	100 (38)	65 (18)	68 (20)	10 to 45 (69 to 310)	255 (1758)
	110 (43)	72 (22)	72 (22)	10 to 45 (69 to 310)	270 (1862)
High (90%)	70 (21)	50 (10)	52 (11)	10 to 25 (69 to 172)	140 (965)
	80 (27)	56 (13)	59 (15)	10 to 32 (69 to 221)	185 (1276)
	90 (32)	65 (18)	67 (19)	10 to 40 (69 to 276)	220 (1517)
	100 (38)	78 (26)	75 (24)	10 to 45 (69 to 310)	255 (1758)
	110 (43)	87 (31)	87 (31)	10 to 45 (69 to 310)	270 (1862)

Table 5, Temperature/Pressure Specifications for Vehicles With Sleepers

Electronic Leak Detectors		
Designation	Manufacturer	Comments
D-TEK, D-Tek Select, and TekMate	Leybold Inficon 2 Technology Place East Syracuse, NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate

Specifications

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
H–10 Professional	Yokogawa Corp. of America 2 Dart Road Newnan, GA 30265 (800) 258–2552	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren, MI 48092 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 6, Electronic Leak Detectors

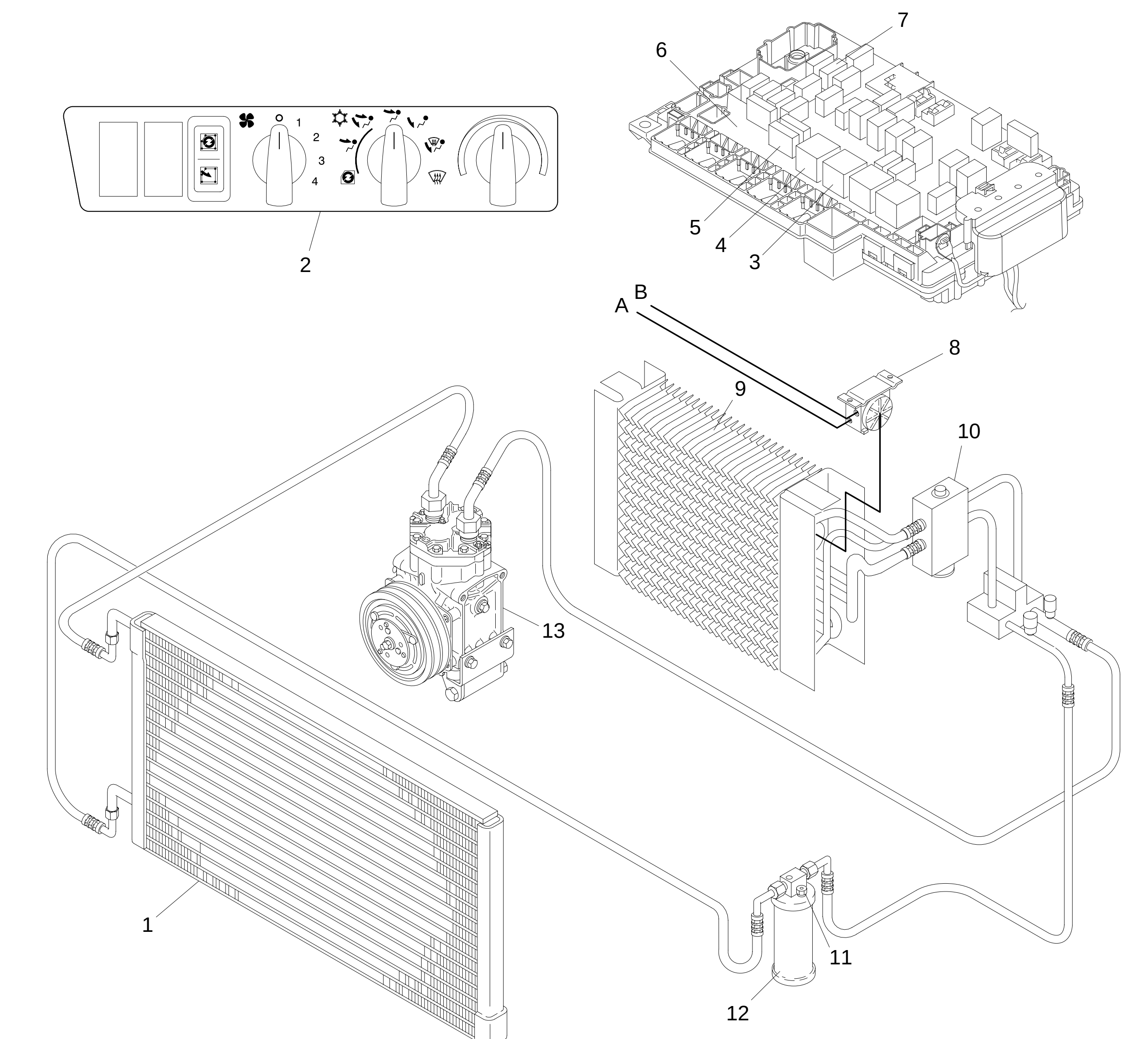
Torque Specification	
Part	**Torque**
Junction Block Retainer Plate Bolt (non-SlimLine Seal)	15 to 19 lbf·ft (20 to 26 N·m)

Table 7, Torque Specification

SlimLine Seal Assembly Bolt Torques	
HVAC Component	**Torque**
A/C Compressor	11 to 15 lbf·ft (15 to 20 N·m)
Condenser	11 to 15 lbf·ft (15 to 20 N·m)
Receiver-Drier	11 to 15 lbf·ft (15 to 20 N·m)
Thermal Expansion Valve	11 to 15 lbf·ft (15 to 20 N·m)
Evaporator	11 to 15 lbf·ft (15 to 20 N·m)
Junction Block	11 to 15 lbf·ft (15 to 20 N·m)

Table 8, SlimLine Seal Assembly Bolt Torques

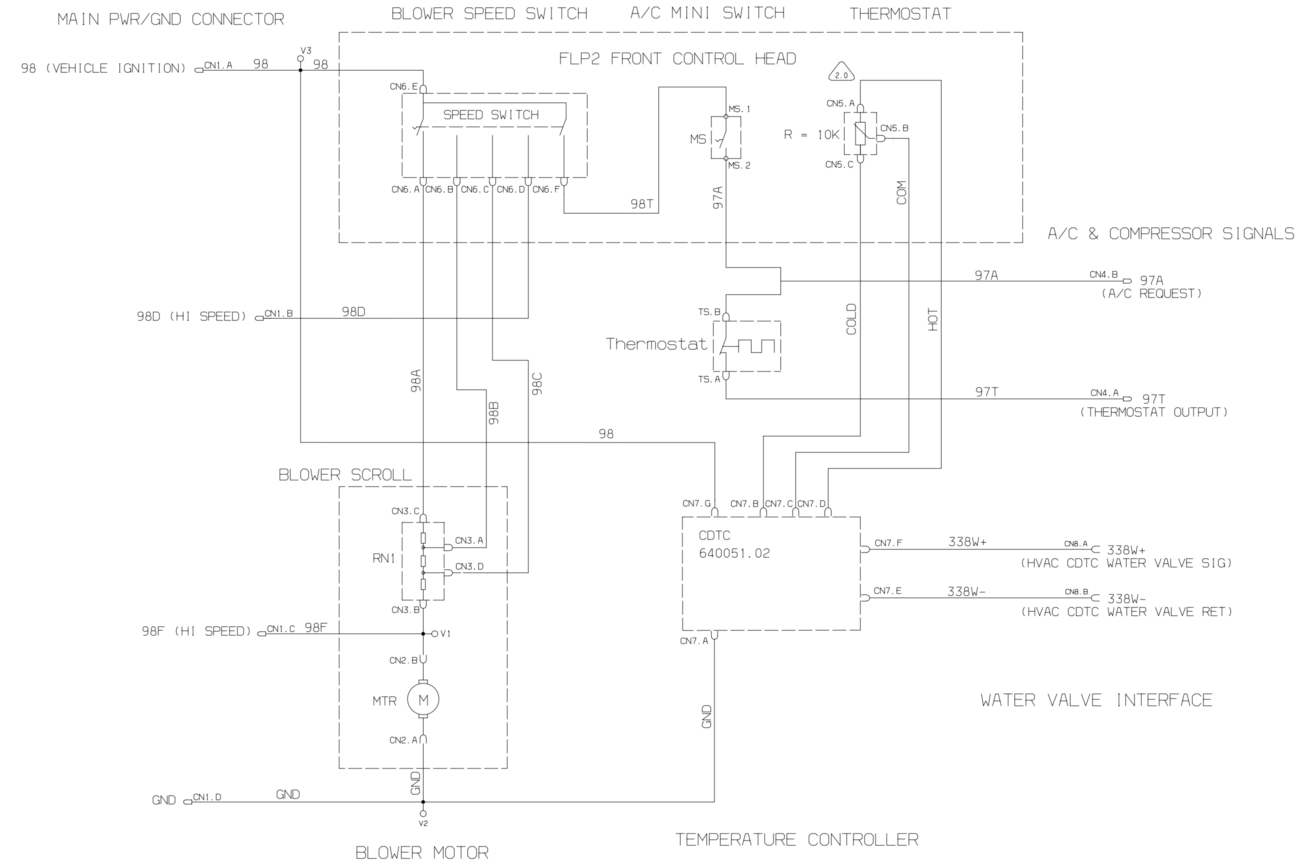
Specifications



A. To A/C clutch relay
B. To blower switch

1. Condenser
2. Climate Control Panel
3. A/C Power Relay
4. A/C High-Speed Relay
5. Circuit Breaker (30A)
6. Power Distribution Module
7. A/C Clutch Circuit Breaker (10A)
8. Thermostatic Switch
9. Evaporator Coil
10. Expansion Valve
11. Moisture Indicator
12. Receiver-Drier
13. Compressor

Fig. 1, Air Conditioning System Components



RUNNING LIST

PL ITEM #	PART	POS.	LINE	DESCRIPTION
1	CN1			MAIN POWER / GROUND CONNECTOR
1.1	CN1	A	98	IGNITION VOLTAGE
1.1	CN1	B	98D	HI BLOWER SPEED
1.1	CN1	C	98F	HI BLOWER SPEED VIA RELAY
1.1	CN1	D	GND	GROUND
2	CN2			BLOWER MOTOR MATING CONNECTOR
2.1	CN2	A	GND	GROUND
2.1	CN2	B	98F	BLOWER MOTOR + TERMINAL
3	CN3			RESISTOR MATING CONNECTOR
3.1	CN3	A	98B	M1 BLOWER SPEED
3.1	CN3	B	98F	HI BLOWER SPEED
3.1	CN3	C	98A	LOW BLOWER SPEED
3.1	CN3	D	98C	M2 BLOWER SPEED
4	CN4			AC / THERMOSTAT MATING CONNECTOR
4.1	CN4	A	97T	THERMOSTAT OUTPUT
4.1	CN4	B	97A	AC REQUEST
5	CN5			POTENTIOMETER MATING CONNECTOR
5.1	CN5	A	HOT	TEMPERATURE SETPOINT, MAX HOT
5.1	CN5	B	COM	TEMPERATURE SETPOINT, COMMON
5.1	CN5	C	COLD	TEMPERATURE SETPOINT, MAX COLD
6	CN6			BLOWER INTFC. CONN. @ CONT. HEAD
6.1	CN6	A	98A	LOW BLOWER SPEED
6.1	CN6	B	98B	M1 BLOWER SPEED
6.1	CN6	C	98C	M2 BLOWER SPEED

RUNNING LIST

PL ITEM #	PART	POS.	LINE	DESCRIPTION
6.1	CN6	D	98D	HI BLOWER SPEED
6.1	CN6	E	98	INGITION VOLTAGE
6.2	CN6	F	98T	BLOWER ON SIGNAL
7	CN7			CDTC MATING CONNECTOR
7.1	CN7	A	GND	GROUND
7.1	CN7	B	COLD	TEMPERATURE SETPOINT, MAX COLD
7.1	CN7	C	COM	TEMPERATURE SETPOINT, COMMON
7.1	CN7	D	HOT	TEMPERATURE SETPOINT, MAX HOT
7.1	CN7	E	338W-	HVAC CDTC WATER VALVE RET
7.1	CN7	F	338W+	HVAC CDTC WATER VALVE SIG
7.1	CN7	G	98	INGITION VOLTAGE
8	CN8			WATERVALVE MATING CONNECTOR
8.1	CN8	A	338W+	HVAC CDTC WATER VALVE SIG
8.1	CN8	B	338W-	HVAC CDTC WATER VALVE RET
9	MS	1	98T	BLOWER ON SIGNAL
9	MS	2	97A	AC REQUEST
10	TS			T-STAT OUTPUT & AC REQUEST CONNECTOR
10.1	TS	A	97T	THERMOSTAT OUTPUT
10.2	TS	B	97A	AC REQUEST
11	V1		98F	SPLICE
11	V2		GND	SPLICE
11	V3		98	SPLICE

Ref. Dia. A22−42255 Chg. Ltr. J

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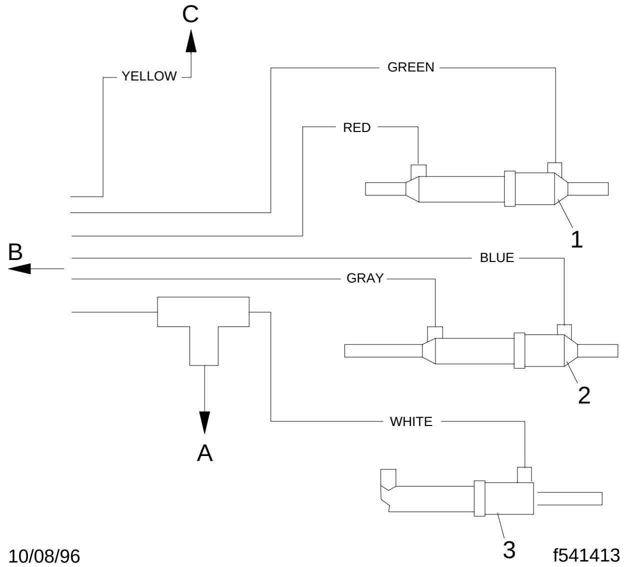
Fig. 2, Heater and Air Conditioning Wiring Schematic

Specifications



A. To recirc air pressure switch
B. To heater-A/C control
C. To air junction block

1. Heater/Defrost Air Cylinder
2. Face Duct Air Cylinder
3. Recirculation Air Cylinder

Fig. 3, Heater and Air Conditioning Plumbing Diagram

General Description and Principles of Operation

The sleeper heater and air conditioner housings are self-contained, and include the heater core/ evaporator coil, blower motor, and control valves. See **Fig. 1** and **Fig. 2**. They are mounted either in the baggage compartment or under the lower bunk, depending on the cab model.

The sleeper heater is plumbed directly to the engine, independent of the cab heater. The sleeper air conditioner is dependent on the cab's air conditioning system, sharing the same refrigerant and compressor.

The Automatic Temperature Control (A.T.C.) system automatically maintains the selected outlet temperature. For general information and principles of operation of the air conditioner, see **Section 83.02**, Subject 050.

The climate control panel for the sleeper heater and air conditioner is installed in various locations in the sleeper, depending on the sleeper size. See **Fig. 3**. See the *Columbia Driver's Manual* for operating instructions.

Opening of the A.T.C. water supply solenoid valve allows engine-heated coolant to flow through the heater core. Heat is absorbed by air passing over the heater core fins.

The blower forces the heated air through the ducts and into the sleeper.

The water supply solenoid valve opens when the rotary temperature control knob is turned clockwise to HEAT.

The A.T.C. system has three major components:

- A.T.C Module

  —Supplies power to the water supply solenoid.

  —Monitors air output temperature.

  —Used with the temperature control knob to select the desired air output temperature.

- Water Supply Solenoid Valve

  —Receives power from the A.T.C. module.

  —Controls the supply of water to the heater core.

- Air Temperature Sensor

  —Monitors air output temperature.

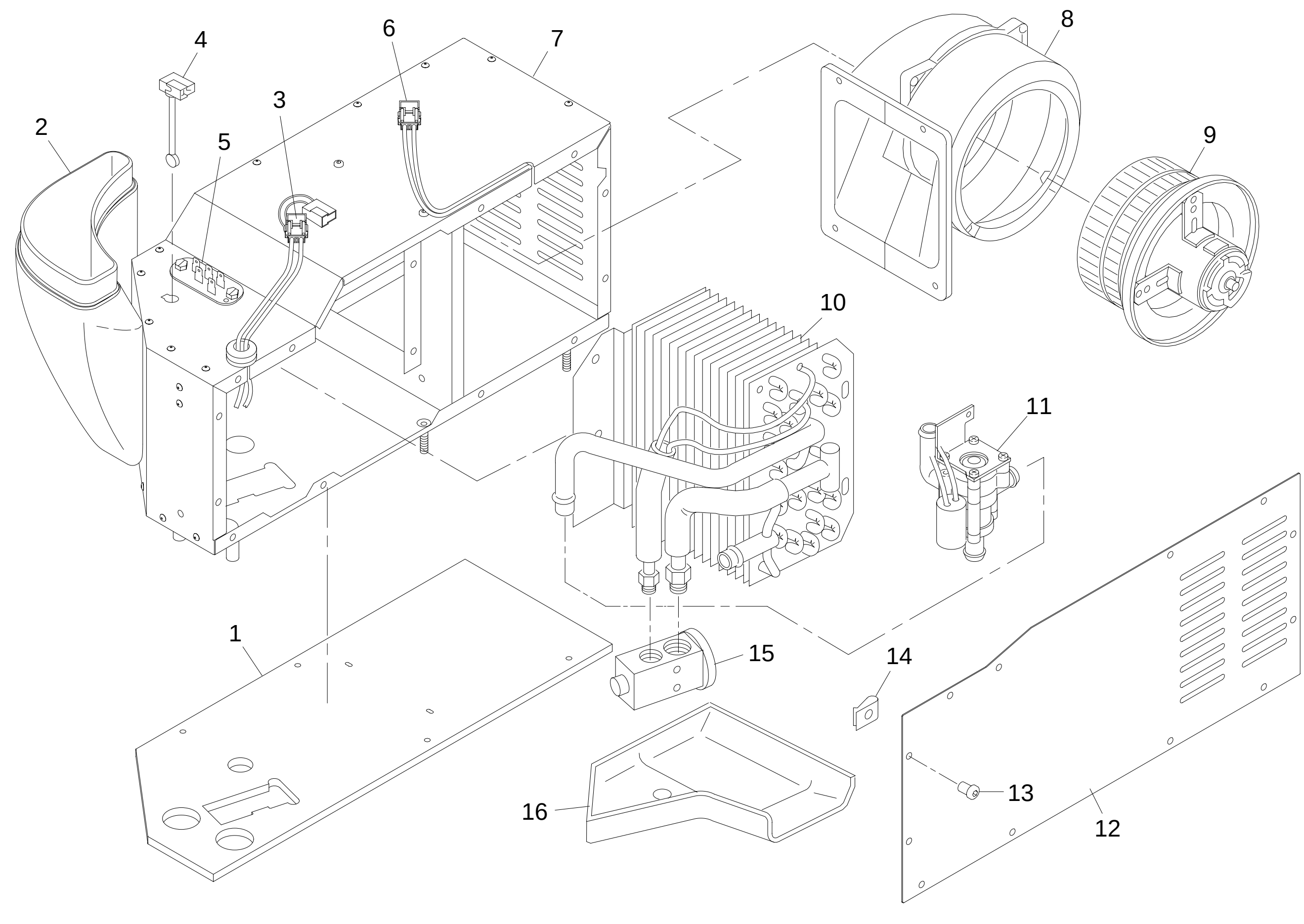
With an A.T.C. system, a preselected temperature is maintained by directing the flow of hot water through the heater core.

Once the operator adjusts the temperature control knob, the air output temperature is monitored by an air temperature sensor at the sleeper heater and air conditioner unit. Any change in output temperature activates the A.T.C. module, energizing or de-energizing the water supply solenoid valve.

If the air is colder than the selected temperature, hot water is allowed to flow into the heater core. As the output temperature reaches the desired setting, the water supply solenoid valve closes, preventing hot water from entering the heater core, until air output temperature becomes too cool again. Then the process starts over.

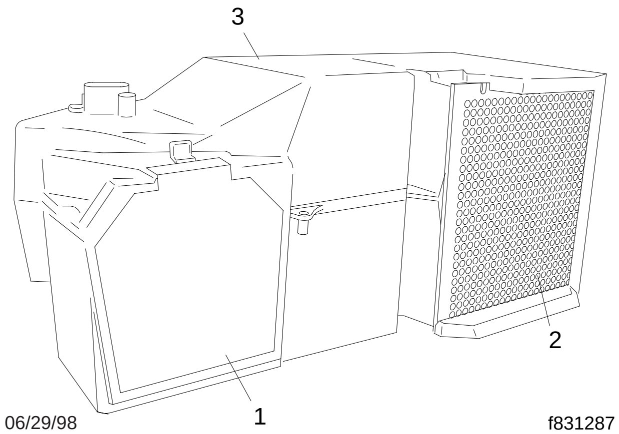
A fan control knob controls a three-speed blower motor and allows the operator to choose the amount of air flow in the sleeper.

General Information



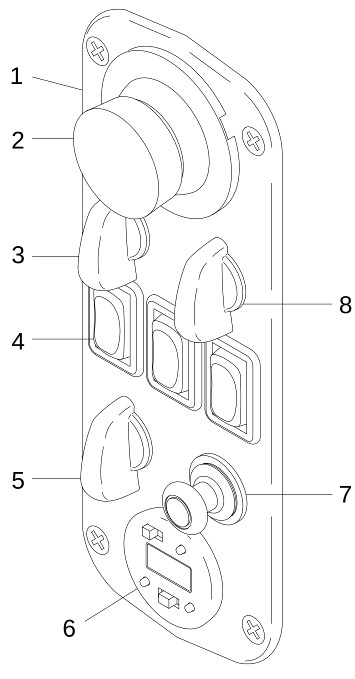
1. Housing Gasket
2. Discharge Air Duct
3. Water Supply Solenoid Valve Electrical Connector
4. Sensor
5. Resistor Block Assembly
6. Blower Motor Electrical Connector
7. Housing Assembly
8. Blower Motor Housing
9. Blower Motor Assembly
10. Evaporator/Heater Core Assembly
11. Water Supply Solenoid Valve
12. Front Cover
13. Screw, 11–16 x 3/4 inch
14. U-Clip
15. Expansion Valve
16. Drain Baffle

Fig. 1, Sleeper Heater and Air Conditioner Assembly



1. Access Panel
2. Filter Screen
3. Sleeper Heater and Air Conditioner Housing

Fig. 2, Sleeper Heater and Air Conditioner Housing With Recirculation Filter



1. Control Panel
2. Reading Lamp
3. Fan Control Knob
4. Dome and Reading Light Switches
5. Volume Control Knob
6. Clock
7. Cigarette Lighter
8. A.T.C. Control Knob

Fig. 3, Control Panel for A.T.C. System

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer’s instructions.

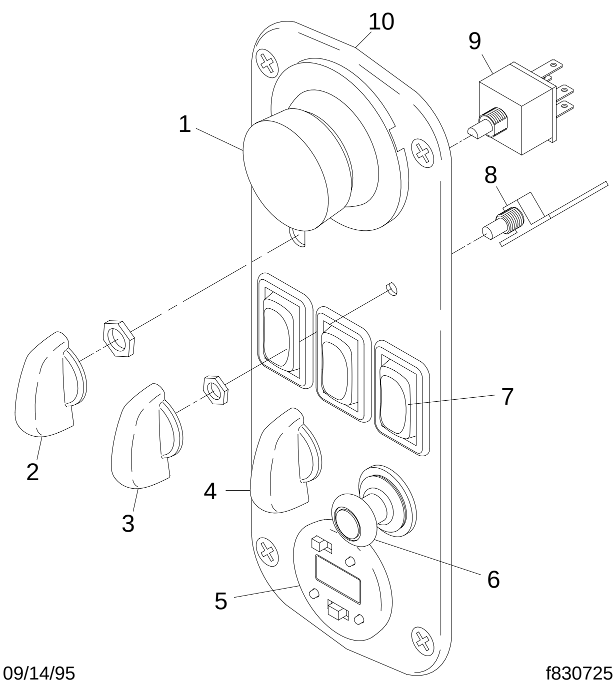
Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG), or polyol ester (POE) oil is used in the compressor. When handling these oils, observe the following:

- Keep the oil free of contaminants;
- Do not expose the a/c system or the oil container to air for long periods of time; PAG and POE oils have a high moisture absorption capacity;
- Use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if the oil is spilled on them;
- Never mix the oils with other types of refrigerant oil.

Automatic Temperature Control (A.T.C.) Module Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the four screws that attach the control panel to the sleeper compartment wall, and pull the panel away from the wall. See **Fig. 1**.



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1. Reading Lamp
2. Fan Control Knob
3. A.T.C. Control Knob
4. Volume Control Knob
5. Clock
6. Cigarette Lighter
7. Dome and Reading Light Switches
8. A.T.C. Control Module
9. Fan Control Switch
10. Control Panel

Fig. 1, Control Panel for A.T.C. System

3. Unplug the wiring connector at the A.T.C. control module.
4. Pull the temperature control knob off of the control switch stem. Remove the nut, and pull the module out of the back of the panel.
5. Install the new module and replace the nut. Replace the temperature control knob.
6. Connect the wiring connector at the A.T.C. module.
7. Install the control panel on the wall. Tighten the four screws firmly.
8. Remove the chocks from the tires.

Fan Control Switch Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the four screws attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall. See **Fig. 1**.
3. On fan control switches that have four wires, mark the four wires before unplugging them from the connectors. On all other fan control switches, unplug the connector from the switch.
4. Pull the fan control knob off of the control switch stem. Remove the nut, and pull the switch out of the back of the panel.
5. Install the new fan control switch and replace the nut. Position the knob so that the indicating dot aligns with OFF.

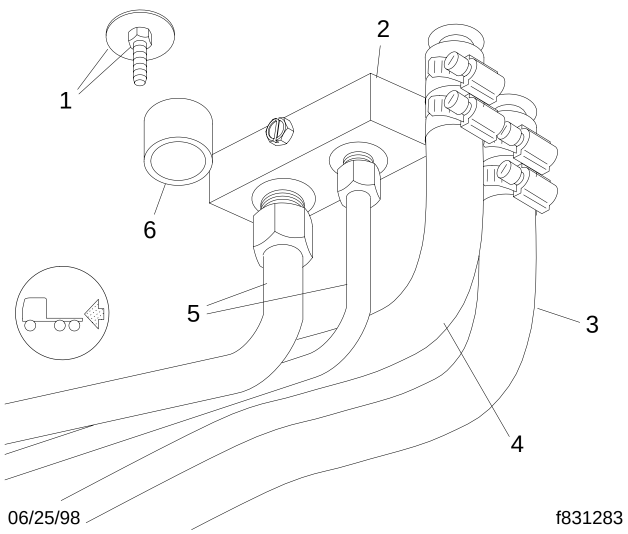
IMPORTANT: The tab on the positioning washer between the control panel and the switch should be in the upright position, and as level as possible in order to obtain the full range of the fan control knob.

6. Connect the wires to the switch, making sure the wires are connected to the correct tabs, or plug the connector to the switch.
7. Install the control panel on the wall. Tighten the four screws firmly.
8. Remove the chocks from the tires.

Heater and Air Conditioner Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 240.
3. Remove enough coolant from the radiator so that the level of coolant is below the inlet and outlet lines at the expansion valve, or clamp off the radiator hoses to prevent coolant loss.
4. From under the sleeper on the right-hand side of the vehicle, remove the standoff bracket (if equipped) that separates the water supply inlet and outlet lines. See **Fig. 1**. Mark the inlet and outlet lines for later reference and drain the heater core by disconnecting the inlet and outlet lines.
5. From under the sleeper, disconnect the refrigerant lines from the expansion valve. Quickly cap the expansion valve inlet and outlet ports and plug the fittings.



1. Mounting Fasteners
2. Expansion Valve
3. Inlet Line
4. Outlet Line
5. Refrigerant Lines
6. Drain Tube

Fig. 1, Expansion Valve

IMPORTANT: Do not leave the expansion valve ports uncapped or the fittings unplugged for longer than a total time of 5 minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

6. From under the sleeper, remove the nuts and washers that attach the heater and air conditioner housing to the cab floor.
7. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

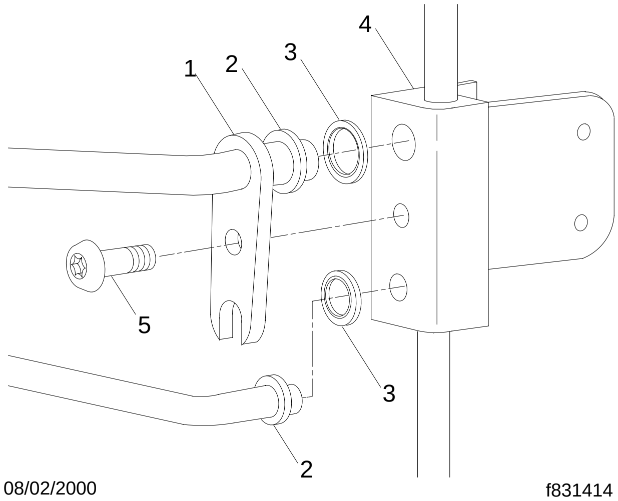
   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
8. Disconnect the wiring harnesses from the sleeper heater and air conditioner housing.
9. Remove the sleeper heater and air conditioner housing from the cab. Be sure not to damage the water drain tube or heater core/evaporator coil while removing the housing.

Installation

1. Place the sleeper heater and air conditioner housing on the cab floor. Make sure the heater core elbows, expansion valve, water drain tube, and mounting studs protrude through the floor.
2. From under the cab, install the washers and nuts on the mounting studs. Tighten the nuts 13 lbf·ft (18 N·m).
3. Connect the wiring harnesses to the sleeper heater and air conditioner housing.
4. Uncap the inlet and outlet ports on the expansion valve. Unplug the fittings. Check the fittings, and the inlet and outlet ports. They must be clean and free of nicks, gasket residue, and other foreign material.
5. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On hose connections that have a SlimLine seal assembly (**Fig. 2**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.

Heater and Air Conditioner Removal and Installation



1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 2, A Typical SlimLine Seal Assembly

6. Attach the refrigerant lines to the expansion valve.

   On hose connections that have threaded fittings, tighten the #6 fitting 20 to 25 lbf·ft (27 to 34 N·m). Tighten the #10 and #12 fittings 35 to 40 lbf·ft (47 to 54 N·m).

   On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal assembly 11 to 15 lbf·ft (15 to 20 N·m).
7. Install the standoff bracket (if equipped) that separates the water supply inlet and outlet lines. Attach the inlet and outlet lines to the heater core elbows as marked. Tighten the clamps 40 lbf·in (452 N·cm).
8. Evacuate and charge the air conditioning system. For instructions, see **Section 83.02**, Subject 240.
9. Fill the cooling system with coolant. For coolant specifications, see Group 20 of the *Columbia Maintenance Manual*.

CAUTION

Coolant must be filled to the proper level in the surge tank. Low coolant could cause engine overheating, which could damage the engine.

10. Start the engine, let it run for 20 to 30 seconds, and then shut it off. Install a pressure tester, test the cooling system at 10 psi (69 kPa), and then inspect for leaks. If leaks are found, tighten the hose clamps 40 lbf·in (452 N·cm) or replace the hoses as needed. Check the coolant level, and add coolant if needed.
11. Turn the temperature control knob clockwise to HEAT.
12. Start the engine. When the radiator thermostat opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and add coolant if needed.
13. Lower the sleeper mattress and bunk panel, or close the baggage compartment door.
14. Remove the chocks from the tires.

Blower Motor Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
3. Remove the blower motor.

   3.1 Disconnect the blower motor cable assembly.

   3.2 On sleeper heater and air conditioner housings that have a one-piece front cover, remove the fasteners that attach the front cover to the housing. Remove the cover.

   On sleeper heater and air conditioner housings that have a recirculation filter, remove the filter screen and filter from the housing. See **Fig. 1**.

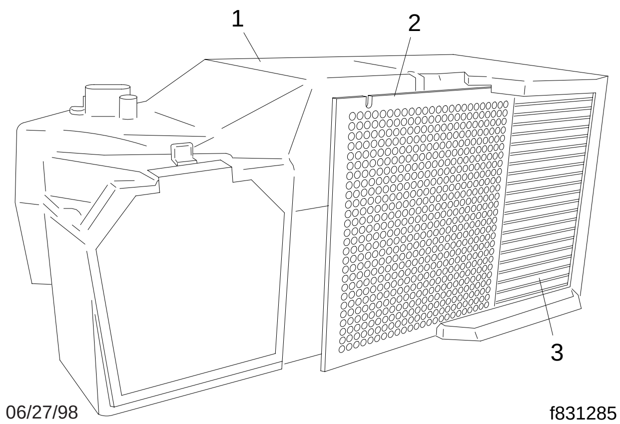
   3.3 Remove the mounting fasteners that attach the motor to the housing. See **Fig. 2**. Remove the blower motor from the housing.
4. Install a new blower motor.

   4.1 Install the fasteners that attach the blower motor to the housing. Tighten the fasteners firmly.

   4.2 Connect the blower motor cable assembly.

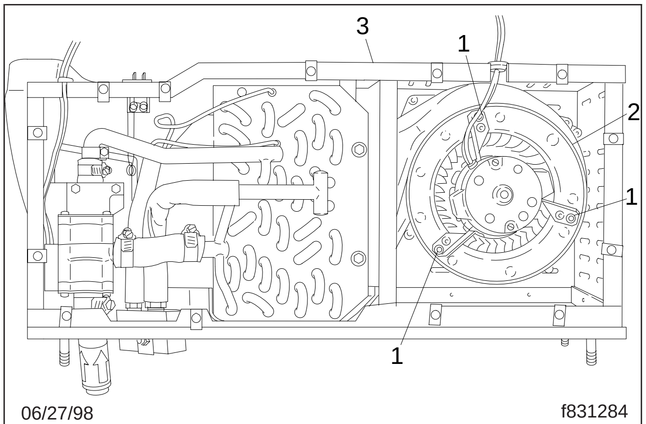
   4.3 On sleeper heater and air conditioner housings that have a one-piece front cover, use the fasteners to attach the front cover to the housing.

   On sleeper heater and air conditioner housings that have a recirculation filter, install the filter and filter screen on the housing.
5. Lower the mattress and bunk panel, or close the baggage compartment door.



1. Sleeper Heater and Air Conditioner Housing
2. Filter Screen
3. Filter

Fig. 1, Sleeper Heater and Air Conditioner Housing With Recirculation Filter



1. Mounting Fastener
2. Blower Motor
3. Sleeper Heater and Air Conditioner Housing

Fig. 2, Blower Motor

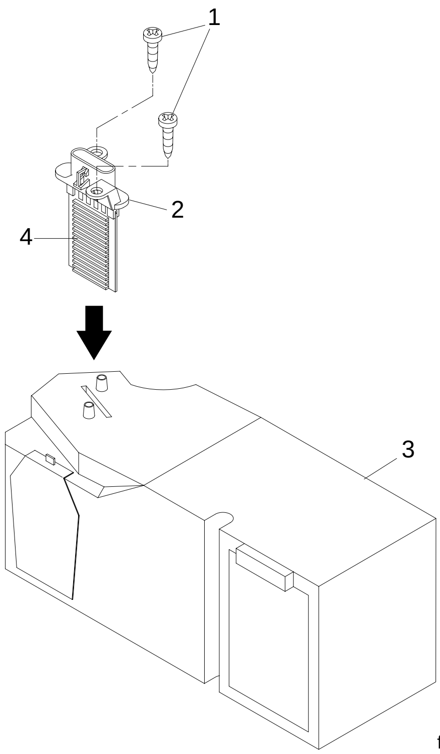
6. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
3. Disconnect the harness from the resistor block assembly. See **Fig. 1**.



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1. Screws
2. Resistor Block Assembly
3. Sleeper Heater and Air Conditioner Housing
4. Heat Sink

Fig. 1, HVAC Resistor Block

4. Remove the screws that attach the resistor block assembly to the sleeper HVAC housing.
5. Remove the resistor block assembly.

CAUTION

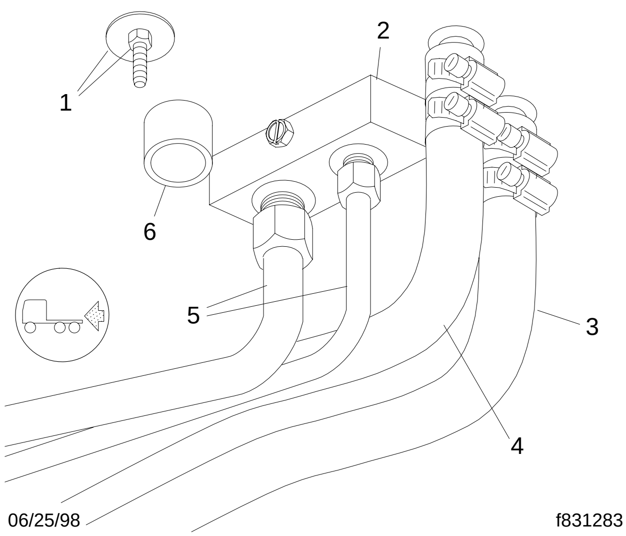
Handle the resistor block assembly carefully. If the resistor block assembly is not handled carefully, the heat sink may be damaged or break off of the board.

6. Install a new resistor block assembly.
7. Install the screws that fasten the resistor block assembly to the sleeper heater and air conditioner housing.
8. Connect the harness to the resistor block assembly.
9. Lower the mattress and bunk panel, or close the baggage compartment door.
10. Remove the chocks from the tires.

A.T.C. Water Supply Solenoid Valve Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove enough coolant from the radiator so that the level of coolant is below the inlet and outlet lines at the expansion valve, or clamp off the radiator hoses to prevent coolant loss.
3. From under the sleeper on the right-hand side of the vehicle, remove the standoff bracket (if equipped) that separates the water supply inlet and outlet lines. Drain the heater core by disconnecting the inlet line. See **Fig. 1**.



1. Mounting Fasteners
2. Expansion Valve
3. Inlet Line
4. Outlet Line
5. Refrigerant Lines
6. Drain Tube

Fig. 1, Expansion Valve

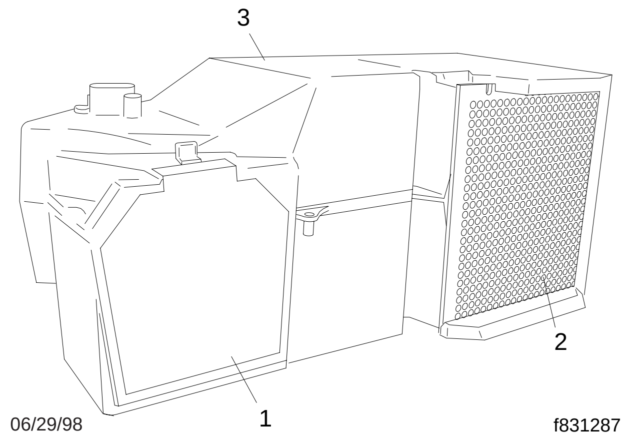
4. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
5. Access the water supply solenoid valve.

   On sleeper heater and air conditioner housings that have a one-piece front cover, remove the fasteners that attach the front cover to the housing. Remove the cover.

   On sleeper heater and air conditioner housings that have a recirculation filter, remove the access panel on the front of the housing. See **Fig. 2**.

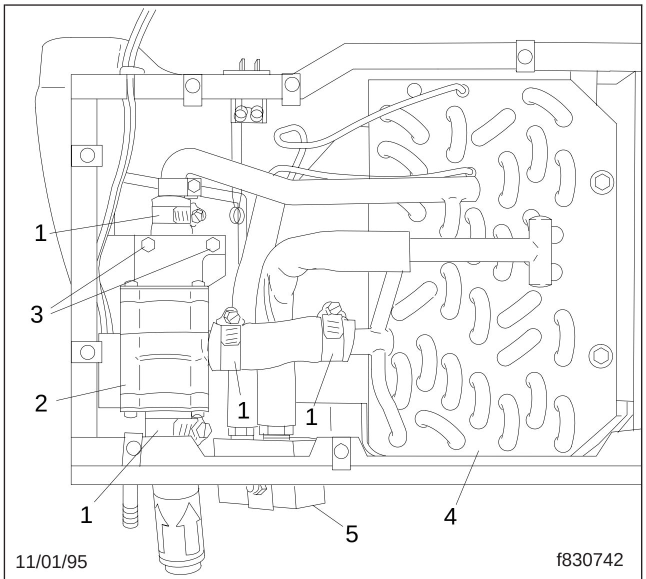


1. Access Panel
2. Filter Screen
3. Sleeper Heater and Air Conditioner Housing

Fig. 2, Sleeper Heater and Air Conditioner Housing With Recirculation Filter

6. Disconnect the water supply solenoid valve wiring harness.
7. Loosen the hose clamps on the hoses that are attached to the water supply solenoid valve, and remove the hoses. See **Fig. 3**.
8. Remove the fasteners that attach the water supply solenoid valve to the housing, and remove the valve.
9. Install a new water supply solenoid valve, and install the fasteners that attach the valve to the housing.
10. Connect the hoses to the water supply solenoid valve, and tighten the hose clamps.
11. Connect the wiring harness to the water supply solenoid valve.
12. Install the standoff bracket (if equipped) that separates the two heater hoses. Reconnect the inlet line under the sleeper. Tighten the clamps 40 lbf·in (452 N·cm).

A.T.C. Water Supply Solenoid Valve Replacement



1. Hose Clamp
2. Water Supply Solenoid Valve
3. Mounting Fasteners
4. Heater Core and Evaporator Coil Assembly
5. Expansion Valve

Fig. 3, A.T.C. Water Supply Solenoid Valve

13. Attach the front cover to the sleeper heater and air conditioner housing, or install the access panel on the housing.
14. Lower the bunk panel and the sleeper mattress, or close the baggage compartment door.
15. Fill the cooling system with coolant. For coolant specifications, see Group 20 of the *Columbia Maintenance Manual*.

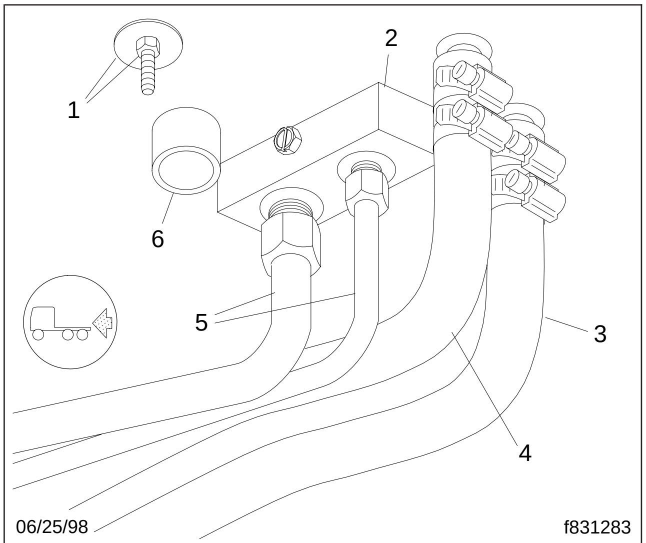
CAUTION

Coolant must be filled to the proper level in the surge tank. Low coolant could cause engine overheating, which could damage the engine.

16. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 240.
3. From under the sleeper on the right-hand side of the vehicle, disconnect the refrigerant lines from the expansion valve. See **Fig. 1**. Quickly cap the inlet and outlet ports and plug the fittings.



1. Mounting Fasteners
2. Expansion Valve
3. Inlet Line
4. Outlet Line
5. Refrigerant Lines
6. Drain Tube

Fig. 1, Expansion Valve

IMPORTANT: Do not leave the ports on the expansion valve uncapped or the fittings unplugged for longer than a total time of five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

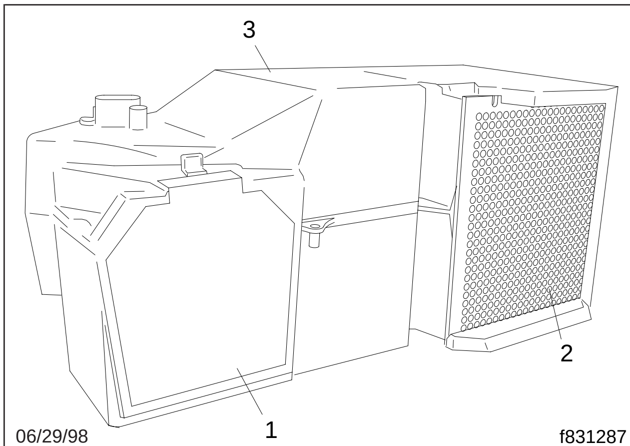
4. Remove enough coolant from the radiator so that the level of coolant is below the inlet and outlet lines at the expansion valve, or clamp off the radiator hoses to prevent coolant loss.
5. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
6. Access the expansion valve.

   On sleeper heater and air conditioner housings that have a one-piece front cover, remove the fasteners that attach the front cover to the housing. Remove the cover.

   On sleeper heater and air conditioner housings that have a recirculation filter, remove the access panel on the front of the housing. See **Fig. 2**.



1. Access Panel
2. Filter Screen
3. Sleeper Heater and Air Conditioner Housing

Fig. 2, Sleeper Heater and Air Conditioner Housing With Recirculation Filter

7. Remove the A.T.C. water supply solenoid valve. For instructions, see **Subject 150**.
8. From inside the sleeper heater and air conditioner housing, disconnect the refrigerant lines from the expansion valve. Quickly cap the inlet and outlet ports and plug the fittings.
9. Remove the bolt and nut that attach the expansion valve to the mounting bracket, and remove the expansion valve.
10. Install a new expansion valve. Attach the expansion valve to the mounting bracket with the bolt and nut and tighten 96 lbf·in (1085 N·cm).

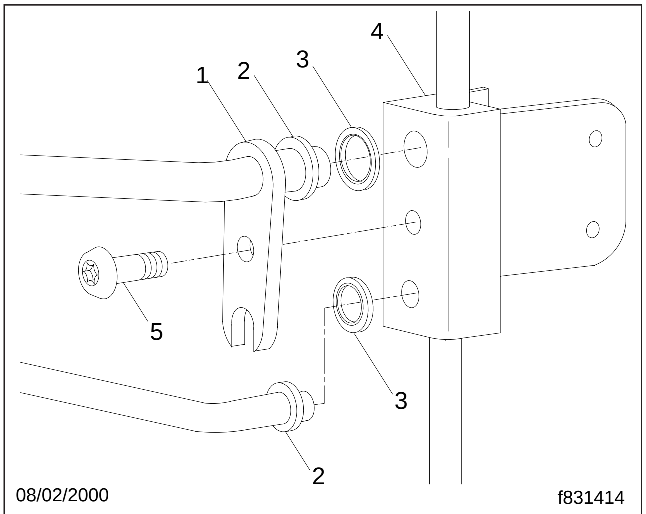
Expansion Valve Replacement

11. Uncap the inlet and outlet ports on the expansion valve. Unplug the fittings. Check the fittings, and the inlet and outlet ports. They must be clean and free of nicks, gasket residue, and other foreign material.
12. On hose connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

    On hose connections that have a SlimLine seal assembly (**Fig. 3**), replace the seals. **Do not** lubricate SlimLine seals prior to installation. Use **only** a SlimLine seal on a SlimLine seal assembly.
13. Install the refrigerant lines on the expansion valve.

    On hose connections that have threaded fittings, torque the #6 fitting 20 to 25 lbf·ft (27 to 34 N·m), and the #10/12 fittings 35 to 40 lbf·ft (47 to 54 N·m).

    On hose connections that have a SlimLine seal assembly, torque the bolt on the SlimLine seal block and plate assembly 11 to 15 lbf·ft (15 to 20 N·m).



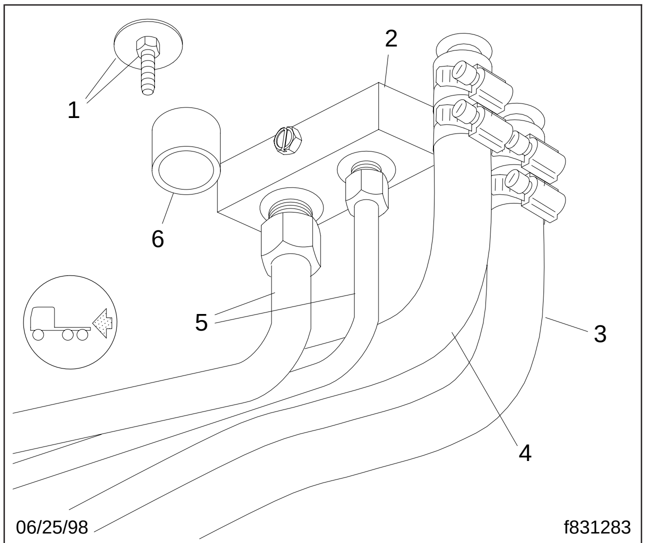
1. Plate
2. Fitting
3. Seal
4. Block
5. Bolt

Fig. 3, A Typical SlimLine Seal Assembly

14. Install the A.T.C. water supply solenoid valve. For instructions, see **Subject 150**.
15. Attach the front cover to the sleeper heater and air conditioner housing, or install the access panel on the housing.
16. Lower the bunk panel and the sleeper mattress, or close the baggage compartment door.
17. Evacuate and charge the air conditioning system. For instructions, see **Section 83.02**, Subject 240.
18. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 240.
3. Remove enough coolant from the radiator so that the level of coolant is below the inlet and outlet lines at the expansion valve, or clamp off the radiator hoses to prevent coolant loss.
4. From under the sleeper, remove the standoff bracket (if equipped) that separates the water supply inlet and outlet lines. Mark the water supply inlet and outlet lines for later reference and drain the heater core by disconnecting the inlet and outlet lines. See **Fig. 1**.



1. Mounting Fasteners
2. Expansion Valve
3. Inlet Line
4. Outlet Line
5. Refrigerant Lines
6. Drain Tube

Fig. 1, Expansion Valve

5. Access the sleeper heater and air conditioner housing.

   On vehicles with a baggage compartment on the right-hand side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right-hand side of the cab, raise the mattress and bunk panel to their locked position.
6. Access the heater core and evaporator coil.

   On sleeper heater and air conditioner housings that have a one-piece front cover, remove the fasteners that attach the front cover to the housing. Remove the front cover.

   On sleeper heater and air conditioner housings that have a recirculation filter, remove the fasteners that attach the top cover to the housing. Remove the top cover.
7. Disconnect the wiring harnesses from the blower motor, the thermistor, the resistor block assembly, and the A.T.C. water supply solenoid valve.
8. Remove the A.T.C. water supply solenoid valve. For instructions, see **Subject 150**.
9. Disconnect the two refrigerant lines from the top of the expansion valve. Quickly cap the expansion valve inlet and outlet ports and plug the fittings.

IMPORTANT: Do not leave the expansion valve ports uncapped or the fittings unplugged for longer than a total time of 5 minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

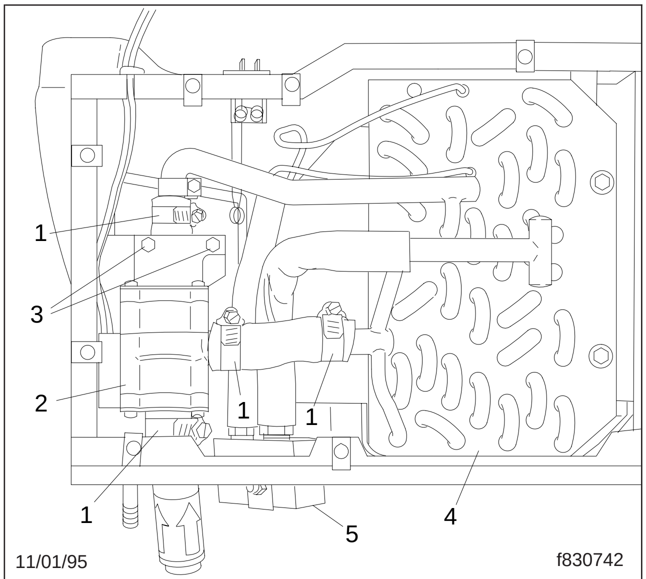
10. Remove the heater core and evaporator coil. See **Fig. 2**.

    10.1 On sleeper heater and air conditioner housings that have a one-piece front cover, remove the four fasteners that attach the heater core and evaporator coil to the housing, and lift the heater core and evaporator coil out of the housing.

    10.2 On sleeper heater and air conditioner housings that have a recirculation filter, lift the heater core and evaporator coil out of the housing.
11. Install a new heater core and evaporator coil.

    11.1 On sleeper heater and air conditioner housings that have a one-piece front cover, install a new heater core and evaporator coil and attach the assembly to the housing using four fasteners. Tighten the fasteners firmly.

Heater Core and Evaporator Coil Replacement



1. Hose Clamp
2. Water Supply Solenoid Valve
3. Mounting Fasteners
4. Heater Core and Evaporator Coil Assembly
5. Expansion Valve

Fig. 2, Heater Core and Evaporator Coil Assembly

11.2 On sleeper heater and air conditioner housings that have a recirculation filter, install a new heater core and evaporator coil.

12. Attach the water outlet line to the heater core.
13. Install and tighten the refrigerant lines on the expansion valve.
    - no. 6 inlet side—20 to 25 lbf·ft (27 to 34 N·m)
    - no. 10 and 12 outlet side—35 to 40 lbf·ft (47 to 54 N·m)
14. Install the A.T.C. water supply solenoid valve. For instructions, see **Subject 150**.
15. On sleeper heater and air conditioner housings that have a one-piece front cover, install the front cover on the housing and attach the fasteners to the cover.
16. On sleeper heater and air conditioner housings that have a recirculation filter, install the top cover on the housing and attach the fasteners to the cover.
17. Evacuate and charge the air conditioning system. For instructions, see **Section 83.02**, Subject 240.
18. Fill the cooling system with coolant. For coolant specifications, see Group 20 of the *Columbia Maintenance Manual*.

CAUTION

Coolant must be filled to the proper level in the surge tank. Low coolant could cause engine overheating, which could damage the engine.

19. Remove the chocks from the tires.

Specifications

See **Fig. 1** for the sleeper heater and air conditioner wiring diagram.

Torque Specifications		
Description	Torque	
	lbf·in (N·cm)	lbf·ft (N·m)
Heater and Air Conditioner Mounting Locknuts	—	13 (18)
Heater Hose Clamps	40 (452)	—
Refrigerant Line (Inlet Side) #6 O-Ring Fitting *	—	20 to 25 (27 to 34)
Refrigerant Line (Outlet Side) #10 O-Ring Fitting *	—	35 to 40 (47 to 54)
Blower Motor Mounting Capscrews	28 to 32 (320 to 360)	—
Expansion Valve Mounting Bolt	96 (1085)	—

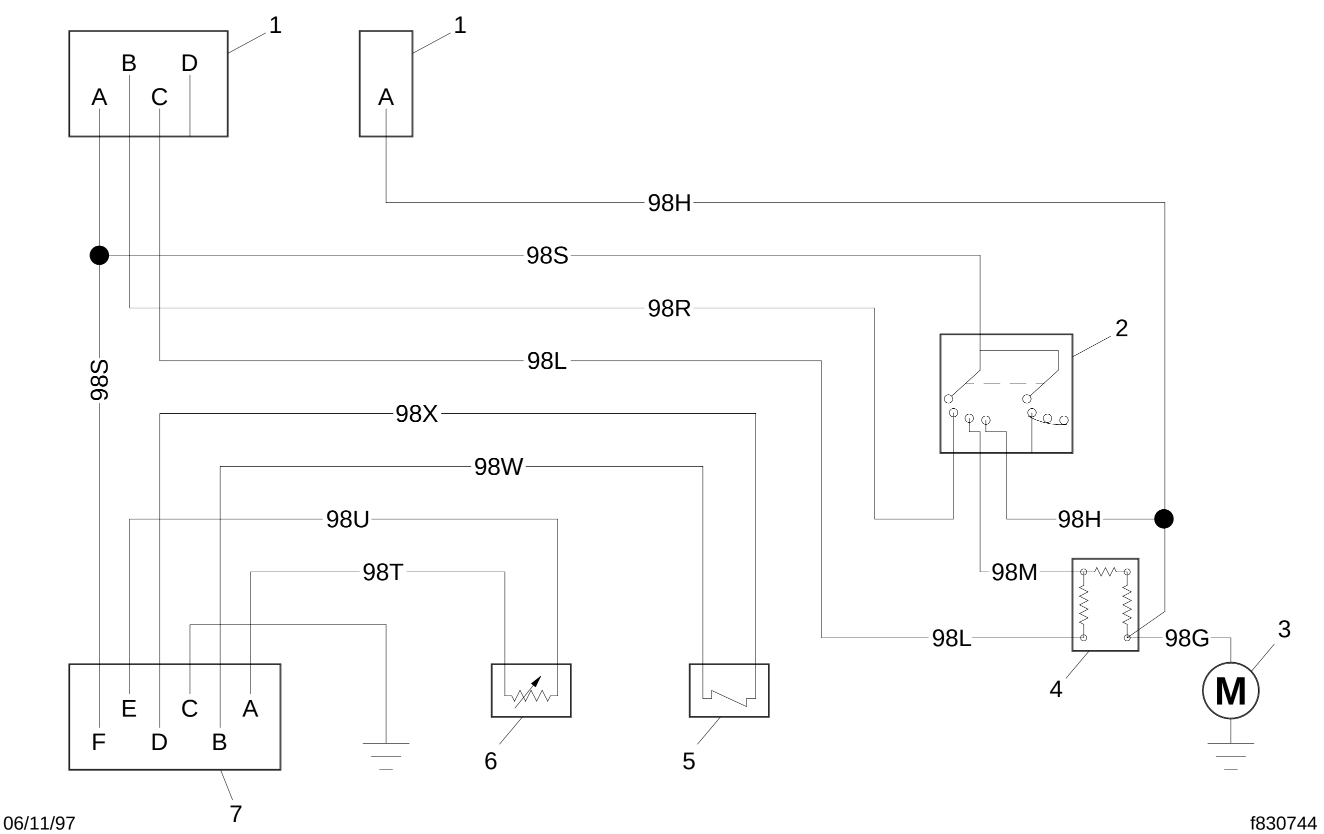
* Replace the O-ring and lubricate it with mineral oil. Apply mineral oil to the male portion of the fitting threads. If equipped with aluminum fittings, apply Molykote M Gear Guard to the male portion of the fitting threads.

Table 1, Torque Specifications

SlimLine Seal Assembly Bolt Torques	
HVAC Component	Torque
A/C Compressor	11 to 15 lbf·ft (15 to 20 N·m)
Condenser	11 to 15 lbf·ft (15 to 20 N·m)
Receiver-Drier	11 to 15 lbf·ft (15 to 20 N·m)
Thermal Expansion Valve	11 to 15 lbf·ft (15 to 20 N·m)
Evaporator	11 to 15 lbf·ft (15 to 20 N·m)
Junction Block	11 to 15 lbf·ft (15 to 20 N·m)

Table 2, SlimLine Seal Assembly Bolt Torques

Specifications



1. Sleeper Heater and Air Conditioner Wiring Connector
2. Fan Switch
3. Blower Motor
4. Blower Motor Resistor Block
5. Water Supply Solenoid Valve
6. Temperature Sensor
7. Automatic Temperature Control Module

Fig. 1, Sleeper Heater and Air Conditioner Wiring Diagram

General Information

The heater and air conditioner assembly is mounted behind the passenger dash panels and contains the following major components:

- brushless blower motor
- evaporator core
- heater core
- a recirculation filter
- an optional outside air filter
- three electric actuators
- temperature control, air selection mode, and recirculation doors
- expansion valve
- evaporator temperature sensor

The heating, air conditioning, and ventilating functions of the cab heater and air conditioner system are controlled by the cab climate control panel mounted on the dashboard. See the *Columbia Driver's Manual* for operating instructions.

Thermodynamic Principles

Air conditioning is the cooling or refrigeration of the air in the passenger compartment. Refrigeration is accomplished by making practical use of three thermodynamic principles. These principles and their practical application are described below.

Heat Transfer

If two objects of different temperatures are placed near each other, the heat in the warmer object will always travel to the cooler object until both are of equal temperature.

For example, a block of ice in a refrigerator does not transfer its coldness to a nearby carton of milk. Rather, the heat in the warm milk automatically flows to the ice.

The British Thermal Unit (BTU) is used to determine the amount of heat transferred from one object to another. One BTU is the amount of heat required to raise the temperature of 1 pound (0.45 kg) of water 1°F (0.55°C).

For example, to raise the temperature of 1 pound (0.45 kg) of water from 32°F to 212°F (0°C to 100°C), one BTU of heat must be added for 1°F (0.55°C) rise in temperature or a total of 180 BTUs of heat. Conversely, in order to lower the temperature of 1 pound (0.45 kg) of water from 212°F to 32°F (100°C to 0°C), 180 BTUs of heat must be removed from the water.

Latent Heat of Vaporization

When a liquid boils, it absorbs heat without raising the temperature of the resulting gas beyond its boiling point. When the gas condenses (changes back to a liquid), it gives off heat without lowering the temperature of the resulting liquid.

For example, when a container holding 1 pound (0.45 kg) of water at 32°F (0°C) is heated, the temperature of the water rises 1°F (0.55°C) with each BTU of heat energy that the water absorbs. After it absorbs 180 BTUs of heat, raising its temperature 180°F (100°C), the water reaches a temperature of 212°F (100°C). This is the boiling point of water at standard sea level conditions.

Even as more heat is absorbed by the water, the temperature of the water will not go above 212°F (100°C). The water starts to boil, to change from a liquid to a gaseous state. It continues to boil until the water has passed off into the atmosphere as vapor. Under normal conditions, the vapor rapidly gives off its heat to the surrounding air, but it rises from the water at a temperature of 212°F (100°C).

In other words, the water and vapor temperatures can rise only 180°F (from 32°F to 212°F [0°C to 100°C]), even though many more than 180 BTUs of heat are absorbed. The heat absorbed by the liquid in the process of boiling dissipates from the vapor into the surrounding air, and the vapor condenses back to water.

The transfer of heat as substances change their physical state, such as water boiling to vapor, and vapor condensing back to water, is called the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 212°F (100°C). This means that 1 pound (0.45 kg) of water at 212°F (100°C), will absorb 970 BTUs of heat when changing to vapor at 212°F (100°C). Conversely, the vapor will give off 970 BTUs of heat when condensing back to water at 212°F (100°C).

General Information

This heat energy transfer, occurring when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigerant systems.

For a liquid to be a refrigerant, it must also have a low boiling point. That is, the temperature at which it boils must be lower than the substance to be cooled.

R–134a is a non-CFC refrigerant. Its temperature/pressure relationship makes it suitable for mobile air conditioning systems.

Effect of Pressure on Boiling or Condensation

As refrigerant passes through an air conditioning system, it flows under high-pressure conditions. , It expands to a low-pressure vapor between the evaporator orifice and the refrigerant return port in the refrigerant compressor. As pressures in the closed refrigerant circuit vary, temperatures will also vary. As pressure increases, temperatures also increase; as the pressure decreases, temperatures also decrease:

- First, as a high-pressure vapor between the refrigerant compressor and the condenser
- Then, as a high-pressure liquid between the condenser and the evaporator orifice.

Description of Components

Binary Switch

Located on the liquid line from the receiver-drier, the binary switch disengages the refrigerant compressor to protect it from harmful operating conditions. It performs two functions:

- If the refrigerant system pressure is too low, the binary switch will keep the compressor from operating. The switch disengages the compressor when the pressure on the high pressure side of the system falls to 27 to 35 psig (186 to 241 kPa). Normal compressor operation resumes when the rising pressure reaches 28 to 36 psig (193 to 248 kPa) above the shutoff pressure. This occurs when the ambient temperature falls to around 31 to 40°F (–0.56 to 4°C) or when refrigerant has leaked out of the system.
- If the refrigerant system pressure on the high-pressure side increases to 427 to 484 psig (2944 to 3337 kPa), the binary switch shuts off the compressor clutch. Too much pressure may be caused by excess refrigerant in the system, or anything that causes poor condenser performance, such as poor air flow through the condenser. When the system pressure has decreased to 313 to 426 psig (2158 to 2937 kPa), the compressor resumes operation.

NOTE: Since the binary switch is on the high-pressure side, the compressor may continue to operate (trying to cool the cab) if most, but not all, of the refrigerant leaks out of the system, until the air conditioner is turned off or the vehicle is shut down for a short time. Continuing to run the compressor with a low charge can lead to a lack of lubrication and high temperatures in the compressor.

Blower Motor

The brushless blower motor forces air through the HVAC assembly, and through the duct work.

Condenser

A condenser turns hot refrigerant gas coming from the compressor into liquid. The condenser is mounted either in front of, or below the radiator. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan and by air that is forced into the engine compartment as the vehicle moves forward.

Electric Actuator

The electric actuator is a combined motor and gearbox and is used to drive the levers and doors within the HVAC assembly. Movement of the levers and doors is controlled by the settings on the climate control panel. There are three actuators on the HVAC assembly: a temperature actuator, a recirculation actuator, and a mode actuator.

Evaporator

Because the evaporator is an area of low-pressure in the system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the evaporator and drains off as water; the air becomes dehumidified.

Evaporator Temperature Sensor

The temperature of the evaporator is monitored by the evaporator temperature sensor.

The evaporator temperature sensor is in front of the evaporator. The temperature sensor disengages the compressor to prevent the evaporator from freezing up due to, for example, an expansion valve that is stuck open.

Expansion Valve

The expansion valve is a dividing point between the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the condenser passes through the expansion valve and moves into the low-pressure area of the evaporator.

An expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator drops off, the temperature of the gas going to the compressor rises. This causes a diaphragm in the expansion valve to react, which causes an orifice in the valve to open or close. Through the orifice, liquid refrigerant is metered into the evaporator as needed.

Fan Cycling Switch

Located on the junction block liquid line, the fan cycling switch sends a ground signal to the ECM (engine control module) to keep the fan off and take away the ground to engage the fan. The fan will come on if refrigerant pressure is greater than 300 ± 10 psi (2070 ± 69 kPa). The fan turns off when pressure drops below 250 ± 10 psi (1725 ± 69 kPa) and the engine ECU timer (0 to 180 seconds) has expired.

Heater Core

When the engine is on, coolant flows through the heater core tubes heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Receiver-Drier

Used as a reservoir and filter for liquid refrigerant from the condenser, a receiver-drier also removes water and acids from the refrigerant. The water-absorbing material, or desiccant, in the unit helps stop blockages from forming in the expansion valve, and in other parts of the system.

Refrigerant

Refrigerant absorbs heat from the air in the cab and releases it to the air outside the cab.

In an open container, refrigerants boil at temperatures below the freezing point of water. Sealing and pressurizing refrigerant in the air conditioning system raises its boiling-point temperature.

During refrigerant compressor operation, refrigerant constantly changes from a liquid to a gas. It absorbs heat (boiling) in the low-pressure evaporator and it changes from a gas to a liquid as it releases absorbed heat in the high-pressure condenser.

Refrigerant Compressor

Heat in the low-pressure gas of the evaporator is not heat that can be noticed by touch because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By touch, the heated gas in the evaporator is very cold. As a result, there is the problem of how to remove heat from cool gas using outside air that may be higher than 100°F (38°C).

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air without adding heat.

Another function of the compressor is to move refrigerant through the system.

Definition of Terms

Refer to the following terms for a better understanding of the heater and air-conditioning system.

Air Conditioner A system used to control the temperature, humidity, and movement of air in the cab.

Ambient Air Temperature The temperature of air around an object, or the outside temperature.

General Information

Binary Switch Disengages the refrigerant compressor to protect it from harmful operating conditions.

Blower Motor A brushless blower motor forces air through the HVAC assembly and through the duct work.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Charge A specific amount of refrigerant or oil by volume or weight. Also the act of placing an amount of refrigerant or oil in the air conditioning system.

Condensate Water taken from the air, which forms on the outer surface of the evaporator.

Condenser A heat exchanger that is used to remove heat from the refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid. Typically the condenser is mounted in front of the radiator.

Condensing Pressure Pressure as read from the gauge at the discharge service valve. Pressure from the discharge side of the compressor into the condenser.

Contaminants Anything other than refrigerant or refrigerant oil in the system. Usually means water, dirt, or air in the system.

Cycling Clutch System A system which controls compressor clutch operation in order to raise or lower the temperature in the cab.

Dehumidify To remove water from the air at the evaporator.

Dehydrate To remove all traces of moisture from the refrigerant system. This process occurs during evacuation.

Desiccant A drying agent used in the receiver-drier to remove water and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure High-side pressure or condensing pressure being discharged from the compressor.

Drive Pulley A pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Duct A passageway for the transfer of air from one area to another.

Electric Actuator The actuator is a combined motor and gearbox used to drive the temperature control doors and the air selection mode door within the HVAC assembly.

Evacuate To place a high vacuum in the air-conditioning system and dehydrate or remove all traces of moisture.

Evaporate To change state from a liquid to a gas.

Evaporator A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. It also removes some moisture from the air.

Expansion Valve A device that causes a pressure-drop of the refrigerant and also regulates its flow.

Flooding A condition caused by too much liquid refrigerant going into the evaporator, usually caused by an expansion valve that is stuck open.

Flushing A process of passing liquid refrigerant through an air-conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt buildup.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator.

Heater Core A part of the heating system in which hot engine coolant flows to provide heat to the cab or to adjust the temperature produced by the air conditioner.

High-Pressure Switch Located on the discharge side of the refrigerant compressor, the high-pressure switch signals the fan on and the refrigerant compressor off in the event of a high-pressurecondition.

High-Side Service Valve A device located on the liquid line. It allows high-side pressure to be checked and other service operations to be performed.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Liquid Pressure Pressure of refrigerant in the liquid line from the receiver-drier to the thermostatic expansion valve.

Low Head Pressure High-side pressure that is lower than normal due to a system problem.

Low-Pressure Switch Located on the suction side of the refrigerant compressor, the low-pressure switch signals the clutch to cycle or shut down in extremely cold temperatures, or if there is a loss of charge.

Low Suction Pressure Low-side pressure that is lower than normal due to a system problem.

Magnetic Clutch An electrical coupling device used to engage or disengage the compressor.

Manifold A device to control refrigerant flow for system test purposes. It is used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

Manifold Gauge Set A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

Micron A metric unit of length equal to one-millionth of a meter. The unit of measure used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Nitrogen A colorless, odorless, dry, inert gas.

Opacity A condition that is used to describe contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

Polyalkylene Glycol (PAG) A highly refined, synthetic oil that is used in R–134a air conditioning systems.

Polyol Ester (POE) A highly refined, synthetic oil that is used in R–134a air conditioning systems.

psia Pounds per square inch, absolute pressure. Pressure exerted by the air at sea level. Atmospheric pressure is usually measured with a mercury barometer.

psig Pounds per square inch, gauge pressure. Any pressure above normal atmospheric pressure (14.7 psi) is referred to as gauge pressure.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Recovery Removal of the refrigerant from air conditioning systems.

Recycling Removal of contaminants and moisture from R–134a using a recovery and recycling station.

Refrigerant–134a (R–134a) The cooling agent used in automotive air conditioning systems. The chemical name for R–134a is tetrafluoroethane.

Refrigerant Compressor A device used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. A second purpose of the compressor is to move refrigerant through the system.

Refrigeration Cycle The complete circulation of refrigerant through an air conditioning system accompanied by changes in temperature and pressure.

Relative Humidity The actual water content of the air in relation to the total water vapor the air can hold at a given temperature.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure or the system’s low-side pressure.

Suction Service Valve A device that allows low-side pressure to be checked and other service operations to be performed.

Suction Side The low-pressure area of the system extending from the expansion valve to the compressor inlet.

Thermistor A vacuum pressure sensor that is used to measure, in microns of mercury, internal system vacuum levels after evacuation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron of mercury with scales reading from 25,000 microns to 1 micron of mercury.

Undercharge A system low on refrigerant resulting in lack of cooling and possible compressor damage.

Vacuum Refers to pressure that is less than atmospheric pressure.

Vacuum Pump A mechanical device used to evacuate and place a high vacuum in the refrigerant system.

General Information

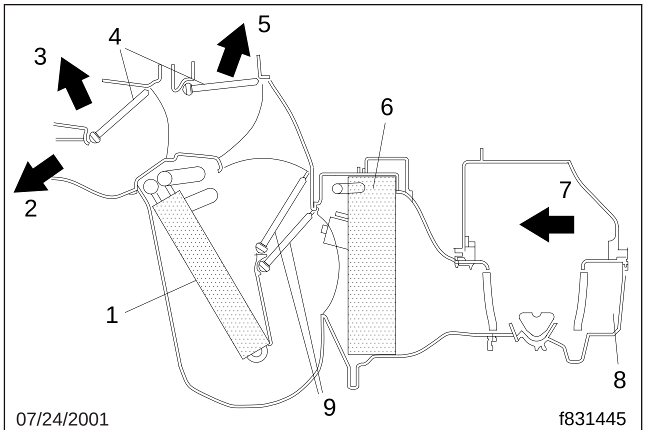
Vacuum Pump Oil Water-soluble oil used in some vacuum pumps, to absorb moisture from the refrigerant system.

Vapor The gaseous state of a material.

Principles of Operation

In a Blend Air HVAC system, the heater core is always filled with warm or hot coolant. Air enters the HVAC assembly through the blower and is always directed through the evaporator. If the refrigerant compressor is engaged, the air is cooled. The temperature control doors then direct the air through or around the heater core depending on the climate control settings. The temperature control doors are used to blend the correct amount of cold and hot air to achieve the selected temperature. The temperature control door, the air selection mode door, and the recirculation door are controlled by electric actuators. See **Fig. 1**.

The brushless blower motor does not have a resistor. Its speed is controlled by a built-in power module.



1. Heater Core
2. Floor Outlet
3. Defrost Outlet
4. Air Selection Mode Door
5. Face Outlet
6. Evaporator Core
7. Recirculation Air Inlet
8. Blower
9. Temperature Control Doors

Fig. 1, Cab Heater and Air Conditioner Unit

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come in contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer’s instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the PAG oil container to air for more than five minutes. PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix PAG oil with other types of refrigerant oil.

Heater Core Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Drain the coolant from the cooling system. For instructions, see **Section 20.01**, Subject 100.
4. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin
    - console cover
    - dash trim cap
    - upper dash assembly, center panel
5. Remove the tie straps on the wiring harness as needed to access the heater core.
6. Remove the capscrew that attaches the right side of the shield to the HVAC assembly. Move the shield to access the heater core. See **Fig. 2**.
7. Remove the capscrews that attach the lower duct to the HVAC assembly and remove the lower duct.
8. Remove the capscrews that attach the heater core service cover to the HVAC assembly and remove the service cover. See **Fig. 3**.
9. Remove the air cleaner. For instructions, see **Section 09.01**.
10. Remove the hose clamps that attach the heater hoses to the heater core tubes. Remove the heater hoses.
11. Remove the heater core retaining plate. See **Fig. 4**.

    11.1 Remove the capscrew that attaches the heater core retaining plate to the front-wall.

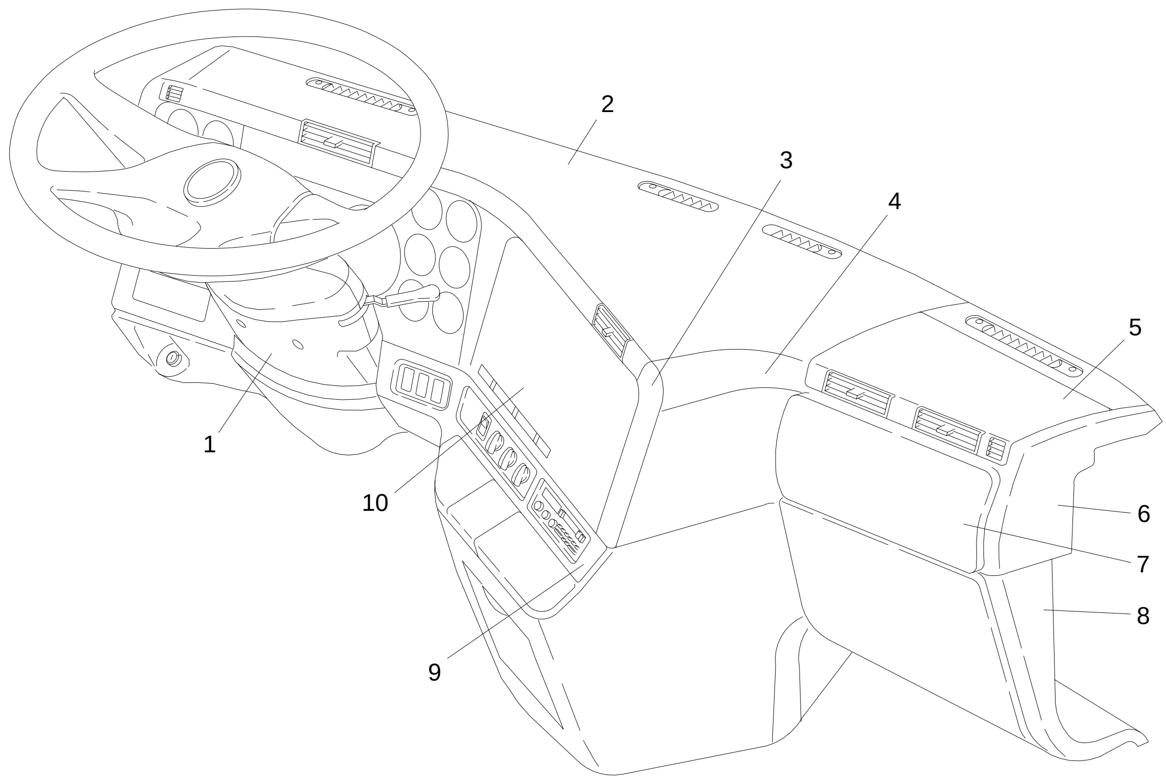
    11.2 Remove and set aside the no-drip tape from around the heater core tubes.

    11.3 Pull on the tab to remove the retaining plate.
12. From inside the cab, remove the heater core.
13. Install a new heater core in the HVAC assembly. Push the heater core into the HVAC assembly until the heater core makes contact with the far side of the HVAC assembly.
14. Using a capscrew, attach the heater core retaining plate to the frontwall.
15. Install the no-drip tape around the heater core tubes at the retaining plate.
16. Using hose clamps, attach the heater hoses to the heater core tubes.

NOTE: Make sure that the string seal is in the groove on the lower portion of the heater core service cover before installing the service cover.

17. Using capscrews, install the heater core service cover on the HVAC assembly.
18. Using capscrews, attach the lower duct to the HVAC assembly.
19. Using a capscrew, attach the shield to the HVAC assembly.
20. If needed, use tie straps to bundle the wiring harnesses.
21. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
22. Install the air cleaner. For instructions, see **Section 09.01**.
23. Fill the cooling system with coolant. For instructions, see **Section 20.01**, Subject 100.
24. Connect the batteries.
25. Remove the chocks from the tires.

Heater Core Replacement



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Columbia Dash Panels

Heater Core Replacement

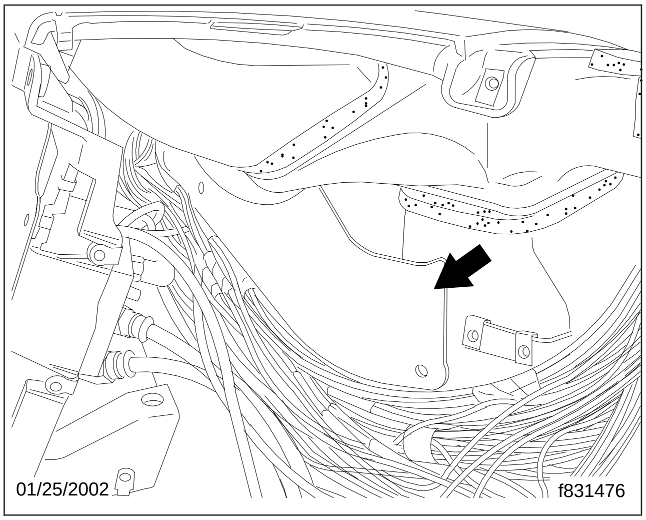
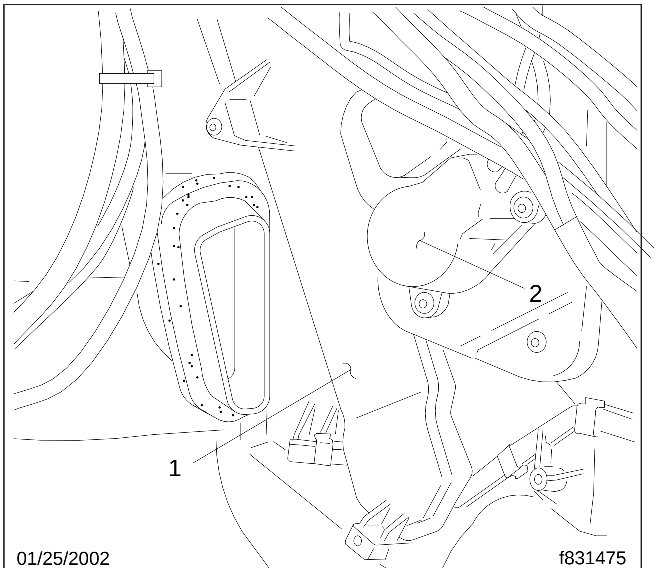
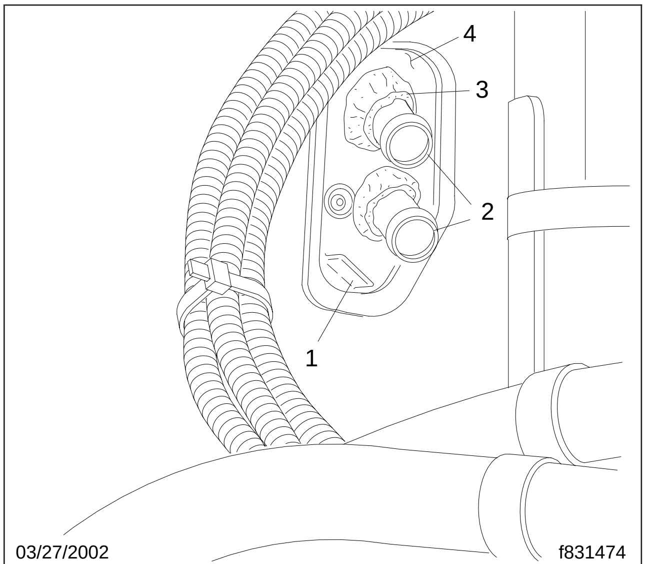


Fig. 2, Shield



1. Heater Core Service Cover
2. Temperature Actuator

Fig. 3, Heater Core Service Cover



1. Tab
2. Heater Core Tubes
3. No-Drip Tape
3. Heater Core Retaining Plate

Fig. 4, Heater Core Tubes

Evaporator Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - upper dash cover
   - heater and air conditioner cover
   - waste bin
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
5. Remove the tie straps on the wiring harness as needed to access the evaporator.
6. Disconnect the electrical connector from the evaporator temperature sensor. See **Fig. 2**.
7. Remove the capscrews that attach the evaporator service cover to the HVAC assembly.
8. Remove the air cleaner. For instructions, see **Section 09.01**.
9. Remove the expansion valve and refrigerant lines. See **Fig. 3**.

   9.1 Remove the capscrew that attaches the lower retaining plate and the refrigerant lines to the expansion valve. Remove the refrigerant lines and the retaining plate. Remove and discard the Mini Stat-O-Seals and quickly cap the lines.

   IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

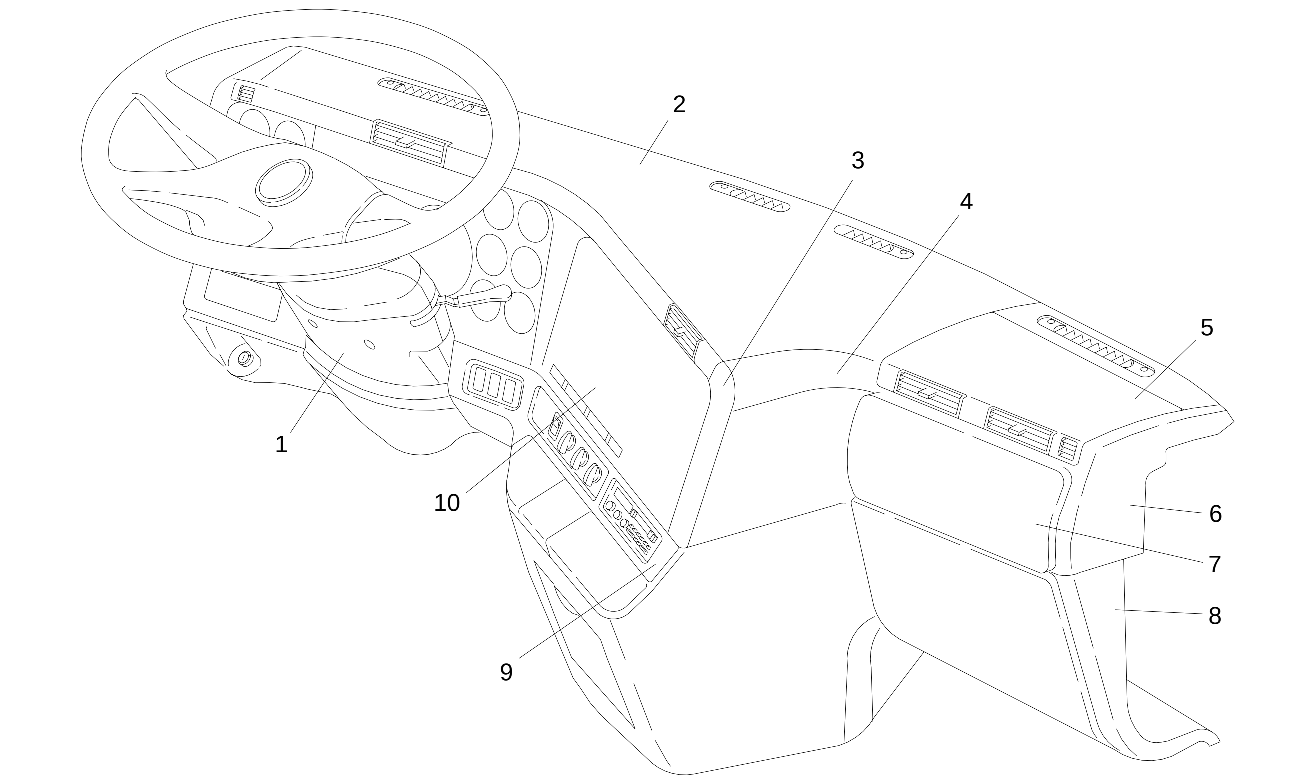
   9.2 Remove the capscrews that attach the upper retaining plate and the expansion valve to the evaporator refrigerant lines. Remove the retaining plate and the expansion valve. Remove and discard the Mini Stat-O-Seals.
10. Remove and set aside the no-drip tape from around the evaporator refrigerant lines at the plate. See **Fig. 4**.
11. Remove the capscrews that attach the plate that fits around the evaporator refrigerant lines to the frontwall. Remove the plate.
12. From inside the cab, remove the evaporator.
13. Install a new evaporator in the HVAC assembly. Press firmly on the evaporator until it makes contact with the far wall of the HVAC assembly.

NOTE: Make sure that the string seal is in the groove on the lower portion of the evaporator service cover before installing the service cover.

14. Using capscrews, install the evaporator service cover on the HVAC assembly. Make sure that the evaporator service cover is correctly seated to the HVAC assembly.
15. Connect the electrical connector to the evaporator temperature sensor.
16. If needed, use tie straps to bundle the wiring harnesses.
17. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
18. Using capscrews, attach the plate that fits around the evaporator refrigerant lines to the frontwall.
19. Install the no-drip tape around the evaporator refrigerant lines at the plate.
20. Install the expansion valve and refrigerant lines.

    IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

Evaporator Replacement



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Columbia Dash Panels

20.1 Install new Mini Stat-O-Seals on the evaporator refrigerant lines.

20.2 Using capscrews and the upper retaining plate, attach the expansion valve to the evaporator refrigerant lines. Torque the capscrews 35 lbf·in (395 N·cm).

20.3 Install new Mini Stat-O-Seals on the lower refrigerant lines.

20.4 Using a capscrew and the lower retaining plate, attach the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).

21. Install the air cleaner. For instructions, see **Section 09.01**.

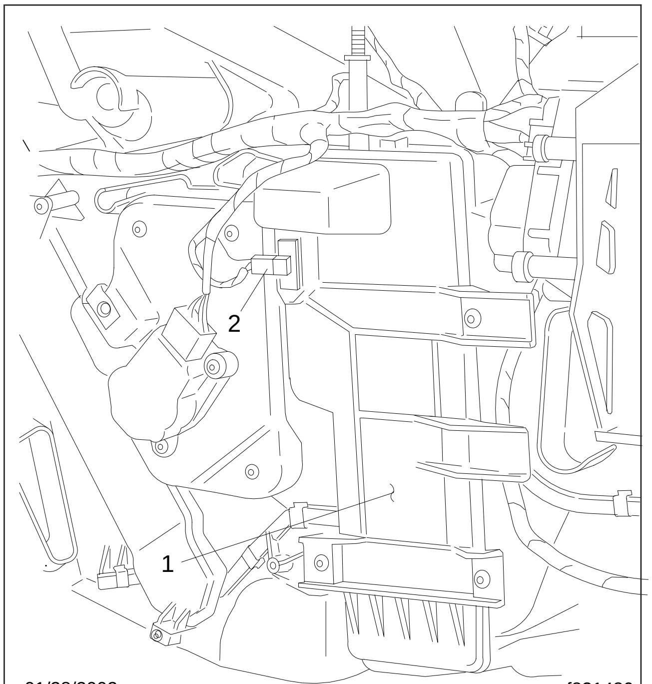
22. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. For instructions, see the applicable refrigerant compressor section in **Group 83**.

23. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.

24. Connect the batteries.

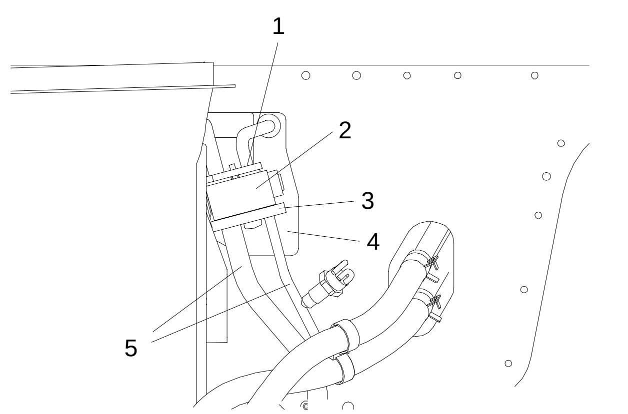
25. Remove the chocks from the tires.

Evaporator Replacement



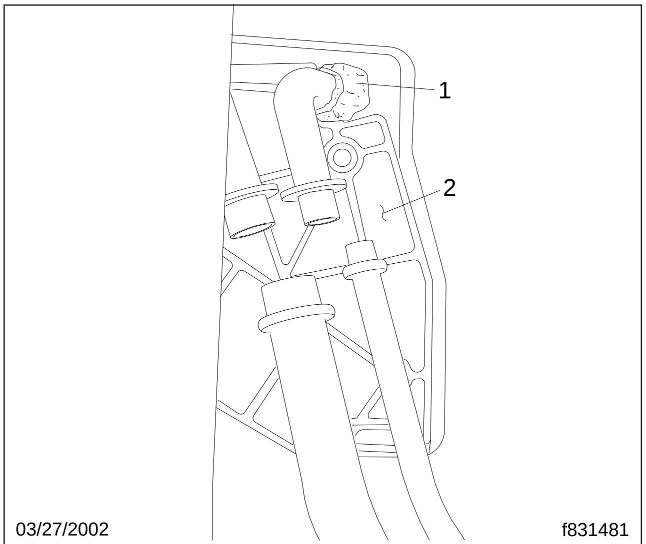
1. Evaporator Service Cover
2. Evaporator Temperature Sensor

Fig. 2, Evaporator Service Cover



1. Upper Retaining Plate
2. Expansion Valve
3. Lower Retaining Plate
4. Plate
5. Refrigerant Line

Fig. 3, Expansion Valve



1. No-Drip Tape
2. Plate

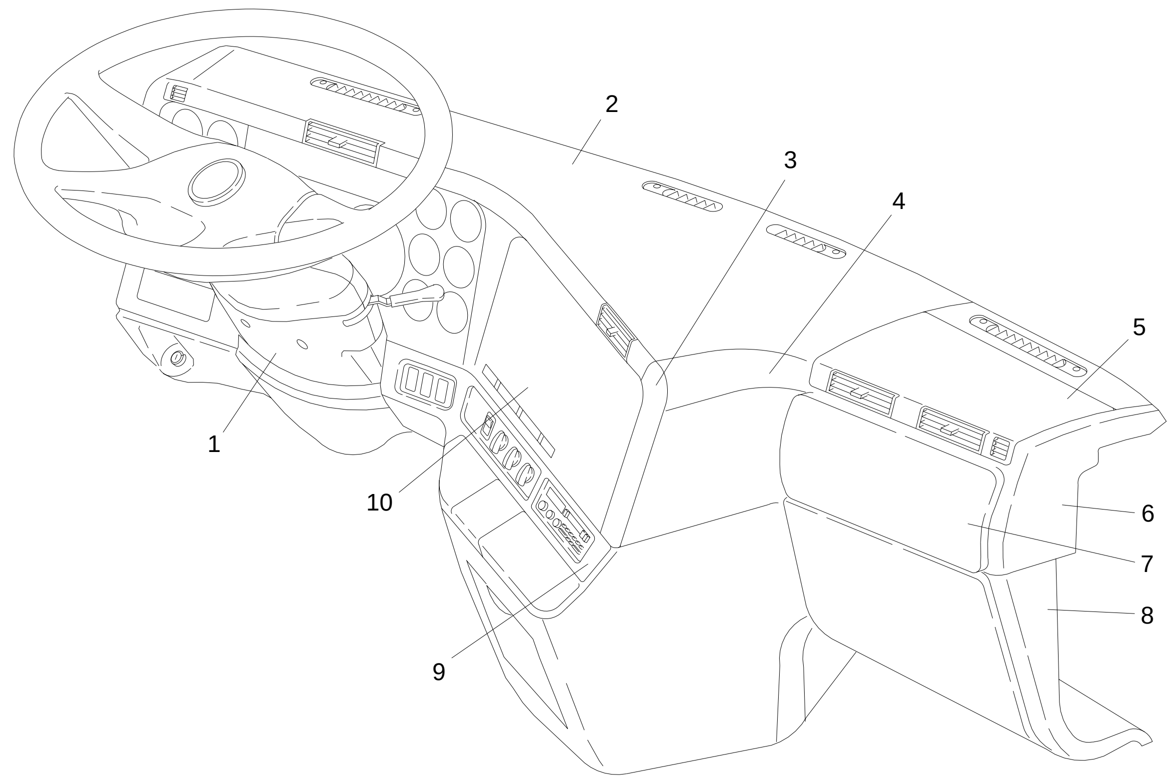
Fig. 4, Plate

Evaporator Temperature Sensor Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the upper dash cover and the heater and air conditioner cover. See **Fig. 1**. For instructions, see **Section 60.08**.
3. Pull the evaporator temperature sensor out of the evaporator. See **Fig. 2**.
4. Disconnect the electrical connector from the temperature sensor.
5. Connect the electrical connector to the new temperature sensor.
6. Install the evaporator temperature sensor in the evaporator.
7. Install the upper dash cover and the heater and air conditioner cover. For instructions, see **Section 60.08**.
8. Remove the chocks from the tires.

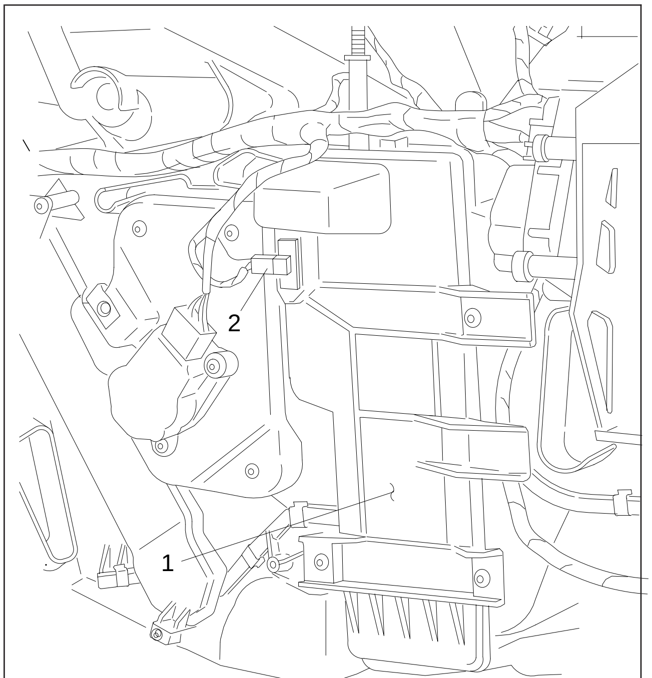
Evaporator Temperature Sensor Replacement



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Columbia Dash Panels

Evaporator Temperature Sensor Replacement



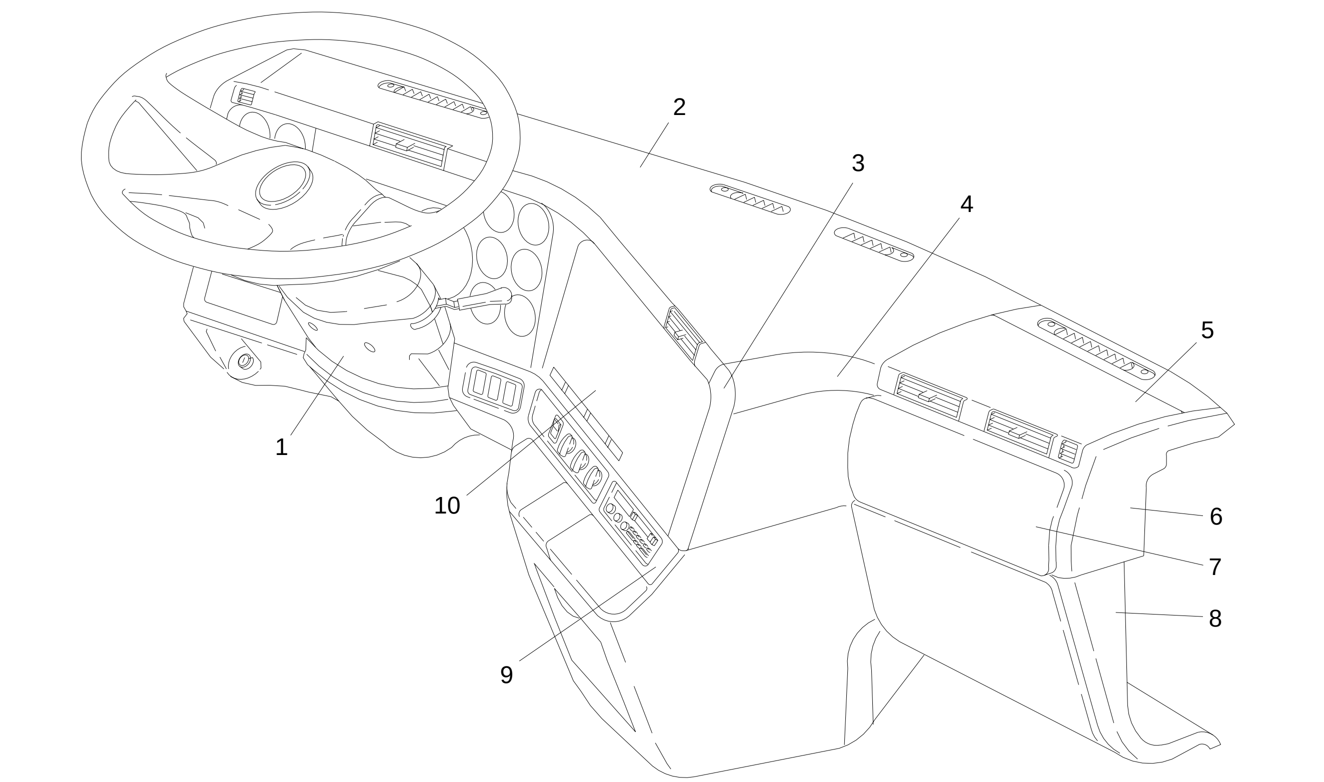
1. Evaporator Service Cover
2. Evaporator Temperature Sensor

Fig. 2, Evaporator Temperature Sensor

Blower Motor Replacement

Replacement

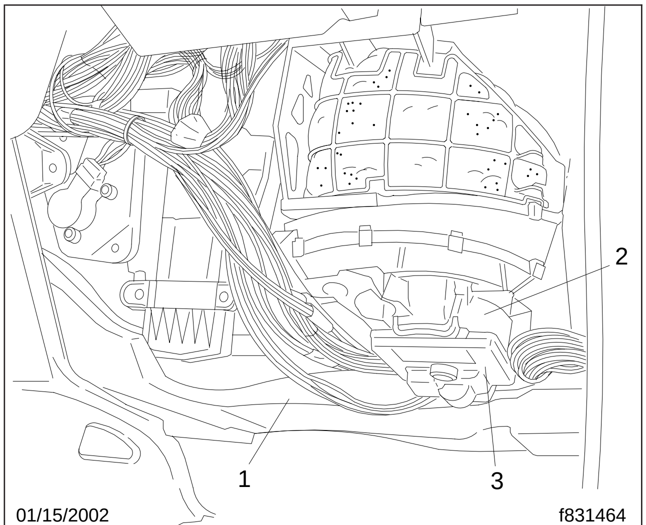
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the upper dash cover and the heater and air conditioner cover. See **Fig. 1**. For instructions, see **Section 60.08**.
4. Remove the capscrews that attach the lower duct to the HVAC assembly and remove the lower duct. See **Fig. 2**.
5. Remove the capscrews that attach the blower motor to the HVAC assembly.
6. Disconnect the electrical connector from the blower motor and remove the blower motor.
7. Connect the electrical connector to the new blower motor.
8. Using capscrews, install the blower motor on the HVAC assembly.
9. Using capscrews, attach the lower duct to the HVAC assembly.
10. Install the heater and air conditioner cover and the upper dash cover. For instructions, see **Section 60.08**.



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Columbia Dash Panels

Blower Motor Replacement



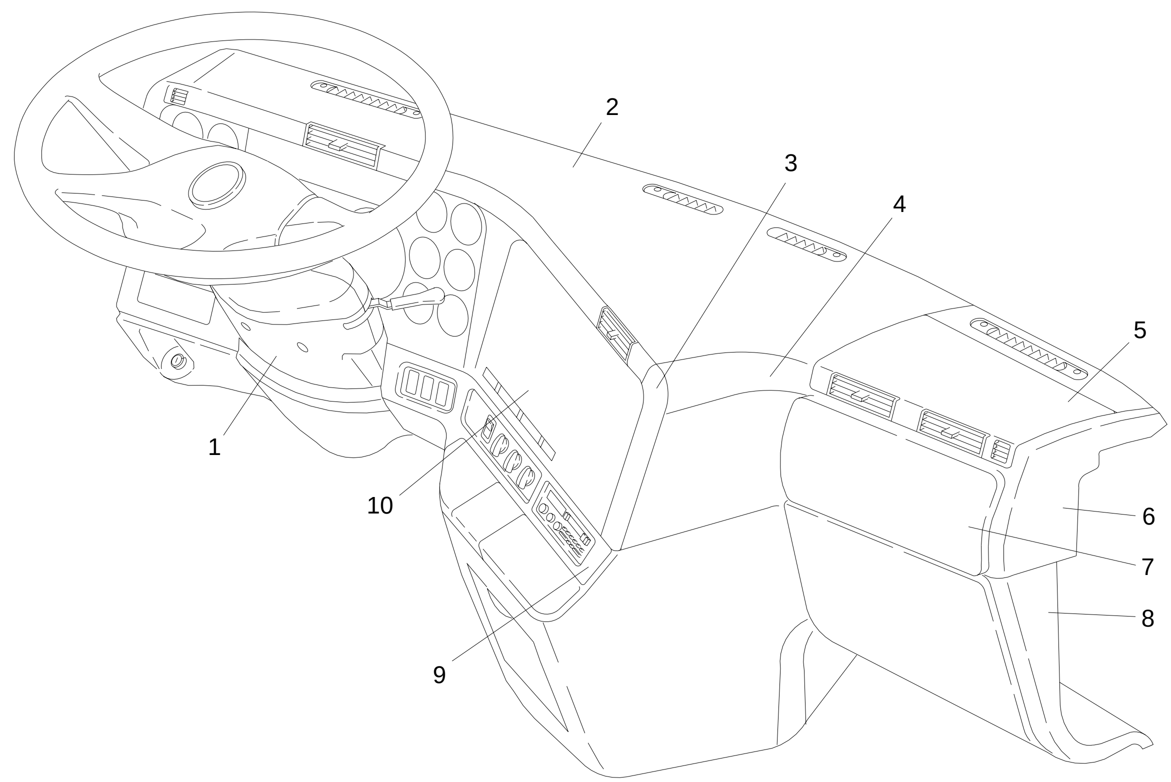
1. Lower Duct
2. Blower Motor
3. Blower Motor Wiring Harness

Fig. 2, Blower Motor

11. Connect the batteries.
12. Remove the chocks from the tires.

Temperature Actuator Replacement

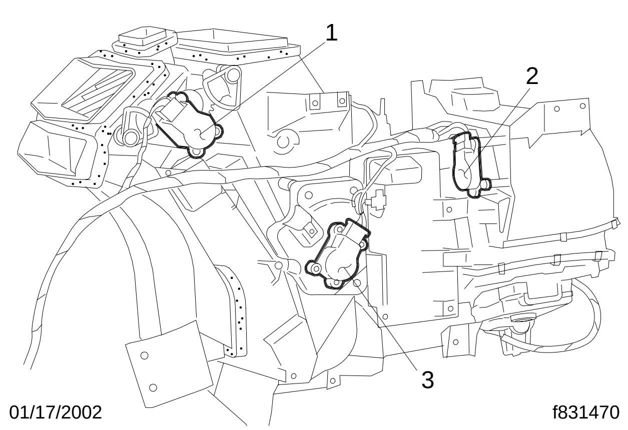
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the upper dash cover and the heater and air conditioner cover. See **Fig. 1**. For instructions, see **Section 60.08**.
3. Remove the capscrews that attach the temperature actuator to the HVAC assembly. See **Fig. 2**.
4. Disconnect the electrical connector from the actuator and remove the actuator.
5. Connect the electrical connector to the new actuator.
6. Align the actuator to the keyed shaft on the door.
7. Using capscrews, attach the actuator to the HVAC assembly.
8. Install the heater and air conditioner cover and the upper dash cover. For instructions, see **Section 60.08**.
9. Manually calibrate the HVAC system after the actuator has been replaced.



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Columbia Dash Panels

Actuator Replacement



1. Mode Actuator
2. Recirculation Actuator
3. Temperature Actuator

Fig. 2, Actuators

9.1 Turn the ignition key to the on position, but keep the engine off.

9.2 Turn the fan switch to the off position.

9.3 Turn the air selection switch to the full defrost mode.

9.4 Turn the temperature control switch to the full hot position.

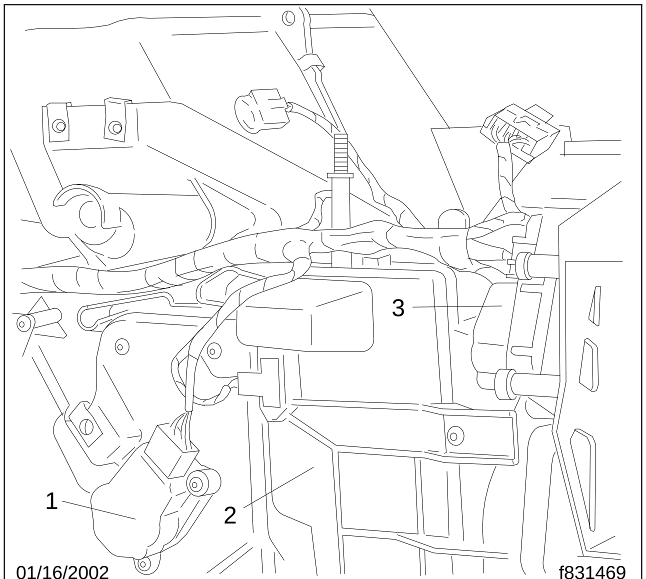
9.5 Press and hold the recirculation and air conditioning buttons for five seconds.

9.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.

10. Remove the chocks from the tires.

Recirculation Actuator Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - upper dash cover
   - heater and air conditioner cover
   - waste bin
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
3. Remove the tie straps on the wiring harnesses as needed to access the capscrews on the recirculation actuator. It may also be necessary to remove the evaporator service cover to access the actuator mounting hardware. See **Fig. 3**.



1. Temperature Actuator
2. Evaporator Service Cover
3. Recirculation Actuator

Fig. 3, Recirculation Actuator

NOTE: If the evaporator service cover is removed, make sure that the string seal is in the groove on the lower portion of the evaporator service cover before installing the service cover.

4. Remove the capscrews that attach the recirculation actuator to the HVAC assembly.
5. Remove the arm from the back of the actuator. Disconnect the electrical connector from the actuator and remove the actuator.

6. Connect the electrical connector to the new actuator.
7. Attach the arm to the back of the actuator and align the actuator to the keyed shaft on the door.
8. Using capscrews, attach the actuator to the HVAC assembly.
9. If needed, use tie straps to bundle the wiring harnesses.
10. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
11. Manually calibrate the HVAC system after the actuator has been replaced.
    - 11.1 Turn the ignition key to the on position, but keep the engine off.
    - 11.2 Turn the fan switch to the off position.
    - 11.3 Turn the air selection switch to the full defrost mode.
    - 11.4 Turn the temperature control switch to the full hot position.
    - 11.5 Press and hold the recirculation and air conditioning buttons for five seconds.
    - 11.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.
12. Remove the chocks from the tires.

Mode Actuator Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin
    - console cover
    - dash trim cap
    - upper dash assembly, center panel
3. If needed, remove the capscrew that attaches the shield to the HVAC assembly and move the shield to access the mode actuator. See **Fig. 4**.

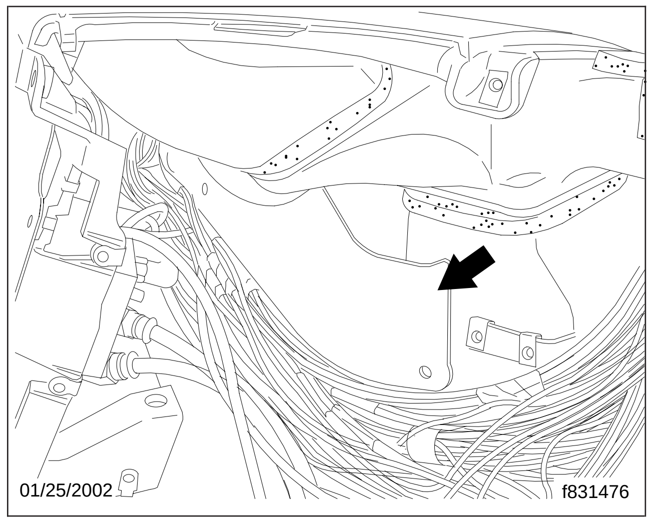


Fig. 4, Shield

4. Remove the capscrews that attach the mode actuator to the HVAC assembly. See **Fig. 2**.
5. Disconnect the electrical connector from the actuator and remove the actuator.
6. Connect the electrical connector to the new mode actuator.
7. Align the actuator to the keyed shaft on the door.
8. Using capscrews, attach the mode actuator to the HVAC assembly.
9. If the shield was moved, move the shield back in place and use a capscrew to attach the shield to the HVAC assembly.

Actuator Replacement

10. Install the dash panels listed below. For instructions, see Section 60.08.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
11. Manually calibrate the HVAC system after the actuator has been replaced.

    11.1 Turn the ignition key to the on position, but keep the engine off.

    11.2 Turn the fan switch to the off position.

    11.3 Turn the air selection switch to the full defrost mode.

    11.4 Turn the temperature control switch to the full hot position.

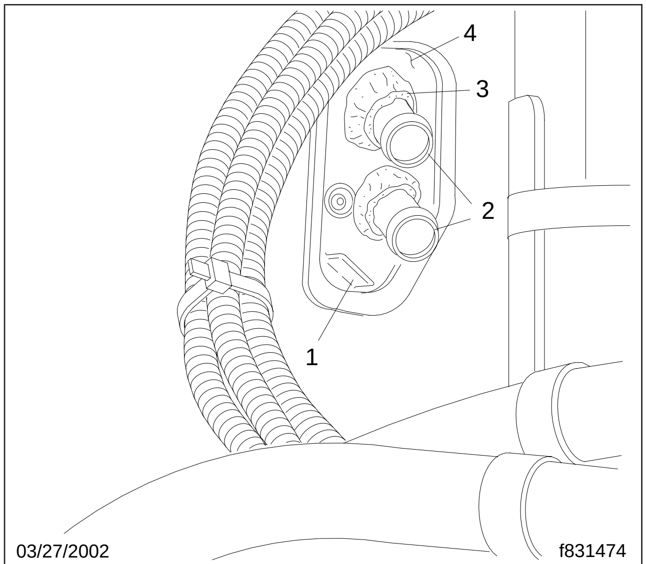
    11.5 Press and hold the recirculation and air conditioning buttons for five seconds.

    11.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.
12. Remove the chocks from the tires.

Heater and Air Conditioner Assembly Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the air cleaner. For instructions, see **Section 09.01**.
4. Drain the coolant from the cooling system. For instructions, see **Section 20.01**, Subject 100.
5. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
6. Remove the hose clamps that attach the heater hoses to the heater core tubes. Disconnect the heater hoses. See **Fig.1**.
7. Remove the heater core retaining plate. See **Fig.1**.



1. Tab
2. Heater Core Tubes
3. No-Drip Tape
4. Heater Core Retaining Plate

Fig. 1, Heater Core Tubes

7.1 Remove the capscrew that attaches the heater core retaining plate to the frontwall.

7.2 Remove and set aside the no-drip tape from around the heater core tubes.

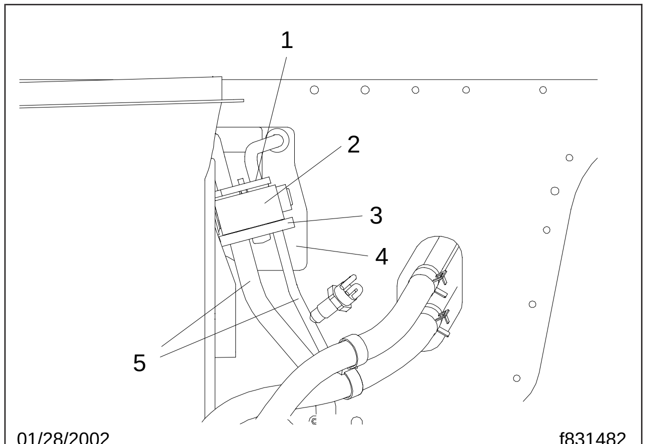
7.3 Pull on the tab to remove the retaining plate.

8. Remove the expansion valve and refrigerant lines.

8.1 Remove the capscrew that attaches the lower retaining plate and the refrigerant lines to the expansion valve. Remove the refrigerant lines and retaining plate. Remove and discard the Mini Stat-O-Seals and quickly cap the lines. See **Fig.2**.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

8.2 Remove the capscrews that attach the upper retaining plate and the expansion valve to the evaporator refrigerant lines. Remove the retaining plate and the expansion valve. Remove and discard the Mini Stat-O-Seals.

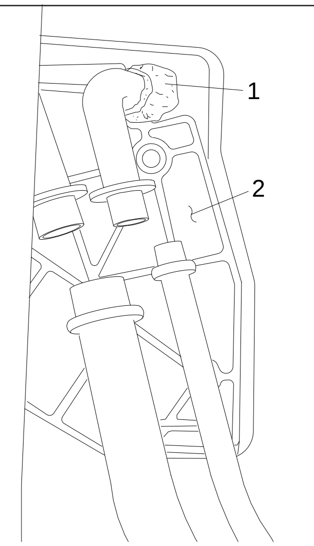


1. Upper Retaining Plate
2. Expansion Valve
3. Lower Retaining Plate
4. Plate
5. Refrigerant Line

Fig. 2, Expansion Valve

9. Remove the capscrews that attach the plate that fits around the evaporator refrigerant lines to the frontwall. Remove the plate. See **Fig.3**.

Heater and Air Conditioner Assembly Replacement



1. No-Drip Tape 2. Plate

Fig. 3, Plate

10. Remove the dash panels listed below. See **Fig.4**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin
    - console cover
    - dash trim cap
    - upper dash assembly, center panel
    - left-side upper dash assembly
11. Remove the capscrew on the wiring harness channel that attaches the channel to the temperature control cover. Remove the plastic fastener that attaches the channel to the HVAC assembly.
12. Remove the capscrews that attach the ducts to the HVAC assembly and remove the ducts.
13. Remove the nuts that attach the power distribution module (PDM) to the HVAC assembly.
14. Disconnect the wiring harnesses from the PDM as necessary.
15. Disconnect the power and communication wiring harnesses from the HVAC wiring harness.
16. From the engine side of the frontwall, remove the nut that attaches the HVAC assembly to the frontwall.
17. Remove the hose clamp that attaches the drain hose to the drain tube and remove the drain hose.
18. From inside the cab, remove the capscrews, nuts, and washers that attach the HVAC assembly to the frontwall and remove the assembly.
19. Using a nut, attach a new HVAC assembly to the engine side of the frontwall. Torque the nut 9 to 11 lbf·ft (12 to 15 N·m).
20. From inside the cab, use capscrews, nuts, and washers to attach the HVAC assembly to the frontwall. Torque the nuts and capscrews 9 to 11 lbf·ft (12 to 15 N·m).
21. Using capscrews, attach the plate that fits around the evaporator refrigerant lines to the frontwall.
22. Install the expansion valve and the refrigerant lines.

    IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

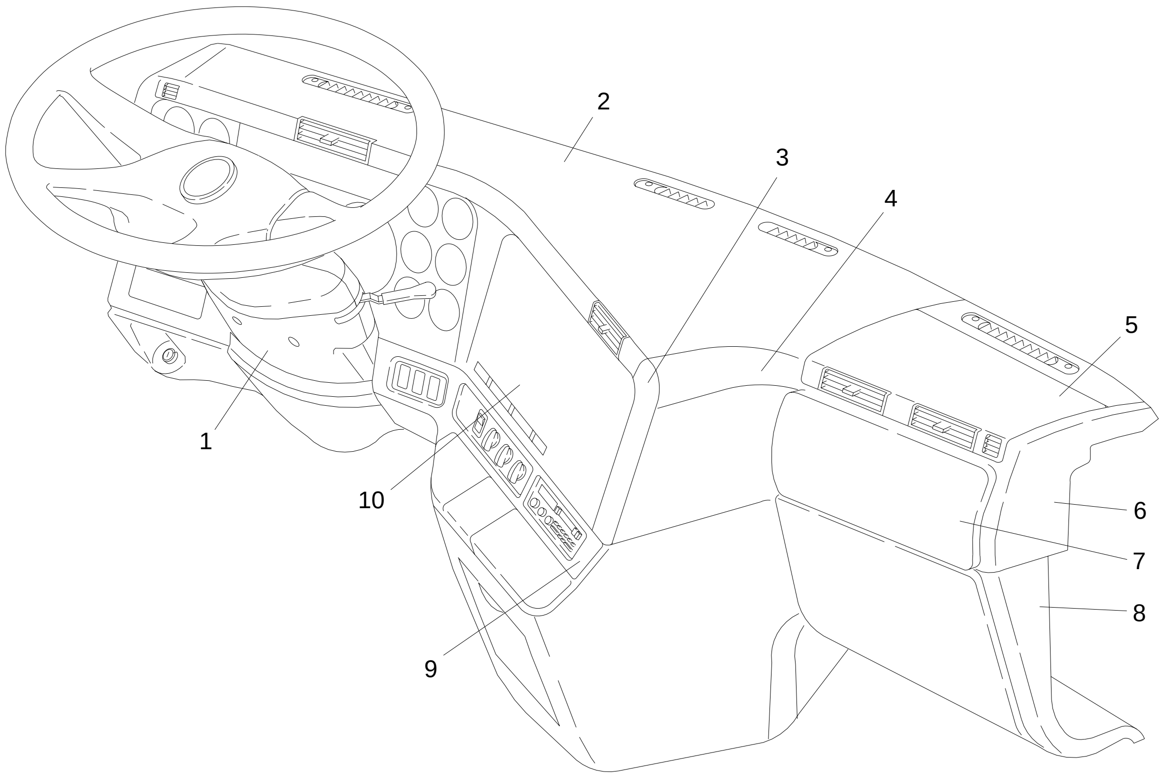
    22.1 Install new Mini Stat-O-Seals on the evaporator refrigerant lines.

    22.2 Using capscrews and the upper retaining plate, attach the expansion valve to the evaporator refrigerant lines. Torque the capscrews 35 lbf·in (395 N·cm).

    22.3 Install new Mini Stat-O-Seals on the lower refrigerant lines.

    22.4 Using a capscrew and the lower retaining plate, attach the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).
23. Using a capscrew, attach the heater core retaining plate to the frontwall.
24. Install the no-drip tape around the heater core tubes at the retaining plate.
25. Using hose clamps, attach the heater hoses to the heater core tubes.
26. Using a hose clamp, attach the drain hose to the drain tube.

Heater and Air Conditioner Assembly Replacement



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1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 4, Columbia Dash Panels

27. Install the air cleaner. For instructions, see **Section 09.01**, Subject 110.
28. Connect the wiring harnesses to the PDM as necessary.
29. Using nuts, attach the PDM to the HVAC assembly.
30. Move the wiring harness channel back in place, and use a capscrew to attach the channel to the temperature control cover. Using a plastic fastener, attach the channel to the HVAC assembly.
31. Connect the HVAC wiring harness to the power and communication wiring harnesses. If needed, use tie straps to bundle the wiring harnesses.
32. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - left-side upper dash assembly
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
33. Fill the cooling system with coolant. For instructions, see **Section 20.01**, Subject 100.

Heater and Air Conditioner Assembly Replacement

34. Be sure to add refrigerant oil to the compressor to replace the oil that is lost when the system is recovered. For instructions, see the applicable refrigerant compressor section in **Group 83**.
35. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.
36. Connect the batteries.
37. Calibrate the HVAC system after the HVAC assembly has been removed or replaced.
    - 37.1 Turn the ignition key to the on position, but keep the engine off.
    - 37.2 Turn the fan switch to the off position.
    - 37.3 Turn the air selection switch to the face mode.
    - 37.4 Turn the temperature control switch to the full hot position.
    - 37.5 Press and hold the recirculation button and the air conditioning button for five seconds.
    - 37.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.
38. Remove the chocks from the tires.

Expansion Valve Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Remove the air cleaner. For instructions, see **Section 09.01**.
5. Remove the expansion valve and refrigerant lines.

   5.1 Remove the capscrew that attaches the lower retaining plate and the refrigerant lines to the expansion valve. Remove the refrigerant lines and the retaining plate. Remove and discard the Mini Stat-O-Seals and quickly cap the lines. See **Fig. 1**.

   IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

   5.2 Remove the capscrews that attach the upper retaining plate and the expansion valve to the evaporator refrigerant lines. Remove the retaining plate and the expansion valve. Remove and discard the Mini Stat-O-Seals.

6. Install the expansion valve and refrigerant lines.

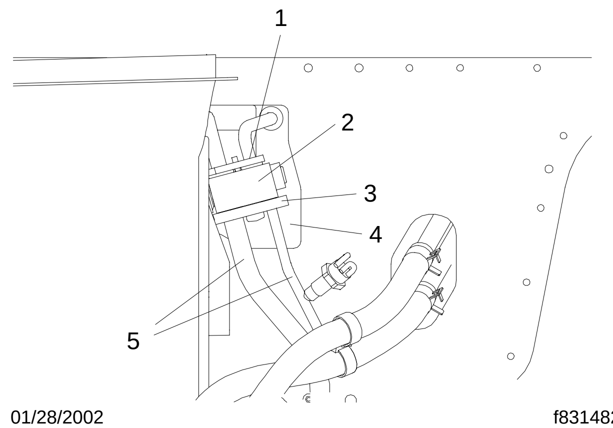
   IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

   6.1 Install new Mini Stat-O-Seals on the evaporator refrigerant lines.

   6.2 Using capscrews and the upper retaining plate, attach the new expansion valve to the evaporator refrigerant lines. Torque the capscrews 35 lbf·in (395 N·cm).

   6.3 Install new Mini Stat-O-Seals on the lower refrigerant lines.

   6.4 Using a capscrew and the lower retaining plate, attach the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).



1. Upper Retaining Plate
2. Expansion Valve
3. Lower Retaining Plate
4. Plate
5. Refrigerant Line

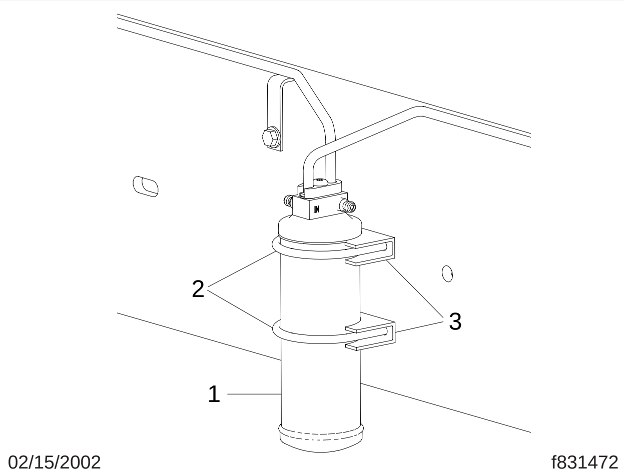
Fig. 1, Expansion Valve

7. Install the air cleaner. For instructions, see **Section 09.01**.
8. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. For instructions, see the applicable refrigerant compressor section in **Group 83**.
9. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.
10. Connect the batteries.
11. Remove the chocks from the tires.

Receiver-Drier Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Remove the capscrew that attaches the retaining plate and refrigerant lines to the receiver-drier. Disconnect the refrigerant lines from the receiver-drier and remove and discard the Mini Stat-O-Seals. Quickly cap the refrigerant lines. See **Fig. 1**.



1. Receiver-Drier
2. U-Bolt
3. Mounting Bracket

Fig. 1, Receiver-Drier

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

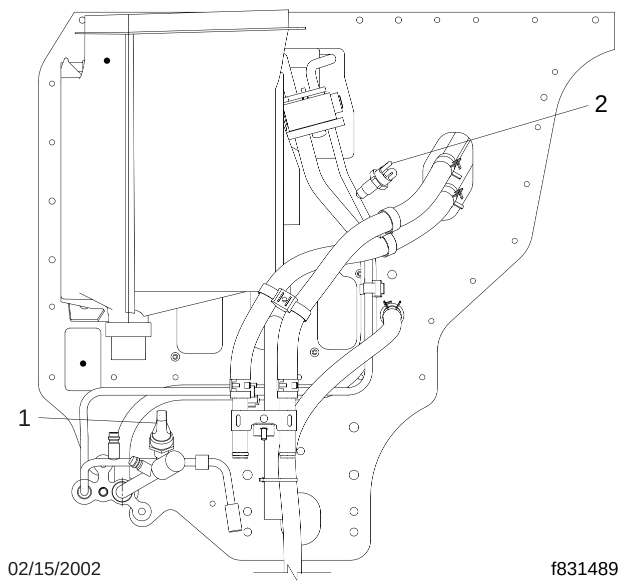
5. Remove the nuts and washers that attach the U-bolts and mounting brackets to the frame rail. Remove the receiver-drier. See **Fig. 1**.

IMPORTANT: If the desiccant cartridge inside the receiver-drier has fallen apart, flush the system and replace the expansion valve and the refrigerant compressor (desiccant matter can't be removed from these parts). A cartridge may fall apart from too much moisture in the system, because of poor evacuation of the system, or lack of maintenance.

6. Using U-bolts, mounting brackets, nuts, and washers, install a new receiver-drier on the frame rail.
7. Uncap the refrigerant lines.
8. Install new Mini Stat-O-Seals on the refrigerant lines. Do not lubricate Mini Stat-O-Seals prior to installation.
9. Using a capscrew, attach the refrigerant lines and retaining plate to the receiver-drier. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).
10. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. For instructions, see the applicable refrigerant compressor section in **Group 83**.
11. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.
12. Return the hood to the operating position.
13. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Disconnect the electrical connector from the binary switch near the junction block. See **Fig. 1**.



1. Binary Switch 2. Fan Cycling Switch

Fig. 1, Engine Side of Frontwall

4. Remove the binary switch and the O-ring.
5. Lubricate a new O-ring with mineral oil before installing it on the new binary switch.
6. Install the binary switch and tighten 60 to 72 lbf·in (678 to 813 N·cm).
7. Connect the electrical connector to the binary switch.
8. Return the hood to the operating position.
9. Remove the chocks from the tires.

Condenser Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Disconnect the refrigerant lines from the condenser and remove and discard the Mini Stat-O-Seals. Quickly cap the condenser inlet and outlet ports if the condenser will be reinstalled and plug the fittings.

IMPORTANT: Under no circumstances should the ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Remove the fasteners that attach the condenser to the radiator and remove the condenser.

Installation

1. Place the condenser on the radiator. Install and tighten the fasteners 108 lbf·in (1220 N·cm).
2. Uncap the inlet and outlet ports on the condenser. Unplug the fittings
3. Using only Mini Stat-O-Seals, replace the Mini Stat-O-Seals on the refrigerant lines. Do not lubricate Mini Stat-O-Seals prior to installation.
4. Connect the refrigerant lines to the condenser. Torque the capscrew on the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).
5. Add refrigerant oil to the compressor to replace that which is lost in the old condenser. For instructions, see the applicable refrigerant compressor section in **Group 83**.
6. Evacuate and charge the air conditioning system with refrigerant. For instructions, refer to **Subject 220**.
7. Return the hood to the operating position.
8. Remove the chocks from the tires.

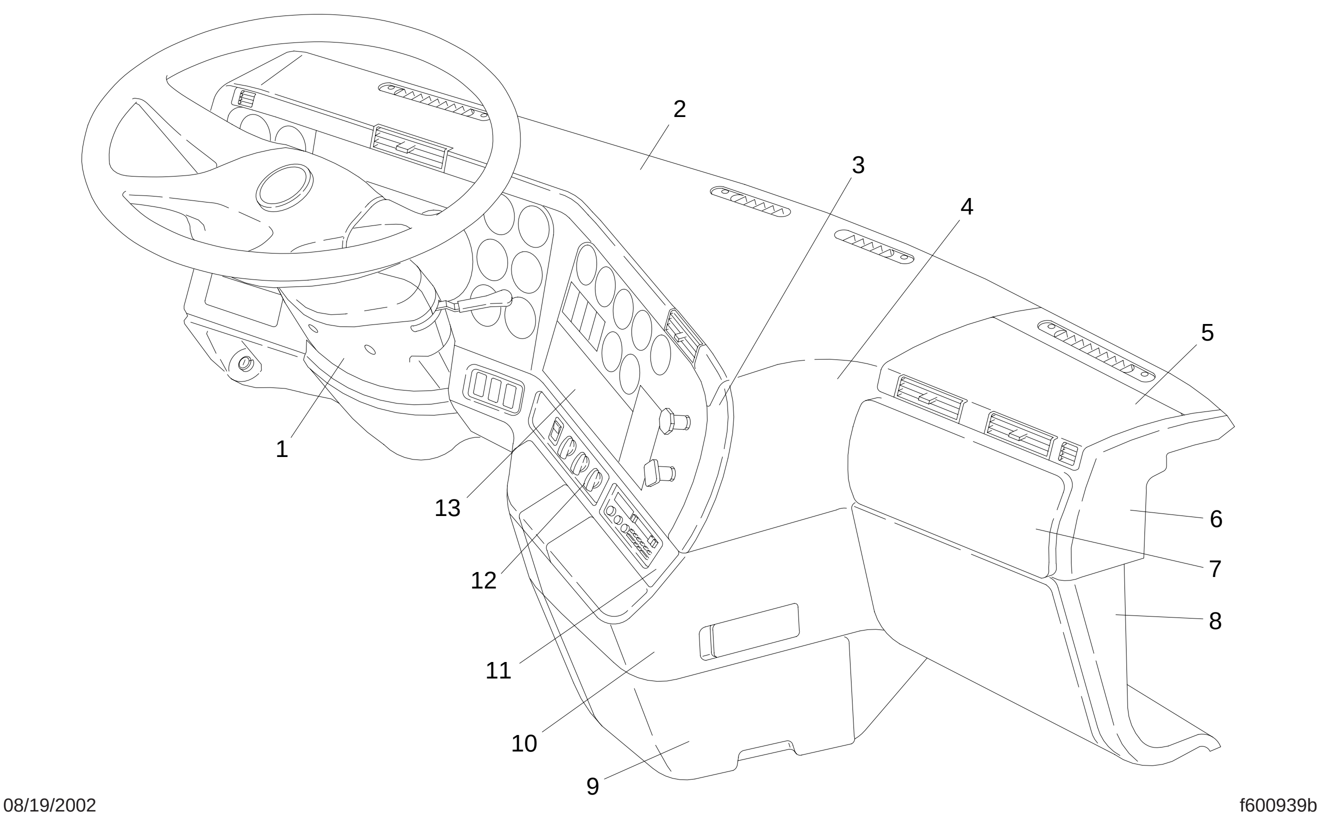
Climate Control Panel (Front Control Unit) Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the dash trim cap and the HVAC/radio trim plate. See **Fig. 1**. For instructions, see **Section 60.08**.
3. Remove the trailer air supply and the parking brake knobs from the auxiliary gauge panel. See **Fig. 1**.
4. Remove the capscrews that attach the auxiliary gauge panel to the console and move the gauge panel to access the capscrews that attach the climate control panel to the console. See **Fig. 1**.

NOTE: The climate control panel is also referred to as the front control unit (FCU).

5. Remove the capscrews that attach the control panel to the console.
6. Disconnect the electrical connectors from the control panel and remove the control panel.
7. Connect the electrical connectors to the new control panel.



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Climate Control Panel
13. Auxiliary Gauge Panel

Fig. 1, Columbia Dash Panels

Climate Control Panel (Front Control Unit) Replacement

8. Using capscrews, attach the control panel to the console.
9. Using capscrews, attach the auxiliary gauge panel to the console.
10. Install the trailer air supply and parking brake knobs to the auxiliary gauge panel.
11. Install the HVAC/radio trim plate and the dash trim cap. For instructions, see **Section 60.08**.
12. Manually calibrate the HVAC system after the climate control panel has been removed or replaced.
    - 12.1 Turn the ignition key to the on position, but keep the engine off.
    - 12.2 Turn the fan switch to the off position.
    - 12.3 Turn the air selection switch to the full defrost mode.
    - 12.4 Turn the temperature control switch to the full hot position.
    - 12.5 Press and hold the recirculation button and the air conditioning button for five seconds.
    - 12.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.
13. Remove the chocks from the tires.

Required Equipment

You will need a machine, or machines, to identify the refrigerant and to recover, evacuate, flush, and charge the refrigerant system. Ideally, the machine will perform all the following functions:

- Identification—The machine must be able to verify the purity of the refrigerant in the refrigerant system and check for the presence of hydrocarbon-based refrigerants or other unapproved refrigerants.
- Recovery—The machine must be able to fully recover the refrigerant from the refrigerant system.
- Evacuation—Ideally, the machine should have a vacuum pump rated at 6 cfm and be maintenance free. A machine that requires maintenance is acceptable, as long as it is properly maintained.
- Charging—The scale used in charging should be accurate to within ±1 ounce (30 mL).
- Flushing—Adaptors for the compressor(s), expansion device(s), and receiver-drier should be purchased or fabricated to flush the system with refrigerant.

Refrigerant Identification

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT: Identify the refrigerant in the refrigerant system if you suspect one of the following conditions:

- an excess noncondensable gas, such as nitrogen or air, is in the system.
- an unapproved refrigerant is in the system.
- the history of refrigerant system repairs is unknown.

1. Using a high-quality refrigerant identifier and the manufacturer's instructions, attach the identifier to the vehicle and perform the test.
2. If the vehicle passed the test, it is safe to recover the refrigerant.
3. If the vehicle failed the test due to an excessive amount of noncondensable gas, recover the refrigerant system, then purge the recovery tank of the noncondensable gas.
4. If the vehicle failed the test due to the presence of a hydrocarbon-based refrigerant or a refrigerant other than R-134a, **do not recover the refrigerant into the general-use machine.** To change the refrigerant, remove the existing refrigerant into a separate container. **Refrigerant must be recycled by a qualified recycling center.** It is best to refer the customer to the place where the vehicle was last serviced.

Recovery

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

The recovery process removes most of the refrigerant charge in the system.

1. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Remove the caps from the suction and discharge service valves.
3. If the history of refrigerant system repairs is unknown, or if you suspect that the system is charged with an unapproved refrigerant, identify the refrigerant using the "Refrigerant Identification" procedures.
4. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses to the valves.

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

5. Follow the refrigerant recovery and charging machine manufacturer's instructions, and recover all of the refrigerant from the refrigerant system.

IMPORTANT: Always comply with all federal and local regulations regarding refrigerant recovery and disposal. You may be subject to substantial penalties for improper procedures.

6. Measure the oil recovered during the recovery process. The refrigerant system will have to be filled with the same quantity of new refrigerant oil. If the system is contaminated with moisture, all of the compressor oil must be replaced with clean oil. If the system is heavily contaminated with desiccant or grit, replace the compressor, expansion valve, and receiver-drier, and flush the condenser and evaporator(s). After the system is charged, check its performance, to ensure that the heat exchangers are not plugged.

Evacuating

The main purpose in evacuating the refrigerant system is to remove noncondensable gases (NCG), such as nitrogen and air. The secondary purpose is to boil off free water molecules.

In rare cases, water forms ice crystals at the expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction, or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Refrigerant oil has an extremely high tendency to absorb any moisture available to it. Typically, the moisture picked up by the oil is passed on to the receiver-drier. If there is excessive moisture in the system, the lubricating ability of the oil is reduced, which can damage the compressor and other components.

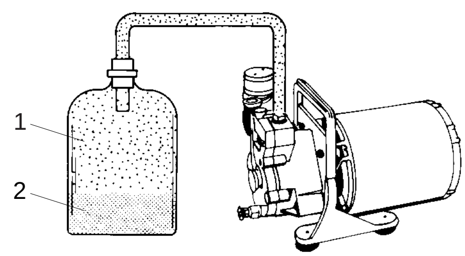
Effects of Pressure on the Boiling Point of Water

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Water boils at 212°F (100°C) at standard sea level atmospheric pressure of 14.7 psi (101 kPa). At higher elevations the atmospheric pressure is lower, which allows water to boil at lower temperatures. See **Table 1** for boiling temperatures of water at converted pressures.

Similarly, you can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum, to cause the moisture to vaporize at normal ambient temperatures. A vacuum pump can reduce the pressure in the system. Since the pressure is lowest at the pump, NCG and water vapor are pulled out of the system. This process is called evacuation or dehydration. See **Fig. 1**.



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1. Vapor
2. Water

Fig. 1, Water to Vapor

Measuring Vacuum

Vacuum should be measured with an electronic thermistor vacuum gauge, which is designed for use with high-vacuum pumps and can accurately read as low as 100 microns. This gauge can have an analog scale, or a digital display.

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower the reading will be. Follow the manufacturer's instructions for proper use of the vacuum gauge.

If the pressure will not stabilize, it indicates a leak. If it stabilizes at a vacuum that is too high, for example 1500 microns Hg, there is probably moisture in the system, and more evacuation is required.

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water: °F (°C)	**Absolute Pressure: psi (microns Hg)**	**Vacuum: inHg (mmHg)**
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (149580.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (30)	0.61540 (31826.2)	28.67 (728.2)
86 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

Table 1, Boiling Temperatures of Water at Converted Pressures

The ability to hold a vacuum, is only an indication that there are not any leaks that are present *under a vacuum*. The system still may leak when it is under positive pressure, so a pressure leak test must be performed in addition.

Maintaining an Oil-Lubricated Vacuum Pump

Maintenance is important for a high-vacuum pump. The PAG oil must be changed at regular intervals to prevent moisture buildup, which will cause decreased pump performance and eventual pump failure.

Pumping down, for extremely wet air conditioning systems, can completely saturate the pump oil, in which case, the oil must be replaced.

CAUTION

Flush the vacuum pump every fourth time it is used, and before storing for long periods of time.

Acid will form and corrode the pump, if water-laden oil remains in the pump for an extended period.

PAG vacuum pump oil is extremely water soluble. This helps the pump reach a high vacuum, by absorbing water and sealing the pump.

Use only specified vacuum pump oil as a lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

Evacuation Procedure

1. The system refrigerant must have been recovered, and the refrigerant compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system conditions require it.
2. Make sure the vacuum pump has been properly maintained.
3. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses, or a vacuum pump, to the valves.

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

4. Follow the refrigerant recovery and charging machine manufacturer's instructions, and evacuate the refrigerant system.
5. Using a 6-cfm pump, the system should be evacuated a minimum of 10 minutes. Evacuate the system for a longer period of time if using a smaller pump. Make sure that the vacuum level reaches a point where water would boil and does not go back toward zero, then proceed with charging and leak testing the system.

Flushing

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Flushing removes moisture-laden oil and some contamination, such as dirty oil and some particles. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to flush or replace a part depends on how much contamination there is, as previously described.

Normally, the system always has pressure in it. Some loss of refrigerant from one season to the next is normal, and does not mean that the system is dirty. If refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, flush all sections of the system. Then change the oil in the compressor, and replace the receiver-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier, expansion valve(s), and inspect the compressor.

Do not flush the receiver-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Flush the system in the opposite direction of refrigerant flow.

Flushing parts with refrigerant, requires a refrigerant recovery and charging machine.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform

the flush. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.

4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new receiver-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done, since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new receiver-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Oil Balancing

General Information

Compressors require refrigerant oil to function. When the air conditioning system is operating, some of the oil leaves the compressor and is circulated through the system with the refrigerant. The refrigerant oil cannot leave the system except when there is a leak, the refrigerant is recovered, or when a system part is replaced. It is important that the air conditioning system has the correct amount of refrigerant oil for proper operation. Too little oil will result in compressor failure. Too much oil will degrade the performance of the air conditioner, and cause damage to the compressor.

IMPORTANT: Whenever the air conditioning system is discharged or recovered, the recovered oil, from the charging machine, must be measured in order to know how much oil must be returned to the system. When a system component is replaced, a quantity of new oil equal to the recovered oil plus the oil coating the inside of the component must be returned to the system.

IMPORTANT: Refrigerant oil is hygroscopic (attracts moisture from its surroundings), and must not be exposed to the moisture that is present in the air. New oil must be from a container that has not been opened or that has been tightly sealed since its last use.

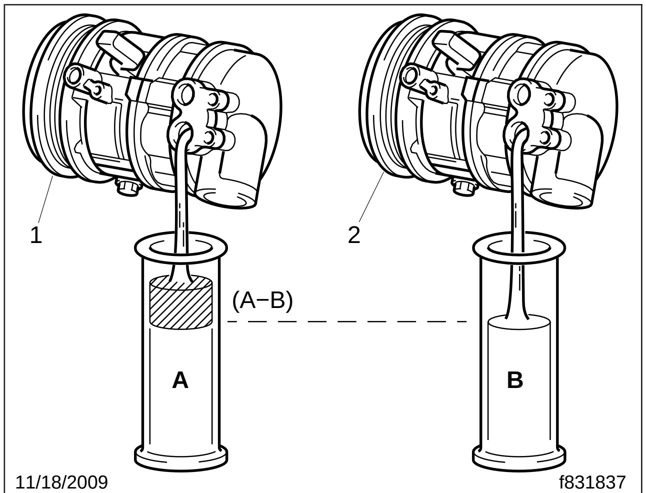
Tubing, funnels, or other equipment used to transfer the oil must be very clean and dry. When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

Compressor Oil Balancing

Replacement refrigerant compressors are supplied with some refrigerant oil. If the air conditioning system has been flushed, the system will need a complete new charge of oil. If the system has not been flushed, use the following procedures to adjust the oil level, when a new compressor or other system component has been installed. The type of oil required depends on the brand of compressor used on the system. See the refrigerant compressor section for details about how the total system volume is determined for the compressor being serviced. See PartsPro MOD 700 to determine the oil type and vehicle specific oil quantities.

1. Drain the remaining oil from the compressor into a clean graduated container, and note the amount. See **Fig. 2**.



1. New Compressor
2 Old Compressor

Fig. 2, Oil Balancing

2. Make note of the total volume of oil recovered.
3. Drain the oil from new compressor into a clean calibrated container, and compare the two quantities of oil.
4. Add only the amount of oil removed during recovery and from the old compressor to the system.
5. Add the new compressor oil as described in the supplier specific compressor service section of the workshop manual.

System Oil Balancing

After repairs are finished, refer to **Table 2** and use the following equation to determine the quantity of refrigerant oil that needs to be added to the system.

[Quantity Recovered] + [Quantity for All Replaced Components] = [Quantity Added to the System]

Table 2 provides the quantities of oil that need to be added to the system for each component that was replaced. Add the quantities listed in the table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less. Inject the calculated oil volume at the high-side pressure port during the refrigerant charging process.

Refrigerant Oil Quantities for Replaced Components	
Add the quantities listed in this table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.	
Component	**Quantity oz (mL)**
High Pressure Line (main A/C)	1 (30)
Low Pressure Line (main A/C)	2 (59)
High Pressure Line (auxiliary A/C)	1 (30)
Low Pressure Line (auxiliary A/C)	3 (89)
Condenser	1 (30)
Evaporator (main A/C)	3 (89)
Evaporator (auxiliary A/C)	2 (59)
Receiver-Drier	3 (89)
Minor Leak at Connector Only	0.5 (15)
Major Leak at Connector Only	2 (59)

Table 2, Refrigerant Oil Quantities for Replaced Components

Charging

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

NOTE: Before charging, the system must be recovered and evacuated with the recovery and charging machine connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. To determine the amount of refrigerant

needed to fully charge the system, read the Air Conditioner label on the vehicle or see **Specifications 400**.

2. Charge the system on the high side following the refrigerant recovery and charging machine manufacturer's instructions.
3. While the compressor is engaged, check the duct temperature and operating pressures at the suction and discharge ports. Compare the temperature and pressures to those in **Section 83.06, Subject 300**. If the operating pressures are not acceptable, see **Section 83.06, Subject 300** for troubleshooting procedures.
4. Disconnect the hoses.
5. Shut down the engine.
6. Recover the refrigerant that is in the hoses.

Leak Testing Methods

General Information

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to take precautions against the dangers involved when working with refrigerant, could lead to serious personal injury.

Refrigerant is nearly odorless. As a result, all of it may leak away and not be noticed until the system stops cooling. All vehicle refrigerant systems lose some refrigerant. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. If unapproved replacement hoses are installed, refrigerant can be lost through hose permeation.

There are two leak testing methods that can be used to detect leaks in the refrigerant system: UV (ultraviolet) dye leak detection and electronic leak detection. Freightliner Trucks recommends using the UV dye leak detection method whenever possible, even though there are some limitations to using this method. A leak on the front seal of the compressor **must** be verified using a heated diode leak detector and the instructions elsewhere in this subject. Visible dye on the front of the compressor clutch **does not** verify that there is a repairable leak at the front seal. Evaporator leaks may not show up with dye, and must be checked using a heated diode leak detector if dye is not present at the condensate drain.

UV Dye Leak Detection

IMPORTANT: When using the UV dye leak detection method, always wear protective eyewear that blocks UV rays and enhances the appearance of the dye. Always wear nonleather gloves and protective eyewear when servicing the air conditioning system.

1. Inspect the refrigerant system for leaks using a UV lamp.
   1.1 Inspect the entire refrigerant system under low lighting using a UV lamp. Low lighting will increase the apparent brightness of the UV dye, and make the leaks easier to see.
   1.2 Move the UV lamp along the entire refrigerant system, looking for signs of damage or corrosion on the fittings, hose-to-line crimps, switch ports, service ports with caps installed (dye inside the port is not an indication of a leak), brazed or welded areas, and around all connections. Check for evaporator leaks by illuminating the condensate drain tube or hole using the UV lamp.
   1.3 Move the UV lamp along the refrigerant system following a continuous path so that no potential leak sites are missed. If a leak is found, continue to check the remainder of the system since other leaks may be present.
2. After repairing a leak, remove all UV dye residue remaining on the outside of the refrigerant system using the cleaner provided by the dye manufacturer, or a comparable cleaner. Use a spray bottle of cleaner, a toothbrush, and a spray bottle of clean water for hard-to-reach areas.

NOTE: Minor UV dye residue, or residue that is impossible to reach, will lose its fluorescence over time.

Refrigerant Service Operations

3. See **Table 3** for a list of products that have been tested and approved for use by Freightliner dealers.
4. Close the hood and remove the chocks from the tires.

Electronic Leak Detection

NOTE: Do not try to use a leak tester right after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely signal a leak. Always verify a leak by blowing shop air in to the area of the suspected leak and checking the area again.

When checking for leaks, move the probe all the way around the fitting or suspected leak.

Freightliner Trucks recommends using only certain makes of the heated diode and infrared (IR) types of electronic leak detectors.

Recommended electronic heated diode type leak detectors are available from their manufacturers. See **Table 4**.

Another type of detector, the corona discharge type, is specifically **not recommended**.

Use the following procedures to locate refrigerant system refrigerant gas leaks using an electronic leak detector.

Approved Products for UV Dye Leak Detection				
Type of Refrigerant Oil	**Product Description**	**Vendor Part Number**	**Freightliner Part Number**	**Website Address**
PAG	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9741CS	ABP N83 327911	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9760-0004CS	ABP N83 327961	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9760-0108	ABP N83 327951	
POE/ universal	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9742CS	ABP N83 327910	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9770-0004CS	ABP N83 327950	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9770-108	ABP N83 327960	
—	Tracerline Optimax UV Lamp	TP-8680	ABP N83 327985	www.tracerline.com
—	Bright Solutions UV Lamp	BSL760	ABP N83 327967	www.brightsol.com
—	Service Valve Cap	—	PH 660412	—

Table 3, Approved Products for UV Dye Leak Detection

1. Operate the electronic leak detector in accordance with the manufacturer’s instructions. Occasionally use a leak reference bottle of R-134a to ensure that the detector is working properly.
2. Leak test with the engine turned off.
3. Charge the air conditioning system with sufficient refrigerant to indicate a gauge pressure of at least 50 psi (345 kPa) with the system not operating. Typically, one-half pound (0.22 kg) of refrigerant is sufficient to create 50 psi (345 kPa) of pressure. It may not be possible to produce this amount of pressure and measure leakage if the ambient temperature is less than 59°F (15°C).
4. Be careful not to contaminate the detector probe tip if the part being tested is not clean. Wipe the part off with a dry shop towel or blow it off with shop air. Do not use cleaners or solvents as many detectors are sensitive to their chemical ingredients.
5. Visually inspect the entire refrigerant system. Look for air conditioning lubricant leakage and corrosion or damage to lines, hoses, and all other components. Inspect each questionable location carefully with the detector probe. Check all fittings, couplings, refrigerant controls, service ports (with caps installed), brazed or welded areas, and areas around attachment points and hold-downs.
6. Follow the path of the refrigerant system methodically, so that no leaks are missed. If a leak is found, continue to test the rest of the system.

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK, D-Tek Select, and TekMate	Leybold Inficon 2 Technology Place East Syracuse, NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Bacharach Inc. c/o Yokogawa Corp. of America 2 Dart Road Newnan, GA 30265 (800) 258–2552	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren, MI 48092–3499 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 4, Electronic Leak Detectors

7. Inspect an area of possible leakage slowly and close to the part, moving completely around the part. Move the probe no faster than one to two inches (25 to 50 mm) per second and no farther away than 1/4 inch (6.4 mm) from the part.
8. If a large leak is present in either the system being serviced or the service equipment, the surrounding air will be saturated with refrigerant gas. In this situation the leak detector operates erratically, and will indicate leakage without being near a possible leak source. Place a large fan so that a light breeze blows through the work area. Verify a leak by blowing shop air into the area and repeating the inspection. Pinpoint a large leak by blowing out the area often.

Refrigerant Service Operations

9. You may test the evaporator core while it is in its housing. Turn on the blower motor for at least 15 seconds. Shut off the blower and wait for refrigerant gas to accumulate in the housing. Wait for the time specified in the detector instructions for the gas to accumulate. Insert the detector probe into the blower resistor block, or condensate drain tube if no water is present. If this is not possible, insert the probe into the closest opening to the evaporator, such as a heater or vent duct.

NOTE: Insert the eraser end of a pencil into the end of the condensate drain tube, to determine whether there is any water present. Inserting the pencil breaks the surface tension of any water near the opening of the drain tube, and allows the water to drain out before inserting the probe tip. It is only necessary to break the plane of the drain tube with the probe tip; it does not need to be inserted far into the tube.

10. Leak test the front seal area of the compressor. Blow shop air into the cavities in and around the clutch for at least 15 seconds. Let the compressor stand for one minute, then test for leakage. Inspect axial-type compressors (Sanden or Sel-Tec) by placing the probe near the holes at the front of the clutch. See **Fig. 3**. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor. See **Fig. 4**.

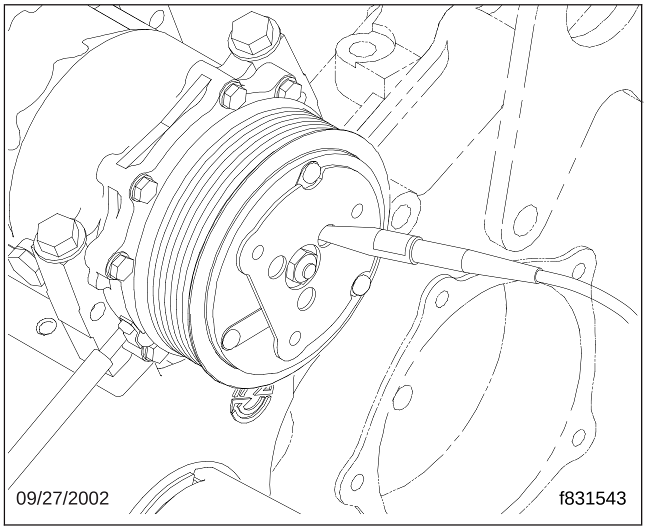


Fig. 3, Axial Type Compressor

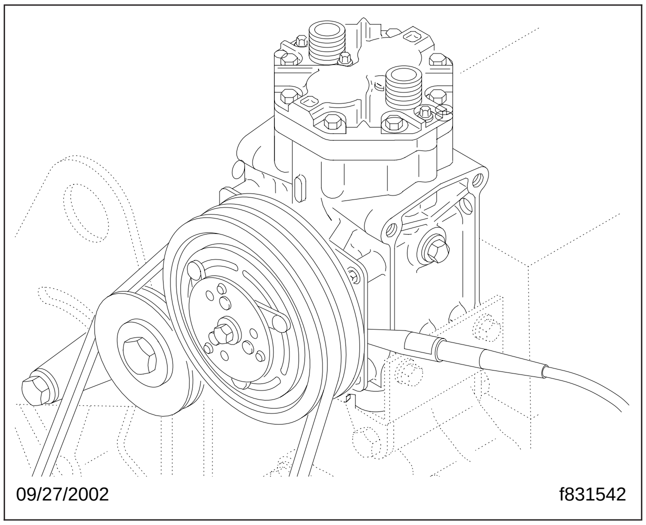


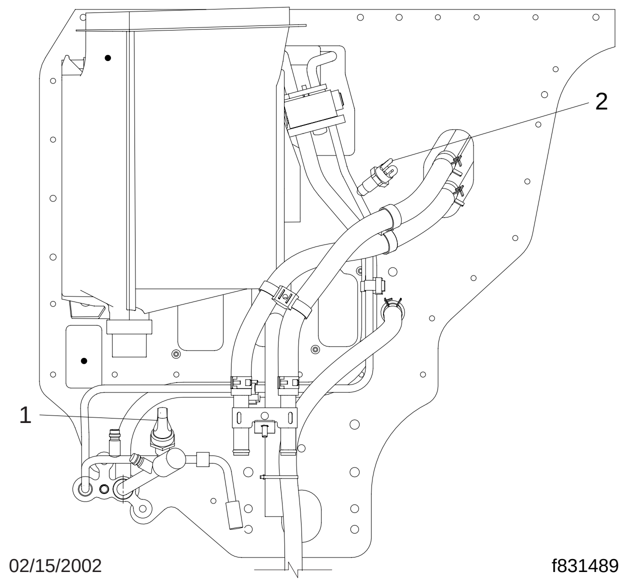
Fig. 4, Two-Cylinder Reciprocating Compressor

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Disconnect the electrical connector from the fan cycling switch near the expansion valve. See **Fig. 1**.



1. Binary Switch
2. Fan Cycling Switch

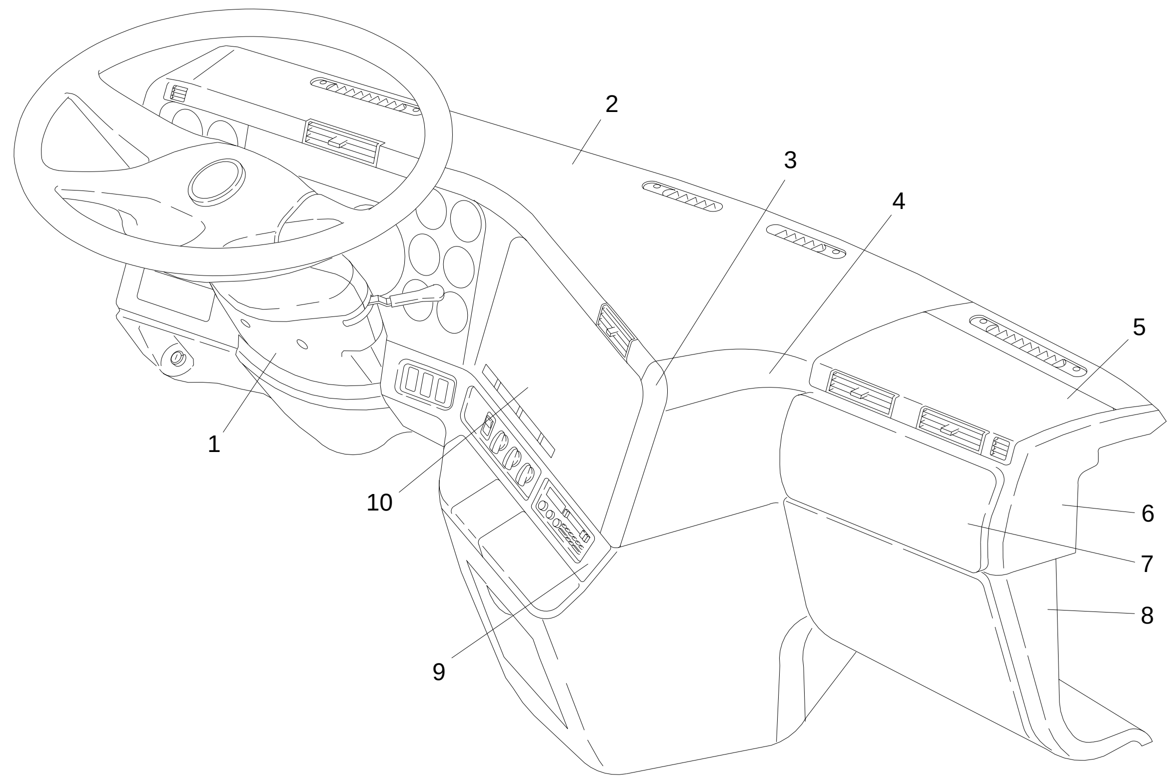
Fig. 1, Engine Side of Frontwall

4. Remove the fan cycling switch and the O-ring.
5. Lubricate a new O-ring with mineral oil before installing it on the new fan cycling switch.
6. Install the fan cycling switch on the receiver-drier and tighten 60 to 72 lbf·in (678 to 813 N·cm).
7. Connect the electrical connector to the fan cycling switch.
8. Return the hood to the operating position.
9. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin
    - console cover
    - dash trim cap
    - upper dash assembly, center panel
3. Remove the tie straps on the wiring harness as needed to access the CDTC sensor. See **Fig. 2**.
4. Remove the capscrew that attaches the right side of the shield to the HVAC assembly. Move the shield to access the CDTC sensor. See **Fig. 3**.
5. Disconnect the electrical connector from the CDTC sensor.
6. Turn the CDTC sensor on-quarter turn and remove the CDTC sensor.
7. Install a new CDTC sensor in the HVAC assembly and turn the sensor one-quarter turn.
8. Connect the electrical connector to the CDTC sensor.
9. Using a capscrew, attach the shield to the HVAC assembly.
10. If needed, use tie straps to bundle the wiring harnesses.
11. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover
12. Remove the chocks from the tires.

CDTC Sensor Replacement



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Auxiliary Gauge Panel

Fig. 1, Columbia Dash Panels

CDTC Sensor Replacement

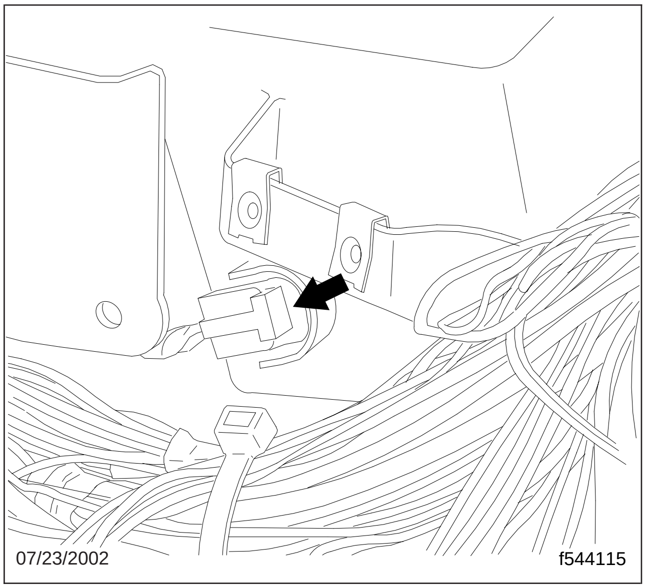


Fig. 2, CDTC Sensor

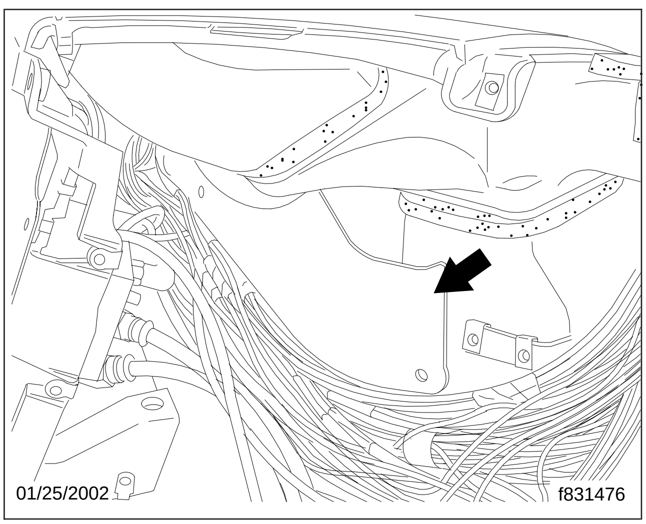
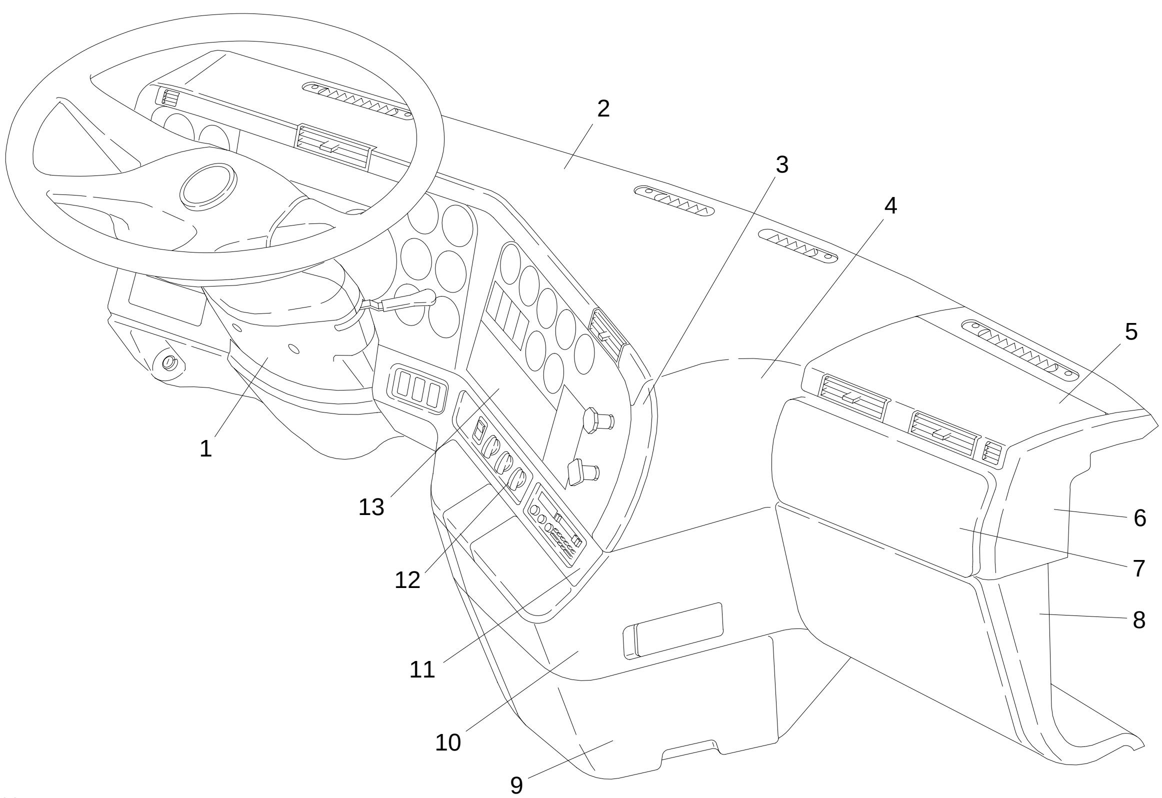


Fig. 3, Shield

Mode Control Kinematics Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
    - electrical cover
    - upper dash cover
    - heater and air conditioner cover
    - waste bin
    - console cover
    - dash trim cap
    - upper dash assembly, center panel
3. Remove the tie straps on the wiring harnesses as needed to access the wiring harness channel on the HVAC assembly.
4. Pull the plastic fastener that attaches the wiring harness channel to the HVAC assembly out of the HVAC assembly, and move the wiring harness channel to access the mode actuator.
5. Remove the mode actuator from the HVAC assembly. See **Fig. 2**.



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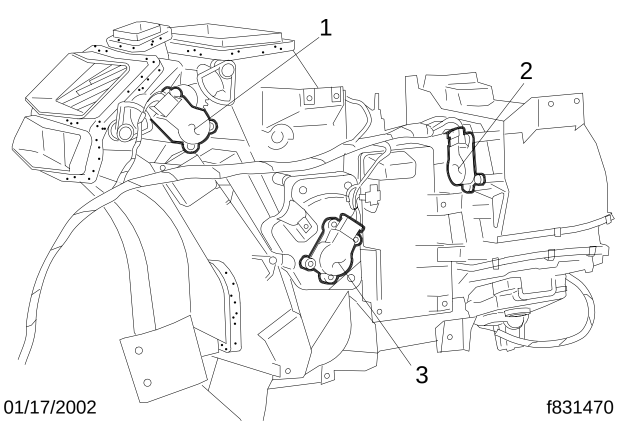
1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Front Control Unit
13. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Mode Control Kinematics Replacement



1. Mode Actuator
2. Recirculation Actuator
3. Temperature Actuator

Fig. 2, Actuators

5.1 Remove the capscrews that attach the mode actuator to the HVAC assembly.

5.2 Disconnect the electrical connector from the actuator, and remove the actuator.

6. Remove the defrost door lever, drive gear, face door lever, and idler. See **Fig. 3**.

6.1 Pull the defrost door lever over the wing clips.

6.2 Pull the drive gear and defrost door lever off the pivot and door shaft.

6.3 Pull the face door lever over the wing clips.

6.4 Pull the idler off the pivot.

6.5 Make sure the wing clips are in good condition. If any of the wings are broken or missing, remove all of the clips.

7. Install a new idler and face door lever.

7.1 Move the face door shaft counterclockwise as far as it will move.

7.2 Install the idler so that it is against the actuator mounting boss. See **Fig. 4**.

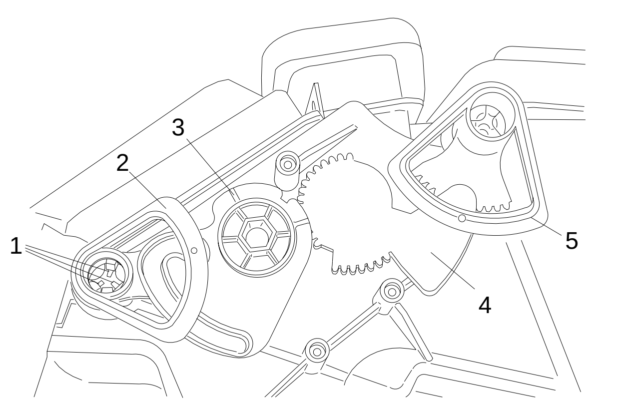
7.3 Press the face door lever on the door shaft until the door lever is secured by the three wing clips. If necessary, use a screwdriver to spread the wing clips for engagement.

7.4 If the wing clips were removed, use a screw similar in size to the actuator mounting screw to install the face door lever on the shaft.

