FREIGHTLINER

Run Smart

CASCADIA WORKSHOP MANUAL

Models: CA125DC
CA125SLP

STI-481, S7 (9/10P)

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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 *Cascadia™ 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, and specifications.

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.

Troubleshooting Manual

Troubleshooting manuals contain diagnostic procedures for determining causes of problems in vehicle components and systems. Information on multiplexing diagnosis is included. These manuals are organized by functional systems, such as cab, chassis, and powertrain. Troubleshooting manuals do not contain 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 pre-trip 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.

Descriptions of Service Publications

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.

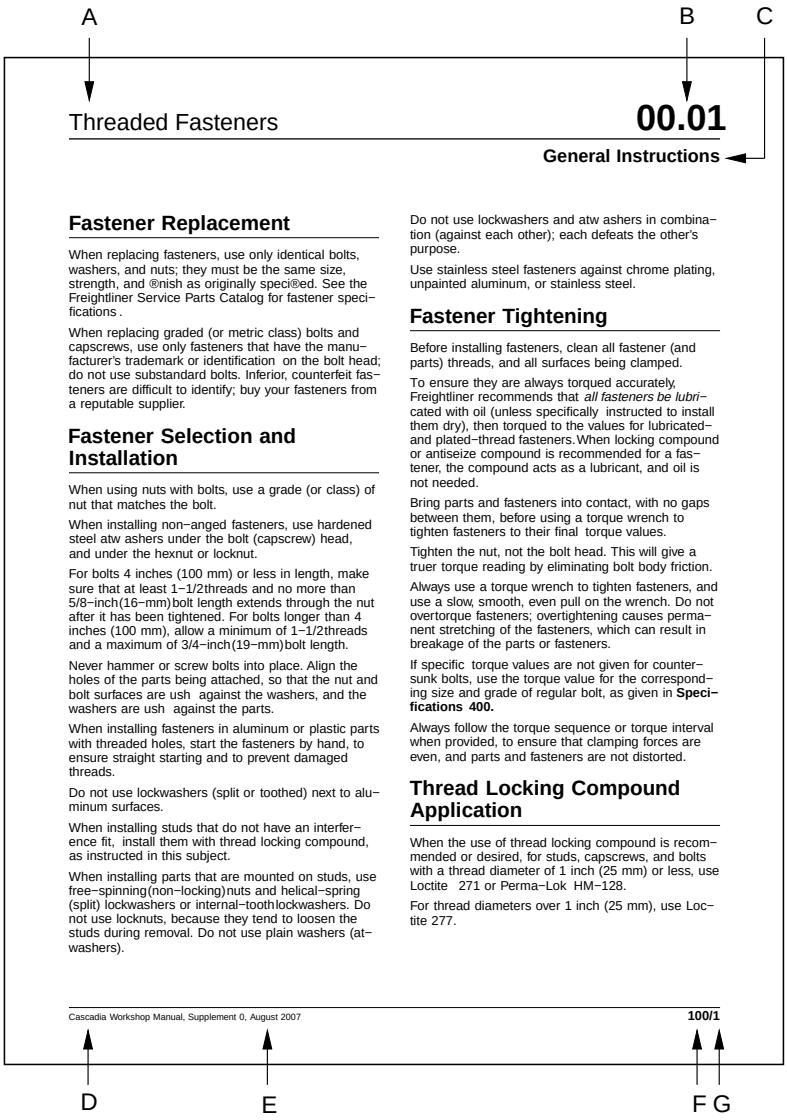
Warranty-related service information available on the AccessFreightliner.com website includes the following documentation.

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 *Cascadia Workshop Manual* page, see **Fig. 1**.



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 Cascadia Workshop Manual Page

Workshop Manual Contents

Group No.	Group Title
00	General Information
01	Engine
09	Air Intake
13	Air Compressor
15	Alternator and Starter
20	Engine Cooling/Radiator
25	Clutch
26	Transmission
30	Throttle Control
31	Frame and Frame Components
32	Suspension
33	Front Axle
35	Rear Axle
41	Driveline
42	Brakes
46	Steering
47	Fuel
49	Exhaust
54	Electrical, Instruments, and Controls
60	Cab
72	Doors
82	Windshield Wipers and Washer
88	Hood, Grille, and Cab Fenders
91	Seats and Restraint Systems
98	Paint

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.

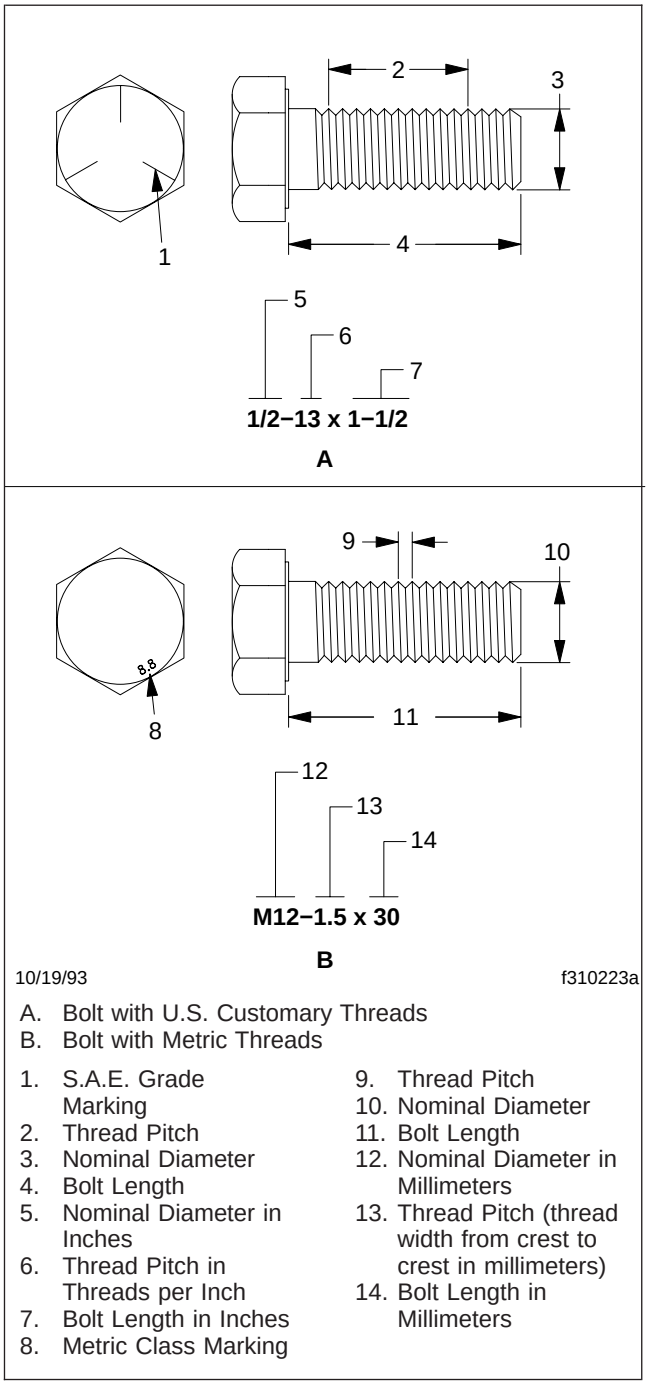
Some fasteners smaller than 1/2-inch diameter are flanged fasteners, which have integral flanges that fit against the parts being fastened. The flanges eliminate the need for washers.

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 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

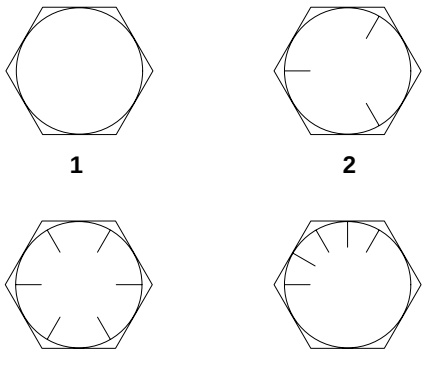


A. Bolt with U.S. Customary Threads
B. Bolt with Metric Threads

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

General Information



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.

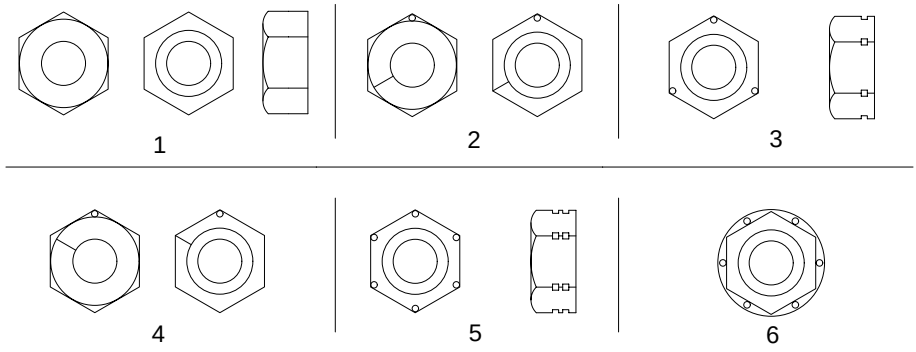
Frame Fasteners

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

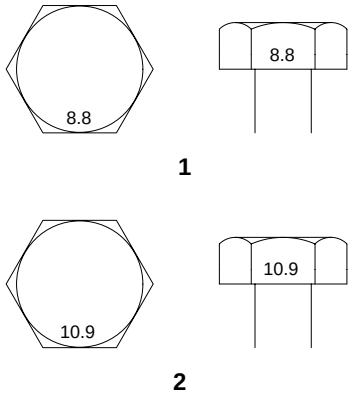
When a capscrew is tightened to its torque value in a threaded hole, or a nut is tightened to its torque value on a bolt, the shank of the capscrew or bolt is



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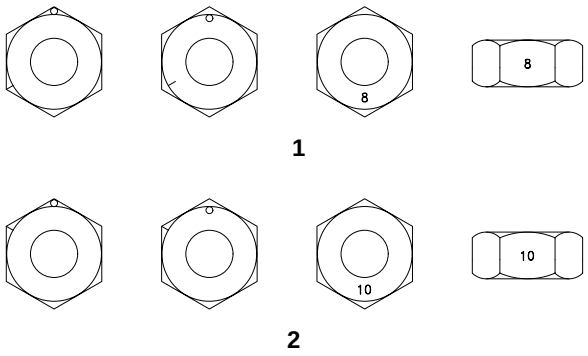
NOTE: In addition to the class markings, the bolt head must also carry the manufacturer's trademark or identification.

1. Class 8.8
2. Class 10.9

Fig. 4, Bolt Classes



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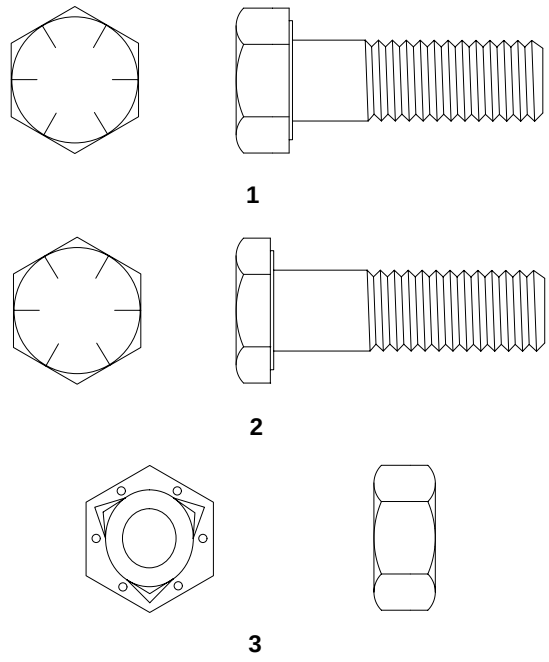
1. Class 8 Nut
2. Class 10 Nut

Fig. 5, Nut Classes

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

General Information

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.

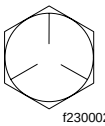
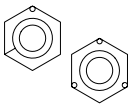
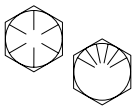
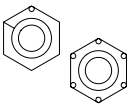
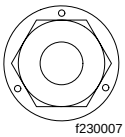
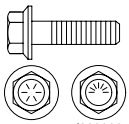
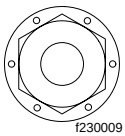
For thread diameters over 1 inch (25 mm), use Loctite 277.

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.

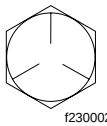
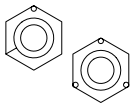
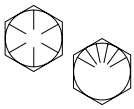
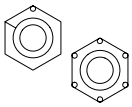
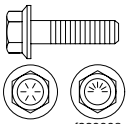
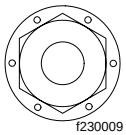
Torque Values for U.S. Customary Thread Fasteners With Lubricated* or Plated Threads†								
Thread Diameter–Pitch	Regular Hex				Flanged			
	Grade 5 Bolt	Grade 5 or B Nut	Grade 8 or 8.2 Bolt	Grade 8 or C Nut	Grade 5 Bolt	Grade B Nut	Grade 8 or 8.2 Bolt	Grade G Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (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

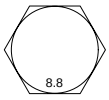
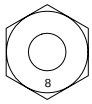
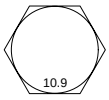
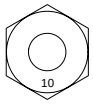
Specifications

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 **Table 1**. 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)	
	 f230010	 f230011	 f230012	 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 Information

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 the last six digits (designating the chassis serial number) are stamped into the metal frame.

Each product line has its own model list; that is, positions 5 and 6 are product-specific. For example, the code AB in positions 5 and 6 for a Freightliner vehicle indicates an FLD112 conventional truck. Code AB in the same position for a FCCC vehicle represents an MB45 chassis.

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
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

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
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

VIN Information

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
L	6 x 6 Truck-Tractor
M	8 x 4 Truck
N	8 x 4 Truck-Tractor
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

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
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
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

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**GVWR**
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
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

VIN Information

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**GVWR**
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
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

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**GVWR**
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
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

VIN Information

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**GVWR**
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 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

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement**	**Configuration**	**Brakes**
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
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

VIN Information

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement**	**Configuration**	**Brakes**
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
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

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement**	**Configuration**	**Brakes**
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
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

VIN Information

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement**	**Configuration**	**Brakes**
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
9	2009
A	2010
B	2011
C	2012
D	2013

Table 6, VIN Position 10 (Model Year)

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)

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

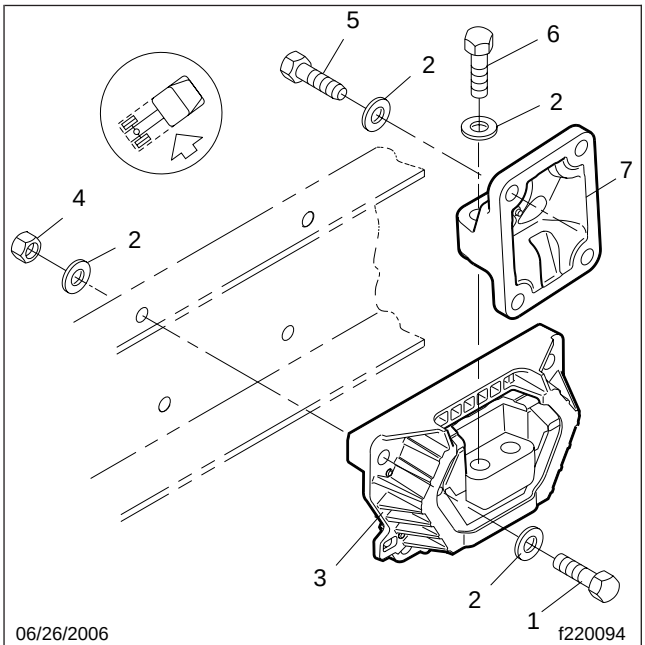
List of Abbreviations

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

Three mounts support the engine and transmission, holding a total of almost 1800 lb (816 kg). Two of the engine mounts support the rear of the engine and transmission assembly. The third supports the front of the engine.

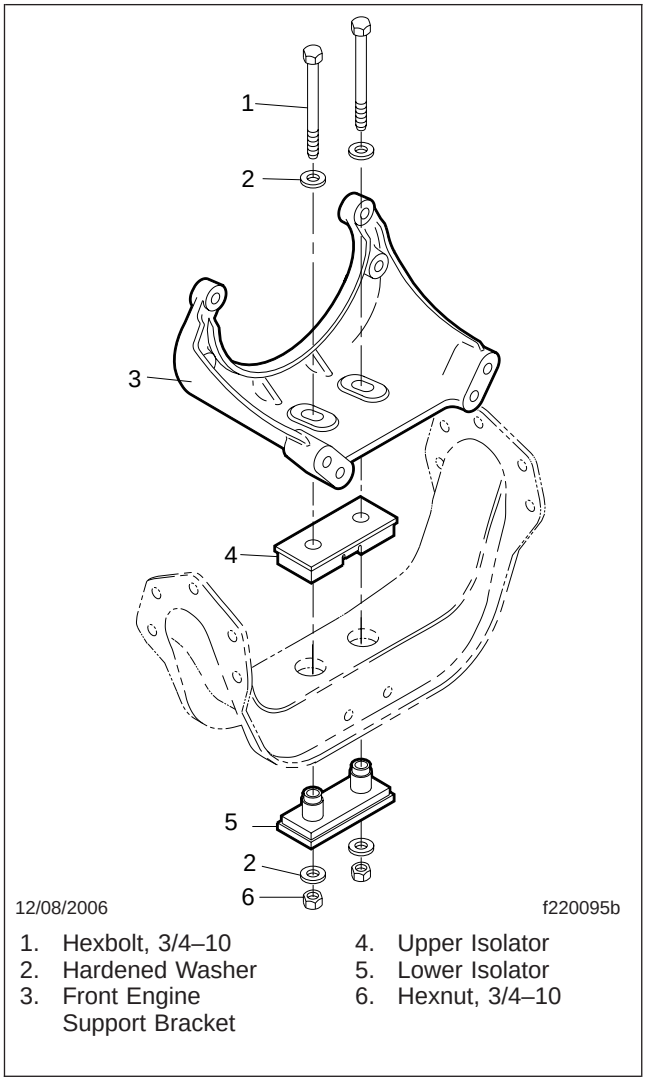
The rear engine mounts, which are bolted to the inside of the frame rail near the flywheel housing, support legs that are bolted to the flywheel housing. Each mount is a one-piece assembly, with the elastomer isolator bonded to the metal bracket. The mounts are designed for longer life and reduced engine vibration. The engine leg fits into a flat recess in the mount. See **Fig. 1**.



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

Fig. 1, Rear Engine Mount and Engine Leg

The front engine mount is an underslung crossmember under the front of the engine. It supports a bracket that is bolted to the engine at each side of the vibration damper pulley. Upper and lower rubber isolators reduce road shock to the front of the engine, and help isolate the vehicle frame from engine vibration. See **Fig. 2**



1. Hexbolt, 3/4–10
2. Hardened Washer
3. Front Engine Support Bracket
4. Upper Isolator
5. Lower Isolator
6. Hexnut, 3/4–10

Fig. 2, Front Engine Mounting

Replacement

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 the cables, 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 as follows.
   - 7.1 Mark the position of each wiper arm on the splined shaft, 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

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 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 as follows.

    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.

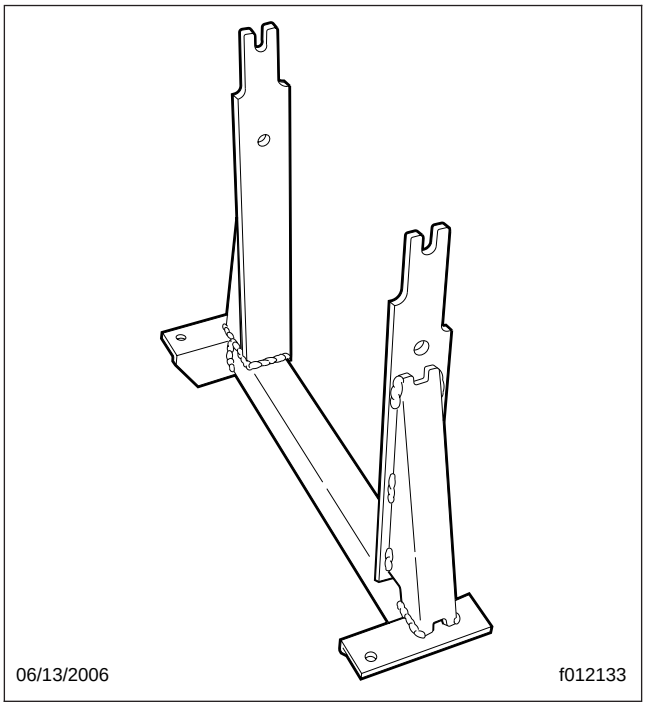
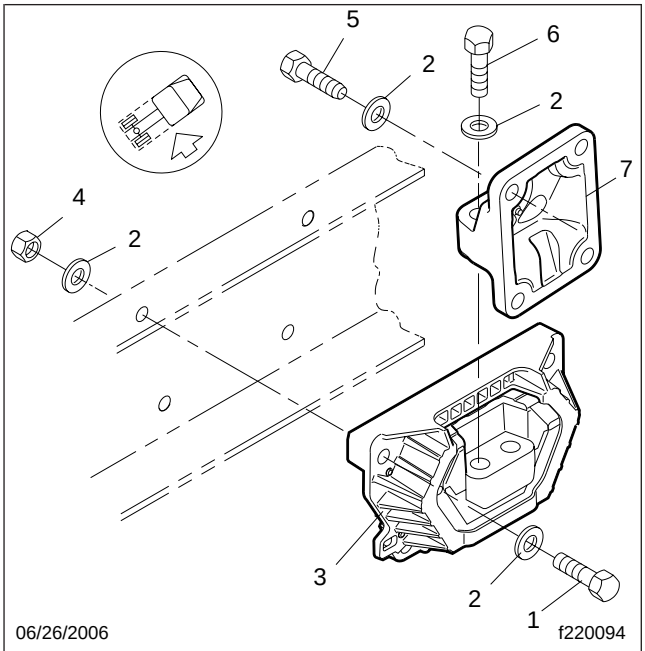


Fig. 1, Engine Shipping Stand, Detroit Diesel Series 60 Engine

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.



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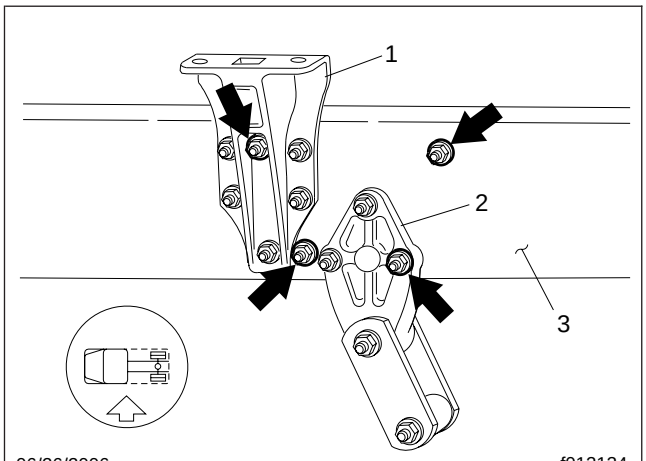
1. Hexbolt, 5/8–11
2. Hardened Washer
3. Rear Engine Mount Assembly
4. Hexnut, 5/8–11
5. Capscrew, 5/8–11
6. Capscrew, 3/4–10
7. Engine Leg

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.
30. 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).



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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

31. 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).
32. If applicable, repeat the above procedure on the other side of the vehicle.
33. Lower the engine onto the rear engine mount.
34. 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).
35. Remove the fasteners that hold the engine shipping stand to the side of the transmission, and remove the stand.
36. Install the clutch linkage.
37. Install the overslung crossmember.
38. Install the shifter and shifter boot on the transmission.
39. Install the standoff bracket for the A/C refrigerant line, then attach the line to the bracket.
40. If it was removed, install the starting-aid bottle to the left-side frame rail.
41. Attach the driveline midship bearing and its bracket to the frame crossmember.

Rear Engine-Mount Replacement

42. Connect the exhaust tubing to the turbocharger.
43. Attach the cab skirts to the bottom of the cab.
44. Connect the ATD to the exhaust tubing. As previously marked, connect the wiring to the sensors on the ATD.
45. Install the primary air tank and connect the air lines to it.
46. In the engine compartment, install the turbocharger heat shield.
47. Install the mounting bracket for the air-intake canister.
48. Attach the air-intake canister to the mounting bracket.
49. Install the right and left inner splash shields.
50. Install the right and left quarter fenders.
51. 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 manual.
52. Using the previously removed fasteners, install the rain tray on the frontwall.
53. Connect the hoses and drains to the bottom of the rain tray.
54. As previously marked, install the wiper arms.
55. If they were removed, install the two tow hooks on the side of the right frame rail.
56. Close the hood.
57. Install the battery MEGA-fuse block on the left-side frame rail, underneath the cab.
58. Connect the battery cables.
59. Remove the chocks.

Front Engine-Mount Isolators Replacement

Replacement

NOTE: It may be necessary to lift the front of the engine clear of the isolators in order to thoroughly check them for damage.

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

⚠ WARNING

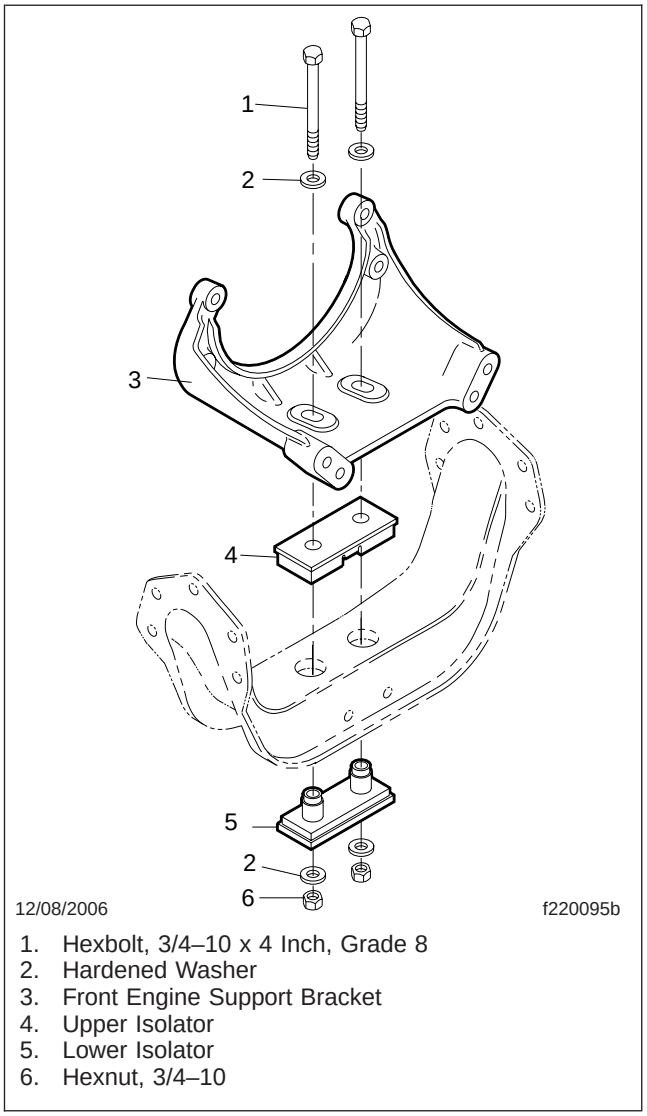
The lifting device and chain used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and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

2. Disconnect the engine from the front engine mount as follows. 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.



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

Fig. 1, Front Engine Mount Assembly, Detroit Diesel Series 60 Engine

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

⚠ 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 en-

Front Engine-Mount Isolators Replacement

gine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

6. Secure the engine to the front engine mount as follows.

   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.

Specifications

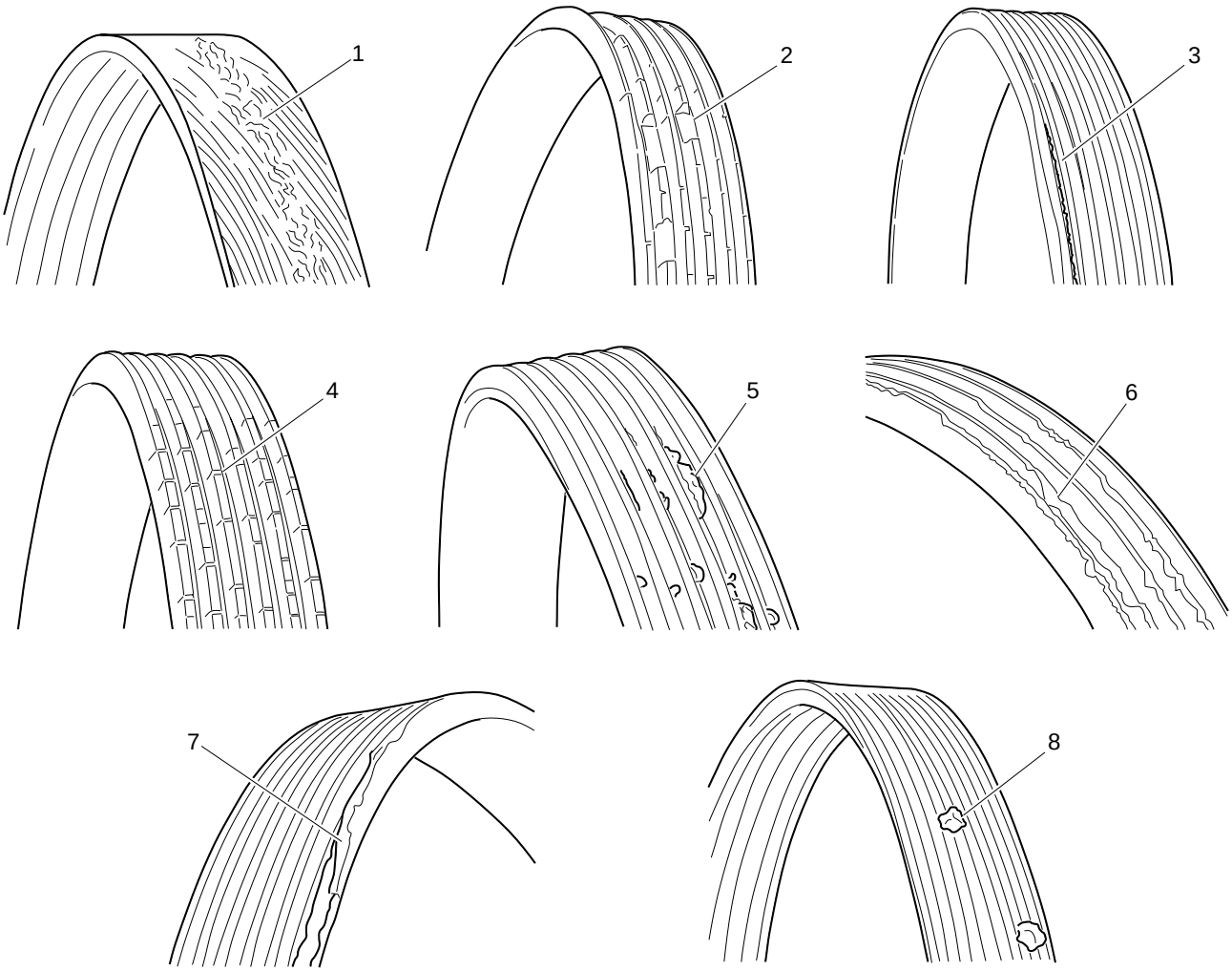
Engine Mount Torques			
Description	**Capscrew Size**	**Grade**	**Torque: lbf·ft (N·m)**
Engine Mount-to-Frame Rail Hexbolts	5/8–11 x 2-1/2	8	120–152 (163 to 206)
Engine Leg-to-Flywheel Housing Bolts	5/8–11 x 1-3/4	8	136 (184)
Engine Leg-to-Engine Mount Capscrews	3/4–10 x 4-1/2	8	213– 269 (289–365)
Front Engine Bracket-to-Front Engine Mount Capscrews	3/4–10 x 4	8	213–269 (289–365)

Table 1, Engine Mount Torques

Pulley and Drive Belt Inspection

Inspection

1. Inspect the belt contact surfaces for chips, flaking, cracks, discoloration, and other damage. See **Fig. 1**.
3. Inspect the springs on the belt tensioner. If the spring is damaged, change the belt tensioner following the engine manufacturer's instructions.



1. Abrasion
2. Chunk-out
3. Improper Install
4. Cracking
5. Pilling
6. Uneven Rib Wear
7. Misalignment
8. Gravel Penetration

Fig. 1, Damaged Belts

2. Inspect the bearings in the idler pulleys, and accessories, by rotating the pulleys to look for bearing slop, or choppy feeling bearings.
4. Inspect the pulleys for damage. If the pulleys are damaged, change both the damaged pulley and the belt. See **Fig. 2**.

Pulley and Drive Belt Inspection

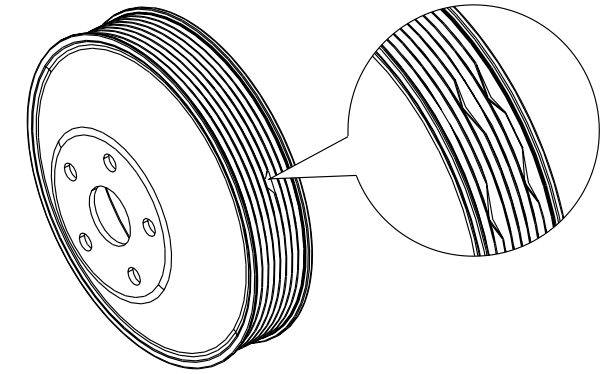
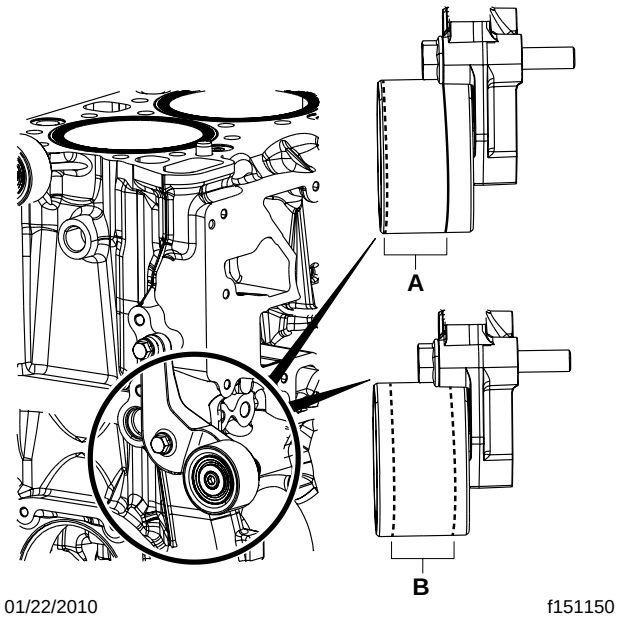


Fig. 2, Damaged Pulley

5. Check the belt allignment on all idler pulleys. If the alignment is incorrect as shown in **Fig. 3**, and pulley wear is visible, replace the pulley and bracket.



A. Incorrect Belt-Alignment Area

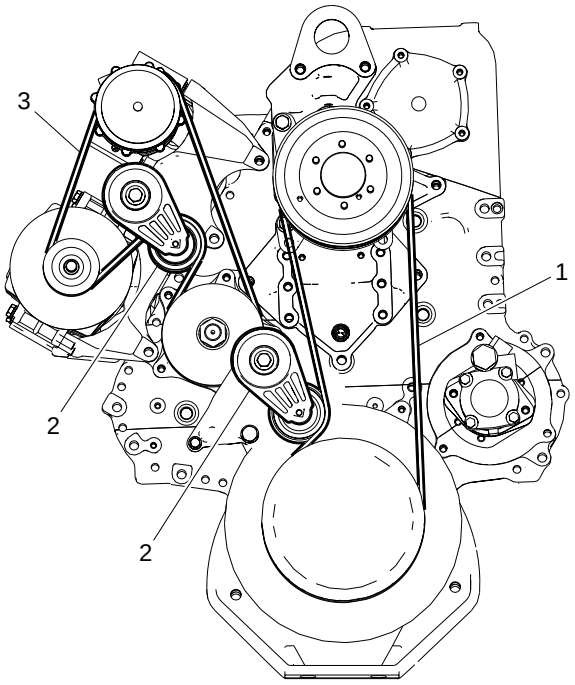
B. Correct Belt-Alignment Area

Fig. 3, Idler-Pulley Belt Alignment

Drive Belt Replacement, Detroit Diesel S60

Alternator and Refrigerant Compressor Drive Belt

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner away from the accessory drive belt. See **Fig. 1**.



1. Fan Drive Belt
2. Automatic Belt Tensioner
3. Alternator and Refrigerant Compressor Drive Belt

Fig. 1, Detroit Diesel Series 60 Drive Belts

4. Holding the belt tensioner down, remove the belt from the alternator pulley.
5. Remove the belt from the refrigerant compressor pulley and the engine pulley.
6. Slowly release the belt tensioner and remove the breaker bar.
7. Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 100**.
8. Install the belt onto the engine pulley.
9. Insert a 1/2-inch breaker bar into the belt tensioner and rotate it out while installing the belt onto the alternator pulley.
10. Slowly release the belt tensioner and remove the breaker bar. The belt tensioner will automatically apply the correct tension on the belt.
11. Close the hood and remove the chocks.

Fan Drive Belt

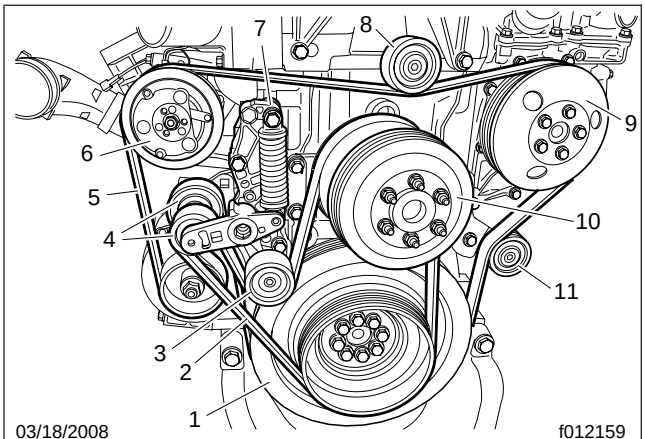
1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner away from the fan drive belt. See **Fig. 1**.
4. Holding the belt tensioner down, remove the belt from the fan pulley and the engine pulley.
5. Slowly release the belt tensioner and remove the breaker bar.
6. Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 100**.
7. Install the belt onto the fan pulley.
8. Insert a 1/2-inch breaker bar into the belt tensioner and rotate it out while installing the belt onto the engine pulley.
9. Slowly release the belt tensioner and remove the breaker bar. The belt tensioner will automatically apply the correct tension on the belt.
10. Close the hood and remove the chocks.

Drive Belt Replacement, DD13/15/16 Engines

Detroit Diesel DD13/15/16 engines are equipped with two serpentine poly-V drive belts. The rear belt (closest to the engine block surface) drives the alternator, the A/C compressor, and the water pump. The front belt drives the engine fan. Both drive belts are kept at the correct tension with pulleys and a dual automatic belt-tensioner assembly. See **Fig. 1**.

NOTICE

When replacing the drive belts for the DD engines, it is crucial to use the correct procedure for releasing and locking the belt tensioners. Because they are part of the same assembly, it may appear that both belt tensioners can be released at the same time by releasing just one, but this is not the case. They must be released and locked separately, and in the correct sequence, or the assembly may be damaged.

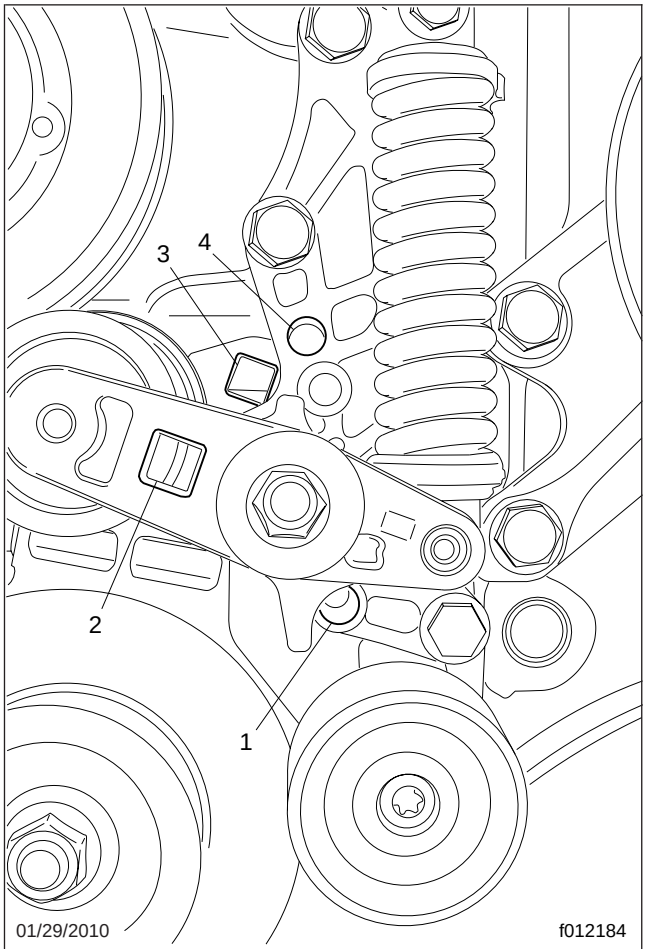


1. Crankshaft Vibration Damper
2. Front Poly-V Drive Belt
3. Idler Pulley
4. Tensioner Pulleys (front is grooved; rear is smooth)
5. Rear Poly-V Drive Belt
6. A/C Compressor
7. Dual Automatic Belt Tensioner Assembly
8. Idler Pulley
9. Water Pump
10. Fan Pulley and Clutch
11. Idler Pulley

Fig. 1, DD13/15/16 Drive Belt Configuration

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative terminals.
3. Raise the hood.
4. Locate the automatic belt tensioner assembly, on the left (passenger) side of the engine, as you are facing it. Familiarize yourself with the location of the square, front and rear 1/2-inch drive holes, and the round, front and rear holes for the locking bolts. See **Fig. 2**.



1. Front Round Hole for 10 mm Locking Bolt
2. Front Square1/2-inch Drive Hole
3. Rear Square 1/2-inch Drive Hole
4. Rear Round Hole for 10 mm Locking Bolt

Fig. 2, Belt Tensioners Assembly

Drive Belt Replacement, DD13/15/16 Engines

NOTICE

Never rotate the automatic belt tensioners clockwise. To do so may damage them, and require replacement of the entire assembly. To prevent damage to the belt tensioners, always rotate them counterclockwise. Never use more force than 66 to 73 lbf (90 to 100 N), or you could damage the tensioner.

IMPORTANT: When releasing the automatic belt tensioners and removing the drive belts, always work on the front tensioner and belt (fan drive) first, then the rear tensioner and belt (alternator, A/C compressor, and water pump). When you unlock the belt tensioners, reverse the procedure; unlock the rear belt tensioner first, then front one.

5. Insert a 1/2-inch breaker bar, or 1/2-inch ratchet into the square hole in the idler arm of the front belt tensioner (grooved pulley), then smoothly rotate it downward (counterclockwise) until you feel resistance. See **Fig. 3**.

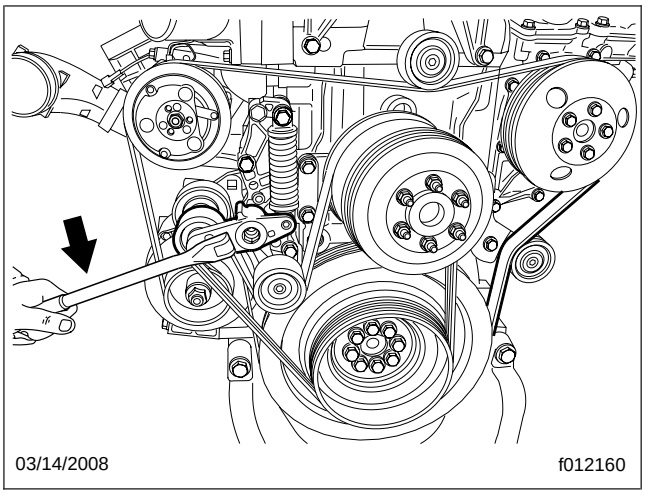
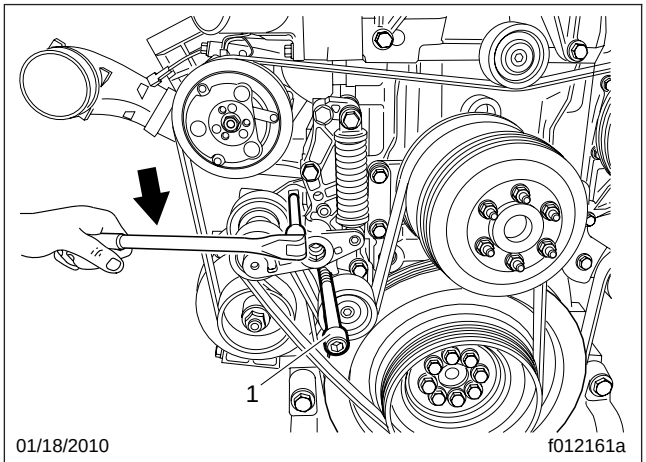


Fig. 3, Releasing the Front Tensioner

6. Insert a 10 mm diameter x 80 mm long bolt into the round hole on the idler arm of the tensioner as shown in **Fig. 4**, then push it all the way in. After the bolt is pushed all the way in, the tensioner will be locked in the released position. Remove the socket wrench from the square hole.
7. Insert a 1/2-inch breaker bar, or 1/2-inch ratchet, into the square hole in the idler arm of the rear belt tensioner (smooth pulley), then smoothly rotate it downward (counterclockwise) until you feel resistance. See **Fig. 4**.



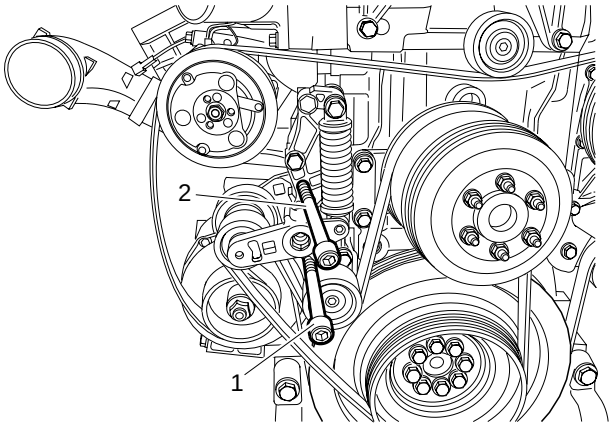
Note: To show the location of the locking bolt, it is shown in position but not pushed all the way in.

1. Locking Bolt Position for Front Belt Tensioner

Fig. 4, Releasing the Rear Tensioner (smooth pulley)

8. Insert a second 10 mm diameter x 80 mm long bolt into the round hole on the idler arm of the rear tensioner as shown in **Fig. 5**, then push it all the way in. After the bolt is pushed all the way in, the tensioner will be locked in the released position. Remove the wrench from the square hole.
9. Replace the drive belts, making sure the new belts are correctly installed on all the pulleys.
10. Using the 1/2-inch breaker bar, or 1/2-inch ratchet, rotate the idler arm on the rear (smooth pulley) tensioner downward (counterclockwise), until you can remove the locking bolt. Smoothly release the idler arm all the way up, being careful not to jerk it.
11. In the same manner as the previous step, remove the locking bolt from the front tensioner.
12. Do a final check to make sure both drive belts are configured correctly, and correctly installed on all the pulleys.
13. Close the hood, connect the batteries, then remove the chocks.

Drive Belt Replacement, DD13/15/16 Engines



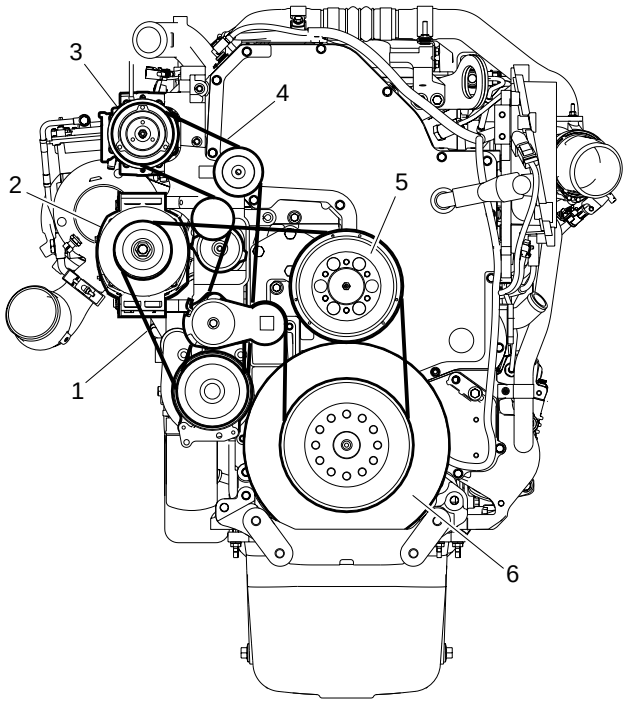
Note: To show the location of the locking bolts, they are shown in position but not pushed all the way in.

1. Locking Bolt for Front Belt Tensioner
2. Locking Bolt for Rear Belt Tensioner

Fig. 5, Position for Locking Bolts

Drive Belt Replacement, Cummins ISX Engine

Cummins ISX engines are equipped with two serpentine, poly-V drive belts and two automatic belt tensioners. The accesory drive belt drives the fan, alternator, and the water pump. The A/C belt drives the A/C compressor. See **Fig. 1**. Both drive belts are kept at the correct tension by a system of pulleys and two automatic belt tensioners.



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1. Fan Belt
2. Alternator
3. AC Compressor
4. AC Drive Belt
5. Fan Drive
6. Crank Shaft Pulley

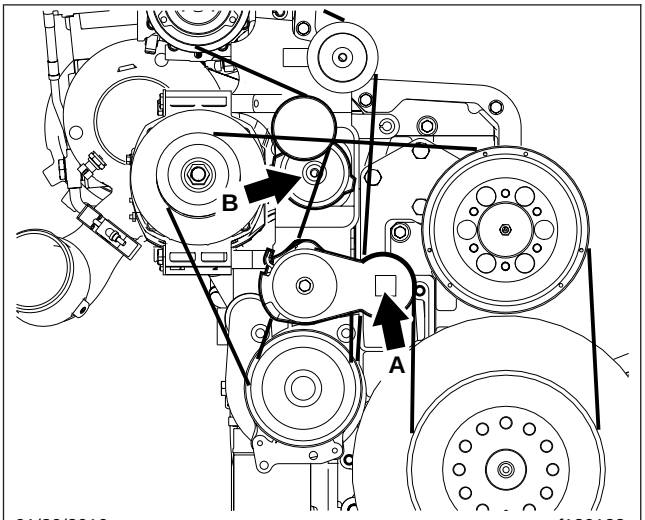
Fig. 1, Cummins ISX Drive Belt Routing

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative terminals.
3. Raise the hood.

IMPORTANT: When replacing drive belts on the Cummins ISX engine you cannot replace the AC-drive belt with the accessory-drive belt in place. The accessory-drive belt must be removed first.

4. Locate the accessory drive-belt-tensioner assembly on the left (passenger) side of the engine, as you are facing it. Insert a 1/2-inch-drive ratchet or 1/2-inch breaker bar into the pivot point on the small end of the tensioner. See **Fig. 2**. Pull up on the wrench, turning the tensioner clockwise, until you feel resistance.



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A. Pivot Point for Fan-Drive Belt Tensioner (rotate clockwise with 1/2-inch-drive socket wrench)
B. Pivot Point for Accessory-Drive Belt Tensioner (rotate counterclockwise with 15mm box wrench)

Fig. 2, Releasing the Tensioners

5. Whle the tensioner is released, remove the accessory-drive belt. Do not replace the accessory-drive belt at this time.
6. Insert a 15-mm box wrench onto the pivot bolt of the AC-belt tensioner. Smoothly rotate it downward, turning the tensioner counterclockwise until you feel resistance. See **Fig. 2**.
7. While the tensioner is released, replace the AC-belt, making sure it is correctly installed on all the pulleys.
8. Repeating the procedure from step 4 to release the tensioner from the accessory-drive belt again. While the tensioner is released, install a new accessory-drive belt.

Drive Belt Replacement, Cummins ISX Engine

9. Do a final check to make sure both drive belts are configured correctly, and correctly installed on all the pulleys.
10. Close the hood, connect the batteries, then remove the chocks.

Principles of Operation

EPA 2007

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.

EPA 2010

The Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2009 must reduce the level of emissions exhausted by the engine to 0.2 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx).

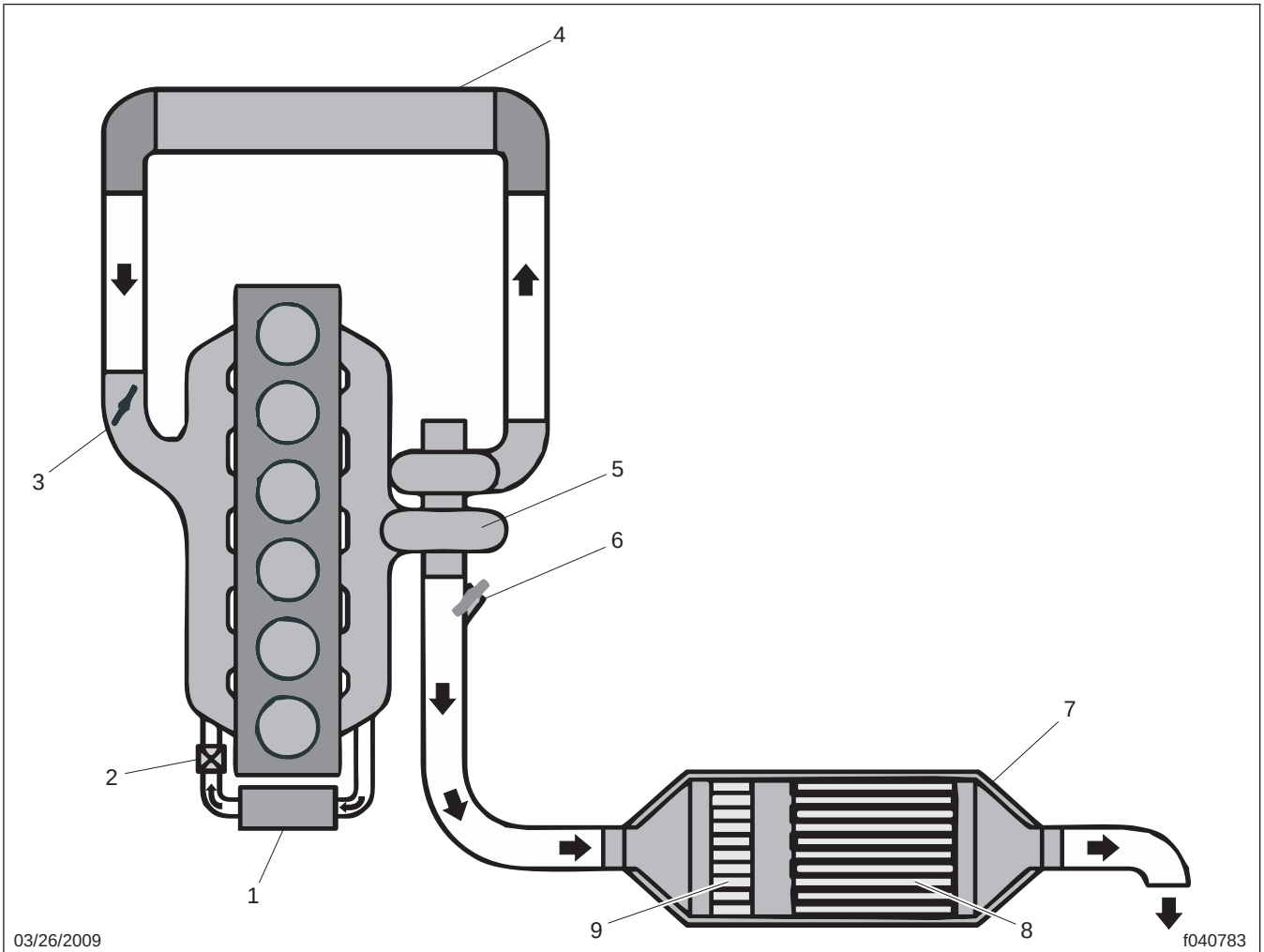
To meet the EPA10 requirements, Daimler Trucks North America is using technology known as Selective Catalytic Reduction (SCR) in the exhaust aftertreatment system (ATS). The ATS will rely on existing EPA07 technology, which includes an aftertreatment device (ATD), with the addition of SCR. See **Fig. 3**. The SCR process requires the introduction of diesel exhaust fluid (DEF) into the exhaust stream.

The ATS is always chassis-mounted, with several different installation options available to fit various vehicle configurations. ATS exhaust piping is made of stainless steel. The ATS includes all piping and equipment between the turbocharger outlet and the end of the exhaust pipe, including the aftertreatment device (ATD), SCR catalyst, DEF tank, DEF tank header unit, DEF pump, DEF metering unit, and the DEF, coolant, and air lines that run between each component.

All EPA10-compliant DTNA vehicles require the use of ultra-low sulfur diesel (ULSD) fuel with a sulfur content of 15 parts per million (ppm) for low emissions and long life of the diesel particulate filter (DPF) in the ATD. In addition, DTNA vehicles require the use of CJ-4 engine oils with less than 1% ash.

Inside the ATD, the exhaust first passes over the diesel oxidation catalyst (DOC), where combustion gases are chemically broken down into water and carbon dioxide. The exhaust then passes through the DPF, a honeycomb-like filter that traps solid soot par-

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)

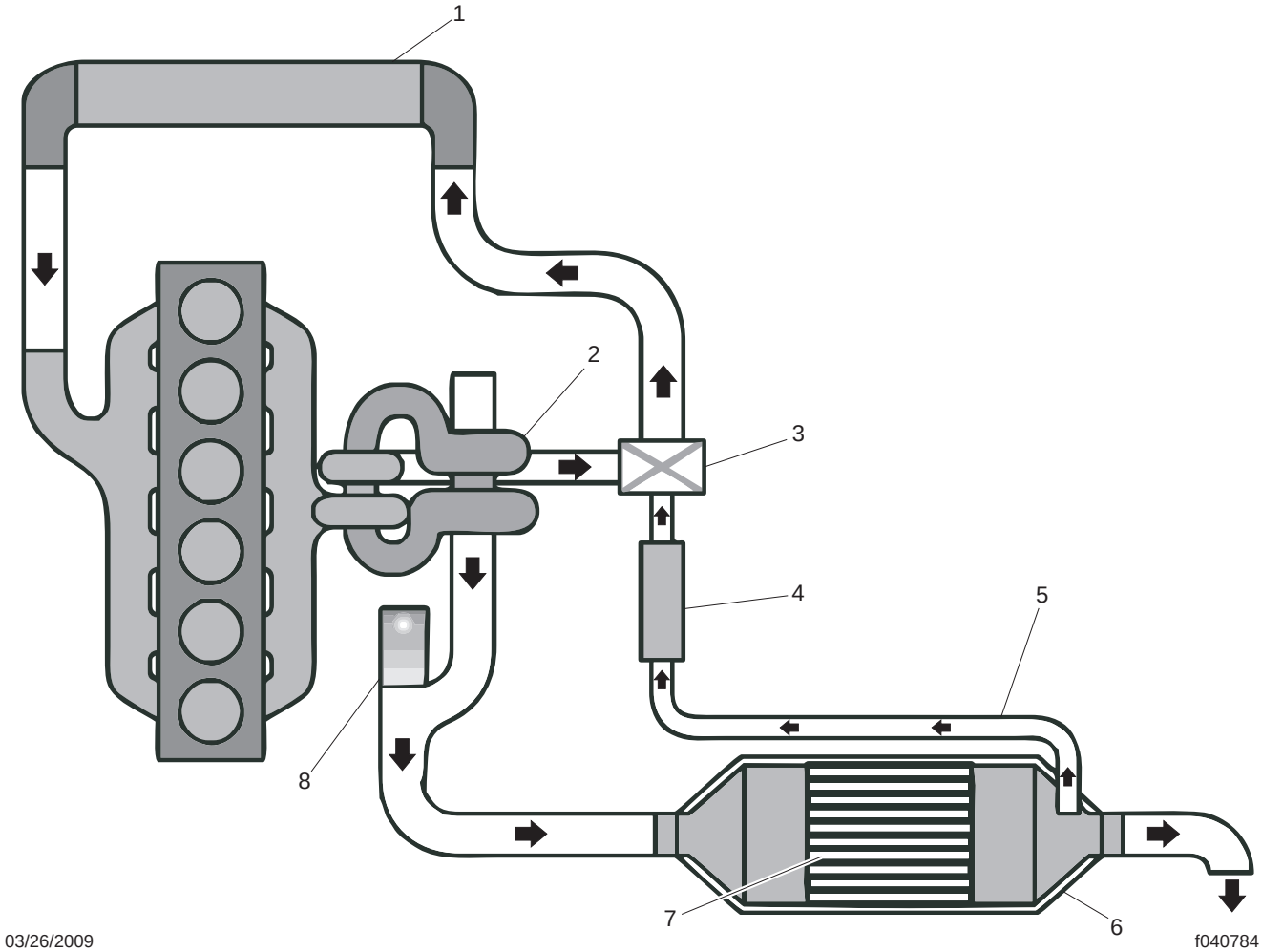
Fig. 1, EPA07 ATS (Detroit Diesel engine shown)

ticles. The soot particles trapped in the DPF are reduced to ash during regeneration (regen).

If the exhaust temperature is high enough, a process called passive regen 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.

Despite the regen process, ash collects in the DPF over time and needs to be removed through cleaning at specific intervals. For DPF maintenance intervals



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, EPA07 ATS (Caterpillar engine shown)

and repair information, see the engine manufacturer's service literature.

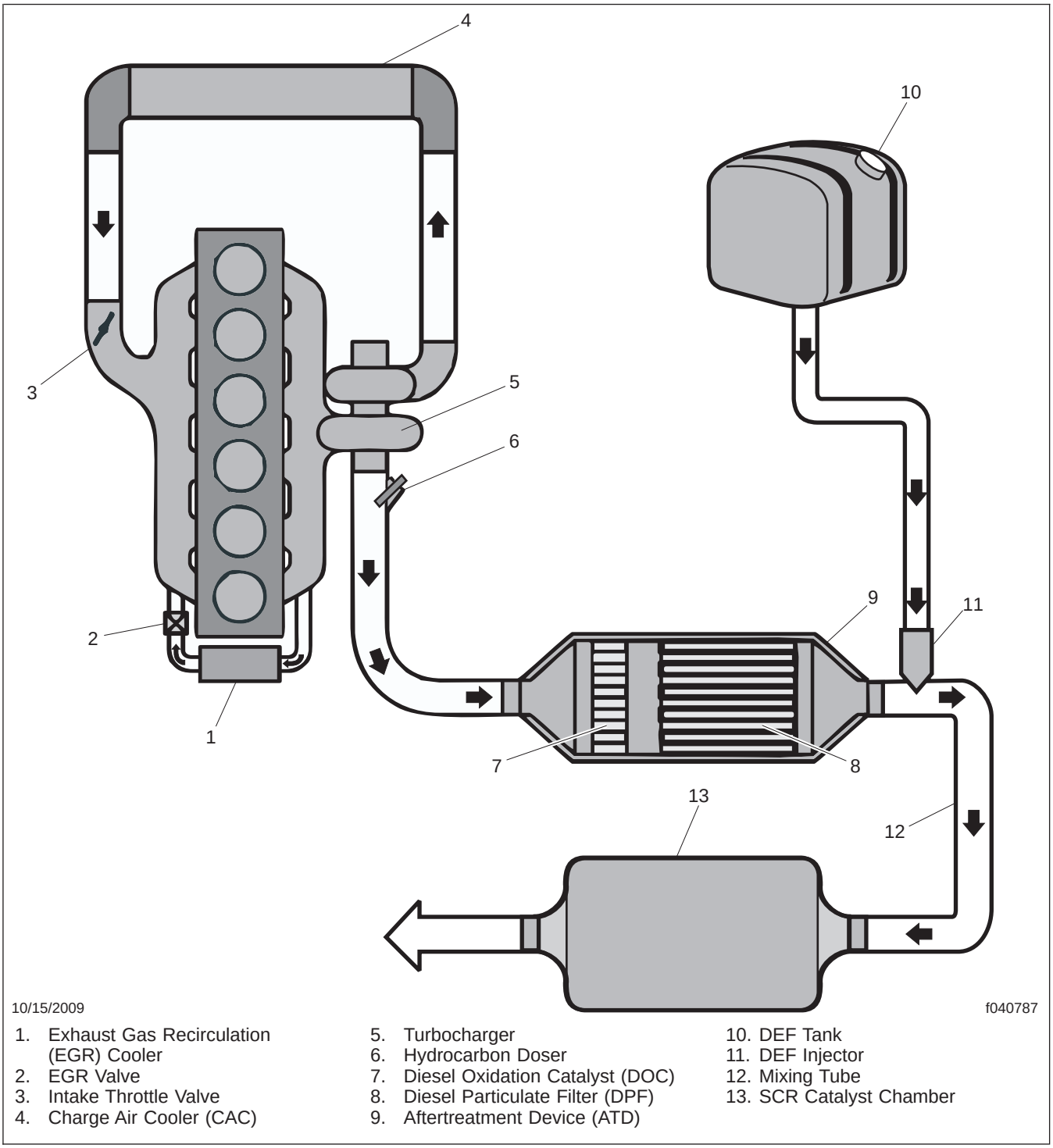
After exhaust gases leave the ATD, a controlled quantity of diesel exhaust fluid (DEF) is injected into the exhaust stream. In the presence of heat, DEF is converted to ammonia gas, which reacts with NOx in the selective catalyst chamber to yield nitrogen and water vapor, which exit through the tailpipe.

EPA10-compliant DTNA vehicles are equipped with an additional tank to carry the DEF necessary for the SCR process. DEF is colorless, non-toxic, and biodegradable. DEF consumption will vary depending on ambient conditions and vehicle application.

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

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. Diesel Oxidation Catalyst (DOC)
8. Diesel Particulate Filter (DPF)
9. Aftertreatment Device (ATD)
10. DEF Tank
11. DEF Injector
12. Mixing Tube
13. SCR Catalyst Chamber

Fig. 3, EPA10 ATS (Detroit Diesel engine shown)

on EPA07/10-compliant parts and systems installed by Daimler Trucks North America:

- **Section 01.00**, Engine Mounts
- **Section 20.00**, Radiator Assembly
- **Section 49.00**, Aftertreatment System, EPA07
- **Section 49.01**, Aftertreatment System, EPA10
- **Section 49.02**, Diesel Exhaust Fluid System, EPA10

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 *Cascadia Maintenance Manual*.

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

Definition of Terms

Refer to the following terms for a better understanding of EPA07/10 engines.

Ash Unburnable solids that remain after regeneration in the ATD.

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.

Diesel Exhaust Fluid (DEF) A colorless, non-toxic, and biodegradable fluid used in the SCR process.

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 in the 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.

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.

Selective Catalytic Reduction (SCR) A vehicle emissions control technology to reduce diesel engine emissions for passenger cars, and light and heavy-duty trucks.

ULSD (Ultra-Low Sulfur Diesel) Fuel A clean burning diesel fuel containing a maximum of 15-ppm sulfur. To meet EPA requirements, all highway diesel fuel sold in the U.S. must be ULSD.

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 serious personal injury 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.

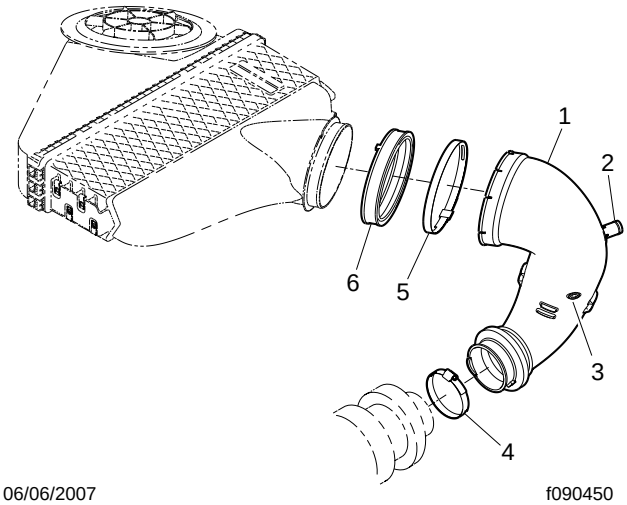
1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood.
3. Remove the air compressor suction hose, if equipped, and the electrical connection for the air intake temperature sensor.
4. Loosen the hose clamps on the air intake ducting at the air cleaner outlet and the turbocharger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

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

Installation

1. Attach the inlet air temperature sensor to the duct. Use pipe thread sealant to ensure there are no air leaks.

NOTE: Do not fully tighten the air intake temperature sensor until after the tube is in position. The altered port location will affect how the sensor should be clocked to obtain the best routing for the wiring harness.



1. One-Piece Duct
2. Air Compressor Outlet
3. Sensor Port
4. Duct-to-Turbocharger Clamp
5. Air Cleaner-to-Duct Clamp
6. Air Cleaner Cuff

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

2. Install the ducting over each connection so that it overlaps at least 1 inch (25 mm). P80 emulsion, or equivalent rubber lubricant, can be used to ease assembly at the air cleaner and duct joint. Check the air ducting for any interference or contact with adjacent components. Loosen and adjust as necessary.

NOTE: Be sure all hose connections are square and have proper overlap before torquing the clamps.

3. Tighten the hose clamp at the turbocharger 8 lbf·ft (11 N·m). Tighten the hose clamp at the air cleaner outlet 3 lbf·ft (5 N·m).
4. Finish clocking the air intake temperature sensor, and connect the wire harness.
5. Connect the air compressor suction line, if equipped, to the air compressor outlet on the duct.

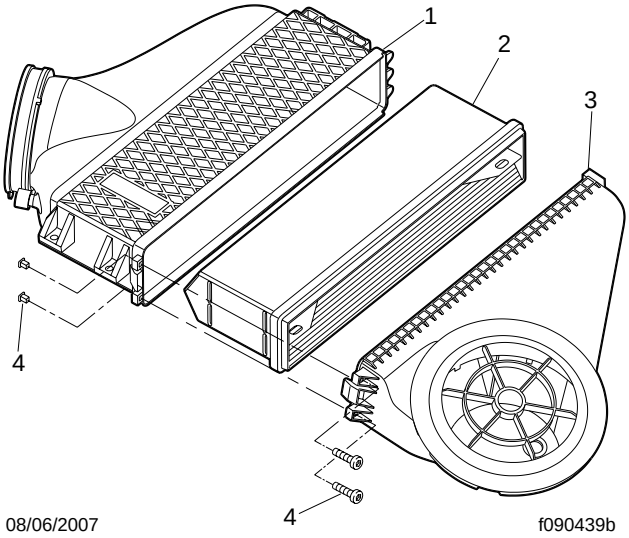
Element Replacement

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.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Check the air cleaner housing for damage, and check all ducting and connections to the air cleaner for leakage. Adjust or replace parts as necessary.
4. Remove the two sets of fasteners from the air cleaner cover. See **Fig. 1**.



1. Air Cleaner Housing
2. Air Cleaner Element
3. Air Cleaner Cover
4. Cover Fasteners

Fig. 1, Air Cleaner Element Replacement

5. Due to high gasket-loading pressures, removing the air cleaner cover may be difficult. After removing the fasteners, gently swing the cover away from the housing.
6. Remove the air cleaner filter element.

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.

7. Check the housing and sealing surfaces for damage or dirt buildup that could cause sealing problems. Remove any dirt buildup.
8. Wipe the inside of the air cleaner housing with a clean damp cloth.
9. Inspect a new filter element for damaged gaskets or parts. If the gaskets are not smooth and flat, or are damaged to the extent that dust might bypass them, discard the element.
10. Install the new filter element.
11. Install the air cleaner cover and fasteners. Tighten the cover fasteners 25 to 35 lbf·in (280 to 400 N·cm).
12. Check all connections for tightness.

Air Cleaner Housing Removal and Installation

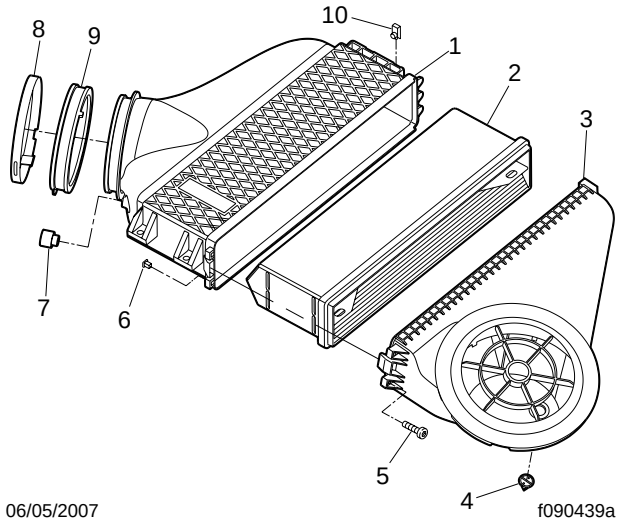
Removal

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.

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Loosen the hose clamp that attaches the flexible duct to the air cleaner outlet port, then pull the duct off the port. See **Fig. 1**.
3. Remove the top nuts from the front isolators. See **Fig. 2**.



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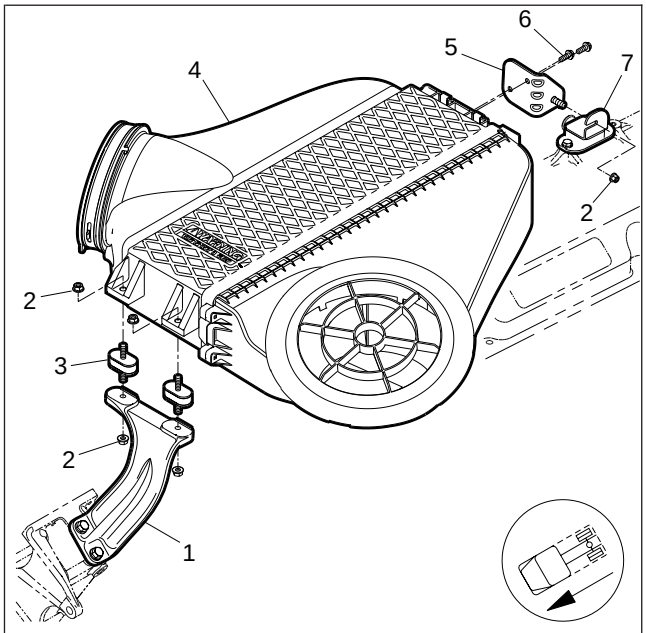
1. Air Cleaner Housing
2. Air Cleaner Element
3. Air Cleaner Cover
4. Vacuator (Spitter) Valve
5. Capscrew
6. Nut
7. Air Restriction Indicator
8. Air Cleaner-to-Ducting Clamp
9. Air Cleaner-to-Ducting Seal
10. Threaded Clip

Fig. 1, Air Cleaner Assembly Mounting



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1. Front Mounting Bracket
2. Nut
3. Front Isolator
4. Air Cleaner Housing
5. Rear Mounting Bracket
6. Capscrews
7. Rear Isolator

Fig. 2, Air Cleaner Housing Mounting

4. Loosen the nut on the rear mounting bracket stud, then slide the stud out of the rear isolator slot. See **Fig. 3**.

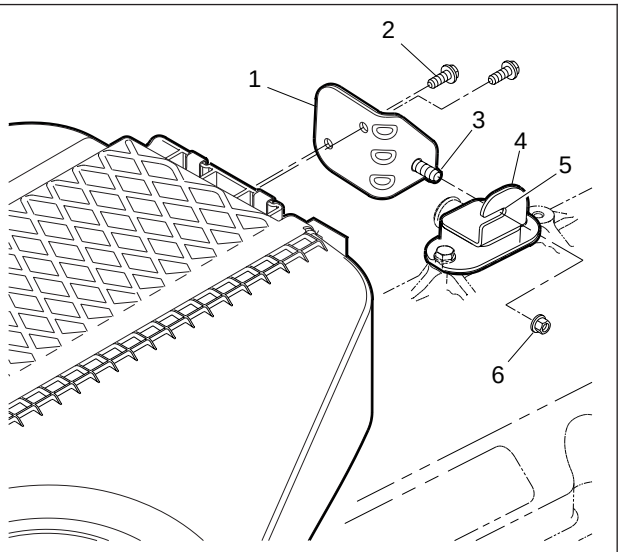
Installation

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.

1. If the air cleaner housing has been damaged, check all ducting and connections to the air cleaner for leakage. Adjust or replace parts as necessary.
2. If the housing is being replaced, transfer the rear mounting bracket to the new air cleaner housing. Tighten the bracket fasteners 13 lbf·ft (18 N·m).

Air Cleaner Housing Removal and Installation



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1. Rear Mounting Bracket
2. Capscrews
3. Rear Mounting Bracket Stud
4. Rear Isolator
5. Rear Isolator Slot
6. Nut

Fig. 3, Air Cleaner Housing Rear Mounting

3. Slide the rear mounting bracket stud at the rear of the housing into the slot of the rear isolator.
4. Install the forward isolator top nuts, and tighten them and the rear mounting bracket stud nut 13 lbf·ft (18 N·m).
5. Install the ducting over the outlet so that it overlaps at least 1 inch (25 mm). The tabs on the seal should line up with the housing and clamp. P80 emulsion, or equivalent rubber lubricant, can be used to ease assembly at the air cleaner and duct joint.
6. Check the air ducting for any interference or contact with adjacent components. Loosen and adjust as necessary.
7. Tighten the hose clamp at the air cleaner outlet 40 lbf·in (450 N·cm)

NOTE: Be sure the hose connection is square and has proper overlap before tightening the clamp.

8. Inspect a new filter element for damaged gaskets or parts. If the gaskets are not smooth and flat, or are damaged to the extent that dust might bypass them, discard the element.
9. Remove the air cleaner cover and install the new element in the air cleaner housing.
10. Attach the cover to the housing, and tighten the cover fasteners 25 to 35 lbf·in (280 to 400 N·cm).

Air Cleaner Restriction Inspection

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**).

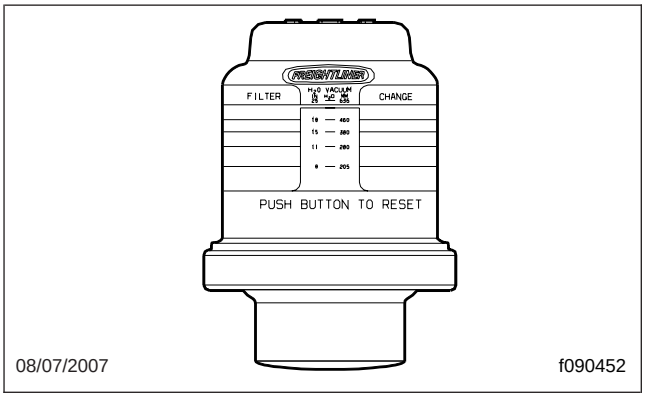


Fig. 1, Manual-Reset Air Restriction Indicator, Graduated

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.

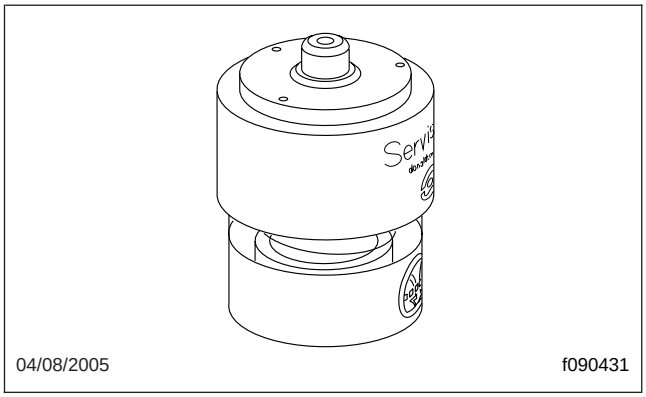


Fig. 2, Manual-Reset Air Restriction Indicator, Go/No-Go

Air Cleaner Element Maximum Restriction	
Engine	**Maximum Restriction**
Caterpillar	25 inH_2O
Cummins	25 inH_2O
Detroit Diesel	22 inH_2O
Mercedes-Benz	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.

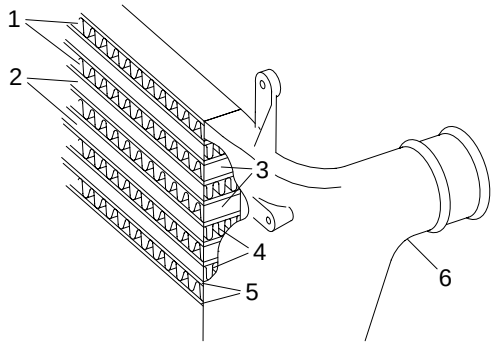
3. Operate the engine to see if air restriction exceeds recommended values again. This can be done by running the vehicle on a dynamometer at **full-load and rated rpm**, or by driving the vehicle for one day in the vehicle's typical operating environment while not exceeding the rated rpm (typically 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.

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.



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

Fig. 1, CAC Construction

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the bumper. For instructions, see **Group 31**.
3. Remove the hood. For instructions, see **Group 88**.
4. Loosen the hose clamps at both ends of the hoses that attach the inlet and outlet air piping to the charge air cooler (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. Loosen the two upper bolts that hold the CAC to the cooling package side rails and completely remove the two lower bolts.
9. Support the CAC, then remove the two upper bolts.
10. While someone else supports the left side of the CAC, 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**.

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.

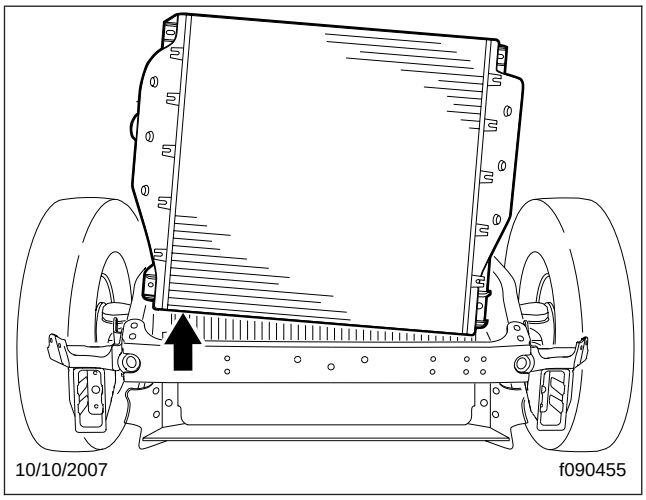


Fig. 1, Charge Air Cooler Tilted for Removal, Front View

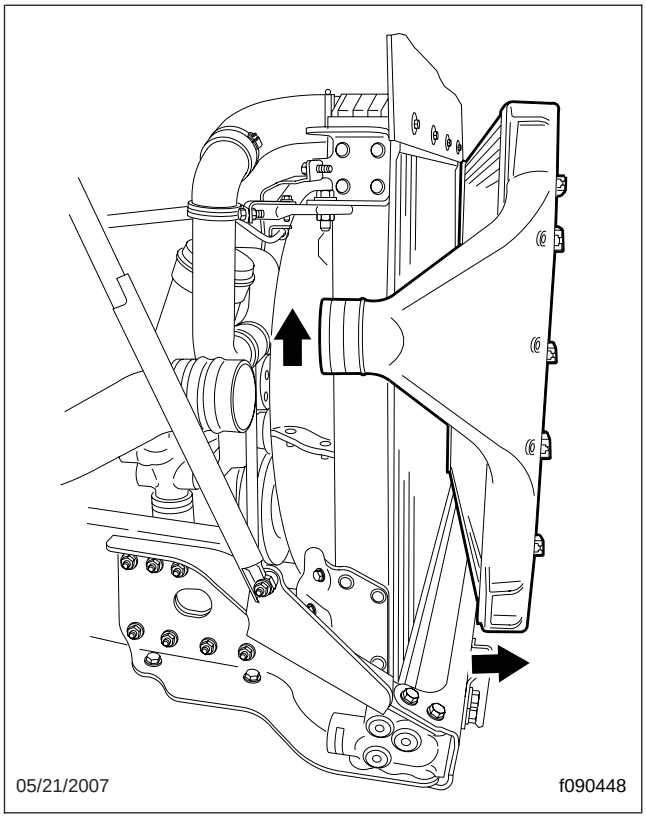


Fig. 2, Charge Air Cooler Tilted for Removal, Side View

2. Pull both sides of the CAC far enough forward to clear the radiator's CAC forward studs, if equipped.

CAC Removal and Installation

3. Install the fasteners that attach the CAC to the radiator. Tighten all CAC mounting fasteners 28 lbf·ft (38 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 fasteners 98 lbf·in (1100 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 98 lbf·in (1100 N·cm).

IMPORTANT: The constant tension clamps adjust to changes in diameter at the hose connection. 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. Install the hood. For instructions, see **Group 88**.
9. Install the bumper. For instructions, see **Group 31**.
10. 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 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.

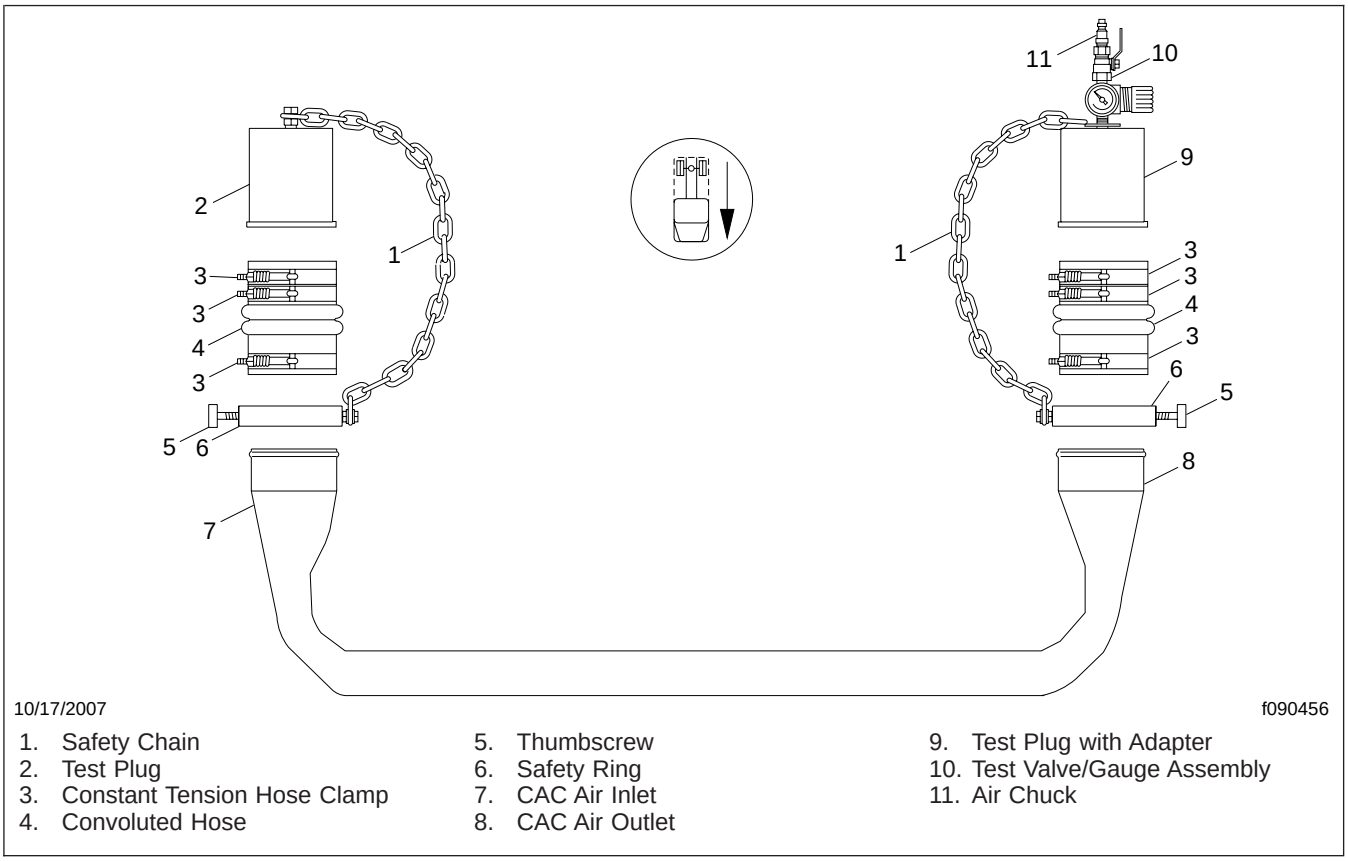
   - 2.6 If not already installed, install a test valve/gauge assembly and air chuck in the test plug with adapter.
   - 2.7 Attach a pressurized air line to the air chuck on the pressure regulator valve.
3. Test the CAC core as follows.

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 suddenly 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**.

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. CAC Air Outlet
9. Test Plug with Adapter
10. Test Valve/Gauge Assembly
11. Air Chuck

Fig. 1, CAC Core Testing

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 clamp screws 98 lbf·in (1100 N·cm).

IMPORTANT: The constant tension clamps adjust to changes in diameter at the hose connection. 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**.
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 leakage.

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, then tip the upright CAC sideways to allow any remaining vapor to leave the CAC.
10. Install the CAC. For instructions, see **Subject 100**.

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.

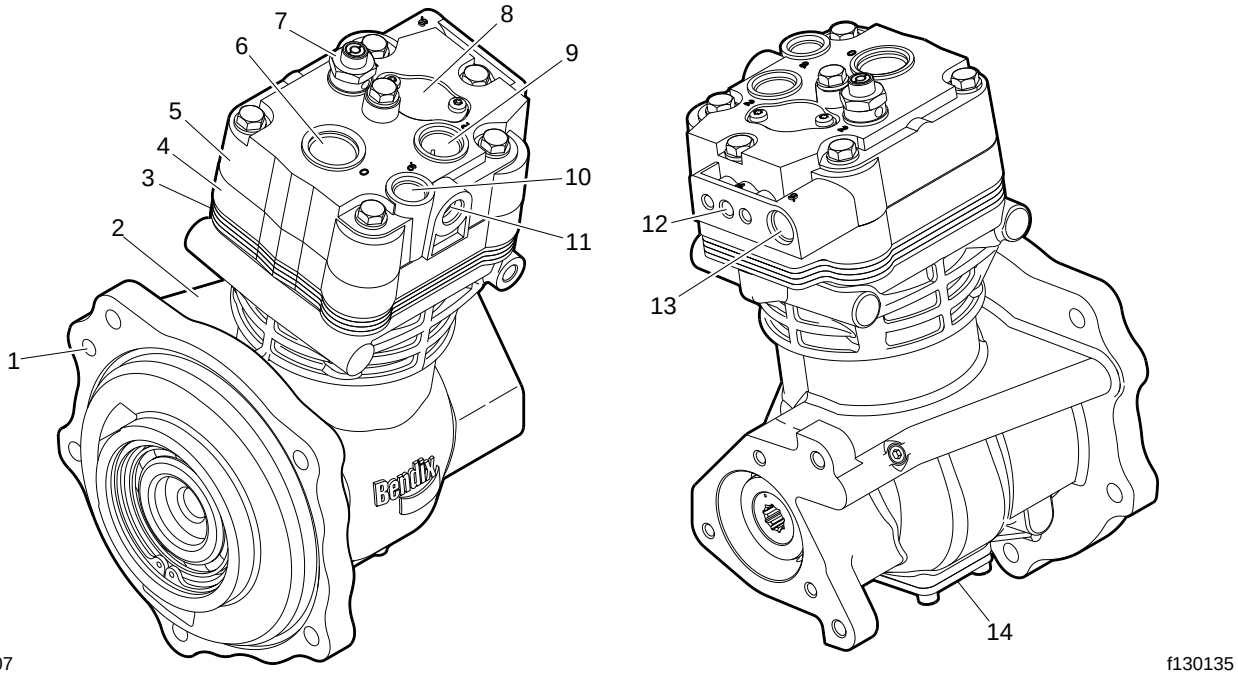
   If the pressure drop is more than 4 inHg (14 kPa), flush or replace the CAC as needed.

General 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.

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



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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

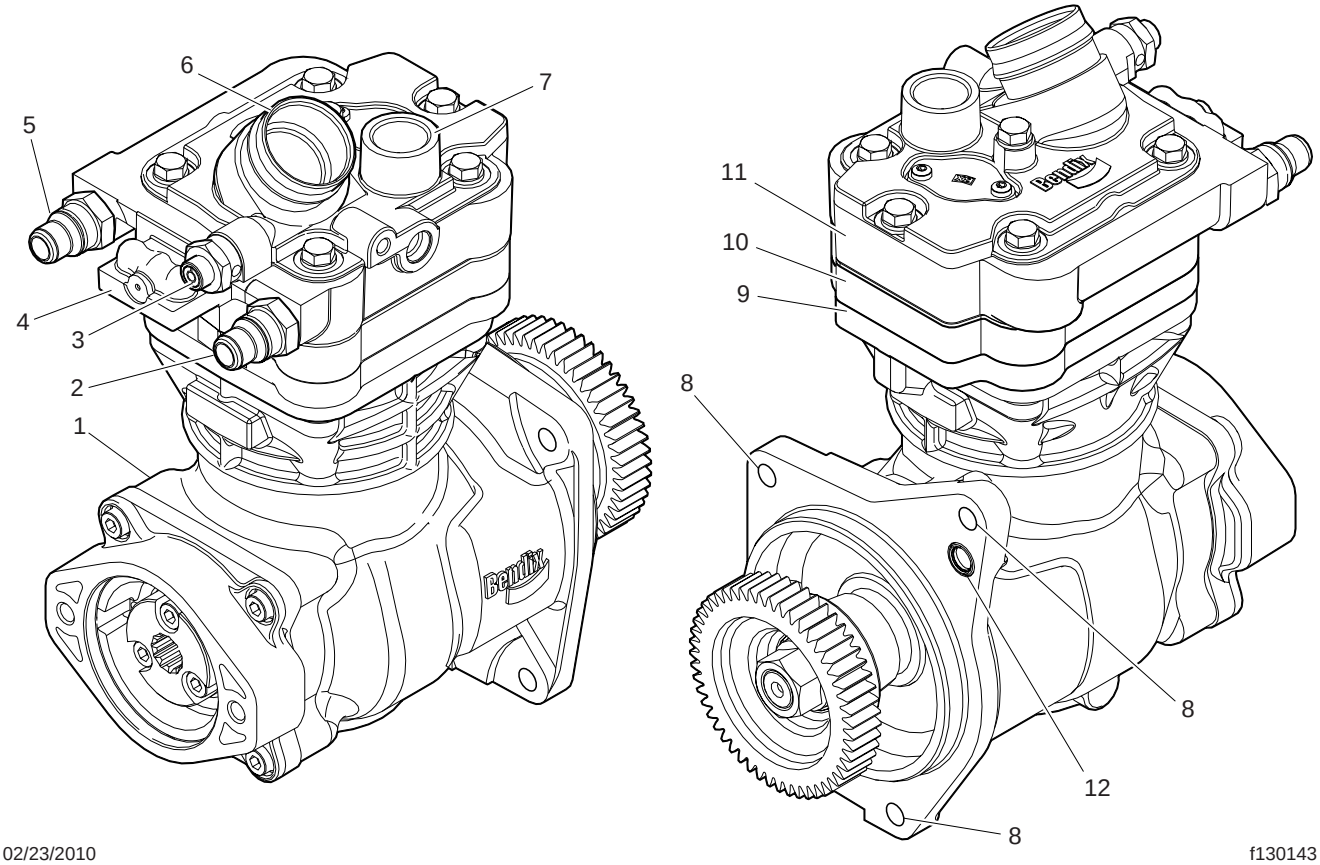
Fig. 1, Bendix BA-921 Air Compressor

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

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,

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.

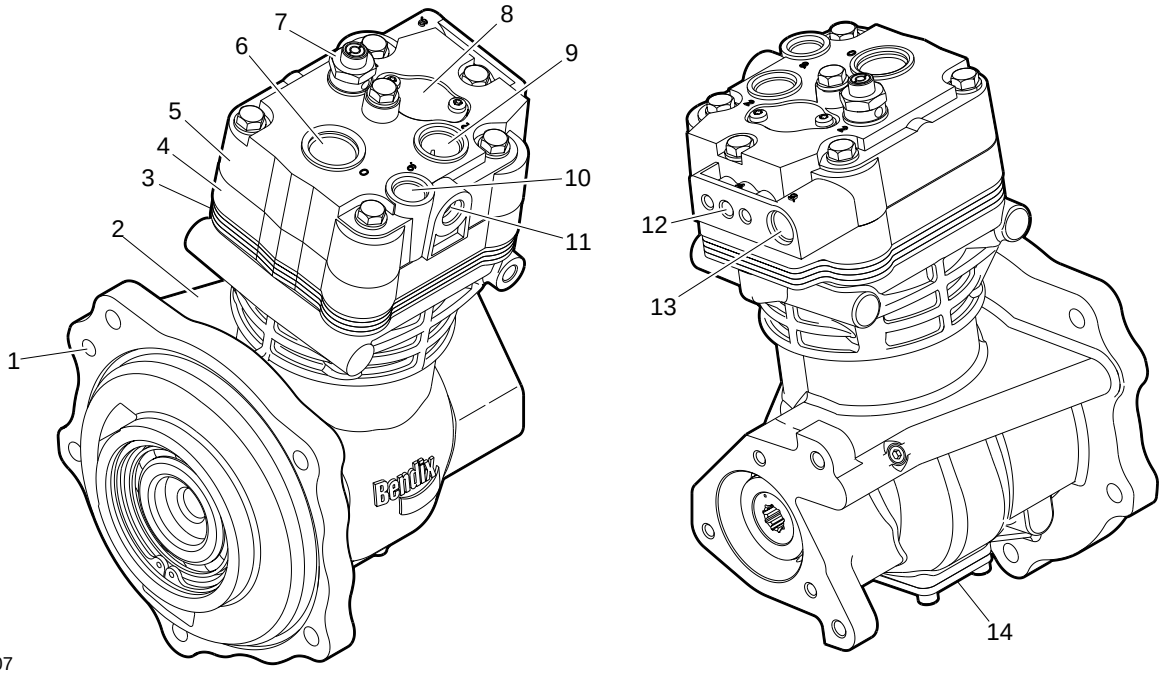
Mounting Fastener Torque Values	
Description	**Torque: lbf·ft (N·cm)**
BA-921 Mounting Capscrews M10 1.50 x 85 (4 qty) M10 1.50 x 35 (1 qty)	43–54 (58–73)
360cc Mounting Capcrews 1.37 in (35 mm) (4 qty)	44 (60)
Power Steering Pump Mounting Fasteners	27–32 (37–43)
Fuel Pump Mounting Fasteners	22–28 (30–38)
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



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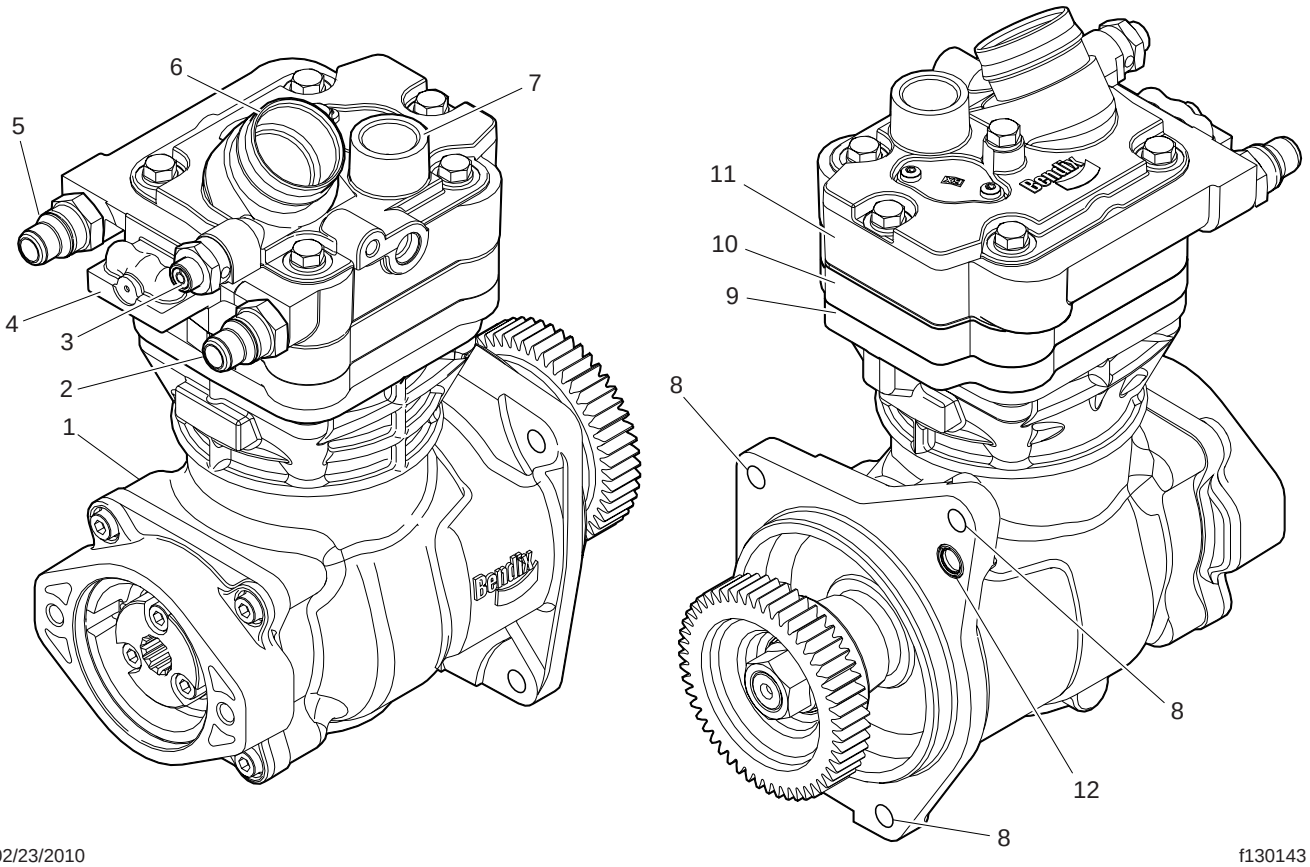
1. Oil Supply Bore
2. Crankcase
3. Valve Plate Assembly
4. Cooling Plate
5. Cylinder Head
6. Air Supply Port
7. Pressure Relief Valve
8. Unloader Valve Cover
9. Discharge Port
10. Coolant Supply Port
11. Freeze Plug
12. Governor Connection Port
13. Coolant Return Port
14. Crankcase Cover

Fig. 1, BA-921 Air Compressor

each coolant line retainer is engaged in the locked position.

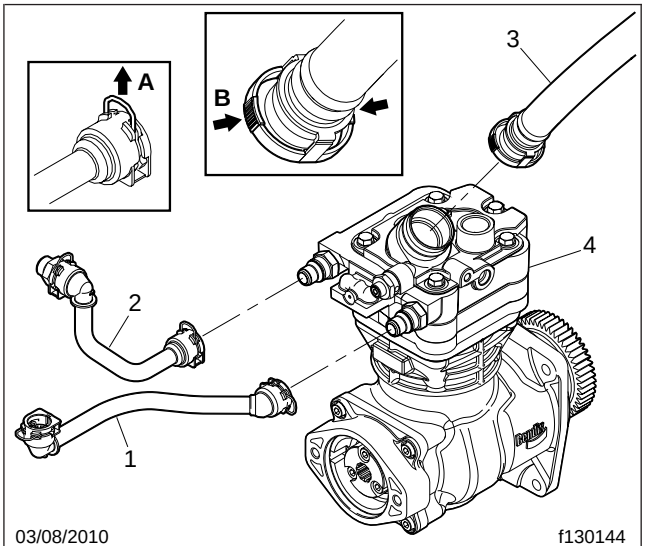
16. Connect the air and coolant lines to the air compressor. Connect the oil line, if equipped, to the compressor.
17. Install any components that were removed from the air compressor, such as the fuel pump (Series 60 engines) or power steering pump (DD13/15/16 engines). See **Table 1** for torque specifications.
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.



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

Compressor Removal, Inspection, and Installation

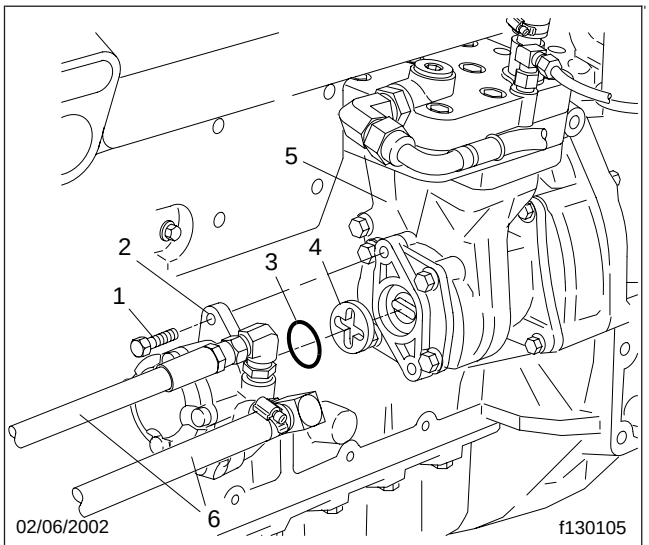
Removal

1. Apply the parking brakes and chock the tires.
2. Drain the air tanks.
3. Open the hood. Clean the fittings and hose connections on the air compressor and power steering pump.
4. Drain the radiator coolant.
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**.

NOTE: Depending on vehicle configuration, it may be necessary to remove the brackets that attach the transmission cooler lines to the engine to obtain enough room to remove the compressor.

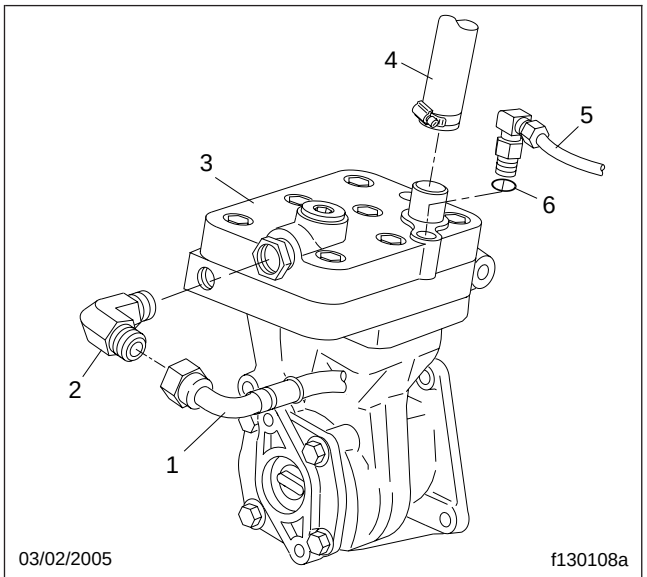
IMPORTANT: Do not remove the power steering lines. Secure the lines and the pump so that they are out of the way.

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.
8. Remove the three air lines from the air compressor (see **Fig. 2**), as follows.
   - 8.1 Remove the discharge air line and the elbow fitting. Check inside the discharge air line for carbon deposits. If deposits are found, install a new discharge line.
   - 8.2 Remove the unloader air line. Check the fittings for damage and replace if necessary.
   - 8.3 Loosen the hose clamp and remove the intake air line.
9. Remove all air fittings from the top of the compressor.
10. Remove the engine trim cover.
11. Remove the coolant delivery and return lines. Discard the seal rings. See **Fig. 3**.
12. Remove the four capscrews that attach the air compressor to the engine and remove the compressor. See **Fig. 4**.



1. Capscrew
2. Power Steering Pump
3. O-Ring
4. Cross Plate
5. Air Compressor
6. Hydraulic Lines

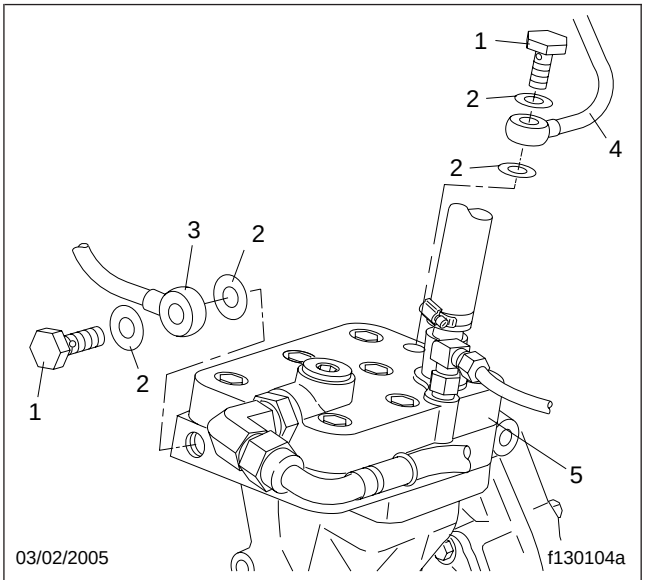
Fig. 1, Power Steering Pump Removal



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

Compressor Removal, Inspection, and Installation



1. Hollow-Core Banjo Capscrew
2. Seal Ring
3. Coolant Return Line
4. Coolant Delivery Line
5. Air Compressor

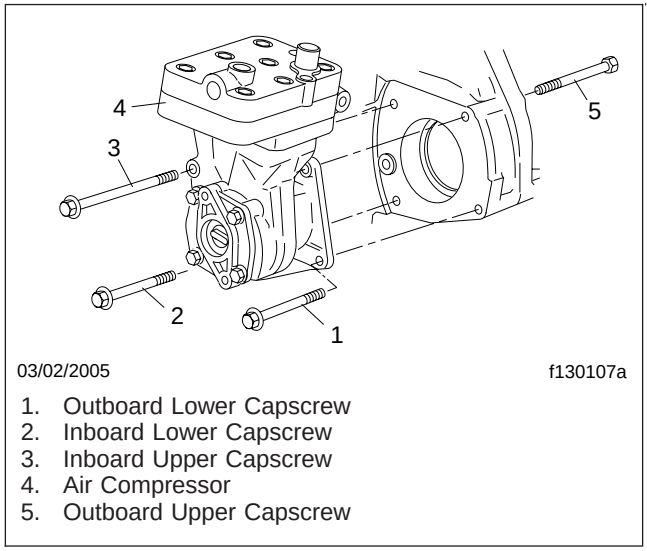
Fig. 3, Air Compressor Coolant Lines

NOTE: The capscrews that attach the air compressor to the engine are different lengths. Be sure to note where each capscrew is located.

13. Slide the drive gear away from the flywheel. Catch any oil that runs out and dispose of it properly.

Inspection

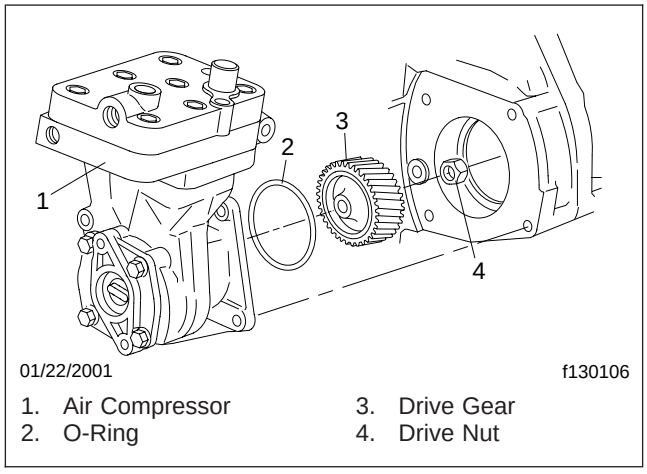
1. Install an SPX Kent-Moore locking device (J 46177) on the air compressor where the power steering pump connects to the air compressor. Tighten the capscrews until the air compressor drive is locked. This device locks the driveshaft to allow removal of the drive nut. See **Fig. 5**.
2. Remove the drive gear from the air compressor, as follows.
   - 2.1 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.
   - 2.2 Using an impact wrench, remove the drive nut from the drive gear.



1. Outboard Lower Capscrew
2. Inboard Lower Capscrew
3. Inboard Upper Capscrew
4. Air Compressor
5. Outboard Upper Capscrew

Fig. 4, Air Compressor Removal

   - 2.3 Remove the drive gear from the air compressor, using a gear puller if necessary.
   - 2.4 Discard the O-ring that seals the compressor hosuing to the engine block.
3. Inspect the drive gear for worn or broken teeth, spalling, and corrosion. If necessary, replace the drive gear.
4. Install a new O-ring on the air compressor housing. Install the drive gear. Tighten the drive nut 214 lbf·ft (290 N·m). See **Fig. 5**.



1. Air Compressor
2. O-Ring
3. Drive Gear
4. Drive Nut

Fig. 5, Air Compressor Drive Gear Installation

Installation

1. Using four capscrews, attach the air compressor to the engine. Tighten the capscrews 44 lbf·ft (60 N·m).

NOTE: Be sure to use the correct capscrew at each mounting location.

2. Install new seal rings on the coolant lines, then install the coolant lines on the air compressor. Tighten the hollow-core banjo capscrews 22 lbf·ft (30 N·m).
3. If the brackets that attach the transmission cooler lines to the engine were removed, install the brackets.
4. Install the engine trim covers.
5. Install the air fittings on top of the air compressor.
6. Install the three air lines on the air compressor, as follows.
    - 6.1 Install the discharge and unloader air lines. Make sure the O-rings are correctly installed on the fittings.
    - 6.2 Tighten the discharge and unloader air line fittings 60 lbf·ft (80 N·m).
    - 6.3 Install the intake air line and tighten the hose clamp.
7. Install the cross plate on the compressor output drive. Use grease to hold it in place while installing the power steering pump.
8. Install a new O-ring between the power steering pump and the cross plate.
9. Using two capscrews, attach the power steering pump to the air compressor. Tighten the capscrews 30 lbf·ft (40 N·m).
10. Fill the cooling system. Check air line and coolant fittings for leaks. Correct any leaks as necessary.

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**
Air Compressor Locking Device	J-46177

Table 1, SPX Kent-Moore Tools

Torque Values	
Description	**Torque: lbf·ft (N·m)**
Air Compressor Capscrews	44 (60)
Air Line Fittings	60 (80)
Coolant Line Hollow-Core Banjo Bolts	22 (30)
Drive Nut	214 (290)
Power Steering Pump Mounting Capscrews	30 (40)

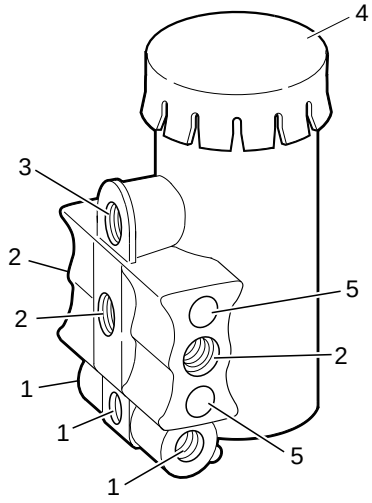
Table 2, Torque Values

General Description

The governor **(Fig. 1),** operating in conjunction with the compressor unloading mechanism, automatically controls the air pressure in the air brake or air supply system between the desired, predetermined maximum and minimum pressures. Normal air pressure in all Freightliner vehicles is 100 to 135 psi (690 to 930 kPa). The compressor runs continuously while the engine runs, but the actual compression of air is controlled by the governor actuating the compressor unloading mechanism, which stops or starts compression when the maximum or minimum reservoir pressures are reached. The D-2 governor has a piston upon which air pressure acts to overcome the pressure setting spring, and control the inlet and exhaust valve to either supply air to, or exhaust air from the compressor unloading mechanism.

D-2 governors have mounting holes, which allow for direct mounting to the compressor.

Porting consists of 3 reservoir ports (1/8-inch NPT), 3 unloader ports (1/8-inch NPT), and 1 exhaust port (1/8-inch NPT).

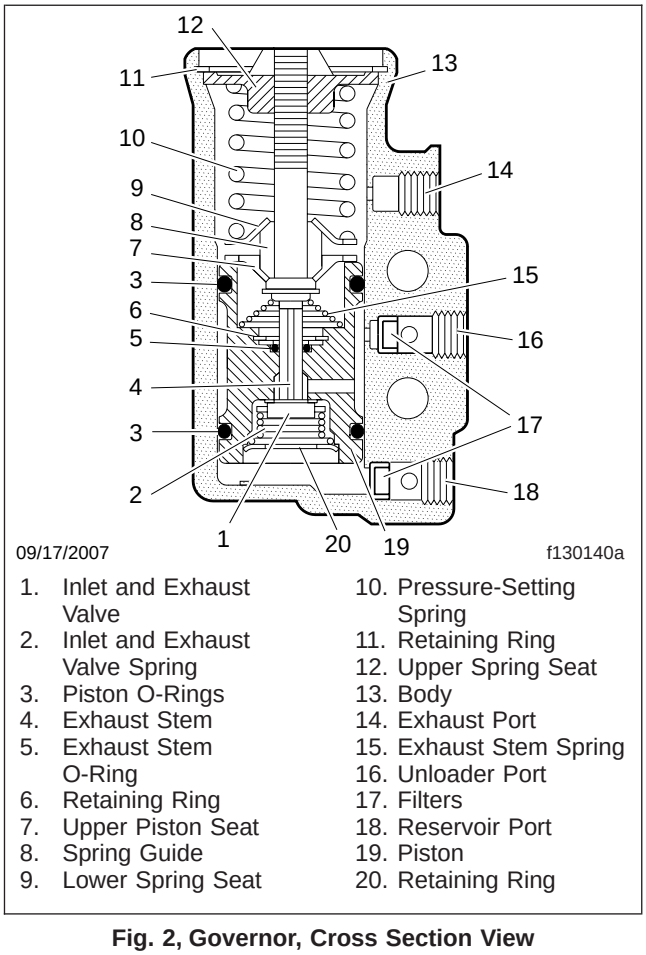


1. Reservoir Port
2. Unloader Port
3. Exhaust Port
4. Top Cover
5. Mounting Hole

Fig. 1, Air Governor, Adjustable Model Shown

Principles of Operation

Pressurized air enters the D-2 governor at one of its reservoir ports, and acts on the area of the piston and beneath the inlet and exhaust valve. See **Fig. 2.** As air pressure builds up, the piston moves against the resistance of the pressure-setting spring. The piston and inlet and exhaust valve move up when the reservoir air pressure reaches the cut-out setting of the governor. The exhaust stem seats on the inlet and exhaust valve, and then the inlet passage opens. Reservoir air then flows by the open inlet valve, through the passage in the piston, and out the unloader port to the compressor unloading mechanism. Air also flows around the piston, and acts upon the additional area of the piston. This added force, which results from a larger area on the piston, ensures a positive action and fully opens the inlet valve.



1. Inlet and Exhaust Valve
2. Inlet and Exhaust Valve Spring
3. Piston O-Rings
4. Exhaust Stem
5. Exhaust Stem O-Ring
6. Retaining Ring
7. Upper Piston Seat
8. Spring Guide
9. Lower Spring Seat
10. Pressure-Setting Spring
11. Retaining Ring
12. Upper Spring Seat
13. Body
14. Exhaust Port
15. Exhaust Stem Spring
16. Unloader Port
17. Filters
18. Reservoir Port
19. Piston
20. Retaining Ring

Fig. 2, Governor, Cross Section View

General Information

As the system reservoir air pressure drops to the cut-in setting of the governor, the force exerted by the air pressure on the piston will be reduced so that the pressure-setting spring will move the piston down. The inlet valve will close and the exhaust will open. With the exhaust open, the air in the unloader line will escape back through the piston, through the exhaust stem and out the exhaust port.

Tests

The following test should be performed whenever the vehicle air pressure is incorrect and the causes are unknown.

If the air governor does not function as described or if leakage is excessive, replace it with a new or remanufactured unit.

1. Apply the parking brakes and chock the tires. Open the hood.
2. Start the engine and build up air pressure in the air brake system.

IMPORTANT: Make sure the test gauge is registering accurately before using it to check or adjust the air governor. Do not use the vehicle's dash pressure gauge to check the governor pressure setting.

3. Using a test gauge attached to the supply reservoir, check the pressure at the time the air governor cuts out. For vehicles with a dryer reservoir module (DRM), install the pressure gauge in either the primary or secondary reservoir.

   The cut-out pressure should be 125 to 135 psi (860 to 930 kPa).

4. With the engine still running, make a series of brake applications to reduce the air pressure and observe at what pressure the air governor cuts in the compressor.

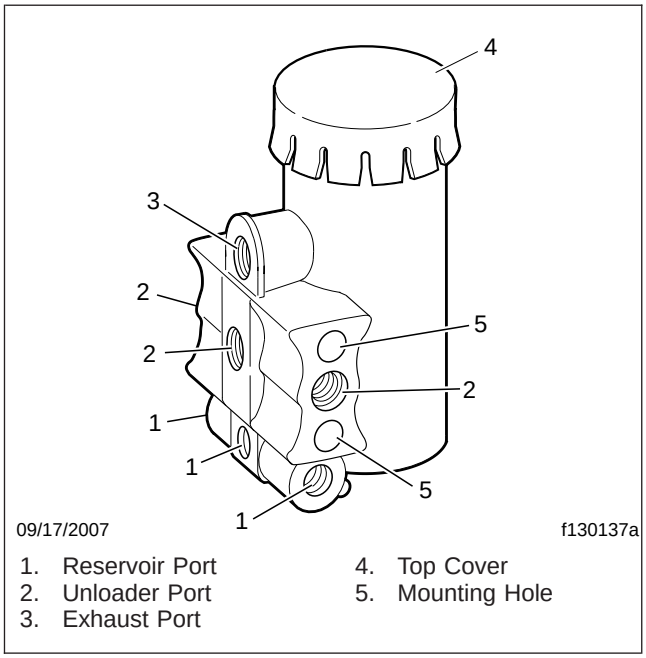
   For vehicles without a DRM, the minimum cut-in pressure should be 100 psi (689 kPa).

   For vehicles with a DRM, the minimum cut-in pressure should be 105 psi (724 kPa).

5. If either the cut-out or cut-in pressures are incorrect, proceed to **Subject 120**.
6. Test the leakage of the air governor in both the cut-in and cut-out positions.

   6.1 With the compressor in the cut-in position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. Excessive leakage indicates that the inlet valve or lower piston O-ring is worn out.

   6.2 With the compressor in the cut-out position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. Excessive leakage indicates that the exhaust valve seat, stem, O-ring, or upper piston O-ring is worn out.



1. Reservoir Port
2. Unloader Port
3. Exhaust Port
4. Top Cover
5. Mounting Hole

Fig. 1, Air Governor, Adjustable Model Shown

Removal

NOTE: The governor may be mounted on the air compressor, on the air dryer, or remote mounted on the vehicle frame.

1. Chock the tires, and drain the air brake system. Open the hood.
2. Disconnect the reservoir and unloader port air lines. Mark the lines for later reference. Cap the air lines tightly to keep out contaminants.
3. Remove the governor mounting capscrews and lockwashers, and remove the governor. See **Fig. 1**.

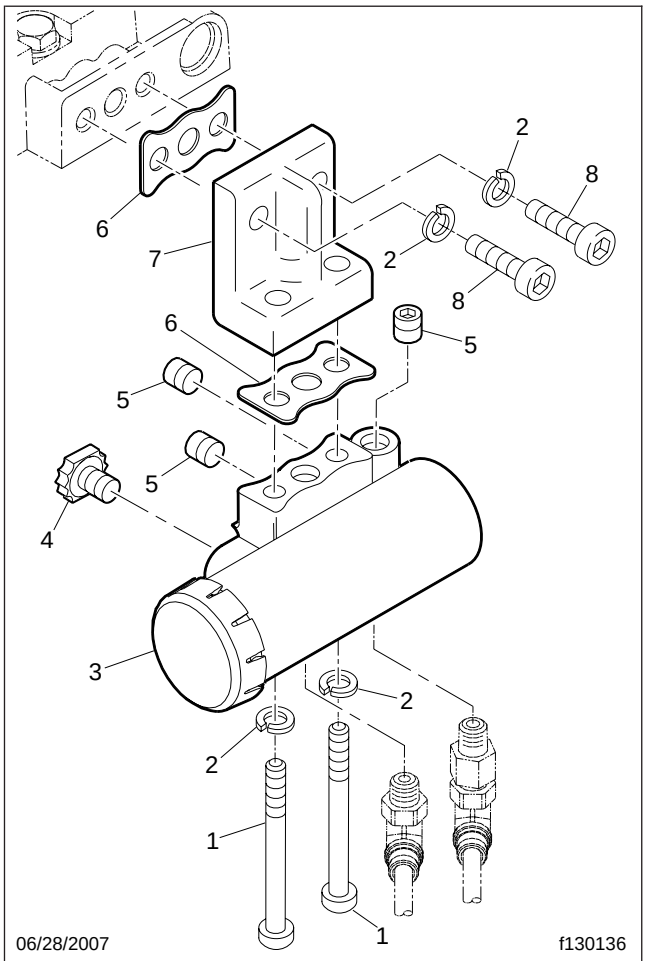
Installation

1. Clean the mounting pad on both the compressor and the governor block, and be sure the compressor unloading port is clear and clean.
2. If the governor needs a governor adapter, install a new governor mounting gasket between the two, and tighten the mounting capscrews 11 to 15 lbf·ft (15 to 20 N·m). See **Fig. 1**.
3. Using a new governor mounting gasket, install the governor, or governor and adapter, and its mounting capscrews and lockwashers. Tighten the capscrews 11 to 15 lbf·ft (15 to 20 N·m).
4. Clean the connecting lines after removing the caps, and apply Loctite® 242, or equivalent sealant in small quantities, to the reservoir and unloader fittings.

⚠ CAUTION

Make sure excess sealant does not get inside the fittings. Loose material inside the plumbing may clog the governor or other components, causing damage.

5. Connect the reservoir and unloader port air lines as referenced earlier. Tighten the fittings 11 to 13 lbf·ft (15 to 18 N·m).
6. Perform the governor operation tests in **Subject 100**.
7. After the tests have been completed and the governor is operating properly, screw the top cover on tightly until it seals the body, preventing the entry of any foreign matter.

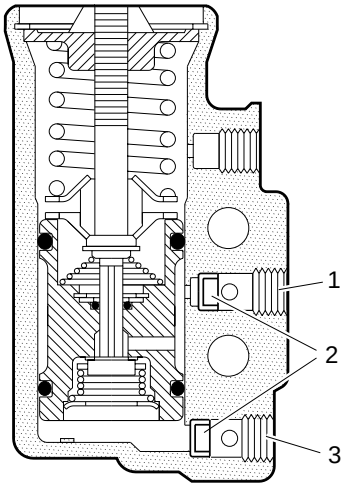


1. Hex Capscrew
2. Lockwasher
3. Air Governor
4. Exhaust Vent Plug
5. Plug
6. Gasket
7. Governor Adapter
8. Hex Capscrew

Fig. 1, Governor Mounting, Bendix BA-921 Air Compressor for DDC Series 60 shown

8. If necessary, install new filters (**Fig. 2**) in the reservoir and unloader ports. These cup-shaped filters can be installed with the eraser-end of a pencil.

Air Governor Removal and Installation



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1. Unloader Port
2. Port Filters
3. Reservoir Port

Fig. 2, Filter Installation

General Information

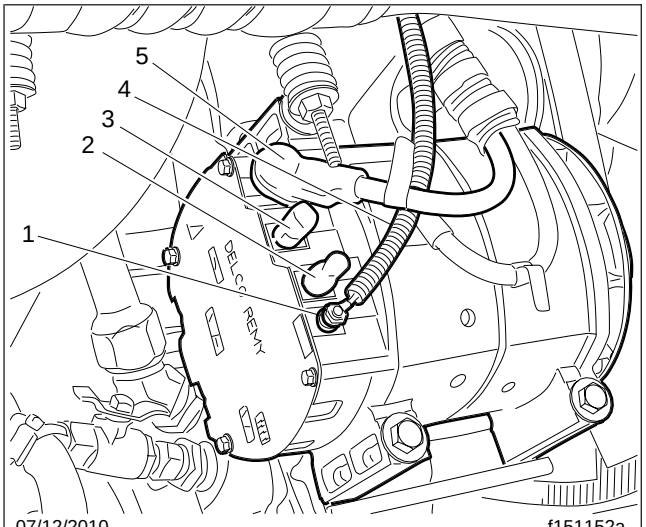
Both Leece-Neville and Delco Remy alternators are available as original equipment on Freightliner vehicles. Installation and removal are the same for all alternators on a given engine design.

Many alternators are equipped with a remote-sense terminal that connects to the batteries, and adjusts the alternator output to keep the system at full charge. See **Fig. 1** for a Delco Remy alternator with remote sense. See **Fig. 2** for a Leece-Neville alternator with remote sense.

⚠ WARNING

Compressed air can dislodge harmful materials or debris and cause eye injury. Use eye protection, and be careful where the stream of debris may go.

The alternator should be cleaned using 20 psi (138 kPa) low-pressure compressed air, to blow away loose debris. Avoid using corrosive solutions to clean the alternator; they leave chemical deposits that cannot be completely removed, and can cause corrosion of electronic components.



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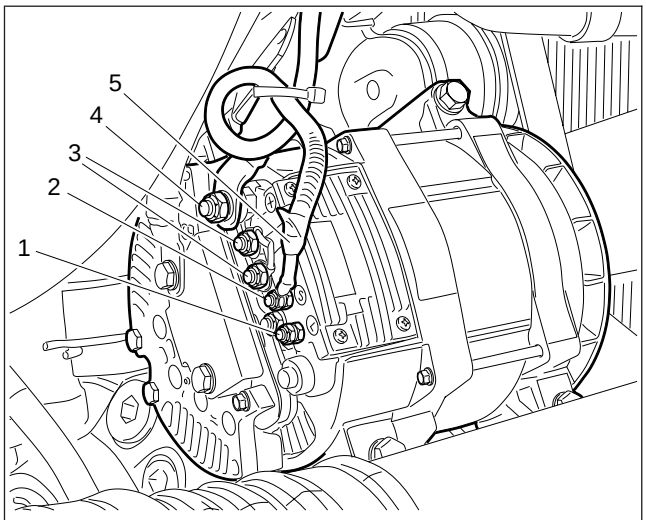
1. Remote-Sense Terminal
2. Indicator Terminal (lamp)
3. Relay Terminal 'R'
4. Remote Sense Circuit 123E
5. Positive Terminal (Battery)

Fig. 1, Delco Remy Alternator with Remote Sense



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1. Lamp Terminal 'L'
2. Remote-Sense Terminal 'S'
3. A.C. Terminals
4. Positive Terminal (Battery)
5. Remote Sense Circuit 123E

Fig. 2, Leece-Neville Alternator with Remote Sense

Removal

1. Apply the parking brake, shut down the engine, and chock the rear tires. Open the hood.
2. Disconnect the batteries.
3. Remove the alternator drive belt, following the instructions in **Section 01.01** of this manual.

NOTE: Be sure the belt is working correctly before replacing the alternator. Many charging system problems originate in the drive belt. Inspect the belt for glazing, wear (frayed edges), damage (breaks or cracks), or oil contamination. Replace the belt if any of these conditions are present.