8. Install a new defrost door lever.

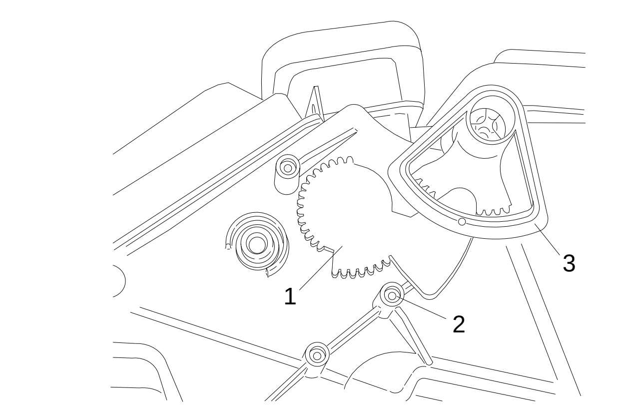
8.1 Move the defrost door shaft counterclockwise as far as it will move.

8.2 Align the defrost door lever with the drive gear as shown in **Fig. 5** before installing the parts on the HVAC assembly.



1. Wing Clips
2. Defrost Door Lever
3. Drive Gear
4. Idler
5. Face Door Lever

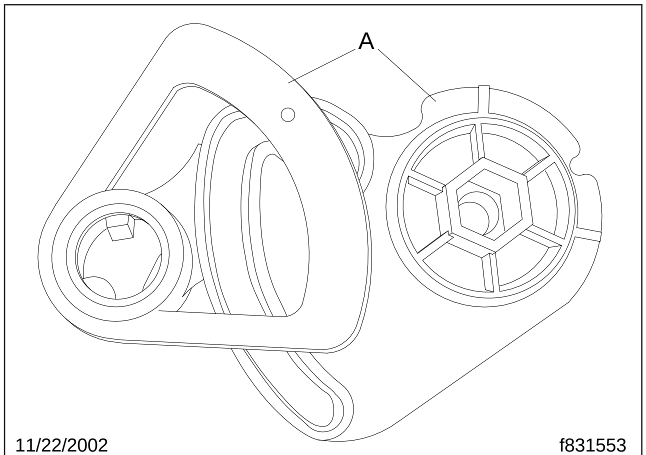
Fig. 3, Defrost Door Lever



1. Idler
2. Mounting Boss
3. Face Door Lever

Fig. 4, Idler and Face Door Lever

Mode Control Kinematics Replacement



A. Align the defrost door lever and drive gear as shown.

Fig. 5, Defrost Door Lever and Drive Gear

IMPORTANT: Make sure the teeth on the defrost door lever align with the wide tooth on the mating gear. See **Fig. 6**.

8.3 Install the defrost door lever and drive gear as a unit on the HVAC assembly. Make sure the wing clips are visible.

8.4 Press the defrost door lever on the door shaft until the door lever is secured by the three wing clips. If necessary, use a screwdriver to spread the wing clips for engagement.

8.5 If the wing clips were removed, use a screw similar in size to the actuator mounting screw to install the defrost door lever on the shaft.

9. Install the mode actuator.

   9.1 Connect the electrical connector to the mode actuator.

   9.2 Align the actuator to the keyed shaft on the door.

   9.3 Using capscrews, attach the mode actuator to the HVAC assembly.

10. Move the wiring harness channel back in place and use the plastic fastener to attach the wiring harness channel to the HVAC assembly.

11. If needed, use tie straps to bundle the wiring harnesses.

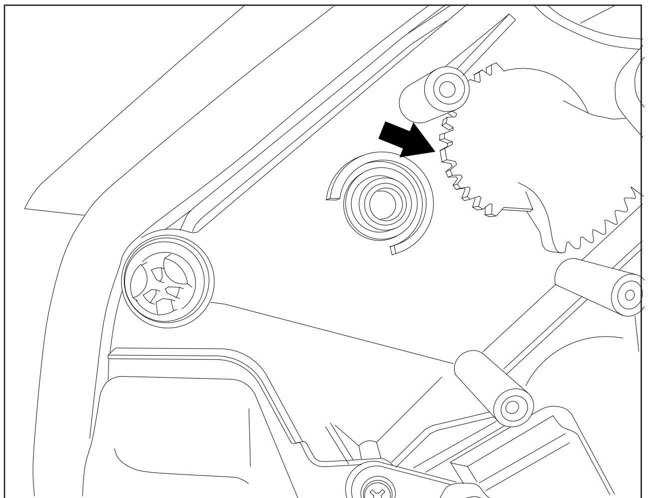


Fig. 6, Wide Tooth on Mating Gear

12. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - waste bin
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover

13. Calibrate the HVAC system after the actuator has been replaced.

    13.1 Turn the ignition key to the on position, but keep the engine off.

    13.2 Turn the fan switch to the off position.

    13.3 Turn the air selection switch to the full defrost mode.

    13.4 Turn the temperature control switch to the full hot position.

    13.5 Press and hold the recirculation and air conditioning buttons until they begin to blink.

    13.6 The recirculation and air conditioning indicators will blink, the fan will turn on the highest fan speed, the air selection switch will cycle through the modes, and the re-

Mode Control Kinematics Replacement

circulation door will open and close. The entire cycle takes about 20 to 30 seconds.

14. Remove the chocks from the tires.

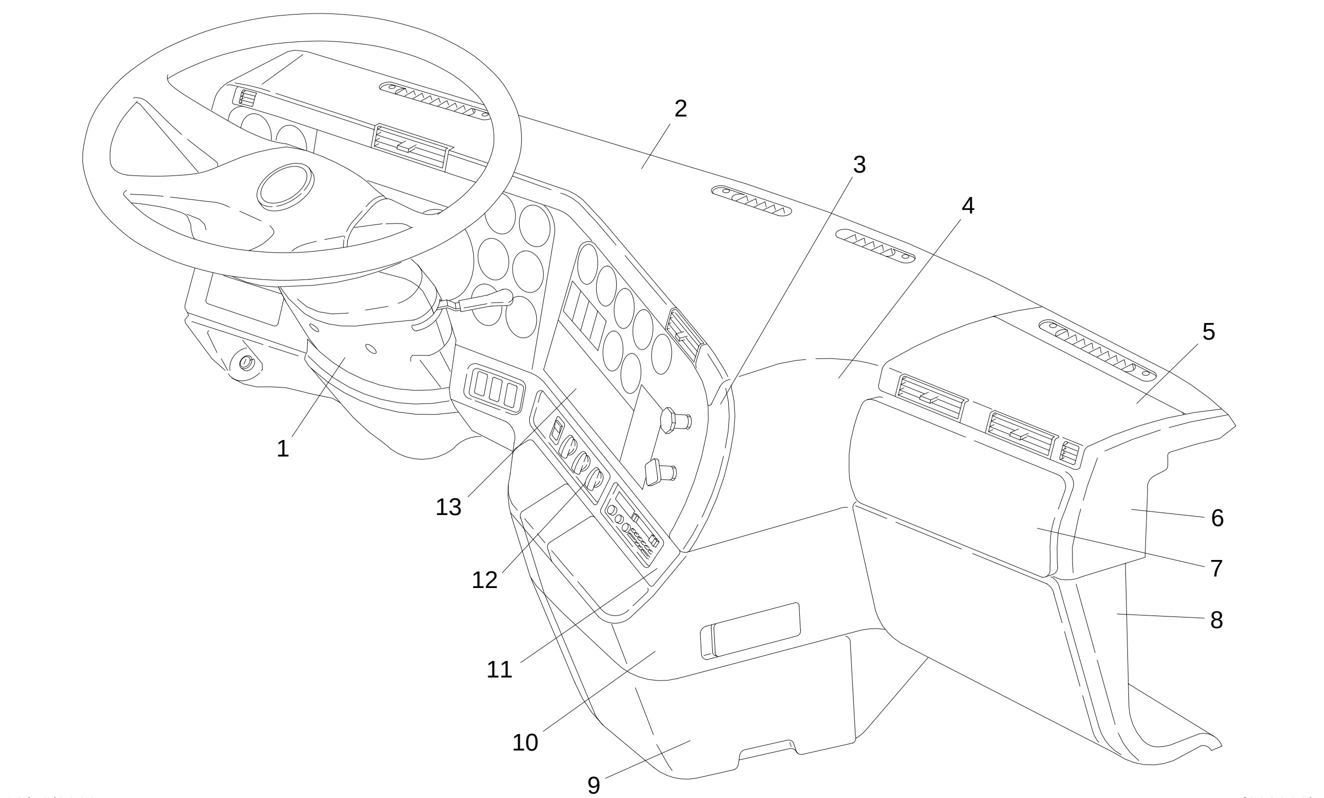
Temperature Control Kinematics Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - upper dash cover
   - heater and air conditioner cover
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
3. Remove the capscrew on the wiring harness channel that attaches the channel to the temperature control cover.
4. Remove the temperature actuator from the temperature control cover. See **Fig. 2**.

   4.1 Remove the capscrews that attach the temperature actuator to the temperature control cover.

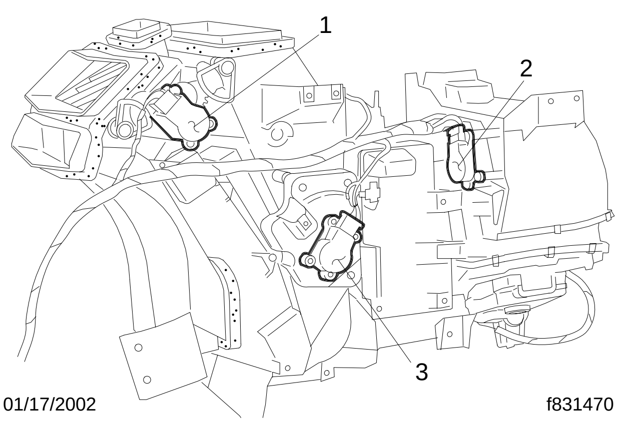
   4.2 Disconnect the electrical connector from the actuator, and remove the actuator.



1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Front Control Unit
13. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Temperature Control Kinematics Replacement



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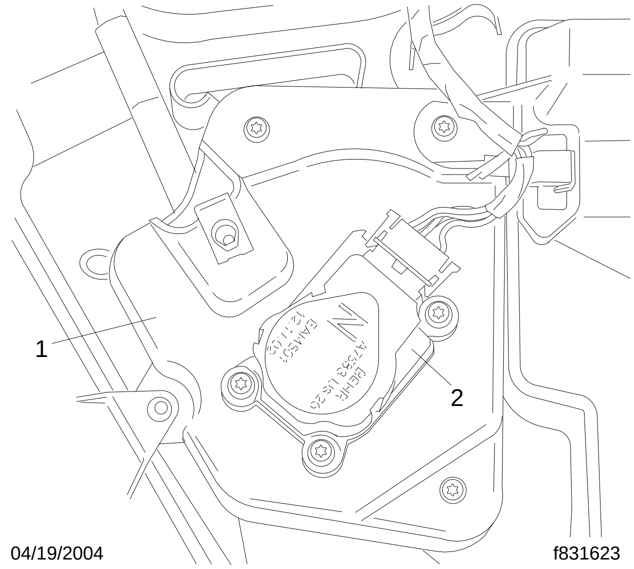
1. Mode Actuator
2. Recirculation Actuator
3. Temperature Actuator

Fig. 2, Actuators

5. Remove the evaporator temperature sensor by turning the sensor counterclockwise one-quarter turn.
6. Remove the capscrews that attach the evaporator service cover to the HVAC assembly. Remove the service cover.
7. Remove the screws that attach the temperature control cover to the HVAC assembly. Remove the cover. See **Fig. 3**.
8. Pull the temperature control cam off the pivot. See **Fig. 4**.
9. Pull the temperature control levers off the wing clips. Make sure the wing clips are in good condition. See **Fig. 4**.
10. Install new temperature control levers.
    - 10.1 If the wing clips are broken, use a screw similar in size to the actuator mounting screw, and a washer to attach the levers to the shafts.
    - 10.2 Install the levers on the shafts. Move the lower lever counterclockwise and the top lever clockwise, then install the cam on the levers. The levers and cam should be in the positions shown in **Fig. 4**.
11. Using capscrews, attach the temperature control cover to the HVAC assembly.
12. Install the temperature actuator.



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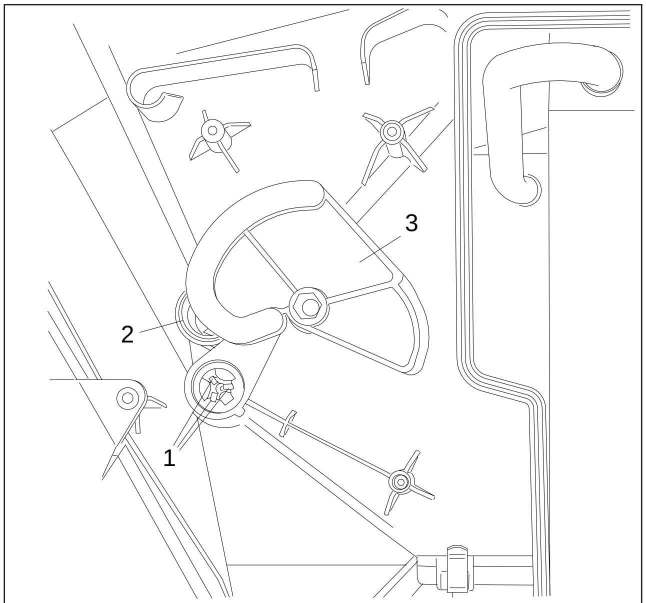
1. Temperature Control Cover
2. Temperature Actuator

Fig. 3, Temperature Actuator



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1. Wing Clips
2. Temperature Control Lever
3. Temperature Control Cam

Fig. 4, Temperature Control Kinematics

Temperature Control Kinematics Replacement

12.1 Connect the electrical connector to the temperature actuator.

12.2 Align the actuator to the keyed shaft on the door.

12.3 Using capscrews, attach the temperature actuator to the temperature control cover.

13. Move the wiring harness channel back in place and use a capscrew to attach the channel to the temperature control cover.

14. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - heater and air conditioner cover
    - upper dash cover
    - electrical cover

15. Calibrate the HVAC system after the actuator has been installed.

15.1 Turn the ignition key to the on position, but keep the engine off.

15.2 Turn the fan switch to the off position.

15.3 Turn the air selection switch to the full defrost mode.

15.4 Turn the temperature control switch to the full hot position.

15.5 Press and hold the recirculation and air conditioning buttons until they begin to blink.

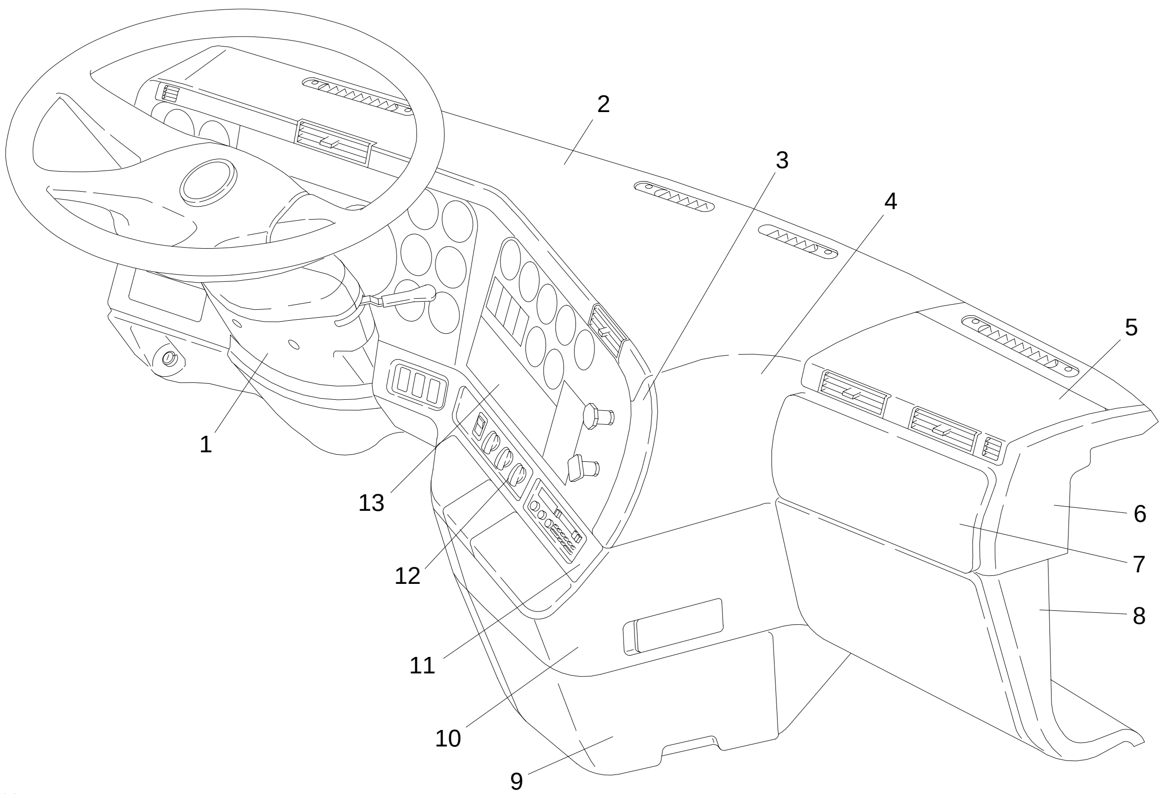
15.6 The recirculation and air conditioning indicators will blink, the fan will turn on at the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.

16. Remove the chocks from the tires.

Recirculation and Fresh Air Kinematics Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Remove the dash panels listed below. See **Fig. 1**. For instructions, see **Section 60.08**.
   - electrical cover
   - right-side upper dash assembly
   - upper dash cover
   - heater and air conditioner cover
   - console cover
   - dash trim cap
   - upper dash assembly, center panel
3. Remove the evaporator temperature sensor by turning the sensor counterclockwise one-quarter turn.
4. Remove the capscrews that attach the evaporator service cover to the HVAC assembly. Remove the service cover.
5. Remove the recirculation actuator. See **Fig. 2**.



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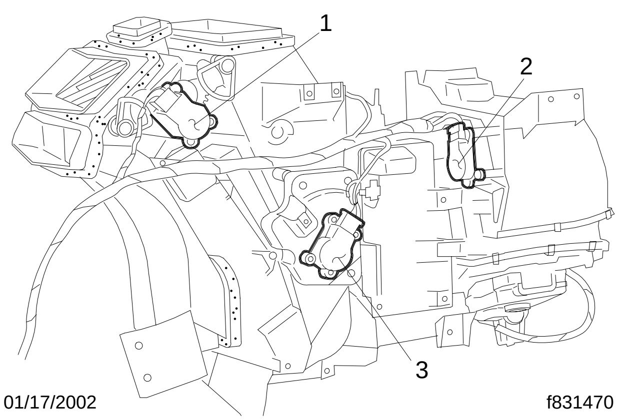
1. Steering Column Cover
2. Left-Side Upper Dash Assembly
3. Dash Trim Cap
4. Upper Dash Assembly, Center Panel
5. Electrical Cover
6. Right-Side Upper Dash Assembly
7. Upper Dash Cover
8. Heater and Air Conditioner Cover
9. Waste Bin Outer Wall
10. Console Cover
11. HVAC/Radio Trim Plate
12. Front Control Unit
13. Auxiliary Gauge Panel

Fig. 1, Dash Panels

Recirculation and Fresh Air Kinematics Replacement



1. Mode Actuator
2. Recirculation Actuator
3. Temperature Actuator

Fig. 2, Actuators

5.1 Remove the capscrews that attach the recirculation actuator to the HVAC assembly.

5.2 Remove the linkage from the back of the actuator. Disconnect the electrical connector from the actuator, and remove the actuator.

6. Remove the nuts that attach the power distribution module (PDM) to the HVAC assembly. Lift the PDM to access the linkage or arm.
7. Remove the linkage from the lever.
8. Install a new linkage on the lever.
9. Lower the PDM. Using nuts, attach the PDM to the HVAC assembly.
10. Install the recirculation actuator.

10.1 Connect the electrical connector to the actuator.

10.2 Attach the linkage to the back of the actuator and align the actuator to the keyed shaft on the door.

10.3 Using capscrews, attach the actuator to the HVAC assembly.

11. Using capscrews, install the evaporator service cover on the HVAC assembly. Make sure that the evaporator service cover is correctly seated to the HVAC assembly.
12. Install the temperature sensor in the evaporator and turn the sensor clockwise one-quarter turn.
13. Install the dash panels listed below. For instructions, see **Section 60.08**.
    - upper dash assembly, center panel
    - dash trim cap
    - console cover
    - heater and air conditioner cover
    - upper dash cover
    - right-side upper dash assembly
    - electrical cover
14. Calibrate the HVAC system after the actuator has been installed.

14.1 Turn the ignition key to the on position, but keep the engine off.

14.2 Turn the fan switch to the off position.

14.3 Turn the air selection switch to the full defrost mode.

14.4 Turn the temperature control switch to the full hot position.

14.5 Press and hold the recirculation and air conditioning buttons until they begin to blink.

14.6 The recirculation and air conditioning indicators will blink, the fan will turn on at the highest fan speed, the air selection switch will cycle through the modes, and the recirculation door will open and close. The entire cycle takes about 20 to 30 seconds.

15. Remove the chocks from the tires.

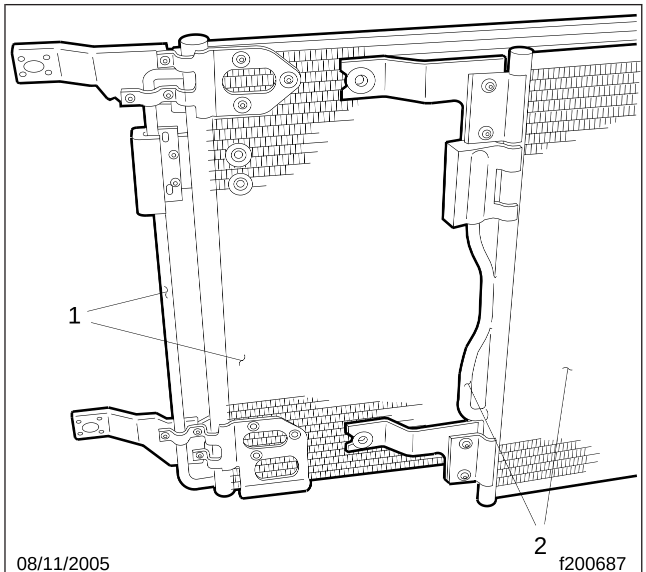
WARNING

R–134a is the only refrigerant that is approved for use on Freightliner vehicles. Several companies offer less expensive, hydrocarbon-based refrigerant, such as propane and methane. Use of these refrigerants will void the warranty on the air conditioning system, cause damage to the air conditioning system, and possibly result in personal injury or property damage. Leaking air conditioning systems charged with hydrocarbon-based refrigerants pose a serious risk of fire or explosion under the hood, or inside the passenger compartment. No vehicle built by Freightliner Trucks can be safely charged with hydrocarbon-based refrigerants, regardless of what the refrigerant supplier states.

When servicing an air conditioning system, be sure to use a refrigerant identifier to ensure that the system has not been charged with something other than R–134a. This should be standard practice since there is no way to tell what services have been previously performed. Identification by service technicians will help to avoid the risk of explosion and guard against contamination of equipment when refrigerant is recovered and recycled.

See **Fig. 1** for an illustration that shows the difference between the Behr and Modine condensers.

Temperature/pressure specifications and wiring diagrams for the blend air HVAC system can be found in **Section 83.06**, Subject 300.



1. Behr Condenser
2. Modine Condenser

Fig. 1, Behr and Modine Condensers

Refrigerant Oil Specifications		
Refrigerant Compressor Make	**Oil Type**	**Refrigerant Oil Capacity**
Sanden	PAG	10.1 oz (286 grams)
Climate Control	PAG	14 oz (397 grams)

Table 1, Refrigerant Oil Specifications

Refrigerant Charge Specifications		
Condenser Make	**Type of Cab**	**Refrigerant Amount**
Behr	Day Cab	2.875 lb or 2 lb 14 oz (1.30 kg)
	SleeperCab	3.438 lb or 3 lb 7 oz (1.56 kg)
Modine	Day Cab	3.25 lb or 3 lb 4 oz (1.47 kg)
	SleeperCab	3.75 lb or 3 lb 12 oz (1.70 kg)

Table 2, Refrigerant Charge Specifications

General Description

The sleeper heater and air conditioner assembly is mounted in either the baggage compartment or under the lower bunk, depending on the cab model, and contains the following major components. See **Fig. 1**.

- brushless blower motor
- evaporator
- heater core
- air filter
- actuator
- temperature control doors
- expansion valve
- CDTC temperature sensor

The heating and air conditioning functions of the sleeper heater and air conditioner system are controlled by the sleeper climate control panel. See **Fig. 2**.

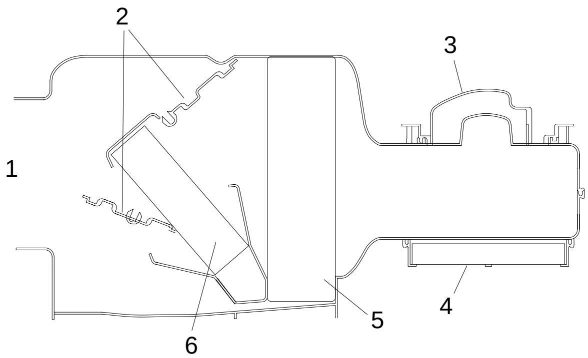
The cab climate control panel may have a bunk override (BUNK OVRD) switch that allows the driver to remotely control the fan speed and temperature settings in the sleeper. The bunk override mode can be canceled by adjusting the fan speed or temperature setting on the sleeper climate control panel when the bunk override mode is on. Refer to the *Columbia Driver's Manual* for operating instructions.

Principles of Operation

The sleeper heater and air conditioner system is a constant discharge temperature control (CDTC) system. The CDTC maintains a constant temperature of airflow in the sleeper regardless of outside air temperature, selected fan speed, or engine coolant temperature. Once the temperature control switch is turned to the desired temperature, no other adjustments are necessary.

The sleeper heater is plumbed directly to the engine, independent of the cab heater. The sleeper air conditioner is dependent on the cab air conditioning system, sharing the refrigerant and compressor.

When the air conditioner is operating, the amber indicator on the air conditioning button will be on whether the request for air conditioning comes from the cab climate control panel or the sleeper climate control panel. When the instrument panel lights are on, the blue snowflake indicator on the air conditioning button will be on.



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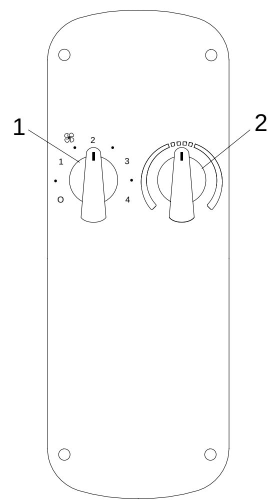
1. Air Outlet
2. Temperature Control Door
3. Blower
4. Air Inlet
5. Evaporator
6. Heater Core

Fig. 1, Sleeper Heater and Air Conditioner Unit



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1. Fan Switch
2. Temperature Control Switch

Fig. 2, Sleeper Climate Control Panel

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come in contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

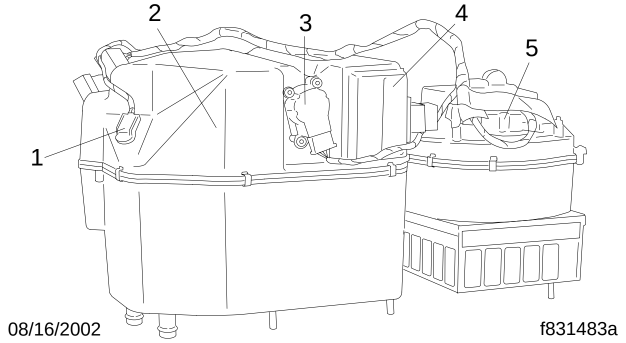
Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the PAG oil container to air for more than five minutes. PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix PAG oil with other types of refrigerant oil.

Replacement

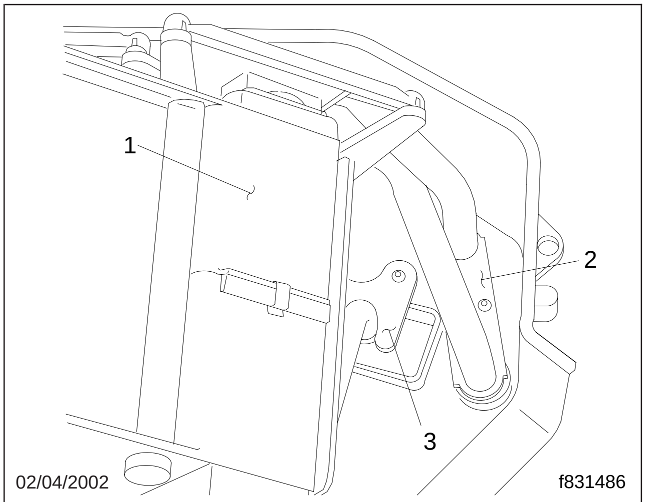
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
4. Drain the coolant from the cooling system. For instructions, see **Section 20.01**, Subject 100.
5. Remove the sleeper heater and air conditioner (HVAC) assembly from the vehicle. For instructions, see **Subject 150**.
6. Remove the capscrews that attach the temperature actuator to the HVAC assembly and remove the actuator. See **Fig. 1**.



1. CDTC Sensor
2. Sleeper HVAC Assembly
3. Temperature Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor

Fig. 1, Sleeper HVAC Assembly

7. Remove the clips that attach the upper housing of the HVAC assembly to the lower housing. Remove the upper housing.
8. Remove the heater core subassembly from the HVAC assembly.
   8.1 Remove the capscrew that attaches the heater tube retention bracket to the lower housing and remove the bracket. See **Fig. 2**.
   8.2 Remove the heater core subassembly from the lower housing.

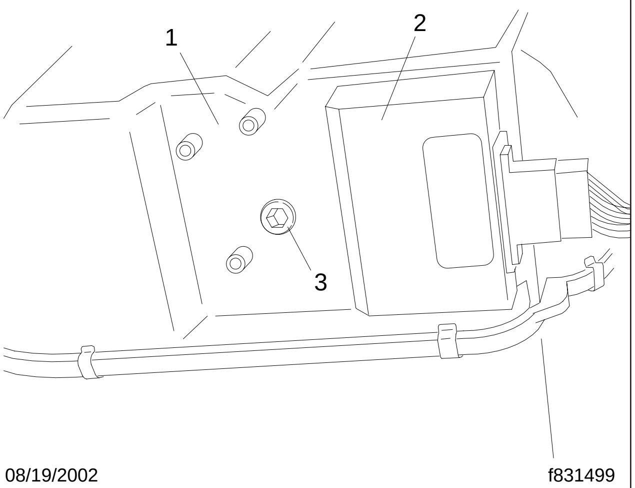


1. Heater Core Subassembly
2. Heater Tube Retention Bracket
3. Evaporator Tube Retaining Bracket

Fig. 2, Heater Core Subassembly

9. Spread the tabs to remove the heater core from the heater core housing. Remove the heater core.
10. Remove the heater core tubes from the heater core.
11. Attach the heater core tubes to the new heater core. Position the heater core tubes as shown in **Fig. 2**.
12. Install the heater core in the heater core housing. Press firmly on the heater core until the tabs are in the locked position.
13. Install the heater core subassembly in the lower housing. Make sure the heater core tubes protrude through the bottom of the housing.
14. Using a capscrew, attach the heater core tubes and the heater tube retention bracket to the lower housing.
15. Install the upper housing on the lower housing. Make sure the entire seam between the two housings is flush.
16. Check that the kinematic drive socket is aligned with the hole in the upper housing. See **Fig. 3**.
17. Using clips, secure the upper housing to the lower housing.

Heater Core Replacement



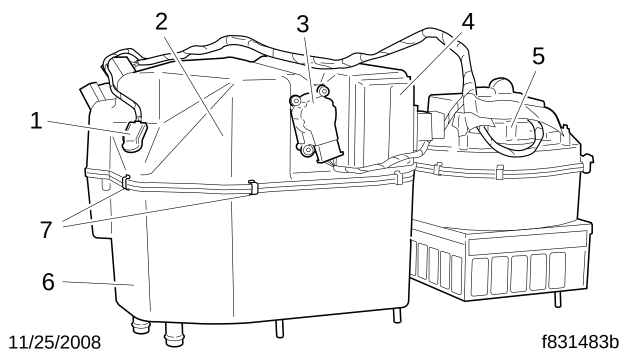
1. Upper Housing
2. Auxiliary Control Unit
2. Kinematic Drive Socket

Fig. 3, Upper Housing

18. Check that the temperature kinematic is working. Turn the kinematic drive lever and verify the temperature mix doors move when the drive lever is turned.
19. Install the temperature actuator.
    19.1 Align the actuator to the keyed shaft on the door.
    19.2 Using capscrews, attach the actuator to the HVAC assembly.
20. Install the HVAC assembly in the vehicle. For instructions, see **Subject 150**.
21. Fill the cooling system with coolant. For instructions, see **Section 20.01**, Subject 100.
22. Evacuate and charge the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
23. Connect the batteries.
24. Remove the chocks from the tires.

Replacement

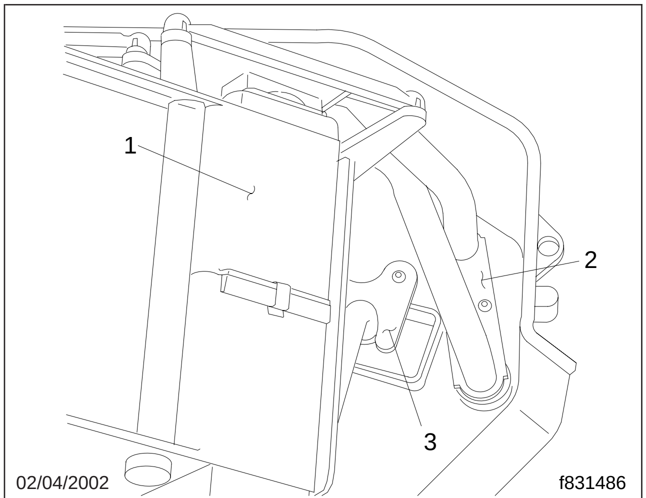
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Recover the refrigerant from the air conditioning system. See **Section 83.04, Subject 220** for instructions.
4. Drain the coolant from the cooling system. See **Section 20.01, Subject 100** for instructions.
5. Remove the sleeper heater and air conditioner (HVAC) assembly from the vehicle. See **Subject 150** for instructions.
6. Remove the capscrews that attach the blend door actuator to the HVAC assembly, and remove the actuator. See **Fig. 1**.



1. CDTC Sensor
2. Upper Housing
3. Blend Door Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor
6. Lower Housing
7. Clips

Fig. 1, Sleeper HVAC Assembly

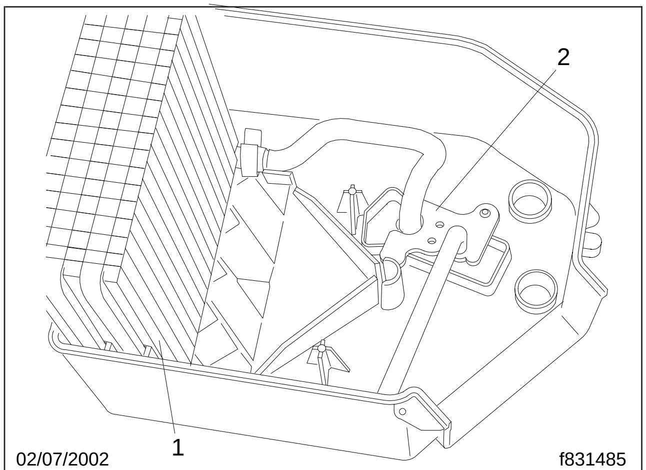
7. Remove the clips that attach the upper housing of the HVAC assembly to the lower housing. Remove the upper housing.
8. Remove the capscrew that attaches the heater tube retention bracket to the lower housing. See **Fig. 2**.
9. Remove the heater core subassembly from the lower housing.



1. Heater Core Subassembly
2. Heater Tube Retention Bracket
3. Refrigerant Line Retaining Bracket

Fig. 2, Heater Core Subassembly

10. Remove the capscrew that attaches the refrigerant line retaining bracket to the lower housing. See **Fig. 3**.



1. Evaporator
2. Refrigerant Line Retaining Bracket

Fig. 3, Evaporator

11. Remove the evaporator.
12. Remove the capscrews that attach the upper retaining plate and the expansion valve to the refrigerant lines. Remove the expansion valve.

Evaporator Replacement

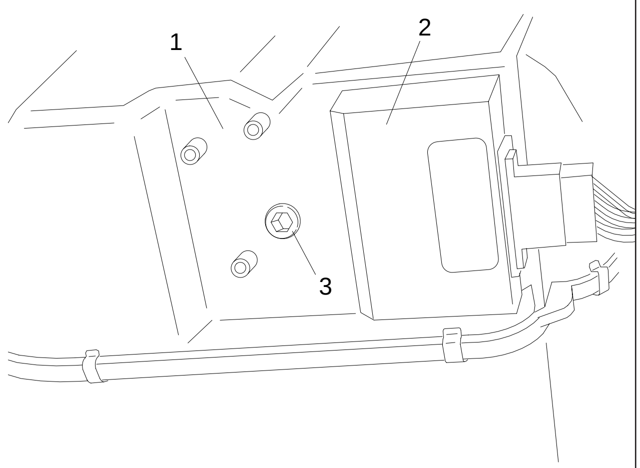
13. Remove and discard the Mini Stat-O-Seals from the evaporator refrigerant lines.

IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

14. Install new Mini Stat-O-Seals on the evaporator refrigerant lines.
15. Using capscrews, attach the expansion valve and the upper retaining plate to the evaporator refrigerant lines. Tighten the capscrews 35 lbf·in (400 N·cm).
16. Install the evaporator in the lower housing as follows.

    16.1 The base of the evaporator should rest on the condensate channels and the expansion valve should protrude through the bottom of the lower housing.

    16.2 Attach the refrigerant line retaining bracket to the housing. See **Fig. 3**.
17. Install the heater core subassembly in the lower housing. Make sure the heater core tubes protrude through the bottom of the housing.
18. Using a capscrew, attach the heater tube retention bracket to the lower housing. See **Fig. 2**.
19. Install the upper housing on the lower housing. Make sure the entire seam between the two housings is flush, and that the kinematic drive socket is aligned with the hole in the upper housing. See **Fig. 4**.
20. Using clips, secure the upper housing to the lower housing.
21. Check that the blend door kinematic is working. Turn the kinematic drive socket and verify the blend doors function correctly.
22. Align the blend door actuator to the drive socket. Then, using capscrews, attach the actuator to the HVAC assembly.
23. Install the HVAC assembly in the vehicle. For instructions, see **Subject 150**.
24. Fill the cooling system with coolant. For instructions, see **Section 20.01, Subject 100**.
25. Connect the batteries.
26. Evacuate and charge the air conditioning system. For instructions, see **Section 83.04, Subject 220**.



1. Upper Housing
2. Auxiliary Control Unit
3. Kinematic Drive Socket

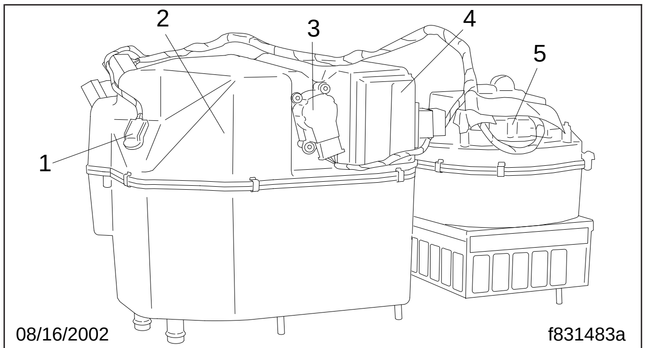
Fig. 4, Upper Housing

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Access the sleeper heater and air conditioner (HVAC) assembly.

   On vehicles with a baggage compartment on the right side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right side of the cab, raise the mattress and bunk panel to the locked position.
4. Disconnect the electrical connector from the blower motor. See **Fig. 1**.



1. CDTC Sensor
2. Sleeper HVAC Assembly
3. Temperature Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor

Fig. 1, Sleeper HVAC Assembly

5. Remove the capscrews that attach the blower motor to the HVAC assembly and remove the blower motor.
6. Using capscrews, install a new blower motor on the HVAC assembly.
7. Connect the electrical connector to the blower motor.
8. Lower the sleeper mattress and bunk panel or close the baggage compartment door.
9. Connect the batteries.
10. Remove the chocks from the tires.

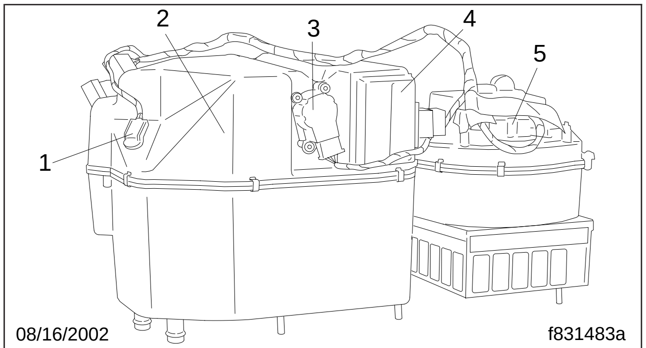
Temperature Actuator Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Access the sleeper heater and air conditioner (HVAC) assembly.

   On vehicles with a baggage compartment on the right side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right side of the cab, raise the mattress and bunk panel to the locked position.
3. Remove the capscrews that attach the temperature actuator to the HVAC assembly. See **Fig. 1**.



1. CDTC Sensor
2. Sleeper HVAC Assembly
3. Temperature Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor

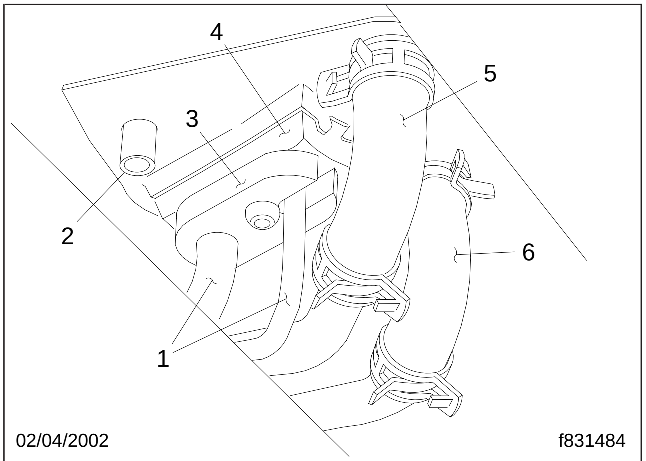
Fig. 1, Sleeper HVAC Assembly

4. Disconnect the electrical connector from the actuator and discard the actuator.
5. Connect the electrical connector to the new actuator.
6. Align the actuator to the keyed shaft on the door.
7. Using capscrews, attach the actuator to the HVAC assembly.
8. Lower the sleeper mattress and bunk panel or close the baggage compartment door.
9. Remove the chocks from the tires.

Heater and Air Conditioner Assembly Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
3. Drain the coolant from the cooling system. For instructions, see **Section 20.01**, Subject 100.
4. Place a drain pan under the sleeper on the right side of the vehicle to catch any coolant that may spill from the coolant lines. Remove the clamps that attach the coolant hoses to the coolant lines and remove the coolant hoses. See **Fig. 1**.



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1. Refrigerant Line
2. Drain Tube
3. Retaining Plate
4. Expansion Valve
5. Coolant Return Line
6. Coolant Supply Line

Fig. 1, Expansion Valve

IMPORTANT: Under no circumstances should the expansion valve ports remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. From under the sleeper on the right side of the vehicle, remove the capscrew that attaches the lower retaining plate and refrigerant lines to the expansion valve. Remove and discard the Mini Stat-O-Seals. Quickly cap the refrigerant lines. See **Fig. 1**.
6. From under the sleeper, remove the nuts and washers that attach the sleeper heater and air conditioner (HVAC) assembly to the floor of the sleeper.
7. Access the HVAC assembly.

   On vehicles with a baggage compartment on the right side of the cab, open the door to the baggage compartment.

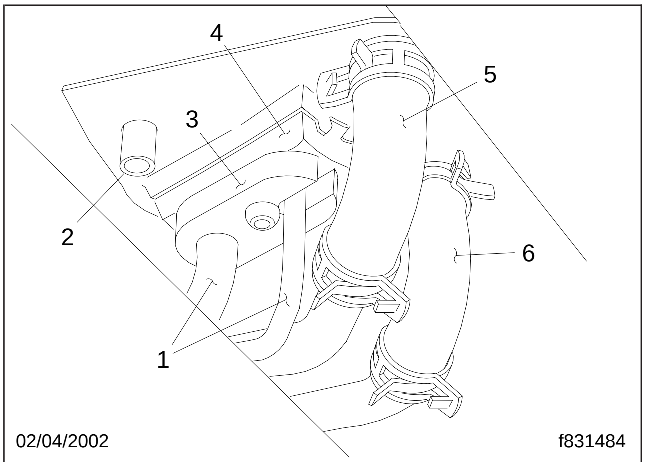
   On vehicles without a baggage compartment on the right side of the cab, raise the mattress and bunk panel to the locked position.
8. From inside the sleeper, disconnect the wiring harnesses from the HVAC assembly.
9. Remove the HVAC assembly from the vehicle.

Installation

1. Place the HVAC assembly on the floor of the sleeper. Make sure the heater core tubes, water drain tube, and mounting studs protrude through the floor.
2. Connect the wiring harnesses to the HVAC assembly.
3. From under the sleeper, install the washers and nuts on the mounting studs. Tighten the nuts 48 lbf·in (542 N·cm) maximum.
4. Uncap the refrigerant lines and install new Mini Stat-O-Seals on the refrigerant lines.
5. Using a capscrew, attach the lower retaining plate and the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).
6. Lower the mattress and the bunk panel or close the baggage compartment door.
7. Fill the cooling system with coolant. For instructions, see **Section 20.01**, Subject 100.
8. Evacuate and charge the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
9. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
3. From under the sleeper on the right side of the vehicle, remove the capscrew that attaches the lower retaining plate and refrigerant lines to the expansion valve. Remove and discard the Mini Stat-O-Seals. Quickly cap the refrigerant lines. See **Fig. 1**.



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1. Refrigerant Lines
2. Drain Tube
3. Retaining Plate
4. Expansion Valve
5. Coolant Return Line
6. Coolant Supply Line

Fig. 1, Expansion Valve

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

4. Remove the capscrews that attach the expansion valve to the upper retaining plate and remove the expansion valve.
5. Remove and discard the Mini Stat-O-Seals from the refrigerant lines.

IMPORTANT: Do not lubricate the Mini Stat-O-Seals prior to installation.

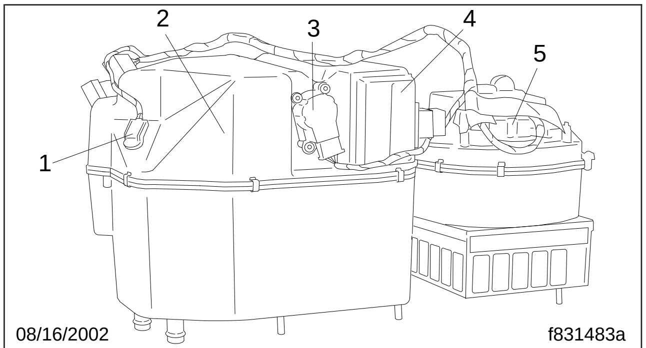
6. Install new Mini Stat-O-Seals on the evaporator refrigerant lines.
7. Using capscrews, attach the new expansion valve to the upper retaining plate. Using a torque wrench set to inch-pounds, tighten the capscrews 35 lbf·in (395 N·cm).
8. Uncap the lower refrigerant lines and install new Mini Stat-O-Seals on the refrigerant lines.
9. Using a capscrew, attach the lower retaining plate and the refrigerant lines to the expansion valve. Torque the capscrew 11 to 15 lbf·ft (15 to 20 N·m).
10. Evacuate and charge the air conditioning system. For instructions, see **Section 83.04**, Subject 220.
11. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Access the sleeper heater and air conditioner (HVAC) assembly.

   On vehicles with a baggage compartment on the right side of the cab, open the door to the baggage compartment.

   On vehicles without a baggage compartment on the right side of the cab, raise the mattress and bunk panel to the locked position.
4. Disconnect the electrical connector from the auxiliary control unit (ACU). See **Fig. 1**.



1. CDTC Sensor
2. Sleeper HVAC Assembly
3. Temperature Actuator
4. Auxiliary Control Unit (ACU)
5. Blower Motor

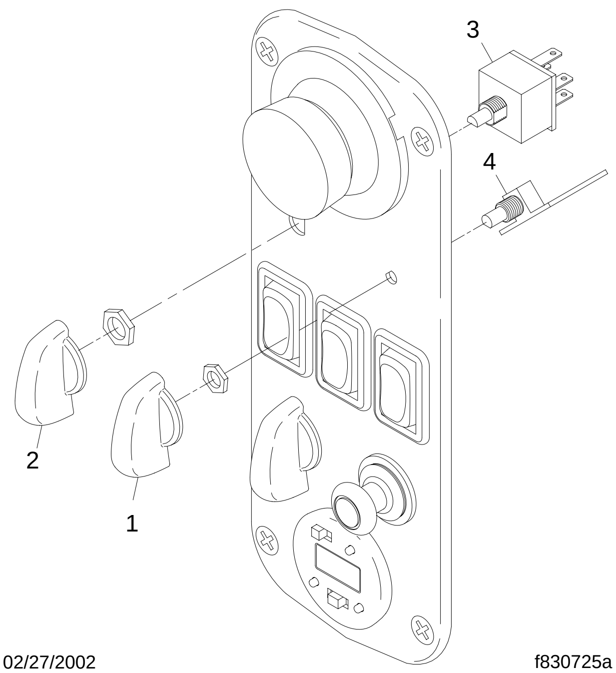
Fig. 1, Sleeper HVAC Assembly

5. Release the clips at the bottom of the auxiliary control unit to remove the ACU from the HVAC assembly.
6. Connect the electrical connector to the new auxiliary control unit.
7. Install the new auxiliary control unit on the HVAC assembly.
8. Lower the sleeper mattress and bunk panel or close the baggage compartment door.
9. Connect the batteries.
10. Remove the chocks from the tires.

Climate Control Panel Component Replacement

Fan Switch Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the Torx® fasteners that attach the climate control panel to the cab wall and pull the panel away from the wall. See **Fig. 1**.



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1. Temperature Control Switch Knob
2. Fan Switch Knob
3. Fan Switch
4. Temperature Control Switch

Fig. 1, Climate Control Panel

4. Pull the fan switch knob off the fan switch.
5. Disconnect the electrical connector from the fan switch.
6. Remove the nut and pull the fan switch out of the control panel.
7. Using a new nut, install a new fan switch on the climate control panel.
8. Attach the fan switch knob to the fan switch.
9. Connect the electrical connector to the fan switch.
10. Using Torx fasteners, attach the climate control panel to the cab wall.
11. Connect the batteries.
12. Remove the chocks from the tires.

Temperature Control Switch Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the Torx fasteners that attach the climate control panel to the cab wall and pull the panel away from the wall. See **Fig. 1**.
4. Pull the temperature control switch knob off the temperature control switch.
5. Disconnect the electrical connector from the temperature control switch.
6. Remove the nut and pull the temperature control switch out of the control panel.
7. Using a new nut, install a new temperature control switch on the climate control panel.
8. Attach the temperature control switch knob to the temperature control switch.
9. Connect the electrical connector to the temperature control switch.
10. Using Torx fasteners, attach the climate control panel to the cab wall.
11. Connect the batteries.
12. Remove the chocks from the tires.

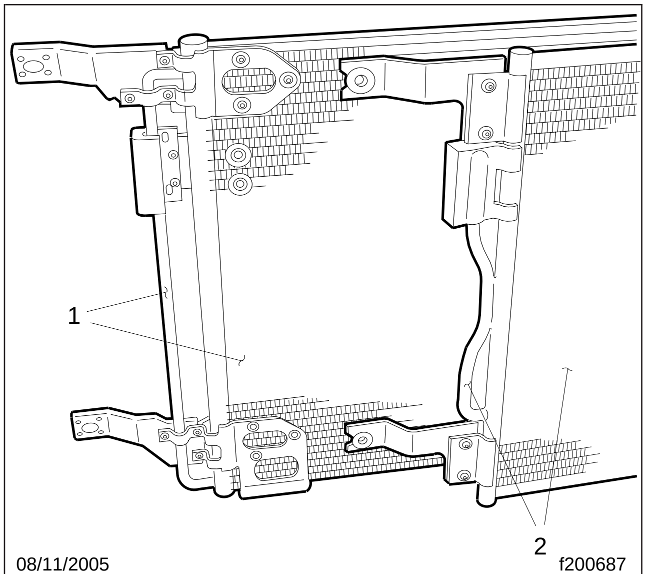
⚠ WARNING

R–134a is the only refrigerant that is approved for use on Freightliner vehicles. Several companies offer less expensive, hydrocarbon-based refrigerant, such as propane and methane. Use of these refrigerants will void the warranty on the air conditioning system, cause damage to the air conditioning system, and possibly result in personal injury or property damage. Leaking air conditioning systems charged with hydrocarbon-based refrigerants pose a serious risk of fire or explosion under the hood, or inside the passenger compartment. No vehicle built by Freightliner Trucks can be safely charged with hydrocarbon-based refrigerants, regardless of what the refrigerant supplier states.

When servicing an air conditioning system, be sure to use a refrigerant identifier to ensure that the system has not been charged with something other than R–134a. This should be standard practice since there is no way to tell what services have been previously performed. Identification by service technicians will help to avoid the risk of explosion and guard against contamination of equipment when refrigerant is recovered and recycled.

See **Fig. 1** for an illustration that shows the difference between the Behr and Modine condensers.

Temperature/pressure specifications and wiring diagrams for the blend air HVAC system can be found in **Section 83.06**, Subject 300.



1. Behr Condenser
2. Modine Condenser

Fig. 1, Behr and Modine Condensers

Refrigerant Oil Specifications		
Refrigerant Compressor Make	**Oil Type**	**Refrigerant Oil Capacity**
Sanden	PAG	10.1 oz (286 grams)
Climate Control	PAG	14 oz (397 grams)

Table 1, Refrigerant Oil Specifications

Refrigerant Charge Specifications		
Condenser Make	**Type of Cab**	**Refrigerant Amount**
Behr	Day Cab	2.875 lb or 2 lb 14 oz (1.30 kg)
	SleeperCab	3.438 lb or 3 lb 7 oz (1.56 kg)
Modine	Day Cab	3.25 lb or 3 lb 4 oz (1.47 kg)
	SleeperCab	3.75 lb or 3 lb 12 oz (1.70 kg)

Table 2, Refrigerant Charge Specifications

Diagnostic Overview

A/C cooling problems fit into two basic failure categories, refrigerant or electrical. The goal of this troubleshooting guide is to provide the information necessary to determine what part is causing the problem. We expect the tech to use approved tools and shop practices, symptom driven diagnostics, and warranty component evaluation guides to properly asses component failures. Refer to www.accessfreightliner.com for available tool information, service training, and warranty documentation.

For system performance testing, ambient temperature must be above 70°F (21°C) to produce reliable results. In order to quickly determine if your symptoms are refrigerant or electrical, two main tools should be utilized by the technician; ServiceLink and a refrigerant gauge set.

General Diagnostic Procedure

1. Perform the preliminary checks.
2. Perform an initial system inspection.
3. Make a determination about which system is suspected (refrigerant or electrical), and follow the symptoms through to a suspected part.
4. Repair the problem.
5. Verify that all of the refrigerant connections removed during the service are properly sealed using an approved refrigerant leak detector.
6. Verify that the problem has been resolved.

System Overview

The blend air system uses Constant Discharge Temperature Control (CDTC) to regulate the temperature in the vehicle. The CDTC is a closed-loop system that uses the climate control panel settings, the temperature sensors, and various J1587 databus inputs to control and maintain the outlet temperature of the system. The blend air system has an electronically controlled, brushless, direct current (BLDC) blower motor that does not require a resistor block to control the blower speed.

In the blend air system, all air is directed through the evaporator. The amount of air needing to be reheated is controlled by the temperature control door, which directs that amount of air through the heater core.

The cab HVAC assembly consists of a blower motor, evaporator, heater core, CDTC sensor, evaporator temperature sensor, and three electric actuators that drive the air direction control doors. The doors perform the following functions:

- temperature control door—controls how much air is directed through or around the heater core
- air selection mode door—directs airflow to the face, floor, or defrost outlets
- recirculation door—controls the amount of outside air that enters the HVAC unit

The cab climate control panel (front control unit) contains the microprocessor that controls the system.

The sleeper or auxiliary HVAC assembly consists of a brushless blower motor, evaporator, heater core, auxiliary control unit, air filter, CDTC temperature sensor, and an electric actuator that drives the temperature control door.

The refrigerant system consists of a compressor, condenser, receiver-drier, thermal expansion valve(s), and pressure sensors.

Preliminary Checks

NOTE: Pay attention to the refrigerant system components for evidence of oil seepage and other potential leaks that will be checked during subsequent diagnostic steps.

Before testing the operation of the air conditioning system, check the following items:

1. Inspect the drive belt and mounting fasteners for signs of wear or looseness.
2. Visually inspect the clutch for signs of over heating, damage, or wear. If necessary, check the clutch gap. For instructions, see **Section 83.01**, Subject 140.
3. Check for road debris buildup on the condenser coil fins. Using air pressure and a whisk broom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
4. Inspect the fresh and recirculation air filter elements, and inspect the intake-air ducting for debris.
5. With the engine off, and Optimized Idle (if applicable) disabled, turn the compressor drive plate by hand to feel for grinding or harshness inside the compressor.

Initial Inspection

1. Connect refrigerant pressure gauges and ServiceLink to the vehicle.
2. Start the vehicle and select A/C mode and a cold temp setting to request compressor engagement. If the following conditions are met, the clutch should engage.
    - The engine is running at, or above 450 RPM for at least 5 seconds.
    - Refrigerant system high side pressure is above 20 psi (140 kPa). Pressure reading is taken at the binary switch.
    - Refrigerant system high side pressure is below 450 psi (3100 kPa). Pressure reading is taken at the binary switch.
    - Vehicle compressed air system is above 60 psi (414 kPa). Pressure is taken at the dash ECU, and transmitted on the J1587 databus.
    - Evaporator core temperature sensor above 44°F (6.5°C). Temperature is taken in the main heater box, as a direct input to the FCU.
    - The blower feedback from the main HVAC unit is connected, and the signal is meeting the minimum RPM requirements for each knob position.

At this point you should be seeing some indication of a problem, either electrical or refrigerant.

Electrical—If there are any faults that affect the front control unit (FCU) or any of the parallel systems that provide input information to the FCU, or if the system requirements are being met, but the clutch is still not engaging, there may be an electrical problem related to the FCU, or the voltage signal to the compressor.

Refrigerant—If the low side pressure is drawing down far below 20 psi (140 kPa), or if the high side pressure is rising above 450 psi (3100 kPa), there is a refrigerant related problem.

Post-Repair Procedures

After repair work is completed, verify that the repair resolved the problem.

1. Verify that all of the refrigerant connections removed during the service are properly sealed using an approved refrigerant leak detector.
2. Check for fault codes. There should be no active fault codes that indicate the problem still exists.
3. If there is still a problem, repeat the appropriate tests, and make repairs as needed.
4. Verify again.

Refrigerant System Tests

Use the following procedure to evaluate the performance of the air conditioning system. If the system does not operate within the following guidelines, further diagnosis and repair may be necessary. The dash outlet temperature will fluctuate during each clutch cycle, and the temperature reading should be taken at the lowest value.

1. Park the vehicle out of direct sunlight, shut down the engine, and chock the tires.
2. Open the hood and leave the hood open for the entire test.
3. Open the driver and passenger doors and leave the doors open for the entire test.
4. Note the current ambient air temperature.

NOTE: High relative humidity reduces cooling and could increase the dash outlet temperatures, and high-side system pressures.

5. Using the ambient air temperature readings noted in the previous step, find the temperature/pressure specifications in **Table 1** that best match your ambient conditions.
6. Connect the test gauges to the high and low side service ports.
7. Place a thermometer in the center dash outlet. If the vehicle is a SleeperCab, place another thermometer in the lower sleeper outlet.

NOTE: EPA07 and owner-set idle limits may prevent the warm-up run from continuing without occasional throttle inputs.

8. Start the engine and run the A/C for 15 minutes.
9. Set the engine speed to 1500 rpm and engage the engine fan.
10. Set the cab climate control panel to the following settings:
    - air selection switch to face mode
    - air conditioning on
    - blower speed switch to high
    - temperature control switch to full cold
    - recirculation switch off
11. On SleeperCabs, set the sleeper climate control panel to the following settings (or initiate "bunk override" mode):
    - blower speed switch to high
    - temperature control switch to full cold
12. Allow the system to stabilize at least five minutes or until the dash and sleeper outlet temperatures have reached a minimum, then compare the system values to the information in **Table 1**. The results should be close to those listed, but minor discrepancies are not a guarantee that the system has a refrigerant system problem.

    Possible causes of refrigerant system complaints:
    - Too much oil - High high-side pressure, poor heat rejection at the condenser
    - Too much refrigerant - High high-side pressure, good cooling
    - No enough refrigerant - Low high-side pressure, low low-side pressure, poor cooling
    - Debris in the system - TXV plugged or uncontrollable, compressor turns hard, receiver/dryer is icing
    - Contaminated or incorrect refrigerant - Very inconsistent system pressures and duct temps

Refrigerant System Tests

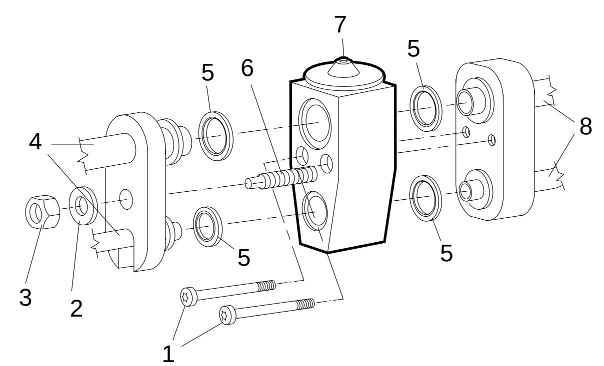
Approximate Temperature/Pressure Specifications at Moderate Humidity (less than 50%)					
Ambient Air Temp.	Center Dash Outlet Temp.	Service Port Pressures		A/C Compressor Status	A/C Compressor Status Comments
		High Side psi (kPa)	Low Side psi (kPa)		
65–75°F (18–24°C)	44–50°F (7–10°C)	94–124 (648–855)	18–25 (124–172)	approximately 50% duty cycle	Cycling on evaporator freeze protection
75–85°F (24–29°C)	45–60°F (7–16°C)	114–125 (786–862)	20–26 (138–179)	approximately 75% duty cycle	
85–95°F (29–35°C)	55–70°F (13–21°C)	135–170 (931–1172)	23–28 (158–193)	On	On steady
95–105°F (35–41°C)	65–80°F (18–27°C)	160–200 (1003–1379)	25–30 (172–207)	On	On steady

Table 1, Approximate Temperature/Pressure Specifications at Moderate Humidity (less than 50%)

Thermal Expansion Valve Testing

General

The thermostatic expansion valve (TXV) (see **Fig. 1**) is a controlling device that regulates the flow of refrigerant into the evaporator. It is actuated by changes in evaporator pressure and the superheat of the refrigerant gas leaving the evaporator. Superheat is defined as any temperature of a gas above the boiling point for that liquid. For example, when a refrigerant liquid boils at a low temperature of 40°F (4.5°C) in the evaporator and then the refrigerant gas increases in temperature, superheat has been added. If this refrigerant changed from a liquid to a gas or vapor at 40°F (4.5°C) and then the refrigerant vapor increased in temperature to 50°F (10°C), then it has been superheated by 10°F (6.5°C). The refrigerant entering the evaporator is metered at a rate that matches the amount of refrigerant being boiled off in the evaporator. In addition to metering refrigerant, the TXV also provides a pressure drop in the system, separating the high-pressure side of the system from the low-pressure side. To operate properly, the TXV must have a steady flow of liquid refrigerant supplied to it by the high side of the system. Issues such as an excessively low refrigerant charge, or contaminates in the system can interrupt this flow of liquid to the valve. In these cases, symptoms may surface making it seem as if the valve is inoperative or plugged. These symptoms can include poor performance, low low-side pressures (even a vacuum) ,etc. Before replacing a TXV, it is important to verify that there are no contaminates in the system and that the refrigerant charge is correct, by performing a refrigerant identification and thorough leak check of the entire system. The TXV is often incorrectly replaced as the primary failed part, but is rarely the cause of a performance issue. In rare instances the power element of the TXV can loose its charge, reducing the range of the TXV, but there is no other situation that can be considered a failure of the TXV. Due to the similarity of symptoms that these root causes have on A/C performance, proper diagnosis is essential to making the correct repairs to the A/C system.



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1. Screw (2)
2. Washer
3. Nut
4. Refrigerant Lines to J-Block
5. Seal
6. Stud
7. Thermal Expansion Valve
8. Refrigerant Lines to Evaporator

Fig. 1, Thermal Expansion Valve Installation

Diagnostics

To determine if the TXV is functioning, watch the low-side pressure while the compressor is engaged. The influence from the TXV modulating can be seen as the low-side gage needle "wags." As the load on the system changes from ambient conditions, the TXV may not wag as much, and care must be taken to prevent false diagnosis. The function of the individual TXVs in a dual evaporator system will be combined to produce the total pressure needle waging that is observed. If a TXV failure is suspected, connect the gage set to the properly charged refrigerant loop, and run the compressor. Watch for the low-side gage needle to wag, indicating that the TXV is working. Depending on the load, the low-side pressure may progress from moderate to high, but the needle will simultaneously wag as the average pressure changes.

Leak Detection

General

The information in this section is intended to convey a general method of leak detecting that should be used to enhance the usefulness of a leak detector being used in accordance with operator's instructions provided by the manufacturer. No technician should attempt to perform leak detection without reading and understanding the owners manuals for the tools being used, and should expect to review those instructions from time to time, to ensure the proper method continues to be used. The process described here was developed using the published list of recommended tools and warranty evaluation guides as a basis for the expectations for repair competence. The only way to confirm that a refrigerant leak exists is by finding a failed or damaged component. A UV flashlight and goggles can be used to provide an indication of a leak, but a approved electronic leak detector must be used to confirm the existence of a leak, and approximate the leak rate. The connections used for A/C refrigerant are intended to seal properly, but given the high level of sensitivity provided by current leak detecting equipment, the detector may indicate a leak even though the connection meets the design specifications. To balance this, the "Acceptable Leak Rates by Component" table in **Specifications** contains the qualifying leak rates for the components used on P2 vehicles. The leak rates, in oz/yr, correspond to the sensitivity values required for all detectors that meet the SAE J2791 functional specifications. By switching between the sensitivity levels, it is possible to discern between leaks of varying sizes and qualify each potential leak. It is expected that a leak rate relates to each component, as it arrives at the factory, but the Mini-Statoseals that connect the components together are specified separately. Additionally, due to the possible difficulty of distinguishing between two minor leaks at a multi-port connection, the leak rate for two Mini-Statoseals should be considered a condemning value if it is not completely clear which seal is leaking.

Method

IMPORTANT: The refrigerant system should be warmed up from completion of the initial inspection, but the engine is off.

1. Shut down the engine.
2. Before testing for compressor leaks, blow shop air near the compressor shaft seal to clear any refrigerant that may have collected.
3. Install caps before testing the service ports.
4. Minimize the amount of wind blowing through the test area, as this will make small leaks harder to find.
5. Set the detector on the most sensitive setting.
6. Start at a point along the refrigerant loop, and methodically follow the refrigerant path, test all around O-ring connections and crimped ends until you reach the starting point.
7. When the detector indicates a suspected leak, move it away from the suspect area, then recheck to the location after the detector has cleared.
    - If the detector continues to indicate a leak, adjust the sensitivity of the detector to match the designed leak specifications shown in "Acceptable Leak Rates by Component" Table, in **Specifications**, and retest the suspected area to confirm the leak.
    - Mark any confirmed leaks, then change the sensitivity back to high and continue checking the system.
8. After the entire system has been checked, recover the refrigerant, investigate each leak point to determine what component failed, and how, then repair leak.

Refrigerant System Tests

9. Recharge the refrigerant system, then use the electronic leak detector to confirm that each connection opened during the repair is sealed within the design specifications provided in the "Acceptable Leak Rates by Component" table in **Specifications**.

Sanden Compressor Testing, Pressure or Pumping Test

NOTE: This test is meant to be performed after a failure has been repaired, which may have caused damage to the compressor due to low refrigerant or oil levels.

Compressors cause refrigerant to flow through the system by creating a pressure differential, high and low pressures. If the compressor can be forced to produce a high pressure in excess of 350 psi (2415 kPa) it is a good compressor.

IMPORTANT: The compressor pumping test must be performed with the refrigerant system charged to the factory specifications, and functioning properly. This test should only be run for a short time period. Shut the system down immediately once 350 psi (2415 kPa) is achieved.

1. Confirm the system is charged per the OEM requirement before proceeding.
2. Disable the engine cooling fan. The condenser can also be blocked with sheet of cardboard. The purpose is to limit heat removal from the system and build compressor discharge pressure.
3. Start engine and engage the compressor clutch.

   Compressors operating within specification should be capable of reaching 350 psi (2415 kPa).
4. Shut the system down immediately, once 350 psi (2415 kPa) is achieved.

Electrical Component Checking

Blower Motor

General Information

The blower used in the blend air HVAC system is a brushless DC motor (BLDC). The FCU or ACU provides a DC voltage signal to the motor to control speed. This eliminates the need for a resistor block as used on the water-valve controlled HVAC system. The blower motor provides a feedback signal to the FCU or ACU to indicate blower speed and error conditions.

Delayed Speed Change

When the blower speed is changed on the control panel, a delay in actual speed change is normal. The speed will ramp up or down at 1000 rpm per second. Therefore, if the fan is off and then turned on high speed, it will take approximately six seconds for the fan to actually reach full speed.

Starting Sequence Protection Mode

In case the blower motor does not start (the feedback line indicates zero speed), the FCU or ACU will apply five consecutive starting sequences. If all five starting sequences are unsuccessful, the blower motor electronic module enters a starting sequence protection mode. The module will no longer attempt to start the blower motor until the control signal from the FCU or ACU is reset to zero. See "Blower Rotor Stall Protection Mode." This means one of the following must occur:

- Turn the blower speed switch to the off position, then back on.
- Cycle the ignition switch.
- Disconnect/reconnect the blower motor connector.

Possible reasons the blower motor may enter the starting sequence protection mode include:

- locked blower motor rotor
- open circuit in blower motor feedback signal line
- faulty blower motor

Temperature Protection Mode

The blower motor has an internal temperature sensor connected to the blower motor electronic module. The electronic module monitors the blower temperature and enters a protection mode when normal temperature is exceeded. When the blower motor enters protection mode, the blower speed is reduced to 1000 rpm to reduce the load on the motor. When the motor temperature has lowered to the normal range, the blower speed resumes operation according to the control panel settings.

If the temperature continues to rise or remains too high after the blower speed is initially reduced, then the speed is further reduced to minimum speed (about 400 rpm) and then the blower motor stops. Once the blower motor temperature returns to normal, the blower speed resumes operation according to the control panel settings. No reset is required.

Blower Motor Voltage Protection Mode

The blower motor electronic module monitors the voltage supply to the motor and enters a protection mode when the voltage is too high or too low. The protection mode works as described in **Table 1**.

Blower Motor Voltage Protection Mode Conditions	
Voltage at the Motor	**Results**
under 8.5 VDC	Blower motor will shut off and will not restart until the voltage reaches 10.5 VDC and will operate at reduced speed if voltage is under 12VDC.
8.5 to 12.0 VDC	Blower motor will operate at reduced speed. The reduced speed varies with voltage. The lower the voltage, the slower the blower speed.
12.0 to 17.0 VDC	Blower motor operates normally at user selected speed.

Electrical System Tests

Blower Motor Voltage Protection Mode Conditions	
Voltage at the Motor	**Results**
over 17.0 VDC	Blower motor will shut off. Will not restart until voltage reaches 16 VDC.

Table 1, Blower Motor Voltage Protection Mode Conditions

Blower Motor Stall Protection Mode

The blower motor electronic module monitors the blower for a locked rotor condition. If the rotor is locked starting from an off condition, the electronic module will attempt a starting sequence before entering this protection mode. See "Starting Sequence Protection Mode." If the blower rotor locks up and stalls from a running condition, the blower will immediately enter this protection mode. The blower motor will not restart until the blower speed control signal has decreased to minimum by cycling the ignition, or turning the blower speed control from on to off, then back on, and the stall condition has disappeared.

Speed/Diagnostics Feedback Line

The blower motor supplies diagnostic and speed information to the FCU/ACU. See **Table 2** and **Table 3**.

Blower Motor Feedback Signal From Blower to FCU or ACU*		
Speed/Error Conditions	**Signal**	**Duty Cycle**
Blower Speed	Three one-millisecond pulses per revolution. Blower speed is determined by the time between each set of three pulses. Time can be viewed using an oscilloscope. rpm=1/(time between sets of three pulses) x 60	NA
Error—temperature protection mode	10Hz	25%
Error—voltage protection mode	10Hz	50%
Error—blocked rotor	10Hz	75%

* Blower speed and diagnostic information are both provided by the BLDC blower motor on the feedback signal wire; however, the FCU and ACU only use the blower speed information.

Table 2, Blower Motor Feedback Signal from Blower to FCU or ACU

Blower Speed Control Signal From FCU or ACU to Blower*†			
Knob Position	**FCU Signal (DC volts)‡**	**Blower Speed (rpm)**	**Blower Speed Comments**
0	0.0 to 0.74	0	Constant speed in this range
1	0.75 to 1.0	400	Constant speed in this range

Electrical System Tests

Blower Speed Control Signal From FCU or ACU to Blower*†			
Knob Position	FCU Signal (DC volts)‡	Blower Speed (rpm)	Blower Speed Comments
2	1.5	800	Speed varies linearly with voltage in this range.
3	2.0	1200	
4	2.5	1600	
5	3.0	2000	
6	3.5	2400	
7	4.0	2800	
8	4.5	3200	
9	5.0+	3600	
10	5.5+	4000	Constant speed above this range

* Error conditions can be monitored on the feedback signal line using a digital multimeter equipped with a duty cycle function.

† Blower speed and diagnostic information are both provided by the BLDC blower motor on the feedback signal wire; however, the FCU and ACU only use the blower speed information.

‡ These values are based on a system operating voltage of 13.5 VDC.

Table 3, Blower Speed Control Signal from FCU or ACU to Blower

A/C Clutch Circuit

General Operation

The air conditioner compressor clutch is controlled by the FCU. When certain inputs to the FCU are met, the FCU sends the A/C request signal to the A/C clutch relay located in the PDM. This signal is +12 VDC. The request signal causes the A/C clutch relay to make contact between the common and normally open contacts of the relay. This allows current to flow through the relay, then through the binary pressure switch and to theA/C compressor clutch, thus engaging the compressor.

In steady state operation, compressor cycling is controlled by two things: evaporator temperature sensor and an internal FCU timer that prevents the compressor from cycling more than four times per minute. The A/C request signal does not become active until the evaporator temperature sensor is at least 44°F (7°C). See **Table 4**. Once the signal is active and as long as the other conditions are met, the signal remains active until the evaporator temperature sensor reaches 37°F (3°C), then becomes inactive. The A/C request signal does not activate again until the temperature is above 44°F (7°C). With the A/C on in warm or humid weather, the evaporator temperature will most likely remain between 37 to 44°F (3 to 7°C), thus keeping the compressor on continuously.

When the blower speed control is set to any speed other than off, and the air selection switch is set to any setting other than one of the defrost modes, then the user may request A/C by pressing the A/C button. The light on the button turns on and the FCU is placed in A/C mode, thus allowing the compressor to engage when other conditions are met. If the air selection switch is in any of the defrost settings, then the A/C mode is turned on automatically and cannot be turned off by pressing the A/C button.

FCU A/C Request Rules*		
Input	Input Type	State All Inputs Must Be for the FCU to Send A/C Request Signal
Ignition power	+12V	On
Engine speed	J1587	Above 450 rpm for at least 5 seconds

Electrical System Tests

FCU A/C Request Rules*		
Input	**Input Type**	**State All Inputs Must Be for the FCU to Send A/C Request Signal**
Low air	J1587	Not low
Evaporator temperature sensor	Sensor	Above 44°F (7°C)
A/C switch/light	Control panel	On
Air selection switch	Control panel	Any A/C or defrost setting except when rear override is active
Temperature control switch	Control panel	Any
Fan switch	Control panel	Any setting other than off except when rear override is active; fan will be at least minimum speed.
Compressor cycling timer	Internal FCU logic	15 seconds elapsed since A/C request last active
Main Blower Feedback Signal	Rotational Signal (Hz)	No active faults from the blower feedback signal

* If any input state does not meet the conditions listed in this table, A/C request will not be sent. The only exception is when the sleeper unit requests A/C support by going into rear override mode. See "Cab Override."

Table 4, A/C Request Rules

A/C Mode

The auxiliary HVAC system has the ability to request A/C causing the FCU to engage the compressor. For more information, see "Cab Override."

Once the HVAC system is in A/C mode, the system is able to send the A/C request when all the conditions are met. See **Table 4**. When the system is in A/C mode, the light on the A/C button comes on. Just because the system is in A/C mode does not necessarily mean that the A/C compressor should be engaged. See **Table 4** for A/C request rules.

NOTE: If the air selection switch is changed to defrost when in A/C mode, the A/C mode will remain active and the light on the A/C button will remain on. When in defrost, the user will not be able to cancel A/C mode by pressing the A/C button. If the mode is changed back to A/C, the A/C mode will remain on, but the user will be able to turn it off by pressing the A/C button. See **Fig. 1**.

NOTE: The A/C mode is remembered after an ignition cycle. If the A/C mode indicator was on because the A/C button was pressed before an ignition cycle or battery kill switch cycle, the FCU will remember this mode and activate it again after the cycle.

Defrost Mode

When the HVAC system is in defrost mode, A/C mode is automatically activated and the system is able to send the A/C request when all the conditions are met. When the system is in defrost mode, the light on the A/C button is on. Just because the system is in defrost mode does not necessarily mean that the A/C compressor should be engaged. See **Table 4** forA/C request rules.

NOTE: If the mode is taken out of defrost, A/C mode and the light will be deactivated unless the system was in A/C mode prior to being in defrost mode. When the system is in defrost mode, A/C mode cannot be disabled by pressing the A/C button. See **Fig. 2**.

A/C Request

Once A/C mode is activated, the A/C compressor clutch can be engaged when all the engagement rules are met. The A/C request rules are described in **Table 4**.

Recirculation

Recirculation Mode

Recirculation mode allows the driver to choose between fresh air or recirculated air moving through the HVAC system. When recirc mode is selected, all of the air through the front HVAC unit is recirculated

Electrical System Tests

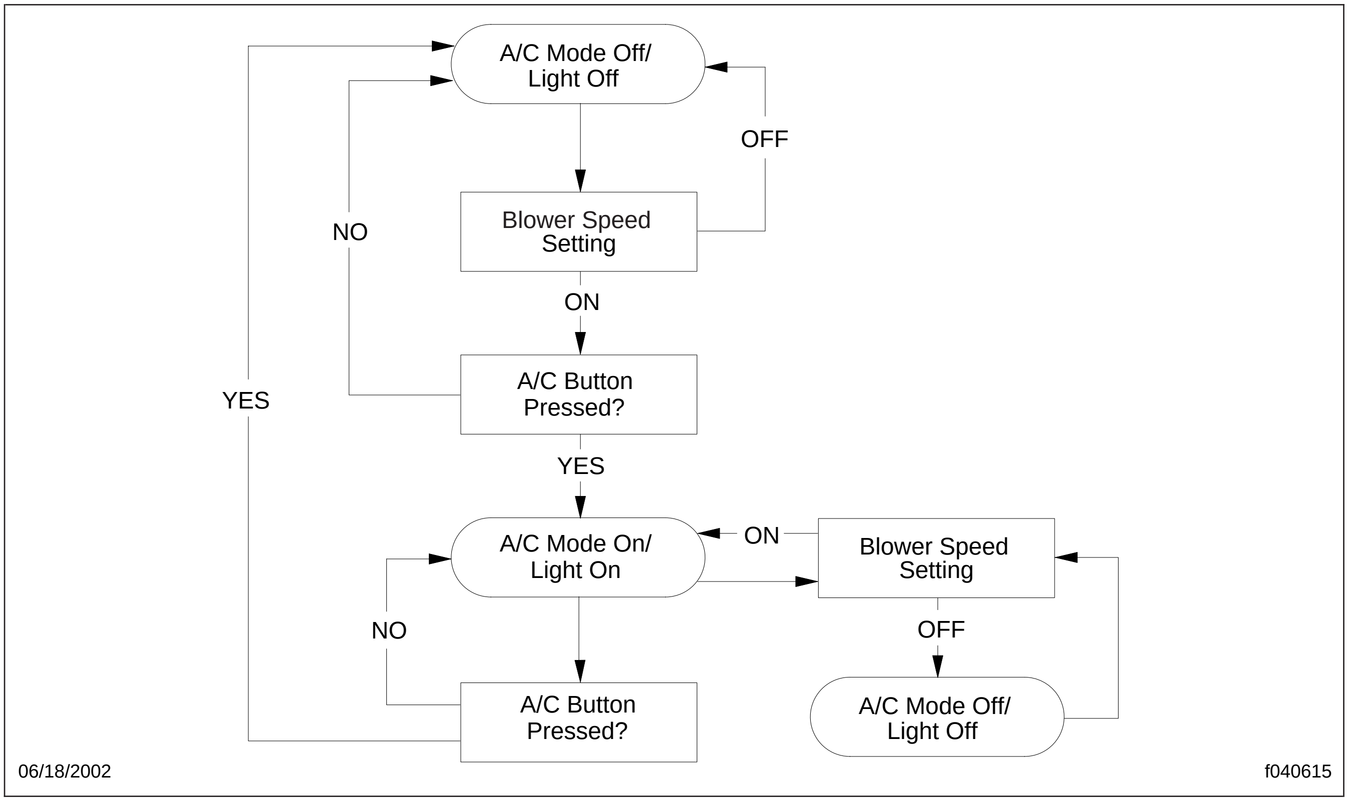


Fig. 1, A/C Mode Function When Not in Defrost Mode

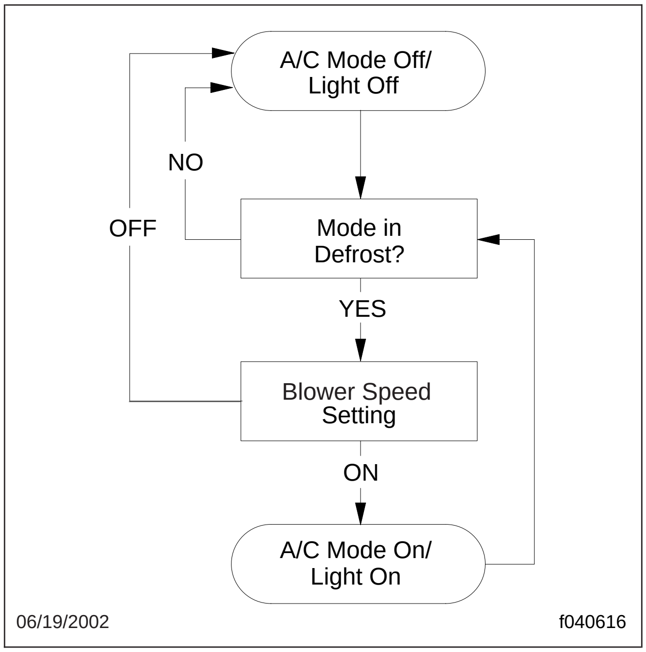


Fig. 2, A/C Mode Function When in Defrost Mode

within the cab, except when the unit is in partial recirc mode, which is explained in "Partial Recirc Mode."

Using the recirculation mode prevents dusty or smoky air from entering the cab and provides better air conditioning performance since the cab air is already cooled and less humid than outside air. Humidity holds a lot of heat.

Partial Recirc Mode

After recirc mode has been on for 20 minutes, the system enters partial recirc mode to introduce a controlled amount of fresh air to the cab. This prevents the air from becoming stagnant if left in recirc mode. The recirc door partially opens to one of two partially open positions depending on vehicle speed. When the vehicle is stopped or moving very slowly, the recirc door opens to its widest partially open position. When the vehicle is moving at slow to moderate speeds, the recirc door opens to its most narrow partially open position. Pressing the recirc button again

Electrical System Tests

resets the 20-minute timer and the system goes into full recirc again. See **Table 5** for information on partial recirc.

Partial Recirc Operation			
Condition	**Vehicle Speed**	**Partial Recirc Door Opening**	**Partial Recirc Door Opening Approximate Height: inch (mm)**
Initial partial recirc position after 20 minutes of full recirculation	Under 5 mph (8 km/h)	Wide	1-1/4 (32)
	Over 5 mph (8km/h)	Narrow	1/8 to 1/4 (3 to 6)
Partial recirc position once initial position is reached	Under 2 mph (3 km/h)	Wide	1-1/4 (32)
	2–8 mph(3–13 km/h)	No change	Either 1-1/4 (32) or 1/8 to 1/4 (3 to 6) depending on vehicle speed prior to entering the 2 to 8 mph (3 to 13 km/h) range.
	Over 8 mph (13km/h)	Narrow	1/8 to 1/4 (3 to 6)

Table 5, Partial Recirc Operation

Recirc Diagnosis

To see the recirc door, remove the heater and air conditioner cover and the recirculation air filter. See **Fig. 3**. When the system is not in recirc mode, the recirc door is fully open. When the system is in recirc mode, the recirc door is closed tight. See **Fig. 3**.

To check partial recirc, turn the engine on and activate the full recirc mode for 20 minutes. After 20 minutes, with the vehicle idling in the shop, the recirc door should open to its widest partially open position. To check if the recirc door adjusts to the narrow, partially open position, have someone drive the vehicle over 8 mph (13 km/h) while observing the recirc door. See **Fig. 3**. Compare the width of the recirc door opening to the values in **Table 5**. If the recirc door does not function as described, check the recirc actuator motor and wiring. If okay, the FCU is probably faulty.

Override

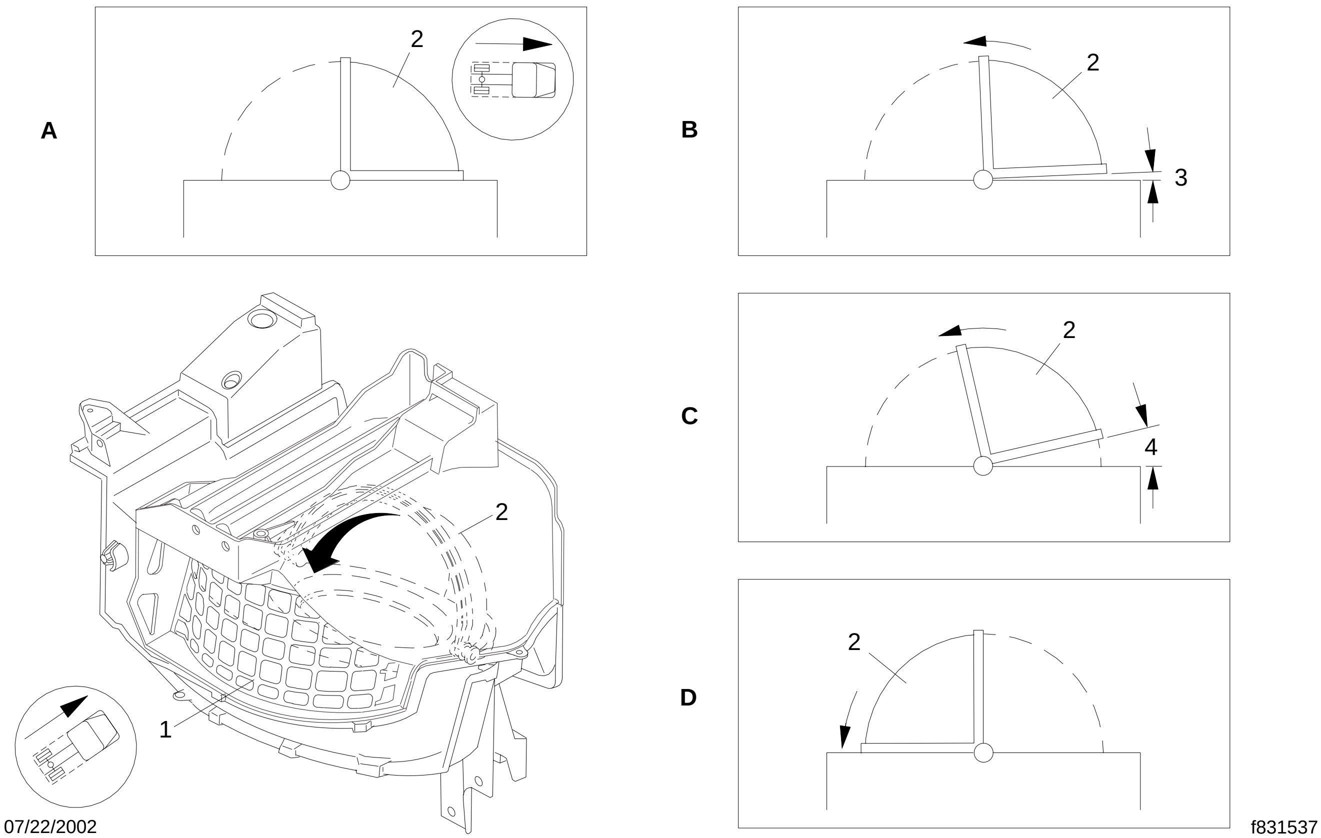
Bunk Override

The auxiliary unit can be controlled from the front control panel by using the bunk override switch. When the upper half of the bunk override switch is pressed to the momentary on position, the front unit broadcasts a snapshot of the front temperature and blower speed settings to the auxiliary unit. The auxiliary unit matches these settings. The temperature and blower speed settings on the front unit can be changed without affecting the auxiliary unit, until the bunk override switch is pressed in the momentary on position again.

When the lower half of the bunk override switch is pressed, bunk override mode turns off and the auxiliary unit reverts to the auxiliary control settings. If the auxiliary control panel settings are changed when the system is in bunk override mode, bunk override will be canceled and the auxiliary unit will operate using the auxiliary control panel settings. See **Table 6** for information on bunk override functionality.

NOTE: If bunk override is activated and then the front blower or temperature settings are changed and the ignition key is cycled, then the bunk override will be active again, but the auxiliary unit will track the new front settings.

Electrical System Tests



A. In recirc mode the recirc door is in the fully closed position.
B. Recirc door in the narrow, partially open position.
C. Recirc door in the widest, partially open position.
D. In non recirc mode the recirc door is in the fully open position.

1. Recirculation Air Filter Retainer
2. Recirc Door
3. Narrow Partially Open Position of approximately1/8 to 1/4 in (3 to 6 mm)
4. Widest Partially Open Position of approximately1-1/4 in (32 mm)

Fig. 3, Recirc Door Operation

Electrical System Tests

Bunk Override Functionality		
Action	**J1587 Messaging/Control**	**Bunk Override Indicator**
Press the upper half of the bunk override switch to turn it on; initially off	When the bunk override switch is pressed to the momentary on position (bunk override mode previously off), the FCU sends a J1587 message to the auxiliary unit requesting that the auxiliary unit go into bunk override mode. The auxiliary unit then goes into bunk override mode and sends a J1587 message to the front unit indicating that bunk override mode in the auxiliary unit is on. Upon receiving this message, the front unit responds by broadcasting a J1587 message that bunk override mode in the front unit is on as well. The front unit then sends a different J1587 message to the auxiliary unit containing the control set points as follows: • blower speed setting • temperature control setting • temperature door position	On NOTE: The indicator on the bunk override switch turns on when the upper half of the switch is pressed.
	The auxiliary unit receives this message and disregards its own temperature and blower speed settings and adjusts its settings to match the front unit settings. The auxiliary unit uses the temperature door position setting as a starting point, then it goes into CDTC operation to maintain the new desired temperature. Blower speed is adjusted to match the front control setting. At this point, the front control panel blower and temperature settings can be changed without affecting the auxiliary unit blower speed and temperature. NOTE: With DataLink Monitor connected to *some early blend air systems*, the auxiliary unit will continuously update its control settings to match the front unit when the system is in bunk override mode. This is not how the system operates without DataLink Monitor connected to the vehicle. The auxiliary unit will maintain the new temperature and blower settings until one of the following occurs: • temperature or blower speed settings changed on the auxiliary control panel • the bunk override switch is pressed to the momentary on or off position • ignition is cycled NOTE: If bunk override was active before an ignition cycle, it will also be active after the ignition cycle, but the auxiliary unit will track the current front setting at the time the ignition is switched on again.	

Electrical System Tests

Bunk Override Functionality		
Action	**J1587 Messaging/Control**	**Bunk Override Indicator**
Press the upper half of the bunk override switch again to the momentary on position; bunk override was already on	When the system is already in bunk override mode and the upper half of the bunk override switch is pressed to the momentary on position, the front control unit sends a new J1587 to the auxiliary unit containing the following new set points: • blower speed setting • temperature control setting • temperature door position The auxiliary unit receives this message and disregards the previous temperature and blower control settings and adjusts its settings to match the new front unit settings (this assumes the front blower setting or temperature setting was changed after the initial bunk override). The auxiliary unit uses the temperature control door position setting as a starting point. Then it goes into CDTC operation to maintain the new desired temperature. Blower speed is adjusted to match the front control setting. NOTE: With DataLink Monitor connected to *some early blend air systems*, the auxiliary unit will continuously update its control settings to match the front unit when the system is in bunk override mode. This is not how the system operates without DataLink Monitor connected to the vehicle. On these early systems you will not be able to change the front settings and update the auxiliary unit with a press of the bunk override switch. The auxiliary unit will maintain the new temperature and blower settings until one of the following occurs: • temperature or blower speed settings changed on the auxiliary control panel • the bunk override switch is pressed to the momentary on or off position • ignition is cycled	On
Press the lower half of bunk override switch to the momentary off position; bunk override mode was on	When the bunk override switch is pressed to the momentary off position (bunk override mode previously on), the FCU sends a J1587 message to the auxiliary unit requesting that the auxiliary unit go out of bunk override mode. The auxiliary unit then goes out of bunk override mode and sends a J1587 message to the front unit indicating that bunk override mode in the auxiliary unit is off. Upon receiving this message, the front unit responds by broadcasting a J1587 message that it too is out of bunk override mode. The auxiliary unit now adjusts its temperature and blower speed to its own settings on the auxiliary control panel and resumes CDTC operation.	Off

Electrical System Tests

Bunk Override Functionality		
Action	**J1587 Messaging/Control**	**Bunk Override Indicator**
Blower or temperature settings on auxiliary control panel changed; bunk override mode was on	When the system is in bunk override mode and the auxiliary blower speed or temperature settings are then changed on the auxiliary control panel, the auxiliary unit goes out of bunk override mode and sends a J1587 message to the front unit indicating that it is no longer in bunk override mode. The front unit receives this message and broadcasts a J1587 message that it too is out of bunk override mode. The indicator light on the bunk override switch turns off. Once out of bunk override mode, the auxiliary unit now adjusts its temperature and blower speed to its own settings on the auxiliary control panel and resumes CDTC operation.	Off
Ignition turned off then back on; bunk override mode was on before the ignition was turned off	When the system is in bunk override mode and the ignition is turned off, then back on, bunk override mode is off. The auxiliary unit will operate to its auxiliary control panel blower and temperature settings.	On

Table 6, Bunk Override Functionality

Cab Override

Rear override is used when the auxiliary unit requires minimum A/C support from the front unit. The front control unit controls the A/C compressor; therefore, if the auxiliary unit requires A/C when the front unit is not in A/C mode or if the front unit is off, then the auxiliary unit can request A/C by initiating rear override.

When the auxiliary unit requires minimum A/C support, it sends a J1587 message requesting that the front control unit go into rear override mode and also sends a message indicating that rear override mode is on in the auxiliary unit. The front unit receives this request and, if not already in A/C mode, goes into rear override mode and sends a J1587 message to the auxiliary unit indicating that rear override mode is on in the front unit. The front unit then sets the blower speed to minimum speed to prevent evaporator core freezing and to allow air to flow across the evaporator temperature sensor to allow compressor cycling. If the blower was previously set to a speed above minimum, that speed will be maintained. The front control unit also turns on the A/C mode indicator on the A/C switch. The front unit will now operate the A/C compressor per A/C request rules. See **Table 4**.

When the auxiliary unit no longer requires minimum A/C support, it sends a J1587 message requesting that the front unit go out of rear override mode and also sends a message indicating that rear override mode is off in the auxiliary unit. The front unit receives this request, goes out of rear override mode, and sends a J1587 message indicating that rear override mode is off in the auxiliary unit. If the front blower speed setting was in the off position, the blower will now shut off. The A/C mode indicator light will turnoff.

Actuator Stepper Motors–Temperature, Recirc, and Mode

General Information

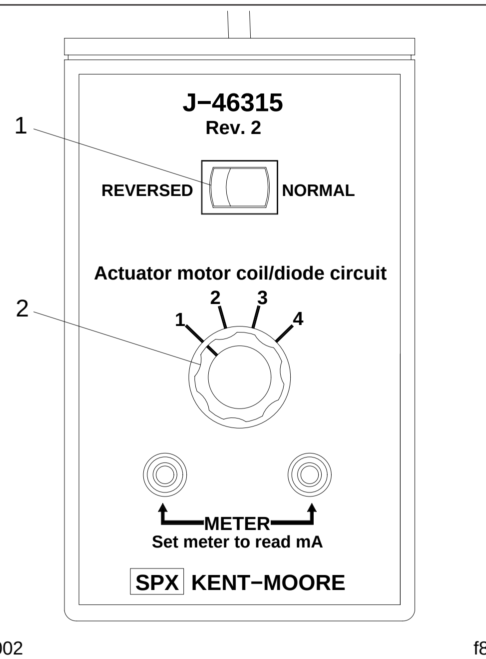
The actuator stepper motors are used to precisely position the temperature control, recirc, and air selection mode doors within the front HVAC unit, and the temperature control door in the auxiliary (bunk) HVAC unit. The motors can operate in both forward and reverse direction. Each motor has four motor windings with diodes wired in series with each winding. The motor direction and position is controlled by the FCU/ACU by applying power and sequencing ground through the four motor windings.

Actuator Stepper Motor Test Procedures

Test the Battery in the Stepper Motor Tester

NOTE: It is very important to check the battery in the stepper motor tester before testing the stepper motor. A weak battery will lead to incorrect test results. See **Fig. 4**.

1. Press the toggle switch on the stepper motor tester to NORMAL and set the rotary switch to position 4.



1. Toggle Switch
2. Rotary Switch

Fig. 4, Actuator Stepper Motor Tester

2. Connect a digital multimeter, set to read DC voltage, as follows:
   - positive lead to the red jack on the stepper motor tester
   - negative lead to pin 6 of the stepper motor tester lead (green wire). See **Fig. 5**.
3. The reading on the digital multimeter should be at least 1.5 VDC. If the reading is less than 1.5 VDC, replace the battery by removing the 4 capscrews that attach the back cover to the stepper motor tester.

   The tester uses a single AA 1.5 VDC battery. It is recommended that you use an alkaline battery.

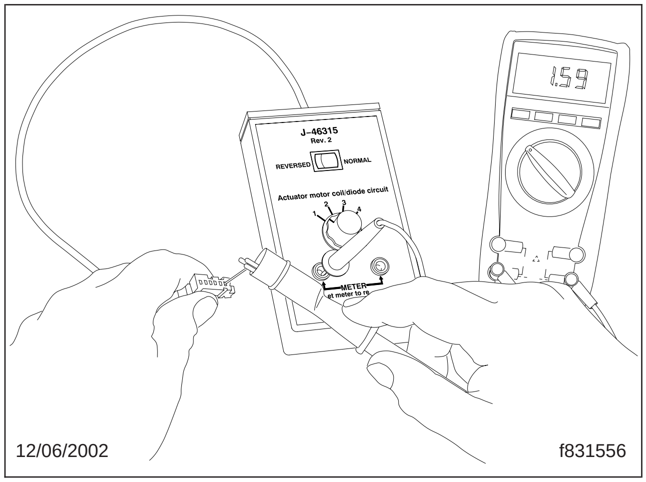


Fig. 5, Place the Negative Lead to Pin 6 of the Stepper Motor Tester Lead

Test the Actuator Stepper Motor

NOTE: The stepper motor has four windings, each with an in-series diode. The stepper motor can be tested on or off the vehicle.

1. Connect the stepper motor tester to the stepper motor. If the stepper motor is being tested while on the vehicle, disconnect the electrical connector from the stepper motor.

   For locations of the actuators and actuator replacement instructions, see **Section 83.04**, Subject 150.
2. Set the digital multimeter to read **milliamps (mA) DC**. Make sure that the test leads on the multimeter are in the appropriate jacks for measuring amperage.
3. Connect the positive lead from the multimeter to the red jack on the stepper motor tester.
4. Connect the negative lead from the multimeter to the black jack. See **Fig. 6**.
5. Press the toggle switch to NORMAL.
6. Set the rotary switch to position 1 and note the reading on the multimeter.

Electrical System Tests

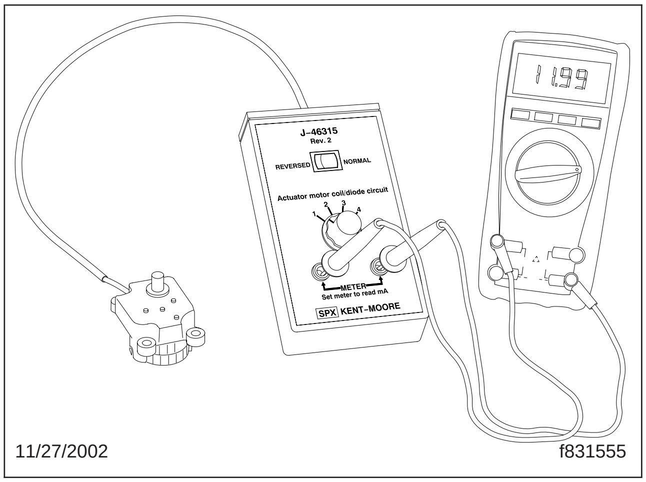


Fig. 6, Testing a Stepper Motor

7. Move the toggle switch to REVERSED and note the reading on the multimeter.

8. Repeat the previous three steps for the 2, 3, and 4 rotary switch positions on the tester. Compare your readings to the readings in **Table 7**.

9. If your readings do not match the readings in **Table 7**, replace the actuator. For instructions, see **Section 83.04**, Subject 150.

10. If the stepper motor was tested on the vehicle, connect the electrical connector to the stepper motor.

Acceptable Readings for the Actuator Stepper Motor Test				
Condition	Toggle Switch Position		Conclusion	Action
	Normal	Reversed		
If the readings in all four rotary switch positions are...	10–14 mA	less than 0.2 mA	Normal	None; actuator is okay electrically.
If the readings in any one or more of the rotary switch positions are...	15–350 mA	less than 0.2 mA	Shorted or partially shorted motor coil	Replace actuator.
	less than 0.2 mA	less than 0.2 mA	Open diode or motor coil*	
	0.3–9.9 mA	less than 0.2 mA	Check tester battery and retest. If battery okay, motor winding has high resistance.	
	19–24 mA	19–24 mA	Shorted diode	

* If the reading for each rotary switch and toggle switch position is less than 0.2 mA, check the fuse in the digital multimeter.

Table 7, Acceptable Readings for the Actuator Stepper Motor Test

Actuator Circuit Diagnosis

See **Table 8** for the actuator circuit test procedures.

Electrical System Tests

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="4">1</td><td rowspan="4">Check for fault codes.</td><td rowspan="4">Check if any one of the following fault codes is active:
<table><tr><th>Group A</th><th>Group B</th></tr><tr><td>146 s005 05</td><td>146 s005 06</td></tr><tr><td>146 s006 05</td><td>146 s006 06</td></tr><tr><td>146 s009 05</td><td>146 s009 06</td></tr><tr><td>200 s009 05</td><td>200 s009 06</td></tr></table>07/02/2002 f040619</td><td>Single fault in Group A is active.</td><td>Go to test no. 2.</td></tr>
<tr><td>All three MID 146 faults are active in Group A.</td><td>Go to test no. 6.</td></tr>
<tr><td>Single fault in Group B is active.</td><td>Go to test no. 8.</td></tr>
<tr><td>No faults listed in Group A or B are active.</td><td>No problem found.</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Check voltage to the actuator.

NOTE: In order to measure a valid voltage, it may be necessary to move the respective control :for recirc, press the recirc button; for mix door actuator, move the temperature control switch; for the mode actuator, move the air selection switch.</td><td rowspan="2">For code 146s005 05 (front unit) disconnect the recirc actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground.

For code 146 s006 05 (front unit) disconnect the mode actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground.

For code 146 s009 05 (front unit) disconnect the temperature actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground.

For code 200 s006 05 (auxiliary unit) disconnect the temperature actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground.

NOTE: See Fig. 7, Fig. 8, and Fig. 9.</td><td>Approximately 12V</td><td>Go to test no. 3.</td></tr>
<tr><td>Much less than12V.</td><td>Check wire between pin 1 of the actuator and the FCU/ACU for open circuit. If okay, replace FCU/ACU. Go to test no. 9.</td></tr>
</table>

Electrical System Tests

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check for short to ground on return side of actuator.	For code **146s005 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the recirc actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **146 s006 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the mode actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **146 s009 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the temperature actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **200 s009 05** (auxiliary unit) disconnect the temperature actuator connector and the ACU connector. At the temperature actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. NOTE: See **Fig. 7**, **Fig. 8**, and **Fig. 9**.	Continuity to ground on any pin.	Locate short to ground, repair as necessary, then **go to test no. 9**.
			No continuity to ground on any pin.	**Go to test no. 4**.

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr>
<td rowspan="2">4</td>
<td rowspan="2">Check continuity of actuator return side.</td>
<td rowspan="2">For code 146s005 05 disconnect the recirc actuator connector.

For code 146 s006 05 disconnect the mode actuator connector.

For code 146 s009 05 disconnect the temperature actuator connector.

Check continuity between the following connector pins:
<table>
<tr><th>FCU</th><th>Actuator</th></tr>
<tr><td>A2</td><td>3</td></tr>
<tr><td>B1</td><td>4</td></tr>
<tr><td>B2</td><td>5</td></tr>
<tr><td>B3</td><td>6</td></tr>
</table>
07/02/2002 f040620

For code 200 s009 05 (auxiliary unit) disconnect the auxiliary unit temperature actuator connector and the ACU connector.

Check continuity between the following connector pins:
<table>
<tr><th>ACU</th><th>Actuator</th></tr>
<tr><td>B8</td><td>3</td></tr>
<tr><td>B7</td><td>4</td></tr>
<tr><td>B6</td><td>5</td></tr>
<tr><td>B5</td><td>6</td></tr>
</table>
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NOTE: See Fig. 7, Fig. 8, and Fig. 9.</td>
<td>Continuity on all pin combinations.</td>
<td>Go to test no. 5.</td>
</tr>
<tr>
<td>No continuity on one or more pin combinations.</td>
<td>Locate open circuit, repair as necessary, then go to test no. 9.</td>
</tr>
</table>

Electrical System Tests

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Check actuator.</td><td rowspan="2">For code 146s005 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the recirc actuator.

For code 146 s006 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the mode actuator.

For code 146 s009 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the temperature actuator.

For code 200 s009 05 (auxiliary unit) perform "Actuator Stepper Motor Electrical Test" on the temperature actuator (auxiliary unit).</td><td>Actuator okay.</td><td>Replace FCU/ACU, then go to test no. 9.</td></tr>
<tr><td>Actuator not okay.</td><td>Replace actuator, then go to test no. 9.</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Check actuator return circuits for open.</td><td rowspan="2">For all three active codes at the same time, 146 s005 05, 146 s006 05, 146 s009 05, disconnect all three actuator connectors and the FCU connector. At each actuator connector, check continuity between the following connector pins:
<table><tr><th>FCU</th><th>Actuator</th></tr><tr><td>A2</td><td>3</td></tr><tr><td>B1</td><td>4</td></tr><tr><td>B2</td><td>5</td></tr><tr><td>B3</td><td>6</td></tr></table>07/02/2002 f040620

NOTE: See Fig. 7, Fig. 8, and Fig. 9.</td><td>Continuity on all pin combinations.</td><td>Go to test no. 7.</td></tr>
<tr><td>No continuity on one or more pin combinations.</td><td>Locate open circuit, repair as necessary, then go to test no. 9.</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Check actuator return circuits for short to ground.</td><td rowspan="2">Disconnect all three actuator connectors and the FCU connector. At the FCU connector, check continuity between pin A2 and ground. Repeat for pins B1, B2, and B3.

NOTE: See Fig. 7, Fig. 8, and Fig. 9.</td><td>Continuity to ground on any pin.</td><td>Repair short to ground, then go to test no. 9.</td></tr>
<tr><td>No continuity to ground on any pin.</td><td>Replace FCU, then go to test no. 9.</td></tr>
</table>

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
8	Check for shorted actuator coil.	For code **146s005 06** disconnect the recirc actuator connector, check if fault no longer active (different fault maybe active). For code **146 s006 06** disconnect the mode actuator connector, check if fault no longer active (different fault may be active). For code **146 s009 06** disconnect the temperature actuator connector, check if fault no longer active (different fault may be active). For code **200 s009 06** disconnect the temperature actuator connector (auxiliary unit), check if fault no longer active (different fault may be active). See **Fig. 7**.	Fault no longer active (FMI06), different fault may be active (FMI 05).	Shorted actuator motor is likely. Perform "Actuator Stepper Motor Electrical Test" to confirm, then **go to test no. 9**.
			Fault still active (FMI06).	Check for short to ground in power wire between actuator and FCU/ACU. If no short is found, replace FCU/ACU, then **go to test no. 9**.
9	Verify repair. NOTE: In order to check if a fault status has changed from active to inactive, the recirc button, temperature control switch, or air selection switch needs to be moved while the ignition is on.	Verify that repair resolved the problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 8, Actuator Circuit Test

Evaporator Temperature Sensor

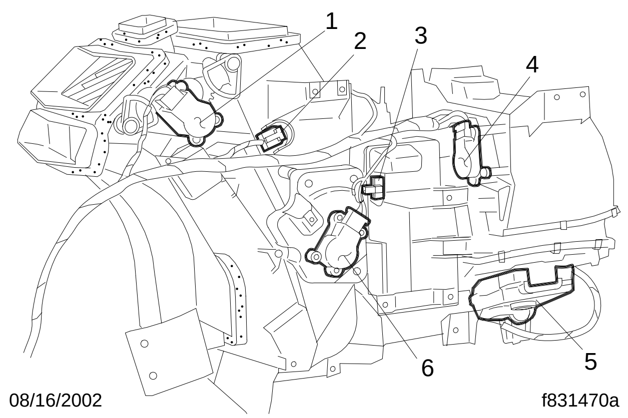
General Information

The evaporator temperature sensor is located on the evaporator. The sensor input to the FCU is used to control the A/C compressor in order to prevent evaporator freezing. The sensor has a negative temperature coefficient (NTC), which means that its resistance decreases as temperature increases.

Evaporator Temperature Sensor Circuit Test

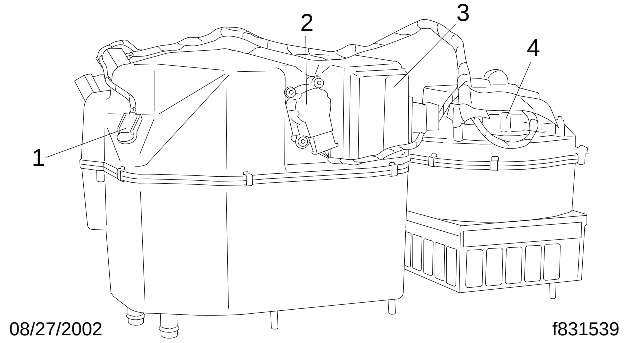
See **Table 9** for the evaporator temperature sensor circuit test procedures.

Electrical System Tests



1. Mode Actuator
2. CDTC Temperature Sensor
3. Evaporator Temperature Sensor
4. Recirculation Actuator
5. Blower Motor
6. Temperature Actuator

Fig. 7, Cab HVAC Assembly



1. CDTC Sensor
2. Temperature Actuator
3. Auxiliary Control Unit (ACU)
4. Blower Motor

Fig. 8, Auxiliary HVAC Assembly

Electrical System Tests

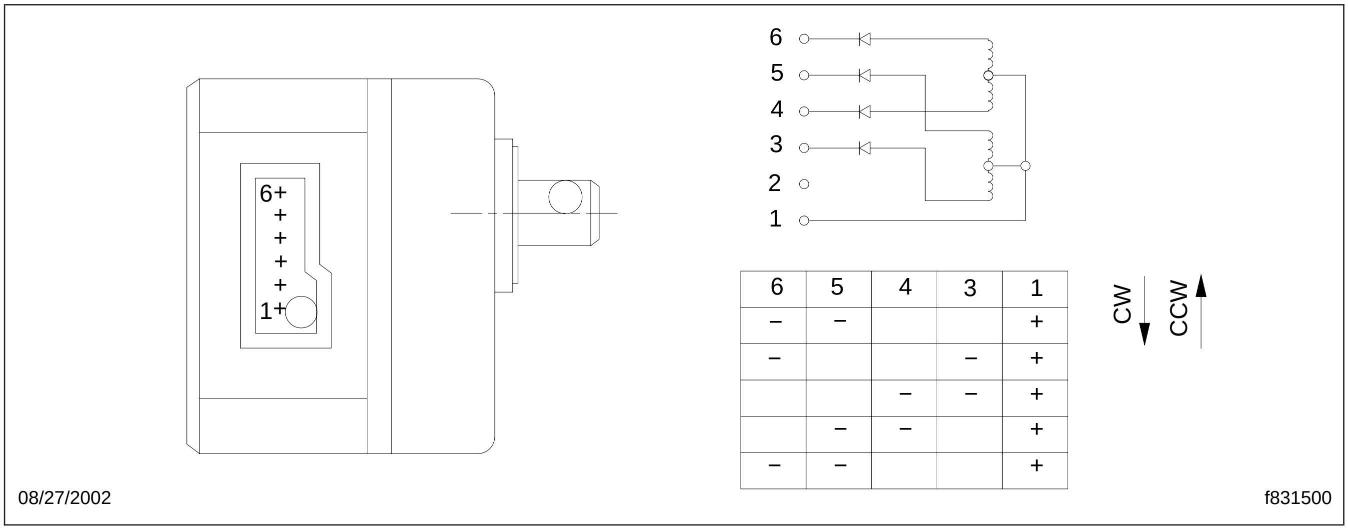


Fig. 9, Actuator Motor Pinouts

Evaporator Temperature Sensor Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Are evaporator temperature sensor fault codes active?	Check if fault code**146 s002 03** or **146 s002 04** is active.	Neither fault isactive.	**Go to test no. 2**.
			146s002 03 is active	Check for sensor signal wire shorted to power. If okay, **go to test no. 2**.
			146s002 04 is active.	Check for sensor signal wire shorted to ground. If okay, replace FCU. **Go to test no. 3**.
2	Check sensor reference voltage.	Disconnect the evaporator sensor. Turn the ignition on and measure the voltage across the sensor connector pins (harness side). The voltage should be 5V if the circuit and FCU are operating correctly.	5V	Perform "Evaporator Temperature Sensor Test."
			Less than 5V.	Check for open circuit in sensor signal and ground wires. If okay, replace FCU. **Go to test no. 3**.
3	Verify repair.	Verify that repair resolved the problem.	Problem solved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 9, Evaporator Temperature Sensor Circuit Test

Electrical System Tests

Evaporator Temperature Sensor Test

When testing the evaporator temperature sensor (**Fig. 10**), the resistance will decrease as the temperature increases, as shown in **Fig. 11**.

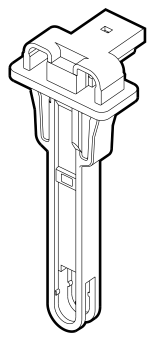


Fig. 10, Evaporator Temperature Sensor

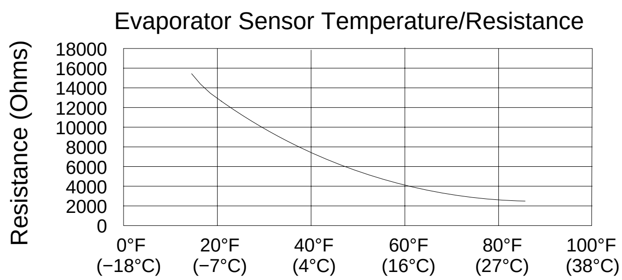


Fig. 11, Evaporator Sensor Temperature/Resistance

1. Remove the sensor and place it in a cup of ice water.
2. After the sensor has been in the ice water for five minutes, measure the sensor resistance.

   The resistance should be 9000 ohms at 32°F (0°C). See **Table 10**.
3. If the resistance differs significantly, replace the sensor.

Evaporator Temperature Sensor Temperature versus Resistance	
Temperature °F (°C)	**Resistance (ohms)**
32 (0)	**9000**
40 (4.4)	7183
50 (10)	5468
60 (15.6)	4209
70 (21.1)	3271
80 (26.7)	2566

Table 10, Evaporator Temperature Sensor Temperature versus Temperature Resistance

Constant Discharge Temperature Control

General Information

CDTC systems maintain a set outlet temperature based on the temperature control switch setting. This is a closed-loop system. The same CDTC sensor is used on both the front and auxiliary HVAC units.

CDTC Temperature Sensor Test

When testing the CDTC temperature sensor (**Fig. 12**), the resistance will decrease as the temperature increases, as shown in **Fig. 13**.

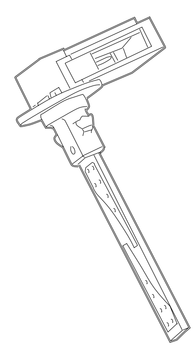


Fig. 12, CDTC Temperature Sensor

1. Allow the system to stabilize to ambient temperatures, and compare the bunk and main evaporator temperature sensor values using the templates in ServicePro. If the two values are significantly different, continue with step #2 to confirm the suspected sensor is not reading properly.

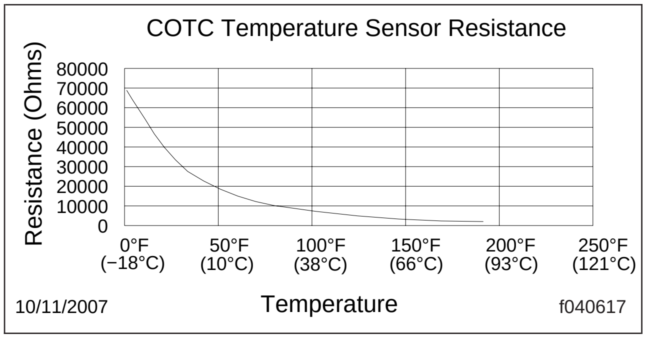


Fig. 13, CDTC Temperature Sensor Temperature vs. Resistance

NOTICE

Do not allow the CDTC temperature sensor to get wet. The circuitry will be damaged.

2. Remove the sensor and place it in a plastic bag, them put the bag and sensor in a cup of ice water.
3. After the sensor has been in the ice water for ten minutes, measure the sensor resistance.

   The resistance should be approximately 29,190 ohms at 32°F (0°C).See **Table 11**.
4. If the resistance differs significantly, replace the sensor.

CDTC Temperature Sensor Temperature versus Resistance	
Temp °F (°C)	**Resistance (ohms)**
32 (0)	**29190**
42 (6)	22180
53 (12)	17050
64 (18)	13250
75 (24)	10400
86 (30)	8240
96 (36)	6590
107 (42)	5320
113 (45)	4790

Table 11, CDTC Temperature Sensor Temperature versus Resistance

Calibration Procedure

When the front control head (FCU) or any actuator motor is replaced, the system must be recalibrated. The calibration procedure allows the FCU to learn the extreme positions of the actuator motors for the recirc door, temperature control door, and the air selection mode door.

Use the following procedure to recalibrate the system.

1. Turn the ignition on, engine off.
2. Set the blower speed to the off position (all the way counterclockwise).
3. Set the air selection switch to full defrost (all the way clockwise).
4. Set the temperature control switch to full hot (all the way clockwise).
5. Press the A/C and recirc buttons at the same time until the indicators on the buttons are both flashing.

   When the indicators on the recirc and A/C buttons start flashing, the FCU has entered calibration mode. Calibration takes place automatically at this point and the blower can be heard operating. When the unit is finished calibrating, the indicators and blower turn off and the system can be operated normally.

DataLink Monitor Templates

General Information

There are two DataLink Monitor templates available in ServiceLink 3.2 or higher, one for day cabs and one for SleeperCabs. The templates allow the technician to monitor temperature and blower speed settings, bunk and rear override mode, A/C mode and A/C request, as well as other information related to the HVAC system. See **Fig. 1** and **Fig. 2**.

DataLink Monitor Template Object Definitions

Front Temperature Control Setting Bar Graph

The front temperature control setting bar graph indicates the position of the temperature control switch in percentage of full hot. Zero percent equals full cold and 100 percent equals full hot. Viewing the bar graph can indicate whether or not the FCU is processing the temperature control switch setting.

When bunk override is initiated, the front temperature setting message is sent to the auxiliary unit. The auxiliary unit then attempts to match this temperature setting.

Front Temperature Mix Door Position Bar Graph

The front temperature mix door position bar graph indicates what the FCU thinks is the position of the temperature mix door in step counts. Step counts range from 0 (when the temperature mix door is in the full cold position) to 3800 (when the temperature mix door is in the full hot position). It is important to know that the actual door position may not be what is indicated by the temperature mix door position bar graph.

When bunk override is initiated, the front temperature mix door step count message is sent to the auxiliary unit. The auxiliary unit uses this as its initial temperature mix door setting to match the front temperature.

Front CDTC Discharge Temperature Bar Graph

The front CDTC discharge temperature bar graph indicates the temperature of the CDTC sensor downstream of the temperature mix door in the front unit. The system uses this temperature sensor to control the mix door to maintain the desired temperature setting of the temperature control switch.

Front Blower Speed Setting Bar Graph

The front blower speed setting bar graph indicates the position of the front blower speed switch in percentage of full speed. Zero percent equals off and 100 percent equals high. Viewing this bar graph can indicate whether or not the FCU is processing the blower speed control switch setting.

When bunk override is initiated, the front blower speed set point message is sent to the auxiliary unit. The auxiliary unit then attempts to match this blower speed setting.

Front Blower Speed Bar Graph

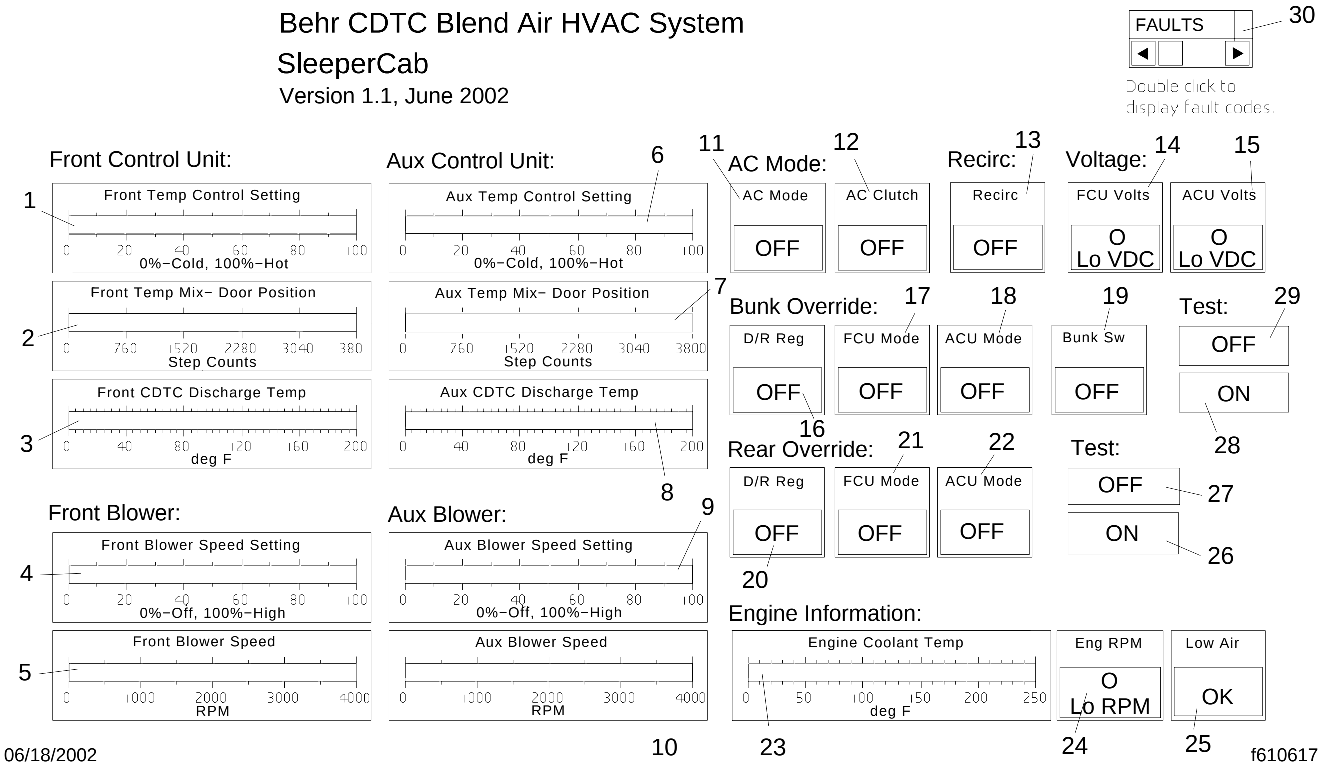
The front blower speed bar graph indicates the front unit blower speed feedback to the FCU.

Auxiliary Temperature Control Setting Bar Graph (SleeperCabs only)

The auxiliary temperature control setting bar graph indicates the position of the auxiliary temperature control switch in percentage of full hot. Zero percent equals full cold and 100 percent equals full hot. Viewing this bar graph can indicate whether or not the ACU is processing the auxiliary temperature control switch setting.

When bunk override is initiated, the front temperature setting message is sent to the auxiliary unit. The auxiliary unit then matches this temperature set point.

Fault Code Driven Diagnosis



1. Front Temperature Control Setting Bar Graph
2. Front Temperature Mix Door Position Bar Graph
3. Front CDTC Discharge Temperature Bar Graph
4. Front Blower Speed Setting Bar Graph
5. Front Blower Speed Bar Graph
6. Auxiliary Temperature Control Setting Bar Graph
7. Auxiliary Temperature Mix Door Position Bar Graph
8. Auxiliary CDTC Discharge Temperature Bar Graph
9. Auxiliary Blower Speed Setting Bar Graph
10. Auxiliary Blower Speed Bar Graph
11. A/C Mode Annunciator
12. A/C Clutch Annunciator
13. Recirc Annunciator
14. FCU Volts Annunciator
15. ACU Volts Annunciator
16. Override Request
17. FCU Mode Annunciator
18. ACU Mode Annunciator
19. Override Switch
20. Override Request
21. FCU Mode Annunciator
22. ACU Mode Annunciator
23. Engine Coolant Temperature Bar Graph
24. Engine rpm Annunciator
25. Low Air Pressure Annunciator
26. Rear Override Mode On Test Button
27. Rear Override Mode Off Test Button
28. Bunk Override Mode On Test Button
29. Bunk Override Mode Off Test Button
30. Fault Code Grid

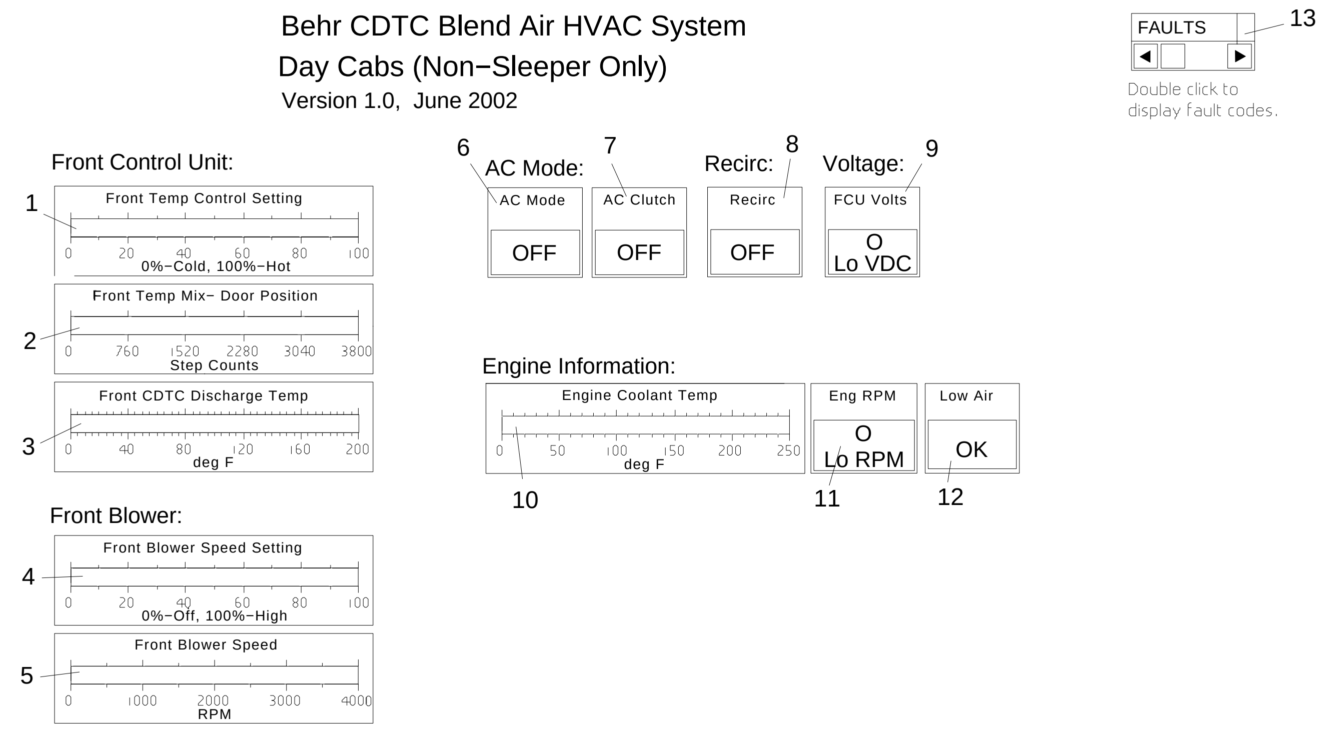
Fig. 1, Behr CDTC Blend Air HVAC System SleeperCab

Auxiliary Temperature Mix Door Position Bar Graph (SleeperCabs only)

The auxiliary temperature mix door position bar graph indicates what the ACU thinks is the position of the temperature mix door in step counts. Step counts range from 0 (when the temperature mix door is in the full cold position) to 3800 (when the temperature mix door is in the full hot position). It is important to know that the actual door position may not be what is indicated by the temperature mix door position bar graph.

When bunk override is initiated, the front temperature mix door step count message is sent to the auxiliary

Fault Code Driven Diagnosis



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1. Front Temperature Control Setting Bar Graph
2. Front Temperature Mix Door Position Bar Graph
3. Front CDTC Discharge Temperature Bar Graph
4. Front Blower Speed Setting Bar Graph
5. Front Blower Speed Bar Graph
6. A/C Mode Annunciator
7. A/C Clutch Annunciator
8. Recirc Annunciator
9. FCU Volts Annunciator
10. Engine Coolant Temperature Bar Graph
11. Engine rpm Annunciator
12. Low Air Pressure Annunciator
13. Fault Code Grid

Fig. 2, Behr CDTC Blend Air HVAC System Day Cabs

unit. The auxiliary unit uses this as its initial temperature mix door setting to match the front temperature.

Auxiliary CDTC Discharge Temperature Bar Graph (SleeperCabs only)

The auxiliary CDTC discharge temperature bar graph indicates the temperature of the CDTC sensor downstream of the temperature mix door in the auxiliary unit. The system uses this temperature sensor to control the mix door to maintain the desired temperature setting of the temperature control switch.

Auxiliary Blower Speed Setting Bar Graph (SleeperCabs only)

The auxiliary blower speed setting bar graph indicates the position of the auxiliary blower speed control switch in percentage of full speed. Zero percent equals off and 100 percent equals high. Viewing this bar graph can indicate whether or not the ACU is processing the blower speed control switch setting.

When bunk override is initiated, the front blower speed set point message is sent to the auxiliary unit. The auxiliary unit then attempts to match this blower speed setting.

Fault Code Driven Diagnosis

Auxiliary Blower Speed Bar Graph (SleeperCabs only)

The auxiliary blower speed bar graph indicates the auxiliary unit blower speed feedback to the ACU.

A/C Mode Annunciator

The A/C mode annunciator indicates whether or not the FCU is in A/C mode. The front unit is in A/C mode whenever the A/C button on the climate control panel is pressed, when the front control panel is set to any of the defrost modes, or when the front unit is off and the auxiliary unit is initiated for minimum A/C support. When A/C mode is on, the compressor can operate when the compressor control rules are met.

The A/C mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

A/C Clutch Annunciator

The A/C clutch annunciator indicates whether or not the signal to the A/C clutch relay is active or not. The A/C relay controls the A/C compressor.

The A/C clutch annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

Recirc Annunciator

The recirc annunciator indicates whether or not the front unit is in recirculation mode. When the unit is in recirculation mode, the front unit will recirculate air within the cab. If recirc is on longer than 20 minutes, the front unit goes into partial recirc mode letting in a small amount of fresh air. When recirc mode is inactive, all of the air circulating through the unit is outside air.

The recirc annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

FCU Volts Annunciator

The FCU volts annunciator indicates the input voltage the front control unit senses. The annunciator will indicate low voltage below 9 volts and high voltage above 16 volts. The normal operating range for the front unit is 9 to 16 volts.

ACU Volts Annunciator (SleeperCabs only)

The ACU volts annunciator indicates the input voltage the auxiliary control unit senses. The annunciator will indicate low voltage below 9 volts and high voltage above 16 volts. The normal operating voltage range for the auxiliary unit is 9 to 16 volts.

Override Request (SleeperCabs only)

The override request annunciator indicates when the FCU sends a message to the ACU requesting that it go into or out of bunk override mode. The request is initiated when the FCU senses that the bunk override switch is in the on or off position.

The override request annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error). The annunciator normally shows NA/ERR except when requesting bunk override mode on or off. On or off is usually displayed briefly.

FCU Mode Annunciator (SleeperCabs only)

The FCU mode annunciator indicates the status of bunk override mode in the auxiliary unit (ACU). After the auxiliary unit receives the bunk override on request message from the front unit, it goes into bunk override mode and sends a message indicating that it is in bunk override mode indicated by the ACU mode annunciator. The front unit acknowledges the message sent by the auxiliary unit and indicates that it too is in bunk override mode indicated by the FCU mode annunciator. The FCU mode annunciator works similarly if bunk override is turned off.

The FCU mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

ACU Mode Annunciator (SleeperCabs only)

The ACU mode annunciator indicates the status of bunk override mode in the auxiliary unit (ACU). After the auxiliary unit receives the bunk override on request message from the front unit, it goes into bunk override mode and sends a message indicating that it is in bunk override mode indicated by the ACU mode annunciator. The ACU mode annunciator works similarly if bunk override mode is turned off.

The ACU mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

Bunk Override Switch (SleeperCabs only)

The bunk override switch annunciator indicates the status of the bunk override switch. The bunk override switch controls the bunk override mode function. The annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error)

The annunciator normally shows NA/ERR except when in the on or off momentary positions.

Override Request (SleeperCabs only)

The override request annunciator indicates when the ACU sends a message to the FCU requesting rear override mode to be on or off. The request is initiated when the auxiliary unit requires minimum A/C support; that is, when it requires the A/C compressor to operate if the front unit is not already controlling the A/C compressor.

The override request annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error). The annunciator normally shows NA/ERR except when requesting rear override mode on or off. On or off is usually displayed briefly.

FCU Mode Annunciator (SleeperCabs only)

The FCU mode annunciator indicates the status of rear override mode in the front unit (FCU). After the front unit receives the rear override on request message from the auxiliary unit, it goes into bunk override mode and sends a message indicating that it is in rear override mode indicated by the FCU mode annunciator. The FCU mode annunciator works similarly if bunk override mode is turned off.

The FCU mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

ACU Mode Annunciator (SleeperCabs only)

The ACU mode annunciator indicates the status of rear override mode in the auxiliary unit (ACU). After the front unit receives the rear override on request message from the auxiliary unit, it goes into rear override mode and sends a message indicating that it is in rear override mode indicated by the ACU mode annunciator. The ACU mode annunciator works similarly if rear override mode is turned off.

The ACU mode annunciator has three possible conditions: ON, OFF, or NA/ERR (not available or error).

Engine Coolant Temperature Bar Graph

Engine coolant temperature is one of the inputs used by the front and auxiliary control units to control unit outlet temperature. It is provided on the template so the technician can be sure that all tests are performed when the engine is at normal operating temperature. Poor A/C performance and poor heater performance can be indicated by improper operating temperature.

Engine RPM Annunciator

The engine rpm annunciator is used to indicate engine rpm. Engine rpm is one of the inputs for controlling the A/C compressor clutch. The A/C compressor clutch does not engage when the engine speed is below 450 rpm.

Low Air Pressure Annunciator

The low air pressure annunciator is used to indicate low air pressure in the primary or secondary air system. The message that controls the low air pressure annunciator comes from the ICU. The message is one of the inputs used by the front control unit to control A/C compressor operation. The A/C compressor clutch does not engage when the system air pressure is low. The message is sent by the ICU, but at intervals long enough that may cause the annunciator to flash periodically. A flashing DLM template object indicates that a message is not being received.

Fault Code Driven Diagnosis

Rear Override Mode ON Test Button (SleeperCabs only)

The rear override mode ON test button is used to manually send a rear override request to the FCU. This is the same message that the ACU sends to the FCU when it requests A/C support from the front unit. To use this test, turn off the front blower then press the rear override mode ON test button. After doing this, the FCU mode annunciator (item 21 in **Fig. 1**) should be in the on state. The A/C mode annunciator (item 11 in **Fig. 1**) should also be in the on state and the front blower should be at minimum speed. The A/C clutch annunciator (item 12 in **Fig. 1**) may or may not be in the on state depending on whether the A/C clutch rules have been met (engine running, adequate system air pressure, evaporator sensor in correct range). This test simulates the ACU. If the test is successful and rear override is not functioning, then the problem most likely is either that the ACU is not communicating on the J1587 databus, or there is a problem with the ACU itself or its control inputs.

Rear Override Mode OFF Test Button (SleeperCabs only)

The rear override mode OFF test button is used to manually send a rear override off request to the FCU. This is the same message the ACU sends to the FCU when it no longer requests A/C support from the front unit. The button should be used after initiating rear override mode with the ON test button.

Bunk Override Mode ON Test Button (SleeperCabs only)

The bunk override mode ON test button is used to manually send a bunk override request to the ACU. This is the same message that the FCU sends to the ACU when the driver presses the bunk override switch on the climate control panel. When the bunk override ON test button is pressed, ACU mode annunciator (item 18 in **Fig. 1**)should be in the ON state. The auxiliary unit should then begin matching the front temperature and blower speed settings.

Bunk Override Mode OFF Test Button (SleeperCabs only)

The bunk override mode OFF test button is used to manually send a bunk override OFF request to the ACU. This is the same message the FCU sends to the ACU when the bunk override switch on the climate control panel is pressed to the off position. The button should be used after initiating bunk override mode with the ON test button.

Fault Code Grid

Double click on the fault code grid to display J1587 fault codes.

Fault Code Diagnostics

Front Control Unit (FCU) (MID 146) J1587 Fault Codes by SID			
SID	**FMI**	**Fault Description**	**Action**
001	03	CDTC sensor: voltage above normal, shorted high, or open circuit	See CDTC Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
	04	CDTC sensor: voltage below normal, shorted low	See CDTC Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
002	03	Evap temp sensor: voltage above normal, shorted high, or open circuit	See Evaporator Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
	04	Evap temp sensor: voltage below normal, shorted low	See Evaporator Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.

Fault Code Driven Diagnosis

Front Control Unit (FCU) (MID 146) J1587 Fault Codes by SID			
SID	**FMI**	**Fault Description**	**Action**
005	05	Recirc/OSA door actuator: current below normal or open circuit	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
	06	Recirc/OSA door actuator: current above normal or circuit shorted to ground	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
006	05	Mode door actuator: current below normal or open circuit	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
	06	Mode door actuator: current above normal or circuit shorted to ground	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
009	05	Temperature control door: current below normal or open circuit	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
	06	Temperature control door: current above normal or circuit shorted to ground	See Actuator Circuit Test talbe, in **Subject 350**, for diagnosis.
010	02	Blower motor: output data erratic or intermittent	The FCU compares the analog output signal (speed signal) with what it thinks it should be. If determined to be in error, this fault will become active. To diagnose: 1. Disconnect blower motor. If fault is no longer active, replace the blower motor. If still active, go to step 2. 2. Disconnect the blower speed signal output wire (pin A11) from the FCU connector. Make sure connector is plugged into FCU after removing wire. If fault is no longer active, check for short to power or short to ground on output wire. If fault is still active, replace FCU.
	12	Blower motor: bad component, speed is invalid or incorrect	This fault can occur if the blower speed feedback differs from the speed control signal being sent by the FCU. See Diagnosis for Blower Speed is Not Available table, in **Subject 350**.
011	05	A/C clutch relay: current below normal or open circuit	This fault indicates an open circuit in one of the following: circuit 97T between the FCU and the A/C clutch relay, open relay coil, or open relay coil ground circuit. See A/C Request Circuit Test table, in **Subject 350**, for diagnosis.
	06	A/C clutch relay: current above normal or circuit shorted to ground	This fault indicates that there is a short to ground in circuit 97T between the FCU and the A/C clutch relay, or a shorted relay. See A/C Request Circuit Test table, in **Subject 350**, for diagnosis.
250	02	J1587 databus: data erratic, intermittent, or incorrect	Check J1587 databus, repair as necessary. See **Group 54** for more information on troubleshooting the J1587 databus.
	12	Bad ECU/EEPROM error	Replace FCU.

Table 1, Front Control Unit (FCU) (MID 146) J1587 Fault Codes by SID

Fault Code Driven Diagnosis

Front Control Unit (FCU) (MID 146) J1587 Fault Codes by PID			
PID	**FMI**	**Fault Description**	**Action**
168	03	Supply voltage too high (above 16.0 VDC)	Check vehicle charging system, repair as necessary. See **Group 15** for more information.
	04	Supply voltage too low (below 9.0 VDC)	Check vehicle batteries and charging system. If okay, check power and ground circuits to HVAC system. Use voltage drop tests to isolate problem.

Table 2, Front Control Unit (FCU) (MID 146) J1587 Fault Codes by PID

Auxiliary Control Unit (ACU) (MID 200) J1587 Fault Codes by SID			
SID	**FMI**	**Fault Description**	**Action**
001	03	CDTC sensor: voltage above normal, shorted high, or open circuit	See CDTC Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
	04	CDTC sensor: voltage below normal, shorted low	See CDTC Temperature Sensor Circuit Test table, in **Subject 350**, for diagnosis.
009	05	Temperature actuator: current below normal or open circuit	See Actuator Circuit Test in **Subject 350**, for diagnosis.
	06	Temperature actuator: current above normal or circuit shorted to ground	See Actuator Circuit Test table, in **Subject 350**, for diagnosis.
010	02	Blower motor: output data erratic or intermittent	The ACU compares the analog output signal (speed signal) with what it thinks it should be. If determined to be in error, this fault will become active. To diagnose: 1. Disconnect blower motor. If fault is no longer active, replace the blower motor. If still active, go to step 2. 2. Remove the blower speed signal output wire (pin B4) from the ACU connector. Make sure connector is plugged into ACU after removing wire. If fault is no longer active, check for short to power or short to ground on output wire. If fault is still active, replace ACU.
	12	Blower motor: bad component, speed is invalid or incorrect	This fault can occur if the blower speed feedback differs from the speed control signal being sent by the ACU. See Diagnosis for Blower Speed is Not Available table, in **Subject 350**.
250	02	J1587 databus: data erratic, intermittent, or incorrect	Check J1587 databus, repair as necessary.
	12	Bad ECU/EEPROM error	Replace ACU.

Table 3, Auxiliary Control Unit (ACU) (MID 200) J1587 Fault Codes by SID

Fault Code Driven Diagnosis

Auxiliary Control Unit (ACU) (MID 200) J1587 Fault Codes by PID			
PID	**FMI**	**Fault Description**	**Action**
168	03	Supply voltage too high (above 16.0 VDC)	Check vehicle charging system, repair as necessary. See **Group 15** for more information.
	04	Supply voltage too low (below 9.0 VDC)	Check vehicle batteries and charging system. See **Group 15** for more information. If okay, check power and ground circuits to HVAC system. Use voltage drop tests to isolate problem.

Table 4, Auxiliary Control Unit (ACU) (MID 200) J1587 Fault Codes by PID

Symptom Driven Diagnosis

A/C Performance Diagnosis

Problem—Warm Airflow When the Air Conditioner is On, A/C Not Working, or Poor A/C Performance (dash outlet temperature is too high)

Problem—Warm Airflow When the Air Conditioner is On, A/C Not Working, or Poor A/C Performance (dash outlet temperature is too high)

Possible Cause	Remedy
Refrigerant charge too low.	Perform leak test. Repair any leaks, evacuate the system, replace the receiver-drier (only if color indicates it is saturated with moisture), add a full charge of refrigerant.
Contaminated refrigerant.	Check refrigerant for moisture and/or mixed refrigerant contamination, repair as necessary.
Refrigerant charge too high.	Evacuate the system, charge system with proper amount of refrigerant.
Moisture in the system.	Moisture in the system may cause ice crystals to form and possibly block the flow of refrigerant at the expansion valve or other places in the system. Recover the refrigerant, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant.
A/C compressor not working.	The refrigerant charge is too high or too low (will cause the binary pressure switch to open and prevent the compressor from operating).
	Worn or loose A/C compressor drive belt, tighten or replace as necessary.
	Faulty A/C compressor or clutch, repair as necessary.
	A/C compressor clutch not engaging. See "A/C Clutch Circuit" for diagnosis.
Ice formed on evaporator core.	Ice buildup on the evaporator core can block airflow through the evaporator, thus producing little or no cooling. This may occur if the compressor is not cycling off at the correct temperature. For evaporator sensor testing, see "Evaporator Temperature Sensor."
Temperature door not operating correctly, front and auxiliary units.	Electrical problem with temperature actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis.
	Mechanical problem with temperature door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
Wiring problem between climate control panel and ACU, auxiliary unit only.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.
Faulty temperature control potentiometer.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.
Blockage or restriction in refrigerant system.	A blockage or restriction can usually be found by locating an abrupt temperature change at a location in the system; for example, in a line or the condenser. Repair as necessary.
Blower motor in protection mode (reduced airflow).	See "Blower Motor."
System out of calibration, front unit only.	See "Calibration Procedure."

Symptom Driven Diagnosis

Problem—No Fresh Air, Front Unit Only (nonrecirculation mode)

Problem—No Fresh Air, Front Unit Only (nonrecirculation mode)	
Possible Cause	**Remedy**
Recirc door not operating correctly.	Electrical problem with recirc door actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Recirculation" and "Actuator Stepper Motors—Temperature, Recirc, and Mode."
	Mechanical problem with recirc door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
Restricted filter or intake.	Clean as necessary.
System out of calibration.	See "Calibration Procedure."

Problem—Low Side Pressure Too Low

Problem—Low Side Pressure Too Low	
Possible Cause	**Remedy**
Refrigerant system restriction or blockage.	Check the expansion valve and other components for blockage (blockage may be due to moisture causing ice buildup).
Refrigerant charge too low.	Perform leak test. Repair any leaks, evacuate the system, replace the receiver-drier (only if color indicates it is saturated with moisture), add a full charge of refrigerant.

Problem—High Side Pressure Too High

Problem—High Side Pressure Too High	
Possible Cause	**Remedy**
Restricted airflow through condenser.	Check for dirt and debris buildup in front of condenser, clean as necessary.
	Check engine fan operation.
Restriction or blockage in condenser or line from condenser to receiver-drier.	Restriction or blockage will usually be indicated by a cool spot or ice buildup near the restriction or blockage. Repair as necessary. NOTE: If the compressor has recently failed, the restriction may be due to leftover debris from the failed compressor.
Air in refrigerant.	Check refrigerant purity, evacuate, and charge as necessary.
Engine overheating.	Check engine cooling system.
Engine fan not working correctly.	See **Group 20**, check fan cycling switch.

Symptom Driven Diagnosis

Problem—Compressor Runs Continuously

Problem—Compressor Runs Continuously*	
Possible Cause	**Remedy**
Refrigerant charge too high.	Evacuate the system, replace the receiver-drier (only if color indicates it is saturated with moisture), add a full charge of refrigerant.
Faulty evaporator temperature sensor.	See "Evaporator Temperature Sensor."

* This is normal when the ambient temperature and/or relative humidity is high.

Problem—Little or No Heat, Front and Auxiliary Units

Problem—Little or No Heat, Front and Auxiliary Units	
Possible Cause	**Remedy**
Low engine coolant.	Check coolant level.
Plugged heater core.	Flush coolant system or replace heater core as necessary. NOTE: This can be checked by feeling the inlet and outlet heater hoses. There should be a slight temperature difference when the temperature is set to hot and the fan is on high (engine at operating temperature). A large temperature difference indicates a blockage.
Faulty engine thermostat.	Check if thermostat is stuck open, this may cause the engine to not reach operating temperature under light load or when ambient temperatures are low.
Temperature door not operating correctly.	Electrical problem with temperature actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Override."
	Mechanical problem with temperature door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
System out of calibration, front unit only.	See "Calibration Procedure."

Problem—Water or Engine Coolant Leaking from HVAC Unit Inside the Cab, Front and Auxiliary Units

Problem—Water or Engine Coolant Leaking from HVAC Unit Inside the Cab, Front and Auxiliary Units*	
Possible Cause	**Remedy**
Plugged drain tubes.	Clean as necessary.
Leaking heater core.	Replace heater core.

* Clear water dripping from the HVAC unit under the hood is normal when the A/C is on. This is from moisture condensing out of the air as it cools going through the evaporator.

Symptom Driven Diagnosis

Problem—Recirculation Mode Not Working, Front Unit Only

Problem—Recirculation Mode Not Working, Front Unit Only	
Possible Cause	**Remedy**
Recirc door not operating correctly.	Electrical problem with recirc actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Recirculation" and "Actuator Stepper Motors—Temperature, Recirc and Mode." Mechanical problem with recirculation door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
System out of calibration.	See "Calibration Procedure."

Problem—Air Does Not Come Out of Correct Outlets, Front Unit Only

Problem—Air Does Not Come Out of Correct Outlets, Front Unit Only*	
Possible Cause	**Remedy**
Mode door not operating correctly.	Electrical problem with mode actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Recirculation" and "Actuator Stepper Motors—Temperature, Recirc and Mode."
	Mechanical problem with mode door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.
Broken or disconnected duct.	Repair as necessary.
System out of calibration.	See "Calibration Procedure."

* For example, air directed to windshield outlets when air selection switch is set to floor outlets.

Problem—Warm Air from Outlets When Temperature is Set to Cold (A/C not on)

Problem—Warm Air from Outlets When Temperature is Set to Cold (A/C not on)	
Possible Cause	**Remedy**
Temperature door not operating correctly.	Electrical problem with temperature actuator. Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. Also see "Actuator Stepper Motors—Temperature, Recirc, and Mode."
	Mechanical problem with temperature door. Check for obstructions or broken components, repair as necessary. NOTE: The actuator has no feedback to the FCU/ACU to verify position. If there are no fault codes and the actuator signal appears to be working in the DataLink Monitor template, then suspect a mechanical problem.

Symptom Driven Diagnosis

Problem—Warm Air from Outlets When Temperature is Set to Cold (A/C not on)	
Possible Cause	**Remedy**
System out of calibration, front unit only.	See "Calibration Procedure."
Wiring/temperature control problem, auxiliary unit only.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.

Problem—No Backlighting, Front Unit Only

Problem—No Backlighting, Front Unit Only	
Possible Cause	**Remedy**
Dim signal not reaching the FCU or faulty FCU.	See "Backlighting Diagnosis."

Problem—Blower Not Working, Operates at Reduced Speed, or Runs Then Shuts Off, Front and Auxiliary Units

Problem—Blower Not Working, Operates at Reduced Speed, or Runs Then Shuts Off, Front and Auxiliary Units	
Possible Cause	**Remedy**
Blower in protection mode.	Check for fault codes. See fault code tables, in **Subject 340**, for diagnosis. If there are no active fault codes, refer to "Blower Motor" for more information.
Wiring problem.	
Faulty blower motor.	
Wiring problem between sleeper climate control panel and ACU, auxiliary unit only.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.
Faulty blower control potentiometer, auxiliary unit only.	See **Table 11**, Sleeper Climate Control Panel Circuit Diagnosis.

Problem—Bunk Override Does Not Work, SleeperCab Only (cannot override auxiliary blower and temperature settings from the front)

Problem—Bunk Override Does Not Work, SleeperCab Only (cannot override auxiliary blower and temperature settings from the front)	
Possible Cause	**Remedy**
Faulty bunk override switch.	Check switch. See "Override" for diagnosis. Verify switch operation using DataLink Monitor template.
Wiring problem.	Check wiring between override switch and FCU.
No J1587 databus communication between FCU and ACU.	Using ServiceLink, make sure both the FCU (MID 146) and ACU (MID 200) appear in the ECU list. If one ECU does not appear in the list, troubleshoot the J1587 databus. See **Group 54** for more information. Also see "Override" for diagnosis. NOTE: Vehicles without a sleeper do not have an ACU.
Faulty FCU.	See "Override" for diagnosis.
Faulty ACU.	See "Override" for diagnosis.

Symptom Driven Diagnosis

Problem—Rear Override Does Not Work, SleeperCab Only (minimum A/C support)

Problem—Rear Override Does Not Work, SleeperCab Only (minimum A/C support)*	
Possible Cause	**Remedy**
Front not providing A/C support for auxiliary (rear override not working).	Check rear override function. See "Override" for diagnosis. Problem may be no J1587 databus communication between the ACU and FCU.

* Rear cannot override to request A/C compressor when front unit is off. This should also cause front unit to operate at minimum blower speed if off.

A/C Clutch Circuit Diagnosis

Before performing tests on the A/C clutch circuit, perform the diagnostic tests in **Table 1**.

NOTE: Do not perform the test procedures in **Table 3** before performing the test procedures in **Table 1**.

A/C Clutch Does Not Engage				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check control settings.	In order for the A/C compressor to operate, the controls must be set as follows: • blower speed at any setting other than off • air selection in one of A/C or defrost settings • A/C button is pressed; light on • engine running above 450 rpm • ambient temperature at the evaporator sensor must be above 44°F (7°C) forA/C compressor to engage If these conditions are met, the A/C compressor should engage. It may cycle on/off.	Conditions met, A/C compressor engages.	No problem found.
			Conditions met, A/C compressor does not engage.	**Go to test no. 2**.
2	Check for fault codes.	Connect ServiceLink and check for fault codes. Check if one of the following fault codes is active: • 146 s011 05 • 146 s011 06 NOTE: See Front Control Unit (FCU) (MID 146) J1587 Fault Codes by SID table, in **Subject 340**, for fault code descriptions.	One of these faults is active.	See **Table 3**.
			Faults other than these are active.	Repair fault before proceeding.
			No active faults.	**Go to test no. 3**.

Symptom Driven Diagnosis

A/C Clutch Does Not Engage				
Test No.	Test	Test Procedure	Test Result	Action
3	Check if A/C request is being sent.	Connect PC to vehicle and open the Behr CDTC Blend Air HVAC System DataLink Monitor template. Do the following: • Start the engine. • Set the blower to any speed except off. • Set the air selection switch to face mode. • Press the A/C button; the light should be on. Observe the A/C request annunciator in the template. The A/C request signal should be active and the A/C compressor should engage when the previous conditions are met and the following conditions are met: • Evaporator sensor is above 44°F (7°C). • Engine speed above 450 rpm. See template. • Low air pressure signal is not being broadcast by the instrument cluster. See template.	A/C request signal is active.	See **Table 4**.
			A/C request signal is not active.	**Go to test no. 4**.
4	Check evaporator sensor.	Note the ambient air temperature. Measure the resistance of the evaporator temperature sensor and compare the reading with the value in **Table 2** or **Fig.1**. The reading should correspond to a temperature approximately equal to the ambient temperature. NOTE: The evaporator sensor temperature must be above 44°F (7°C) before the FCU will send the A/C request signal to the A/C clutch relay. Therefore the sensor resistance must be below approximately 6500 ohms. See **Table 2** or **Fig. 1**. Also see **Fig. 2**.	Less than 6500 ohms	Check wiring between FCU and evaporator temperature sensor. If okay and all other inputs are met, such that the A/C request signal should be sent, then replace the FCU.**Go to test no. 5**.
			More than 6500ohms	The FCU is not sending an A/C request signal because the sensor is indicating the temperature is below 44°F (7°C). If temperature is known to be well above this temperature, then replace the sensor. **Go to test no. 5**.

Symptom Driven Diagnosis

A/C Clutch Does Not Engage				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
5	Verify repair.	Verify that repair resolved the problem.	Problem resolved	Done
			Problem unresolved	**Repeat test no. 1**.

Table 1, A/C Clutch Does Not Engage

Evaporator Temperature Sensor Temperature versus Resistance			
Temperature °F (°C)	**Resistance (ohms)**	**Temperature °F (°C)**	**Resistance (ohms)**
20 (–6.7)	12,814	55 (12.8)	4792
25 (–3.9)	11,036	60 (15.6)	4209
30 (–1.1)	9535	65 (18.3)	3706
32 (0)	**9000**	70 (21.1)	3271
35 (1.7)	8265	75 (23.9)	2894
40 (4.4)	7183	80 (26.7)	2566
45 (7.2)	6259	85 (29.4)	2281
50 (10)	5468		

Table 2, Evaporator Temperature Sensor Temperature versus Temperature Resistance

A/C Request Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Which fault code is active?	NOTE: Circuit problems between the FCU and A/C clutch relay (coil side) will activate fault codes.	146 s011 05 is active	**Go to test no. 2**.
			146 s011 06 is active	**Go to test no. 5**.
2	Check A/C clutch relay.	Remove the A/C clutch relay from the PDM. Measure the resistance across the relay coil (pins 85 and 86). NOTE: If the relay coil is open, the resistance will be approximately 680 ohms.	72–87 ohms	**Go to test no. 3**.
			Not 72–87 ohms	Replace relay.**Go to test no. 7**.
3	Check A/C clutch relay coil ground.	With the A/C clutch relay removed, check resistance between the ground side of the relay coil (PDM side) and the negative battery terminal. Make sure the batteries are disconnected or result may be inconclusive.	Less than 1 ohm	**Go to test no. 4**.
			More than 1 ohm	Repair relay coil ground circuit. **Go to test no. 7**.

A/C Request Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
4	Check circuit 97T.	Remove the A/C clutch relay. Disconnect the B connector from the back of the FCU. Measure resistance between the power side of the relay coil (PDM side) and pin B10 at the FCU B connector.	Less than 1 ohm	No problem found.**Repeat test numbers 1 through 4**.
			More than 1 ohm	Locate and repair high resistance or open in circuit 97T. **Go to test no. 7**.
5	Check A/C clutch relay.	Remove the A/C clutch relay from the PDM. Measure the resistance across the relay coil (pins 85 and 86). NOTE: If the relay coil is open, the resistance will be approximately 680 ohms.	72–87 ohms	**Go to test no. 6**.
			Not 72–87 ohms	Replace relay.**Go to test no. 7**.
6	Check circuit 97T for short to ground.	Disconnect the B connector from the back of the FCU. Measure resistance between pin B10 of the FCU B connector and the negative battery terminal. Make sure batteries are disconnected or result may be inconclusive.	72–87 ohms	No problem found. Repeat tests and look for possible intermittent short to ground in circuit 97T. **Go to test no. 7**.
			Less than 72 ohms	Locate short to ground in circuit 97T. Repair as necessary. **Go to test no. 7**.
7	Verify repair.	Verify that repair corrected the fault code and the problem is resolved.	Problem resolved	Done.
			Problem unresolved	**Repeat test no. 1**.

Table 3, A/C Request Circuit Test

NOTE: Do not perform the test procedures in Table 4 before performing the test procedures in Table 1.

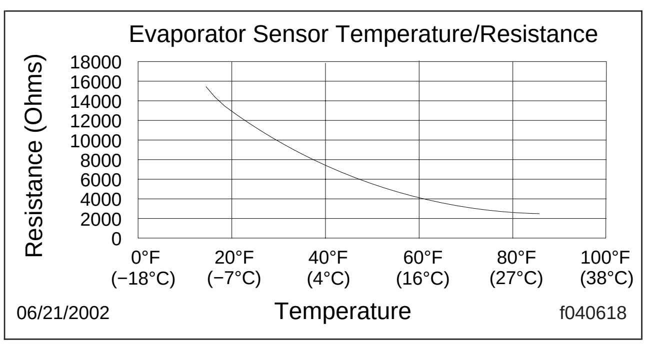


Fig. 1, Evaporator Sensor Temperature/Resistance

Symptom Driven Diagnosis

A/C Clutch Circuit Test

Test No.	Test	Test Procedure	Test Result	Action
1	Check power to A/C clutch relay.	Remove the A/C clutch relay from the PDM. Turn the ignition on and check for voltage on the PDM socket that corresponds to pin 87 A/C clutch relay.	No voltage	**Go to test no. 2**.
			12V	**Go to test no. 3**.
2	Check A/C clutch fuse.	Check the 20A A/C clutch fuse in the PDM (fuse 55).	Fuse okay	Check to make sure power is getting to fuse. If okay, check circuit between fuse and A/C clutch relay. Repair as necessary, then **go to test no. 6**.
			Fuse blown	Locate source of high current between the PDM and the A/C compressor clutch. The circuit may be shorted to ground. Repair as necessary, then **go to test no. 6**.
3	Check A/C clutch circuit resistance.	Remove the A/C clutch relay from the PDM. Measure the resistance between the PDM socket that corresponds to circuit 97T and the negative battery terminal. NOTE: Make sure batteries are disconnected. Failure to do so may give inconclusive results.	2.85 to 4 ohms	Check the A/C clutch relay. Make sure pin 87 is making contact with pin 30 when the relay is energized. Replace as necessary, then **go to test no. 6**.
			More than 4 ohms	**Go to test no. 4**.
4	Check binary switch.	Disconnect the binary switch and check continuity across the switch terminals.	Continuity	**Go to test no. 5**.
			No continuity	Check refrigerant pressures. If pressure is below the binary switch cutout pressure, the system is severely undercharged. Locate source of leak and recharge. If pressures are within the binary switch range, replace the binary switch then **go to test no. 6**.

A/C Clutch Circuit Test				
Test No.	Test	Test Procedure	Test Result	Action
5	Measure resistance of the A/C clutch.	Disconnect the connector at the A/C compressor. Measure resistance on the compressor side of the connector.	2.85–3.33 ohms	Problem is most likely high resistance or open circuit in wiring between the A/C clutch relay in the PDM and the A/C compressor. Be sure to check A/C compressor clutch ground circuit. The most definitive way to isolate the problem is to manually energize the circuit at the relay and use voltage drop measurements to isolate the problem, then **go to test no. 6**.
			Not 2.85–3.33 ohms	Replace A/C compressor clutch, then **go to test no. 6**.
6	Verify repair.	Verify that repair corrected the fault code and the problem is resolved.	Problem resolved	Done.
			Problem unresolved	**Repeat test no. 1**.

Table 4, A/C Clutch Circuit Test

Bunk Override Diagnosis

The front control unit will remember bunk override setting after an ignition cycle and initiate bunk override again. Both the front and auxiliary units will be in bunk override mode.

See **Table 5** for bunk override diagnosis procedures.

Bunk Override Diagnosis				
Test No.	Test	Test Procedure	Test Result	Action
1	Check bunk override function with DataLink Monitor Test.	Open the DataLink Monitor template for this system. Turn the ignition on. Set the front blower to high and the temperature to hot. Set the auxiliary blower to off and the temperature to cold. In the template, press the bunk override ON test button. The ACU bunk override mode annunciator state should be ON and the auxiliary blower and temperature settings should match the front settings (can be observed on the template. Note that it takes about a minute for the settings to completely change.)	The ACU bunk override mode state is ON and auxiliary blower and temperature settings closely match front settings.	**Go to test no. 3**.
			The ACU bunk override mode state is ON and auxiliary blower and/or temperature settings do not match the front unit.	Replace ACU, then **go to test no. 5**.
			The ACU bunk override mode state is OFF or NA/ERR.	**Go to test no. 2**.

Symptom Driven Diagnosis

Bunk Override Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
2	Verify J1587 communication.	Connect ServiceLink to the vehicle. Check if both the FCU (MID 146) and ACU (MID 200) appear in the ECU list.	Both ECUs appear in the ECU list.	**Go to test no. 3**.
			One or both ECUs do not appear in the ECU list or ServiceLink is unable to connect to vehicle.	Troubleshoot and repair J1587 databus. Refer to **Group 54** for more information. **Go to test no. 5**.
3	Check override switch operation.	Open the DataLink Monitor template for this system. While observing the bunk override switch annunciator in DLM, press the switch to the momentary on position, then to the momentary off position. The annunciator should indicate switch position. When the switch is in the normal position, the annunciator should indicate NA/ ERR.	Switch functions as described.	**Go to test no. 4**
			Switch does not function as described.	Check override switch and wiring. Repair as necessary. If okay, replace the FCU. **Go to test no. 5**.
4	Check if FCU is sending bunk override request.	Open the DataLink Monitor template for this system. While observing the Bunk O/R Request annunciator, press the bunk override switch to the momentary on position then release it. The O/R request annunciator should be in the ON state then read NA/ERR.	Bunk O/R request annunciator briefly indicates ON then goes to NA/ERR and FCU and ACU bunk override mode state is ON.	Problem not found. Verify complaint, check for intermittent problems, repeat tests if necessary.
			Bunk O/R request annunciator remains in the ON state.	Check ACU; it is not responding to the bunk override request. Make sure it has power and ground andJ1587 databus communication. If okay, replace ACU. **Go to test no. 5**.
			Bunk O/R request annunciator does not ever indicate it is in the ON state.	Repeat test 3. If okay, replace FCU, then **go to test no. 5**.
5	Verify repair.	Verify that repair corrected the fault code and the problem is resolved.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 5, Bunk Override Diagnosis

See **Table 6** for rear override diagnosis procedures.

Symptom Driven Diagnosis

Rear Override Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check rear override function with DataLink Monitor Test. NOTE: If the front unit diagnoses a bad blower motor, then it will not go into rear override mode and will not activate the A/C request signal.	Open the DataLink Monitor template for this system. Turn the ignition on. Set the front blower to off. Set the auxiliary blower to high and the temperature to full cold. In the template, press the rear override ON test button. On the template, the FCU rear override mode annunciator state should be ON and the A/C mode annunciator should be ON. The A/C clutch annunciator will not be on unless the A/C request rules are met (engine running, air pressure up, etc.). The front blower should be on low speed and the A/C indicator light on the A/C button should be on.	FCU rear override mode state annunciator in ON and A/C mode annunciator is ON.	**Go to test no. 3**.
			FCU rear override mode state annunciator is ON and A/C mode annunciator is OFF.	Replace FCU, then **go to test no. 4**.
			FCU rear override mode state annunciator is OFF.	**Go to test no. 2**
2	Verify J1587 communication.	Connect ServiceLink to the vehicle. Check if both the FCU (MID 146) and ACU (MID 200) appear in the ECU list.	Both ECUs appear in the ECU list.	Replace FCU, then **go to test no. 4**.
			One or both ECUs do not appear in the ECU list or ServiceLink is unable to connect to vehicle.	Troubleshoot and repair J1587 databus. Refer to **Group 54** for more information. **Go to test no. 4**.

Symptom Driven Diagnosis

Rear Override Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check if ACU is sending rear override request.	Open the DataLink Monitor template for this system. Start the engine. Turn the front blower off. While observing the Rear Override O/R Request annunciator in DataLink monitor, set the auxiliary temperature control switch to full cold and the auxiliary blower speed to high. The O/R Request annunciator should momentarily be in the ON state, then read NA/ERR. It may take a moment for this to happen.	O/R Request annunciator briefly indicates ON , then goes to NA/ERR, and FCU and ACU rear override mode state annunciators are ON, and A/C mode state annunciator is ON.	Problem not found. Rear override is functioning normally.
			O/R Request annunciator stays in the ON state.	Check FCU. It is not responding to the rear override request. Make sure it has power and ground andJ1587 databus communication. If okay, replace FCU. **Go to test no. 4**.
			O/R Request annunciator does not ever indicate it is in the ON state.	Repeat test no. 3. If ambient temperature is low, the auxiliary unit may not request rear override. Replace ACU if repeated test fails. **Go to test no. 4**
4	Verify repair.	Verify that repair resolved the problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 6, Rear Override Diagnosis

Actuator Diagnosis

See **Table 7** for the actuator circuit test procedures.

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Check for fault codes.	Check if any one of the following fault codes is active: **Group A** / **Group B** 146 s005 05 / 146 s005 06 146 s006 05 / 146 s006 06 146 s009 05 / 146 s009 06 200 s009 05 / 200 s009 06 07/02/2002 f040619	Single fault in Group A isactive.	**Go to test no. 2**.
			All three MID 146 faults are active in Group A.	**Go to test no. 6**.
			Single fault in Group B is active.	**Go to test no. 8**.
			No faults listed in Group A or B are active.	No problem found.