4. Disconnect the wiring harness at the alternator. Note the wire positions on the terminals, for correct installation. Refer to **Subject 050** in this section for wiring connections.
5. Remove the alternator-mounting capscrews. Remove the alternator.
6. Remove the pulley for use on the new alternator. If the alternator is a Delco Remy, remove the pulley as follows:

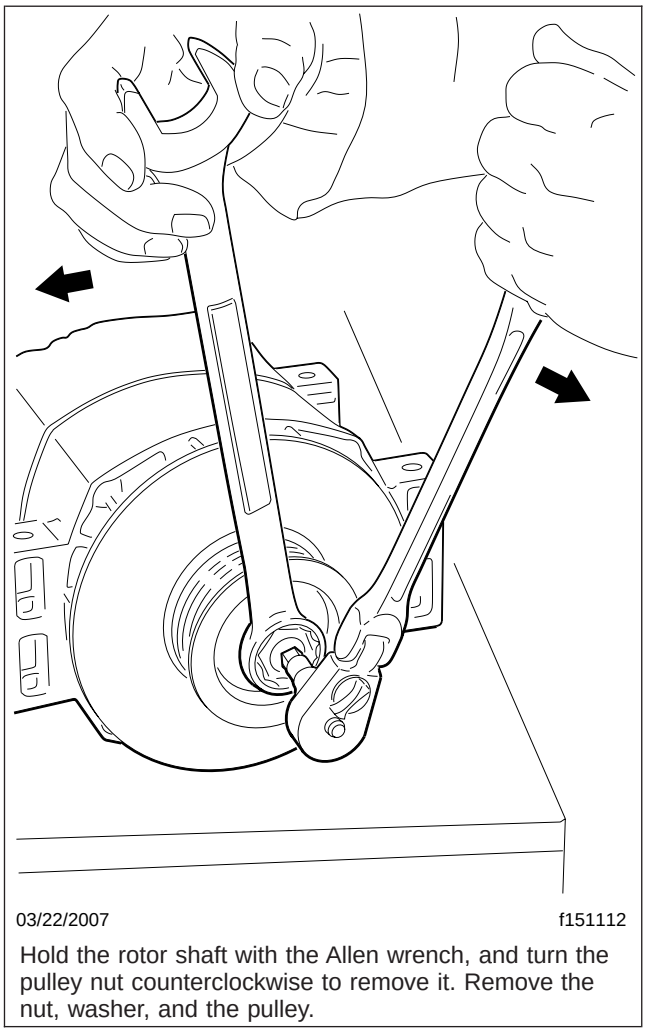
⚠ WARNING

Do not attempt to keep the pulley from turning with your hand, and do not jam a screwdriver into the cooling fins to keep it from turning, as you attempt to loosen the pulley nut. Using pulley nut removal and installation methods other than the one described below may cause personal injury, or damage the alternator and void the warranty.

6.1 Hold the alternator pulley retaining nut with a box-end wrench.

6.2 Insert a 5/16-inch Allen wrench into the Allen fitting in the rotor shaft.

6.3 Hold the rotor shaft with the Allen wrench, and turn the pulley nut counterclockwise to remove it. See **Fig. 1**. Remove the nut, washer, and pulley.



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Hold the rotor shaft with the Allen wrench, and turn the pulley nut counterclockwise to remove it. Remove the nut, washer, and the pulley.

Fig. 1, Loosening a Delco Remy Alternator Pulley Nut

Installation

1. For a Delco Remy alternator, install the pulley on the new alternator.

1.1 Hold the alternator pulley retaining nut with a box-end wrench.

1.2 Insert a 5/16-inch Allen wrench into the Allen fitting in the rotor shaft.

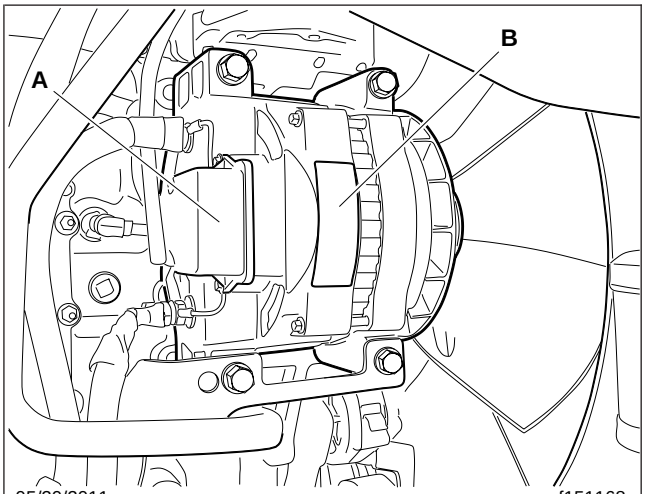
1.3 Hold the rotor shaft with the Allen wrench, and turn the pulley nut clockwise to tighten.

1.4 Tighten the pulley nut 75 lbf·ft (101 N·m).

Removal and Installation

2. Install the alternator.
   2.1 Position the alternator on the engine. and start the mounting capscrews.

   On Leece Neville pad-mounted alternators, belt alignment is obtained by the two mounting bolt holes closest to the alternators pulley. These holes are precision drilled so the alternator is positioned correctly on the engine bracket for proper belt alignment. When mounting a Leece-Neville alternator, it is important that the label or regulator face away from the engine block. If this is not adhered to then the belt alignment will not be correct. See **Fig. 2**.



A. Regulator must face away from the engine block.
B. Label must face away from the engine block.

Fig. 2, Leece-Neville Pad-Mounted Alternator Installation

   2.2 Tighten the mounting capscrews 35 lbf·ft (48 N·m).

   2.3 Install the drive belt following the instructions in **Section 01.01** of this manual.

3. Connect the wiring harness to the alternator, as it was before. Tighten the output-terminal hexnut 100 lbf·in (1140 N·cm). Tighten the ground-terminal hexnut 65 lbf·in (730 N·cm). Tighten the other terminal hexnuts 20 lbf·in (225 N·cm).
4. Protect any exposed terminal connectors with dielectric red enamel.
5. Connect the batteries.
6. Close and latch the hood, and remove the tire chocks.

Specifications

Delco Remy Alternator, Terminal Fastener Torque		
Description	**Size**	**Torque: lbf·in (N·cm)**
Output ("BAT") Terminal Hexnut	5/16–18	100 (1140)
Ground ("GND") Terminal Hexnut	1/4–20	50 to 60 (565 to 675)
	5/16–18	60 to 90 (675 to 1016)
Terminal Hexnuts	10–24	20 (220)

Table 1, Delco Remy Alternator, Terminal Fastener Torque

Leece Neville Alternator, Terminal Fastener Torque		
Description	**Size**	**Torque: lbf·in (N·cm)**
Output ("BAT") Terminal Hexnut	5/16–24	100 (1140)
Ground ("GND") Terminal Hexnut	1/4–28	75 to 80 (850 to 900)
Remote Sense Terminal or Lamp Driver	M5 x 0.8	25 to 30 (280 to 330)

Table 2, Leece Neville Alternator, Terminal Fastener Torque

Pulley and Mounting Fastener Torque		
Description	**Size**	**Torque: lbf·ft (N·m)**
Pulley Nut Delco Remy	1/2–20	75 (102)
Pulley Nut Leece Neville	5/8–18	75 (102)
Mounting Capscrew	M10 X 1.5	35 (48)

Table 3, Pulley and Mounting Fastener Torque

General Information

The starting system converts electrical energy into mechanical rotation, to crank the engine. When the starter is cranked, the pinion gear extends outward to mesh with the ring gear on the engine flywheel. A clutch prevents the starter from spinning too fast.

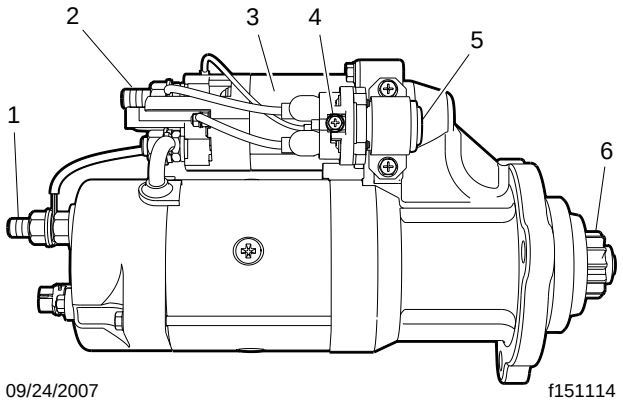
The starter is capable of drawing over 2000 amps, which can cause quick heat build-up and possible damage.

The starter system may have an optional overcranking-protection circuit with a thermoswitch that cuts power to the starter if the starter motor begins to overheat. After the starter motor cools (usually within 6 minutes) the thermoswitch will allow the starter motor to crank again.

Turning the keyswitch to "Start" sends battery power to the magnetic switch. The magnetic switch sends power to the starter solenoid. The solenoid moves a lever which causes the pinion gear to engage with the ring gear on the fly wheel.

When properly operated under normal conditions, the starter requires no maintenance.

For a typical starter, see **Fig. 1**.



1. Battery Ground Post
2. Battery Positive Post
3. Solenoid
4. Crank Circuit Connection
5. Integrated Magnetic Switch
6. Drive Gear

Fig. 1, Starter

Principles of Operation

On Cascadia vehicles without optimized idle, engine starting is controlled by the Signal Detection and Actuation Module (SAM) Cab electronics. Turning the keyswitch to START sends a signal to the SAM Cab, then the SAM Cab sends a signal to activate the starter magnetic switch.

See **Fig. 2** for a generic starting circuit.

In order for the starter motor to engage and crank the engine, all of the following criteria must be satisfied:

- The engine speed must be less than 55 RPM.
- A minimum of 30 seconds must have elapsed if any of the timeout conditions caused cranking to be halted during the previous start attempt.
- Any interlock conditions that are enabled in the SAM cab parameter group under "Starter Control" must be met.

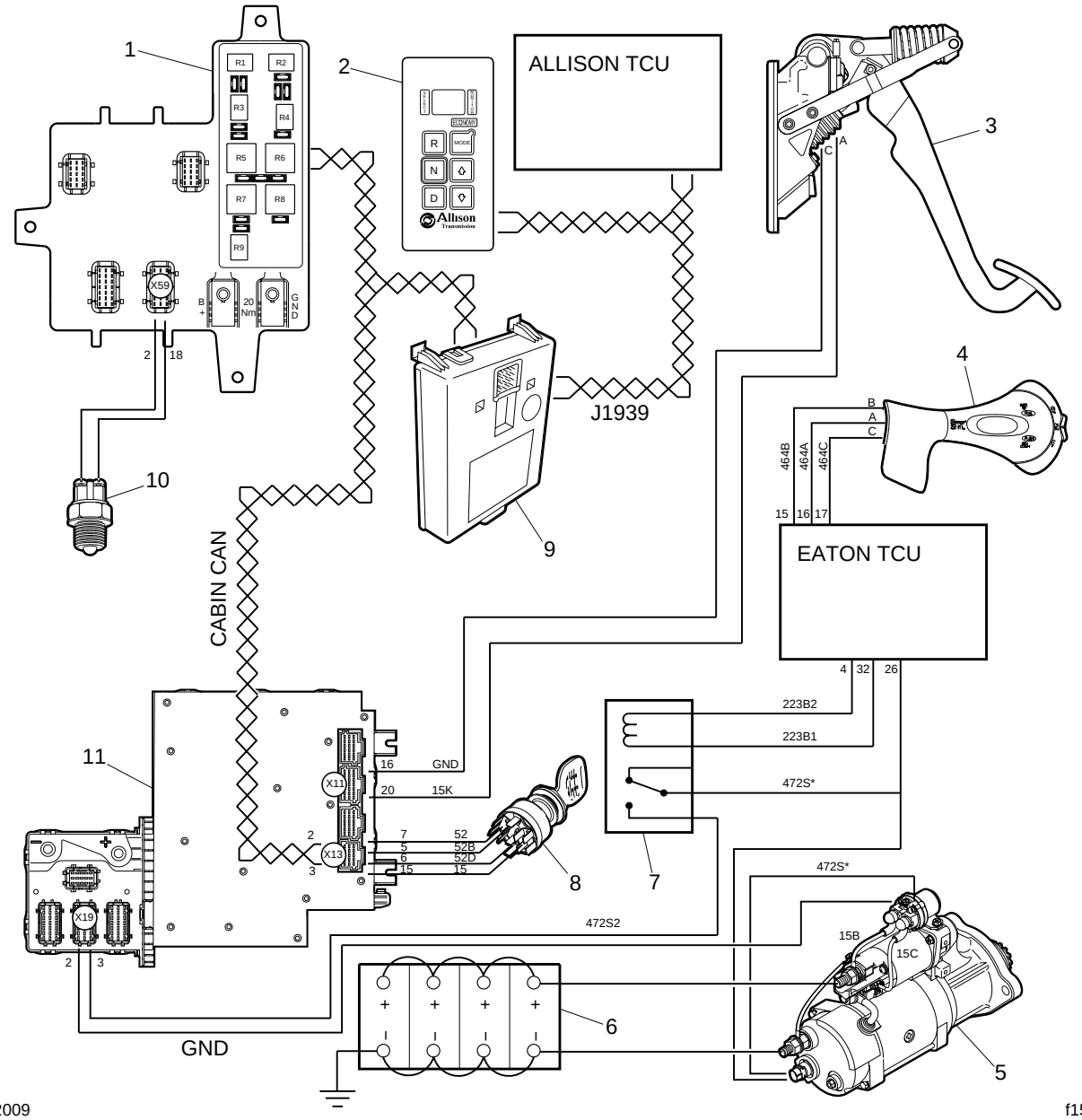
The SAM Cab provides thermal and antigrinding protection to the starter.

The following six criteria will deactivate the starter:

- If the engine RPM never gets above 55 RPM, cranking is limited to 6 seconds.
- If the engine RPM is greater than 300 RPM, cranking is terminated, because the engine is running under its own power.
- If the engine RPM gets above 200 RPM within 3 seconds of cranking, then cranking will be limited to a total of 5 seconds.
- If the engine RPM is greater than 55 RPM but never gets above 200 RPM, cranking is limited to 20 seconds.
- If the engine speed does not get above 200 RPM within the first 3 seconds of cranking, then exceeds 200 RPM, cranking is limited to 15 seconds.
- If valid RPM data is not received by the SAM cab within 1.3 seconds of switching the ignition to crank position, cranking is allowed for a maximum of 20 seconds.

After any of these time limits deactivate starting, 30 seconds must pass before another start attempt will be allowed.

General Information



NOTE: This figure depicts all the functional components that may be used to control starting on Cascadia vehicles. Every Cascadia will have some of these components, but not all of them.

1. SAM Chassis
2. Allison Transmission Shifter
3. Clutch Control
4. Eaton Smart Shift
5. Starter
6. Batteries
7. PT-PDM R1
8. Keyswitch
9. Central Gateway
10. Neutral Switch (Closed in Neutral)
11. SAM Cab

Fig. 2, Cascadia Starting Circuit, Without Optimized Idle Option

Starter Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the negative battery cables at the batteries, and open the hood.
3. Disconnect and label the wiring that connects to the starter.
4. Support the weight of the starter, and remove the three bolts that mount it to the flywheel housing.
5. Remove the starter from the vehicle.

Installation

1. Place the starter into the mounting hole in the flywheel housing.
2. Hand start the three mounting bolts, then tighten them until snug. Using a torque wrench, tighten them to the torque values shown in **Subject 400**.
3. Connect the wiring to the solenoid and starter as previously marked. Tighten the terminals to the torque values shown in **Subject 400**.
4. Protect all exposed terminal connectors with di-electric red enamel.
5. Connect the batteries, and apply dielectric grease to the connections as necessary.

Keyswitch Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the negative battery cables at the batteries.
3. Use a 1-5/16 inch socket to remove the nut on the face of the keyswitch, then remove the switch from behind the dash panel.
4. Disconnect the electrical connector.

Installation

1. Connect the electrical wiring to the new key switch.
2. Insert the keyswitch into the dash panel, then install the nut.
3. Connect the batteries.

Specifications

Torque Values, Starter-Motor to Flywheel-Housing Bolts		
Flywheel-Housing Description	**Size**	**Torque Value: lbf·ft (N·m)**
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, Torque Values, Starter-Motor to Flywheel-Housing Bolts

Torque Values, Delco Remy Starter Connections					
Starter	**Solenoid Switch (+)**	**Solenoid Battery (+)**	**Solenoid Ground (–)**	**Starter Ground (–)**	**IMS Crank Circuit**
12 Volt 37MT, 41MT, 42MT	16 to 30 lbf·in 180 to 340 N·cm	20 to 25 lbf·ft 37 to 34 N·m	16 to 30 lbf·in 180 to 340 N·cm	20 to 25 lbf·ft 37 to 34 N·m	10 to 21 lbf·in 110 to 240 N·cm
24 Volt 37MT, 41MT, 42MT	16 to 30 lbf·in 180 to 340 N·cm	15 to 20 lbf·ft 20 to 27 N·m	16 to 30 lbf·in 180 to 340 N·cm	15 to 20 lbf·ft 20 to 27 N·m	10 to 21 lbf·in 110 to 240 N·cm
38MT, 39MT	18 to 20 lbf·in 200 to 225 N·cm	18 to 20 lbf·ft 24.5 to 27.5 N·m	18 to 20 lbf·in 200 to 225 N·cm	18 to 20 lbf·ft 24.5 to 27.5 N·m	17 to 21 lbf·in 190 to 240 N·cm
29MT	18 to 20 lbf·in 200 to 225 N·cm	10 to 13 lbf·ft 14.7 to 17.7 N·m	18 to 20 lbf·in 200 to 225 N·cm	10 to 13 lbf·ft 14.7 to 17.7 N·m	27 to 45 lbf·in 310 to 510 N·cm
28MT	22 to 27 lbf·in 250 to 310 N·cm	12 to 14 lbf·ft 15.7 to 19.6 N·m	14 to 19 lbf·in 160 to 210 N·cm	NA	NA

Table 2, Torque Values, Delco Remy Starter Connections

General Information

The cooling system's main purpose is to keep the engine at its optimum operating temperature. This provides the best fuel economy, and helps keep the engine oil at the temperature that is best for flow and lubrication.

The radiator assembly is the central component of the cooling system. The radiator assembly includes the surge tank, the radiator, the transmission oil cooler, and the surge tank pressure relief cap. See **Fig. 1** and **Fig. 2**.

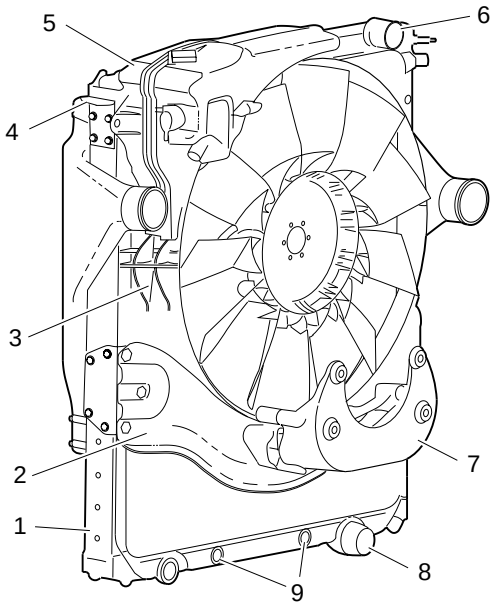
The surge tank (see **Fig. 2**) provides storage space for reserve coolant, expansion space for heated coolant, and deaeration space. When the coolant level in the radiator drops, reserve coolant flows from the surge tank through the fill hose, to the water pump. As the coolant heats and expands, it travels back through the fill hose, from the water pump up 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 sends a signal to the driver display screen to warn the driver of a low coolant condition. The Gentech low coolant level sensor is located in the coolant surge tank on EPA07 and later vehicles. A float with an embedded magnet operates a switch in the sensor body to signal low or normal levels of coolant. The surge tank is translucent, so the coolant level is visible in relation to the maximum- and minimum-level marks on the tank.

When the engine is running, some of the reserve coolant in the surge tank is drawn into the engine. A coolant level that appears acceptable when the engine is off may fall below the acceptable level when the engine is running at high speed. Many engine systems need the coolant level in the surge tank to be filled to the upper fill mark.

Cascadias use down-flow radiators. The coolant flows into the radiator at the right side of the top tank, and flows out of the radiator at the right (all engines except for HDEP) or left (HDEP engine) side of the bottom tank. Most of the engine coolant is routed through the radiator, and it moves relatively quickly in a single pass.

The radiators use glass-filled nylon tanks. The tanks and core are held between steel side channels that mount through the radiator module support to the front of the engine. The radiator is also secured by struts that run between the top of the radiator and the engine. The fins of the radiator core are reinforced along their forward edge, to resist damage from road debris and pressure washing.



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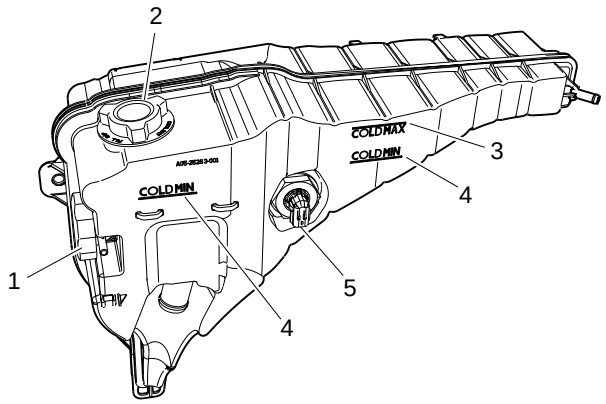
1. Radiator Side Channel
2. Radiator Module Support
3. Two-Piece Fan Shroud
4. Radiator Side Bracket
5. Surge Tank
6. Radiator Inlet Port
7. Radiator Module to Engine Mount
8. Radiator Outlet Port
9. Transmission Oil Cooler Ports

Fig. 1, Radiator Assembly

To meet EPA07 and later cooling requirements, radiator assemblies are engine-mounted, instead of chassis-mounted. See **Fig. 1**. This enables running tight clearance between the fan and the fan shroud, to make most efficient use of the radiator area, and the fan's air-moving capability. Mid-2012 and later engine-mounted radiators may have different lower mounts with isolators.

The surge tank cap limits system pressure to about 11 to 12 psi, which raises the boiling point of the coolant, but allows it to vent excessive pressure. If

General Information



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1. Surge Tank Pressure Relief Cap
2. Surge Tank Filler Cap
3. Cold Maximum Coolant Level
4. Cold Minimum Coolant Level
5. Coolant Level Sensor

Fig. 2, Surge Tank

the cooling system overheats, excess coolant is released from the surge tank, through the overflow tube.

NOTICE

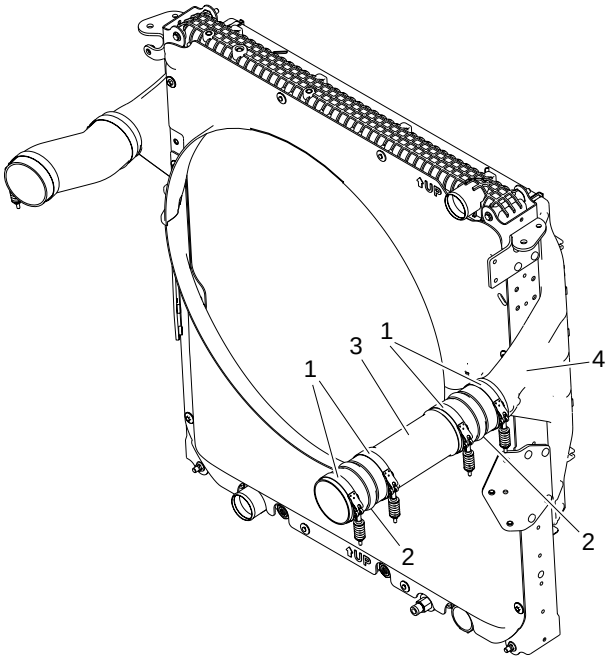
If the radiator is being replaced due to a failure of the transmission cooler, cleaning contamination from the transmission is necessary. Failure to do so can lead to a transmission failure.

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.

GHG14 Engine-Mounted Radiator Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Remove the bumper. For instructions, refer to **Group 31**.
4. Drain the coolant.
   - 4.1 Remove the surge tank cap.
   - 4.2 Place a clean 14-gallon (53-liter) container near the radiator drain.
   - 4.3 Connect a 1/2-inch hose to the drain fitting on the radiator, and place the other end in the container.
   - 4.4 Drain the radiator into the container.
5. Remove the hood. For instructions, refer to **Subject 88.00, 100**.
6. Remove the right side CAC hose. See **Fig. 1**.
7. Remove the left side CAC hose. See **Fig. 2**.
8. Disconnect the surge tank vent line. See **Fig. 3**.



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1. Clamp
2. CAC Outlet Hose
3. Turbo Inlet Tube
4. CAC

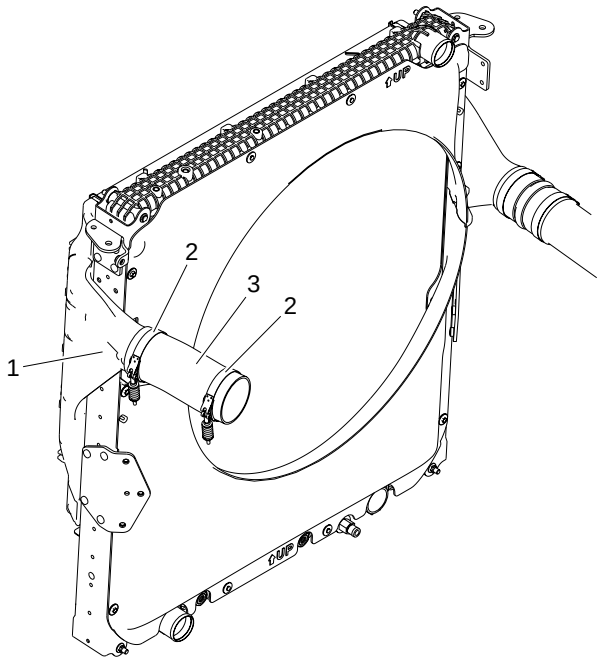
Fig. 1, CAC Hose, Right Side

9. Remove the upper radiator hose. See **Fig. 4**.
10. Remove the three radiator strut rods.
11. Remove the upper fan shroud. See **Fig. 5**.
12. Remove the fan. For instructions, refer to **Group 20** for appropriate fan installation.
13. Loosen the condenser and move it out of the way as follows.
    - 13.1 Remove the receiver-drier and upper A/C hose mounting nuts, then free the receiver-direr. See **Fig. 6**.
    - 13.2 Remove the radiator baffle from the right side of the radiator. See **Fig. 7**.
    - 13.3 Unbolt the A/C condenser from the CAC. See **Fig. 8**.

    NOTE: Wrap the condenser in cardboard to protect it while it is moved.

    - 13.4 Carefully move the condenser around and set it on right front tire. Secure it as needed. See **Fig. 9**.

Radiator Removal and Installation



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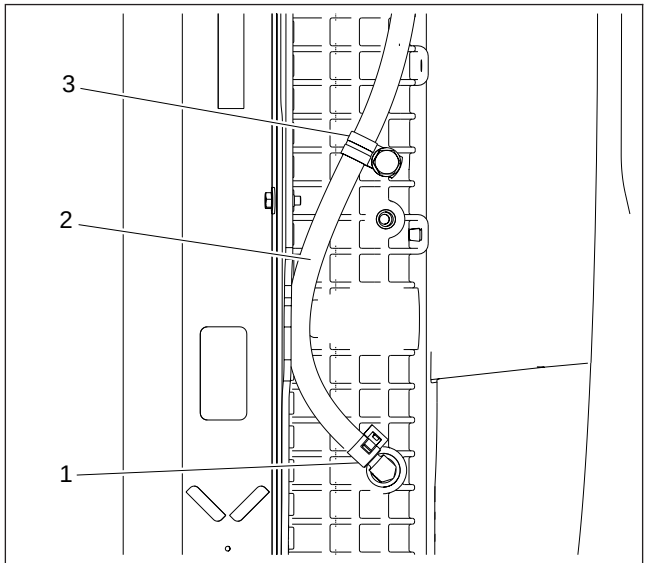
1. CAC
2. Clamp
3. CAC Inlet Hose

Fig. 2, CAC Hose, Left Side

14. Unbolt the radiator from the lower mounts. See **Fig. 10**.
15. Using an appropriate lifting device, remove the radiator from the truck.
16. Disconnect the lower radiator hose from the radiator. See **Fig. 11**.
17. Remove the lower fan shroud from the radiator. See **Fig. 2**.
18. Remove the CAC from the radiator.

GHG14 Engine-Mounted Radiator Installation

1. Install the CAC on the new radiator. Tighten the nuts 23 to 27 lbf·ft (31 to 37 N·m).
2. Install the lower fan shroud. See **Fig. 2**.
3. Install the radiator.
4. Tighten the radiator mounting nuts 182 to 223 lbf·ft (247 to 302 N·m)



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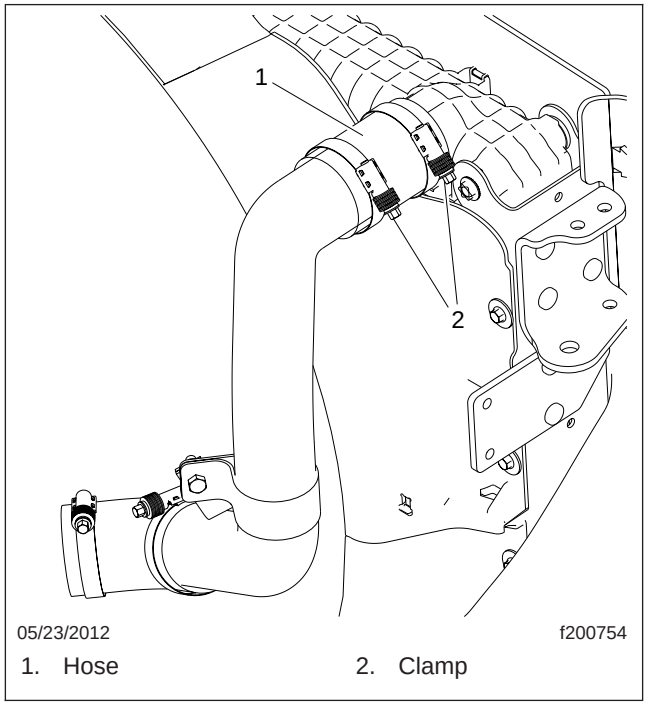
1. Clamp
2. Vent Line
3. P-Clamp

Fig. 3, Surge Tank Vent Line



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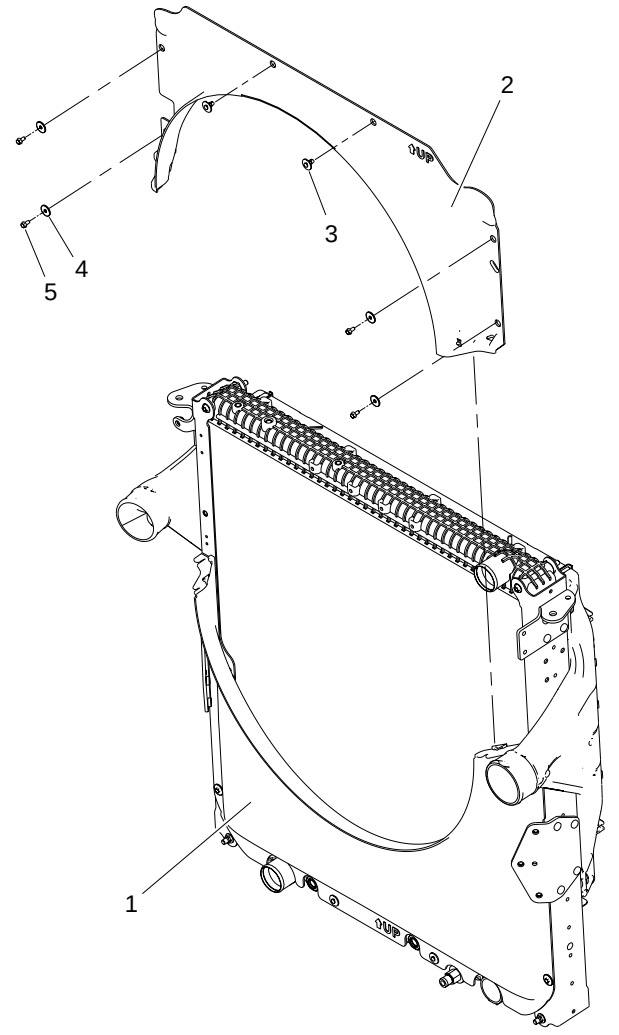
1. Hose
2. Clamp

Fig. 4, Upper Radiator Hose

5. Install the A/C condenser as follows.



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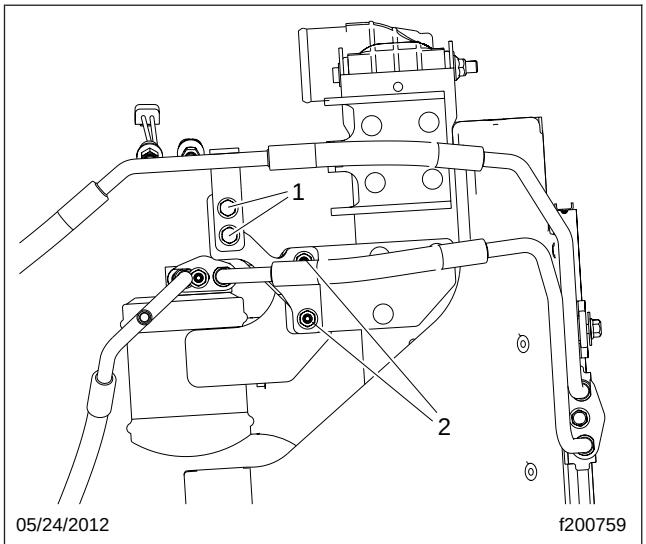
1. Lower Fan Shroud
2. Upper Fan Shroud
3. Push Fastener
4. Washer
5. Screw

Fig. 5, Fan Shroud Installation

5.1 Move the condenser into position and secure it temporarily. See **Fig. 8**.

5.2 Position the receiver-drier and upper A/C line on their respective brackets and install the mounting nuts. See **Fig. 6**. Tighten the nuts 14 to 16 lbf·ft (19 to 22 N·m).

5.3 Install the right-side radiator baffle. See **Fig. 7**.



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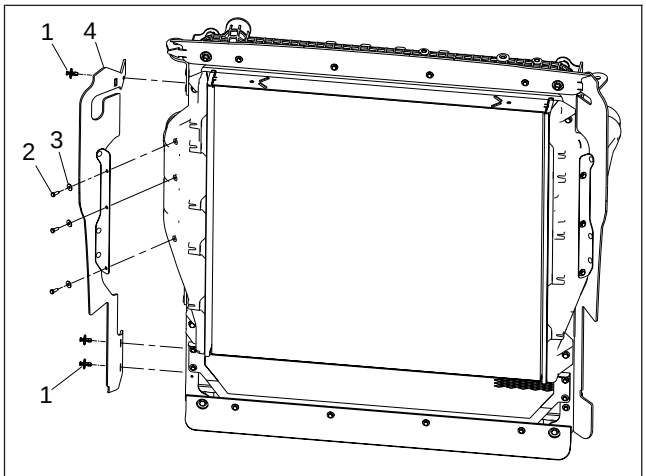
1. Upper Condenser Line Mounting Nuts
2. Receiver-Drier Mounting Nuts

Fig. 6, Receiver-Drier Installation



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1. Push Fastener
2. Screw
3. Washer
4. Baffle

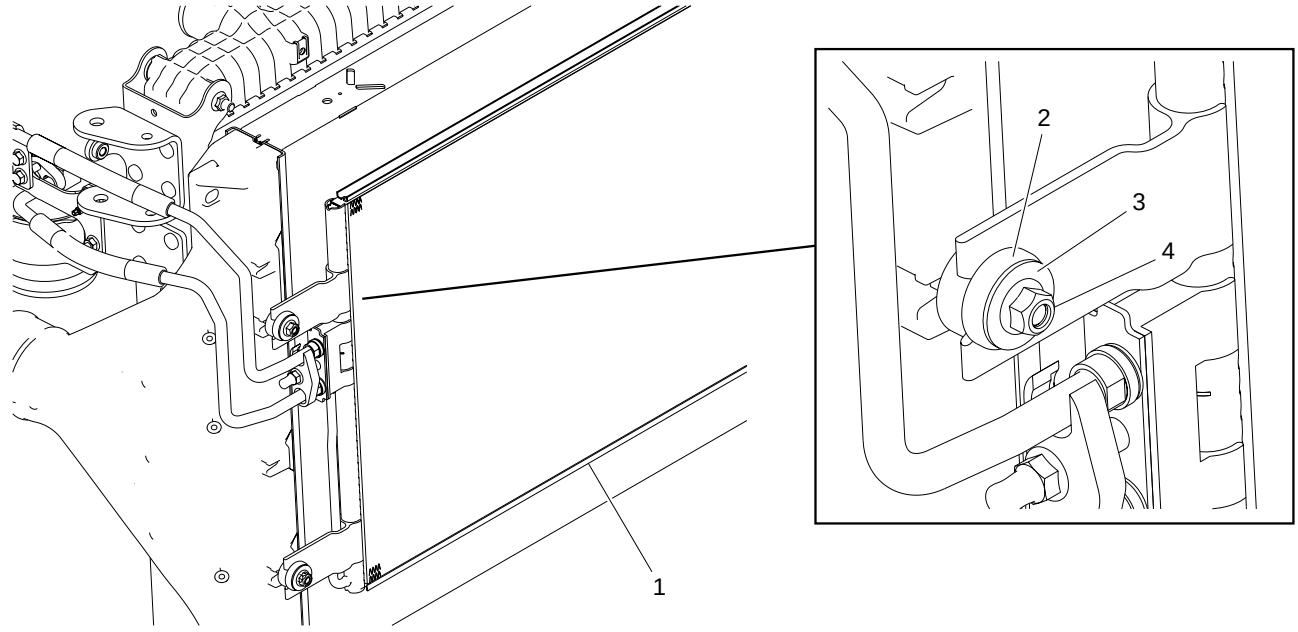
Fig. 7, Radiator Baffle, Right Side

5.4 Tighten the condenser mounting bolts 112 to 144 lbf·in (1266 to 1627 N·cm).

6. Apply sealant 48-00094-141 to the threads of the fasteners, then install the fan. Tighten 30 lbf·ft (41 N·m).

7. Install the upper fan shroud. See **Fig. 2**.

Radiator Removal and Installation



1. A/C Condenser
2. Isolator
3. Washer
4. Nut

Fig. 8, A/C Condenser Installation

8. Install the radiator strut rods.
9. Connect the surge tank vent line. See **Fig. 4**.
10. Install the upper and lower radiator hoses. See **Fig. 4**.
11. Install the hood. For instructions, refer to **Subject 88.00, 100**.
12. Install the CAC hoses. See **Fig. 2**.
13. Fill the coolant system.
14. Install the bumper. For instructions, refer to **Group 31**.

Pre-GHG14 Radiator Removal

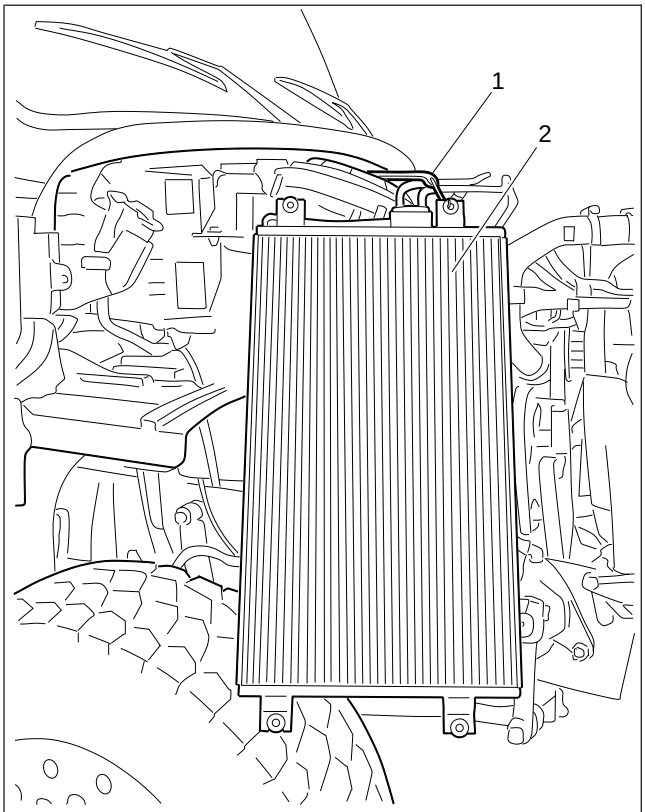
1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Remove the front bumper. For instructions, refer to **Group 31**.
4. Remove the surge tank cap.

⚠ 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.

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. 12**) and place the other end in the container.
7. Drain the radiator into the container.
8. Remove the lower elbow from the radiator end tank.
9. Put a ratchet strap in position on the passenger side of the vehicle, to support the hood when the gas shocks 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.



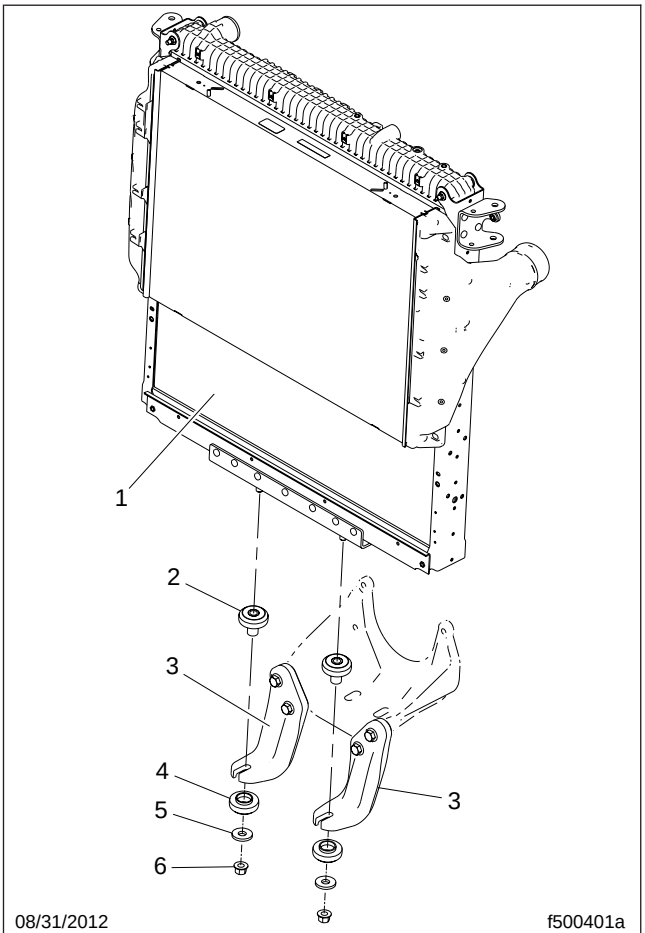
1. Bungee Cord
2. Condenser

Fig. 9, Securing the A/C Condenser

10. Remove the upper radiator struts.
11. Disconnect the gas shocks that support the hood 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.
12. Disconnect the charge air cooler (CAC) hoses from the CAC; see **Fig. 13** and **Fig. 14**.
13. Place a container of at least 2-gallon (7.5-liter) capacity under the transmission oil cooler lines; see **Fig. 12**.
14. Disconnect the transmission oil cooler lines from the radiator, and let them drain into the container.

    14.1 Beginning in July 2005, transmission oil cooler lines equipped with Gates Quick-Detach (QLD) fittings were fitted on some limited production class 8 vehicles. From January 2007 into May 2007, Gates QLD fittings were installed in full production vehicles.

    Vehicles produced since May 2007, have standard JIC fittings, instead of the Gates QLD fittings.

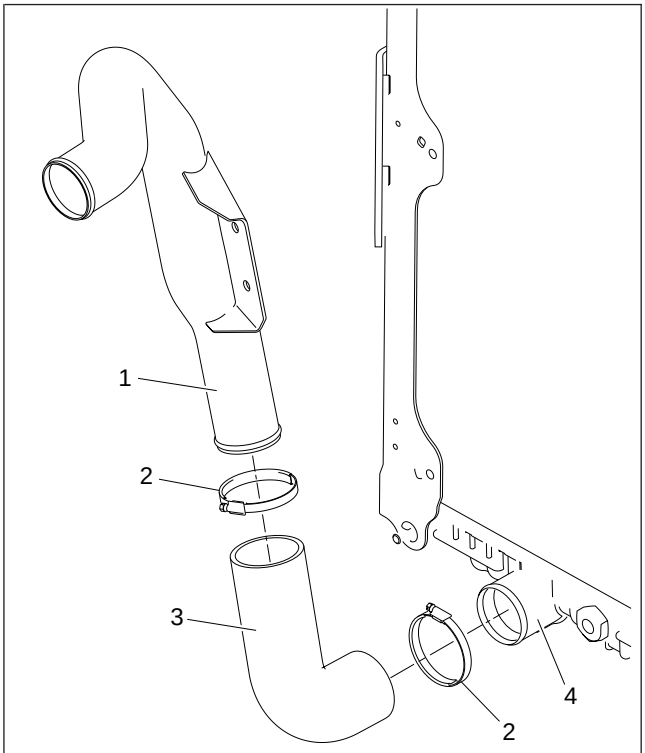


1. Radiator
2. Upper Isolator
3. Lower Radiator Mount
4. Lower Isolator
5. Washer
6. Nut

Fig. 10, Radiator Lower Mounts

IMPORTANT: The female ports of the QLD fittings are brazed into the radiator. They are not threaded. **Do not attempt to turn a QLD fitting; you may destroy the fitting, and severely damage the radiator.**

Radiator Removal and Installation



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1. Tube to Engine
2. Clamp
3. Lower Radiator Hose
4. Radiator

Fig. 11, Lower Radiator Hose Installation

14.2 The Kent-Moore QLD tool (see **Fig. 15**) is the proper tool to use when disconnecting the fittings.

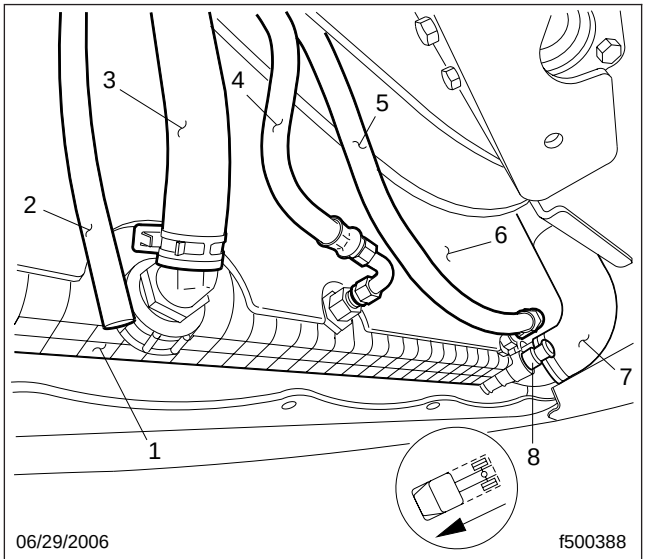
One set of tools was sent to each dealer, in December 2006.

The tool is available from Kent-Moore in two sizes; J-48548-1 is used on Allison automatic transmissions, tool J-48548-2 is used for all other transmissions.

14.3 Thoroughly clean the area around the fitting.

14.4 Insert the tool onto the fitting as shown in **Fig. 16**.

14.5 Push the installed connector straight into the port until it stops and the rubber dust boot is compressed; see **Fig. 17**.



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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

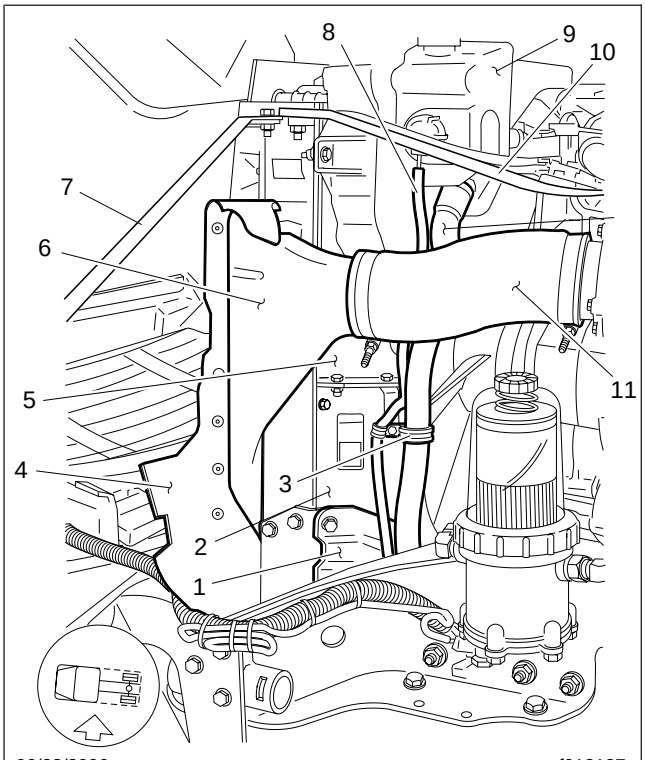
Fig. 12, Bottom of Installed Radiator

NOTE: WD-40, or a similar substance, can be helpful if the quick-disconnect fitting is difficult to release. Clean the fitting, and spray it with the lubricant. Push and pull the fitting straight in and out, to distribute the lubricant so it will ease disassembly. Then, use the tool to disconnect the fitting.

14.6 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. 17**. Use the tool so that pressure is equal on both ears, where they 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.

14.7 Once the male connector is pulled out, it is no longer necessary to keep the tool in place. The male connector can now be



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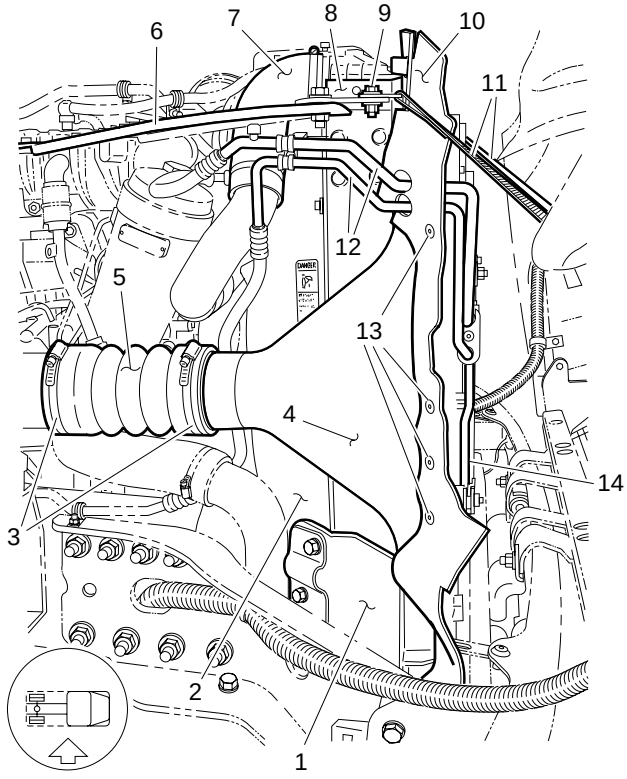
NOTE: MBE900 installation, others are similar.

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 Strut Rod
11. CAC Hose

Fig. 13, Left Side Radiator Assembly

pulled from the female port. Protect the openings of the fittings when they are disconnected, to keep dirt out.

15. 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. 13**.
16. Disconnect the electrical sensors on the radiator.
17. Remove the surge tank.
18. Place alignment marks on the upper and lower fan shrouds, and mark the shroud-to-channel



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1. Radiator Module Support
2. Lower Fan Shroud
3. CAC Hose Clamps
4. Charge Air Cooler (CAC)
5. CAC Hose
6. Upper Radiator Strut Rod
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. 14, Right Side Radiator Assembly

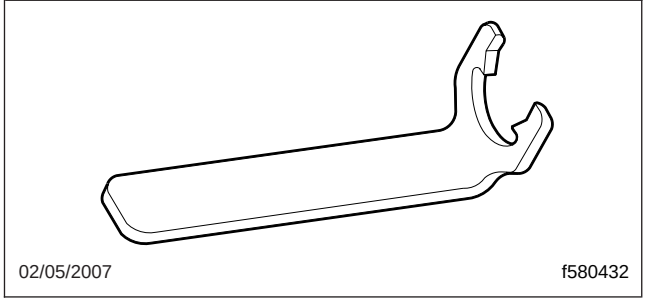

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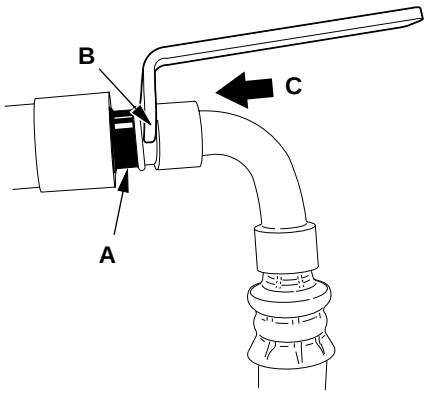
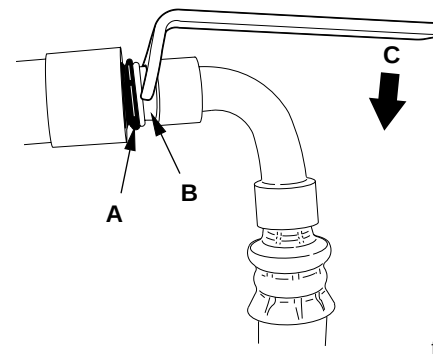
Fig. 15, Kent-Moore Tool J48548

Radiator Removal and Installation



A. Dust Boot Not Compressed
B. Tool Head Inserted Perpendicular To Fitting
C. Push Male Connector Straight In, To Release

Fig. 16, Quick-Disconnect Fitting with Kent-Moore Tool J-48548 in Place



A. Dust Boot Compressed
B. Tool Applied to Metal Flange, Not Rubber Dust Boot
C. Tool Levered Straight Toward Fitting

Fig. 17, Quick-Disconnect Fitting Removal with Kent-Moore Tool J-48548

positions, so the shrouds can be installed in the same position on the radiator and other components.

19. Remove the four fasteners that connect the upper and lower fan shrouds.
20. Remove the fasteners that hold the fan shrouds to the radiator.
21. Remove the upper fan shroud from the vehicle.
22. Remove the six hexscrews that hold the fan to the fan clutch, and remove the fan.

NOTE: Wrap the condenser in cardboard to protect it while it is moved.

23. 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 set on the passenger-side tire.
24. Remove the four hexnuts that hold the A/C condenser to the radiator, and set the condenser on top of the passenger-side tire.
25. 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.
26. Attach an engine hoist to the radiator using the flanges and fasteners, where the upper radiator struts attached.
27. Remove the six hexscrews that hold the radiator to the module support.
28. Lift the radiator about 6 inches (150 mm). Remove the bottom recirculation baffle from the radiator.
29. Lift the radiator clear of the vehicle.
30. Remove the lower fan shroud from the radiator.
31. Set the radiator on a workbench, with the CAC facing up.
32. Remove the four hexscrews that hold the CAC to the radiator, then remove the CAC and set it aside.
33. Use a paint pen to mark the position of the channels on the radiator.
34. Remove the fasteners that hold the channels to the radiator, and remove the channels.

Pre-GHG14 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. Do not tighten the fasteners yet.
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. Tighten the fasteners that hold the channels and CAC to the radiator.
5. Move the radiator into position about six inches above the module support.
6. Install the bottom radiator recirculation baffle.
7. Apply sealant 48-00094-141 to the threads of the fasteners, then attach the fan. Tighten the fasteners 30 lbf·ft (40 N·m).
8. 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.
9. Install the side recirculation baffles.
10. Install the upper fan shroud.
11. Install the radiator.
12. Install the A/C condenser, and attach the P-clamps that hold the A/C soft lines.
13. Install the surge tank.
14. Connect the radiator strut rods.
15. Connect the hood support gas shocks, and remove the temporary support straps.
16. Connect the lower radiator elbow and transmission cooler lines. If the fittings are quick-disconnect, do the following:

    16.1 If the fitting is new, remove the plastic end cap.

    16.2 Align the male connector directly with the female port.

    16.3 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.

    16.4 Test the connection by pulling the male connector with a 10 lb force, straight out from the female port. It should be held solidly in place.
17. Fill the cooling system with coolant.
18. Fill the transmission with transmission oil.
19. Install the bumper.
20. Close the hood and remove the tire chocks.
21. Test drive the vehicle.
22. Check for leaks and for correct transmission oil level.

Installing a Radiator with PIC Fittings on the Transmission Oil Cooler, in a Vehicle Equipped with QLD Transmission Oil Cooler Lines

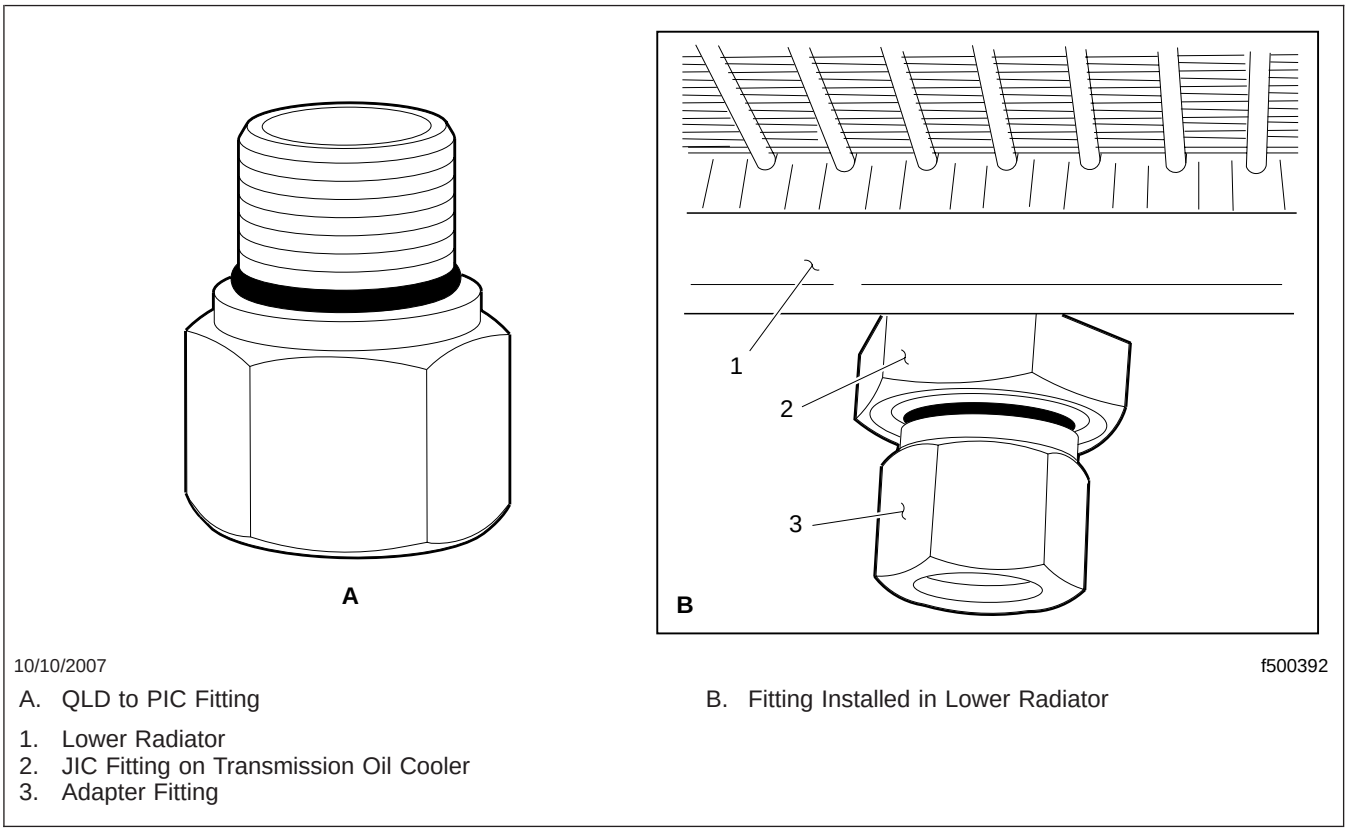
Because a limited number of vehicles are fitted with the QLD fittings, when current stock of QLD-fitted replacement radiators is gone, only radiators with JIC fittings will be available. To adapt a replacement radiator with JIC fittings to a vehicle with QLD-fitted transmission oil cooler lines, order two adapters, P/N: GT 7213-0003 (see **Fig. 18**), and install them in the JIC fittings so that the existing QLD lines can attach.

The adapter fittings are installed only at the radiator; the original QLD transmission oil cooler lines continue to be used.

Thread the adapters into the transmission oil cooler; tighten them 52 lbf·ft (70 N·m).

Install the QLD-equipped lines into the adapters as described in *Step 16*.

Radiator Removal and Installation



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A. QLD to PIC Fitting

B. Fitting Installed in Lower Radiator

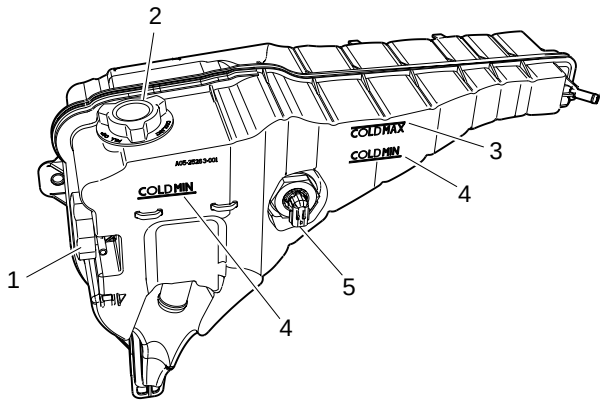
1. Lower Radiator
2. JIC Fitting on Transmission Oil Cooler
3. Adapter Fitting

Fig. 18, Adapter P/N: GT 7213-0003

Surge Tank Removal and Installation

Removal

The Cascadia surge tank (see **Fig. 1**) is mounted on the top of the radiator; see **Fig. 2**.



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1. Surge Tank Vent Outlet
2. Surge Tank Filler Cap
3. Cold Maximum Coolant Level
4. Cold Minimum Coolant Level
5. Coolant Level Sensor

Fig. 1, Surge Tank

1. Drain coolant from the radiator drain, until no coolant shows in the surge tank. For instructions, refer to **Subject 100**.

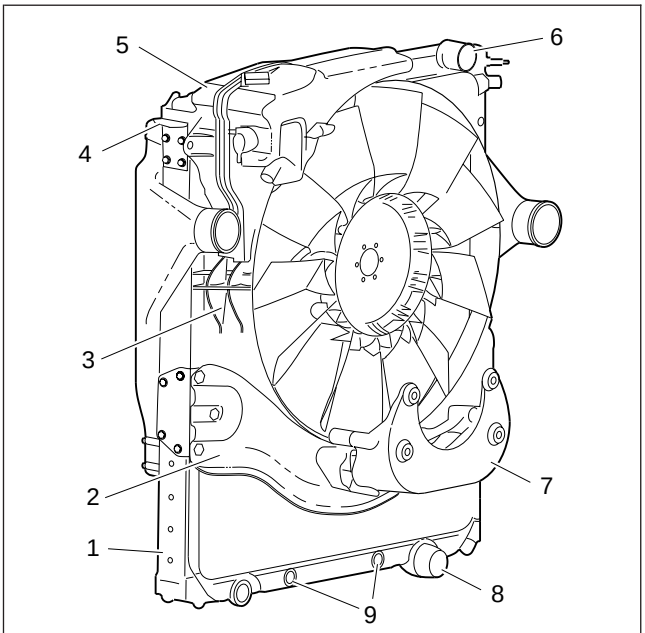
⚠ WARNING

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. Disconnect the hoses from the surge tank, being careful to avoid spills.
3. If replacing the surge tank, remove the coolant level sensor. For instructions, refer to **Subject 130**.
4. Remove the fasteners that hold the surge tank to the radiator assembly.

Installation

1. Install the coolant level sensor into the new surge tank.



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1. Radiator Side Support
2. Radiator Mount
3. Fan Shroud
4. Radiator Strut Bracket
5. Surge Tank
6. Radiator Inlet
7. Radiator Engine Mount
8. Radiator Outlet
9. Transmission Oil Cooler Ports

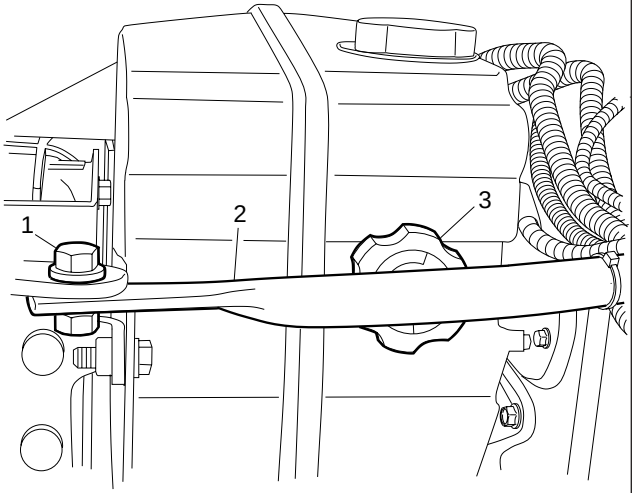
Fig. 2, Radiator Assembly with Surge Tank

2. Position the surge tank on the radiator assembly, and install the fasteners.
3. Connect the hoses to the tank.
4. Fill the cooling system. For instructions, refer to **Subject 100**.

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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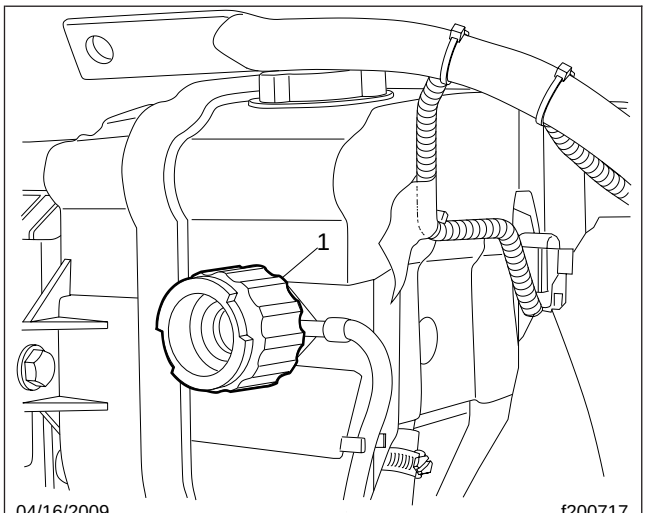
1. Strut Rod Mounting Capscrew and Nut
2. Strut Rod
3. Pressure Cap

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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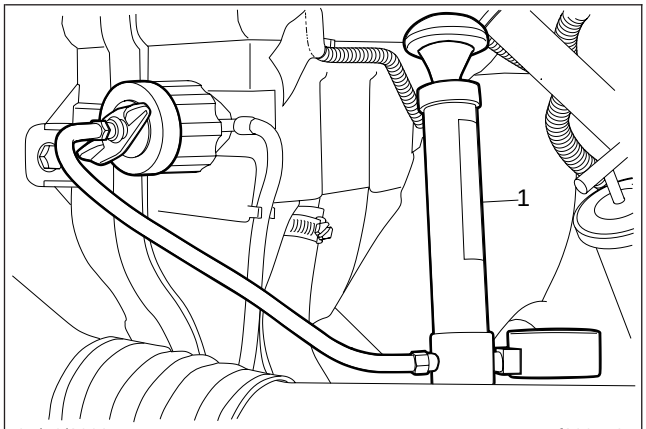
1. Adaptor

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).

Coolant Level Sensor Removal and Installation

Removal

Complete the following instructions to remove the coolant level sensor. Refer to Subject **Subject 110** for sensor location.

1. Shut down the engine and chock the tires.
2. Allow the engine to cool down to ambient temperature.
3. Drain the coolant below the sensor if needed.
4. Disconnect the electrical sensor by releasing the locking tab, then pressing on the retaining tab.
5. Twist the large, black locknut counterclockwise until it disengages from the reservoir.
6. Remove the sensor.

Installation

Complete the following instructions to install the coolant level sensor.

1. Lubricate the o-ring of the new sensor using a small amount of light silicone grease, or a bit of coolant.
2. Align the new sensor. Make sure the tabs are aligned at tangent to the surge tank neck.
3. Twist the large, black locknut clockwise until the sensor securely engages into the reservoir.
4. Connect the eletrical connector to the sensor.
5. Add coolant as needed.

General Information

The 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 MCM, which controls the solenoid valve. 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 controlled by a pressure transducer, located in the high side of the refrigerant system close to the TXV, it is used in place of the conventional binary and fan cycling switches. The transducer is connected to the SAM Cab. Although an engine fan request is made by the HVAC controller, based on high-side pressure, the fan is controlled by the engine MCM, which considers a number of other factors and parameters that are specific to each engine. 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.

Fan Clutch Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires.

⚠ WARNING

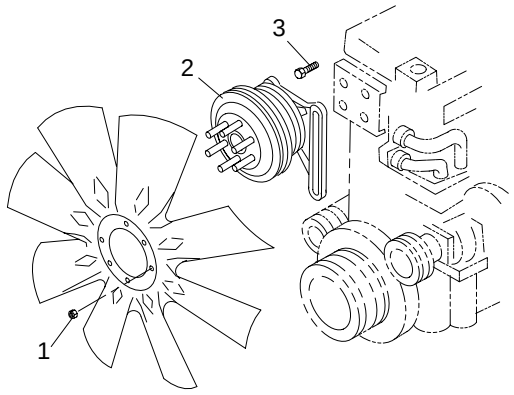
Wear safety goggles when draining the air system or disconnecting an air line because dirt and sludge could fly out at high speeds. Don't direct the airstreams at anyone. Do not disconnect pressurized air lines, as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Drain the air tanks.
3. Open the hood.
4. Disconnect the left-side hose from the charge air cooler.
5. Remove the surge tank as follows.
   - 5.1 Drain coolant from the radiator drain, until no coolant shows in the surge tank. For instructions, refer to **Section 20.00, Subject 100**.
   - 5.2 Disconnect the hoses from the surge tank, being careful to avoid spills.
   - 5.3 Remove the fasteners that hold the surge tank to the radiator assembly. Set the surge tank aside.
6. Remove the upper fan shroud as follows.
   - 6.1 Place alignment marks on the upper and lower fan shrouds, and mark the shroud-to-channel positions, so the shroud can be installed in the same position on the radiator.
   - 6.2 Remove the four fasteners that connect the upper and lower fan shrouds.
   - 6.3 Remove the fasteners that hold the upper fan shrouds to the radiator.
   - 6.4 Remove the upper fan shroud from the vehicle.
7. Remove the drive belts from the engine.
8. Disconnect the air line from the fan hub.
9. Remove the fan.

⚠ CAUTION

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.

10. Remove the fasteners holding the fan clutch mounting bracket to the front of the engine. Then remove the fan clutch assembly from the vehicle. See **Fig. 1**.



05/29/2002 f200576

1. Hexnut
2. Fan Clutch Assembly
3. Hexbolt

Fig. 1, Fan Clutch Removal (typical)

Installation

1. Using either a helper or a hoist, position the fan clutch assembly on the front of the engine, aligning the holes in the mounting bracket with those in the front of the engine. Install the fasteners.
2. Install the drive belts.
3. Connect the air line to the fan clutch.
4. Apply sealant Loctite 242 to the threads of the fasteners, then attach the fan. Tighten the fasteners 30 lbf·ft (40 N·m).
5. Tighten the fan-clutch mounting fasteners 75 to 93 lbf·ft (100 to 125 N·m).

Fan Clutch Removal and Installation

6. Position the upper fan shroud on the radiator; align the marks, then install the fasteners that hold it to the radiator and the lower fan shroud.
7. Position the surge tank on the radiator assembly, and install the fasteners.
8. Connect the hoses to the surge tank.
9. Fill the cooling system. For instructions, refer to **Section 20.00, Subject 100**.
10. Connect the left-side hose to the charge air cooler.
11. Start the engine and check for coolant leaks. Repair as needed.

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.

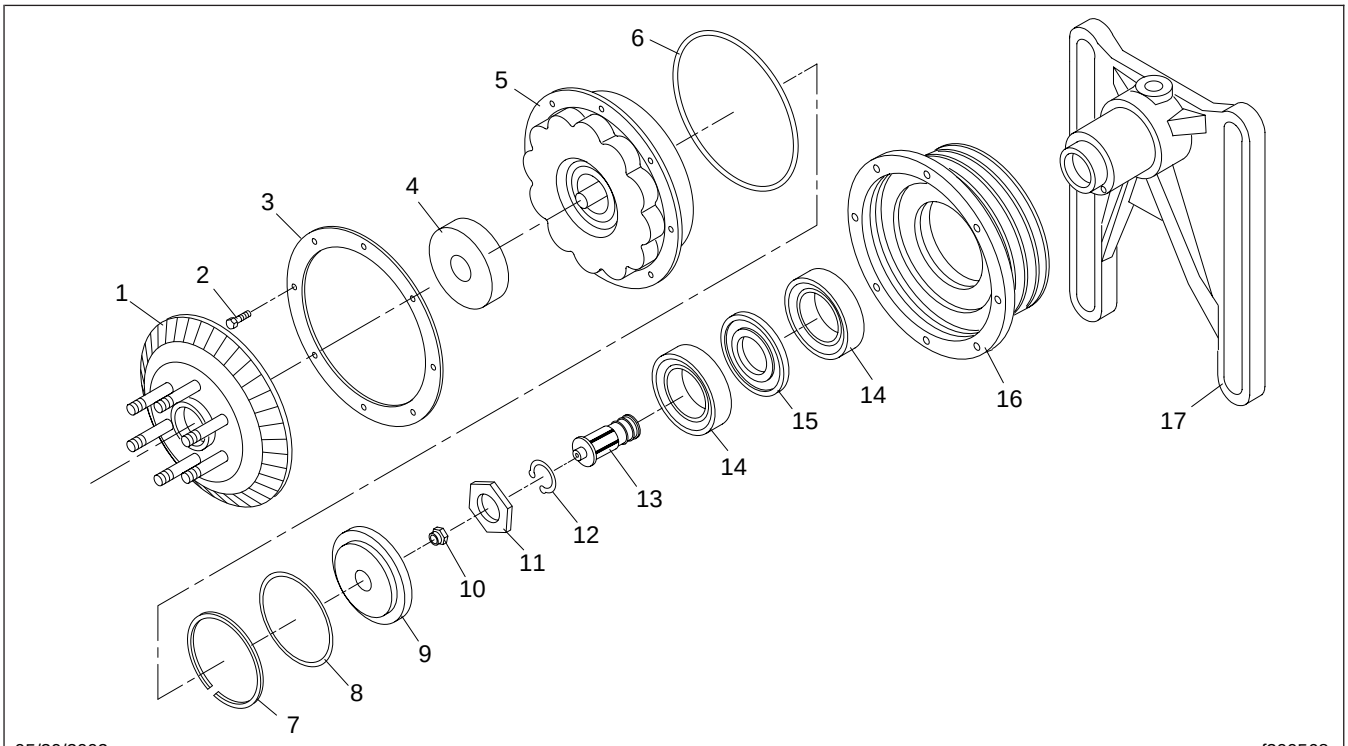
Refer to **Fig. 1** for this procedure.

1. 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.

NOTICE

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**.

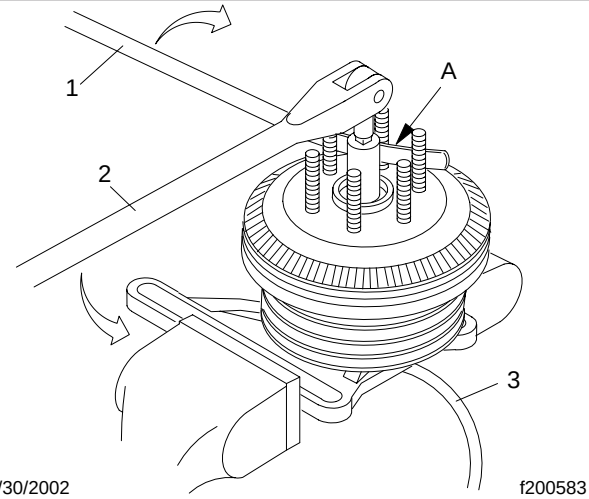


05/30/2002 f200568

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

Fan Clutch Major Rebuild

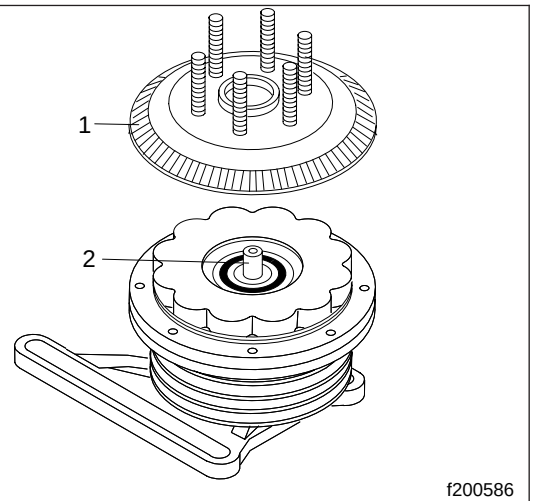


A. Place the pry bar here.

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

6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 3**.



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.

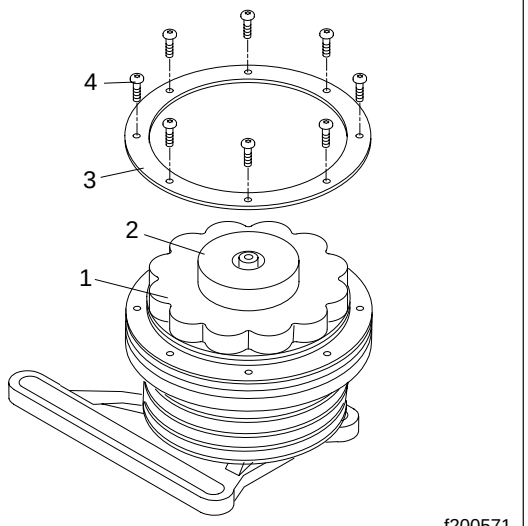
   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

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.

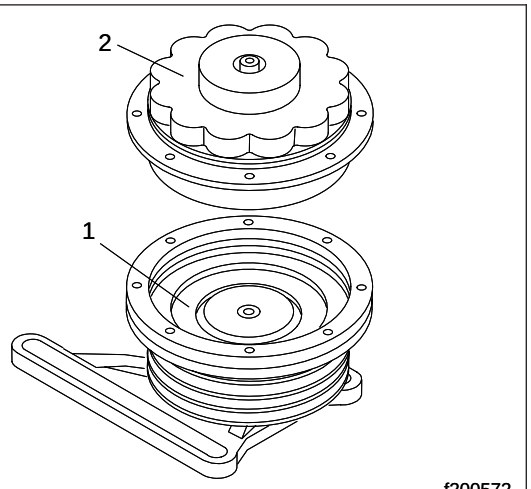
10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 4**.
12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 5**.
13. Remove the air chamber seal. See **Fig. 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**.
19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system



06/05/2002 f200571

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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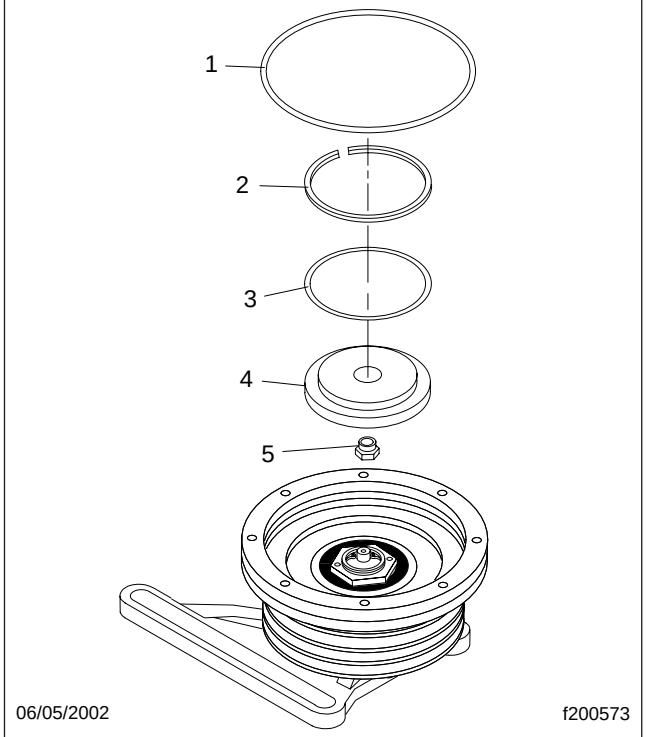
1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 5, Spring Housing/Piston Assembly Removal and Installation

20. Remove the bearing nut from the mounting bracket. See **Fig. 7**.



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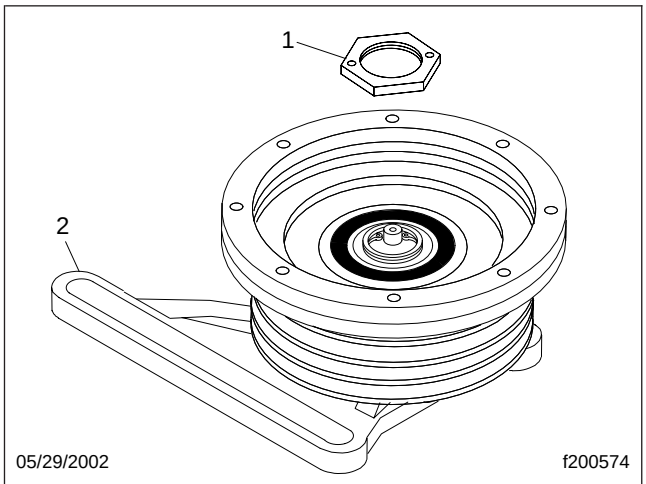
1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

Fig. 6, Air Chamber Seal Removal and Installation



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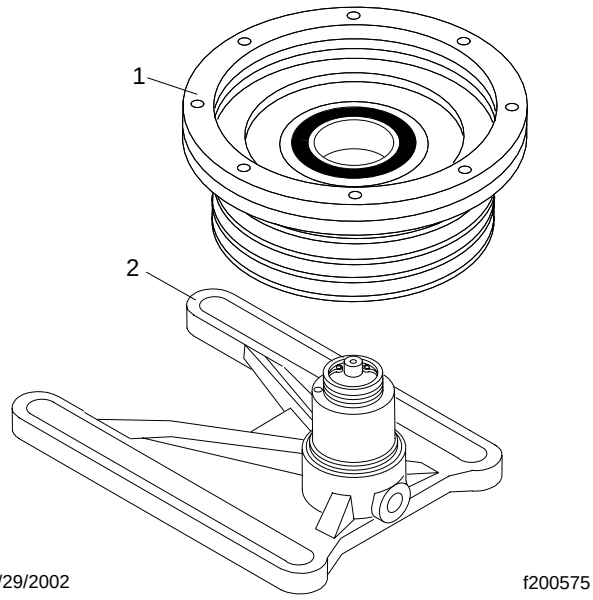
1. Bearing Nut
2. Mounting Bracket

Fig. 7, Bearing Nut Removal and Installation

Fan Clutch Major Rebuild

21. Remove the sheave from the mounting bracket. See **Fig. 8**.



1. Sheave
2. Mounting Bracket

Fig. 8, Removing the Sheave

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.

NOTE: The sheave bearings do not require lubrication.

2. If replacing the sheave bearings, do the following:
    - 2.1 If equipped with two bearings, assemble the bearings so the markings on their edges line up to form an arrow. See **Fig. 11**. It doesn't matter which way the arrow faces when the bearings are installed.

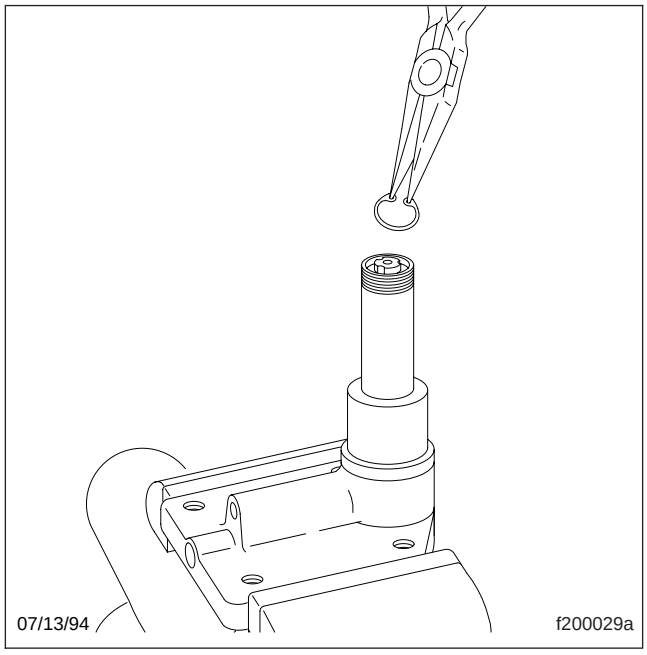
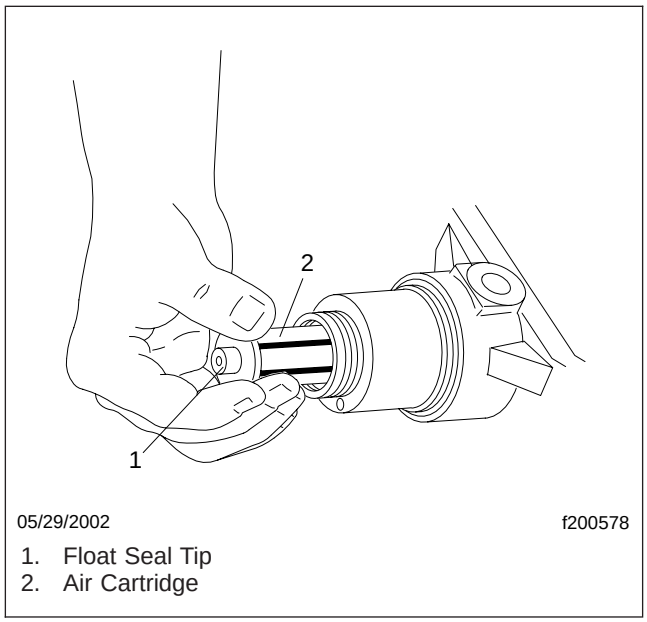
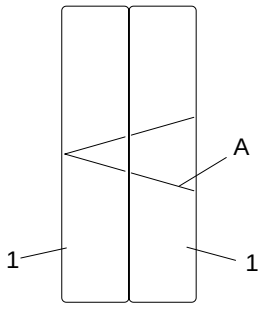


Fig. 9, Retaining Ring Removal and Installation



1. Float Seal Tip
2. Air Cartridge

Fig. 10, Removing the Air Cartridge



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A. Align the markings to form an arrow.

1. Sheave Bearing

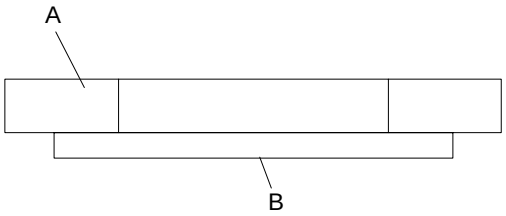
Fig. 11, Aligning the Bearings

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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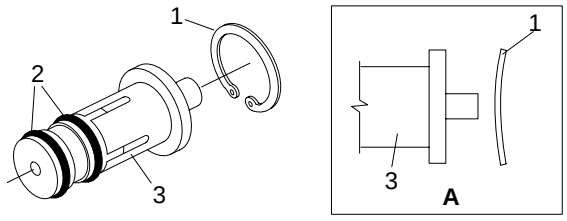
A. Hex faces up.
B. Relief faces toward mounting bracket and bearings.

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.

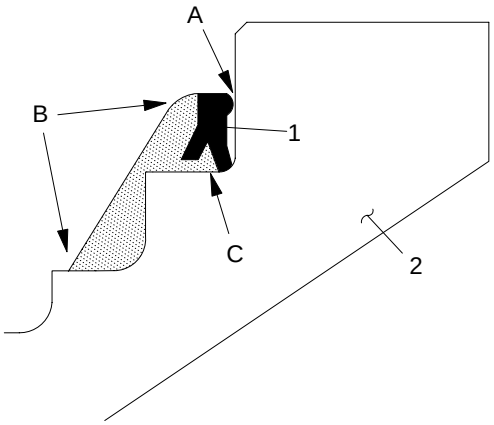
1. Retaining Ring
2. O-Rings
3. Air Cartridge

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



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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. 5**. 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.

NOTICE

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.

NOTICE

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.

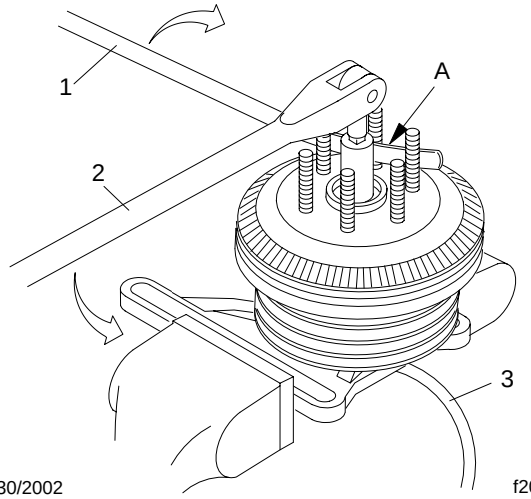
⚠ WARNING

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.

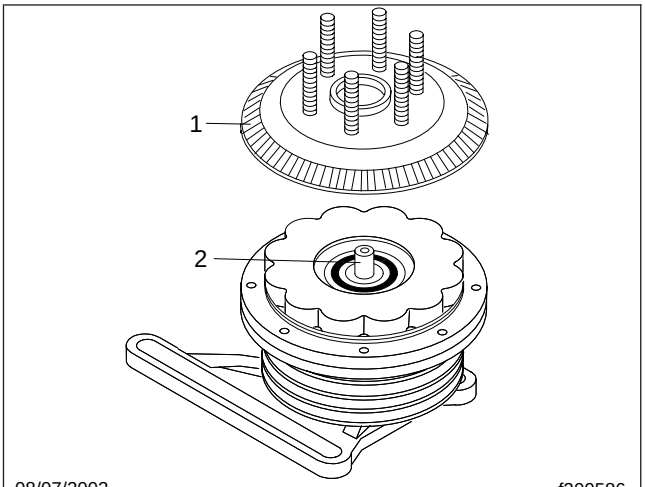
9. Release the air pressure from the fan clutch.



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)

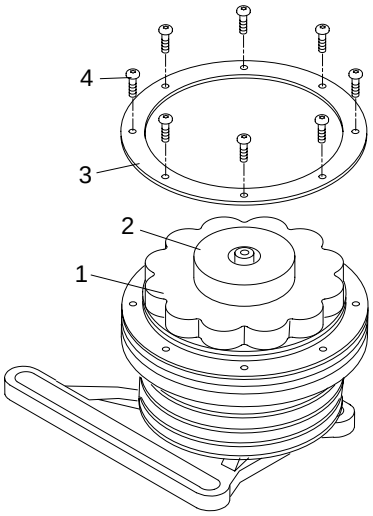
Fig. 2, Fan Mounting Disc Removal and Installation

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**.



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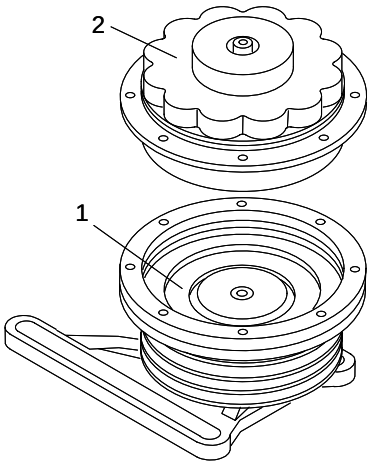
1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

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.



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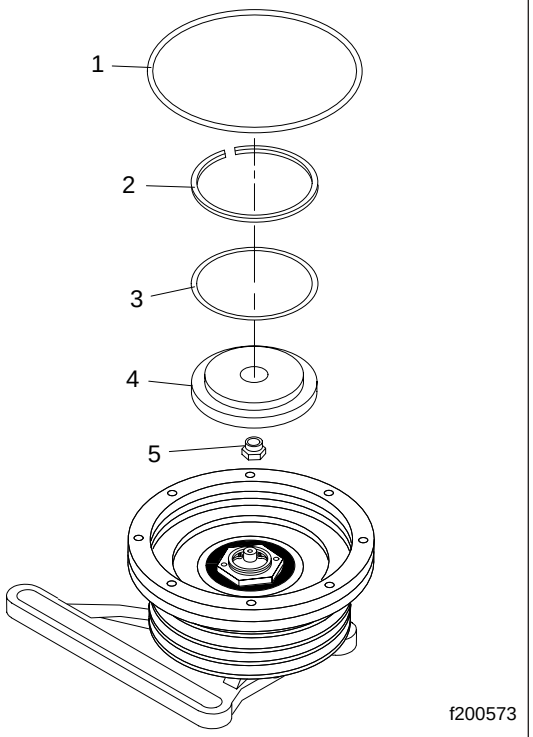
1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

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**.
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.



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

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.

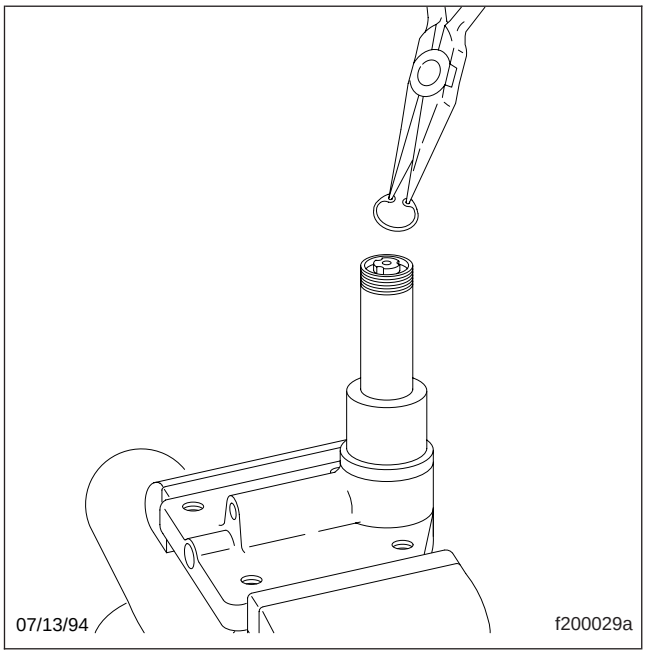
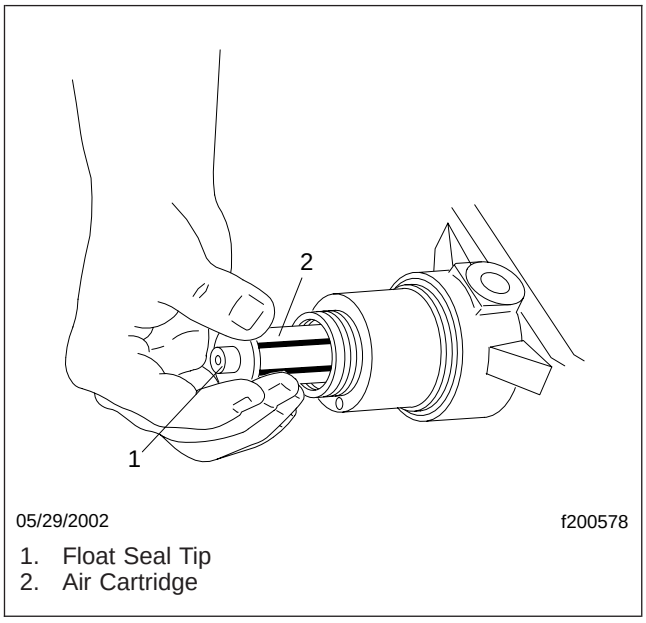


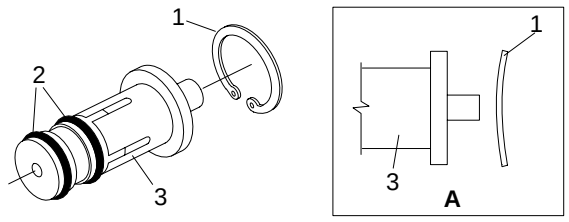
Fig. 6, Retaining Ring Removal and Installation (sheave not shown)



1. Float Seal Tip
2. Air Cartridge

Fig. 7, Removing the Air Cartridge (sheave not shown)

Fan Clutch Minor Rebuild



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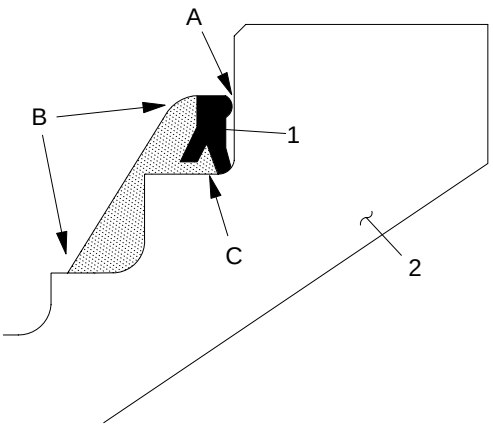
A. Convex surface of the retaining ring goes toward the air cartridge.

1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 8, Installing the Air Cartridge Retaining Ring



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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.

NOTICE

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-drier is set too low.	Check the switch at the receiver-drier, 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

General Information

The 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 MCM, which controls the solenoid valve. 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 controlled by a pressure transducer, located in the high side of the refrigerant system close to the TXV, it is used in place of the conventional binary and fan cycling switches. The transducer is connected to the SAM Cab. Although an engine fan request is made by the HVAC controller, based on high-side pressure, the fan is controlled by the engine MCM, which considers a number of other factors and parameters that are specific to each engine. 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.

Fan Clutch Removal and Installation, Kysor K26RA

Removal

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

⚠ 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. Do not disconnect pressurized air lines, as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

3. Drain the air tanks.
4. Disconnect the air line from the fan clutch.
5. Remove the surge tank as follows.
   - 5.1 Drain coolant from the radiator drain, until no coolant shows in the surge tank. For instructions, refer to **Section 20.00, Subject 100**.
   - 5.2 Disconnect the hoses from the surge tank, being careful to avoid spills.
   - 5.3 Remove the fasteners that hold the surge tank to the radiator assembly. Set the surge tank aside.
6. Remove the upper fan shroud as follows.
   - 6.1 Place alignment marks on the upper and lower fan shrouds, and mark the shroud-to-channel positions, so the shroud can be installed in the same position on the radiator.
   - 6.2 Remove the four fasteners that connect the upper and lower fan shrouds.
   - 6.3 Remove the fasteners that hold the upper fan shrouds to the radiator.
   - 6.4 Remove the upper fan shroud from the vehicle.
7. Remove the fasteners that hold the fan to the fan clutch, then remove the fan.

⚠ 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.

8. Align the access holes in the fan clutch with the allen screws on the fan hub. See **Fig. 1**.

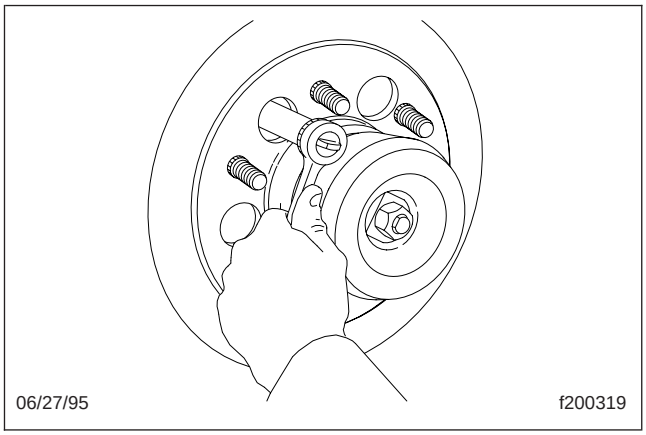


Fig. 1, Line Up the Access Holes

   - 8.1 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.
   - 8.2 Line up the access holes.
9. Remove the air pressure from the fan clutch, and allow the fan to engage.
10. Remove the allen screws holding the fan clutch to the fan hub.
11. 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

Fan Clutch Removal and Installation, Kysor K26RA

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.
3. Connect the air line to the fan clutch.
4. Position the upper fan shroud on the radiator; align the marks, then install the fasteners that hold it to the radiator and the lower fan shroud.
5. Position the surge tank on the radiator assembly, and install the fasteners.
6. Connect the hoses to the surge tank.
7. Fill the cooling system. For instructions, refer to **Section 20.00, Subject 100**.
8. Connect the left-side hose to the charge air cooler.
9. Start the engine and check for coolant leaks. Repair as needed.

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. 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**.

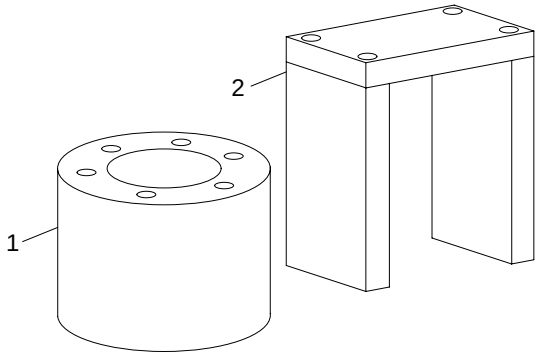
   If using the optional method of caging the engagement spring, do the following:

   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.

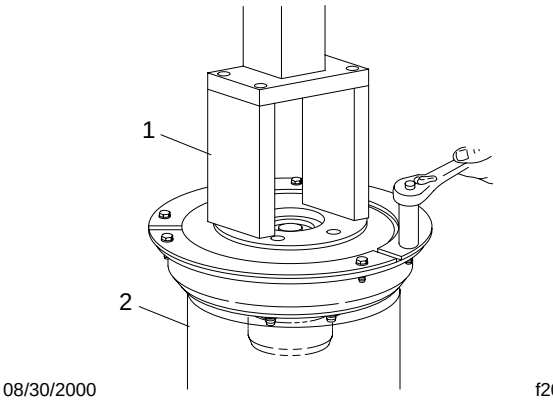
   3.3 Install a wingnut on the end of each carriage bolt and tighten the wingnuts evenly until the engagement spring is caged.

4. Remove the lining retaining plates and the lining. See **Fig. 2** and **Fig. 3**.



1. Support
2. Compressor

Fig. 1, Special Tools



1. Compressor Tool
2. Support Tool

Fig. 2, Caging the Engagement Spring and Removing the Lining Retaining Plates

Fan Clutch Minor Rebuild

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

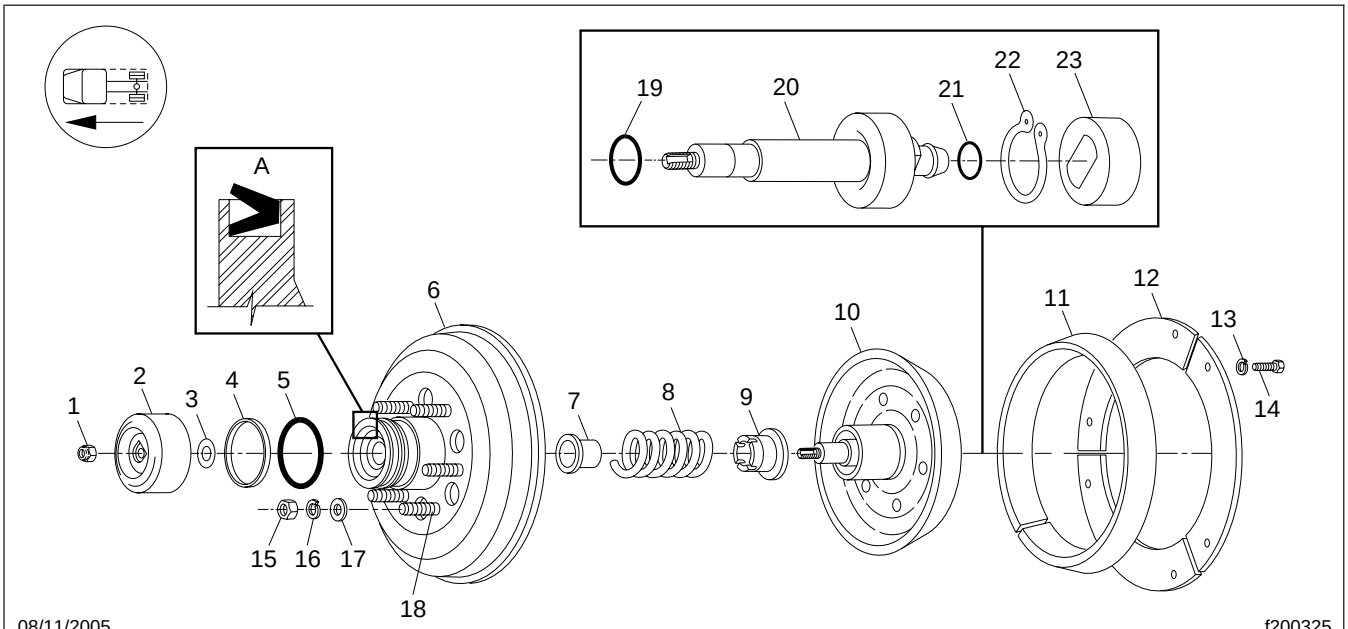
NOTICE

When caging 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.

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).
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 to **Group 20** in the *Cascadia Maintenance Manual*.
14. Install the fan clutch on the engine. For instructions, refer to **Subject 100**.



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 K26RA Fan Clutch (exploded view)

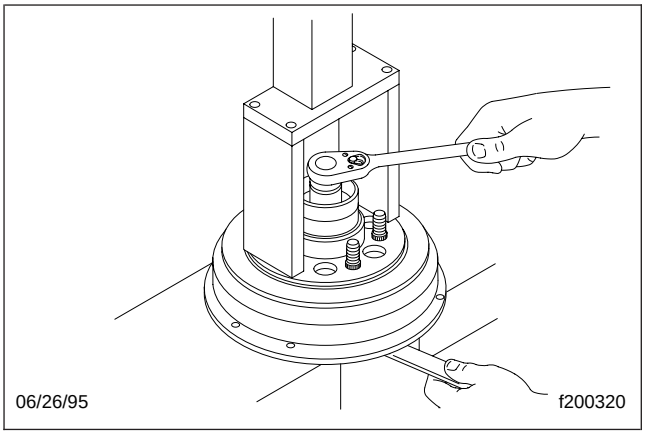


Fig. 4, Removing the Cylinder Nut and Cylinder

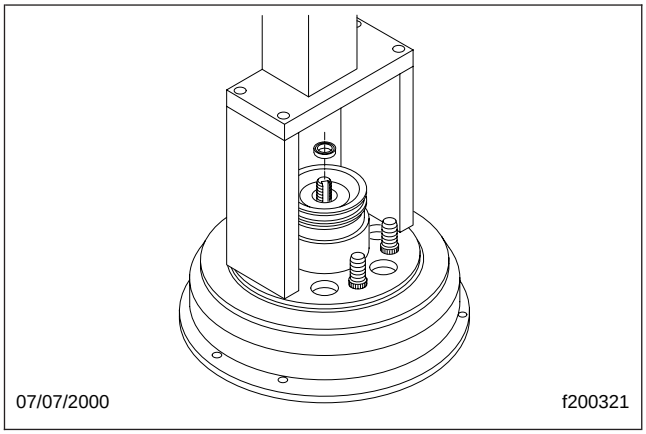


Fig. 5, Installing the Piston Rod Seal Washer

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

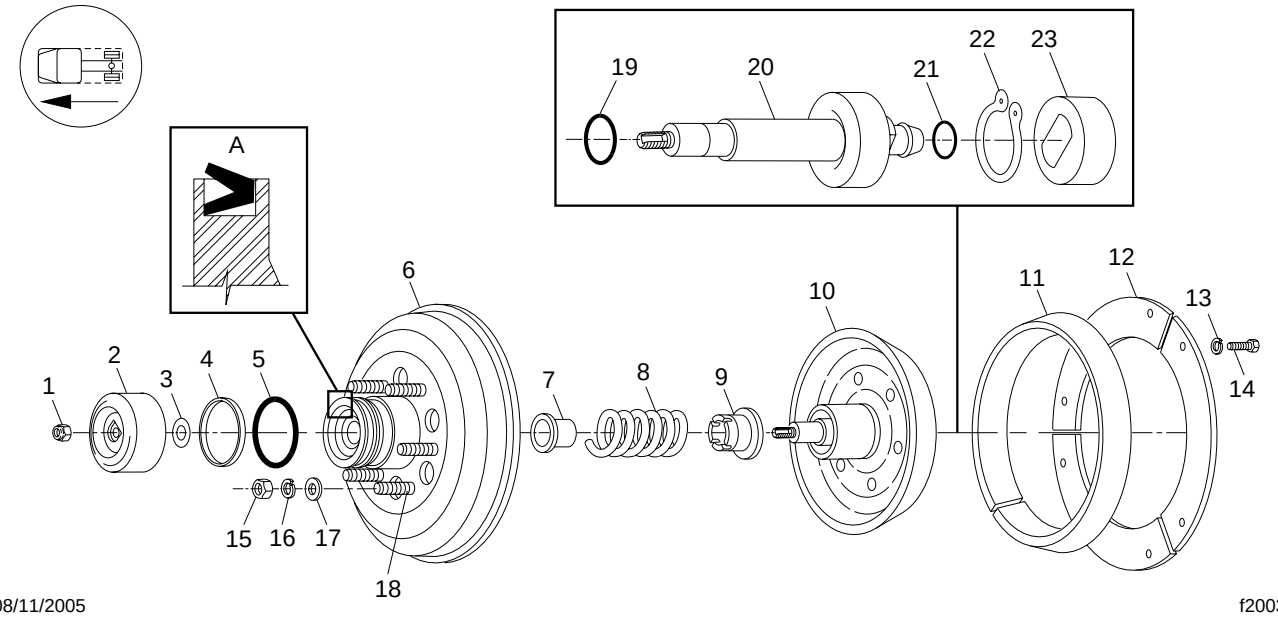
If the fan clutch engages during the next step, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (620 and 827 kPa) of air pressure.

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



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 K26RA Fan Clutch (exploded view)

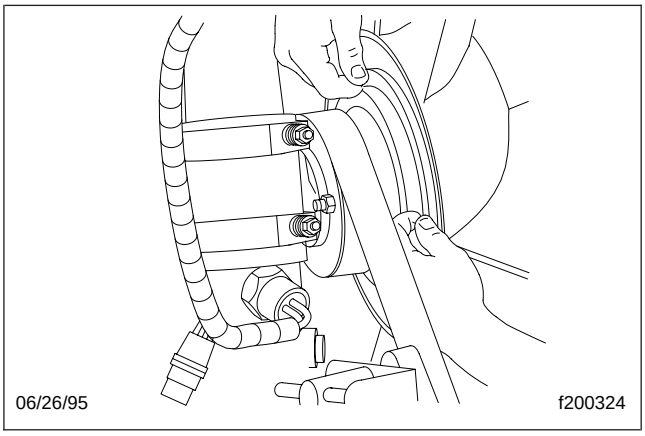
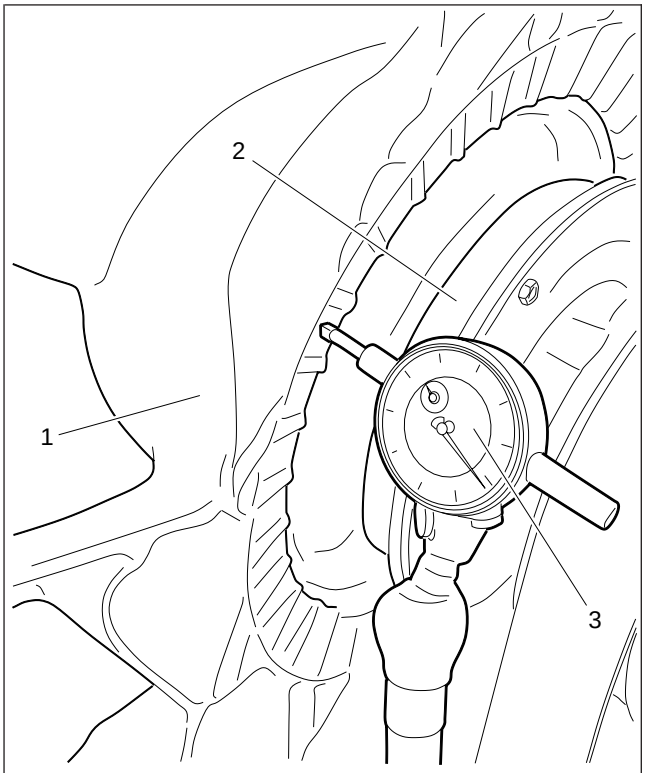


Fig. 2, Removing the Lining Plates

Fan Clutch Rock Runout Measurement

NOTE: Do not try to measure the fan rock runout at the end of the fan blade. An inaccurate reading will result.

1. Park the vehicle on a level surface, shut down the engine, and set parking brake. Chock the tires.
2. Position the indicator on a flat surface near the outside diameter (OD) of the clutch hub section of the fan as shown in **Fig. 1**.



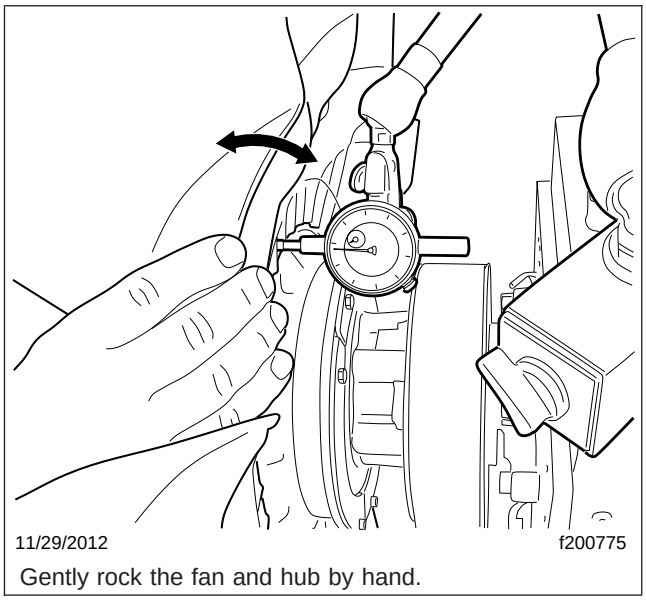
1. Fan
2. Fan Clutch
3. Indicator

Fig. 1, Positioning the Indicator

3. Drain the air from the air system.
4. Disconnect the air line to the fan clutch.
5. Disengage the clutch. Apply, and maintain, 90 to 120 psi (620 to 830 kPa) shop air to the fan clutch for the test.
6. Grasp the fan at the hub and gently rock the fan fore and aft. See **Fig. 2**.

   The total indicator reading should not exceed 0.050 in (1.27 mm).

   If reading is greater than 0.050 in (1.27 mm), replace the fan clutch. For instructions, see **Subject 100**.



Gently rock the fan and hub by hand.

Fig. 2, Checking the Rock Runout Measurement

7. Remove the indicator.
8. Connect the air line to the fan clutch.
9. Pressurize the system, and check for leaks. Repair as needed.

Specifications

If the lubricant that comes with the rebuild kit for the Kysor K26RA 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 K26RA 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 K26RA Fan Clutch Torques

General Information

An engine block heater keeps the engine coolant about 80°F (40°C) warmer than the ambient air temperature. This makes it possible for combustion to happen when the engine is cold. The block heater also reduces engine wear by warming the oil film on the piston walls, and reduces piston drag caused by cold oil film.

When the engine is starting, the air/fuel mixture normally ignites when the pistons compress it to about 725°F (385°C). In cold weather, the engine block may be too cold for the fuel to reach ignition temperature. The engine block heater warms the engine enough for combustion to be possible.

The heater element threads into the water jacket through the side of the engine. See **Fig. 1** and **Fig. 2**. An electric cord runs from the outside end of the element to a receptacle below the driver-side door; see **Fig. 3**. To use the block heater, an extension cord connected to an external AC electrical source plugs into the receptacle.

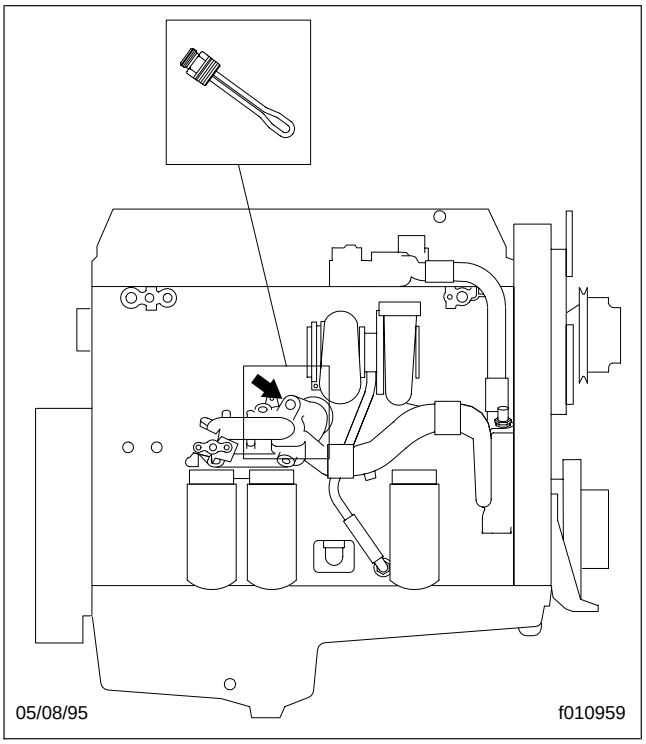


Fig. 1, Block Heater Element Location (Detroit Diesel Series 60 Engine)

The element has no thermostat. Heat dissipating through the engine block prevents coolant overheating.

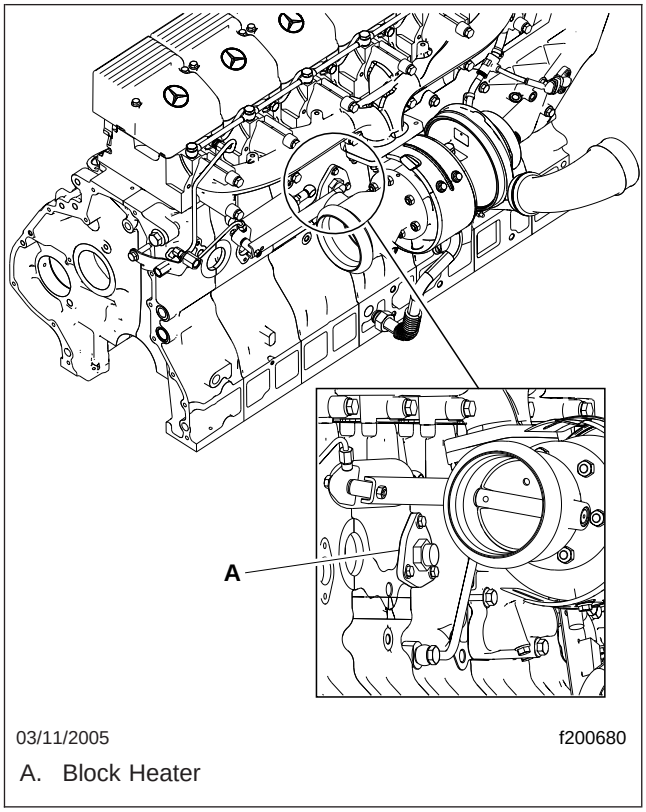


Fig. 2, Block Heater Element Location (Mercedes-Benz MBE4000 Engine)

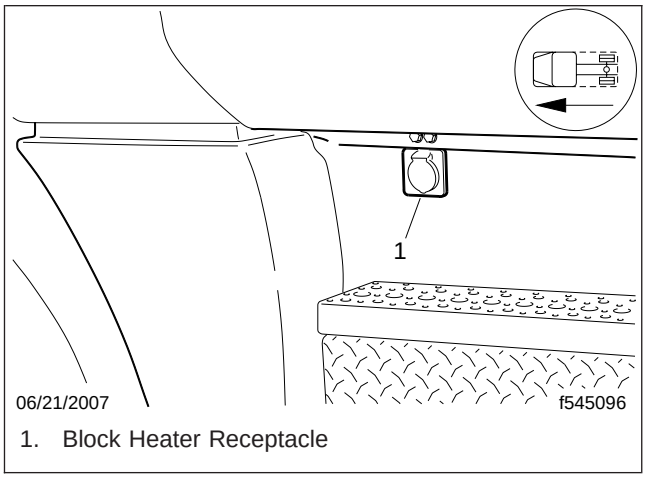


Fig. 3, Block Heater Receptacle Under Driver Door

Removal

1. Apply the parking brake and chock the tires.
2. Tilt the hood.
3. Drain the radiator until the coolant level is below the level of the engine block heater. For instructions, refer to **Section 20.01**.

⚠ WARNING

Opening the cooling system when it is hot and pressurized can allow hot, scalding coolant to shoot out forcefully, potentially causing severe personal injury. Do not open the cooling system when it is hot or pressurized.

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. Coat the threads of the element with a small amount of sealant. For 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 heater 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.

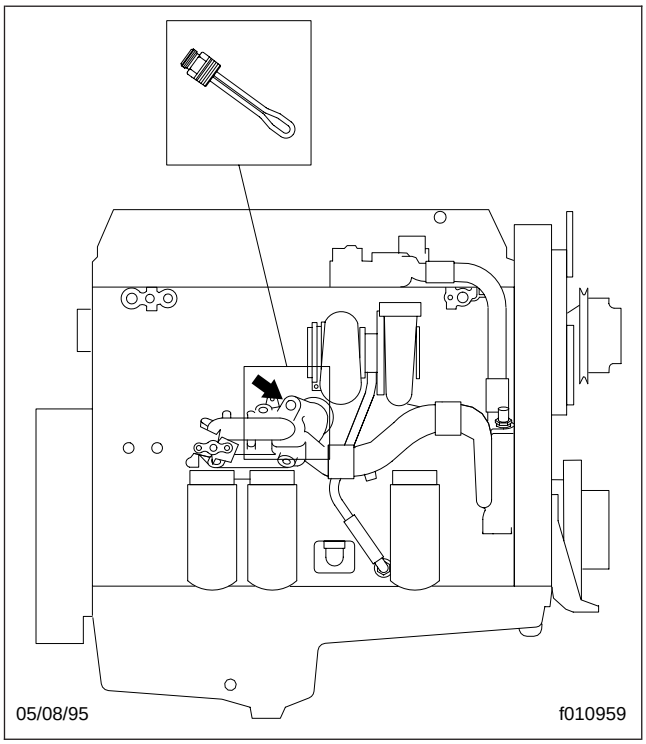


Fig. 1, Block Heater Location (Detroit Diesel Series 60 engine)

Specifications

Approved Sealants

- Loctite 567
- Henkel 790 Pipegrip
- Perma-Loc LH-150

General Description

Eaton® Fuller® Solo™ clutches are pull-type clutches of a dry-disc design. They are 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.

Eaton Fuller Solo clutches are adjustment-free. See **Fig. 1**. As the clutch wears, its 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.

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.

For clutch capacities, see the appropriate table in **Specifications, 400**.

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 3/8-inch to 5/8-inch (10 to 16 mm) of pedal movement (clutch free-pedal) causes the master cylinder piston to close the opening to the fluid reservoir of the hydraulic clutch control system. See **Fig. 5**. Note, the clutch free-pedal does not correlate to a gap between the clutch release yoke fingers and the wear pads of the clutch release bearing (release yoke free-travel), since the release yoke is in constant contact with the wear pads due to pre-load from the slave cylinder of the hydraulic clutch control system.

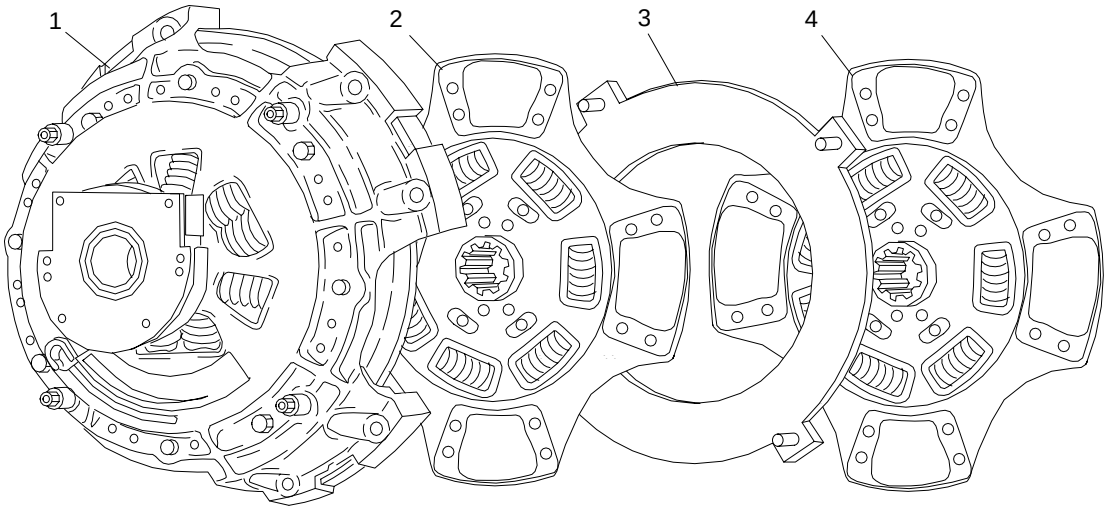
The release yoke pulls the release bearing away from the pressure plate inside the clutch cover. This compresses the pressure springs, allowing the driven discs to slip freely, and at a different speed from the drive discs.

Further downward movement of the clutch pedal (clutch release-pedal), causes the release bearing to move into contact with the clutch brake (release 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 1-1/4 inches to 1 inch (33 to 25 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 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

General Information



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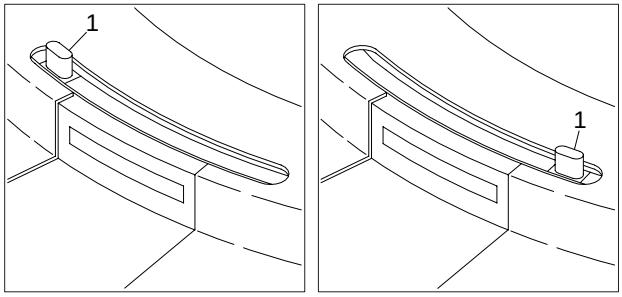
1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc

Fig. 1, Solo Heavy-Duty Clutch



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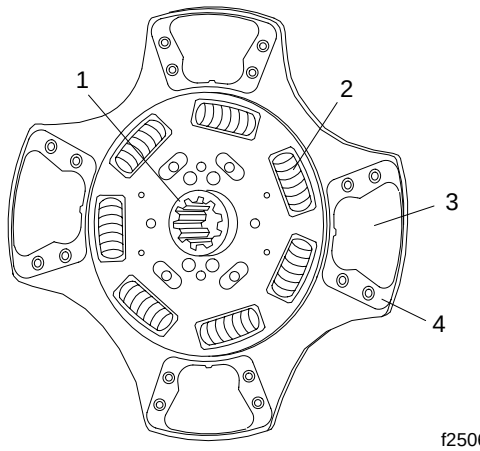
NOTE: "NEW" position on the left, "REPLACE" position on the right.

1. Wear Indicating Tab

Fig. 2, Wear Indicator

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.



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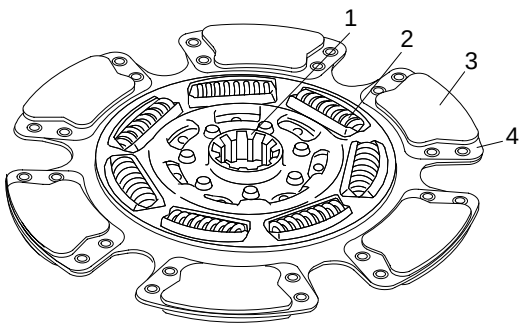
1. Hub
2. Damper
3. Facing
4. Paddle

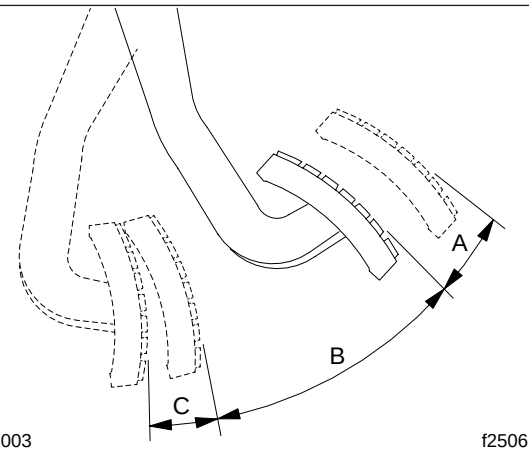
Fig. 3, Driven Disc With Four Ceramic Facings

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.



1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 4, Driven Disc With Six Ceramic Facings



A. Clutch Free-Pedal
B. Clutch Release-Pedal
C. Clutch Brake Squeeze

Fig. 5, Clutch Pedal Movement

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.

Removal

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.

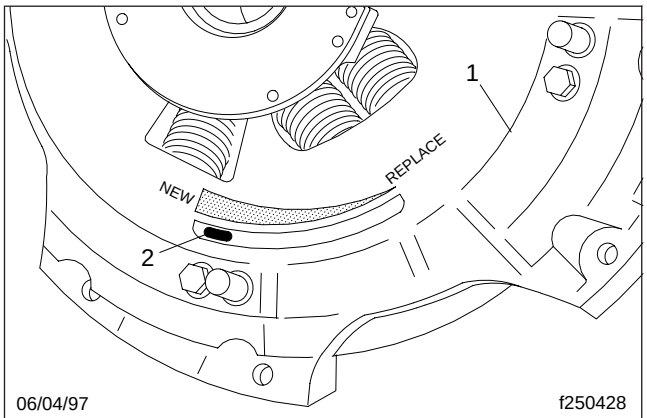
   1.1 From inside the cab, press the clutch pedal all the way down. Hold the clutch pedal down until the wear indicating tab is reset.

   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**.
4. 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.

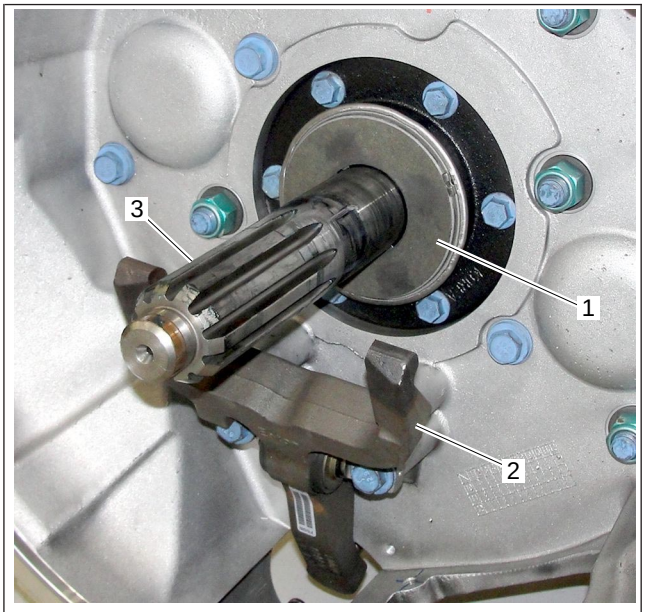
NOTE: Shipping bolts are installed on the clutch cover prior to installation to prevent the clutch adjustment mechanism from unloading.

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

Clutch Removal



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1. Clutch Brake
2. Release Yoke
3. Input Shaft

Fig. 2, Clutch Brake Installation

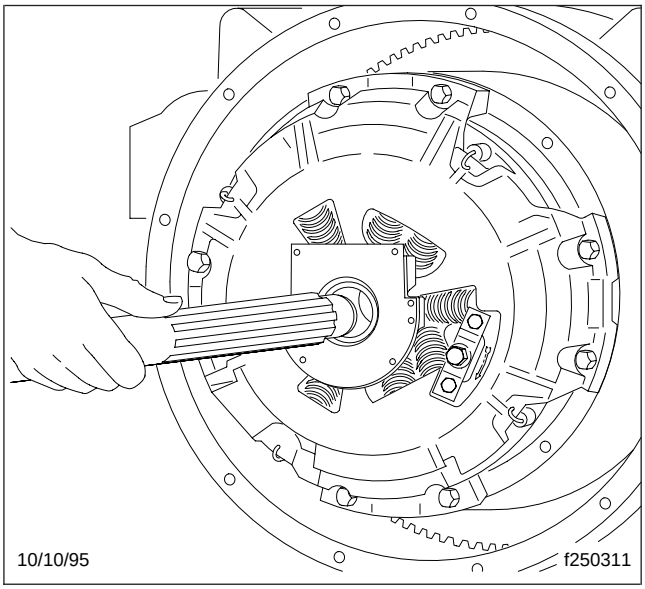

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Fig. 3, Installing a Spline Aligning Tool

prevent warping or bending within the clutch, and will ease removal of the clutch mounting capscrews.

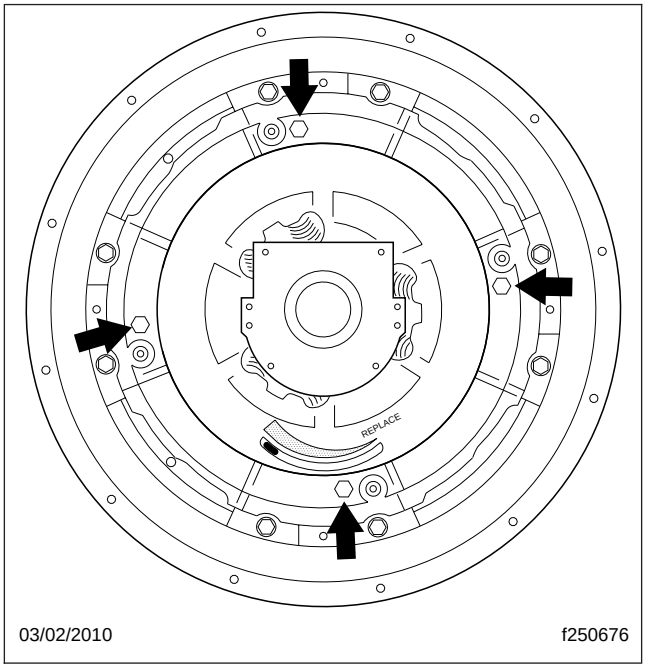

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Fig. 4, Installed Shipping Bolts

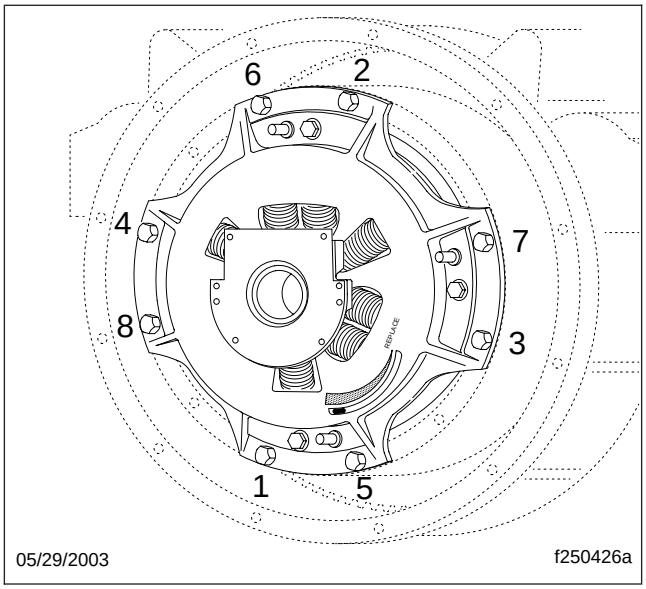

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Fig. 5, Loosening Sequence

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**.

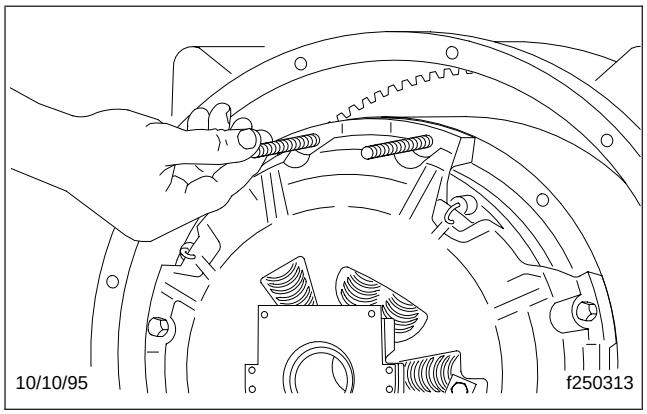


Fig. 6, Installing the Guide Studs

NOTE: Mark the positions of the clutch components so they can be properly oriented during installation.

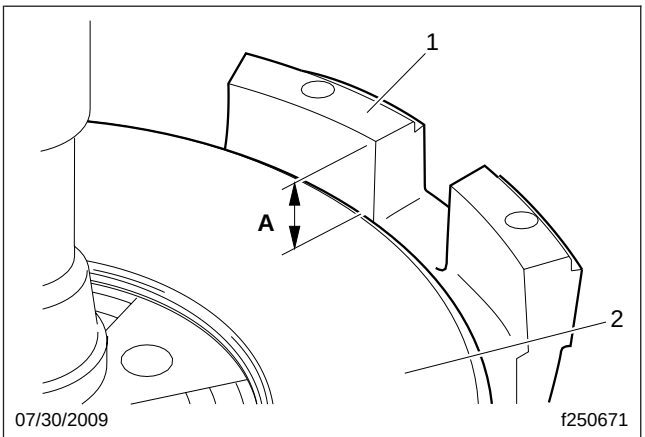
⚠ WARNING

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**.
   - 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.



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

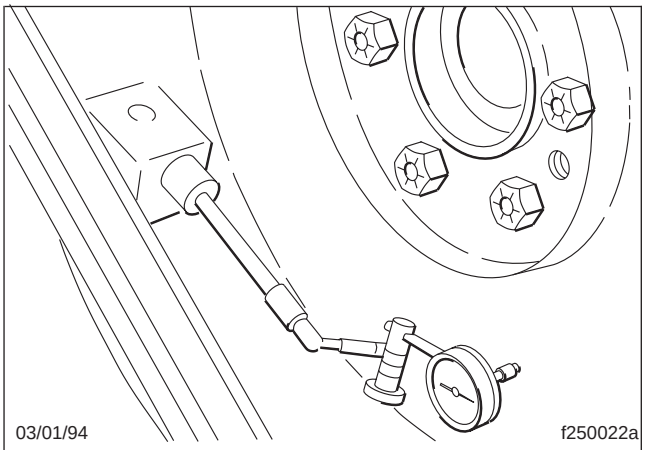
Clutch Inspection

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), as follows. See **Fig. 1** for the correct setup.



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Secure the dial indicator to the flywheel housing, with the gauge finger against the flywheel face, and near the outer edge.

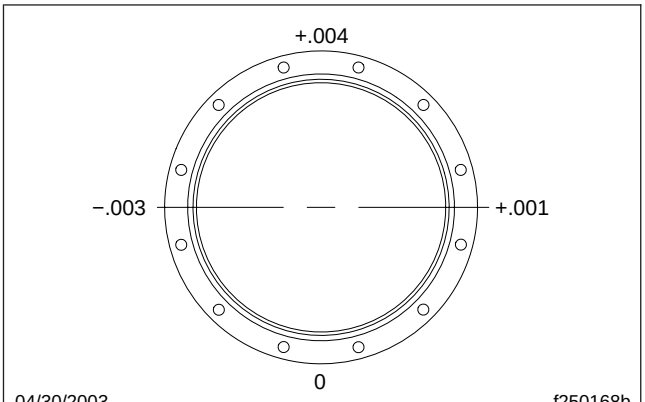
Fig. 1, Measuring the Flywheel Face

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 lowest 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.



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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, Calculating 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, as follows. See **Fig. 3** for the correct setup.

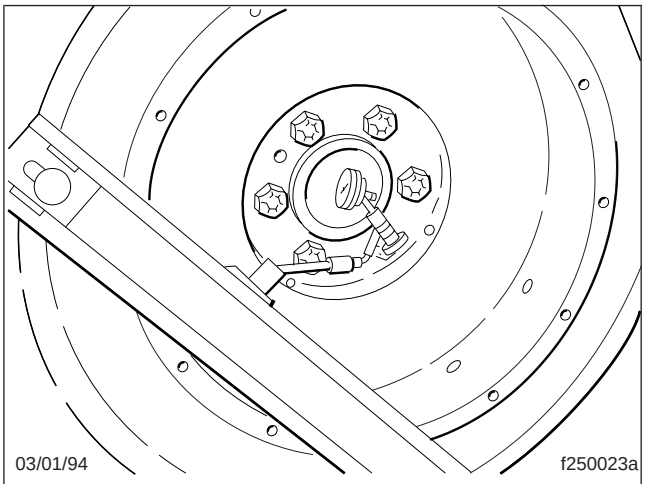
3.1 With the indicator still secured to the flywheel housing, move the gauge finger to contact the surface of the pilot-bearing bore.

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.

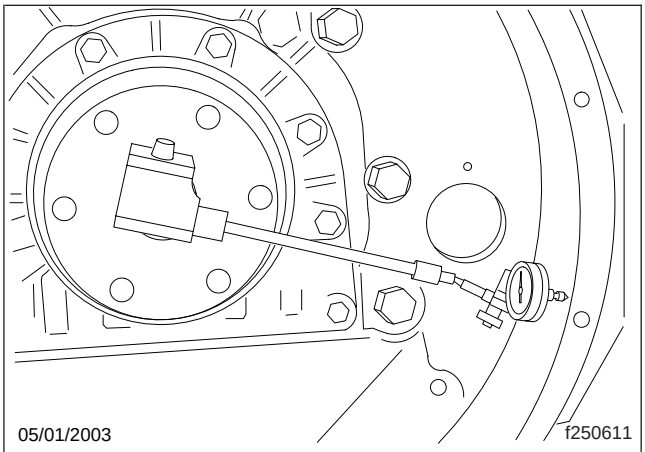
Clutch Inspection and Pre-Installation Procedures



Secure the dial indicator to the flywheel housing, with the gauge finger on the surface of the pilot-bearing bore.

Fig. 3, Measuring the Pilot-Bearing Bore

4. Measure the runout of the flywheel housing bore, as follows. See **Fig. 4** for the correct setup.



Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

Fig. 4, Measuring the Flywheel Housing Bore

4.1 Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

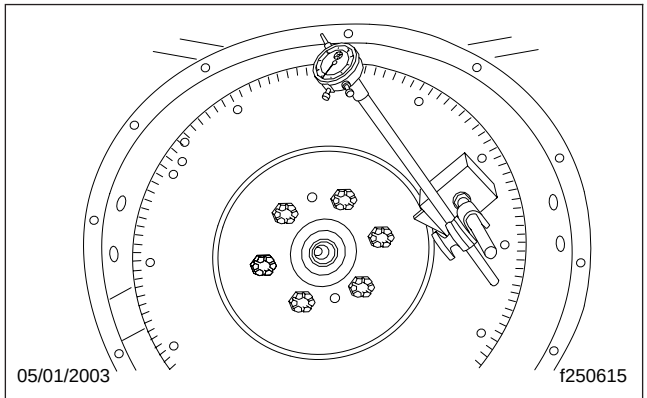
4.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the side of the flywheel housing.

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, as follows. See **Fig. 5** for the correct setup.



Secure the dial indicator to the outer diameter of the flywheel, with the gauge finger against the face of the flywheel housing.

Fig. 5, Measuring 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.

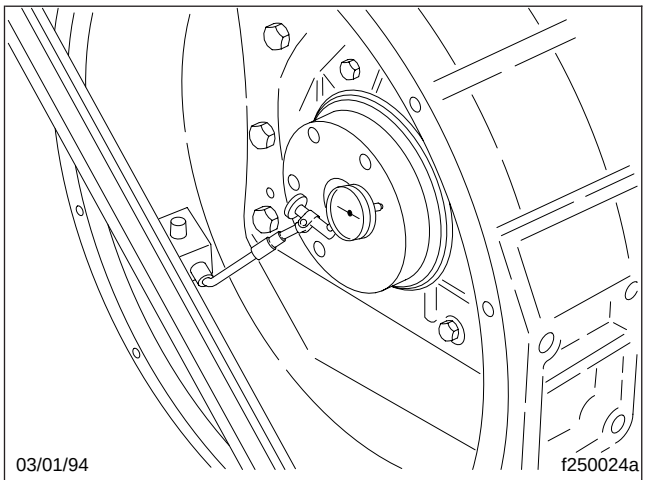
NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

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, as follows.
   - 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**.
   - 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.



Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.

Fig. 6, Measuring the Crankshaft Face Runout

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**.
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) clearance for both movement of the release bearing and access to install shipping bolts. See **Fig. 8**.
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.

Clutch Inspection and Pre-Installation Procedures

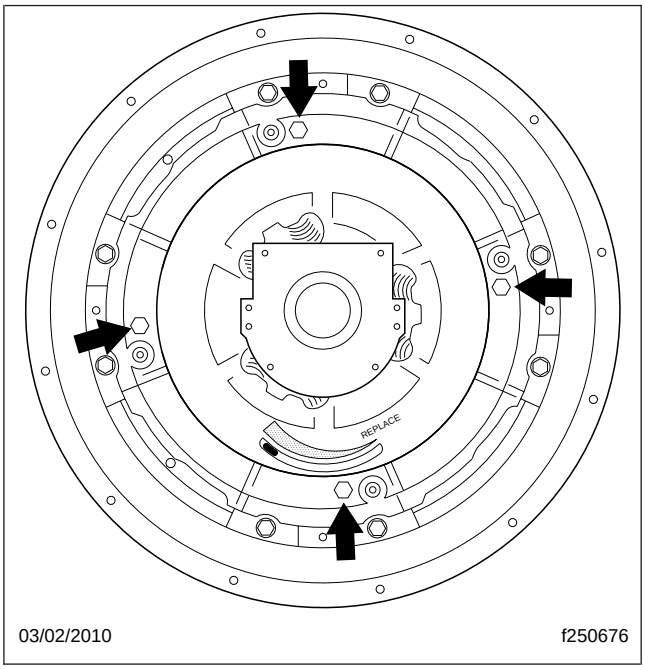


Fig. 7, Installed Shipping Bolts

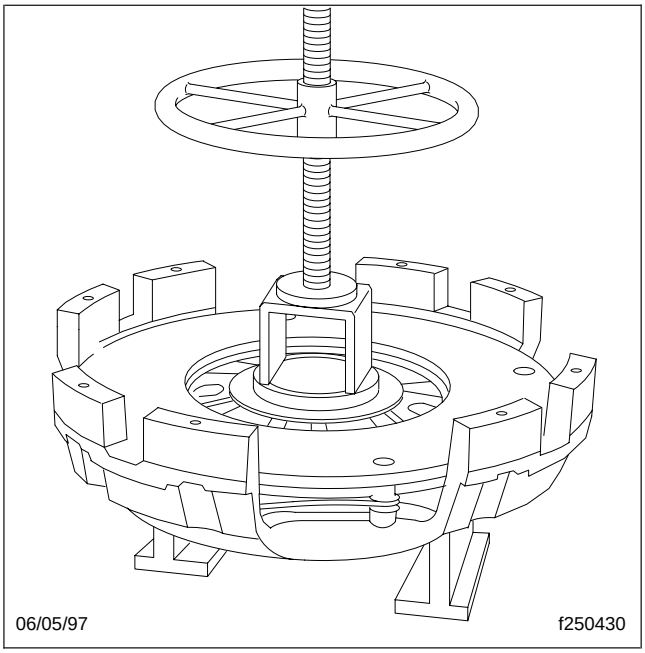
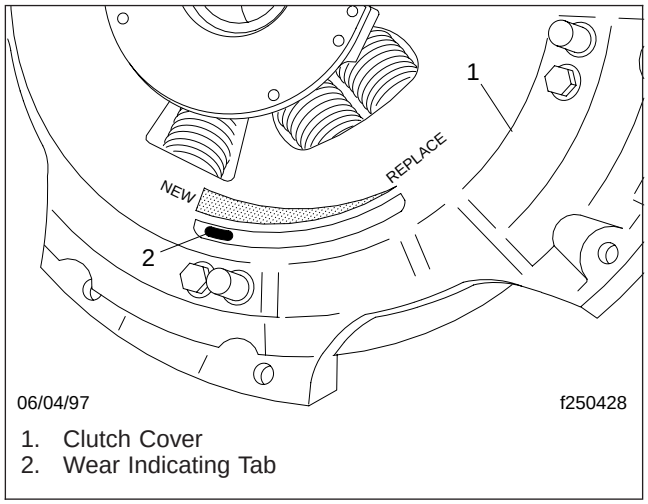


Fig. 8, Arbor Press Setup

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**.



1. Clutch Cover
2. Wear Indicating Tab

Fig. 9, Resetting the Wear Indicating Tab

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.
   - 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**.

Pre-Installation Procedures

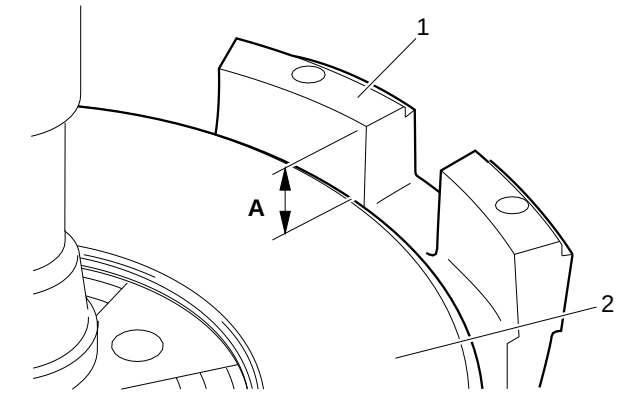
Before installing a new, rebuilt, or used clutch, do the following procedures:

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 tem-



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

peratures 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**.

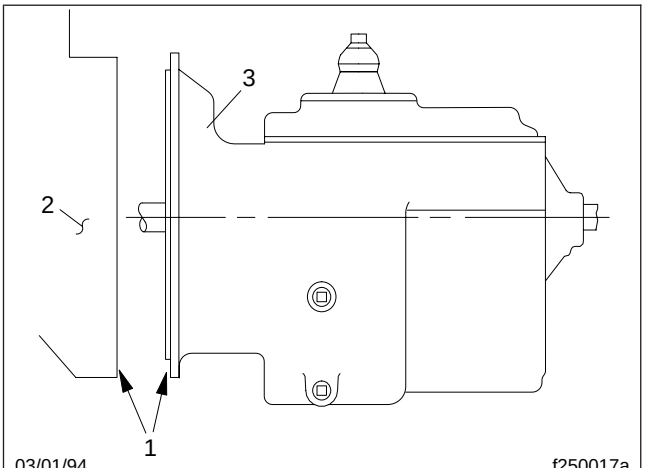
3. Check the flywheel housing for wear caused by the bell housing pilot (projecting lip of the bell housing). The correct dimension is 1/8-inch (3.2-mm). Wear is most likely to appear between the 3 o'clock and 8 o'clock positions. See **Fig. 12**.

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, as follows. Replace or repair the flywheel if the wear is extreme.

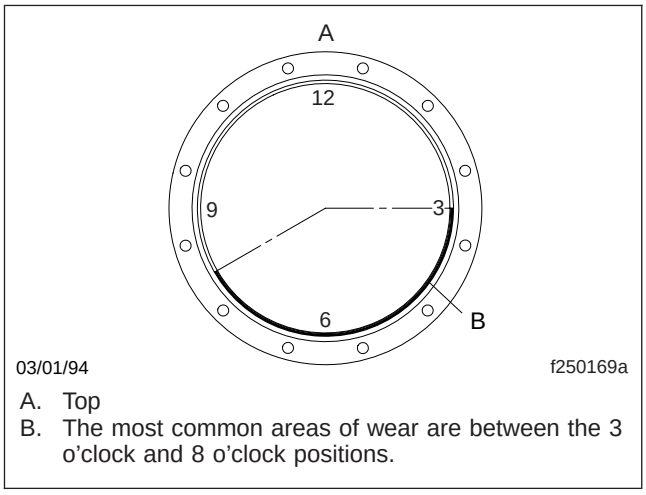
   4.1 Visually inspect the friction surface of the flywheel for heat checks and scoring.

   4.2 Measure the friction surface wear with a straightedge and feeler gauge. For instructions, see the engine manufacturer's manual.



1. Mating Surfaces
2. Engine Flywheel Housing
3. Transmission Bell Housing

Fig. 11, Inspecting the Mating Surfaces



A. Top

B. The most common areas of wear are between the 3 o'clock and 8 o'clock positions.

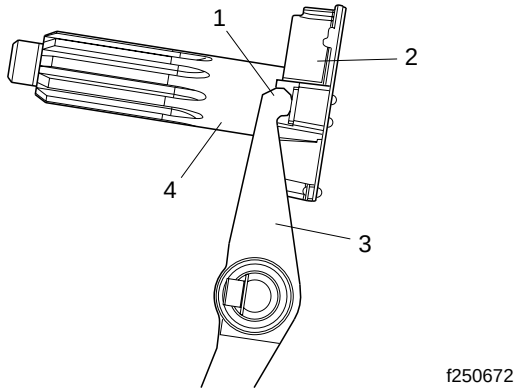
Fig. 12, Checking the Flywheel Housing for Wear

5. Inspect the input shaft, both the splined and the smooth area, as follows. 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

Clutch Inspection and Pre-Installation Procedures



1. Release Fork Finger
2. Release Bearing
3. Release Fork
4. Input Shaft

Fig. 13, Input Shaft, Release Bearing, and Release Fork

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.

6. Check for excessive wear at the fingers of the release fork. See **Fig. 13**.

7. To prevent clutch brake wear, check the input-shaft bearing cap, as follows, and measure it as shown in **Fig. 14**.

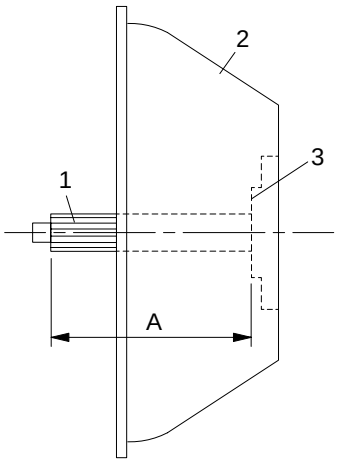
   7.1 Visually check the bearing cap for excessive wear.

   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® transmission, install the smaller face toward the transmission.

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.

9. Measure the diameter of the flywheel bore opening (this is the recessed area for the flywheel bolt

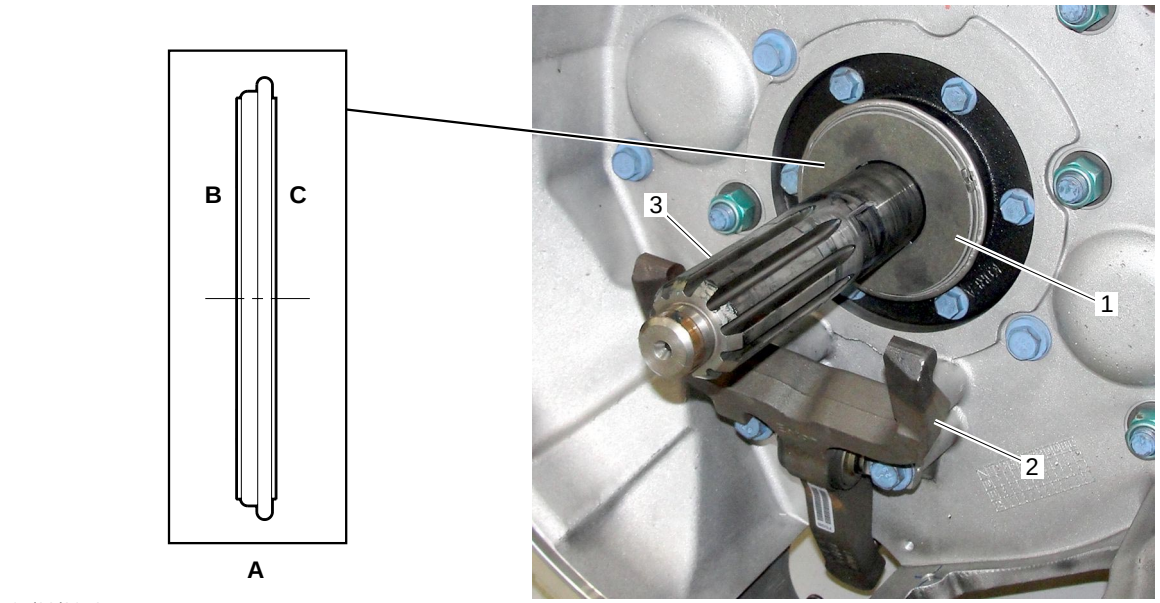


A. Length of Input Shaft, from the Splined End to the Bearing Cap

1. Input Shaft
2. Bell Housing
3. Bearing Cap

Fig. 14, Measuring the Input Shaft

circle). The minimum flywheel bore diameters for a 7-spring disc is 9.75 inches (25 cm).



A. Clutch Brake (side view)
B. Install deep side toward the release bearing.
C. Install shallow side toward the transmission.

1. Clutch Brake
2. Release Yoke
3. Input Shaft

Fig. 15, Clutch Brake Installation

Installation

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.

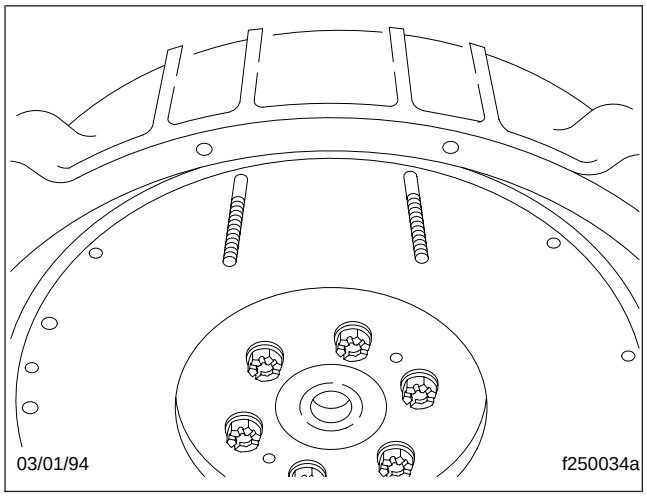


Fig. 1, Installing the Guide Studs

2. If installing a new clutch, 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**.
4. Install the rear driven disc and intermediate plate, as follows.
   - 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**.
   - 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 separator pins protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.

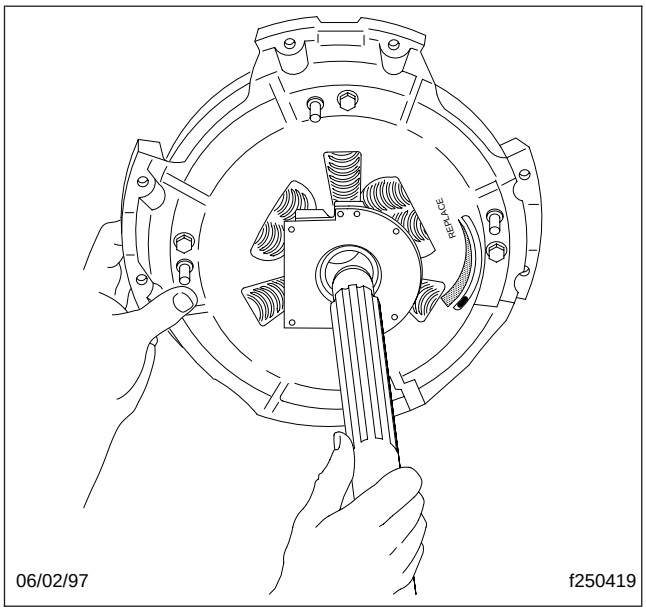


Fig. 2, Inserting an Aligning Tool

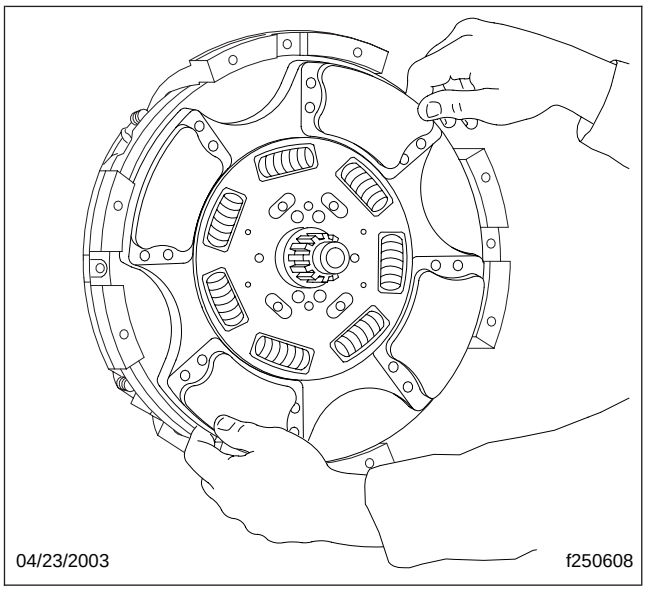
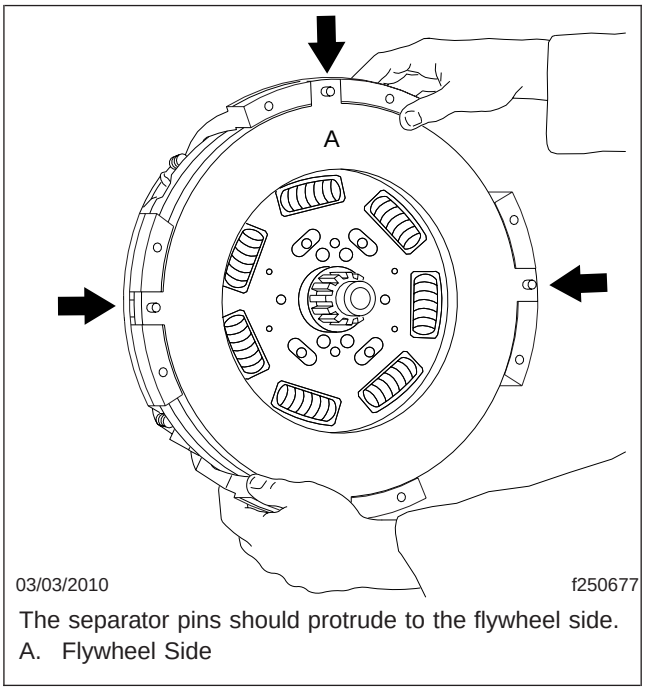


Fig. 3, Installing the Rear Driven Disc

5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

Clutch Installation



The separator pins should protrude to the flywheel side.
A. Flywheel Side

Fig. 4, Positioning the Intermediate Plate

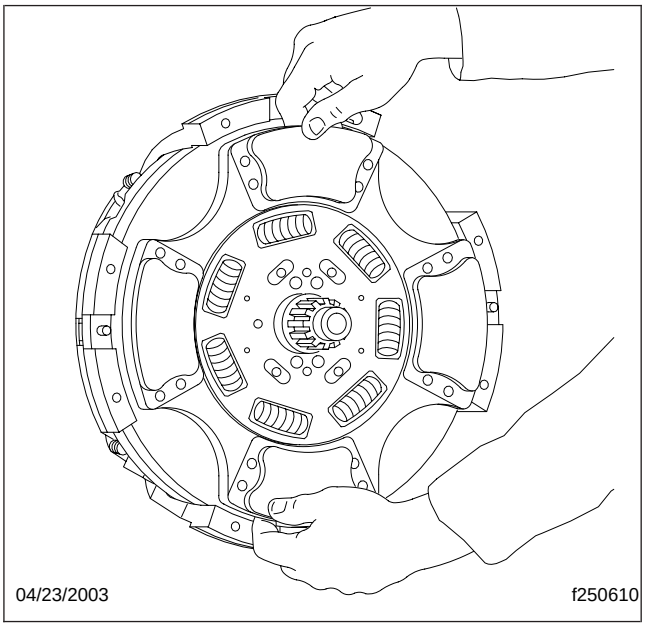


Fig. 5, Installing the Front Driven Disc

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**.

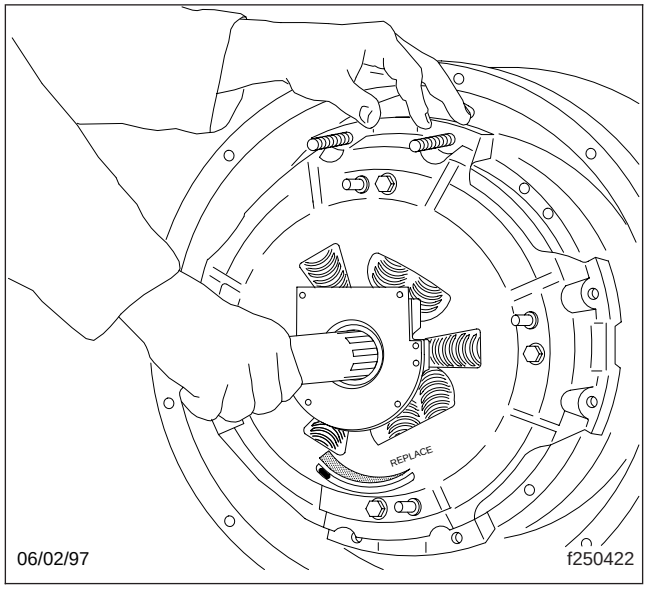


Fig. 6, Positioning the Clutch Cover

7. Install the mounting capscrews, as follows.
   - 7.1 Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting capscrews with lockwashers, and tighten them finger-tight.
   - 7.2 Tap the aligning tool to make sure it is centered and seated in the pilot bearing. See **Fig. 7**.
   - 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**. Final torque is 40 to 50 lbf·ft (54 to 68 N·m).

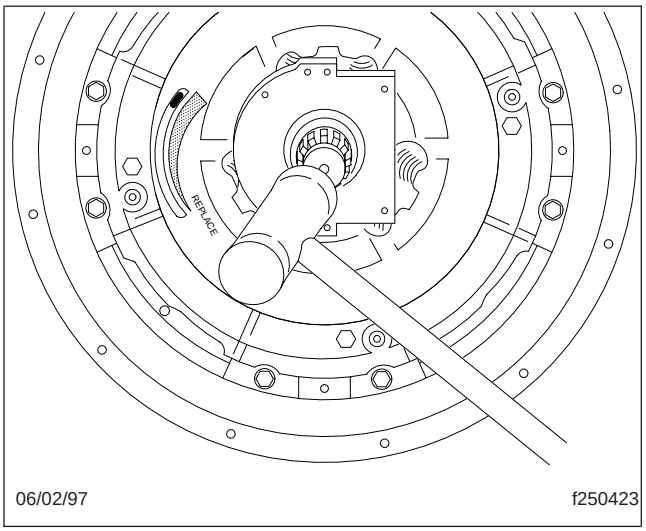


Fig. 7, Tap Aligning Tool

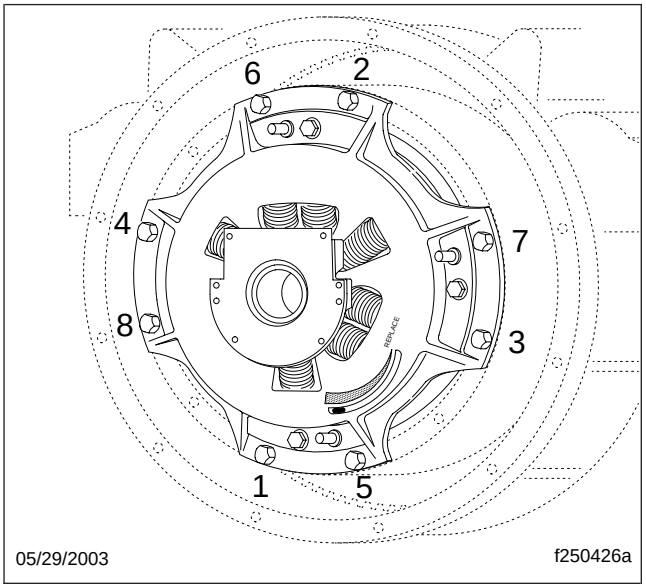


Fig. 8, Tightening Sequence

NOTICE

Failure to tighten the bolts according to this procedure can have the following effects:

- preventing the clutch cover from centering into the pilot area of the flywheel;
- causing the clutch assembly to be out-of-balance with the flywheel;
- causing permanent damage to the clutch cover.

9. Following a crisscross pattern, remove and retain the four shipping bolts from the clutch cover. See **Fig. 9**.

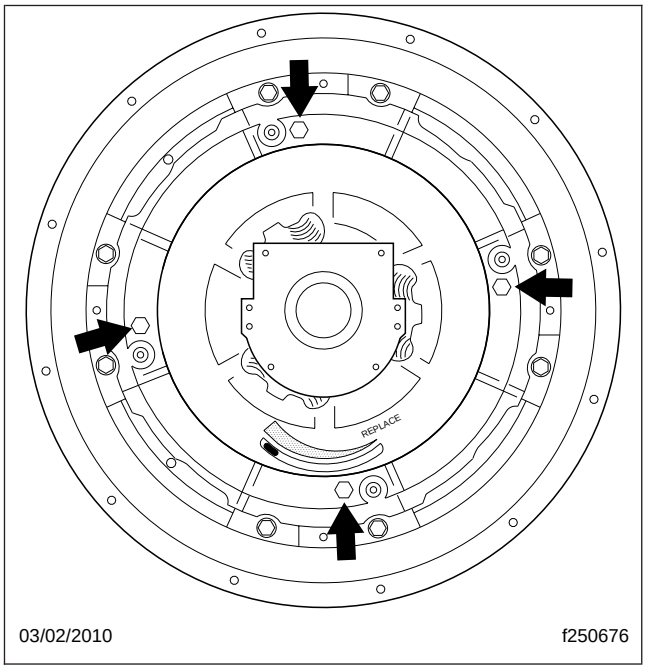


Fig. 9, Installed Shipping Bolts

NOTE: Retain these four shipping bolts. These bolts will be needed to secure future clutch assemblies 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.

⚠ 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. To ensure that all four separator pins are flush against the flywheel, insert a 1/4-inch (6-mm) diameter flat-nose punch through the access holes and *lightly* tap each of them toward the flywheel. See **Fig. 10** and **Fig. 11**.

Clutch Installation

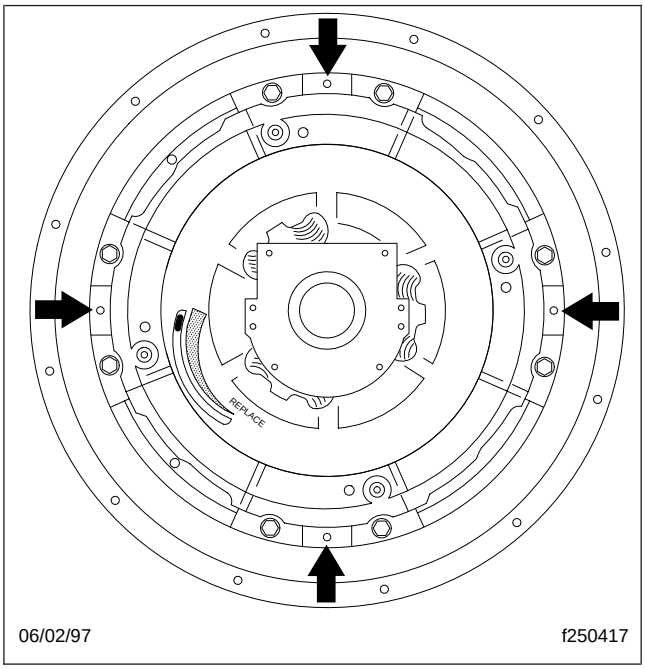


Fig. 10, Separator Pin Access Holes

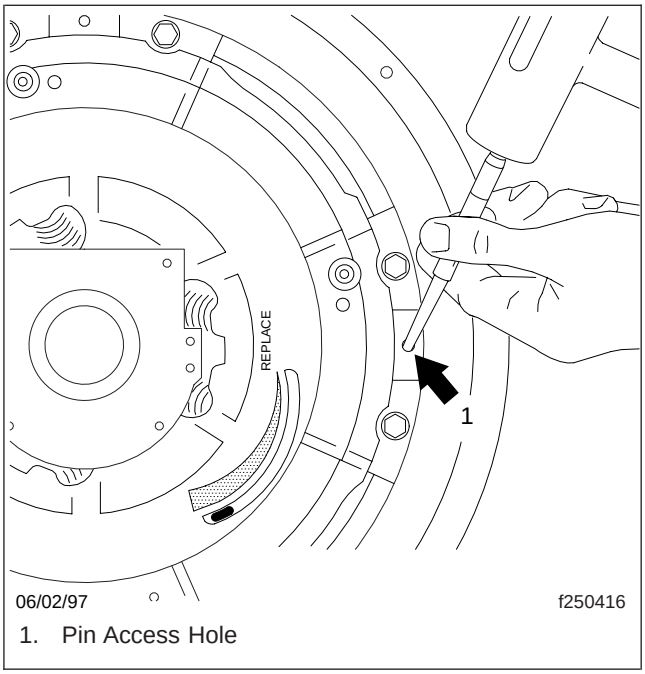


Fig. 11, Tapping A Separator Pin

NOTE: Failure to perform this step properly may cause the clutch to drag or not release.

12. Using a clean cloth, remove all grease from the input shaft.

NOTE: For lubrication of the release fork fingers, Eaton Fuller recommends a lithium-base grease that can operate up to at least 325°F (163°C) and meets the NLGI Grade 2 or 3 specification.

13. Lubricate the release fork fingers. See **Fig. 12**.

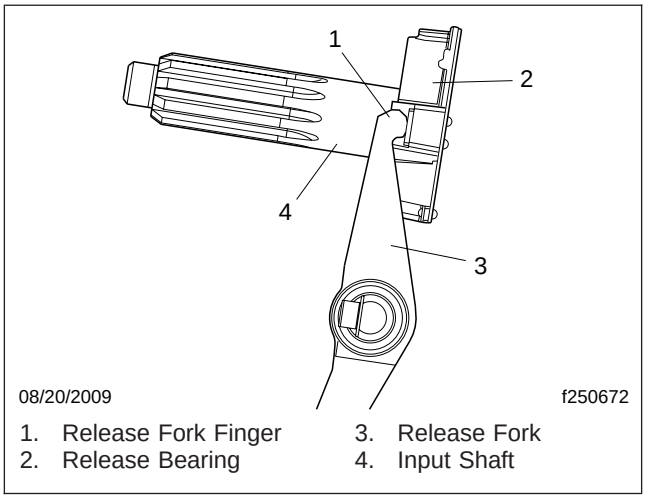


Fig. 12, Release Fork

14. 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.
15. Install the clutch brake.

NOTICE

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).

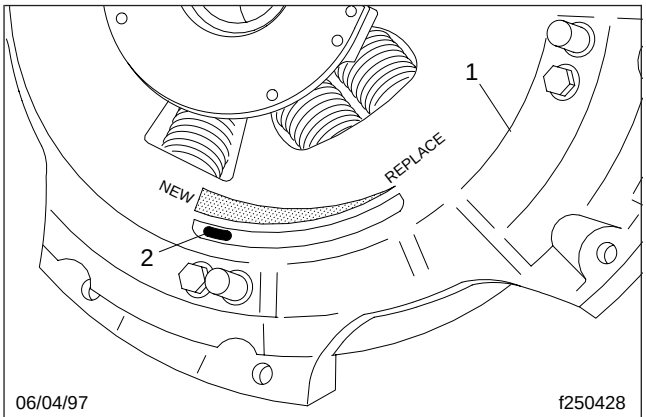
16. Install the transmission and attach the clutch linkage.

17. Lubricate the release bearing. For instructions and recommended lubricants, see **Group 25** of the *Cascadia™ Maintenance Manual*.

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 inspection panel, 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".



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.

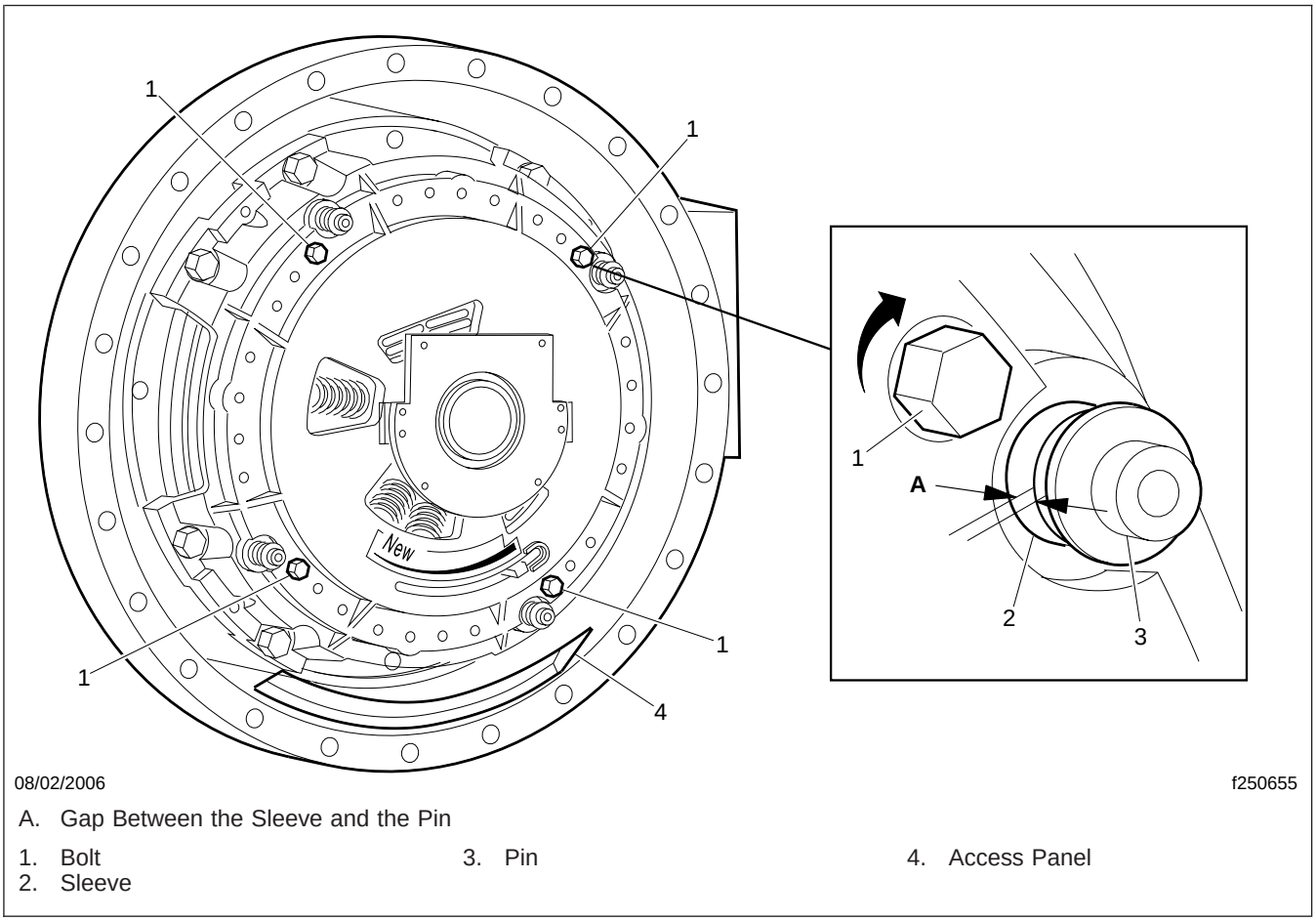
4. Use sideways pressure to the right and lightly pull the tool away from the engine to separate the top cam from the bottom cam. If the cam moves slightly to the right, let up on the clutch pedal. If the cam is still seized, spray WD-40 into the cam slot and three spring perches. To access all three 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

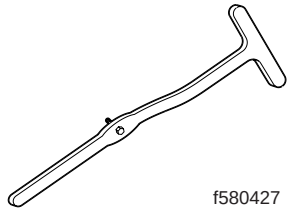
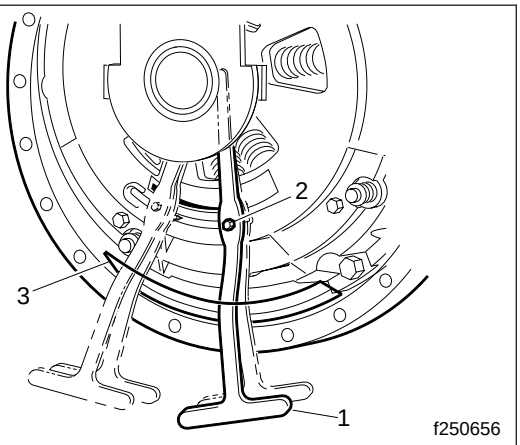
Tool	Description	Eaton Tool Part Code
 f580427	Seized Cam Adjustment Tool	CLPI-SOLOTOOL

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

Specifications

For specifications related to various aspects of Eaton Fuller Heavy-Duty clutches, see the following tables.

Clutch Torque Values			
Description	**Size**	**Grade**	**Torque: lbf.ft (N.m)**
Clutch Cover to Flywheel Bolts	7/16–14 x 2-1/4	5	40–50 (54–68)

Table 1, Clutch Torque Values

Clutch Adjustments		
Dimension	**Definition**	**Specification: 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.	N/A (Pre-loaded)
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: 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 Bore	
Disc Type	**Flywheel Bore: inch (cm)**
7-Spring	9.75 (25)

Table 4, Minimum Flywheel Bore

Solo Heavy-Duty Clutch Specifications				
Solo Part Number	**Flywheel Bore: inch (mm)**	**Damper Style**	**No. of Springs**	**No. of Facings**
109701–82 (Standard Yoke)	10.0 (254)	Low Rate	7	4

Table 5, Solo Heavy-Duty Clutch Specifications

Specifications

Solo Heavy-Duty Clutch Capacity			
Solo Part Number	**Plate Load: lbf (N)**	**Torque: lbf·ft (N·m)***	**Damper Spring Color**
109701–82 (Standard Yoke)	3600 (16 000)	1700 (2305)	Plain

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 6, Solo Heavy-Duty Clutch Capacity

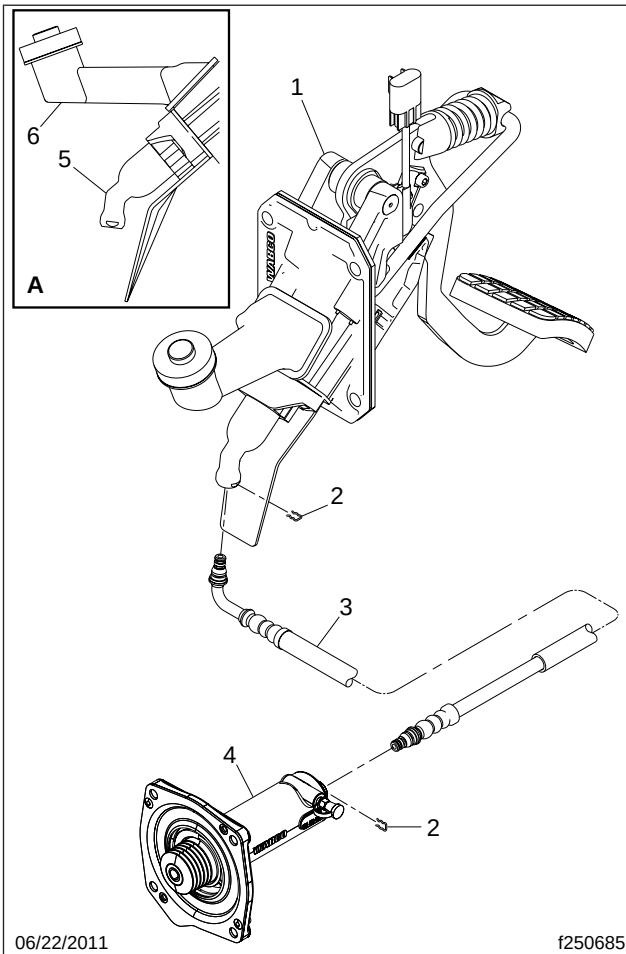
General Information

The hydraulic clutch control system consists of a pedal unit and a slave cylinder, connected by a hydraulic hose that is fastened with quick-disconnect clips. See **Fig. 1**. The hydraulic system is self-adjusting, and it uses DOT 4 brake fluid.

The pedal unit includes a hydraulic subassembly, composed of the master cylinder and reservoir, which can be removed from the pedal unit for service purposes; see **Subject 110** for instructions.

Principles of Operation

When the clutch pedal is pressed, the fluid in the master cylinder is forced through a hydraulic line to the slave cylinder. The fluid pressure moves the slave cylinder piston, pushing the plunger rod and clutch release lever, which disengages the clutch.



A. Hydraulic Subassembly

1. Pedal Unit
2. Clip
3. Hydraulic Hose
4. Slave Cylinder
5. Master Cylinder
6. Reservoir

Fig. 1, Components, Hydraulic Clutch Control

Pedal Unit Removal and Installation

Removal

WARNING

Clutch hydraulic fluid (DOT 4 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Remove the lower steering column cover, if needed.
4. As needed, cut zip ties to allow the hydraulic hose to move freely when the pedal unit is removed.

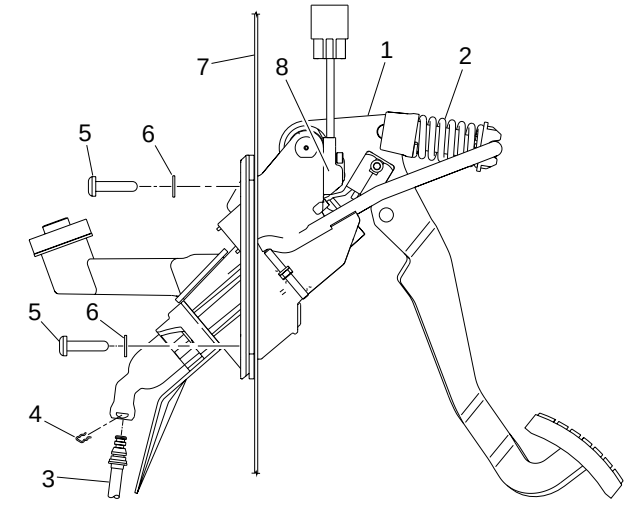
WARNING

Do not attempt to disassemble the preloaded assist spring. Sudden release of the assist spring could cause property damage and serious personal injury.

5. Remove the fasteners that attach the pedal unit to the frontwall, and withdraw the unit until you can access the clutch control switch. Retain the fasteners for later installation. See **Fig. 1**.
6. Disconnect the clutch control switch, as follows.
   - 6.1 Retract the secondary lock. See **Fig. 2**.
   - 6.2 Depress the latch to unlock the switch connector, then separate the clutch control switch from the wire harness.
7. Remove the pedal unit from the vehicle.

IMPORTANT: To avoid spilling fluid when the hose is removed from the master cylinder, turn the pedal unit upside down so that the fluid drains into the master cylinder and reservoir.

8. Use a flat-tip screwdriver to remove the quick-disconnect clip that locks the hydraulic hose into the master cylinder. See **Fig. 3**. Remove the hose and, with the end pointing upwards to prevent fluid spillage, secure it temporarily to a safe point on the vehicle. Retain the clip for later installation.



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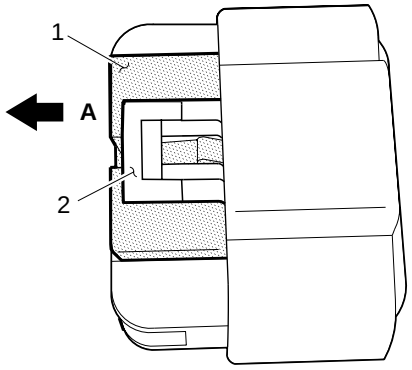
1. Pedal Unit
2. Assist Spring
3. Hydraulic Hose
4. Clip
5. Bolt
6. Washer
7. Frontwall
8. Clutch Control Switch

Fig. 1, Pedal Unit Installation



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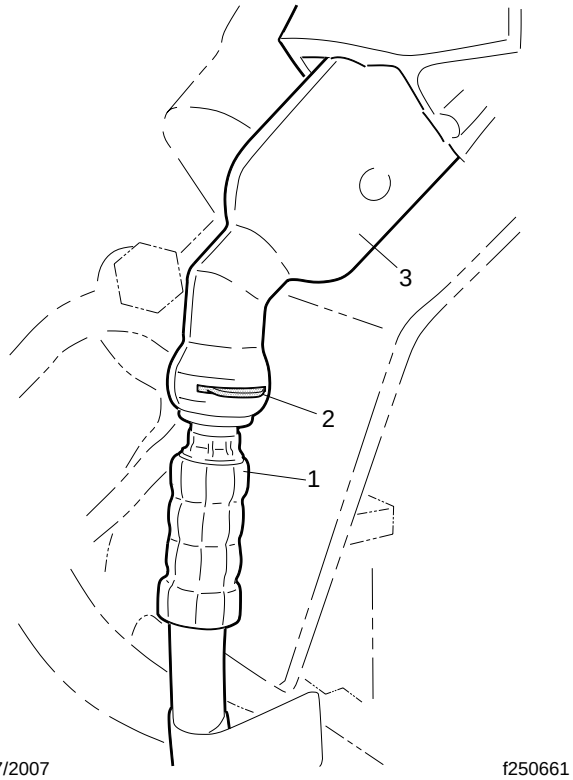
A. Retract the secondary lock, then depress the latch to release the connector.

1. Secondary Lock
2. Latch

Fig. 2, Clutch Control Switch Connector

Pedal Unit Removal and Installation



1. Hydraulic Hose
2. Quick-Disconnect Clip
3. Master Cylinder

Fig. 3, Quick-Disconnect Clip at the Master Cylinder

Installation

1. Install the pedal unit, and tighten the four mounting plate capscrews 11 lbf·ft (15 N·m).
2. Install the quick-disconnect clip and hydraulic hose, as follows.
   - 2.1 Insert the clip arms into the recessed areas on the nozzle of the master cylinder.
   - 2.2 Snap the hydraulic hose into place.
   - 2.3 Tug on the hose to make sure it is installed correctly. The hose should not pull out.

   IMPORTANT: Do not force the hose into the slave cylinder. If the clip is incorrectly installed, the hose will not snap into place.
3. As removed, brace the hydraulic hose with zip ties.
4. Connect the clutch control switch.
5. Install the lower steering column cover, if removed.

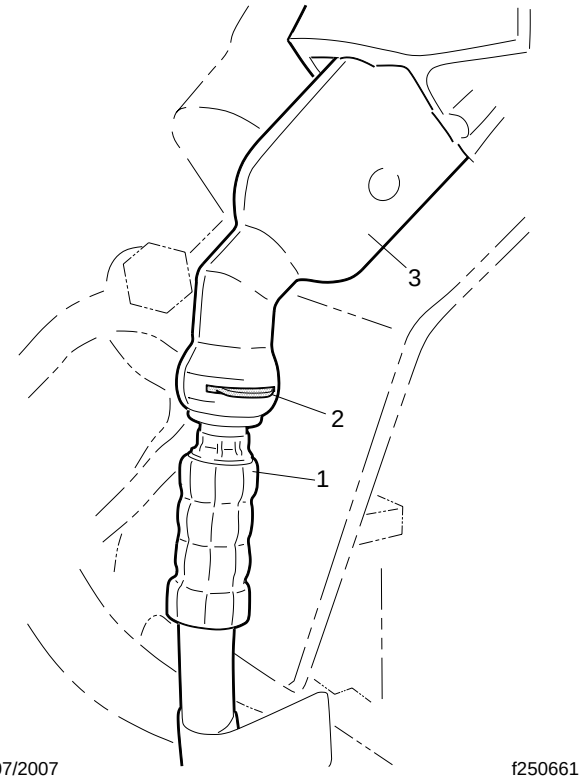
⚠ WARNING

Use only approved clutch hydraulic fluid (DOT 4 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

6. Fill the reservoir with approved DOT 4 hydraulic brake fluid and bleed the system as instructed in **Subject 130**.
7. Check the function of the clutch actuation system as instructed in the *Cascadia™ Troubleshooting Manual*.

Replacement

1. Place a suitable container under the master cylinder to collect the fluid that will drain as the hose is removed from the master cylinder.
2. Use a flat-tip screwdriver to remove the quick-disconnect clip that locks the hydraulic hose into the master cylinder. See **Fig. 1**. Remove the hose and, with the end pointing upwards to prevent fluid spillage, secure it temporarily to a safe point on the vehicle. Retain the clip for later installation.



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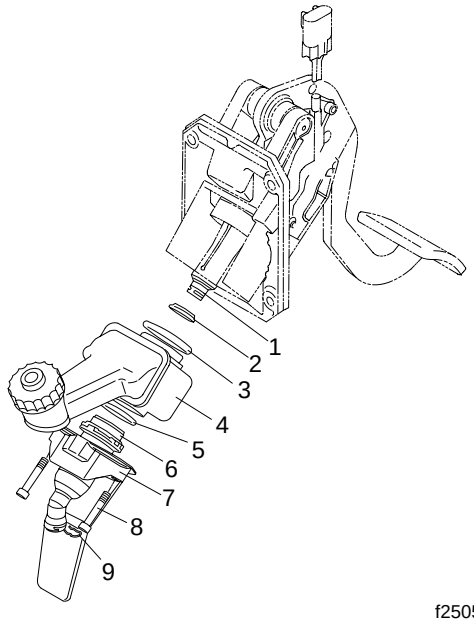
1. Hydraulic Hose
2. Quick-Disconnect Clip
3. Master Cylinder

Fig. 1, Quick-Disconnect Clip at the Master Cylinder

3. Drain the fluid from the master cylinder.
4. Remove the two screws that attach the hydraulic subassembly to the mounting plate. See **Fig. 2**.



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1. Piston
2. Lip Seal
3. Reservoir O-Ring
4. Reservoir
5. Body O-Ring
6. Hydraulic Body
7. Base
8. Screw
9. Clip

Fig. 2, Hydraulic Subassembly

5. Pull carefully on the hydraulic subassembly until it comes loose from the pedal unit. Discard the old hydraulic subassembly.
6. Carefully remove the lip seal from the piston of the master cylinder. Discard the lip seal.

NOTE: Avoid damaging the piston.

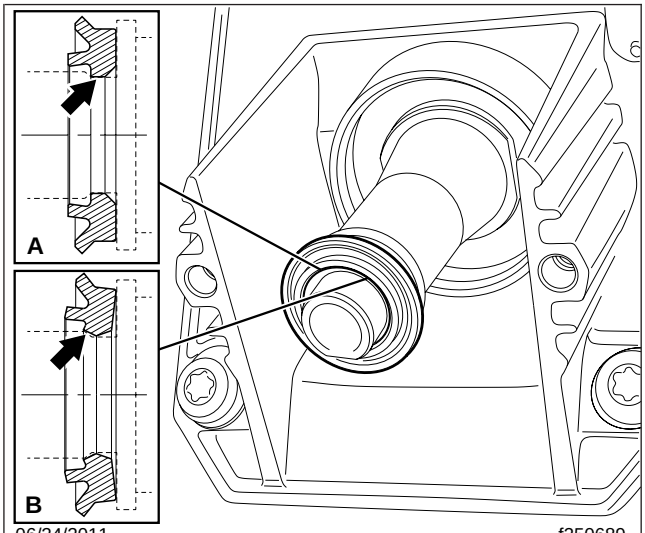
7. Lubricate a new lip seal and mount it on the piston. See **Fig. 3**.

NOTICE

Use only the special grease provided in the assembly kit. Do not use mineral oil or any other lubricant which could damage the seals and cause loss of clutch function.

8. Lubricate the new O-rings and the O-ring seats in the new reservoir and hydraulic body.
9. Put the reservoir and hydraulic body together with the O-rings properly seated and lubricated.

Hydraulic Subassembly Replacement



A. Correct Installation
B. Incorrect Installation

Fig. 3, Hydraulic Subassembly

10. While holding the reservoir and hydraulic body together, insert the base over the hydraulic body.
11. Install the screws, and tighten them to 44 lbf·in (500 N·cm).
12. Install the quick-disconnect clip and hydraulic hose, as follows.
    - 12.1 Insert the clip arms into the recessed areas on the nozzle of the master cylinder.
    - 12.2 Snap the hydraulic hose into place.
    - 12.3 Tug on the hose to make sure it is installed correctly. The hose should not pull out.

    IMPORTANT: Do not force the hose into the slave cylinder. If the clip is incorrectly installed, the hose will not snap into place.

⚠ WARNING

Use only approved clutch hydraulic fluid (DOT 4 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

13. Fill the reservoir with approved DOT 4 hydraulic brake fluid and bleed the system as instructed in **Subject 130**.
14. Check the function of the clutch actuation system as instructed in the *Cascadia™ Troubleshooting Manual*.

Replacement

⚠ WARNING

Clutch hydraulic fluid (DOT 4 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Using a flat-tip screwdriver, remove the quick-disconnect clip that attaches the hydraulic hose to the slave cylinder. See **Fig. 1**. Retain the clip for later installation.

⚠ WARNING

Do not depress the clutch pedal while the slave cylinder is removed from the clutch housing. The slave cylinder piston could be ejected, causing component damage or serious personal injury.

4. Drain the hydraulic fluid from the entire system.
5. Loosen the four slave cylinder mounting capscrews that attach the slave cylinder to the clutch housing.
6. After bracing the slave cylinder so that it does not fall, remove and save the four slave cylinder mounting capscrews.

IMPORTANT: Handle the slave cylinder carefully to prevent spillage.

IMPORTANT: Be sure to mount the slave cylinder with the bleed valve on top of the unit and horizontal to the ground, as shown in **Fig. 1**.

7. Mount a new slave cylinder on the clutch housing, as follows.
   - 7.1 Make sure that the pushrod is attached to the clutch fork and inserted into the pushrod bore in the slave cylinder.
   - 7.2 Push the slave cylinder against the clutch housing to compress the internal spring.
8. Install the four slave cylinder mounting capscrews and tighten them 13 lbf·ft (18 N·m).
9. Install the quick-disconnect clip and hydraulic hose, as follows.
   - 9.1 Insert the clip arms into the recessed areas on the nozzle of the master cylinder.
   - 9.2 Snap the hydraulic hose into place.
   - 9.3 Tug on the hose to make sure it is installed correctly. The hose should not pull out.

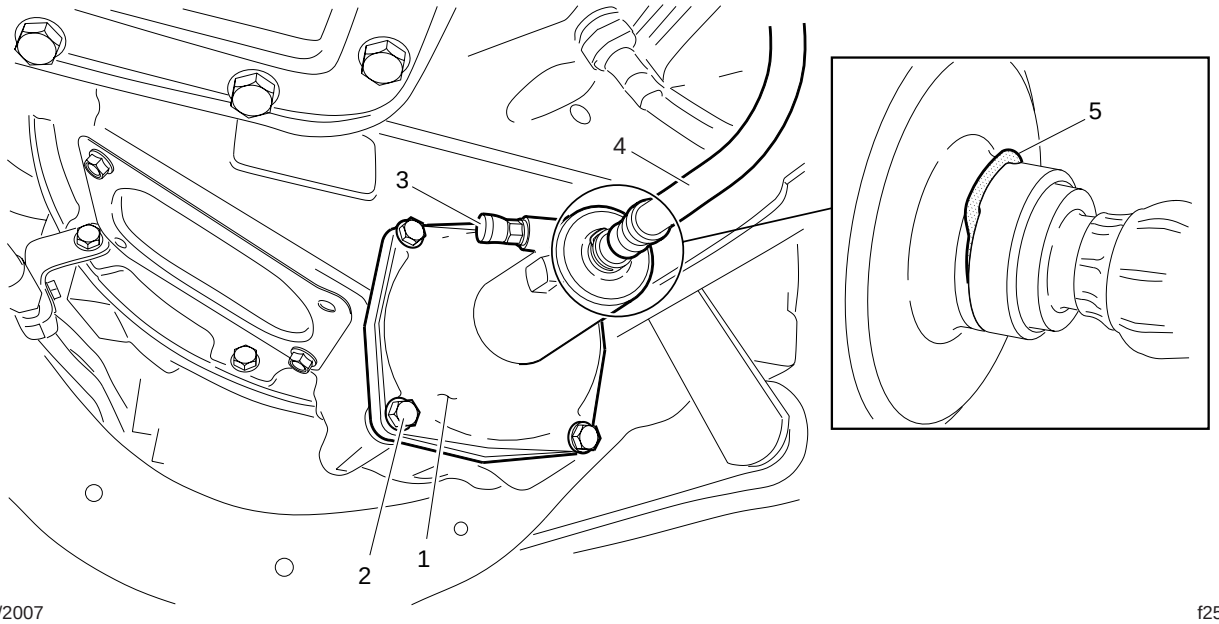
   IMPORTANT: Do not force the hose into the slave cylinder. If the clip is incorrectly installed, the hose will not snap into place.

⚠ WARNING

Use only approved clutch hydraulic fluid (DOT 4 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

10. Fill the reservoir with approved DOT 4 hydraulic brake fluid, and bleed the system as instructed in **Subject 130**.
11. Check the function of the clutch actuation system as instructed in the *Cascadia™ Troubleshooting Manual*.

Slave Cylinder Replacement



1. Slave Cylinder
2. Capscrew
3. Bleed Valve
4. Hydraulic Hose
5. Quick-Disconnect Clip

Fig. 1, Clutch Slave Cylinder

WARNING

Hydraulic clutch control fluid (DOT 4 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling it or bleeding hydraulic lines. If you get it on your skin, wash it off as soon as possible.

NOTICE

Do not spill hydraulic clutch control fluid on the cab paint. Clean it off immediately if any is spilled. Brake fluid can damage paint.

Filling

The hydraulic system holds approximately 0.5 quart (0.5 liter) of fluid. Use new DOT 4 brake fluid from a tightly sealed container to fill the system until the fluid level is between the MIN and MAX lines marked on the side of the reservoir. See **Fig. 1**.

Bleeding

IMPORTANT: The pressure line must slope continuously downward between the master and slave cylinders. On some vehicles, the securing clamps may need to be removed to achieve this and allow the air to be purged.

The hydraulic clutch control can be bled by using a pressure bleeder or manual bleeding. Pressure bleeding can be done by one person and manual bleeding requires two.

Pressure Bleeding

NOTE: A bleeder system (J-29532) and a bleed adaptor (J-35798) for the fluid reservoir are available through SPX Kent-Moore Tools and may be used to complete the following procedure. To order these parts, call Kent-Moore at 1-800-328-6657.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires and open the hood.
2. Prepare the pressure bleeding equipment according to the manufacturer's instructions. Use new DOT 4 brake fluid from a tightly sealed container. Pressurize the bleed adaptor to 15 psi (103 kPa).
3. Remove the reservoir lid, and install the pressure bleed adaptor on the reservoir. See **Fig. 1**.

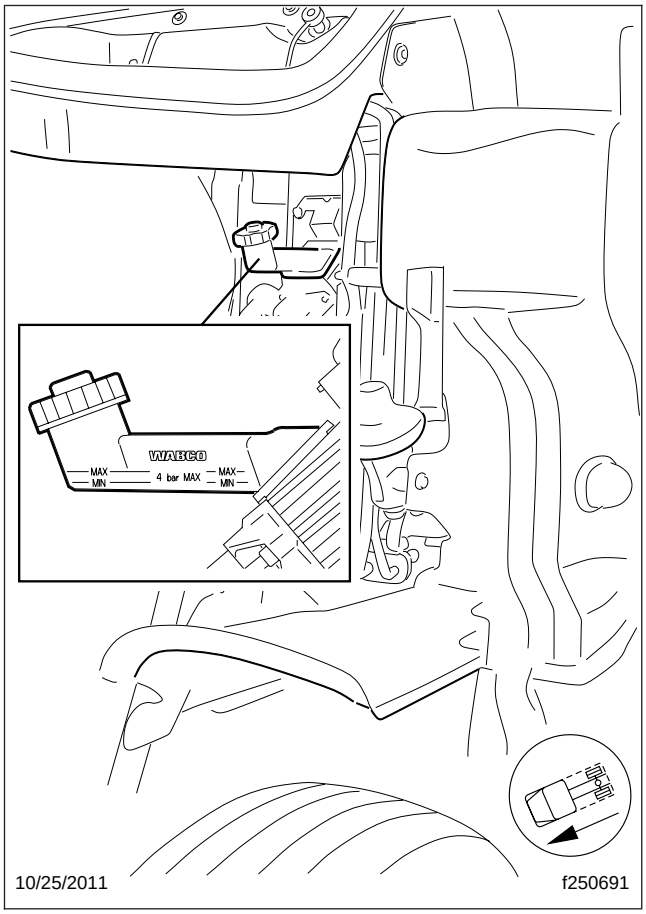
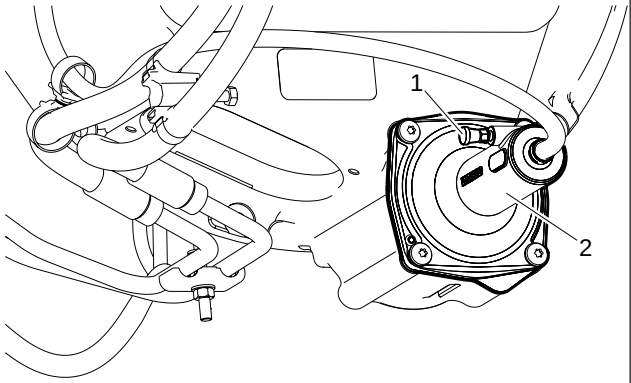


Fig. 1, Reservoir, Hydraulic Clutch Control

4. Bleed the hydraulic system, as follows.
   - 4.1 Open the bleed valve on the bleed tank to pressurize the reservoir.
   - 4.2 Remove the cap from the bleed valve of the slave cylinder. See **Fig. 2**. On the valve, install a transparent drain hose connected to a catch bottle. The hose needs to fit the bleed valve tight enough so it does not fall off when fluid is pumped out.
   - 4.3 Open the bleed valve on the slave cylinder.

Fluid Filling and Bleeding



1. Bleed Valve
2. Slave Cylinder

Fig. 2, Slave Cylinder, Hydraulic Clutch Control

4.4 When the draining fluid is clear and free of air bubbles, close the bleed valve.

5. Check the fluid level in the reservoir. If necessary, add or drain fluid to bring the fluid level to between the MIN and MAX lines marked on the side of the reservoir.
6. Install the reservoir lid.
7. Disconnect the transparent hose. Tighten the bleed valve 88 lbf·in (1000 N·cm) and install the cap on the slave cylinder bleed valve.
8. Depress the clutch pedal a few times. There should be resistance over the full pedal stroke.

Manual Bleeding

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires and open the hood.

NOTE: The hydraulic system holds approximately 0.5 quart (0.5 liter) of fluid. It may need to be refilled during the bleeding process to prevent air from re-entering the system.

2. Remove the reservoir lid and fill the reservoir (see **Fig. 1**) with new DOT 4 brake fluid from a tightly sealed container.
3. Remove the cap from the bleed valve of the slave cylinder. See **Fig. 2**. On the valve, install a transparent drain hose connected to a catch bottle. The hose needs to fit the bleed valve tight enough so it does not fall off when fluid is pumped out.

NOTE: The following steps require two people—one in the cab to work the clutch pedal, and one to open and close the bleed valve and watch the fluid.

4. Bleed the system, as follows.
   - 4.1 Open the bleed valve.
   - 4.2 Depress the clutch pedal until it stops.
   - 4.3 Close the bleed valve.
   - 4.4 Return the pedal to the upper position.
   - 4.5 Repeat the previous steps until the fluid is clear and free of air bubbles.
   - 4.6 Depress the clutch pedal. There should be resistance over the full pedal stroke.
5. Check the fluid level in the reservoir. If necessary, add or drain fluid to bring the fluid level to between the MIN and MAX lines marked on the side of the reservoir. Install the reservoir lid.
6. Disconnect the transparent hose. Tighten the bleed valve 88 lbf·in (1000 N·cm) and install the cap on the slave cylinder bleed valve.

Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.

⚠ WARNING

Clutch hydraulic fluid (DOT 4 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

3. Using a flat-tip screwdriver, remove the quick-disconnect clip that attaches the hydraulic hose to the slave cylinder. Retain the clip. See **Fig. 1**.
4. Drain the hydraulic fluid from the entire system.
5. At the quick-disconnect clip that attaches the hydraulic hose to the master cylinder, note the position of the clip for later installation, then remove it using a flat-tip screwdriver. See **Fig. 2**.
6. Route the new hydraulic hose between the slave cylinder and the master cylinder.
7. Install the quick-disconnect clip and hydraulic hose, as follows.

   7.1 Insert the clip arms into the recessed areas on the nozzle of the master cylinder.

   IMPORTANT: Do not force the hose into the slave cylinder. If the clip is incorrectly installed, the hose will not snap into place.

   7.2 Snap the hydraulic hose into place.

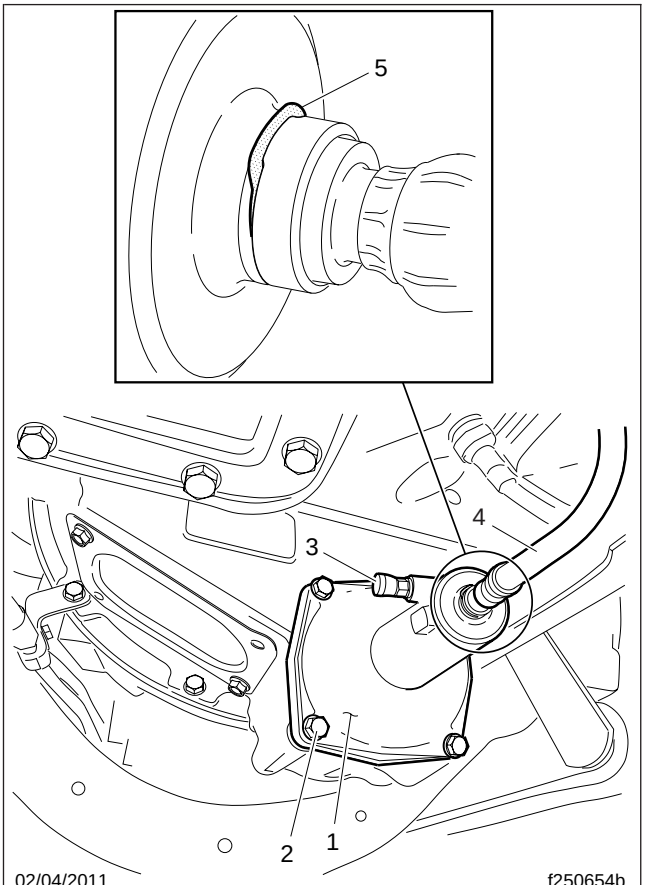
   7.3 Tug on the hose to make sure it is installed correctly. The hose should not pull out.

   7.4 Insert the clip at the slave cylinder, and install the hose as described above.

⚠ WARNING

Use only approved clutch hydraulic fluid (DOT 4 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

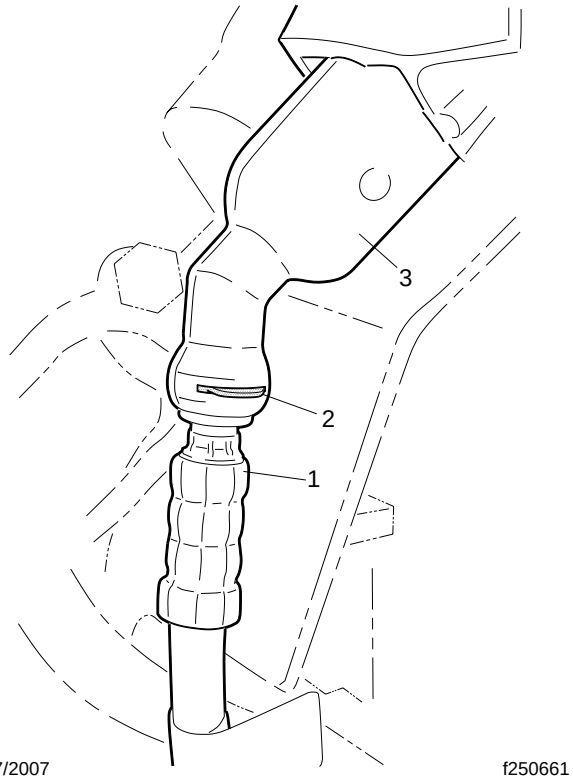
8. Fill the reservoir with approved DOT 4 hydraulic brake fluid and bleed the system as instructed in **Subject 130**.
9. Check the function of the clutch actuation system as instructed in the *Cascadia™ Troubleshooting Manual*.



1. Slave Cylinder
2. Capscrew
3. Bleed Valve
4. Hydraulic Hose
5. Quick-Disconnect Clip

Fig. 1, Clutch Slave Cylinder

Hydraulic Hose Replacement

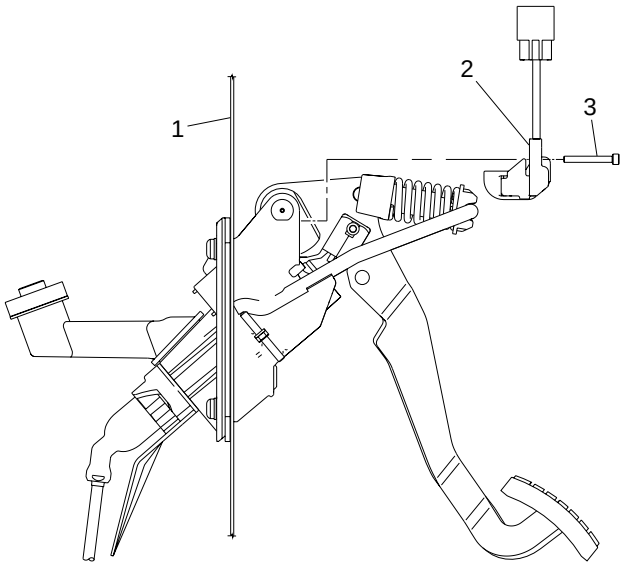


1. Hydraulic Hose
2. Quick-Disconnect Clip
3. Master Cylinder

Fig. 2, Quick-Disconnect Clip at the Master Cylinder

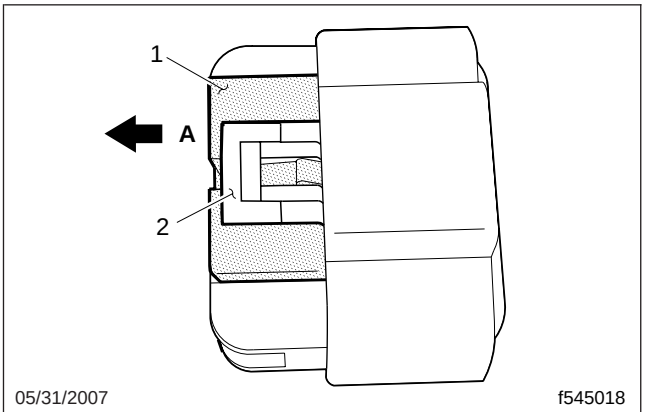
Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Remove the lower steering column cover.
4. Disconnect the clutch control switch located under the dash and above the clutch pedal, as follows. See **Fig. 1**.
   - 4.1 Retract the secondary lock. See **Fig. 2**.
   - 4.2 Depress the latch to unlock the switch connector, then separate the clutch control switch from the wire harness.
5. Remove the screw that holds the switch assembly to the pedal unit, and remove the switch.
6. Mount the new switch assembly on the connector and tighten the M5 screw 23 lbf·in (260 N·cm).
7. Check the function of the clutch actuation system as instructed in the *Cascadia™ Troubleshooting Manual*.
8. Install the lower steering column cover.



1. Frontwall
2. Clutch Control Switch
3. Screw

Fig. 1, Clutch Control Switch



A. Retract the secondary lock, then depress the latch to release the connector.

1. Secondary Lock
2. Latch

Fig. 2, Clutch Control Switch Connector

Specifications

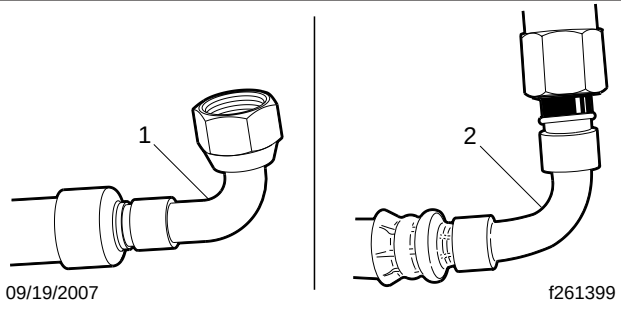
Description	Size	Grade/Class	Torque: lbf·ft (N·m)	Torque: lbf·in (N·cm)
Bleed Valve	M7	—	—	88 (1000)
Clutch Switch Mounting Screw	M5	—	—	23 (260)
Hydraulic Sub-Assembly Retainer	—	—	—	44 (500)
Pedal Unit Mounting Plate Capscrews	M8	8.8	13 (18)	—
Slave Cylinder Mounting Capscrews	M8	10.9	13 (18)	—
Standoff Bracket Mounting Capscrews	1/4–20	8	10 (14)	—

Table 1, 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, Subject 120**.
4. If needed, remove the aftertreatment device (ATD). For instructions, see **Section 49.00, Subject 100**.
5. Disconnect the transmission cooler lines from the transmission. On some transmissions, these lines are attached with quick-disconnect fittings (see **Fig. 1**) that must be removed using a special tool and a specific technique to prevent damage. See **Section 20.00, Subject 100** for the procedure.



1. JIC Fitting
2. Quick-Disconnect Fitting

Fig. 1, Transmission Cooler Line Fittings

6. Disconnect the driveline from the transmission output yoke. For instructions, see **Section 41.00**.
7. Disconnect the driveline midship bearing from the midship bearing bracket, and set the driveline out of the way. For instructions, see **Section 41.00**.
8. Disconnect the EquiFlo bracket from the top of the transmission.
9. Drain the air system if not already emptied.
10. Remove or disconnect the shift linkage, as follows.
    - 10.1 Remove the shift tower boot and air lines.
    - 10.2 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.
    - 10.3 Disconnect the electrical connectors from the top of the transmission.

WARNING

Do not depress the clutch pedal while the slave cylinder is removed from the clutch housing. The slave cylinder piston could be ejected, causing component damage or serious personal injury.

11. Remove the slave cylinder. For instructions, see **Section 25.01, Subject 120**.
12. 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.
13. Disconnect all air lines from the transmission, and mark those lines for reassembly. Plug all air lines, and cap all transmission air fittings.
14. 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.
15. Raise the transmission jack until it fits securely against the bottom of the transmission, then secure the transmission to the jack with a chain.
16. 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.

17. 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. 2**.

Manual Transmission Removal and Installation

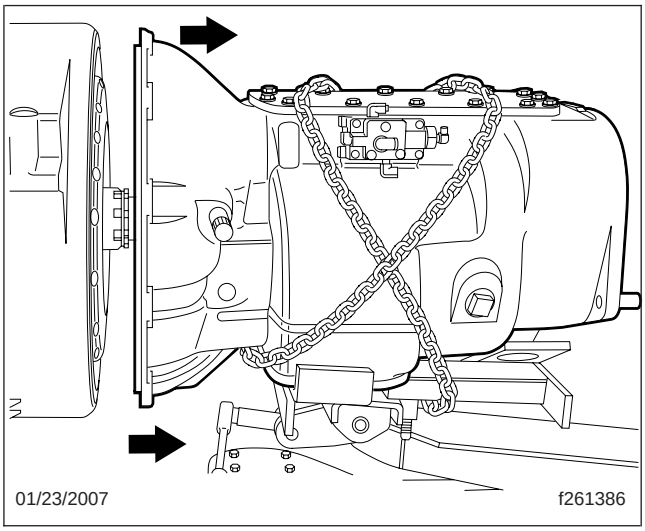


Fig. 2, Transmission Removal

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.

18. If needed, raise the front axle of the vehicle until you can remove the transmission by rolling it out behind the front tire.

Installation

1. If the clutch brake was removed, install the clutch brake on the transmission input shaft. See **Fig. 3**. Slide it tight against the input shaft bearing cap.

IMPORTANT: Torque-limiting clutch brakes are a one-piece assembly with a larger and a smaller face. When installing a torque-limiting clutch brake on an Eaton® Fuller® transmission, install the *smaller* face toward the transmission.

2. Check for wear on the fingers of the clutch release yoke, release shafts, and the release shaft bushings. Replace worn parts as necessary.
3. 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.
4. 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. 4**.

NOTE: If necessary, wipe the input shaft clean with a clean, dry cloth. It is not necessary to lubricate the input shaft.

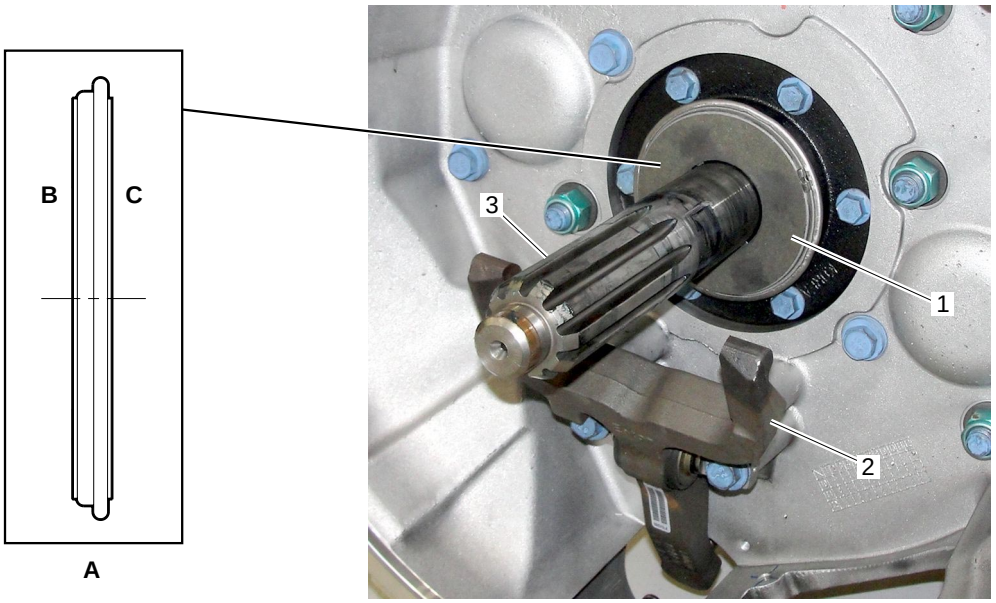
5. While making sure the flanges remain parallel, push the transmission and jack straight forward until the transmission input shaft begins to enter the clutch release bearing.
6. Rotate the top of the clutch release yoke forward, and rotate the release bearing until the flat portion is at the bottom. Roll the transmission slowly forward. Raise or lower the transmission as needed to maintain alignment. See **Fig. 4**.

IMPORTANT: Be sure that the release yoke clears the release bearing, and is rotated under the wear pads as the transmission is moved forward. See **Fig. 5**. Align the input shaft splines 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.

7. 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.
8. Remove the chain that secures the transmission to the jack, and remove the jack from under the vehicle.



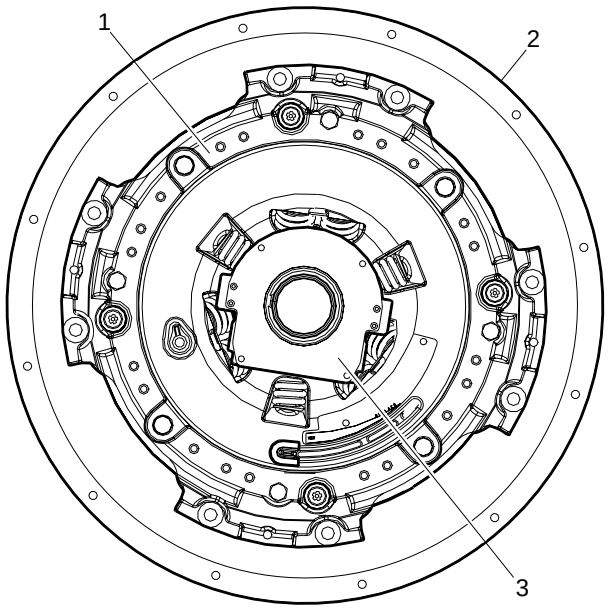
A. Clutch Brake (side view)
B. Install deep side toward the release bearing.
C. Install shallow side toward the transmission.

1. Clutch Brake
2. Release Yoke
3. Input Shaft

Fig. 3, Clutch Brake Installation

9. Install or connect the shift linkage, as follows.
   - 9.1 Install the shift tower inside the cab.
   - 9.2 Install the air lines and shift boot.
   - 9.3 Install the electrical connectors on the top of the transmission.
10. If removed, install the ATD. For instructions, see **Section 49.00, Subject 100**.
11. Connect the air lines and wiring to the transmission as previously marked.
12. Install the slave cylinder. For instructions, see **Section 25.00, Subject 120**.
13. Connect the driveline to the transmission output yoke. For instructions, see **Section 41.00**.
14. Connect the midship bearing to the midship bearing bracket. For instructions, see **Section 41.00**.
15. Connect the EquiFlo bracket to the top of the transmission. Open the fuel shut-off valves or fill the fuel tanks as applicable.
16. Connect the transmission cooler lines to the transmission. On some transmissions, these lines attach with quick-disconnect fittings that must be installed using a specific technique. See **Section 20.00, Subject 100** for the procedure.
17. Install the air reservoirs on the vehicle. For instructions, see **Section 42.06, Subject 120**.
18. Connect the batteries.
19. Grease the clutch release bearing and the release shafts. For instructions, see **Group 25** of the *Cascadia Maintenance Manual*.
20. Check the clutch for proper clutch brake operation. For instructions, refer to the *Cascadia Driver's Manual*.
21. Start the engine and run it until the air system pressurizes to at least 80 psi (550 kPa). Lower the hood, and remove the chocks from the tires.

Manual Transmission Removal and Installation



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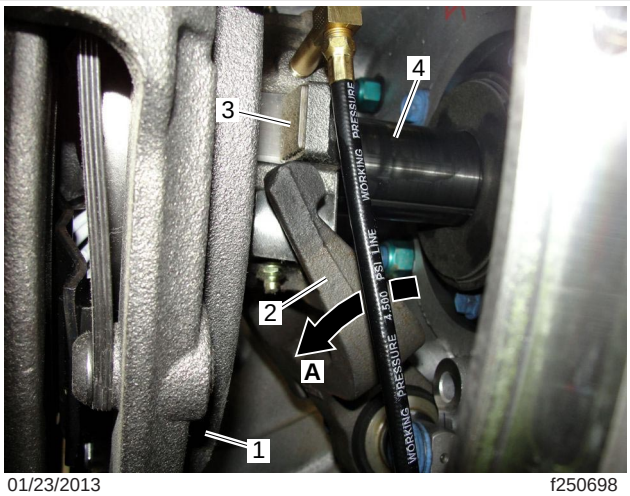
1. Clutch
2. Flywheel Housing
3. Release Bearing

Fig. 4, Aligning the Transmission and Release Bearing



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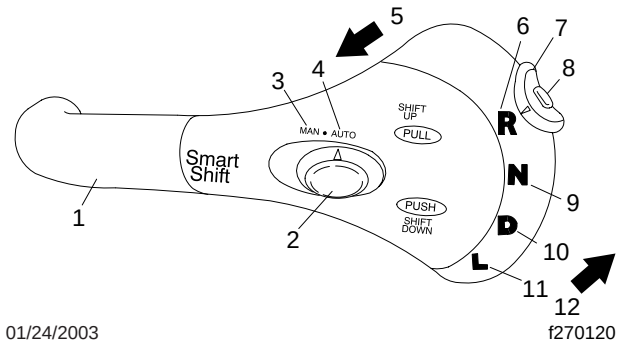
A. Rotate the yoke down to clear the release bearing.

1. Clutch
2. Release Yoke
3. Release Bearing Wear Pad
4. Input Shaft

Fig. 5, Release Yoke Clearing the Release Bearing

General Information

The SmartShift™ transmission shift control is an electronic transmission control device that is applicable to automated transmissions. It is included with the Eaton® Fuller® AutoShift™ and UltraShift® transmissions. It mounts to the right side of the steering column and is operated by the driver's right hand. See **Fig. 1**.



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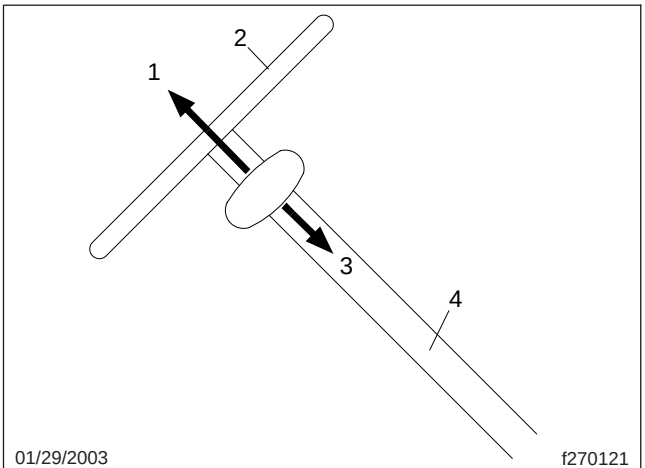
To upshift manually, pull the control up (towards you). To downshift manually, push the control down (away from you).

1. SmartShift Control
2. Slide Switch (forward driving mode switch)
3. MAN Position (on slide switch)
4. AUTO Position (on slide switch)
5. Upshift Direction
6. Reverse Position (on selector switch)
7. Selector Switch
8. Safety Release
9. Neutral Position (on selector switch)
10. Drive Position (on selector switch)
11. Low Position (on selector switch)
12. Downshift Direction

Fig. 1, SmartShift Control

A slide switch on the SmartShift allows the driver to choose between automatic and manual forward driving modes. In automatic drive mode, forward drive gears are shifted automatically, without driver interaction. In manual mode the driver has direct control over gear shifts.

Manual gear shifts are accomplished by a momentary pull or push on the control. Pull upward (toward you) on the control to upshift, and push downward (away from you) to downshift. See **Fig. 2**. The control is spring-loaded and returns to mid-position when released after an upshift or downshift. All shifts into reverse (R) are done manually.



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1. Upshift (in manual mode, pull upward)
2. Steering Wheel
3. Downshift (in manual mode, push downward)
4. Steering Column

Fig. 2, SmartShift Control Operation

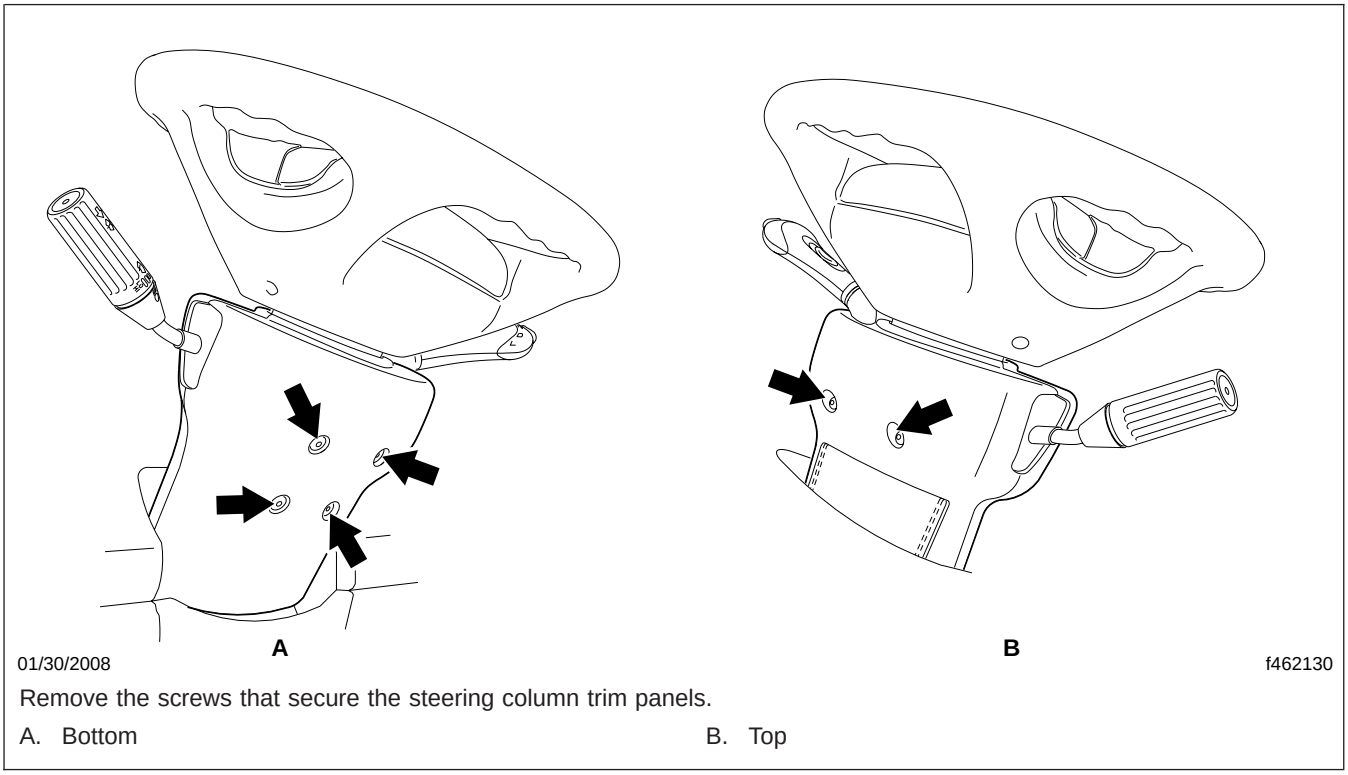
The selector switch is located at the end of the control and has four positions (R, N, D, L). See **Fig. 1**. It has a small yellow "safety release" button which must be pressed to move the switch.

IMPORTANT: The safety release prevents accidental movement of the switch.

SmartShift accepts driver requests for transmission functions and transmits them through hard wiring to the transmission control unit (TCU). It offers two main advantages over conventional transmission control devices. Usable cab space is increased and sleeper access is improved by removing the shift lever from the floor. Because of the steering column mounting, the transmission control is within fingertip reach of the steering wheel, which enhances safety.

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the six screws that secure the steering column panels (see **Fig. 1**), then separate the upper and lower panels to access the shift control unit.



Remove the screws that secure the steering column trim panels.

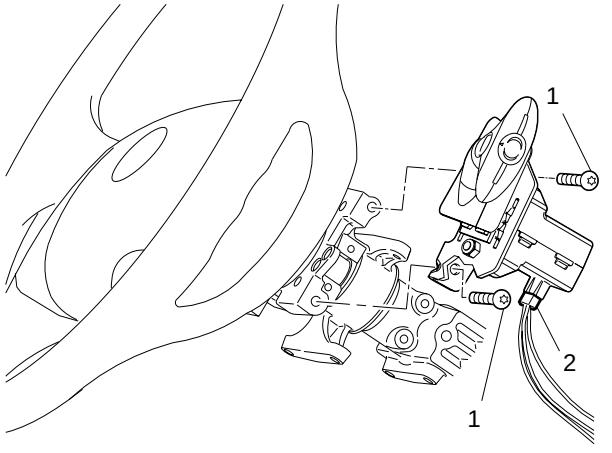
A. Bottom

B. Top

Fig. 1, Steering Column Screws

3. Disconnect the electrical connector from the lever. See **Fig. 2**.
4. Remove the two screws that secure the SmartShift bracket to the column.
5. Remove the SmartShift.
6. Position the new SmartShift, and secure it using the screws previously removed. See **Fig. 2**.
7. Connect the electrical connector to the SmartShift.
8. Using the screws previously removed, fasten the upper and lower column panels.
9. Remove the chocks from the tires.

Shift Control Lever Replacement



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1. Screw
2. Electrical Connector

Fig. 2, SmartShift Lever Replacement

Safety Precautions

When working with a Detroit Transmission, observe the following:

⚠ WARNING

To avoid injury, do not install a PTO that is not Detroit Diesel approved onto a Detroit Transmission. Use of a non-Detroit Diesel approved PTO with a Detroit Transmission could result in unintended operation which could lead to severe personal injury.

Special Tools

A special tool is required for this procedure. See **Table 1**.

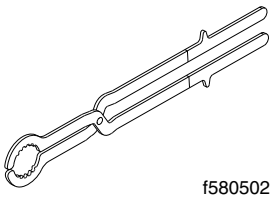
Special Tool for Transmission Installation			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580502	Input Shaft Pliers	Daimler	DDE W715 589 01 37 00

Table 1, Special Tool for Transmission Installation

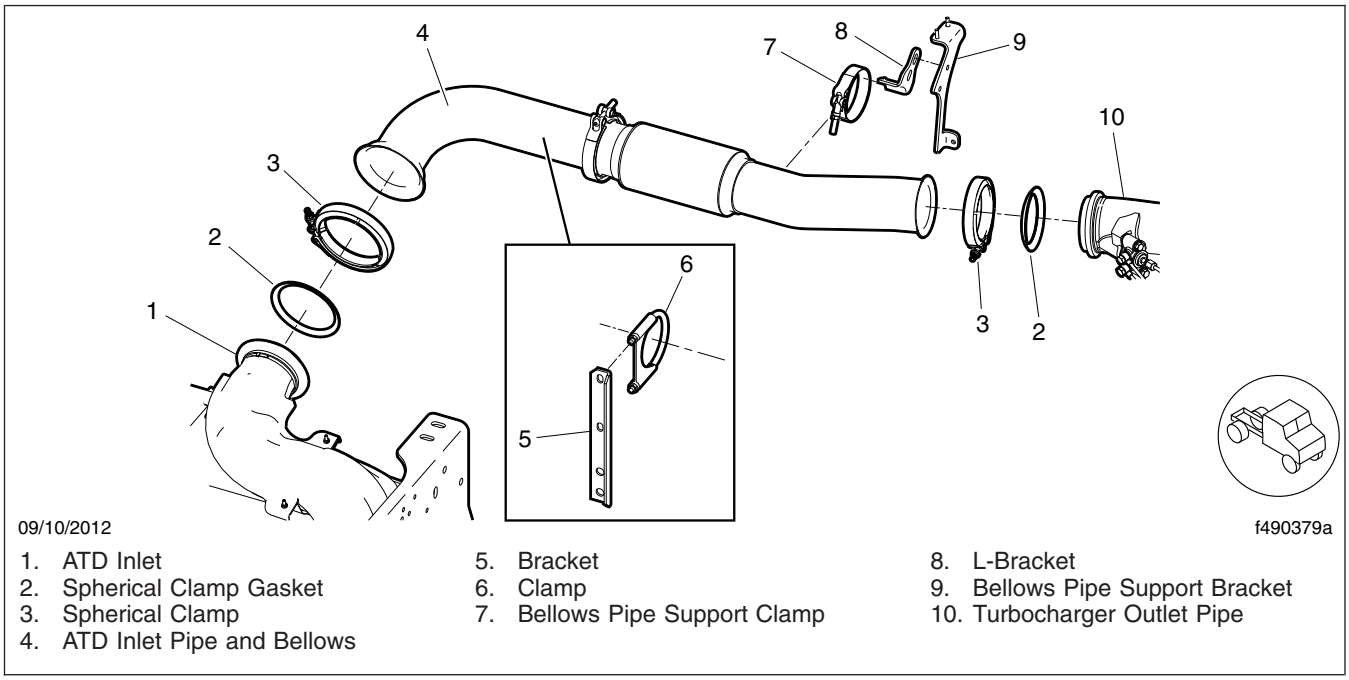
Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the batteries at the negative post, including the batteries for the auxiliary HVAC, if equipped.
3. Remove the ATD outlet/tail pipe, if it is routed inboard of the frame rail.
4. Remove the right-hand side-fairing panels. See **Section 31.07**.
5. Remove the right-hand cab-mounted splash shield. See **Section 88.01, Subject 100**.
6. Remove the one-box understep ATD. See **Section 49.01, Subject 110**.
7. Remove the ATD inlet pipe and bellows in one piece. See **Fig. 1**.
8. Drop the front of the driveline. See **Section 41.00**.
9. Remove any fuel and coolant line brackets and fasteners attached to the top of the transmission.
10. On the bottom of the transmission, remove the battery cable and the oil cooler line fasteners (if applicable).
11. Disconnect the oil cooler lines, if so equipped.
12. Disconnect the chassis harness connector from the transmission control module (TCM). See **Fig. 2**.
13. Drain the main air system and the isolated transmission reserve air tank. See **Fig. 3**.
14. While using a wrench to hold the air pressure adapter fitting, disconnect the air supply from the shift controller.
15. Raise a transmission jack against the bottom of the transmission, then secure the transmission to the jack with a chain.
16. Remove the flywheel-housing-to-clutch-housing fasteners. 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.

Installation

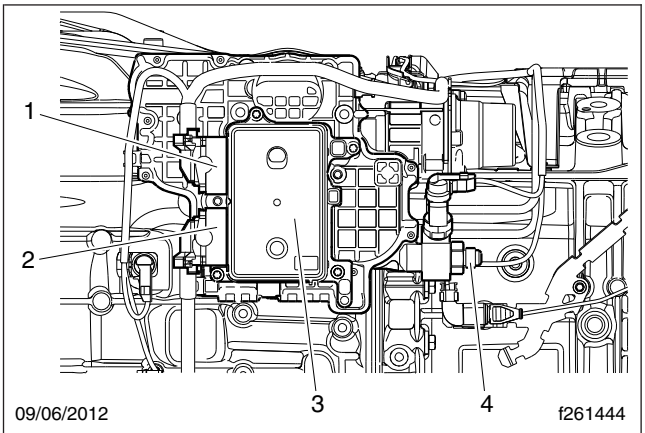
1. Ensure that the clutch actuator (CPCA) is fully collapsed before mating the transmission to the engine. If not, collapse the CPCA by hand. See **Fig. 4**.
2. Raise the transmission up. Using input shaft pliers (**Table 1**), align the splines with the clutch, then fit the transmission to the flywheel housing. See **Fig. 5**.
3. Install the flywheel-housing-to-clutch-housing fasteners, and using a star pattern, tighten them finger-tight. Then, using the same star pattern,

Transmission Removal and Installation



1. ATD Inlet
2. Spherical Clamp Gasket
3. Spherical Clamp
4. ATD Inlet Pipe and Bellows
5. Bracket
6. Clamp
7. Bellows Pipe Support Clamp
8. L-Bracket
9. Bellows Pipe Support Bracket
10. Turbocharger Outlet Pipe

Fig. 1, ATD Inlet Pipe and Bellows Installation



1. Transmission Harness Connector
2. Chassis Harness Connector
3. Transmission Control Module (TCM)
4. Air Supply Connector

Fig. 2, TCM and Shift Controller Connectors

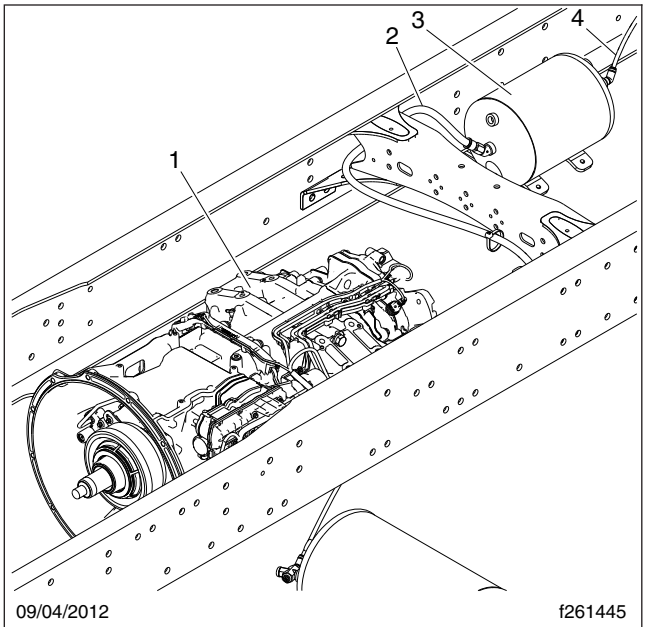
tighten the capscrews 45 to 53 lbf·ft (61 to 72 N·m), and the threaded stud 35 to 45 lbf·ft (47 to 61 N·m). See **Fig. 6**.

4. Remove the jack from under the vehicle.
5. Connect the chassis wire harness to the TCM. See **Fig. 2**.

NOTICE

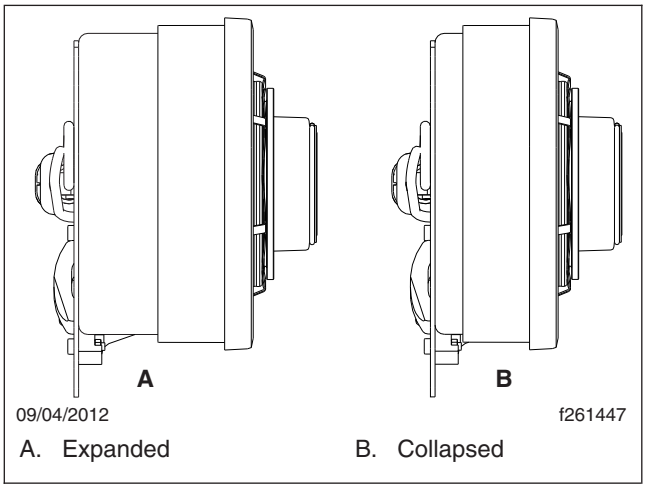
To prevent damage to the shift controller, use a back-up wrench to support the air pressure adapter fitting.

6. Attach the air supply connection to the shift controller. Tighten the connection 43 to 47 lbf·ft (58 to 64 N·m).
7. If applicable, attach the battery cable and the oil cooler line fasteners to the bottom of the transmission.
8. Attach any brackets to the top of the transmission.
9. Connect the driveline to the transmission output yoke. See **Section 41.00**.
10. Clean the gasket material from all the exhaust connection surfaces, being sure not to drop any material in the ATD or piping.
11. Install a new exhaust tube gasket, then loosely install the ATD inlet pipe and bellows.



1. Transmission
2. Air Supply to Transmission
3. Transmission Reserve Air Tank
4. Air Supply to Reserve Air Tank

Fig. 3, Isolated Transmission Reserve Air Tank (typical installation)



A. Expanded B. Collapsed

Fig. 4, CPCA Expanded and Collapsed Positions

12. Install the one-box understep ATD. See **Section 49.01, Subject 110**.
13. Confirm that the ATD inlet pipe and bellows are seated properly, then tighten the clamps 115 to 125 lbf·in (1300 to 1400 N·cm) and the support bracket fasteners 14 to 16 lbf·ft (19 to 22 N·m).
14. Install the right-hand cab-mounted splash shield. See **Section 88.01, Subject 100**.
15. Install the right-hand side-fairing panels. See **Section 31.07**.

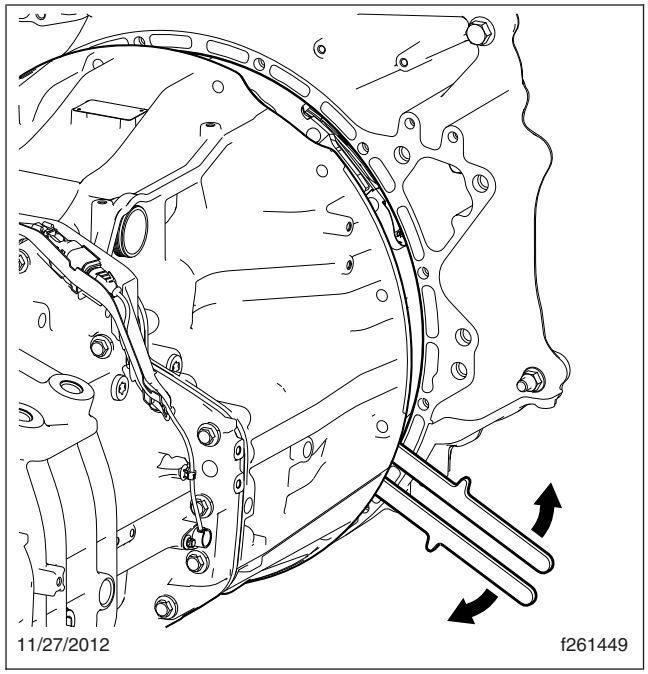


Fig. 5, Aligning the Input Shaft Splines with the Clutch

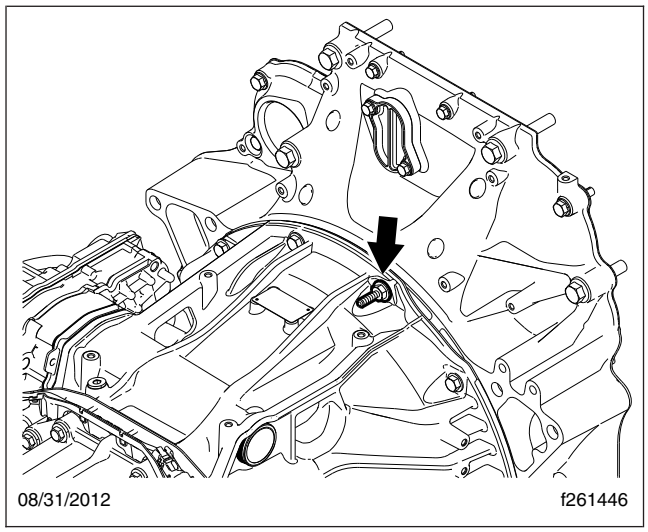


Fig. 6, Threaded Stud Location

16. If applicable, install the ATD outlet piping,

NOTICE

Detroit transmissions use synthetic lubricant that meets the requirements of the MB 235.11 specification, such as Detroit Synth 75W-90. Using lubricant that does not comply with this specification will result in damage to the transmission. The oil part number can be found in module 348 in PartsPro.

17. Add transmission fluid; for instructions, see the *Cascadia Maintenance Manual*.
18. Connect all the batteries.
19. Start the engine, and charge the air system.
20. Shut down the engine.
21. Using the DDDL software interface, perform the "transmission learn" steps.

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.01**.

Torque Specifications				
Fastener Description	**lbf·ft**	**N·m**	**lbf·in**	**N·cm**
Flywheel-Housing-to-Clutch-Housing Capscrews	45–53	61–72	—	—
Flywheel-Housing Threaded-Stud Nut	35–45	47–61	—	—
Air Supply Connection	43–47	58–64	—	—
ATD Inlet Pipe and Bellows Clamps	—	—	115–125	1300–1400
ATD Inlet Pipe Bracket Fasteners	14–16	19–22	—	—

Table 1, Torque Specifications

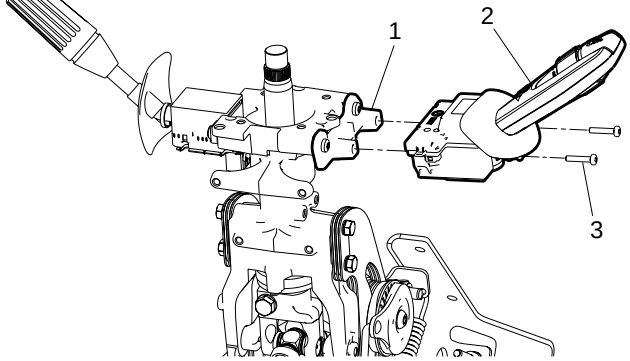
Shift Control Lever Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the batteries at the negative post, including the batteries for the auxiliary HVAC, if equipped.
3. Remove the upper and lower cover panels from the steering column. See **Fig. 1**.
4. Remove the fasteners that attach the shift control lever to the column adapter. See **Fig. 2**.
5. Disconnect the shift control lever from the wiring harness.

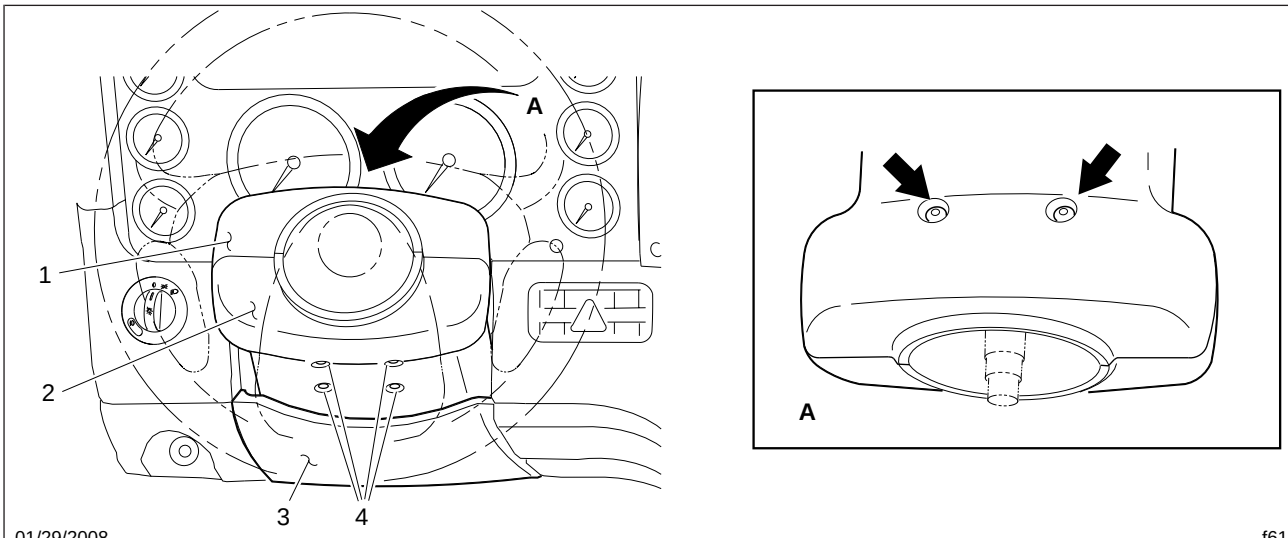
Installation

1. Connect the shift control lever to the wiring harness.
2. Install the shift control lever on the column adapter. Tighten the screws 590 to 740 lbf·in (800 to 1000 N·cm). See **Fig. 2**.
3. Install the upper and lower cover panels on the steering column. See **Fig. 1**.



1. Column Adapter
2. Shift Lever
3. Screw

Fig. 2, Shift Control Lever Installation



A. Upper Cover Fasteners

1. Upper Cover
2. Lower Cover
3. Bolster Panel
4. Bolster Panel Fasteners

Fig. 1, Steering Column Cover Panels

Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.01**.

Torque Specifications		
Fastener Description	**lbf·in**	**N·cm**
Shift Lever Mounting Screws	590–740	800–1000

Table 1, Torque Specifications

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.

NOTE: Never remove the pedal position sensor from the pedal assembly. The sensor is not serviceable or replaceable. The pedal assembly uses 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:

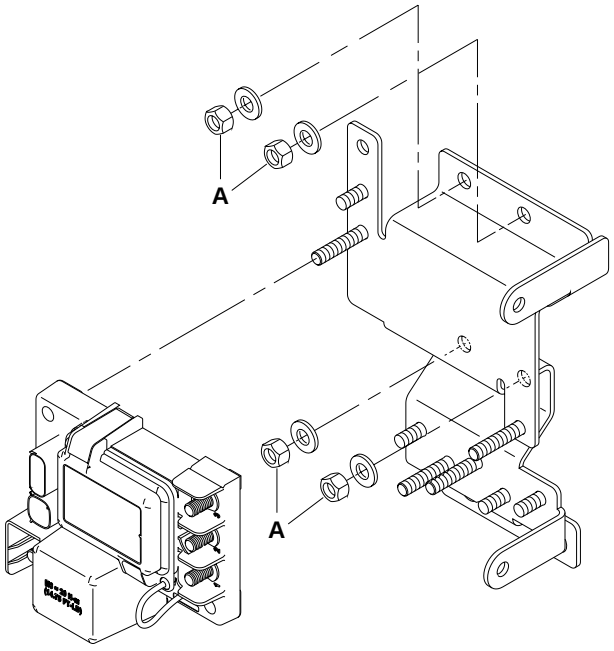
- A ratiometric sensor that generates a DC voltage output in proportion to the pedal position. The ratiometric sensor is used on Detroit Diesel and Mercedes-Benz engines.
- A pulse-width-modulating (PWM) sensor that generates a series of discrete voltage pulses. The width of the pulses is proportional 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 pedal assembly must be replaced.

Accelerator Pedal Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. On EPA10 vehicles, remove the powernet distribution box (PNDB) from the frontwall. Refer to **Section 54.11, Subject 130** in this manual for instructions.
4. On EPA10 vehicles, remove the four nuts and washers that secure the PNDB mounting bracket to the frontwall. See **Fig. 1**. Remove the mounting bracket to gain access to the accelerator mounting bolts.



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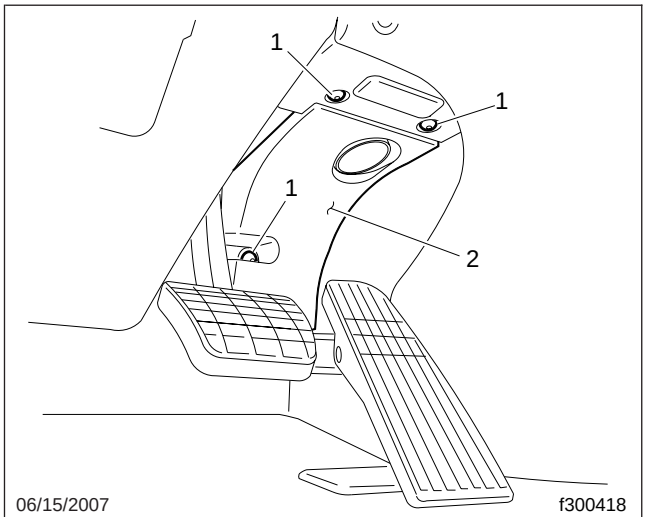
A. The four mounting nuts and washers that secure the mounting bracket to the frontwall are located behind the PNDB.

Fig. 1, PNDB Mounting Assembly

5. Remove the three fasteners that secure the dash pedal cover and remove the cover. See **Fig. 2**.
6. Disconnect the pedal position sensor wiring harness.
7. Remove the four fasteners that secure the accelerator pedal assembly to the frontwall. See **Fig. 3**.



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1. Fasteners (3 qty.) 2. Dash Pedal Cover

Fig. 2, Dash Pedal Cover Fasteners

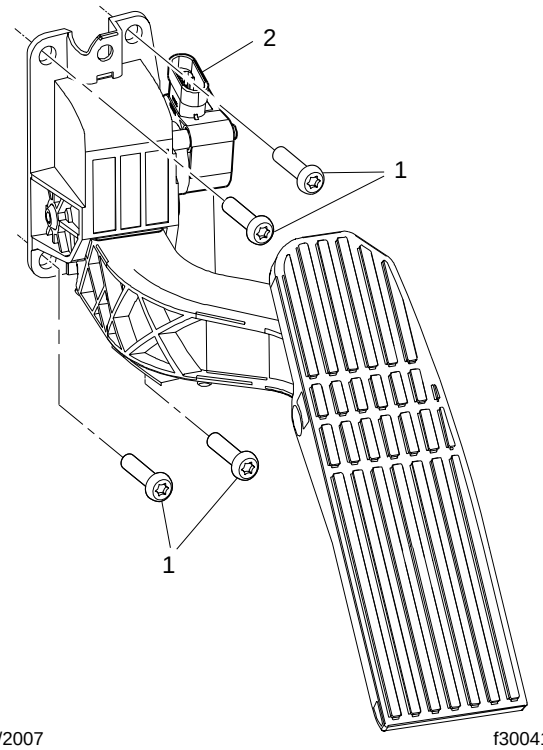
8. Remove the pedal assembly.
9. Remove the U-type spring nut from the pedal assembly for use on the new pedal assembly, if equipped.

Installation

1. Install the U-type spring nut on the pedal assembly, if equipped.
2. Align the accelerator pedal assembly with the mounting holes on the inside of the frontwall.
3. Install the pedal assembly mounting fasteners and tighten them 7 to 10 lbf·ft (9 to 14 N·m).
4. Connect the pedal position sensor wiring harness.
5. Install the dash pedal cover and tighten the fasteners 26 to 34 lbf·in (290 to 380 N·cm).
6. On EPA10 vehicles, position the mouting bracket on the frontwall and install the four washers and nuts. Tighten the nuts 7 to 10 lbf·ft (9 to 14 N·m).
7. Install the PNDB. Refer to **Section 54.11, Subject 130** in this manual for instructions.
8. 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 insu-

Accelerator Pedal Removal and Installation



1. Fastener (4 qty.)
2. Pedal Position Sensor

Fig. 3, Accelerator Pedal Assembly

lation. 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.

9. Connect the batteries.
10. 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

General Description

IMPORTANT: This manual *does not cover* the procedures and calculations necessary to do frame modifications. Before doing any modification to the frame rails, consult your regional service representative.

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 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**.

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 **Subject 130**, for crossmember replacement.

Frame Stations

A frame station is a reference point from which the location of each component mounted on the frame rail is measured. There are two frame stations: station zero; and station 2540.

Station zero is located 13.19 inches (335 mm) forward of the most forward edge of the frame rail. See **Fig. 3**.

Station 2540 is located 100 inches (2540 mm) to the rear of station zero. Station 2540 is used when station zero is not accessible because of vehicle assembly. Station 2540 is identified by three vertical center-punch marks on the frame rail web. In some cases, however, these marks may be obscured by a vehicle component.

The vehicle's frame drilling chart lists the location of each frame rail component. For example, if a component is given a location of 3000, then that component is installed on the frame rail 118-1/8 inches (3000 mm) aft of station zero, and 18-1/8 inches (460 mm) aft of station 2540.

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.

Welding Precautions

WARNING

Improper welding technique may fatigue the frame and lead to structural failure and serious personal injury. The frame rails are made of heat treated steel. Only experienced, qualified persons using proper equipment should attempt welding the frame rails.

WARNING

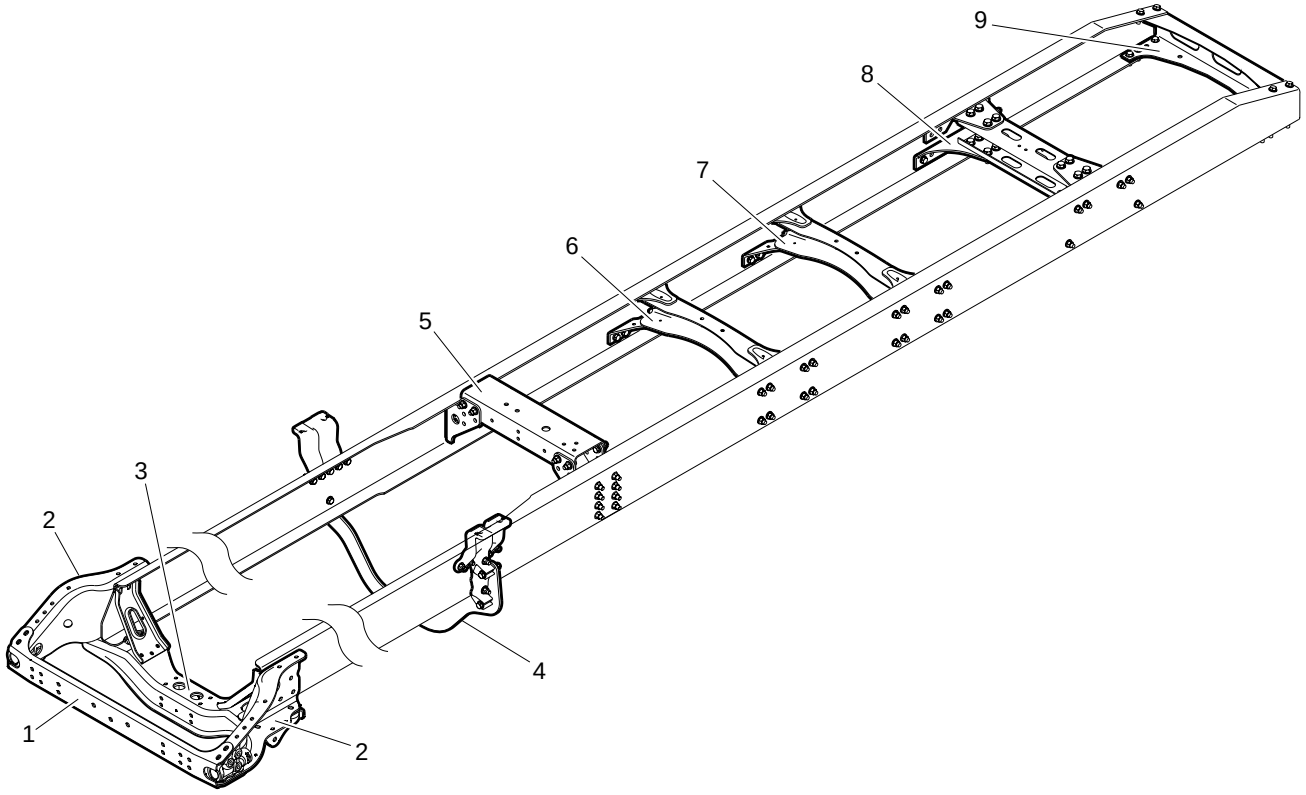
Wear protective welding masks and gloves when welding. Failure to do so could result in personal injury, due to the intensity of heat, sparks, and flying debris.