Symptom Driven Diagnosis

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
2	Check voltage to the actuator. NOTE: In order to measure a valid voltage, it may be necessary to move the respective control :for recirc, press the recirc button; for mix door actuator, move the temperature control switch; for the mode actuator, move the air selection switch.	For code **146s005 05** (front unit) disconnect the recirc actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground. For code **146 s006 05** (front unit) disconnect the mode actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground. For code **146 s009 05** (front unit) disconnect the temperature actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground. For code **200 s006 05** (auxiliary unit) disconnect the temperature actuator connector, turn the ignition on, measure voltage between connector pin 1 and ground. NOTE: See **Fig. 2**, **Fig. 3**, and **Fig. 4**.	Approximately 12V	**Go to test no. 3**.
			Much less than 12V.	Check wire between pin 1 of the actuator and the FCU/ACU for open circuit. If okay, replace FCU/ACU. **Go to test no. 9**.

Symptom Driven Diagnosis

Actuator Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check for short to ground on return side of actuator.	For code **146s005 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the recirc actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **146 s006 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the mode actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **146 s009 05** (front unit) disconnect all three actuator connectors and the FCU connector. At the temperature actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. For code **200 s009 05** (auxiliary unit) disconnect the temperature actuator connector and the ACU connector. At the temperature actuator connector, check continuity between connector pin 3 and ground. Repeat for pins 4, 5, and 6. NOTE: See **Fig. 2**, **Fig. 3**, and **Fig. 4**.	Continuity to ground on any pin.	Locate short to ground, repair as necessary, then **go to test no. 9**.
			No continuity to ground on any pin.	**Go to test no. 4**.

Symptom Driven Diagnosis

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Check continuity of actuator return side.</td><td rowspan="2">For code 146s005 05 disconnect the recirc actuator connector.

For code 146 s006 05 disconnect the mode actuator connector.

For code 146 s009 05 disconnect the temperature actuator connector.

Check continuity between the following connector pins:
<table><tr><th>FCU</th><th>Actuator</th></tr><tr><td>A2</td><td>3</td></tr><tr><td>B1</td><td>4</td></tr><tr><td>B2</td><td>5</td></tr><tr><td>B3</td><td>6</td></tr></table>07/02/2002 f040620

For code 200 s009 05 (auxiliary unit) disconnect the auxiliary unit temperature actuator connector and the ACU connector.

Check continuity between the following connector pins:
<table><tr><th>ACU</th><th>Actuator</th></tr><tr><td>B8</td><td>3</td></tr><tr><td>B7</td><td>4</td></tr><tr><td>B6</td><td>5</td></tr><tr><td>B5</td><td>6</td></tr></table>07/02/2002 f040621

NOTE: See Fig. 2, Fig. 3, and Fig. 4.</td><td>Continuity on all pin combinations.</td><td>Go to test no. 5.</td></tr>
<tr><td>No continuity on one or more pin combinations.</td><td>Locate open circuit, repair as necessary, then go to test no. 9.</td></tr>
</table>

Symptom Driven Diagnosis

<table>
<tr><th colspan="5">Actuator Circuit Test</th></tr>
<tr><th>Test No.</th><th>Test</th><th>Test Procedure</th><th>Test Result</th><th>Action</th></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Check actuator.</td><td rowspan="2">For code 146s005 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the recirc actuator.

For code 146 s006 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the mode actuator.

For code 146 s009 05 (front unit) perform "Actuator Stepper Motor Electrical Test" on the temperature actuator.

For code 200 s009 05 (auxiliary unit) perform "Actuator Stepper Motor Electrical Test" on the temperature actuator (auxiliary unit).</td><td>Actuator okay.</td><td>Replace FCU/ACU, thengo to test no. 9.</td></tr>
<tr><td>Actuator not okay.</td><td>Replace actuator, thengo to test no. 9.</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Check actuator return circuits for open.</td><td rowspan="2">For all three active codes at the same time, 146 s005 05, 146 s006 05, 146 s009 05, disconnect all three actuator connectors and the FCU connector. At each actuator connector, check continuity between the following connector pins:
<table><tr><th>FCU</th><th>Actuator</th></tr><tr><td>A2</td><td>3</td></tr><tr><td>B1</td><td>4</td></tr><tr><td>B2</td><td>5</td></tr><tr><td>B3</td><td>6</td></tr></table>07/02/2002 f040620

NOTE: See Fig. 2, Fig. 3, and Fig. 4.</td><td>Continuity on all pin combinations.</td><td>Go to test no. 7.</td></tr>
<tr><td>No continuity on one or more pin combinations.</td><td>Locate open circuit, repair as necessary, then go to test no. 9.</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Check actuator return circuits for short to ground.</td><td rowspan="2">Disconnect all three actuator connectors and the FCU connector. At the FCU connector, check continuity between pin A2 and ground. Repeat for pins B1, B2, and B3.

NOTE: See Fig. 2, Fig. 3, and Fig. 4.</td><td>Continuity to ground on any pin.</td><td>Repair short to ground, thengo to test no. 9.</td></tr>
<tr><td>No continuity to ground on any pin.</td><td>Replace FCU, thengo to test no. 9.</td></tr>
</table>

Actuator Circuit Test				
Test No.	Test	Test Procedure	Test Result	Action
8	Check for shorted actuator coil.	For code **146s005 06** disconnect the recirc actuator connector, check if fault no longer active (different fault maybe active). For code **146 s006 06** disconnect the mode actuator connector, check if fault no longer active (different fault may be active). For code **146 s009 06** disconnect the temperature actuator connector, check if fault no longer active (different fault may be active). For code **200 s009 06** disconnect the temperature actuator connector (auxiliary unit), check if fault no longer active (different fault may be active). See **Fig. 2**.	Fault no longer active (FMI06), different fault may be active (FMI 05).	Shorted actuator motor is likely. Perform "Actuator Stepper Motor Electrical Test" to confirm, then **go to test no. 9**.
			Fault still active (FMI06).	Check for short to ground in power wire between actuator and FCU/ACU. If no short is found, replace FCU/ACU, then **go to test no. 9**.
9	Verify repair. NOTE: In order to check if a fault status has changed from active to inactive, the recirc button, temperature control switch, or air selection switch needs to be moved while the ignition is on.	Verify that repair resolved the problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 7, Actuator Circuit Test

Temperature Sensor Diagnosis

See **Table 8** for the evaporator temperature sensor circuit test procedures.

Symptom Driven Diagnosis

Evaporator Temperature Sensor Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Are evaporator temperature sensor fault codes active?	Check if fault code**146 s002 03** or **146 s002 04** is active.	Neither fault isactive.	**Go to test no. 2**.
			146s002 03 is active	Check for sensor signal wire shorted to power. If okay, **go to test no. 2**.
			146s002 04 is active.	Check for sensor signal wire shorted to ground. If okay, replace FCU. **Go to test no. 3**.
2	Check sensor reference voltage.	Disconnect the evaporator sensor. Turn the ignition on and measure the voltage across the sensor connector pins (harness side). The voltage should be 5V if the circuit and FCU are operating correctly.	5V	Perform "Evaporator Temperature Sensor Test."
			Less than 5V.	Check for open circuit in sensor signal and ground wires. If okay, replace FCU. **Go to test no. 3**.
3	Verify repair.	Verify that repair resolved the problem.	Problem solved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 8, Evaporator Temperature Sensor Circuit Test

See **Table 9** for the CDTC temperature sensor circuit test procedures.

CDTC Temperature Sensor Circuit Test				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Are CDTC temperature sensor fault codes active?	Check if one of the following fault codes is active: **146 s001 03**, **146 s001 04**, or**200 s001 03**, **200 s001 04**.	None of these faults isactive.	**Go to test no. 2**.
			146s001 03 or **200 s001 03** is active.	Check for sensor signal wire shorted to power. If okay, **go to test no. 2**.
			146s001 04 or **200 s001 04** is active.	Check for sensor signal wire shorted to ground. If okay, replace FCU/ACU. **Go to test no. 3**.
2	Check sensor reference voltage.	Disconnect the CDTC sensor. Turn the ignition on and measure the voltage across the sensor connector pins (harness side). The voltage should be 5V if the circuit and FCU/ACU are operating correctly.	5V	Perform "CDTC Temperature Sensor Test."
			Less than 5V.	Check for open circuit in sensor signal and ground wires. If okay, replace FCU/ACU. **Go to test no. 3**.

CDTC Temperature Sensor Circuit Test				
Test No.	Test	Test Procedure	Test Result	Action
3	Verify repair.	Verify that repair resolved the problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 9, CDTC Temperature Sensor Circuit Test

Backlighting Diagnosis

See **Table 10** for backlighting diagnosis.

Backlighting Diagnosis				
Test No.	Test	Test Procedure	Test Result	Action
1	Check backlighting operation.	Turn on the headlights and check for the following conditions: • Condition 1—all backlighting (instrument cluster, panel switches, and HVAC FCU) not working • Condition 2—HVAC FCU and bunk override switch backlighting not working • Condition 3—only HVAC FCU backlighting not working • Condition 4—only bunk override switch backlighting not working	Condition 1	See Group 54 for backlighting diagnosis.
			Condition 2	**Go to test no. 2**.
			Condition 3	**Go to test no. 3**.
			Condition 4	**Go to test no. 4**.
2	Check circuits 29A and GND1.	Disconnect AS2 connector. Turn headlights on. Measure voltage at pins A(+) and F(–) of the AS2 connector on the main cab harness side.	9–16V	Check AS2 connector for damaged pins. If damaged pins are found, repair as necessary then **go to test no. 5**. If no damage is found, **repeat test no. 1**.
			Less than 9V (0V)	Check for open in circuits 29A and GND1 in the main cab harness. Repair as necessary, then **go to test no. 5**.
3	Check circuits DIM+ and GND1 to FCU.	Disconnect the FCU connector. Turn headlights on. Measure voltage at pins A6(+) and A7(–) of the FCU connector.	9–16V	Replace FCU, then **go to test no. 5**.
			Less than 9V (0V)	Check circuits DIM+ and GND1 between the FCU connector and the AS2 connector for circuit fault (open or short). Repair as necessary, then **go to test no. 5**.

Symptom Driven Diagnosis

Backlighting Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
4	Check circuits DIM+ and GND1 to override switch.	Disconnect the override switch connector. Turn headlights on. Measure voltage at pins 10(+) and 8(–) of the override switch connector.	9–16V	Replace the override switch, then **go to test no. 5**.
			Less than 9V (0V)	Check circuits DIM+ and GND1 between the override switch and AS2 connectors for circuit faults (open or short). Repair as necessary, then **go to test no. 5**.
5	Verify repair.	Verify that repair solved the backlighting problem.	Problem resolved.	Done.
			Problem unresolved.	**Repeat test no. 1**.

Table 10, Backlighting Diagnosis

Sleeper Climate Control Panel Circuit Diagnosis

See **Table 11** for sleeper climate control panel circuit diagnosis.

Sleeper Climate Control Panel Circuit Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Does the symptom involve both the blower and temperature control?	—	No, affects only one of these	**Go to test no. 4**.
			Yes, affects both	**Go to test no. 2**.
2	Check the 12VDC ignition supply to the control panel.	Gain access to the back of the sleeper control panel. Disconnect the blower and temperature potentiometer connectors. Turn the ignition on. At the blower speed potentiometer connector, check for voltage at pin A (circuit 98N). Repeat test for temperature potentiometer connector pin A (circuit 98N).	Voltage at both pins	**Go to test no. 3**.
			Voltage at only one pin	Check circuit 98N between connector with no voltage and splice in harness. Repair as necessary.
			No voltage at either pin	Check 10A fuse in B-pillar PDM. If blown, check for short in circuit 98N. If okay, check circuit 98N for open and check ignition supply to fuse panel. Repair as necessary.

Symptom Driven Diagnosis

Sleeper Climate Control Panel Circuit Diagnosis				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
3	Check control panel ground circuit.	Make sure the ignition is off and the batteries are disconnected. Failure to do this may give inconclusive test results. Disconnect the blower and temperature potentiometer connectors. At the blower speed potentiometer connector, check resistance between pin C (circuit GND) and the battery negative terminal. Repeat test for temperature potentiometer connector pin C (circuit GND).	Both less than one ohm	Check ACU power and ground wiring. ACU may be malfunctioning.
			One more than 1 ohm	Check GND circuit between affected potentiometer circuit and the splice in the harness. Repair as necessary.
			Both more than 1 ohm	Check GND wiring to potentiometers. Check ACU ground circuit.
4	Which potentiometer circuit is affected?		Blower control	**Go to test no. 5**.
			Temperature control	**Go to test no. 6**.
5	Check for blower potentiometer voltage signal at the ACU.	Remove the ACU from the HVAC unit; leave the connector plugged in. Turn the ignition on. Backprobe ACU connector pin A2 and check for voltage while rotating the blower speed control knob from low to high.	Voltage ranges from 0.5 to 12.5VDC	Sleeper climate control panel circuit is not the problem. Check for fault codes and see "Blower Motor Diagnostics–Front and Auxiliary Units."
			Voltage does not vary; remains steady regardless of value	Check circuit 98M between blower speed potentiometer and ACU. Repair as necessary. If okay, replace potentiometer.
6	Check for temperature potentiometer voltage signal at the ACU.	Remove the ACU from the HVAC unit; leave the connector plugged in. Turn the ignition on. Backprobe ACU connector pin A5 and check for voltage while rotating the temperature control knob from cold to hot.	Voltage ranges from 0.5 to 12.5 VDC	Sleeper climate control panel circuit is not the problem. Check for fault codes and see "Actuator Stepper Motors—Temperature, Recirc, and Mode" for temperature actuator diagnostics.
			Voltage does not vary; remains steady regardless of value	Check circuit 98T between temperature potentiometer and ACU. Repair as necessary. If okay, replace potentiometer.

Table 11, Sleeper Climate Control Panel Circuit Diagnosis

Blower Motor Diagnostics—Front and Auxiliary Units

See **Table 12** and **Table 13** for blower motor diagnostics.

Symptom Driven Diagnosis

Blower Will Not Operate or Operates at Reduced Speed				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Is fault 146 s010 02 or 200 s010 02 active?	—	Yes	See fault code tables, in **Subject 340**, for diagnosis.
			No	**Go to test no. 2**.
2	Check power and ground.	Disconnect the blower motor connector. Turn ignition on. Check for voltage across pins 3 and 4 of the connector. NOTE: If system voltage is too high or too low, this may cause the blower motor to enter voltage protection mode. This will cause the blower to operate at reduced speed or stop working altogether.	12–17V (should be approx. battery voltage)	**Go to test no. 3**.
			0V	Check 30A blower motor fuse in PDM. Check blower motor power and ground circuits for open (circuits 98 and GND). Repair as necessary, then **go to test no. 7**.
			Less than 12V (not 0) or more than 17V	Blower has most likely entered voltage protection mode. Correct voltage problem as necessary, then **go to test no. 7**.
3	Check speed control signal at blower motor.	Disconnect the blower motor connector. Turn ignition on. Check voltage between connector pin 6 and ground while rotating the blower control switch from off to full speed. The voltage should be approximately 0V (off) to 5V+ (high).	Voltage full range (0–5V+)	**Go to test no. 4**.
			Voltage stays at 0V	Check speed control wire for open circuit between blower motor and FCU or ACU. If okay, check FCU/ACU. Repair/replace as necessary, then **go to test no. 7**.
4	Check for mechanical obstruction/locked rotor.	Remove the blower motor from the HVAC housing. Check for obstruction preventing blower from turning. Check if rotor spins freely by hand.	Obstruction	Remove obstruction as necessary, then **go to test no. 7**.
			Rotor locked	Replace blower motor, then **go to test no. 7**.
			Neither	**Go to test no. 5**.

Symptom Driven Diagnosis

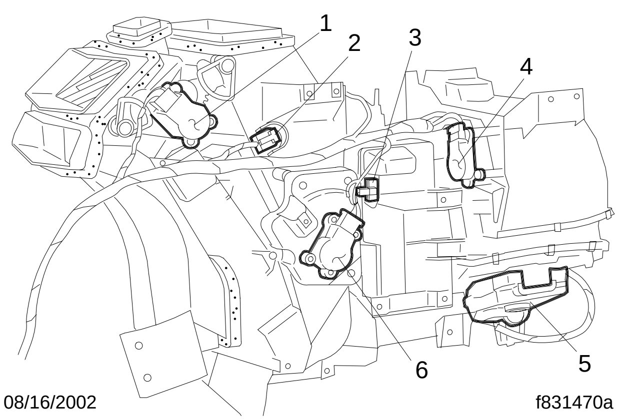
Blower Will Not Operate or Operates at Reduced Speed				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
5	Check voltage drop.	Remove the blower motor from the HVAC housing. Turn ignition on, set blower speed to high. Check voltage on the power and ground circuits by back-probing the blower motor connector. Check between the positive and negative battery posts. NOTE: High voltage drop may cause the blower motor to enter voltage protection mode. This will cause the blower to operate at reduced speed and, if severe enough, may stop the blower altogether.	Less than 0.2V	**Go to test no. 6**.
			More than 0.2V	Locate source of high resistance causing voltage drop. Repair as necessary then **go to test no. 7**.
6	Does the blower motor operate at all?	—	Yes	Check if blower motor feels hot and make sure there are no obstructions to airflow. If no obstructed airflow or blower feels hot, replace blower motor then**go to test no. 7**.
			No	Replace blower motor, then **go to test no. 7**.
7	Verify repair.	Verify that repair resolved the problem.	Problem resolved	Done
			Problem unresolved	**Repeat test no. 1**.

Table 12, Blower Will Not Operate or Operates at Reduced Speed

Diagnosis for Blower Speed is Not Available				
Test No.	**Test**	**Test Procedure**	**Test Result**	**Action**
1	Does blower operate at all?	—	Yes	**Go to test no. 2**.
			No	Perform the tests in **Table 12**.
2	Check feedback speed/diagnostic circuit.	Check for open or short circuit in blower motor feedback speed/diagnostic circuit between the blower motor and the FCU/ACU.	Circuit is open or shorted	Repair blower motor feedback speed/diagnostic circuit then, **go to test no. 3**.
			Circuit okay	Perform the tests in **Table 12**.
3	Verify repair.	Verify that repair resolved the problem.	Problem resolved	Done
			Problem unresolved	**Repeat test no. 1**.

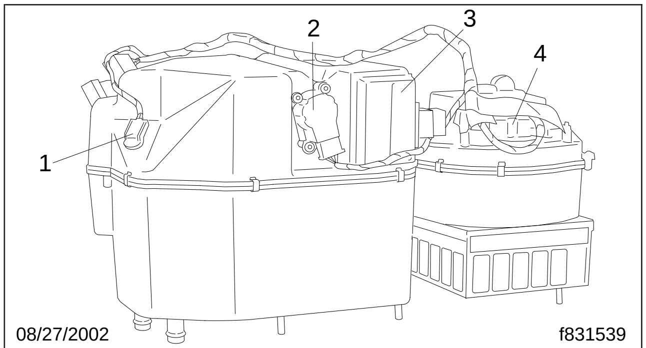
Table 13, Diagnosis for Blower Speed is Not Available

Symptom Driven Diagnosis



1. Mode Actuator
2. CDTC Temperature Sensor
3. Evaporator Temperature Sensor
4. Recirculation Actuator
5. Blower Motor
6. Temperature Actuator

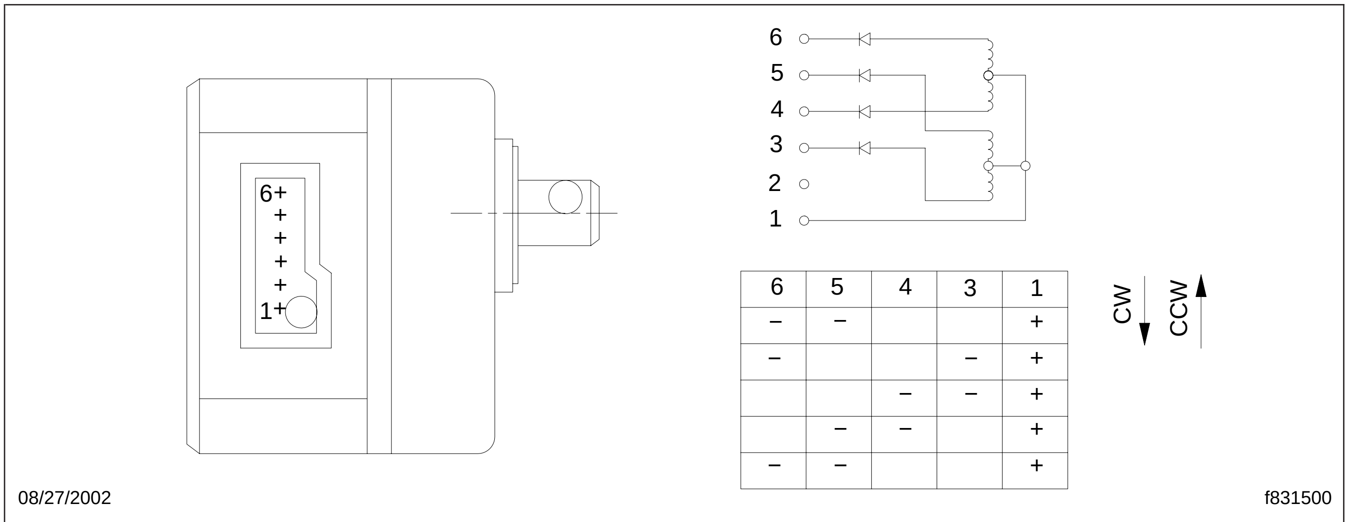
Fig. 2, Cab HVAC Assembly



1. CDTC Sensor
2. Temperature Actuator
3. Auxiliary Control Unit (ACU)
4. Blower Motor

Fig. 3, Auxiliary HVAC Assembly

Symptom Driven Diagnosis



6	5	4	3	1
−	−			+
−			−	+
		−	−	+
	−	−		+
−	−			+

Fig. 4, Actuator Motor Pinouts

Specifications

Acceptable Leak Rates by Component	
Component	**Acceptable Leak Rates**
J-Block Body	0.25 oz/yr and greater condemns these components
Evaporators (main and auxiliary)	
Condenser	
Receiver Dryer (Body)	
Lines/Hoses	
Capped Charge Ports	
Mini-Stato seal (1 - when the leak can be tied to a single seal)	
Mini-Stato seals (2 - when the leak cannot be tied to a single seal)	0.50 oz/yr and greater condemns these components
Compressor (shaft seal, housing, etc.)	
TXV (Power Valve and Super Heat Cap)	
Sensor/Switches (O-ring and crimped body connections)	

Table 1, Acceptable Leak Rates by Component

General Information

Overview

The Bergstrom NITE (No Idle Thermal Environment) parked, or no-idle, air conditioning system is a compact, electrically powered, 3000-BTU system. It is designed to provide a means of air conditioning to the sleeper area without having the engine running. It is completely self-contained, and runs on 12-volt deep-cycle batteries. The system is designed to maintain cool air in the sleeper interior. For optimal operation, the curtain between the cab and the sleeper must be closed when using the A/C system. The parked A/C unit will not cool down a hot sleeper that has been sitting in the sun without the vehicle A/C running. If the interior temperature is higher than desired, start the engine and run the vehicle A/C system until the desired sleeper temperature is achieved. This will help cool the sleeper to a temperature the parked A/C system can maintain. Once the sleeper temperature is lowered, the system will maintain a comfortable setting.

The unit is located under the lower bunk in the sleeper compartment. The unit gets its intake air from the under-bunk area through a grate in the top panel. An air intake grille is located on the front panel of the lower bunk. The outlet ducting runs from the left side of the unit to an outlet near the bunk occupant's face on the back wall of the sleeper. It is important to keep the air intake grille, and the area under the bunk, free of objects that might block air flow or put objectionable odors into the cooling air. Air for the condenser is taken in from under the cab and exhausted through another opening in the cab floor.

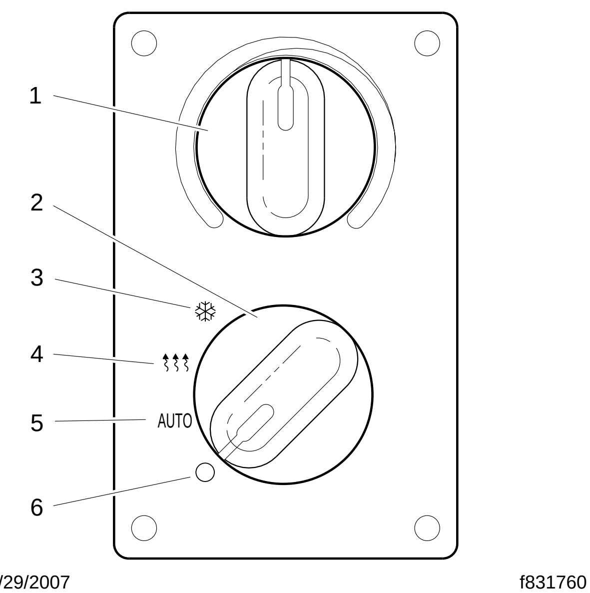
The system receives power from four deep-cycle batteries located between the frame rails. These batteries are completely isolated from the starting batteries to keep the starting batteries from being drawn down during operation.

IMPORTANT: The refrigerant system in the parked A/C unit is a sealed system, it is not serviceable. If problems occur; contact the NITE line at 1-866-204-8570, or visit **www.nitesystem.com**.

Operation

The control panel for the parked A/C and heater is located on the back wall of the sleeper near the left side. It has a temperature control dial, and a four-position mode selector switch. Turn the temperature setting dial to the left for cooling, and to the right for heat. See **Fig. 1**. See **Table 1** for a description of the function of the mode switch.

The system must be turned off whenever it is not in use, or the batteries may not charge properly. After using the system, turn the mode switch to the OFF position, even if the unit is not running.



1. Temperature Control Dial
2. Mode Switch
3. A/C Only
4. Heat Only
5. AUTO
6. Off

Fig. 1, Parked A/C and Heater Control Panel

Parked A/C and Heater Mode Switch Operation	
Mode	**Function**
Off	Turns the unit off.
AUTO	Allows the unit to automatically heat or cool the sleeper, depending on the temperature setting and the sleeper temperature. Adjusts the compressor, heater, and fans to keep temperature constant.
Heat Only	Allows only the heat portion of the system to run. Adjusts the heater only to keep the temperature constant.

General Information

Parked A/C and Heater Mode Switch Operation	
Mode	**Function**
A/C Only	Allows only the A/C portion of the system to run. Adjusts compressor and fans only to keep the temperature constant.

Table 1, Parked A/C and Heater Mode Switch Operation

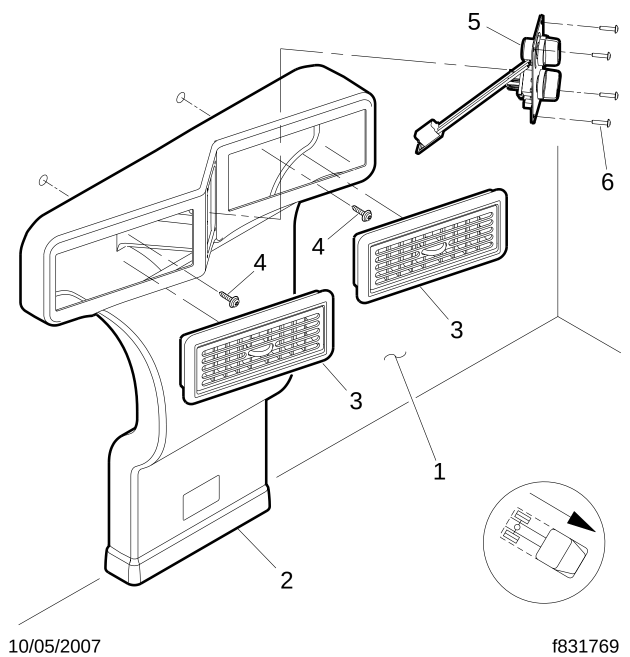
Safety Precautions

IMPORTANT: The refrigerant system on this unit is **not** servicable. Do not attempt to open the refrigerant system. The only reason you should come in contact with the refrigerant is if there is a leak in the system.

Control Panel Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.
2. Remove the outlet grilles. See **Fig. 1**.



1. Sleeper Back Wall
2. Plenum
3. Outlet Grille
4. Plenum Screws
5. Control Panel
6. Control Panel Fasteners

Fig. 1, Plenum and Control Panel Installation

3. Remove the screws that hold the plenum to the back wall of the sleeper.
4. Tilt the plenum out from the wall, and disconnect the wires.
5. Remove the control panel fasteners, and remove the control panel.

Installation

1. Position the control panel in the opening in the housing, and install the fasteners.
2. Connect the wires to the control panel.
3. Position the plenum, and install the fasteners.
4. Install the outlet grilles.
5. Connect the batteries.

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.

NOTE: Mark all wires for reference before disconnecting them.

2. Disconnect the harness and the battery cables at the terminals under the sleeper floor. See **Fig. 1**.

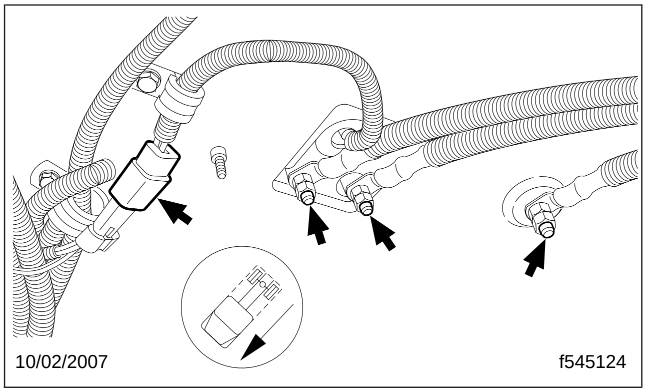


Fig. 1, Harness and Battery Cables

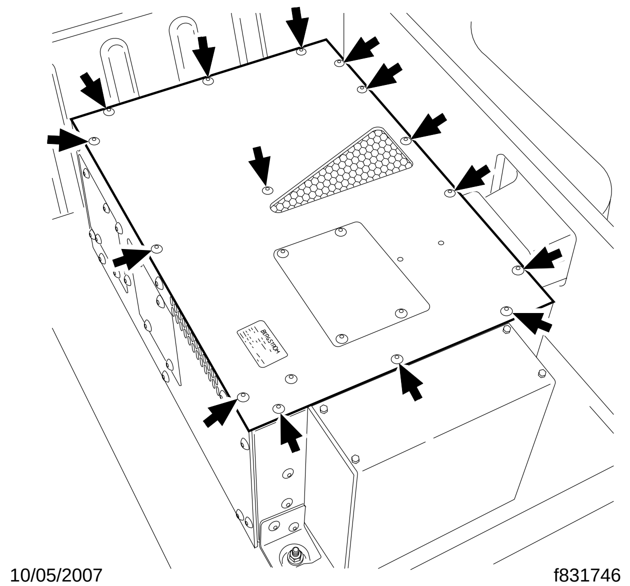
3. Raise and secure the lower bunk.
4. Disconnect the air duct from the outlet opening on the left side of the unit.
5. Disconnect the wires that go to the control panel.
6. Remove the nuts at the corners of the unit.

NOTE: The unit weighs approximately 70 lb (32 kg), and it is awkward to handle in the tight confines of the sleeper. Be careful when lifting it, to avoid personal injury or damaging the cab interior parts.

7. Lift the unit out of the under-bunk area.
8. Position the unit on the mounting studs in the under bunk area, and install the mounting nuts.
9. Connect the wires to the control panel.
10. Attach the air duct to the outlet opening in the left side of the unit.
11. Connect the harness and the battery cables to the terminals under the sleeper floor.
12. Connect the batteries.
13. Lower the bunk.

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.



Remove the indicated fasteners only.

Fig. 1, Top Access Panel

4. Remove the two fasteners on the inside panel of the unit. See **Fig. 2**.
5. Remove the two fasteners on the outside of the unit, below the outlet duct.
6. Disconnect the wire connector at the blower.
7. Lift the blower assembly out of the unit housing.
8. Position the blower assembly in the unit housing.
9. Connect the wire connector at the blower.
10. Install the blower mounting fasteners; two inside, and two outside.
11. Connect the batteries.
12. Install the top panel.
13. Lower the bunk.

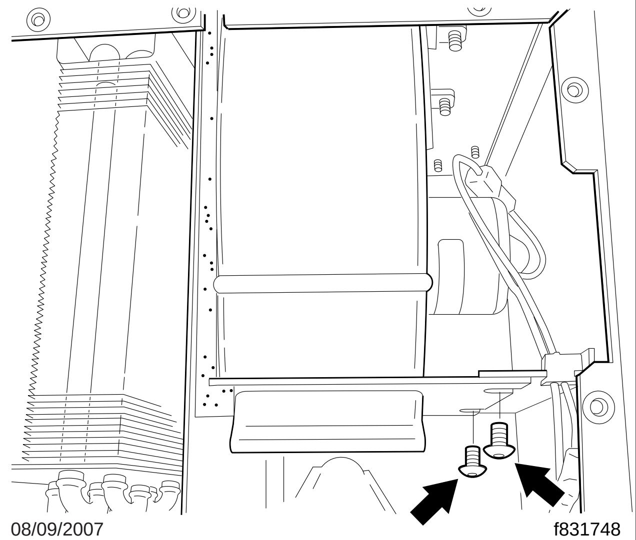
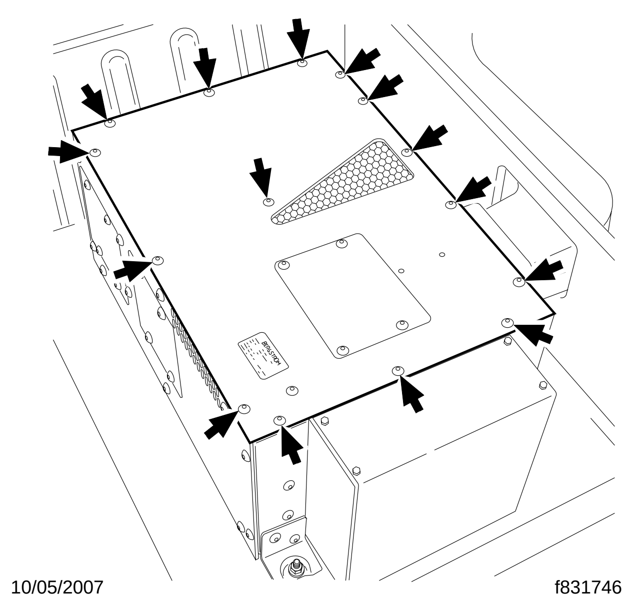


Fig. 2, Inside Blower Fasteners

Condenser Fan Replacement

Replacement

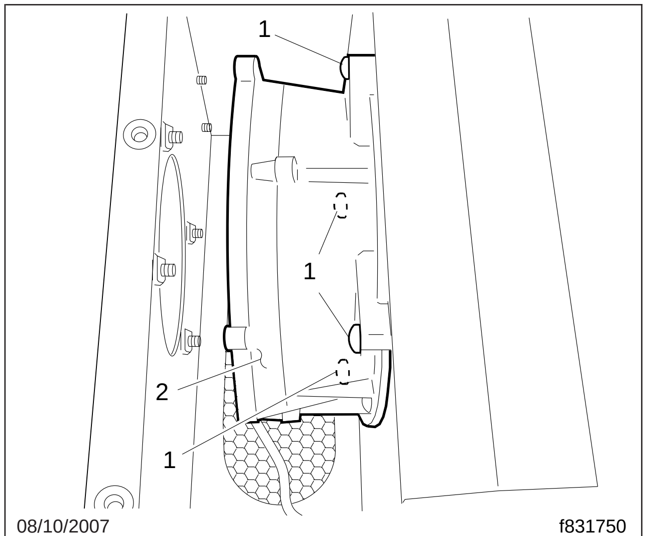
1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See Fig. 1.



Remove the indicated fasteners only.

Fig. 1, Top Access Panels

4. Remove the fasteners from the condenser fan assembly. See Fig. 2.
5. Cut any wire ties as needed, and disconnect the wire connector from the condenser fan.
6. Remove the condenser fan assembly from the unit housing.
7. Position the condenser fan assembly in the unit housing, and install the fasteners.
8. Connect the wire connector and install wire ties as needed.
9. Connect the batteries.
10. Install the top panel.
11. Lower the bunk.



1. Fasteners (4)
2. Condenser Fan

Fig. 2, Condenser Fan Installation

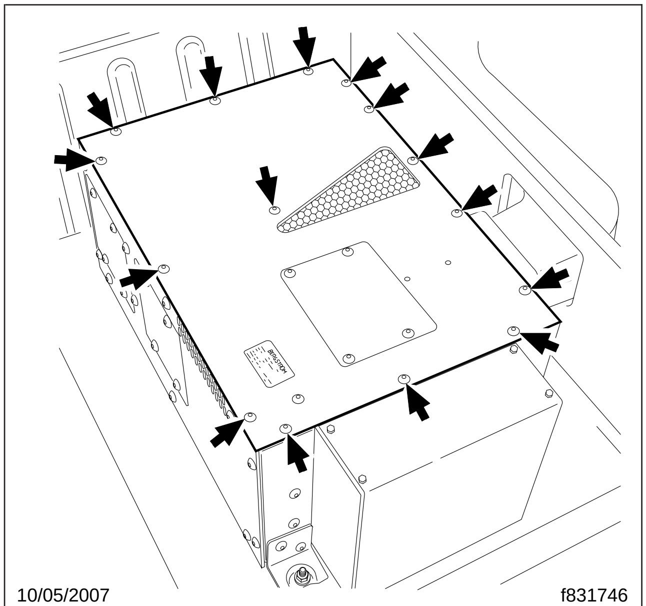
Compressor Control Module Replacement

Replacement

NOTICE

When removing or installing the control module housing, be very careful not to damage the exposed control board. Even a small chip or crack in the control board can ruin it.

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect both sets of vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.

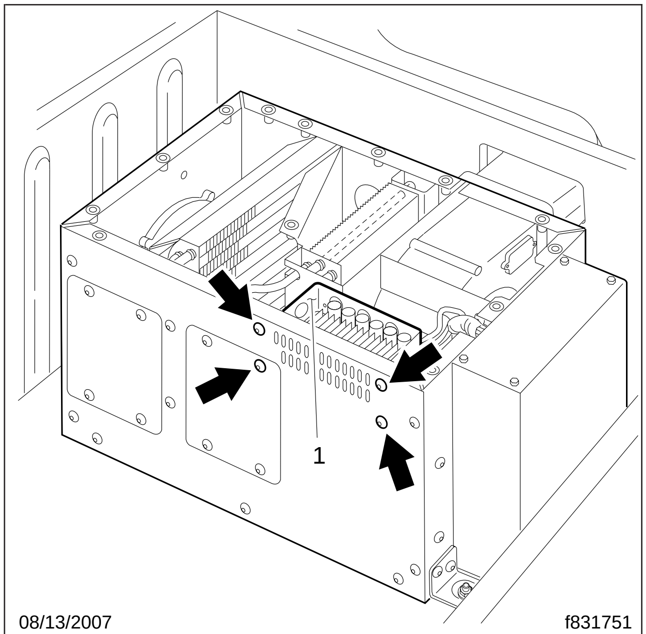


Remove only the indicated fasteners.

Fig. 1, Top Access Panels

4. Remove the four control module housing fasteners on the side panel. See **Fig. 2**.

IMPORTANT: Make sure to note the positions of the wires to the compressor motor. Connecting them incorrectly will cause the compressor to malfunction. The wires to the temperature sensor can go either way. See **Fig. 3** for wire positions.

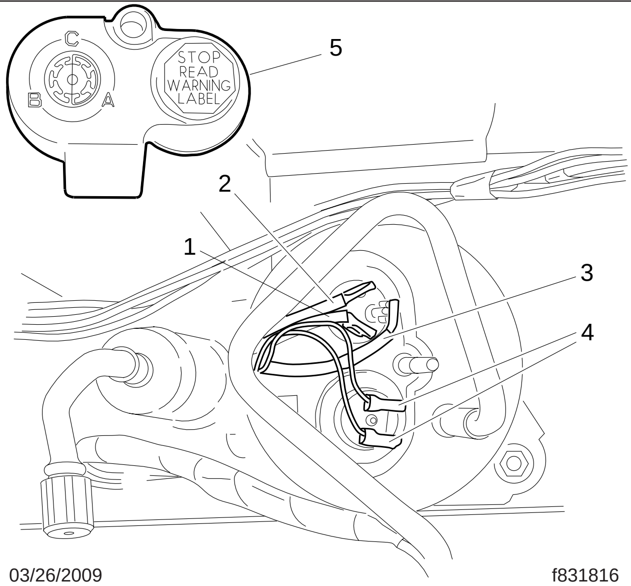


1. Compressor Control Module

Fig. 2, Control-Module-Housing Fasteners

5. Remove the connector cap from the compressor, and disconnect the wires to the motor and temperature sensor.
6. Disconnect the power supply wires from the compressor.
7. Disconnect the connector from the harness to the control board.
8. Carefully remove the compressor control module.
9. Connect the power supply wires to the compressor. See **Fig. 3** for wire positions.
10. Install the compressor cap and nut.
11. Position the compressor control module in the unit housing.
12. Connect the wire connectors to the power supply and the control board.
13. Install the compressor control module fasteners.
14. Connect the batteries.
15. Install the top panel.
16. Lower the bunk.

Compressor Control Module Replacement

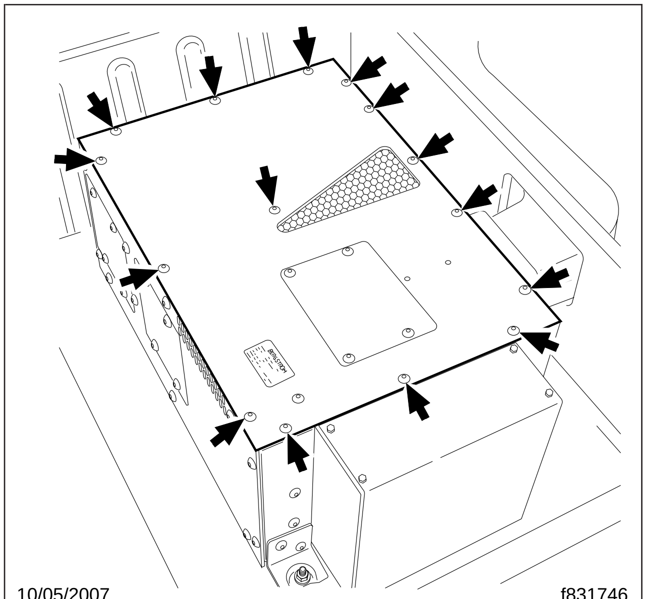


1. Blue Wire (position A)
2. Orange Wire (position B)
3. Yellow Wire (position C)
4. Black Wires, Temperature Sensor
5. Connector Cap

Fig. 3, Compressor Wire Connections

Replacement

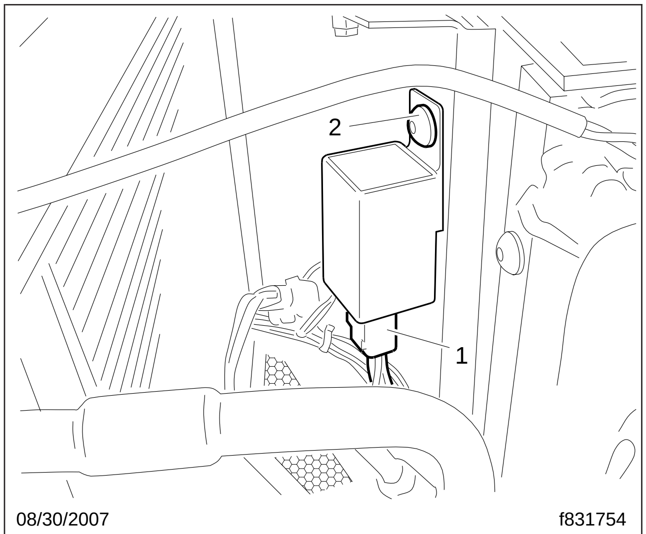
1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect the vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.



Remove only the indicated fasteners.

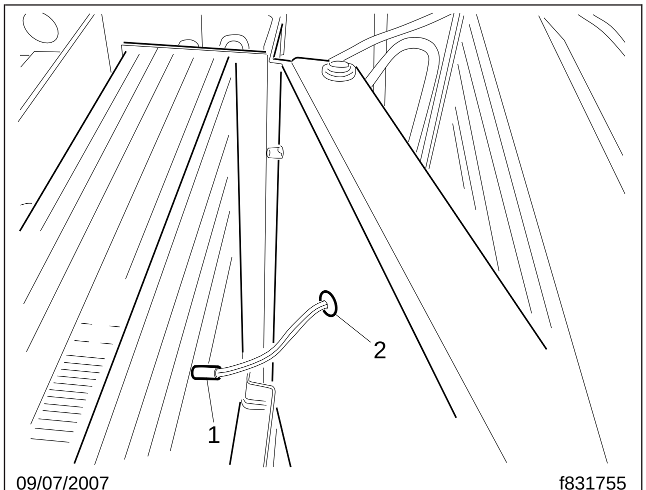
Fig. 1, Top Access Panels

4. Unplug the freeze switch.
5. Remove the fastener. See **Fig. 2**.
6. Remove the freeze switch probe from the evaporator coil, and pull the probe, wire, and rubber grommet out the hole on the panel. See **Fig. 3**.
7. Remove the freeze switch.
8. Insert the probe into the evaporator core in the same location as the original. Install the grommet in the hole in the panel.
9. Position the new freeze switch and install the fastener.
10. Connect the wire into the switch.
11. Connect the batteries.
12. Install the top panel.
13. Lower the bunk.



1. Wire Connector
2. Fastener

Fig. 2, Freeze Switch



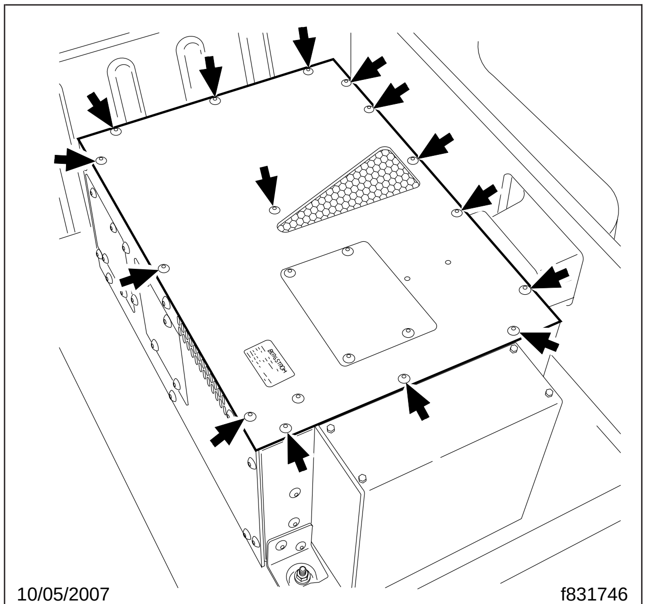
1. Probe
2. Grommet

Fig. 3, Freeze Switch Probe

Unit Control Module Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect both sets of vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the top panel. See **Fig. 1**.



Remove only the indicated fasteners.

Fig. 1, Top Access Panel

4. Disconnect the three wire connectors from the unit control module. See **Fig. 2**.
5. Remove the electrical box cover. See **Fig. 3**.
6. Disconnect the wires that connect to the bottom of the electrical box, under the sleeper. See **Fig. 4**.

NOTE: There may be a vapor barrier affixed to the bottom of the unit, including electrical box. If so, carefully cut it loose in order to be able to tilt the electrical box out from the unit without damaging the vapor barrier.

7. Remove the four sheetmetal screws that hold the electrical box to the front of the unit, and tilt the electrical box away from the unit. See **Fig. 5** or **Fig. 6**.

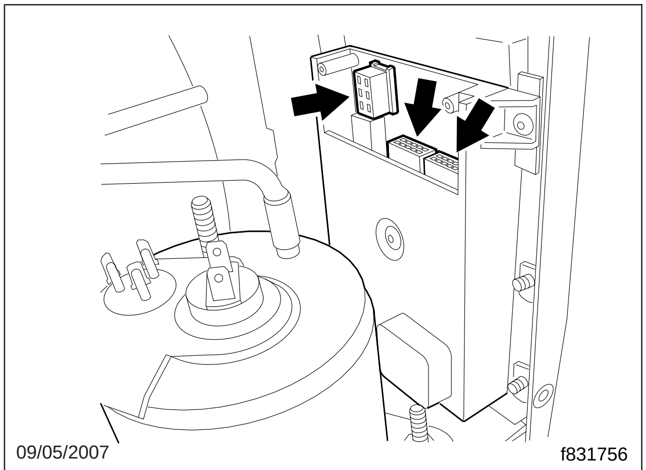
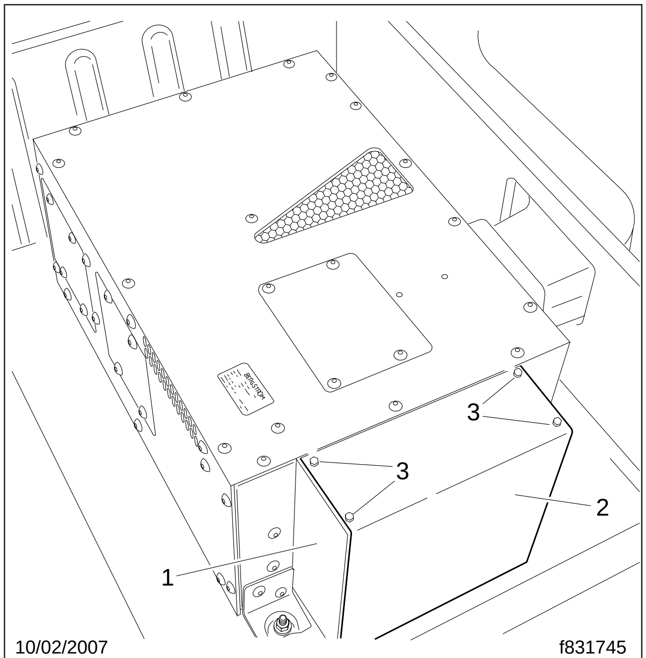


Fig. 2, Control Module Wiring



1. Electrical Box
2. Electrical Box Cover
3. Cover Fasteners

Fig. 3, Electrical Box Installation

8. Remove the fasteners for the control module mounting plate from the outside of the unit. See **Fig. 7**. Slide the mounting plate out of the unit with the control module attached.

Unit Control Module Replacement

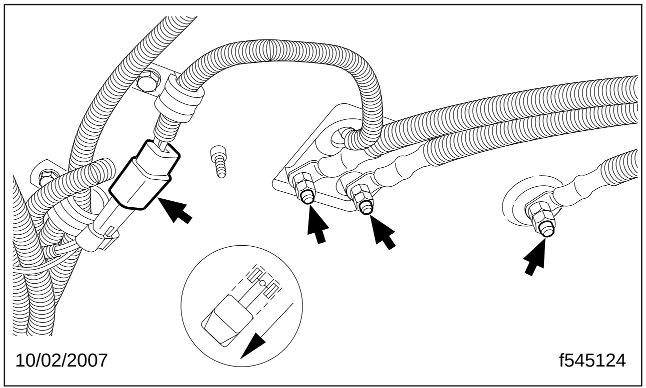
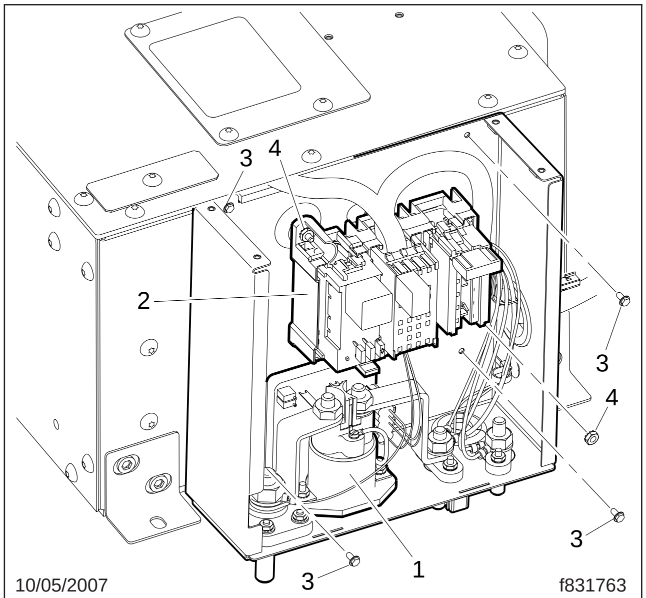


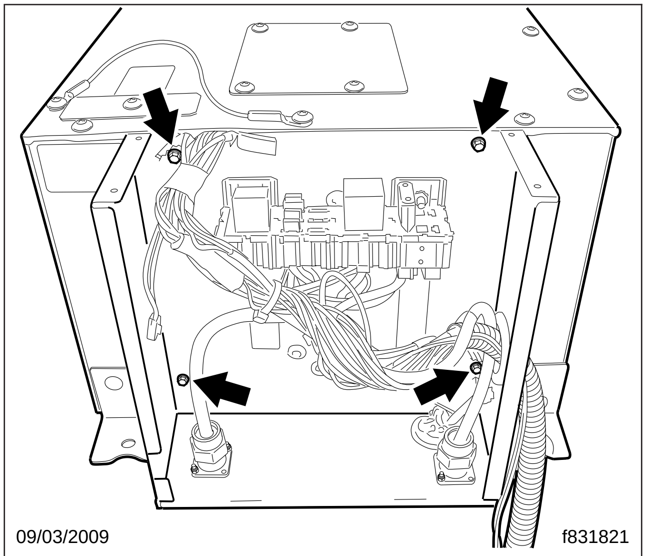
Fig. 4, Under Cab Wires (internal separator wiring shown)



1. Separator
2. Fuse Panel
3. Sheetmetal Screws, Electrical Box (4)
4. Fuse Panel Nuts

Fig. 5, Fuse Panel and Separator

9. Remove the control module fasteners, and remove the control module from the mounting plate. See **Fig. 8**.
10. Position the control module on the mounting panel, and install the fasteners.
11. Position the mounting panel in the unit housing, and install the fasteners from the outside.
12. Position the electrical box, and install the screws.



Remove these screws.

Fig. 6, Electrical Box, Frame-Rail Mounted Separator

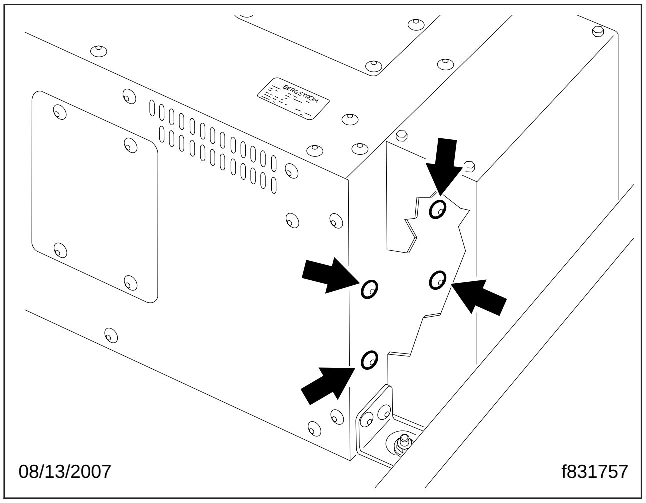


Fig. 7, Control Module Mounting-Plate Fasteners

13. Connect the wires to the bottom of the electrical box, under the sleeper.
14. Connect the three wiring connectors to the control module.
15. Connect the batteries.
16. Install the top panel and electrical box cover.
17. Lower the bunk.

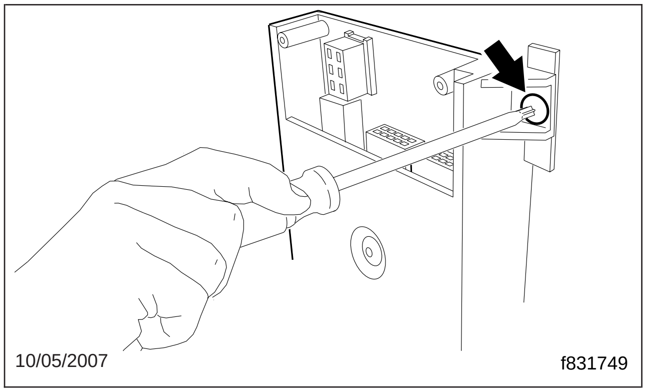
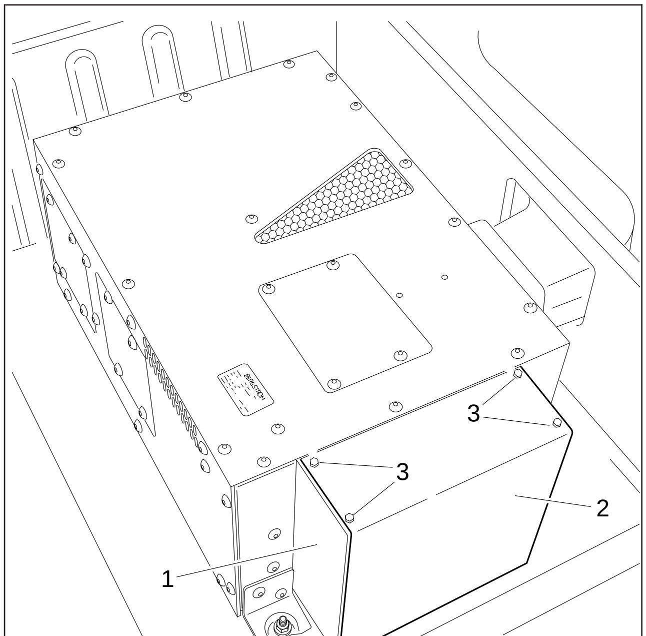


Fig. 8, Control Module Fastener

Electrical Box Mounted Interconnect Controller Replacement

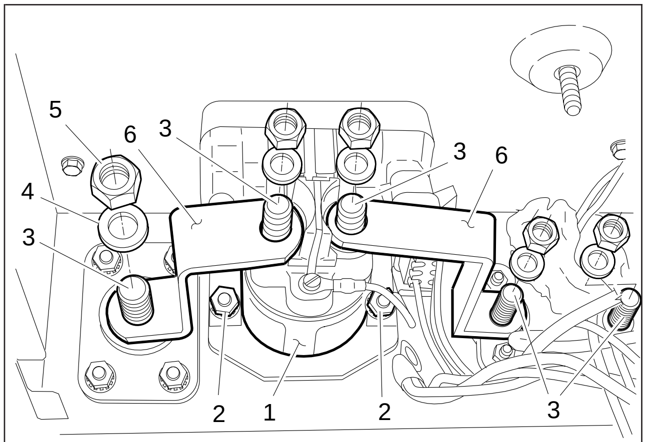
1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires. Disconnect both sets of vehicle batteries.
2. Raise and secure the lower bunk.
3. Remove the electrical box cover. See **Fig. 1**.



1. Electrical Box
2. Electrical Box Cover
3. Cover Fasteners

Fig. 1, Electrical Box Cover

4. Remove the nuts and washers from the terminals, and remove the two copper buss bars. See **Fig. 2**.
5. Remove the separator mounting nuts, and remove the separator.
6. Position the new separator, and install the mounting nuts.
7. Position the buss bars and install the mounting nuts and washers.



1. Separator
2. Separator Mounting Nut
3. Terminal
4. Washer
5. Terminal Nut
6. Copper Buss Bars

Fig. 2, Separator Installation

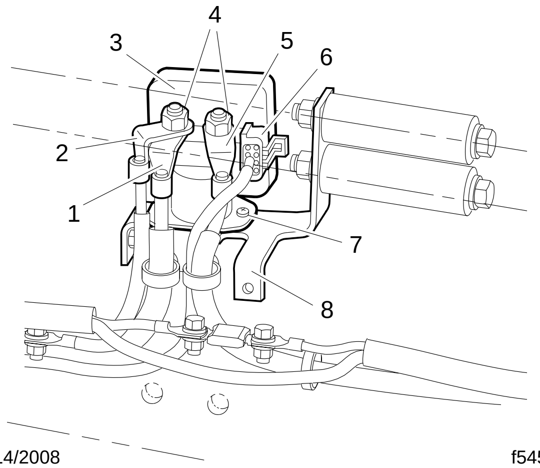
8. Connect the batteries.
9. Install the electrical box cover.
10. Lower the bunk.

Crossmember Mounted Interconnect Controller Replacement

The battery interconnect controller is located on the left-hand side of one of the crossmembers under the back of the cab. See **Fig. 3**.

1. Apply the parking brakes, and chock the tires.
2. Disconnect the vehicle batteries.
3. Disconnect the parked HVAC batteries.
4. Remove the cover from the interconnect controller.
5. Unplug the controller-to-PHVAC unit harness.
6. Remove the nuts and washers, and disconnect the battery cables and controller-to-battery harness from the controller posts.
7. Remove the mounting fasteners and remove the controller.

Separator Replacement



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1. Cable, Controller-to-PHVAC Unit
2. Harness, Controller-to-Battery
3. Interconnect Controller
4. Controller Posts and Nuts
5. Cable, Battery-to-Controller
6. Harness, Controller-to-PHVAC Unit
7. Fasteners
8. Bracket

Fig. 3, Interconnect Controller Installation (typical)

8. Position the new controller and install the mounting fasteners. Tighten 4 to 5 lbf·in (6 to 7 N·cm).
9. Connect the battery cables and controller-to-battery harness to the controller posts, and install the nuts and washers. Tighten 112 lbf·in (1270 N·cm).
10. Connect the controller-to-PHVAC unit harness.
11. Install the controller cover.
12. Connect both sets of batteries.

Operational Checks

Table 1 explains how to check the main components of the system for proper operation.

Operational Checks		
Component	**Function**	**Operational Check**
Evaporator Blower	Draws cab air through the evaporator coils and blows it through the ducting back to the cab. The system is 100% recirculation. There are two air intakes; one on the unit, and one on the front lower panel of the bunk.	Switch the NITE control to position 1; you must feel air coming out of the duct louvers. Then switch the NITE control to position 2; you must feel an increase of the airflow coming out of the duct louvers. NOTE: Make sure nothing blocks the air intake opening (recirculation) on the NITE unit or the bunk.
Condenser Fan	Takes ambient outside air from under the sleeper floor and blows it through the condenser coil to cool it, then exhausts it through the floor outside the vehicle.	With the unit running, go under the sleeper and check that air is flowing into the unit at the intake, and out of the condenser air outlet.
Compressor	Compresses the refrigerant and moves it through the system.	With the compressor running at LOW speed, listen or feel the compressor speed by its sound and vibration. Wait 1 minute. Then set the control to HIGH speed: you must notice a change in the sound and/or vibration of the unit when the compressor speed changes.

Table 1, Operational Checks

Unit Electrical Power Checking

1. Check the NITE unit voltage.
   1.1 Locate the power supply cables (red and black cables) close to the unit.
   1.2 Check the voltage.
   When the NITE batteries are fully charged, and when the control position is on HIGH, you must read between 12 and 12.5 volts.
2. Check the NITE unit current.
   2.1 Switch the NITE unit control to the HIGH position.
   2.2 Using a clamp-on inductive ammeter, measure the current on the NITE unit power supply (red) cable. You must read between 27 and 35 Amps.

Air Temperature at the Louvers

Check the louvers temperature: when the NITE unit control is on HIGH position, when the sleeper temperature is between 75 and 80°F (24 and 27°C), and when the outside temperature is between 90 and 95°F (195 and 205°C), measure the temperature directly at one of the duct louvers. You must read between 55 and 62°F (13 and 17°C).

Condenser Outlet Temperature

As described earlier in this document the NITE unit pulls air from outside, under the sleeper floor, to cool down the condenser coil, then the air is rejected to the outside from the sleeper floor too. When the NITE unit is running in HIGH position, go under the sleeper and locate the condenser air outlet (rectangle opening with a screen). The temperature at the condenser outlet must be 10 to 20°F (6 to 12°C) higher than the outside temperature.

Temperature/Amperage Testing

1. Set mode to A/C only.
2. Set the temperature setting to max cold.
3. Place your hand on the sensor so it detects high temperature.

Troubleshooting

4. Open the vehicle doors and allow the ambient temperature to stabilize on the condenser and unit.
5. Let the unit run about 10 minutes before measuring the temperature and current.

   Table 2 shows temperature and amperage parameters for testing the system.

Separator Electrical Checking, Engine OFF

1. Check for loose electrical connections.
2. Check that the installation is wired according to the electrical diagram. See **Specifications, 400** for wiring diagrams.
3. Check that the 16 gauge ground wire is connected to the bottom blade terminal of the separator on one end, and to a good ground on the other end.
4. Check that the batteries are properly connected.
5. Make sure the battery ground cable is connected to a good ground.
6. Make sure the NITE unit power cables are connected to the correct terminals of the NITE batteries. The red cable goes to the positive terminal; the black cable goes to the ground.
7. Check that the voltage on the vehicle batteries is the same as the voltage at the separator (main batteries side). When checking the voltage on the separator, use the ground terminal on the separator. Both voltage readings should be the same.
8. Check that the voltage on the NITE batteries is the same as the voltage on the separator ("AUX" batteries side). When you check the voltage at the separator, use the ground terminal on the separator. Both voltage readings should be the same (approximately 12 volts).

Separator Electrical Checking, Engine Running

The separator controls the charging of the batteries as follows.

- When the engine is running, the alternator charges the vehicle batteries only, until the vehicle battery voltage reaches 13.2 volts. During this period, the separator is open and the NITE batteries are not being charged.
- When the vehicle batteries reach 13.2 volts, the separator closes, allowing the NITE batteries to charge.

1. With the engine running, check the voltage of the vehicle batteries. It should be higher than the voltage when the engine is OFF, more than 13 volts.
2. Check that the separator is operating properly. When the vehicle battery voltage reaches 13.2 volts, the separator closes, and the system starts charging the NITE batteries. There is an audible "click" when the separator closes.
3. With the engine running, check the voltage of the NITE batteries. It should be higher than the voltage when the engine is OFF, and approximately the same as the vehicle batteries.
4. Verify that the separator is allowing the NITE batteries to charge. Using a clamp-on-type inductive ammeter, on the cable that connects the separator to the NITE batteries positive terminal, measure the amps going to the NITE batteries. It should read more than 0 amps.

Temperature and Amperage Parameters		
Ambient Temperature: °F (°C)	**Louver Temperature: °F (°C)**	**Amps**
65 (18)	47–53 (8–12)	21–27
66 (19)	48–54 (9–12)	21–27
67 (19)	49–55 (9–13)	22–28
68 (20)	50–56 (10–13)	22–28
69 (21)	51–57 (11–14)	23–29
70 (21)	52–58 (11–14)	23–29

Temperature and Amperage Parameters		
Ambient Temperature: °F (°C)	Louver Temperature: °F (°C)	Amps
71 (22)	54–60 (12–16)	24–30
72 (22)	55–61 (13–16)	24–30
73 (23)	56–62 (13–17)	25–31
74 (23)	57–63 (14–17)	25–31
75 (24)	58–64 (14–18)	26–32
76 (24)	59–65 (15–18)	26–32
77 (25)	60–66 (16–19)	27–33
78 (26)	60–66 (16–19)	27–33
79 (26)	61–67 (16–19)	27–33
80 (27)	62–68 (17–20)	28–34
81 (27)	63–69 (17–21)	28–34
82 (28)	64–70 (18–21)	29–35
83 (28)	65–71 (18–22)	29–35
84 (29)	66–72 (19–22)	30–36
85 (29)	67–73 (19–23)	30–36
86 (30)	68–74 (20–23)	30–36
87 (31)	69–75 (21–24)	31–37
88 (31)	69–75 (21–24)	31–37
89 (32)	70–76 (21–24)	32–38
90 (32)	71–77 (22–25)	32–38
91 (33)	72–78 (22–26)	32–38
92 (33)	73–79 (23–26)	33–39
93 (34)	73–79 (23–26)	33–39
94 (34)	74–80 (23–27)	33–39
95 (35)	75–81 (24–27)	34–40
96 (36)	76–82 (24–28)	34–40
97 (36)	77–83 (25–28)	35–41
98 (37)	77–83 (25–28)	35–41
99 (37)	78–84 (26–29)	35–41
100 (38)	79–85 (26–29)	36–42
101 (38)	80–86 (27–30)	36–42
102 (39)	80–86 (27–30)	36–42
103 (39)	81–87 (27–31)	37–43
104 (40)	82–88 (28–31)	37–43
105 (41)	82–88 (28–31)	37–43

Table 2, Temperature and Amperage Parameters

Specifications

Table 1 details technical specifications of the NITE system as installed on Columbia vehicles. Table 2 shows temperature and amperage parameters for testing the system.

Figure 1, Fig. 2, and Fig. 3 show the wiring diagram for the Parked HVAC system.

System Specifications		
A/C	Cooling Capacity	3100 BTU/hour
	Voltage	12 Volts DC
	System Power	400–450 Watts
	Dimensions	22 x 16 x 11 inch (560 x 406 x 280 mm)
Power	Capacity	440 amp hours
	Battery Life	2+ years
	Operation time	10–12 hours
	Recharge Time	4–6 hours
	Battery Count	4

Table 1, System Specifications

Temperature and Amperage Parameters		
Ambient Temperature: °F (°C)	**Louver Temperature: °F (°C)**	**Amps**
65 (18)	47–53 (8–12)	21–27
66 (19)	48–54 (9–12)	21–27
67 (19)	49–55 (9–13)	22–28
68 (20)	50–56 (10–13)	22–28
69 (21)	51–57 (11–14)	23–29
70 (21)	52–58 (11–14)	23–29
71 (22)	54–60 (12–16)	24–30
72 (22)	55–61 (13–16)	24–30
73 (23)	56–62 (13–17)	25–31
74 (23)	57–63 (14–17)	25–31
75 (24)	58–64 (14–18)	26–32
76 (24)	59–65 (15–18)	26–32
77 (25)	60–66 (16–19)	27–33
78 (26)	60–66 (16–19)	27–33
79 (26)	61–67 (16–19)	27–33
80 (27)	62–68 (17–20)	28–34
81 (27)	63–69 (17–21)	28–34
82 (28)	64–70 (18–21)	29–35
83 (28)	65–71 (18–22)	29–35
84 (29)	66–72 (19–22)	30–36

Specifications

Temperature and Amperage Parameters		
Ambient Temperature: °F (°C)	**Louver Temperature: °F (°C)**	**Amps**
85 (29)	67–73 (19–23)	30–36
86 (30)	68–74 (20–23)	30–36
87 (31)	69–75 (21–24)	31–37
88 (31)	69–75 (21–24)	31–37
89 (32)	70–76 (21–24)	32–38
90 (32)	71–77 (22–25)	32–38
91 (33)	72–78 (22–26)	32–38
92 (33)	73–79 (23–26)	33–39
93 (34)	73–79 (23–26)	33–39
94 (34)	74–80 (23–27)	33–39
95 (35)	75–81 (24–27)	34–40
96 (36)	76–82 (24–28)	34–40
97 (36)	77–83 (25–28)	35–41
98 (37)	77–83 (25–28)	35–41
99 (37)	78–84 (26–29)	35–41
100 (38)	79–85 (26–29)	36–42
101 (38)	80–86 (27–30)	36–42
102 (39)	80–86 (27–30)	36–42
103 (39)	81–87 (27–31)	37–43
104 (40)	82–88 (28–31)	37–43
105 (41)	82–88 (28–31)	37–43

Table 2, Temperature and Amperage Parameters

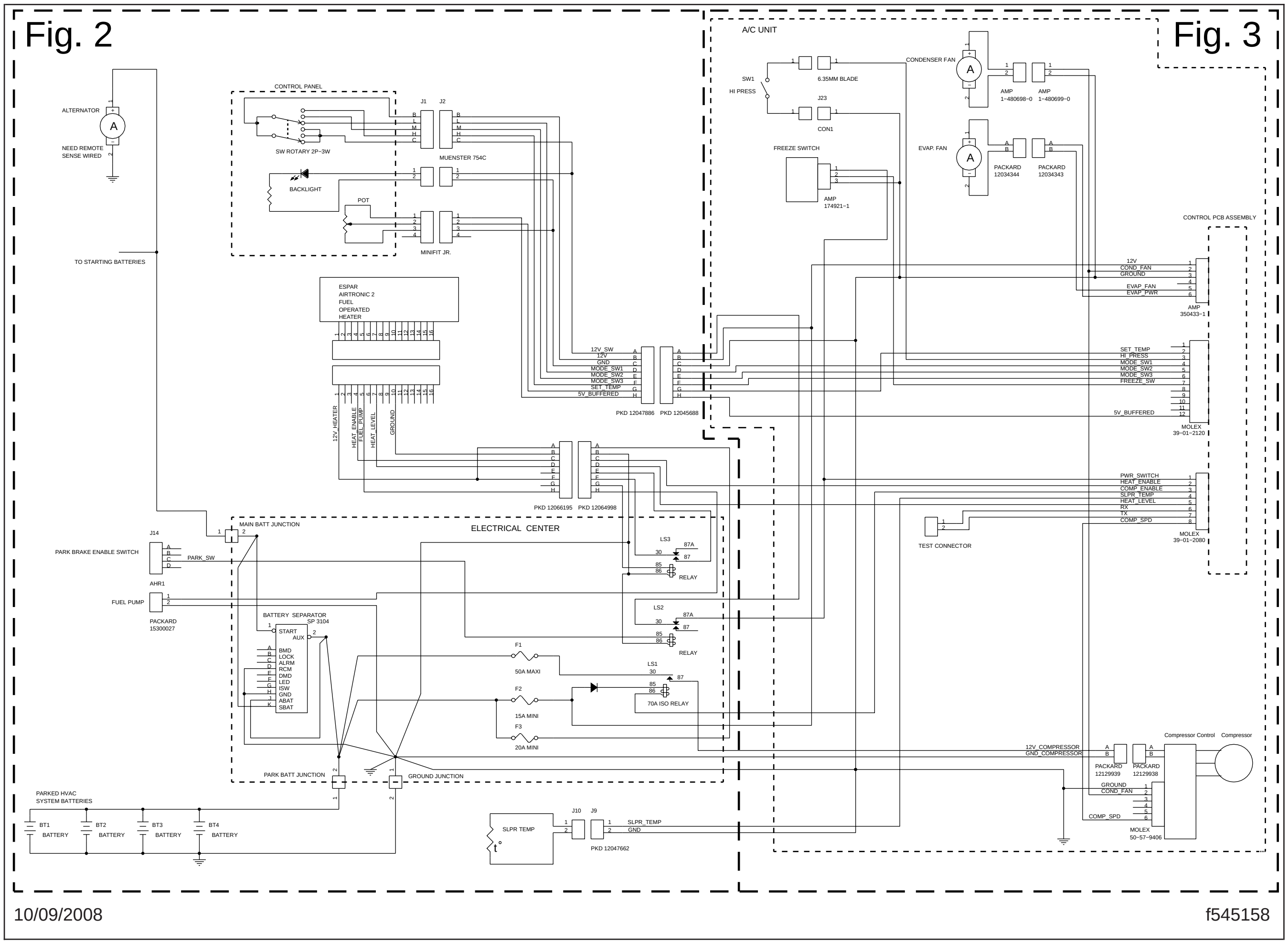


Fig. 1, Parked HVAC Wiring

Specifications

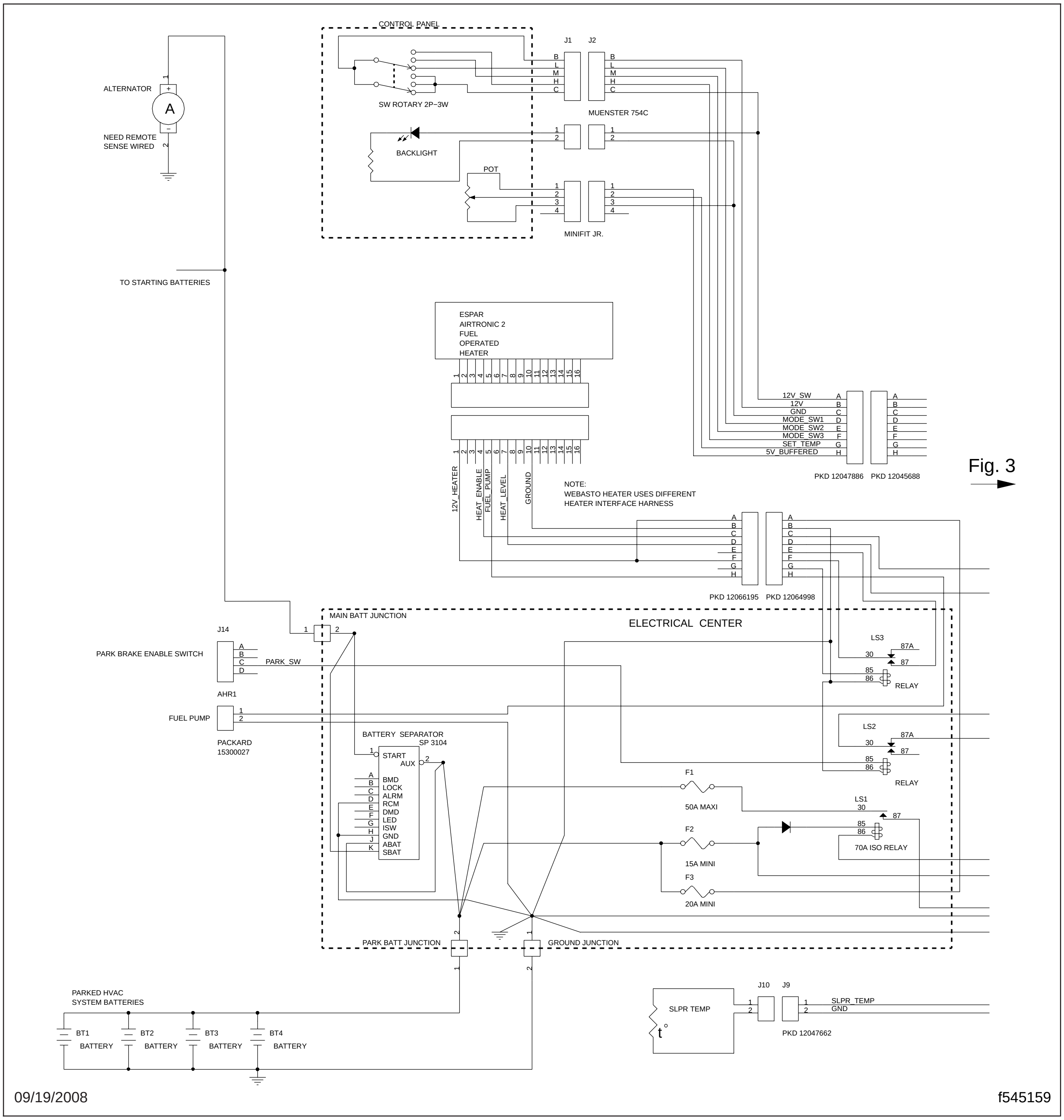


Fig. 2, Parked HVAC Wiring (expanded, part 1)

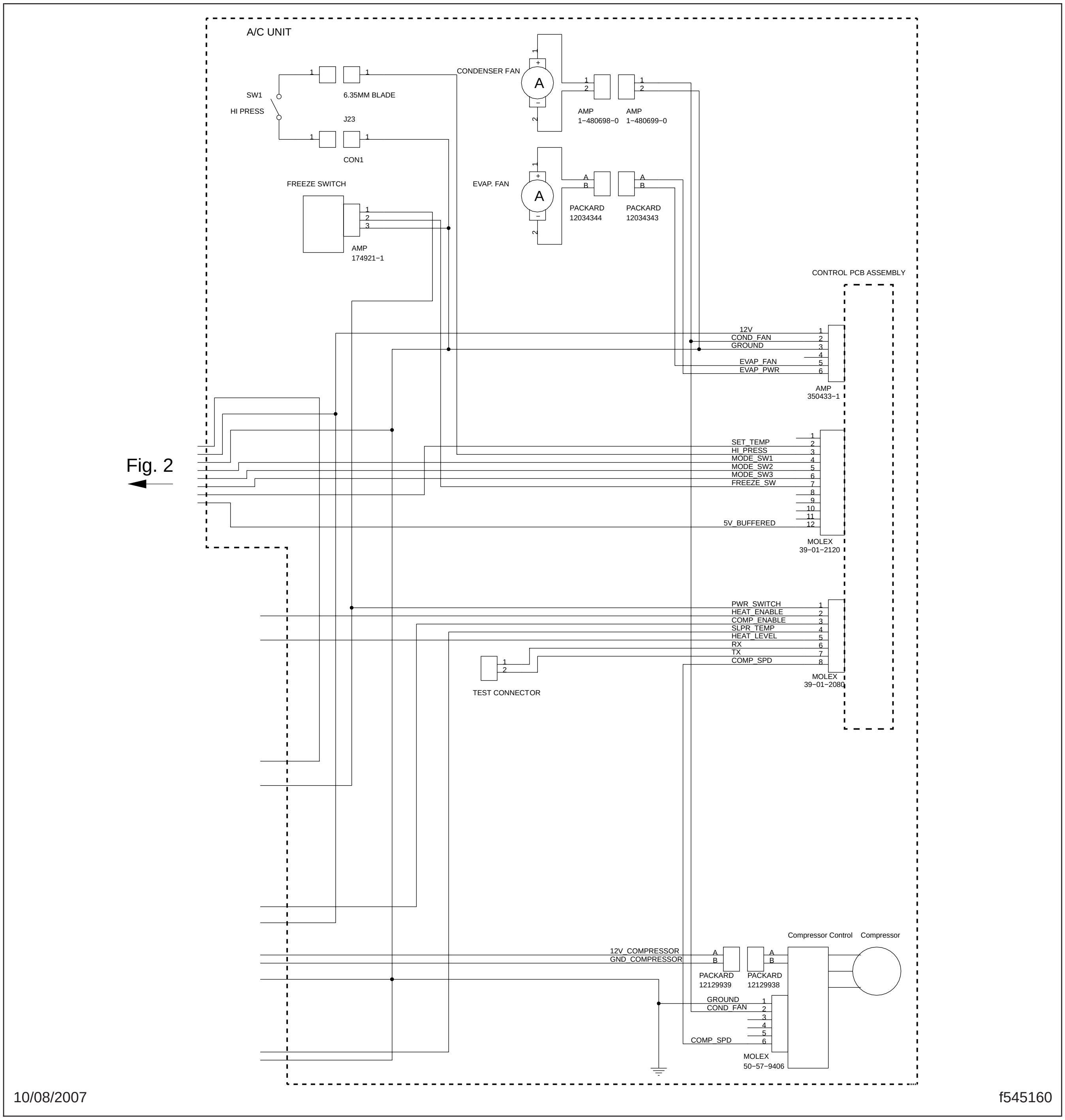


Fig. 3, Parked HVAC Wiring (expanded, part 2)

General Description

Columbia hoods are made of fiberglass by one of two processes; SMC or spray-up. The 120 hood is manufactured with the SMC process, and the 112 hood is manufactured with the spray-up process.

SMC Hoods

SMC, which stands for sheet molding compound, is a fiberglass and thermosetting polyester material. SMC hoods are easily recognized by their smooth inner surface. To make each part, SMC sheets are first placed between matching mold halves. Heat and pressure are applied to the mold in order to cure (solidify) the SMC resin. At the end of the process, an in-mold coating is injected onto the part to prepare it for priming and topcoating.

Spray-Up Hoods

Spray-up hoods are made using a "contact molding" technique. They are easily recognized by their rough inner surface. As illustrated in **Fig. 1**, contact molding is done with an open mold, or a female configuration, which controls external shape and finish.

A gel coating is first sprayed onto the mold. The gel coating eventually becomes the smooth outer surface of the hood. It provides impact and abrasion resistance to the laminate underneath. In addition, it readily accepts a coating of paint. A laminate of fiberglass reinforcement and resin is then built up by use of a special chopper/spray-gun which directs short glass fibers and catalyzed resin onto the mold (gel) surface. The glass fibers are rapidly "chopped" from a feeder roll of continuous strand roving, which consists of numerous, untwisted fiberglass strands wound into a cylindrical package.

The resin used in this process is air-inhibited. It will not completely cure when the laminate is exposed to the air. All portions not directly exposed to the air (including those portions of the laminate contacting the gel), dry instantly. As a result, no matter how many "passes" are made with the roving fiberglass chopper/spray-gun in a particular area, the final structure will have only one layer of fiberglass (distinct layers of fiberglass will not be present) when using this process.

Upon completion of this phase in the manufacture of a fiberglass hood (termed "spray-up"), major stress areas are reinforced by hand (termed "hand lay-up").

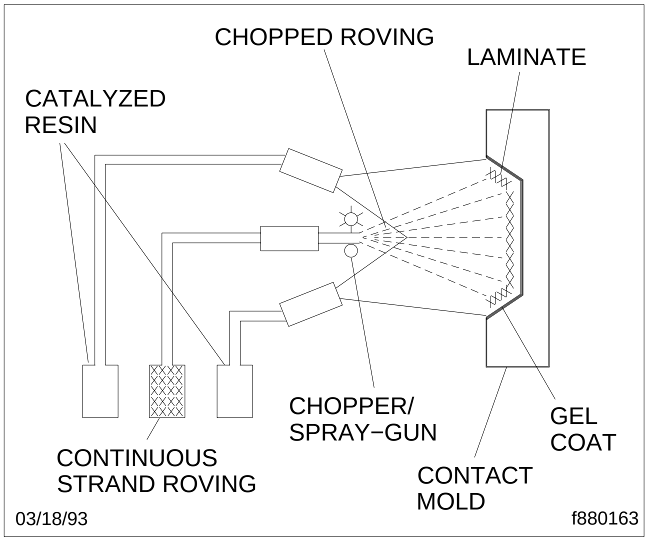


Fig. 1, Fiberglass Contact Molding Technique

During hand lay-up, fiberglass reinforcement in the form of woven roving (a heavy, drapable fabric) is manually built up, with air-inhibited resin added as needed.

Hood Mounting and Components

The hood assembly is mounted on two pivot brackets. The hood pivots work in conjunction with the tilt-assist and tilt-limiting mechanisms to allow a forward hood tilt adequate for vehicle service.

In the closed position, the rear of the hood is supported by hood mounting brackets, which are attached to the cab. The rear brackets hold the hood in the correct position for operation. The hood is held in place with latches; one on each side.

The hood hinge brackets are adjustable forward and backward. The rear hood mounting brackets are adjustable up and down.

Each hood assembly is equipped with a chrome-plated plastic grille. The grille is attached to the hood with four fasteners and double-sided tape. The hood is also equipped with a headlight assembly, which features a headlight and turn signal/parking light combination on each fender.

Hood Removal, Installation, and Adjustment

Removal

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.

WARNING

Do not attempt to lift the hood; it weighs about 150 lb (68 kg). Lifting the hood could result in personal injury or damage to the hood assembly and other components.

2. Remove the grille; see **Subject 110**.
3. Remove the bumper; see **Section 31.03**.
4. Place a support between the floor and the front of the hood. The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Place cardboard, carpet, rags, or other padding on top of the support to protect the hood.
5. Open the hood to the full-tilt position.
6. Disconnect the headlight bucket wiring connectors from both sides of the hood.
7. Remove the torsion bars; see **Subject 170**.
8. Move the hood to a less than full-tilt position to allow slackness in the tilt-limiting straps. Disconnect the straps by removing the fasteners attached to the inside surface of the hood; see **Fig. 1**.
9. Tilt the hood fully open, and rest it on the support.
10. Remove the cotter pins and washers from the clevis pins, then use a punch and hammer to tap the clevis pins from the hood hinge. For vehicles with engines manufactured through December 31, 2006, see **Fig. 2**. For vehicles with EPA07 compliant engines, see **Fig. 3**.
11. Carefully roll or slide the hood support away from the vehicle; do not try to lift the hood.

Installation

1. With the tires chocked, place the disconnected electrical wiring onto the front crossmember to avoid problems during installation.

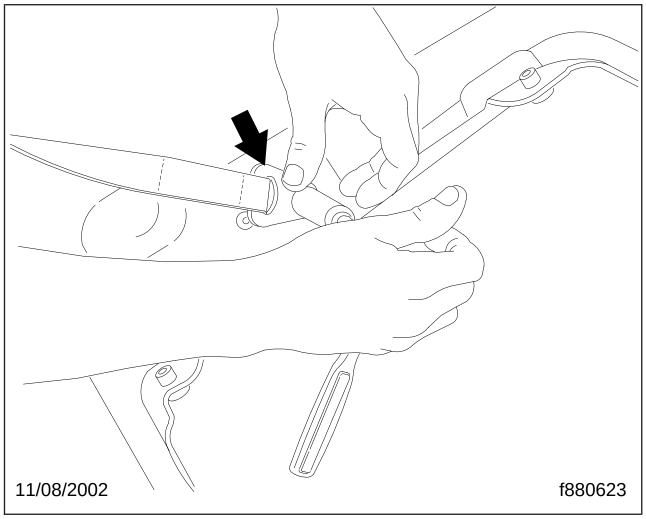


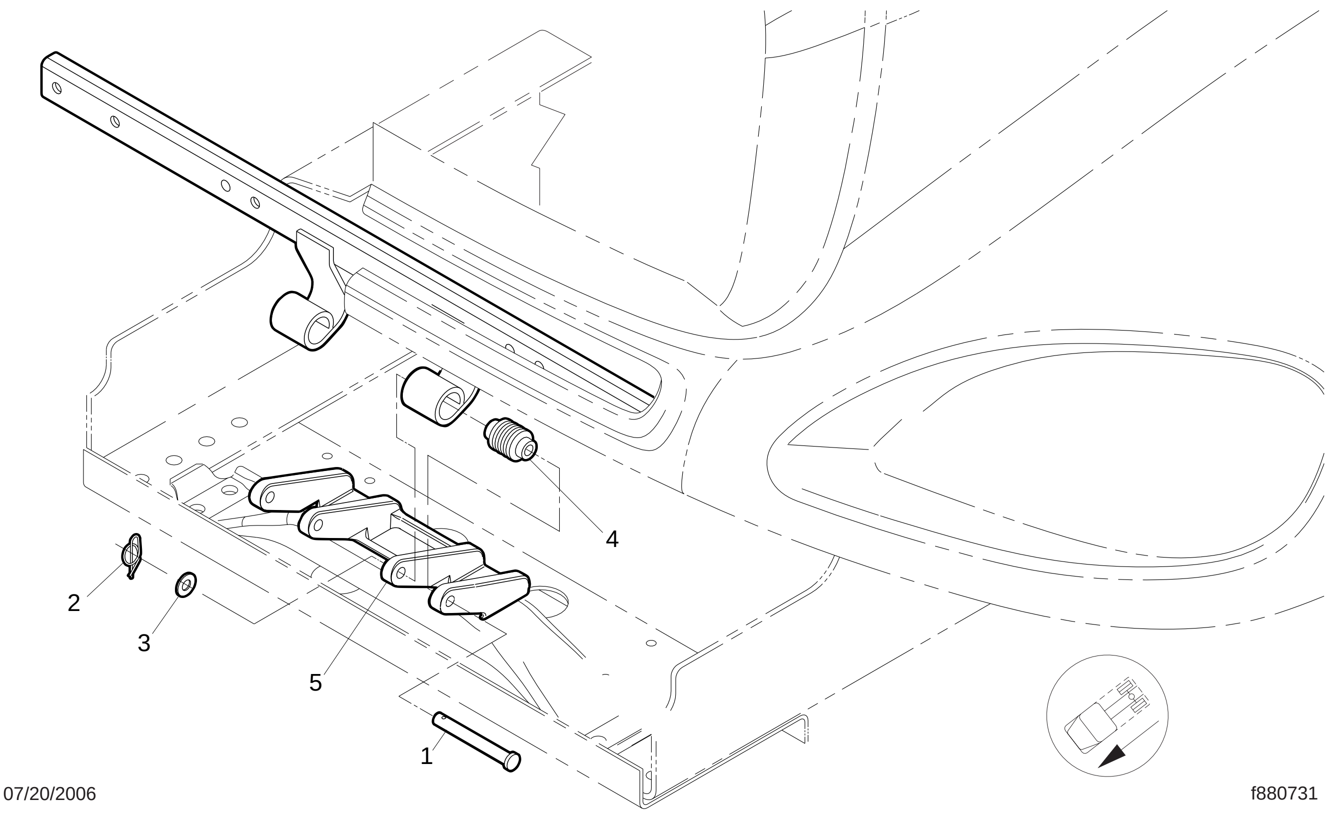
Fig. 1, Hood Tilt-Limiting Strap

WARNING

Do not attempt to lift the hood; it weighs about 150 lb (68 kg). Lifting the hood could result in personal injury or damage to the hood assembly and other components.

2. With the hood in the forward-tilt position and resting on the support at about the same height as the top of the bumper, move the support and hood into alignment with the front of the vehicle. Do not try to lift the hood.
3. Tap the clevis pins into place with a rubber hammer. Install the washers and new cotter pins. For vehicles with engines manufactured through December 31, 2006, see **Fig. 2**. For vehicles with EPA07 compliant engines, see **Fig. 3**.
4. Install the torsion bars; see **Subject 170**.
5. Lower the hood until it is balanced over the pivots, between the full-tilt and closed positions. Have an assistant hold the hood in this position.
6. Attach the two tilt-limiting straps to the inside surface of the hood; see **Fig. 1**.
7. Open the hood to the full-tilt position.
8. Connect the electrical connectors to the headlight bucket assemblies.
9. Install the bumper; see **Section 31.03**.
10. Close and latch the hood.
11. Install the grille; see **Subject 110**.

Hood Removal, Installation, and Adjustment



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1. Clevis Pin
2. Cotter Pin
3. Washer
4. Hood Hinge Bushing
5. Hood Hinge Bracket

Fig. 2, Hood Installation (vehicles with engines manufactured through December 31, 2006)

12. Remove the chocks.

Adjustment

NOTE: If the vehicle has had damage to the chassis, the frame must be straightened before adjusting the hood.

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
2. Determine whether hood adjustment is necessary by checking, with the hood in the operating position and the hood latches latched, the hood's alignment with the connecting seam that runs along each side of the hood. The connecting seam and the A-pillar to cowl seam should approximately match.
3. If the hood needs to be vertically adjusted, follow these steps:

   3.1 Open the hood to the full-tilt position.

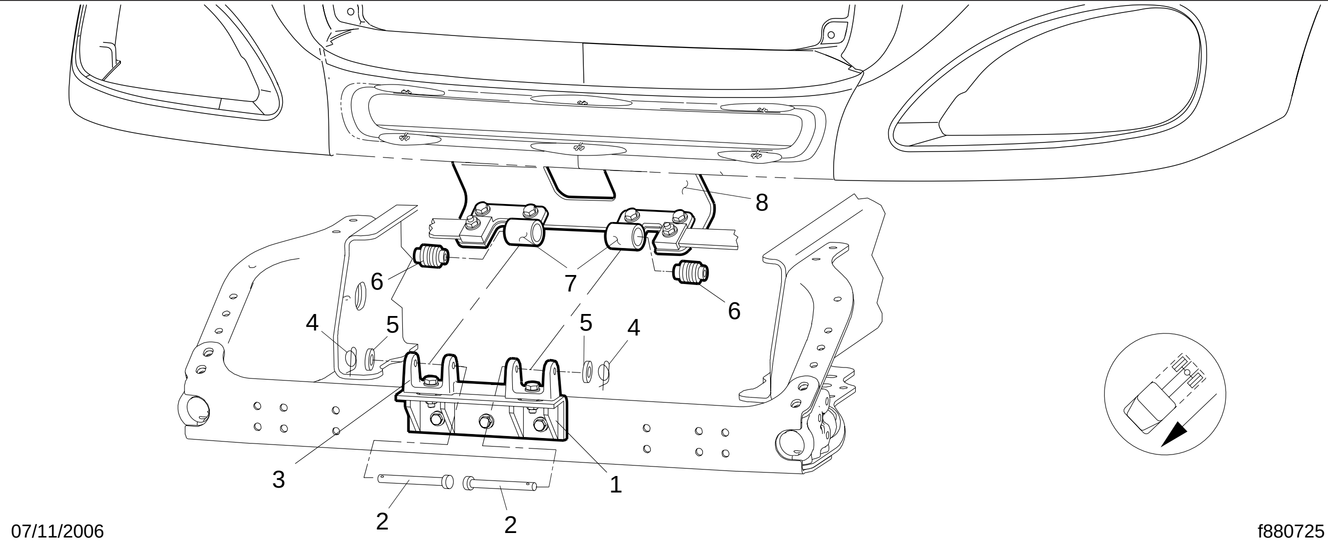
   3.2 Loosen the carriage bolts that secure the hood rear isolators to the vehicle. Move the isolator to its highest position.

   3.3 Close and latch the hood.

   3.4 Unlatch and open the hood to the full-tilt position.

   3.5 Tighten the carriage bolts on the isolators to 16 lbf·ft (22 N·m).

Hood Removal, Installation, and Adjustment



1. Support Bracket
2. Clevis Pin
3. Hood Hinge Bracket
4. Cotter Pin
5. Washer
6. Hood Hinge Bushing
7. Hood Hinges
8. Hood Hinge Plate

Fig. 3, Hood Installation (vehicles with EPA07 compliant engines)

3.6 Lower the hood and fasten the hood latches.

NOTE: The forward and aft adjustment of the hood should not be necessary as the hoods are manufactured to be adjustment-free. However, this adjustment can be performed by loosening the bolts that secure the hood hinge brackets to the front crossmember.

4. Remove the chocks.

Grille Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the rear tires.
2. From the front side of the grille, remove the fasteners that hold the grille to the hood. See **Fig. 1**.
3. Remove the grille from the hood and lift up on the top lip of the grille to loosen the double-sided tape on the underside.
4. If the grille is to be reinstalled remove the double-sided tape.

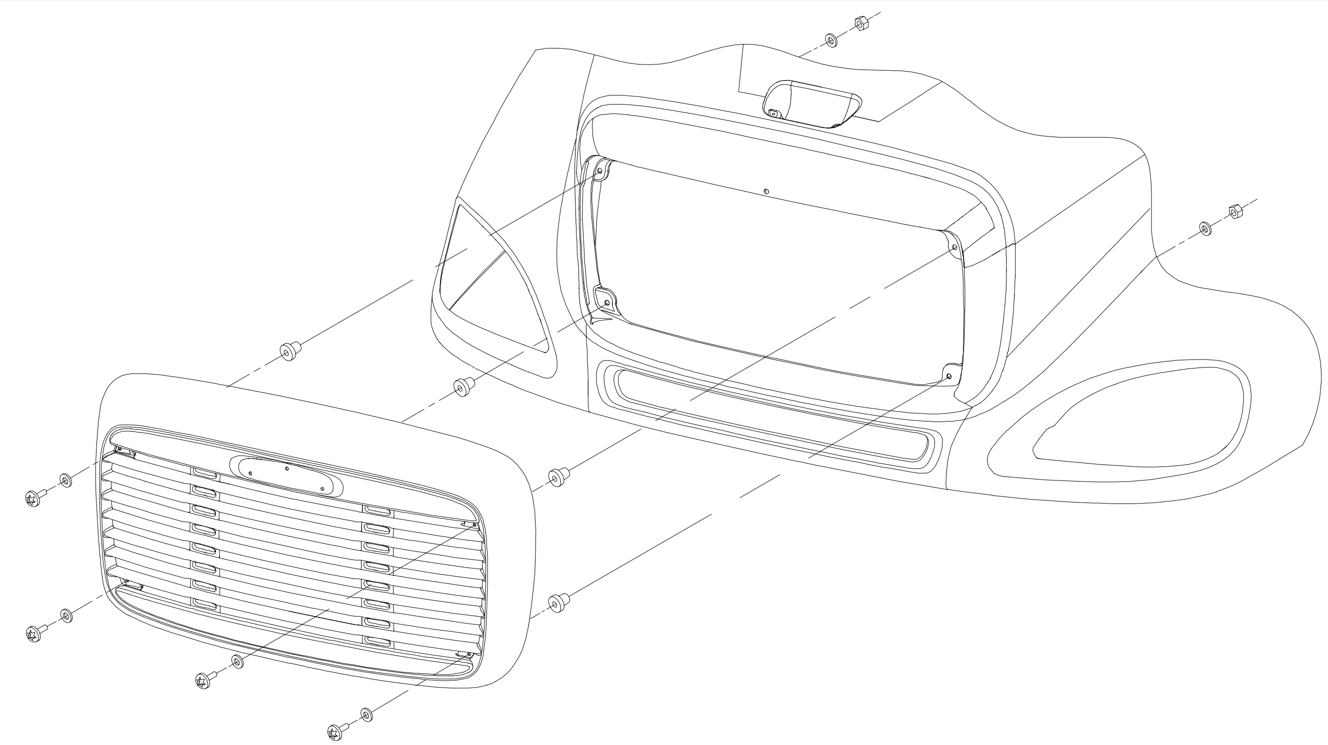


Fig. 1, Columbia Grille Mounting (112 Hood Grille Shown)

Installation

1. Clean and dry the hood surface area that is covered by the grille.
2. If a new grille is being installed, remove the backing from the adhesive strip on the underside of the new grille.
3. If the original grille is being reinstalled, clean and dry the underside surface of the grille and affix a piece of double-sided tape.
4. Place the grille in position on the hood with the grille fastener holes lined up with the holes on the hood.
5. Install the fasteners into the threaded isolators.
6. Install the washer and nut to the bottom left and upper right grille mounting stud.
7. Tighten the fasteners to 12 lbf·in (140 N·cm).
8. Apply firm pressure to the top of the grille over the adhesive strip to ensure good adhesion.

Columbia 112 Hood

Removal

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the rear tires.
2. Remove the grille from the hood. See **Subject 110**.
3. Remove the 7 rivets that fasten the lower grille screen to the grille opening reinforcement. See **Fig. 1**.
4. Remove the grille screen from the hood.

Installation

1. Install the rivet in the center hole of the hood and the center hole of the lower grille screen for alignment.
2. Install the remaining rivets.
3. Close the hood.
4. Install the grille. See **Subject 110**.

Columbia 120 Hood

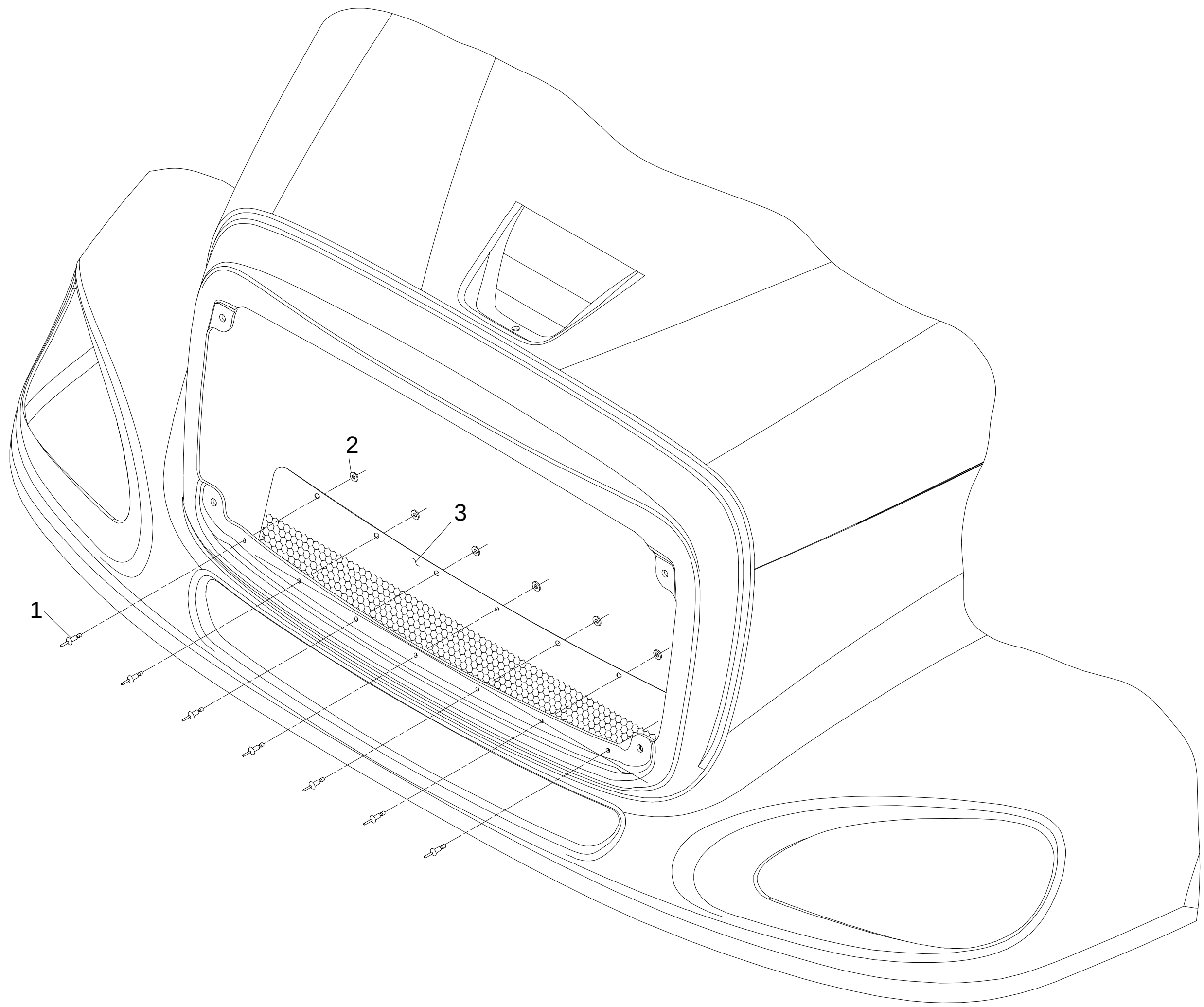
Removal

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the rear tires.
2. Open the hood.
3. Remove the 6 clips that fasten the lower screen. See **Fig. 2**.
4. Remove the lower grille screen.

Installation

1. Install the grille screen.
2. Install the clips with the tabs facing upwards.
3. Close the hood.

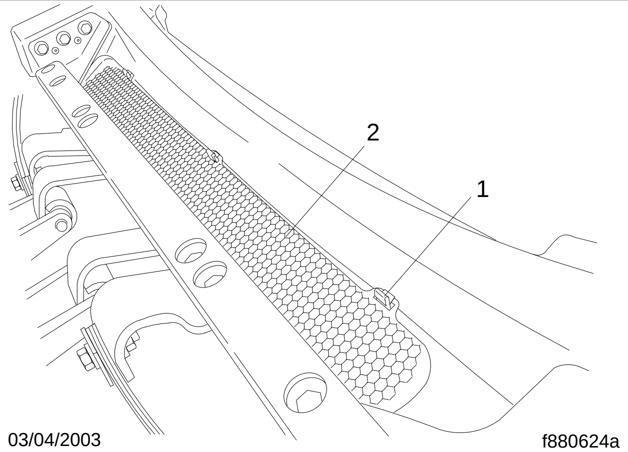
Lower Grille Screen Removal and Installation



1. Rivet
2. Washer
3. Grille Screen

Fig. 1, Lower Grille Screen Installation, Columbia 112 Hood

Lower Grille Screen Removal and Installation



1. Clip
2. Lower Grille Screen

Fig. 2, Lower Grille Screen Installation, Columbia 120 Hood

Hood Repair Safety Precautions

Precautions

Before performing any fiberglass repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing fiberglass are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of fiberglass dust, or adhesive contacting your eyes.
2. Adhesive can be a skin irritant. Do not allow adhesive to contact skin. Wear protective gloves made from the following recommended materials: butyl rubber, nitrile rubber, polyvinyl alcohol.

IMPORTANT: If adhesive contacts skin, wash with soap and water. If adhesive contacts eyes, rinse with plenty of water (15 minutes), and call a doctor.

3. Perform repairs in a well ventilated area. If ventilation is not adequate wear appropriate respiratory protection.
4. Most of the materials involved in fiberglass repair and cleanup are flammable; some are also toxic. Do not perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material. Store adhesives in a cool, dry, well ventilated area that is out of direct sunlight.
5. Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred for frequent use.

NOTE: Do not store adhesive syringes on their sides. Storing the syringes in the upright or upside down position allows any air that enters the syringe to accumulate at either end, instead of throughout the syringe.

General Information

The Columbia 120 (SMC) hoods, and Columbia 112 (spray-up) hoods, consist of several parts which are bonded together with a structural adhesive and rivets. See **Fig. 1** and **Fig. 2**.

If a joint between two parts has separated and there is no damage at the joint area, the parts can be rebonded. Or, if a part is damaged and its adjoining parts are not damaged, the damaged part can be separated from the hood and new or used parts can be bonded in place. A section of a part can be replaced as long as the section does not include a joint between two parts. Fenders and headlight reinforcements are available as replacement parts or for use in section replacements. If the damage is such that the parts cannot be replaced, or a section replacement cannot be done, replace the entire hood assembly.

For minor surface cracks (cracks that do not go through the laminate), see *Surface Damage Repair*.

For cracks that go through the laminate, or for large damaged areas, see *Structural Damage Repair*.

For section replacement, or to rebond parts, see *Hood Component Rebonding*.

Before performing any fiberglass repairs, read the precautions listed in **Subject 130**. Observe any additional precautions given by the manufacturers of the repair materials used.

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks on the outer surface of the hood. Use the following instructions to repair surface damage:

1. Inspect the damaged area. If the cracks go all the way through the hood, see *Structural Damage Repair* for instructions.
2. Clean the area with 3M™ General Purpose Adhesive Cleaner. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint around the damaged area to a distance of about 1-1/2 inches (4 cm).
4. Clean the area with dry compressed shop air.
5. Apply 3M Automix™ 08275 adhesive, spreading a thin layer with a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of adhesive, slightly higher than the painted surface.

NOTE: When dispensing 3M Automix two-part adhesives, the first few inches to come from the cartridge will be discolored; discard this adhesive. Apply the adhesive when a continuous bead of uniform size and color is produced.

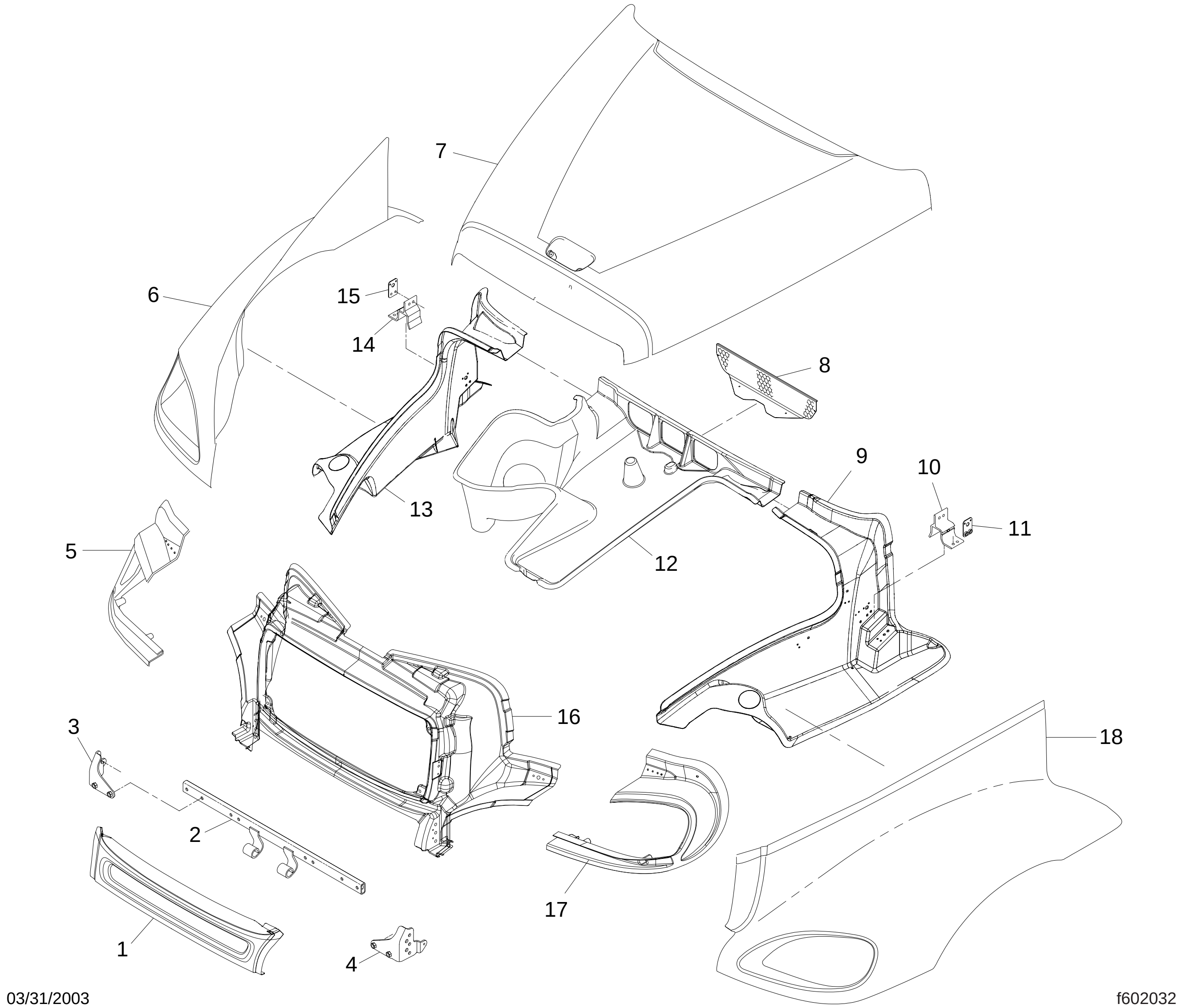
6. After the adhesive dries (about 35 minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with dry compressed shop air. Mask the area, then spot prime and paint it. Primer can be applied immediately after sanding. See **Group 98** for spot-painting instructions.

Structural Damage Repair

Structural damage refers to any type of damage, from hairline cracks to large fractures or punctures, that penetrate through the laminate and affect the structural soundness of the damaged part. For large damaged areas it may be easier to replace the panel. In such cases see *Hood Component Rebonding*.

1. If a sound absorbent liner is present on the underside of the damaged area, remove the panel(s) to provide an adequate working area.
2. Clean both sides of the damaged area with 3M General Purpose Adhesive Cleaner. Inspect the area closely; all dirt, water, grease, and oils must be removed.
3. Inspect the area to determine the extent of the damage by pushing on the surfaces immediately surrounding and underneath the damaged area. All ragged edges, cracks, and unsound fragments will need to be removed. Using a marking pen mark a circle on both sides of the hood, 3 to 4 inches (8 to 10 cm) around the damaged area.
4. Using a grinder on both sides of the hood, grind through the hood at the point of damage, and taper out to the marked circle. In some cases it will be necessary to greatly enlarge the hole in order to grind back to sound material; see **Fig. 3**.
5. Using dry compressed shop air, blow off the area and inspect for any remaining cracks. If cracks still exist, grind the area tapering out towards sound material.

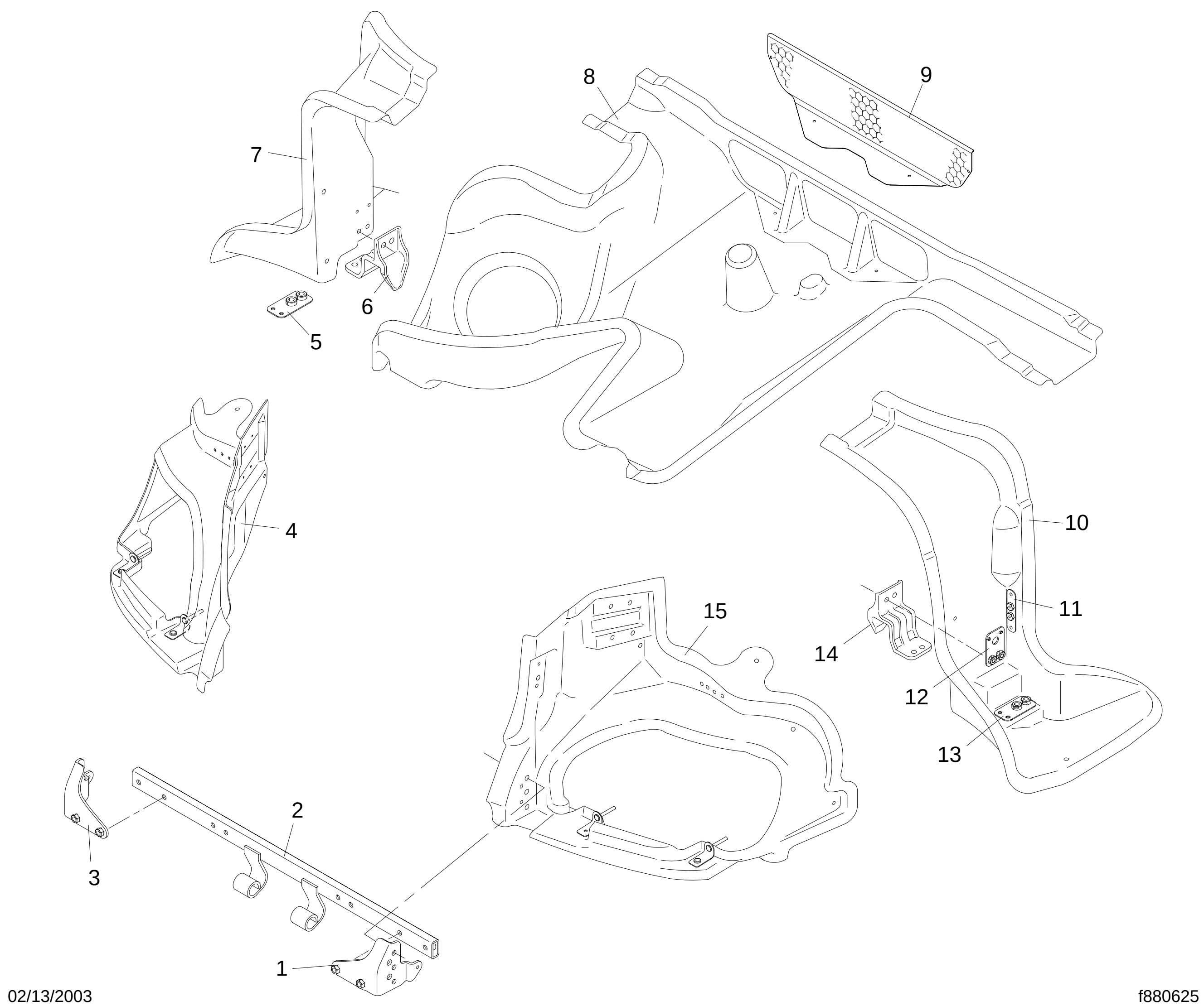
Hood Repair



1. Front Lower Panel
2. X-Bar Assembly
3. End Tie Bracket, RH
4. End Tie Bracket, LH
5. Headlamp Reinforcing, RH
6. Side Panel, RH
7. Top Panel
8. Hood Screen, Center Plenum
9. Reinforcing Side, LH
10. Locator, Hood Rear, LH
11. Backing Plate, LH
12. Center Plenum Reinforcing
13. Side Reinforcing, RH
14. Locator, Hood Rear, RH
15. Backing Plate, RH
16. Grille Opening Reinforcing
17. Headlight Reinforcing, LH
18. Side Panel, LH

Fig. 1, Columbia 120 (SMC) Hood Assembly Components

6. Sand the surface of the tapered area around the hole, using a DA sander with 80-grit or less sandpaper, to even out the tapers and leave a rough bonding surface.
7. Clean the sanded areas using dry compressed shop air, then wipe the area with a clean cloth.
8. For the underside of the hood, cut a series of patches out of fiberglass matting. The first patch

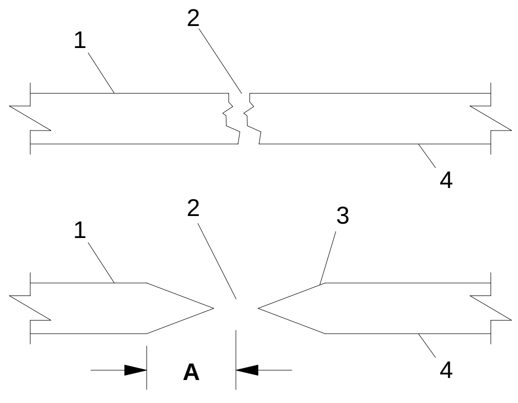


1. End Tie Bracket Assembly, Left Hand
2. X-Bar Assembly
3. End Tie Bracket Assembly, Right Hand
4. Grille Opening Reinforcing, Right Hand
5. Lower Backing Plate, Rear Hood Locator
6. Hood Rear Locator
7. Hood Rear Side Reinforcing, Right Hand
8. Plenum Center Reinforcing
9. Hood Screen, Center Plenum
10. Hood Rear Side Reinforcing, Left Hand
11. Backing Plate, Latch
12. Upper Backing Plate, Hood Rear Locator
13. Lower Backing Plate, Hood Rear Locator
14. Hood Rear Locator
15. Grille Opening Reinforcing, Left Hand

Fig. 2, Columbia 112 (Spray-Up) Hood Assembly Components

should be about 2 inches (5 cm) larger than the hole, but still able to fit in the sanded area. Cut additional sections from the matting, cutting each section progressively smaller.

Hood Repair



A. Grind a recess one-half the depth of the laminate and extending 3 to 4 inches (8 to 10 cm) outward in all directions from the damaged area.

1. Laminate
2. Crack
3. Taper
4. Engine Side of Hood

Fig. 3, Tapered Hole

9. On the outside of the hood, tape over the damaged area using aluminum panel repair tape.
10. Apply 3M Automix 08277 to the underside of the area to be repaired.

NOTE: When dispensing 3M Automix 08277, the first few inches to come from the cartridge will be discolored. Discard this adhesive. Apply the adhesive when a continuous bead of uniform size and color is produced.

11. Using a plastic squeegee applicator, spread a thin layer of 3M Automix 08277 adhesive over the damaged area.
12. Lay the largest piece of fiberglass matting on a piece of clean cardboard, and work a generous amount of 3M Automix 08277 into the matting.
13. On the underside of the hood, center the adhesive-permeated matting over the repair area, apply it, and work out any air bubbles.
14. Apply adhesive to the next smaller section of fiberglass matting, using the same technique as with the larger piece.
15. Apply the next smaller section of fiberglass matting to the larger piece, again working out any air bubbles.
16. Add a final thin layer of adhesive to the embedded sections of matting until the damaged area is even with the surrounding surfaces. The adhesive should be hard enough in 50 minutes to allow sanding.
17. Remove the tape backing from the outside surface.
18. Wipe the outside surface of the repair area with 3M General Purpose Adhesive Cleaner.
19. Using a DA sander with 80-grit sandpaper, sand the adhesive on the outside of the hood.
20. Clean the sanded area using dry compressed air, and wipe with a clean cloth.
21. Add a generous amount of 3M Automix 08275 over the entire repair area, building it up slightly above the level of the hood panel surface.
22. Allow the hood to dry for 30 minutes before sanding.
23. After the adhesive dries, sand the repaired area to a smooth flat surface. Prime and paint the surfaces on both sides of the hood.

NOTE: Open time is affected by temperature only. The open time is cut in half for every 20°F over 72°F (11°C over 22°C). The time doubles for every 20°F below 72°F (11°C below 22°C). The adhesive is not recommended for use when the temperature is less than 62°F (16°C).

Hood Component Rebonding

1. If rebonding a joint that has separated, or if replacing a damaged part, completely separate each part, using a heat gun and putty knife. Remove all of the old adhesive. The heat gun will soften the adhesive and allow it to be peeled from the fiberglass.

CAUTION

To release the adhesive, the bond area should be heated to 260°F (126°C). Heating the area above this temperature will damage the fiberglass panel.

2. Clean the surfaces to be bonded with 3M General Purpose Adhesive Cleaner. Inspect the area closely to be sure all of the old adhesive, dirt, water, grease, and oils are removed.

3. Scuff the surfaces with 80 to 220-grit sandpaper.
4. Before applying adhesive, test fit the parts by clamping the replacement part in position. Remove the replacement part for application of the adhesive.
5. Select a 3M Automix adhesive based on the desired working time, and apply the adhesive to the areas to be bonded. See **Table 1** for open times.

NOTE: When dispensing 3M Automix two-part adhesives, the first few inches to come from the cartridge will be discolored; discard this adhesive. Apply the adhesive when a continuous bead of uniform size and color is produced.

6. Clamp the parts together and remove any excessive adhesive that squeezes out.

NOTE: When clamping parts together there should be a gap between the parts for the adhesive to bond properly. The spacing of the gap should be about the thickness of a paper clip. If necessary, cut a paper clip in half and place the paper clip sections at two (or more, if needed) places along the bond seam to act as spacers.

7. Let the adhesive dry for 5 times the specified open time before removing the clamps. For example, if using 3M Automix 08277 adhesive: 10 minutes open time X 5 = 50 minutes clamping time.

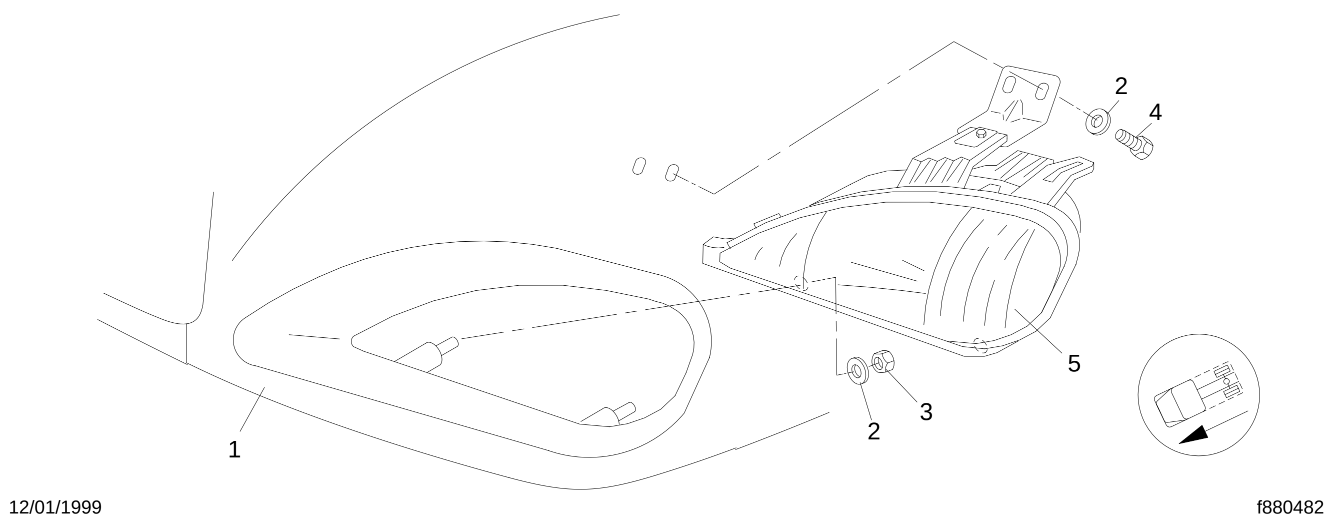
3M Adhesives Open Time			
3M Part Number	**Syringe Size**	**Open Time**	**Use**
08270	400 ml	1.5 min.	Minor crack repair and small part replacement
08271	400 ml	3.5 min.	Inner hood structure replacement
08267	600 ml	3.5 min.	Inner hood structure replacement
08277	400 ml	10.0 min.	Inside crack repair (self leveling)
08272	400 ml	10.0 min.	Fender replacement
08268	600 ml	10.0 min.	Fender replacement
08273	400 ml	35.0 min.	Large part replacement
08269	600 ml	35.0 min.	Large part replacement
08275	400 ml	10.0 min.	Permanent adhesive (not for removable sections)

Table 1, 3M Adhesives Open Time

Headlight Assembly Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes and chock the rear tires.
2. Open the hood.
3. Disconnect the headlight wiring connectors from the hood.
4. Remove the screws and nuts that attach the headlight assembly to the hood. See **Fig. 1**.



1. Headlight Assembly
2. Washer
3. Nut
4. Capscrew
5. Headlight

Fig. 1, Headlight Assembly Installation

5. Remove the headlight assembly from the hood.

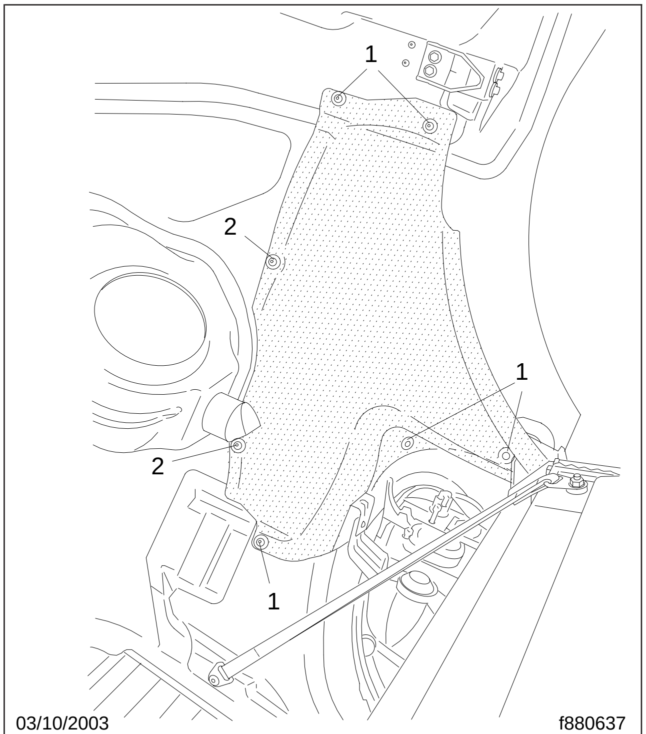
Installation

1. Install the headlight assembly on the hood.
2. Tighten the screws and nuts to 7 lbf·ft (10 N·m).
3. Connect the headlight wiring connectors.
4. Return the hood to the operating position.

Inner Fender Removal and Installation, 112 Hood

Removal

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the rear tires. Tilt the hood open.
2. Remove the 5 hexbolts, 2 nuts (from the studs on the hood), and washers that fasten the inner fender to the hood reinforcement. See **Fig. 1**.
3. Remove the fender.



1. Hexbolt
2. Stud

Fig. 1, Inner Fender Fasteners

Installation

1. Mount the inner fender to the hood using the fasteners and tighten them to 6 lbf·ft (8 N·m).
2. Return the hood to the operating position. Remove the chocks from the tires.

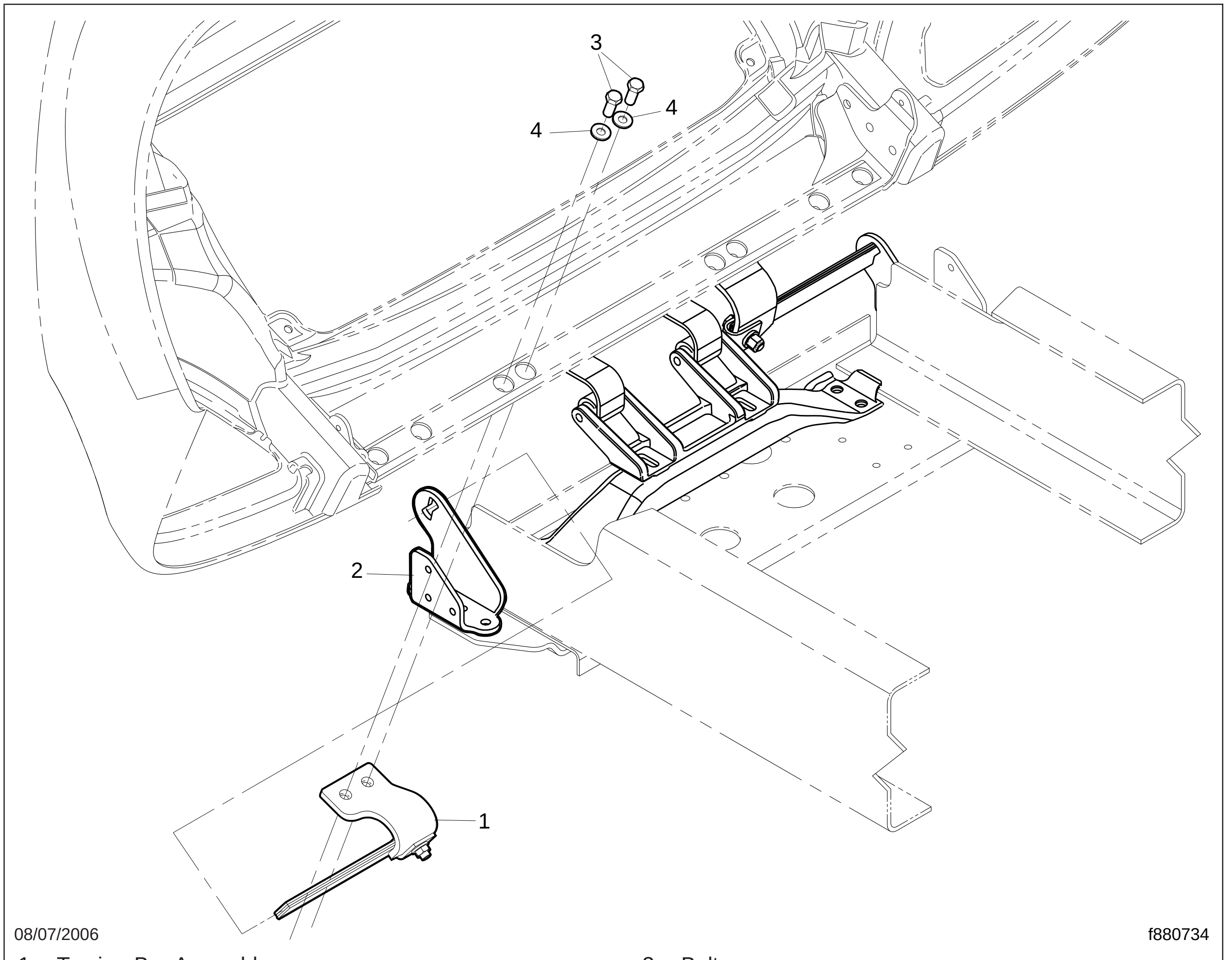
Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation

Vehicles with Engines Manufactured Through December 31, 2006

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the grille; see **Subject 110**.
3. Tilt the hood completely open.
4. Remove the four mounting bolts that attach the torsion bar assemblies to the hood crossbar; see **Fig. 1**.
5. Slide each torsion bar assembly out of the slot in the pivot bracket.

NOTE: If the torsion bars are pushing against the pivot brackets, slightly close the hood to loosen them.



1. Torsion Bar Assembly
2. Pivot Bracket
3. Bolt
4. Washer

Fig. 1, Hood Tilt-Assist Assembly (vehicles with engines manufactured through December 31, 2006)

Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation

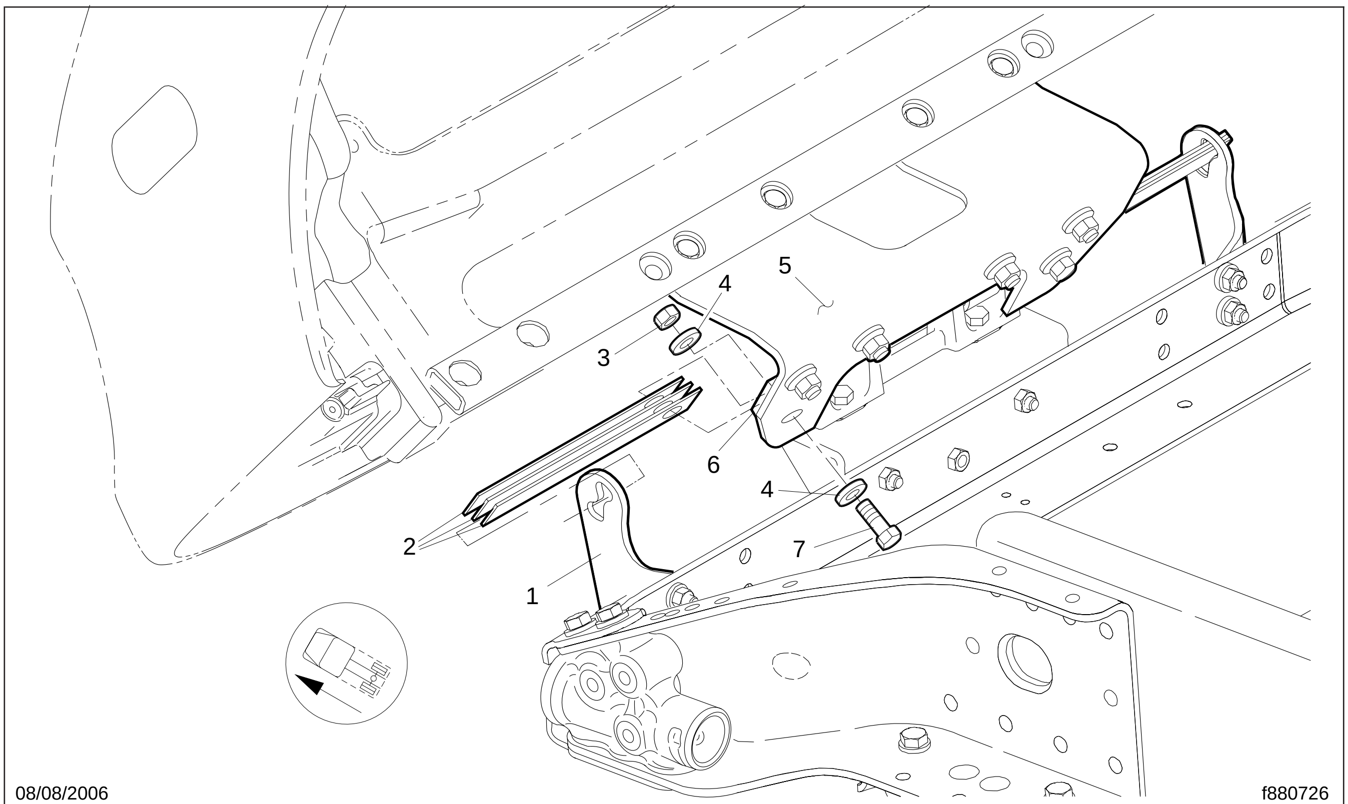
Installation

1. With the tires chocked and the hood open, on each side of the vehicle, slide the torsion bar assembly into the slot in the pivot bracket.
2. Install the four bolts that attach the torsion bar assemblies to the hood crossbar; see **Fig. 1**. Tighten the bolts 68 lbf·ft (92 N·m).
3. Close and latch the hood.
4. Install the grille; see **Subject 110**.
5. Remove the chocks.

Vehicles with EPA07 Compliant Engines

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the grille; see **Subject 110**.
3. Tilt the hood completely open.
4. Remove the fasteners that attach the torsion bars to the pivot-end clamps/hood hinges; see **Fig. 2**.
5. Slide each torsion bar, first out of the pivot-end clamp, then out of the slot in the pivot bracket.



1. Pivot Bracket
2. Torsion Bars
3. Nut
4. Washer
5. Hood Hinge Plate
6. Pivot-End Clamp/Hood Hinge
7. Bolt

Fig. 2, Hood Tilt-Assist Assembly (vehicles with EPA07 compliant engines)

Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation

NOTE: If the torsion bars are pushing against the pivot brackets, slightly close the hood to loosen them.

Installation

1. With the tires chocked and the hood open, on each side of the vehicle, slide the torsion bars into the slot in the pivot bracket, and then into the pivot-end clamp.
2. Install the fasteners that attach the torsion bars to the pivot-end clamps/hood hinges; see **Fig. 2**.
3. Close and latch the hood.
4. Install the grille; see **Subject 110**.
5. Remove the chocks.

Repair Tools and Materials

Surface Damage

Required tools and materials:

- 3M™ General Purpose Adhesive Cleaner
- 220 or finer grit sandpaper
- Applicator squeegee
- 3M Automix adhesive

Structural Damage

Required tools and materials:

- 3M™ General Purpose Adhesive Cleaner
- Grinder
- DA Sander
- 80 to 220 grit sandpaper
- Fiberglass matting
- 3M Automix adhesive
- Applicator squeegee

Hood Component Rebonding

Required tools and materials:

- Heat gun
- 80 to 220 grit sandpaper
- Adhesive

General Information

National Cush-N-Aire II air suspension seats offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, and seat cushion tilt.

The air-suspension and height-adjustment features are provided by an inflatable air spring (air bag) that receives air pressure from the vehicle air system. Pressure in the air spring is controlled by a set of switches attached to the seat frame.

Each seat is equipped with a shock absorber to dampen unwanted up-and-down motion of the seat. A Chugger-Snubber® isolator assembly allows the seat to move in a simple pendulum motion to isolate its occupant from the cab's fore-and-aft motion. An isolator lockout handle, at the side of the seat's lower frame, can be used whenever the isolator feature is not desired.

Refer to Chapter 5 in the *Columbia Driver's Manual* for a complete description of, and operating instructions for, all seat adjustment features.

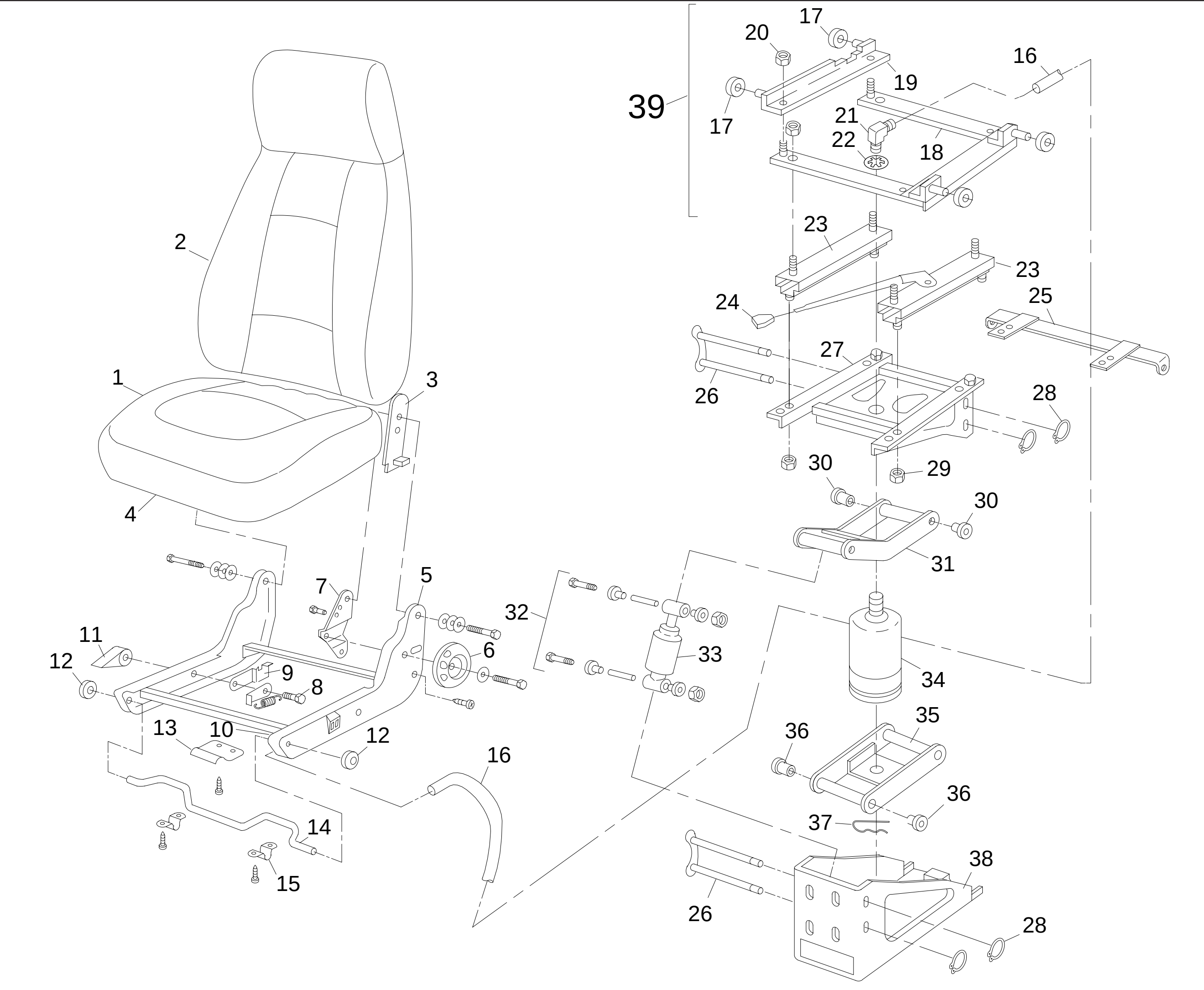
Removal

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension shroud, remove the shroud. It is held in place with Velcro® and upholstery-panel fasteners.
4. Cut a wooden block to the length required to support the seat at its maximum height. Place the block between the seat base and the rear crosstube of the lower arm. See **Fig. 1**, lower right-hand corner.
5. Drain the vehicle air reservoirs. Push in on the bottom of the seat ride-height rocker switch until all air is exhausted from the air spring.
6. Disconnect the air spring supply hose at the quick-disconnect union on the top of the air spring.
7. Remove the jam nut that attaches the air valve to the lower frame. See **Fig. 2**.
8. Using an 11/16-inch wrench or a T50 Torx wrench, remove the capscrews that attach the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod.
9. Remove the capscrews and washers that attach the seat base to the cab deck. Remove the seat from the cab.

Installation

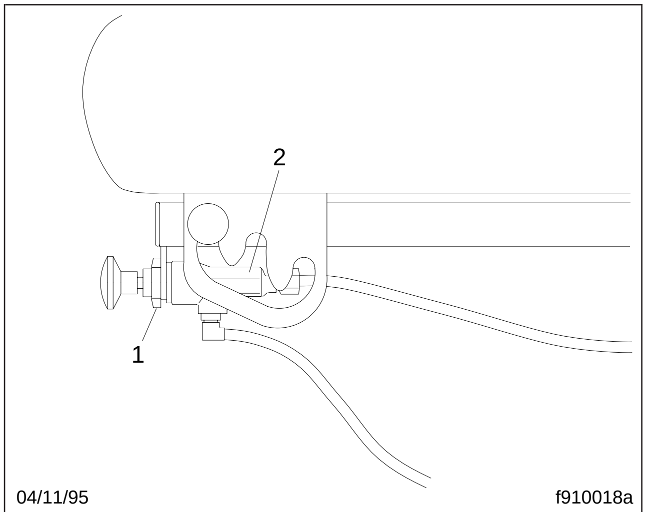
1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt and tether straps to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air spring supply hose at the quick-disconnect union on the top of the air spring.
4. Using a lockwasher and jam nut, attach the air valve to the lower frame. Tighten the nut finger-tight. Then, using a wrench, tighten the nut an additional one-half turn.
5. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height. Shut down the engine and remove the wooden block that supports the seat suspension.
6. If the seat is equipped with a seat suspension shroud, install the shroud.
7. Remove the chocks from the tires.

Seat Removal and Installation



1. Seat Cushion	14. Cushion Adjustment Rod	27. Seat Support
2. Seat Back	15. Adjustment Rod Bracket	28. Snap Ring
3. Back Frame Bracket	16. Air Hose	29. Locknut (8 qty.)
4. Upper Seat Frame	17. Isolator Bearing (4 qty.)	30. Bearing
5. Lower Frame	18. Bearing Support Frame	31. Upper Arm
6. Back Recline Adjustment Knob	19. Bearing Support Bar	32. Shock Absorber Assembly
7. Back Limit Bolt Bracket	20. Hexnut (2 qty.)	33. Shock Absorber
8. Cushion Adjustment Bolt	21. Air Quick-Disconnect	34. Air Spring
9. Cushion Adjustment Bracket	22. Retaining Ring	35. Lower Arm
10. Air Valve	23. Track Assembly	36. Bearing
11. Cushion Adjustment Lever	24. Fore-and-Aft Adjustment Lever	37. Pin Clip
12. Adjustment Rod Cap	25. Belt Bar	38. Seat Base
13. Cushion Handle	26. Connected Shaft	39. Isolator Assembly

Fig. 1, National Cush-N-Aire II Seat



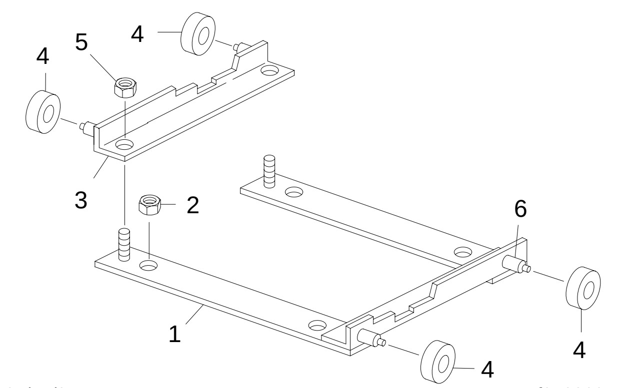
1. Air Valve Jam Nut 2. Air Valve

Fig. 2, Air Valve Mounted on Lower Frame

Isolator Assembly (Chugger-Snubber®) Replacement

Replacement

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Cut the plastic tie strap securing the seat cushion to the lower frame. Make sure the isolator handle on the side of the lower frame is in the up position.
3. Pull up and support the rear edge of the seat cushion as needed to gain access to the isolator assembly.
4. Remove the two 5/16–8 hexnuts that attach the bearing support rail to the bearing support frame. See **Fig. 1**.



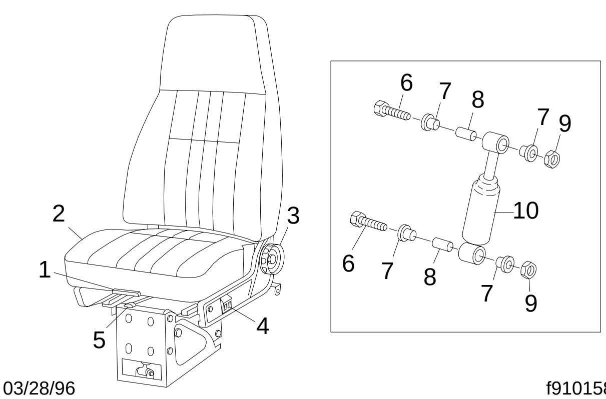
1. Welded Bearing Support Frame
2. Locknut, 5/16–18 (4 qty.)
3. Bearing Support Rail
4. Bearing
5. Hexnut, 5/16–18 (2 qty.)
6. Bearing Stud

Fig. 1, Isolator Assembly

5. Holding the seat cushion up, slide the bearing support rail up and off the bearing support frame. Two of the bearings will fall off when the support rail is removed.
6. Move the seat frame so you can see the two remaining bearings. Remove the bearings and the unattached upper seat components.
7. Remove the four 5/16–18 locknuts from the bearing support frame. Remove the frame from the track assembly.
8. Using a multi-purpose chassis grease, lubricate the bearing cups on the upper seat frame, and four new isolator bearings.
9. Install the bearing support frame (without bearings) on the studs on the track assembly. Install four 5/16–18 locknuts on the studs, and tighten 15 lbf·ft (20 N·m).
10. Install two lubricated bearings on the bearing support frame. Align the bearing cups on the upper seat frame over the bearings.
11. Install the bearing support rail assembly on the bearing support frame.
    - 11.1 Install the the remaining two lubricated bearings on the bearing support rail.
    - 11.2 Holding the seat cushion up, install the bearing support rail on the bearing support frame.
    - 11.3 Install two 5/16–18 hexnuts on the bearing support rail studs, and tighten them finger-tight.
    - 11.4 Make sure the bearing cups on the upper seat frame are aligned over all four bearings.
12. Push the isolator assembly forward and back to check the position of the bearing support rail before tightening the hexnuts. The isolator assembly should be tight enough to eliminate side play without interfering with the fore-and-aft movement of the seat.
13. Tighten the two 5/16–18 hexnuts on the bearing support rail 15 lbf·ft (20 N·m).
14. Install a new plastic tie strap to attach the seat cushion to the lower frame.
15. Remove the chocks from the tires.

Removal

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height. Place a wooden block between the seat base and the rear crosstube of the lower arm.
3. If the seat is equipped with a seat suspension shroud, remove the shroud. It is held in place with Velcro® and upholstery-panel fasteners.
4. Move the fore-and-aft adjustment lever to the right, and slide the seat assembly back as far as possible.
5. Remove the shock absorber, bushings, and bearings. See **Fig. 1** and **Fig. 2**.



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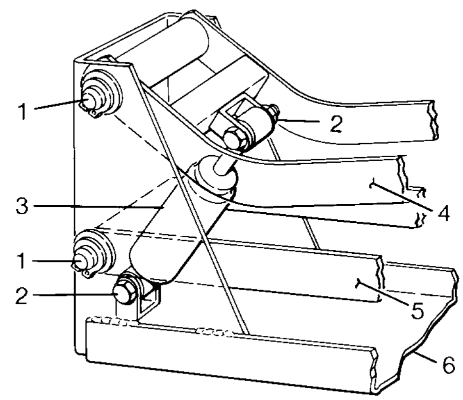
1. Cushion Handle
2. Seat Cushion
3. Back Recline Adjustment Knob
4. Height Adjustment Switch
5. Fore-and-Aft Alignment Lever
6. Hexbolt
7. Bearing
8. Bushing
9. Locknut
10. Shock Absorber

Fig. 1, Shock Absorber Assembly

5.1 Remove the locknuts and hexbolts that attach the shock absorber to the upper arm and the seat base. Remove the shock absorber.



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1. Arm Shaft Assembly
2. Hexbolt, Locknut
3. Shock Absorber
4. Upper Arm
5. Lower Arm
6. Seat Base

Fig. 2, Shock Absorber Installation

5.2 Remove the bushings and bearings from the shock absorber.

Installation

1. Check the operation of the shock absorber, and replace it if necessary.
2. Install the shock absorber.

   2.1 Install new bearings and bushings in the shock absorber eyes.

   2.2 With the upper arm supported by the wooden block, place the shock absorber so its piston-rod end is in the mounting bracket of the upper arm.

   2.3 Insert a hexbolt through the bracket, bushings, bearings, and shock absorber. Install a locknut on the hexbolt, and tighten the locknut 25 lbf·ft (34 N·m).

   2.4 Place the cylinder end of the shock absorber in the seat base mounting bracket.

   2.5 Insert a hexbolt through the bracket, bushings, bearing, and shock absorber. Install a locknut on the hexbolt, and tighten the locknut 25 lbf·ft (34 N·m).
3. Raise the seat to release pressure on the wooden block. Remove the block.

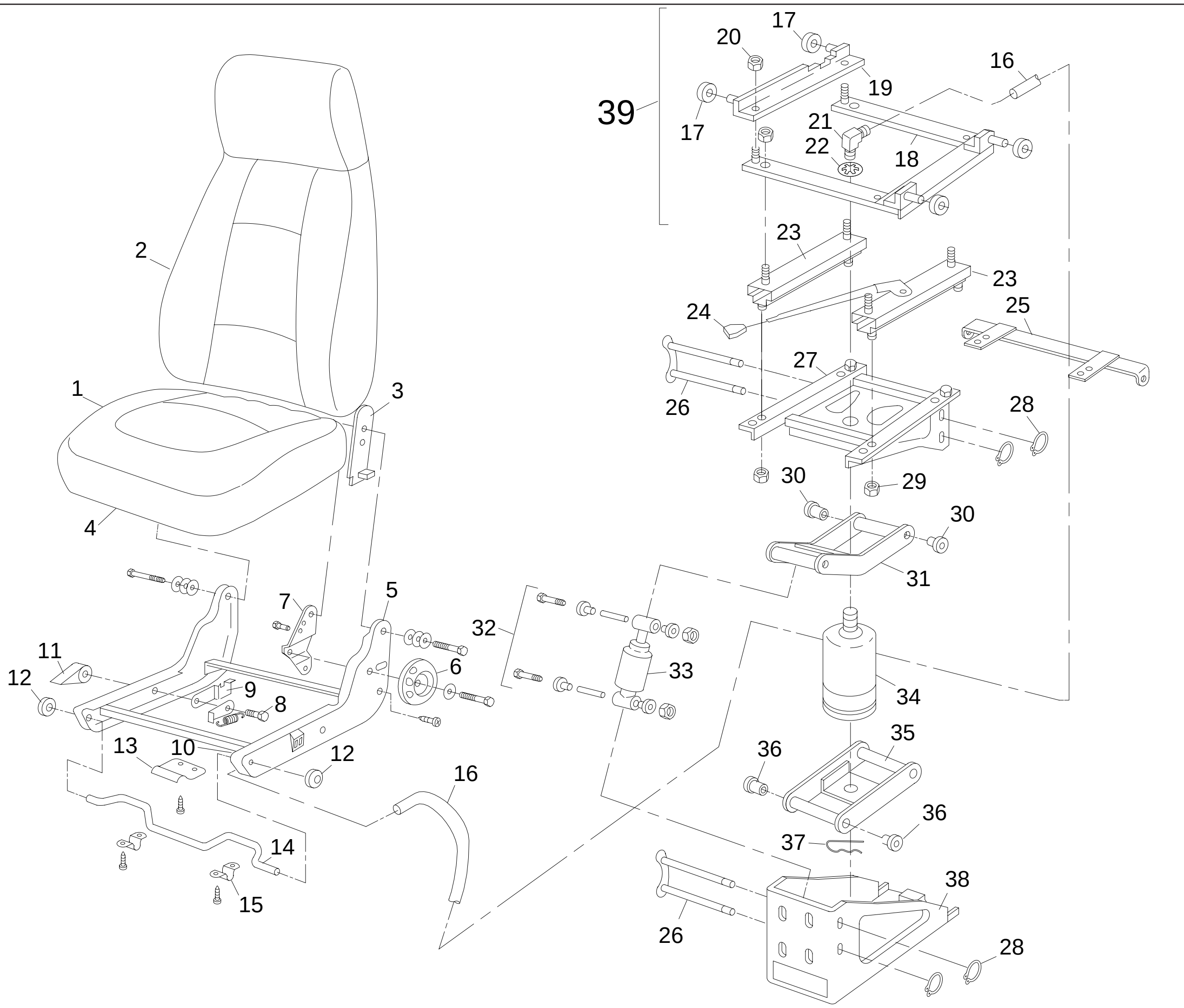
Shock Absorber Removal and Installation

4. If the seat is equipped with a seat suspension shroud, install the shroud.
5. Remove the chocks from the tires.

Replacement

1. Remove the seat from the vehicle as instructed in **Subject 100**.
2. Lay the seat on its side, with the wooden block still in place.
3. Disconnect the air spring supply hose at the quick-disconnect union on the top of the air spring. See **Fig. 1**.
4. Pry the pin clip from the bottom of the air spring.
5. Remove the retaining ring that secures the air spring to the seat support. Remove the air spring.
6. Place the new air spring in the seat base, and secure it with a new pin clip.
7. Insert the top of the air spring in the opening in the seat support. Install the retaining ring on the air spring.
8. Install the air spring supply hose quick-disconnect on the air spring.
9. Install the seat as instructed in **Subject 100**.

Air Spring Replacement



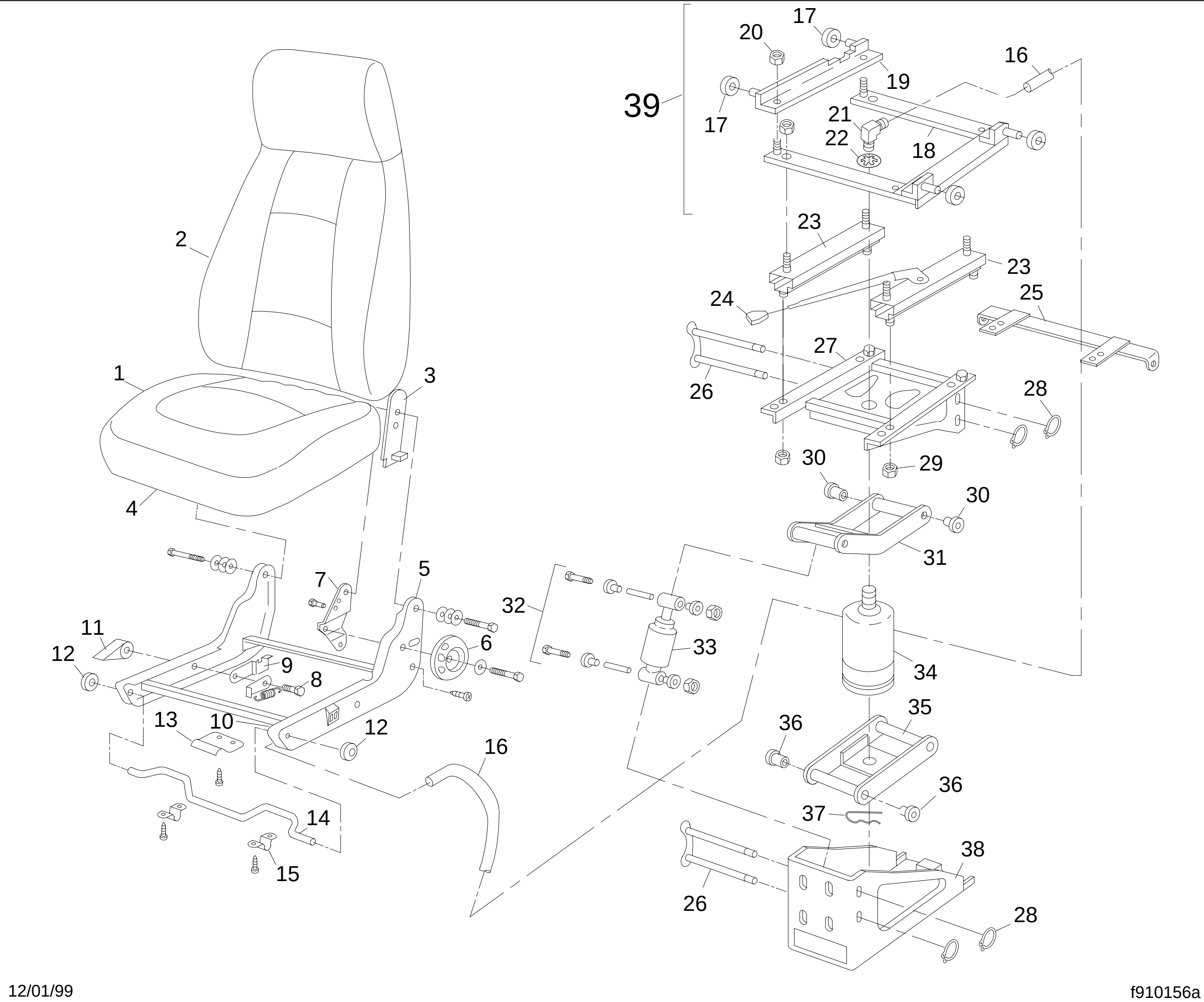
1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Lower Frame
6. Back Recline Adjustment Knob
7. Back Limit Bolt Bracket
8. Cushion Adjustment Bolt
9. Cushion Adjustment Bracket
10. Air Valve
11. Cushion Adjustment Lever
12. Adjustment Rod Cap
13. Cushion Handle
14. Cushion Adjustment Rod
15. Adjustment Rod Bracket
16. Air Hose
17. Isolator Bearing (4 qty.)
18. Bearing Support Frame
19. Bearing Support Bar
20. Hexnut (2 qty.)
21. Air Quick-Disconnect
22. Retaining Ring
23. Track Assembly
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut (8 qty.)
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base
39. Isolator Assembly

Fig. 1, National Cush-N-Aire II Seat

Replacement

1. Remove the seat as instructed in **Subject 100**.
2. Remove the isolator assembly as instructed in **Subject 110**.
3. Remove the four 5/16–18 locknuts from under the top flange of the seat support. Remove the track assembly and belt bar. See **Fig. 1**.
4. Remove the air spring.
    4.1 Remove the retaining ring that secures the air spring to the seat support.
    4.2 Remove the pin clip that secures the air spring to the lower arm. Remove the air spring.
5. Remove the locknuts and hexbolts that attach the shock absorber to the upper arm and to the seat base. Remove the shock absorber. Discard the bearings and bushings.
6. Remove the connected shafts from the seat support and seat base, if so equipped. Otherwise, remove the pivot bolts.
    6.1 Using snap-ring pliers, remove the snap rings from the connected shafts on the seat support and seat base.
    6.2 Using a drift punch, drive out the connected shafts. Place the punch against the snap-ring end of one shaft, and alternately drive each shaft end a little at a time. Each vertical pair of shafts are connected on the opposite side.
7. Remove the seat support and upper and lower arms from the seat base.
8. Remove the bearings and/or sleeves from the upper and lower arms. Discard the bearings/sleeves.
9. If equipped, remove the sleeves/bearings from the seat support and the seat base. Discard the sleeves/bearings.
10. Install new bearings and/or sleeves, as equipped.
    10.1 Install new bearings and/or sleeves in the upper and lower arm tubes.
    10.2 If equipped, install new sleeves/bearings in the seat support and the seat base.
11. Install the lower and upper arms in the seat support and seat base.
    11.1 Align the forward tubes of the lower and upper arms with the holes in the seat base. Be sure the notch in the lower arm is forward and up, and the notch in the upper arm is to the rear and down.
    11.2 Install one connected shaft assembly through the seat base and the upper and lower arm forward tubes.
    11.3 Align the rear tubes of the lower and upper arms with the holes in the seat support.
    11.4 Install the second connected shaft assembly through the seat support and the upper and lower arm tubes or, if so equipped, install and tighten the pivot bolts.
    11.5 For connected shafts, use snap-ring pliers to install the four snap rings that secure the shafts and the arms to the seat base and the seat support.
12. Using new bearings and bushings, install the shock absorber.
    12.1 Place the piston-rod end of the shock absorber in the upper arm mounting bracket.
    12.2 Install the bolt and locknut. Tighten the locknut 25 lbf·ft (34 N·m).
    12.3 Place the cylinder end of the shock absorber in the seat base mounting bracket.
    12.4 Install the bolt and locknut. Tighten the locknut 25 lbf·ft (34 N·m).
13. Install the air spring.
    13.1 Insert the top of the air spring into the hole in the seat support.
    13.2 Install the retaining ring on the air spring to secure it to the seat support.
    13.3 Place the air spring on the lower arm. Insert a pin clip into the air spring below the lower arm.
14. Install the belt bar and track assembly on the seat support. Install four 5/16–18 locknuts on the

Base Assembly Bearing/Sleeve Replacement



1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Lower Frame
6. Back Recline Adjustment Knob
7. Back Limit Bolt Bracket
8. Cushion Adjustment Bolt
9. Cushion Adjustment Bracket
10. Air Valve
11. Cushion Adjustment Lever
12. Adjustment Rod Cap
13. Cushion Handle
14. Cushion Adjustment Rod
15. Adjustment Rod Bracket
16. Air Hose
17. Isolator Bearing (4 qty.)
18. Bearing Support Frame
19. Bearing Support Bar
20. Hexnut (2 qty.)
21. Air Quick-Disconnect
22. Retaining Ring
23. Track Assembly
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut (8 qty.)
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base
39. Isolator Assembly

Fig. 1, National Cush-N-Aire II Seat

studs under the top flange of the seat support. Tighten the nuts 15 lbf·ft (20 N·m).

15. Install the isolator assembly as instructed in **Subject 110**.

16. Install the seat as instructed in **Subject 100**.

Lower Seat Frame Removal and Installation

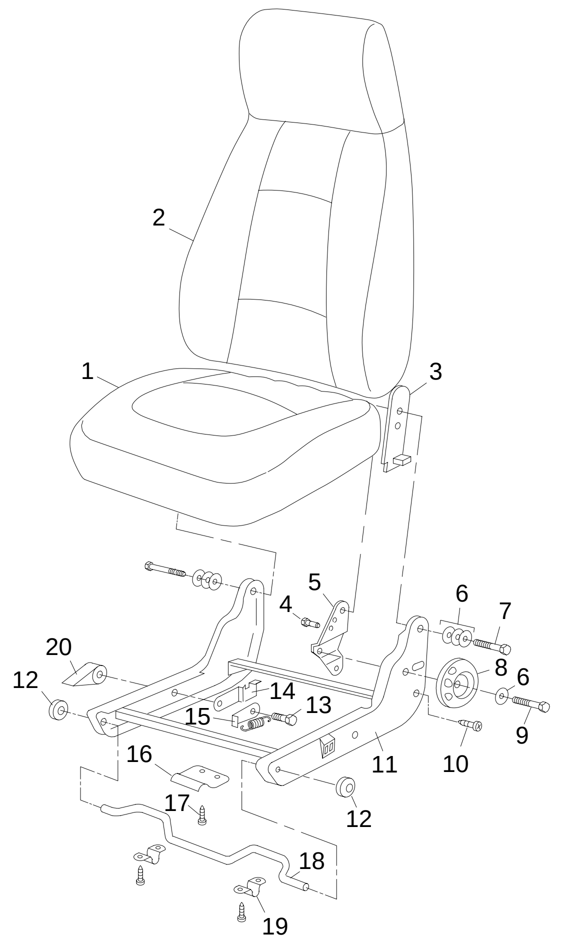
Removal

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. If the seat is equipped with a seat suspension shroud, remove the shroud. It is held in place with Velcro® and upholstery-panel fasteners.
3. Remove the plastic tie strap that attaches the seat cushion to the lower frame.
4. Remove the cushion adjustment rod.
   - 4.1 Remove the two adjustment rod brackets that attach the cushion adjustment rod to the seat. See **Fig. 1**.
   - 4.2 Remove the seat cushion.
   - 4.3 Remove the two adjustment rod caps.
   - 4.4 Remove the adjustment rod from the lower frame.
5. Remove the jam nut that attaches the air valve to the lower frame. See **Fig. 2**. Remove the valve and air hose from the lower frame.
6. Remove the four locknuts from under the top flange of the seat support.
7. Remove the lower frame from the seat support.

Installation

1. Place the lower frame on the seat support. Install four locknuts under the top flange of the seat support. Tighten the locknuts 10 lbf·ft (15 N·m).
2. Using a jam nut and lockwasher, attach the air valve to the lower frame. Tighten the nut finger-tight. Using a wrench, tighten the nut an additional one-half turn.

   Make sure that the air hose moves without any restrictions when the seat is moved forward or back.
3. Place the seat cushion on the upper seat frame. Install the two adjustment rod brackets that attach the cushion adjustment rod to the seat.
4. Install a new plastic tie strap to secure the seat cushion to the lower frame.