NOTICE

The vehicle is equipped with electronic control units. Serious damage to ECUs and components may result when welding unless the following precautions are taken.

- Never allow an electronic component to be situated between the ground electrode and the weld site.

General Information



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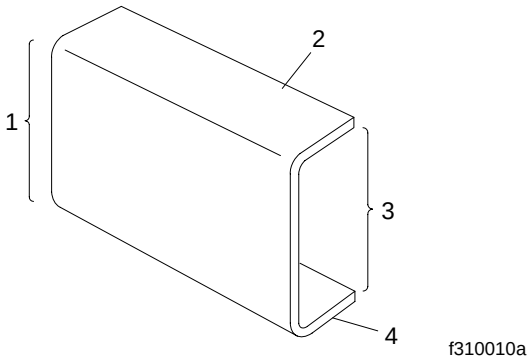
1. Front Closing Crossmember—Module 550
2. Front Frame Bracket—Module 550
3. Engine Crossmember—Module 550
4. Underslung Crossmember—Module 560
5. Back-of-Transmission Crossmember—Module 561
6. Midship Crossmember—Module 562, 563, and 564
7. Forward-Rear Suspension Crossmember (when shared with suspension bracket)—Module 565
8. Rearmost-Rear Suspension Crossmember—Module 565
9. Rear-Closing Crossmember—Module 572

Fig. 1, Frame Assembly and Crossmembers

- Never lay welding cables on, near, or across any electronic component or wiring.
- Protect electronic components and wiring near the weld site from heat and splatter.
- Disconnect the battery power and ground cables.

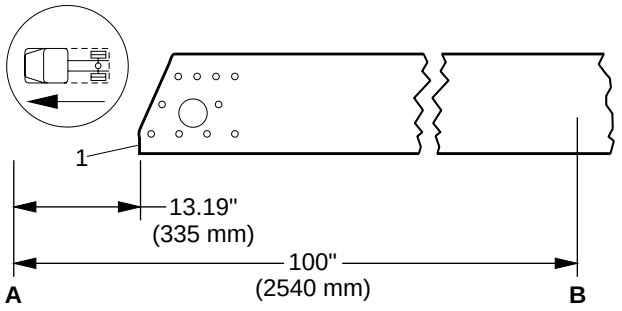
Before welding, prepare the vehicle as follows.

1. Park the vehicle, shut down the engine, and set the parking brake. Chock the front and rear tires.
2. Disconnect the battery negative cables first, then the positive cables. Take precautions to prevent them from making connection with the frame or any other electrically conductive surface.
3. If a supplemental restraint system (SRS) is installed, disconnect it.
4. Disconnect all wiring from electronic control modules near the weld site.
5. Attach the ground electrode as close as possible to the weld site (within 18 inches).
6. Remove paint, rust, and grease to provide a clean, bare metal connection for the ground electrode. When welding work is completed, apply touch-up paint to protect the frame rail.



1. Web
2. Upper Flange
3. Channel
4. Lower Flange

Fig. 2, Frame Terminology



A. Station Zero (0.00)
B. Station 2540

1. Front Edge of Frame Rail

Fig. 3, Frame Rail Stations

Repairing Frame Rail Cracks, Filling Unused Holes, and Drilling Holes

Repairing Cracks

IMPORTANT: Freightliner Trucks 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.

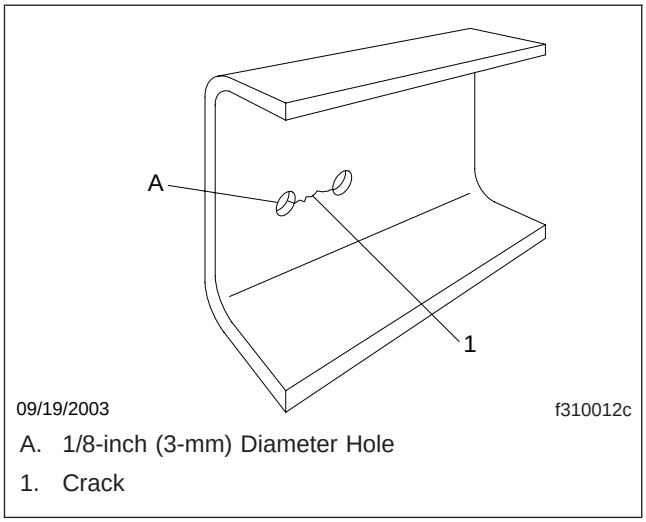
Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

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**.

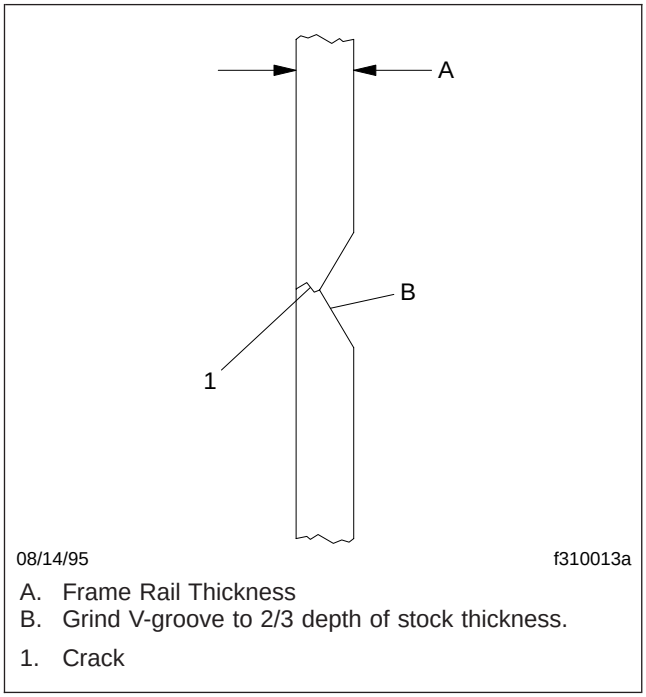
NOTE: The crack repair includes grinding a groove on each side of the frame rail. If it is not possible to grind both sides of the rail, then grind the groove on one side to the full depth of the stock thickness. See **Fig. 3**.

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

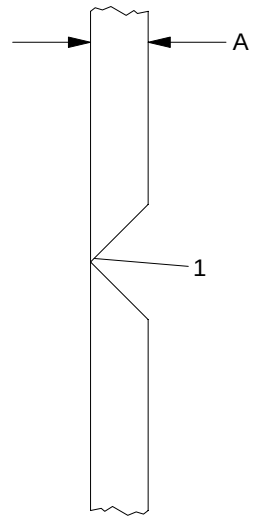


A. Frame Rail Thickness
B. Grind V-groove to 2/3 depth of stock thickness.
1. Crack

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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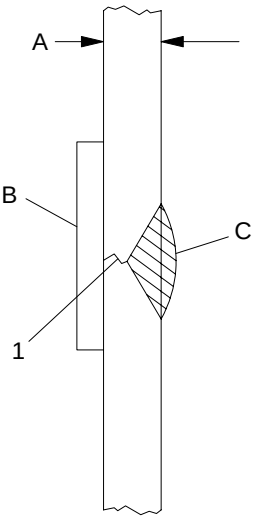
A. Frame Rail Thickness

1. V-Groove (Full Depth)

Fig. 3, Full-Depth Groove



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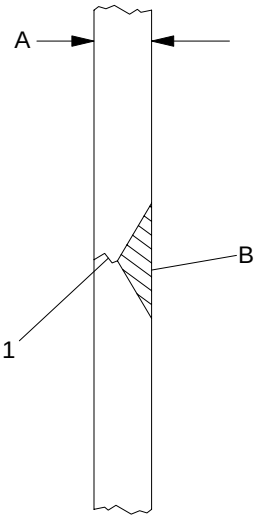
A. Frame Rail Thickness
B. Clamp the "chill" strip on opposite side of groove.
C. Deposit weld material.

1. Crack

Fig. 4, Using a Chill Strip



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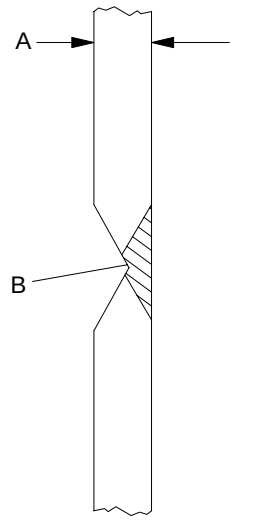
A. Frame Rail Thickness
B. Grind weld flush with frame rail.

1. Crack

Fig. 5, Weld Ground Flush



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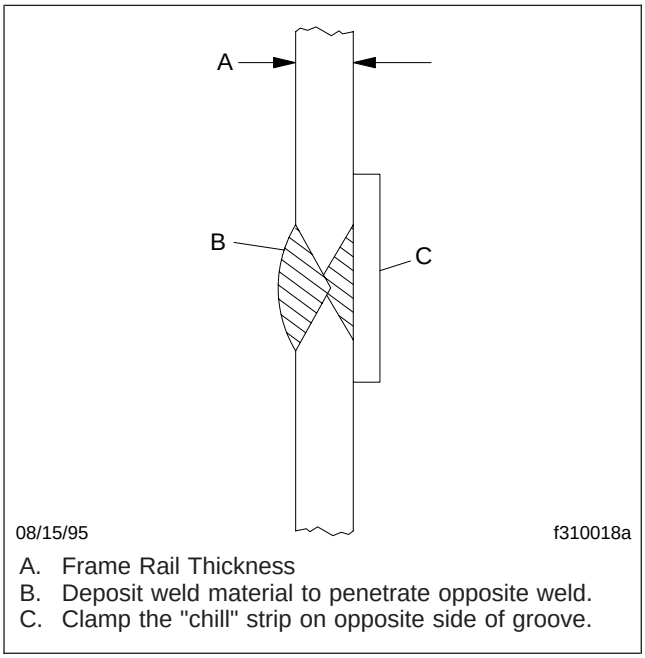
A. Frame Rail Thickness
B. Grind V-groove deep enough to reach weld.

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.

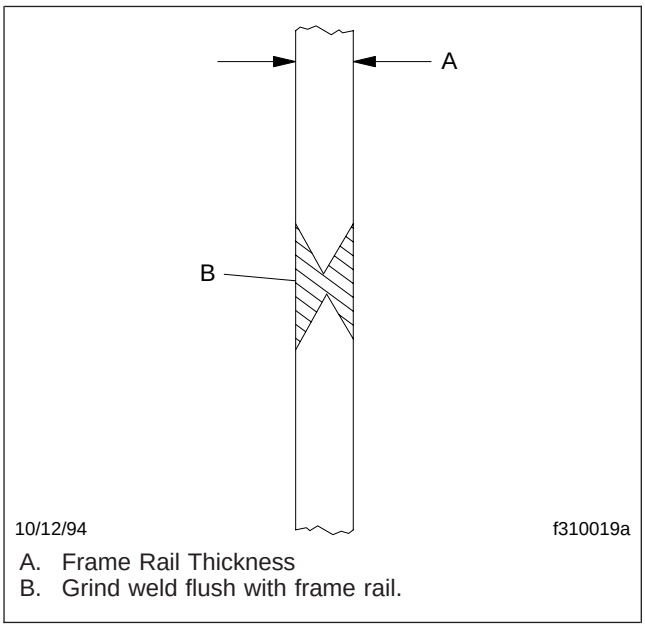
Repairing Frame Rail Cracks, Filling Unused Holes, and Drilling Holes

8. Grind the weld flush with the frame rail. See **Fig. 8**.



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



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**.

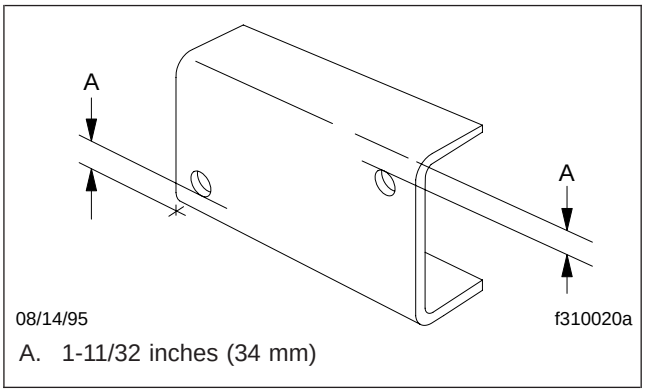
Drilling Holes

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 frame structure—including front frame bracket—and the rearmost suspension bracket 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

WARNING

Improper welding technique may fatigue the frame and lead to structural failure and serious personal injury. The frame rails are made of heat treated steel. Only experienced, qualified persons using proper equipment should attempt welding the frame rails.

CAUTION

The vehicle is equipped with electronic control units. Serious damage to ECUs and components may result when welding unless the following precautions are taken.

- **Never allow an electronic component to be situated between the ground electrode and the weld site.**
- **Never lay welding cables on, near, or across any electronic component or wiring.**
- **Protect electronic components and wiring near the weld site from heat and splatter.**

1. Park the vehicle, shut down the engine, and set the parking brake. Chock the front and rear tires.
2. From the batteries, disconnect all negative cables first, then the positive cables, and prevent them from making connection with the frame or any other electrically conductive surface.
3. If a supplemental restraint system (SRS) is installed, disconnect it.
4. Disconnect all wiring from electronic control modules near the weld site, including any installed by the customer.
5. Attach the ground electrode as close as possible to the weld site (within 18").
6. Remove paint, rust, and grease to provide a clean, bare metal connection for the ground electrode. When welding work is completed, apply touch-up paint to protect the frame rail.

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.

Welding Frame Rails

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 **Subject 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 **Subject 400**.

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.

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

The vehicle is equipped with electronic control units. Serious damage to ECUs and components may result when welding unless the following precautions are taken.

- **Never allow an electronic component to be situated between the ground electrode and the weld site.**
- **Never lay welding cables on, near, or across any electronic component or wiring.**
- **Protect electronic components and wiring near the weld site from heat and splatter.**

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 (1.6- 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.

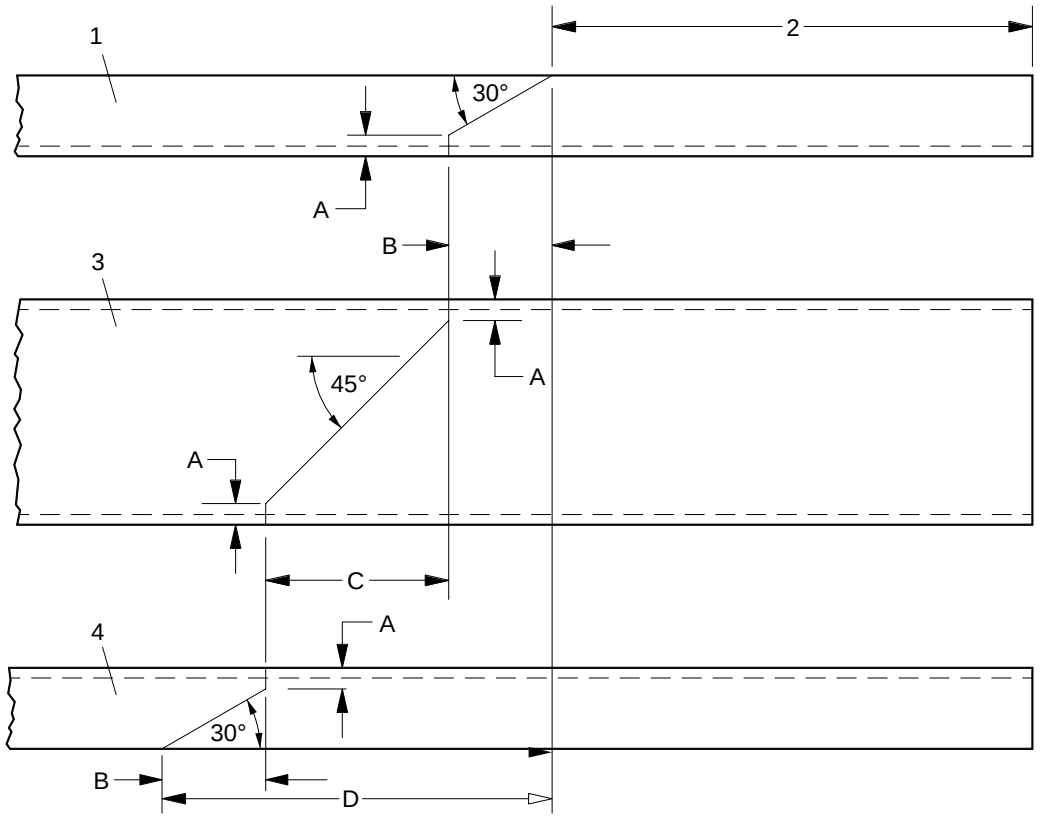
   Remove any slag between passes and back-gouge the root of the first vee before welding the other side.

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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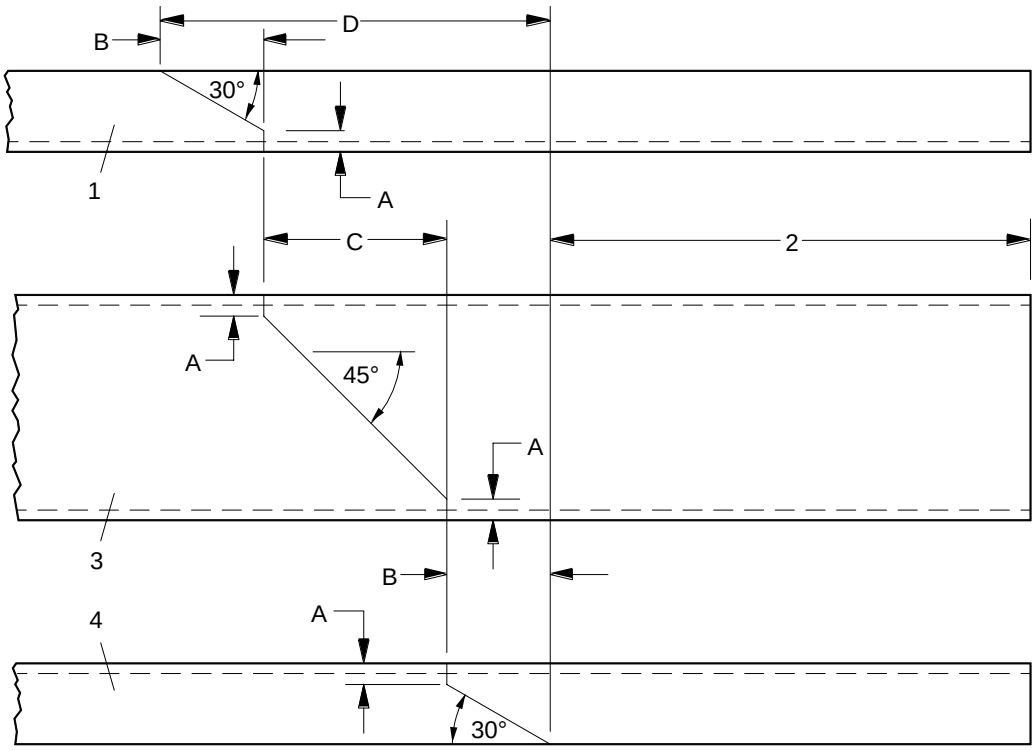
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

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)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

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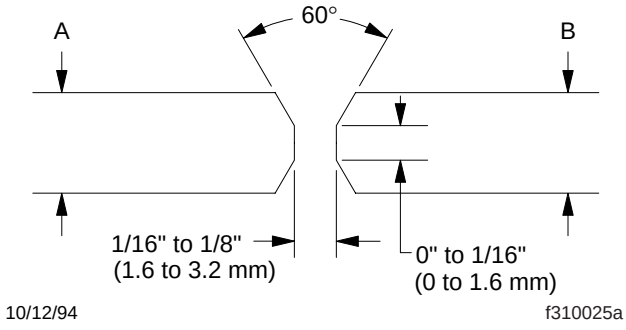
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

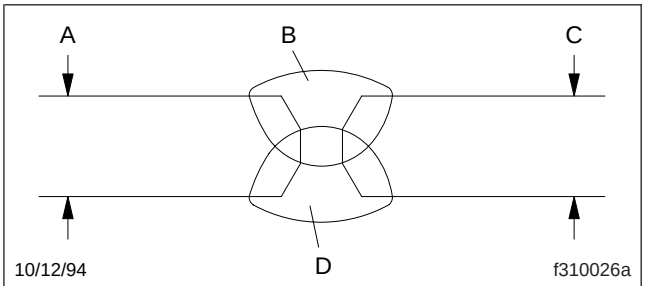
Fig. 2, Frame Rail and Extension Cutting Dimensions for Tractor Vehicles

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

Crossmember and Front Frame Bracket 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.

Front Closing Crossmember

Removal

1. Remove the bumper. See **Section 31.02, Subject 100**.
2. Remove the hood. See **Section 88.00, Subject 100**.
3. Remove the bumper mounting assembly brackets. See **Fig. 1**.
4. Remove the capscrews that attach the front closing crossmember to the front frame brackets, then remove the crossmember and front tow fittings from each side of the vehicle.

Installation

IMPORTANT: Each front tow fitting 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 fitting bore.

1. Place the front tow fittings in the front frame brackets and mount the front closing crossmember. Tighten the capscrews 180 lbf·ft (244 N·m). See **Fig. 1**.
2. Install the bumper mounting assembly brackets on the front frame brackets and tighten the capscrews 64 lbf·ft (87 N·m).
3. Install the hood. See **Section 88.00, Subject 100**.
4. Install the bumper. See **Section 31.02, Subject 100**.

Front Frame Bracket

Removal

1. Remove the front closing crossmember. See instructions provided earlier in this subject.
2. Drain the air system.

NOTE: It may be necessary to remove the primary air tank to make room for a jack stand behind the front suspension, under the frame rail.

3. As needed, remove the primary air tank.
4. Place a jack under the front axle, and lift the vehicle until jack stands can be properly situated under each frame rail.

IMPORTANT: Ensure that the jack stands are adjusted high enough to support the vehicle when the jack is lowered. Do not allow any weight on the front axle when the jack is lowered.

5. Place a jack stand under each frame rail.
6. Remove the jack from under the front axle.
7. Attach an engine hoist to the front of the engine. Raise the hoist to support the engine without raising the frame from the jack stands.
8. As needed, cut the tie straps that attach the wiring harnesses to the front frame brackets, and pass the harnesses through the holes in the frame brackets.

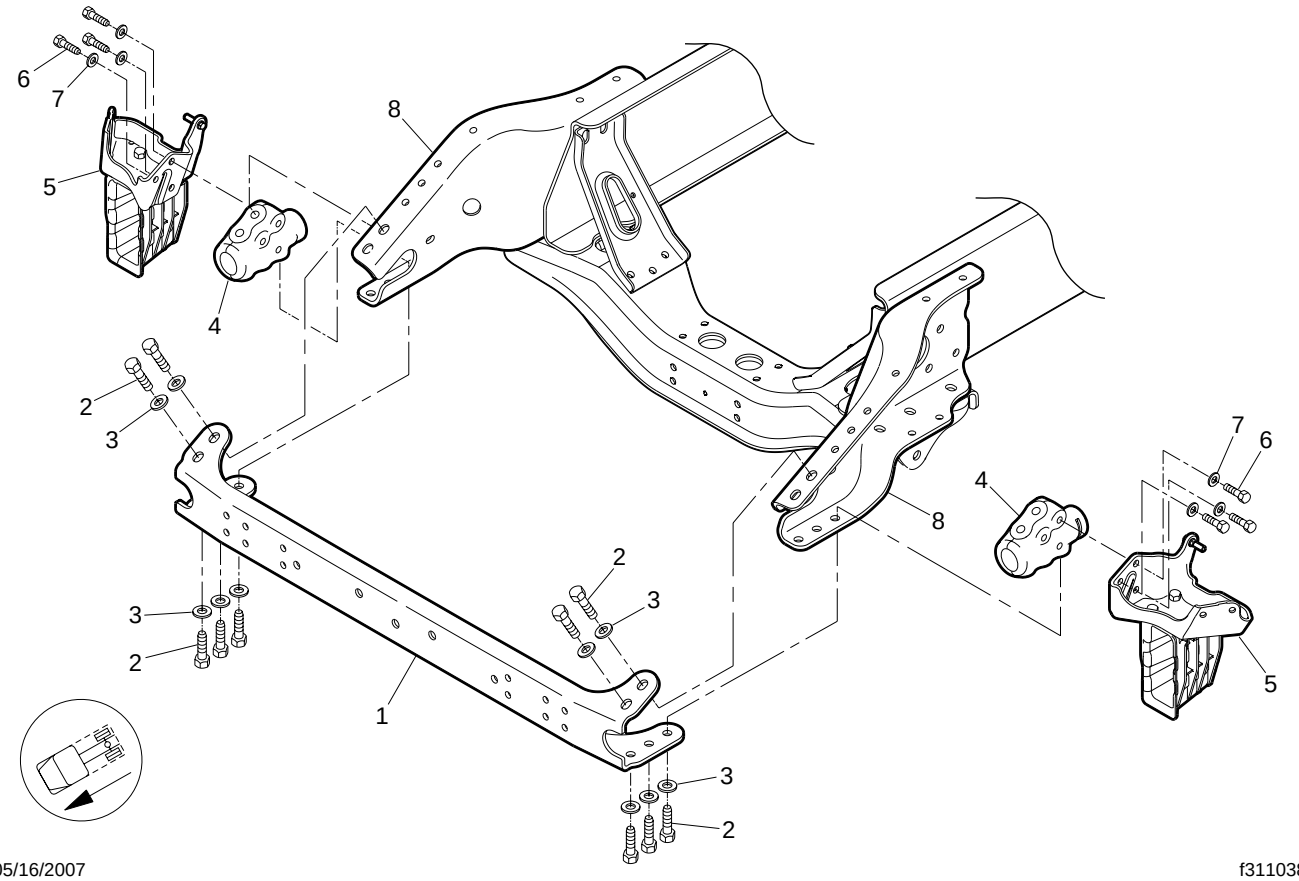
IMPORTANT: When removing the air dryer or fuel filter/separator from the front frame bracket, do not allow it to dangle.

9. If an air dryer assembly or fuel filter/separator assembly is mounted to the left front frame bracket, remove the fasteners that attach the assembly to the bracket, and secure it with tie straps.
10. Remove the capscrews that attach the front frame bracket to the frame rail and suspension. Remove the frame brackets. See **Fig. 1**.

Installation

1. Attach a front frame bracket to the frame rail and suspension. Hand-tighten the capscrews.

Crossmember and Front Frame Bracket Removal and Installation



1. Front Closing Crossmember
2. Capscrew, 5/8–11
3. Washer
4. Tow Device Fitting
5. Bumper Mounting Assembly Bracket
6. Capscrew, 5/8–11
7. Washer
8. Front Frame Bracket

Fig. 1, Front Closing Crossmember

NOTE: Hand-tightening the capscrews allows for some play in the front frame brackets, which is helpful when attaching the front closing crossmember.

IMPORTANT: Each front tow fitting 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 fitting in the front frame bracket and mount the front closing crossmember. Hand-tighten the capscrews and make any adjustments needed to properly align the components. Tighten the capscrews that attach the front frame brackets and front closing crossmember 180 lbf·ft (244 N·m).
3. If removed, pass the harnesses through the hole in the front frame bracket and secure them with tie straps.
4. Remove the engine hoist.
5. Place a jack under the front axle, and lift the vehicle until the jack stands can be removed.
6. Remove the jack stands, then lower the vehicle and remove the jack.
7. If an air dryer assembly or fuel filter/separator assembly was removed, install it.
8. If an air tank was removed, install it.

Crossmember and Front Frame Bracket Removal and Installation

9. Install the hood. See **Section 88.00, Subject 100**.
10. Install the bumper. See **Section 31.02, Subject 100**.

Engine Crossmember

Removal

1. Remove the bumper.
2. Remove the hood.
3. Drain the air system.
4. Raise the vehicle, so that there is no weight compressing the front suspension, then support the frame with safety stands.
5. Support the front of the engine from the forward-upper hook point.

IMPORTANT: Confirm that the weight of the vehicle is still on the safety stands that support the frame.

6. Remove any air valves, lines, and hoses that may be attached to the crossmember.
7. Remove the two engine-mount bolts that secure the front engine mount to the crossmember.
8. Remove the fasteners that attach the engine crossmember to the forward spring brackets. Remove the forward spring bracket on one side of the vehicle.
9. Slide the crossmember out from under the vehicle.

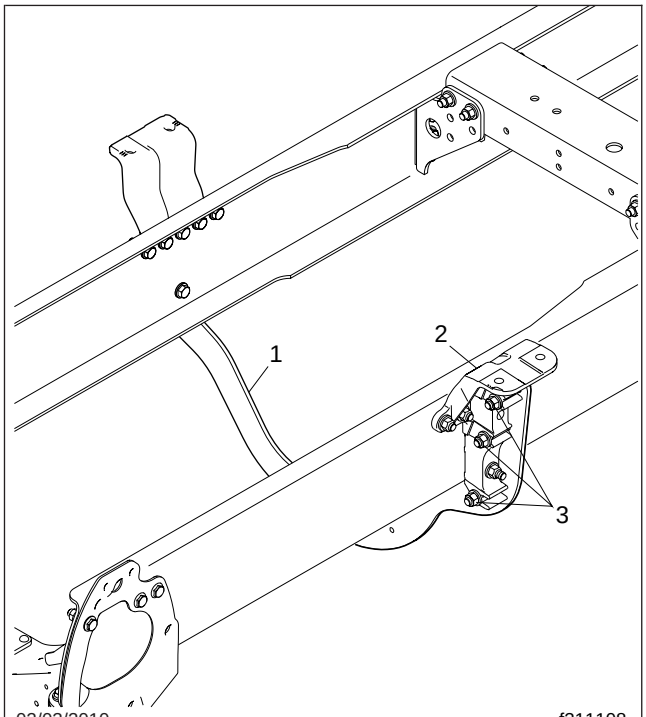
Installation

1. Slide the new crossmember into place.
2. Install the engine-mount bolts, but do not tighten them at this time.
3. Install the forward spring bracket that was removed.
4. Install the fasteners that attach the crossmember to the frame and forward spring. Tighten the fasteners to the torque value shown in **Specifications, 400**.
5. Install any air valves, brackets, air lines, or hoses that were removed.
6. Remove the engine hoist.
7. Remove the safety stands.
8. Install the hood.
9. Install the front bumper.

Underslung Crossmember

Removal

1. Remove the fasteners that attach the crossmember to the mounting bracket. See **Fig. 2**.



1. Underslung Crossmember
2. Mounting Bracket
3. Mounting Fasteners

Fig. 2, Underslung Crossmember Removal

2. Lower the underslung crossmember to remove it from the vehicle.

Installation

1. Align the holes in the crossmember with the holes in the mounting brackets.
2. Install the fasteners that attach the crossmember to the mounting brackets.

Crossmember and Front Frame Bracket Removal and Installation

3. Tighten the frame fasteners to the torque value shown in **Specifications, 400**.

Back-of-Cab Crossmember

Removal

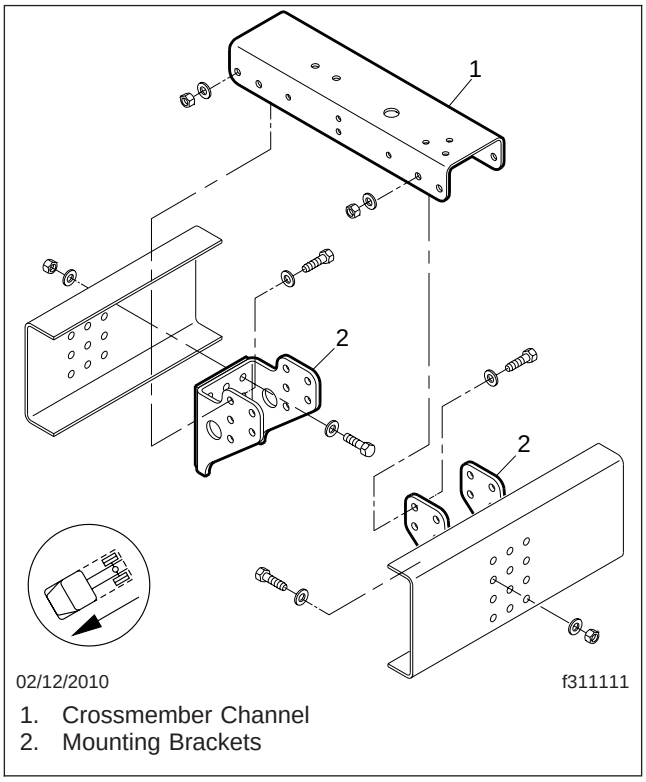
This style of crossmember is used to the rear of the day cab.

1. Remove the cab suspension from the crossmember.
   - 1.1 Disconnect the cab leveling-valve linkage from the cab.
   - 1.2 Manually operating the leveling valve, fill the air bags to maximum height.
   - 1.3 Support the cab in the raised position.

   IMPORTANT: Confirm that there is back-up support, as the cab will remain raised for the remainder of the procedure.

   - 1.4 Manually operating the leveling valve, exhaust the air from the air bags.
   - 1.5 Remove the air bags, cab shock absorbers, hoses, harnesses, and brackets that are attached to the crossmember.
2. Remove the fasteners that attach the crossmember and any mounting brackets that are being replaced, then remove the crossmember. See **Fig. 3**.

NOTE: It may necessary to remove one or both of the brackets in order to remove the crossmember.



1. Crossmember Channel
2. Mounting Brackets

Fig. 3, Back-of-Cab Crossmember (day cabs)

Installation

1. Place the crossmember and brackets in position, then install the fasteners finger tight. After all the fasteners are installed, tighten them 136 lbf·ft (184 N·m).
2. Attach any brackets, hoses, and harnesses that were removed.
3. Attach the cab suspension.
   - 3.1 Install the air bag brackets, air bags, shock absorbers, and any other components that were removed.
   - 3.2 Manually moving the leveling-valve lever arm slightly downward, slowly inflate the air bags until they are completely inflated.
   - 3.3 Connect the leveling-valve linkage.
   - 3.4 Remove the cab supports.

Midship Welded Crossmember

Five- or six-piece welded midship crossmembers are factory installed as midship-bearing crossmembers, or rear suspension crossmembers. See **Fig. 4**. When a five- or six-piece welded crossmember is replaced, a bolted crossmember is installed as a service replacement.

IMPORTANT: See the applicable parts technical bulletin for service replacement part numbers.

The following instructions are for removal of the five-piece welded midship crossmember, then the installation of a five-piece bolted crossmember.

Crossmember and Front Frame Bracket Removal and Installation

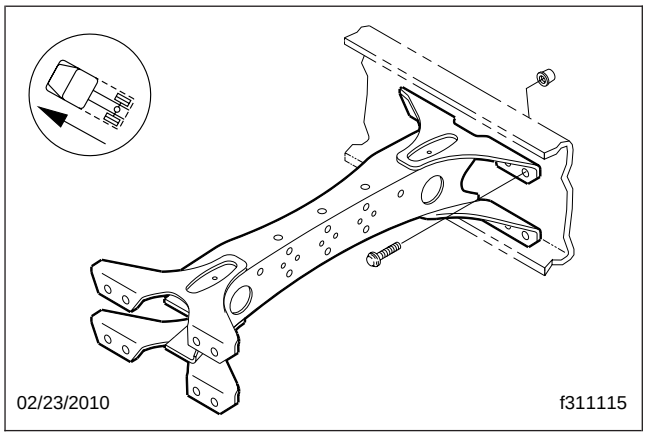


Fig. 4, Midship Five-Piece Welded Crossmember

Removal

1. If an air brake valve is attached to the crossmember, drain the air reservoirs, then remove the valve from the crossmember.
2. Remove any clamps that attach air lines or wiring to the crossmember, and secure the lines or wiring away from the crossmember.
3. If replacing a forward-rear-suspension crossmember with suspension brackets that share frame fasteners with the crossmember, use safety stands to support the rear of the frame at a height that the tires are just touching the floor, so there is no weight on the suspension.
4. If replacing a midship-bearing crossmember, support the driveline on a safety stand, then remove the the midship-bearing bracket from the crossmember.
5. Using a metal-cutting reciprocating saw or cutting torch, cut the crossmember channel into two pieces. A slightly diagonal cut will make removal of the crossmember pieces easier.
6. Remove the fasteners that attach the crossmember halves to the frame rails, and remove the crossmember.

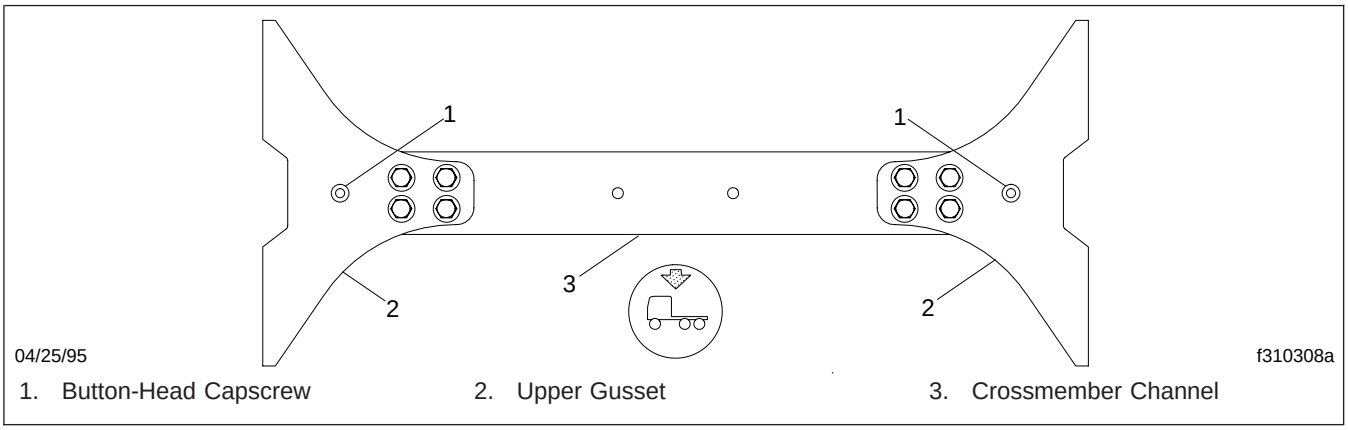
Installation, Service Crossmember

1. Attach one new upper gusset to the crossmember channel. Tighten the fasteners snugly, but not to final torque value. See **Fig. 5**.
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 the 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 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).

NOTE: The locknuts must be tightened now since, when the crossmember is in place, the frame upper flange blocks access to the capscrews.

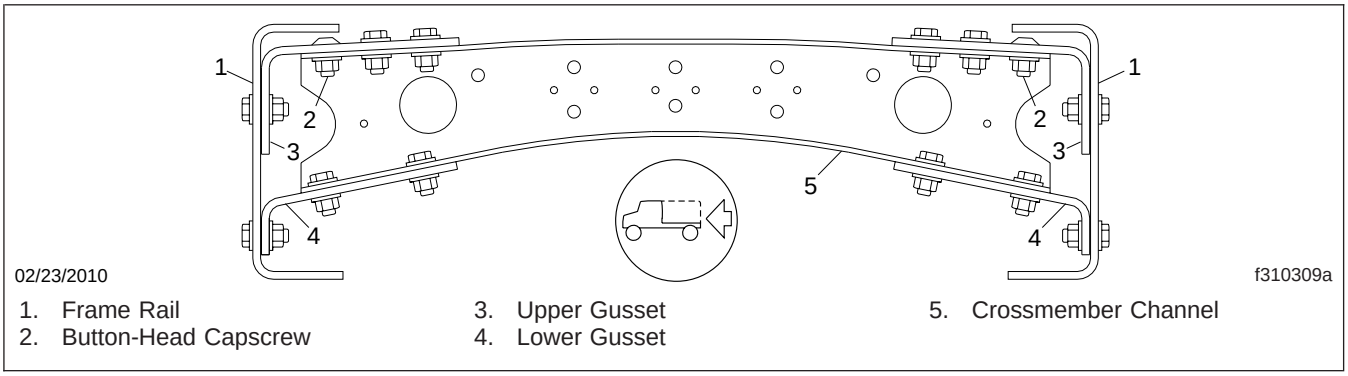
5. Using a dead-blow hammer, tap the crossmember into place. Align the mounting holes of the upper gussets with the holes in the frame rails. Install the fasteners, but do not tighten them. Attach the suspension bracket with the same capscrews, if they were removed.
6. Place the lower gussets in position against the crossmember channel and insert the fasteners that secure the gussets to the channel. See **Fig. 6**.
7. Reposition any frame mounted components such as fuel tank brackets, then install the fasteners that attach the gussets to the frame rails. Attach the suspension bracket with the same capscrews, if they were removed.
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 the driveline was disconnected, attach the midship bearing bracket to the crossmember.
10. Remove the supports.

Crossmember and Front Frame Bracket Removal and Installation



1. Button-Head Capscrew
2. Upper Gusset
3. Crossmember Channel

Fig. 5, Five-Piece Bolted Crossmember, Top View



1. Frame Rail
2. Button-Head Capscrew
3. Upper Gusset
4. Lower Gusset
5. Crossmember Channel

Fig. 6, Five-Piece Bolted Crossmember, Rear View

Rearmost Rear-Suspension (Channel) Crossmember

Removal

1. Use safety stands to support the rear of the frame at a height that the tires are just touching the floor, so there is no weight on the suspension.
2. Disconnect any suspension torque-rod brackets that are attached to the crossmember. Note the number and location of any spacers.
3. If any air valves or components are attached to the crossmember channel, drain the air reservoirs, then remove the valve from the crossmember.
4. Remove all fasteners that attach the crossmember channel to the upper and lower gussets. See **Fig. 7**.
5. Remove any gussets that will interfere with the crossmember center channel removal. Note the direction the fasteners are installed.
6. Work the crossmember out of the top or bottom of the frame rails.

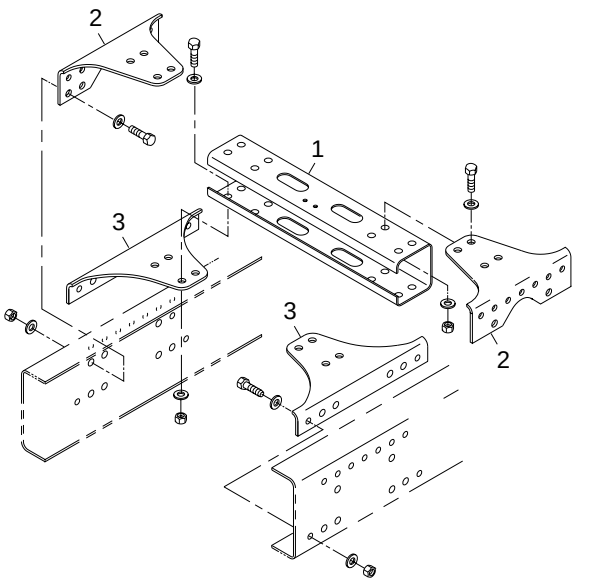
Installation

1. Install the crossmember, gussets, and any frame spacers (if used), in the reverse order in which they were removed. Be sure the spacers are installed in the same location noted during removal.

IMPORTANT: Be sure to install fasteners in the same direction that was noted during removal.

2. Tighten the frame fasteners to the torque value shown in **Specifications, 400**.

Crossmember and Front Frame Bracket Removal and Installation



1. Crossmember Channel
2. Upper Gusset
3. Lower Gusset

Fig. 7, Rearmost Rear-Suspension Crossmember

3. Attach any air valves or clamps that were removed from the crossmember during disassembly.
4. Attach any suspension torque rods that were disconnected.
5. Remove the supports.

One-Piece Rear-Closing Crossmember

Removal

1. Remove the taillights from the rear-closing crossmember. If equipped, remove the backup alarm.
2. Remove any components attached to the crossmember.

IMPORTANT: Some mudflap brackets are spring-loaded and may recoil violently when disconnected improperly.

3. Remove the rear mudflap brackets and fasteners. If the mudflap bracket is spring loaded, to prevent the spring from recoiling violently during removal, push downward on the outboard end of the mudflap and insert a screwdriver between the anchor of the spring and the bracket, before removing it. See **Fig. 8**.
4. If ground studs are welded to both frame rails, remove the the ground stud on the right-hand side.
5. Remove the fasteners that attach the crossmember to the top and bottom flange of the frame rails. See **Fig. 9**.
6. Push the crossmember forward, along the upper flange of the frame rails. Angle the right side forward leaving the left side rearward. When the right side is angled far enough forward for clearance, lift the crossmember out of the frame.

Installation

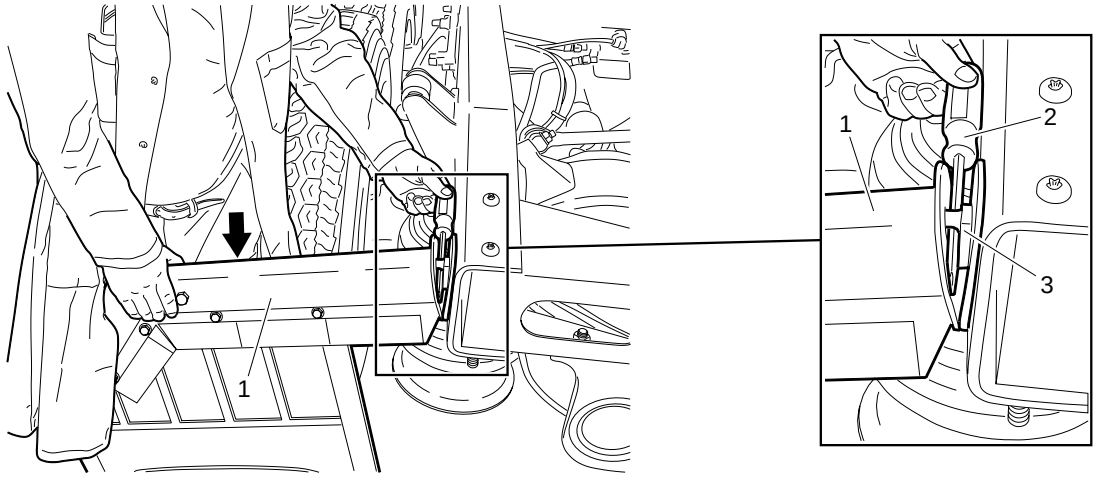
1. Slide the crossmember into position, then attach the fasteners and tighten them to specifications.
2. If a welded ground stud was removed, drill a 13/32-inch diameter hole 1-inch forward of the weld stud location, then attach the ground wire using a 3/8-inch capscrew, nut and lockwasher.
3. Attach any clamps for air lines or wiring to the crossmember.
4. Install the rear mudflap-hanger brackets.
5. Install the taillights on the rear closing crossmember. If equipped, install the backup alarm.

5-Piece Rear-Closing Crossmember

Removal

1. Remove the taillights from the rear-closing crossmember. If equipped, remove the backup alarm.
2. Remove any components that are attached to the crossmember.
3. Remove the fasteners that attach the crossmember to the mounting brackets, and lower the crossmember out of the frame. See **Fig. 10**.
4. If a mounting bracket needs to be replaced, remove the fasteners that attach the mounting bracket to the frame rail, then remove it.

Crossmember and Front Frame Bracket Removal and Installation



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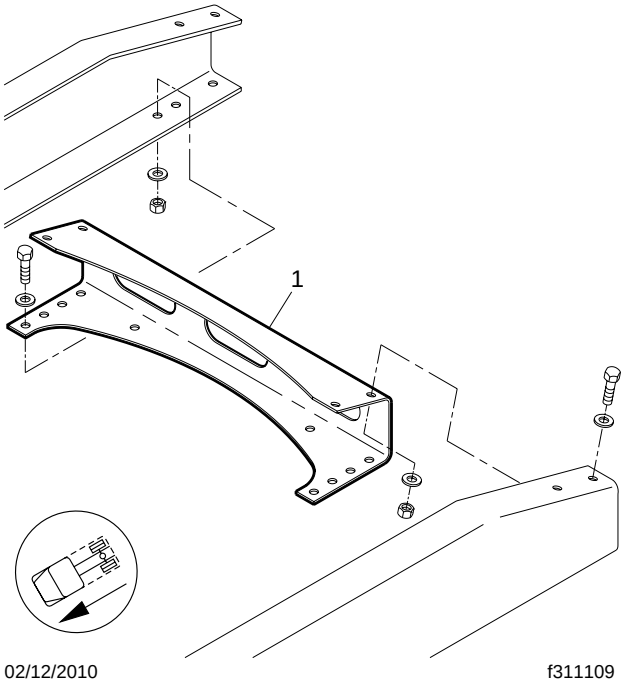
1. Spring-Loaded Mudflap Hanger
2. Screwdriver
3. Anchor

Fig. 8, Spring-Loaded Mudflap Hanger Removal



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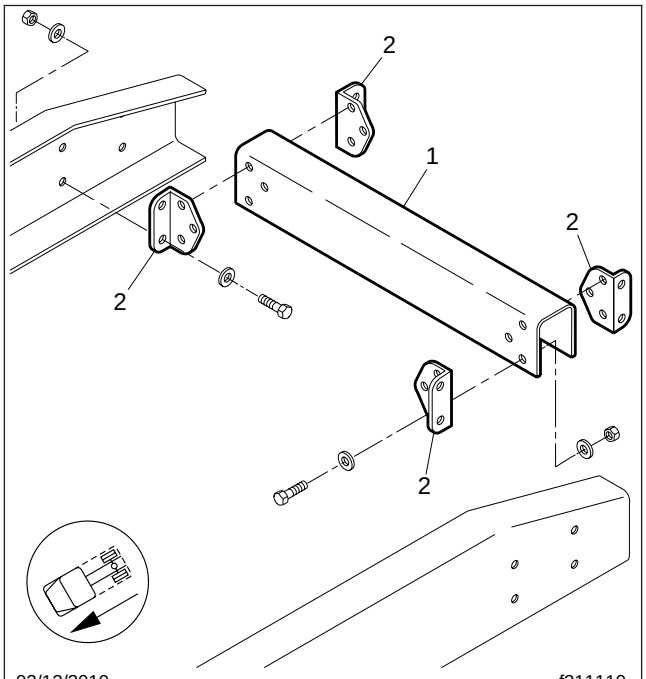
1. Tapered Closing Crossmember

Fig. 9, One-Piece Rear-Closing Crossmember



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1. Crossmember Channel
2. Mounting Brackets

Fig. 10, Five-Piece Rear-Closing Crossmember

Crossmember and Front Frame Bracket Removal and Installation

Installation

1. If the mounting brackets were removed, install the forward mounting brackets, but do not tighten the fasteners at this time.
2. Slide the crossmember into the frame rails, then turn it upright to position it against the mounting brackets.
3. Attach the rear mounting brackets to the frame rails, but do not completely tighten the fasteners at this time.
4. Install the fasteners that attach the crossmember to the mounting brackets. Tighten the fasteners that attach the mounting brackets to the frame rails, then tighten the fasteners that attach the crossmember to the mounting brackets. Tighten the fasteners to the torque values shown in **Specifications, 400**.
5. Install all components previously removed from the rear closing crossmember, including the tail-lights and backup alarm.

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. 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.

Measuring Frame Rail Alignment

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 2540 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 2540 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. At identical locations on both frame rails, measure and mark a point 5 cm (2 inches) inboard from the outside face of the frame web.
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 5 cm (2 inches) 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 inside face of each frame rail web. At both locations, this distance must be 854 mm (33.62 inches) for standard frame rails, or 841 mm (33.11 inches) if an inner liner is present. 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.

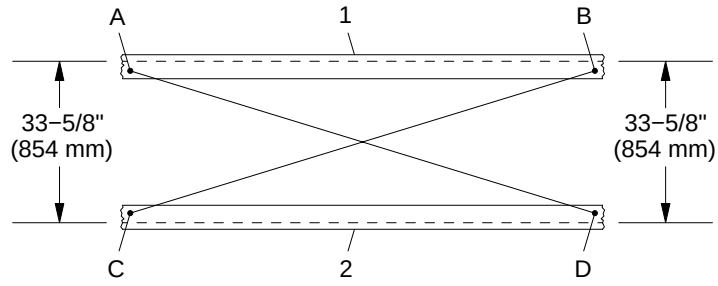
   If the measurements are within 1/8 inch (3 mm) of each other, the frame rails do not need to be aligned.

   If the values differ by more than 1/8 inch (3 mm), align the frame rails.

Aligning Frame Rails

IMPORTANT: To align the frame rails, the frame assembly must be assembled with all of the

Frame Rail Alignment



A. Right Forward Point
B. Right Rear Point
C. Left Forward Point
D. Left Rear Point
1. Right Frame Rail
2. Left Frame Rail

Fig. 1, Frame Rail Squaring

crossmembers in place, but the attachment fasteners not tightened.

1. Loosen all of the frame fasteners just enough to allow movement of the parts when force is applied.
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. Then, using a large hammer, tap the block until the measurements are within 1/8 inch (3 mm) of each other.
3. Tighten the fasteners for the front- and rear-closing crossmembers to the applicable torque values. See **Specifications, 400**.
4. Check the frame rail alignment again, and adjust as needed.
5. 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.
6. 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**.
   - 6.1 Tighten the fasteners that attach crossmembers to the frame.
   - 6.2 Tighten the fasteners that attach the upper and lower struts or gussets to the frame.
   - 6.3 Tighten the fasteners that attach the lower struts or gussets to the crossmembers.
7. 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

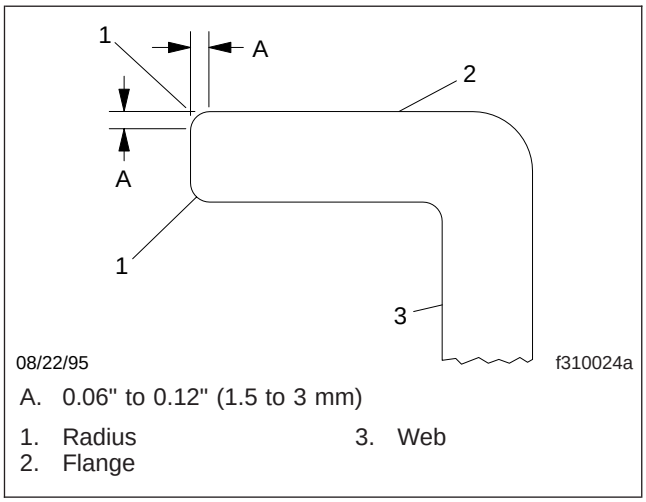
Wear protective eye and facial gear when grinding. Failure to wear this gear can result in personal injury due to flying metal debris from the grinding process.

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.

⚠ 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.

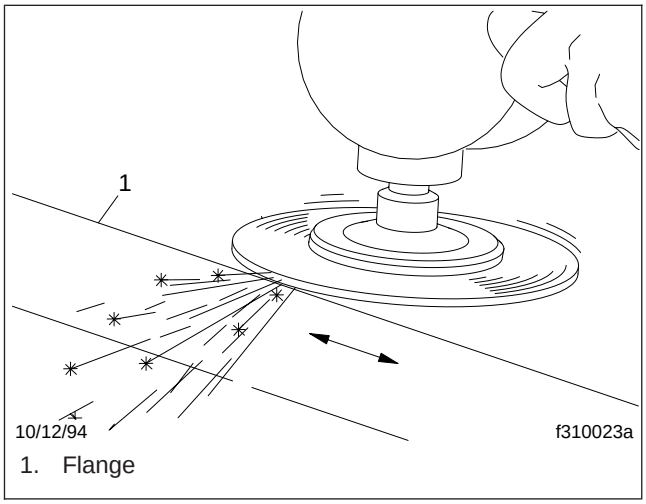
2. Using a clean, sharp, rotary drum grinder or flapper wheel grinder, apply light pressure and grind the cut edges in the direction of the length of the frame rail, to form the radius. See **Fig. 2**. Do not grind across the edges.



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

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*	
Fastener 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)

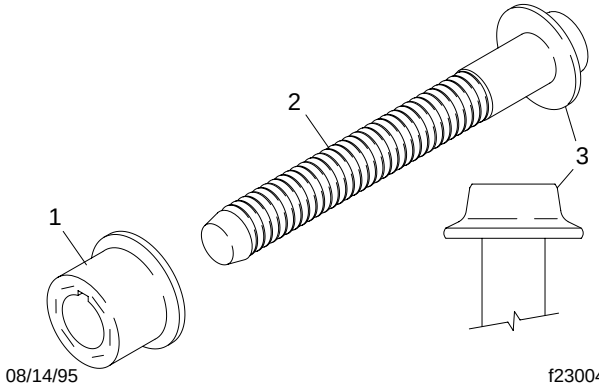
* Lubricated or plated threads.

Table 3, Frame Fastener Torque Specifications

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**. Huck fasteners are used for frame components and cross-member assemblies.

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

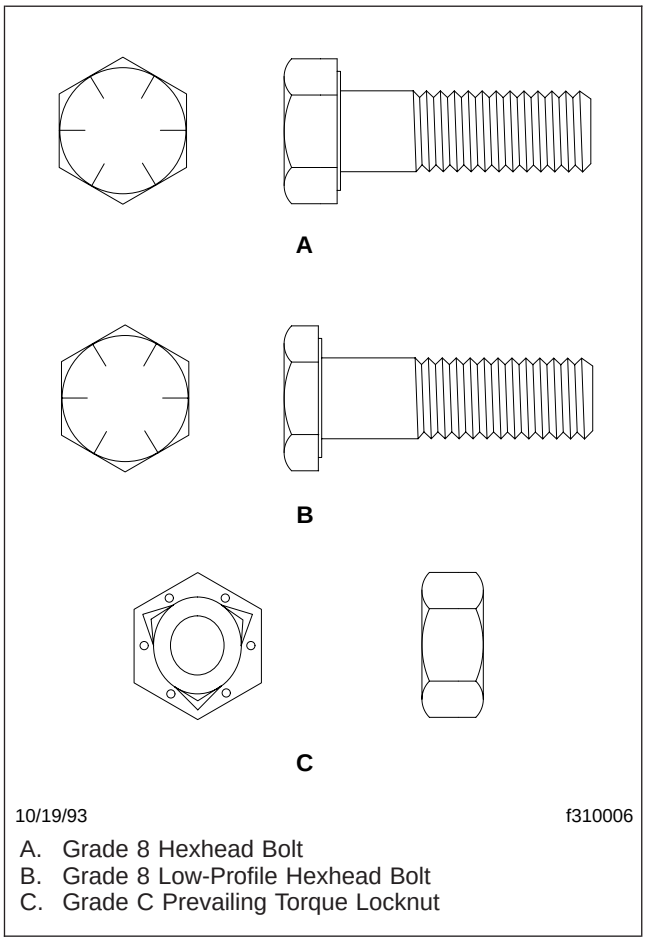
Fig. 1, Huck Fastener

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. They are cadmium- or zinc-plated, and have a hardness rating of 38 to 45 HRC.

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**.



A. Grade 8 Hexhead Bolt
B. Grade 8 Low-Profile Hexhead Bolt
C. Grade C Prevailing Torque Locknut

Fig. 2, Hexhead Fasteners

Then, drive out the lock pin with a punch.

Discard the fastener after removing it. Install standard Grade 8 threaded fasteners to replace the removed Huck fasteners.

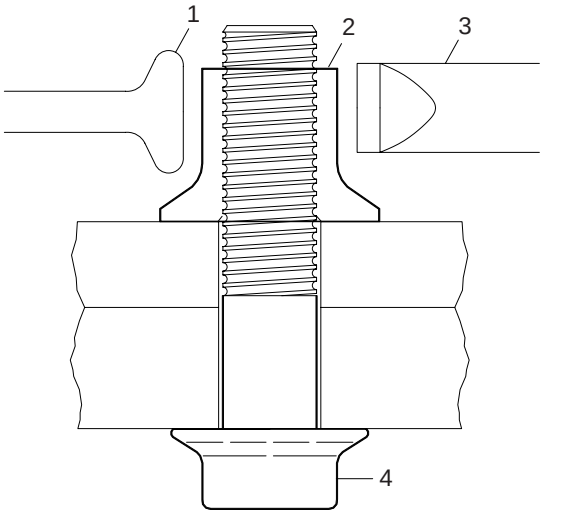
CAUTION

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.

Hexhead Bolt Replacement

Replace hexhead bolts with identical fasteners. Refer to the Freightliner Parts Book for fastener specifications.

General Information



1. Anvil
2. Spin Collar
3. Chisel
4. Lock Pin

Fig. 3, Huck Fastener Removal

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**.

Frame Fastener Tightening

NOTE: Huck fasteners do not require periodic 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 **Group 31** of the *Cascadia™ 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, Subject 400**.

Thread Extension Specifications		
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

Removal

1. Park the vehicle, shut down the engine, and apply the parking brake. Chock the tires.
2. From the bumper, disconnect all electrical connectors (such as fog lights), and remove bulbs to protect them.

IMPORTANT: Support the bumper so it will not fall when you remove the attaching capscrews.

3. Remove the two capscrews that attach the bumper mounting assembly bracket to the bumper, then remove the two capscrews that attach the bumper receptacle to the bumper. Repeat at the opposite side of the bumper. See **Fig. 1**.

NOTE: Do not remove the Torx screws from the bumper receptacles.

4. Pulling from the center of the bumper, remove it from the vehicle.

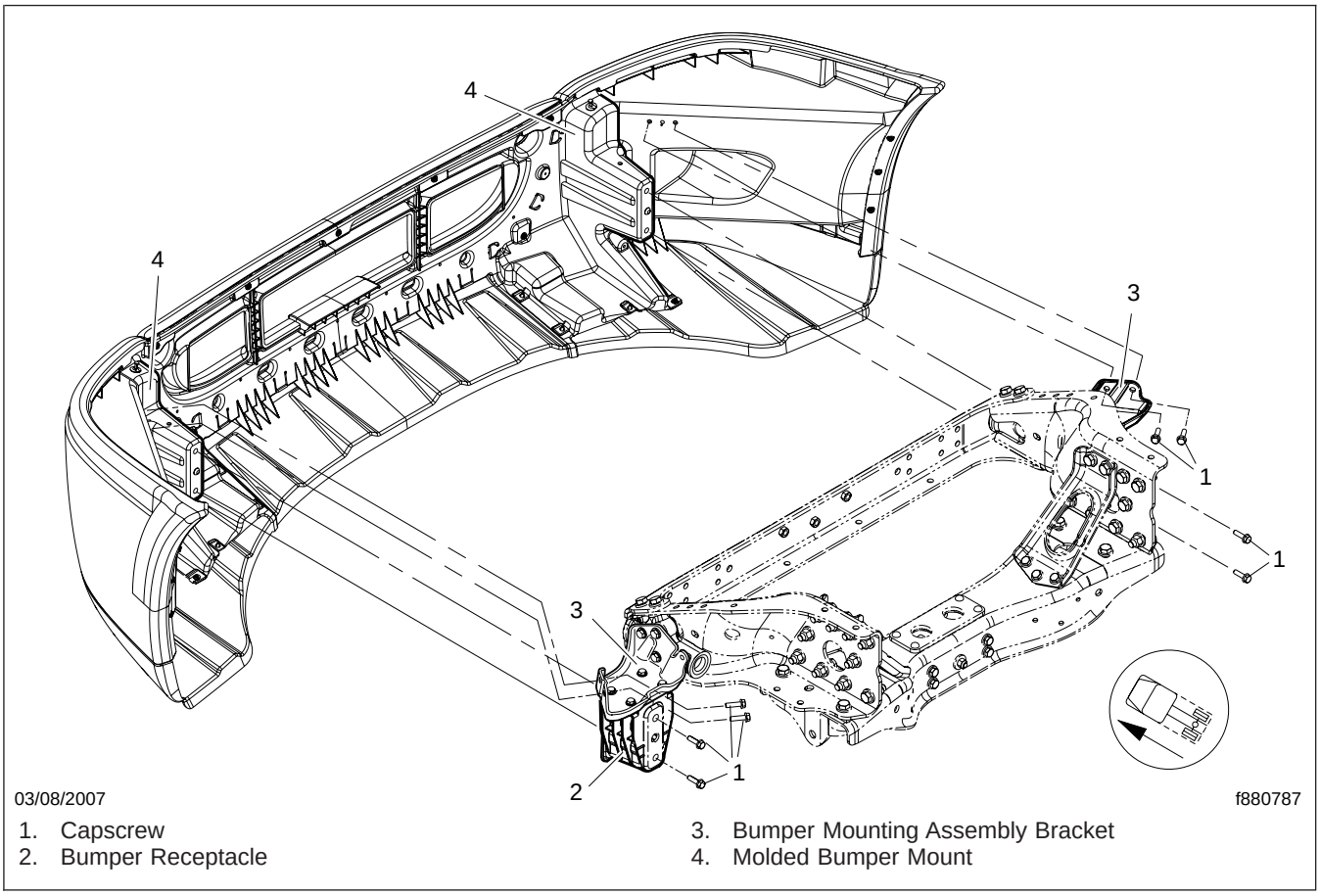
Installation

1. Insert the molded bumper mounts into the bumper receptacles. See **Fig. 1**.

NOTE: Hand-tightening the capscrews allows for some play in the bumper alignment, which is helpful when aligning the bumper with the hood.

2. At one side of the bumper, install and hand-tighten the two capscrews that attach the bumper receptacle to the bumper, then the two capscrews that attach the bumper mounting assembly bracket to the bumper. Repeat at the opposite side of the bumper.
3. Align the bumper with the hood; ensure that there is an even gap between them. Tighten the capscrews 20 lbf·ft (27 N·m).
4. As needed, install the bulbs and connect all electrical connectors.
5. Remove the chocks from the tires.

Removal and Installation



1. Capscrew
2. Bumper Receptacle
3. Bumper Mounting Assembly Bracket
4. Molded Bumper Mount

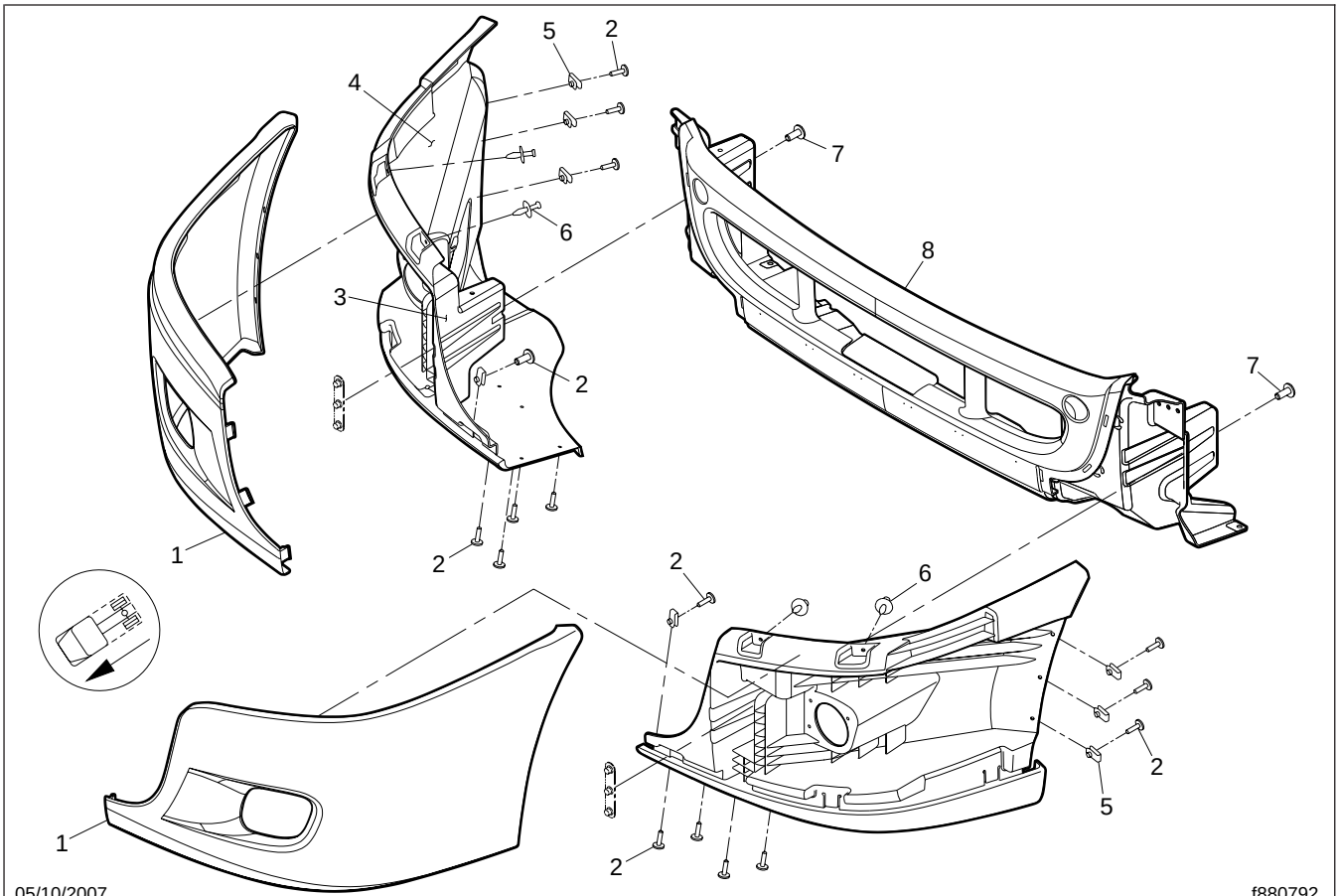
Fig. 1, Aerodynamic Bumper

End Fascia Replacement

Replacement

1. Remove the bumper. For procedures, see **Subject 100**.
2. Remove the nylon fasteners from the endcap. See **Fig. 1**.
3. At the molded bumper mount, remove the Torx screw that helps secure the endcap to the center piece.
4. Where the endcap is attached to the center piece, remove the fasteners.
5. From the outside edge of the endcap, remove the fasteners that help attach the fascia to the reinforcement.
6. Disengage the endcap retainers and remove the endcap from the center piece, as follows.

   6.1 Insert a screwdriver behind a retainer, and a second screwdriver between the fascia tab and the body of the reinforcement. Carefully pry the retainer upward, and pivot the second screwdriver toward the retainer to release the tab. See **Fig. 2**.



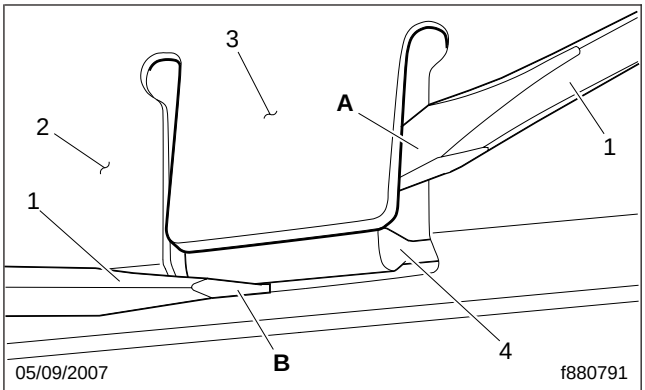
NOTE: Together, an end fascia and endcap reinforcement comprise an "endcap".

1. End Fascia
2. M6 Fastener
3. Molded Bumper Mount
4. Endcap Reinforcement
5. Washer
6. Nylon Fastener
7. Torx Screw
8. Center Piece

Fig. 1, Aerodynamic Bumper Components

End Fascia Replacement

6.2 Disengage the remaining retainers that attach the endcap to the center piece, and carefully separate the two.



A. Use a screwdriver to pry the retainer upward.
B. Insert a second screwdriver between the tab and reinforcement, and pivot it toward the retainer to release the tab.

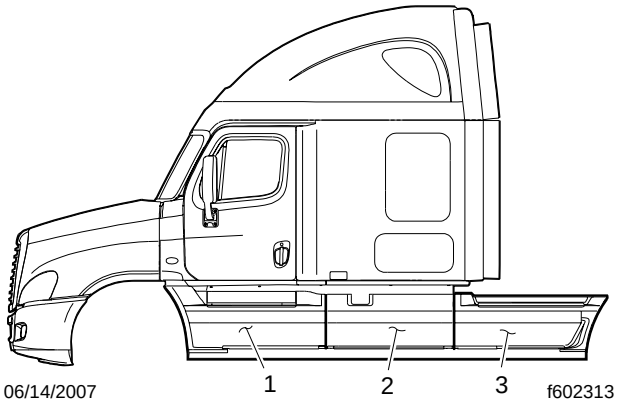
1. Screwdriver
2. Endcap Reinforcement
3. Retainer
4. Fascia Tab

Fig. 2, Disengaging a Retainer

7. Disengage the retainers that fasten the fascia to the reinforcement (see **Fig. 2)**, and carefully separate the two pieces.
8. Align the replacement fascia piece with the reinforcement and, using a rubber mallet, gently hammer the fascia to engage the retainers with the fascia tabs.
9. At the molded bumper mount, install the Torx screw, and tighten it 20 lbf·in (230 N·cm).
10. At the outside edge of the endcap, install the fasteners, and tighten them 42 lbf·in (475 N·cm).
11. Align the endcap with the center piece and, using a rubber mallet, gently hammer the fascia to engage the retainers with the fascia tabs.
12. Where the endcap attaches to the center piece, install the fasteners and tighten them 55 lbf·in (621 N·cm).
13. Install nylon fasteners, as removed.
14. Install the bumper. For procedures, see **Subject 100**.

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. Center Panel
3. Rear Panel

Fig. 1, Side Fairing (wheel-to-wheel installation)

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.

Full wheel-to-wheel side fairings have three panels. Partial fairings for sleeper cabs have two panels. Daycabs have only one panel.

NOTE: The following procedures cover 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 forward panel first, then the rear, and finally the center panel. See **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the rear tires.

NOTICE

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.

2. Remove the forward panel.
   - For the LH side of the vehicle, lower the hinged kickplate to access the latch handles. Use the latch handles to disengage the forward panel from the vehicle, then, holding the panel by its edges, remove it from the vehicle.
   - For the RH side of the vehicle, remove the fasteners that attach the upper and lower tread steps and the panels to the support rails. Remove the tread steps, then hold the panel by its edges and remove it from the vehicle.
3. Remove the rear panel.
   - 3.1 Remove the fasteners that attach the upper and lower tread steps and the panels to the support rails. Remove the tread steps.
   - 3.2 Holding the panel by its edges, remove it from the support rails.
4. Remove the center panel.
   - 4.1 Remove the fasteners that attach the center panel to the upper support rail — there are two at the fuel fill port and one at the rear of the panel.
   - 4.2 Holding the panel by its edges, remove it from the 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 the center panel first, then the rear panel, and finally the forward panel. This sequence allows the panels to fit together correctly.

NOTICE

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.

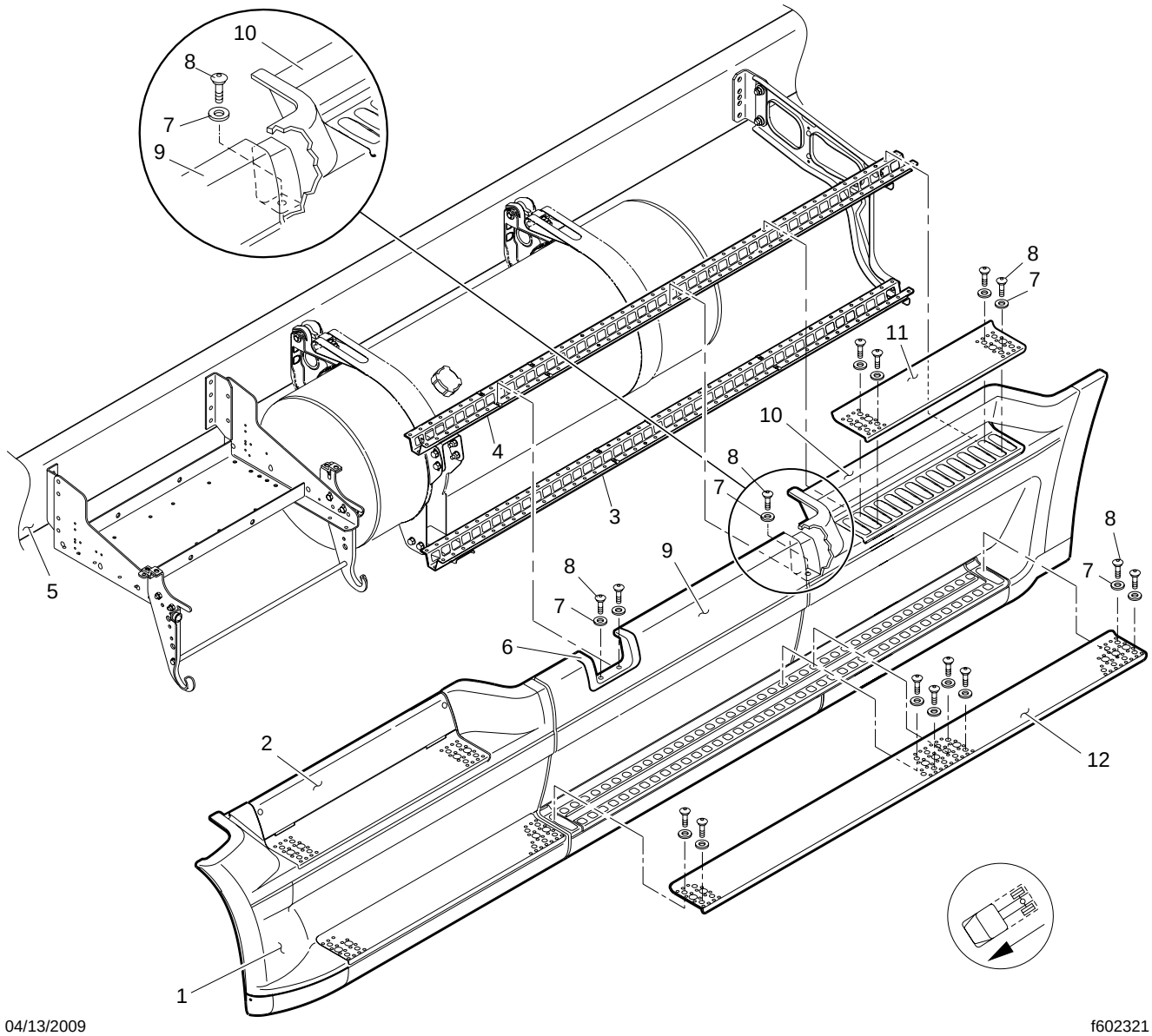
1. Put the center panel in place on the upper and lower support rails, and install the fasteners that attach it to the upper support rail — there are two at the fuel fill port and one at the rear of the panel. See **Fig. 1**. Hand-tighten the screws; keep them loose enough to adjust the panel.

IMPORTANT: Belleville washers are flat on the bottom, and convex (curved) on the top. Make sure they are installed correctly.

2. Put the rear panel in place on the upper and lower support rails, then install the fasteners to attach it and the upper and lower tread steps to the support rails. Hand-tighten the screws; keep them loose enough to adjust the panel.
3. Install the forward panel.
   - For the LH side of the vehicle, put the forward panel in place, and using the latch handles, attach the forward panel to the vehicle. Push the latch handles as far as possible toward the battery box to ensure a strong hold.
   - For the RH side of the vehicle, install the fasteners that attach the upper and lower tread steps and the panels to the support rails. Hand-tighten the screws; keep them loose enough to adjust the panel.

IMPORTANT: The cab suspension must be fully inflated when measuring the gaps between the panels and the cowl side panel.

Panel Removal and Installation



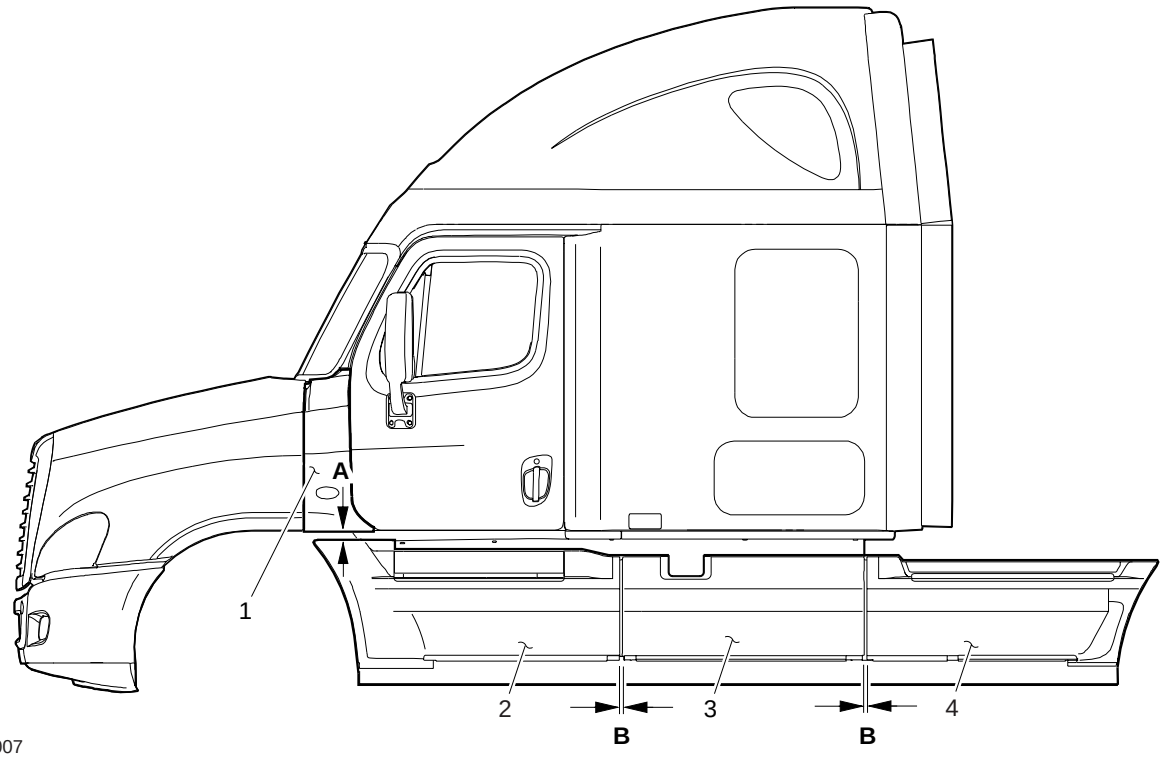
1. Forward Panel
2. Hinged Kickplate
3. Lower Support Rail
4. Upper Support Rail
5. Frame Rail
6. Fuel Fill Port
7. Washer, Belleville, 0.94 x 0.32 x 0.07 in
8. Screw, Torx, 5/16–18
9. Center Panel
10. Rear Panel
11. Upper Tread Step, Rear Panel
12. Lower Tread Step

Fig. 1, Side Fairing Installation (Three Panel Configuration, LH shown)

4. Measure the gap between of the upper edge of the forward panel and the lower edge of the cowl side panel. The edges of the panels should be parallel and the gap should be 60 ± 5 mm. See **Fig. 2**.

If necessary, adjust the position of the panels by loosening the fairing frame bracket or fuel tank bracket that holds the support rails, and move the support rails and panels up or down as needed. See **Fig. 3**.

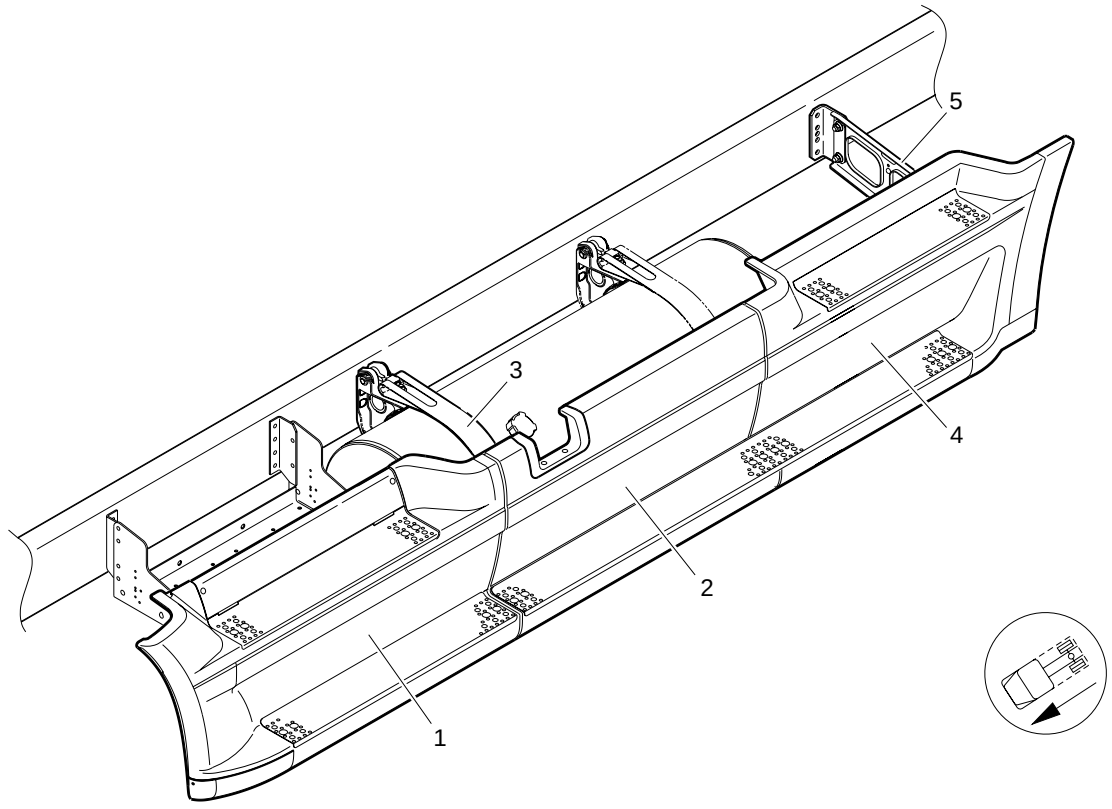
5. Check the vertical gaps between the panels. They should be 15 ± 2 mm wide. See **Fig. 2**. Move the panels forward or backward as needed.
6. Tighten all the Torx screws 16 lbf·ft (22 N·m).
7. Remove the chocks from the tires.



A. These edges should be parallel and 60 ± 5 mm apart.
B. 15 ± 2 mm
1. Cowl Side Panel
2. Forward Panel
3. Center Panel
4. Rear Panel

Fig. 2, Fairing Panel Alignment

Panel Removal and Installation



1. Forward Panel
2. Center Panel
3. Fuel Tank Bracket
4. Rear Panel
5. Fairing Frame Bracket

Fig. 3, Fairing Panel Adjustment

Support Rail Removal and Installation

Removal

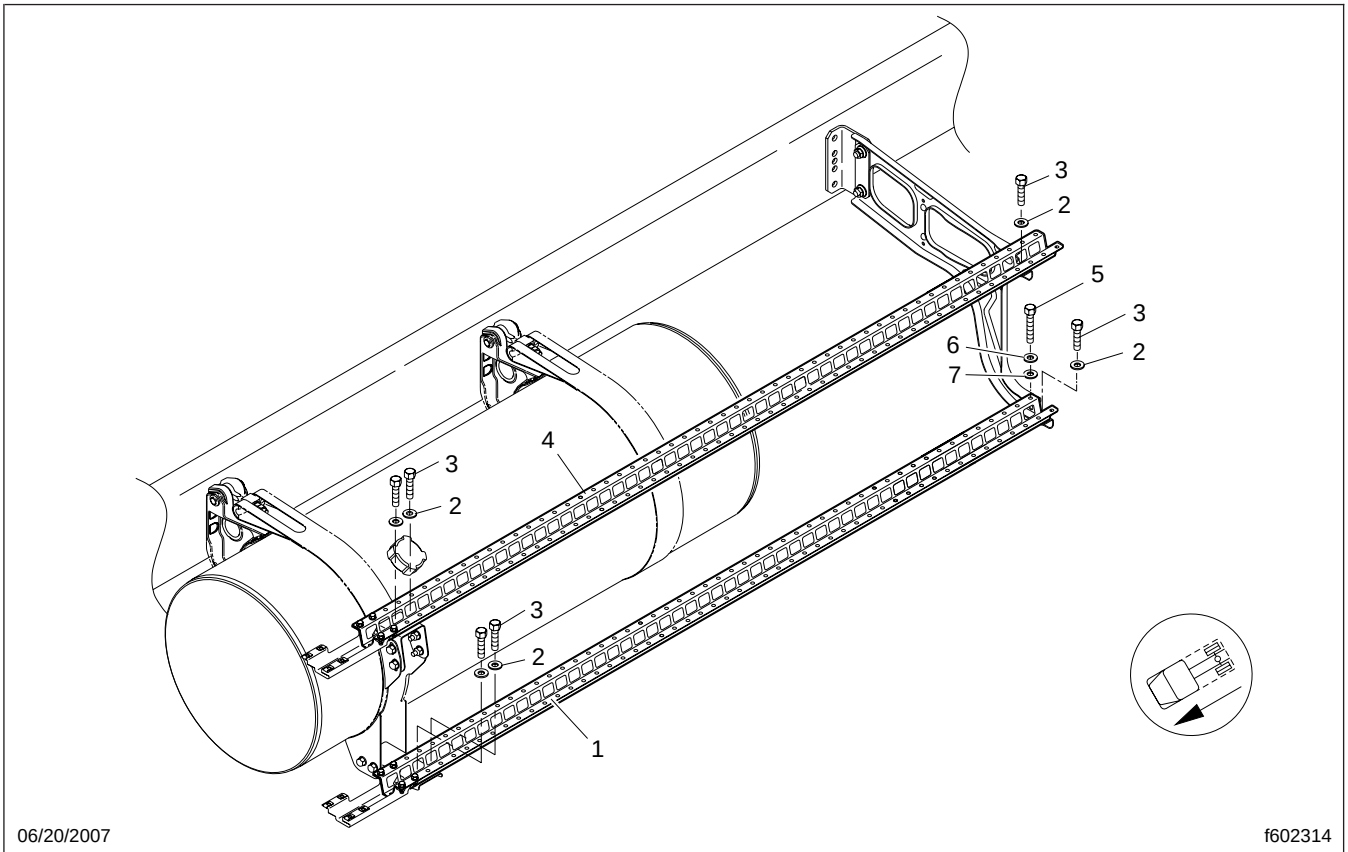
NOTE: This procedure includes removal of support rails that span the center and rear fairing panels. Not all vehicles are equipped with center and rear panels. Follow the applicable steps for the vehicle on which you are working.

1. Remove the side-fairing panels from the vehicle. See **Subject 100** for instructions.
2. Remove the fasteners that attach the upper support rail, and remove the rail from the vehicle. See **Fig. 1**.
3. Remove the fasteners that attach the lower support rail, and remove the rail from the vehicle.

Installation

1. Install the lower support rail on the brackets. Tighten the 3/8–16 capscrews 28 lbf·ft (38 N·m), and the 5/16–18 capscrew 16 lbf·ft (22 N·m). See **Fig. 1**.
2. Install the upper support rail on the brackets. Tighten the 3/8–16 capscrews 28 lbf·ft (38 N·m).
3. Install the side-fairing panels on the vehicle. See **Subject 100** for instructions.

Support Rail Removal and Installation



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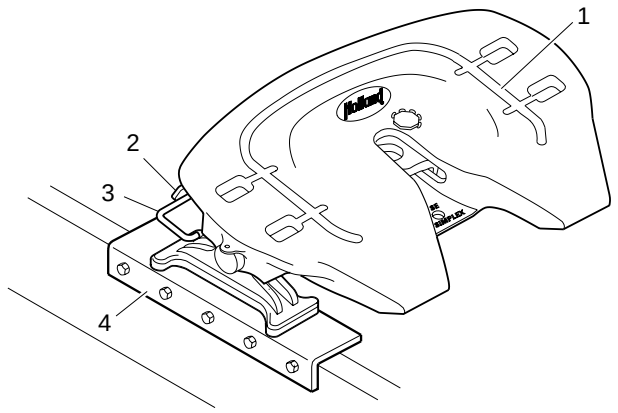
1. Lower Support Rail
2. Washer, 0.41 x 0.81 x 0.08 in
3. Capscrew, 3/8–16
4. Upper Support Rail
5. Capscrew, 5/16–18
6. Lockwasher
7. Washer, 0.34 x 0.69 x 0.08 in

Fig. 1, Support Rails Installation

General Information

The Holland Simplex SE 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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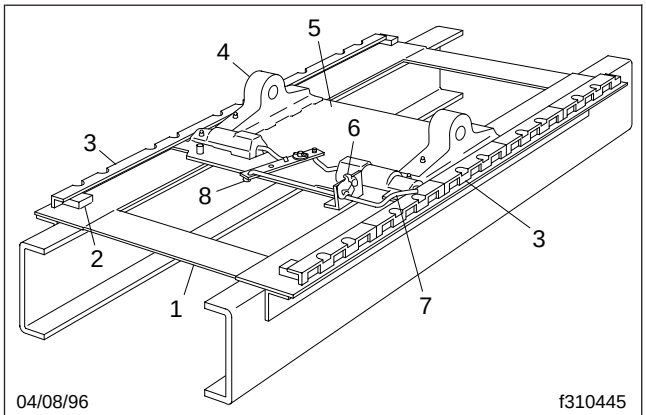
1. Lubricant Grooves
2. Safety Latch
3. Lock Control Handle
4. Mount

Fig. 1, Stationary Fifth Wheel

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 (curb-side) or left side (roadside) of the fifth wheel. On fifth wheels equipped with an air-operated TouchLoc release, the kingpin lock can be opened by air cylinder activation. 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**.



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1. Baseplate
2. Stop
3. Rail
4. Bracket
5. Sliding Mount
6. Safety Latch
7. Plunger
8. Operating Lever

Fig. 2, Taperloc Slider, Manually Operated Release

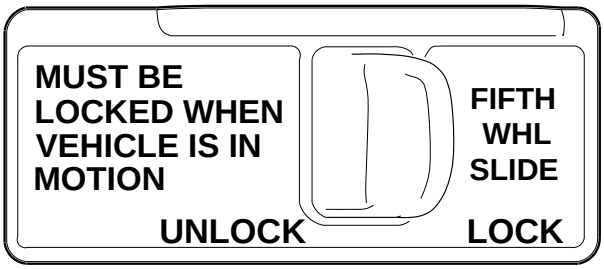

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Fig. 3, Air Control Valve in Cab

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.

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.

During coupling, the motion of the kingpin entering the jaw rotates the jaw into the locked position, locking the jaw around the kingpin.

For operating instructions, see **Chapter 18** in the *Cascadia Driver's Manual*.

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.

Removal

1. Using a bar, lock the fifth wheel.
2. Steam clean the fifth wheel.
3. Remove the retaining bolts, clinch pins, and bracket pins. If needed, use a clamp to compress the top plate and brackets to relieve the pressure on the bracket pins. See **Fig. 1**.

   If cotter pins are present instead of clinch pins, discard them. Clinch pins may be reused.
4. Using an overhead hoist, lift the fifth wheel off the mount and tractor frame.

Installation

1. Using an overhead hoist, place the fifth wheel on the mount brackets.
2. Clamp the fifth wheel in place to compress the bracket pads.
3. Insert the bracket pins, clinch pins, and retaining bolts.
4. Measure the clearance between the jaw and kingpin, and adjust as needed to permit proper locking and to accommodate SAE kingpin tolerances. For instructions, see **Subject 110** in this section.

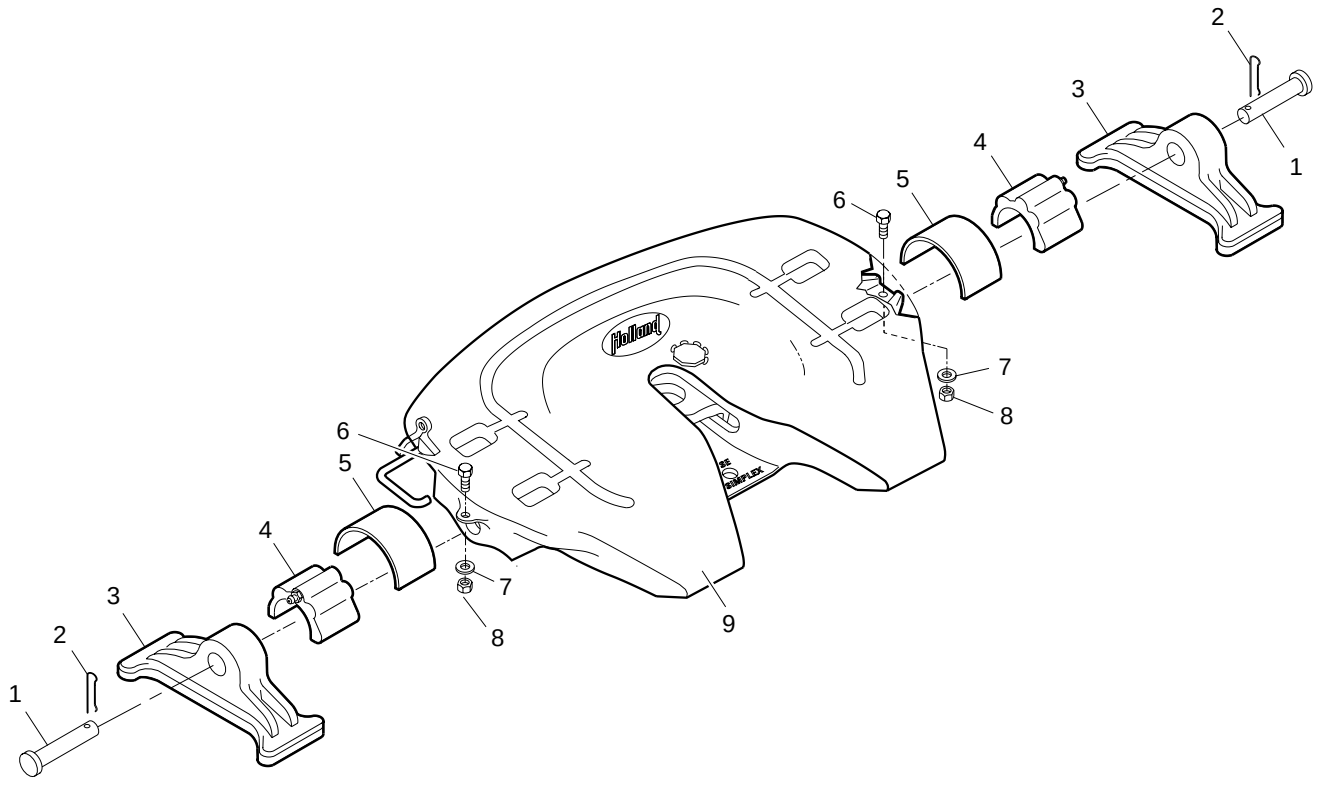
IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to **Group 31** in the *Cascadia Maintenance Manual* for maintenance and lubrication instructions.

5. Using a multipurpose chassis grease, grease the top plate and the grease fittings.
6. Check the fifth wheel operation. Refer to **Chapter 18** in the *Cascadia 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.

Removal and Installation



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1. Bracket Pin
2. Clinch Pin
3. Mounting Bracket (for stationary mounts)
4. Bracket Shoe
5. Bracket Pad
6. Retaining Bolt
7. Washer
8. Nut
9. Top Plate

Fig. 1, Simplex Fifth Wheel

Jaw and Kingpin Clearance Adjustment

Adjustment

Check for excessive clearance at the kingpin regularly. New fifth wheels provide a minimum 1/16-inch (1.6-mm) clearance between the kingpin and jaw. This clearance is necessary to permit proper locking and to accommodate SAE kingpin tolerances.

1. Check the clearance between the jaw and kingpin, as follows.

   1.1 With the jaw open, insert Holland gauge 4000171 or a new kingpin in the fifth wheel. See **Fig. 1**.

   1.2 Make sure the safety latch swings freely over the lock control handle. See **Fig. 2**. This places the fifth wheel in the coupled and locked position.

   NOTE: For complete instructions on a properly coupled condition, see the tag affixed to the side of the fifth wheel near the operating handle and the drivers card that is furnished with each fifth wheel.

   1.3 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.

   1.4 Remove the gauge or kingpin.

2. 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, as follows.

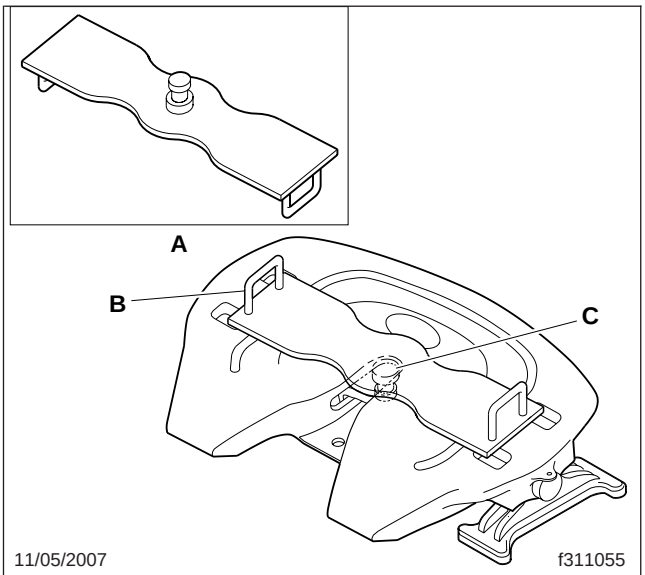
   2.1 Using a bar, move the jaw to the locked position. This will relieve the pressure on the jaw pin.

   IMPORTANT: Do not turn the jaw pin past position 4 (**Fig. 3**). If more than 1/8-inch (3-mm) clearance remains at position 4, replace the jaw, jaw pin, and lock.

   2.2 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).

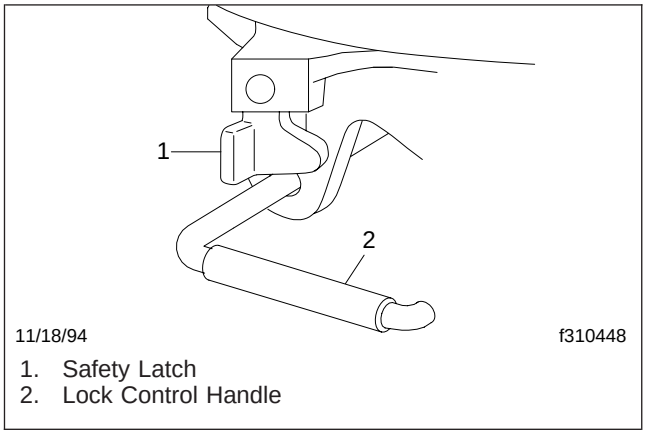
   NOTE: Starting from the original position, with the arrow pointing to the rear, each turn of the jaw pin (**Fig. 3**) to one of the four positions on the casting reduces the distance between the kingpin and jaw by the amount shown in **Table 1**.

   2.3 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



A. Bottom view of Holland gauge 4000171
B. Gauge installed
C. Feeler shim opening

Fig. 1, Jaw Gauge



1. Safety Latch
2. Lock Control Handle

Fig. 2, Left-Side View

Jaw and Kingpin Clearance Adjustment

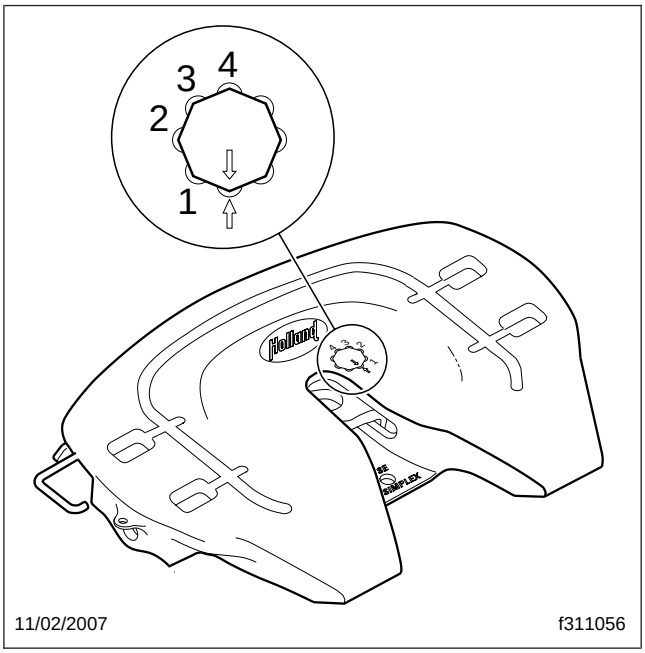


Fig. 3, Jaw Pin Positions

inch (3 mm) or less. Do not turn the jaw pin past position 4.

3. After the final adjustment, install the clinch pin in the jaw pin.
4. Check the fifth wheel operation. Refer to **Chapter 18** in the *Cascadia Driver's Manual* for complete fifth-wheel operating instructions.

Jaw Pin Position	Clearance Reduction: inch (mm)	
	Each Turn	Total
1	1/32 (0.8)	1/32 (0.8)
2	1/16 (1.6)	3/32 (2.4)
3	1/16 (1.6)	5/32 (4.0)
4	1/32 (0.8)	3/16 (4.8)

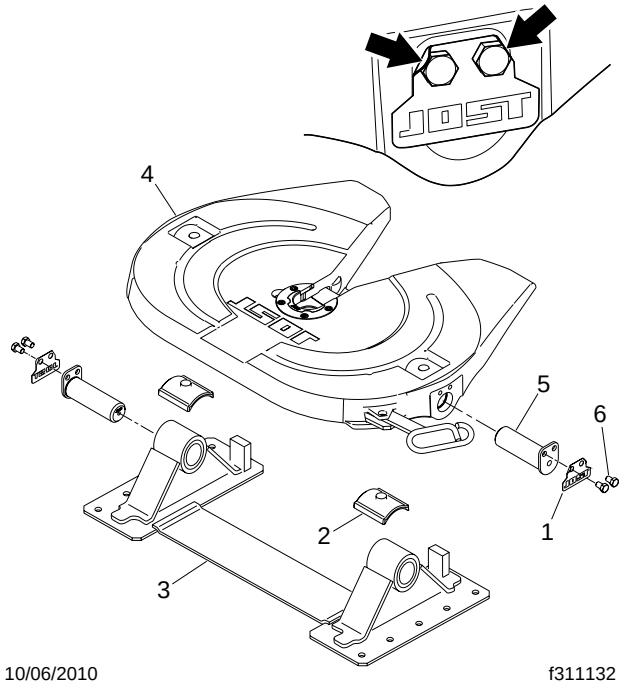
Table 1, Clearance Adjustment

⚠ 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.

Removal

1. Apply the parking brake, shut down the engine, and chock the rear tires.
2. To assist in positioning the top plate during installation, set wooden blocks between the top plate and the mounting assembly.
3. On each side of the top plate, bend back the locking tabs on the tab washer, then remove the mounting bolts and the tab washer. See **Fig. 1**.



1. Tab Washer
2. Pivot Collar
3. Mounting Bracket
4. Top Plate
5. Bracket Pin
6. Mounting Bolts

Fig. 1, Top Plate Removal and Installation

4. Remove the bracket pins.
5. Using an overhead hoist and harness, remove the top plate from the vehicle.

Installation

1. Using an overhead hoist and harness, position the top plate over the mounting bracket.
2. Place a liberal amount of grease on the tops of the pivot collars, then set them onto the bottom of the top plate at the pivots.
3. Lower the top plate onto the mounting bracket.
4. Install the bracket pins, tab washers, and the mounting bolts.
5. Bend the upper corners of the tab washers up against a flat side of the mounting bolts. See **Fig. 1**.
6. Remove the harness and wooden blocks.
7. Test the top plate to insure it pivots freely in the mount.
8. Follow the manufacturer's instructions to test the lock adjustment.

IMPORTANT: See the Jost 5th Wheels web site, **www.jostinternational.com** for complete information on Jost 5th wheel service procedures.

Fifth Wheel Assembly Removal and Installation

Removal

1. Apply the parking brake, shut down the engine, and chock the rear tires.
2. If the fifth wheel has a sliding mount, move the top plate to the center position.
3. If equipped, ensure the fifth-wheel slide switch is in the locked positon, and the kingpin release switch is in the locked position.
4. Disconnect the air lines from the slide cylinder, and the kingpin release cylinder.
5. Remove the fasteners that attach the fifth-wheel assembly to the frame rail.
6. Using an overhead hoist and harness, lift the fifth wheel assembly from the vehicle and remove it to the work area.

Installation

1. Using an overhead hoist and harness, lower the fifth wheel assembly onto the vehicle then adjust it into position.
2. Fasten the fifth wheel assembly to the frame rail.
3. If equipped, connect the air lines to the slide cylinder and the kingpin release cylinder. Secure the air lines, replacing any cable ties that were removed.

Troubleshooting

Problem	Cause	Correction
Hard to couple	Coupling too fast.	After picking up the trailer (standard top plate) or sliding under the trailer (low lube top plate) with the fifth wheel, STOP, then continue backing until coupled. NOTE: See the *Cascadia Driver's Manual* for coupling instructions.
	Trailer is too high.	Lower the trailer. The fifth wheel MUST pick up the trailer (applies to standard style top plate only) or there should be NO GAP between the trailer bolster and the fifth wheel (applies to low lube top plate).
	Lock is already closed.	Pull the release handle open.
	Bent release handle.	Inspect, and/or pull the release handle. Replace it.
	Damaged lock, or debris interfering with the lock operation.	Have an assistant pull the release handle out, while attempting to swing the lock. The lock should swing freely. Then lock and unlock using a lock tester.
	Using lube plate with wrong length kingpin.	Inspect kingpin length using a Jost kingpin gauge.
	Bent kingpin or damaged trailer bolster plate.	Check the kingpin with a Jost kingpin gauge. Inspect and repair the bolster plate as required.
	Release arm or release handle pivot nuts too tight, or double coil spring not installed.	Review the rebuild procedures, and repair as required.
Hard to uncouple	Lock is closed, release handle was never pulled.	Pull the handle out, rotate it forward and rest it on the notch provided.
	Release handle will not pull out. The tractor may be putting pressure on the lock.	Set the trailer brakes, back up to the trailer with the tractor, then set the tractor brakes. Pull the release handle.
	Release handle will not pull out. Lock is adjusted too tight.	Review the lock adjustment procedure for a lock that is adjusted too tight. See the Jost 5th Wheels web site, **www.jostinternational.com** for complete information on Jost 5th wheel service procedures.
	Release handle will not pull out. Release handle and release arm pivots are too tight.	Review the rebuild procedure and repair as required. See the Jost 5th Wheels web site, **www.jostinternational.com** for complete information on Jost 5th wheel service procedures.
	Bent kingpin or damaged trailer bolster plate.	Check the kingpin with a Jost kingpin gauge. Inspect and repair the bolster plate as required
	Release-handle notch damaged or worn.	Check the notch on the release handle, and replace if required.
	Release-handle slot in the casting is damaged or worn.	Inspect the release-handle slot in the casting, and replace or repair as required.
Fore-and-Aft Play at Kingpin	Lock is adjusted too loose.	Review the lock adjustment procedure for a lock that is adjusted too loose. See the Jost 5th Wheels web site, **www.jostinternational.com** for complete information on Jost 5th wheel service procedures.

Table 1, Troubleshooting

AERO CLAD Bumper Removal and Installation

Removal

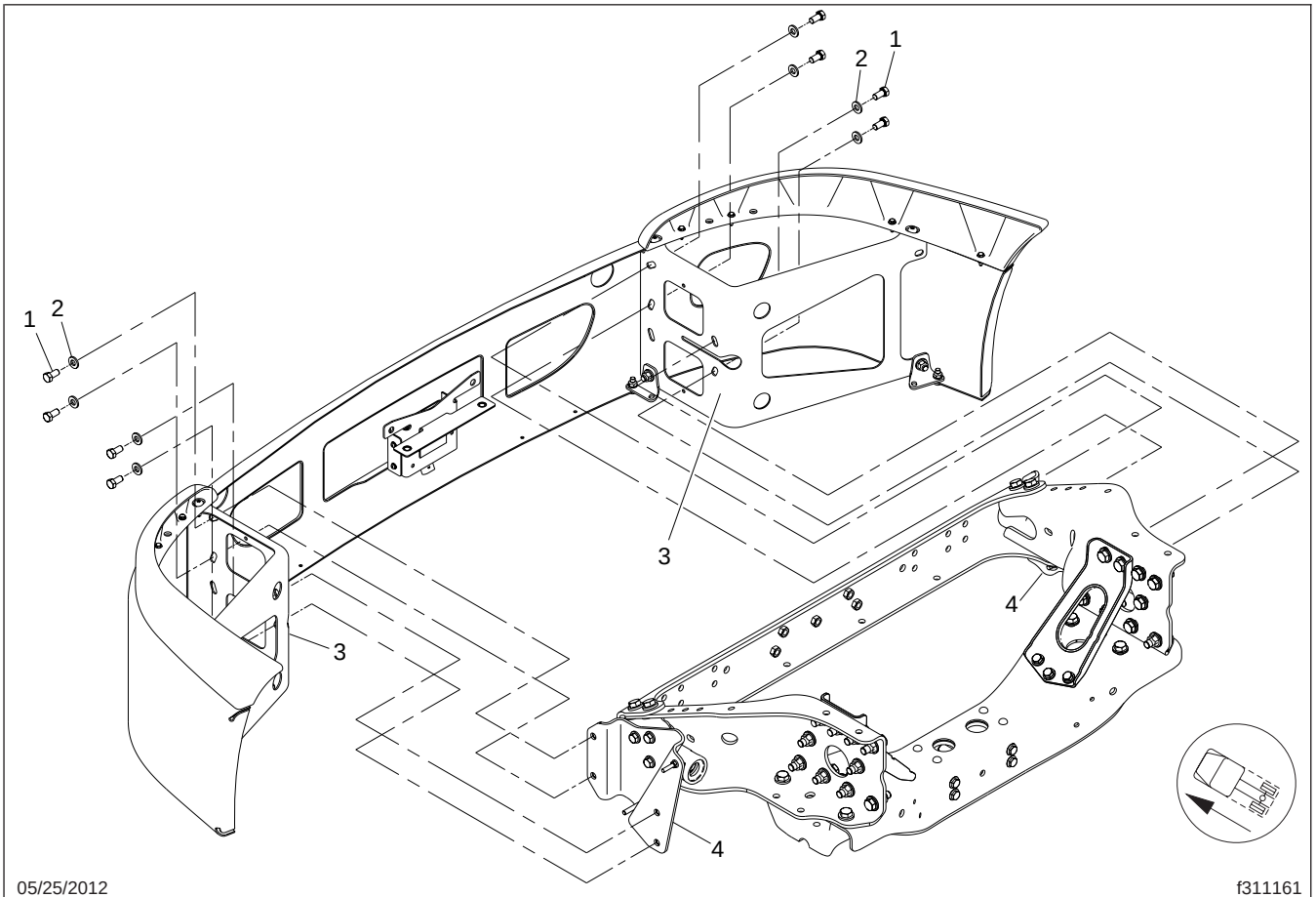
1. Park the vehicle, shut down the engine, and apply the parking brake. Chock the tires.
2. If equipped, disconnect all electrical connectors from the bumper assembly, and remove any bulbs to protect them.

IMPORTANT: Support the bumper so it cannot fall when the capscrews are removed.

3. On each side, remove the four capscrews that attach the bumper bracket to the mounting bracket. See **Fig. 1**.
4. Pulling from the center of the bumper, remove it from the vehicle.

Installation

1. Install the bumper, making sure to align the guide stud on the mounting bracket in the center groove on the bumper bracket. See **Fig. 2**.
2. On each side of the bumper, install and hand-tighten the four capscrews that attach the bumper to the mounting bracket.
3. With the fasteners loose, align the bumper with the hood while ensuring an even gap between



1. Capscrew
2. Washer
3. Bumper Bracket
4. Bumper Mounting Bracket

Fig. 1, AERO CLAD Bumper

AERO CLAD Bumper Removal and Installation

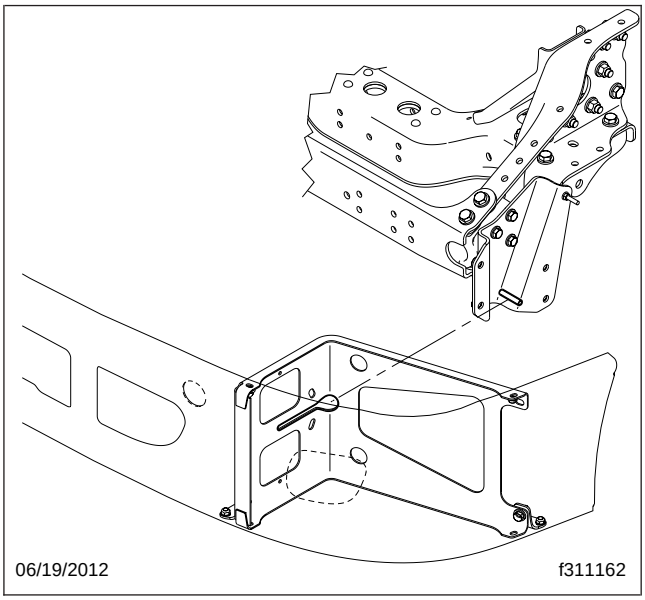


Fig. 2, Aligning the Bumper Bracket Slot and Rod

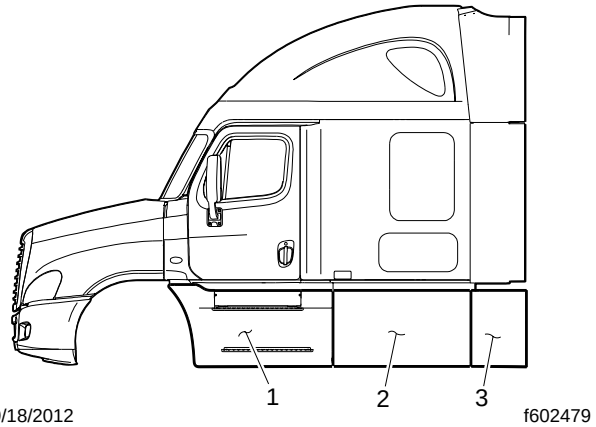
them. Once the bumper is positioned, tighten the capscrews 64 lbf·ft (87 N·m).

4. If equipped, install the bulbs and connect all electrical connectors.

Aero Chassis Side Fairings

Chassis side fairings ease air turbulence, reducing drag. In 2012, new, more aerodynamic side fairings were introduced as the standard side fairing option for Cascadia vehicles. These new "aero" fairings have steps on only the forward fairing panel, directly underneath the cab doors; older fairings have steps along the length of the side fairings.

Chassis side fairings are sized to the cab or wheelbase. Fairings may extend to the back of the cab or to the back of the side extender. Sleepers with aero side fairings also have a center fairing panel, and may have a rear "flare" extension panel.



1. Front Panel
2. Center Panel
3. Flare Extension Panel

Fig. 1, Chassis Side Fairing Panels

Vehicles may be equipped with either a bolted or latched forward side fairing panel on the right or left-hand side.

Bolted Forward Panel Removal

1. Remove the eight fasteners attaching the upper and lower aluminum treads to the forward panel and rails, and remove the treads. See **Fig. 1**.

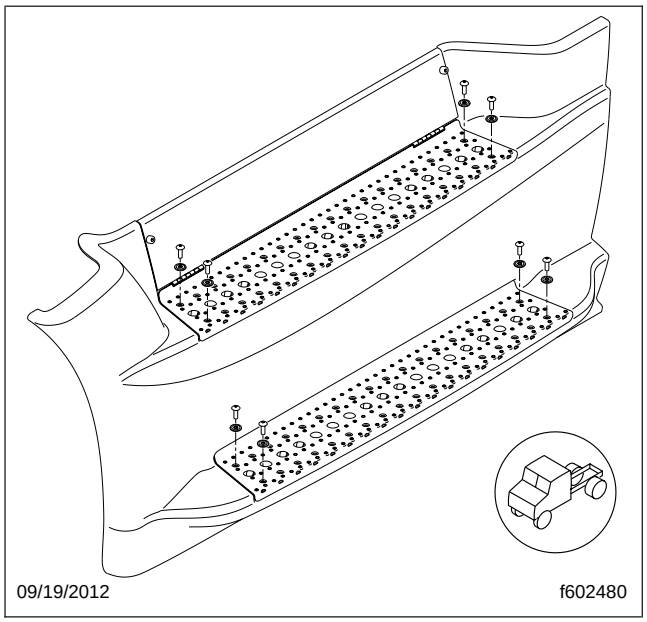


Fig. 1, Fastener Locations on Fairing Treads

2. Hold the panel by the outer edges and remove it.

NOTICE

Do not hold the panel by the slots on the steps, as they are not designed to bear the weight of the panel, and may crack.

Bolted Forward Panel Installation

1. Position the forward panel on the step support rails.
2. Position the upper and lower aluminum treads on the panel and install the eight fasteners. See **Fig. 1**.

Latched Forward Fairing Removal and Installation

1. To remove, lower the kickplate door, pull out the latch pins, and release the latches. Pull the fairing slightly up and outward. See **Fig. 2**.

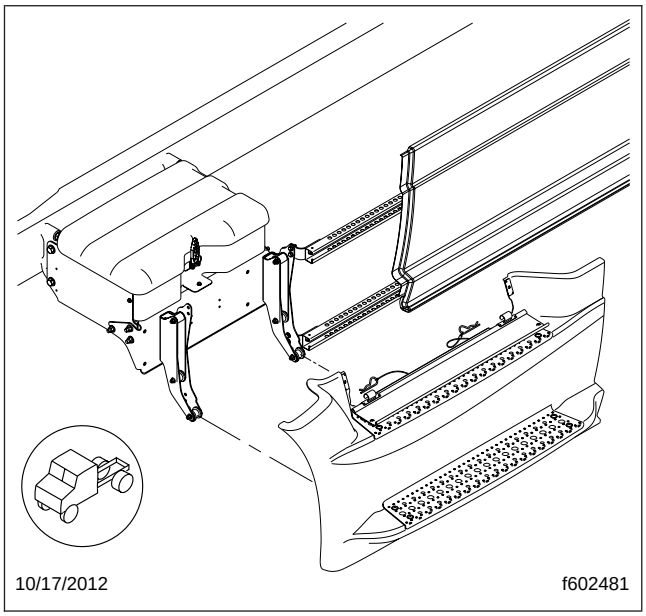


Fig. 2, Latched Forward Fairing Removal

2. To install, seat the bottom of the fairing support on the rubber isolators, then push the fairing inward to latch. Install the two pins to secure the latches closed. Shut the kickplate door.

Center Fairing Removal and Installation

Removal, Center Fairing Mounted to Fuel Tank Band

1. Remove the forward side-fairing (latched version) or panel (bolted version). For instructions, see **Subject 100**.
2. Support the center fairing.
3. Remove the four fasteners that attach the forward mounting area of the fairing support rails to the step support bracket. See **Fig. 1**.
4. Remove the two fasteners at the top-rear of the fairing where it attaches to the fuel tank bracket. See **Fig. 1**.
5. Move the fairing rearward slightly to move the top-rear bracket off the fuel tank bracket studs, then lift the fairing up and slightly inward, toward the vehicle, to unseat the bottom support hook.

Installation, Center Fairing Mounted to Fuel Tank Band

1. Carefully lower the panel inward, toward the vehicle, fitting the bottom support hook over the plastic sleeve bushing. The bottom bushing allows for forward and rearward movement of the fairing and support hook. With the bottom support hook seated, position the top-rear bracket of the fairing onto the top fuel tank bracket studs. See **Fig. 2**.
2. Position the forward mounting area of the fairing support rails onto the studs at the step support bracket. Do not tighten the fasteners yet. Check that the fairing is properly positioned on the forward and rear mounting points.

   Tighten the fasteners.

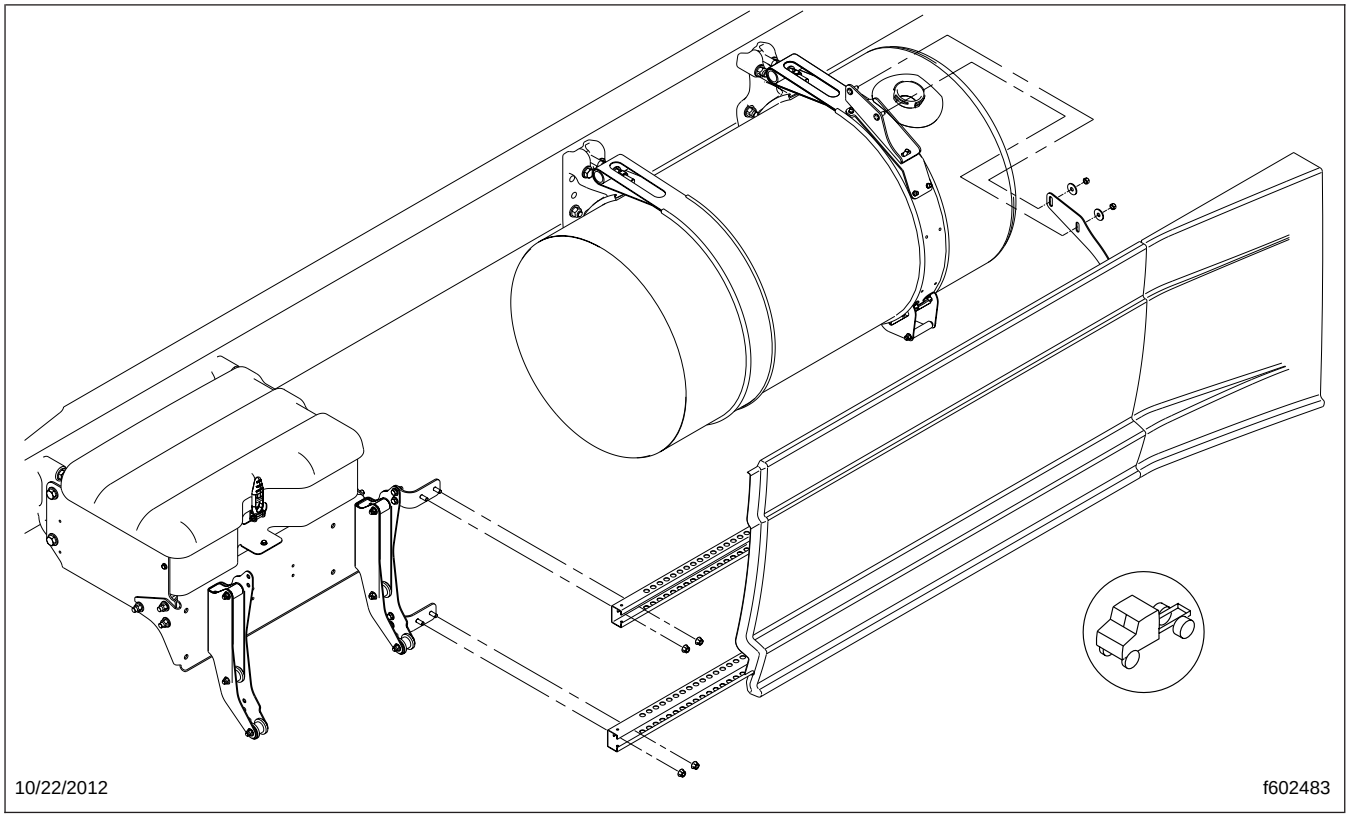
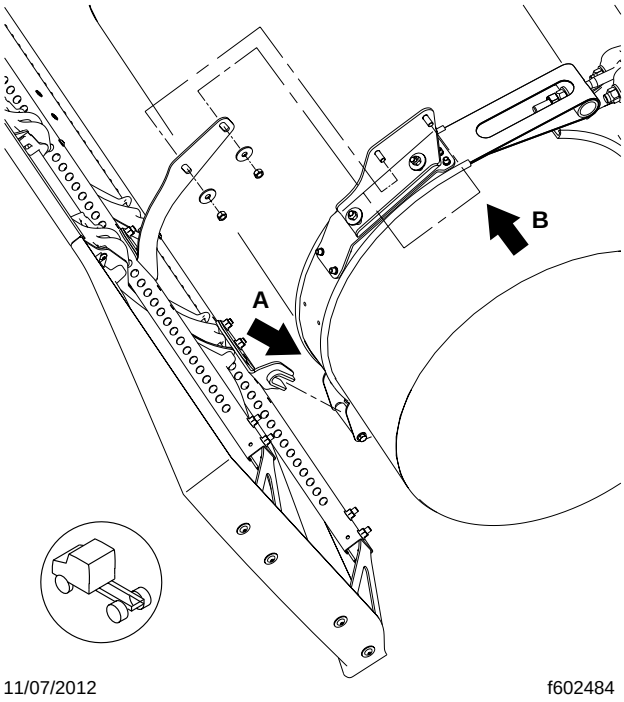


Fig. 1, Forward and Top Mount of Center Fairing, Fuel-Tank Mounted

Center Fairing Removal and Installation



A. Seat the support hook on the plastic sleeve bushing.
B. Move the fairing foward onto the mounting studs.

Fig. 2, Installing the Center Fairing, Rear Mounting, Fuel-Tank Mounted

3. Check the clearance along the length of the fairing. Use the slotted holes in the top-rear bracket to adjust as needed.
4. Install the four fasteners that attach the forward mounting area of the fairing support rails to the step support bracket.

Removal, Center Fairing Mounted to Frame Bracket

1. Remove the forward side-fairing (latched version) or panel (bolted version). For instructions, see **Subject 100**.
2. Support the center fairing.
3. Remove the four fasteners that attach the forward mounting area of the fairing support rails to the step support bracket. See **Fig. 3**.
4. Remove the fasteners at the top and bottom of the fairing where they attach to the frame bracket. See **Fig. 3**.

Installation, Center Fairing Mounted to Frame Bracket

1. Position and support the center fairing.
2. Install fasteners to attach the top and bottom of the center panel bracket to the frame bracket. Do not tighten the fasteners yet.
3. Install the four fasteners that attach the forward mounting area of the fairing support rails to the step support bracket. Ensure the panel is positioned properly before tightening the fasteners.

Center Fairing Removal and Installation

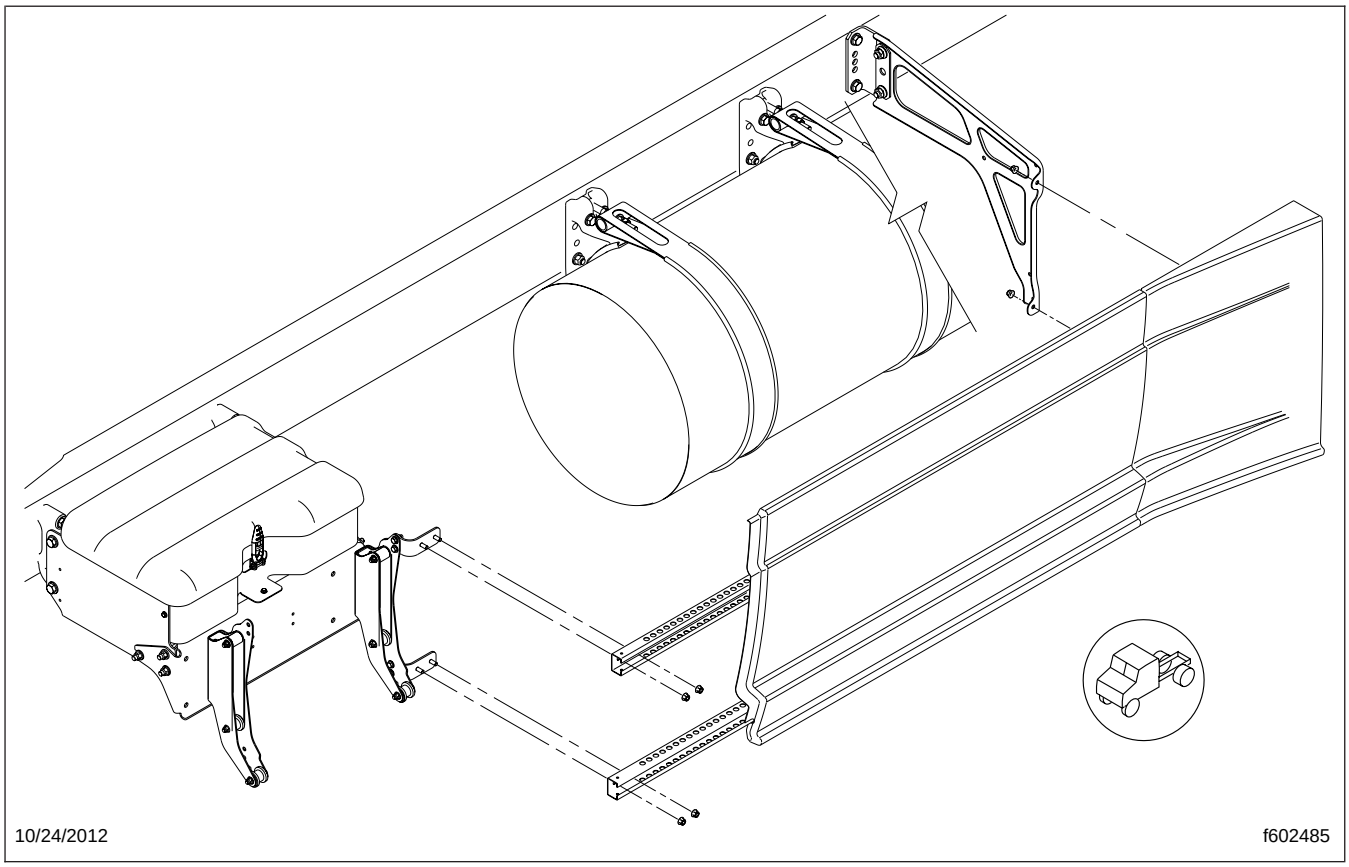


Fig. 3, Center Fairing, Frame-Mounted

Checking Panel Alignment

Included are dimensons for panel alignment and position. Panels out of alignment may indicate damage to the panels or their supports. See **Fig. 1** and **Fig. 2**.

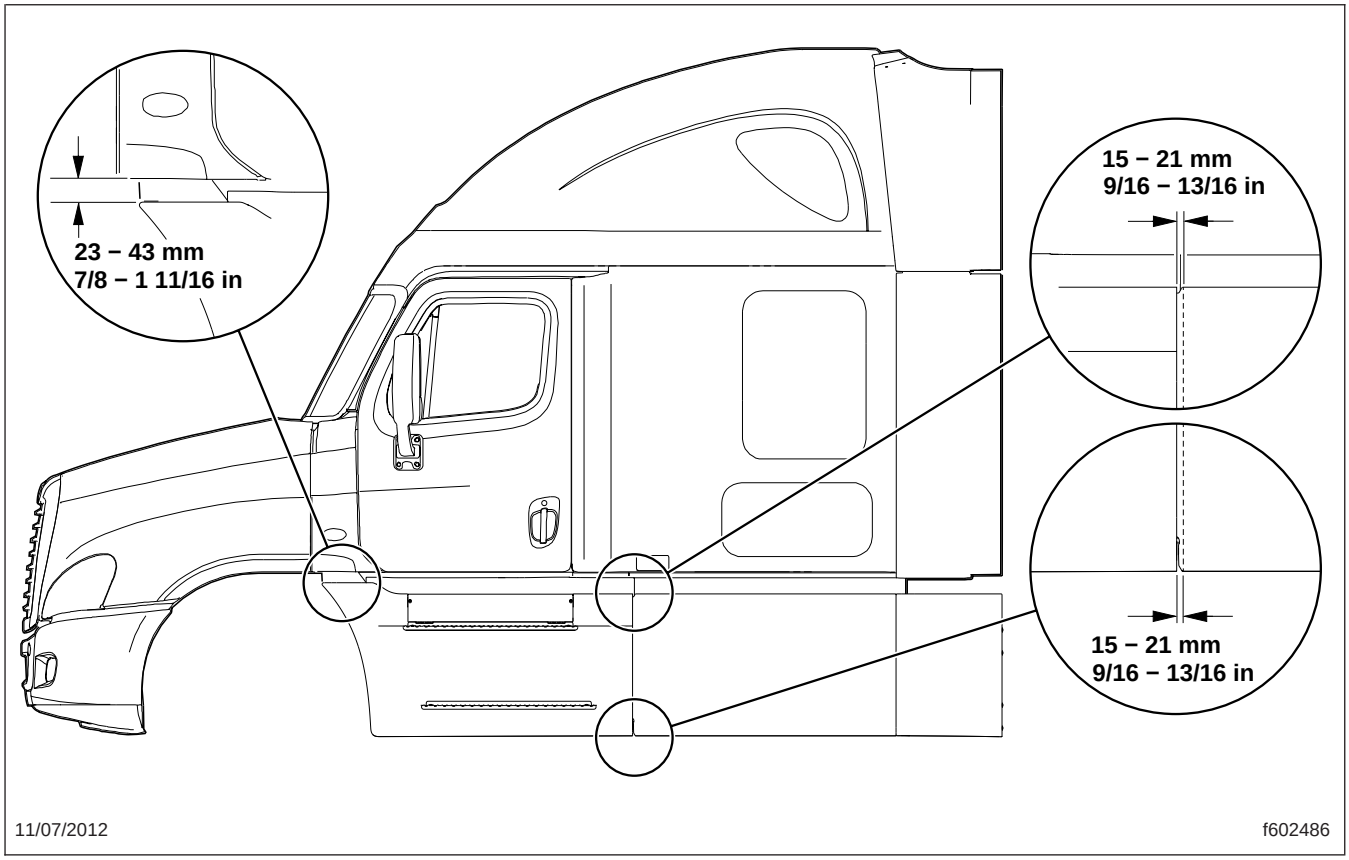


Fig. 1, Spacing Between Side Fairing Panels

Chassis Side Fairing Alignment

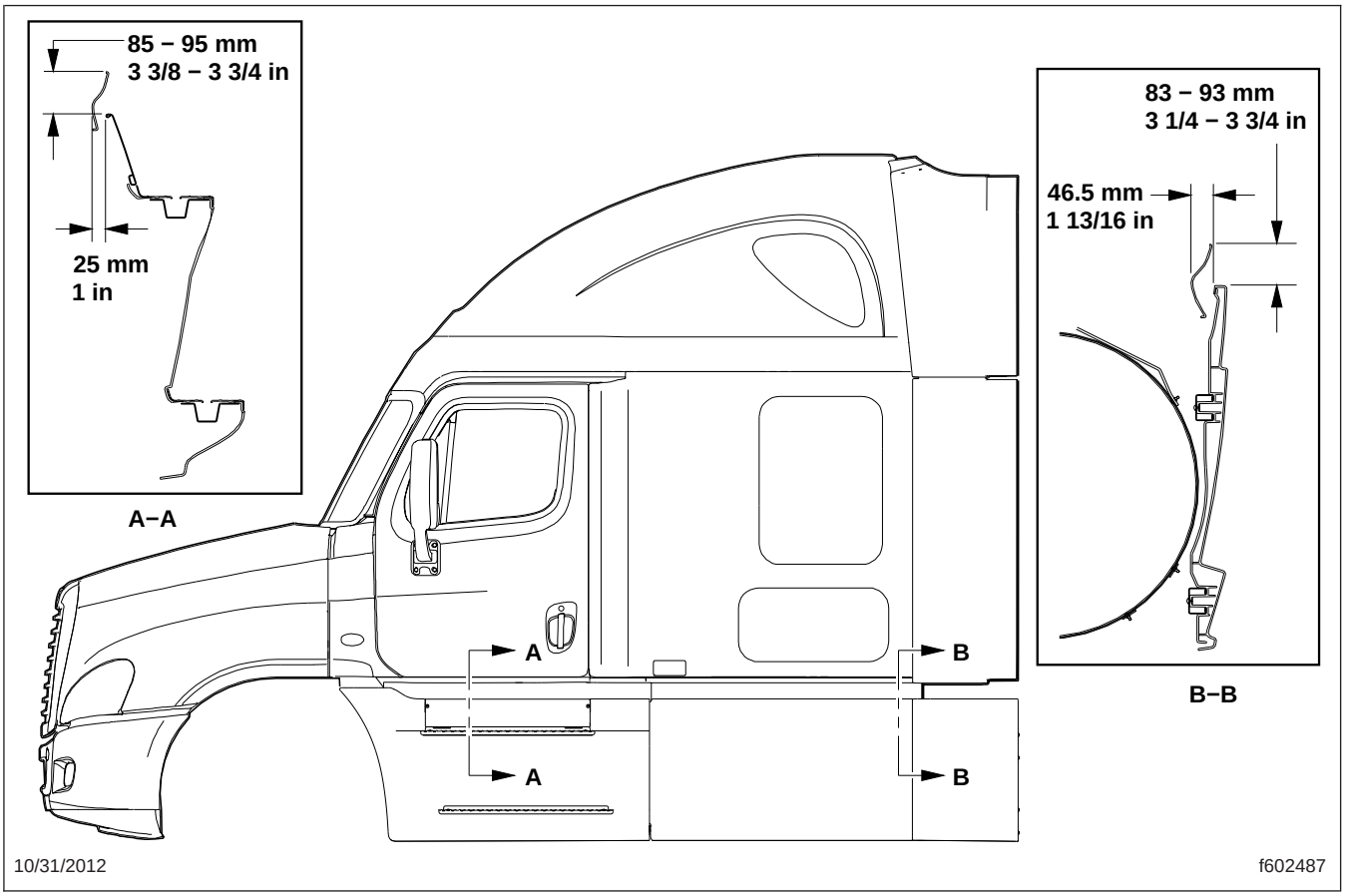


Fig. 2, Spacing Between Cab and Side Fairing Panels

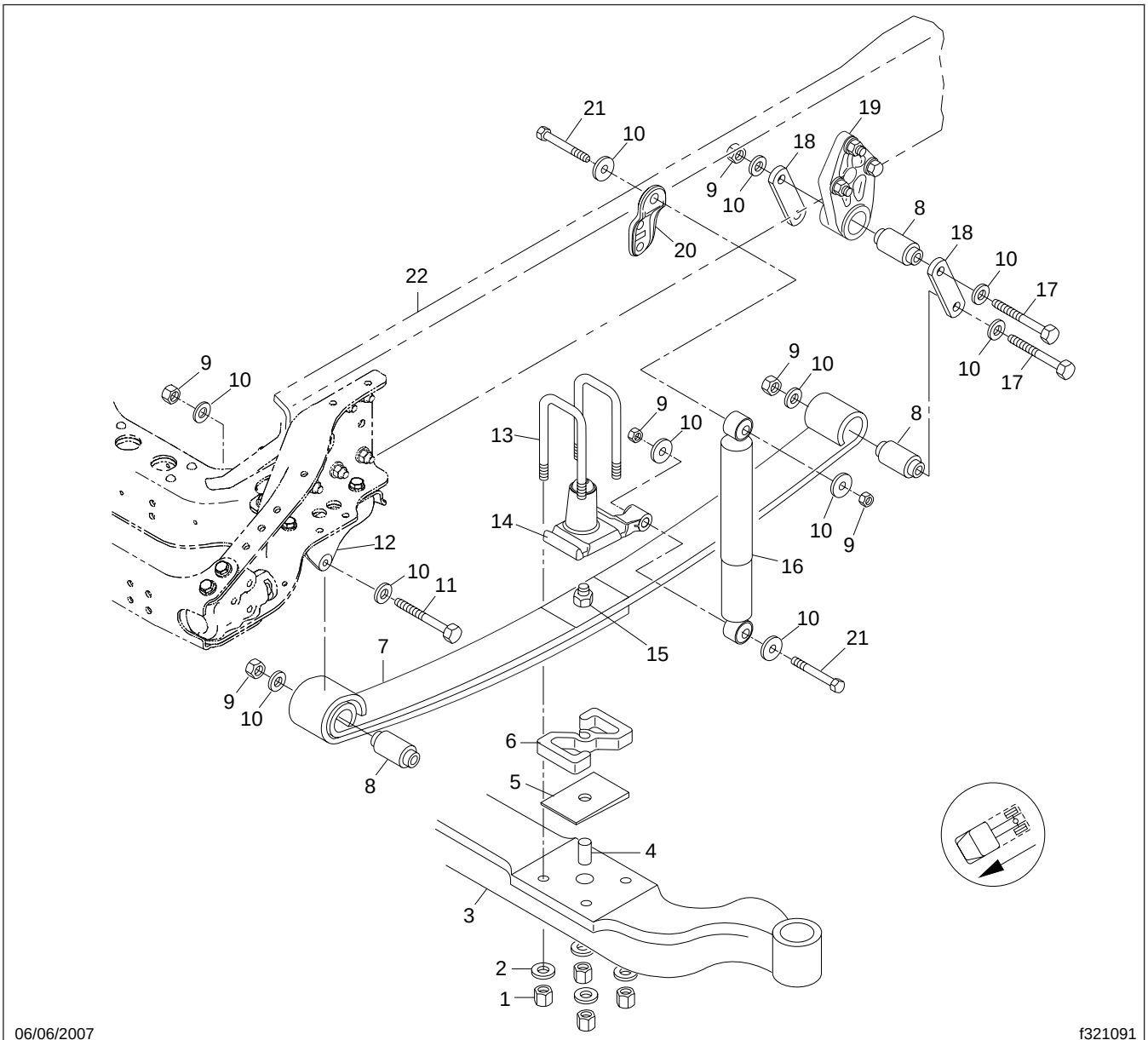
General Information

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.

General Information



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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. Rubber Bushing Assembly
9. Locknut, 3/4–10
10. Hardened Washer
11. Spring-Eye Bolt, 3/4–10
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 Mounting Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

Fig. 1, Front Suspension

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

Removal

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

1. Shut down the engine, apply the parking brakes, and chock the rear tires.

⚠ WARNING

Never work under a vehicle that is supported only by jacks. Jacks can slip, which can result in serious personal injury, death, or component damage. Always support the vehicle with safety stands capable of supporting the weight of the vehicle.

2. Raise the vehicle until both front tires are off the ground and the frame is supported with safety stands. If necessary, drain the air tanks, and remove the primary air tank to make room for the safety stand. The axle and leaf springs can now be manipulated with the floor jack.

IMPORTANT: Make sure the frame rails are level side-to-side and an equal distance off the ground.

NOTE: If necessary, remove the mud guards to access the shackles.

3. Using the floor jack, raise the axle just enough so the jack is supporting the weight of the axle, then support the axle with safety stands.
4. Remove the high nuts, U-bolts, axle-stop assembly, and spring liner (if equipped) from the spring.
5. Compress the shock absorber to prevent it from interfering with further work.
6. Remove the hexnuts from the spring-eye bolt and the shackle bolt that goes through the rear spring eye and shackle, then remove the bolts.
7. Remove the spring assembly by lifting it up off the axle and out the front of the vehicle. Note the taper direction of the caster shim so that it will not be reversed during installation.

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 any damaged parts.
3. Inspect the spring for cracks and corrosion. If any spring 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 accident 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 leaf spring.
5. Check the spring-eye bolt and shackle bolts for wear. Replace any bolt that shows wear, cracking, pitting, or other damage.
6. Inspect the spring and bracket bushings. Replace the bushings if gouged, cracked, pitted, or otherwise damaged. For instructions, see **Subject 110**.

Installation

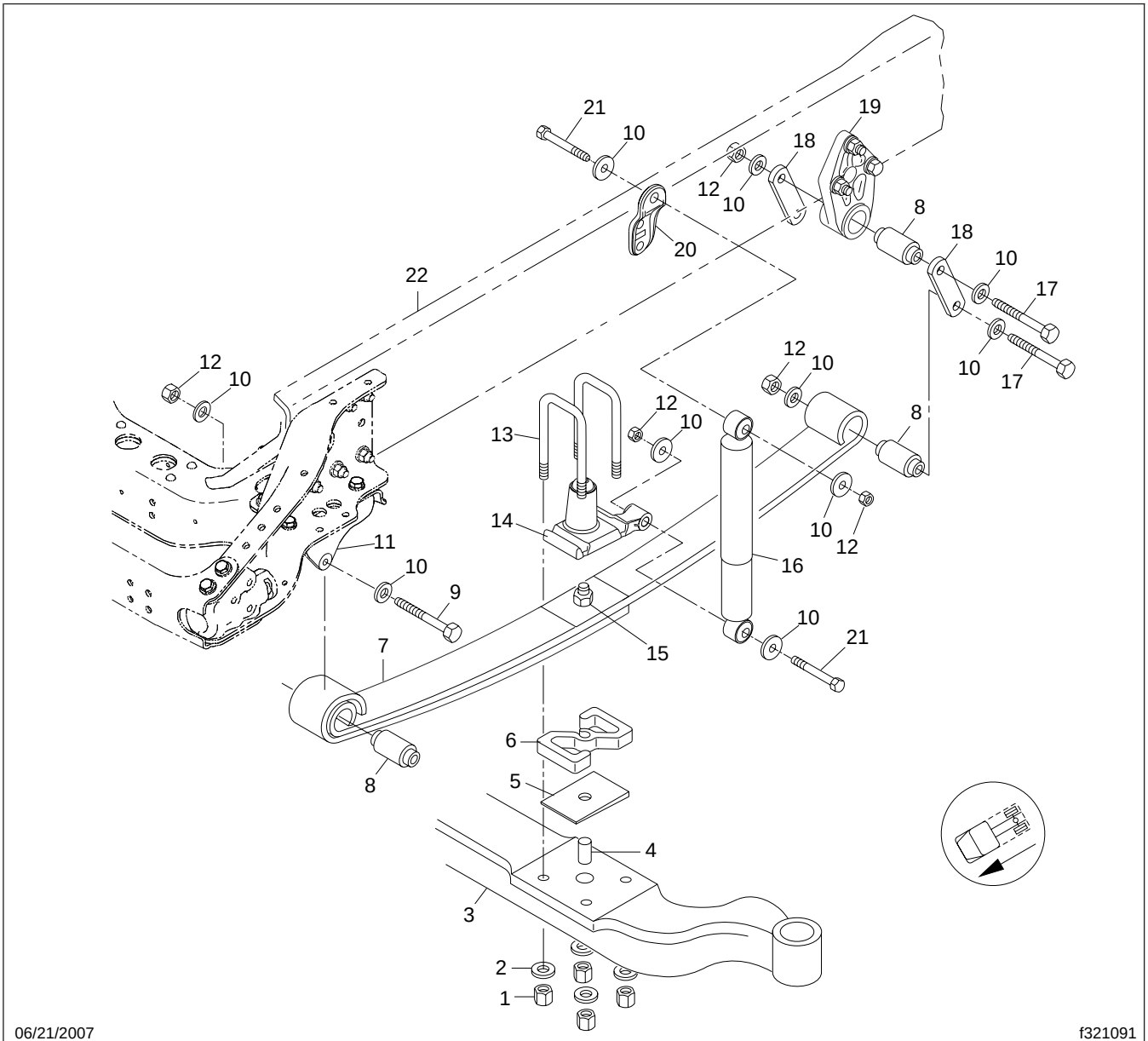
⚠ WARNING

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.

NOTE: Suspension bracket (frame) fasteners require periodic retorquing. Refer to **Group 31** in the *Cascadia Maintenance Manual* for instructions.

1. If the shackle was disconnected from the shackle bracket, attach it to the bracket, using the shackle bolt, hardened washers, and locknut.

Leaf Spring and Components Removal, Cleaning and Inspection, 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. Rubber Bushing Assembly
9. Spring-Eye Bolt, 3/4–10
10. Hardened Washer
11. Forward Spring Bracket
12. Locknut, 3/4–10
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 Mounting Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

Fig. 1, Front Suspension

Tighten the locknut just enough to hold the components together.

2. Place the caster shim on the front axle in the position referenced earlier.
3. Install the spring assembly on the caster shim; make sure the spring center-bolt head fits into the bore in the axle.
4. Place the axle-stop assembly and spring liner (if equipped) on top of the spring assembly.

IMPORTANT: Suspension U-bolts, washers, and high nuts cannot be reused; they must be replaced with new ones.

5. Place new 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.
6. Install new hardened washers and high nuts on the U-bolts. Tighten the nuts just enough to hold the components in place.
7. Using the spring-eye bolt, washers, and the locknut, attach the spring assembly to the forward frame bracket. Make sure the bolt head is outboard. Tighten the locknut finger-tight.
8. Using the shackle bolt, washers, and the locknut, attach the leaf spring assembly to the shackle bracket. Make sure the bolt head is outboard. Tighten finger-tight.
9. Tighten the locknuts on the spring-eye bolt and the shackle bolt 240 lbf·ft (325 N·m). If applicable, tighten the locknut on the upper shackle bolt 240 lbf·ft (325 N·m).
10. Tighten the U-bolt high nuts. For 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.

11. Raise the vehicle, remove the jack stands from the chassis, then lower the vehicle.
12. If it was removed, install the primary air tank and connect the air lines to it.
13. Remove the chocks.

Shackle-Bracket Bushing Replacement

The shackle bracket comes with the bushing already installed. If the shackle-bracket bushing needs replacement, replace the entire shackle bracket and bushing as a unit.

1. Remove the shackle bracket from the frame rail.

IMPORTANT: The shackle bracket has one common fastener with the rear engine mount. In order to remove the upper fastener for the shackle bracket, you must also remove the rear engine mount. It is not possible to access the upper shackle-bracket fastener without doing this. Refer to the procedure in **Group 01** to remove the rear engine mount.

2. Check the shackle bolt for ease of fit in the bushing. It should have an easy slip fit without wobble between it and the bushing.
3. Check the shackle 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.

CAUTION

Failure to apply Alumilastic or similar compound will result in electrolytic corrosion of dissimilar metal components, and will damage the suspension system.

4. Install the shackle bracket. Refer to **Group 01** for instructions on installing the rear engine mount and the torque value for the common fastener for the engine mount and the shackle bracket.

   Apply Alumilastic® or similar compound to all areas of the aluminum shackle bracket that contact the frame rail. This includes the fasteners that contact the shackle bracket. Do not apply the compound to the fastener threads.

Spring-Eye Bushing Replacement

1. Remove the leaf spring. See **Subject 100** for instructions.
2. Press out the worn or damaged bushing(s).

CAUTION

Do not press in the bushing by the center sleeve. To do so could damage the bushing.

3. Apply a coating of Perma-Bond® HM–160 or Loctite® RC–609 adhesive to the inside of the spring eye(s), and to the outside of the rubber bushing(s). Press the new bushing(s) into the spring eye(s) until flush with the edges of the spring eye(s).
4. Install the leaf spring. See **Subject 100** for instructions.

Replacement

1. Remove the 3/4–10 hexbolt, hardened washers, and locknut from the shock absorber and the upper mounting bracket.
2. Swing the shock absorber down away from the upper mounting bracket.
3. Remove the 3/4–10 hexbolt, hardened washers, and locknut from the shock absorber and the lower mounting bracket.
4. Remove the shock absorber.
5. Align the upper eye of the shock absorber with the hole of the upper mounting bracket.
6. Install a hardened washer and the 3/4–10 hexbolt through the mounting hole and the eye of the shock absorber. Make sure the hexbolt head is facing inboard.
7. Install a washer and 3/4–10 locknut on the hexbolt. Tighten 140 lbf·ft (190 N·m).
8. Align the lower eye of the shock absorber with the holes in the lower mounting bracket.
9. Install a hardened washer and the 3/4–10 hexbolt through the the eye of the shock absorber and the holes of the lower mounting bracket. Make sure the hexbolt head is facing outboard.
10. Install a washer and 3/4–10 locknut on the hexbolt. Tighten 140 lbf·ft (190 N·m).

Vehicle Lean Inspection

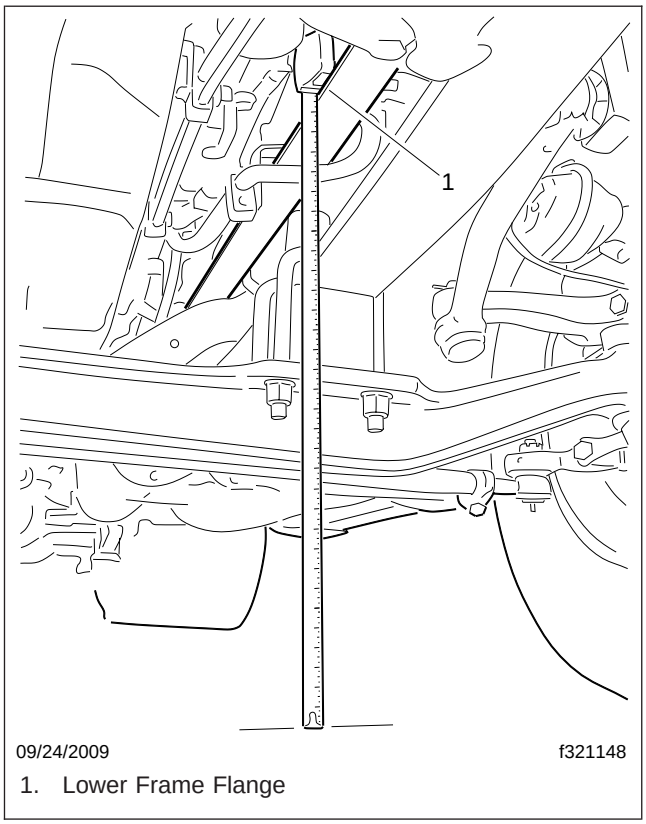
IMPORTANT: Chassis lean can be caused by several factors such as uneven vehicle weight distribution, mismatched springs, or improper spacer installation. The following instructions detail inspecting for and correcting chassis lean due to improper spring or spacer installation. Additional troubleshooting 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

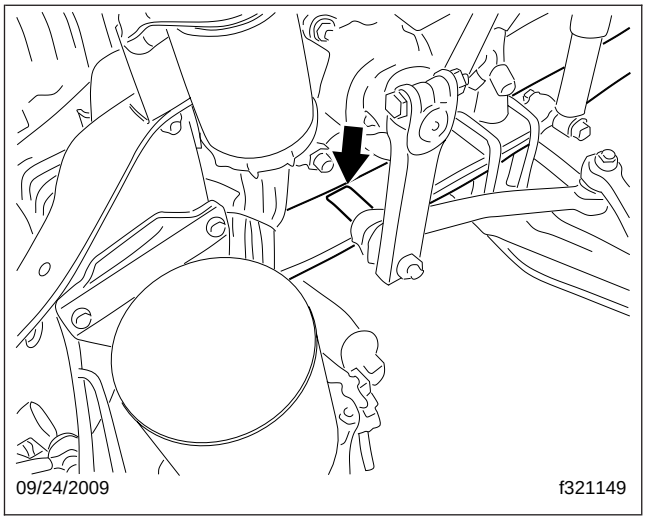


Fig. 2, Spring Label Location

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

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.

Parts Information		
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.

Problem—Frequent Spring Breakage	
Possible Cause	**Remedy**
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**.
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

Specifications

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

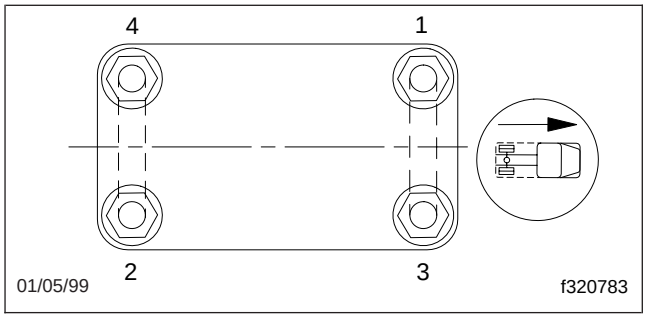


Fig. 1, Tightening Pattern for U-bolt High Nuts

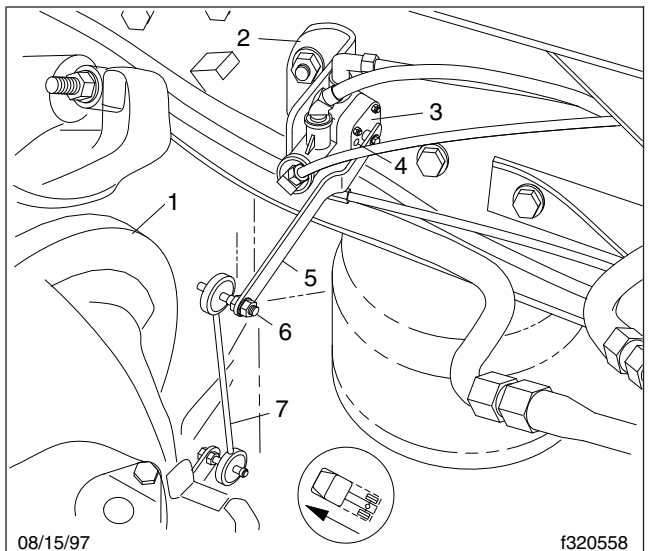
General Information

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.

The 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: This adjustment procedure is for height-control valves only, not height sensors as equipped on vehicles with Electronically Controlled Air Suspension (ECAS). For more information on ECAS ride height adjustment, see "ECAS Ride Height Adjustment" in this Subject.

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 labeled the "E" dimension; the target ride height should be in a table on the same page of the drawing.
5. Measure the distance between either forward-most 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.
7. Disconnect the height-control valve linkage at the lever stud. (For dual valves, disconnect both.)
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**.

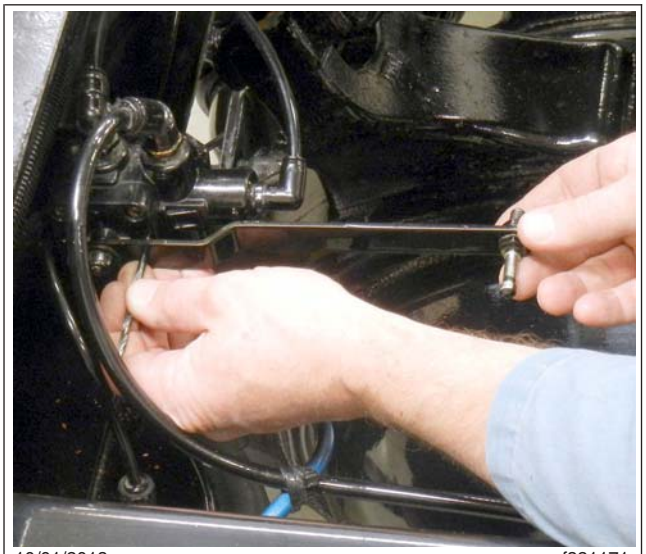

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Fig. 1, Inserting a 5/32-inch drill bit or nylon rod to lock the lever in neutral position.

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.)

Ride Height Adjustment

12. Move the lever to neutral and pin. (For dual valves, pin both.) The vehicle should now be at the target ride height.

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.

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**. (For dual valves, loosen both valves.)

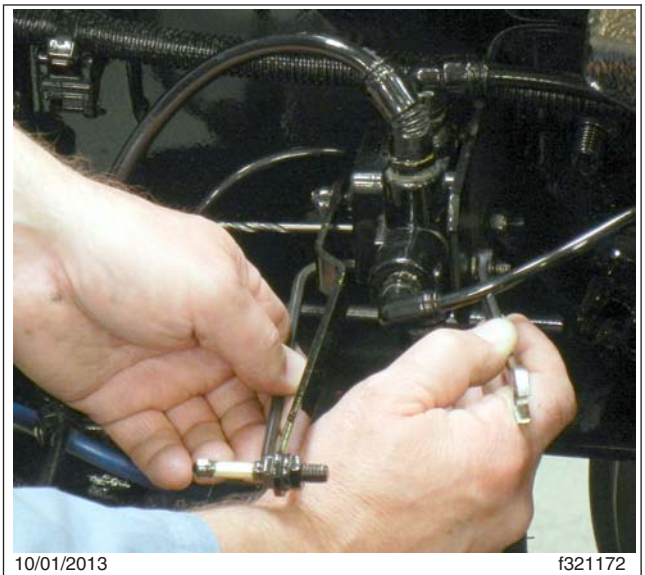


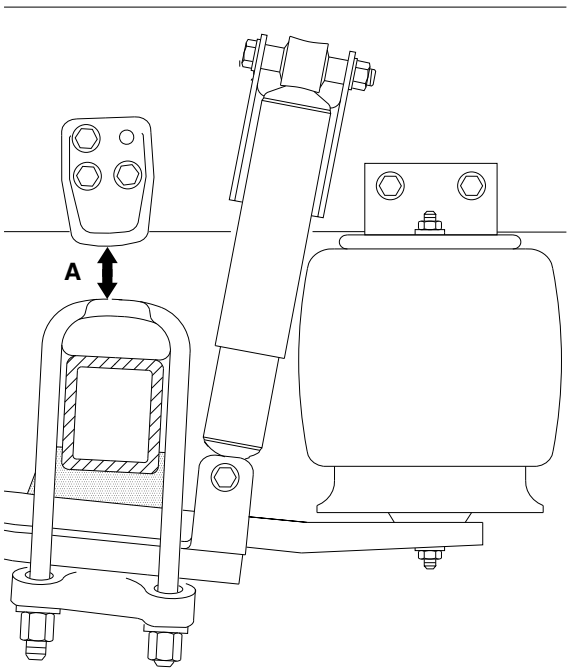
Fig. 2, Holding the height control valve mounting stud in place with an Allen wrench when loosening the nut.

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. (For dual valves, tighten both.)
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 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.
21. Check the ride height of the vehicle again, measuring where indicated in the drawing or figure for the suspension.

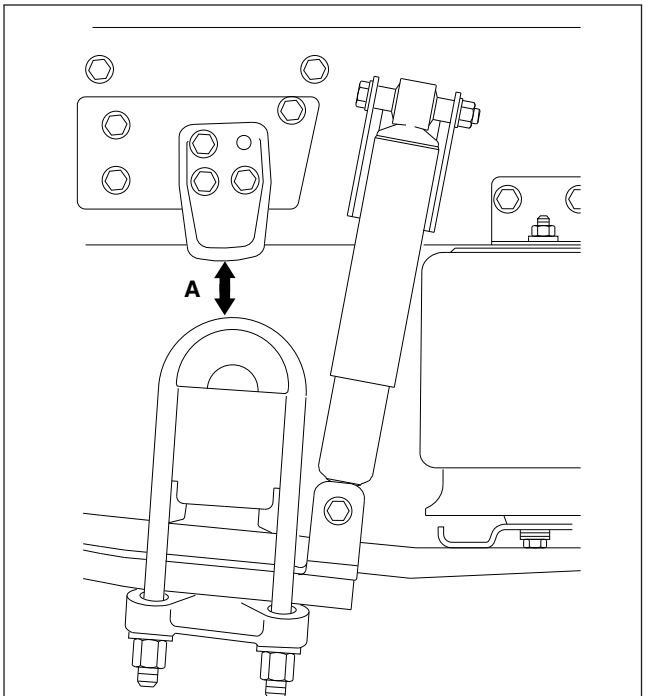
    If the distance is within the acceptable range, the ride height is correctly set. Apply the parking brakes.

    If the distance is not within the acceptable range, repeat the adjustment procedure.



Measure Point	Height Measurement (A) Inches (mm)		
	Min.	Target	Max.
A = Measure Here	2-3/8 (60)	2-5/8 (67)	2-7/8 (73)

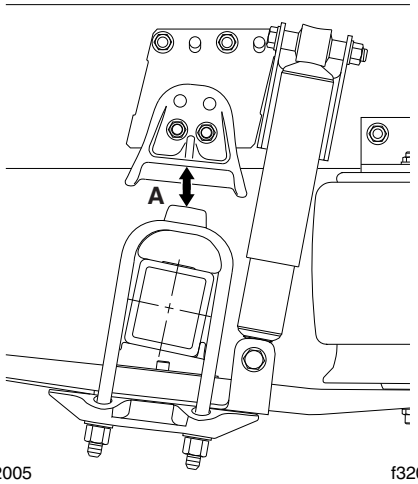
Table 1, Suspension Ride-Height Measurement, Dual-Leaf Spring, 20k/21k/22k/40k High-Ride



Measure Point	Height Measurement (A) Inches (mm)		
	Min.	Target	Max
A = Measure Here	2-3/4 (70)	3 (76)	3-1/4 (83)

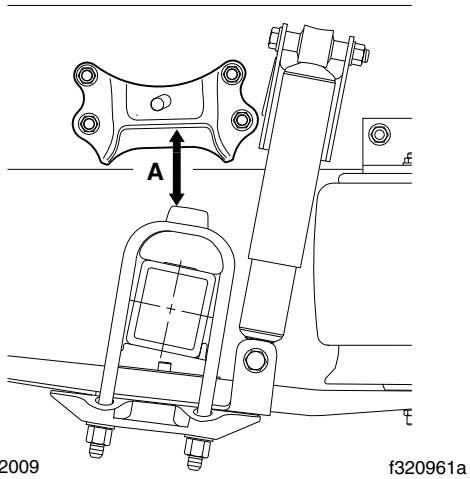
Table 2, Suspension Ride-Height Measurement, Dual-Leaf Spring, 23k/46k/69k High-Ride

Ride Height Adjustment



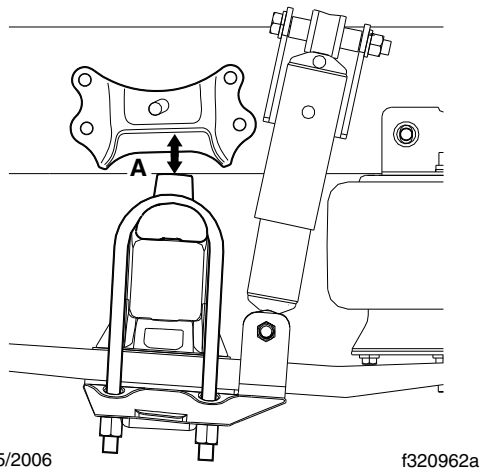
Measure Point	Height Measurement (A) Inches (mm)		
	Min.	Target	Max.
A = Measure Here	2-3/8 (60)	2-5/8 (67)	2-7/8 (73)

Table 3, Suspension Ride-Height Measurement, Single-Leaf Spring, 20k/40k, High-Ride Height



Measure Point	Height Measurement (A) Inches (mm)		
	Min.	Target	Max.
A = Measure Here	2-3/8 (60)	2-1/2 (64)	2-7/8 (73)

Table 4, Suspension Ride-Height Measurement, Single-Leaf Spring, 10k/12k/15k/18k Mid-Ride Height and 40k Low- and Mid-Ride Height



Measure Point	Height Measurement (A) Inches (mm)		
	Min.	Target	Max.
A = Measure Here	2-1/8 (54)	2-9/32 (58)	2-5/8 (67)

Table 5, Suspension Ride-Height Measurement, Single-Leaf Spring, 10k/12k/15k Low or Extra-Low Ride-Height

Electronically Controlled Air Suspension (ECAS) Ride Height Adjustment

On vehicles equipped with MeritorWabco ECAS, the height-control sensor is adjusted differently from typical height-control valve installations. The vehicle ride height can only be set using MeritorWabco Toolbox software to run a calibration procedure for the ECAS system. For the calibration procedure, contact MeritorWabco OnTrac support.

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 Cascadia 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.

NOTICE

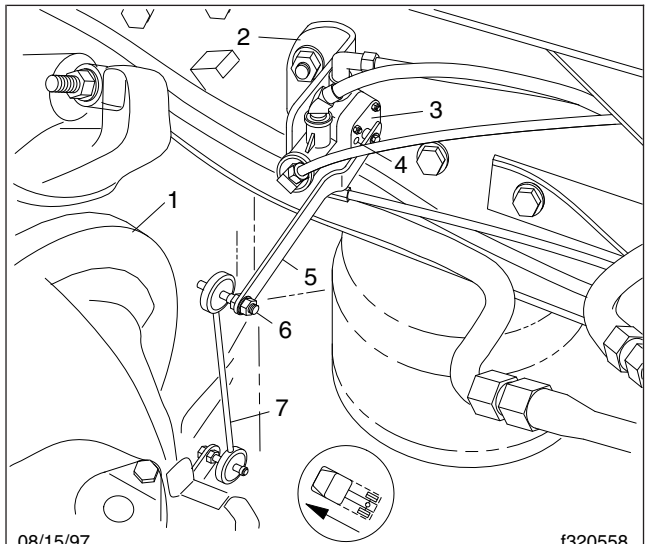
When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening 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. Linkage Rod

Fig. 1, 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 110**. 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 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 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.

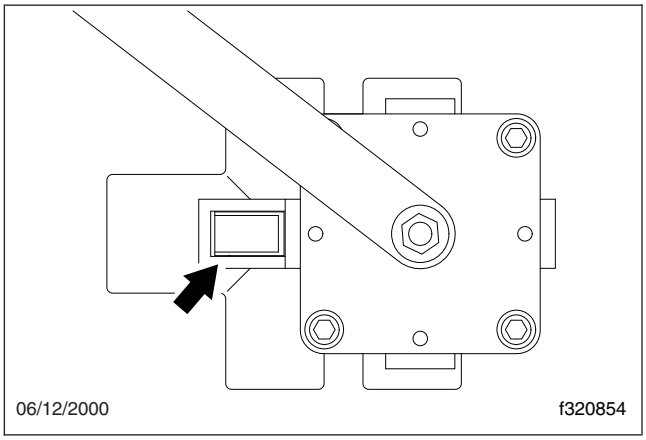
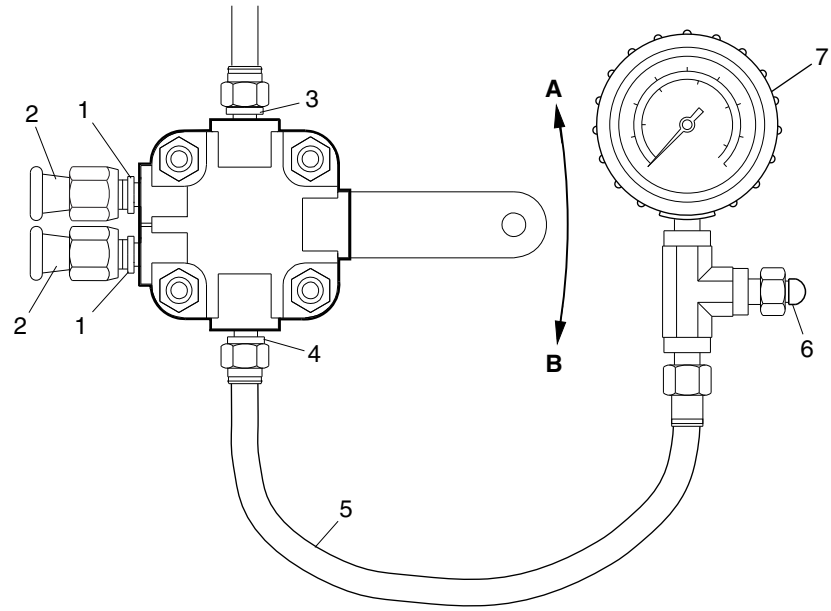


Fig. 2, Exhaust Flap Location (height-control valve with integral dump port)

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

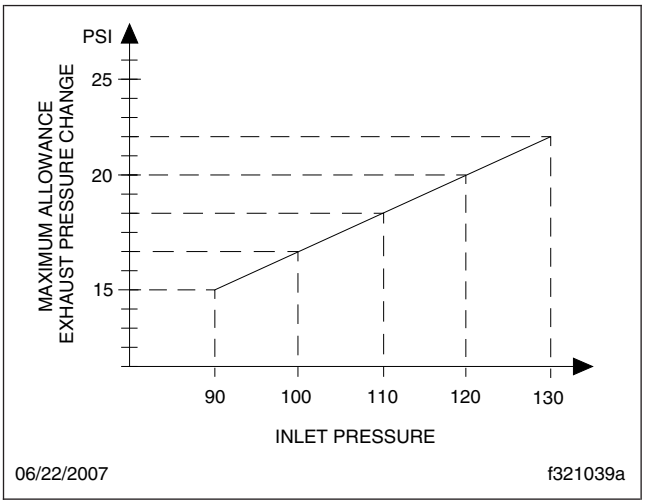


Fig. 4, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

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 120**.
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.

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 all air from the air tanks.

⚠ WARNING

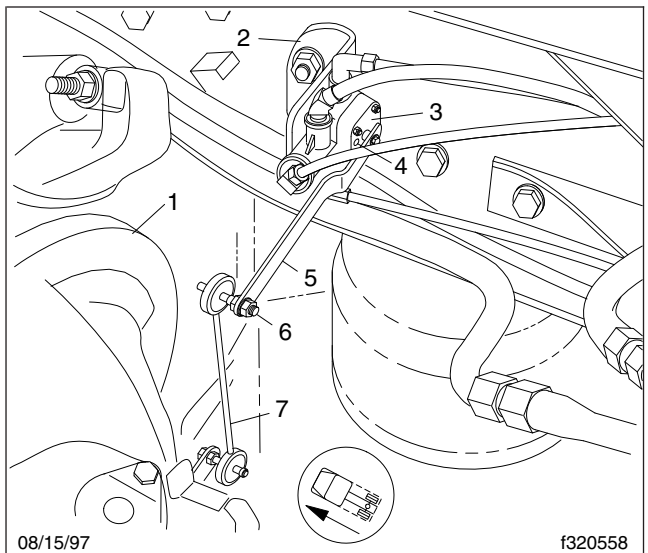
Air lines under pressure can whip dangerously if disconnected. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

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.

NOTICE

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. 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, Height-Control Valve Installation

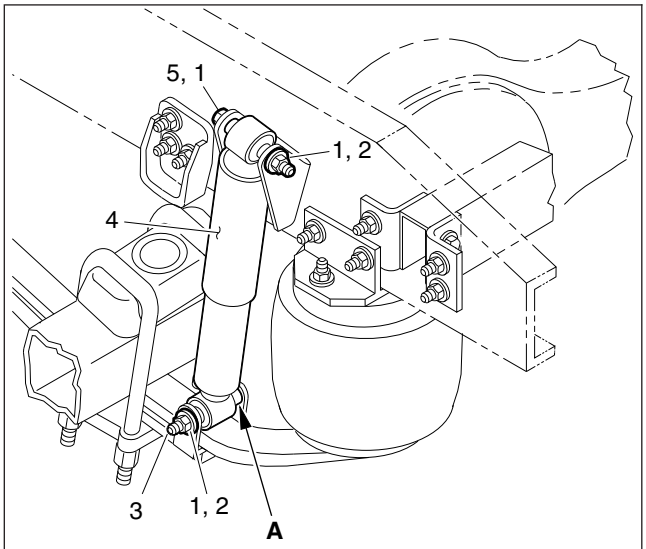
6. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
7. Position the new height-control valve on the height-control bracket. While holding the height-control 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. 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.

Height-Control Valve Replacement

9. Connect the vertical linkage to the horizontal control lever.
10. Close the drain cocks on all reservoirs.
11. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
12. Adjust the height-control valve; see **Subject 110**.

Replacement

1. Chock the tires.
2. Remove the hexnut, hexbolt, and hardened washers from the shock-absorber lower mounting bracket. See **Fig. 1**.



A. Longer Section of Sleeve Facing Inboard

1. Hardened Washer
2. Hexnut, 3/4–10
3. Hexbolt, 3/4–10 x 5
4. Shock Absorber
5. Hexbolt, 3/4–10 x 6

Fig. 1, Shock Absorber Installation

3. Remove the nut, upper retainer, and upper bushing from the top of the shock absorber, then pull the shock absorber out of the upper mounting bracket,
4. Install the replacement shock absorber. At the lower mounting, make sure the longer section of the sleeve is facing inboard. See **Fig. 1**.
5. Tighten the shock-absorber mounting hexnuts 165 lbf·ft (220 N·m).

Replacement

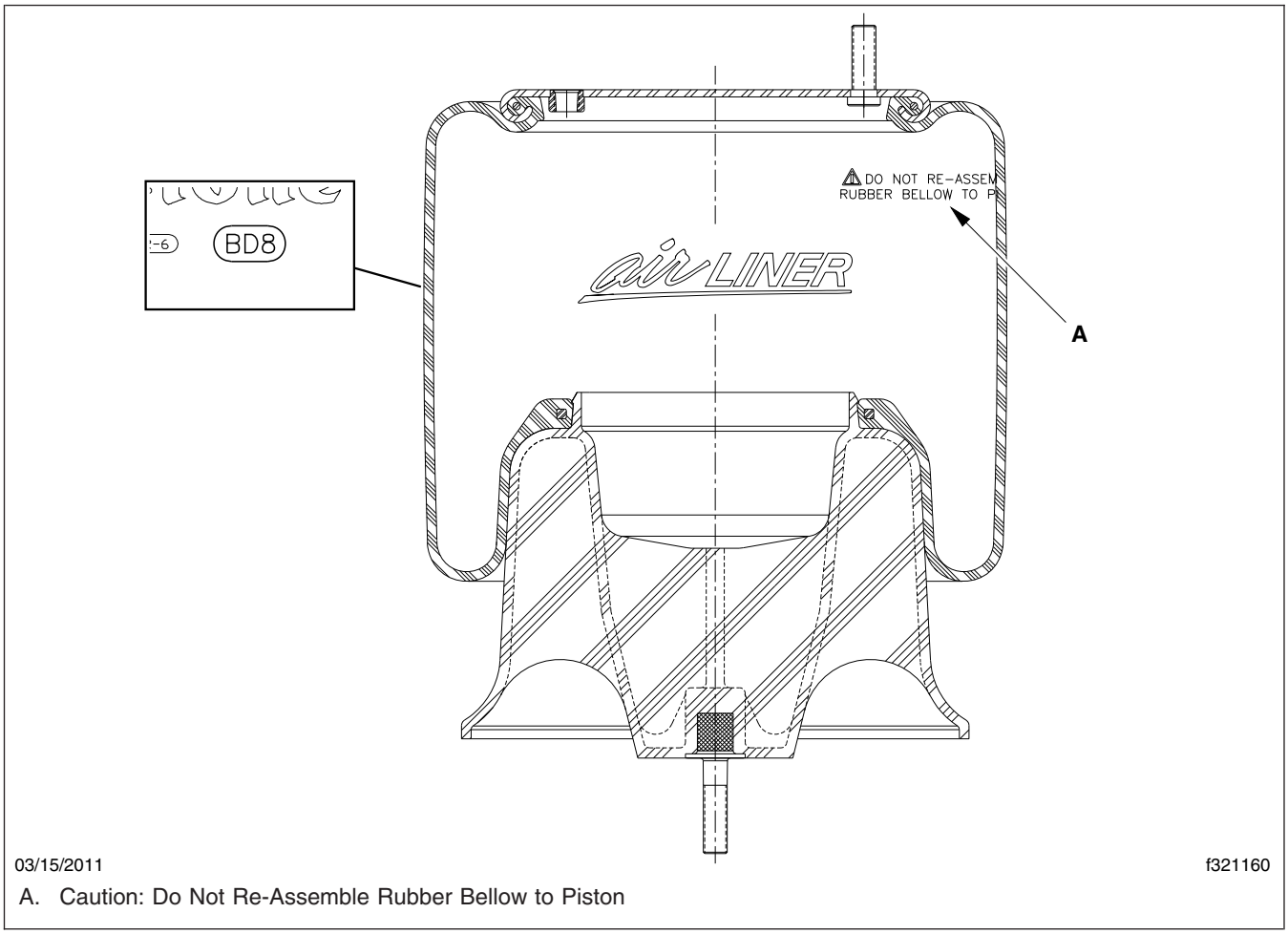
IMPORTANT: Effective March 2011, the steel bead on the inside of the air bag where it attaches to the piston, changed to a square bead to increase the pull-off force between the air bag and piston. The new air bag is stamped “BD8” and “Do Not Re-Assemble Rubber Bellow to Piston.” See **Fig. 1**. With 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.

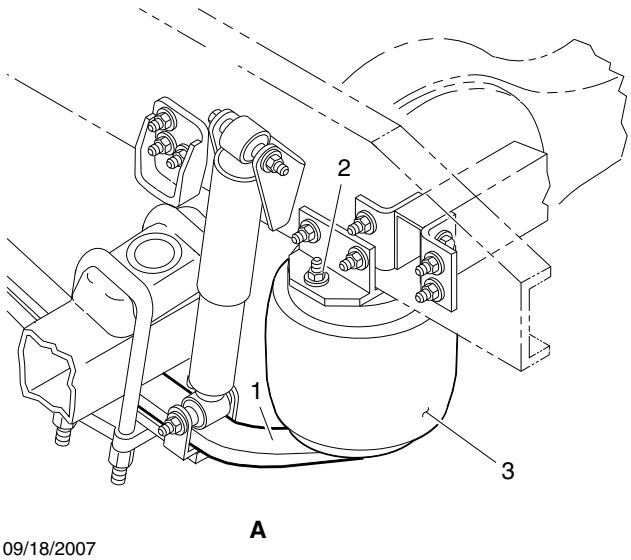
1. Apply the parking brakes and chock the tires.
2. Raise the vehicle frame and support it with safety stands to remove all weight from the air springs. The height-control valve automatically releases air from the air springs when all weight is removed from the suspension.
3. Disconnect the air supply 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.
4. Remove the locknut and washer that hold the top of the air spring to the mounting bracket on the frame rail; see **Fig. 2**.
5. Remove the locknut and lockwasher that connect the air spring to the rear of the leaf spring, or the crossbar, as applicable. Remove the air spring.
6. Place the new air spring on the rear of the leaf spring (or the crossbar on the 23,000- and 46,000-pound suspensions), and install the washers and locknut that hold the air spring (and crossbar) in place. Tighten the locknut 55 lbf·ft (75 N·m).
7. Using a 1/2–13 locknut and washer, attach the top of the air spring to the mounting bracket on the frame. Tighten it 23 lbf·ft (31 N·m).
8. 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.
9. Raise the vehicle, remove the safety stands, then lower the vehicle.

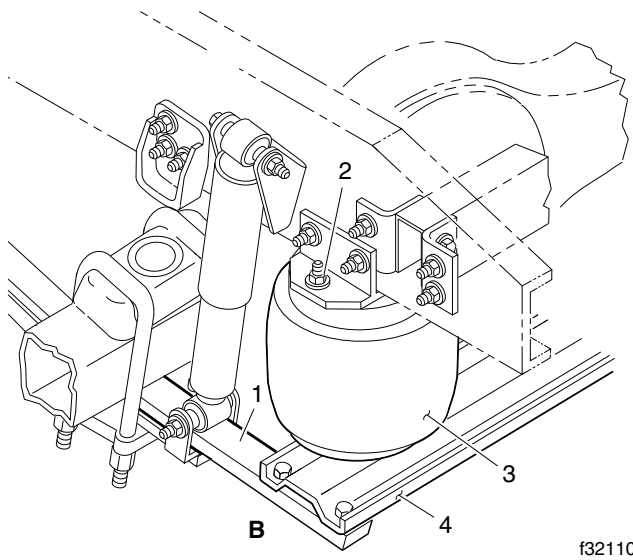
Air Spring Replacement



A. Caution: Do Not Re-Assemble Rubber Bellow to Piston

Fig. 1, Air-Spring and Piston Assembly





A. 21,000- and 40,000-lb Suspensions

1. Leaf Spring
2. Air Bag Upper Mounting Hexnut, 1/2–13

B. 23,000- and 46,000-lb Suspensions

3. Air Spring
4. Crossbar

Fig. 2, AirLiner Rear Suspension

Leaf Spring 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. 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.
4. Note and record the direction of the arrow on the bottom of the axle clamp. Remove the high nuts and flatwashers from each U-bolt, then the axle clamp. Support the leaf spring assembly with a jack. See **Fig. 1**
5. 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 crossbar, disconnect the crossbar from the leaf spring by removing the capscrews, nuts, and washers. See **Fig. 2**.
6. Note the number and position of the alignment shims on the spring mounting bolt. See **Fig. 1**.
7. Remove the hexnut, washers, alignment shim(s), spring mounting bolt, and wear-shoe clip from the spring hanger. See **Fig. 1**.

WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

8. Remove and discard the leaf spring assembly.
9. 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.
10. 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 crossbar, attach the crossbar to the leaf spring assembly. The longer capscrews attach in the forwardmost holes; the shorter capscrews attach in the aft holes.
11. 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. Install the axle clamps with the arrows pointing in the same direction as previously recorded.

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, make sure that the axle bump-stop on the U-bolt pad is positioned toward the vehicle centerline. See **Fig. 4**.

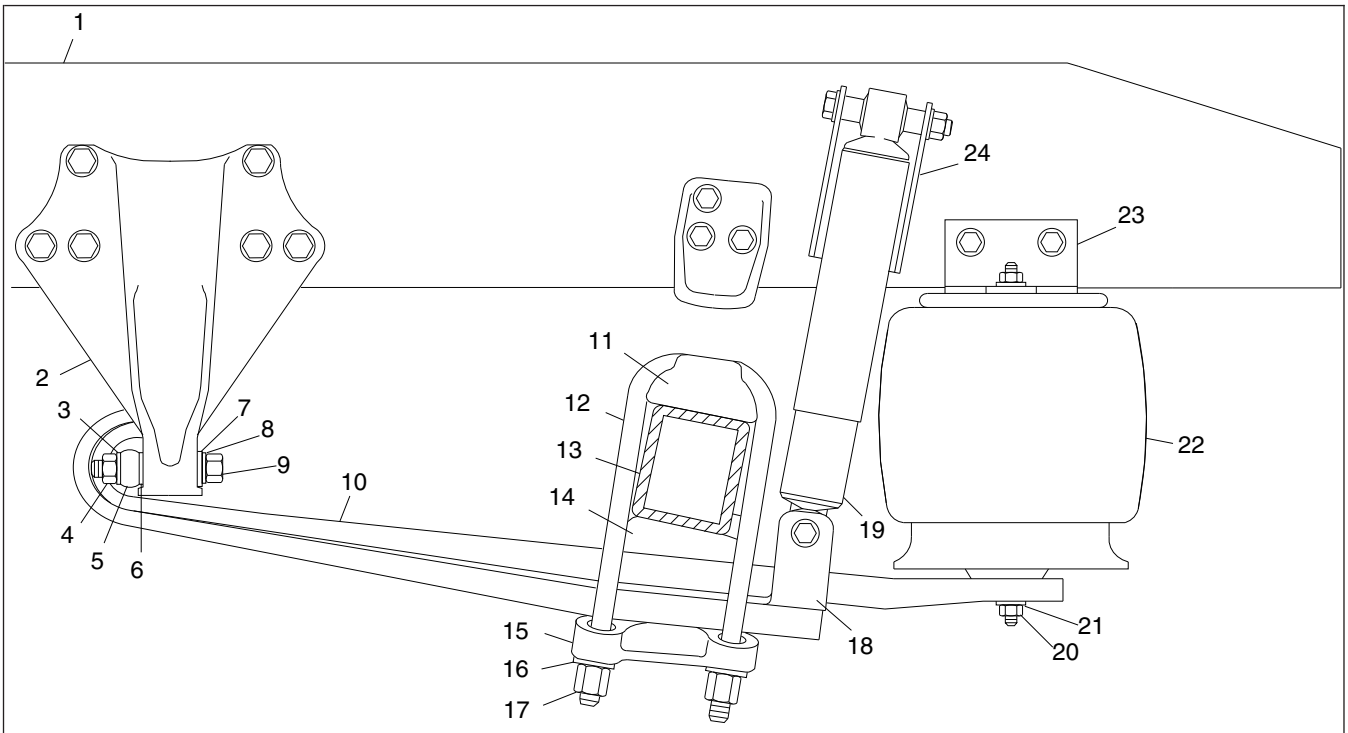
On tandem axle suspensions, refer to **Table 1** for U-bolt pad orientation.

12. 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, tighten to a final torque value of 420 to 500 lbf·ft (571 to 680 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).
13. Using the bolt, washers, and hexnut, attach the shock absorber to its lower mounting bracket. Tighten the hexnut 165 lbf·ft (220 N·m).
14. 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 crossbar 241 lbf·ft (327 N·m).
15. Tighten the hexnuts at the front of the leaf spring 170 lbf·ft (230 N·m).

Leaf Spring Replacement



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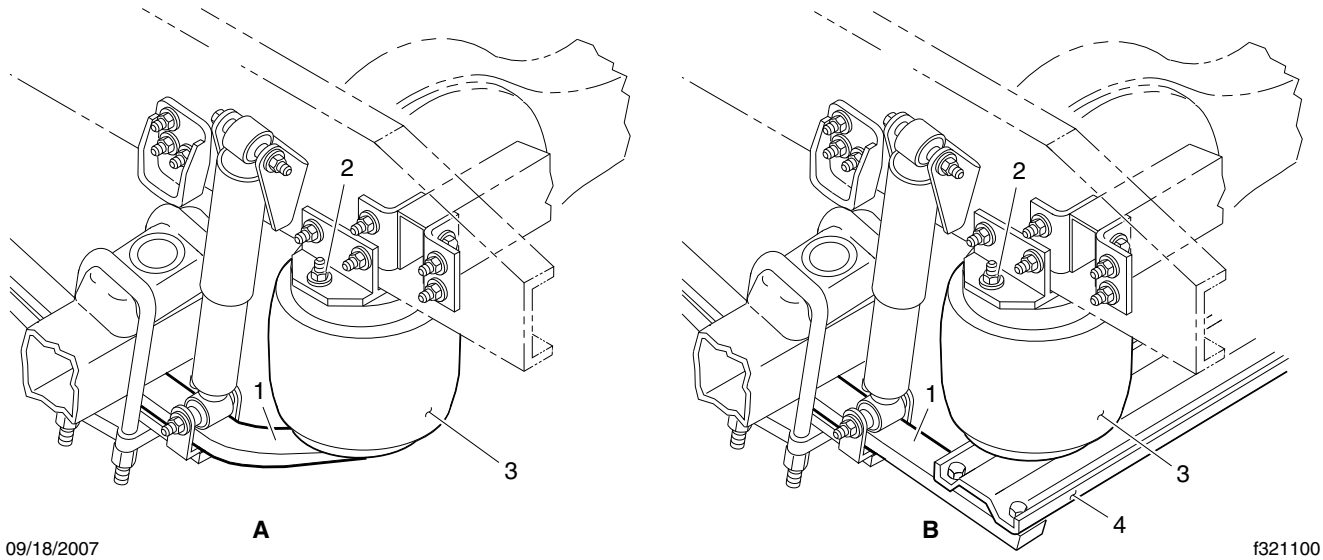
1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring-Eye Mounting Pin
6. Alignment Shim
7. Wear-Shoe Clip
8. Washer
9. Spring Mounting Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock-Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air-Spring Mounting Bracket
24. Shock-Absorber Upper Mounting Bracket

Fig. 1, AirLiner Leaf Spring Assembly

16. Install the wheel and tire assembly. For instructions, refer to **Group 40**.
17. Raise the vehicle, remove the safety stands, then lower the vehicle.
18. Check the rear axle alignment. For instructions, refer to **Group 33**. If necessary, adjust the rear axle alignment using the instructions in **Subject 180**.



A. 21,000- and 40,000-lb Suspensions

1. Leaf Spring
2. Air Bag Upper Mounting Hexnut

B. 23,000- and 46,000-lb Suspensions

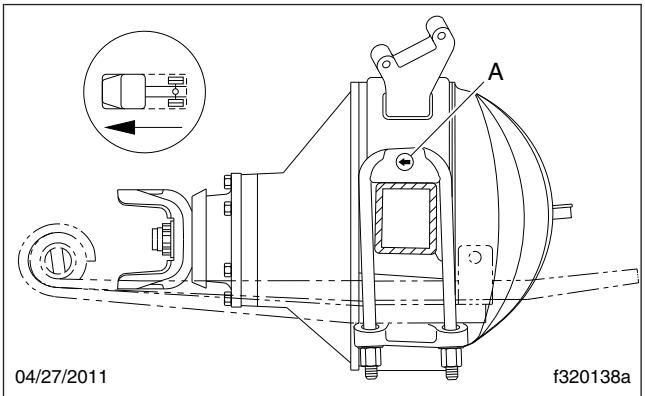
3. Air Spring
4. Crossbar

Fig. 2, Leaf Spring and Air Spring Assembly

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.

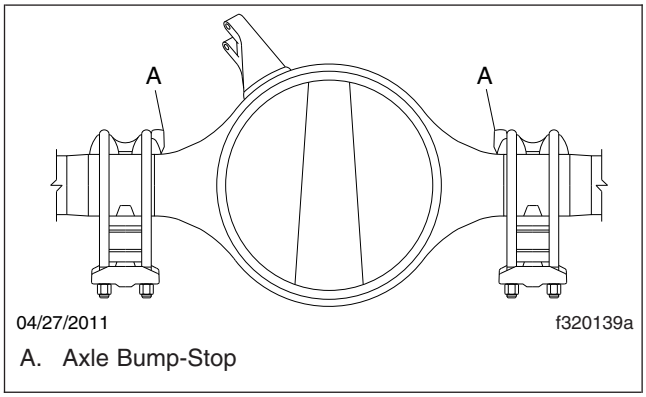
Table 1, U-Bolt Pad Orientation for Axles

Leaf Spring Replacement



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

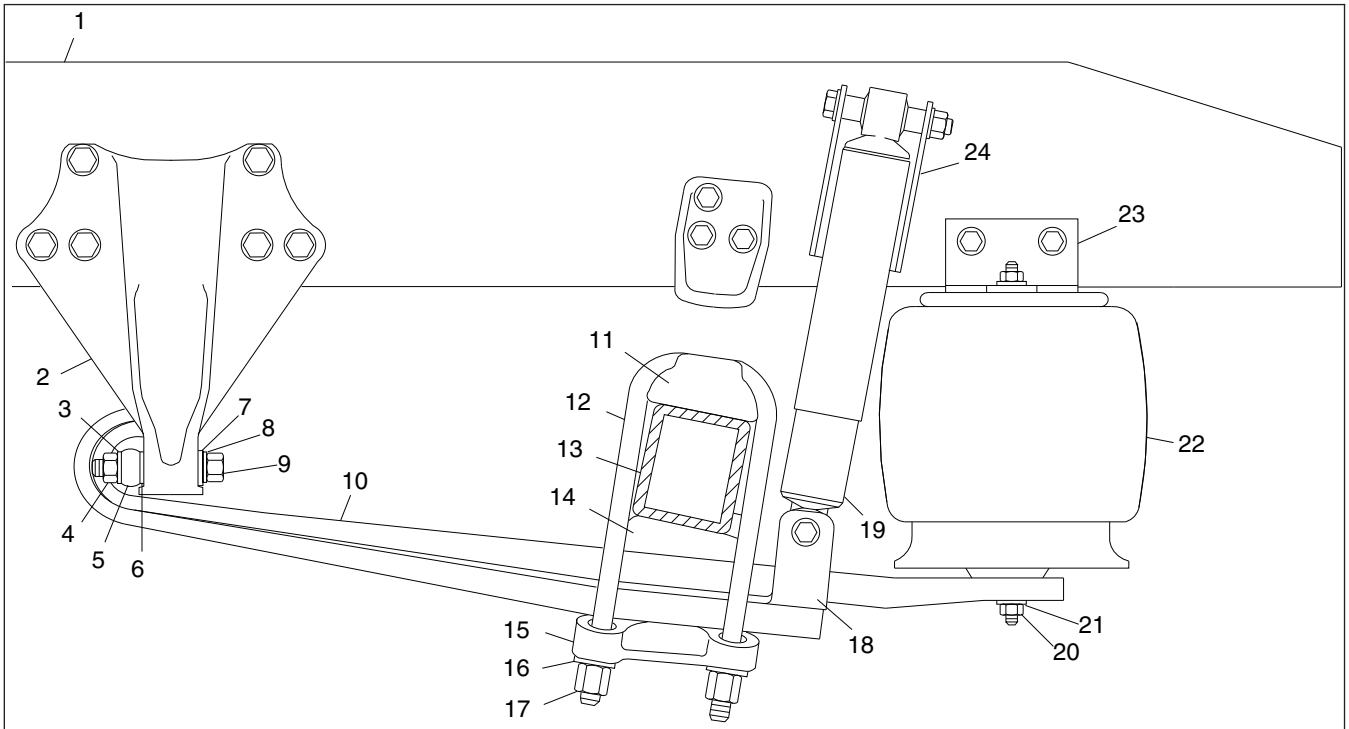
NOTE: See **Fig. 1** for this procedure.

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:

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**.
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 each pinch bolt. The pinch bolts must be shimmed equally.

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.



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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

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**.

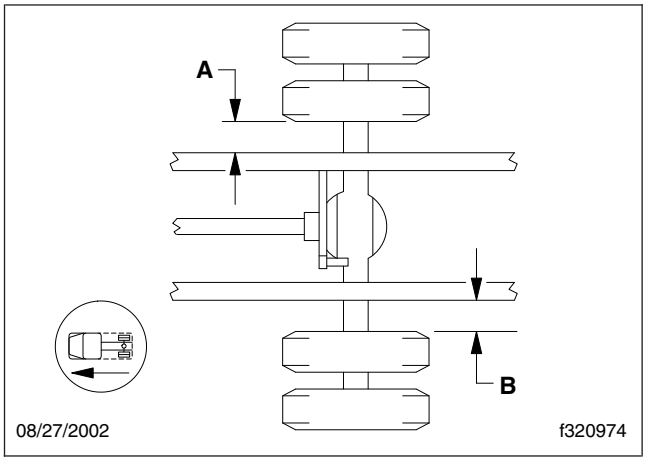


Fig. 2, Rear-Axle Tracking Measurements (single axle)

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 that hold the lateral torque rod to the frame rail. Add or remove torque-rod shims as needed.
4. Tighten the torque rod fasteners 136 lbf·ft (184 N·m).

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. 3**.
3. At both sides of the rear-rear drive axle, measure the distance from the inner side of the rear tires

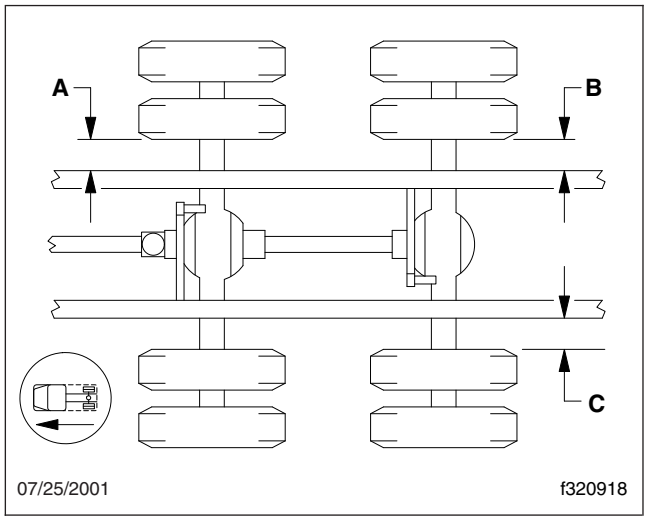


Fig. 3, Rear-Axle Tracking Measurements (tandem axles)

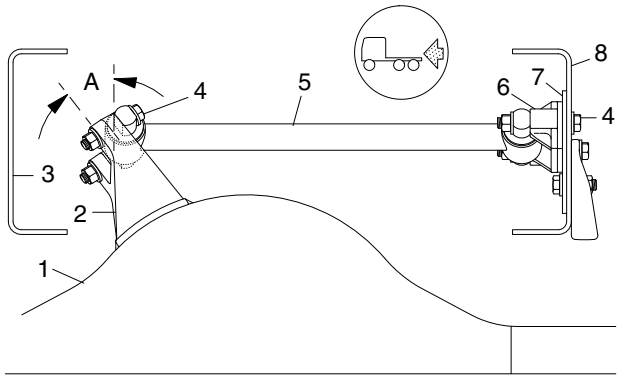
   to the outer side of each frame rail. Measure at the rear edge of each tire. See **Fig. 3**.

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 that hold the axle lateral torque rod at the rear-rear drive axle to the frame rail. Add or remove torque-rod shims as needed.
5. Tighten the torque rod fasteners 136 lbf·ft (184 N·m).

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Raise the vehicle. Support the frame rails with jack stands.
3. Remove the fasteners that hold 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**.
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. Raise the vehicle, remove the jack stands, then lower the vehicle.
11. Remove the chocks.



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

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. Shut down the engine, set the parking brakes, 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**.
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 spring eye as follows:

⚠ 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 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 7700 lb (3490 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**. Raise the vehicle, remove the safety stands, then lower the vehicle.
9. Check the rear axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment using the instructions in **Subject 180**.
10. Remove the chocks.

Torque Specifications

For fastener torque values, see **Table 1**.

Torque Values for AirLiner Suspension			
Description	**Size**	**Torque**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Height-Control Valve Housing Bolts*	1/4–20	—	45 (500)
Height-Control Valve Housing Bolts*	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 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

NOTICE

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.

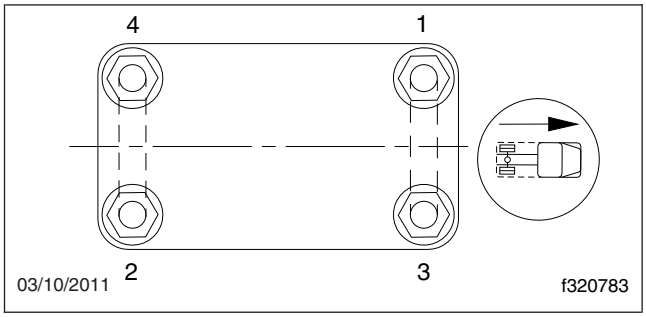
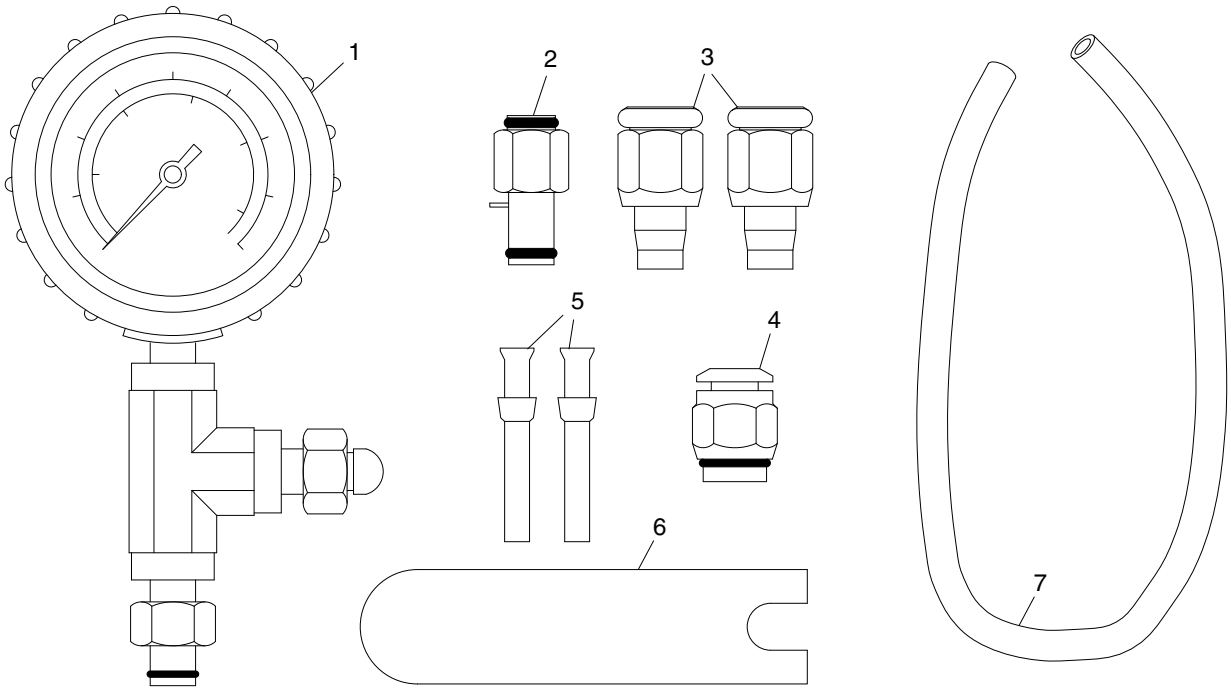


Fig. 1, Tightening Pattern for U-Bolt High Nuts

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

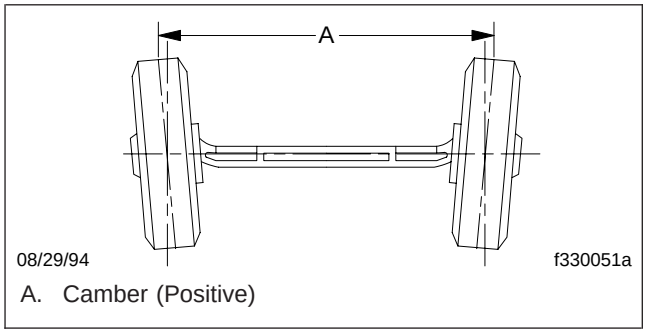
General Information

The front axle requires periodic servicing to maintain accurate wheel alignment. Correct front axle wheel alignment is needed to ensure long tire life, ease of handling, and steering stability.

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**.

Three factors are involved in wheel alignment: camber angle, caster angle, and wheel toe-in.

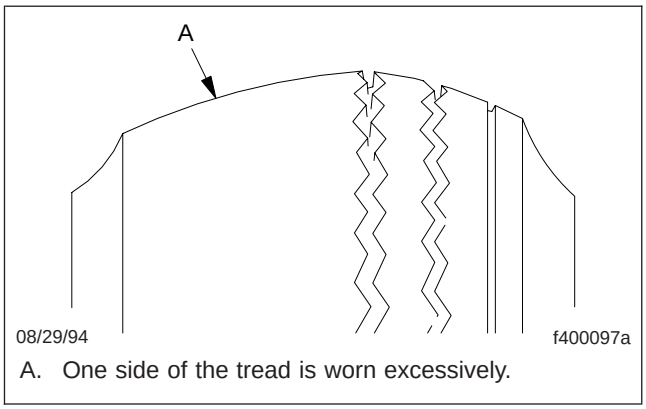
Camber angle (**Fig. 1**) is the vertical tilt of the wheel as viewed from the front of the vehicle. Camber angle is measured in degrees, and is not adjustable. Positive camber is the outward tilt of the wheel at the top. Excessive positive camber in one wheel causes the vehicle to pull in the opposite 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**. If the front axle is damaged enough to affect the camber angle it must be replaced.



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 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**.

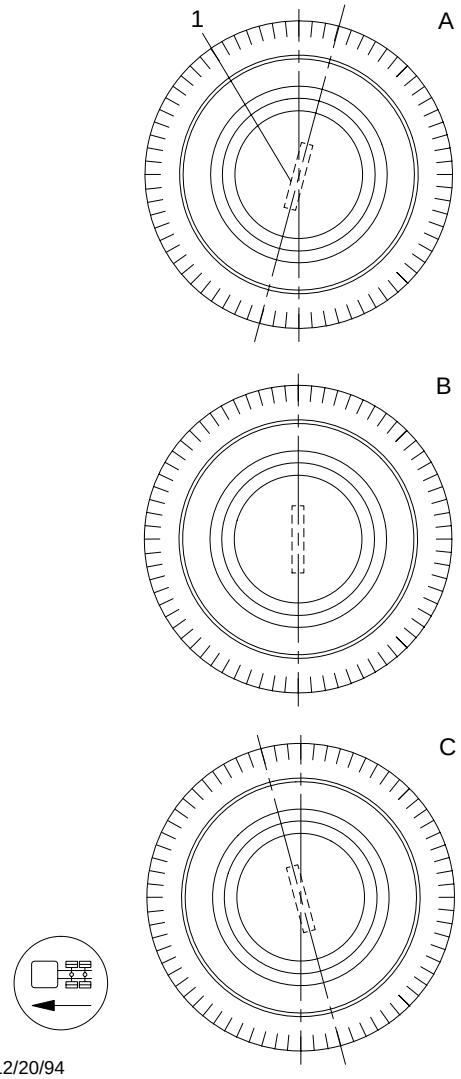
Advanced wear patterns can be seen, but less severe wear patterns are detected only by rubbing the palm of your hand flat across the tire tread.

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.

General Information

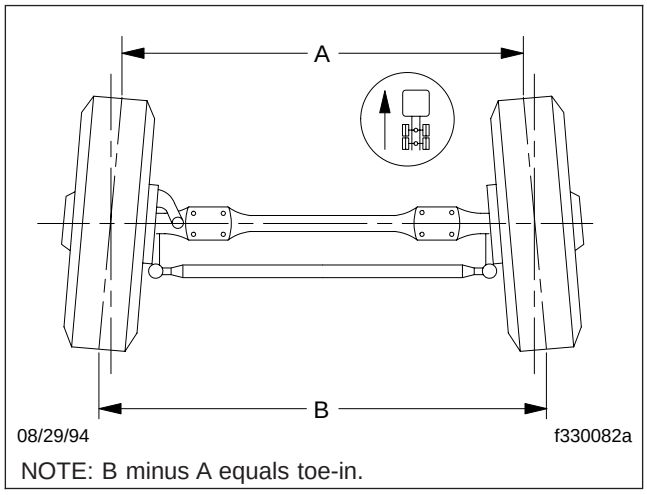
If excessive tire tread wear has resulted from incorrect wheel alignment, replace the damaged tires. For minimum tread wear specifications, refer to **Group 40** of the *Cascadia Maintenance Manual*.



1. Knuckle Pin (King Pin)

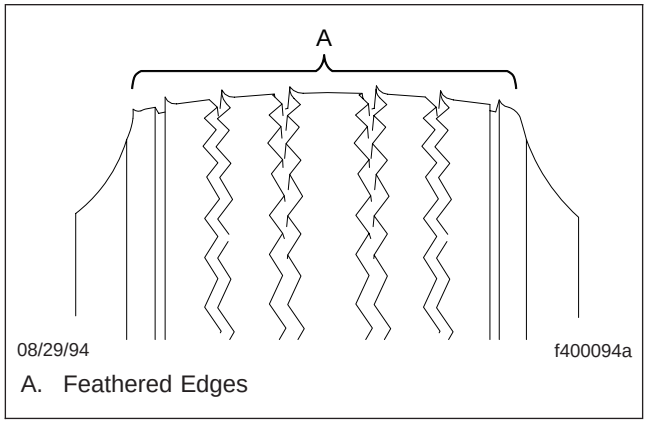
A. Positive Caster
B. Zero Caster
C. Negative Caster

Fig. 3, Caster Angle



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

The following preliminary checks should be completed before checking the camber or caster angles.

Preliminary Checks

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**.

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 **Group 40** in the *Cascadia 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.**

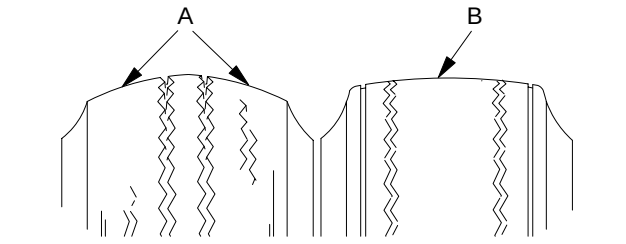
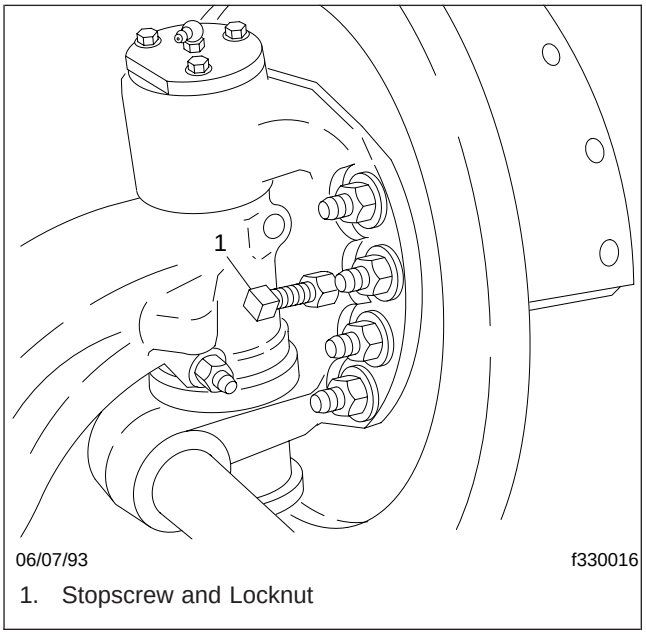


Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires

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. 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 applicable suspension section.
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 applicable steering section.
8. Check the steering angle, and adjust the axle steering stops as needed. Refer to **Subject 110**.
9. Check the tie-rod ends for correct adjustment, tightness, and damage. Refer to **Group 33** of the *Cascadia Maintenance Manual* for instructions.
10. Check the front wheel bearings for wear and incorrect adjustment. Refer to **Section 33.01, Subject 110** for instructions.

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.



1. Stopscrew and Locknut

Fig. 1, Axle Stop

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 applicable 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.

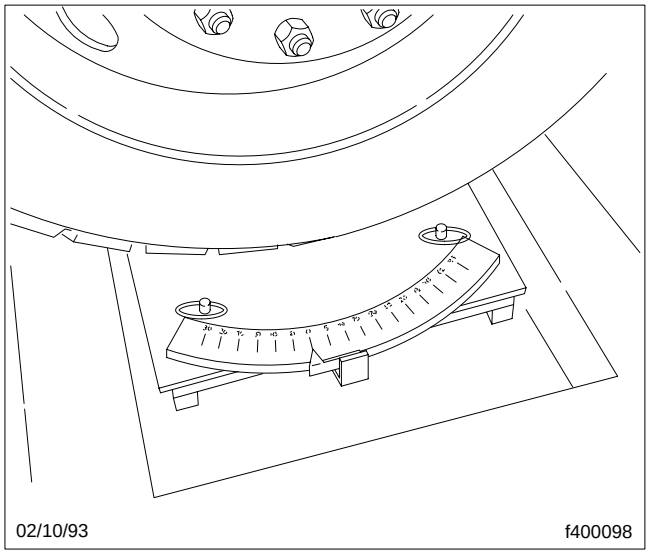


Fig. 2, Turn-Plate (Turntable), Stationary Type

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**.
5. Repeat the step above with the steering wheel turned counterclockwise. Adjust the axle stop, as needed.

Steering Angle Checking and Adjusting

6. 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**.
7. Drive the vehicle off the turn-plates or turntables, or remove them from under the tires and lower the vehicle.

Measuring Front Axle Wheel Alignment Angles

Measuring

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 wheels are centered and the vehicle is traveling straight, the upper steering wheel spokes should be at the 9 and 3 o'clock positions, or within 10 degrees of that position. See **Fig. 1.**

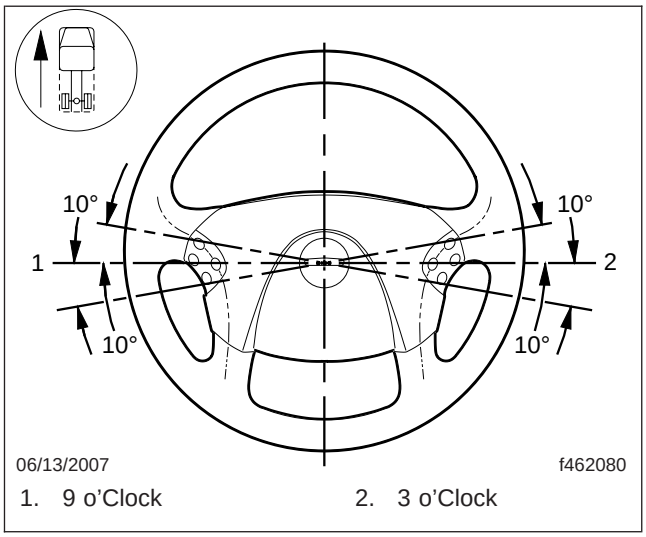
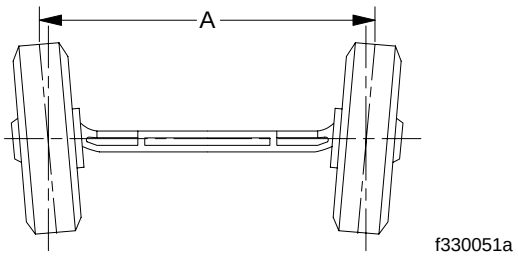


Fig. 1, Steering Wheel Position

Camber Angle Checking

Camber angle is the vertical tilt of the wheel as viewed from the front of the vehicle. See **Fig. 1**.

IMPORTANT: Do all the preliminary checks in **Subject 100** before checking the camber angle.



A. Camber (Positive)

Fig. 1, Camber Angle

Checking

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. Using the alignment equipment manufacturer's instructions, measure the front wheel camber.
3. 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.
4. Remove the chocks from the tires.

Caster Angle Checking and Adjusting

Caster angle is the tilt of the knuckle pin (or kingpin) as viewed from the side of the vehicle. See **Fig. 1**.

IMPORTANT: Do all the preliminary checks in **Subject 100** before checking the caster angle.

Checking 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.

Using the alignment equipment manufacturer's operating instructions, measure the front wheel caster.

Compare the caster angles with those shown in 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**):

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.

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**.

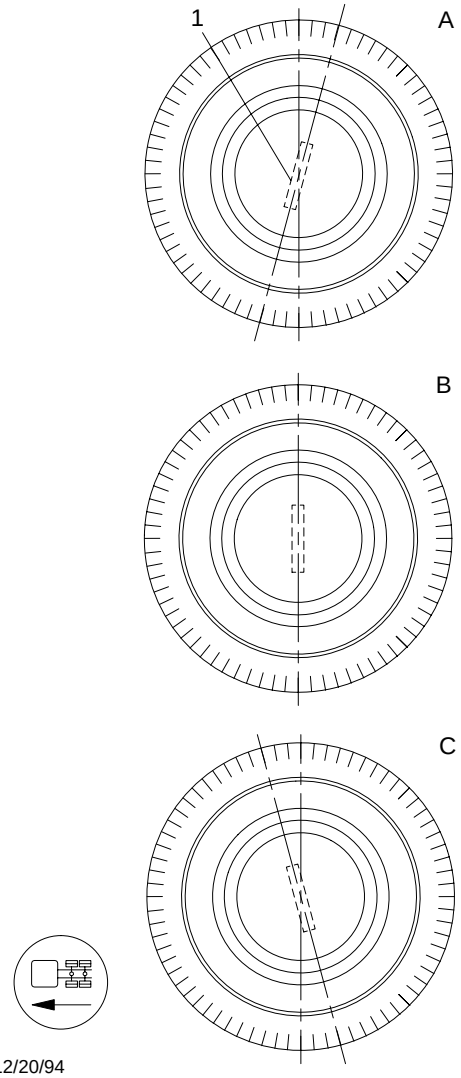
   U-bolt nuts need periodic retightening. Refer to **Group 32** of the *Cascadia Maintenance Manual* for recommended intervals.

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. Do a final caster angle check.

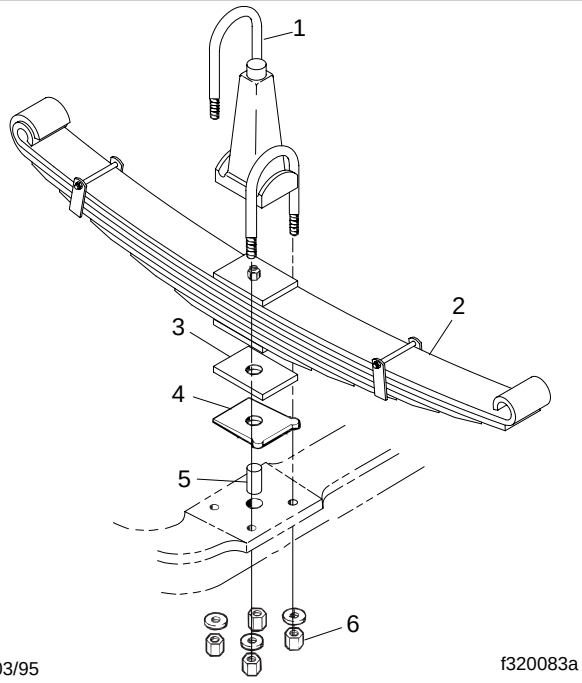
Caster Angle Checking and Adjusting



A. Positive Caster
B. Zero Caster
C. Negative Caster

1. Knuckle Pin (Kingpin)

Fig. 1, Caster Angle



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

Wheel Toe-In Checking and Adjusting, Integral Gear Steering

Wheel toe-in is the distance that the front of the wheels are closer together than the rear of the wheels, as viewed from the top. See **Fig. 1**.

For wheel toe-in adjustment procedures for rack and pinion steering, see **Section 46.04, Subject 100**.

Checking Toe-In Using Alignment Equipment

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 wheel toe-in. Compare the measurement with that shown in the appropriate table in **Specifications 400**. If corrections are needed, go to "Adjusting Toe-In".

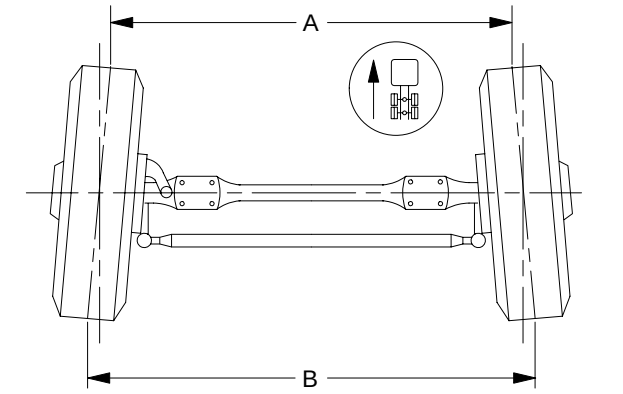


Fig. 1, Wheel Toe-In (Overhead View)

Checking Toe-In Using a Manual Method

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). Apply the parking brakes and chock the rear tires.

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.**

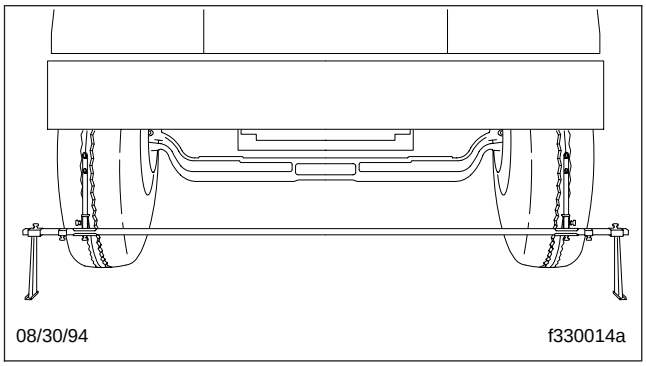


Fig. 2, Trammel Bar Positioning

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 heading.

Wheel Toe-In Checking and Adjusting, Integral Gear Steering

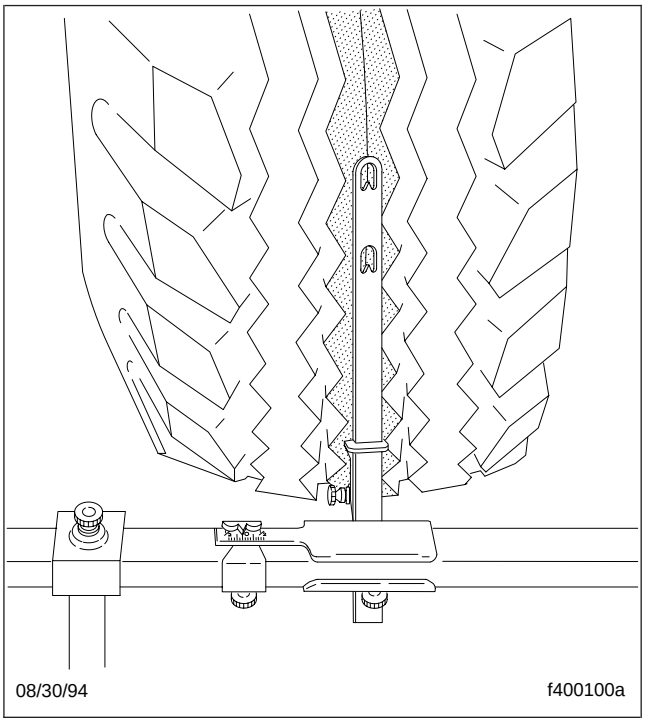


Fig. 3, Calculating Wheel Toe-In

Adjusting Toe-In

1. 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. Apply the parking brakes and chock the rear tires.

   Do a final wheel toe-in check to make sure that it is correct.

   Tighten the clamp nuts to the values in the appropriate table in **Specifications 400**.

2. Road test the vehicle.

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 1/2 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 E Series	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)

Table 10, Miscellaneous Torque Values

General Information

A wheel end assembly consists of a wheel hub, wheel bearings, wheel studs, and brake drum or, for disc brakes, a rotor and caliper. See **Fig. 1** and **Fig. 2**. Cascadia vehicles are typically equipped with one of the following wheel end assemblies:

- A ConMet PreSet® hub and double spindle nut system.

  Most Cascadias are equipped with PreSet hubs, which have the bearings and oil seal pre-installed. To install a new hub, mount it on the axle spindle, and secure it with a double spindle nut. For instructions, see **Subject 180**. A spacer between the inner and outer bearings adjusts the bearings to the correct end play and preload when the retaining nut is tightened.

- A ConMet PreSet hub and Axilok® spindle nut.

  Some ConMet PreSet hubs use an Axilok nut (see **Subject 140**). As with ConMet PreSet hubs that use the double spindle nut, the bearings and oil seal are pre-installed and a spacer between the inner and outer bearings adjusts the bearings to the correct end-play and preload when the retaining nut is tightened.

- A ConMet PreSet Plus™ hub and spindle nut system.

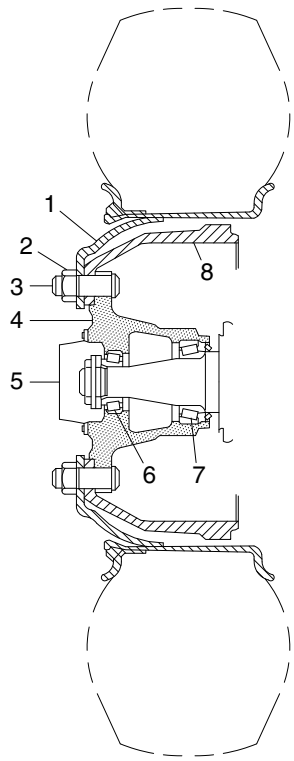
  The ConMet PreSet Plus system is specially designed for easy and reliable hub removal and installation. As with ConMet PreSet hubs, the spacer between the inner and outer bearings adjusts the bearings to the correct end play and preload when the nut is tightened. For instructions, see **Subject 200**.

- The traditional hub and bearings, and a double spindle nut system.

  With traditional wheel ends, the bearings and oil seal must be assembled with the hub when the hub is installed on the axle spindle. First the oil seal is placed on the spindle (some brands of oil seal are installed in the hub bore), then the inner bearing and the hub are mounted on the axle spindle. Then, the outer bearing is mounted in the hub bore. A nut is installed on the axle spindle end and tightened and loosened to adjust the bearings. Finally, a locking device and jam nut are installed to secure the hub and bearings on the axle. For instructions, see **Subject 180**.

- The traditional hub and bearings, and a Pro-Torq® nut system.

  This system is the same as the above traditional hub and bearing system, but in place of the four-piece bearing-lock system, it has one adjusting nut and a lockring device. For instructions, see **Subject 150**.



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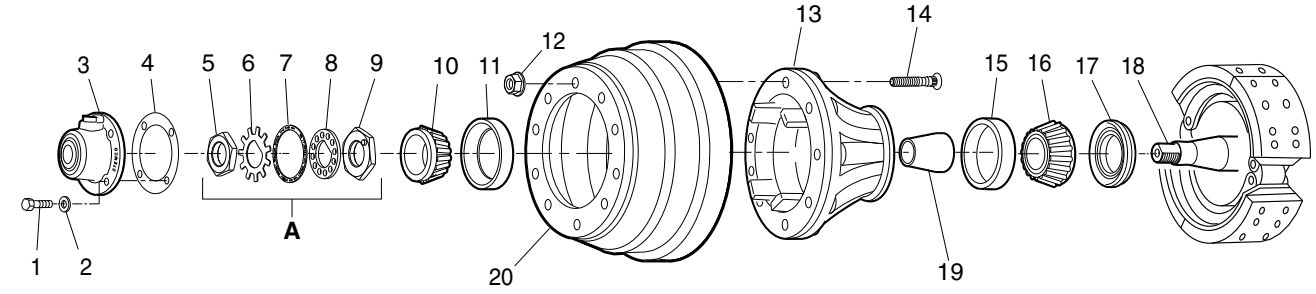
1. Disc Wheel
2. Wheel Nut
3. Wheel Stud
4. Hub
5. Hub Cap
6. Outer Wheel Bearing
7. Inner Wheel Bearing
8. Brake Drum

Fig. 1, Wheel Assembly, Cutaway View

Tapered Wheel Bearings

A traditional 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. 3**. All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

General Information



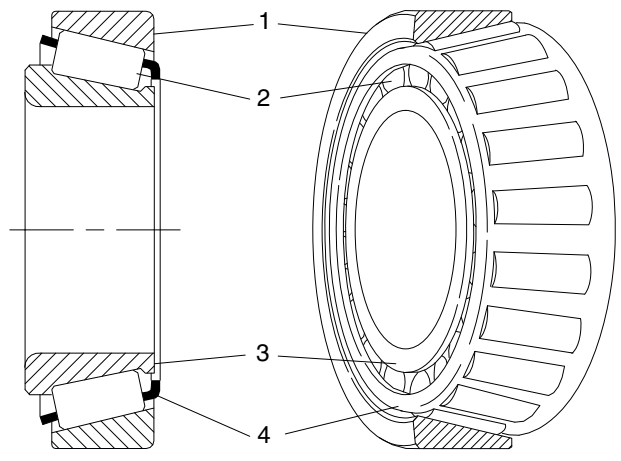
NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations. ConMet PreSet Plus hubs use a special spindle nut system.

1. Hub Cap Capscrew
2. Washer
3. Hub Cap
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Wheel Nut
13. Hub
14. Wheel Stud
15. Inner Wheel Bearing Cup
16. Inner Wheel Bearing
17. Oil Seal
18. Axle Spindle
19. Bearing Spacer
20. Brake Drum

Fig. 2, Typical Wheel End Assembly, Front Axle with Drum Brakes

ConMet PreSet and PreSet Plus hubs have special bearing assemblies.



1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 3, Tapered Wheel Bearing Assembly

Wheel Hub

The wheel and the brake drum are mounted on an aluminum or iron wheel hub. Both the inner and outer wheel bearing cups and the wheel studs are press-fit in the hub.

Wheel Studs

A headed wheel stud (**Fig. 4**) 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.

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. The brake drum is mounted on the outboard face of the hub and fits over the wheel studs.

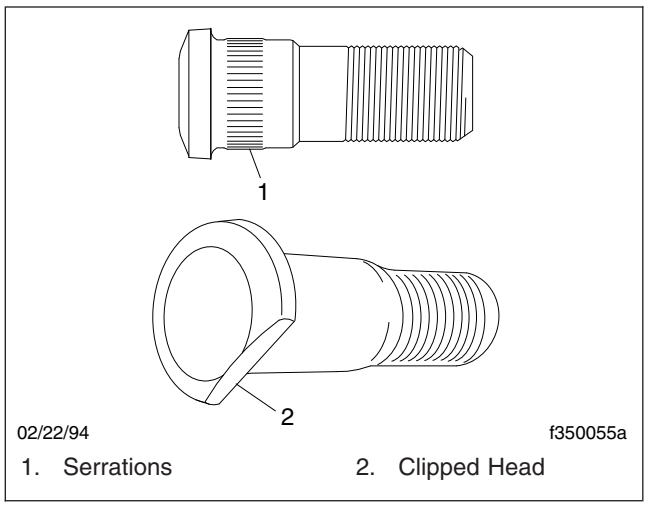
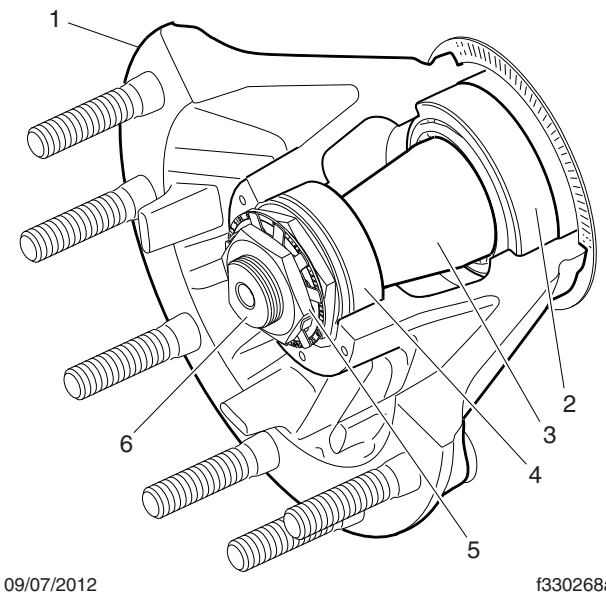


Fig. 4, Typical Wheel Studs

General Information

ConMet PreSet® and PreSet Plus™ steer axle hubs are equipped with a special tubular spacer inside the hub, between the inner and outer bearings. See **Fig. 1**.

When installing a PreSet or PreSet Plus hub with the spacer and special PreSet bearings, the correct end play is set automatically and wheel bearing adjustment is unnecessary.



NOTE: PreSet Plus hubs use a special spindle nut system.

1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Retaining Nut (double spindle nut system)
6. Axle Spindle

Fig. 1, ConMet PreSet Hub, Cut-Away View

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.

Wheel ends equipped with ConMet PreSet Plus hubs must use PreSet Plus components. Do not substitute non-PreSet-Plus components on these installations.

Removal

For typical wheel end and axle assemblies, see **Fig. 2** and **Fig. 3**.

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.

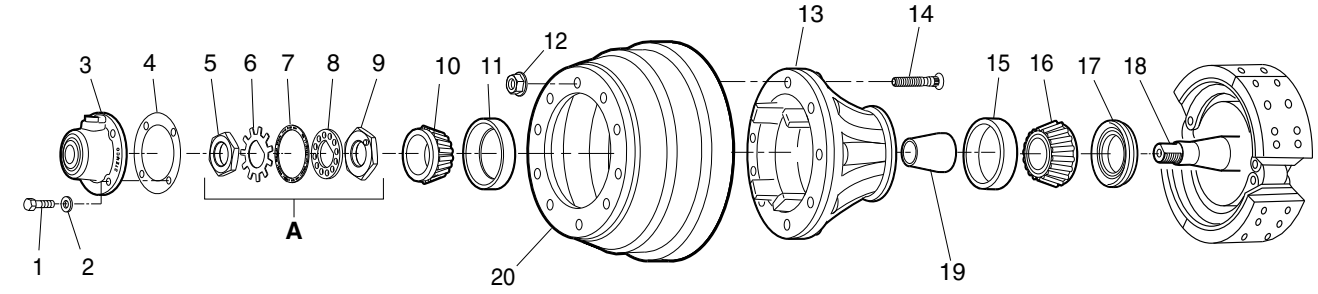
4. Remove the wheel and tire assembly. See **Group 40** for instructions.
5. For drum brakes, remove the brake drum. See **Subject 160** for instructions.

   For disc brakes, remove the brake caliper. See **Section 42.21** for instructions.

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 140**; 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 double spindle nut system, see **Subject 180**; then go to the next step.

Hub Assembly Removal and Installation

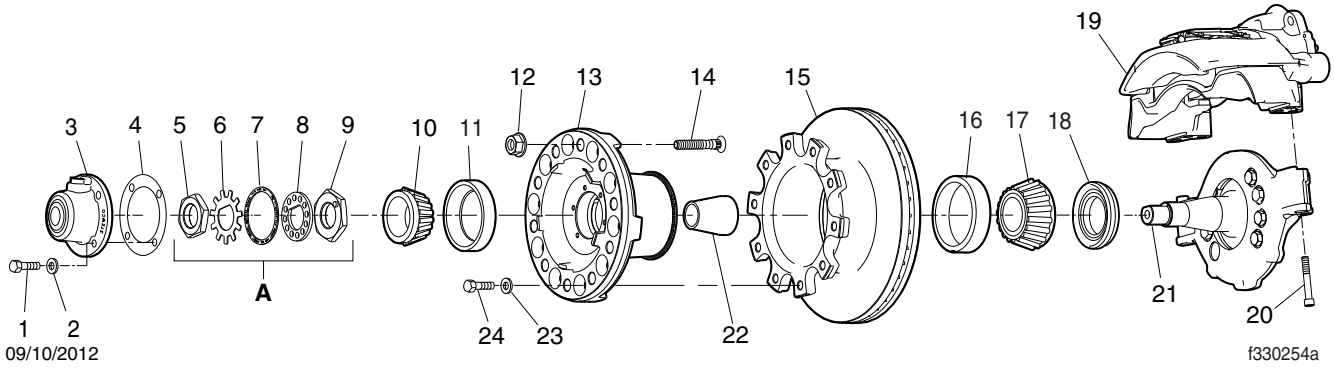


NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations. ConMet PreSet Plus hubs use a special spindle nut system.

1. Hub Cap Capscrew
2. Washer
3. Hub Cap
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Wheel Nut
13. Hub
14. Wheel Stud
15. Inner Wheel Bearing Cup
16. Inner Wheel Bearing
17. Oil Seal
18. Axle Spindle
19. Bearing Spacer
20. Brake Drum

Fig. 2, Typical Wheel End Assembly, Front Axle with Drum Brakes



NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations. ConMet PreSet Plus hubs use a special spindle nut system.

1. Hub Cap Capscrew
2. Washer
3. Hub Cap
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Wheel Nut
13. ConMet PreSet Hub
14. Wheel Stud
15. Brake Rotor
16. Inner Wheel Bearing Cup
17. Inner Wheel Bearing
18. Oil Seal
19. Brake Caliper
20. Caliper Mounting Capscrew
21. Axle Spindle
22. Bearing Spacer
23. Washer
24. Capscrew

Fig. 3, Typical Wheel End Assembly, Front Axle with Disc Brakes

- For ConMet PreSet Plus hubs, see **Subject 200**; then go to the next applicable 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.

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.

NOTE: For vehicles equipped with disc brakes, instructions for removing the brake rotor are given in **Section 42.21**.

Installation

For typical wheel end and axle assemblies, see **Fig. 2** and **Fig. 3**.

NOTE: For vehicles equipped with disc brakes, instructions for installing the brake rotor are given in **Section 42.21**.

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 clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.

   For PreSet hubs that are being reused, the bearing spacer must be replaced. For PreSet Plus hubs, the bearing spacer must be cleaned and inspected before being reused; see **Subject 110**. If the bearing spacer is worn or damaged, replace it with a new one.

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.

2. 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.
3. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing. Do not lubricate the seal journal.
4. 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.

5. If using PreSet bearings, ensure the tubular spacer is in the PreSet hub.

Hub Assembly Removal and Installation

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.

NOTICE

When installing a hub, remember the following:

- **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.**

6. Mount the hub assembly on the axle spindle.
7. Remove the friction tape, then adjust (if needed) and secure the bearings:
   - For an Axilok spindle nut, see **Subject 140**; 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 double spindle nut system, see **Subject 180**; then go to the next step.
   - For ConMet PreSet Plus hubs, see **Subject 200**; then go to the next applicable step.
8. 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).
9. If applicable, add fresh oil to the wheel hub to the level indicated on the hub cap.

⚠ 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.

10. Rotate the hub to distribute the oil, then check the level at the hub cap. Add lubricant as needed.
11. For drum brakes, install the brake drum on the wheel hub. See **Subject 160** for instructions.

    For disc brakes, install the the brake caliper. See **Section 42.21** for instructions.
12. Install the wheel and tire assembly. See **Group 40** for instructions.

⚠ WARNING

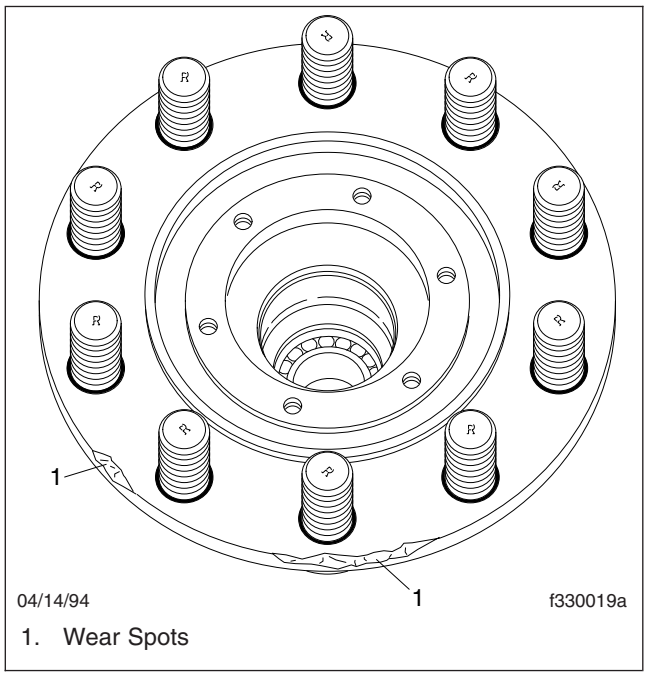
If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the wheel hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

13. Adjust the front axle brakes. For instructions, see **Group 42**.
14. 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.

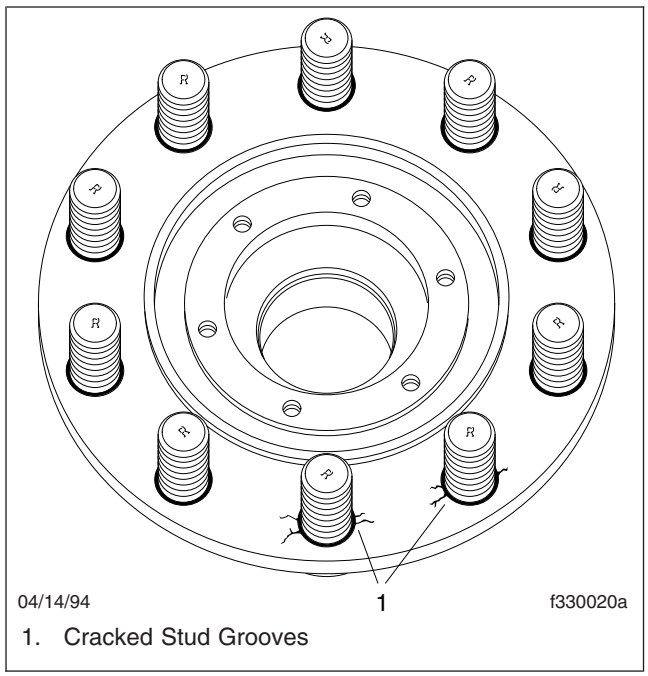
   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. See **Fig. 2**. If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.



1. Wear Spots

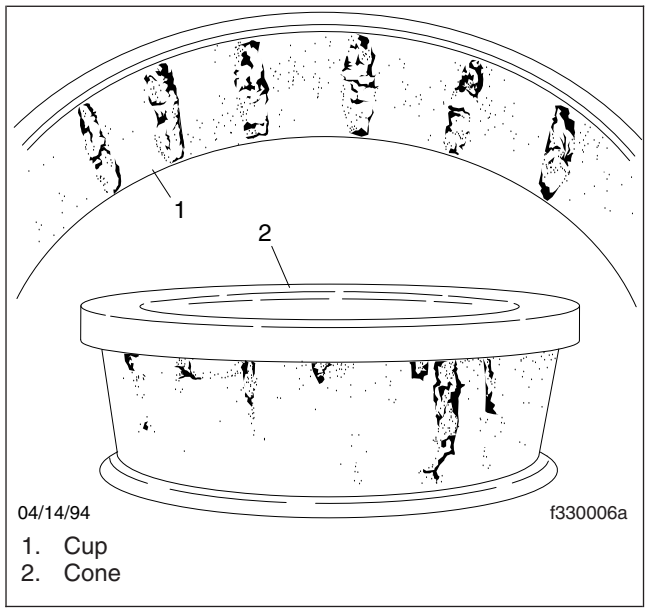
Fig. 1, Damaged Front Axle Wheel Hub

2. Remove all the 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 130**.



1. Cracked Stud Grooves

Fig. 2, Damaged Front Axle Wheel Hub



1. Cup
2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

4. Inspect the wheel studs. Replace studs that are stripped, broken, bent, or otherwise damaged. For instructions, see **Subject 170**.

Axle Components Cleaning and Inspection

Wheel Bearing Inspection

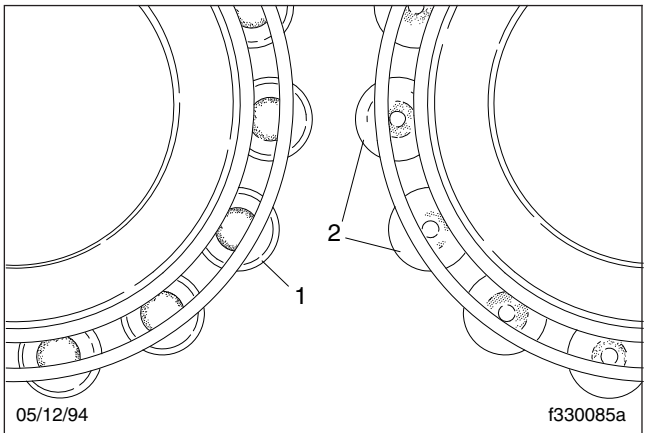
Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush. Before inspecting, clean the bearings.

1. Remove the wheel hub and bearing cones. For instructions, see **Subject 100**.
2. Using nonflammable solvent and a stiff brush, clean all the oil from the bearings and hub cavity. Do not 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 that 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:
   - 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. 4**.
   - Visible step wear, particularly at the small end of the roller track. Deep indentations, cracks, or breaks in the cone surfaces. See **Fig. 5**.
   - Bright rubbing marks on the dark phosphate surfaces of the bearing cage. See **Fig. 6**.
   - Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens the affected area. If water etch is present, replace the bearing seals.
   - Etching or pitting on functioning surfaces. See **Fig. 7**.



1. New Bearing
2. Worn Bearing Rollers

Fig. 4, Wheel Bearing Roller Wear

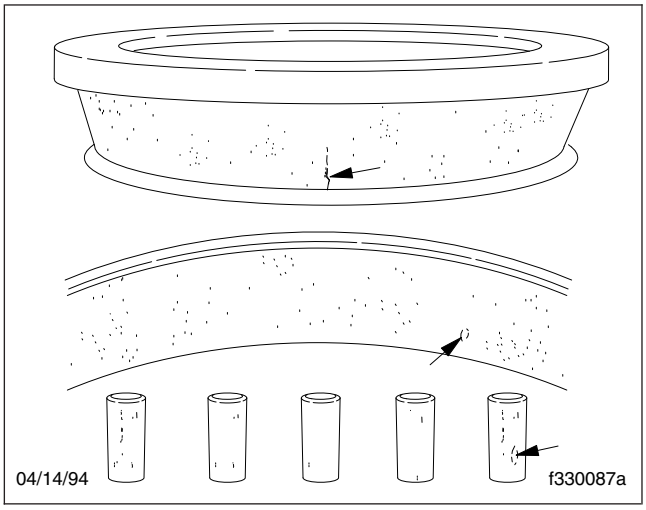


Fig. 5, Indentations, Cracks, or Breaks in Bearing Surfaces

   - 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

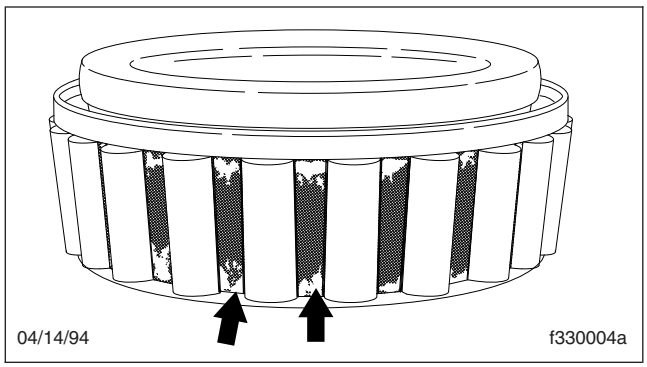


Fig. 6, Rubbing Marks on Bearing Cage

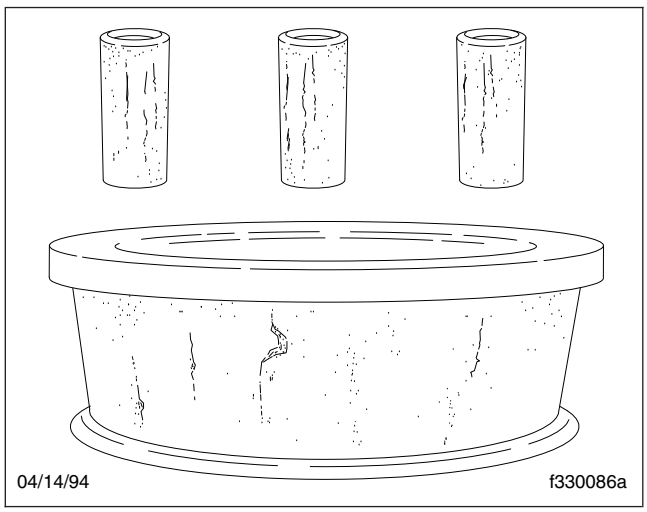
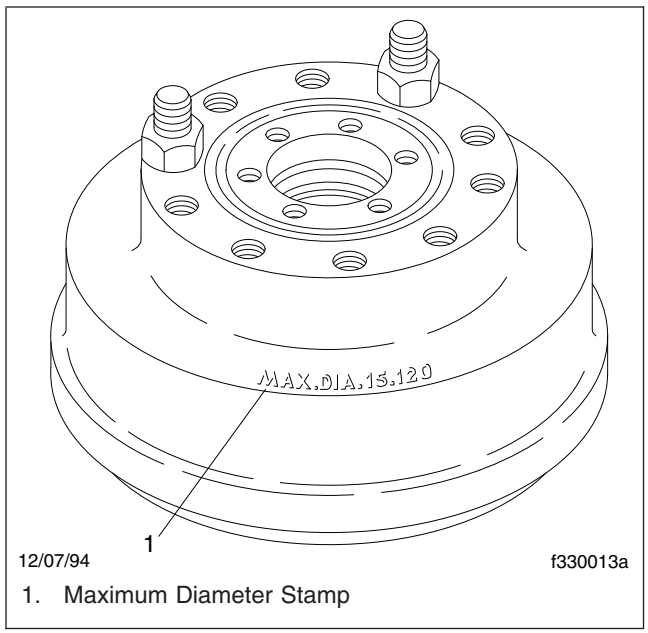


Fig. 7, Etching (Pitting) on Bearing Surfaces

to drum installation, then rinsed with hot water. 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. 8** for a typical location of this stamp.

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.



1. Maximum Diameter Stamp

Fig. 8, Outboard Mounted Hub and Drum Assembly

CAUTION

Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will result in drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimately, drum breakage.

If the drums are turned or replaced, replace the brake linings. See **Group 42** in this manual for instructions.

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

Axle Components Cleaning and Inspection

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.

NOTE: It may be necessary to remove the brake dust shield to measure the roundness of the drum.

5. Ensure the roundness of the drum is within acceptable limits, as follows. Set the measuring tip of a dial indicator against the working surface of the drum between the brake shoes as far outboard as possible. Zero the gauge, then turn the drum one revolution and note the highest and lowest measurements.

   If the difference is 0.010 inch (0.25 mm) or less, proceed to the next step. If the difference is more than 0.010 inch (0.25 mm), mark the drum and hub to record their relative positions, and remove the drum. Clean the mating surfaces of the hub and drum, and re-install the drum rotated 90 degrees from its earlier position. Tighten four wheel nuts 50 lbf·ft (68 N·m), and repeat the measurement. If the difference is more than 0.010 inch (0.25 mm), the drum is out of round beyond acceptable limits and all drums on the axle must be re-machined or replaced.

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.

Bearing Spacer Cleaning and Inspection, PreSet Plus™ Hubs

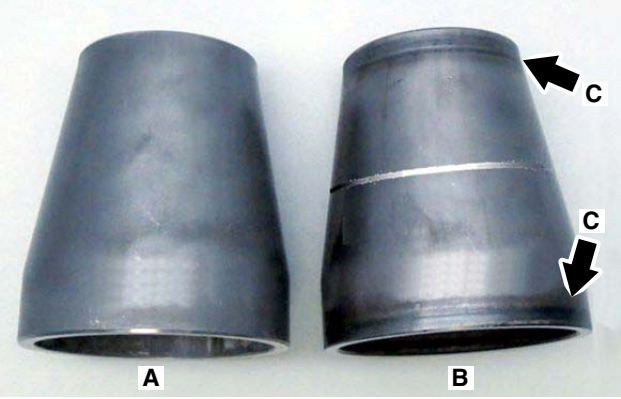
⚠ WARNING

Do not repair or recondition a damaged or worn bearing spacer; replace it. Using repaired, reconditioned, damaged, or worn components can cause wheel end failure, which can result in serious injury and property damage.

1. Use a cleaning solvent to clean the bearing spacer; do not use gasoline. Remove the solvent completely with clean, absorbent cloth or paper.

NOTE: PreSet Plus bearing spacers have undergone a heat-treating process that discolors the ends; see **Fig. 9**. This type of discoloration is normal for heat-treated spacers.

2. Inspect the bearing spacer for signs of wear or damage. Look for a sharp ring of standing metal that has been worn into the spacer at either end; see **Fig. 10**. If the spacer is worn or damaged, replace it.



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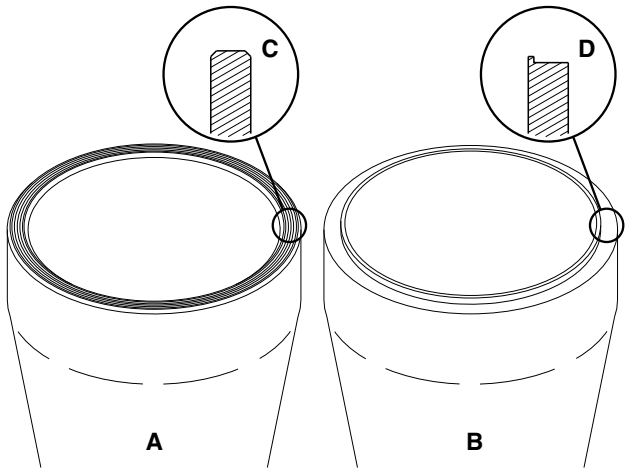
A. PreSet Spacer (Not Heat-Treated)
B. PreSet Plus Spacer (Heat-Treated)
C. Discoloration from Heat Treating Process

Fig. 9, PreSet and PreSet Plus Bearing Spacers



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A. New Spacer
B. Worn Spacer
C. Machined Surfaces with Chamfers and Grooves
D. Sharp Edge Worn into Machined End

Fig. 10, Comparison of New and Worn Bearing Spacers

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

Removal

To ensure a tight fit, wheel bearing cups (**Fig. 1**) are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded using the heat of an oven or boiling water (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.

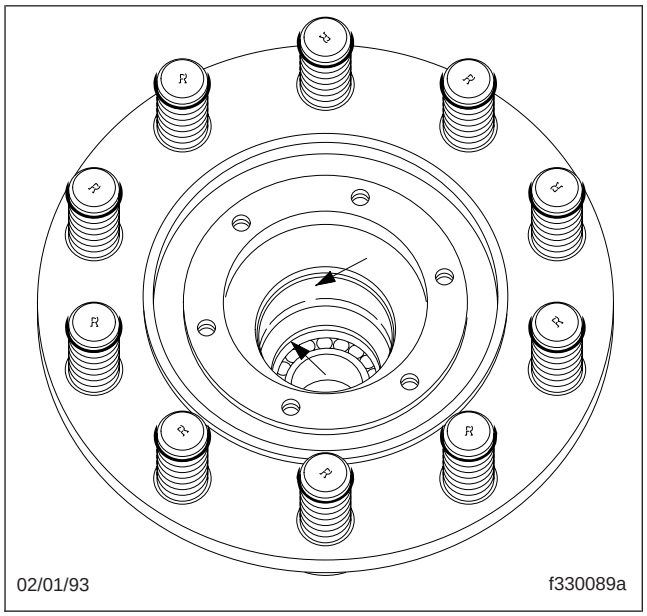


Fig. 1, Wheel Bearing Cup Locations

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Heat the hub to a temperature range of 175 to 215°F (79 to 102°C). If using an oven, make sure the thermostat is accurate; 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 or water. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

   If the cup is loose, allow a few minutes for the temperatures of the components to equalize before moving the hub.

IMPORTANT: Inspect the bearing cup bore for evidence of cup rotation (spun cups). If found, replace the hub.

Installation

To install the bearing cups, aluminum hubs must be temporarily expanded using the heat of an oven or boiling water. When the hub is properly heated throughout, the bearing cup and hub can be press-fit together, using a suitable press. Cooling the cups in a freezer can further ease the 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. Heat the hub to a temperature range of 175 to 215°F (79 to 102°C). If using an oven, verify that the oven thermostat is accurate; 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 or water.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

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.

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 hub-contact surface of the replacement bearing cup 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.

Axilok Spindle Nut Removal, Installation, and Adjustment

General Information

Axilok® spindle nuts may be 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

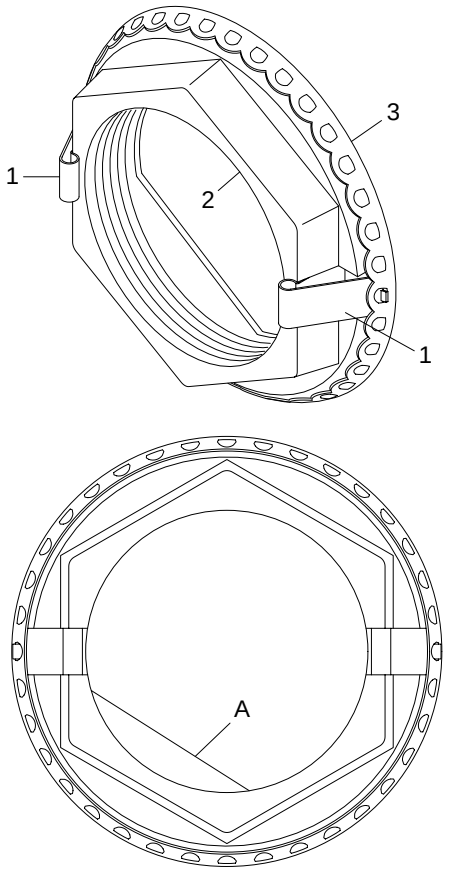
Instructions for installing an Axilok nut for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

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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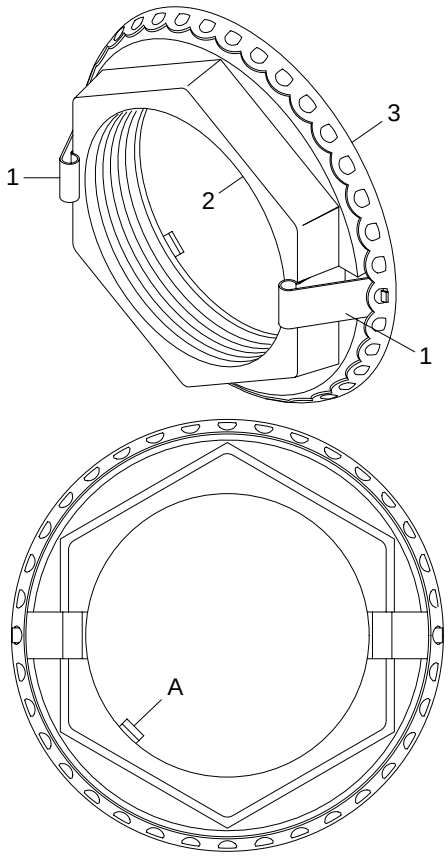
A. The flat side of the retainer must engage the flat side of the axle spindle.