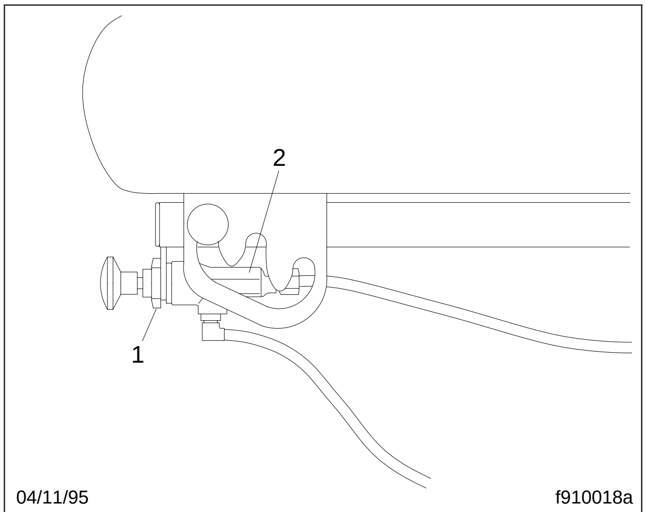


1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Back Limit Bolt
5. Back Limit Bracket
6. Flatwashers
7. Back Frame Bolt
8. Back Recline Adjustment Knob
9. Hexbolt
10. Screw
11. Lower Frame
12. Adjustment Rod Cap
13. Cushion Adjustment Bolt
14. Cushion Adjustment Bracket
15. Cushion Adjustment Spring Bracket
16. Cushion Handle
17. Fastener
18. Adjustment Rod
19. Adjustment Rod Bracket
20. Cushion Adjustment Lever

Fig. 1, Lower Frame Assembly

5. If the seat is equipped with a seat suspension shroud, install the shroud.
6. Remove the chocks from the tires.

Lower Seat Frame Removal and Installation



1. Air Valve Jam Nut
2. Air Valve

Fig. 2, Air Valve Mounted on Lower Frame

Replacement

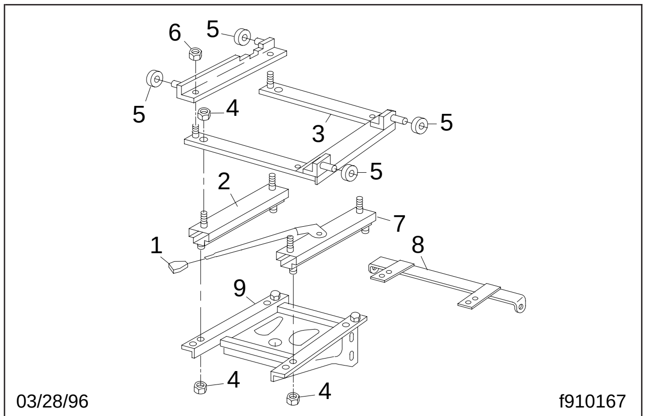
1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height. Place a wooden block between the seat base and the rear crosstube on the lower arm.
3. If the seat is equipped with a seat suspension shroud, remove the shroud.
4. Pull up and support the rear edge of the seat cushion as needed to gain access to the isolator assembly to the track assembly.
5. Remove the air spring supply hose from the seat assembly.

   5.1 Cut and remove the tie straps that attach the air spring supply hose to the belt bar and the track assembly latch mechanism.

   5.2 Disconnect the quick-disconnect supply hose fitting. Remove the air spring supply hose assembly and lay it on the cab deck, behind the seat.
6. Remove the four 5/16–18 locknuts that attach the isolator assembly to the top of the track assembly. See **Fig. 1**. Remove the isolator assembly.

NOTE: If needed, refer to **Subject 110** for detailed instructions on removing the isolator assembly.

7. Remove the four 5/16–18 locknuts from under the top flange on the seat support. Remove the track assembly and belt bar.
8. With the holes in the belt bar, belt bar spacers, and seat track stop aligned with the holes in the seat support, install the new track assembly on the seat support. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
9. Move the upper half of the track assembly as needed to align the studs with the holes in the isolator assembly. Place the isolator assembly on the track assembly. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).



1. Fore-and-Aft Adjustment Lever
2. Right-Side Track
3. Welded Bearing Support Frame
4. Locknut, 5/16–18 (4 qty.)
5. Bearing (4 qty.)
6. Hexnut, 5/16–18 (2 qty.)
7. Left-Side Track
8. Belt Bar
9. Seat Support

Fig. 1, Track Assembly (exploded view)

NOTE: If needed, refer to **Subject 110** for detailed instructions on installing the isolator assembly.

10. Install the air spring supply hose.

    10.1 Install the quick-disconnect hose fitting on the air spring.

    10.2 Install a new tie strap to attach the air spring supply hose to the track assembly latch mechanism.

    10.3 Install a new tie strap to attach the air spring supply hose to the belt bar.
11. Move the fore-and-aft adjustment lever to the right, and slide the seat assembly forward and back while making sure that the air hose moves without restriction.
12. Return the seat cushion to its original position. Make sure the bearing cups on the upper seat frame are aligned over the isolator bearings.
13. Raise the seat to release pressure on the wooden block, and remove the block.
14. Remove the chocks from the tires.

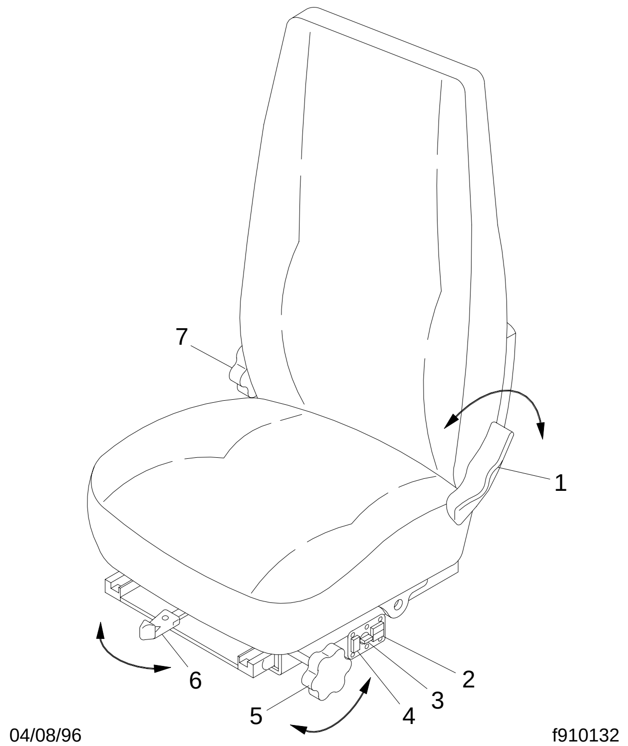
Specifications

Torque Specifications	
Description	**Torque lbf·ft (N·m)**
Seat Base to Cab Deck Capscrews	27 (37)
Seat Support to Lower Frame Locknuts	10 (15)
Seat Belt to Belt Bar Capscrews	40 (54)
Shock Absorber to Bracket Locknuts	25 (34)
Track Assembly to Isolator Assembly Locknuts	15 (20)
Track Assembly to Seat Support Locknuts	15 (20)

Table 1, Torque Specifications

General Information

The Bostrom Talladega 900 series air suspension seats offer weight-height adjustment, infinite adjustment Parabar II® lumbar support and a fore and aft roller-track isolator system. See **Fig. 1**.



NOTE: LSO = Luxury Seat Option.

1. Back Angle Adjustment
2. Air Lumbar Adjustment (LSO model only)
3. Damper Adjustment (LSO model only)
4. Weight and Height Adjustment
5. Seat Cushion Tilt Adjustment
6. Fore and Aft Isolation and Seat Position Adjustment
7. Lumbar Adjustment (non-LSO models)

Fig. 1, Bostrom Talladega 900 Series Seat

For complete operating instructions, refer to Chapter 5 in the *Columbia Driver's Manual*.

Removal

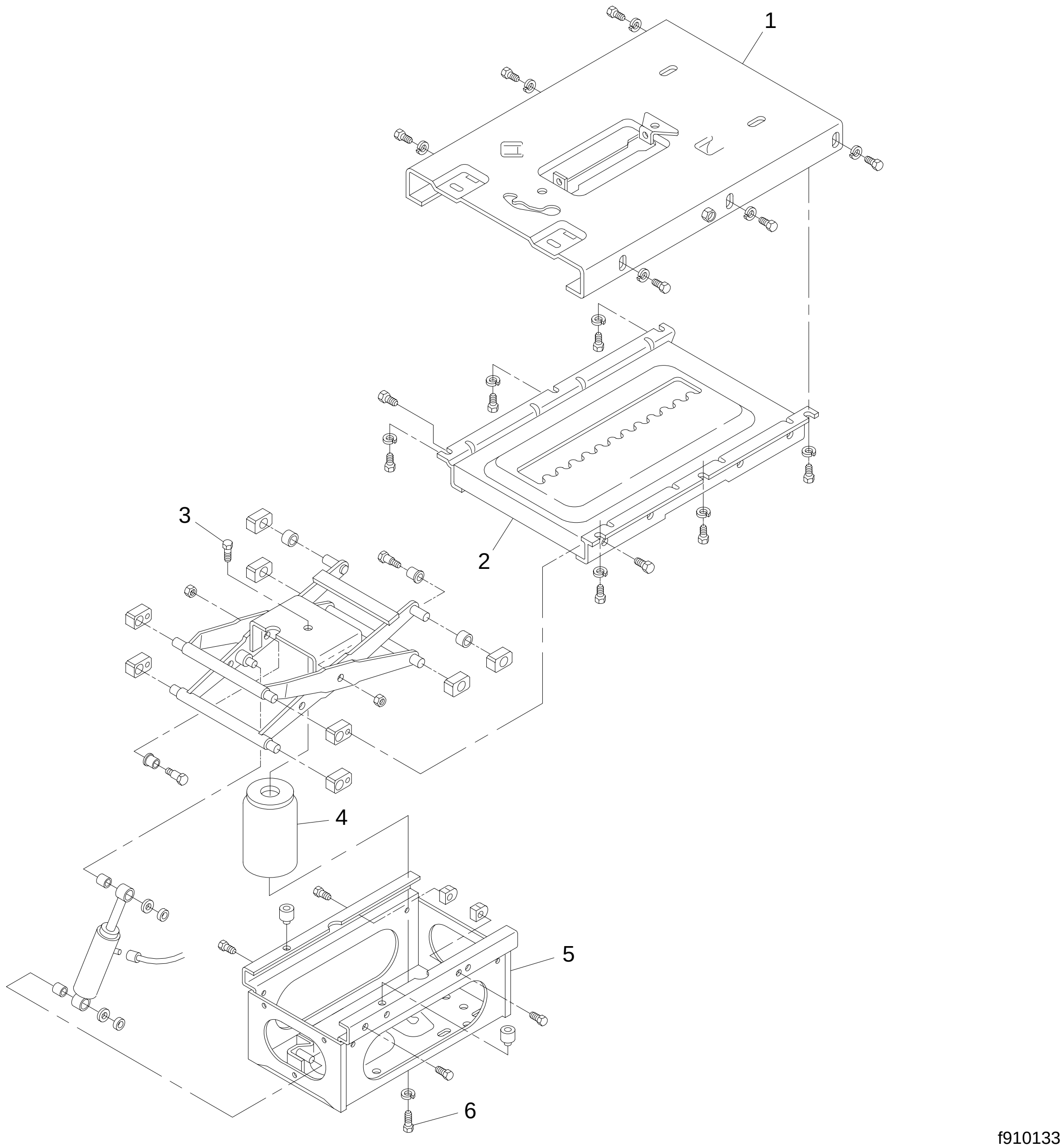
NOTE: The seat, the seat/back assembly, and the channel assembly do not need to be removed.

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Move the channel assembly aft to provide access to the air spring.
3. Fill the air spring so that the seat is at maximum height. See **Fig. 1**. Support the seat in this position by placing a wooden block between the base riser and the upper frame.
4. Release the air pressure from the air spring so that the seat is supported by the spacer.
5. Disconnect the air line from the air spring by pushing in the collar of the fitting while pulling the air line out of the fitting.
6. Remove the air spring.
   - 6.1 Remove the top capscrew.
   - 6.2 Loosen the bottom capscrew through the rear opening in the base riser.
   - 6.3 Remove the air spring from the suspension.
   - 6.4 Remove the capscrew and washer from the bottom of the air spring.

Installation

1. Install the new air spring.
   - 1.1 Loosely install the capscrew and washer in the bottom of the new air spring.
   - 1.2 Place the air spring in the base riser by fitting the bottom capscrew in the keyhole opening in the bottom of the base riser.
   - 1.3 Turn the air spring so the fitting at the base of the air spring faces the front of the seat.
   - 1.4 Tighten the bottom capscrew 9 to 11 lbf·ft (12 to 15 N·m).
   - 1.5 Install the top capscrew and tighten 15 to 19 lbf·ft (20 to 26 N·m).
2. Connect the air line to the fitting in the air spring by pushing the tube into the fitting.
3. Fill the air spring and remove the wooden block.
4. Remove the chocks from the tires.

Air Spring Removal and Installation



1. Channel Assembly
2. Upper Frame
3. Top Capscrew
4. Air Spring
5. Base Riser
6. Bottom Capscrew

Fig. 1, Bostrom Talladega 900 Series Seat Air Spring

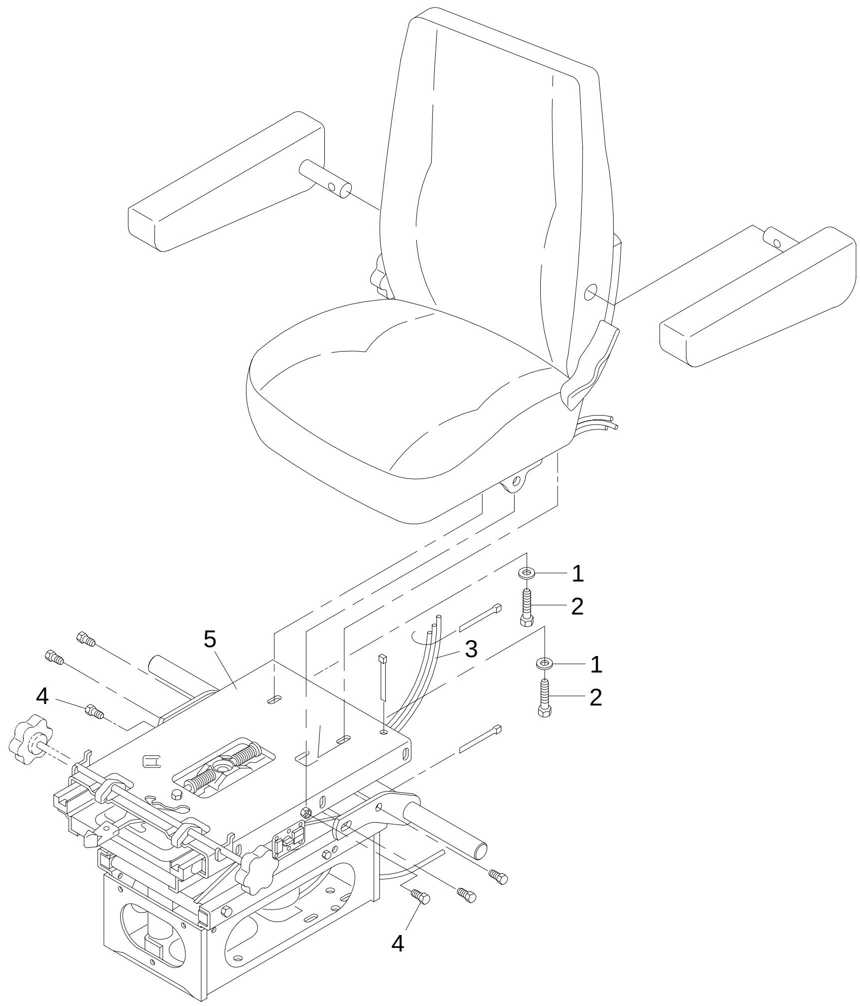
Seat/Back Assembly Removal and Installation

Removal

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Move the seat/back assembly aft to provide access to the channel assembly.
3. Remove the two capscrews and flatwashers from the underside of the channel assembly. See **Fig. 1**.
4. Remove the two shoulder bolts from the channel assembly.
5. Disconnect the air lines.
6. Remove the seat/back assembly.

Installation

1. Place the seat/back assembly onto the channel assembly.



1. Flatwasher
2. Capscrew
3. Air Lines
4. Shoulder Bolt
5. Channel Assembly

Fig. 1, Bostrom Talladega 900 Series Seat

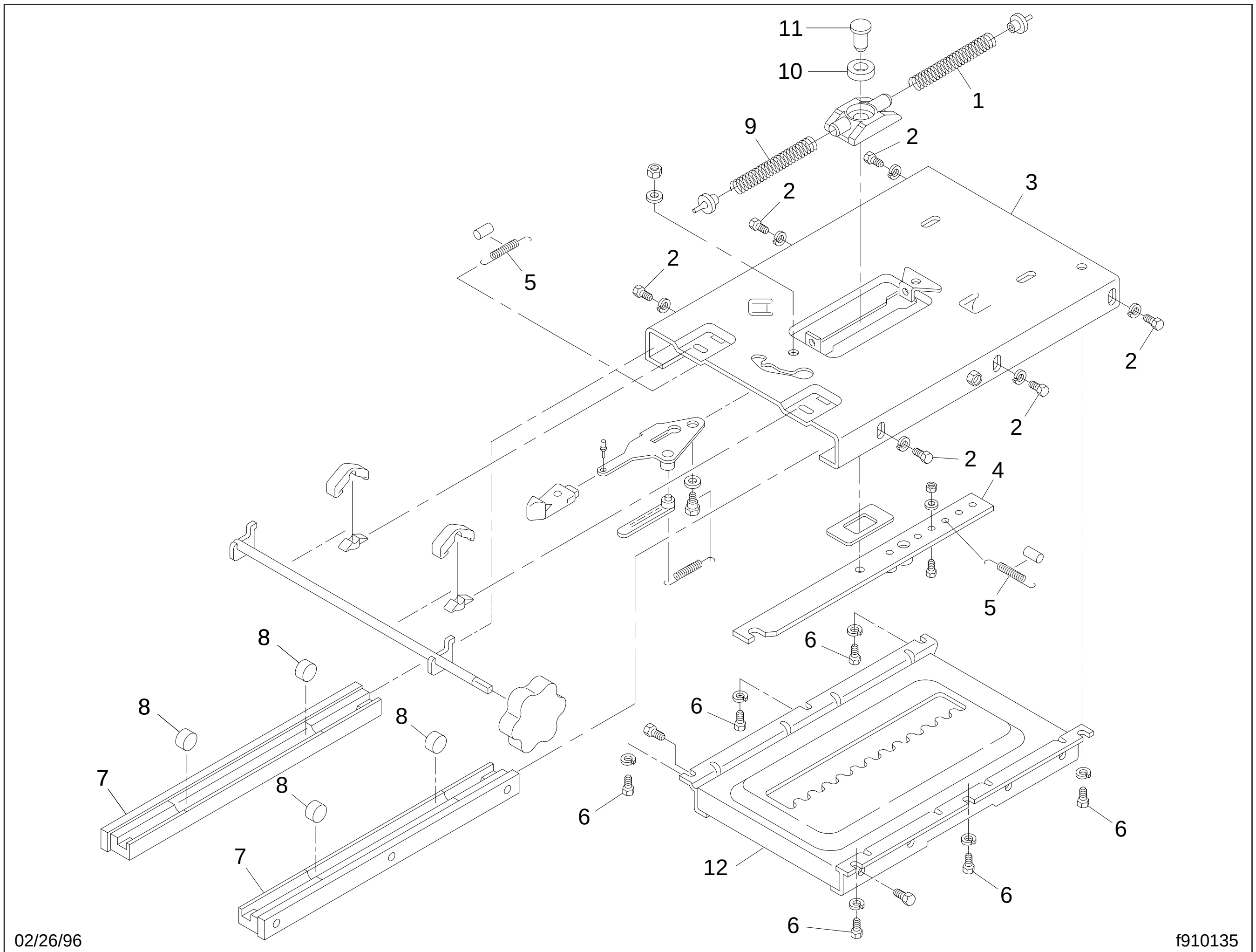
Seat/Back Assembly Removal and Installation

2. Connect the air lines to the air spring, and the air line to the vehicle air supply.
3. Install the two shoulder bolts in the channel assembly.
4. Install the two capscrews and flatwashers in the underside of the channel assembly.
5. Remove the chocks from the tires.

Fore and Aft Isolation Channel Removal and Installation

Removal

1. Remove the seat/back assembly. See **Subject 110**.
2. With the channel assembly set in its unlocked position (isolation position), push the channel assembly aft and remove the rear isolator spring. See **Fig. 1**.
3. Pull the channel assembly forward and remove the front isolator spring.
4. Adjust the channel assembly until the cutouts in the underside of the channel line up with the Allen-head screws. Remove the Allen-head screws.
5. Remove the three capscrews on each side of the channel assembly.



1. Rear Isolator Spring
2. Capscrew
3. Channel Assembly
4. Latch Bar
5. Spring
6. Allen-Head Screw
7. Guide Assembly
8. Roller
9. Front Isolator Spring
10. Washer
11. Pivot Bolt
12. Upper Frame

Fig. 1, Channel Assembly

Fore and Aft Isolation Channel Removal and Installation

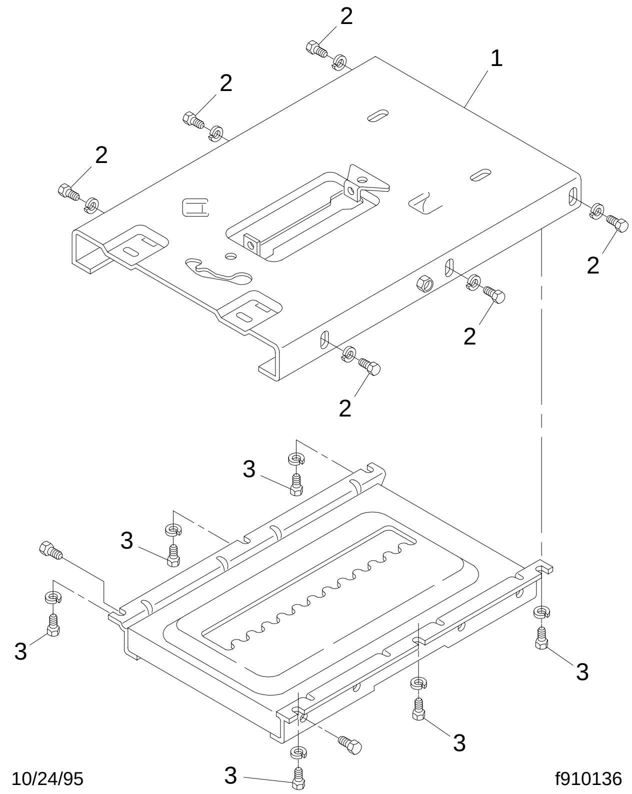
6. Remove both guide assemblies and the four rollers.
7. Disconnect the spring from the latch bar.
8. Remove the pivot bolt and washer, and slide the latch bar out. Remove the channel assembly.

Installation

1. Place the channel assembly on the upper frame. Slide the latch bar in, and install the pivot bolt and washer. Tighten the bolt 26 to 34 lbf·ft (36 to 46 N·m).
2. Connect the springs to the latch bar.
3. Install both guide assemblies and the four rollers.
4. Install three capscrews on each side of the channel assembly. Tighten the capscrews 15 to 17 lbf·ft (20 to 23 N·m).
5. Install six Allen-head screws on the underside of the channel assembly. Tighten the screws 15 to 17 lbf·ft (20 to 23 N·m).
6. With the channel assembly in the isolation position, pull the assembly forward and install the front isolator spring.
7. Push the assembly aft and install the rear isolator spring.
8. Adjust the channel assembly using the instructions in **Subject 130**.
9. Install the seat/back assembly. See **Subject 110**.

Adjustment

1. Remove the seat/back assembly from the channel assembly using the instructions in **Subject 110**.
2. Adjust the channel assembly so the cutouts in the underside of the channel assembly line up with the Allen-head screws. See **Fig. 1**.



1. Channel Assembly
2. Capscrew
3. Allen-Head Screw

Fig. 1, Channel Assembly

3. Use a 5/32-inch Allen wrench to loosen the six screws underneath the channel assembly.
4. Push the slide track outward to take up excessive lateral movement and retighten the six screws. Tighten the screws 60 to 84 lbf·in (680 to 940 N·cm).
5. Loosen the six capscrews along the side of the channel assembly.
6. Push down on the channel assembly to adjust the vertical play, and tighten the six capscrews 60 to 84 lbf·in (680 to 940 N·cm).

Damper Removal and Installation

Removal

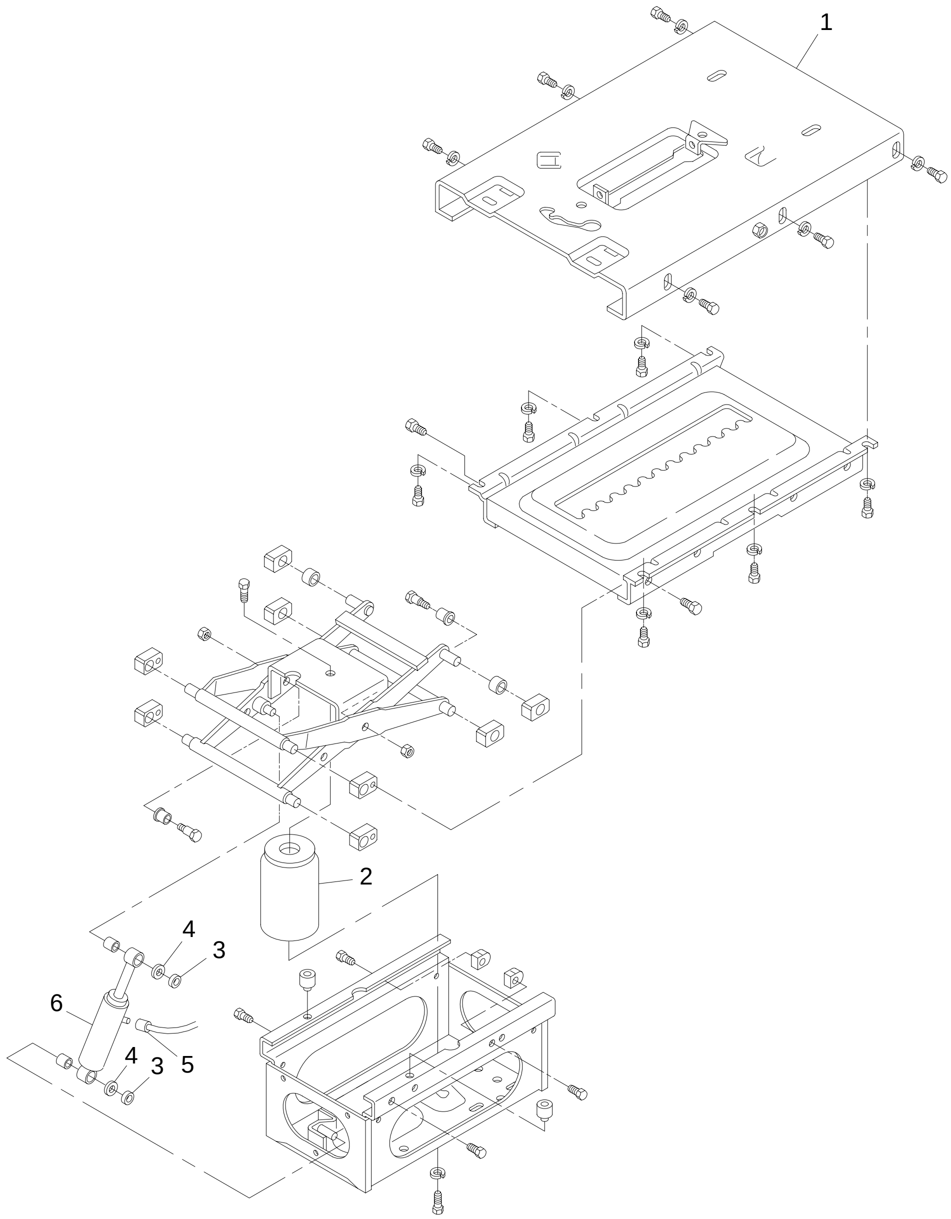
NOTE: The seat/back assembly does not need to be removed.

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the tires.
2. Move the channel assembly aft to provide access to the damper assembly. See **Fig. 1**.
3. Fill the air spring so that the seat is at maximum height.
4. Using pliers or a screwdriver, twist off the push-on fasteners. The push-on fasteners are not reusable.
5. On luxury seat option (LSO) models only, disconnect the control cable from the damper. Remove the damper.

Installation

1. Install the new damper with the flanges of the bearings toward the outside of the suspension. On LSO models only, connect the control cable.
2. Install the thrustwashers and the new push-on fasteners until they seat. A 1/2-inch box-end wrench works well to push the fasteners on.
3. Remove the chocks from the tires.

Damper Removal and Installation



1. Channel Assembly
2. Air Spring
3. Push-On Fastener
4. Thrust Washer
5. Control Cable (LSO model only)
6. Damper

Fig. 1, Channel Assembly

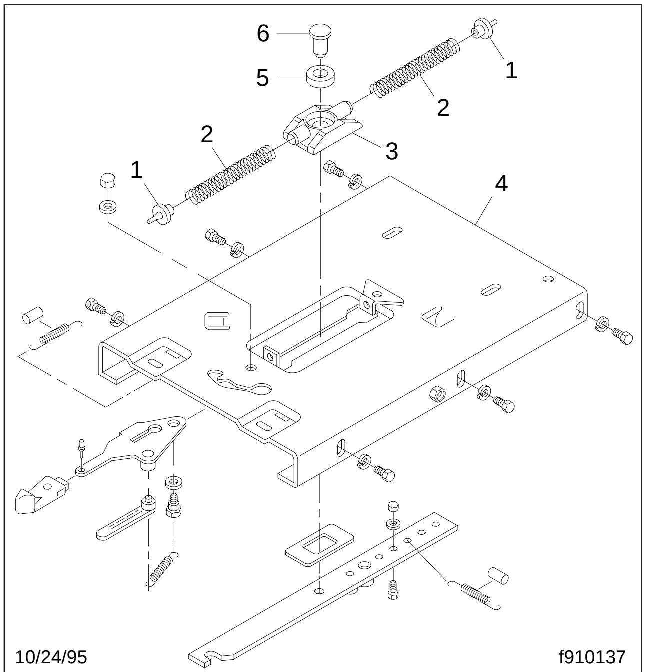
Isolation Bumper Removal and Installation

Removal

1. Remove the seat/back assembly using the instructions in **Subject 110**.
2. Remove the two isolation springs. See **Fig. 1**.
   - 2.1 Push the channel assembly aft to remove the rear spring.
   - 2.2 Pull the channel assembly forward to remove the front spring.
3. Remove the isolation bumpers.

Installation

1. If the pivot block was removed, install the pivot block with the pivot bolt and washer. Tighten the bolt 26 to 34 lbf·ft (36 to 46 N·m).
2. Install the isolation bumpers.
3. Install the two isolation springs.
   - 3.1 Pull the channel assembly forward to install the front spring.
   - 3.2 Push the channel assembly aft to install the rear spring.
4. Install the seat/back assembly using the instructions in **Subject 110**.



1. Isolation Bumper
2. Isolation Spring
3. Pivot Block
4. Channel Assembly
5. Washer
6. Pivot Bolt

Fig. 1, Channel and Isolation Bumper Assembly

Back Cover/Pad Assembly Removal and Installation

Removal

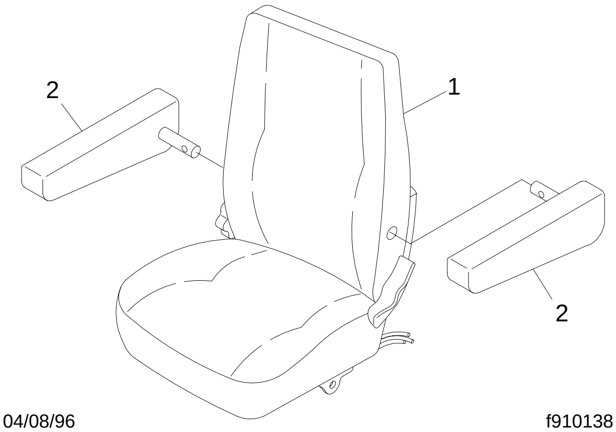
1. Remove the seat/back assembly from the suspension, using the instructions in **Subject 110**.
2. Remove the armrests, if equipped. See **Fig. 1**.
3. Remove the back cover and pad from the seat frame assembly. Note the location of the fasteners on the existing back cover.

Installation

1. Place a new pad over the back frame. If the seat has lumbar adjustment, make a cut in the edge of the pad to fit around the handle.
2. Install the back cover.
   - 2.1 Place the cover (inside out) over the top of the back pad.
   - 2.2 Pull down the cover until the three tie-down tabs are even with the three slots in the pad.
   - 2.3 Pull the tie-down tabs through the slots in the pad and run a short wire through all three tabs.

   NOTE: If the seat has a high back, there will be two sets of tie-down tabs (six total, with two wires) to be pulled through the back pad and wired.

   - 2.4 Continue to pull the cover down completely over the pad.
   - 2.5 Tuck the front flap of the back cover between the seat cushion and the bottom of the back pad, and lock the J-welt together.
3. Attach the upper seat assembly to the suspension using the instructions in **Subject 110**.
4. Install the armrests, if equipped.



04/08/96 f910138

1. Upper Seat Assembly
2. Armrest

Fig. 1, Upper Seat Assembly (armrests removed)

Suspension Rebuild Bearing/Slide Block Removal and Installation

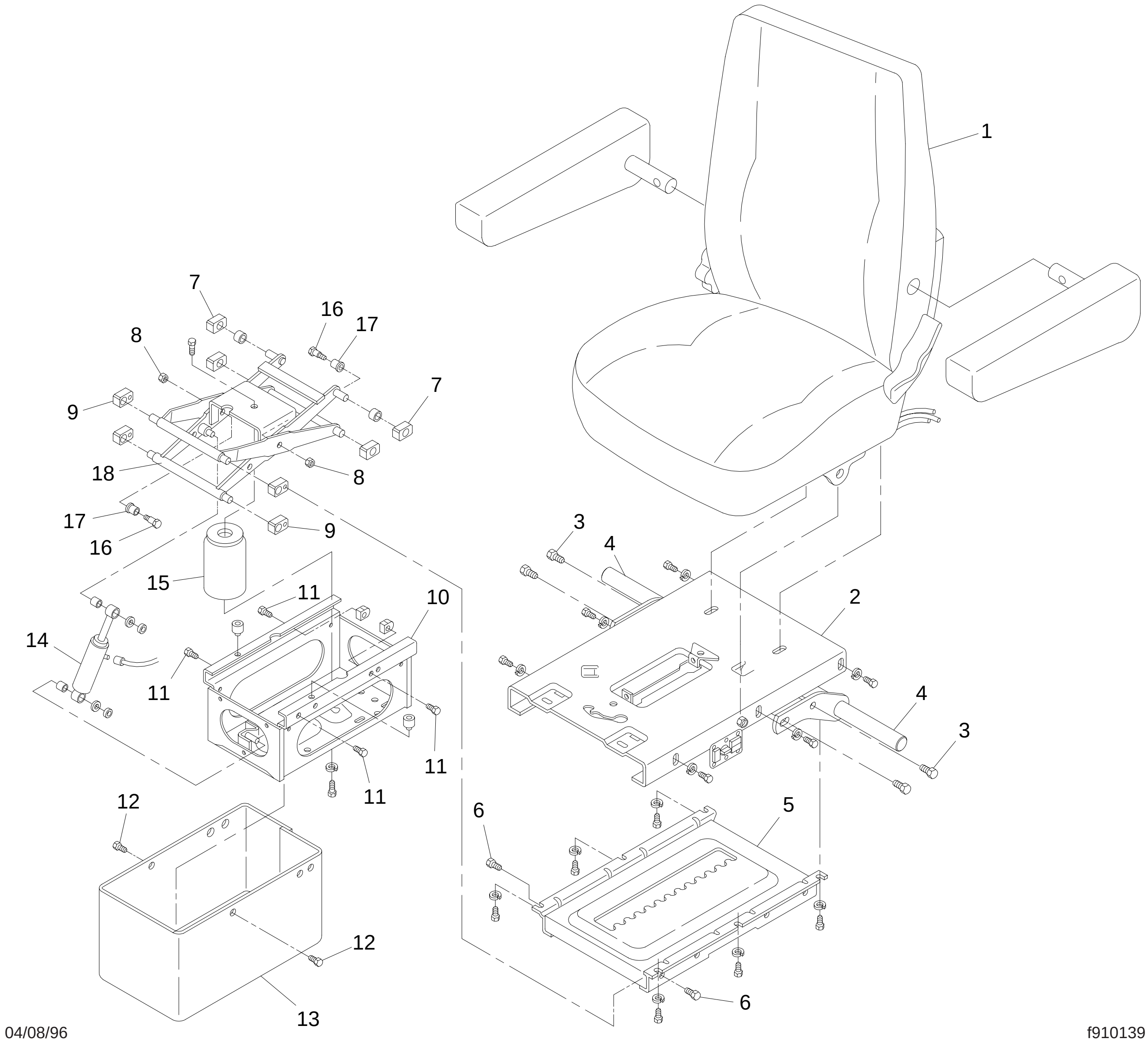
Removal

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Fill the air spring so that the seat is at maximum height. Support the seat in this position by placing a wooden block between the base riser and the upper frame.
3. Bleed all the air from the supply line. Disconnect the air supply line from the seat. Using the air valve, exhaust all air from the air spring.
4. If the seat assembly has a suspension cover, remove the fasteners and the suspension cover.
5. Remove the complete seat assembly from the vehicle.
6. Remove the seat/back assembly using the instructions in **Subject 110**.
7. Remove the channel assembly using the instructions in **Subject 120**.
8. Remove the capscrews and the ICP bracket. See **Fig. 1**.
9. Remove the capscrews from the upper bearing blocks.
10. Remove the upper frame assembly by sliding it forward off the bearing blocks and the slide blocks.
11. Remove the air spring using the instructions in **Subject 100**. Mark the air lines for reassembly.
12. Remove the damper using the instructions in **Subject 140**.
13. Remove the bearing and slide blocks.
    - 13.1 Remove the capscrews from the lower bearing blocks.
    - 13.2 Slide the lever assemblies forward until the bearing blocks can be removed from the channel on the base riser.
    - 13.3 Slide the lever assemblies aft to remove the slide blocks from the channel.
14. Remove the shoulder bolts and nuts from the pivots of the lever assemblies. Inspect the bolts; replace them if they are worn.

Installation

1. Replace the bearings at the pivots on the lever assembly by pushing out the old bearings and pressing in the new bearings. The flange on the bearings should be on the outside of the lever assembly.
2. Install the shoulder bolts and nuts in the pivots of the lever assemblies. Tighten the bolts 18 to 22 lbf·ft (24 to 30 N·m).
3. Install new bearing blocks, spacers, and slide blocks on the levers, with the beveled surfaces outward.
4. Slide the levers with the blocks into the channel on the base riser. Tighten the capscrews 27 to 33 lbf·ft (37 to 45 N·m).
5. Slide the upper frame assembly over the blocks. Align the capscrews with the bearing blocks, and tighten the capscrews 27 to 33 lbf·ft (37 to 45 N·m).
6. Manually move the suspension up and down to make sure there are no clearance problems.
7. With the wooden block in place between the base riser and the upper frame, install the air spring using the instructions in **Subject 100**.
8. Install the damper using the instructions in **Subject 140**.
9. Install the ICP bracket and capscrews.
10. Install the channel assembly using the instructions in **Subject 120**.
11. Install the seat/back assembly using the instructions in **Subject 110**.
12. Adjust the lateral (side) play using the instructions in **Subject 130**.
13. Install the seat assembly in the vehicle. Connect the air supply line to the seat.
14. If the seat assembly has a suspension cover, install the suspension cover and the fasteners.
15. Remove the chocks from the tires.

Suspension Rebuild Bearing/Slide Block Removal and Installation



1. Seat/Back Assembly
2. Channel Assembly
3. Capscrew
4. ICP Bracket
5. Upper Frame
6. Capscrew
7. Slide Block
8. Nut
9. Bearing Block
10. Base Riser
11. Capscrew
12. Fastener
13. Suspension Cover
14. Damper
15. Air Spring
16. Shoulder Bolt
17. Bearing
18. Slide Lever Assembly

Fig. 1, Bostrom Talladega 900 Series Seat

Basic Wiring Diagram

For the basic wiring diagram for the Bostrom power seat, see **Fig. 1**.

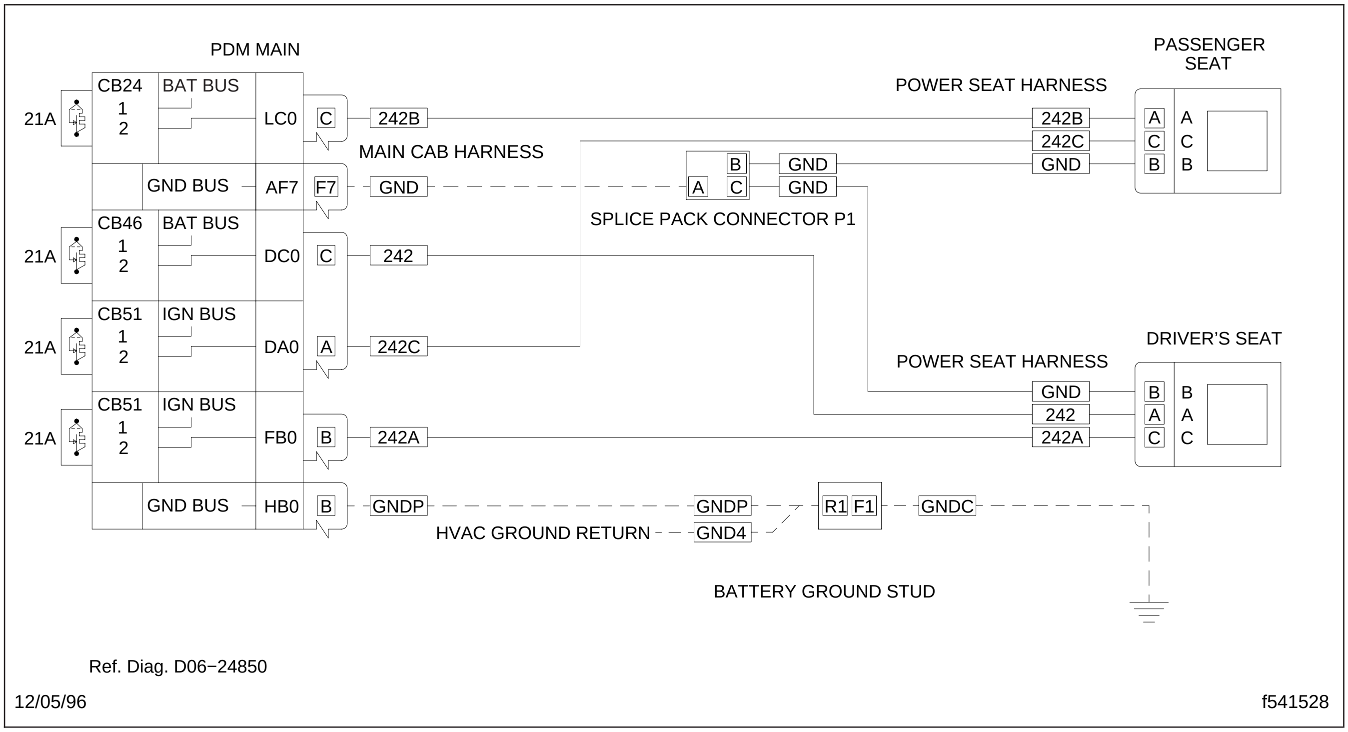


Fig. 1, Basic Wiring, Bostrom Power Seat

General Information

WARNING

Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.

Although the three-point seat belts installed in Freightliner vehicles appear similar to the seat belts used in passenger cars, there are some important differences that can affect service life:

- A heavy truck can travel more miles in a year than a car might go in its lifetime.
- There is more movement in a truck seat belt system, especially with air ride seats.
- Trucks often operate in more severe environments than cars, such as gravel pits, cement plants, and grain elevators, where the belts are exposed to abrasive dirt and dust.

Because of these factors, truck seat belt systems need to be inspected regularly to ensure that they are in proper condition; see **Subject 130**.

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

Seat Belt/Tether Belt Replacement

Replacement

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts. See **Fig. 1** and **Fig. 2**.

Any time a vehicle is involved in an accident, the entire seat-belt system must be replaced before operating the vehicle.

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Using an 11/16-inch socket or a T50 Torx® wrench, remove the capscrews from the following belt brackets:
    - For air-adjustable seats with seat-belt straps and, if equipped, tether belts, remove the brackets that attach the belts to the intermediate-connecting-point threaded rod. Remove and discard the buckle-side of the seat belt.
    - For air-adjustable seats with two tether-belt brackets, remove both brackets that attach the belts to the cab deck. Remove and discard the tether belts.
    - For static passenger seats, remove both seat-belt angled brackets that attach the belts to the cab deck. Remove and discard the buckle-side of the seat belt.
3. Using an 11/16-inch socket or a T50 Torx wrench, remove the seat-belt retractor.

    3.1 Remove the capscrews that attach the seat belt retractor to the lower cab wall.

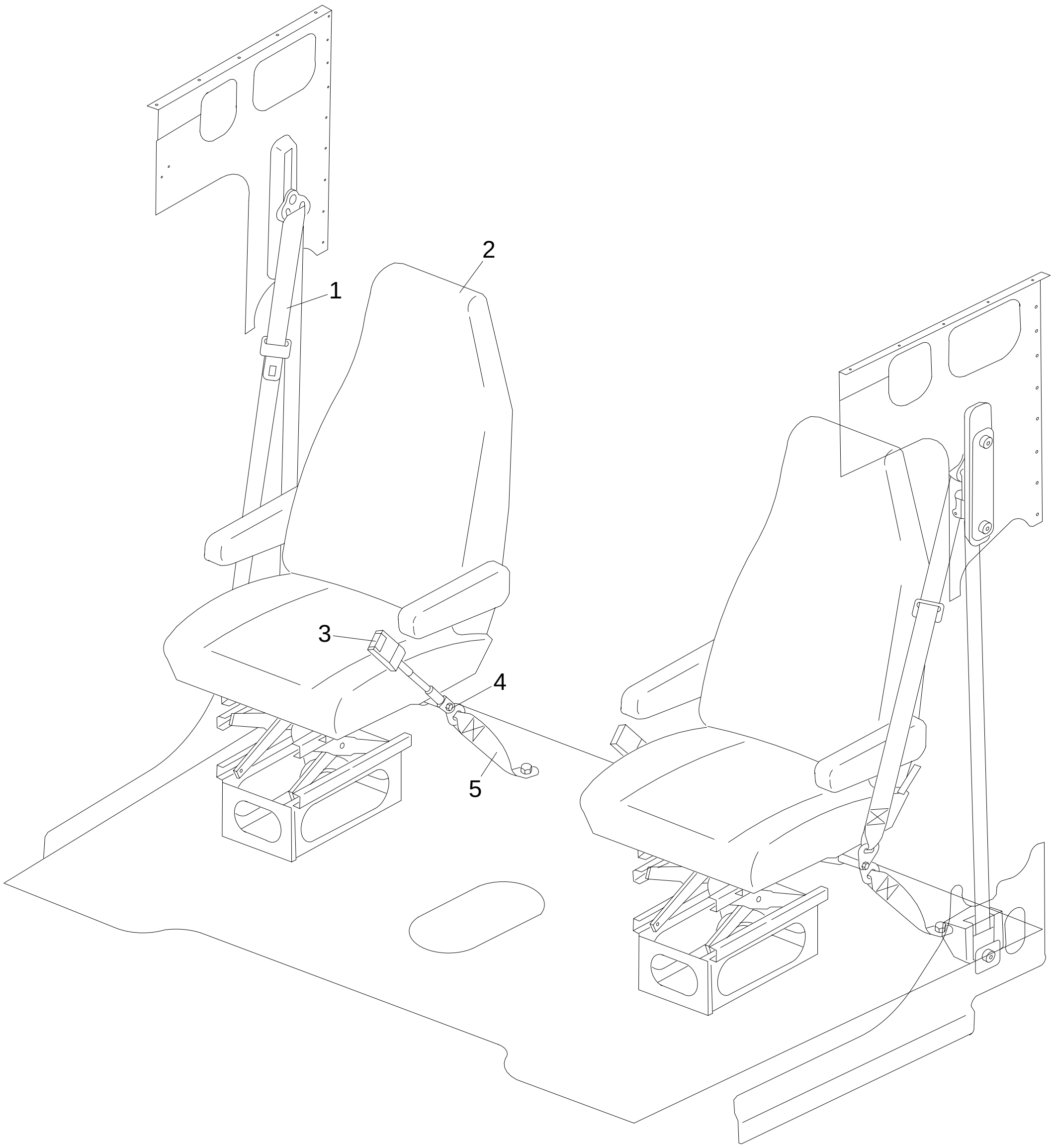
    3.2 Remove the T50 Torx-head capscrews that attach the adjustable D-loop mechanism to the upper cab wall.

    3.3 Remove and discard the retractor side of the seat belt.
4. Install the seat-belt retractor.

    4.1 Attach the adjustable D-loop mechanism of the new seat belt to the upper cab wall. Tighten the T50 Torx-head capscrews 40 lbf·ft (54 N·m).

    4.2 Attach the seat belt retractor to the lower cab wall. Tighten the capscrews 40 lbf·ft (54 N·m).
5. If tether belts are required for an air-adjustable seat, attach the angled brackets of the new tether belts to the cab floor. Tighten the capscrews 40 lbf·ft (54 N·m).
6. Install the seat-belt brackets.
    - For air-adjustable seats, insert the capscrews of the seat belt brackets through the straight brackets of the tether belts (if so equipped), and attach the brackets to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).
    - For static passenger seats, attach both seat-belt angled brackets to the cab deck. Tighten the capscrews 40 lbf·ft (54 N·m).
7. Remove the chocks from the tires.

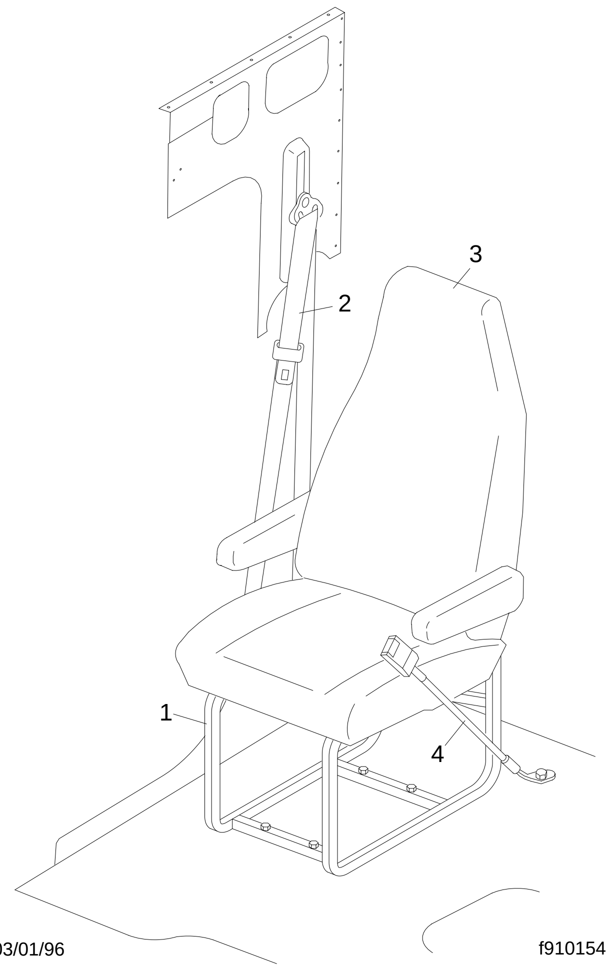
Seat Belt/Tether Belt Replacement



1. Seat Belt
2. Seat
3. Buckle
4. Intermediate Connection Point
5. Tether Belt

Fig. 1, Seat Belt/Tether Belt Assembly (dual adjustable seats shown)

Seat Belt/Tether Belt Replacement



1. Static Passenger Seat Frame
2. Seat Belt, Retractor Side
3. Seat
4. Seat Belt, Buckle Side

Fig. 2, Seat Belt Assembly (static passenger seat shown)

Bunk Restraint Removal and Installation

Removal

IMPORTANT: When any part of a restraint system needs replacement, the entire restraint system must be replaced.

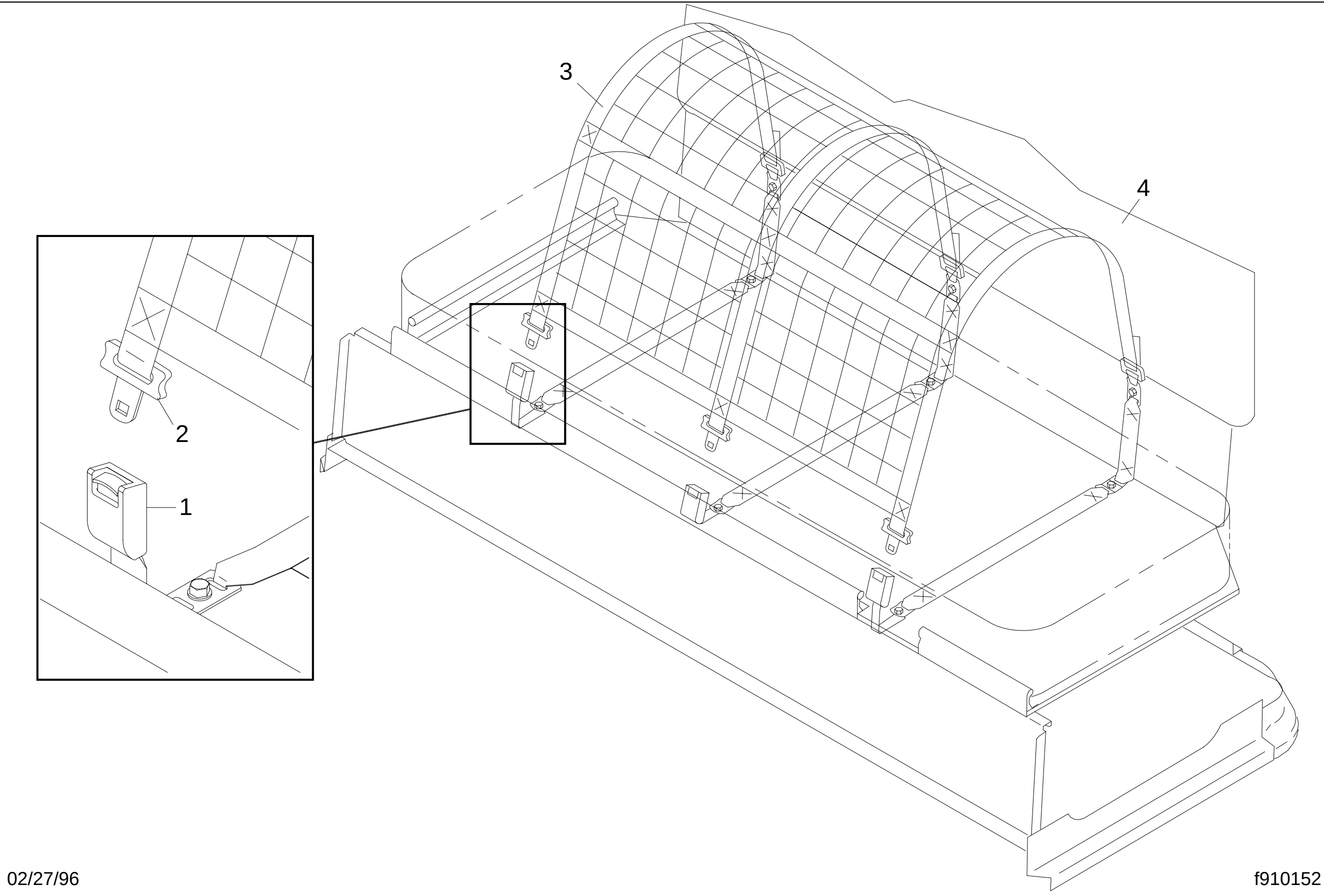
Any time a vehicle is involved in an accident, the entire restraint system must be replaced before again operating the vehicle.

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the rear tires.
2. Remove the mattress from the bunk.
3. Remove the bolt cover caps and hexhead bolts that attach the bunk restraint to the rear wall of the cab. See **Fig. 1**.
4. Remove the bolt cover caps and hexhead bolts from the bunk hatch. Lift the bunk hatch to access the hexnuts attached to the bolts.
5. Remove the bunk restraint.

Installation

1. Place the bunk restraint on the bunk.
2. Insert the hexhead bolts in the bunk-restraint bolt plates and the bunk hatch. Lift the hatch to install hexnuts on the bolts. Tighten the nuts 35 to 45 lbf·ft (47 to 61 N·m).
3. Lower the bunk hatch.
4. Install the hexhead bolts that attach the bunk restraint to the rear wall of the cab. Tighten the bolts 35 to 45 lbf·ft (47 to 61 N·m).
5. Attach the cover caps to all nine hexhead bolts.
6. Return the mattress to the bunk.
7. Remove the chocks from the tires.

Bunk Restraint Removal and Installation



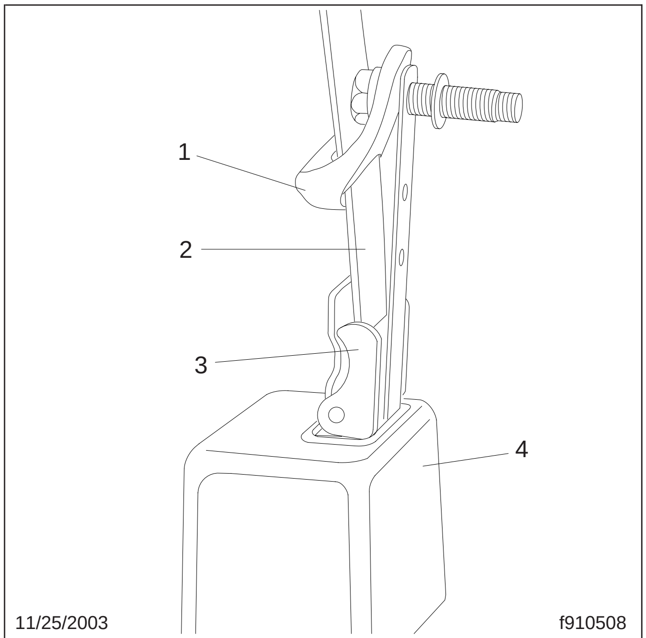
1. Buckle
2. Grip
3. Restraint
4. Rear Cab Wall

Fig. 1, Bunk Restraint Assembly

Unlocking an Installed Retractor

Seat belt retractors are locking up and preventing the webbing from being extracted. This condition is known as reverse lock-up and is caused by excessive webbing spooling into the retractor before installation in the vehicle.

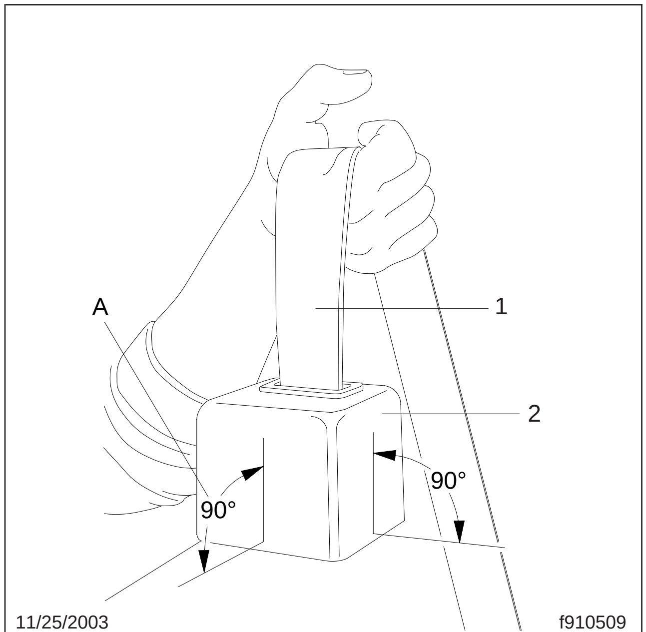
1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Verify that the retractor is mounted in the 90-degree position. See **Fig. 1**.
3. Firmly grasp the web close to the retractor. See **Fig. 2**.



1. Web Guide Loop
2. Web
3. Komfort Latch®
4. Retractor Cover

Fig. 1, Retractor in the 90-Degree Position

4. Pull on the web with enough force to tighten the web onto the spool until the webbing locks back onto the retractor. The retractor should unlock when tension is released.
5. Remove the chocks from the tires.



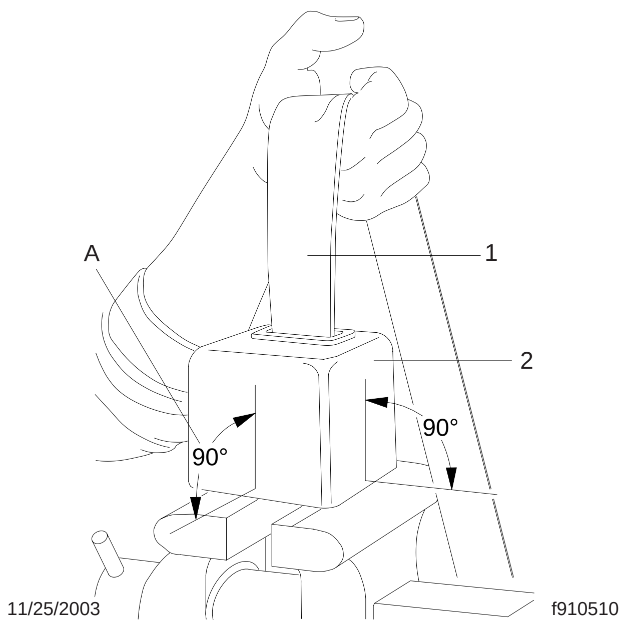
A. Orient the retractor at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 2, Firmly Grasp the Webbing

Unlocking an Uninstalled Retractor

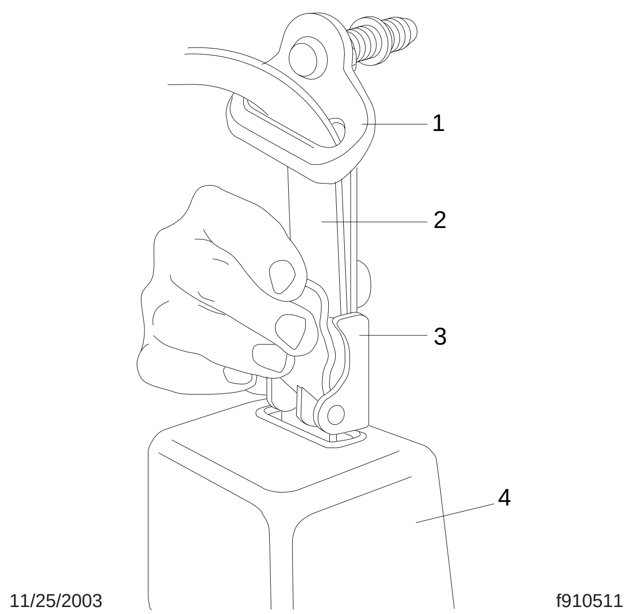
1. Clamp the retractor in a vice at a 90-degree angle. See **Fig. 3**.
2. Pull on the web with enough force to tighten the web onto the spool.
3. Release the web. This allows 1/2-inch (12.7-mm) of the webbing to feed back into the retractor storage housing and unlock the retractor.
4. Pull all the webbing out of the retractor, and allow only 12 to 15 inches (304 to 381 mm) to retract. Lock the Komfort Latch on the web. See **Fig. 4**.

Seat Belt Retractor Unlocking



A. Retractor oriented at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 3, Place the Retractor in a Vice



1. Web Guide Loop
2. Web
3. Komfort Latch
4. Retractor Cover

Fig. 4, Lock the Komfort Latch

Inspection

⚠ WARNING

Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.

Seat belts and tether belts have a finite life which may be much shorter than the life of the vehicle. Regular inspections and replacement as needed are the only assurance of adequate seat belt security over the life of the vehicle.

1. Check the web for fraying, cuts, extreme dirt and dust, or for severe fading from exposure to sunlight, especially near the buckle latch plate and in the D-loop guide area.
2. Check operation of the buckle, latch, Komfort Latch or Sliding Komfort Latch (if equipped), web retractor, and upper seat belt mount on the door pillar. Check all visible components for wear or damage.
3. Check the seat belt and tether belt connection points, and tighten any that are loose.

Air Bag Sensor Module Replacement

Replacement

NOTE: The following clockspring replacement procedure is for the air bag system that became available May 12, 2000.

NOTE: Before replacing the air bag sensor due to a lighted SRS warning lamp, make sure that all historic (inactive) fault codes are cleared. The SRS warning lamp will stay on even after the repairs indicated by the fault codes are corrected. After correcting the faults, use ServiceLink to clear all historic (inactive) codes. The SRS lamp should now be off, unless an uncorrected fault exists.

WARNING

Consider undeployed air bags to be dangerous and capable of deploying at any time. Before performing any work on the air bag system, review all service literature and comply with the following warnings and precautions. Unintentional or improper air bag deployment can result in injury or death.

Damaged or deployed air bag systems should be inspected for leaking propellant chemicals before any attempt is made to remove, replace, or handle the components. If a leak is found, contact LifeGuard Technologies (1-866-765-5835) for handling instructions.

- **Do not attempt to service or to dissassemble the air bag sensor module. The sensor module cannot be serviced.**
- **Do not cut, drill, braze, solder, weld, strike, or probe any part of the air bag sensor module.**
- **Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the air bag sensor module.**
- **Do not attempt to adapt, reuse, or install an air bag sensor module in any vehicle other than the specific vehicle for which it is designed.**
- **Do not cut wires or tamper with the connectors between the vehicle wiring harness and the air bag sensor module. Cutting or removing the electrical connectors could cause unintentional deployment of the air bags.**
- **Do not expose the air bag sensor module to electricity. Never probe a circuit.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

WARNING

Before removing the mounting capscrews from the sensor module, be sure to disconnect the batteries and disconnect the wiring from the sensor module. Failure to follow these precautions may result in the air bag being unintentionally deployed, which could cause severe bodily injury or death.

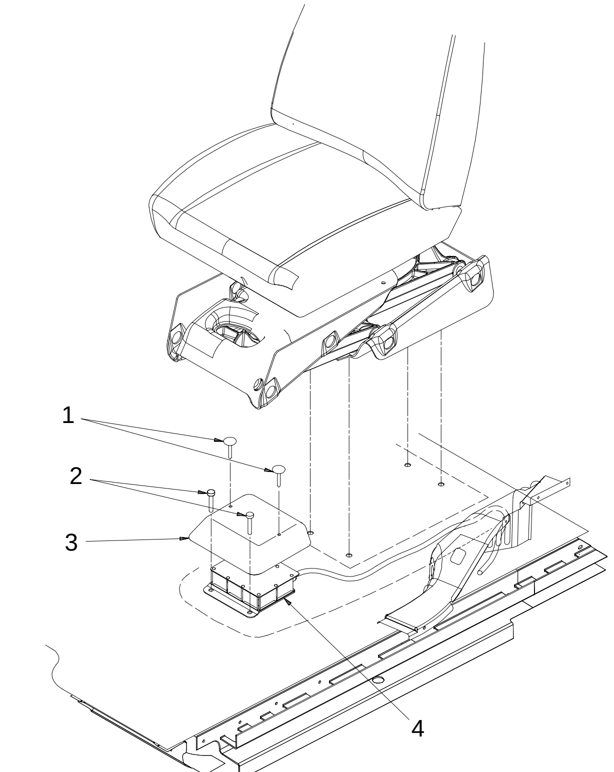
2. Disconnect the batteries and wait two minutes before proceeding.

WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag to deploy, resulting in severe bodily injury or death.

3. Raise the seat to its maximum position. If the seat is equipped with a seat shroud, lift the shroud to access the air bag sensor module.
4. Remove the plastic retainers that attach the sensor module cover to the sensor module and remove the cover. See **Fig. 1** or **Fig. 2**.
5. Disconnect the wiring from the sensor module at the AS2 connector under the B-pillar cover.
6. Remove the sensor module.
   - On vehicles with an EzyRider seat, remove the capscrews that attach the sensor module to the cab floor. See **Fig. 1**.
   - On vehicles with a nonproprietary seat, remove the capscrews that attach both the sensor module and the seat to the cab floor. The front mounting capscrews for the seat may need to be loosened to remove the sensor module. See **Fig. 2**.

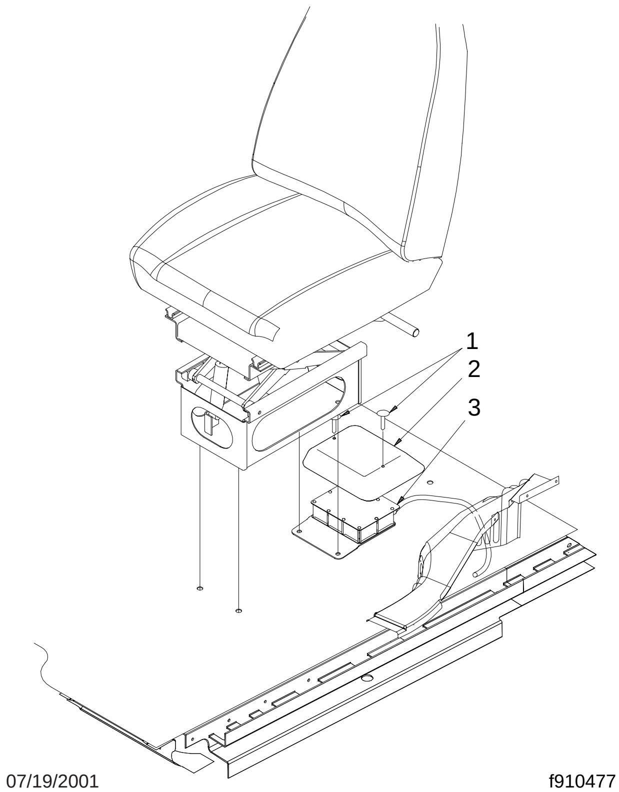
Air Bag Sensor Module Replacement



07/19/2001 f910476

1. Sensor Module Cover Plastic Retainer
2. Sensor Module Capscrew
3. Sensor Module Cover
4. Sensor Module

Fig. 1, EzyRider Seat With Air Bag Sensor Module



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1. Sensor Module Cover Plastic Retainer
2. Sensor Module Cover
3. Sensor Module

Fig. 2, Nonproprietary Seat With Air Bag Sensor Module

WARNING

Do not substitute the air bag sensor mounting fasteners. Use the fasteners provided with the sensor to ensure adequate engagement.

7. Install the new sensor module.
   - On vehicles with an EzyRider seat, use two capscrews to attach the sensor module to the cab floor. Tighten the capscrews 25 to 29 lbf·ft (34 to 39 N·m).
   - On vehicles with a nonproprietary seat, use two capscrews to attach both the sensor module and the seat to the cab floor. If the front mounting capscrews for the seat were loosened, tighten the capscrews. Tighten the capscrews 35 to 40 lbf·ft (47 to 54 N·m).

WARNING

Before attaching the wiring to the sensor module and before connecting the batteries, be sure to attach and tighten the mounting capscrews to the sensor module. Failure to follow these precautions may result in the air bag being unintentionally deployed, which could cause personal injury or property damage.

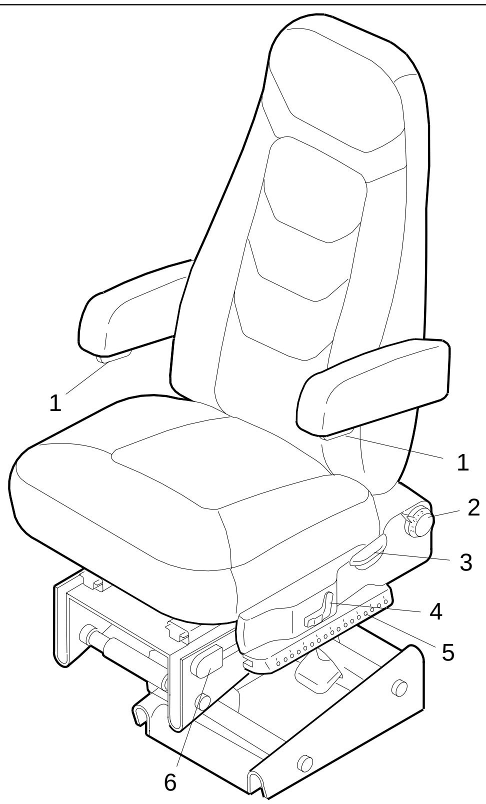
8. Attach the wiring to the sensor module.
9. Using two plastic retainers, attach the sensor module cover to the sensor module.

Air Bag Sensor Module Replacement

10. Lower the seat. If the seat is equipped with a seat shroud, lower the shroud around the base of the seat.
11. Connect the batteries.

General Information

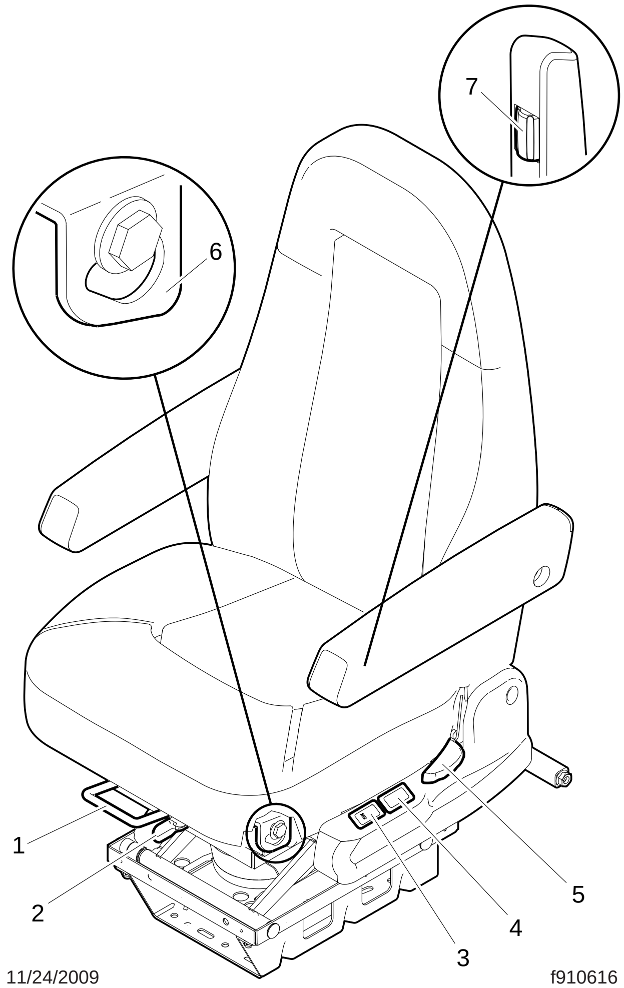
EzyRider seats (Fig. 1 and Fig. 2) offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, seat cushion tilt, and armrest adjustment. The air suspension and height-adjustment features are provided by an air spring that receives air pressure from the vehicle air system; pressure in the air spring is controlled by a switch attached to the seat frame. Each seat is equipped with a shock absorber to dampen unwanted up-and-down motion of the seat. An isolator reduces the amount of road shock by isolating the occupant from the motion of the vehicle. A lockout feature is used whenever the isolator is not desired.



06/24/2005 f910555

1. Armrest Adjustment Knob
2. Back Cushion Tilt Position Indicator
3. Back Cushion Tilt Lever
4. Height Adjustment and Lumbar Support Lever
5. Fore/Aft Seat Position Indicator
6. Isolator and Fore/Aft Seat Adjustment Lever

Fig. 1, EzyRider Seat (early model)



11/24/2009 f910616

1. Fore/Aft Seat Adjustment Lever
2. Isolation Adjustment
3. Height Adjustment
4. Lumbar Support Switch
5. Back Cushion Tilt Lever
6. Bottom Cushion Angle Guide
7. Armrest Adjustment

Fig. 2, EzyRider Seat (from May 2010)

The availability and configuration of the seat adjustment features may vary from those shown. For detailed operating instructions and descriptions of all seat adjustment features, refer to the *Columbia® Driver's Manual*.

Seat Removal and Installation

Removal

1. Apply the parking brake and chock the tires.
2. Press the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. Remove the seat suspension skirt (if equipped) from the seat base.
4. Secure the seat suspension in the extended position, using the method appropriate to the suspension type, as described below.

   For seats equipped with a scissor-type suspension, bind the two cross-rods together with a large tie strap, at either the top or bottom of the fully extended scissor arms.

   For seats equipped with a parallel arm suspension, cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.

WARNING

Do not remove the seat without first draining the seat air spring, and using an appropriate method to secure the seat suspension in the extended position. If the seat suspension is not properly secured, the seat could lower unexpectedly, pinching a hand or finger between the suspension parts, resulting in personal injury.

5. Drain the vehicle air reservoirs. Then press the seat-height adjustment switch until all the air is exhausted from the air spring.

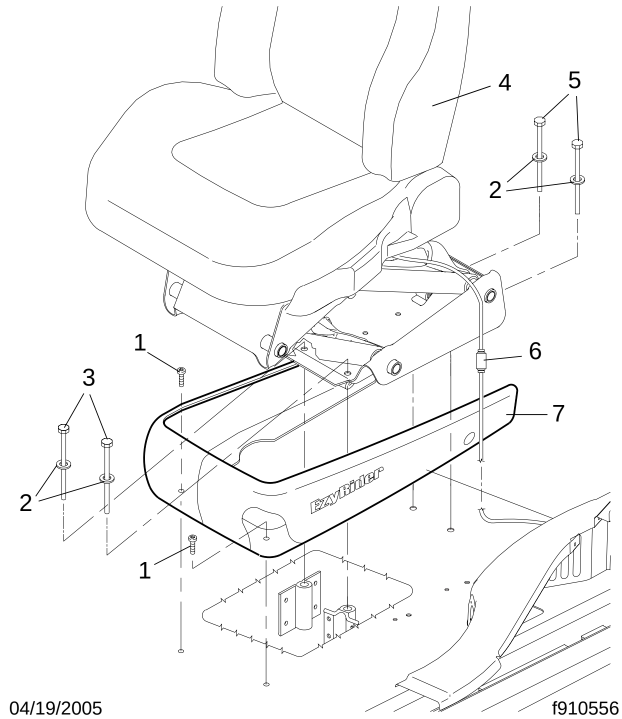
WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

6. Remove the seat heel guard (if equipped) as follows. See **Fig. 1**.

   6.1 Remove the two capscrews that attach the heel guard to the cab deck.

   6.2 Loosen the four capscrews that attach the seat to the cab deck.



1. Torx Capscrew, T20
2. Washer
3. Torx Capscrew, Long T50 (qty. 2)
4. Seat
5. Torx Capscrew, Short T50 (qty. 2)
6. Air Supply Quick-Connect Union
7. Heel Guard

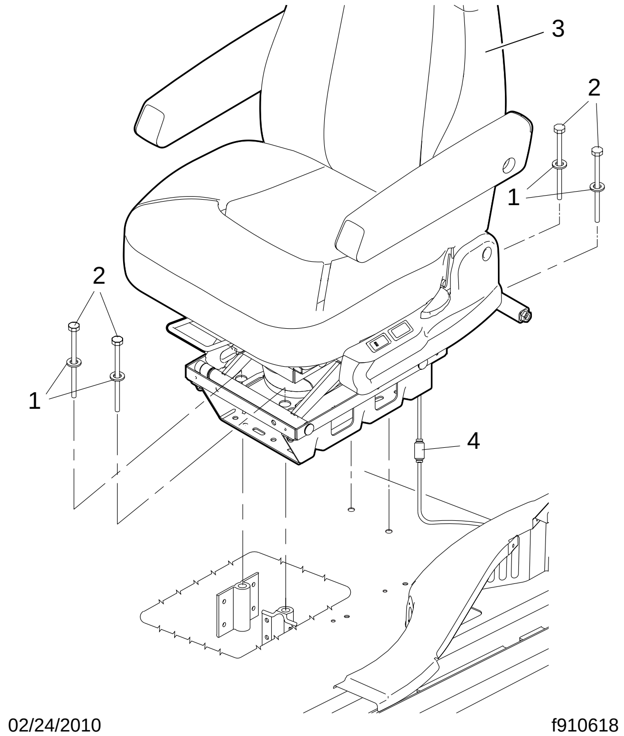
Fig. 1, EzyRider Seat Installation (with heel guard)

   6.3 Slide the heel guard, first backward to unseat the locating bosses from the holes in the seat base, then forward to unseat the bottom flange from under the outer edges of the seat base. Remove the heel guard.

7. Disconnect the air valve air-supply hose at the quick-connect union behind the seat. See **Fig. 1** or **Fig. 2**.
8. Remove the capscrews that attach the seat and tether belts to the intermediate-connecting-point (ICP) rod.

NOTE: On day cab models it may be necessary to detach the seat from the cab deck before removing the seat-belt strap.

Seat Removal and Installation



1. Washers
2. Capscrews
3. Seat
4. Air Supply Quick-Connect Union

Fig. 2, EzyRider Seat Installation (from May 2010)

9. Remove the four capscrews and the washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base, as shown in **Fig. 1** or **Fig. 2**.

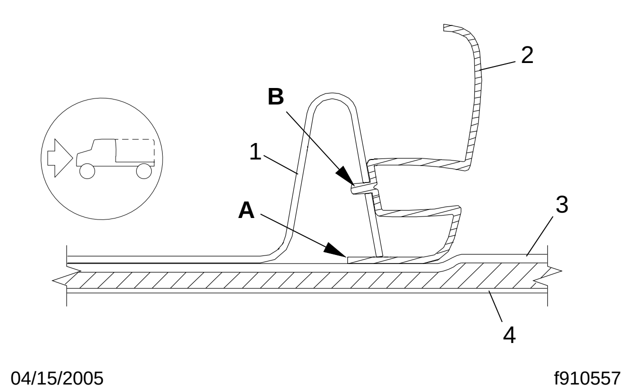
   If equipped with a heel guard, do not tighten the capscrews until the heel guard is installed.

   If not equipped with a heel guard, tighten the capscrews 25 to 29 lbf·ft (34 to 39 N·m).

NOTE: On day cab models it may be necessary to first attach the seat-belt strap.

2. Attach the seat and tether belts to the intermediate-connecting-point (ICP) rod. Tighten the capscrews 35 to 50 lbf·ft (47 to 68 N·m).
3. Connect the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
4. Install the seat heel guard (if equipped) as follows.

   4.1 Place the heel guard around the seat base, first sliding it backward to seat the bottom flange under the outer edge of the seat base on both sides, then forward to seat the locating bosses in the holes in the seat base. See **Fig. 3**.



A. Slide the bottom flange of the heel guard under the outer edge of the seat base.
B. Insert the heel guard locating bosses into the holes on the seat base.

1. Seat Base
2. Heel Guard
3. Floor Covering
4. Cab Deck

Fig. 3, Installing the Heel Guard

   4.2 Tighten the four capscrews that attach the seat to the cab deck 25 to 29 lbf·ft (34 to 39 N·m).

   4.3 Attach the front of the heel guard to the cab deck with the two capscrews.

5. Start the engine and allow the air reservoirs to fill. Adjust the seat to its maximum height, then remove the tie strap or block that supports the suspension in the extended position.
6. Install the seat suspension skirt (if equipped).

Air Spring Replacement

NOTE: The following procedure applies to vehicles built before May 2010.

Replacement

1. Apply the parking brake and chock the tires.
2. Press the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. Pull the slide lever, and slide the seat to the forward position.
4. Lift the suspension skirt up and out of the way.
5. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.

WARNING

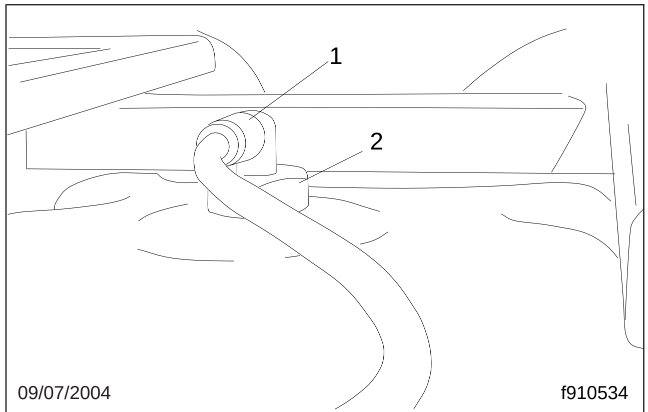
Do not remove the air spring without first draining the air from it, and securing the seat suspension with a block. If the seat suspension is not properly secured, the seat could lower unexpectedly, pinching a hand or finger between the suspension parts, resulting in personal injury.

6. Drain the vehicle air reservoirs. Then press the seat-height adjustment switch until all the air is exhausted from the air spring.

WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

7. Remove the air line from the air spring. See **Fig. 1**.
8. Remove the air fitting from the top of the air spring.
9. Remove the nut that secures the air spring to the spring plate.
10. Use a 9/16-inch socket wrench to remove the lower air spring bolt.
11. Remove the air spring.
12. Install the new air spring.