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

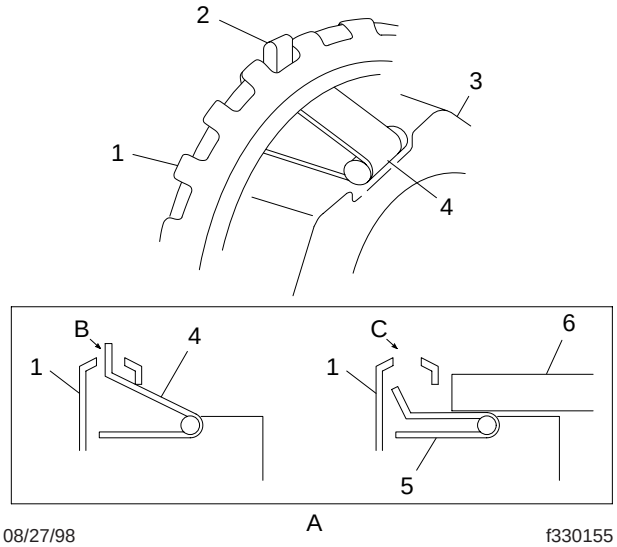
Fig. 2, Axilok Retaining Nut, Eaton Front Axle

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.

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. Measure the end play; see **Subject 190** for instructions.

⚠ WARNING

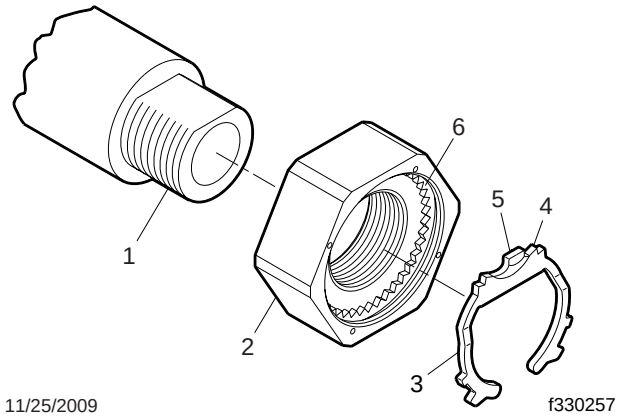
Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to 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.

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

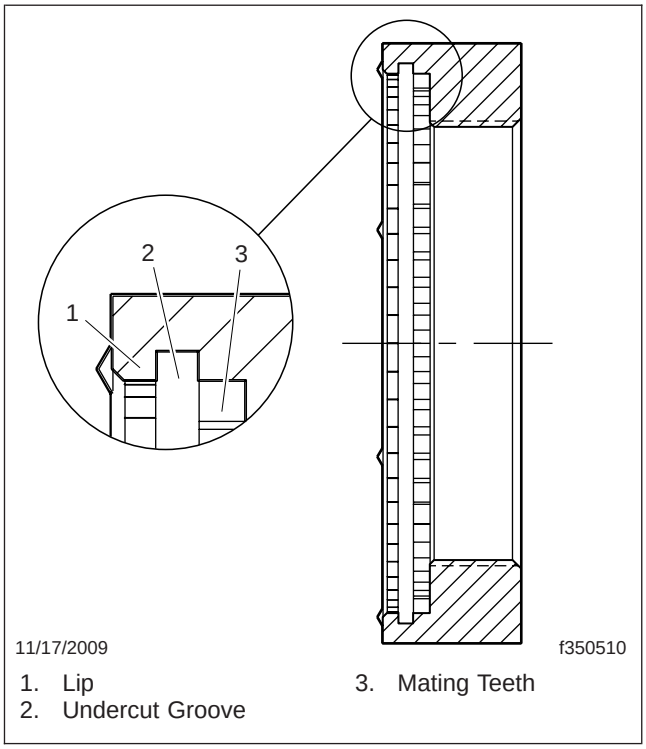
Each time the Pro-Torq nut assembly is removed for maintenance purposes, replacing the "keeper" is recommended.

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.



1. Lip
2. Undercut Groove
3. Mating Teeth

Fig. 2, Pro-Torq Spindle Nut, Cross Section

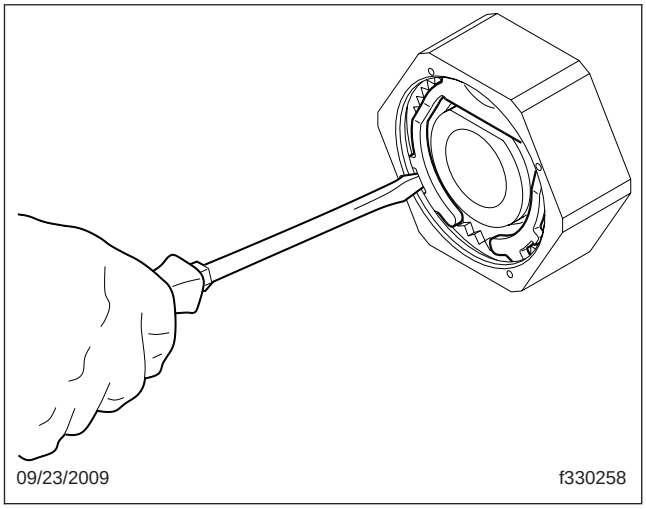


Fig. 3, Removing the Keeper

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.

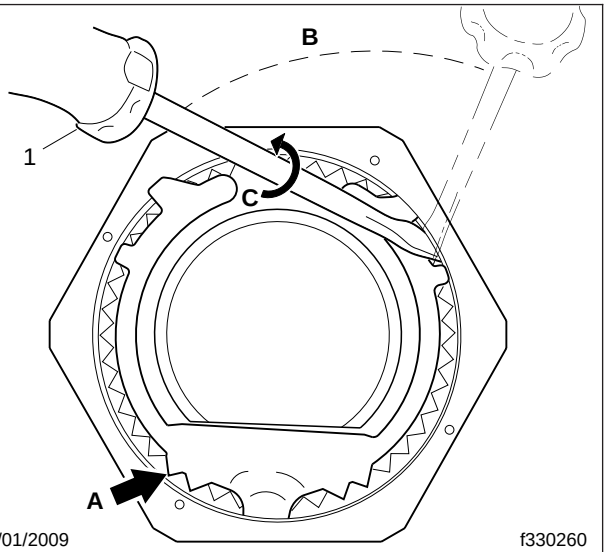
   3.1 With the correct side of the keeper facing out, insert the keeper tab in the undercut groove of the Pro-Torq nut, and engage the mating teeth.

   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.*

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. Measure the end play; see **Subject 190** for instructions.

⚠ WARNING

Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. 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, 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.

Removal

1. Chock the rear tires and 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. See **Group 42** for instructions.

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. Install the brake drum on the wheel hub.

   1.1 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. 1**.

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are tightened.

   1.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

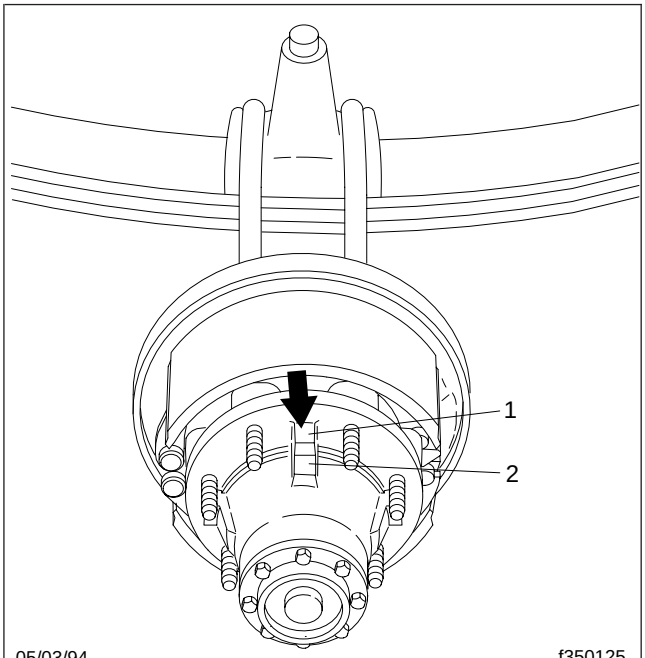
   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary to hold the drum in position, adjust the brakes before installing the wheels.
2. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the proper nut tightening 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.

3. Adjust the front axle brakes.
4. Remove the safety stands from under the axle; lower the vehicle.
5. Remove the chocks from the rear tires.

Outboard-Mounted Drum Removal and Installation



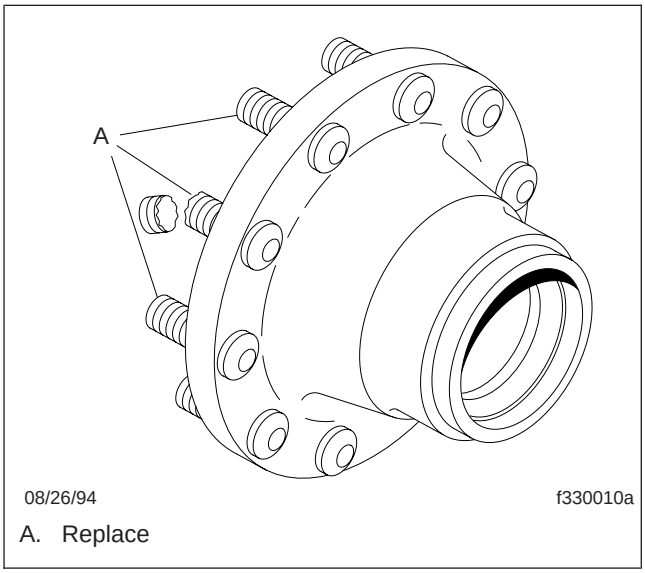
NOTE: Pilot pad at 12 o'clock position
1. Drum Pilot
2. Wheel Pilot

Fig. 1, Hub Pilot Pads

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.

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

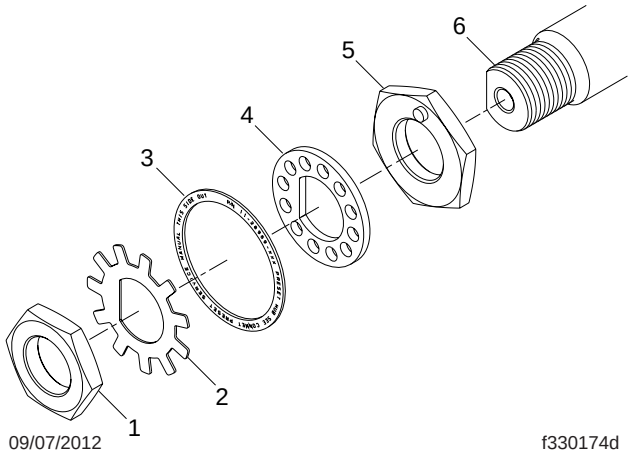
Do not embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss of a wheel or loss of steering control, possibly resulting in personal injury.

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**.

Double Spindle Nut Removal, Installation, and Adjustment

General Information

ConMet PreSet hubs may use a double spindle nut system. See **Fig. 1**. A plastic ID ring between the adjusting nut and locking washer indicates that a ConMet Preset hub has been installed.



NOTE: ID ring used with ConMet PreSet hubs only.

1. Jam Nut
2. Bend-Type Locking Washer
3. ID Ring
4. Lockring
5. Adjusting Nut
6. Axle Spindle

Fig. 1, Double Spindle Nut Set

Removal

Once a double spindle nut set is removed, discard the bend-type locking washer. Inspect the adjusting nut, lockring, and jam nut for visible damage prior to reuse.

Installation

Instructions for installing a double spindle nut 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), ID ring (for ConMet PreSet hubs only), 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**.

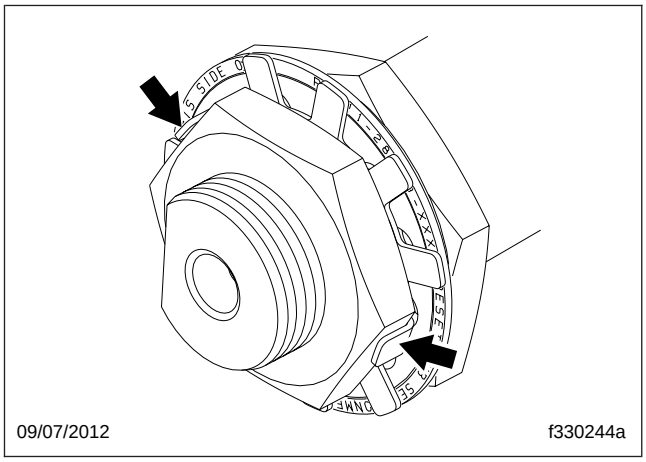


Fig. 2, Tabs Bent to Lock the Jam Nut

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).

Double Spindle Nut 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. Measure the end play; see **Subject 190** for instructions.

⚠ WARNING

Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. 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.

Wheel Bearing End Play Measurement

⚠ WARNING

Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.

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.

Measurement

Using a dial indicator, measure the end play as follows.

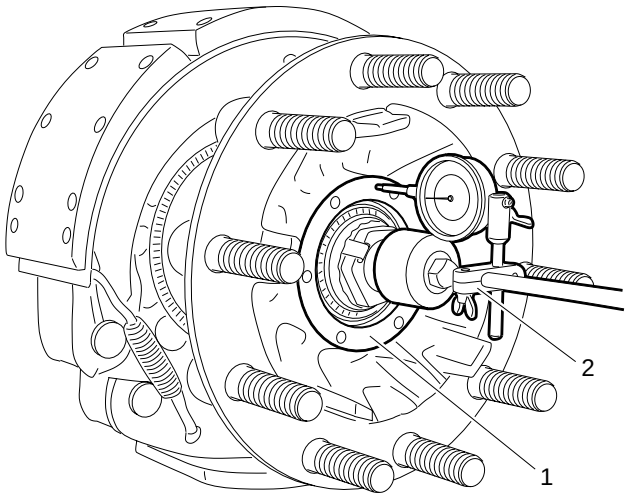
1. Attach the magnetic base of a dial indicator to the end of the spindle, and place the measuring end of the indicator against the hub cap mounting flange. See **Fig. 1**.

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.

2. 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, note the inboard measurement, and then pull the hub outward while oscillating it as before. Maintain pressure on the hub, and note the outboard measurement. See **Fig. 2**.

   The end play is the difference between the two measurements.

NOTE: If the end play exceeds the limit, the hub may need to be serviced. See **Subject 110** and manufacturer literature for procedures.



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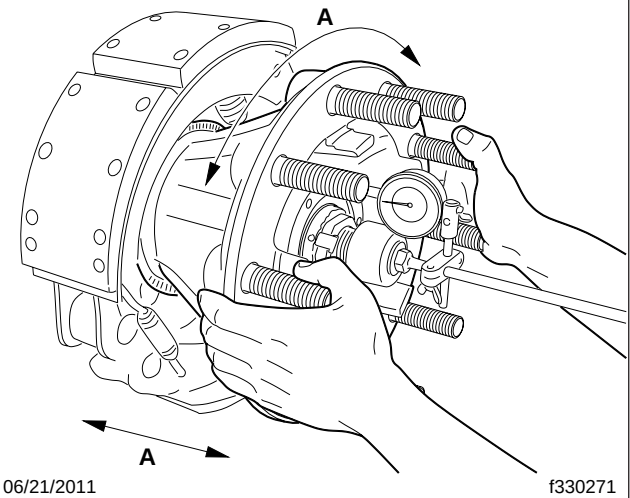
1. Hub Cap Mounting Flange
2. Dial Indicator (with magnetic base)

Fig. 1, Dial Indicator Setup



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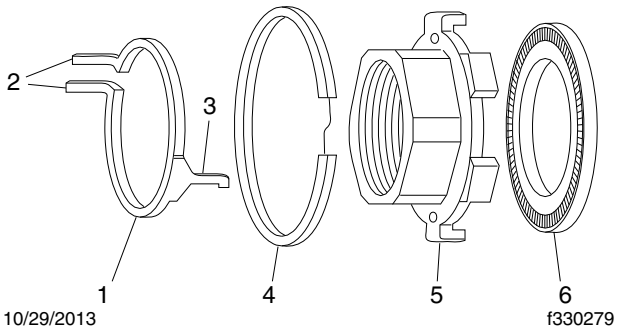
A. Pull and push the hub while oscillating it.

Fig. 2, Measuring End Play

ConMet PreSet Plus Spindle Nut Removal and Installation

General Information

ConMet PreSet Plus hubs use a special integrated spindle nut designed specifically for PreSet Plus hubs. See **Fig. 1**.



1. Locking Ring
2. Tabs
3. Lock Tab
4. Spiral Snap Ring
5. Spindle Nut
6. Locking Washer

Fig. 1, PreSet Plus Spindle Nut System

Removal

1. To remove the red locking ring from the spindle nut assembly, compress the tabs and pivot the ring to unlock it from the nut.

IMPORTANT: Do not exceed 50 lbf·ft (68 N·m) of torque when removing a PreSet Plus hub using the spindle-nut system as a hub puller.

2. Loosen the spindle nut. As the spindle nut is loosened, it can act as a hub puller. However, if the hub will not come off of the spindle without exceeding 50 lbf·ft (68 N·m) of torque, remove the spiral snap ring (see **Fig. 2**) and then the spindle nut assembly.

Installation

⚠ WARNING

Each PreSet Plus hub assembly requires special bearings, a PreSet Plus bearing spacer, and the unique PreSet Plus spindle nut system. Wheel ends equipped with the PreSet Plus hub assembly must use these special components; do not use non-PreSet-Plus components with a PreSet Plus hub.

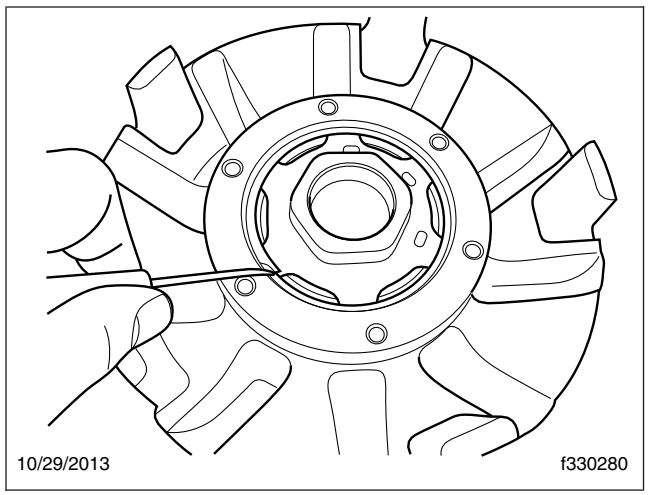


Fig. 2, Removing a Spiral Snap Ring

If a PreSet Plus hub is not correctly installed with the required components, the hub could separate from the axle, resulting in property damage, severe personal injury, or death.

The following instructions are for installing a PreSet Plus spindle nut. In some cases, the spindle nut components will have been removed along with the hub; in other cases, they will have been already installed in the hub. Use the pertinent instructions for your installation.

1. If the red locking snap ring is locked into the spindle nut, compress the tabs and pivot the ring to remove it from the nut. See **Fig. 1**.
2. If needed, begin installing the PreSet Plus spindle nut components, as follows.
   - 2.1 Seat the flat washer into the back of the spindle nut.
   - 2.2 Position the spindle nut and washer against the outer bearing.
   - 2.3 Install the spiral snap ring into the snap ring groove in the hub. Ensure that it fully seats into the groove in the hub. See **Fig. 3** and **Fig. 4**.
3. Tighten the spindle nut 300 lbf·ft (407 N·m) while rotating the hub. Do not back off the spindle nut.

ConMet PreSet Plus Spindle Nut Removal and Installation

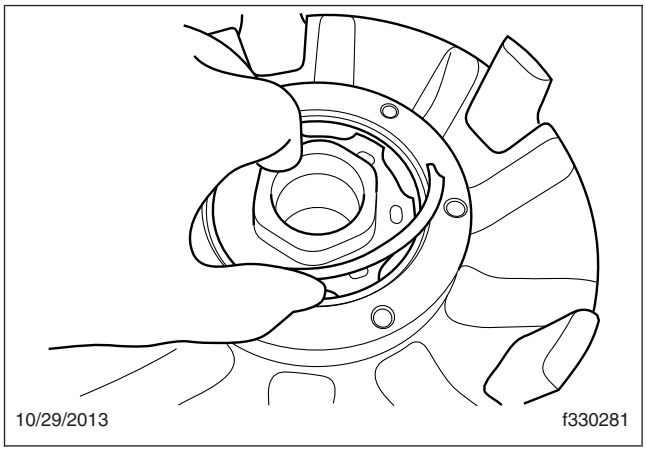


Fig. 3, Installing a Spiral Snap Ring

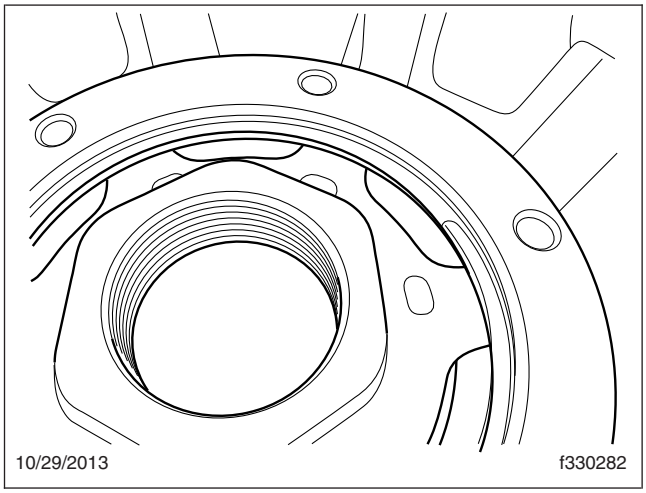


Fig. 4, Fully Seated Spiral Snap Ring

NOTICE

When bending the locking ring, be careful not to deform it permanently. If the locking ring is damaged or bent, replace it with a new one.

4. Install the locking ring, as follows.
   - 4.1 One of the holes in the face of the spindle nut will line up with a hole in the washer. Insert the lock tab of the locking ring through aligned holes.
   - 4.2 Using the handle tabs, seat the locking ring in the machined grooves of the spindle nut.

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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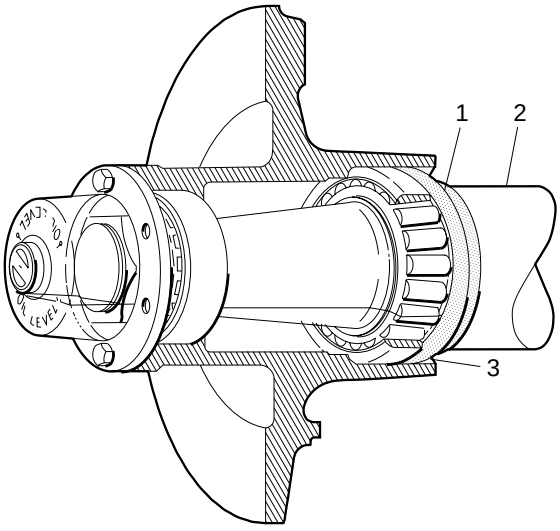
1. Hub
2. Dial Indicator (with roller point)

Fig. 2, Setup to Measure Radial Runout

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. 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**.



1. Wheel Oil Seal
2. Axle Spindle
3. Wheel Hub Bore

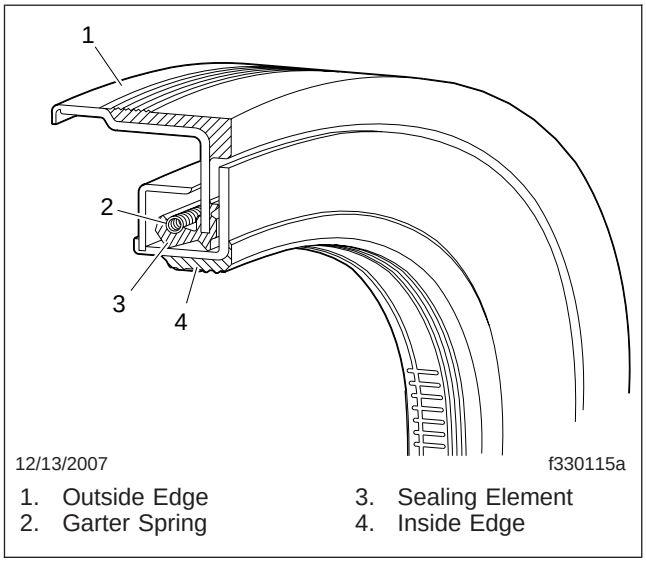
Fig. 1, Wheel Oil Seal

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

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.



1. Outside Edge
2. Garter Spring
3. Sealing Element
4. Inside Edge

Fig. 2, Wheel Oil Seal Parts

The sealing element is usually molded rubber, leather, or a synthetic such as nitrile or silicone. The element is molded into lips that will seal against the axle spindle or against the outside or inside edge described above.

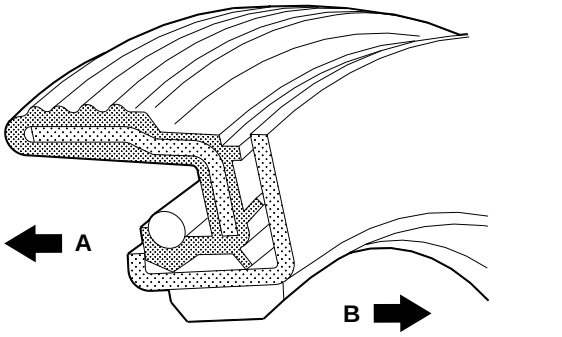
The garter spring is a loop of coiled wire spring that presses the sealing element against the sealing surface.

Chicago Rawhide Scotseal Plus XL

The Chicago Rawhide Scotseal Plus XL is a unitized, one-piece seal with one primary spring-loaded sealing lip and three secondary contacting sealing lips, which rotate with the housing. See **Fig. 3**. The outer diameter of the metallic case and the bore diameter of the seal counter face are coated with rubber. The seal is press fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal Plus XL directly onto the axle spindle.*

Although you install the Scotseal Plus XL 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.

General Information

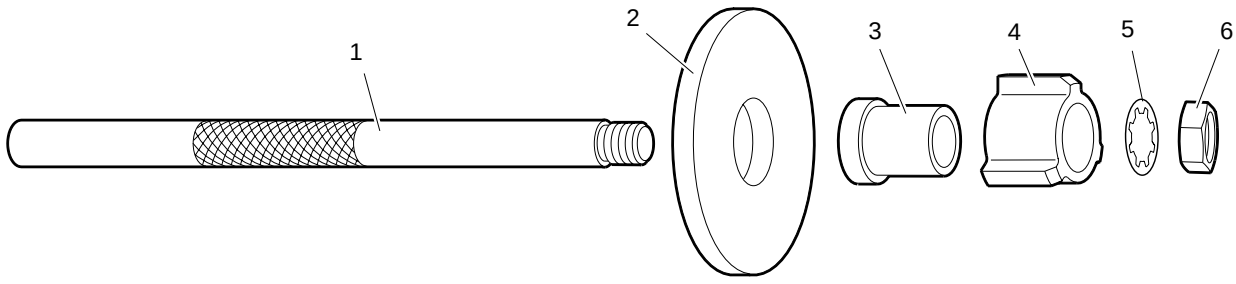


A. Oil and Bearing Side B. Air Side

Fig. 3, Scotseal Plus XL Oil Seal

Seal Replacement, Chicago Rawhide Scotseal Plus XL

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See **Fig. 1** for a diagram of the installation tool. See **Specifications, 400** for tool and seal numbers.



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1. Handle
2. Drive Plate
3. Plug Bushing
4. Centering Plug
5. Washer
6. Nut

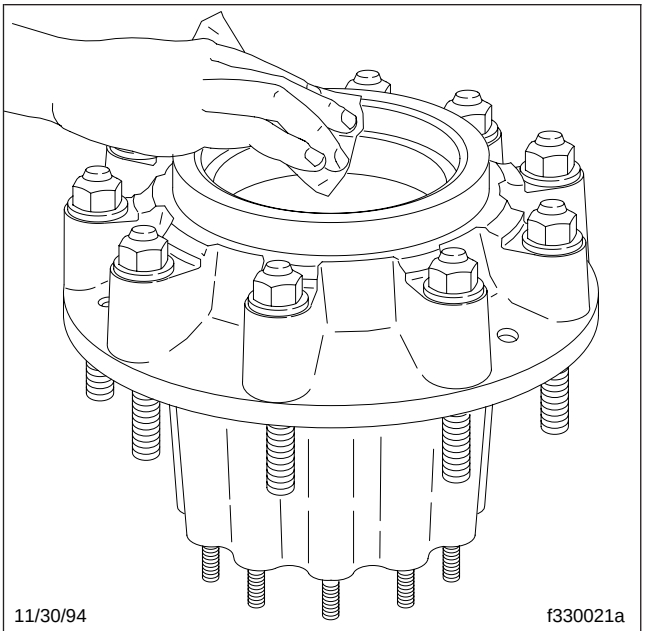
Fig. 1, Installation Tool

Replacement

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. Discard the seal.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 2** and **Fig. 3**.
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.



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NOTE: Rear hub shown.

Fig. 2, Cleaning the Hub

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the

Seal Replacement, Chicago Rawhide Scotseal Plus XL

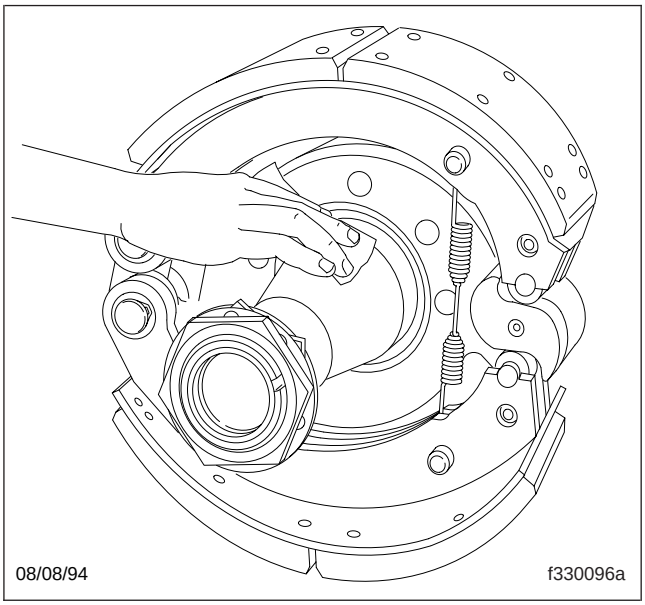


Fig. 3, Cleaning the Spindle

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.
8. Inspect a new seal for damage (such as cuts or being out of round) and contamination. If damage is evident, discard it and use a suitable seal.
9. Apply a thin layer of lubricant to the inside and outside diameters of the seal using the same lube used in the hub.
10. Seat the seal in the seal bore with the "air side" facing outward ("air side" is stamped on the sleeve flange of the seal), then press it down firmly with the flat side of the drive plate.
11. Insert the centering plug of the tool in the bore of the inner bearing cone. The plug prevents cocking of the seal in the bore.
12. Hold the tool handle firmly, and strike it until the seal bottoms out. See **Fig. 4**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
13. 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. If any damage is visible, remove the seal and install a new one.
14. Install the wheel, drum, and 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.

15. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

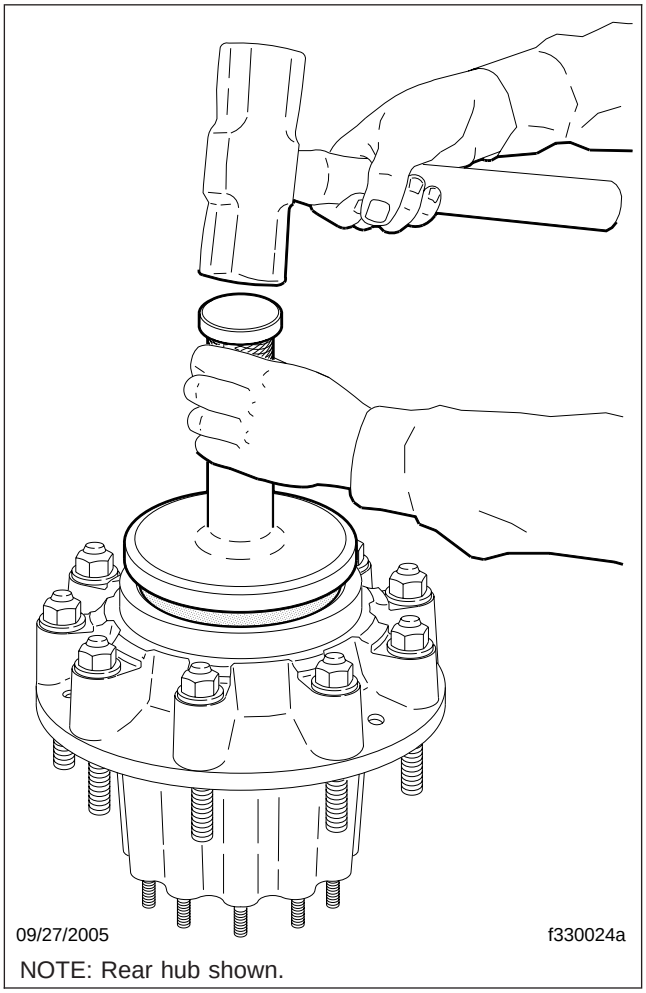


Fig. 4, Striking the Tool

Specifications

Chicago Rawhide Scotseal Plus XL Tool and Seal Numbers					
Spindle Type	**Cone, Inner Bearing**	**Cone, Outer Bearing**	**Centering Plug**	**Drive Plate**	**Seal**
FF	HM212049	3782	706	436	35058*
FL	CM 10003823	CM 10003824	708		

* The seal stock number is listed on the air-side flange of the seal.

Table 1, Chicago Rawhide Scotseal Plus XL Tool and Seal Numbers

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 industry-standard brakes, hubs, and wheel bearings.

The following explains a typical model code found on a Detroit front axle identification tag. See **Fig. 1**.

Typical Model Code: AF-12-3.

- *AF* = front axle
- *12* = Weight Rating (times 1000 lb)
- *3* = Model Number

Fig. 1, Front Axle ID Tag

NOTE: Detroit axles are a proprietary product, though in some applications they may be referred to as "Freightliner axles," "Axle Alliance axles," or "M-B 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. If the vehicle is equipped with an integral steering gear, 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 that hold 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 the vehicle is equipped with rack and pinion steering, remove its mounting brackets from the axle.
18. If you are replacing the steering knuckles, put the axle on a suitable stand and secure it to prevent it from moving.

Installation

1. If the vehicle is equipped with rack and pinion steering, use new fasteners to install the mounting brackets on the axle. Tighten the fasteners 202 to 256 lbf·ft (274 to 347 N·m).
2. With the axle on a suitable jack, position it under the vehicle.
3. For vehicles with front air suspension, raise the axle so that the holes in the axle beam line up with the bolts that hold 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**.
4. If so equipped, connect the sway bar to the axle brackets. Tighten the sway bar fasteners 100 lbf·ft (136 N·m).
5. If the vehicle is equipped with an integral steering gear, connect the drag link to the steering arm. For instructions, see the applicable section in **Group 46**.
6. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
7. Install the brake air chambers and slack adjusters onto the axle. For instructions, see the applicable sections in **Group 42**.
8. Install the ABS sensors.
9. Install the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
10. Install the hubs and adjust the wheel bearings. For instructions, see **Section 33.01, Subject 100**.
11. Install the brake drums.

Axle Removal and Installation

12. Adjust the slack adjusters. For instructions, see the applicable section in **Group 42**.
13. Install the tire and wheel assemblies. For instructions, see **Group 40**.
14. Raise the vehicle, remove the safety stands, and lower the vehicle.
15. Start the engine and build the air pressure.
16. If equipped with a front air suspension, verify that the suspension air bags are inflating correctly.
17. Align the vehicle.

    If the vehicle is equipped with rack and pinion steering, see **Section 46.04, Subject 100** for instructions.

    If the vehicle is equipped with an integral steering gear, see **Section 33.00, Subject 120** for instructions.

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 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 side of the vehicle, the steering arm connects to the steering knuckle. On the passenger 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. For integral steering gear, see **Fig. 1**. For rack and pinion steering, see **Fig. 2**.

IMPORTANT: On vehicles equipped with an integral steering gear, the steering arm capscrews are shorter than the tie-rod arm capscrews. Note the corresponding lengths for correct component installation.

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) 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.

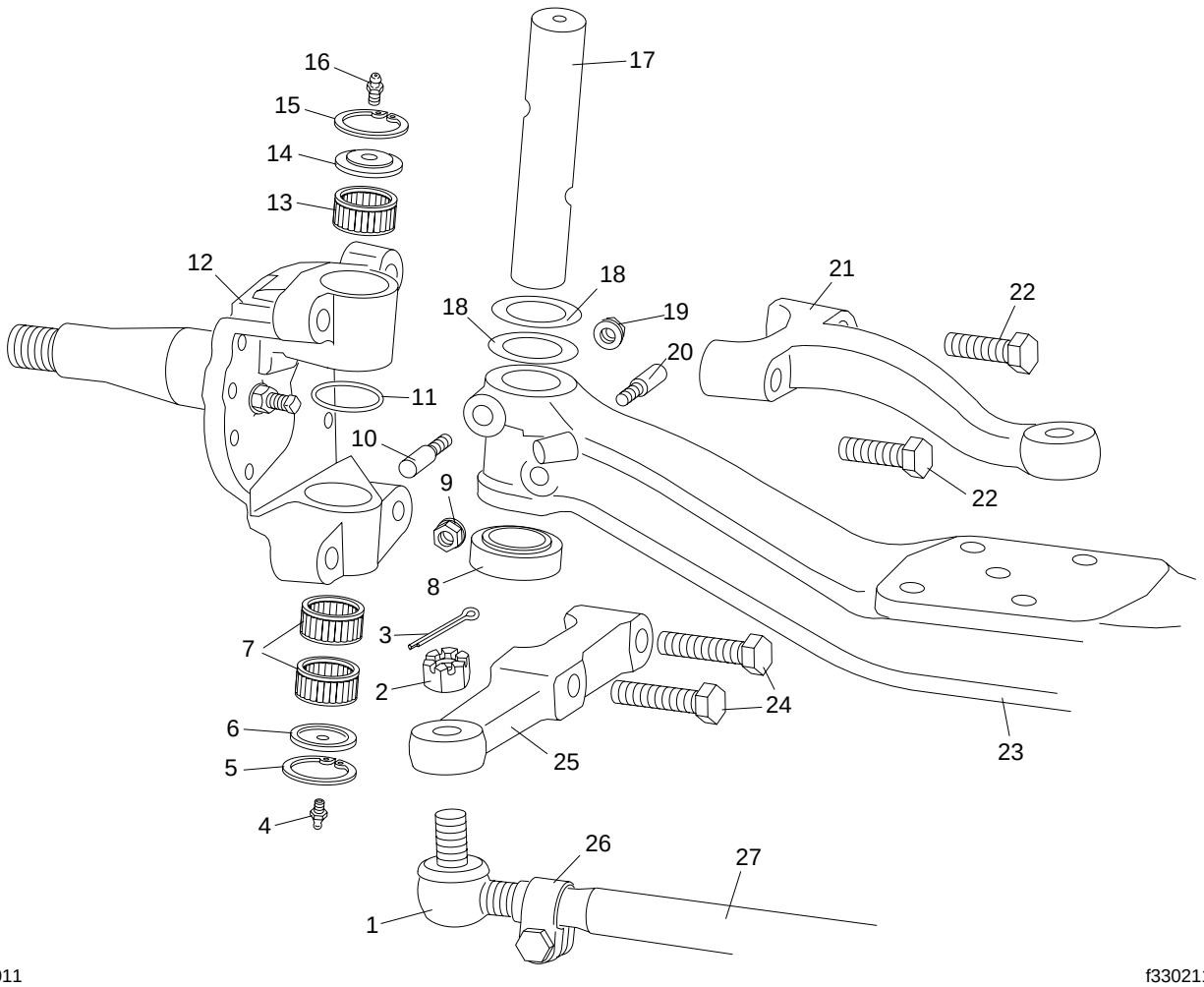
NOTE: The steering knuckle on the passenger side (side without a steering arm) has a thrust roller bearing instead of a thrust friction bearing. Unlike the thrust friction bearing, the thrust roller bearing has no protruding lip at the top. When removing the thrust roller bearing from the axle beam bore, 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 side) or the thrust roller bearing (passenger side) from the top of the lower steering knuckle bore.

NOTE: If removing the thrust friction bearing (driver side), note the orientation of the bearing for future reference.

Steering Knuckle Disassembly and Assembly



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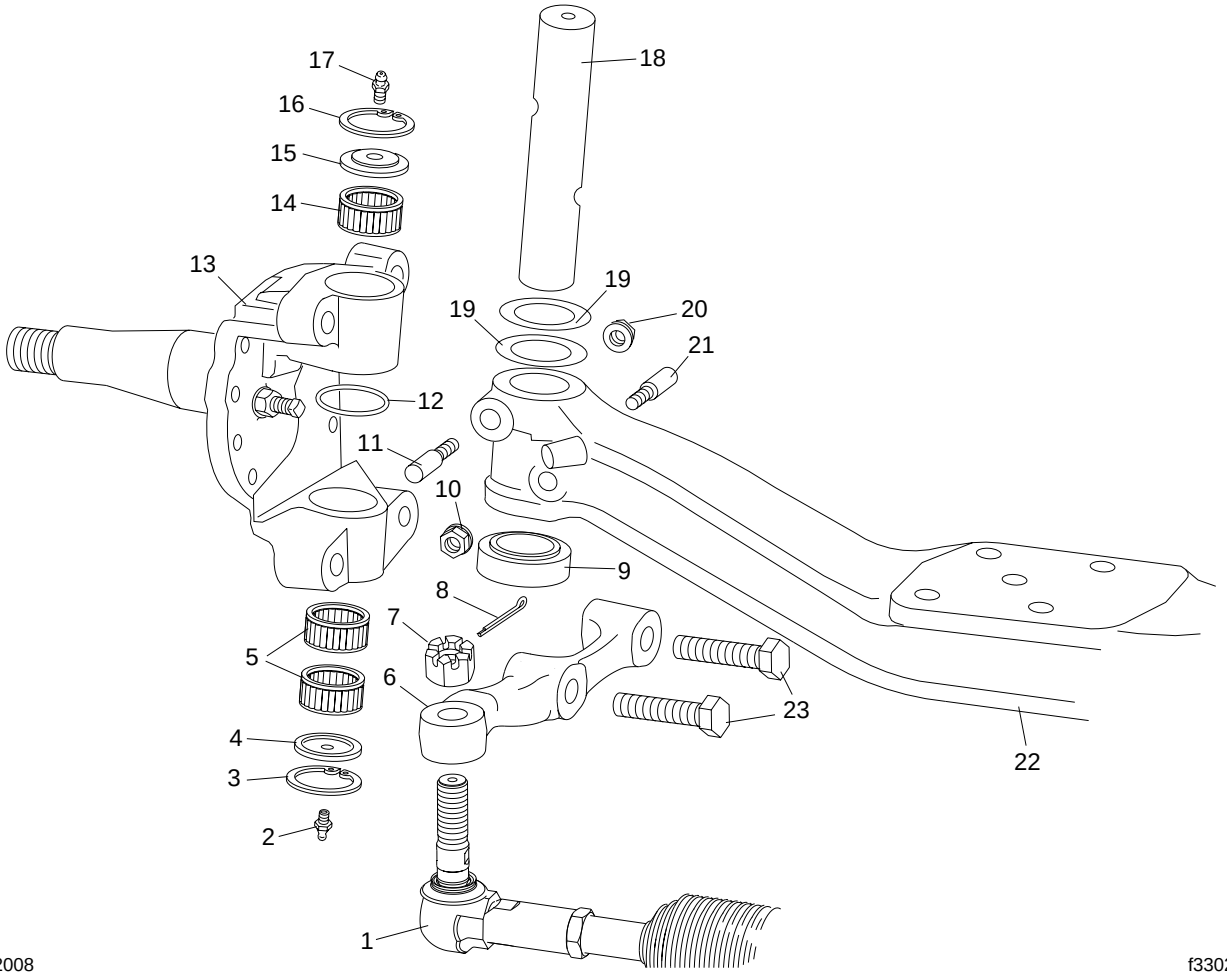
NOTE: The number of upper and lower needle bearing sets may vary, depending on the axle model.

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, Integral Steering Gear (driver side shown)

9. Using a suitable bushing driver, 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.



NOTE: The number of upper and lower needle bearing sets may vary, depending on the axle model.

1. Left Tie Rod
2. Lower Grease Fitting
3. Lower Snap Ring
4. Lower Cover Plate
5. Lower Needle Bearings (may be one or two sets)
6. Tie-Rod Arm
7. Castellated Nut
8. Cotter Pin
9. Thrust Friction Bearing (thrust roller bearing on the passenger side)
10. Lower Draw Key Nut
11. Upper Draw Key
12. Grease Seal
13. Steering Knuckle
14. Upper Needle Bearing (may be one or two sets)
15. Upper Cover Plate
16. Upper Snap Ring
17. Upper Grease Fitting
18. Kingpin
19. Shim
20. Upper Draw Key Nut
21. Lower Draw Key
22. Axle Beam
23. Tie-Rod Arm Capscrews

Fig. 2, Front Axle Components, Rack and Pinion Gear (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.

Steering Knuckle Disassembly and Assembly

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 side) or thrust roller bearing (passenger 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 0.007 inch (0.18 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 a maximum of 0.007 inch (0.18 mm).
6. Install the kingpin fully into the steering knuckle bores, ensuring that the flats on the kingpin are still aligned with the draw-key holes in the axle beam, and that the top of the kingpin (marked "Top") is properly positioned.

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. Install new upper and lower draw keys and nuts. See **Fig. 1** or **Fig. 2**.

   IMPORTANT: Incorrect installation of the draw keys could cause interference with the steering stop bolt.

   - 7.1 Install the upper draw key from the back of the axle, and the lower one from the front of the axle.
   - 7.2 Tighten the draw-key nuts 30 to 55 lbf·ft (40 to 75 N·m).

NOTE: There should be no lateral play at the upper or lower kingpin bearings.

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.

IMPORTANT: On vehicles equipped with an integral steering gear, the steering arm capscrews are shorter than the tie-rod arm capscrews. For capscrew sizes, see **Specifications, 400**.

9. If applicable, 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. Install the tie-rod arm. Apply Loctite® 277 to the threads and tighten the tie-rod arm:

    For rack and pinion steering, tighten M20 or M22 capscrews 425 lbf·ft (575 N·m).

    For integral steering gear, 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 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.

Specifications

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)
Steering Arm Capscrews	M20–1.5 x 80	10.9	425 (575)*
	M24–1.5 x 90		664 (900)*
Sway Bar Fasteners	—	—	100 (136)
Tie-Rod Arm Capscrews, Rack and Pinion Gear	M20–1.5 x 90	10.9	425 (575)*
	M22–1.5 x 90		
Tie-Rod Arm Capscrews, Integral Steering Gear	M20–1.5 x 90	10.9	425 (575)*
	M24–1.5 x 100		664 (900)*

* Apply Loctite® 277.

Table 1, Torque Values

The following procedures apply to MFS-12 Series axles.

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, remove the bumper.

1. Park the vehicle on a level surface, set the parking brakes, then chock the rear tires.
2. Raise the vehicle, then support the frame rails with safety stands.
3. Remove the front wheel and tire assemblies. For instructions, see **Group 40**.

⚠ WARNING

When draining the air system, do not look into the air jets or direct them toward another person, as 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 while working on the air brake system can cause personal injury.

4. Drain the air system.
5. Disconnect the air lines from the front brake chambers.
6. Remove the front brake drums and 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. See **Section 46.06, Subject 100**
12. If needed, remove the front bumper. See **Group 31** for instructions.
13. Using a suitable jack, support the front axle.
14. Disconnect the axle from the leaf springs, as follows.
    - 14.1 Take the weight off the leaf springs by raising the axle.
    - 14.2 On one side of the axle, remove all of the U-bolt nuts and washers, then remove the two U-bolts.
    - 14.3 Repeat the procedure on the other side of the axle.
15. Remove the axle stops from the top of the leaf springs.
16. Remove the axle spacers from the top of the axle beam.
17. Using a suitable axle jack, remove the axle by sliding it out from the front of the vehicle.
18. If you are replacing the steering knuckles, put the axle on a suitable stand and secure it to prevent it from moving.

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, as follows.
    - 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.

Axle Removal and Installation

5.3 Repeat on the other side of the vehicle.

5.4 Tighten each of the U-bolts fully. See **Section 32.00, Subject 400** for torque values.

6. Connect the drag link to the steering arm. For instructions, see **Section 46.06, Subject 100**.
7. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
8. Install the brake air chambers and slack adjusters onto the axle. For instructions, see the applicable sections in **Group 42**.
9. Install the ABS sensors.
10. Install the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
11. Install the hubs and adjust the wheel bearings. For instructions, see **Section 33.01, Subject 100**.
12. Install the brake drums.
13. Adjust the slack adjusters. For instructions, see the applicable section in **Group 42**.
14. Install the tire and wheel assemblies. For instructions, see **Group 40**.
15. If the bumper was removed, install it. See **Group 31** for instructions.
16. Raise the vehicle, remove the safety stands, and lower the vehicle.
17. Align the vehicle. See **Section 33.00** for instructions.

General Information

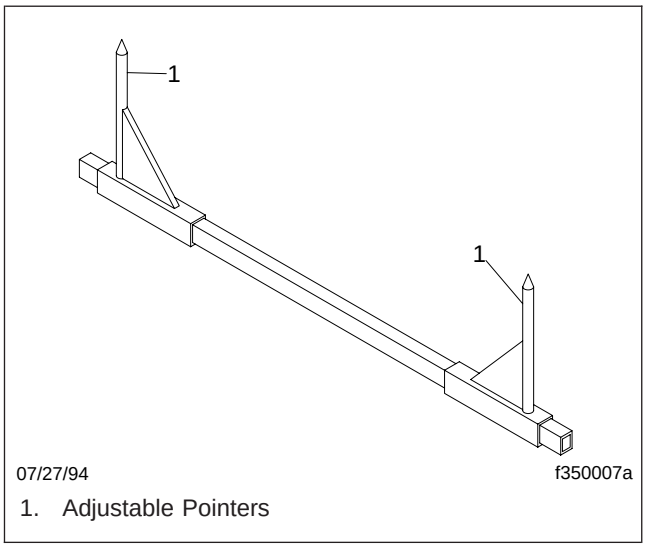
Rear axle alignment should be checked whenever rear axle or suspension components are replaced. It should also be checked when there is excessive front and rear tire wear, or hard or erratic steering.

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 Pointers

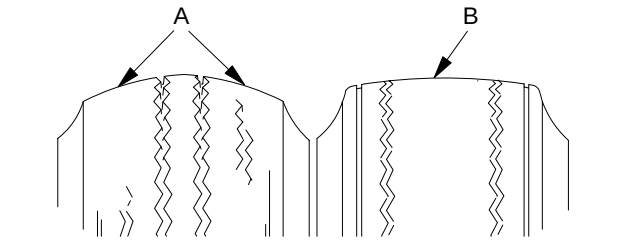
Fig. 1, Center Point Bar

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 *Cascadia 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; refer to **Section 32.01** for instructions. 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. Refer to **Section 32.01, Subject 180** for instructions.
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.

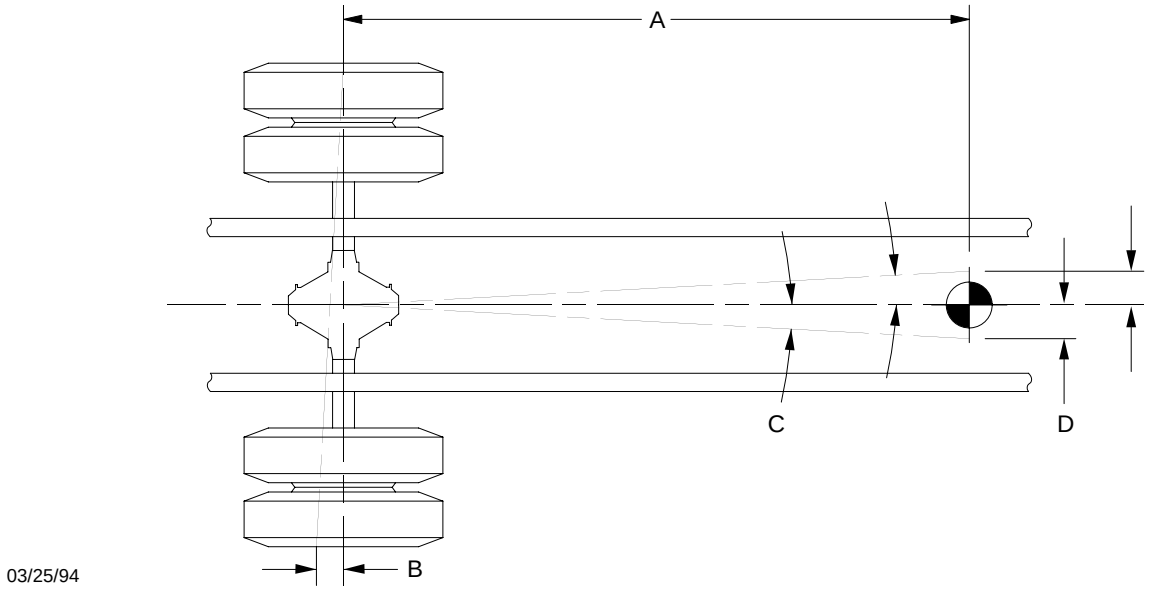
3. Select a point on the frame rail forward of the rear axle, and mark it using a pencil or soapstone. Then mark two other points, exactly 4 inches (102 mm) forward and to the rear of the original point. Make sure that all three marks are aligned and of equal distance from the outside edge of the frame rail. Using a center point or trammel bar, place one pointer on the forwardmost 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.

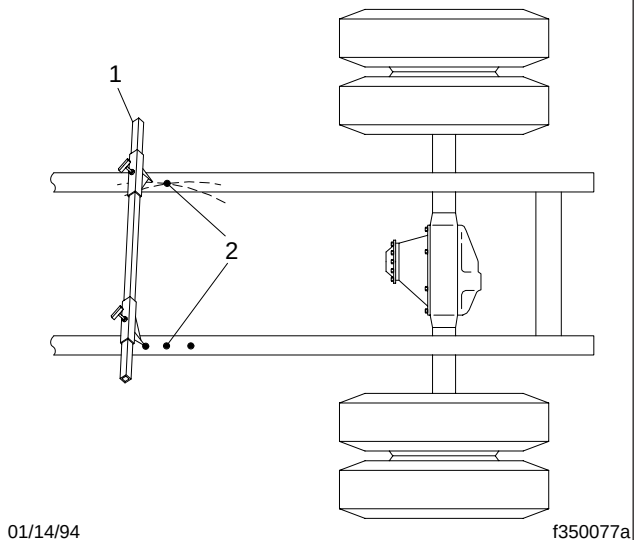
Alignment Checking, Single Axle



For items A and D, see **Specifications 400**.

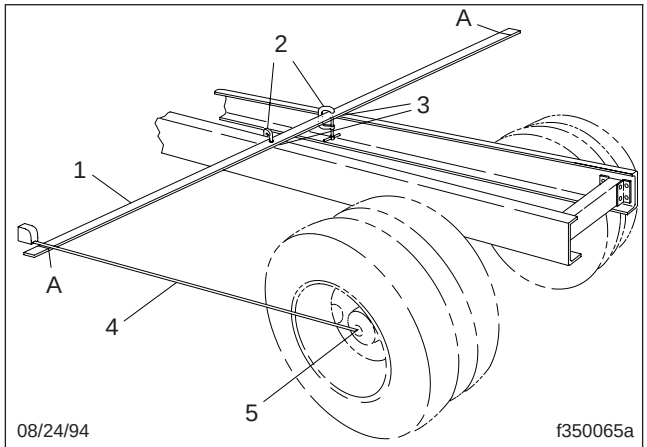
A. Distance from Rear Axle to Target (using Bee Line Alignment Tools)
B. Maximum Allowable Difference if Aligned Manually = ±1/4 inch (6 mm)
C. Maximum Allowable Tolerance if Aligned with Hunter Tools = ±0.18 degree
D. Maximum Allowable Tolerance if Aligned with Bee Line Tools

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.

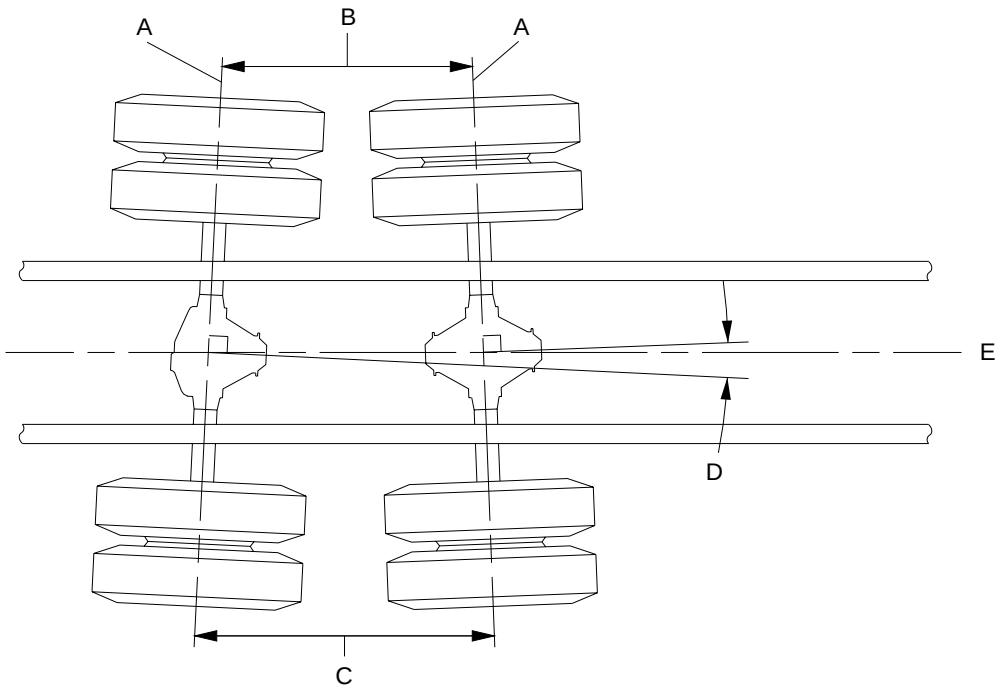
Follow the manufacturer's instructions for use of the alignment equipment, and use the alignment measurements given in **Fig. 1** and the applicable tables in **Specifications 400**.

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.

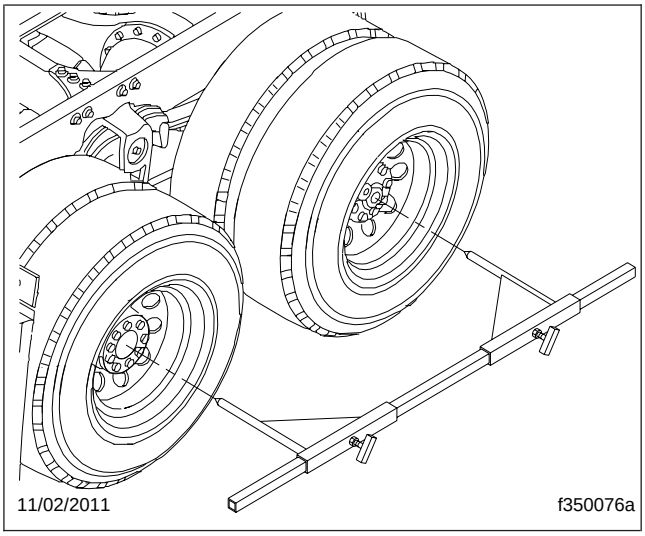


Fig. 2, Center Point Bar Placement

Center Point Bar Construction

Materials Required

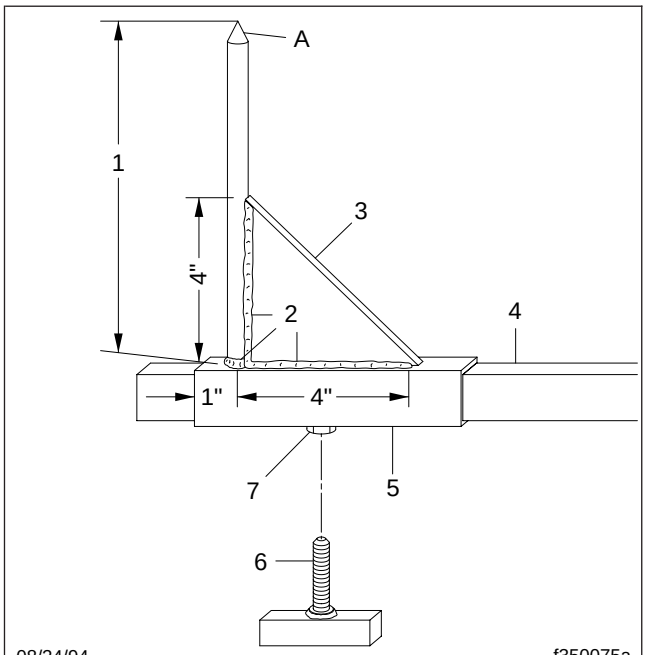
NOTE: To obtain metric conversions (millimeters), multiply the number of inches by 25.4.

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

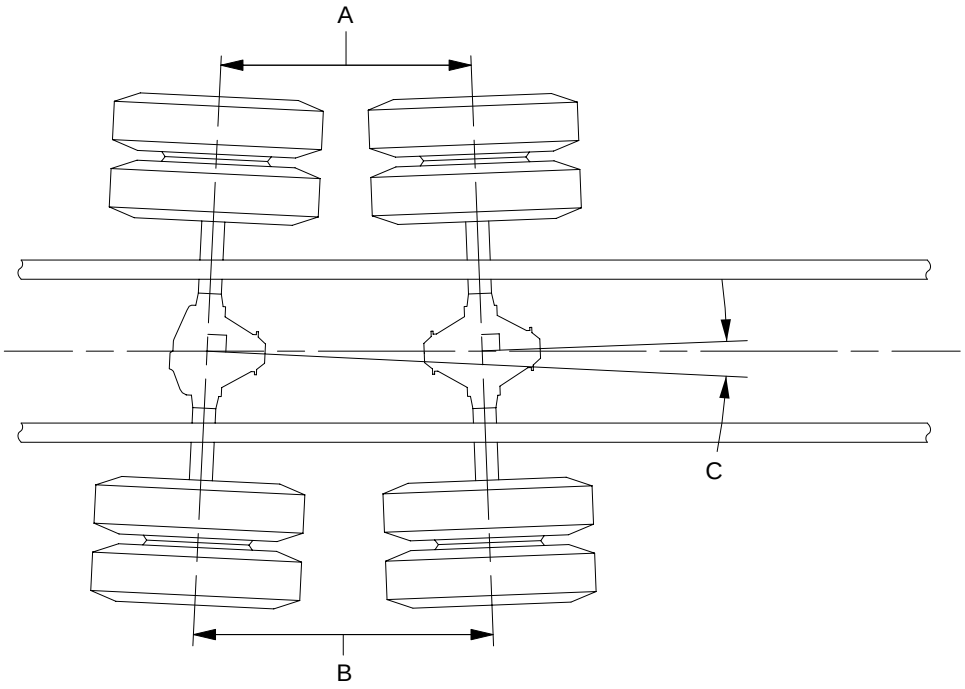
Maximum Tolerance from Perpendicular at Target, Bee Line Equipment	
Distance from the Forward or Rear Drive Axle to Target: inches (mm)	**Maximum Tolerance ± from Perpendicular: inches (mm)**
100 (2540)	5/16 (8)
120 (3048)	3/8 (10)
140 (3556)	7/16 (11)
160 (4064)	1/2 (13)
180 (4572)	9/16 (14)
200 (5080)	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**.
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



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NOTE: See **Table 4** for values corresponding to callouts A, B, and C.

Fig. 1, Tandem Axle Measurements

General Information

A wheel end assembly consists of a wheel hub, wheel bearings, axle spindle, wheel studs, and brake drum or, for disc brakes, a rotor and caliper. See **Fig. 1** and **Fig. 2**. Cascadia vehicles are typically equipped with one of the following wheel end assemblies:

- A ConMet PreSet® hub and double spindle nut system.

  Most Cascadias are equipped with PreSet hubs, which have the bearings and oil seal pre-installed. To install a new PreSet hub, mount it on the axle spindle, and secure it with a double spindle nut. For instructions, see **Subject 190**. A spacer between the inner and outer bearings adjusts the bearings to the correct end-play and preload when the retaining nut is tightened.

- A ConMet PreSet hub and Axilok® spindle nut.

  Some ConMet PreSet hubs use an Axilok nut (see **Subject 140**). As with ConMet PreSet hubs that use the double spindle nut, the bearings and oil seal are pre-installed and a spacer between the inner and outer bearings adjusts the bearings to the correct end-play and preload when the retaining nut is tightened.

- A ConMet PreSet Plus™ hub and spindle nut system.

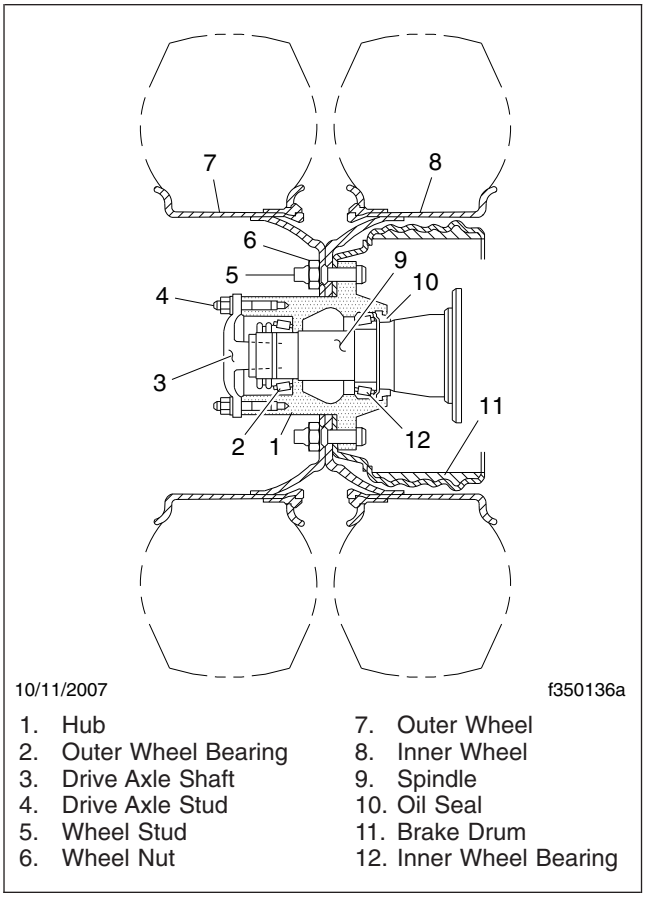
  The ConMet PreSet Plus system is specially designed for easy and reliable hub removal and installation. As with ConMet PreSet hubs, the spacer between the inner and outer bearings adjusts the bearings to the correct end play and preload when the nut is tightened. For instructions, see **Subject 220**.

- The traditional hub and bearings, and a double spindle nut system.

  With traditional wheel ends, the bearings and oil seal must be assembled with the hub when the hub is installed on the axle spindle. First the oil seal is placed on the spindle (some brands of oil seal are installed in the hub bore), then the inner bearing and the hub are mounted on the axle spindle. Then, the outer bearing is mounted in the hub bore. A nut is installed on the axle spindle end and tightened and loosened to adjust the bearings. Finally, locking device and jam nut are installed to secure the hub and bearings on the axle. For instructions, see **Subject 190**.

- The traditional hub and bearings, and a Pro-Torq® nut system.

  This system is the same as the above traditional hub and bearing system, but in place of the double spindle nut system, it has one adjusting nut and a lockring device. For instructions, see **Subject 150**.



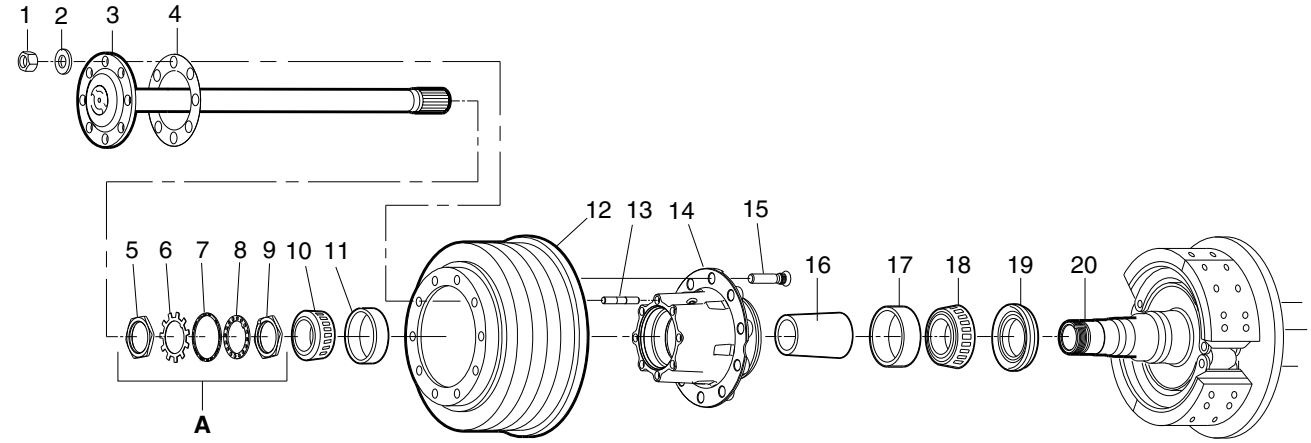
1. Hub
2. Outer Wheel Bearing
3. Drive Axle Shaft
4. Drive Axle Stud
5. Wheel Stud
6. Wheel Nut
7. Outer Wheel
8. Inner Wheel
9. Spindle
10. Oil Seal
11. Brake Drum
12. Inner Wheel Bearing

Fig. 1, Wheel End Assembly with Brake Drums

Wheel Hub

The brake drum is mounted on an aluminum or iron wheel hub. See **Fig. 2**. Both the inner and outer bearing cups and certain types of wheel studs are press-fit in the hub. The hub is also the interconnecting point for the drive axle shaft and wheels.

General Information



NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations. ConMet PreSet Plus hubs use a special spindle nut system.

1. Drive Axle Stud Nut
2. Washer
3. Drive Axle Shaft
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Brake Drum
13. Drive Axle Stud
14. ConMet PreSet Hub
15. Wheel Stud
16. Bearing Spacer
17. Inner Wheel Bearing Cup
18. Inner Wheel Bearing
19. Oil Seal
20. Axle Spindle

Fig. 2, Typical Wheel End Assembly, Drive Axle with Drum Brakes

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.

The brake drum is mounted on the outboard face of the hub and fits over the wheel studs. See **Fig. 2**.

Tapered Wheel Bearings

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. 3**. All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

Each hub has a set of inner and outer tapered wheel bearing assemblies. See **Fig. 2**. ConMet PreSet and PreSet Plus hubs have special bearing assemblies.

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.

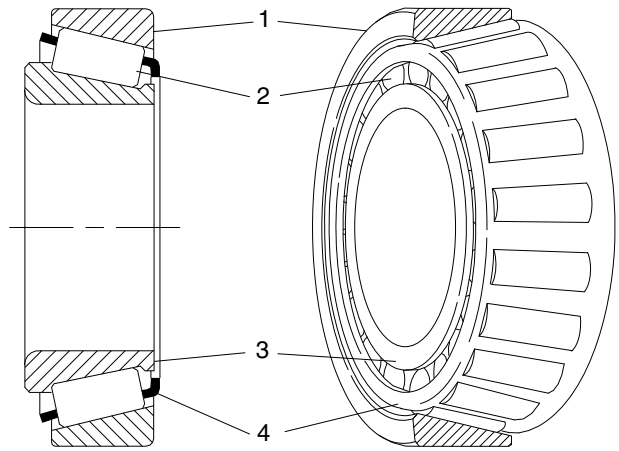
⚠ CAUTION

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 co-

rrectly aligned on the spindle. This can cause damage to the spindle nut.

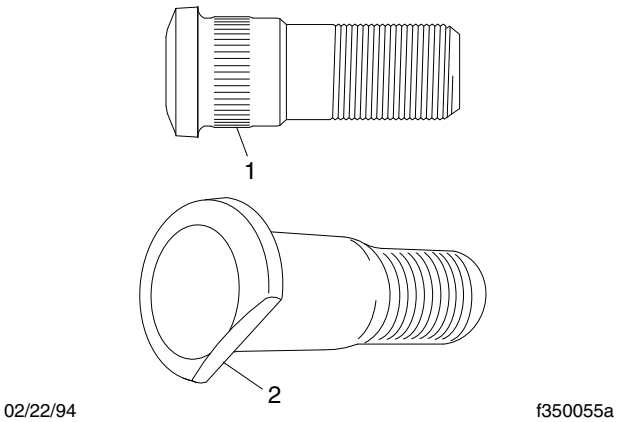
Wheel Studs

A headed wheel stud is used on rear 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. See **Fig. 4**.



1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 3, Tapered Wheel Bearing Assembly

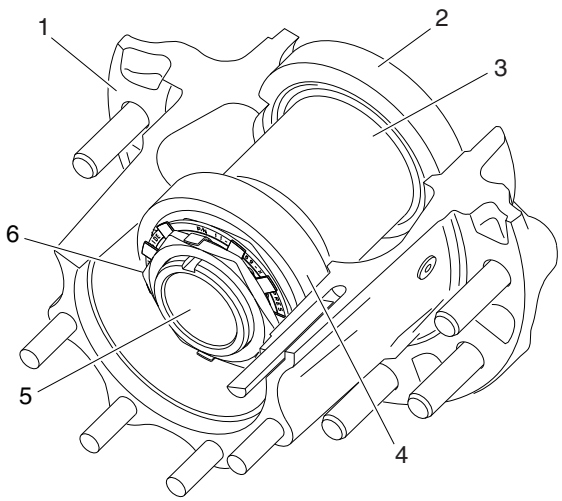


1. Serrations
2. Clipped Head

Fig. 4, Typical Headed Wheel Studs

General Information

ConMet PreSet® and PreSet Plus™ hubs are equipped with a unique bearing spacer between special inner and outer bearings. See **Fig. 1.**



NOTE: PreSet Plus hubs use a special spindle nut system.

1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Axle Spindle
6. Retaining Nut (double spindle nut system)

Fig. 1, ConMet PreSet Hub, Cut-Away View

When installing a PreSet or PreSet Plus 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.

Wheel ends equipped with ConMet PreSet Plus hubs must use PreSet Plus components. Do not substitute non-PreSet-Plus components on these installations.

Removal

For typical wheel end and axle assemblies, see **Fig. 2** and **Fig. 3**.

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.

   For disc brakes, remove the brake caliper. See **Section 42.21** 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.

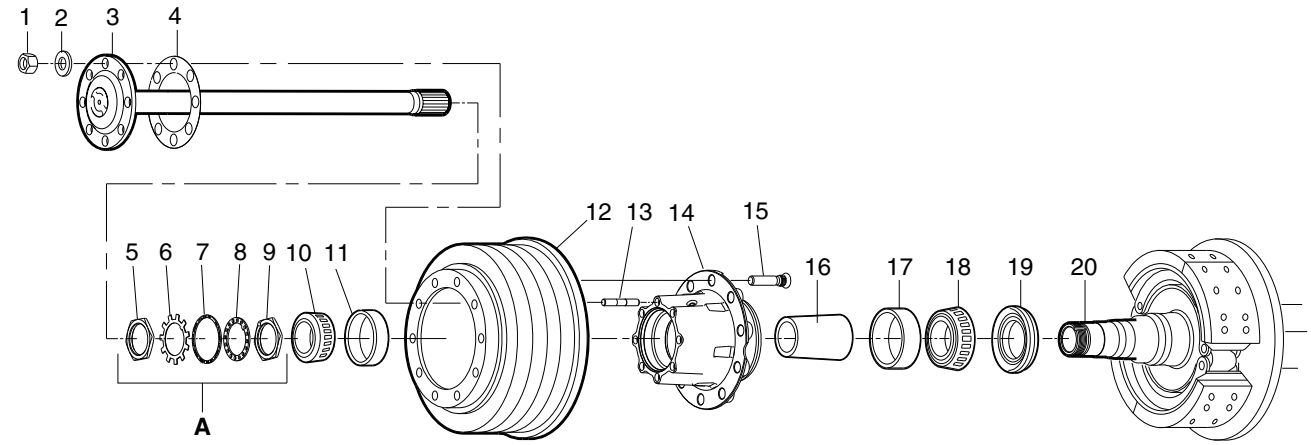
6. Remove the drive axle stud nuts and washers. See **Fig. 4**.

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.

Hub Assembly Removal and Installation



NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations. ConMet PreSet Plus hubs use a special spindle nut system.

1. Drive Axle Stud Nut
2. Washer
3. Drive Axle Shaft
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Brake Drum
13. Drive Axle Stud
14. ConMet PreSet Hub
15. Wheel Stud
16. Bearing Spacer
17. Inner Wheel Bearing Cup
18. Inner Wheel Bearing
19. Oil Seal
20. Axle Spindle

Fig. 2, Typical Wheel End Assembly, Drive Axle with Drum Brakes

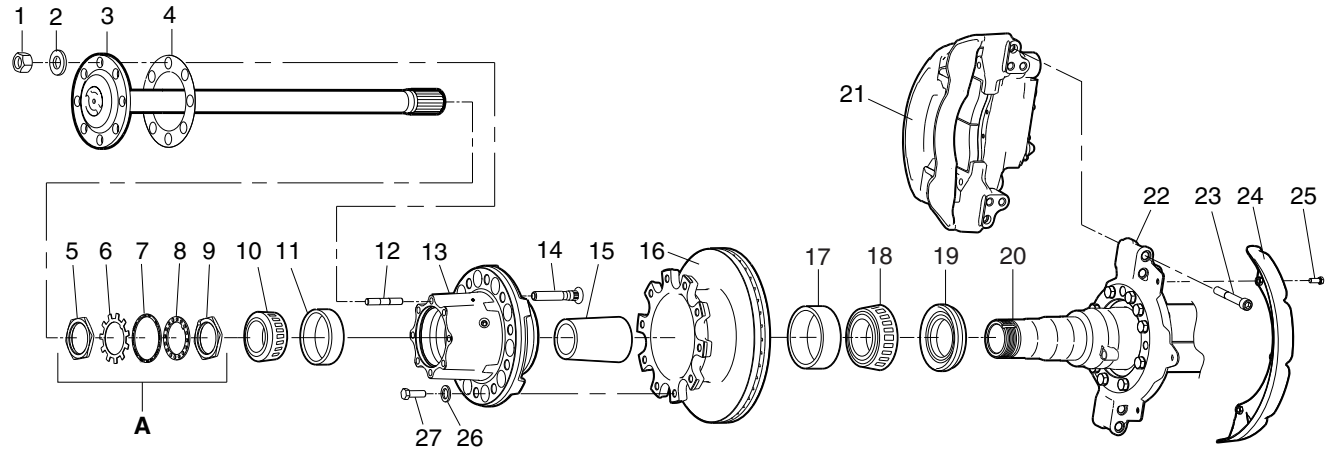
NOTE: Even if the drive axle shaft doesn't spring outward, the seal may have loosened enough to allow the shaft to be pulled from the axle housing. If the seal has not broken, repeat the step above.

8. If so equipped, remove the tapered dowels and washers from the drive axle flange.
9. Remove the drive axle shaft.
10. Remove and discard the gasket.
11. Remove the wheel bearing locking device:
    - For an Axilok spindle nut, see **Subject 140**; 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 double spindle nut system, see **Subject 190**; then go to the next step.
    - For ConMet PreSet Plus hubs, see **Subject 220**; then go to the next applicable 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.



NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations. ConMet PreSet Plus hubs use a special spindle nut system.

1. Drive Axle Stud Nut
2. Washer
3. Drive Axle Shaft
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Drive Axle Stud
13. ConMet PreSet Hub
14. Wheel Stud
15. Bearing Spacer
16. Brake Rotor
17. Inner Wheel Bearing Cup
18. Inner Wheel Bearing
19. Oil Seal
20. Axle Spindle
21. Brake Caliper
22. Anchor Plate
23. Caliper Mounting Capscrew
24. Rotor Shield
25. Rotor Shield Capscrew
26. Washer
27. Capscrew

Fig. 3, Typical Wheel End Assembly, Drive Axle with Disc Brakes

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.

NOTE: For vehicles equipped with disc brakes, instructions for removing the rotor from the hub are given in **Section 42.21**.

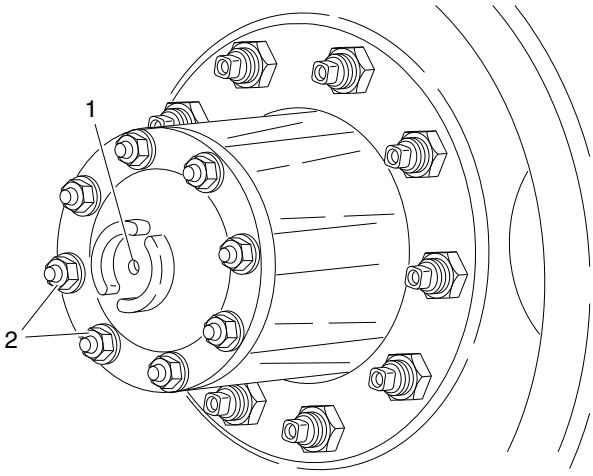
Installation

For typical wheel end and axle assemblies, see **Fig. 2** and **Fig. 3**.

NOTE: For vehicles equipped with disc brakes, instructions for installing the rotor to the hub are given in **Section 42.21**.

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

Hub Assembly Removal and Installation



1. Center Portion of Drive Axle Flange
2. Drive Axle Studs and Nuts

Fig. 4, Wheel Assembly and Hub

protective layer of friction tape on the axle spindle threads.

For PreSet hubs that are being reused, the bearing spacer must be replaced. For PreSet Plus hubs, the bearing spacer must be cleaned and inspected before being reused; see **Subject 110**. If the bearing spacer is worn or damaged, replace it with a new one.

2. 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.

3. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing. Do not lubricate the seal journal.

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.

4. 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.

NOTICE

When installing a hub, remember the following:

- **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 hub. It will be pushed out when the hub is installed on the axle spindle. If it is present, remove and discard this sleeve.

5. Mount the bearings and hub on the spindle.
6. Remove the friction tape, then adjust and secure the bearings:
   - For an Axilok spindle nut, see **Subject 140**; 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 double spindle nut system, see **Subject 190**; then go to the next step.
   - For ConMet PreSet Plus hubs, see **Subject 220**; then go to the next applicable step.

7. 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.
8. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle stud nuts. Using the sequence shown in **Fig. 5**, tighten the nuts to the torque values given in the table in **Specifications, 400**.
9. For drum brakes, install the brake drum on the wheel hub. See **Subject 160** for instructions.

   For disc brakes, install the the brake caliper. See **Section 42.21** for instructions.

⚠ 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.

10. 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.

11. Lubricate the wheel bearings, as follows.
    - For drive axles, see **Subject 210**.
    - 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.
12. Adjust the rear axle brakes. For instructions, see **Group 42**.
13. Remove the safety stands from under the axle, then lower the vehicle.

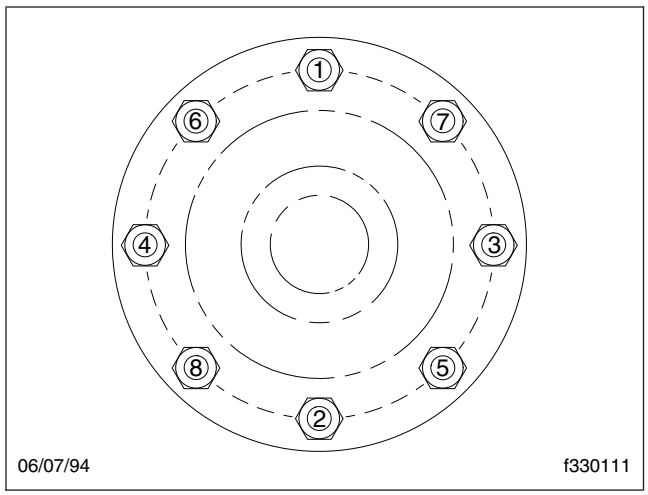
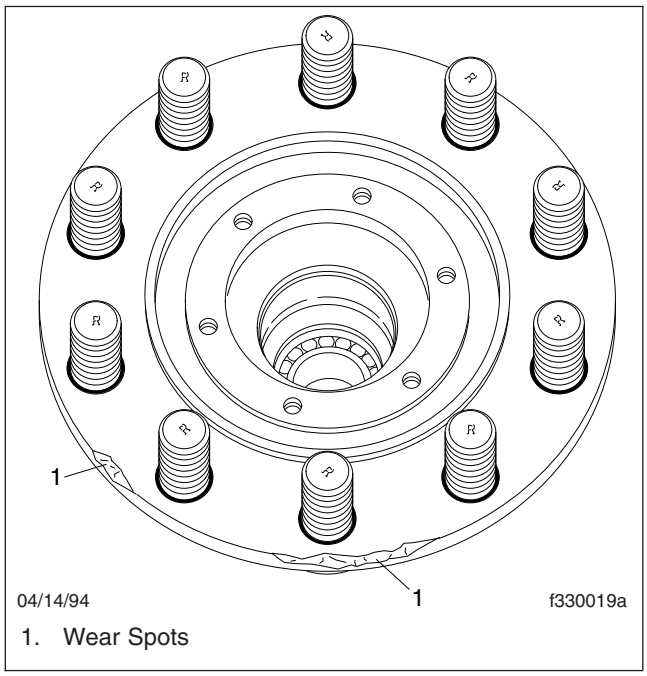


Fig. 5, Tightening Sequence, Drive Axle Stud Nuts

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.

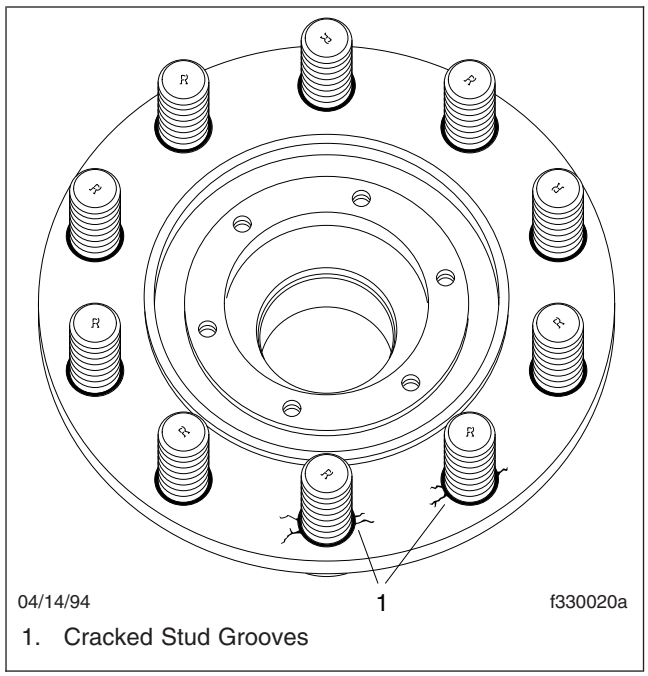
   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. See **Fig. 2**. If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.



1. Wear Spots

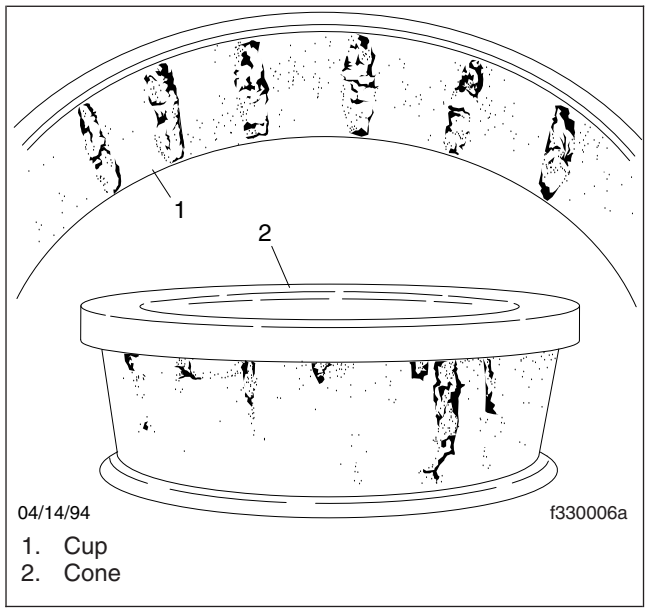
Fig. 1, Damaged Front Axle Wheel Hub

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**.



1. Cracked Stud Grooves

Fig. 2, Damaged Front Axle Wheel Hub



1. Cup
2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

4. Inspect the wheel studs. Replace studs that are stripped, broken, bent, or otherwise damaged. See **Subject 180**.

Axle Components Cleaning and Inspection

Wheel Bearing Inspection

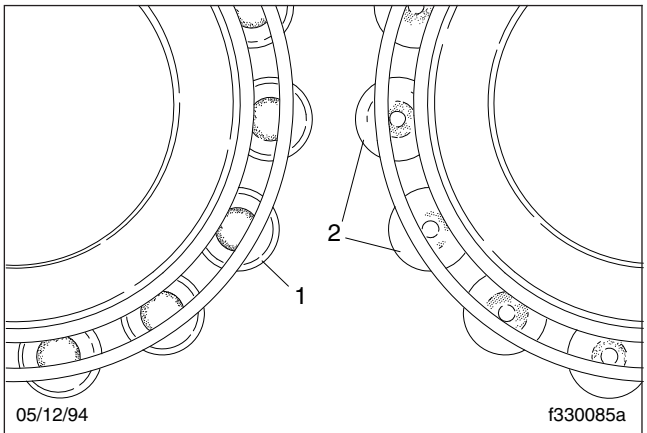
Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using nonflammable solvent and a stiff brush. Before inspecting, clean the bearings.

1. Remove the wheel hub and bearing cones. See **Subject 100**.
2. Using nonflammable solvent and a stiff brush, clean all the oil from the bearings and hub cavity. Do not 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 that 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:
    - 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. 4**.
    - Visible step wear, particularly at the small end of the roller track. Deep indentations, cracks, or breaks in the cone surfaces. See **Fig. 5**.
    - Bright rubbing marks on the dark phosphate surfaces of the bearing cage. See **Fig. 6**.
    - Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens the affected area. If water etch is present, replace the bearing seals.
    - Etching or pitting on functioning surfaces. See **Fig. 7**.



1. New Bearing
2. Worn Bearing Rollers

Fig. 4, Wheel Bearing Roller Wear

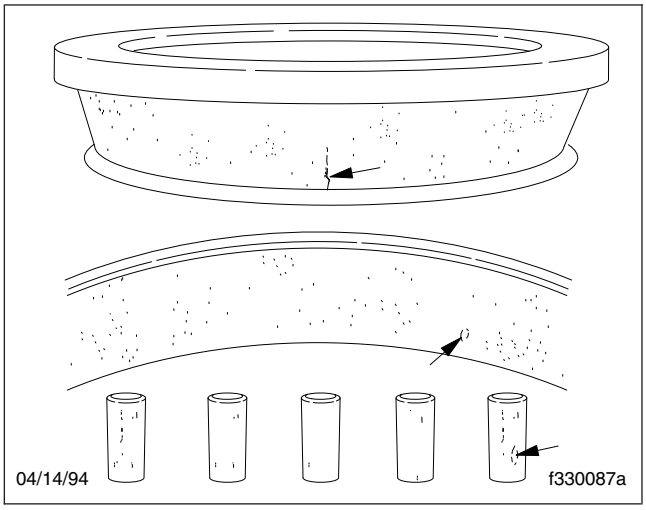


Fig. 5, Indentations, Cracks, or Breaks in Bearing Surfaces

- 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

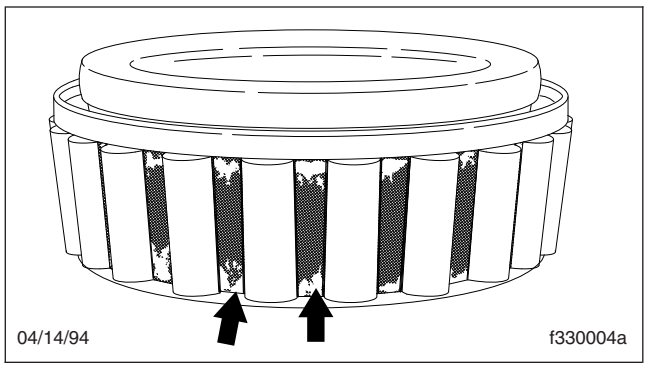


Fig. 6, Rubbing Marks on Bearing Cage

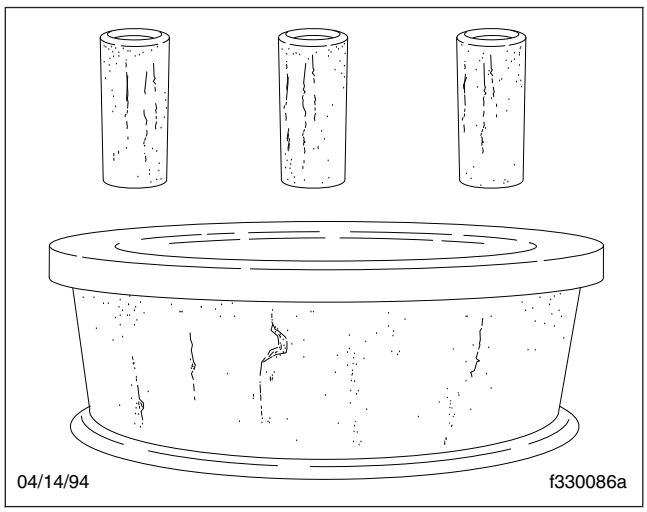
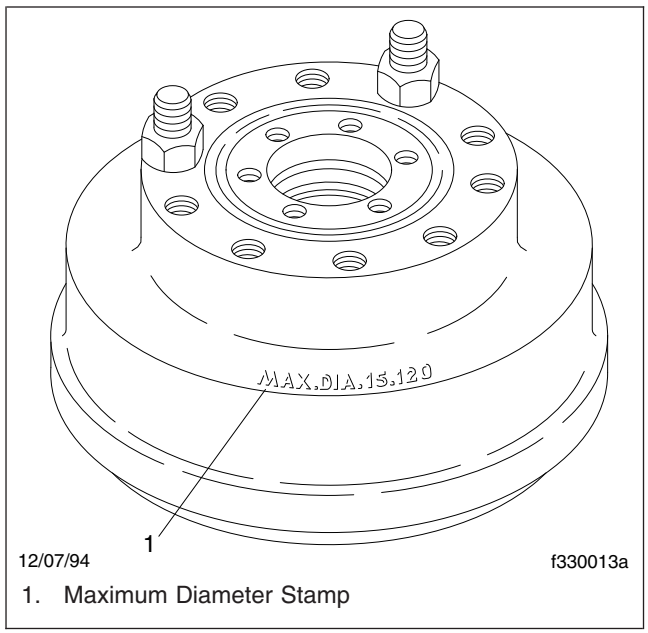


Fig. 7, Etching (Pitting) on Bearing Surfaces

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. 8** for a typical location of this stamp.

NOTE: Drums that have been turned should then be cleaned, using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be washed with hot water.



1. Maximum Diameter Stamp

Fig. 8, Outboard Mounted Hub and Drum Assembly

CAUTION

Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will result in drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimately, drum breakage.

If the drums are turned or replaced, replace the brake linings. See **Group 42** for instructions.

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.

Axle Components Cleaning and Inspection

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**.

⚠ 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.

NOTE: It may be necessary to remove the brake dust shield to measure the roundness of the drum.

5. Ensure the roundness of the drum is within acceptable limits, as follows. Set the measuring tip of a dial indicator against the working surface of the drum between the brake shoes as far outboard as possible. Zero the gauge, then turn the drum one revolution and note the highest and lowest measurements.

   If the difference is 0.010 inch (0.25 mm) or less, proceed to the next step. If the difference is more than 0.010 inch (0.25 mm), mark the drum and hub to record their relative positions, and remove the drum. Clean the mating surfaces of the hub and drum, and re-install the drum rotated 90 degrees from its earlier position. Tighten four wheel nuts 50 lbf·ft (68 N·m), and repeat the measurement. If the difference is more than 0.010 inch (0.25 mm), the drum is out of round beyond acceptable limits and all drums on the axle must be re-machined or replaced.

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.

Bearing Spacer Cleaning and Inspection, PreSet Plus™ Hubs

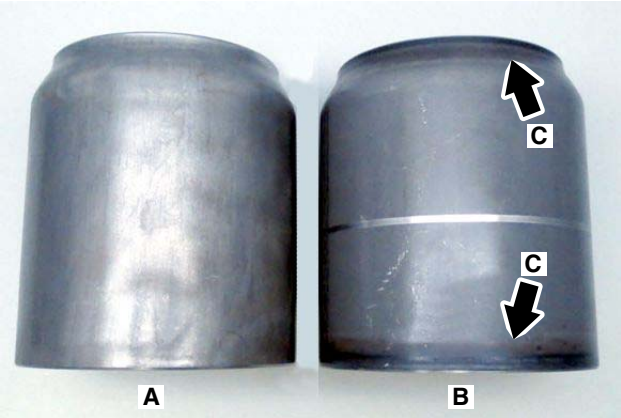
⚠ WARNING

Do not repair or recondition a damaged or worn bearing spacer; replace it. Using repaired, reconditioned, damaged, or worn components can cause wheel end failure, which can result in serious injury and property damage.

1. Use a cleaning solvent to clean the bearing spacer; do not use gasoline. Remove the solvent completely with clean, absorbent cloth or paper.

NOTE: PreSet Plus bearing spacers have undergone a heat-treating process that discolors the ends; see **Fig. 9**. This type of discoloration is normal for heat-treated spacers.

2. Inspect the bearing spacer for signs of wear or damage. Look for a sharp ring of standing metal that has been worn into the spacer at either end; see **Fig. 10**. If the spacer is worn or damaged, replace it.



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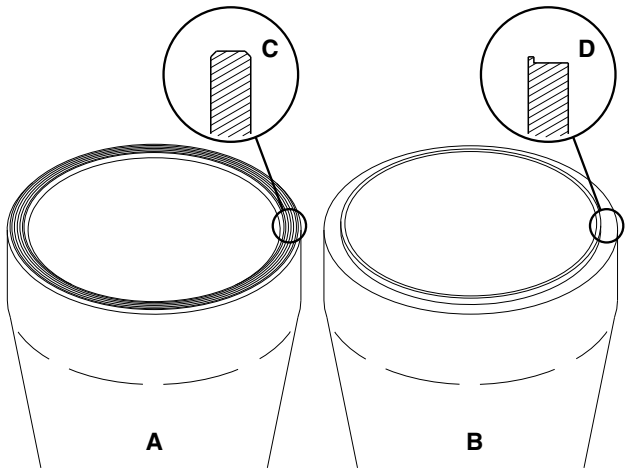
A. PreSet Spacer (Not Heat-Treated)
B. PreSet Plus Spacer (Heat-Treated)
C. Discoloration from Heat Treating Process

Fig. 9, PreSet and PreSet Plus Bearing Spacers



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A. New Spacer
B. Worn Spacer
C. Machined Surfaces with Chamfers and Grooves
D. Sharp Edge Worn into Machined End

Fig. 10, Comparison of New and Worn Bearing Spacers

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 hub-contact surface of the replacement bearing cup 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.

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.

Axilok Spindle Nut Removal, Installation, and Adjustment

General Information

Axilok® spindle nuts may be 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

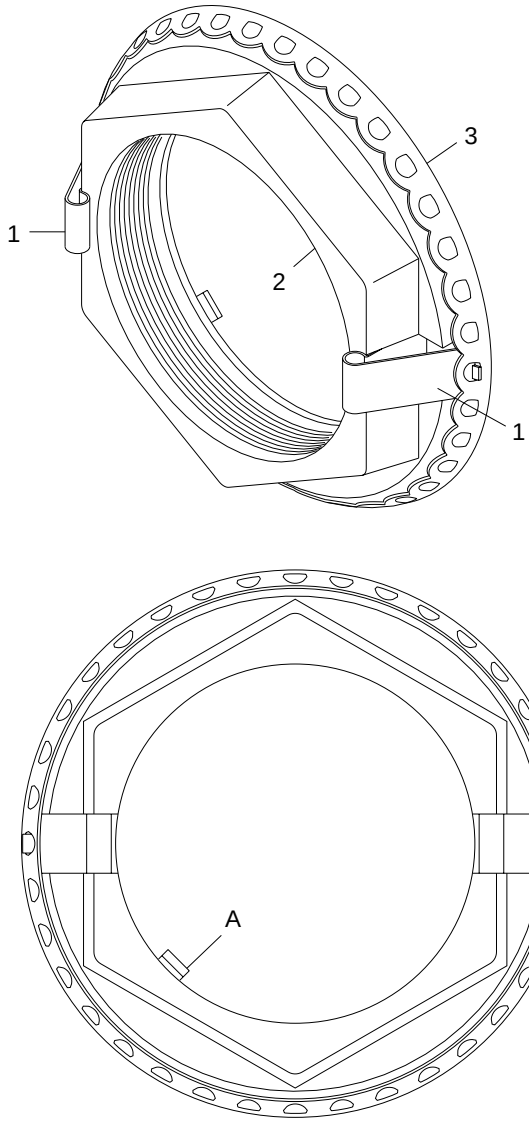
Instructions for installing an Axilok nut for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

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**.



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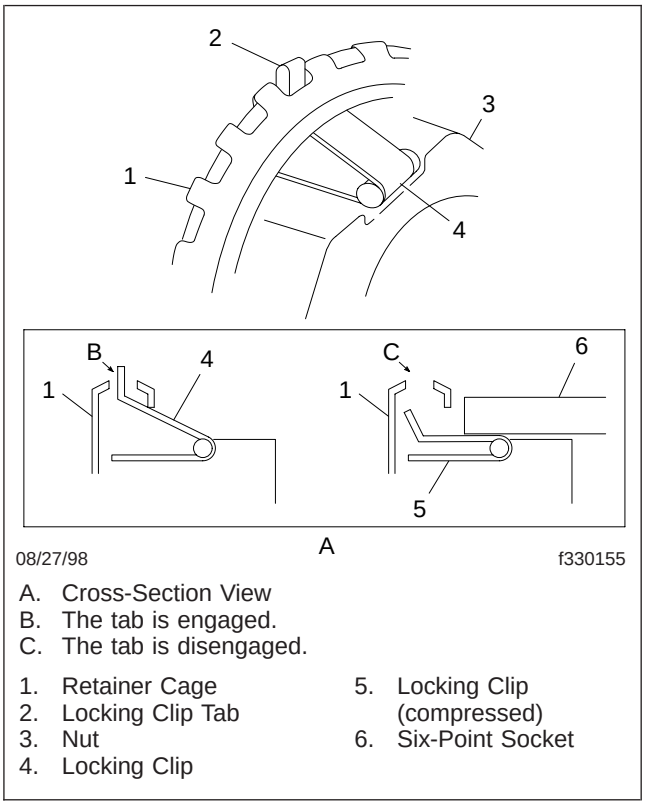
A. The retainer tab must engage the keyway of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer

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 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.

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. Measure the end play; see **Subject 200** for instructions.

⚠ WARNING

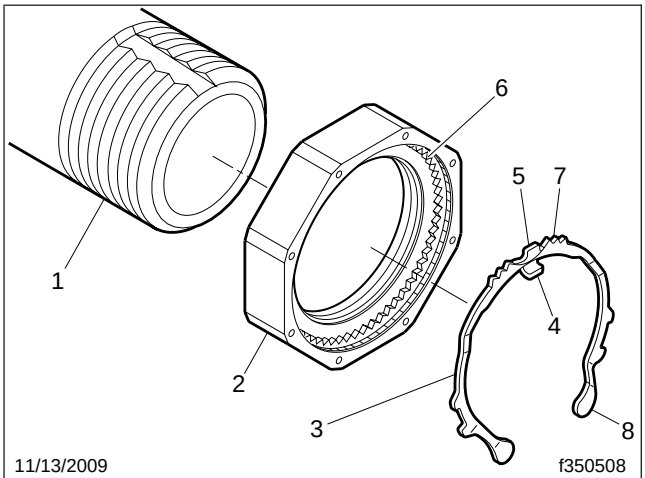
Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to 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.

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. Keyway Tab
5. Keeper Tab
6. Mating Teeth, Nut
7. Mating Teeth, Keeper
8. Keeper Protrusion

Fig. 1, Pro-Torq Spindle Nut and Keeper

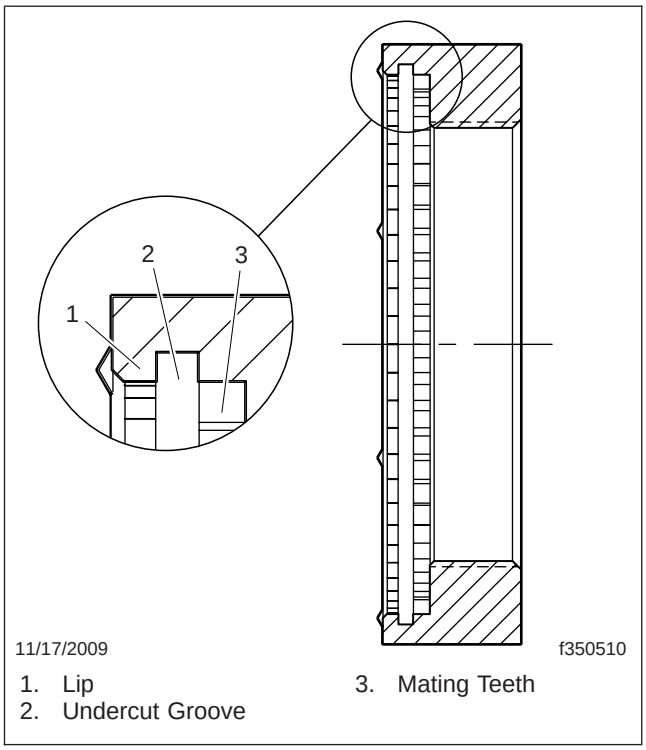
Each time the Pro-Torq nut assembly is removed for maintenance purposes, replacing the "keeper" is recommended.

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.



1. Lip
2. Undercut Groove
3. Mating Teeth

Fig. 2, Pro-Torq Spindle Nut, Cross Section

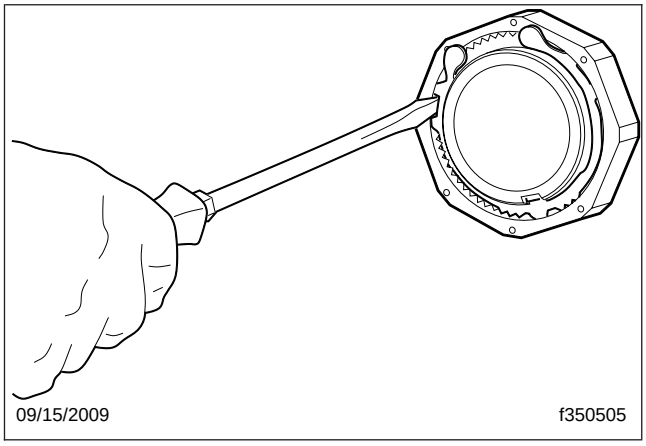


Fig. 3, Removing the Keeper

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**.

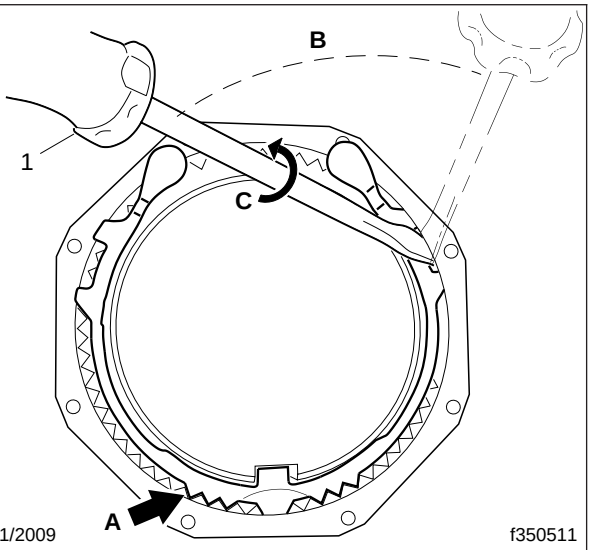
⚠ WARNING

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 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.

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. Measure the end play; see **Subject 200** for instructions.

WARNING

Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. 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, continue your service procedure.

Outboard-Mounted Brake 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.

Removal

1. 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. See **Group 42** for instructions.

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.

Installation

1. Install the brake drum on the wheel hub, as follows.

   1.1 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. 1**.

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are tightened.

   1.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

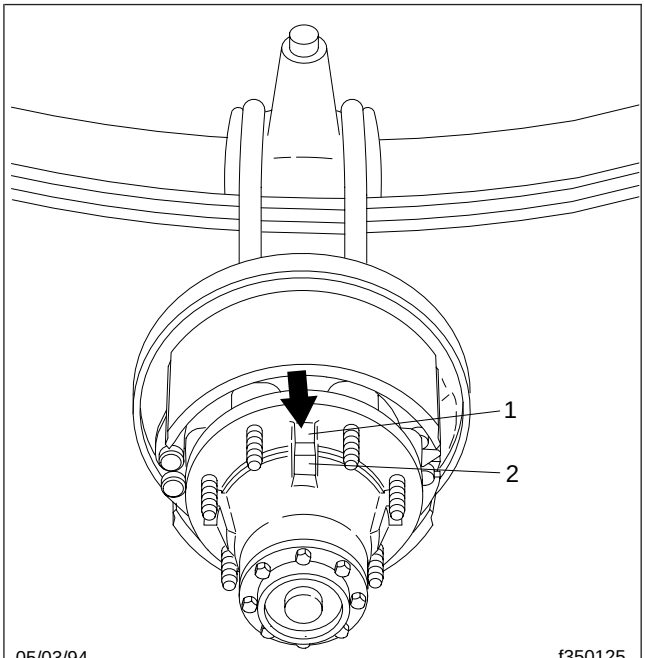
   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary to hold the drum in position, adjust the brakes before installing the wheels.
2. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the correct nut tightening sequence. For instructions, see **Group 40**.

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.

3. Adjust the rear axle brakes.
4. Remove the safety stands from under the axle; lower the vehicle.
5. Remove the chocks from the tires.

Outboard-Mounted Brake Drum Removal and Installation



NOTE: Pilot pad at 12 o'clock position

1. Drum Pilot
2. Wheel Pilot

Fig. 1, 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 using the heat of an oven or boiling water (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. Heat the hub to a temperature range of 175° to 215°F (79° to 102°C). If using an oven, make sure the thermostat is accurate; 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.

IMPORTANT: If a bearing cup or cone shows signs of deterioration, replace the suspect part along with the mating component. Use the appropriate replacement parts to help ensure proper bearing adjustment.

3. Wearing heavy protective gloves, remove the hub from the oven or water. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

   If the cup is loose, allow a few minutes for the temperatures of the components to equalize before moving the hub.

IMPORTANT: Inspect the bearing cup bore for evidence of cup rotation (spun cups). If found, replace the hub.

Installation

To install the bearing cups, aluminum hubs must be temporarily expanded using the heat of an oven or boiling water. When the hub is properly heated throughout, the bearing cup and hub can be press-fit together, using a suitable press. Cooling the cups in a freezer can further ease the 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. Heat the hub to a temperature range of 175° to 215°F (79° to 102°C). If using an oven, verify that the oven thermostat is accurate; 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 hub-contact surface of the replacement bearing cup with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven or water.
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.

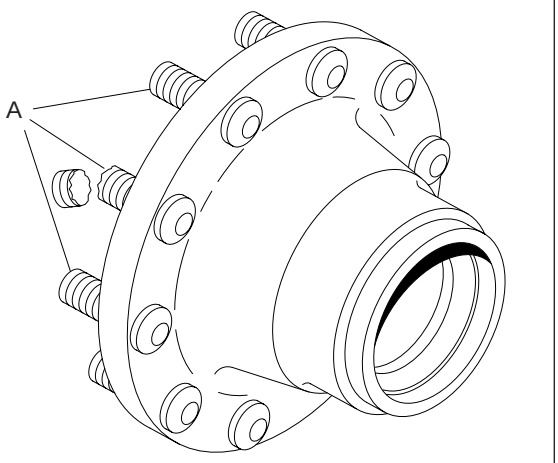
Wheel Bearing Cup Removal and Installation, Aluminum Hubs

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.



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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.

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

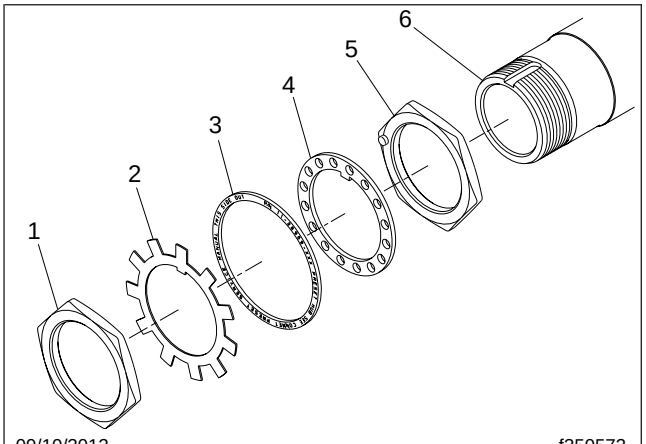
Do not embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss of a wheel or loss of steering control, possibly resulting in personal injury.

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**.

Double Spindle Nut Removal, Installation, and Adjustment

General Information

ConMet PreSet hubs may use a double spindle nut system. See **Fig. 1**. A plastic ID ring between the adjusting nut and locking washer indicates that a ConMet Preset hub has been installed.



NOTE: ID ring used with ConMet PreSet hubs only.

1. Jam Nut
2. Bend-Type Locking Washer
3. ID Ring
4. Lockring
5. Adjusting Nut
6. Axle Spindle

Fig. 1, Double Spindle Nut Set

Removal

Once a double spindle nut set is removed, discard the bend-type locking washer. Inspect the adjusting nut, lockring, and jam nut for visible damage prior to reuse.

Installation

Instructions for installing a double spindle nut 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 (410 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), ID ring (for ConMet PreSet hubs only), 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**.

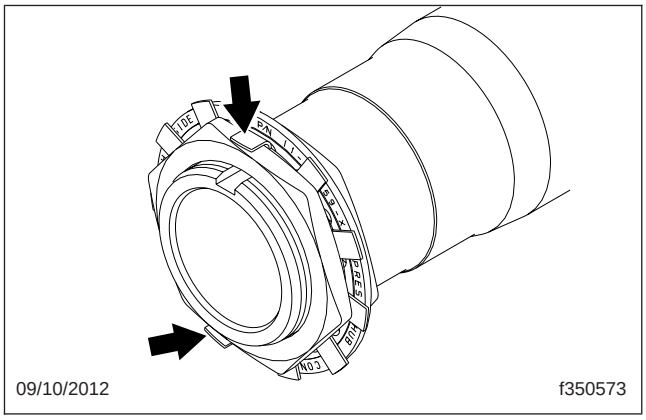


Fig. 2, Tabs Bent to Lock the Jam Nut

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).
   - 1.3 Back off the adjusting nut one full turn.

Double Spindle Nut Removal, Installation, and Adjustment

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 bend-type locking washer.
3. Install the jam nut, and tighten it 300 to 400 lbf·ft (410 to 540 N·m).
4. Measure the end play; see **Subject 200** for instructions.

⚠ WARNING

Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. 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.

Wheel Bearing End Play Measurement

⚠ WARNING

Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.

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.

Measurement

Using a dial indicator, measure the end play as follows.

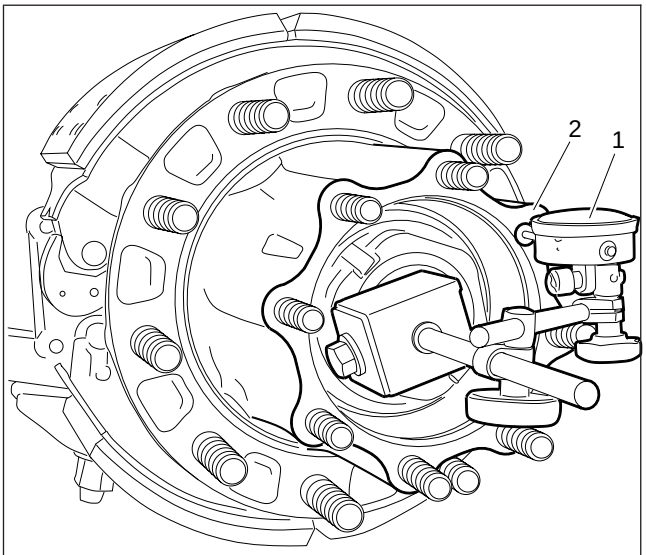
1. Attach the magnetic base of a dial indicator to the spindle, and place the measuring end of the indicator squarely against the flange as shown in **Fig. 1**.

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.

2. 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, note the inboard measurement, and then pull the hub outward while oscillating it as before. Maintain pressure on the hub, and note the outboard measurement.

   The end play is the difference between the two measurements.

NOTE: If the end play exceeds the limit, the hub may need to be serviced. See **Subject 110** and manufacturer literature for procedures.



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1. Dial Indicator (with magnetic base)
2. Axle Shaft Mounting Flange

Fig. 1, Dial Indicator Setup

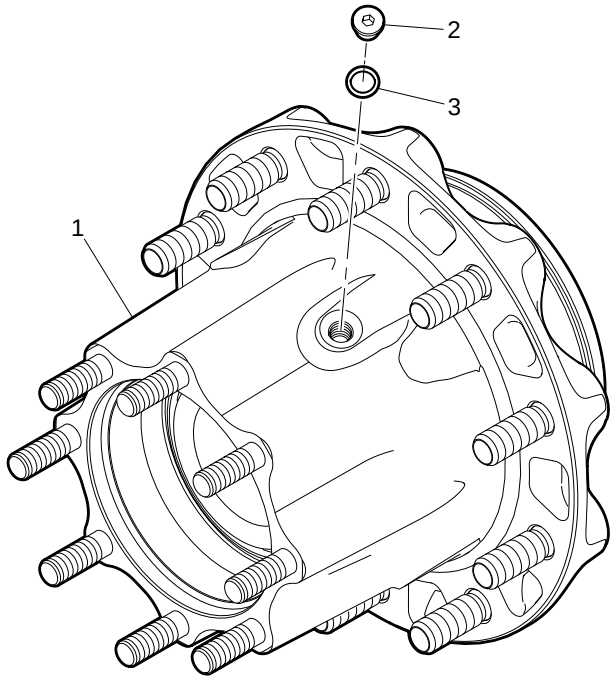
General Information

Proper wheel bearing lubrication is critical to sound wheel end health and safe vehicle operation. Insufficient lubrication can lead to catastrophic consequences that can be avoided.

The procedure for lubricating wheel bearings depends on whether or not the hub has an oil fill port. This subject provides instructions for ConMet hubs with and without a fill port.

ConMet Hub with an Oil Fill Port

For ConMet hubs with an oil fill port, lubricant is added through the fill port; see **Fig. 1** and use the following instructions.



1. Hub
2. Fill Port Plug
3. O-Ring

Fig. 1, ConMet Hub with Oil Fill Port

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

IMPORTANT: When removing the fill port plug, make sure the rubber O-ring is attached to it and not stuck inside the fill port.

2. Clean the area surrounding the oil fill port plug, then remove the plug and O-ring.

NOTE: The fill port plug is magnetic. On drive axles, it is normal to find a small amount of very fine metallic particles from the carrier housing on the magnetic fill plug. These particles should be removed from the magnet anytime the plug is removed for inspection.

3. Inspect the plug for metallic particles picked up by the magnet. If very fine metallic particles are found, remove them from the magnet. If larger particles or chunks of metal are found, remove the hub from the spindle and inspect the bearings and other wheel end and axle components for signs of damage or excessive wear, and make the necessary repairs.

⚠ WARNING

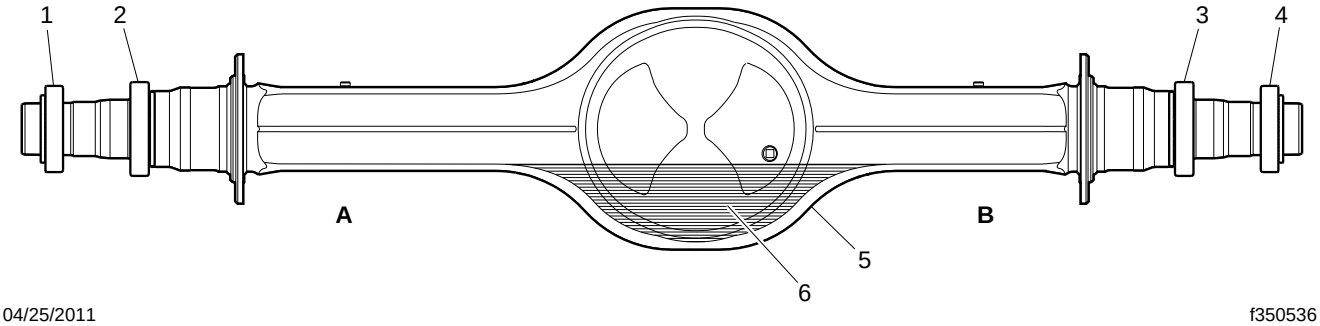
Failure to adequately lubricate wheel bearings can cause them to seize during vehicle operation. Seized wheel bearings can cause sudden, catastrophic damage to the wheel end and axle, possibly resulting in severe personal injury or death.

4. Using a clean funnel, add 1.0 quart (0.95 liter) of the recommended drive axle lubricant through the oil fill port. For recommended lubricants, see the vehicle maintenance manual.
5. Install the fill port plug, and tighten it 20 to 25 lbf·ft (27 to 34 N·m).

ConMet Hub without an Oil Fill Port

For ConMet hubs without an oil fill port, lubricant must be transferred from the axle carrier housing to the hubs. To ensure each bearing is adequately lubricated, the axle must be filled with lubricant and tilted *three* times. See **Fig. 2** and use the following instructions to lubricate the wheel bearings on a rear drive axle.

Wheel Bearing Lubrication



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For an axle equipped with hubs without fill ports, when side A is raised first, bearing 4 is lubricated. Side B is raised next to lubricate bearings 3 and 1. Side A is raised again to lubricate bearing 2. The carrier housing must be refilled before and after each time the axle is lifted to ensure there is enough lubricant to reach the bearings.

A. Driver Side
B. Passenger Side

1. Outer Wheel Bearing, Driver Side
2. Inner Wheel Bearing, Driver Side
3. Inner Wheel Bearing, Passenger Side
4. Outer Wheel Bearing, Passenger Side
5. Carrier Housing
6. Lubricant (full)

Fig. 2, Rear Drive Axle and Wheel Bearings

1. Park the vehicle on level ground, apply the parking brakes, and chock the front wheels.

NOTE: Some Detroit and Meritor axles have a small tapped and plugged hole located below the housing oil fill hole. This smaller hole is for a lubricant temperature sensor only and must not be used as a fill hole.

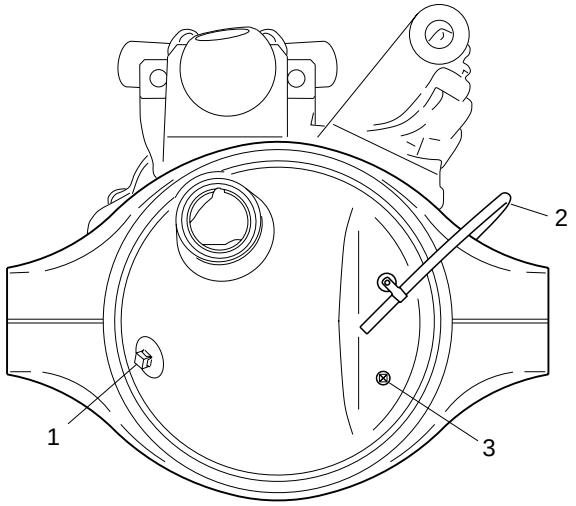
2. With the axle level and all wheels on the ground, clean the oil fill hole plug and the area surrounding it, then remove the fill plug. For Detroit axles, see **Fig. 3**; for Meritor axles, see **Fig. 4**; for Dana Spicer axles, see **Fig. 5**.

⚠ WARNING

Failure to adequately lubricate wheel bearings can cause them to seize during vehicle operation. Seized wheel bearings can cause sudden, catastrophic damage to the wheel end and axle, possibly resulting in severe personal injury or death.

IMPORTANT: A lubricant level close enough to be seen or touched is not sufficient; it must be level with the bottom of the fill hole. See **Fig. 6**.

3. Use a clean funnel to add lubricant until it reaches the fill hole, then install the fill plug. For recommended lubricants, see the vehicle maintenance manual. For fill plug torque values, see **Table 1**.



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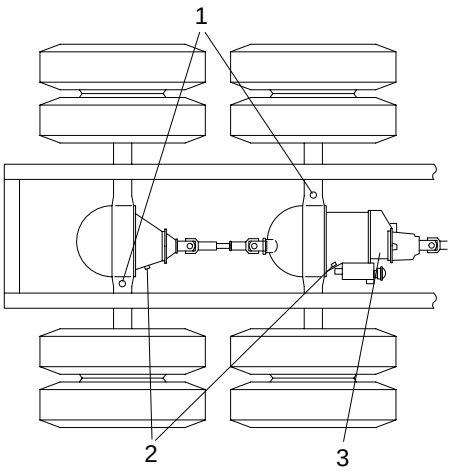
NOTE: Rear view of forward-rear axle shown.

1. Oil Fill Plug
2. Breather Hose
3. Temperature Sensor Port Plug

Fig. 3, Fill Hole Plug Location, Detroit Tandem Axle



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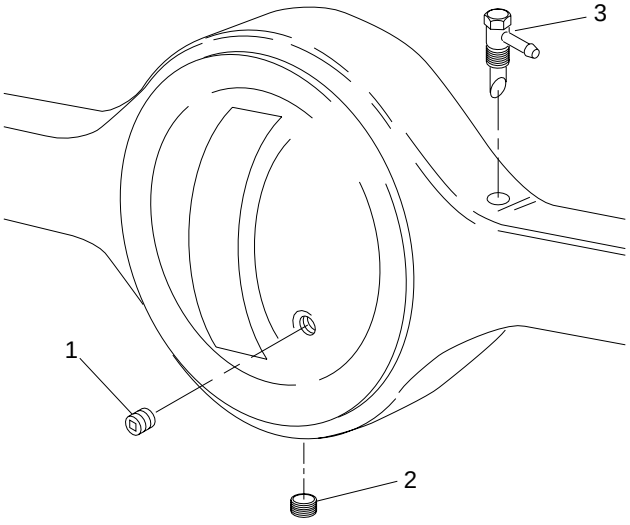
1. Axle Housing Breathers
2. Carrier Oil Fill Plugs
3. Interaxle Differential

Fig. 4, Fill Hole Plug Locations, Meritor Axles



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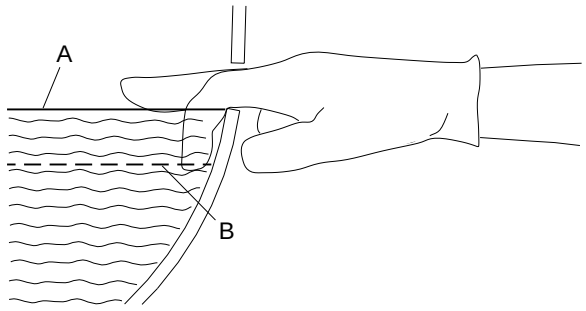
1. Oil Fill Plug
2. Oil Drain Plug
3. Axle Breather

Fig. 5, Fill Hole Plug Location, Dana Spicer Axles



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A. Correct (lube level at bottom of fill hole)
B. Incorrect (lube level below fill hole)

Fig. 6, Axle Lubricant Level Check

Oil Fill Plug Torque Values	
Brand	**Torque: lbf·ft (N·m)**
Detroit	30 (41)
Meritor	35 (47)
Dana Spicer	40 to 60 (54 to 81)

Table 1, Oil Fill Plug Torque Values

IMPORTANT: The axle must be tilted three times and the tilted position must be held for two minutes each time to allow enough lubricant to reach the hub and wheel bearings.

4. To tilt the axle, position a suitable jack at a leaf spring U-bolt, and raise it until the bottom of the outside part of the outside tire is 8 inches (20 cm) above the ground. See **Fig. 7** and **Fig. 8**.

   After two minutes, lower the axle, and add lubricant as described earlier in this procedure.

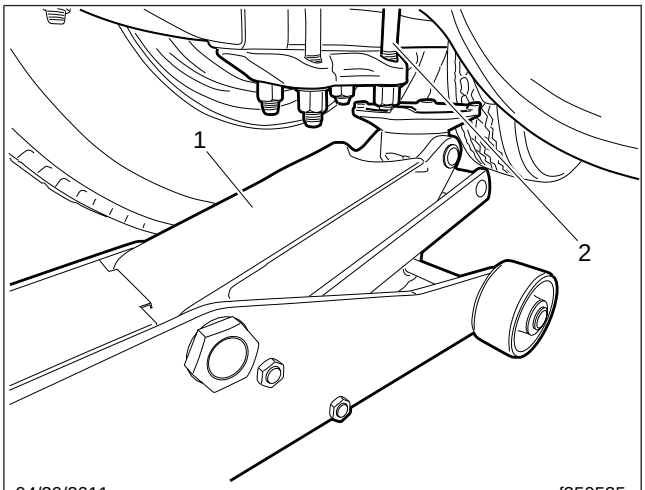
5. At a leaf spring U-bolt on the other end of the axle, tilt the axle as described earlier in this procedure.

   After two minutes, lower the axle, and add lubricant as described earlier in this procedure.

6. At the U-bolt where the axle was first lifted, tilt the axle as described earlier in this procedure.

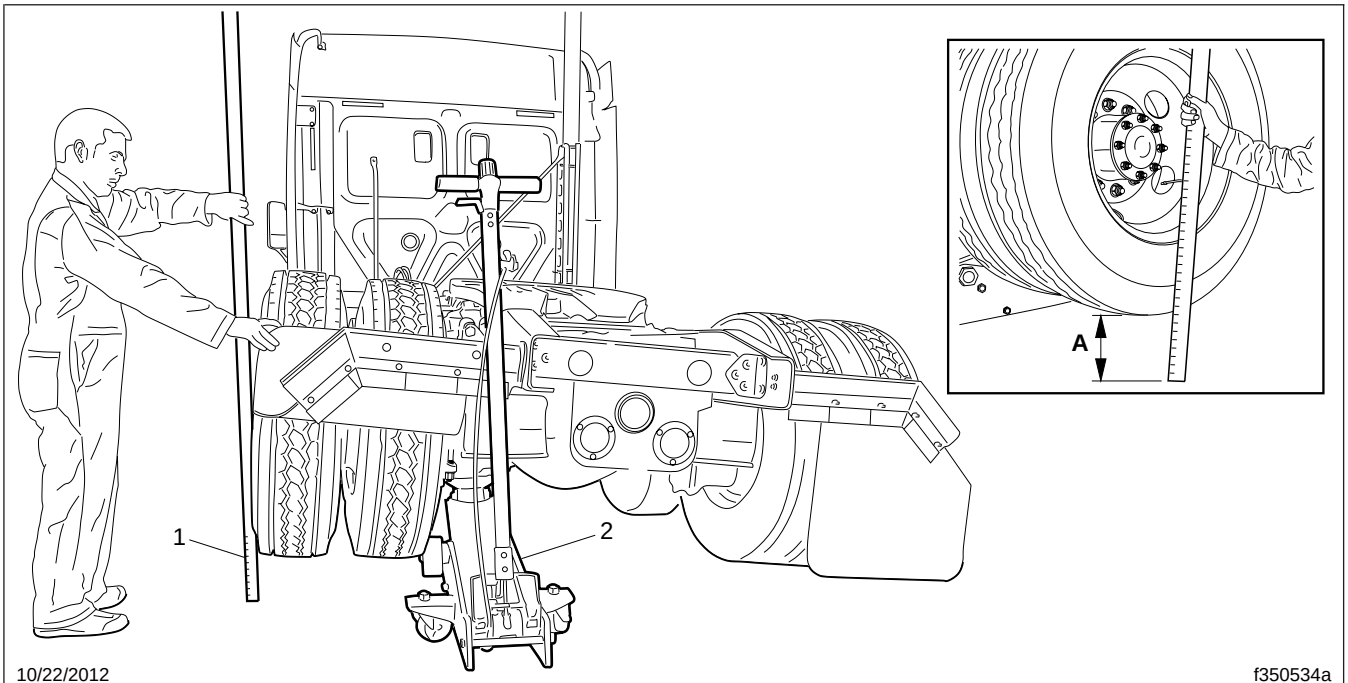
   After two minutes, lower the axle, and add lubricant as described earlier in this procedure.