1. Air Line Fitting
2. Spring Plate Mounting Nut

Fig. 1, Air Line and Fitting

13. Install the spring plate mounting nut and torque 130 lbf·in (1470 N·cm).
14. Install the air fitting and tighten securely. Make sure that the fitting is oriented forward.
15. Cut 1/4 inch (6 mm) off of the air line using a hose cutter.
16. Insert the air line into the air fitting.
17. Apply Loctite™ 454 to the bottom six threads of the mounting bolt. See **Fig. 2**.

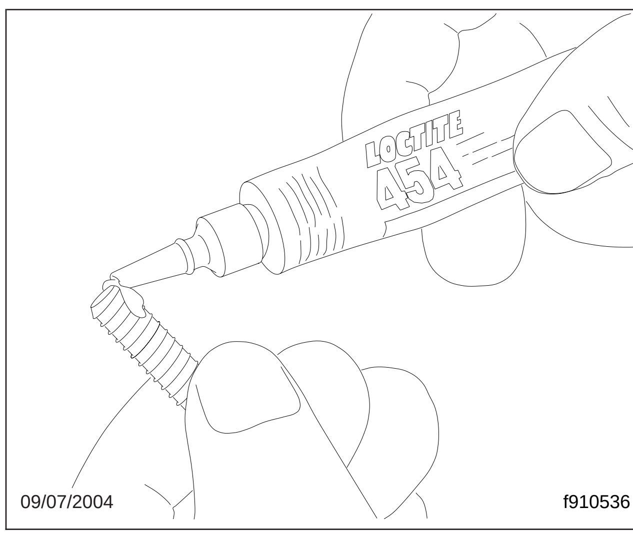


Fig. 2, Apply Loctite to the Bottom Six Threads

Air Spring Replacement

18. Install the bolt through the bottom casting of the seat to the air spring and tighten the bolt 45 lbf·in (510 N·cm).
19. Start the engine and allow the air reservoirs to fill. Adjust the seat to its maximum height.
20. Remove the block.

Specifications

Torque Specifications				
Fastener Description	**lbf·ft**	**N·m**	**lbf·in**	**N·cm**
Seat/Tether Belt-to-ICP Bar Capscrews	35–50	47–68	—	—
Seat Mounting Capscrews	25–29	34–39	—	—
Spring Plate Mounting Nut (vehicles built before May 2010)	—	—	130	1470
Air Spring Mounting Bolt (vehicles built before May 2010)	—	—	45	510

Table 1, Torque Specifications

General Information

⚠ DANGER

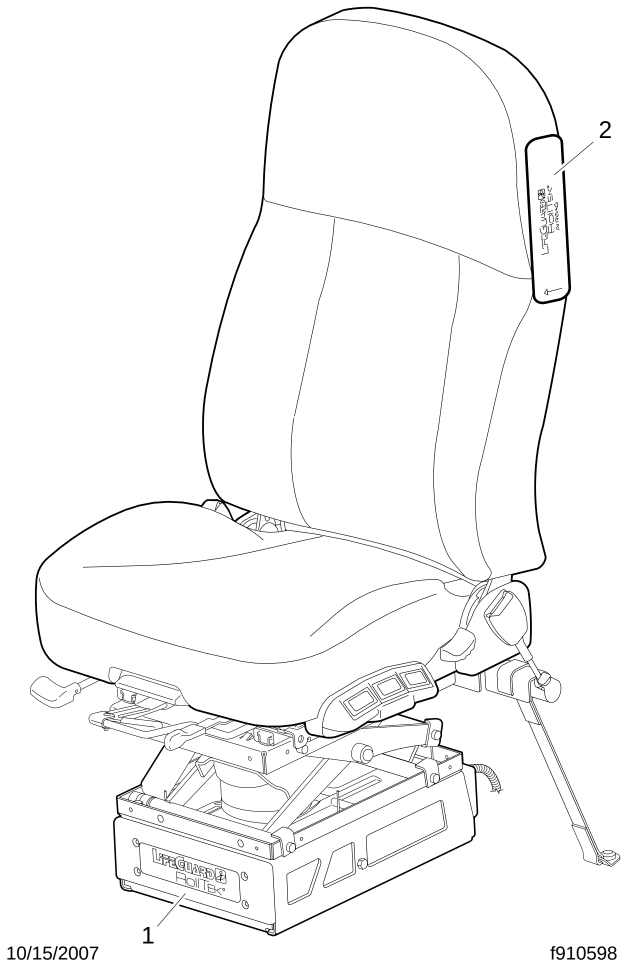
Do not place objects on the seat back or block the side-roll air bag. Objects that block the side-roll air bag may prevent proper inflation and may increase the potential for serious injury or death.

The RollTek system, when used with seat belts, provides additional protection to the driver and passenger (if equipped with a passenger-side system) in rollover accidents. The RollTek system provides a significant increase in seat stability during a rollover.

Vehicles equipped with RollTek rollover protection have a sensor mounted in the seat base that activates the side-roll air bag and seat pull-down device during a rollover; see **Fig. 1**. When the RollTek module senses a rollover, the module triggers gas cylinders mounted in the base of the seat. The gas cylinders activate the power cinches that then tighten the lap and shoulder belts against the occupant of the seat and lower the seat suspension, moving the occupant down and away from the steering wheel and ceiling. The side-roll air bag deploys from the outboard side of the seat as the seat is pulled down to its lowest position.

Damaged seat belts and tethers, or seat belts and tethers that were worn in an accident, must be replaced, and their anchoring points must be checked.

The operational readiness of the RollTek system is indicated by the supplemental restraint system (SRS) indicator on the dash. The SRS indicator comes on for approximately 10 seconds when the engine is started and then goes off. The indicator will remain on if there is a problem with the air bag or RollTek system. The vehicle must be serviced if the SRS indicator does not come on when the engine is started or if the SRS indicator remains on.



1. RollTek Module
2. Side-Roll Air Bag Cover

Fig. 1, RollTek Protection System Components

Safety Precautions

⚠ WARNING

Before performing any work on the RollTek system, review all service literature and comply with the following warnings and precautions. Unintentional or improper deployment of the RollTek system can result in injury or death.

Damaged or deployed RollTek systems should be inspected for leaking propellant chemicals before any attempt is made to remove, replace, or handle the components. If a leak is found, contact LifeGuard Technologies (1-866-765-5835) for handling instructions.

- **Do not attempt to modify the RollTek system. Doing so could change the effectiveness of the system. The RollTek system must be replaced after being activated.**
- **Do not attempt to service or to disassemble the RollTek module. The RollTek module cannot be serviced.**
- **Do not attempt to deploy an undeployed pyrotechnic inflator device, such as the RollTek Rollover Protection module. For disposition of an undeployed pyrotechnic inflator device, please contact LifeGuard Technologies (1-866-765-5835) for handling and forwarding instructions.**
- **Do not cut, drill, braze, solder, weld, strike, or probe any part of the RollTek system. Air bags and seat cylinders contain explosives and pressurized gas that can be dangerous if punctured, damaged, or cut.**
- **Keep all liquids, acids, halogens, heavy metals, and heavy salts away from the RollTek system.**
- **Do not remove the RollTek sensors from the mounted locations if connected. Movement from a connected sensor can deploy the devices. The sensors should not be removed except for replacement.**
- **Do not connect electrical power to the RollTek module or sensors unless they are securely mounted in their designated locations.**
- **Do not attempt to adapt, reuse, or install a RollTek system in any vehicle other than the specific vehicle for which it is designed.**
- **Keep hands and tools away from the scissor points under the seats.**
- **Do not cut wires or tamper with the connectors between the vehicle wiring harness and the RollTek system. Cutting or removing the electrical connectors could cause unintentional deployment.**
- **Do not expose the RollTek system to electricity. Never probe a circuit.**
- **Store, transport, dispose, and recycle deployed RollTek system components in accordance with all applicable federal, state, and local regulations.**
- **Replace damaged seat belts, or seat belts that were worn in an accident, and check all anchoring points.**
- **The RollTek system requires a special seat belt. Care must be taken to ensure the correct seat belt is used.**
- **The seat must be attached to the RollTek module and seat riser with the capscrews and spacers provided with the module.**
- **Always disconnect the SRS system when welding on the vehicle.**
- **Before connecting or disconnecting the SRS sensors, always turn the battery switch to OFF and disconnect the batteries, then wait one minute before connecting or disconnecting the sensors.**

The RollTek system contains components with pyrotechnic inflator devices, which use combustible chemicals. The RollTek module and the air bags have inflators. Use care when replacing or handling these system components.

For disposition of a deployed pyrotechnic inflator device, follow and comply with any current and applicable state laws.

RollTek Module Replacement

Replacement

IMPORTANT: Prior to performing any service work on the RollTek Rollover Protection System, perform the diagnostic check using the procedure under "Diagnostics" in **Troubleshooting 300**.

WARNING

Before attempting to service the RollTek system, read and comply with the precautions in Subject 060. Failure to do so may result in severe injury or death.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Lower the side window. In the event of an accidental deployment, an open window will prevent the pressure wave created by deploying air bags from damaging cab components.

WARNING

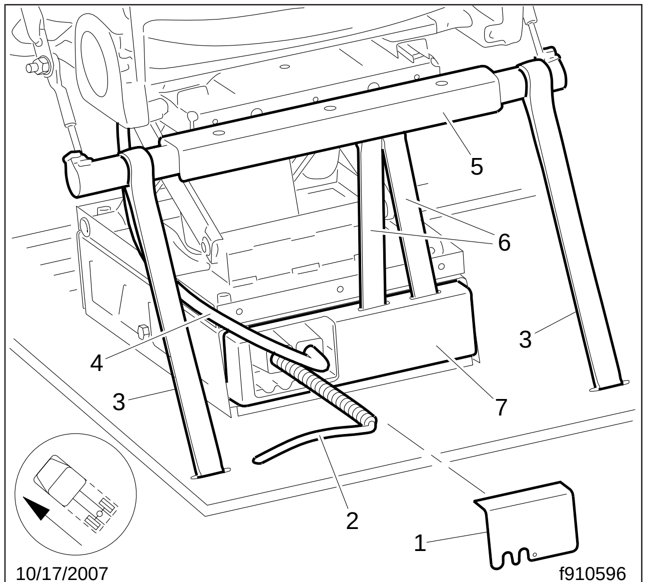
Before removing the mounting capscrews from the RollTek module, be sure to disconnect the batteries and disconnect the wiring from the module. Failure to follow these precautions may result in the air bag(s) being unintentionally deployed, which could cause severe bodily injury or death.

3. Turn the battery disconnect switch to the OFF position (if so equipped). Disconnect the batteries and wait two minutes before proceeding.

WARNING

Wait two minutes after disconnecting the batteries to allow the internal components to discharge. Failure to allow the components to discharge could cause the air bag and pretensioner to deploy, resulting in severe bodily injury or death.

4. Raise the seat to its maximum position. If the seat is equipped with a seat shroud, remove or lift the shroud to access the RollTek module.
5. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle. Wear the connected grounding strap while working with the RollTek module and wiring.
6. Remove the access panel from the back of the RollTek module; see **Fig. 1**.

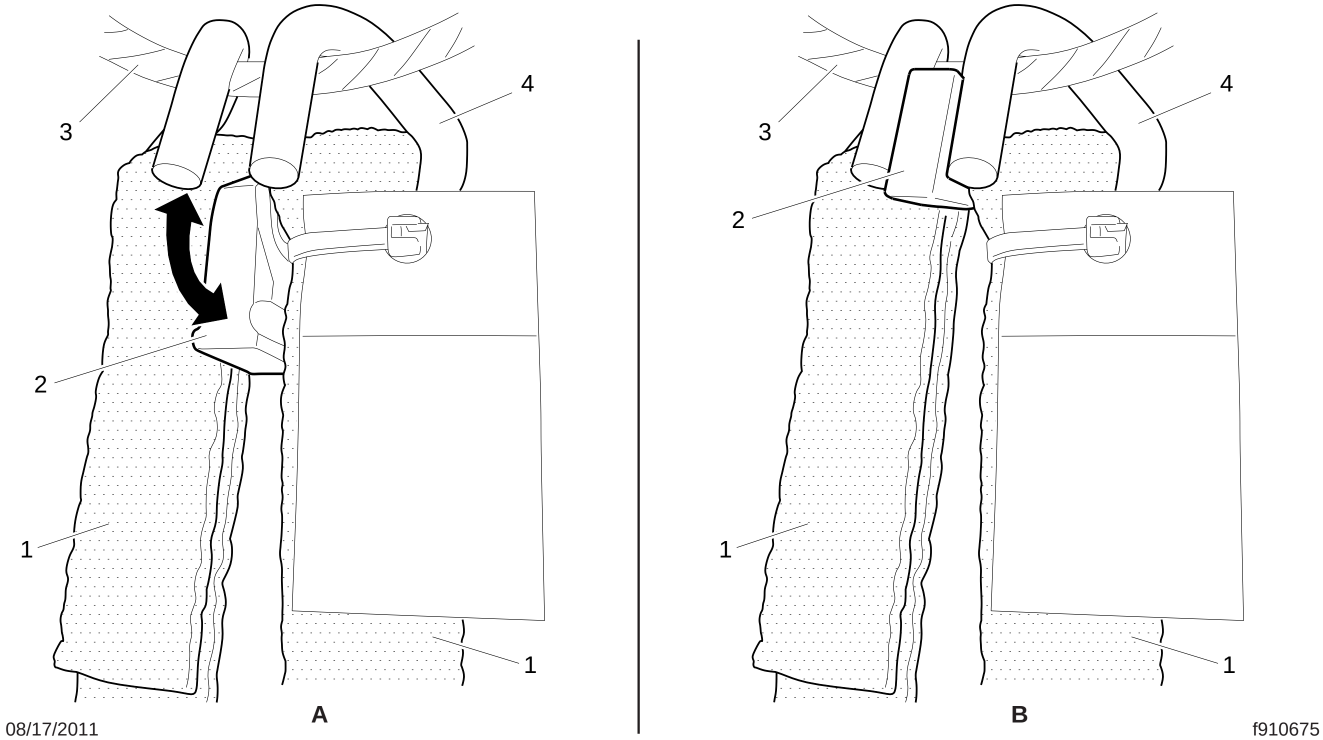


1. Access Panel
2. Cab Harness
3. Tether
4. Side-Roll Air Bag Harness
5. Intermediate-Connecting-Point (ICP) Bar
6. Pull-Down Straps
7. RollTek Module

Fig. 1, RollTek Module Wiring Access

7. Disconnect the wiring from the back of the RollTek module.
8. Rotate the rubber keeper down to release the pulldown-strap hook from the seat belt pretensioner cable; see **Fig. 2**.
9. Lower the seat to its mid-height position.
10. Unhook the pulldown straps from the seat belt pretensioner cable.
11. Raise the seat to its maximum height position.
12. Remove the four capscrews and spacers that attach the RollTek module to the seat and to the seat riser; see **Fig. 3**. Slide the RollTek module forward, out of the seat riser.

RollTek Module Replacement

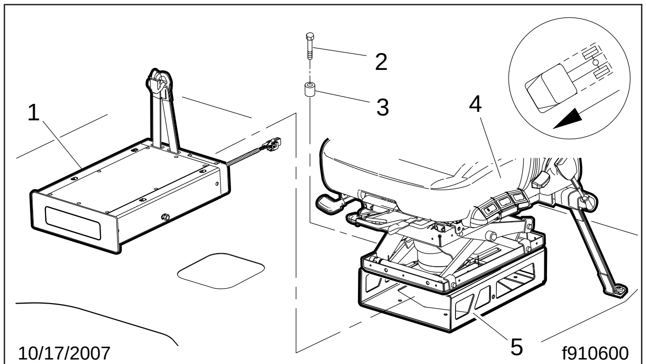


A. Rotate rubber keeper to release/secure the pulldown-strap hook.

B. Rubber keeper rotated in place to secure the pulldown-strap hook to the pretensioner cable.

1. Pull-Down Straps
2. Rubber Keeper
3. Pretensioner Cable
4. Hook

Fig. 2, Pulldown-Strap Hook, J1939 RollTek System



1. RollTek Module
2. Capscrew
3. Spacer
4. Seat
5. Seat Riser

Fig. 3, RollTek Module Installation

WARNING

Do not substitute the RollTek module mounting fasteners. Use the fasteners provided with the module to ensure adequate engagement.

13. Install the new RollTek module using the capscrews and spacers provided with the module. Make sure that the module is oriented correctly, with the arrow on the top pointed to the front of the vehicle, and that the mounting surface is flat, with no foreign objects inside the riser. Tighten the capscrews 16 to 18 lbf·ft (22 to 24 N·m).

WARNING

Before attaching the wiring to the RollTek module and before connecting the batteries, be sure to attach and tighten the mounting capscrews to the

RollTek module. Failure to follow these precautions may result in the air bag(s) being unintentionally deployed, which could cause personal injury or property damage.

14. Lower the seat to its mid-height position.
15. Hook the pulldown straps to the seat belt pretensioner cable; see **Fig. 2**.
16. Rotate the rubber keeper up to secure the pulldown-strap hook to the seat belt pretensioner cable; see **Fig. 2**.
17. Raise the seat to its maximum height position.
18. Connect the wiring to the RollTek module, and place the connectors inside the recess on the back of the module; see **Fig. 1**.
19. Install the access panel over the recess on the back of the RollTek module.
20. Lower the seat. If the seat is equipped with a seat shroud, install or lower the shroud.
21. Connect the batteries. Turn the battery disconnect switch (if so equipped) to the ON position.
22. Verify that no one is in the cab, and while standing outside the cab and clear of the driver's seat, turn the ignition key to the ON position for a few seconds, then turn it to the OFF position.

NOTE: Do not turn the ignition key past the ON position to START.

23. Follow the diagnostic procedure to test for proper installation; see **Troubleshooting 300**.

WARNING

Before attempting to service the RollTek system, read and comply with the precautions in Subject 060. Failure to do so may result in severe injury or death.

Terms and Abbreviations

CGW Central Gateway

FMI Failure Mode Indicator. The part of a J1939 fault code that identifies how part of a device, or item on a device, failed.

ICU Instrumentation Control Unit

SPN Suspect Parameter Number

General Information

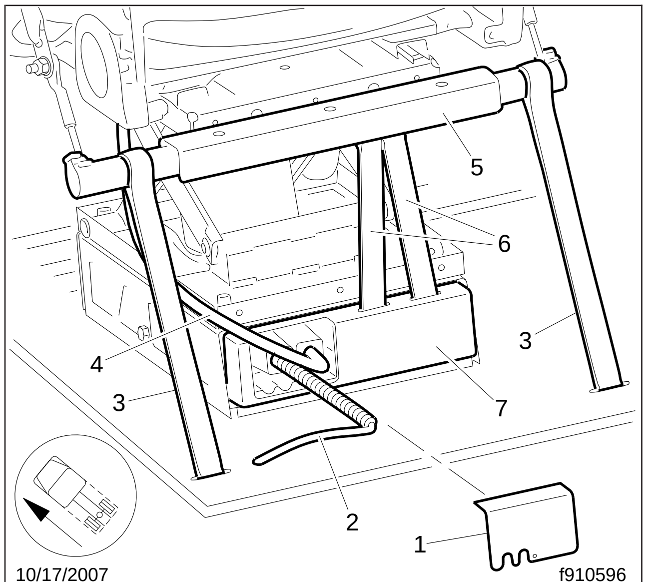
The J1939 RollTek system uses the AB10 sensor, with sensing elements that detect both frontal impact and side roll events. Even if battery power is lost during an event, deployment of restraint devices will still be possible through its energy reserve capacitors. Upon deployment, crash-relevant parameters are saved in the AB10 sensor.

System diagnostics continuously monitor internal AB10 functions and external circuits. Fault conditions are indicated using the SRS fault lamp and communicated over the SAE J1939 data bus.

When the ignition is turned on, the AB10 performs an initialization that takes approximately six seconds. The SRS fault lamp is on during this time.

The number of igniter circuits the AB10 controls is parameterized, based on vehicle content. There are five different configurations for the AB10 system:

- Driver Frontal Impact Protection—controls a driver frontal air bag and only uses the AB10 sensor.
- Driver Side Roll Protection—controls the driver's seat belt pretensioner and side air bag. The AB10 is internal to the RollTek Module; see **Fig. 1**.
- Driver Frontal and Side Roll Protection—controls the drivers seat belt pretensioner, frontal, and side air bag. The AB10 is internal to the RollTek module.
- Driver and Passenger Side Roll Protection—controls the driver's and passenger's seat belt pretensioners. The AB10 is internal to the RollTek module under the driver's seat. The RollTek module under the passenger's seat is used only for deploying the passenger-side seat belt pretensioner.
- Driver and Passenger Frontal and Side Roll Protection—controls the driver's and passenger's seat belt pretensioners, and the frontal and side air bags. The AB10 is internal to the RollTek module under the driver's seat. The RollTek module under the passengers seat is used only for deploying the passenger-side seat belt pretensioner and the passenger-side air bag.



1. Access Panel
2. Cab Harness
3. Side-Roll Air Bag Harness
4. Seat Back
5. Pull-Down Straps
6. RollTek Module

Fig. 1, RollTek Module

Diagnostic Tool

The diagnostic procedures described in this subject require the following tool:

- ServiceLink connected to J1939

Troubleshooting

Diagnostics

The RollTek system is powered by ignition circuit 454 from the main PDM. The 5-amp fuse feeding circuit 454 receives ignition power through circuit 81C. Circuit 81C is sourced through the main PDM on the 15-amp circuit breaker CB13.

The RollTek/AB10 system communicates over the J1939 data bus and is assigned the source address 83 (0x53).

The operational readiness of the RollTek system is indicated by the supplemental restraint system (SRS) indicator on the dash. The SRS indicator comes on for approximately 10 seconds when the engine is started and then goes off. The indicator will remain on if there is a problem with the air bag or RollTek system. The vehicle must be serviced if the SRS indicator does not come on when the engine is started or if the SRS indicator remains on.

WARNING

Before performing any service, deactivate the SRS system by turning off the ignition and battery switch. Do NOT service a live system. Accidental deployment could cause serious injury and property damage.

Prior to performing any service work on the RollTek Rollover Protection System, it is necessary to determine the nature and exact cause of the problem, using the applicable diagnostic procedure in this subject.

1. Determine the appropriate service procedure based on the information provided by the active fault code(s).
2. Complete the service procedure, then clear fault codes following specific fault clearing instructions, if identified in the procedure.
3. Turn the ignition OFF. After 5 seconds, turn it back ON, and verify that no RollTek faults are active.

Fault Codes

ICU3 J1939 Fault Codes				
SPN (Dec)	**FMI (Dec)**	**Description**	**Connector/ Pin**	**Action**
624	03	Warning Lamp Circuit Out of Range High	A-E	Troubleshoot for a wiring fault on circuit 454L between the RollTek module and the ICU. This fault can also be set if the lamp in the ICU has been replaced with one that does not draw the amperage that the RollTek module expects.
	04	Warning Lamp Circuit Out of Range Low		
	05	Warning Lamp Circuit Current Low or Open		
	06	Warning Lamp Circuit Current High or Short to Battery		
	31	Warning Lamp Circuit Cross Coupling		
	14	Warning Lamp Circuit Configuration		

<table>
<tr><th colspan="5">ICU3 J1939 Fault Codes</th></tr>
<tr><th>SPN (Dec)</th><th>FMI (Dec)</th><th>Description</th><th>Connector/ Pin</th><th>Action</th></tr>
<tr><td rowspan="6">4818</td><td>03</td><td>Driver Front Air Bag Circuit Out of Range High</td><td rowspan="6">B-1
B-2</td><td rowspan="6">Follow the disconnect sequence:
1. Disconnect the batteries and wait one minute.
2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle.
3. Disconnect all RollTek module connectors.
4. Disconnect the driver's front air bag connector at the steering column.
With the air bag disconnected and placed aside, troubleshoot for a wiring fault with the clockspring and on circuits 454A+ and 454A– between the RollTek module and the driver's front air bag connector at the clockspring. If no wiring fault is found, place a 2.2Ω +/-5% 1/4-watt resistor across the 454A+ and 454A– circuits in the vehicle side of the harness. Reconnect the RollTek module but leave the driver's front air bag disconnected. Connect the batteries, then turn on the ignition without starting the engine.
If the fault does not reset as active, replace the air bag. If the fault is still active, replace the RollTek module from under the driver's seat; see Subject 100.</td></tr>
<tr><td>04</td><td>Driver Front Air Bag Circuit Out of Range Low</td></tr>
<tr><td>05</td><td>Driver Front Air Bag Circuit Current Low or Open</td></tr>
<tr><td>06</td><td>Driver Front Air Bag Circuit Current High</td></tr>
<tr><td>31</td><td>Driver Front Air Bag Circuit Cross Coupling</td></tr>
<tr><td>14</td><td>Driver Front Air Bag Circuit Configuration</td></tr>
<tr><td rowspan="6">4822</td><td>03</td><td>Driver Buckle Pretensioner Circuit Out of Range High</td><td rowspan="6">Internal</td><td rowspan="6">Internal circuit fault with the driver-side buckle pretensioner. Replace the RollTek module; see Subject 100.</td></tr>
<tr><td>04</td><td>Driver Buckle Pretensioner Circuit Out of Range Low</td></tr>
<tr><td>05</td><td>Driver Buckle Pretensioner Circuit Current Low or Open</td></tr>
<tr><td>06</td><td>Driver Buckle Pretensioner Circuit Current High</td></tr>
<tr><td>31</td><td>Driver Buckle Pretensioner Circuit Cross Coupling</td></tr>
<tr><td>14</td><td>Driver Buckle Pretensioner Circuit Configuration</td></tr>
</table>

Troubleshooting

<table>
<tr><th colspan="5">ICU3 J1939 Fault Codes</th></tr>
<tr><th>SPN (Dec)</th><th>FMI (Dec)</th><th>Description</th><th>Connector/ Pin</th><th>Action</th></tr>
<tr><td rowspan="6">4823</td><td>03</td><td>Passenger Buckle Tension Interconnect Circuit Out of Range High</td><td rowspan="6">D-1
D-2
E-1
E-2</td><td rowspan="6">Follow the disconnect sequence:
1. Disconnect the batteries and wait one minute.
2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle.
3. Disconnect all Rolltek module connectors from all Rolltek modules.
Troubleshoot for a wiring fault on circuits 454C+ and 454C– between the driver-side Rolltek module connector D, pins 1 and 2, and the passenger-side Rolltek module connector E, pins 1 and 2. Repair any wiring fault that is found.</td></tr>
<tr><td>04</td><td>Passenger Buckle Tension Interconnect Circuit Out of Range Low</td></tr>
<tr><td>05</td><td>Passenger Buckle Tension Interconnect Circuit Current Low or Open</td></tr>
<tr><td>06</td><td>Passenger Buckle Tension Interconnect Circuit Current High</td></tr>
<tr><td>31</td><td>Passenger Buckle Tension Interconnect Circuit Cross Coupling</td></tr>
<tr><td>14</td><td>Passenger Buckle Tension Interconnect Circuit Configuration</td></tr>
<tr><td rowspan="6">4824</td><td>03</td><td>Driver Side Air Bag Circuit Out of Range High</td><td rowspan="6">C-1
C-2</td><td rowspan="6">1. Turn off the ignition and wait one minute.
2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle.
3. Unzip the driver-side seat back cover and locate the connectors in the lower outboard area of the seat back. See Fig. 2. Disconnect the yellow connector that connects to the Rolltek module to the driver-side air bag.
4. Place a 2.2Ω +/– 5% 1/4-watt resistor in the connector on the side of the harness from the Rolltek module. This resistor will simulate the air bag that will remain disconnected.
5. Turn the ignition on without starting the engine. If the fault does not reset as active, replace the air bag. If the fault remains active, troubleshoot for and repair a fault in the wiring to the Rolltek module. If no wiring fault is found, replace the Rolltek module; see Subject 100.</td></tr>
<tr><td>04</td><td>Driver Side Air Bag Circuit Out of Range Low</td></tr>
<tr><td>05</td><td>Driver Side Air Bag Circuit Current Low or Open</td></tr>
<tr><td>06</td><td>Driver Side Air Bag Circuit Current High</td></tr>
<tr><td>31</td><td>Driver Side Air Bag Circuit Cross Coupling</td></tr>
<tr><td>14</td><td>Driver Side Air Bag Circuit Configuration</td></tr>
</table>

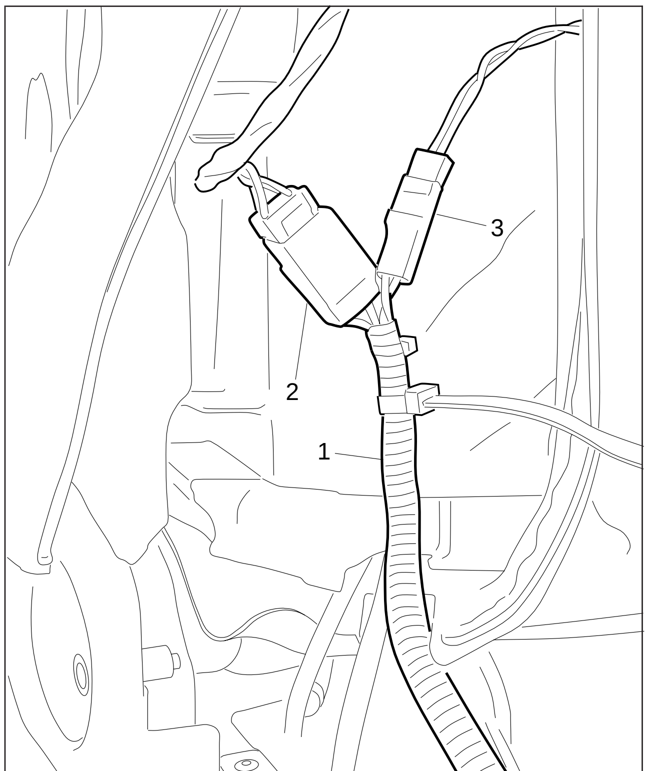
<table>
<tr><th colspan="5">ICU3 J1939 Fault Codes</th></tr>
<tr><th>SPN (Dec)</th><th>FMI (Dec)</th><th>Description</th><th>Connector/ Pin</th><th>Action</th></tr>
<tr><td rowspan="6">4826</td><td>03</td><td>Passenger Side Air Bag Circuit Out of Range High</td><td rowspan="6">D-3
D-4
E-3
E-4
F-1
F-2</td><td rowspan="6">Follow the disconnect sequence:
1. Disconnect the batteries and wait one minute.
2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle.
3. Disconnect all Rolltek module connectors from all Rolltek modules.
Troubleshoot for and repair a wiring fault on circuits 454C+ and 454C– between the driver-side Rolltek module connector D, pins 3 and 4, and the passenger-side Rolltek module connector E, pins 3 and 4.
If there is no wiring fault, unzip the passenger-side seat back cover and locate the connectors in the lower outboard area of the seat back. See Fig. 2. Disconnect the yellow connector for the wiring from the Rolltek module to the side air bag.
1. Place a 2.2Ω +/– 5% 1/4-watt resistor in the yellow connector on the side of the harness from the passenger-side Rolltek module. This resistor will simulate the air bag that will remain disconnected.
2. While wearing the ground strap, reconnect all the other Rolltek module connectors.
3. Turn the ignition on without starting the engine. If the fault does not reset as active, replace the air bag. If the fault remains active, troubleshoot for and repair a fault in the wiring to the Rolltek module. If no wiring fault is found, replace the Rolltek module; see Subject 100.</td></tr>
<tr><td>04</td><td>Passenger Side Air Bag Circuit Out of Range Low</td></tr>
<tr><td>05</td><td>Passenger Side Air Bag Circuit Current Low or Open</td></tr>
<tr><td>06</td><td>Passenger Side Air Bag Circuit Current High</td></tr>
<tr><td>31</td><td>Passenger Side Air Bag Circuit Cross Coupling</td></tr>
<tr><td>14</td><td>Passenger Side Air Bag Circuit Configuration</td></tr>
</table>

Troubleshooting

<table>
<tr><th colspan="5">ICU3 J1939 Fault Codes</th></tr>
<tr><th>SPN (Dec)</th><th>FMI (Dec)</th><th>Description</th><th>Connector/ Pin</th><th>Action</th></tr>
<tr><td rowspan="5">4952</td><td>03</td><td>Driver Side Seat Belt Buckle Circuit Out of Range High</td><td rowspan="5">G-1
G-2
I-1
I-2</td><td rowspan="5">1. Turn off the ignition and wait one minute.
2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle.
3. Unzip the driver-side seat back cover and locate the connectors in the lower outboard area of the seat back. See Fig. 2. Disconnect the smaller white connector that connects to the Rolltek module to the driver-side seat belt buckle.
4. Measure resistance across the seat belt buckle (white) connector with the seat belt latched and unlatched. The latch circuit should measure 100Ω when the seat belt is latched and 400Ω when the seat belt is unlatched. If the resistance measurement is significantly different than these values, replace the seat belt buckle assembly.
5. If the seat belt buckle side of the circuit passes all testing, troubleshoot for and repair a wiring fault in the harness between the Rolltek module and the connector.
6. If there is no wiring fault, replace the Rolltek module; see Subject 100.</td></tr>
<tr><td>04</td><td>Driver Side Seat Belt Buckle Circuit Out of Range Low</td></tr>
<tr><td>05</td><td>Driver Side Seat Belt Buckle Circuit Current Low or Open</td></tr>
<tr><td>06</td><td>Driver Side Seat Belt Buckle Circuit Current High</td></tr>
<tr><td>31</td><td>Driver Side Seat Belt Buckle Circuit Cross Coupling</td></tr>
<tr><td rowspan="5">4953</td><td>03</td><td>Passenger Side Seat Belt Buckle Circuit Out of Range High</td><td rowspan="5">H-1
H-2
I-1
I-2</td><td rowspan="5">1. Turn off the ignition and wait one minute.
2. Connect an anti-static grounding strap from your wrist to a ground surface on the vehicle.
3. Unzip the passenger-side seat back and locate the connectors in the lower outboard area of the seat back. See Fig. 2. Disconnect the smaller white connector that connects the Rolltek module to the passenger-side seat belt buckle.
4. Measure resistance across the seat belt buckle (white) connector with the seat belt latched and unlatched. The latch circuit should measure 100Ω when the seat belt is latched and 400Ω when the seat belt is unlatched. If the resistance measurement is significantly different than these values, replace the seat belt buckle assembly.
5. If the seat belt buckle side of the circuit passes all testing, troubleshoot for and repair a wiring fault in the harness between the Rolltek module and the connector.
6. If there is no wiring fault, replace the Rolltek module; see Subject 100.</td></tr>
<tr><td>04</td><td>Passenger Side Seat Belt Buckle Circuit Out of Range Low</td></tr>
<tr><td>05</td><td>Passenger Side Seat Belt Buckle Circuit Current Low or Open</td></tr>
<tr><td>06</td><td>Passenger Side Seat Belt Buckle Circuit Current High</td></tr>
<tr><td>31</td><td>Passenger Side Seat Belt Buckle Circuit Cross Coupling</td></tr>
<tr><td>4973</td><td>14</td><td>Deployment Event</td><td>—</td><td>The Rolltek controller has deployed an air bag or seat belt pretensioner. Contact the Customer Assistance Center at 1-800-385-4357 or 1-800-FTL-HELP.</td></tr>
<tr><td>32512</td><td>14</td><td>Not Programmed—Container 1</td><td>—</td><td>The Rolltek ECU is not programmed/configured with application parameters. Replace the Rolltek module; see Subject 100.</td></tr>
</table>

ICU3 J1939 Fault Codes				
SPN (Dec)	FMI (Dec)	Description	Connector/ Pin	Action
32513	14	Not Programmed—Container 2	—	The Rolltek ECU is not programmed/configured with application parameters. Replace the Rolltek module; see **Subject 100**.
36590	12	Internal Fault	—	The Rolltek module has an internal fault. Do not issue a Clear Fault (DM3) message. Replace the Rolltek module; see **Subject 100**.
49267	11	CAN Bus Off	A-C A-D	Fault with CAN communications. Troubleshoot for a circuitry fault with CAN-H and CAN-L.
61696	03	Vbat Out of Range High	A-A	The operating voltage range is 8–16 volts. Troubleshoot for a fault with the vehicle charging system; see **Group 15** and **Section 54.02**.
	04	Vbat Out of Range Low	A-B	

Table 1, ICU3 J1939 Fault Codes



NOTE: Driver's side shown, with seat back cover unzipped.

1. Harness to RollTek Module
2. Driver-Side Air Bag Connector
3. Driver-Side Seat Belt Switch Connector

Fig. 2, Seat Back Connectors

Torque Specifications

For fastener torque values, see **Table 1**.

Torque Specifications		
Fastener Description	**lbf·ft**	**N·m**
RollTek Module Mounting Screws	16–18	22–24

Table 1, Torque Specifications

Connectors

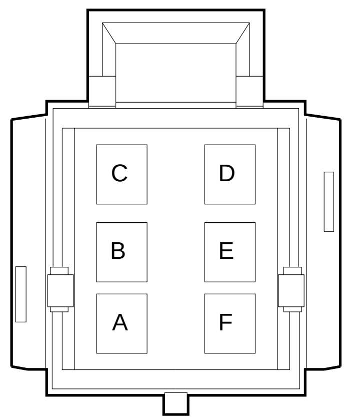
<table>
<tr><th colspan="5">6-Pin Communication and Power Connector Pin Destination</th></tr>
<tr><td colspan="5">Connector Manufacturer: Packard
Housing Part Number: 12064754
Secondary Lock Part Number: 12064755
Terminal Part Number: 12034047
Color: Black

f545796
Connector Front View</td></tr>
<tr><th>Connector Name</th><th>Location</th><th>Pin</th><th>Wire Color</th><th>Description</th></tr>
<tr><td rowspan="5">A</td><td rowspan="5">B-Pillar (frontal only) or on RollTek Module</td><td>A</td><td>Red</td><td>+12V</td></tr>
<tr><td>B</td><td>Black</td><td>Ground</td></tr>
<tr><td>C</td><td>Yellow</td><td>J1939 (+)</td></tr>
<tr><td>D</td><td>Green</td><td>J1939 (–)</td></tr>
<tr><td>E</td><td>White</td><td>Warning Lamp</td></tr>
</table>

Table 2, 6-Pin Communication and Power Connector Pin Destination

Specifications

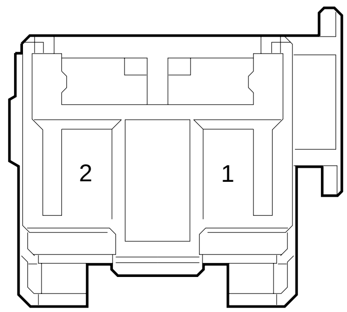
2-Pin Front Air Bag Connector Pin

Connector Manufacturer: Tyco

Housing Part Number: 348794-4

Terminal Part Number: 173645-3

Color: Yellow



f545797

Wire Insertion Side

Connector Name	Location	Pin	Wire Color	Description
B	On RollTek Module	1	Blue	Driver Front Air Bag (+)
		2	White	Driver Front Air Bag (–)

Table 3, 2-Pin Front Air Bag Connector Pin

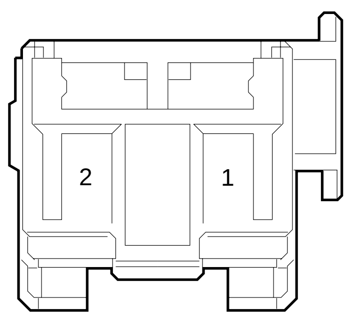
2-Pin Driver-Side Air Bag Connection

Connector Manufacturer: Tyco

Housing Part Number: 348794-4

Terminal Part Number: 173645-3

Color: Yellow



f545797

Wire Insertion Side

Connector Name	Location	Pin	Wire Color	Description
C	Back of Driver Seat	1	Blue	Driver SRA (+)
		2	White	Driver SRA (–)

Table 4, 2-Pin Driver-Side Air Bag Connection

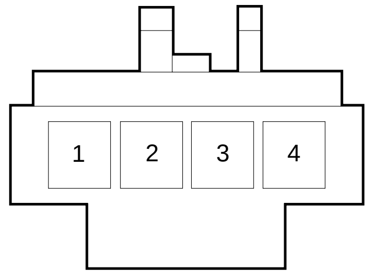
4-Pin Signal to Deploy Passenger-Side Pyrotechnics

Connector Manufacturer: FCI

Housing Part Number: 54550400

Terminal Part Number: 54001803

Color: Yellow



f545798

Wire Insertion Side

Connector Name	Location	Pin	Wire Color	Description
D	Inside Driver-Side Component Box	1	Orange	Passenger S4 (+)
		2	White	Passenger S4 (–)
		3	Yellow	Passenger SRA (+)
		4	White	Passenger SRA (–)

Table 5, 4-Pin Signal to Deploy Passenger-Side Pyrotechnics

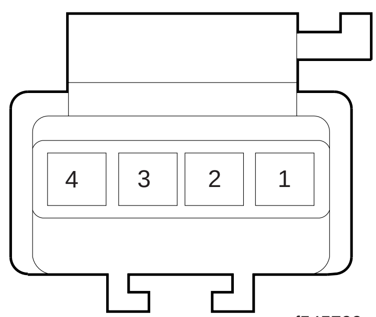
4-Pin Passenger Side Pyrotechnics

Connector Manufacturer: FCI

Housing Part Number: 54550402

Terminal Part Number: 54001819

Color: Yellow



f545799

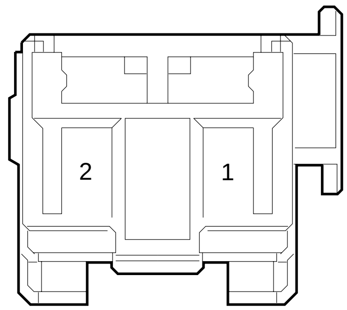
Wire Insertion Side

Connector Name	Location	Pin	Wire Color	Description
E	Inside Passenger-Side Component Box	1	Blue/ Orange	Passenger S4 (+)
		2	Gray/White	Passenger S4 (–)
		3	Yellow	Passenger SRA (+)
		4	White	Passenger SRA (–)

Table 6, 4-Pin Passenger Side Pyrotechnics

Specifications

2-Pin Passenger-Side Air Bag				
Connector Manufacturer: Tyco Housing Part Number: 348794-4 Terminal Part Number: 173645-3 Color: Yellow				
Connector Name	Location	Pin	Wire Color	Description
F	Back of Driver Seat	1	Blue	Passenger SRA (+)
		2	White	Passenger SRA (–)

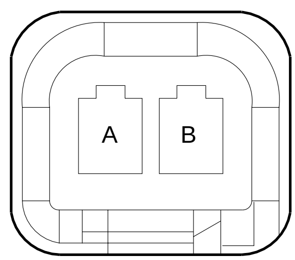


f545797

Wire Insertion Side

Table 7, 2-Pin Passenger-Side Air Bag

Driver's Buckle Connector				
Connector Manufacturer: Packard Housing Part Number: 12047663 Lock Part Number: 12047665 Terminal Part Number: 12047581 Color: Black				
Connector Name	Location	Pin	Wire Color	Description
G	Back of Driver Seat from AB10-ECU	A	Gray	Driver's Buckle (+)
		B	White	Driver's Buckle (–)

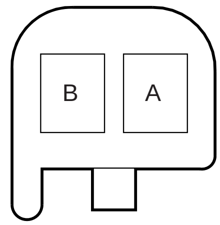


f545800

Connector Front Side

Table 8, Driver's Buckle Connector

Passenger Buckle Switch From AB10-ECU				
Connector Manufacturer: Packard Housing Part Number: 12047662 Lock Part Number: 12047664 Terminal Part Number: 12047767 Color: Black				



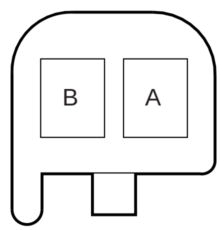
f545801

Connector Front Side

Connector Name	Location	Pin	Wire Color	Description
H	Inside Driver's Component Box	A	Gray	Driver's Buckle (+)
		B	White	Driver's Buckle (–)

Table 9, Passenger Buckle Switch From AB10-ECU

Buckle Connector Passenger and Driver				
Connector Manufacturer: Packard Housing Part Number: 12047662 Lock Part Number: 12047664 Terminal Part Number: 12047767 Color: Black				



f545801

Connector Front Side

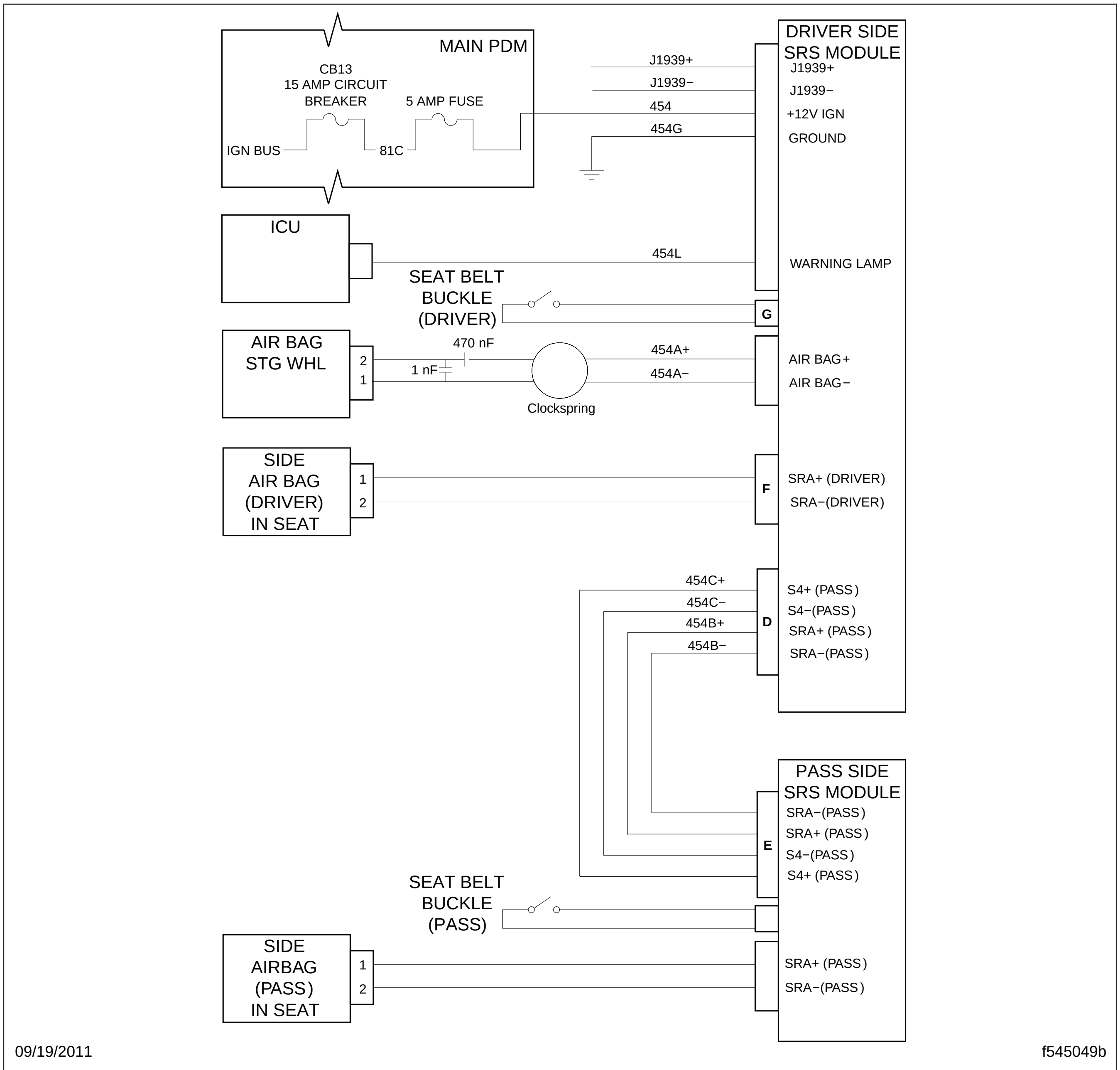
Connector Name	Location	Pin	Wire Color	Description
I	End of Buckle Harness (driver and passenger)	A	Gray	Driver's Buckle (+)
		B	White	Driver's Buckle (–)

Table 10, Buckle Connector Passenger and Driver

SRS Wiring Schematic

For the SRS wiring schematic, see **Fig. 1**.

Specifications



NOTE: Not all components may be installed.

Fig. 1, SRS Wiring Schematic

General Information

Freightliner Trucks applies DuPont® single-stage Imron® 5000 high-solids polyurethane enamel on the vehicle cab at the factory.

Black high-solids polyurethane or Imron 5000 is used on the vehicle chassis. The chassis includes the frame, spoke spider, running gear, and any components attached to the frame. Fuel tanks are not painted.

To meet the federal air quality regulations imposed by the EPA and local jurisdictions, these products contain low levels of volatile organic compounds (VOCs), and are formulated free of lead and chrome.

The procedures in this section are for use with DuPont products. Unless otherwise noted, all products are manufactured by E. I. du Pont de Nemours and Company, Inc. Obtain approval from a Daimler Trucks North America Regional Office for use of topcoats produced by other manufacturers.

Color-Matching

Imron 5000 is the recommended aftermarket paint for color-matching factory-applied paint on both the cab a chassis.

NOTE: The black high-solids polyurethane applied to the chassis at the factory is sold to original equipment manufacturers (OEMs) only, and is not available for aftermarket sale. Use Imron 5000, N0001 Black, for repainting.

To determine the correct paint number for color-matching any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. Refer to Chapter 1 in the *Columbia Driver's Manual* for the location of this decal.

General Guidelines

This subject provides instructions for preparing large panels or the entire cab for topcoating with DuPont® products. For spot repairs or touch-ups, see **Subject 120**.

Before topcoating, the surface must be thoroughly cleaned and sanded. Any bare areas must also be conditioned and primed.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.

CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Preparation for Prime Coat

Use the cleaners and conditioners specified in each step to prepare the surface for priming. See **Specifications, 400** for a summary of the products used in this procedure.

WARNING

Do not use solvent-based cleaners on large areas of plastic or fiberglass, such as the hood or air fairing. Wiping down these large areas may cause a buildup of static electricity. The resulting spark could cause a flash fire, which could result in personal injury or property damage.

Cab and Hood Preparation

1. Wash and dry the entire vehicle with a mild detergent.
2. Wipe all surfaces to be painted with a clean cloth soaked with solvent or cleaner. Remove all traces of wax, polish, grease, and silicones.
    - Metal—use DuPont Prep-Sol 3919 S.
    - Plastic—use DuPont Plastic Prep 2319 S.
    - Fiberglass—use DuPont Prep-N-Solv.

    2.1 Work on small areas at a time, wetting the surface liberally.

    2.2 Quickly wipe the surface with a clean cloth before the solvent or cleaner has a chance to dry. Change cloths frequently.
3. Feather the edge of all repaired areas, chipped surfaces, and scratches.

    3.1 Cut down the edges of broken spots with no. 220 sandpaper.

    3.2 Feather the edges by hand, using a sanding block with no. 400 sandpaper.
4. Sand the entire area to be painted. Using a sanding block and no. 400 sandpaper, remove the gloss to improve adhesion of the primer.
5. Using a clean cloth soaked with cleaner, remove any sanding dust.
    - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
    - Fiberglass—use a solution of one part water and one part isopropyl alcohol (IPA).
6. Treat bare metal and rusted areas.
    - Aluminum—use DuPont 225 S aluminum cleaner.
    - Steel—use DuPont 5717 S metal conditioner.

    6.1 Mix one part of the cleaner with two parts of water in a plastic bucket.

    6.2 Apply the cleaner with a cloth or sponge. If corrosion is present, work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.

    6.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the surface to dry before applying a conversion coating.
7. Apply a conversion coating to all bare metal.
    - Aluminum—use DuPont 226 S aluminum conversion coating.
    - Steel—use DuPont 5718 S metal conversion coating.

Preparing for Topcoating

- Zinc casings or galvanized surfaces (iron or steel)—use DuPont 5718 S metal conversion coating.

7.1 Pour the conversion coating into a plastic container (do not dilute). Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to the metal surface. Work only as much area as can be coated and rinsed before the solution dries.

7.2 Leave the coating on the surface for two to five minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

If the metal surface dries before rinsing, reapply the conversion coating, then repeat the previous substep.

7.3 Wipe the surface dry with a clean cloth, or air dry.

8. With paper and tape, mask all areas that are not to be painted.

Air Fairing Kit Preparation

Before installing a new air fairing, prepare the surface for topcoating.

1. Wash the air fairing with a mild detergent. Dry with a clean, absorbent, lint-free cloth or paper towels.
2. Using a clean cloth soaked with DuPont Prep-N-Solv, wipe the entire surface to remove any trace of grease or oil.
3. Scuff-sand the air fairing with no. 320 grit sandpaper.
4. Wipe the air fairing with a clean cloth soaked in a solution of one part water and one part isopropyl alcohol. Allow 10 to 15 minutes for the air fairing to dry.
5. With tape and paper, mask all areas that are not to be painted.

Prime Coat

Prime all bare and feathered areas before topcoating. The specified primers can be used on any surface.

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

3. Prime all bare metal and feathered areas with DuPont Corlar® 824 S epoxy primer.

3.1 Stir Corlar 824 S primer thoroughly.

3.2 Mix two parts Corlar 824 S primer with one part DuPont 826 S activator.

3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

3.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

3.5 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (0.018 to 0.025 mm).

3.6 Clean equipment immediately after use with DuPont 3602 S lacquer thinner.

3.7 Air dry 2 hours or force dry 20 minutes.

4. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.
5. Dry the surface. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use solution of 1 part water and 1 part isopropyl alcohol (IPA).

General Guidelines

This subject provides instructions for applying a topcoat of DuPont® enamel to full panels or the entire cab. For spot repairs or touch-ups, see **Subject 120**.

CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer. See **Specifications, 400** for a summary of the products used in this procedure.

Before applying any topcoat:

1. Prepare the surface for topcoating. See **Subject 100** for instructions.
2. Clean all cracks and surfaces with dry compressed air.
3. Using a tack cloth, wipe all surfaces to be painted.

After topcoating, remove the masking as follows:

- After normal air drying—remove all masking when the surface is reasonably dry.
- After forced drying—remove the masking immediately after the finish has been baked.
- After two-toning—remove the masking used for the first coat as soon as it has set up, usually in about 35 to 40 minutes. Follow the same procedure for the second color.

Imron 5000 Topcoating

Imron 5000 is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 5000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

Mixing

1. Stir the Imron 5000 enamel thoroughly.
2. Mix three parts Imron 5000 enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 9 to 20 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

Application

1. Set the air pressure at the spray gun to 60 psi (414 kPa) for solid colors, and 65 psi (448 kPa) for metallics. For pressure feed systems, set the fluid delivery at 10 to 12 ounces (296 to 355 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Using a cross-coat technique, spray one medium-wet coat in a north-to-south direction
   - 2.3 Flash 5 minutes.
   - 2.4 Apply a second medium-wet coat in an east-to-west direction.
   - 2.5 A third medium-wet coat may be needed for good coverage of some colors.
3. To air dry, allow 2 to 4 hours with accelerator 389 S, and 6 to 8 hours without the accelerator.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

Topcoating

4. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Recoating or Decorating

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

General Guidelines

This subject provides instructions for making spot repairs or touch-ups with DuPont® Imron® 5000 polyurethane enamel. Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied. For striping, lettering, or decal application after the repair is complete, see **Subject 110**.

1. Preparation materials specified for one type of surface should not be used for any other type of surface. See **Specifications, 400** for a summary of the materials used in this section.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.
3. Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer.

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer or enamel, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes or spray mist can cause serious personal injury.

CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Buffing Minor Imperfections

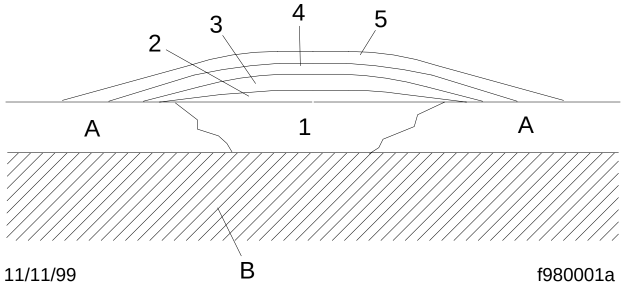
1. Clean the area carefully with a mild detergent and rinse.
2. Remove imperfections using ultra-fine or microfine sandpaper (1500 or 2000 grit) and water. Rinse the area with clean water, then dry.
3. Buff the area.
   - 3.1 Use a clean foam pad at low speed (about 1600 rpm) with one of the following products:
     - DuPont 1500 S
     - Meguiar's No. 2
     - 3M Finesset Two 5928
   - 3.2 Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.
   - 3.3 Rinse the area with clean water, then dry.
4. Polish the area.
   - 4.1 Apply one of the following products with a clean pad (3M Waffle Pad):
     - DuPont 3000 S
     - Meguiar's No. 9
     - 3M 5996
   - 4.2 Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary.

Preparing for Topcoating

1. Wash the entire panel with mild detergent. Dry with a clean, lint-free cloth.
2. Clean the area to be repaired with DuPont 3939 S solvent and quickly wipe the surface with a clean, lint-free cloth before the solvent dries. Remove all traces of wax, polish, grease, and silicones.
3. Sand or grind all dents and scratches.
4. Wet sand the area being repaired with no. 320 grit or finer sandpaper, or a 3M Scotch-Brite® or similar non-iron abrasive pad. Feather the edge.
5. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
6. Mask all areas that will not be painted.
7. Clean all cracks and surfaces with dry compressed air.

Spot Repair

8. Using a tack cloth, wipe all surfaces to be painted.
9. Prime all bare metal and feathered areas with DuPont Corlar® 824 S epoxy primer. See Fig. 1.



NOTE: Scale exaggerated for clarity. The number of layers depends on the specific application.

A. Existing Paint
B. Panel Material (substrate)
1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clear Coat

Fig. 1, Spot Repair Cross-Section

9.1 Stir Corlar 824 S primer thoroughly.

9.2 Mix two parts Corlar 824 S primer with one part DuPont 826 S activator.

9.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

9.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

9.5 Spray one wet coat to give a dry film thickness of 0.7 to 1.0 mil (0.018 to 0.025 mm).

9.6 Clean equipment immediately after use with DuPont 3602 S lacquer thinner.

9.7 Air dry 2 hours or force dry 20 minutes.

10. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.
11. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
12. Wipe the repair area with a tack cloth.
13. If the finish is old, apply one coat of DuPont 222 S adhesion promoter over the entire repair area.

13.1 Set the air pressure to 35 psi (310 kPa) at the spray gun.

13.2 Flash for 5 to 10 minutes at 70°F (21°C) before topcoating.

Topcoating a Spot Repair

1. Mix the Imron 5000 polyurethane enamel.

1.1 Stir the Imron 5000 enamel thoroughly.

1.2 Mix three parts Imron 5000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure to 60 to 65 psi (414 to 448 kPa) at the spray gun. For pressure feed systems, set the fluid delivery at 10 to 12 ounces (296 to 355 mL) per minute.
3. For metallic topcoats only, apply one coat of DuPont 500 S urethane clear.

3.1 Mix eight parts of 500 S urethane with one part 193 activator.

3.2 Reduce the activated 500 S urethane mixture 50 percent with 8685 S reducer.

3.3 Set the air pressure to 50 to 60 psi (345 to 414 kPa) at the spray gun.

3.4 Apply a medium-wet coat of the reduced 500 S urethane over the entire repair area, and well beyond where the color will be applied.

3.5 Flash 3 minutes before applying the Imron 5000 topcoat.

4. Apply the solid color or metallic topcoating.

4.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

4.2 Spray one medium-wet coat over the primed area.

4.3 Flash 5 to 10 minutes.

4.4 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4.5 A third medium-wet coat may be needed for good coverage of some colors. Allow each coat to flash before applying the next coat.

NOTE: A mist coat of five parts of color to three parts of 8022 S is recommended when applying metallics. Hold the gun about 18 inches (45 cm) from the surface.

5. Blend the repair area into the OEM finish.

   5.1 Lower the air pressure to 15 to 20 psi (103 to 138 kPa) at the spray gun.

   5.2 Empty the spray cup and refill it with DuPont 8022 S reducer or a blend of 8022 S and 8093 S.

   5.3 Carefully blend the edge of the repair with even coats to melt in the overspray.

   5.4 Spray one or two medium coats of the reducer over the entire area.

   5.5 If a haze appears around the edge after the reducer has dried, lightly rub the edge with DuPont 1500 S one-step polish.

6. To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

7. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Specifications

DuPont Surface Preparation Materials

Step	Surface Preparation Materials			
	Aluminum	Steel	Plastic	Fiberglass
Wash and dry	Mild detergent (such as diswashing detergent)			
Wipe with cleaner	Prep-Sol 3919 S		Plastic Prep 2319 S	Prep-N-Solv
Sand and feather	220 grit, then 400 grit			320 grit
Remove sanding dust	3939 S lacquer and enamel cleaner			1 part water; 1 part isopropyl alcohol
Treat bare metal	225 S aluminum cleaner	5717 S metal conditioner	—	—
Apply conversion coating to bare metal	226 S aluminum conversion coating	5718 S metal conversion coating	—	—
Apply sealer primer	2 parts Corlar 824 S primer; 1 part DuPont 826 S activator Reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner			

DuPont Topcoating Materials

Step	Topcoating Materials
Mix enamel	3 parts Imron 5000; 1 part 193 S or 194 S activator
Add accelerator (optional)	389 S accelerator (up to 2 oz/gal of activated enamel)
Pressure at gun	60 psi (414 kPa)
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer

DuPont Spot Repair Materials

Step	Spot Repair Materials
Cleaning	3939 S lacquer and enamel cleaner
Sanding	320 grit or finer
Sealer primer	2 parts Corlar 824 S primer; 1 part DuPont 826 S activator Reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner
Adhesion promoter	222 S adhesion promoter
Topcoat	3 parts Imron 5000; 1 part 193 S or 194 S activator
Topcoat viscosity	9–20 sec (#3 Zahn cup)
Accelerator (optional)	389 S accelerator
Blending clear	1 coat 3401 S blending clear
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer

General Description

PPG Delta® DUHS base-coat and DCU2070 clear-coat paint is used on the vehicle cab. To meet the federal air quality regulations imposed by the EPA and local jurisdictions, these products contain low amounts of solvent and are formulated to be free of lead and chrome.

The procedures in this section are for use with PPG products. Unless otherwise noted, all products are manufactured by PPG. Obtain approval from Daimler Trucks North America LLC for use of topcoats produced by other manufacturers.

Color Matching

PPG Delta® high solids polyurethane is the recommended aftermarket PPG paint. For repairs, use PPG Delta DFHS paint for color-matching the chassis and PPG Delta DUHS base coat with DCU2070 clear coat paint for color-matching the cab.

To determine the correct paint number for color-matching of any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. See **Fig. 1**. Refer to the vehicle operator's manual for the location of this decal.

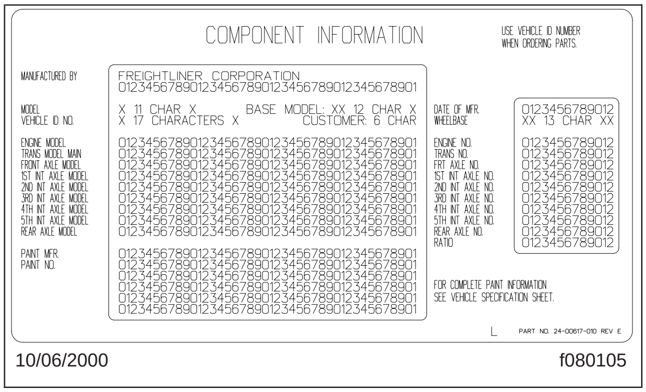


Fig. 1, Vehicle Specification Decal

General Guidelines

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as sealers, to the brand and type specified by the finish coat manufacturer.
3. Do not mix additives with the finish coats, unless the finish coat manufacturer specifies them.

IMPORTANT: Only experienced, qualified persons, using proper equipment, should attempt repainting and touch-up painting.

Preparation for Topcoating

1. Wash and dry the entire surface to be painted.
2. Using a clean cloth soaked with PPG DX436 Wax and Grease Remover, remove all traces of wax, polish, grease, and silicones, as follows:
   - 2.1 Work on small areas at a time, wetting the surface liberally.
   - 2.2 Change cloths frequently.
   - 2.3 Wipe off the surface with a clean cloth before the PPG DX436 wax and grease remover has a chance to dry.
3. Feather-edge all repaired areas, chipped surfaces, and scratches, as follows:
   - 3.1 Cut down the edges of broken spots with 220-grit sandpaper.
   - 3.2 Feather the edges by hand, using a sanding block with 400-grit sandpaper.
4. Sand the entire area to be repainted. Use a sanding block and 400-grit sandpaper to remove the gloss and to improve adhesion of the primer.
5. Using a clean cloth soaked with PPG DX436 wax and grease remover, remove any sanding dust from the area to be painted. Remove all traces of wax, polish, grease, dust, and silicones, as follows:
   - 5.1 Work on small areas at a time, wetting the surface liberally.
   - 5.2 Change cloths frequently.
   - 5.3 Wipe off the surface with a clean cloth before the PPG DX436 wax and grease remover has a chance to dry.
6. Treat bare metal and corroded areas. For aluminum, use PPG DX533 Aluminum Cleaner; for all other metals, use PPG DX579 Metal Cleaner.
   - 6.1 For aluminum, mix one part of PPG DX533 Aluminum Cleaner with three parts of water in a plastic bucket.

     For all other metals, mix one part of the PPG DX579 Metal Cleaner with two parts of water in a plastic bucket.
   - 6.2 All corroded areas must be abraded until the area is free of rust or corrosion. Use 80-grit followed by 220-grit sandpaper to abrade the area.
   - 6.3 Spray cleaner on the surface and allow it to react for 2 to 3 minutes.
   - 6.4 Rinse off the cleaner with fresh water and dry thoroughly with a clean, lint free, dry cloth.

Preparing for Topcoating

IMPORTANT: Carbon steel must be primed immediately after abrading and cleaning. Aluminum must be primed within 4 to 8 hours of abrading and cleaning.

7. With paper and tape, mask all areas that are not to be painted, then prime immediately.

Primers for the Cab

PPG has several compatible primers to use when repainting or repairing. The recommended primers are:

- DP-LF — A chrome- and lead-free epoxy primer with excellent corrosion resistance.
- DPU217 — A chrome-free polyurethane primer that can be applied as low as 2.1 lb./gal VOC with excellent adhesion and corrosion resistance properties.
- DEP351 — A 3.5 VOC chrome- and lead-free epoxy primer with excellent adhesion and corrosion resistance properties.
- DPHS-52 — A non-isocyanate, chrome- and lead-free, corrosion resistant, sandable primer with excellent adhesion and filling properties.

DP-LF Primer

NOTE: Refer to PPG Product Information Bulletin P-196 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C), when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist.

1. Stir the DP-LF Primer thoroughly. Then, mix two parts of DP-LP with one part of DP 401LF.
2. Stir thoroughly and allow a 30-minute induction time to obtain maximum performance.
3. Apply two light-to-medium wet coats to achieve a 1.0 mil minimum to 2.0 mil maximum dry film thickness (DFT).
4. Allow 15 minutes flash time between coats.
5. Allow a drying time of 1 hour at 70°F (21°C) before topcoating.
6. Clean all cracks and surfaces with dry compressed air.
7. Using a tack cloth, wipe all surfaces to be painted.

DPU217 Primer

NOTE: Refer to PPG Product Information Bulletin FL304 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C), when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist.

NOTE: This mixture has a VOC of 2.8 lb/gal. To spray at 2.1 lb/gal do not add the DRS reducer.

1. Stir the DPU217 primer thoroughly.
2. Mix five parts of DPU217 with one part of DPU218.
3. Add 6 fluid ounces (177 mL) of DX39/DX53 per ready-to-spray gallon (3.8 L).
4. Add one part of DRS reducers.

NOTE: When adding DRS reducers in the 2.8 VOC blend, for best results, the DRS solvents must be added last, after the addition of the DX39/DX53.

5. Apply one to two coats.
6. Allow 10 to 15 minutes flash time between coats.
7. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.

NOTE: After four days, DPU217 must be sanded before additional primer or topcoat can be applied.

8. Clean all cracks and surfaces with dry compressed air.
9. Using a tack cloth, wipe all surfaces to be painted.

DEP351 Primer

NOTE: Refer to PPG Product Information Bulletin FL305 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C), when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist.

1. Stir the DEP351 Primer thoroughly. Then, mix two parts of DEP351 with one part of DEP352.

   The addition of 10 to 20 percent Acetone or DES1570 Exempt Solvent Blend should be used for sealer application.
2. Apply one to two coats.
3. Allow 5 minutes flash time between coats.
4. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.
5. Clean all cracks and surfaces with dry compressed air.
6. Using a tack cloth, wipe all surfaces to be painted.

DPHS52 Primer

NOTE: Refer to PPG Product Information Bulletin FL301 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C), when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist.

1. Stir the DPHS52 Primer thoroughly. Then, mix two parts of DPHS52 with one part of DPHS521 and mix thoroughly.
2. Apply two to three wet coats to achieve a 2.0 mil minimum to 3.0 mil maximum DFT.
3. Allow 10 minutes flash time between coats.

NOTE: A minimum of 2.0 mil DFT after sanding must be maintained to ensure proper adhesion and corrosion protection.

4. Allow a drying time of 45 minutes at 70°F (21°C) before topcoating.

   Or, if sanding before topcoating, allow a drying time of 3 to 4 hours, then DA sand with 320- to 360-grit dry sandpaper, followed with a finish DA sanding using 1500-grit or finer paper.
5. Clean all cracks and surfaces with dry compressed air.
6. Using a tack cloth, wipe all surfaces to be painted.

Delta® DFHS High Solids Polyurethane

NOTE: Refer to PPG Product Information Bulletin P-FL504 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while mixing and spraying, and until the work area has been exhausted of all vapor and spray mist.

Mixing

1. Stir Delta DFHS Single Stage thoroughly.
2. Mix four parts Delta DFHS Single Stage with one part DFH535/DFH536.
3. Add six fluid ounces (177 ml) DX39 per ready-to-spray (RTS) gal.

NOTE: May substitute with DX53 or DX49, but pot life, dry times, and recoat ability may be affected.

4. Mix thoroughly and strain.

Spraying

1. For High Velocity, Low Pressure (HVLP) systems, the air pressure at the air cap should be set at 10 psi (69 kPa).

   For conventional spray guns, set the air pressure to 45 to 60 psi (310 to 414 kPa) at the gun.

   The fluid tip size for conventional HVLP guns should be 1.3 to 1.7 mm.

   The fluid tip size for pressure-feed HVLP guns should be 1.0 to 1.4 mm.
2. Apply two coats, or until hiding is achieved. Flash time between coats is 5 to 10 minutes at 70°F (21°C).
3. Dry times: See **Table 1** for air dry times. See **Table 2** for force dry times.

Air Dry Time - at 70°F (21°C) with DFH535	
Using DX39	12 hours
Using DX53	16 hours
Using DX49	5 hours

Table 1, Air Dry Times

Force Dry with DX53 only.	
Flash	10 minutes
@ 120°F (49°C)	30 minutes
@ 180°F (82°C)	15 minutes

Table 2, Force Dry Times

Delta® DUHS Basecoat

NOTE: Refer to PPG Product Information Bulletin P-FL507 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while mixing and spraying, and until the work area has been exhausted of all vapor and spray mist.

Mixing

NOTE: One-quarter part DHSX Converter is the minimum quantity and one part is the maximum quantity of converter to add to DUHS Basecoat. Increasing the level of DHSX will speed dry time, but will shorten pot time, especially in warm and humid conditions.

1. Stir Delta DUHS Basecoat thoroughly.
2. Mix two parts of Delta DUHS Basecoat with one-quarter to one part of DHSX Converter.
3. Add one part DDH526.
4. Mix thoroughly and strain.

Spraying

1. For High Velocity, Low Pressure (HVLP) systems, the air pressure at the air cap should be set at 10 psi (69kPa).

   For conventional spray guns, set the air pressure to 45 to 60 psi (310 to 414 kPa) at the gun.

The fluid tip size should be 1.3 to 1.7 mm for conventional HVLP guns and 1.0 to 1.4 mm for pressure feed HVLP guns.

2. Apply two coats of the basecoat, or until hiding is achieved. Minimum film build for each coat should be 1.5 mils wet and no more then 2.0 mil wet. Flash time between coats is 5 to 10 minutes at 70°F (21°C).
3. Dry time to clearcoat is 10 to 15 minutes minimum and up to 72 hours maximum at 70°F (21°C). After 72 hours the DUHS basecoat must be sanded and additional color applied before clearcoating.
4. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.

Delta® Urethane Clear DCU2070

NOTE: Refer to PPG Product Information Bulletin FL600 for additional information.

IMPORTANT: Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while mixing and spraying, and until the work area has been exhausted of all vapor and spray mist.

Mixing

1. Mix four parts of DCU2070 with one part of DRS Reducer.
2. Add two parts DCX2071/DCX2072.
3. Add four fluid ounces (118mL) of DX39/DX54 per RTS gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

Spraying

1. For HVLP systems, the air pressure at the air cap should be set at 10 psi (69 kPa).

   For conventional spray guns, set the air pressure to 55 to 60 psi (379 to 414 kPa) at the gun.

   The fluid tip size should be 1.0 to 1.4 mm for pressure feed HVLP and 1.3 to 1.5 mm for conventional feed HVLP.
2. Apply two coats allowing 10 to 15 minutes between coats.
3. For dry times at 70°F (21°C), See **Table 3**. Force dry time is 30 minutes at 140°F (60°C).

DCU2070	**With DCX2071**	**With DCX2072**
With DX39	3 hours	1 to 2 hours
With DX53	4 to 5 hours	2 hours

Table 3, Dry Times

4. Buffing may begin 4 to 6 hours after the unit is air dried, or immediately after cool off, if force dried.

NOTE: If polishing is required, use DCX2071 Polish within 24 hours.

Buffing

Refer to PPG Product Information Bulletin PD768 for polishing and compounding.

General Guidelines

These are instructions for making spot repairs or touch-ups with PPG Delfleet® Evolution urethane topcoat single stage or basecoat/clearcoat.

Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the paint manufacturer.
3. Do not use any products or additives that are not specifically recommended by the paint manufacturer in published literature.
4. Substrate and ambient temperature should be above 65°F (18°C) for optimum performance.

Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent, then rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500- or 2000-grit) and water.
3. Rinse the area with clean water, then dry.
4. Buff the area, using a clean foam pad at low speed (about 1600 rpm) with one of the following products:
    - Meguiar's No. 2 Fine-Cut Cleaner
    - 3M Finesse-it II 05928

    Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.
5. Rinse the area with clean water, then dry.
6. Polish the area with a clean pad, such as a 3M Waffle Pad, using either of the following products:
    - Meguiar's No. 9 Swirl Remover
    - 3M Perfect-It 05996

    Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary

Preparing for Topcoating

1. Wash the entire panel in mild detergent, containing no lanolin or additives. Before the solution dries, rinse with fresh water. Dry with a clean, lint-free cloth.
2. Cover areas around the repair area to prevent damage to surrounding objects from solvent overspray or drips.

WARNING

Solvents are flammable. Keep the container closed. Use only with adequate ventilation. Keep solvents away from heat, sparks, and open flame. Breathing the vapor can cause headache, nausea, impaired reaction time, and impaired coordination.

3. Clean the area to be repaired with PPG D436/DX437/DX438 Substrate Cleaner. Choose the product depending on local regulations and degree of contamination. Quickly wipe the surface with a clean, lint-free cloth before the substrate cleaner dries.

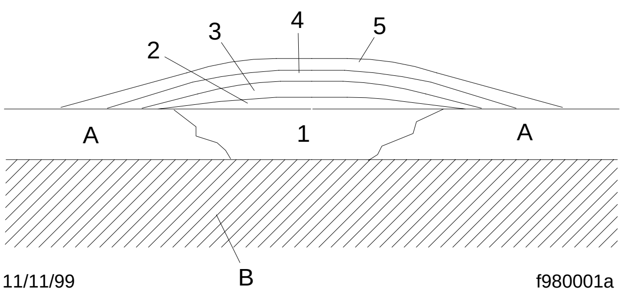
    Remove all traces of substrate contamination such as wax, polish, grease, diesel exhaust residue, and silicones. Do not allow substrate cleaners to air dry on the repair area.
4. Sand or grind all dents and scratches.
5. DA sand the area being repaired with 320- or 400-grit, or finer sandpaper, or a 3M Scotch-Brite® pad. Feather the edge.
6. Remove sanding dust using the method detailed in step 3 above.
7. Mask all areas not to be painted.
8. Clean all cracks and surfaces with dry compressed air.
9. Use a tack cloth to wipe all surfaces to be painted.

Spot Repair

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

10. Prime all bare metal and feathered areas with PPG primer. Use F3995 primer for fiberglass, steel, and aluminum. See **Fig. 1**.



NOTE: The number of paint layers depends on the specific use.

A. Existing Paint
B. Panel Material (Substrate)
1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clearcoat

Fig. 1, Spot Repair Cross Section, Scale Exaggerated for Clarity.

10.1 Stir or shake primer thoroughly.

10.2 Mix three parts F3995 epoxy primer with one part F3996 activator and one-half part F–series reducer.

10.3 Set the air pressure at the spray gun to 55 psi (380 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute.

10.4 Spray one wet coat to yield a minimum dry film thickness of 0.7 mils (18µm).

10.5 Clean equipment immediately after use with PPG Gun Cleaning Solvent.

10.6 Air dry 1 hour or force dry 20 minutes at 120 to130°F (49 to 55°C).

11. If the original paint was a basecoat/clearcoat, hand rub the area around the spot repair with a medium grade compound to ensure a seamless finish. Use Scotch–Brite® 7448 or 2000-grit wet or dry sandpaper.
12. Remove the sanding dust. Use the same cleaner and wipe on, wipe off method used earlier to clean the area.
13. Wipe the repair area with a tack cloth.

Topcoating a Spot Repair

Delfleet® Evolution Single Stage Topcoating

1. Mix the Delfleet® Evolution Single Stage (FDGH) polyurethane enamel.

1.1 Stir the Delfleet® Evolution Single Stage (FDGH) polyurethane enamel thoroughly.

1.2 Mix three parts Delfleet® Evolution color (FDGH) with one part F3260 activator to 6 ounces additive F34XX per RTS gallon (44 ml per liter), to an optional 10 percent F33XX reducer. The pot life is 2 to 3 hours at 70°F (22°C). See **Table 1**.

Speed Rating	F34XX Additives	F33XX Reducers
Fast Dry	F3400	F3320
Medium Dry	F3405	F3330
Slow Dry	F3410	F3340
Extra Slow Dry	—	F3350

Table 1, PPG Additives and Reducers

1.3 Mix thoroughly and strain.

NOTE: the viscosity of the mixture should be at 25 to 35 seconds in a No. 2 Zahn cup. Check the designated shelf life if using a product from a previously opened container.

2. Set the air pressure at 50 to 60 psi (345 to 415 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. The fluid tip should be 1.3 to 1.5 mm.
3. Apply the solid or metallic color topcoat.

3.1 Spray one medium-wet coat over the primed area.

3.2 Flash 10 to 15 minutes.

3.3 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4. FDGH dry film thickness must be a minimum of 1.5 mils (38µm).
5. To air dry, allow overnight cure at 65°F (19°C) minimum.
6. To force dry, flash 5 to 10 minutes, then cure 40 minutes at 140°F (60°C) metal temperature.
7. If taping, allow 3 hours at 68°F (20°C). To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied.
8. If decals are to be applied, let the paint cure at 70°F (21°C) for 3 days prior to putting them on.
9. Clean the equipment immediately after use with PPG Gun Cleaning Solvent.

Delfleet Evolution Basecoat/ Clearcoat Topcoating

1. **Option 1:** Mix the Delfleet Evolution Basecoat (FBCH) polyurethane enamel.

   1.1 Stir/shake the Delfleet Evolution Basecoat (FBCH) thoroughly.

   1.2 Mix three parts FBCH basecoat color with one part F3260 activator to one-half part F3440 converter. Pot life is 1 to 2 hours at 70°F (21°C) and 50 percent relative humidity.

   1.3 Mix thoroughly and strain.

   1.4 The viscosity of the mixture is 20 to 25 seconds in a No. 2 Zahn cup, depending on the color.

2. **Option 2:** Mix the Delfleet Evolution Basecoat-Fast (FBCS) polyurethane enamel.

   2.1 Stir or shake the Delfleet Evolution Basecoat-Fast (FBCS) color thoroughly.

   2.2 Mix three parts FBCS basecoat color with one part F3200. Ten percent F33XX Reducer is optional for this application. Pot life is 1 hour at 70°F (21°C) and 50 percent relative humidity.

   2.3 Mix thoroughly and strain.

   2.4 The viscosity of the mixture is 20 to 30 seconds in a No. 2 Zahn cup, depending on the color.

3. Set the air pressure at 50 to 60 psi (345 to 415 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. The fluid tip should be 1.3 to 1.5 mm.
4. Apply the basecoat (FBCH or FBCS): Apply one or two coats of FBCH or FBCS basecoat color over the primed area until full hiding is achieved. Allow 5 to 10 minutes between coats.
5. If blending the repair area into the OEM finish, see instructions at the end of the top coat instructions.
6. Allow 30 minutes flash, prior to applying clearcoat.
7. If clearcoat is not applied within 8 hours, FBCH/ FBCS basecoat color must be sanded and recoated.
8. Mix the Delfleet Evolution High Build Clear

   8.1 Mix three parts Delfleet Evolution Clearcoat F3905 with one part F3240 activator to one-half part reducer (F33XX) to 2 ounces accelerator per RTS gallon (16 ml per liter). Pot life is 1 hour to 1.5 hours at 70°F (21°C) and 50 percent relative humidity. See **Table 2**.

PPG Thinners	
Fast	F3320
Medium	F3330
Slow	F3340
Extra Slow	F3350

Table 2, F33XX Thinner Selection

   8.2 Mix thoroughly and strain.

   8.3 The viscosity of the mixture is 32 seconds in a No. 2 Zahn cup.

9. Set the clearcoat air pressure at the spray gun at 45 to 55 psi (310 to 380 kPa). For pressure feed

systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. Use a 1.3 to 1.5 mm fluid tip.

10. Apply 2 coats of F3905 clearcoat with a 10 to 15 minute flash time between coats to reach 2.0 mils (50 µm) minimum dry film thickness.

NOTE: For best results, apply the clearcoat over the entire panel.

11. To blend the clearcoat:
    - 11.1 Apply one coat of the activated Delfleet Evolution F3905 Clearcoat.
    - 11.2 Mix one part DX840 to one part ready-to-spray F3905 clearcoat and apply this mixture to the blend edge. Additional DX840 may be added if a second coat to extend the blend edge is necessary or desired.
    - 11.3 Moving the gun from the outside in, mist a light coat onto the edge of the repair to melt in the dry overspray.
    - 11.4 To air dry, allow overnight cure at 65°F (18°C).
    - 11.5 If taping, allow 6 hours at 68°F (20°C). To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied.
    - 11.6 To force dry, flash off up to 5 minutes, then dry for 40 minutes at 150°F (65°C).
    - 11.7 If sanding or polishing are desired, allow the finish to sit 16 hours if air dried, and 4 to 8 hours after bake cool-down before polishing.
    - 11.8 Clean the equipment immediately after use with PPG Gun Cleaning Solvent.

Solid Color Blends in FBCH/FBCS/FDGH

1. Prepare the repair area as outlined above.
2. Spray color to full hiding in two or three coats, allowing specified flash time between coats.
3. Once hiding is achieved, pour out the remaining ready-to-spray (RTS) color from the gun.
4. Add several ounces of DX840 to the gun that still contains residual RTS color and lightly blend the outside edge.

NOTE: It is very important to add DX840 to the gun that still contains some residual RTS color. This keeps the outside edge from breaking or de-wetting.

5. For FBCH or FBCS repair jobs, apply clearcoat following a 30 minute flash time, or a similar force-dry.

Blending Metallic Colors in FDGH and Blending Metallic/Pearl Colors in FBCH/FBCS

NOTE: Spot repairs in high-solid colors often show a dark ring or halo around their edges. Spraying a wet bed helps prevent the ring or halo when repairing high-solid colors.

On very light colors, it may be necessary to spray the wet bed completely to the edge of the panel but not over the repair area, to prevent the halo effect.

1. Follow the steps outlined above to prepare the area for applying the wet bed.
2. Prior to applying the wet bed, the area that is to receive the wet bed should be scuffed with a gray scuff pad and cleaned with an appropriate substrate cleaner.
3. Mix F3905. Reduce the RTS F3905 1:1 by volume with DX840 and spray a wet bed on the outside of the spot.
    - 3.1 Spray one medium-wet coat to establish the wet bed. Keep the wet bed 4 to 6 inches outside the repair spot.
    - 3.2 Apply the color system mixed as detailed in previous headings, but do not add DX840 in this step. Spray from the repair spot into the wet bed, while the wet bed is still wet.

    NOTE: Do not apply DX840 to the edge of the color in this application. Doing so causes a halo effect.

3.3 For basecoat repairs, allow the color to become tack-free before applying the final overall color. The overall clear (F3905) is not reduced with DX840. DX840 can be used to melt in the edges of the clearcoat, once this step is complete.