Wheel Bearing Lubrication



1. Jack
2. U-bolt

Fig. 7, Axle Lifted at Leaf Spring U-bolt



Each time you lift a side of the axle to distribute lubricant, raise it until the bottom of the outside part of the outside tire is 8 inches (20 cm) above the ground.

A. 8 inches (20 cm)

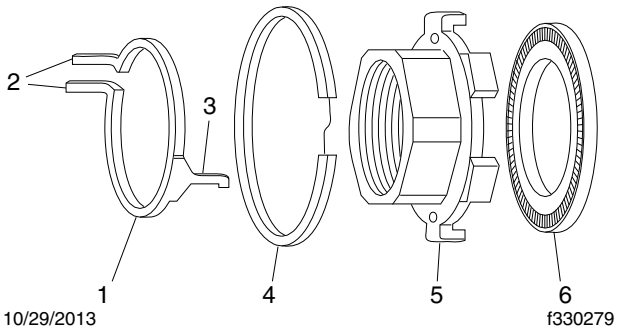
1. Ruler
2. Jack

Fig. 8, Distributing Lubricant from Carrier Housing to Wheel Bearings for ConMet Hubs without Oil Fill Ports

ConMet PreSet Plus Spindle Nut Removal and Installation

General Information

ConMet PreSet Plus hubs use a special integrated spindle nut designed specifically for PreSet Plus hubs. See **Fig. 1**.



1. Locking Ring
2. Tabs
3. Lock Tab
4. Spiral Snap Ring
5. Spindle Nut
6. Locking Washer

Fig. 1, PreSet Plus Spindle Nut System

Removal

1. To remove the red locking ring from the spindle nut assembly, compress the tabs and pivot the ring to unlock it from the nut.

IMPORTANT: Do not exceed 50 lbf·ft (68 N·m) of torque when removing a PreSet Plus hub using the spindle-nut system as a hub puller.

2. Loosen the spindle nut. As the spindle nut is loosened, it can act as a hub puller. However, if the hub will not come off of the spindle without exceeding 50 lbf·ft (68 N·m) of torque, remove the spiral snap ring (see **Fig. 2**) and then the spindle nut assembly.

Installation

⚠ WARNING

Each PreSet Plus hub assembly requires special bearings, a PreSet Plus bearing spacer, and the unique PreSet Plus spindle nut system. Wheel ends equipped with the PreSet Plus hub assembly must use these special components; do not use non-PreSet-Plus components with a PreSet Plus hub.

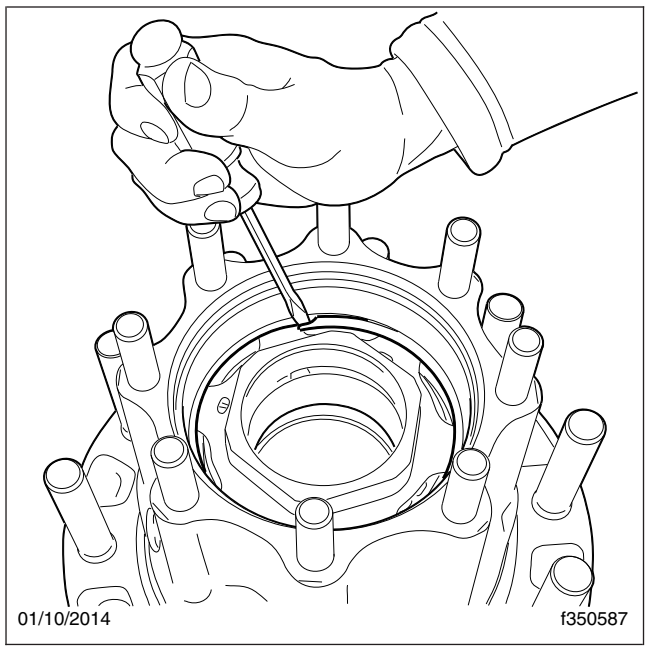


Fig. 2, Removing a Spiral Snap Ring

If a PreSet Plus hub is not correctly installed with the required components, the hub could separate from the axle, resulting in property damage, severe personal injury, or death.

The following instructions are for installing a PreSet Plus spindle nut. In some cases, the spindle nut components will have been removed along with the hub; in other cases, they will have been already installed in the hub. Use the pertinent instructions for your installation.

1. If the red locking snap ring is locked into the spindle nut, compress the tabs and pivot the ring to remove it from the nut. See **Fig. 1**.
2. If needed, begin installing the PreSet Plus spindle nut components, as follows.
   - 2.1 Seat the flat washer into the back of the spindle nut.
   - 2.2 Position the spindle nut and washer against the outer bearing.
   - 2.3 Install the spiral snap ring into the snap ring groove in the hub. Ensure that it fully seats into the groove in the hub. See **Fig. 3** and **Fig. 4**.
3. Tighten the spindle nut 500 lbf·ft (678 N·m) while rotating the hub. Do not back off the spindle nut.

ConMet PreSet Plus Spindle Nut Removal and Installation

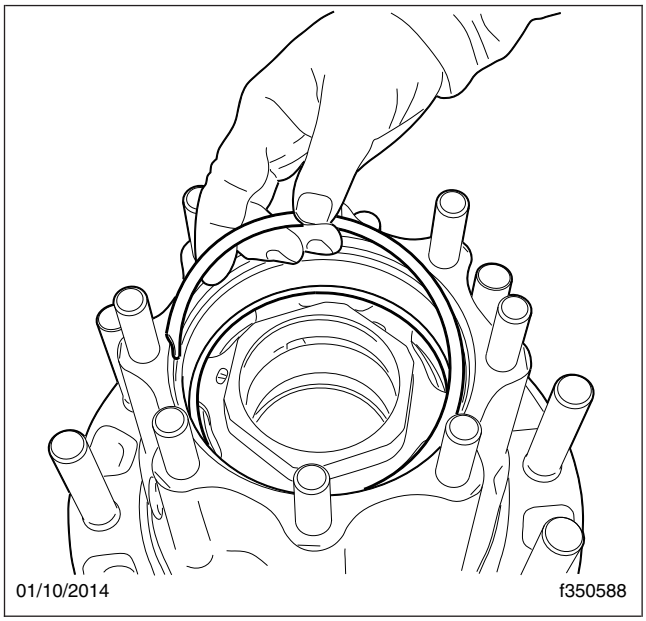


Fig. 3, Installing a Spiral Snap Ring

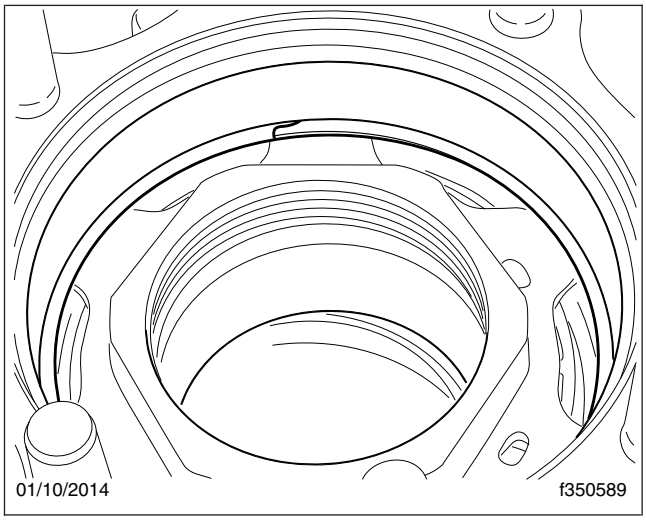


Fig. 4, Fully Seated Spiral Snap Ring

NOTICE

When bending the locking ring, be careful not to deform it permanently. If the locking ring is damaged or bent, replace it with a new one.

4. Install the locking ring, as follows.
   - 4.1 One of the holes in the face of the spindle nut will line up with a hole in the washer. Insert the lock tab of the locking ring through aligned holes.
   - 4.2 Using the handle tabs, seat the locking ring in the machined grooves of the spindle nut.

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.

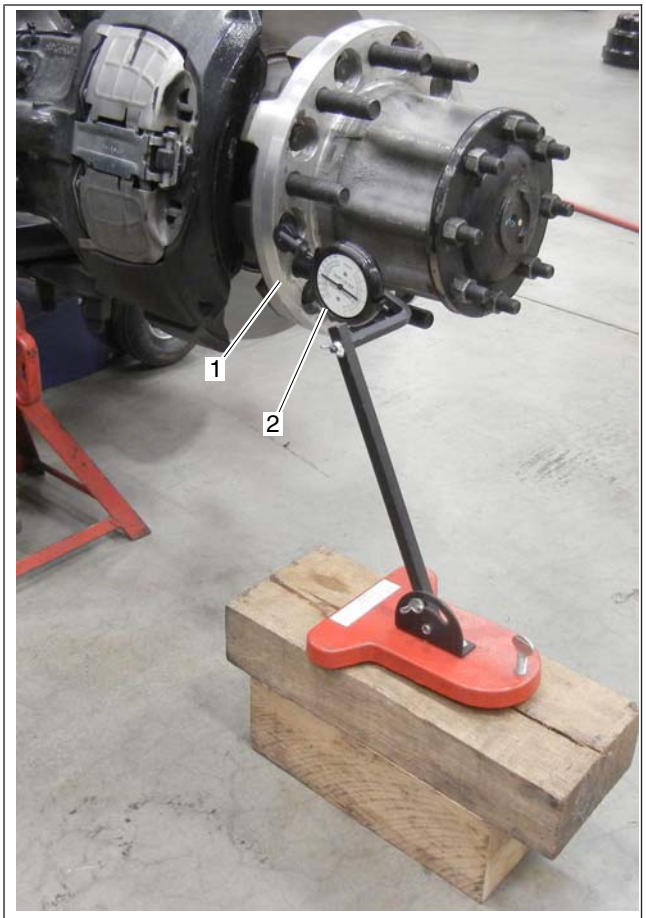
⚠ WARNING

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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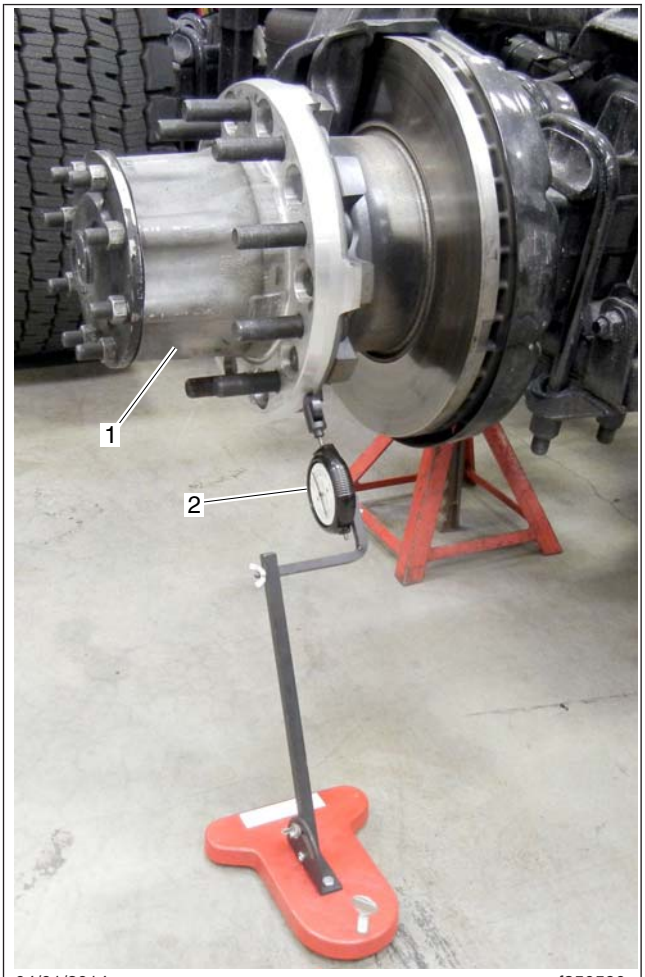
1. Hub
2. Dial Indicator (with roller point)

Fig. 1, Setup to Measure Lateral Runout

Hub Runout Measurements



1. Hub
2. Dial Indicator (with roller point)

Fig. 2, Setup to Measure Radial Runout

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)
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)
Hub Cap Capscrews		5/16–18	15 (20)
Oil Fill Plug (Meritor axles)		—	35 (47)
Oil Fill Plug (Detroit axles)		—	30 (41)

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 is installed between the hub bore, which rotates, and the non-rotating axle spindle.

Most wheel oil seals consist of four basic parts (**Fig. 1**):

- outside edge (also called outer "cup" or "case")
- inside edge (also called inner "cup" or "case")
- sealing element
- garter spring

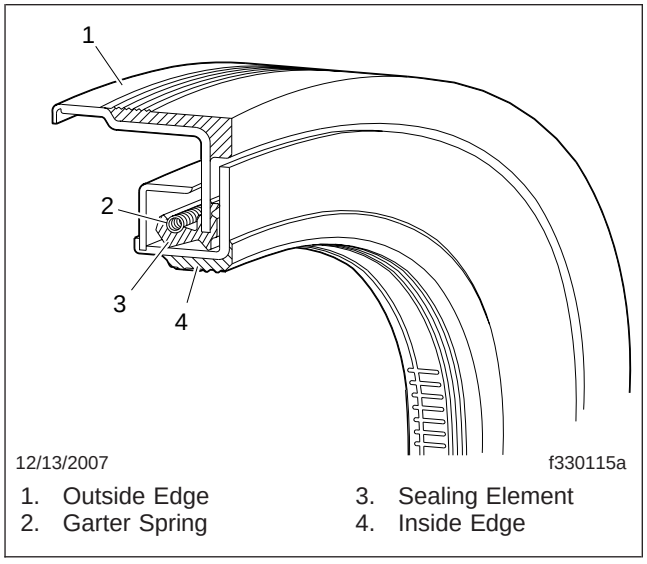


Fig. 1, Wheel Oil Seal Parts

The outside edge is usually metal that's coated with rubber or another sealing agent so that it grips the hub bore tightly enough to prevent oil from 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 that seal against the axle spindle or against the outside or inside edge described above.

The garter spring is a loop of coiled wire spring that presses the sealing element against the sealing surface.

Chicago Rawhide Scotseal Plus XL

The Chicago Rawhide Scotseal Plus XL (see **Fig. 2**) is a unitized, one-piece seal. The outer diameter of the metallic case and the bore diameter of the seal counter face are coated with rubber. The seal is press-fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal Plus XL directly onto the axle spindle.*

Although you install the Scotseal Plus XL 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.

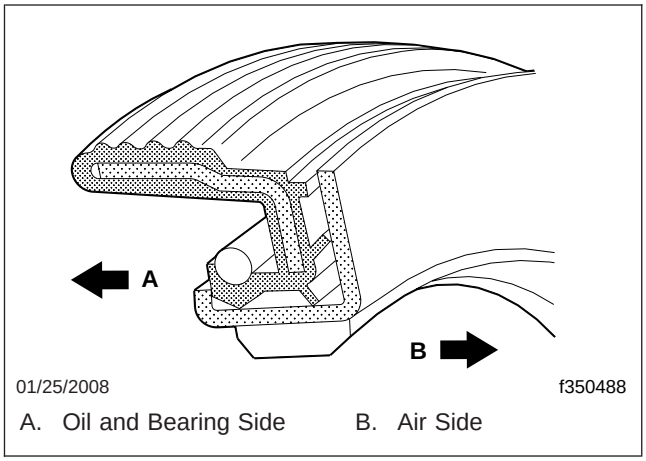


Fig. 2, Chicago Rawhide Scotseal Plus XL

Seal Replacement, Chicago Rawhide Scotseal Plus XL

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See **Fig. 1** for a diagram of the installation tool. Ensure that the **flat side** of the driver plate faces the seal. See **Specifications, 400** for tool and seal numbers.

Replacement

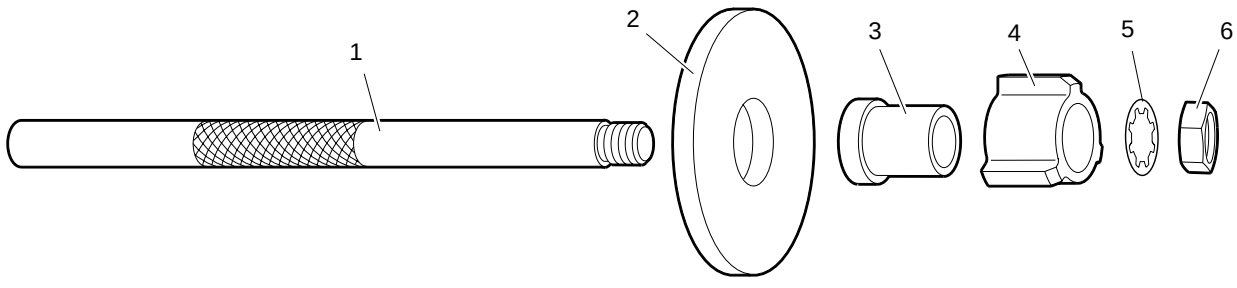
1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the inner wheel bearing assembly from the axle. Handle the bearings with clean dry hands, and wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone 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. Discard the seal.
3. Clean the spindle, spindle threads, seal bore, and hub cavity. See **Fig. 2** and **Fig. 3**.
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.

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.

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.
8. Inspect a new seal for damage (such as cuts or being out of round) and contamination. If damage is evident, discard it and use a suitable seal.
9. Apply a thin layer of lubricant to the inside and outside diameters of the seal using the same lube used in the hub.
10. Using the appropriate driver plate and centering tool, assemble the installation tool so that the flat side of the plate is the seal installation surface. See **Fig. 4**. To determine which driver tool to use, see **Specifications, 400**.



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1. Handle
2. Driver Plate
3. Bushing
4. Centering Tool
5. Washer
6. Nut

Fig. 1, Installation Tool

Seal Replacement, Chicago Rawhide Scotseal Plus XL

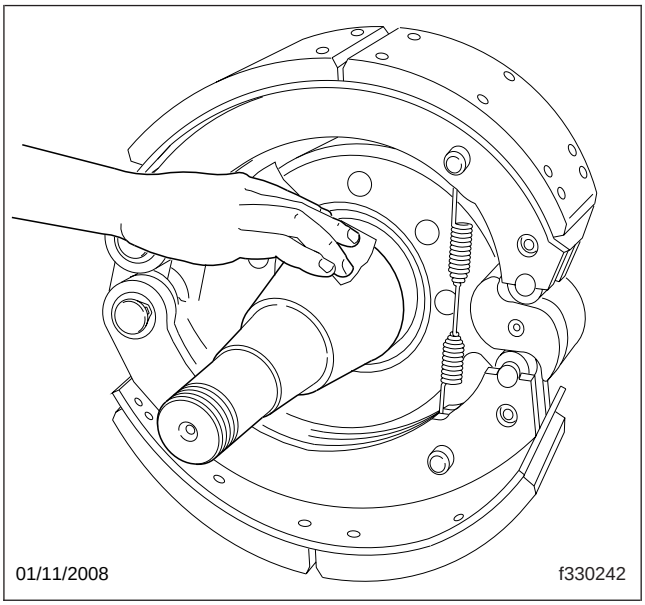


Fig. 2, Cleaning the Spindle

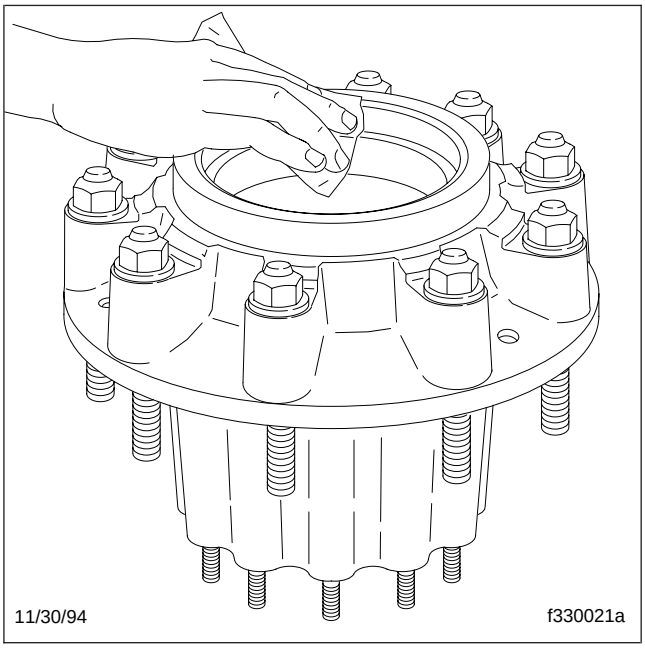


Fig. 3, Cleaning the Hub

11. Seat the seal in the seal bore with the "air side" facing outward ("air side" is stamped on the sleeve flange of the seal).
12. Insert the centering tool into the bore of the inner bearing cone (to prevent cocking of the seal),

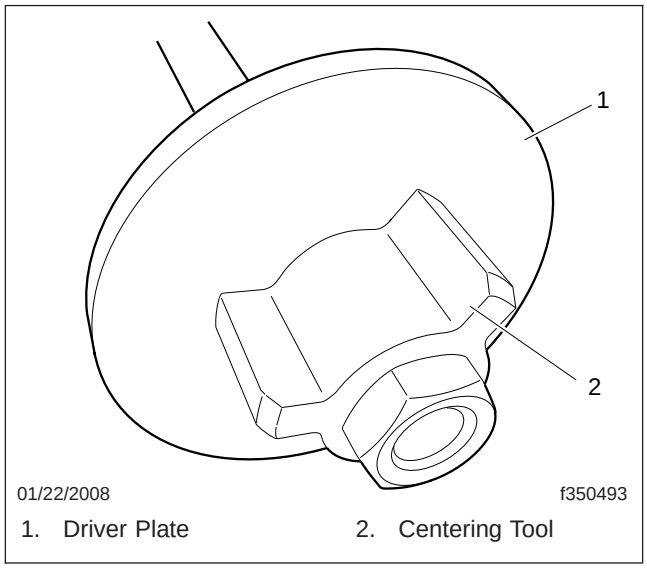


Fig. 4, Installation Tool

and press the seal down firmly with the flat side of the driver plate. See **Fig. 5**.

13. To avoid bounce or unseating of the seal, hold the tool handle firmly, and strike it until the seal bottoms out. See **Fig. 6**.

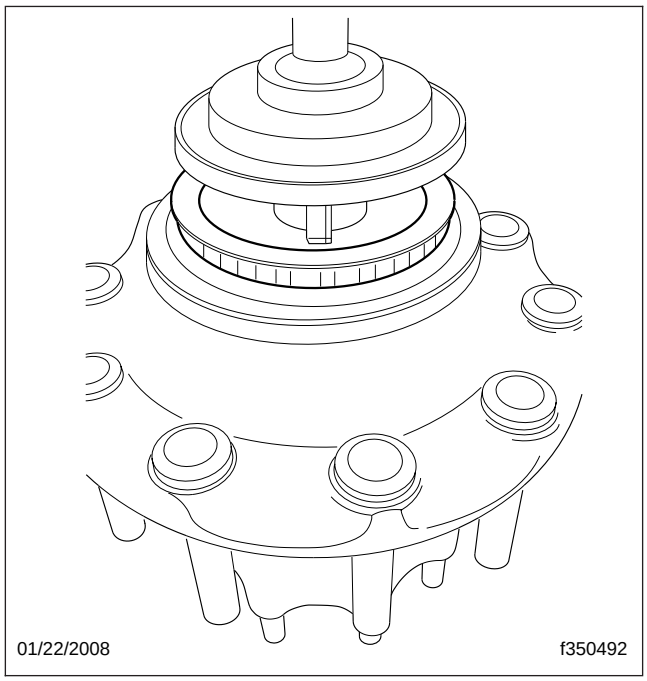


Fig. 5, Inserting the Centering Tool into the Hub Bore

Seal Replacement, Chicago Rawhide Scotseal Plus XL

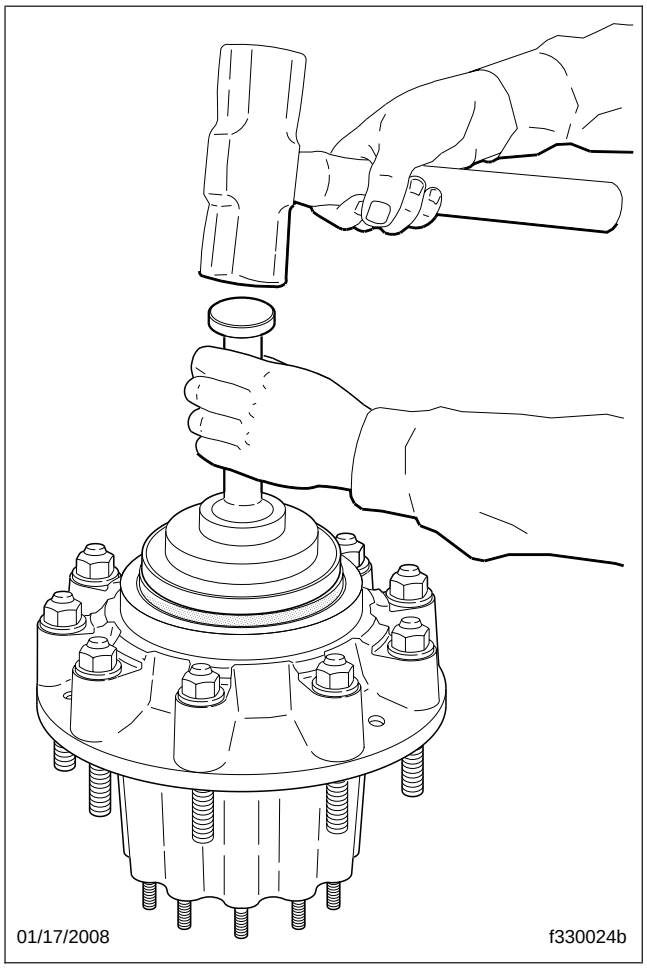


Fig. 6, Striking the Tool

14. 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. If any damage is visible, remove the seal and install a new one.
15. Install the hub and drum on the axle, adjust the wheel bearings, then install the wheel. For instructions, see **Section 35.01**.

Specifications

For Scotseal Plus XL seal stock number 47691, see **Table 1** to identify the installation tool parts needed to install the seal. The seal stock number is listed on the air-side flange of the seal.

Scotseal Plus XL Seal and Tool Numbers			
Bearing Cone	**Seal Stock Number**	**Centering Tool Number**	**Driver Tool**
594A	47691	715	435*

* The number 435 driver tool is the same one used for the Scotseal Classic.

Table 1, Scotseal Plus XL Seal and Tool Numbers

General Information

Although these axles are a proprietary product, in some applications they may be referred to as "Freightliner axles," "Axle Alliance axles," or "M-B components."

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

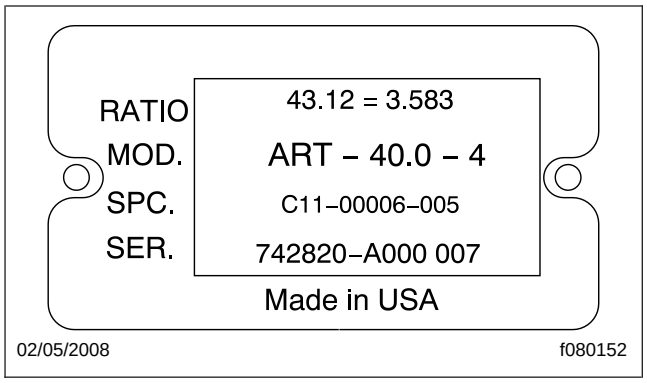


Fig. 1, Rear Axle ID Tag

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.

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**

Single or Rearmost Axle Removal and Installation

For rear axle components, see **Fig. 1**.

Removal

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; 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; 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; see **Section 35.01, Subject 100**.
17. If the axle is equipped with drum brakes, 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 brake mounting hardware 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.

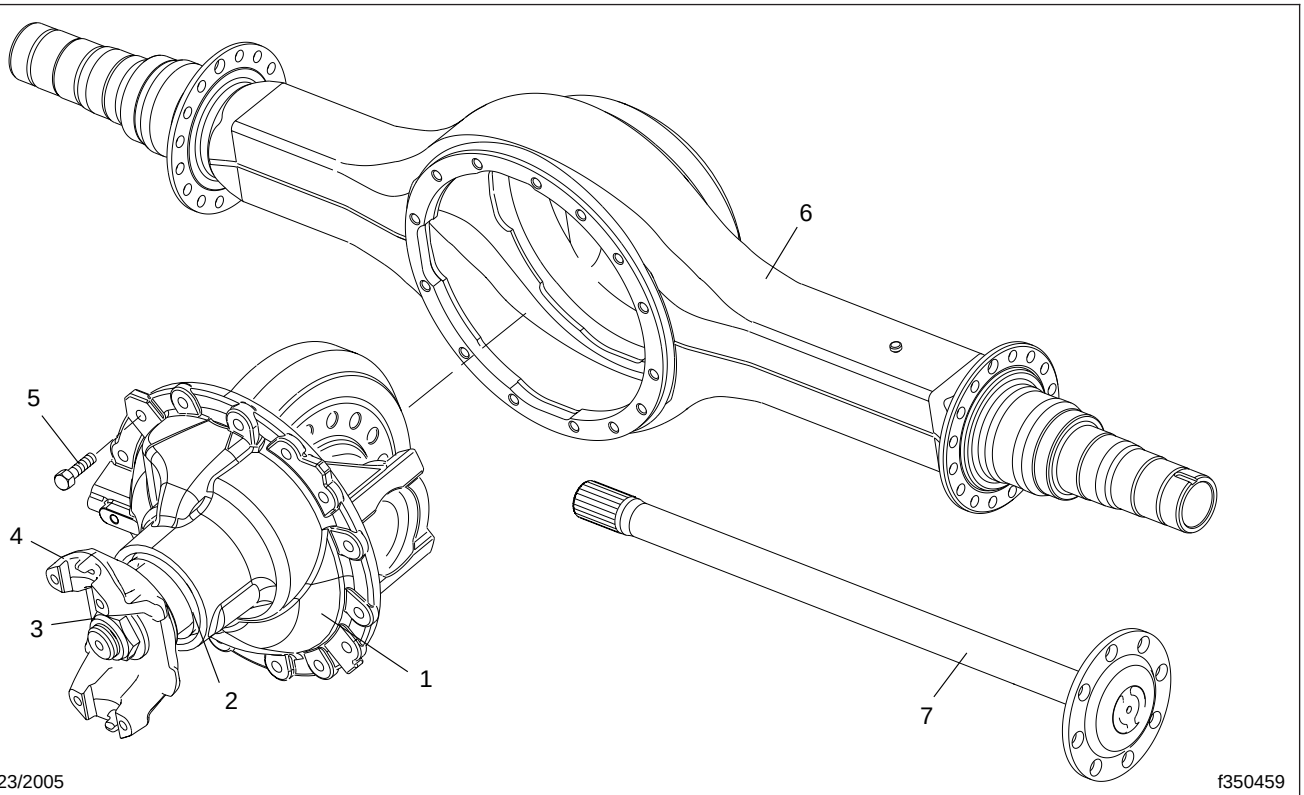
Installation

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, new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

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

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; see **Section 41.00, Subject 120**.
4. Install the brake mounting hardware on the axle. 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 or pads, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. See **Section 35.01, Subject 100** to install the hub, axle shaft, brake components, and wheel and tire assembly.

NOTICE

Make sure the hubs are filled with lubricant. Driving with the hubs dry will cause bearing damage.

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. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
12. Uncage the parking brake springs.
13. 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 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

14. Raise the vehicle, remove the safety stands, then lower the vehicle.
15. 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**.
16. 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.

Single or Rearmost Axle Differential Carrier Removal and Installation

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; 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; 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.

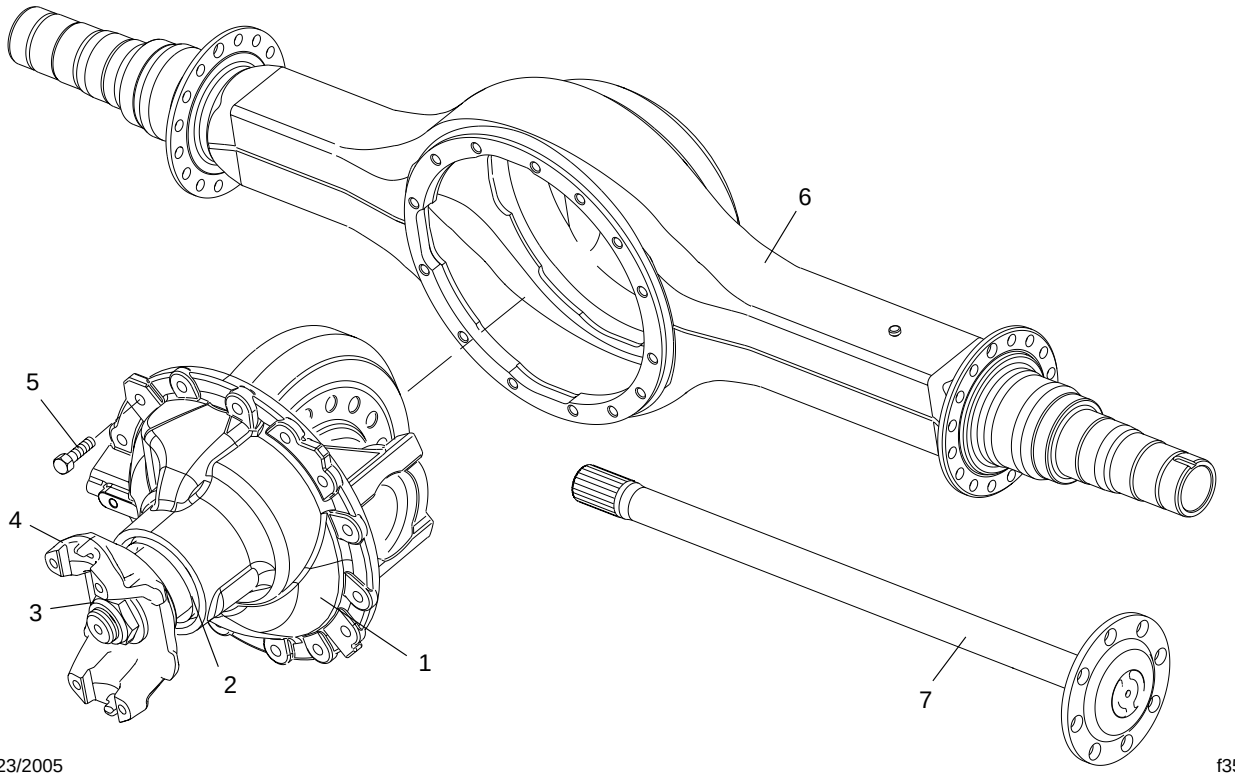
4. Install alignment dowels 180 degrees apart at the 3 o'clock and 9 o'clock positions on the axle housing flange.
5. If DCDL is installed on the vehicle, ensure it is engaged.

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.

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.

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

7. Install the end caps at the sides of the carrier into the corresponding slots in the axle housing. See **Fig. 2**.

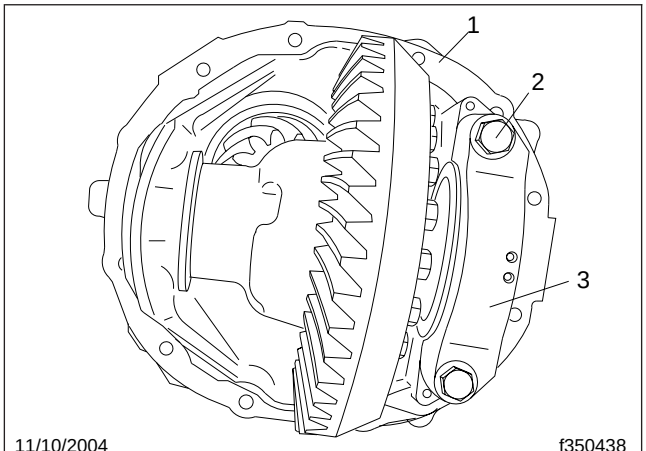
   7.1 For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

   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; see **Subject 100**.



1. Differential Carrier
2. End Cap Bolt
3. End Cap

Fig. 2, Carrier End Caps

If the axle is already on the vehicle, go to the next step.

9. Connect the driveshaft to the carrier yoke; see **Section 41.00, Subject 120**.
10. Using new gaskets, install the axle shafts; see **Subject 120**.
11. Install the wheels and tires; 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 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

NOTICE

Make sure the hubs are filled with lubricant. Driving with the hubs dry will cause bearing damage.

13. Lubricate the wheel bearings; see **Section 35.01, Subject 210**.
14. Raise the vehicle, remove the safety stands, then lower the vehicle.
15. 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.
16. 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.

Removal

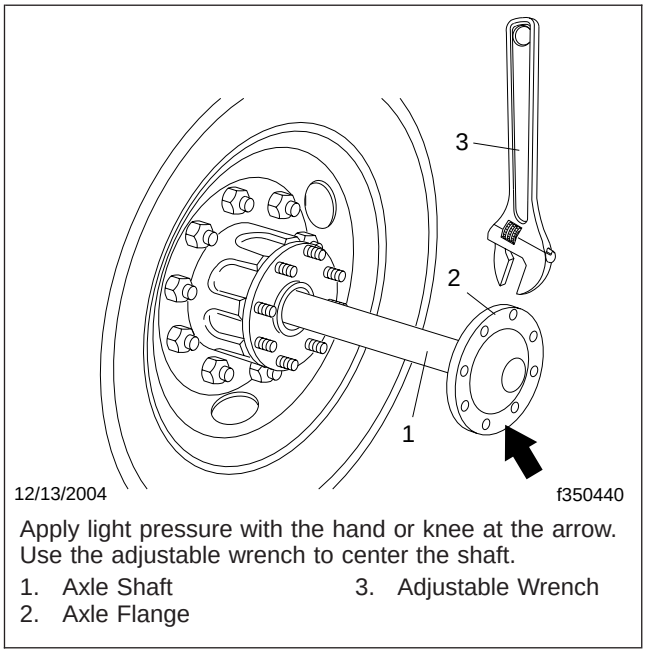
1. Chock the front tires.
2. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
3. Raise the rear of the vehicle with a suitable jack 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.

Forward-Rear Axle Removal and Installation

For forward-rear axle components of a tandem installation, see **Fig. 1**.

Removal

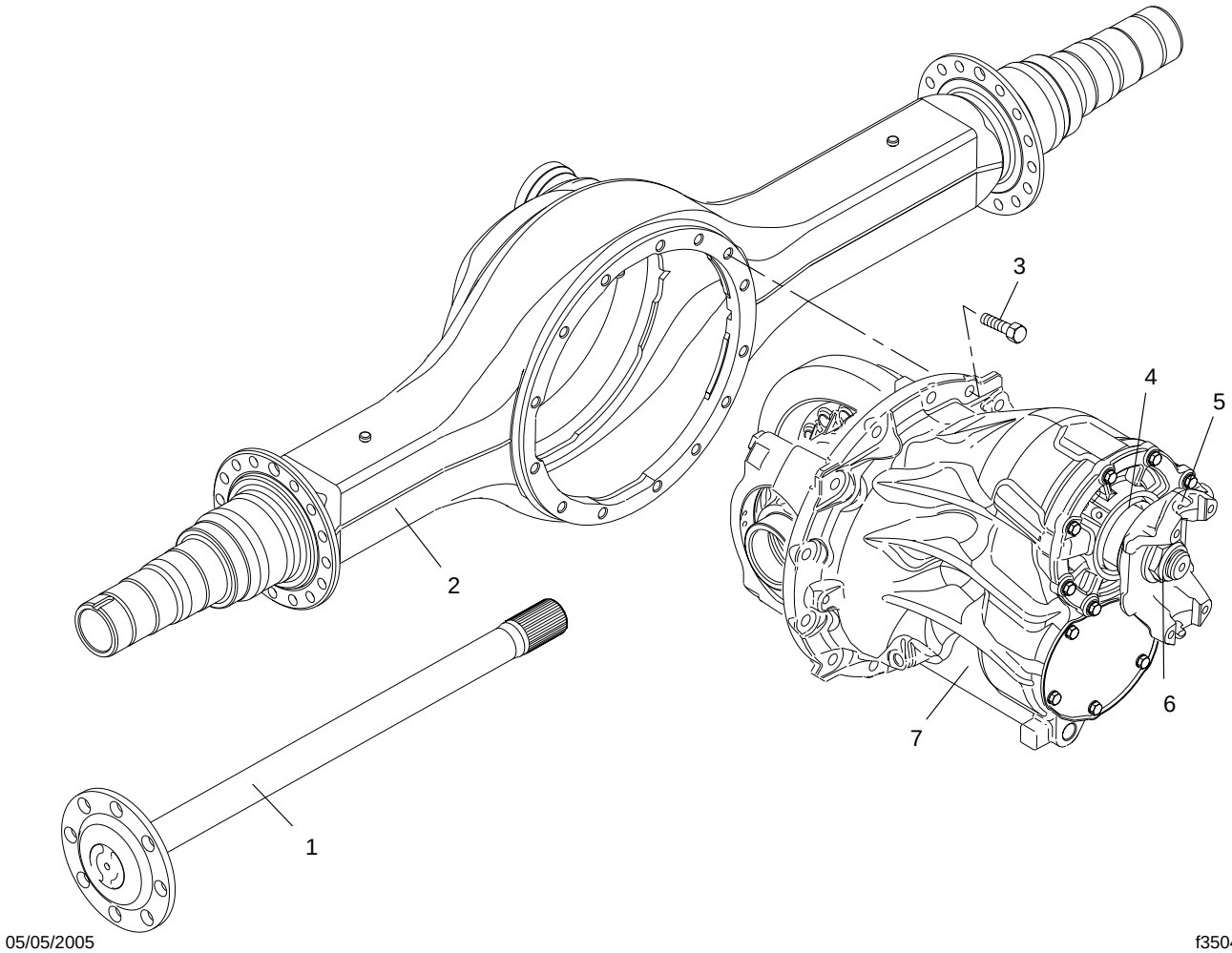
1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the 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.

⚠ 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; see **Section 35.01, Subject 100**.
18. If the axle is equipped with drum brakes, remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
19. Remove the ABS sensors and wiring, and the brake mounting hardware 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.

Forward-Rear Axle 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

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.

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 mounting hardware on the axle. 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 or pads, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. Connect the main driveshaft to the forward input yoke. For instructions, see **Section 41.00, Subject 120**.
10. Connect the air hoses to the air cylinder for the interaxle lock and (if installed) the wheel lock.
11. Connect the electrical connector of the sensor unit for axles equipped with a wheel lock.
12. See **Section 35.01, Subject 100** to install the hub, axle shaft, brake components, and wheel and tire assembly.

NOTICE

Make sure the hubs are filled with lubricant. Driving with the hubs dry will cause bearing damage.

NOTE: See **Table 1** for approved axle oils.

13. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
14. Uncage the parking brake springs.
15. 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**.

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

16. Turn the wheels, wait one minute, and check the lubricant level.
17. Raise the vehicle, remove the safety stands, then lower the vehicle.
18. 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**.
19. Check the operation of the wheel lock, if installed.
20. 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.

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; 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 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.

   9.3 Using a pry bar, separate the mating surfaces of the differential carrier and axle housing.

   NOTE: Use a pry bar that has a round end to help separate the carrier from the housing.

   9.4 When the surfaces are separated, remove the top two capscrews.

   9.5 With the carrier on the jack, slide the carrier away from the 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

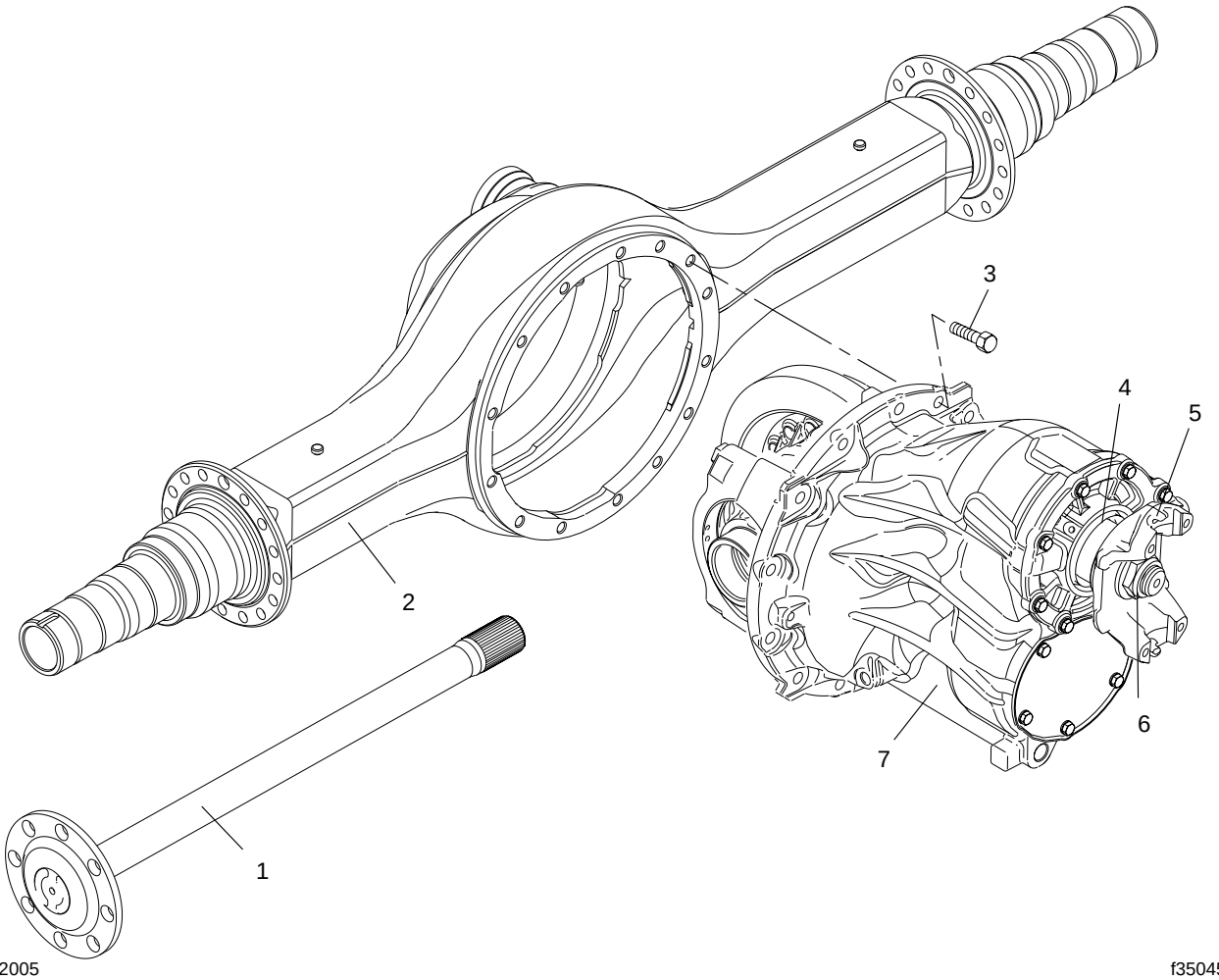
NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

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 at 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.

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		

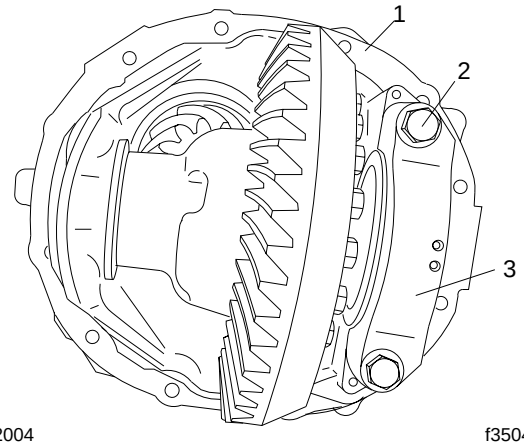
Table 1, Forward-Rear Axle Oil Type and Capacity

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.

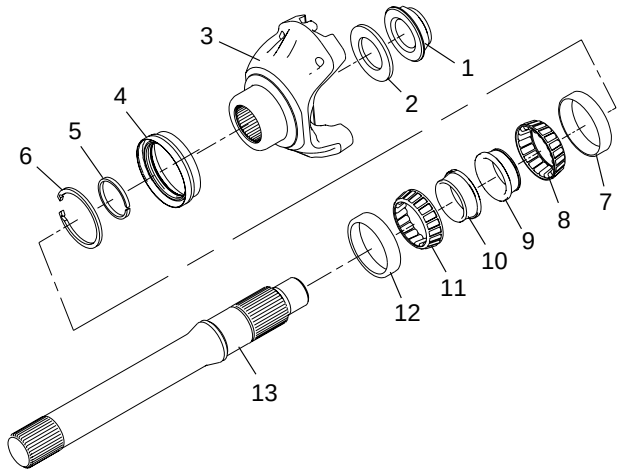


1. Differential Carrier
2. End Cap Bolt
3. End Cap

Fig. 2, Carrier End Caps

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**.



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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 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

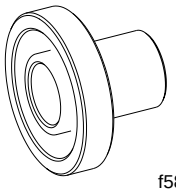
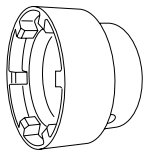
Special tools are required for this procedure. See **Table 1**.

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 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.
6. Install the carrier yoke on the input shaft. If the yoke is damaged or worn, install a new yoke.

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

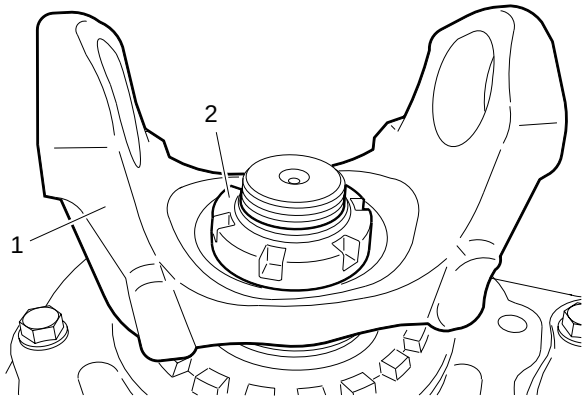
Single or Rearmost Axle Yoke and Seal Replacement

NOTE: It is not necessary to replace the yoke when replacing the seal.

7. Install a new M45 x 1.5 yoke 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**.

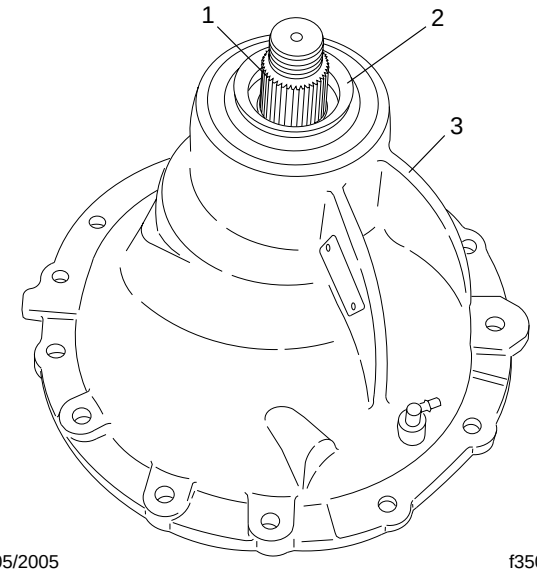


04/01/2008 f350496

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



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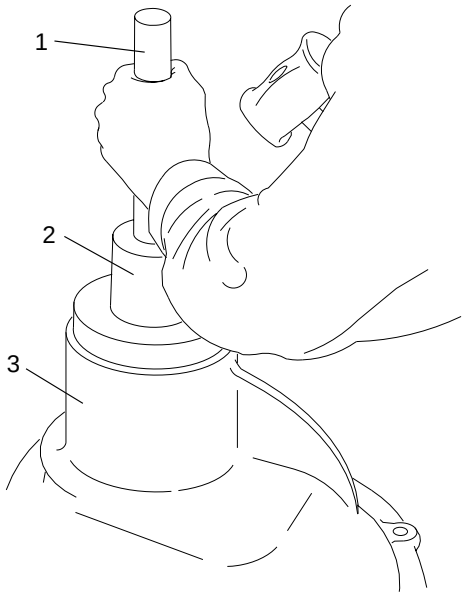
1. Input Shaft
2. Rear Pinion Seal
3. Carrier Housing

Fig. 2, Rear Pinion Seal



05/12/2005 f350448

1. Universal Handle
2. Rear Pinion Seal Installer
3. Carrier Housing

Fig. 3, Installing the Rear Pinion Seal

Forward-Rear Axle Yoke and Seal Replacement

Special Tools

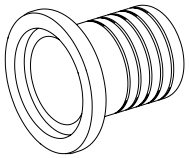
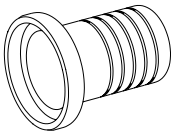
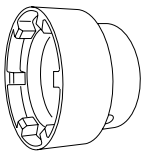
Special tools are required for this procedure. See **Table 1**.

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**.

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

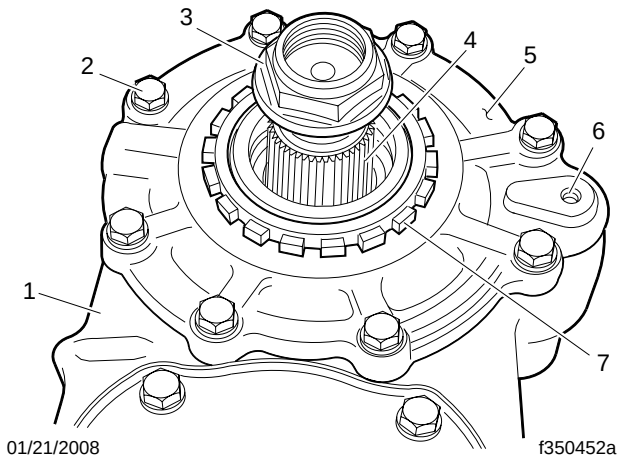
* To order Kent-Moore tools call 1-800-328-6657.

† 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

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.

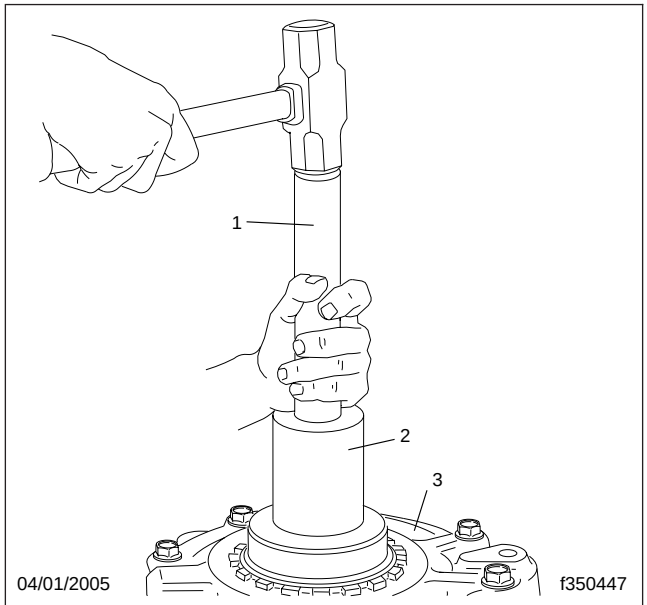
5.2 Pry the bearing cage from the forward carrier housing. Clean any remnants of sealant clinging to the mating surfaces of the carrier housing and the bearing cage.

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**.

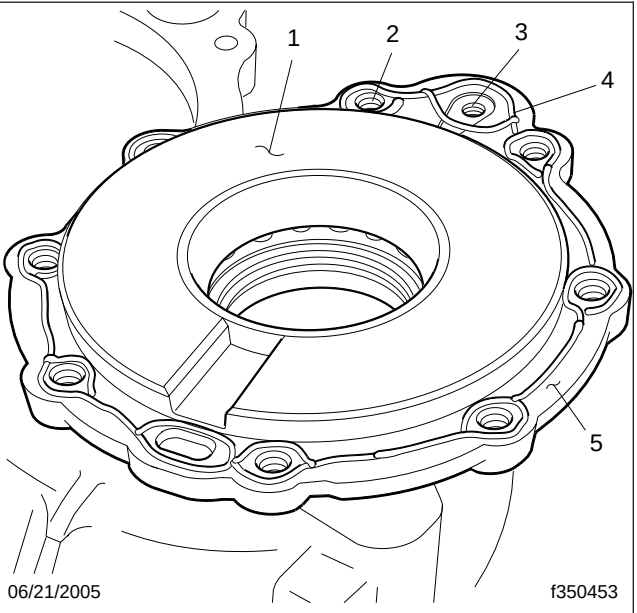
IMPORTANT: Do not allow sealant to get into the interaxle lock bore. See **Fig. 4**. Do not attempt to repair the interaxle differential lock (IAD). No repairs to this component are possible.

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.

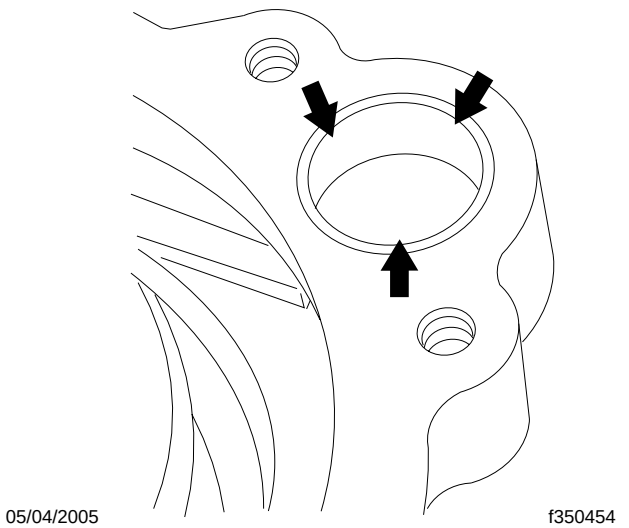
11. Coat the threads of a new M45 x 1.5 input yoke nut with Loctite® 277. Install the new washer and



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.

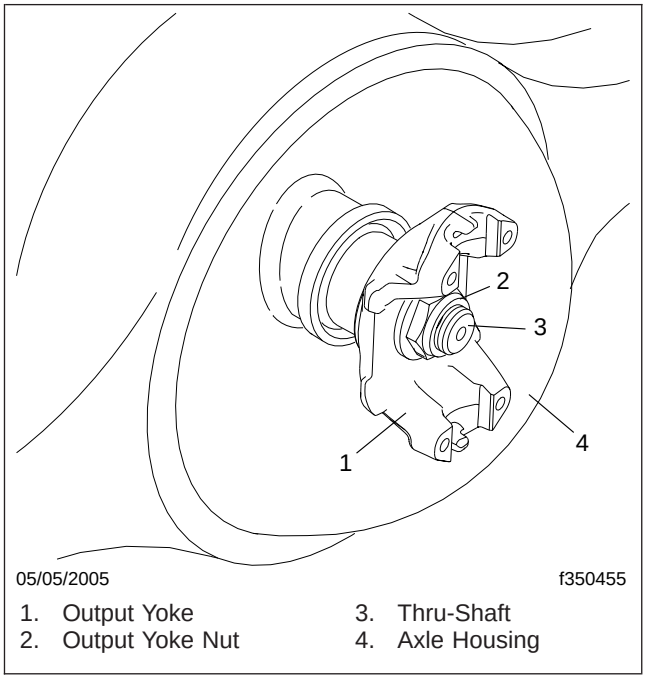
Fig. 4, Interaxle Lock Bore

input yoke nut on the forward carrier input yoke. Tighten the nut 627 lbf·ft (850 N·m).

12. Connect the main driveshaft; see **Section 41.00, Subject 120**.

Output Yoke and Seal

1. Disconnect the interaxle driveshaft from the output yoke; 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.

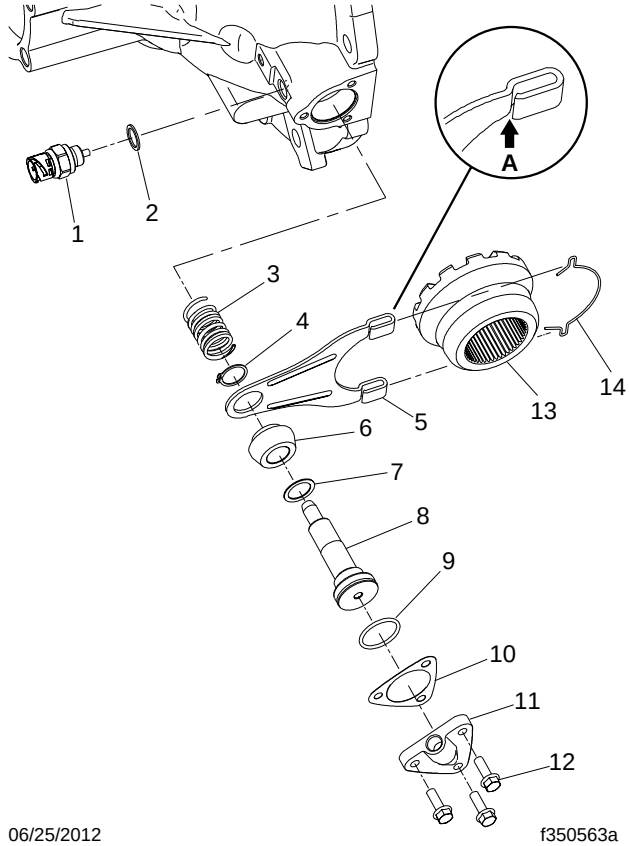
7. Coat the threads of a new M39 x 1.5 output yoke nut with Loctite® 577. Install the new washer and output yoke nut on the forward carrier output yoke. Tighten the nut 516 lbf·ft (700 N·m).
8. Connect the interaxle driveshaft; see **Section 41.00, Subject 120**.

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**.



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

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. 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 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.
5. Install the retaining clip on the shift fork.

Main Differential Lock Disassembly and Assembly

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**.

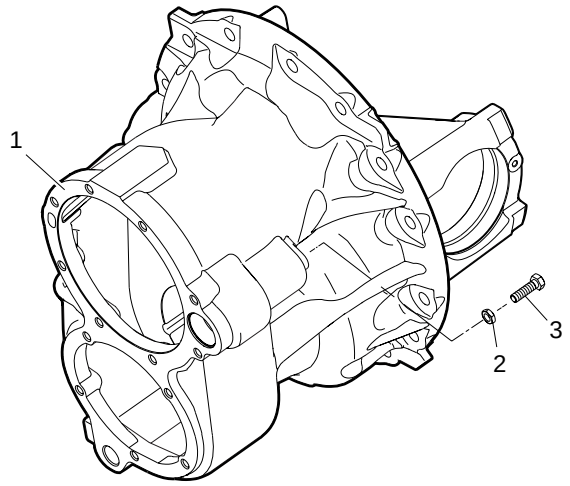
   For instructions on installing a forward-rear axle differential carrier, see **Subject 140**.

Interaxle Differential Lock Adjustment

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.



1. Carrier Housing
2. Lock Nut
3. Adjustment Screw

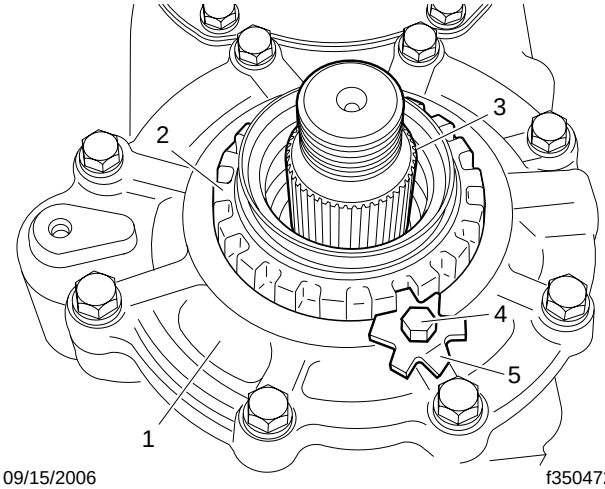
Fig. 1, Interaxle Differential and Adjustment Screw

Special Tools

Special tools are required for this procedure. See **Table 1**.

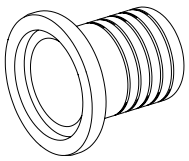
Repair

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.



1. Bearing Cage
2. Threaded Ring
3. Input Shaft (yoke removed)
4. Capscrew
5. Locking Plate

Fig. 1, Forward-Rear Axle Differential Housing

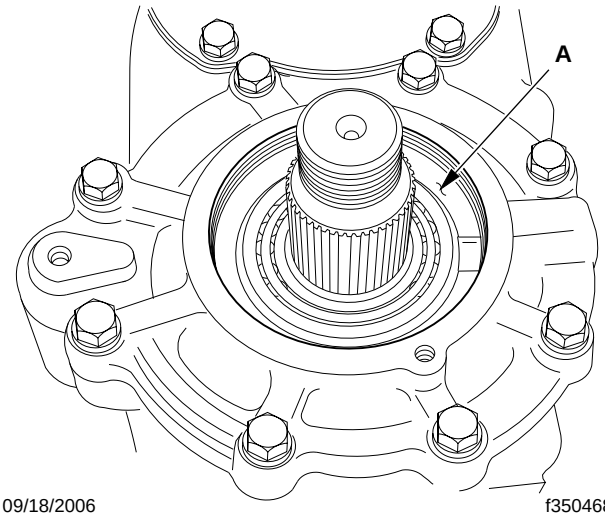
Special Tools for Threaded Ring Repair			
Tool	**Description**	**Manufacturer**	**Part Number**
f580400	Universal Handle*	Kent-Moore	J-8092
 f580410	Input Seal Installer*	Kent-Moore	J-47369

* To order Kent-Moore tools call 1-800-328-6657.

Table 1, Special Tools for Threaded Ring Repair

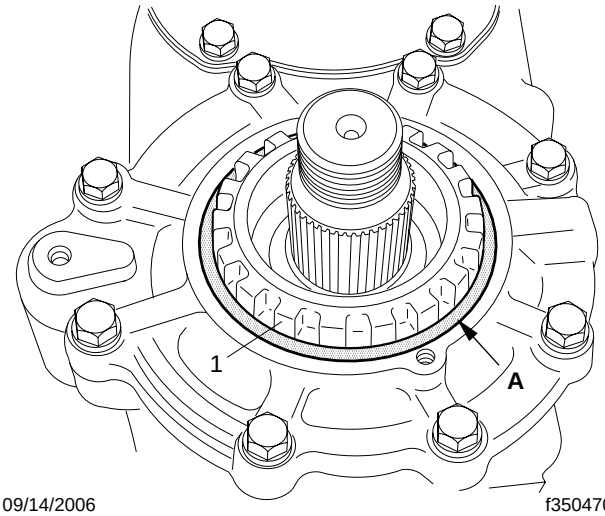
Threaded Ring Repair

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**.



A. Clean and dry this entire surface.

Fig. 2, Bearing Cavity Exposed



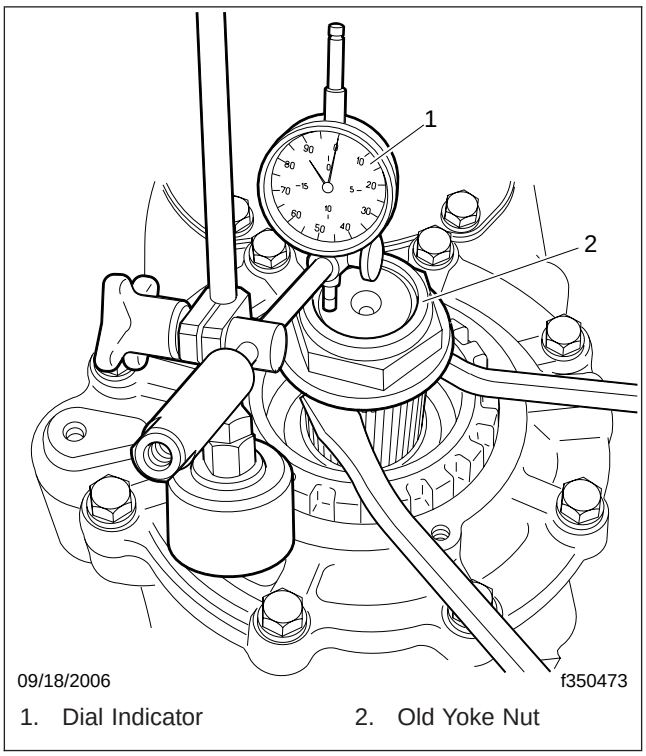
A. Loctite Bead from the Threads

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**.



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.

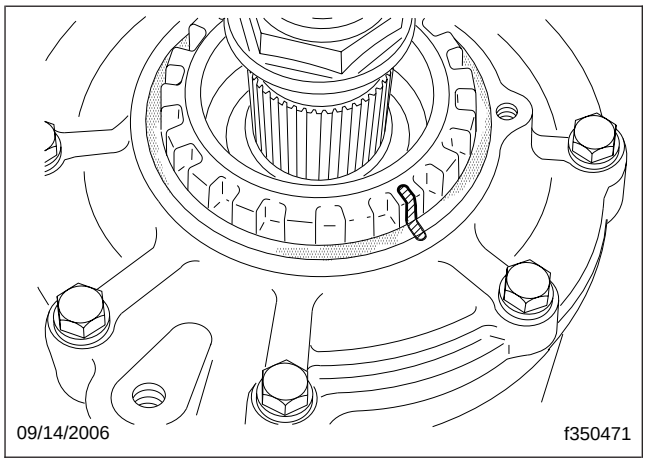


Fig. 5, Marking the Tooth and Bearing Cage

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.

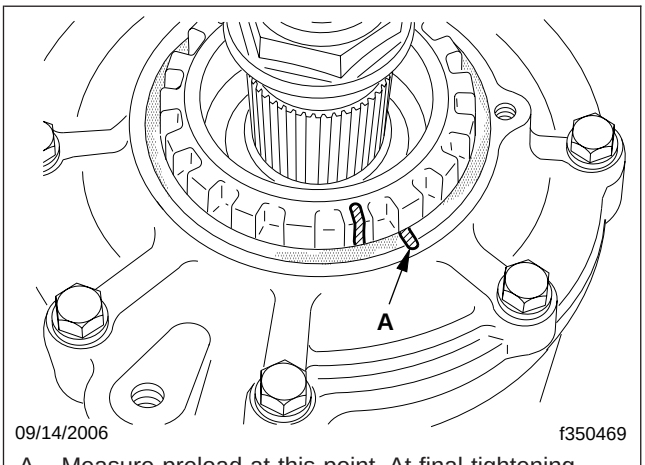
13. When the bearing preload is correct, install the new locking plate and capscrew. Tighten the capscrew 18 lbf·ft (24 N·m).

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.

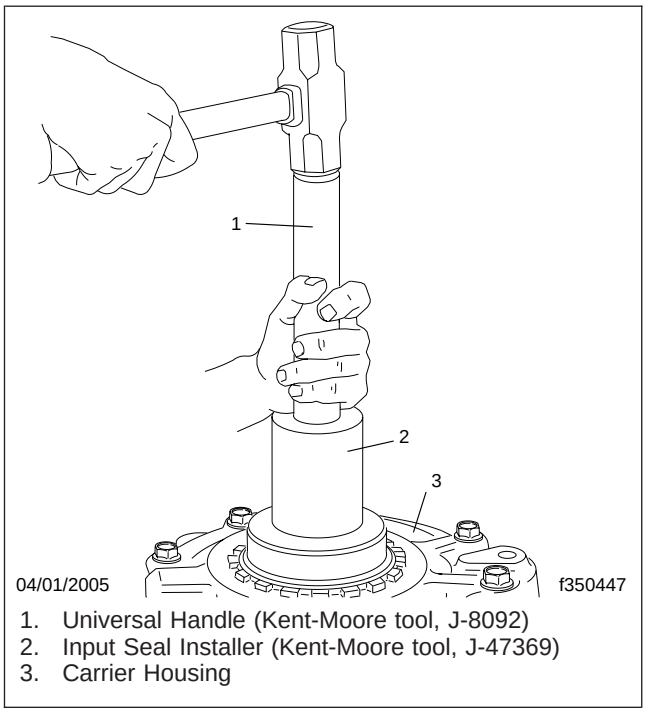
    14.2 Apply a light coating of axle oil to the seal bore.

    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**.

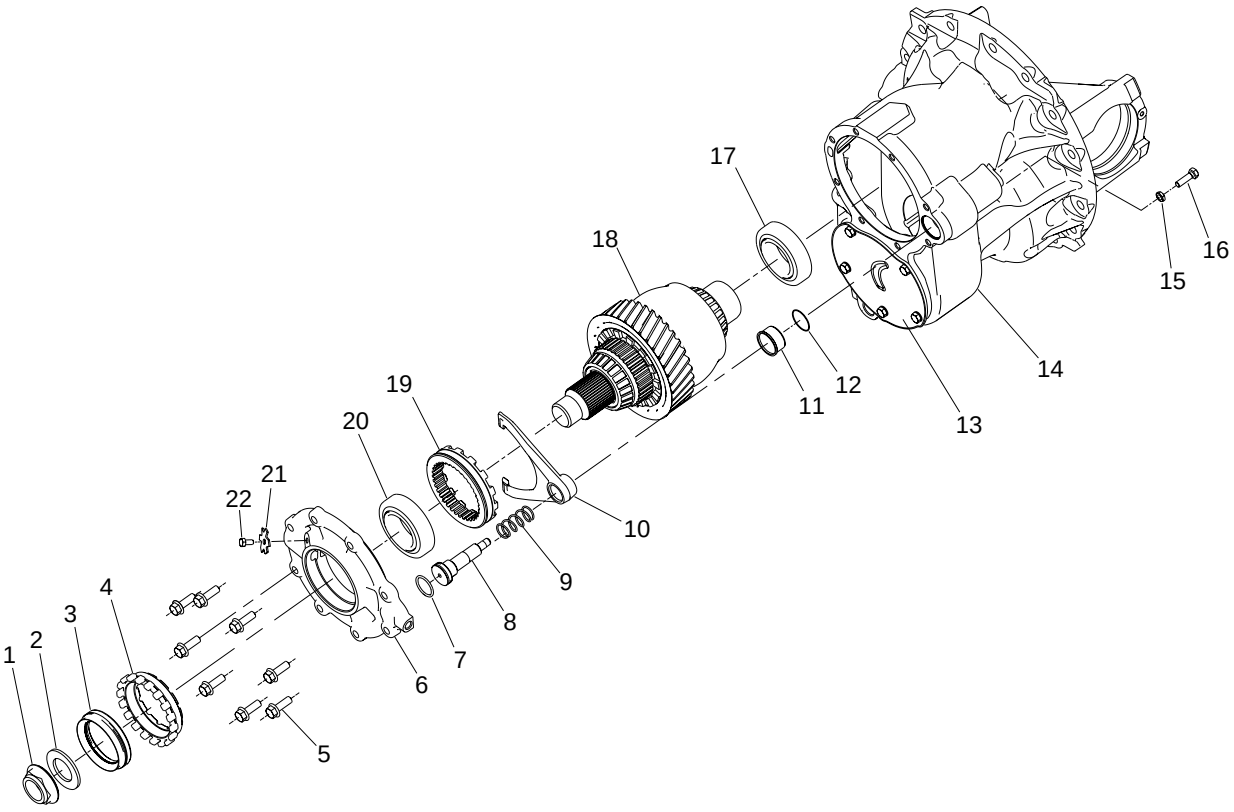
14.5 Using the input shaft seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

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 628 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.

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

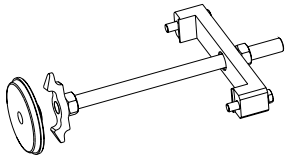
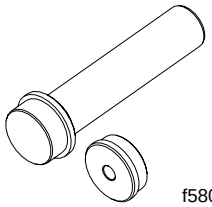
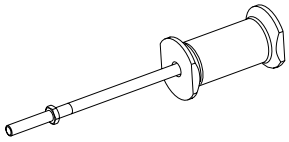
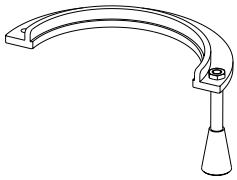
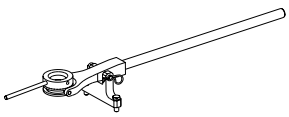
Special tools are required for this procedure. See **Table 1**.



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	Daimler	MBA 420589003300
 f580480	Shift Shaft Bushing Remover and Installer	Daimler	MBA 420589013300
 f580476	Slide Hammer	Daimler	MBA 060589003300
 f580479	Half-Moon Device	Daimler	MBA 420589006300
 f580477	Push-Pull Device	Daimler	MBA 420589001600

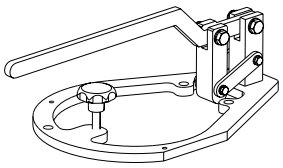
Special Tools for Interaxle Differential Replacement			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580481	Shift Shaft Piston Installer	Daimler	MBA 420589023300

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**.

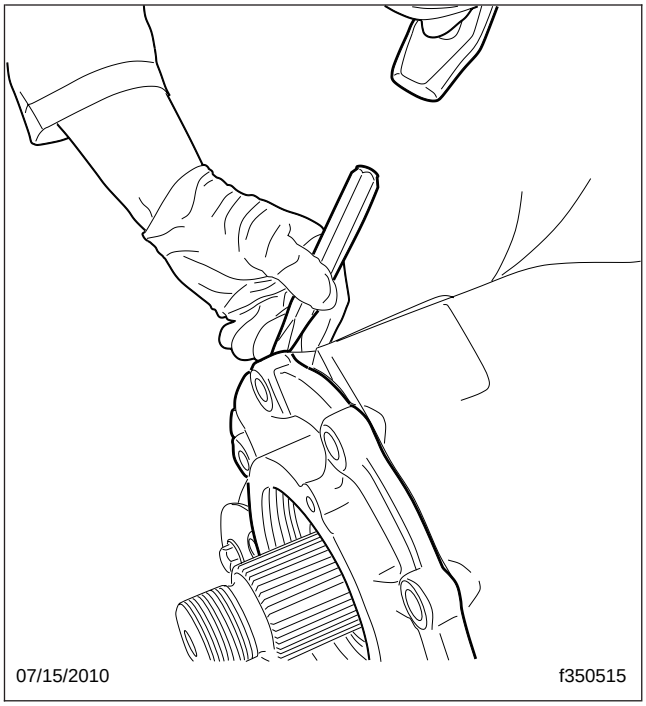


Fig. 2, Tapping the Bearing Cage Loose

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.

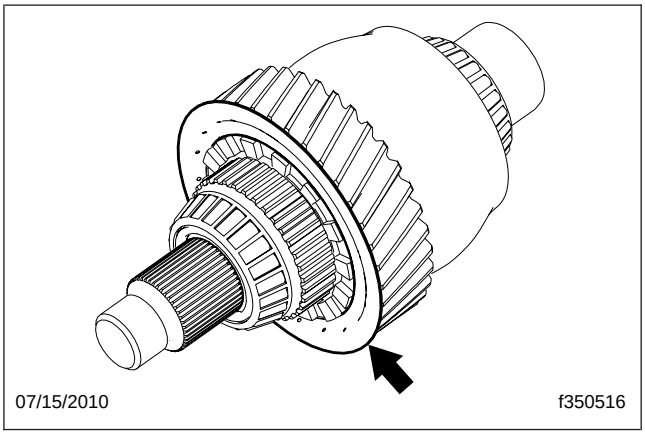


Fig. 3, Oil Slinger

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.

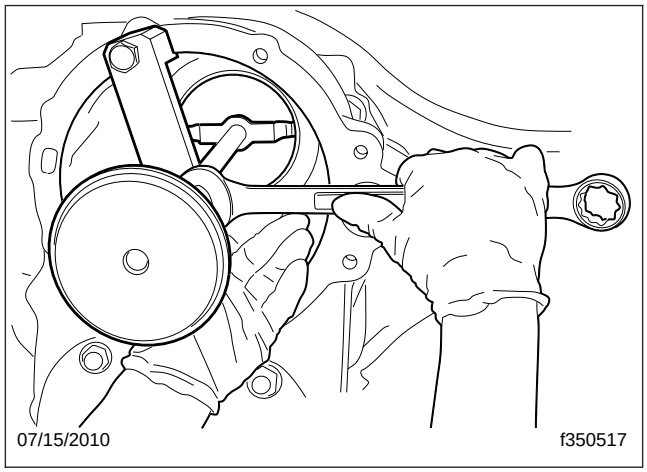
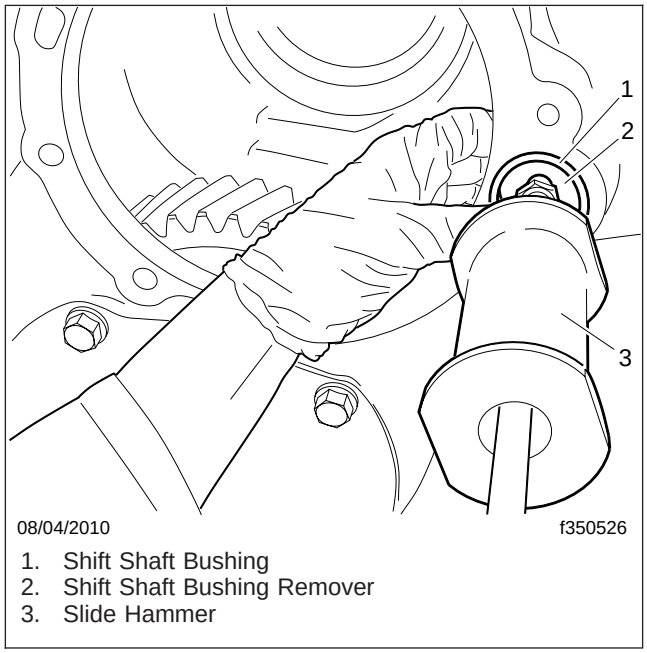


Fig. 4, Removing the Output Bearing Race



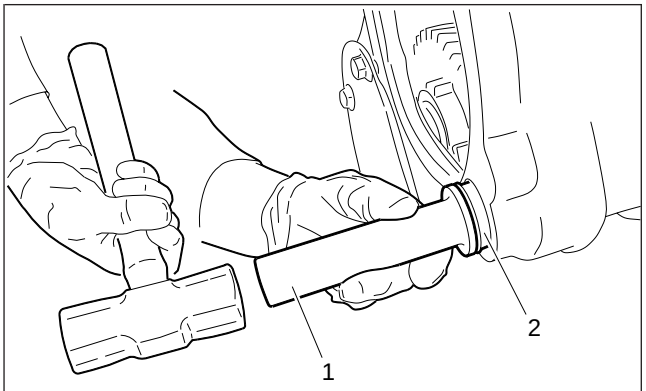
1. Shift Shaft Bushing
2. Shift Shaft Bushing Remover
3. Slide Hammer

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**.



1. Shift Shaft Bushing Installer
2. Shift Shaft Bushing

Fig. 6, Installing the Bushing

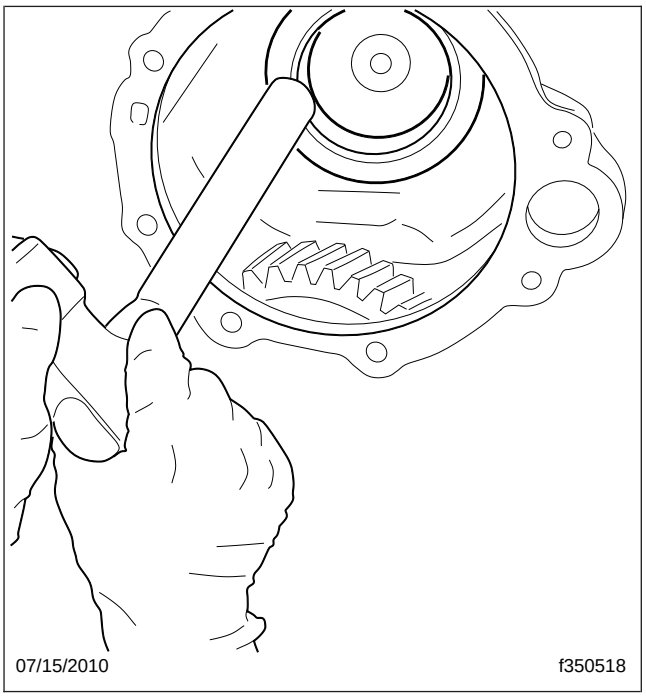


Fig. 7, Setting the Race

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**.

22. Lubricate the output gear and bearing of the new IAD assembly with white grease.

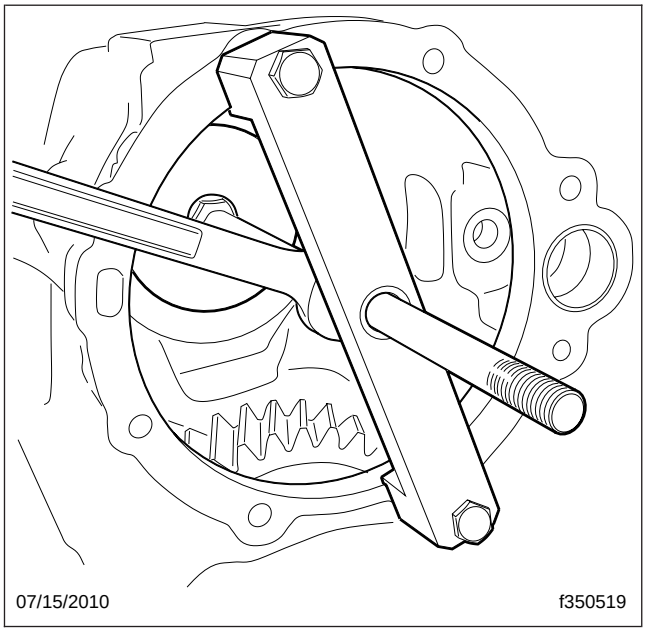


Fig. 8, Pressing a New Race into the Housing

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.

Interaxle Differential Replacement

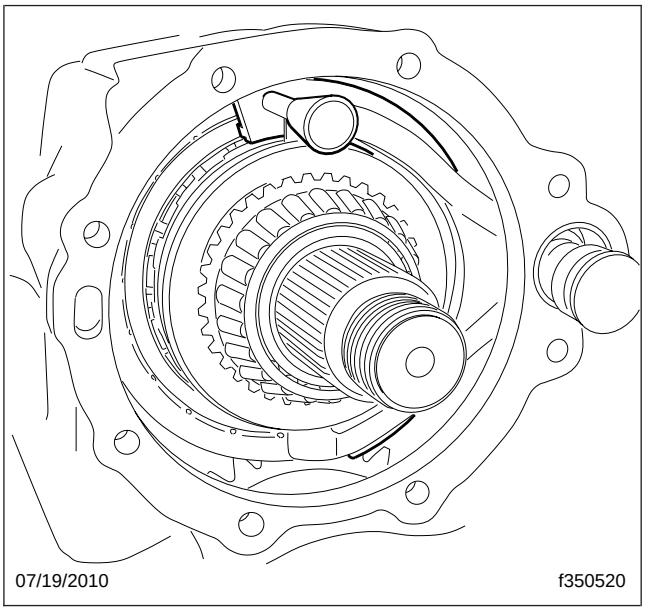


Fig. 9, The Half-Moon Device, Installed

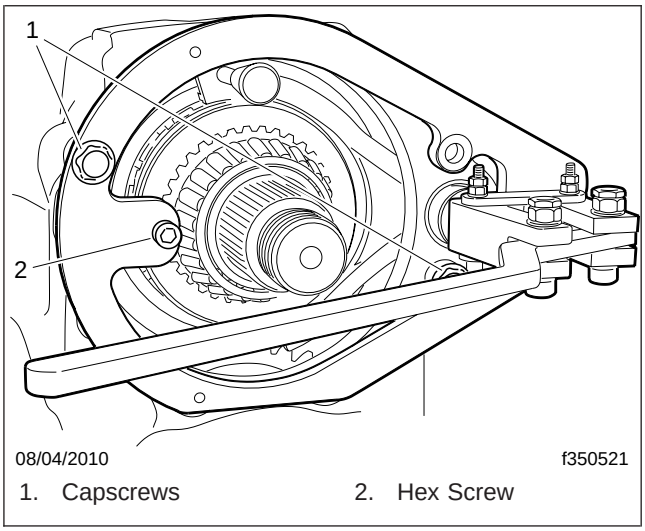


Fig. 10, Shift Shaft Piston Installer, Mounted

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 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.

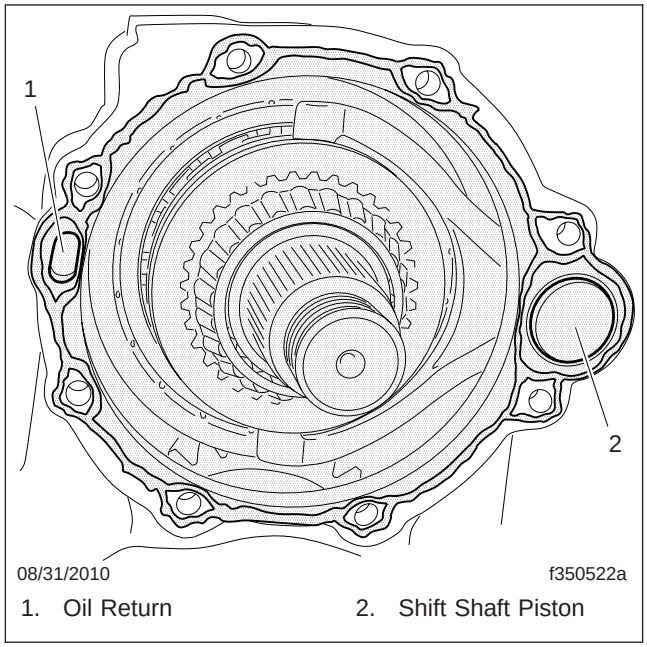


Fig. 11, Sealant Applied to Carrier Housing

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.

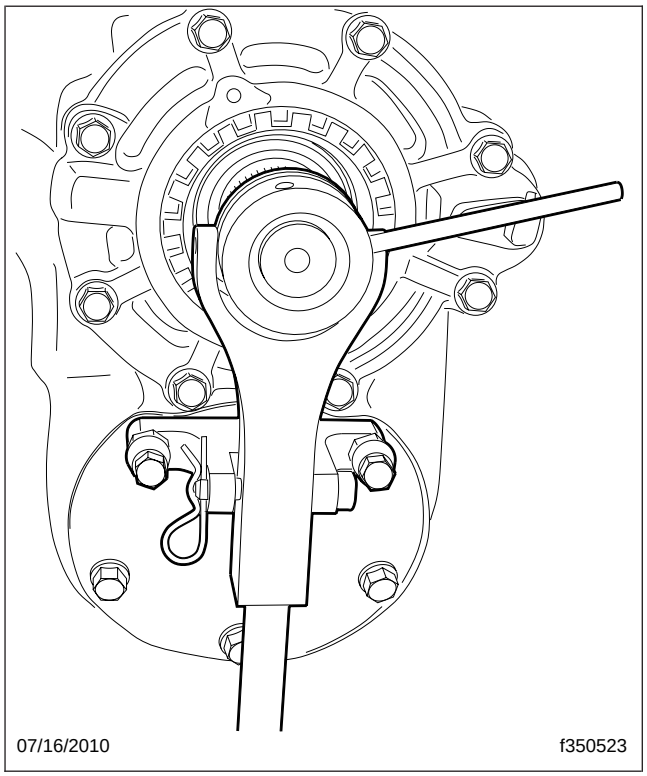


Fig. 12, Push-Pull Device, Installed

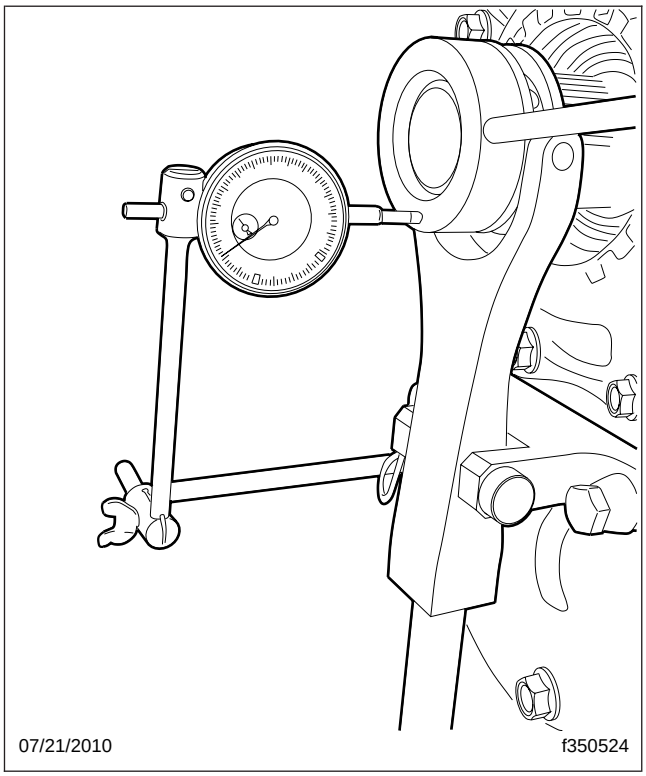


Fig. 13, Dial Indicator and Push-Pull Device

33.1 Set up a dial indicator as shown in **Fig. 13**.

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).

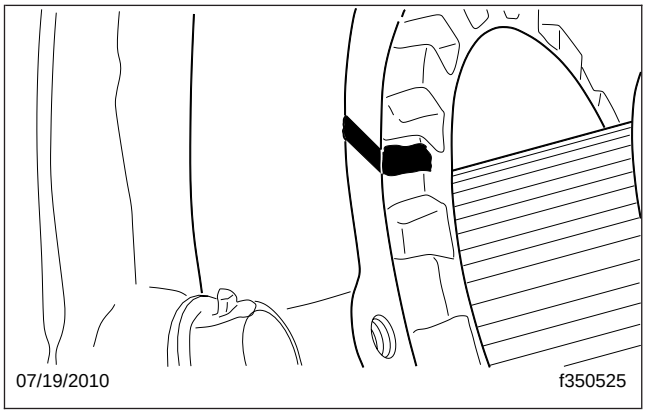


Fig. 14, Threaded Ring and Bearing Cage, Marked

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).

Interaxle Differential Replacement

34. Install a new input shaft seal and the yoke, nut, and washer; see **Subject 170** for instructions.
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**.

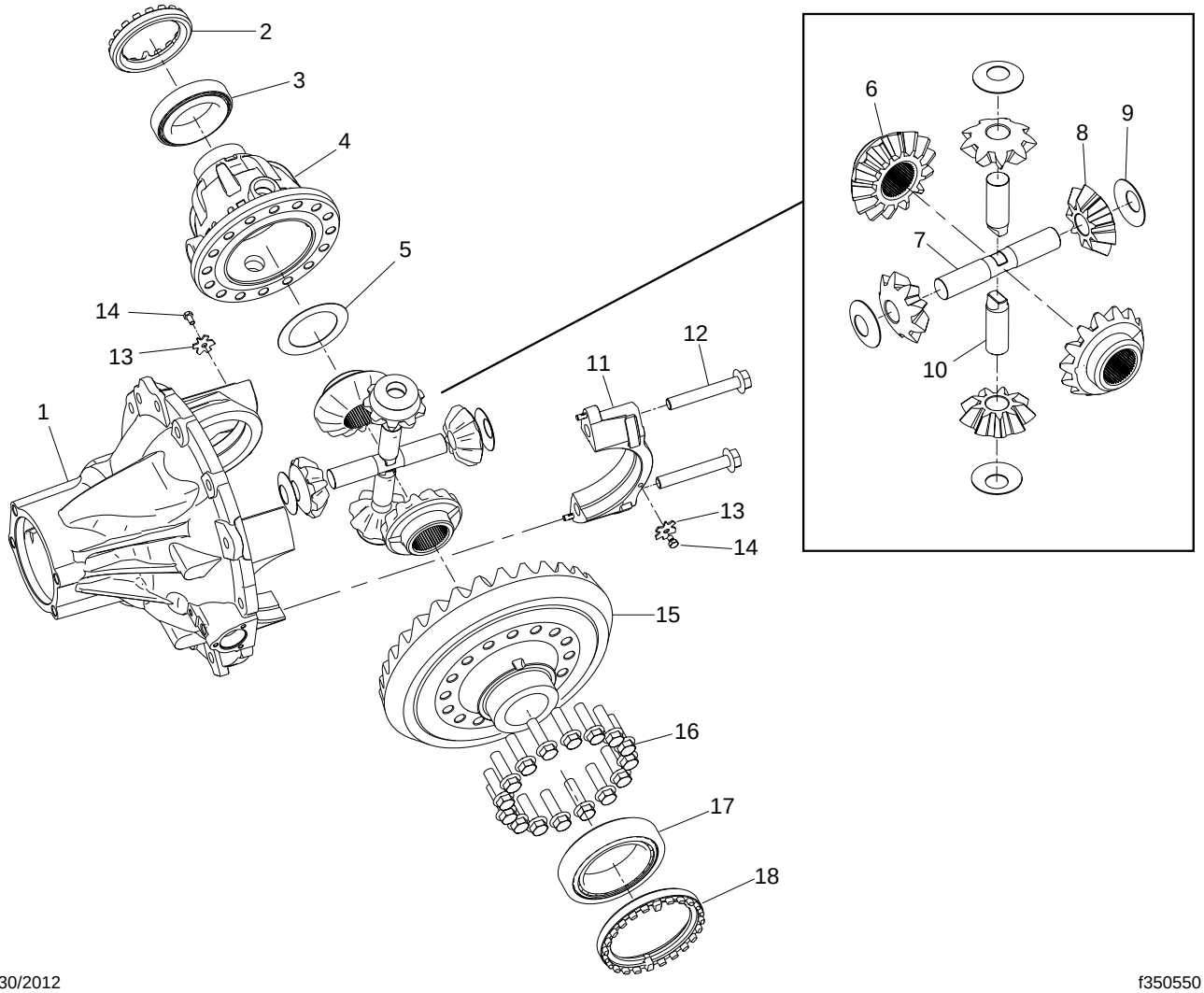
Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	**Capacity: quarts (liters)**	
	Hubs Full	**Hubs Dry**
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

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.

General Information

Use the following procedure to rebuild a Model 2 or Model 4 differential. See **Fig. 1**.



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NOTE: Model 4 components shown.

1. Carrier Housing
2. Threaded Ring M135
3. Bearing (85 x 130 x 29)
4. Differential Case
5. Thrust Washer
6. Side Gear
7. Differential Pin, Long
8. Differential Pinion (qty 4)
9. Spherical Washer (qty 4)
10. Differential Pin, Short (qty 2)
11. Bearing Cap
12. Bolt, M18 x 1.5 x 120 (qty 2)
13. Locking Plate
14. Capscrew
15. Ring Gear
16. Capscrew, M16 x 1.5 x 55 (qty 16)
17. Bearing (110 x 170 x 38)
18. Threaded Ring M175

Fig. 1, Detroit Axle Differential Components

Differential Rebuild

Special Tools

Special tools are required for this procedure. See **Table 1**.

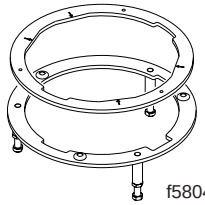
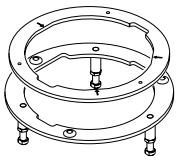
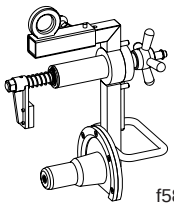
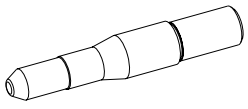
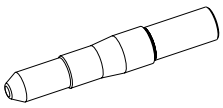
Special Tools for Rebuilding the Differential			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580485	Preload Gauge (Model 4 axles)	Daimler	W 420 589 01 23 00
 f580486	Preload Gauge (Model 2 axles)	Daimler	W 420 589 00 23 00
 f580487	Differential Lifting Tool	Daimler	W 420 589 01 63 00
 f580488	Guide Pin (Model 4 axles)	Daimler	W 420 589 01 61 00
 f580489	Guide Pin (Model 2 axles)	Daimler	W 420 589 00 61 00

Table 1, Special Tools for Rebuilding the Differential

Rebuild

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the differential carrier, and place it on a suitable work stand. See **Subject 110**.
3. If the carrier is equipped with a differential lock, remove it. See **Subject 180**.
4. At the M135 threaded ring, remove the locking plate and capscrew, and then the threaded ring.

NOTE: The two groove pins (dowel pins) in the bearing cap may disengage and fall as the bearing cap is removed.

5. Remove the bearing cap. If needed, strike the M175 threaded ring with a brass hammer to loosen it.
6. Remove the M175 threaded ring.
7. Install the differential lifting tool as shown in **Fig. 2**, and use a suitable lifting device to remove the differential assembly from the housing and set it on a work bench.
8. Remove the differential case from the ring gear, as follows.

   8.1 Remove and discard all but two of the ring gear capscrews; leave these two capscrews opposite each other and seated six to seven threads deep.

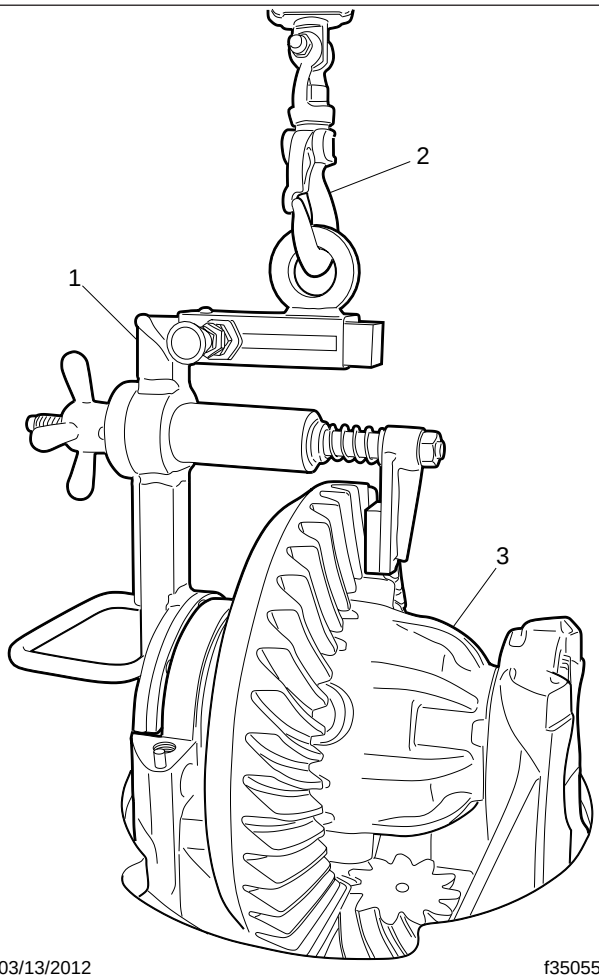
   NOTE: The ring gear capscrews will not be reused, they are single use only. These capscrews will be damaged when hammered, but new capscrews will be used to install the ring gear later in this procedure.

   8.2 Place the assembly on wood blocks and hammer the two capscrews to separate the differential case from the ring gear.

   8.3 Remove the two capscrews to release the ring gear. Discard the capscrews.

9. Remove the side gears, differential pinion gears, differential pins, and thrust washers.

NOTE: The differential case and ring gear each have indentations to accommodate a two-jaw puller.



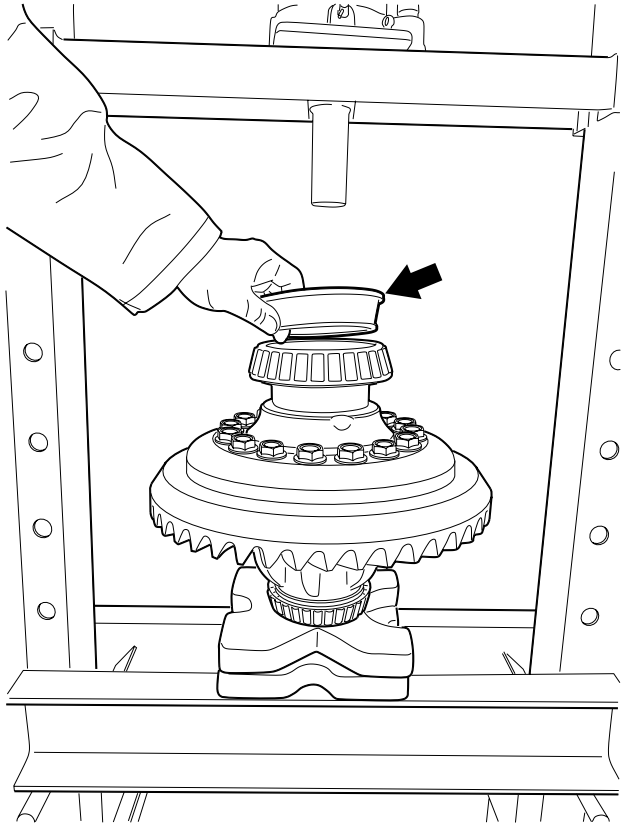
1. Ring Gear Lifting Tool
2. Hoist
3. Differential Assembly

Fig. 2, Removing the Differential Assembly

10. Inspect the bearings. If they need to be replaced, use a two-jaw puller to remove them from the differential case and ring gear. Discard the cages and rollers, and retain the races for the replacement bearings.
11. Clean the inside of the differential case with degreaser.

IMPORTANT: Each inner race must be reinstalled using the old race with the opposite orientation (flipped over) of how they were removed. This will prevent damage to the new bearing rollers and cage. See **Fig. 3**.

12. If the bearings are being replaced, use a shop press and the old races oriented opposite of how they were removed to install the replacement bearings on the differential case and ring gear.



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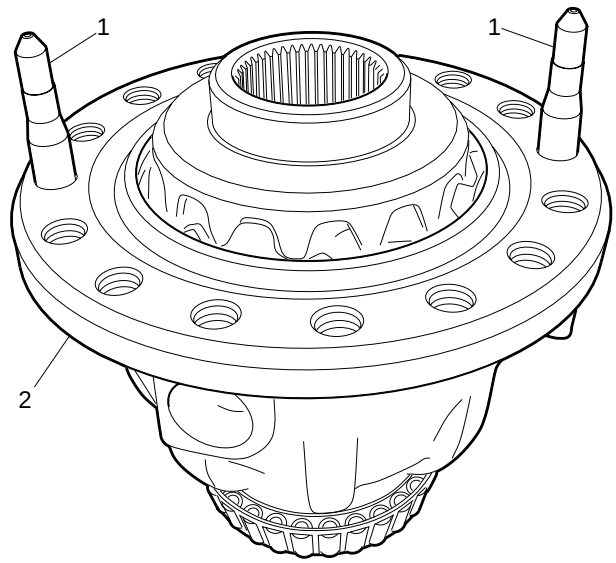
To install the inner race, orient it opposite (flipped over) of how it was removed.

Fig. 3, Press Setup for Bearing Installation

IMPORTANT: Do not lubricate the case side of the spherical washers. Lubricant between the washers and case cause the washers to rotate and wear the case.

13. Lubricate the side gears, differential pinions, pins, thrust washer, and the *gear side* of the spherical washers with white lithium grease, and install them into the differential case.
14. Install the guide pins. See **Fig. 4**.
15. Lower the ring gear onto the differential case using the guide pins.



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1. Guide Pin
2. Differential Case

Fig. 4, Guide Pins Installed in Differential Case

16. Install the ring gear on the differential case, as follows.

    IMPORTANT: If the capscrews will not start, level the ring gear by tapping it with a dead blow.

    16.1 Except where the guide pins are set, install new capscrews three threads deep.

    16.2 Seat the ring gear by tightening the capscrews in a crisscross pattern.

    16.3 Remove the guide pins and install new capscrews in their place.

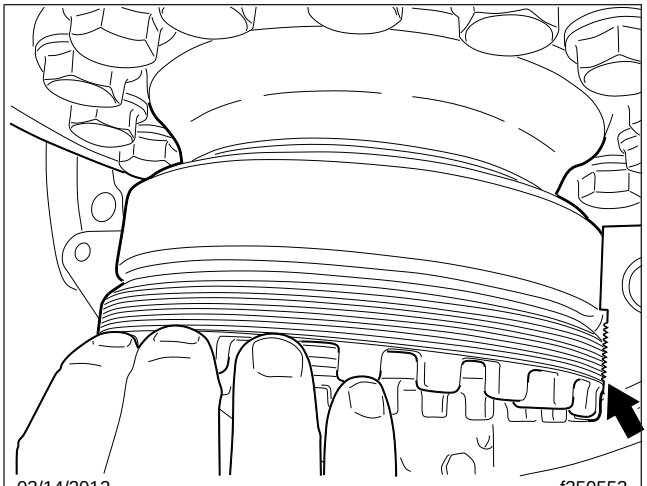
    16.4 In a star pattern, tighten each capscrew 150 lbf·ft (200 N·m) plus a 90-degree turn.

17. Using the lifting tool and a suitable lifting device as before, install the differential assembly into the carrier housing.

IMPORTANT: Install the threaded rings carefully to avoid cross threading them.

18. To install the M175 threaded ring, carefully align the threads in the ring with the threads in the carrier housing (see **Fig. 5**), and hand tighten it until it is flush with the bearing race.

19. Install the bearing cap, hand tighten the capscrews, and then tighten each one 150 lbf·ft (200 N·m) plus a 90 degree turn.



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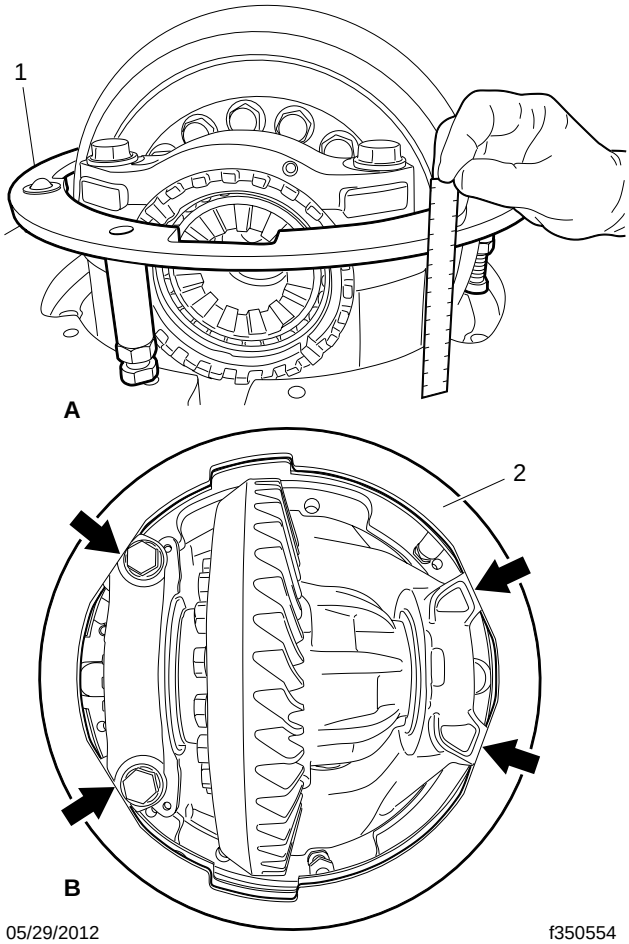
Install the threaded rings carefully to avoid cross threading them.

Fig. 5, Threaded Ring Installation

20. To install the M135 threaded ring, carefully align the threads in the ring with the threads in the carrier housing, and hand tighten it until it is flush with the bearing race.
21. Gauge and adjust preload, as follows.
    - 21.1 Set up the base of the preload gauge, and ensure it is level with the top of the work station by measuring it at three points and, if needed, adjusting the legs. See **Fig. 6**.
    - 21.2 Set the preload ring on the base, and align the flat, inner parts of the ring with the bearing cap and carrier housing as shown in **Fig. 6**.
    - 21.3 Rotate the ring along the flat surfaces to gauge preload; see **Fig. 7**. The ring should touch the bearing cap and carrier housing and rotate with light resistance. If it needs to be adjusted, use a hammer and punch to tighten or loosen the threaded rings.
22. There must be between 0.0078 and 0.011 inch (0.2 and 0.28 mm) of backlash between the pinion and the ring gear. Measure and adjust the backlash as follows.



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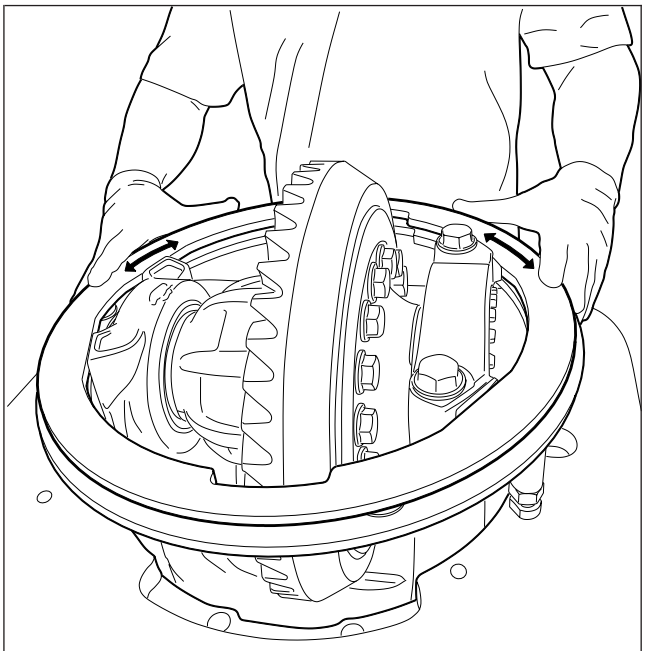
NOTE: Model 4 axle shown.

A. Ensure the base is level.
B. Align the ring with the carrier housing at the flat points of the inner part of the preload ring.

1. Base
2. Preload Ring

Fig. 6, Preload Gauge Set Up

- 22.1 Help settle the bearings in the races by tapping the carrier housing and bearing cap (at the raised area as shown in **Fig. 8**) with a hammer.
- 22.2 Set up a dial indicator with the measuring tip on a tooth of the ring gear. See **Fig. 9**.
- 22.3 Turn the ring gear to measure backlash. If it needs to be adjusted, use a hammer and punch to tighten and/or loosen the



Rotate the ring along the flat surfaces to gauge preload.

Fig. 7, Gauging Preload

threaded rings. To increase backlash, move the ring gear away from the pinion by loosening the large threaded ring and tightening the small one.

IMPORTANT: Both preload and backlash must meet the stated criteria before proceeding to the next step.

23. Secure both threaded rings, as follows.

    For Model 2 axles, tighten the lock pins at the bearing caps.

    For Model 4 axles, place a tab of each locking plate between two teeth of the threaded rings, and tighten the capscrews 19 lbf·ft (25 N·m). Using a hammer, flatten the plates over the bearing cap and carrier housing, and tighten the capscrew again 19 lbf·ft (25 N·m). Use a punch to bend the tabs to secure the threaded rings.

24. If the carrier is equipped with a differential lock, install it. See **Subject 180**.

25. Install the differential carrier. See **Subject 110**.

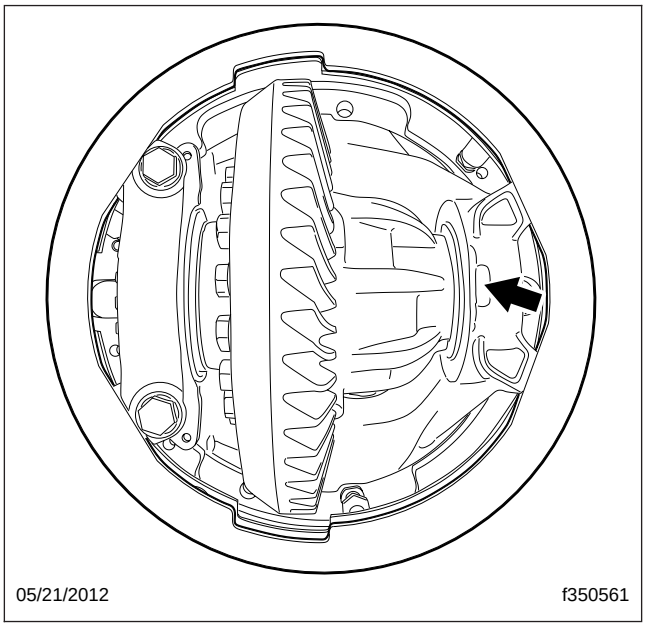
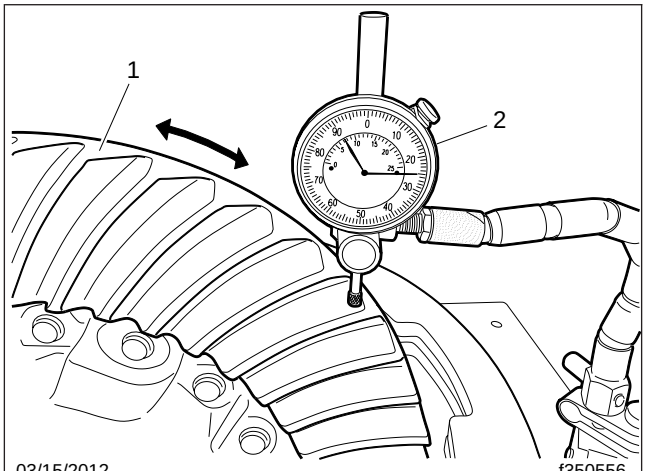


Fig. 8, Tapping Area for Bearing Cap



Rotate the ring gear to measure backlash.
1. Ring Gear
2. Dial Indicator

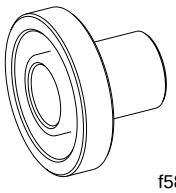
Fig. 9, Measuring Backlash

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)

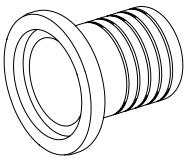
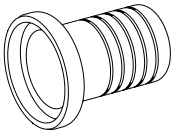
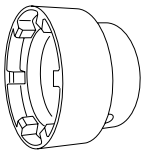
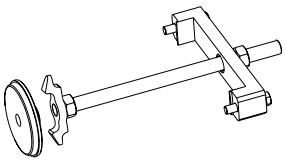
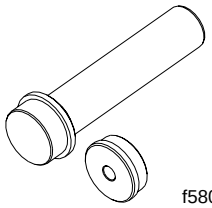
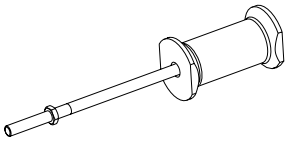
Table 1, Torque Values

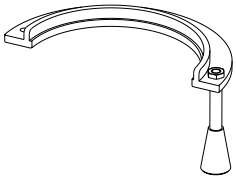
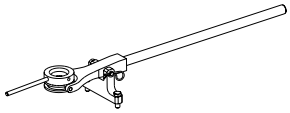
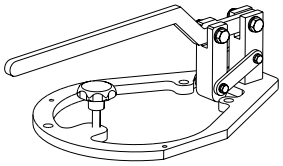
Rear Axle Lubricant Type and Capacity			
Approved Lubricant Type	**Axle**	**Oil Capacity: quarts (liters)**	
		Hubs Full	**Hubs Dry**
80W/90 Gear Oil	Forward-Rear	14.3 (13.5)	15.9 (15.0)
75W/90 Synthetic Gear Oil			
80W/90 Gear Oil	Single and Rearmost Tandem	10.6 (10.0)	12.2 (11.5)
75W/90 Synthetic Gear 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†	Daimler	MBA 742589020700
 f580478	Output Bearing Remover and Installer	Daimler	MBA 420589003300
 f580480	Shift Shaft Bushing Remover and Installer	Daimler	MBA 420589013300
 f580476	Slide Hammer	Daimler	MBA 060589003300

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580479	Half-Moon Device	Daimler	MBA 420589006300
 f580477	Push-Pull Device	Daimler	MBA 420589001600
 f580481	Shift Shaft Piston Installer	Daimler	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

Tires support the weight of the vehicle, and are integral parts of the transmission and braking systems. Wheels serve as load carrying members between the tires and the axle.

Disc wheels are comprised 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. All standard and optional steel and aluminum disc wheels are hub-mounted, using ten 2-piece flanged nuts to hold single front wheels and both, inner and outer, dual rear wheels centered on the pilot pads of the hub.

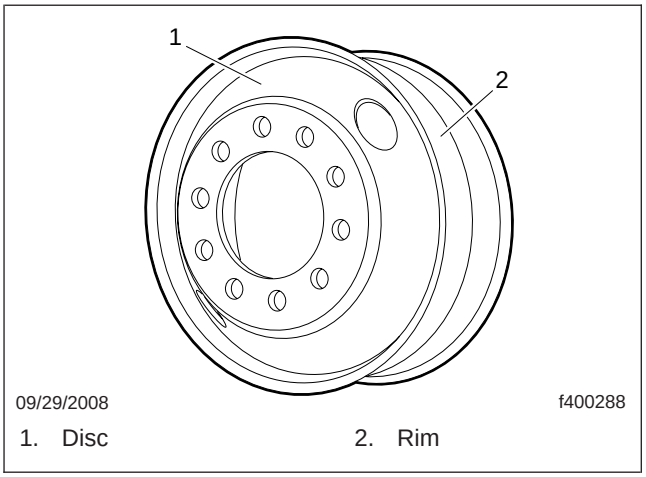


Fig. 1, Disc wheel

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.

Tire Matching and Mixing

IMPORTANT: Review and follow these requirements for matching and mixing tires, before installing any tire and wheel assembly on a vehicle.

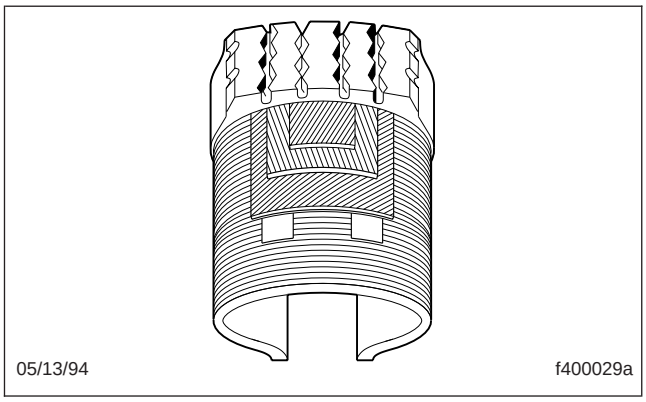


Fig. 2, Radial Ply Tire Construction

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 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**.

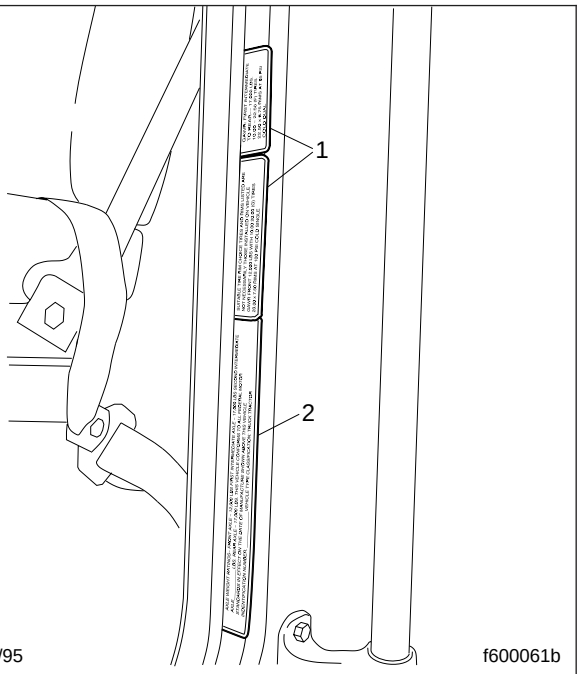
Tire and wheel labels certify the minimum tire and wheel combinations that can be installed on the vehicle for the given GAWRs. See **Fig. 3** and **Fig. 4**. Each GAWR is determined by considering each component of the axle system, including suspension, axle, wheels, and tires. The lowest component's capacity is the value used for the system. Therefore, the tires and wheels installed on the vehicle at the time of vehicle manufacture may have a higher load capacity than that certified by the tire and wheel label.

Tires and wheels of the minimum capacity can be installed without changing the load limitations. If tires and wheels are installed that have a lower load capacity than that shown on the tire and wheel label, then the tires and wheels determine the load limitations (the GAWRs and GVWR will be lower).

Changing to tires of a different overall diameter also negatively affects the antilock braking system, which is set to respond to the tire diameter that's programmed into the ABS when the vehicle is built. A different tire diameter can also cause speedometer and odometer readings to be too high or too low.

When pairing tires in a dual assembly, the tire diameters must not differ by more than 1/4 inch (6.4 mm),

General Information



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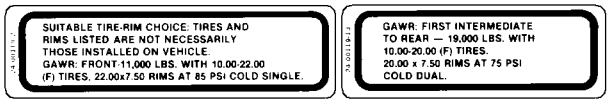
1. Tire and Wheel Labels
2. Certification Label

Fig. 3, Certification Label, U.S.



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NOTE: Examples only. Actual specifications may vary from vehicle to vehicle.

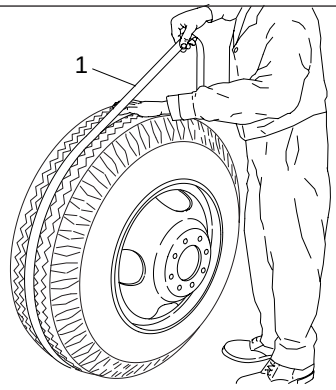
Fig. 4, Tire and Rim Labels

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 or square, measure the diameter of the tires 24 hours after inflation. See **Fig. 5**, and **Fig. 6**. A matching stick, string gauge, or tire straight edge can also be used to determine the difference in tire radius, which is then doubled to calculate the diameter difference. See **Fig. 7**, **Fig. 8**, and **Fig. 9**.



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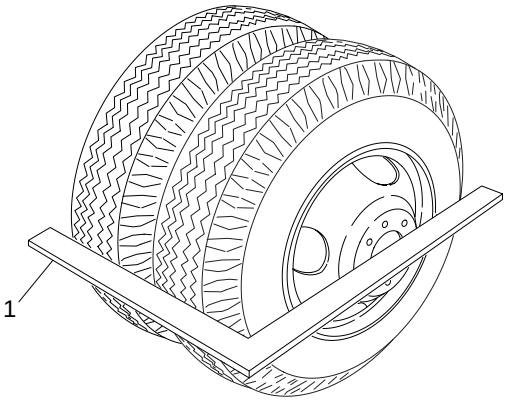
1. Endless Pi Tape

Fig. 5, Endless Pi Tape



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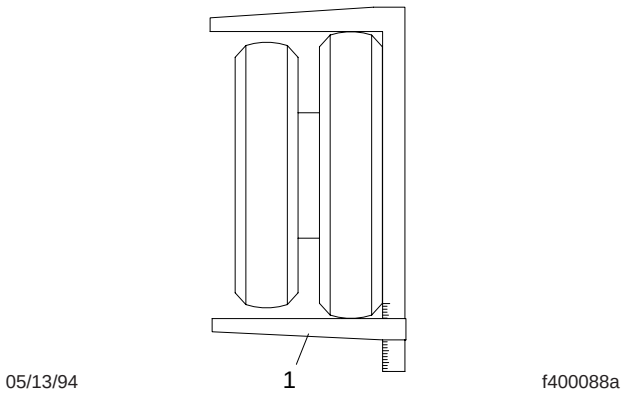
1. Square

Fig. 6, Square

When pairing tires of unequal diameters (but within the above limits), mount the larger tire on the outside.

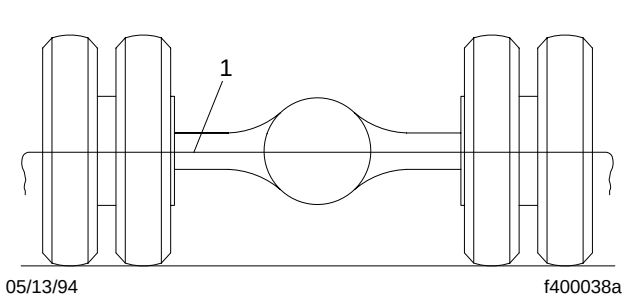
⚠ CAUTION

Driving a vehicle on one tire of a dual assembly dangerously exceeds the carrying capacity of the



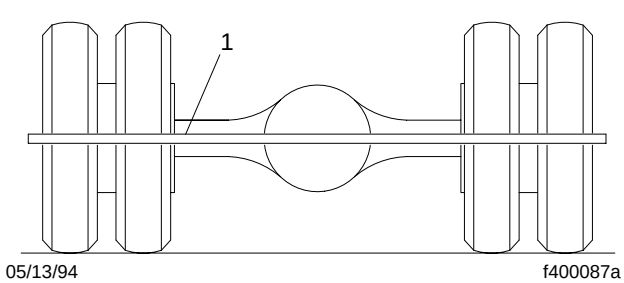
1. Matching Stick

Fig. 7, Matching Stick



1. String Gauge

Fig. 8, String Gauge



1. Tire Straight Edge

Fig. 9, Tire Straight Edge

single tire and wheel. Operating in this manner can cause damage to the wheel and tire.

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. 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 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.

Disc Wheel Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Chock all tires that will not be serviced.
2. If removing wheels and tires from the front axle, 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, 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

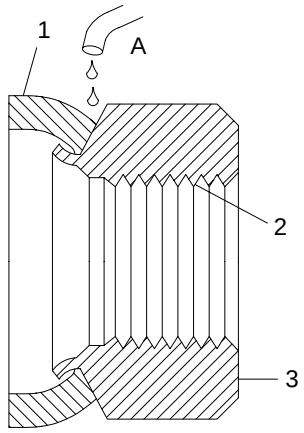
Keep the wheel square to the hub during removal. The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads.

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 two-piece flange nuts.



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A. Apply oil here.

1. Flange
2. Nut Threads
3. Nut Body

Fig. 1, Two-Piece Flange Nut

IMPORTANT: Freightliner "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 2**.

IMPORTANT: Before installing the wheels, make sure the drum is in position on the raised step of the pilot pad. One of the hub 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.

5. Turn the hub until one hub-pilot pad is in the top-center position.

Disc Wheel Removal and Installation

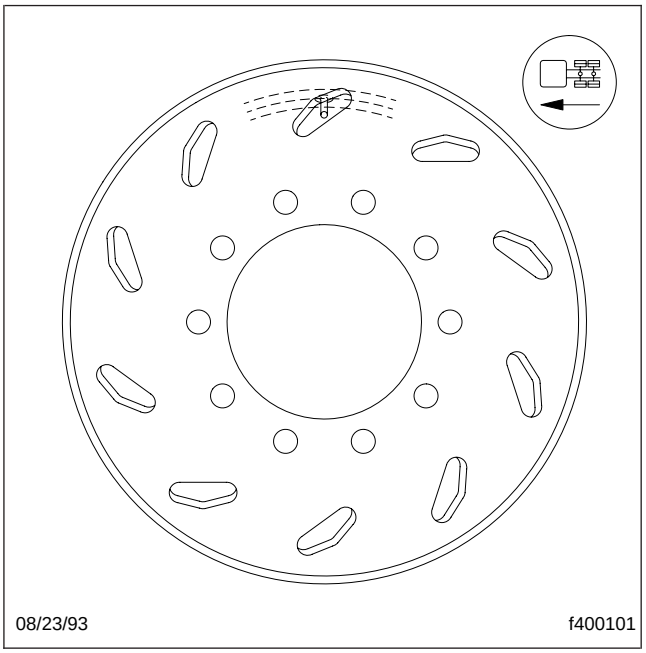


Fig. 2, Directional Freightliner "Turbo" Wheel

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.

   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. 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 and hand-tighten the 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. 3** .

    11.1 Tighten the flange nuts initially to 50 to 100 lbf·ft (68 to 136 N·m).

    11.2 Tighten the flange nuts to 450 to 500 lb·ft (610 to 678 N·m).

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.

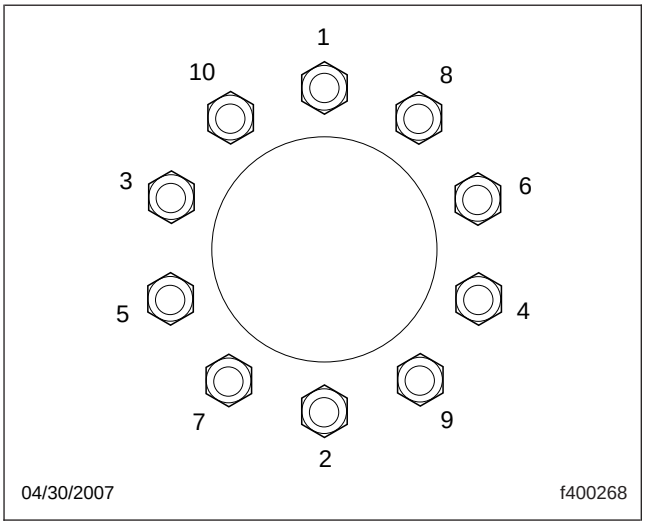


Fig. 3, 10-Hole Disc Wheel Tightening Sequence

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 to the original specification, following the tightening sequence in **Fig. 3**.
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

- Examine all wheel and tire parts as explained in **Subject 130** and **Subject 140**. Replace damaged, rusted, or worn parts.
- Do not reinflate a tire that has been driven flat, or has been driven at 80 percent or less of its recommended operating pressure.
- Before removing a low tire from the vehicle, make sure it is completely deflated.

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, and considerable force may be required. The use of a machine designed for loosening tire beads is recommended.

Handling

- To prevent nicking or gouging the wheels, handle them on a wooden floor or rubber mat.
- Store tires indoors, or under cover outdoors, to prevent water from 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, before using tools to break the bead.
- Michelin also recommends applying a sufficient but sparing amount of lubricant to the entire wheel face when mounting a tire on a wheel, 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 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

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 wheel.
   - 2.1 Place the wheel 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 wheel flange.
   - 2.3 Holding the tool upright, hammer on the neck to free the tire bead from the wheel. See **Fig. 1**.
   - 2.4 Repeat at 8-inch (20-cm) intervals around the flange, until the bead is free from the wheel.
   - 2.5 Turn the wheel over and repeat the previous substeps to loosen the second bead from the wheel.
3. Remove one bead from the wheel.
   - 3.1 Make sure the wide side of the wheel is down.
   - 3.2 Lubricate the tire bead and the wheel.
   - 3.3 Insert the curved end of two tire tools between the bead and the wheel, just to one side of the tire valve. See **Fig. 2**.

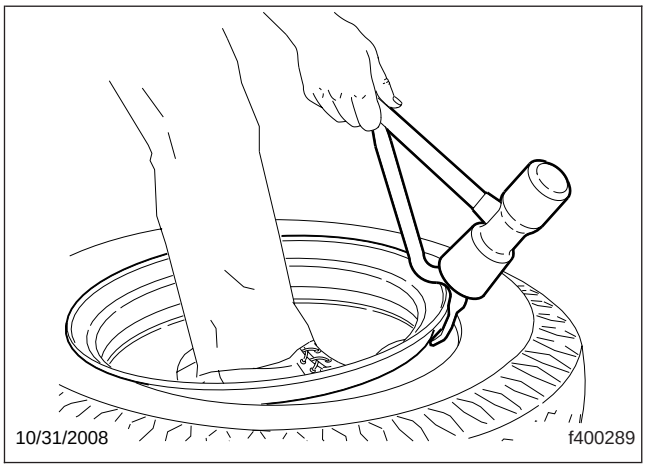


Fig. 1, Loosening the Beads

   - 3.4 Step on the side of the tire opposite the valve to force the first bead into the wheel 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 wheel flange.
   - 3.6 Continue prying around the tire to work the first bead off of the wheel. Leave the second bead in the wheel well.

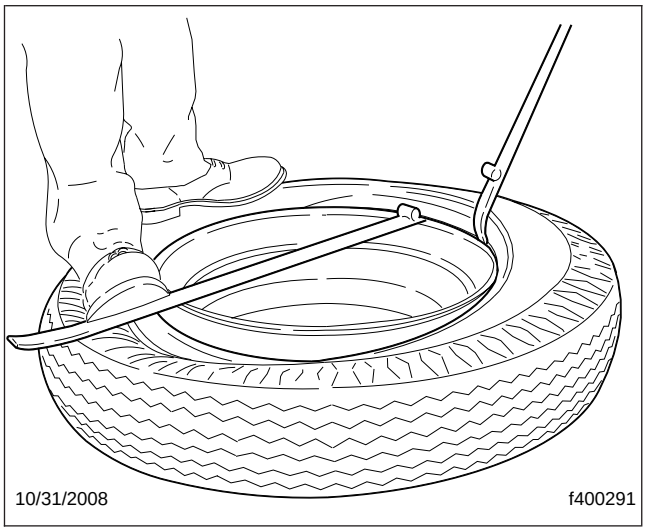


Fig. 2, Forcing First Bead From Wheel

4. Remove the wheel from the tire.
   - 4.1 Stand the wheel and tire assembly upright, with the valve stem near the top.

Demounting and Mounting Tubeless Tires

4.2 Lubricate the second bead and wheel.

4.3 Insert the straight end of the tool between the tire bead and the back wheel flange, 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 wheel out of the tire.

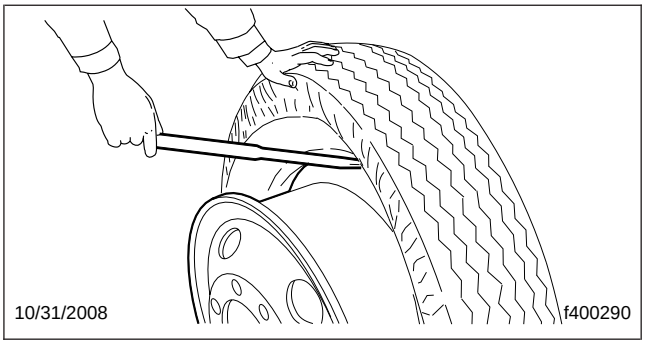


Fig. 3, Prying the Wheel Out of the Tire

5. Clean and inspect all parts. Follow the instructions in **Subject 130** and **Subject 140**.

Mounting

1. Install the valve stem in the wheel.

   1.1 Place the valve stem, with a rubber washer, through the valve hole from the tire side of the wheel.

   1.2 Screw the valve nut onto 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.

2. Lubricate the bead seats on the wheel and both tire beads.

   2.1 Place the wheel 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 wheel, and both tire beads, with an approved lubricant. Do not let excess lubricant run inside the tire.

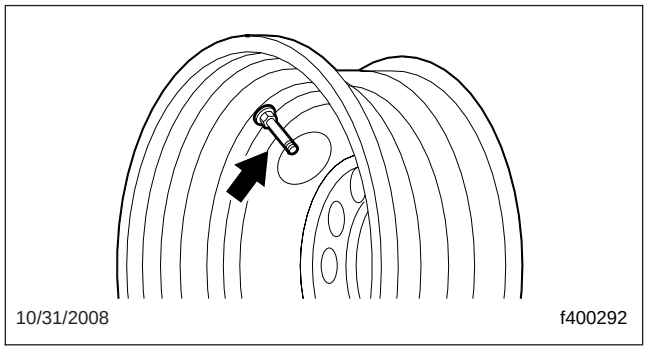


Fig. 4, Valve Stem Installation

Apply enough lubricant to enable correct bead seating and to make mounting easier.

3. Work the lower tire bead into the wheel well.

   3.1 Lay the tire on the wheel. If there is a balance mark on the tire, align the mark with the valve stem.

   3.2 Push one area of the lower bead over the flange and into the wheel well.

   3.3 Using the straight end of the tire tool, with the stop resting on the wheel flange, work small sections until the remaining bead slips into the wheel. See **Fig. 5**.

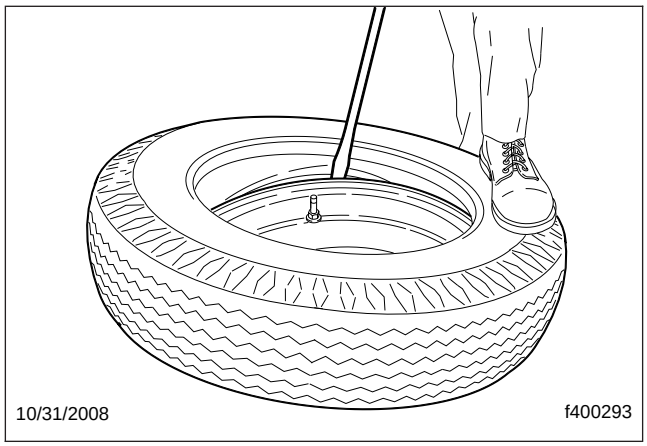


Fig. 5, Working the Lower Bead into the Wheel

4. Work the upper tire bead into the wheel well.

   4.1 Start the upper tire bead over the wheel flange and into the wheel well by standing on the tire. If necessary, push a section of the bead into the wheel well and anchor it

by attaching Vise-Grip® pliers to the wheel flange with the snub side toward the tire.

4.2 Using the spoon end of the tire iron, with the stop toward the wheel, work around the bead. See **Fig. 6**. Work small sections, until the bead slips over the flange and into the wheel well.

4.3 If necessary, insert a second tire iron and relubricate the last 8 inches (20 cm) of the bead.

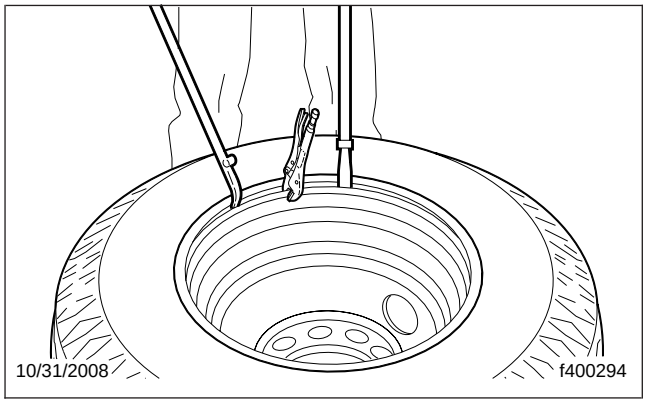


Fig. 6, Working the Upper Bead into the Wheel

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.

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, and all parts. Remove any grease, dirt, or rust. Using a wire brush, remove any rubber from the bead seat. 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.

A cracked wheel, or brake drum, damaged inner or outer wheel nuts or an out-of-round wheel, requires replacement of the damaged part.

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.

Inspect valve cores for cracks, bends, and air retention. Replace damaged or leaky cores.

Do not attempt to rework, weld, heat, or braze any wheel parts that are cracked, broken, or damaged.

Remove all foreign matter, such as grease and dirt, from the wheel mounting surface. Smooth any projections on the mounting surface to ensure even pressure when tightening the wheel nuts.

Inspection

WARNING

Inspect the tires and wheels, and correct any problems. Failure to do so could cause tire 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 (i.e.: 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. Discard the tire if it cannot be retreaded.

Michelin Tire Corporation recommends using only new 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.

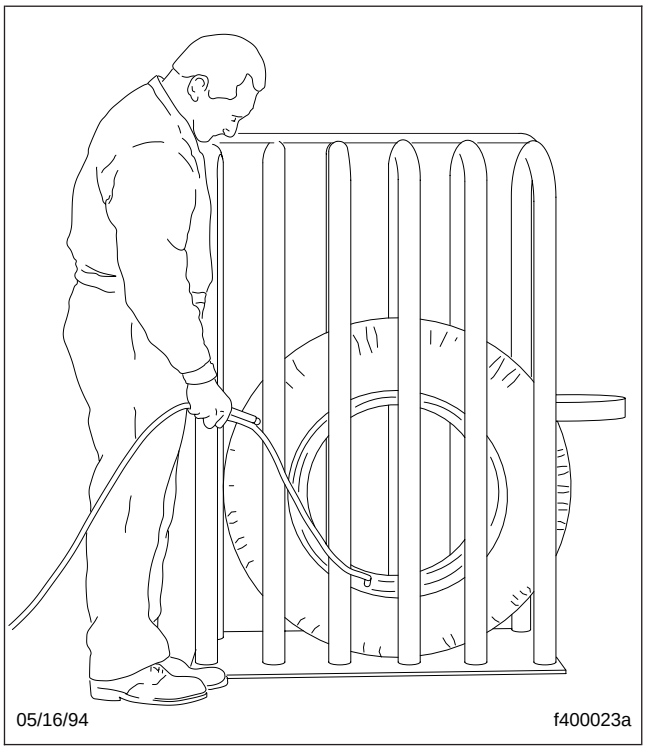
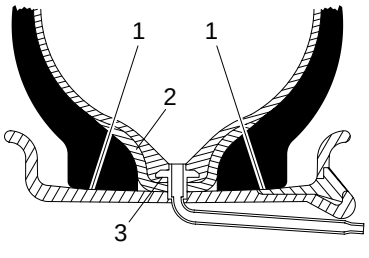


Fig. 1, Safety Cage for Tire Inflation

- 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.

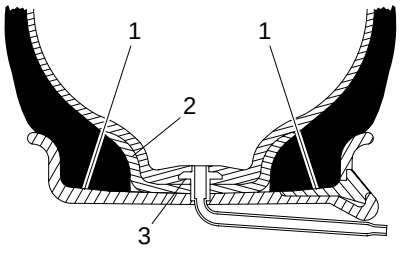
5. Continue to inflate the tire to the recommended pressure. See **Specifications, 400** for correct cold-inflation pressures.
   - Michelin Tire Corporation recommends an initial pressure of 90 to 100 psi (620 to 690 kPa) for this step to correctly seat the tire beads.
   - The position of the beads, 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.

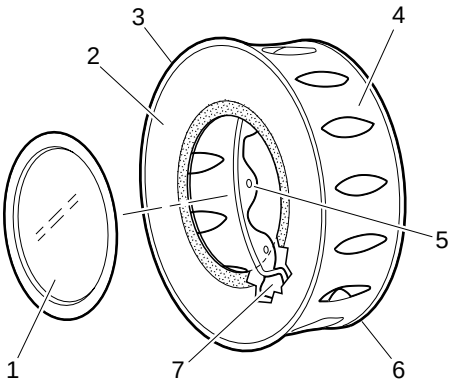
7. Inflate the tire to the recommended cold inflation pressure listed in **Specifications, 400**.
8. Install the valve cap and tighten finger-tight.
9. Check the inflation pressure 24 hours after mounting new tires.

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.

Wheel Cover Removal and Installation

Removal

NOTE: **Figure 1** shows all of the wheel cover components and can be referred to, along with the specific illustrations mentioned below, when completing the wheel cover installation.



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1. Detachable View Cover
2. Face Cover
3. Outer Retaining Ring
4. Wheel Liner
5. Canvas Tabs
6. Inner Retaining Ring
7. V-Notch

Fig. 1, Wheel Cover Components

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Pull the Velcro® strips apart and remove the detachable view cover.
3. Pull the inner V-notch opposite the valve stem to remove the wheel liner and inner retaining ring. See **Fig. 2**.

Installation

1. Wash the wheels before installing the wheel covers.

NOTE: Take the time to carefully inspect the wheels for corrosion. Corroded wheels may prevent proper installation of the wheel covers.

2. Inspect each wheel for corrosion.
3. Using a soapy water solution, wet the surface of the wheel.

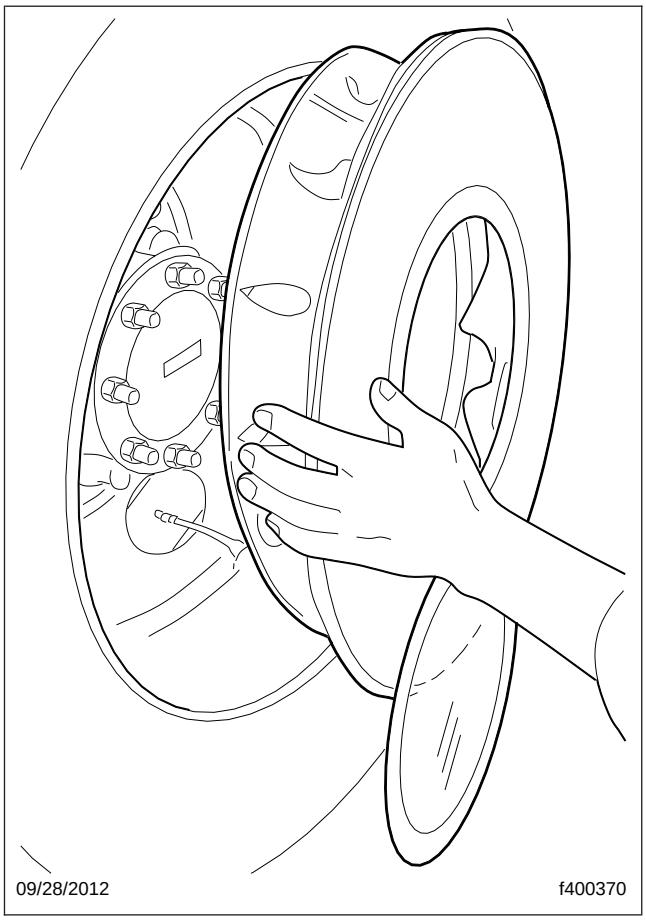

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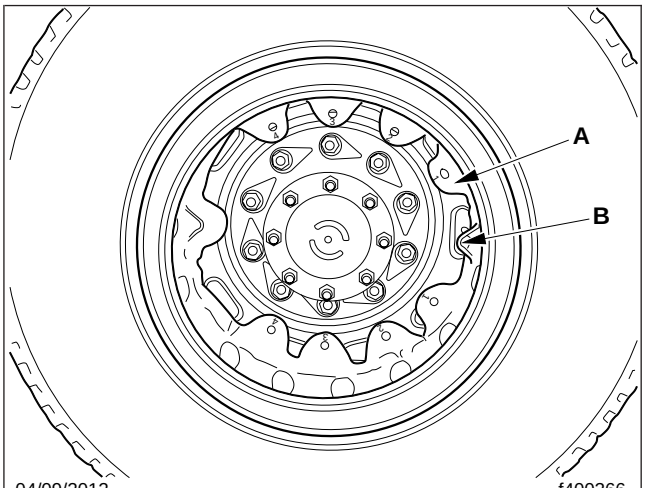
Fig. 2, Removing the Wheel Cover

IMPORTANT: Ensure the valve stem is centered in the V-notch of the inner retaining ring. The inner and outer retaining rings should be uniformly aligned to each other and to the wheel rim.

4. Place the wheel liner into the wheel with the labeled V-notch of the inner retaining ring centered on the valve stem, as shown in **Fig. 3**. This provides access to the valve stem.
5. The wheel liner inner retaining ring has sets of tarpaulin tabs that are labeled 1 through 4. The tabs on either side of the V-notch are labeled 1. Beginning with the numeral 1 tabs, push the tabs in. Then push in both numeral 2 tabs, and so on until all of the tabs are pushed in. See **Fig. 3**.

Wheel Cover Removal and Installation



A. Tabs are labeled 1 through 4.
B. V-Notch is centered on the valve stem.

Fig. 3, Wheel Liner Placement

Make certain that the inner and outer retaining rings are uniformly aligned with each other and with the wheel rim.

6. Center the detachable view cover on the face cover and press the Velcro surfaces together to close the detachable view cover.

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".

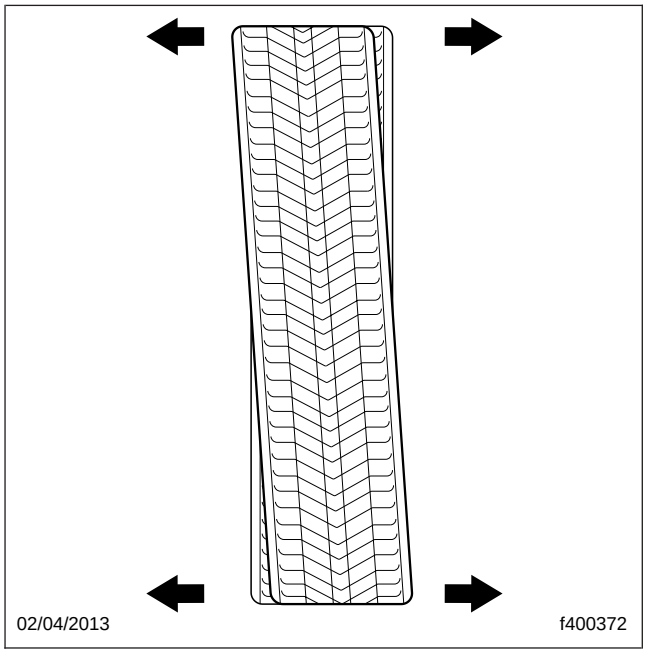


Fig. 1, Lateral Runout

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:

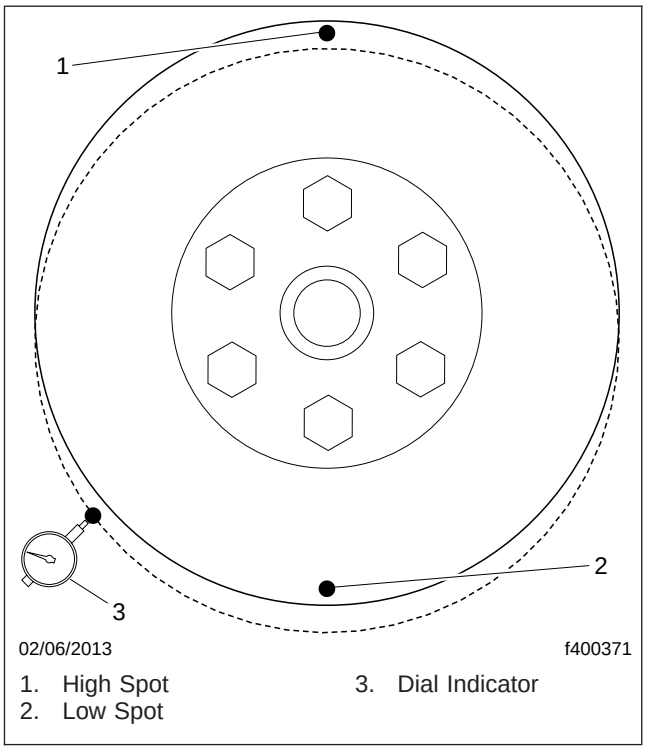


Fig. 2, Radial Runout

- 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)

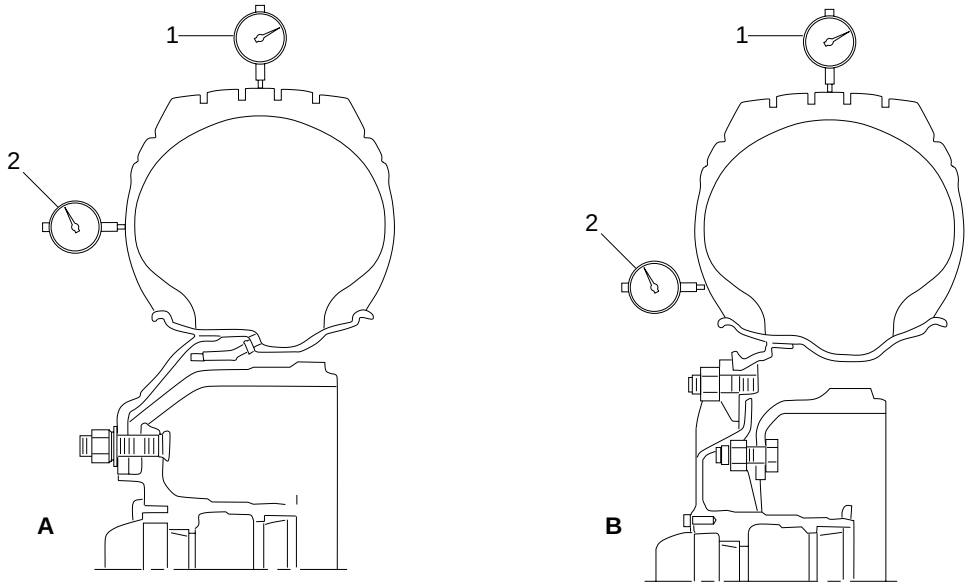
Wheel and Tire Runout Measurements

- 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



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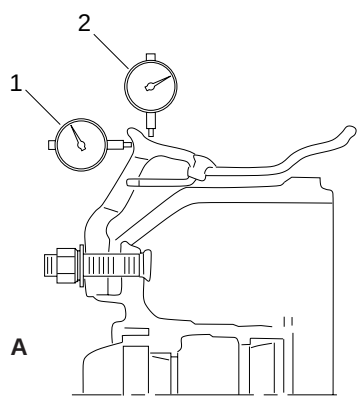
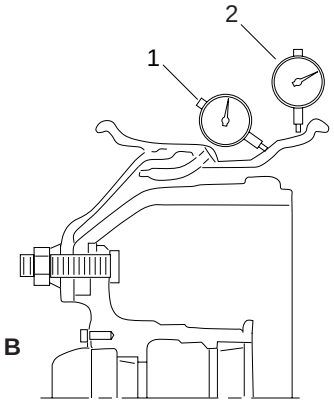
A. Tubeless Steel Disc Wheel
1. Radial Runout
B. Tubeless Demountable Wheel
2. Lateral Runout

Fig. 3, Runout Check for Tires

Wheel and Tire Runout Measurements





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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 and wheels 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 **Subject 050**.
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 or tires are out-of-round, bent, or distorted.	Replace damaged components.
Tires, wheels, or brake drums are out-of-balance.	Determine the out of balance component and balance it.
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.
Driveline, suspensions, or steering components are loose or worn.	Determine the location of the vibration, then repair or replace the loose or worn components.

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 and wheels 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 **Subject 050**.

Troubleshooting

Problem—Excessive On-the-Road Tire Failures	
Possible Cause	**Remedy**
Water or foreign material is inside the casing.	Clean and dry the tires 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.
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 wheel manufacturer's recommendations, even though the tire may be approved for a higher load or inflation. Some wheels are stamped with a maximum load and maximum cold inflation rating. If they are not stamped, consult the wheel manufacturer for the correct tire inflation pressure for the vehicle load. If the load exceeds the maximum wheel capacity, the load must be adjusted or reduced.

For further information about 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 about 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-Stud Hub-Piloted Disc Wheel With Two-Piece Flange Nuts**			
Front and Rear Wheel Nut	M22 x 1.5	All	450–500 (610–678)

* Torque values for SAE 30W engine oil lubricated threads.

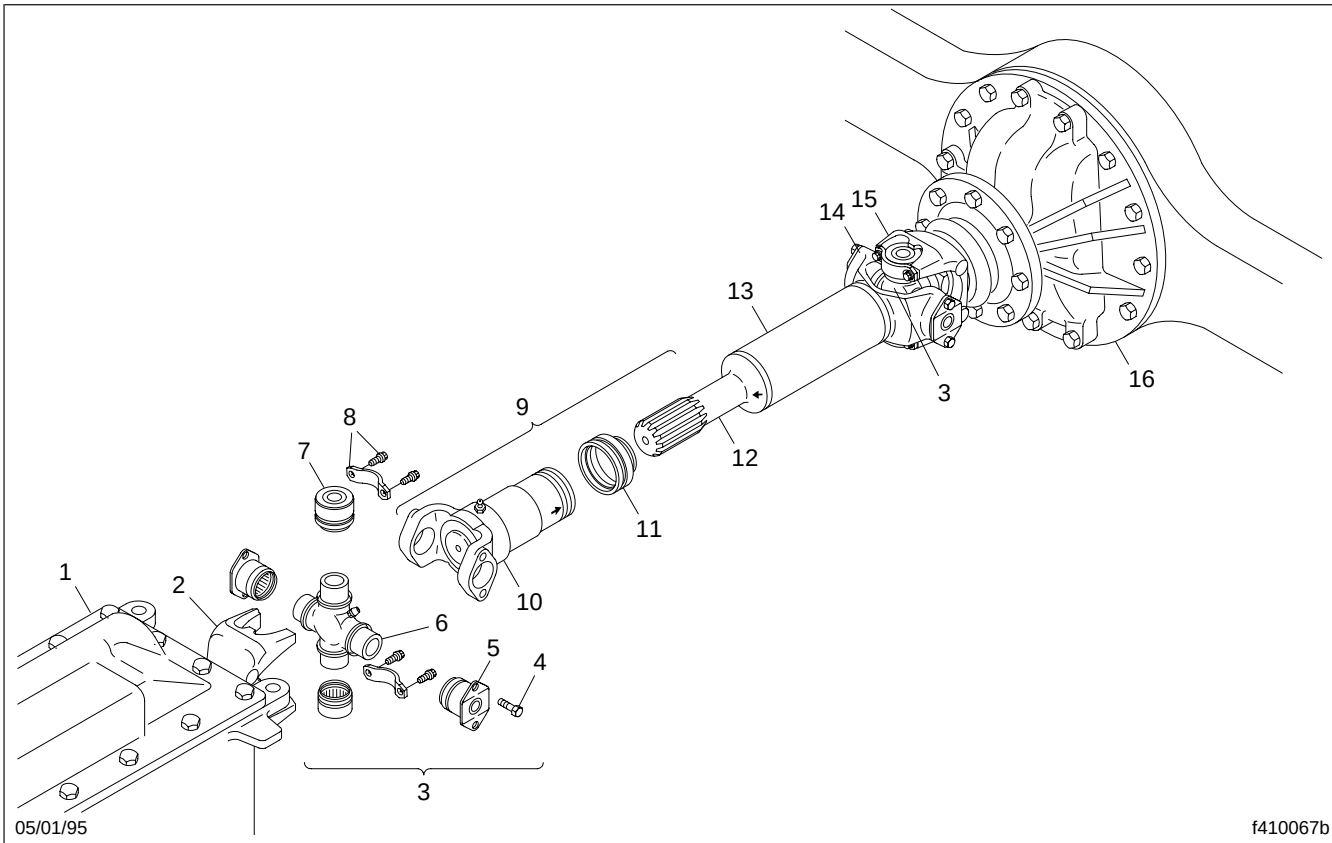
Table 1, Disc Wheel Fastener Torque

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



NOTE: Not all fasteners are shown.

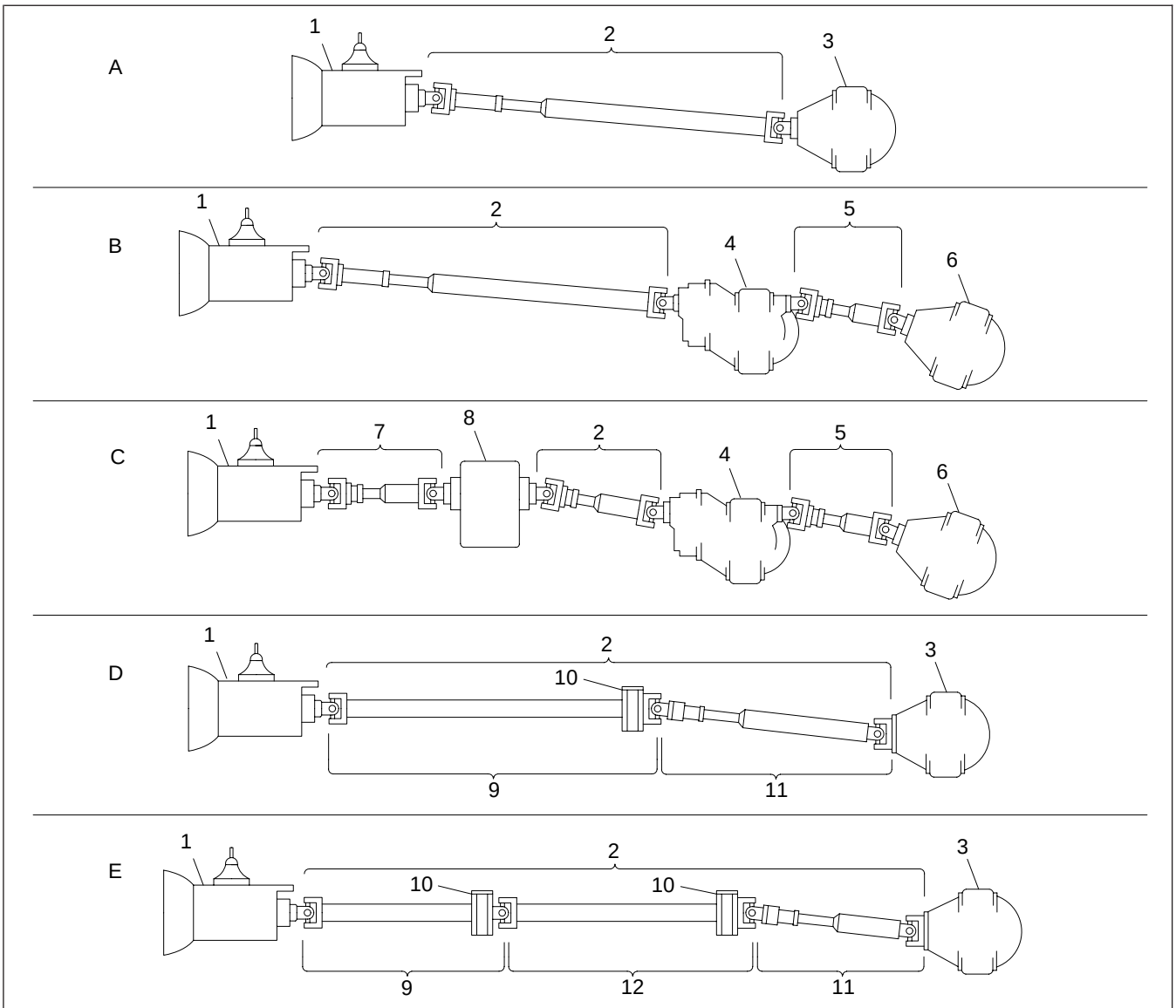
1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Bearing Plate Self-Locking Capscrew
5. Bearing Cup (for full-round yoke)
6. U-Joint Cross
7. Bearing Cup (for half-round yoke)
8. Bearing Strap and Bearing-Strap Capscrew
9. Slip-Joint Assembly
10. Sleeve-Yoke (full-round)
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

General Information

No. 3 driveline. 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

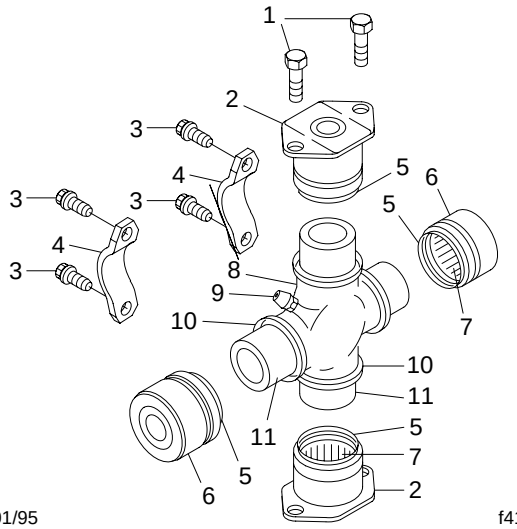
The basic function of the driveline is to send torque from the transmission to the axle in a smooth and continuous action. Because the vehicle axles are not attached directly to the frame, but are suspended by springs, they ride in an irregular, floating motion (when going over bumps or depressions), 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

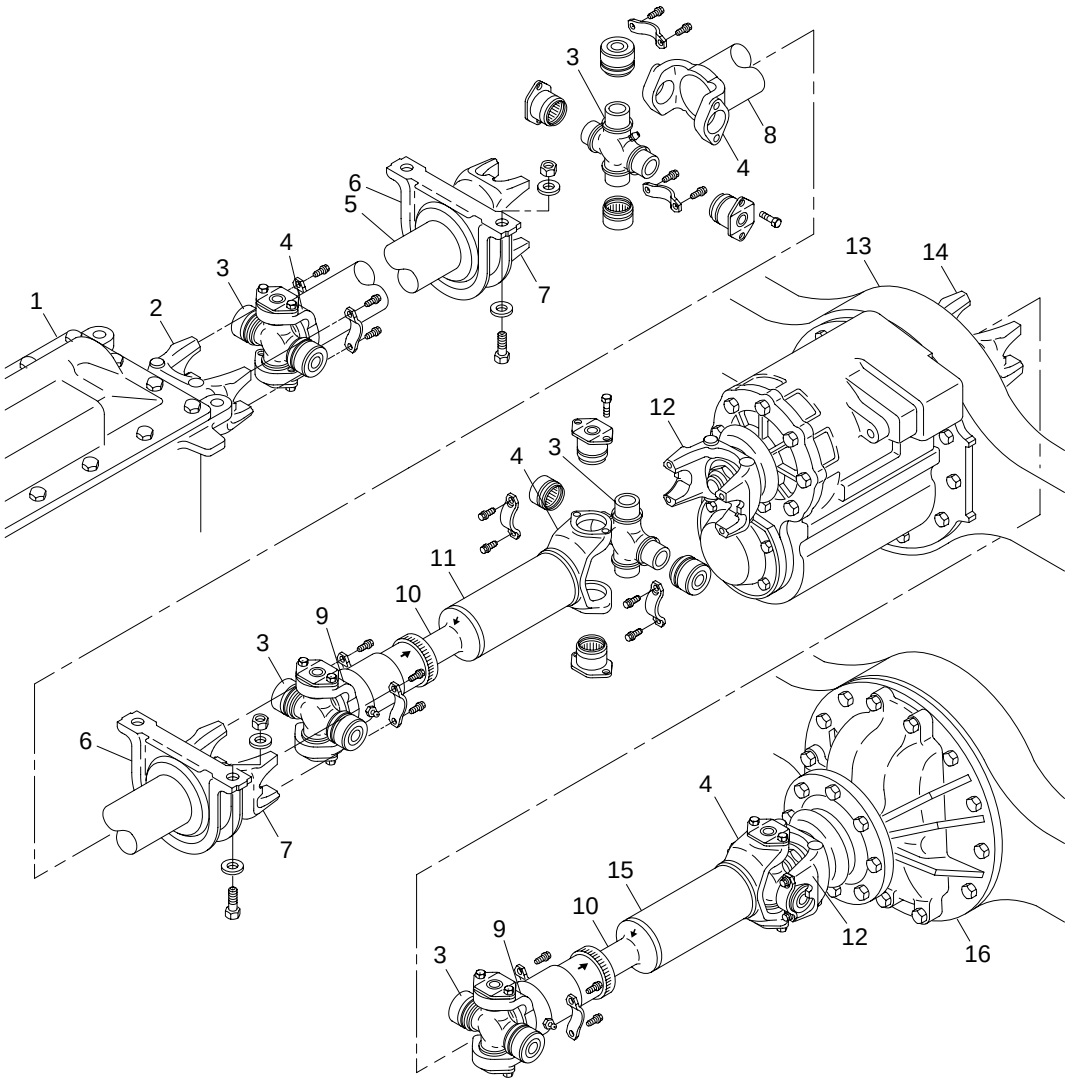
equipment, all No. 2 driveline end-yokes are half-round, with full-round optional. And, as standard equipment, all No. 3 driveline end-yokes are full-round, with half-round optional. End-yokes are installed on the transmission output shaft, on each axle input and output shaft, and behind the midship 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-

General Information



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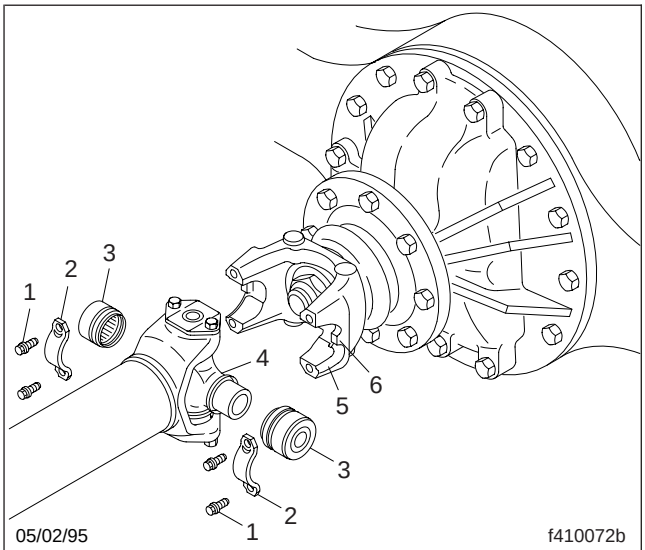
NOTE: Not all fasteners are shown.

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

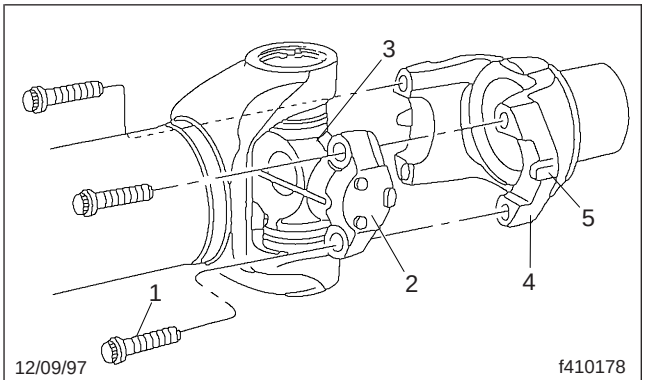
Fig. 4, Dual-Drive Installation With Primary and Intermediate Coupling Shafts

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

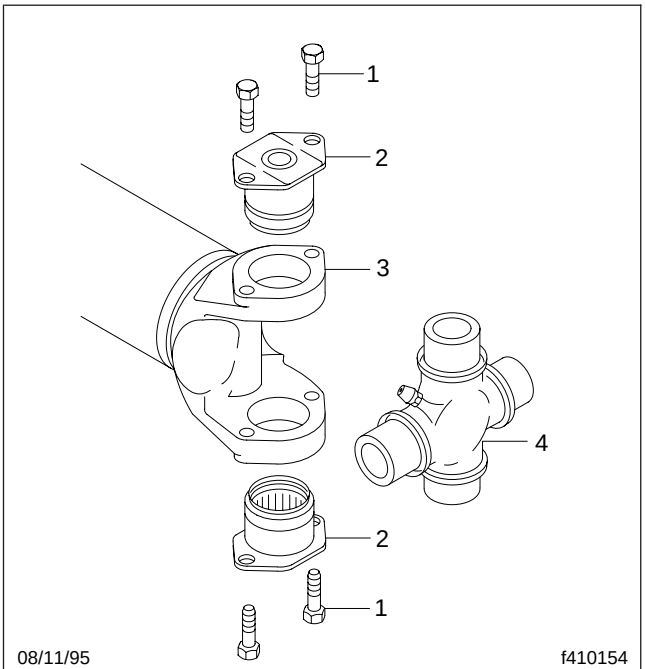


1. Capscrew
2. Bearing Cup
3. U-Joint Cross
4. Half-Round Yoke
5. Yoke Cross-Hole Tab

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

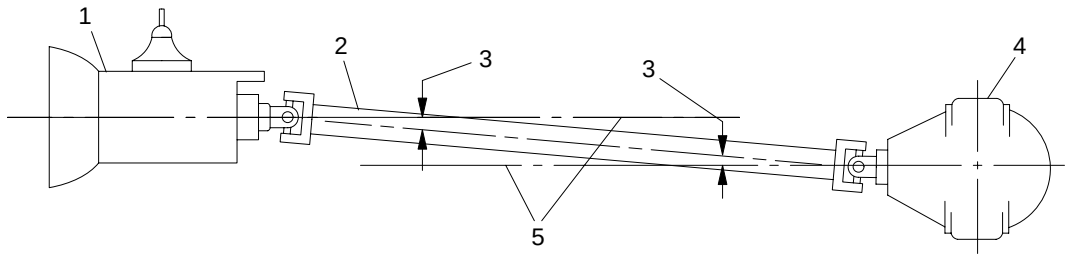
Fig. 7, Installation of a U-Joint in a Full-Round Yoke

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 which 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.

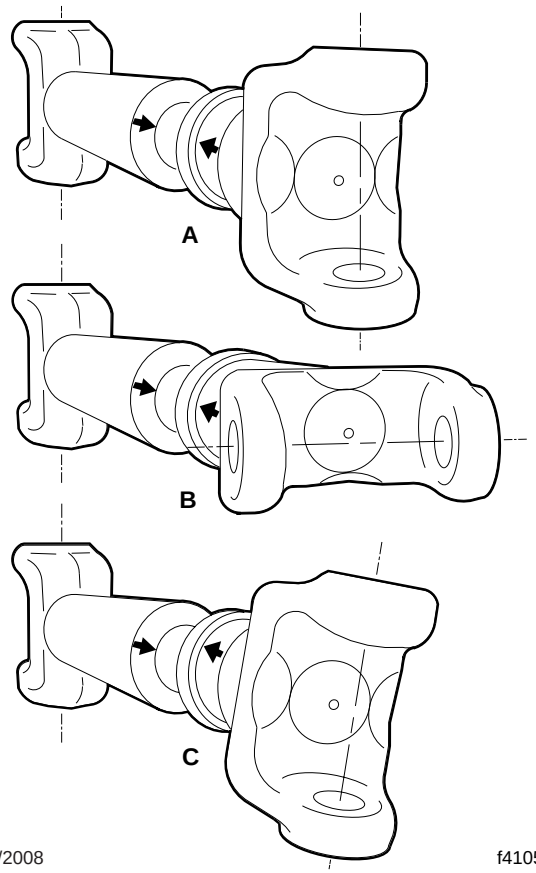
After manufacture, each driveline yoke is statically balanced. After assembly, each driveshaft and cou-

General Information



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 *Cascadia™ Maintenance Manual*.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

U-Joint Uncoupling

Refer to **Fig. 1** and **Fig. 2** for driveline configuration.

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**.

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 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**.
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** for driveline configuration.

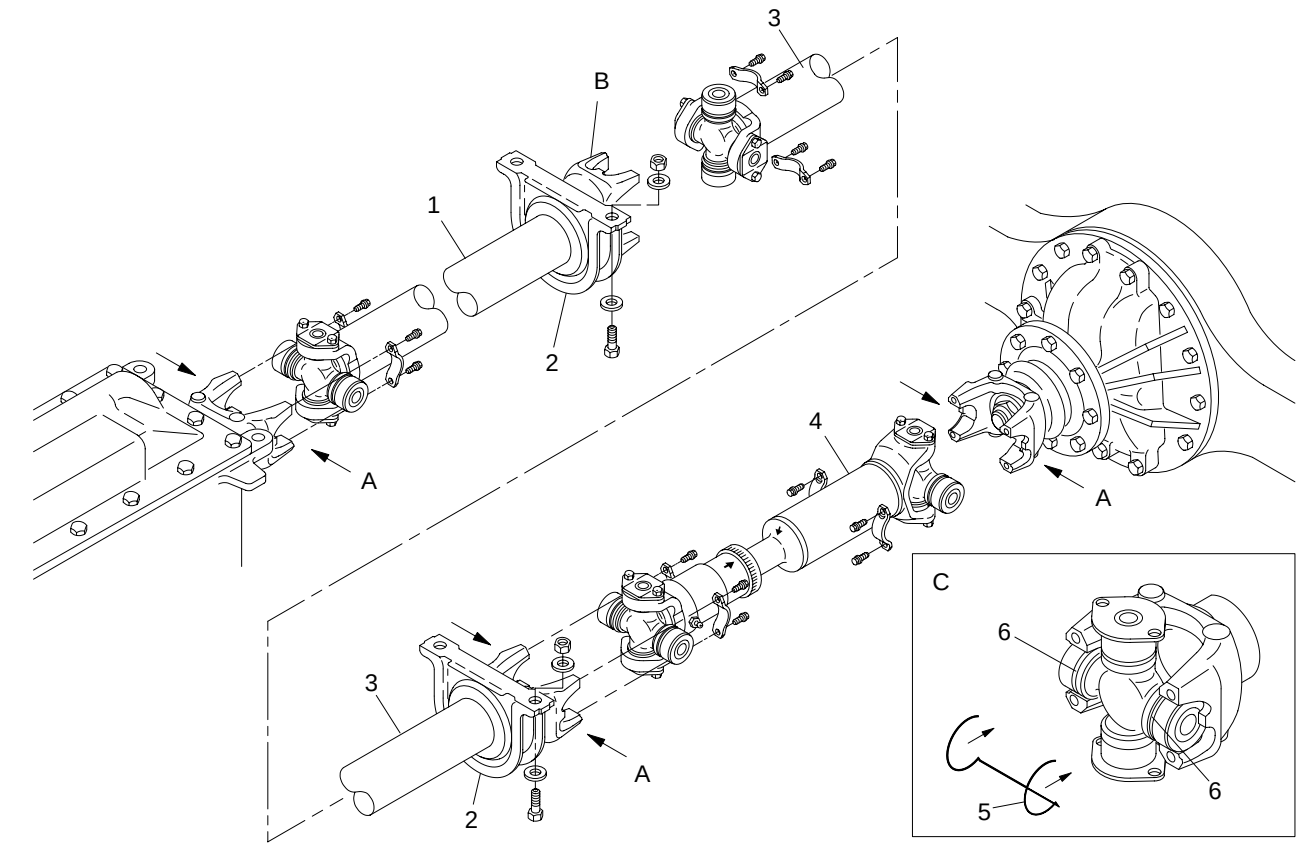
1. Check and clean the end-yoke, as follows.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a half-round file, remove burrs or raised metal. See **Fig. 3**.
   - 1.3 Using fine emery cloth, smooth and 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, as follows.
   - 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**.
   - 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**.
   - 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.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



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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

3. Extend the slip-joint, while pressing the cross and bearing cups into place in the yoke cross-holes. Using a rubber or plastic mallet, gently tap the bearing cups to seat them in the yoke. See **Fig. 7**.

⚠ CAUTION

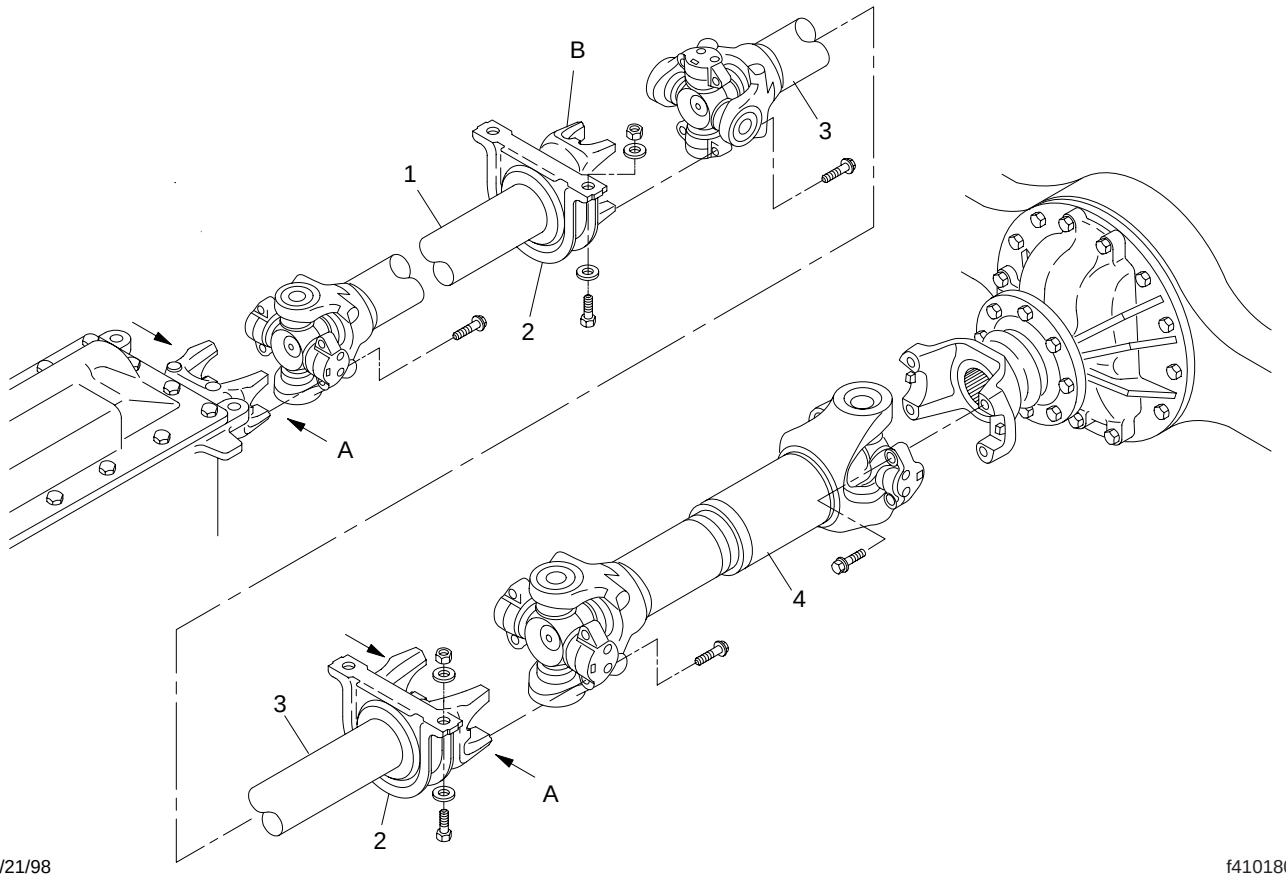
Do not use the capscrews and bearing straps (if equipped) to seat the bearing cups in the yoke. Seating the cross by tightening the bearing straps can deform the bearing straps, allowing the bearing cups to spin, which will cause rapid wear and serious damage to the U-joint.

4. Place the bearing straps (if equipped) over the cups. Install the capscrews, finger-tight.

⚠ 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 drive-

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

line 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 *Cascadia™ Maintenance Manual*.
8. Remove the nylon support straps.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

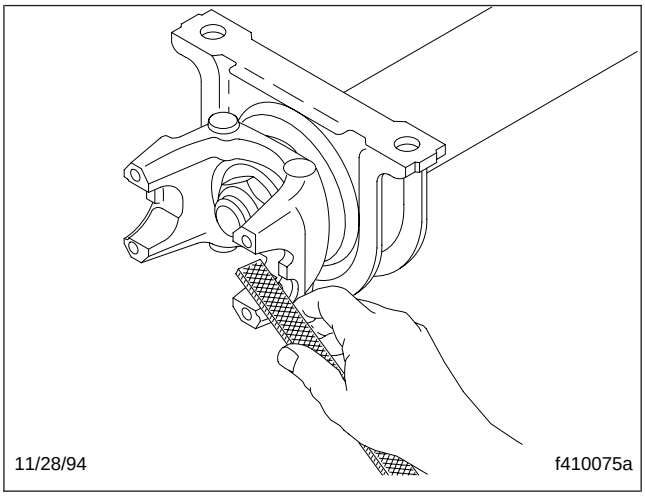
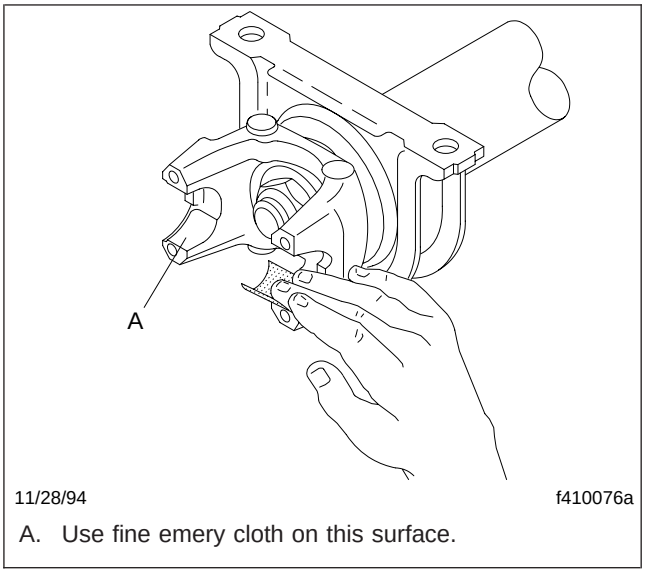
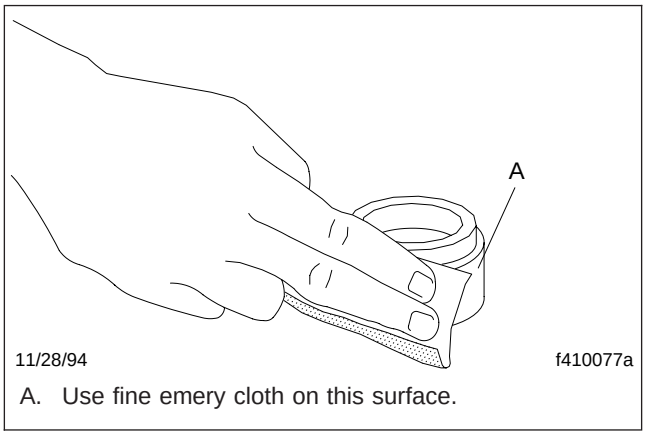


Fig. 3, Removing Burrs from a Half-Round End-Yoke Cross-Hole



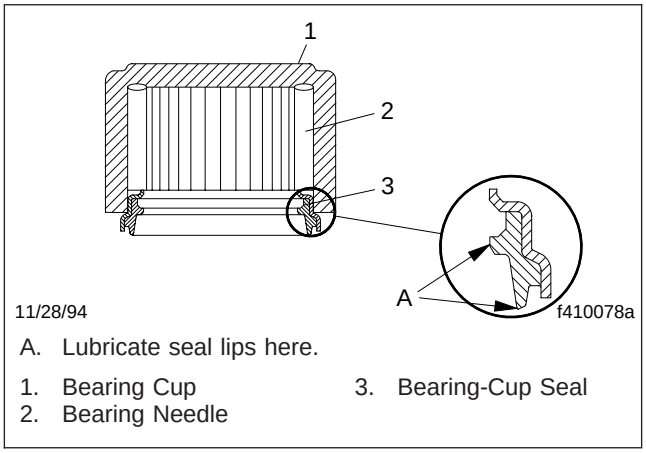
A. Use fine emery cloth on this surface.

Fig. 4, Smoothing a Half-Round End-Yoke Cross-Hole



A. Use fine emery cloth on this surface.

Fig. 5, Smoothing a Half-Round End-Yoke U-Joint Bearing Cup

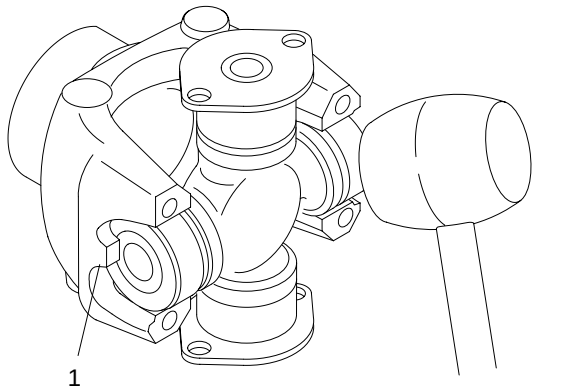


A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

Fig. 6, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



1. Retaining Tab

Fig. 7, Seating a U-Joint in a Half-Round End-Yoke

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

U-Joint Uncoupling

Refer to **Fig. 1** for U-joint configuration.

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**.

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

Refer to **Fig. 1** for U-joint coupling.

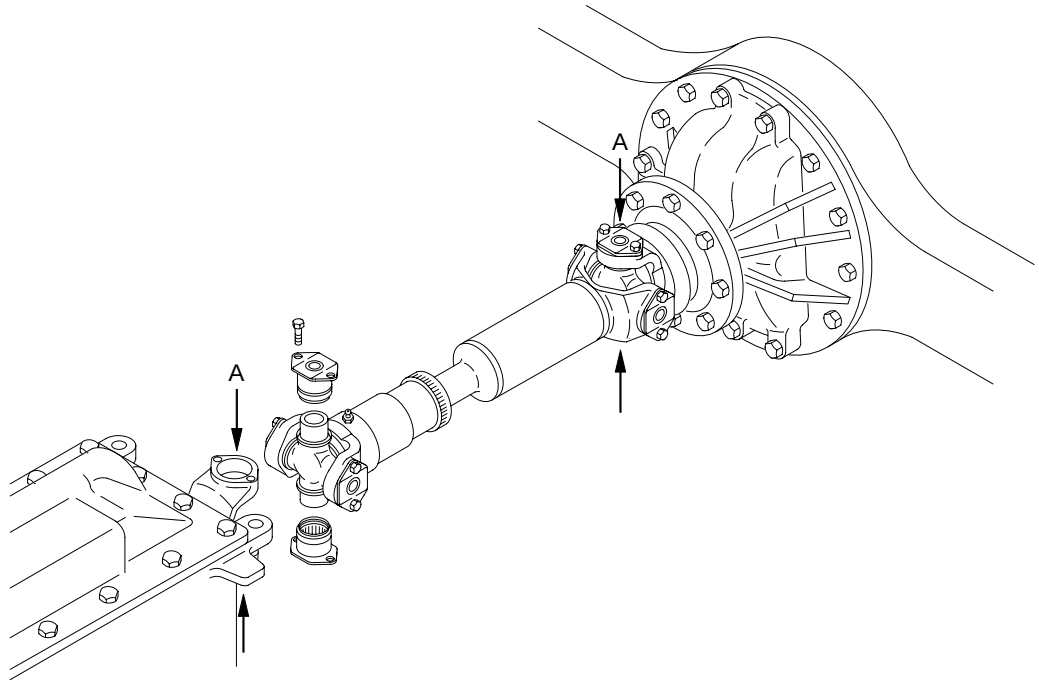
1. Check and clean the end-yoke, as follows.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications, 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.
   - 1.3 Using a mill file, and 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, as follows.
   - 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, as folows:
   - 3.1 Extend the slip-joint, while pivoting the U-joint cross into place in the yoke cross-holes.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



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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

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. 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. 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.

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 60 lbf·in (680

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

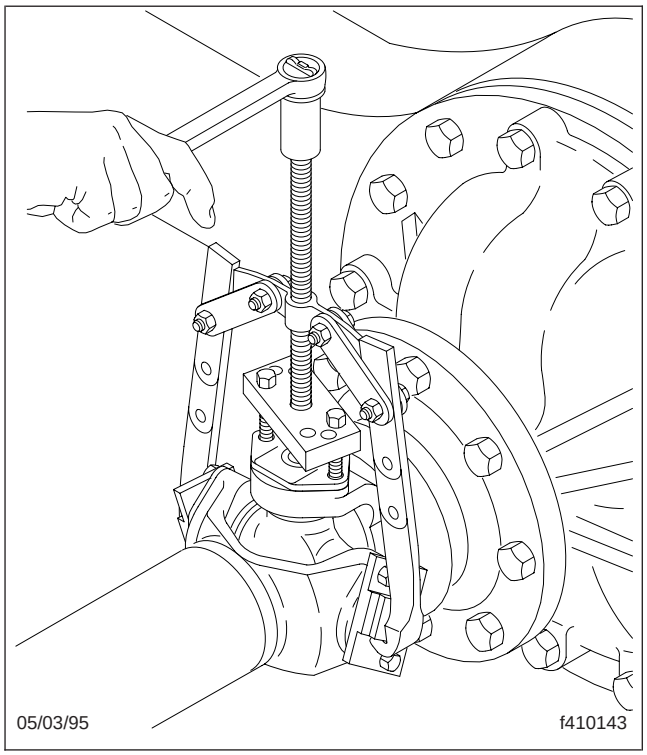


Fig. 2, Removing a Bearing Cup from a Full-Round End-Yoke

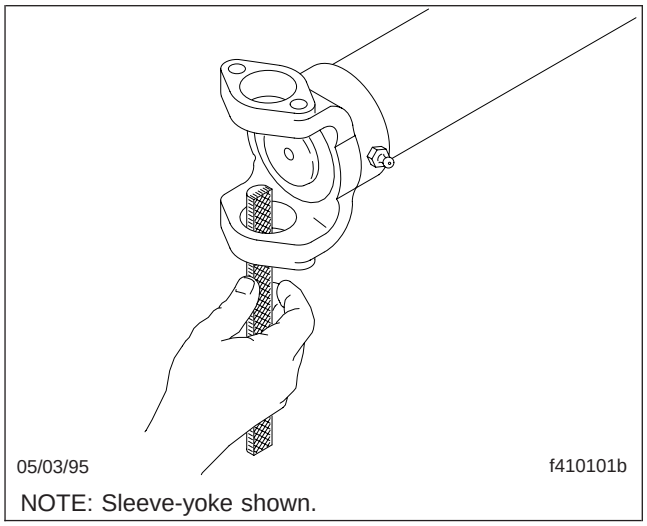


Fig. 3, Removing Burrs from a Full-Round Yoke Cross-Hole

N·cm), to the torque value in **Specifications, 400**.

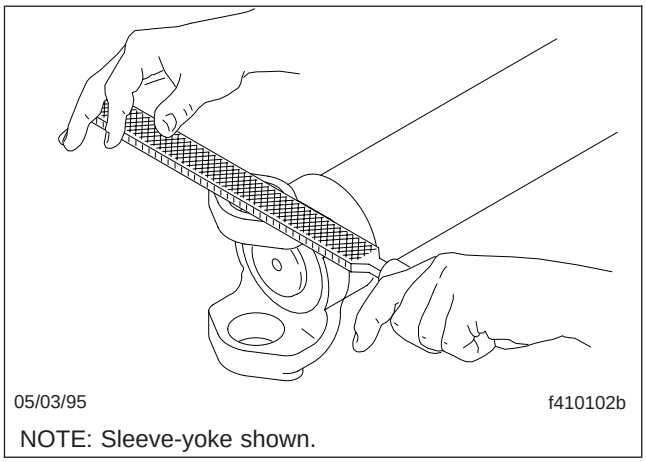


Fig. 4, Removing Burrs from the Machined Surface of a Full-Round Yoke Lug

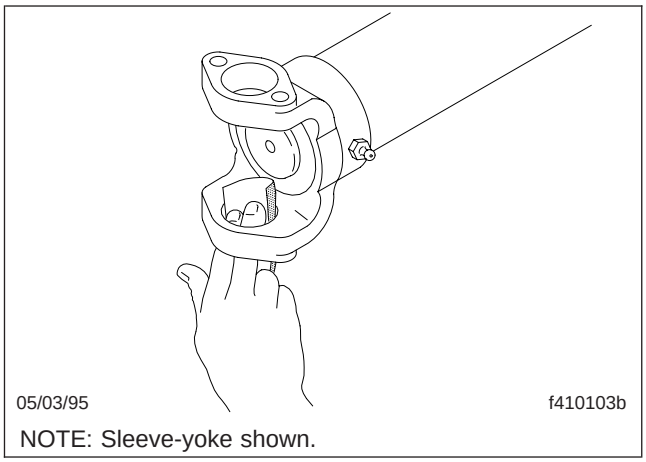
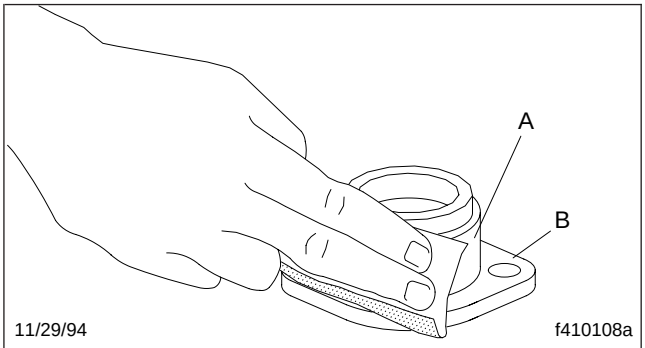


Fig. 5, Smoothing a Full-Round Yoke Cross-Hole

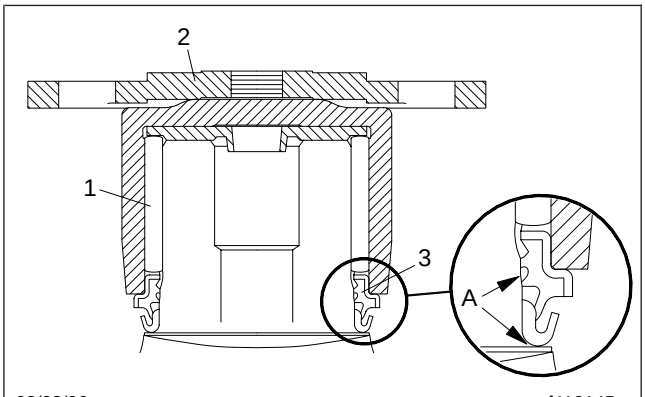
4. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 68 lbf·ft (92 N·m).
5. Lubricate the U-joint, following the procedure in **Group 41** of the *Cascadia™ Maintenance Manual*.
6. Remove the nylon support straps.

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.

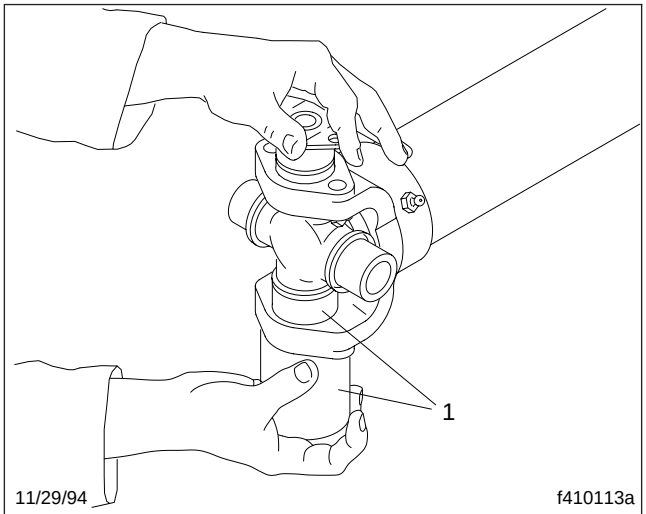
Fig. 6, Smoothing a Full-Round Yoke U-Joint Bearing Cup



A. Lubricate seal lips here.

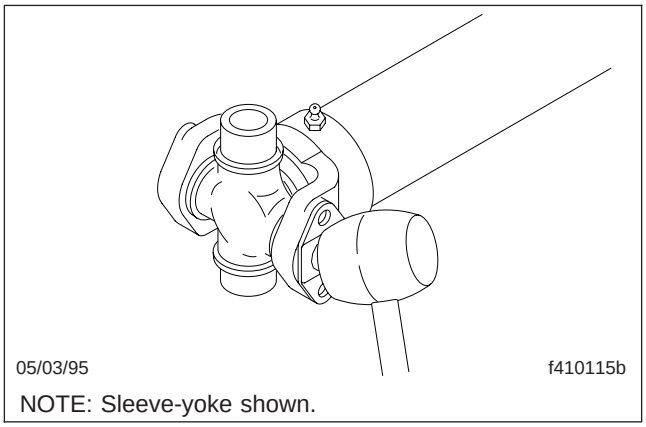
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 7, Sectional View of a Full-Round Yoke U-Joint Bearing Cup



NOTE: Sleeve-yoke shown.
1. Trunnion Locator

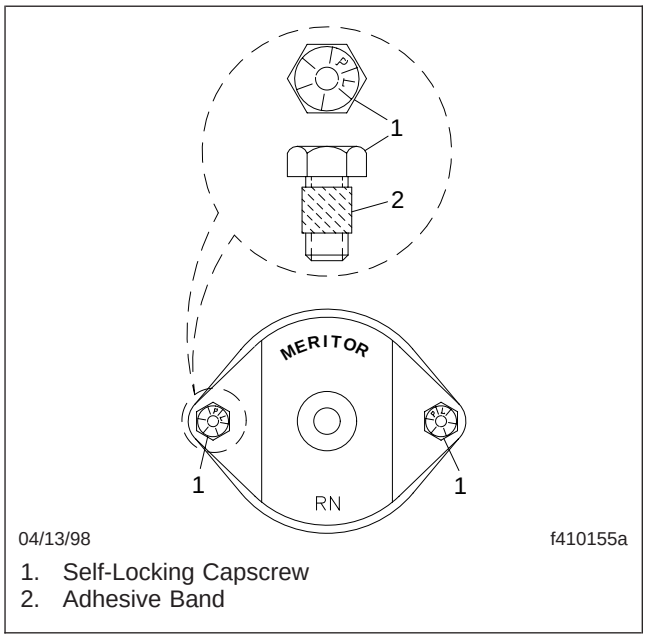
Fig. 8, Using a U-Joint Trunnion Locator



NOTE: Sleeve-yoke shown.

Fig. 9, Seating a U-Joint Bearing Cup in a Full-Round Yoke

U-Joint Uncoupling and Coupling With a Full-Round End-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.

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** for driveline configuration.

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. Remove the No. 3 driveshaft from the chassis.

No. 2 Driveshaft Removal

See **Fig. 3** and **Fig. 4** for driveline configuration.

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. Remove the No. 2 driveshaft from the chassis.

Intermediate Coupling Shaft Removal

See **Fig. 5** and **Fig. 6** for driveline configuration.

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. Remove the intermediate coupling shaft from the chassis.

Primary Coupling Shaft Removal

See **Fig. 7** and **Fig. 8** for driveline configuration.

1. *For a vehicle with one coupling shaft:*

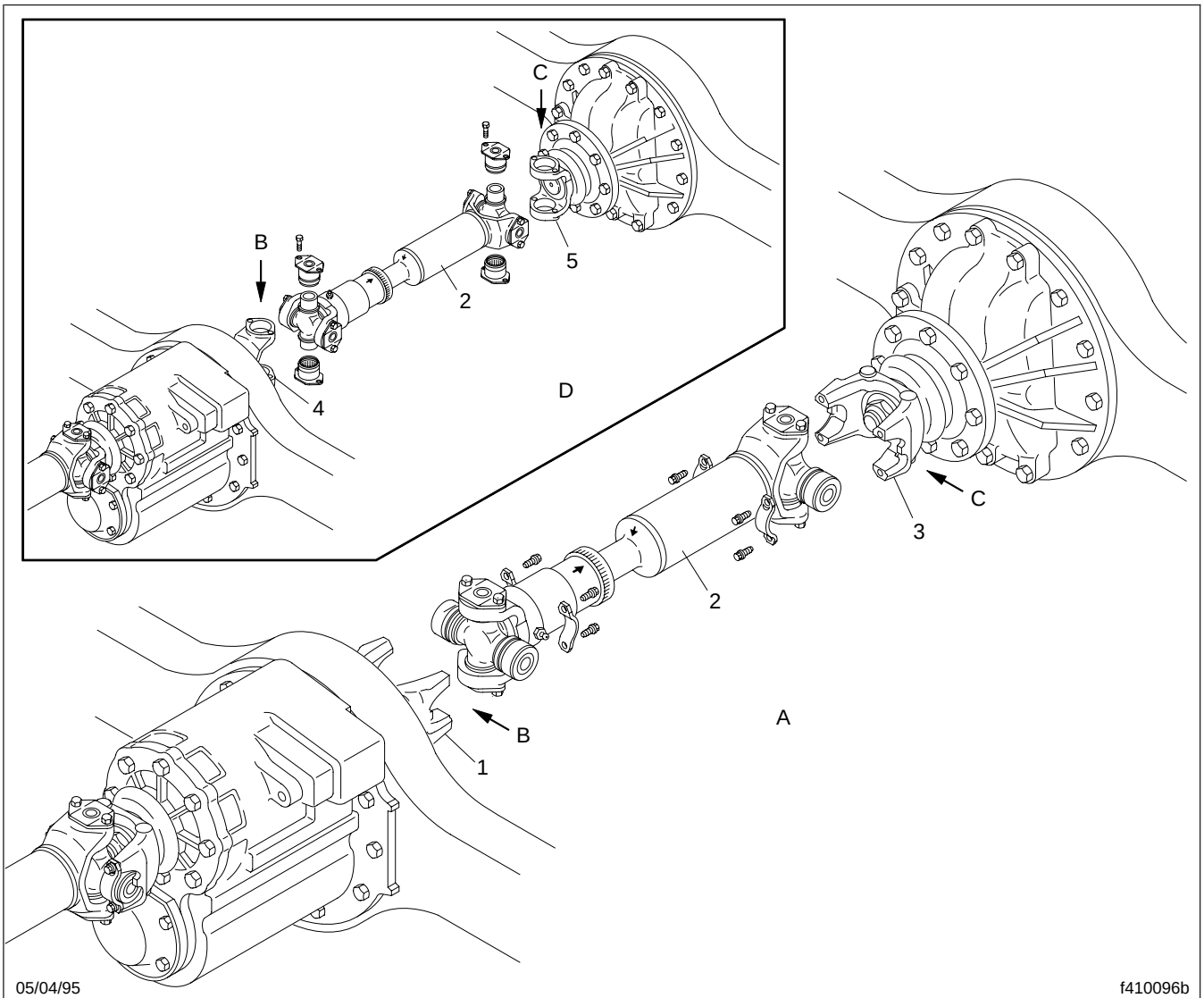
   If the No. 2 driveshaft is also being removed, remove it first.

   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.

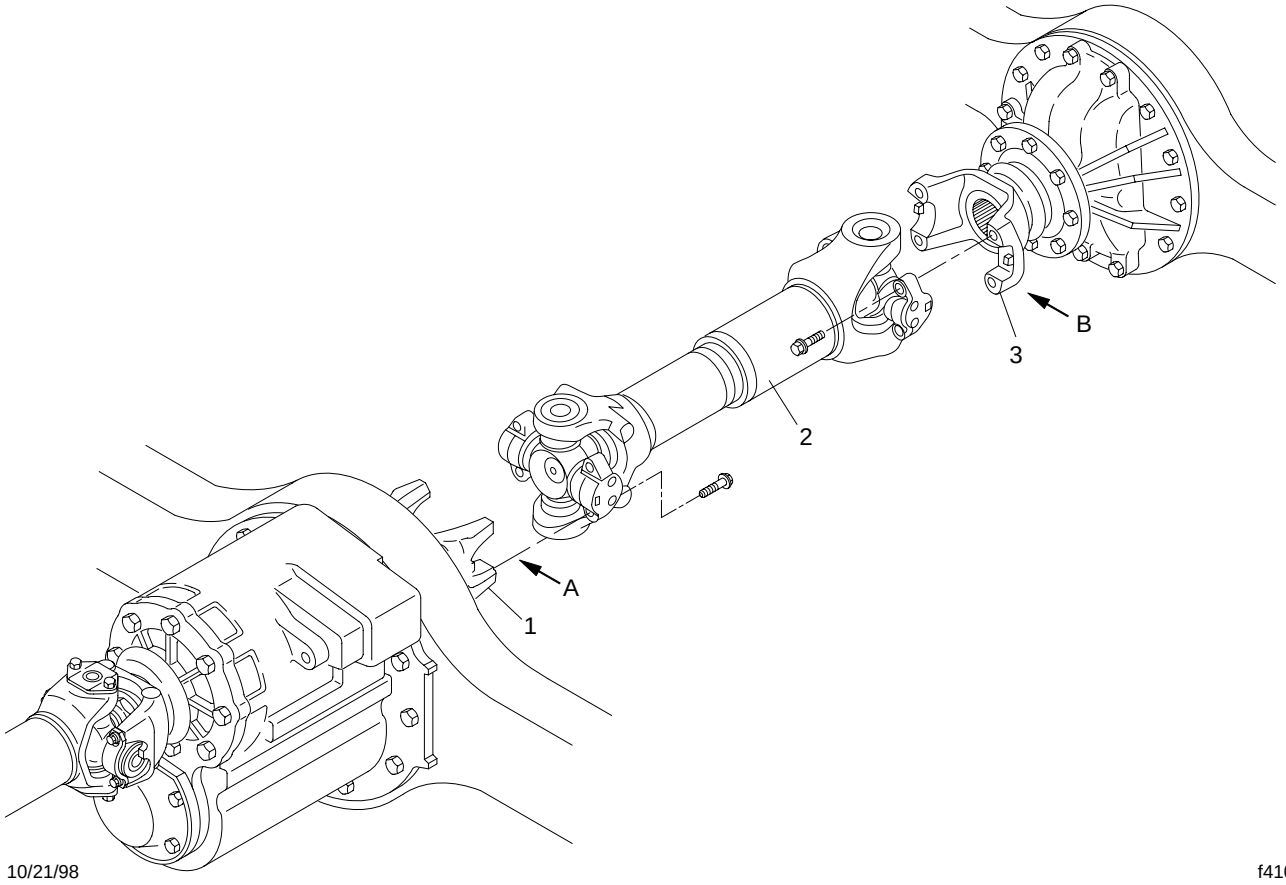
A. No. 3 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 3 Driveshaft Coupled to Full-Round End-Yokes

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**.

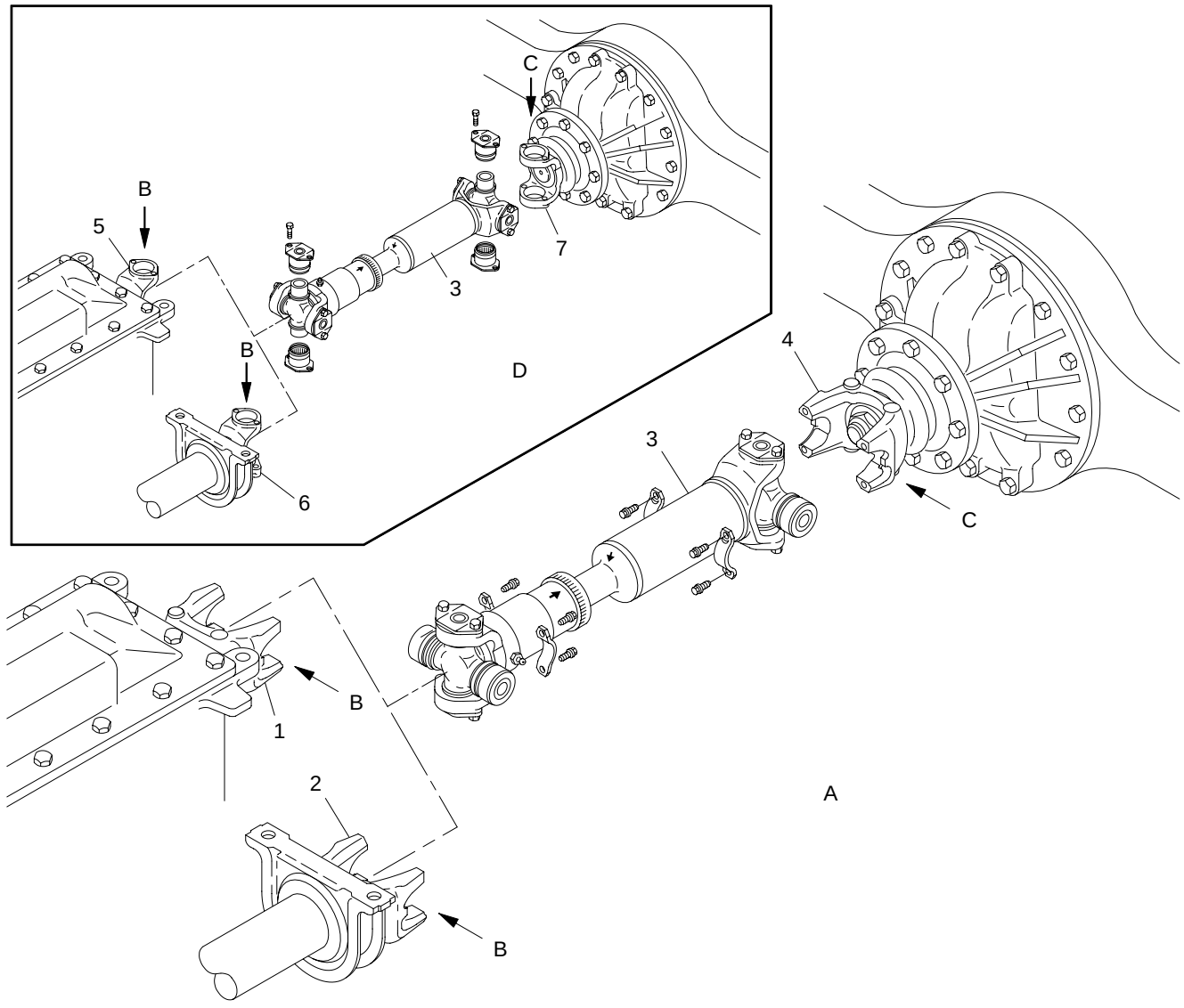
2. If not already done, uncouple the primary coupling shaft from the No. 2 driveshaft or intermediate coupling shaft. If the primary coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a *full-round* end-yoke, follow the uncoupling 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. Remove the primary coupling shaft from the chassis.

Driveshaft Removal and Installation



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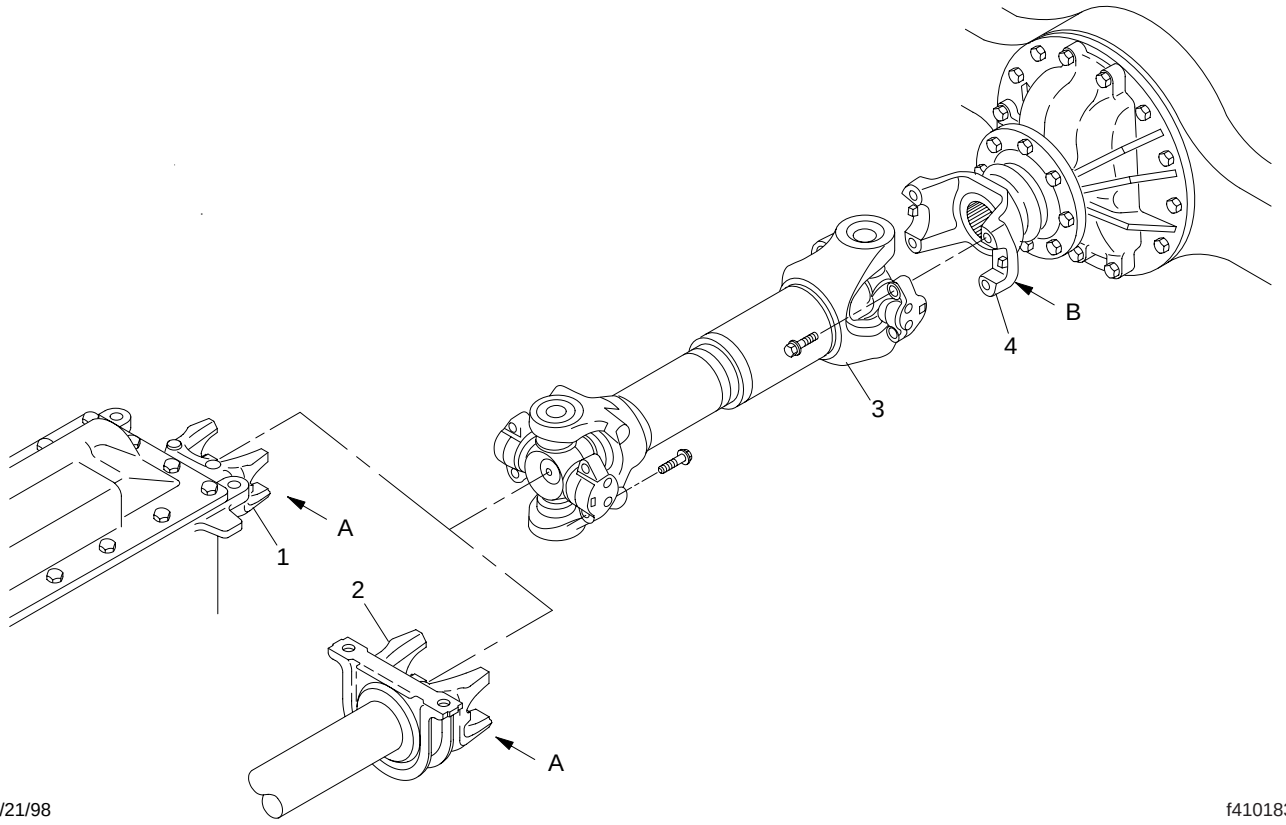
NOTE: Not all fasteners are shown.

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** for driveline configuration.

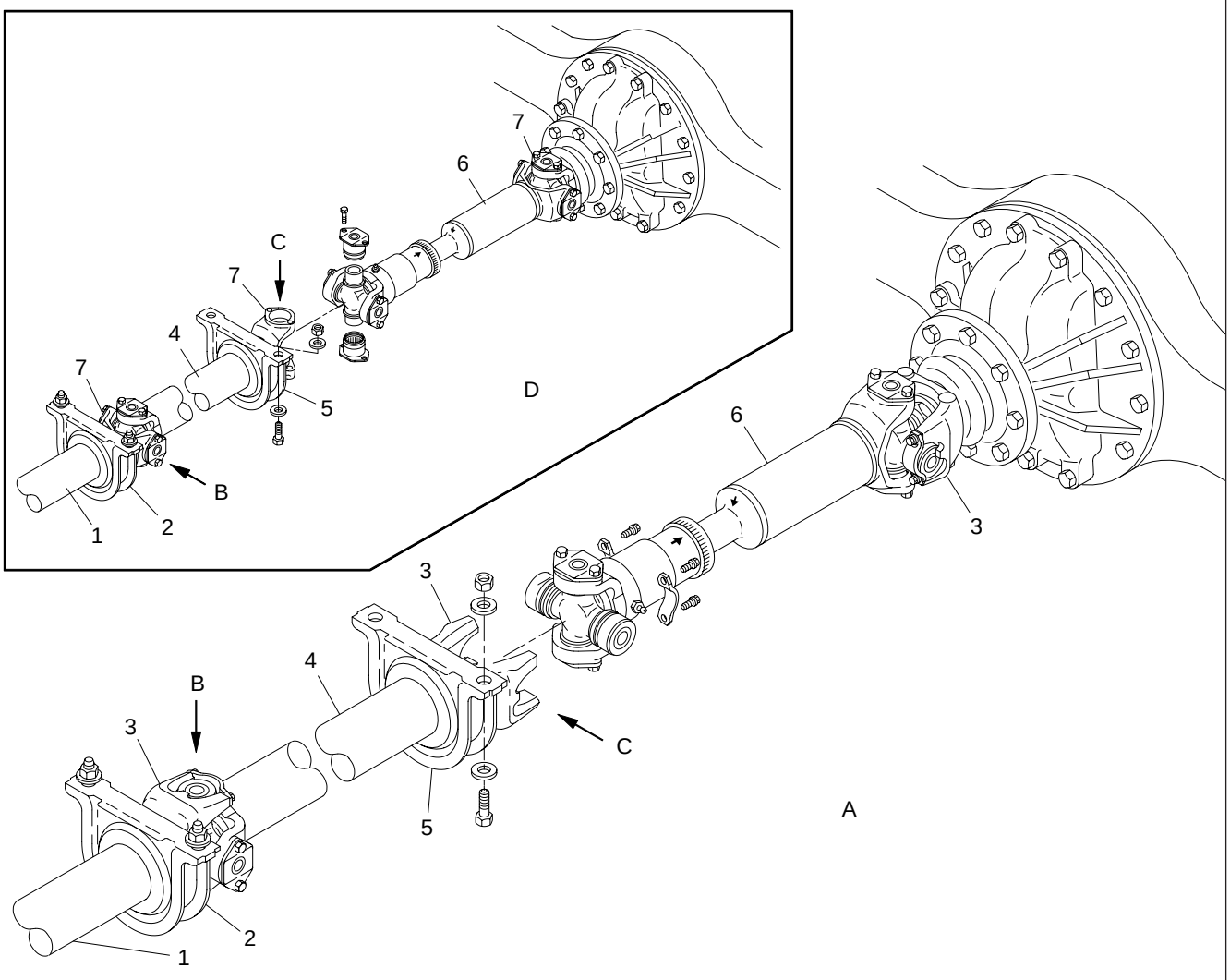
IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

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

Driveshaft Removal and Installation



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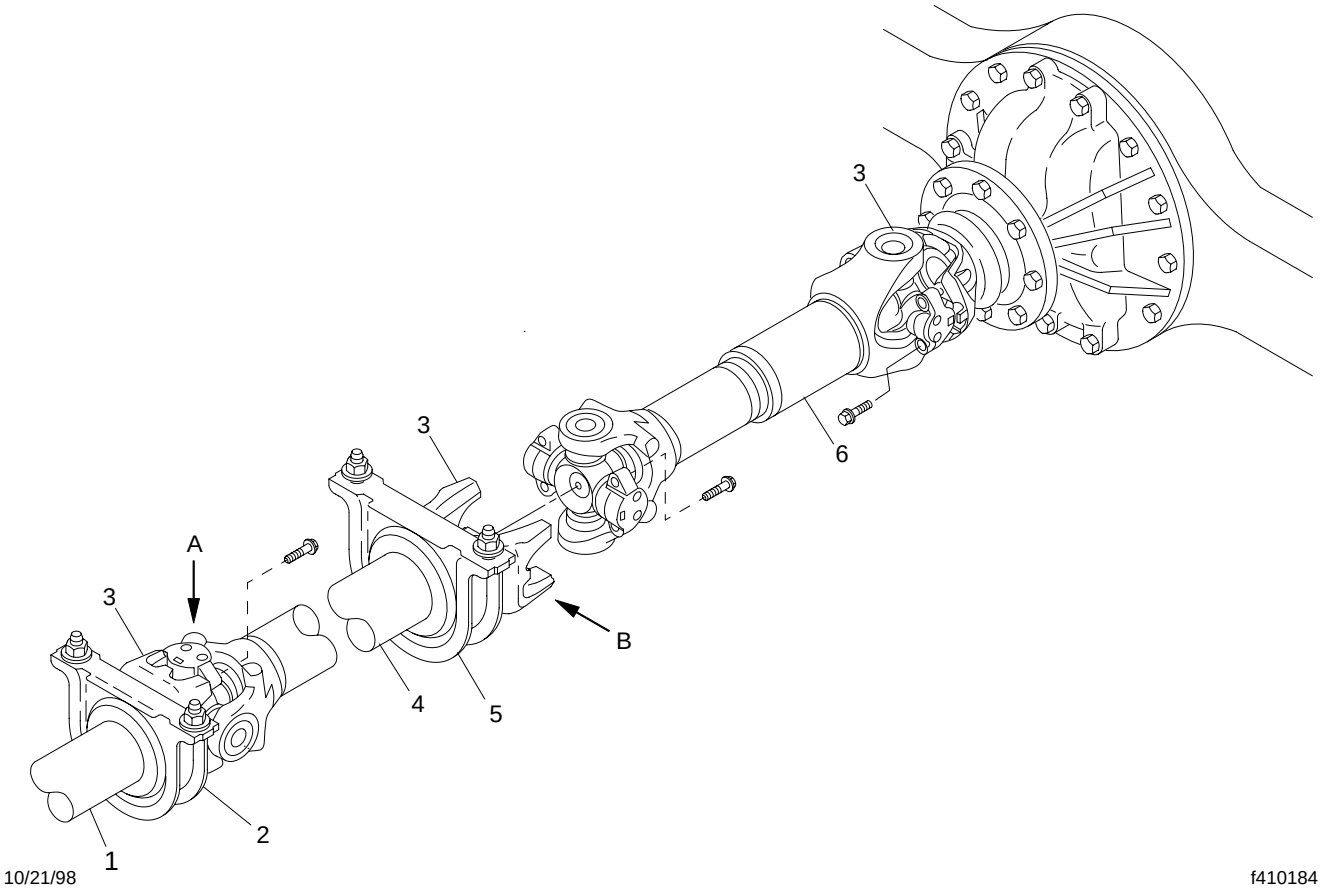
NOTE: Not all fasteners are shown.

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

the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

For a vehicle with two coupling shafts:

If the intermediate coupling shaft was also removed, install it, as instructed in this subject.

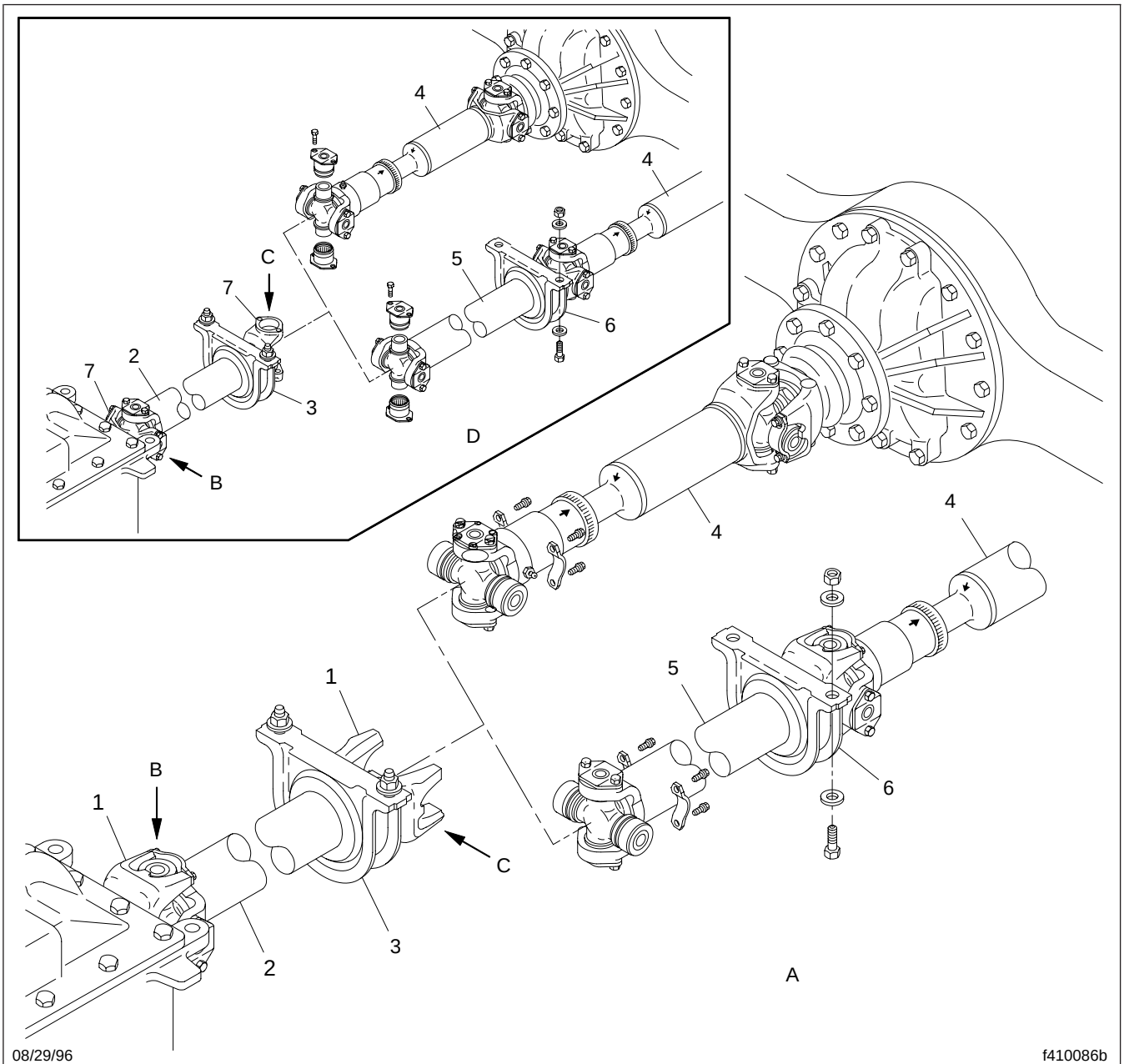
If only the primary coupling shaft was removed, couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

Intermediate Coupling Shaft Installation

See **Fig. 5** and **Fig. 6** for driveline configuration.

IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

Driveshaft Removal and Installation

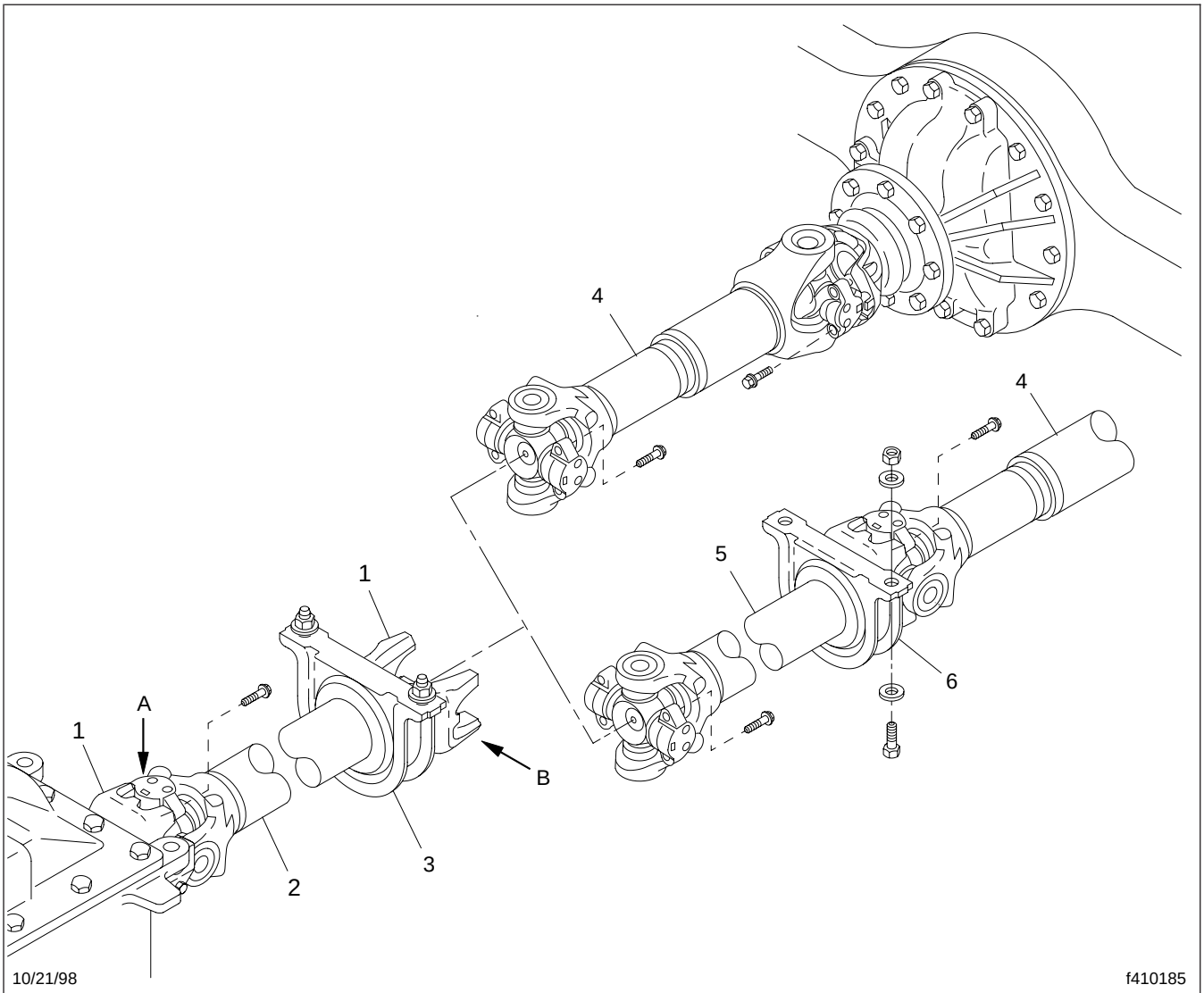


NOTE: Not all fasteners are shown.

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.

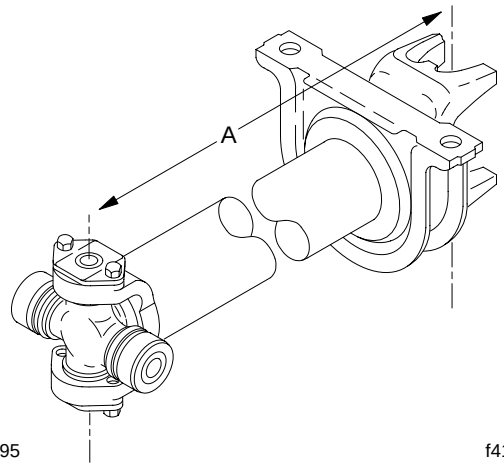
B. Uncouple this end first; couple this end last.

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

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 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

Driveshaft Removal and Installation



A. Cross-hole centerlines of both yokes must be in alignment.

Fig. 9, U-Joint Phasing of a Coupling Shaft

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.

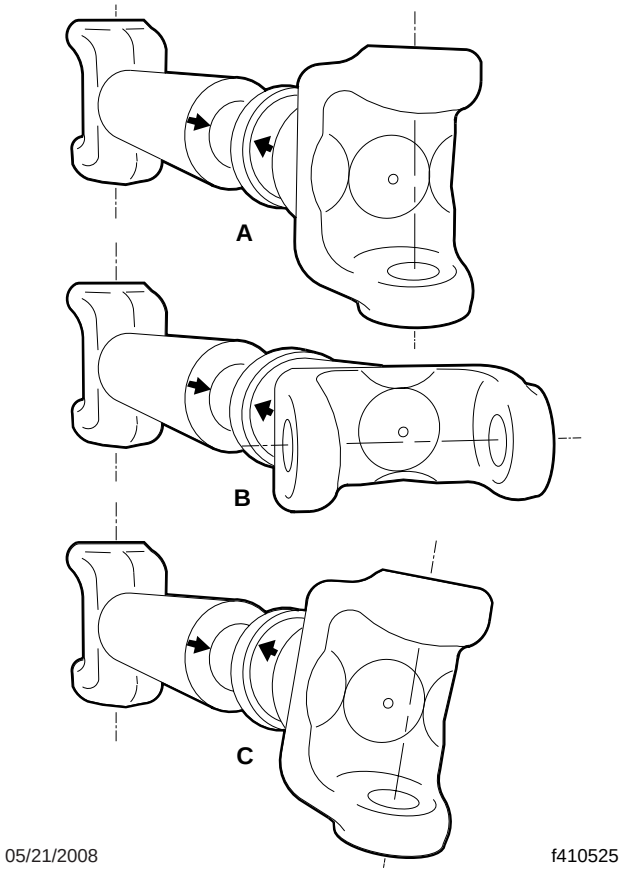
   If the No. 2 driveshaft was not removed, couple it to the intermediate coupling shaft end-yoke. If the intermediate coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

No. 2 Driveshaft Installation

See **Fig. 3** and **Fig. 4** for driveline configuration.

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.



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 10, U-Joint Phasing

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**.
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** for driveline configuration.

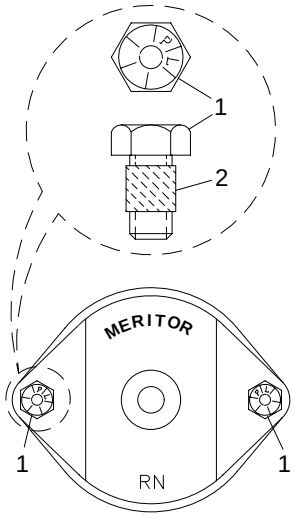
IMPORTANT: Before installing a No. 3 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

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**.



04/13/94 f410155a

1. Self-Locking Capscrew
2. Adhesive Band

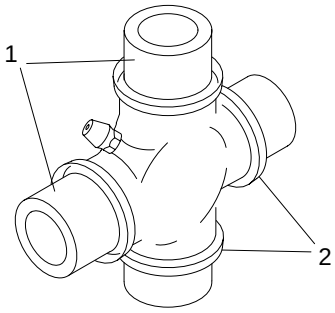
Fig. 1, Meritor U-Joint Fasteners for Full-Round Yokes

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.



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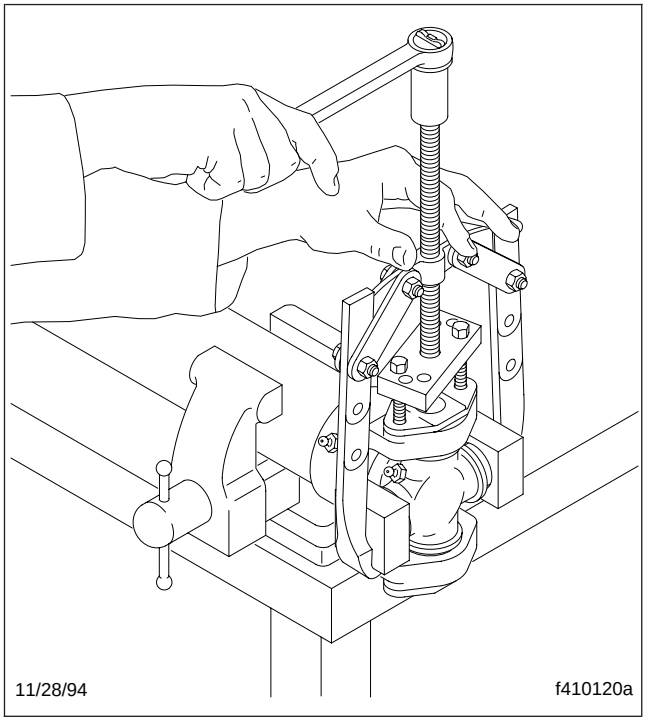
1. Trunnions 2. Slingers

Fig. 2, U-Joint Cross

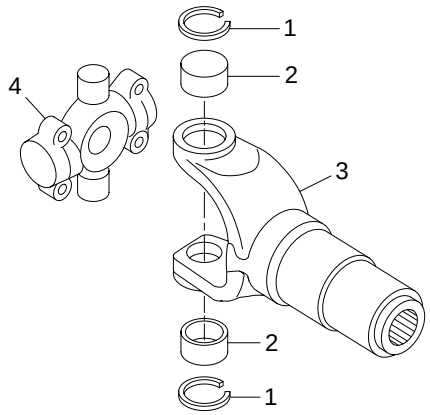


11/28/94 f410120a

Fig. 3, Removing a Bearing Cup from a Full-Round Yoke

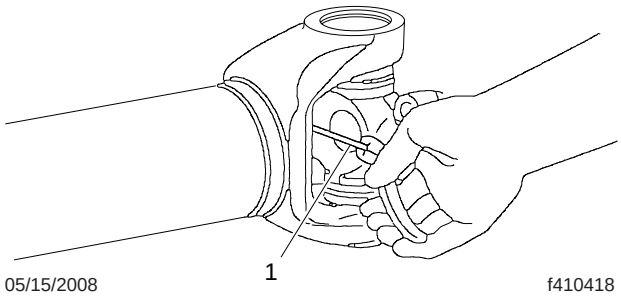
1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard snap rings. See **Fig. 4**.
4. Cut the weld strap (see **Fig. 5**) that retains the bearing cups, then remove both 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

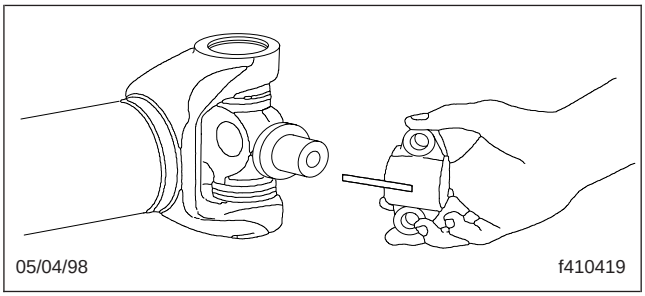
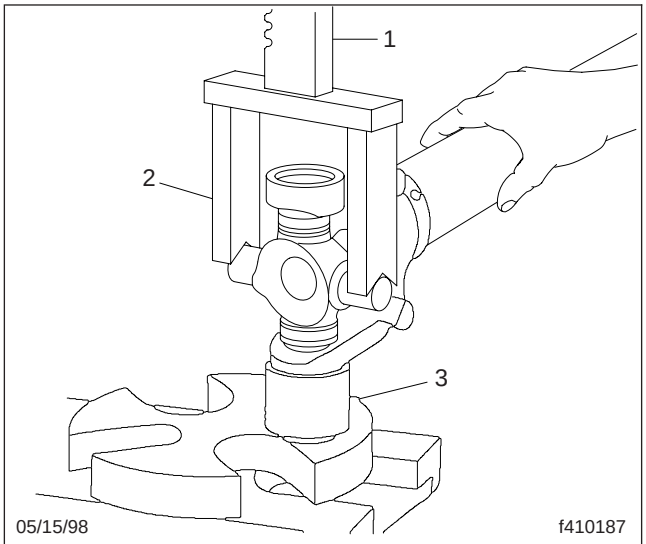


Fig. 6, Removing the Bearing Cups

5. Remove both bearing cups from the yoke cross-holes. See **Fig. 7**. Remove the cross from the yoke. Discard the U-joint assembly.



1. Press
2. Bridge
3. Bearing Cup Receiver

Fig. 7, Removing Bearing Cups from an RPL U-Joint

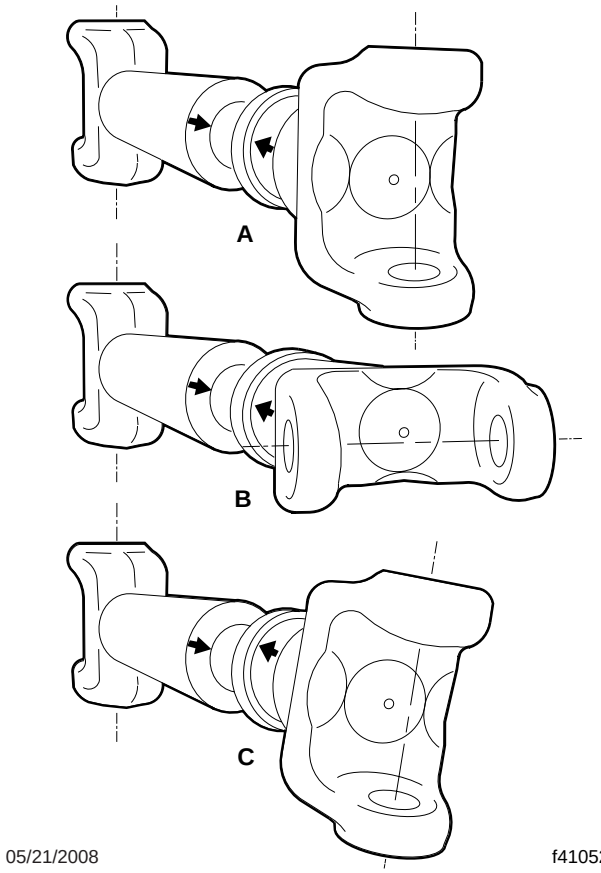
Slip-Joint Disassembly

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**.



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

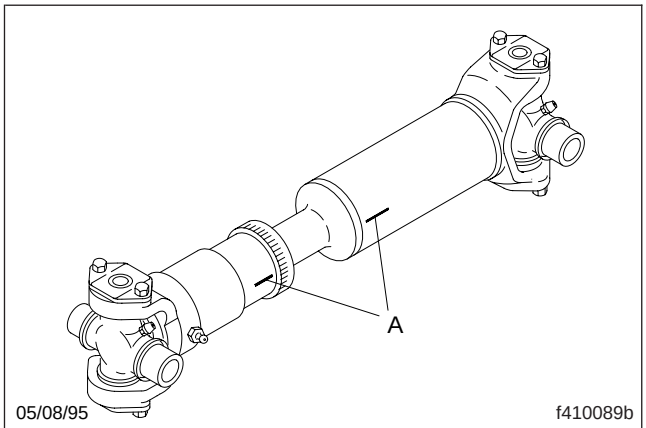
Fig. 8, U-Joint Phasing

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.

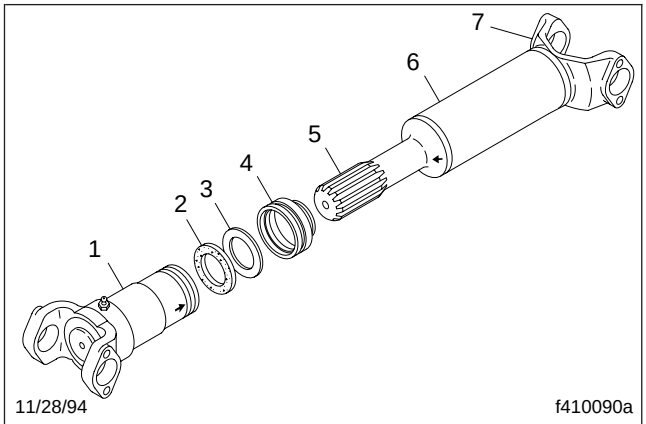
IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a brass hammer and punch to tap the shroud off the slip seal. See **Fig. 11**.



A. Use a marking stick or paint to add alignment marks.

Fig. 9, Slip-Joint Alignment Marks



1. Sleeve-Yoke
2. Cork Seal
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

Fig. 10, Slip-Joint Components

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.

Driveline Component Removal/Disassembly

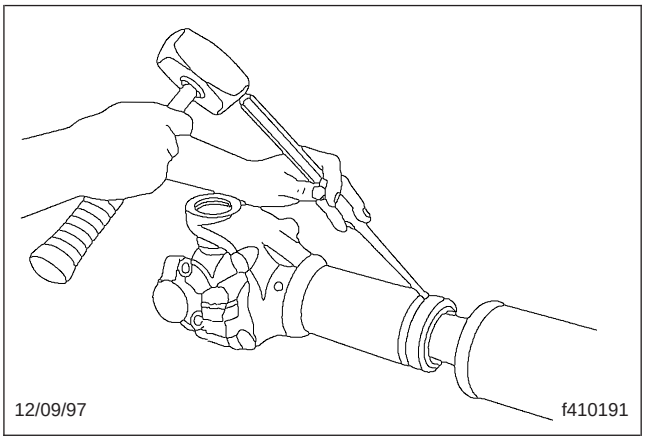


Fig. 11, Shroud Removal

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 (see **Subject 100** for a half-round yoke or **Subject 110** for a full-round yoke), or remove the driveshaft from the vehicle (see **Subject 120**).
2. Remove the end-yoke locknut. See **Fig. 12**.

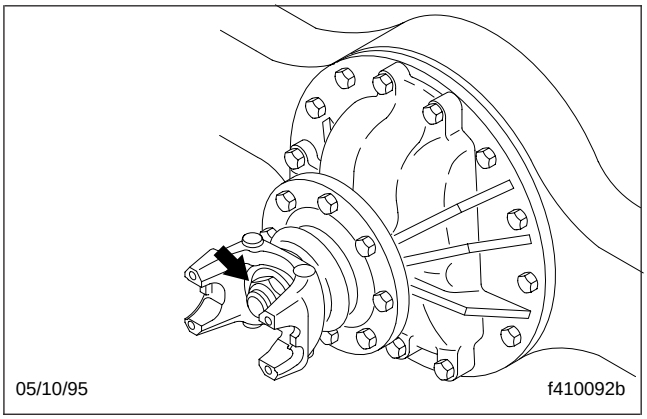
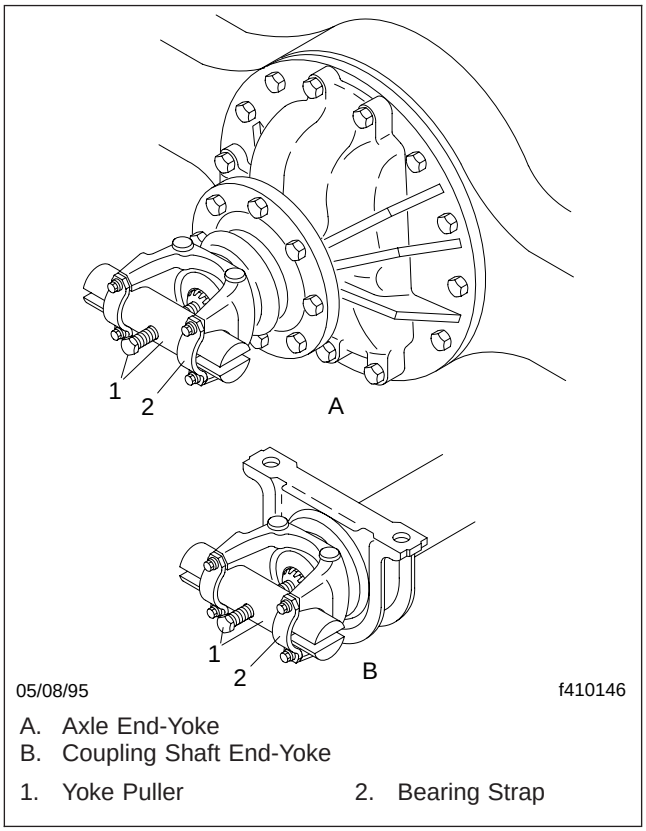


Fig. 12, Axle End-Yoke Locknut

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.

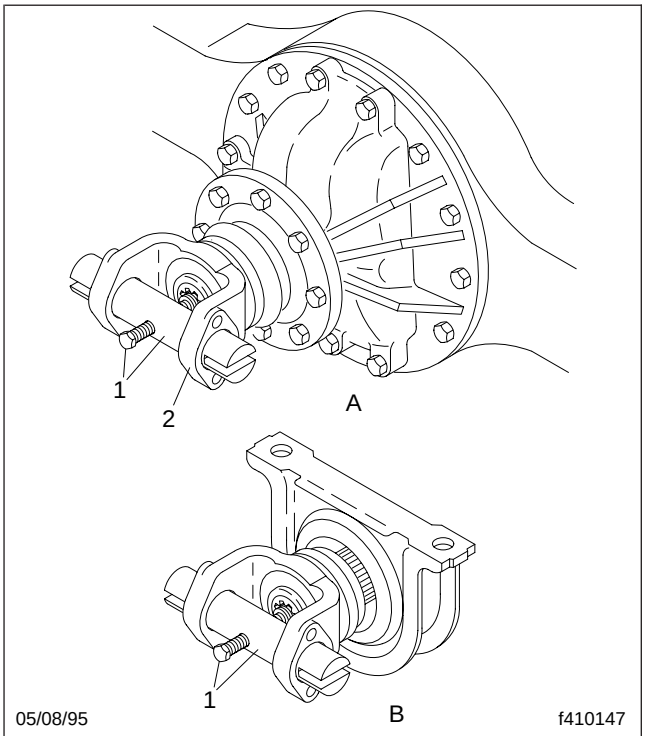


A. Axle End-Yoke
B. Coupling Shaft End-Yoke
1. Yoke Puller
2. Bearing Strap

Fig. 13, Removing a Half-Round End-Yoke

Coupling Shaft End-Yoke and Midship Bearing Removal

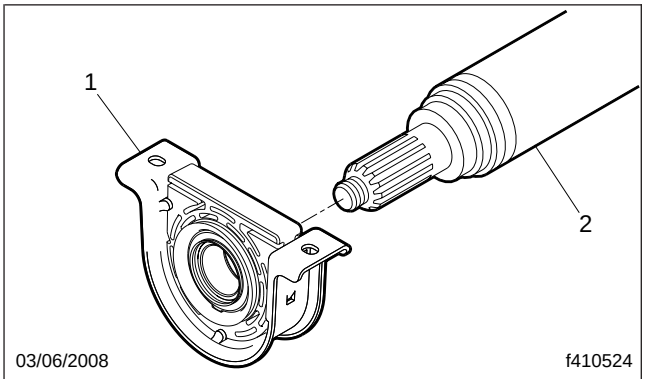
1. Remove the coupling shaft from the vehicle. See **Subject 120**.
2. Clamp the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove the end-yoke; see **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke. Then, remove the midship bearing as follows. 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.



A. Axle End-Yoke
B. Coupling Shaft End-Yoke

1. Yoke Puller
2. Full-Round End-Yoke

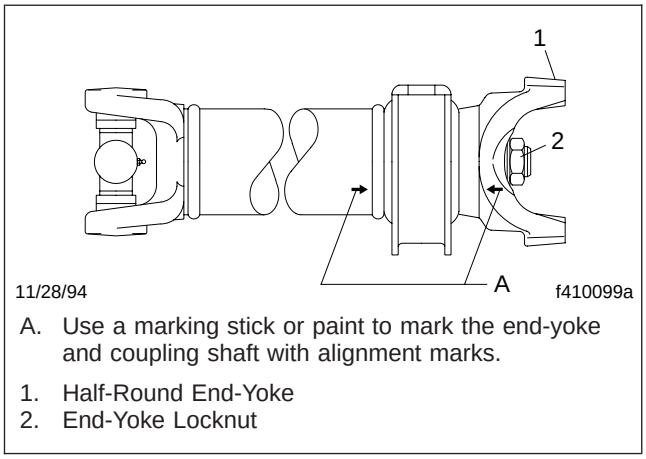
Fig. 14, Removing a Full-Round End-Yoke



1. Midship Bearing
2. Midship Bearing Shaft

Fig. 15, Midship Bearing

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.



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

3.4 Use a hammer and a brass drift to remove the midship bearing. See **Fig. 15**.

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.

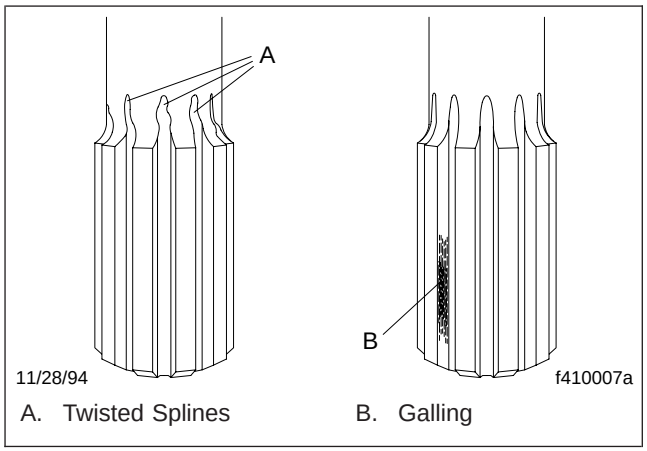


Fig. 1, Damaged Slip-Joint Splines

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**.

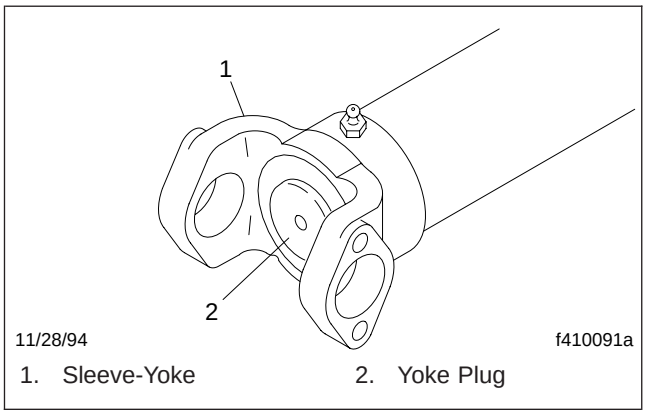


Fig. 2, Sleeve-Yoke Plug

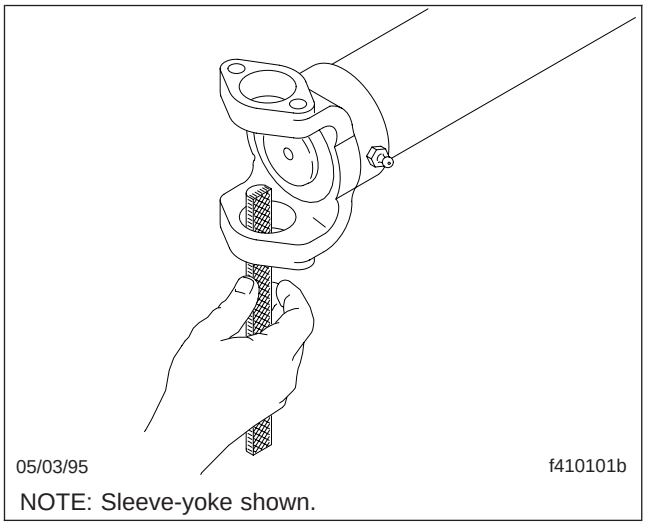


Fig. 3, Removing Burrs From a Full-Round Yoke Cross-Hole

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

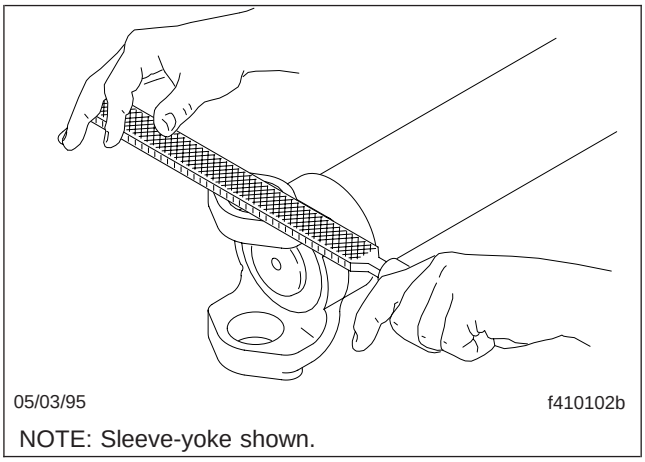


Fig. 4, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug

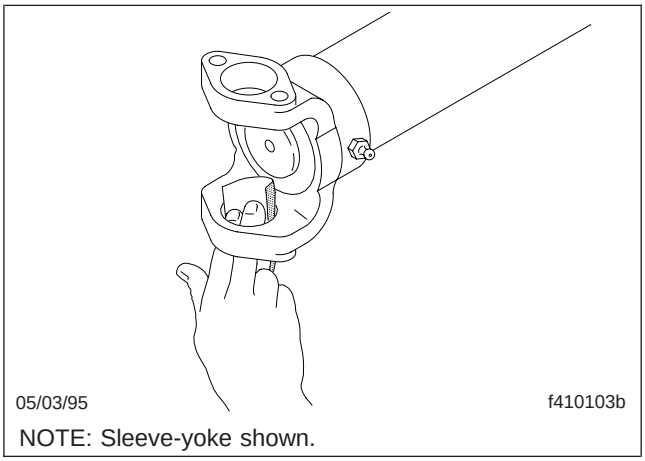


Fig. 5, Smoothing a Full-Round Yoke Cross-Hole

wipe off the outside of the midship bearing and rubber cushion.

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.

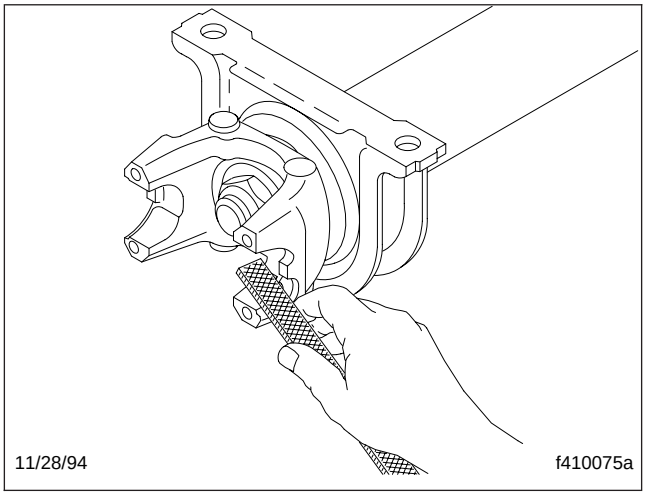
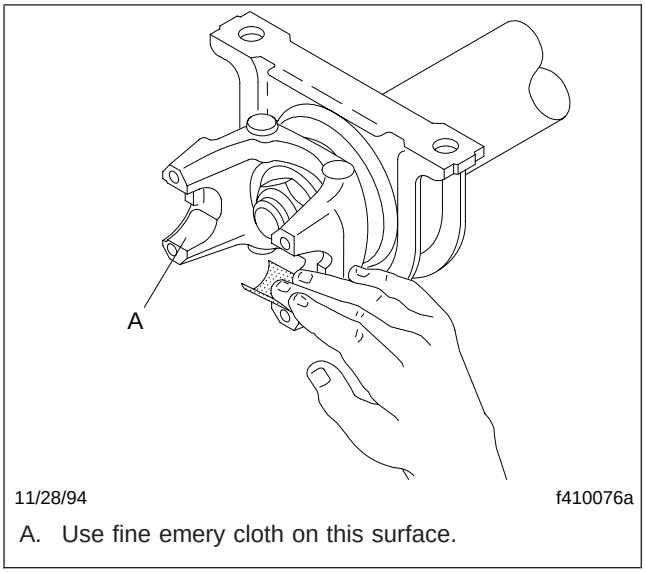


Fig. 6, Removing Burrs From a Half-Round End-Yoke Cross-Hole

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.



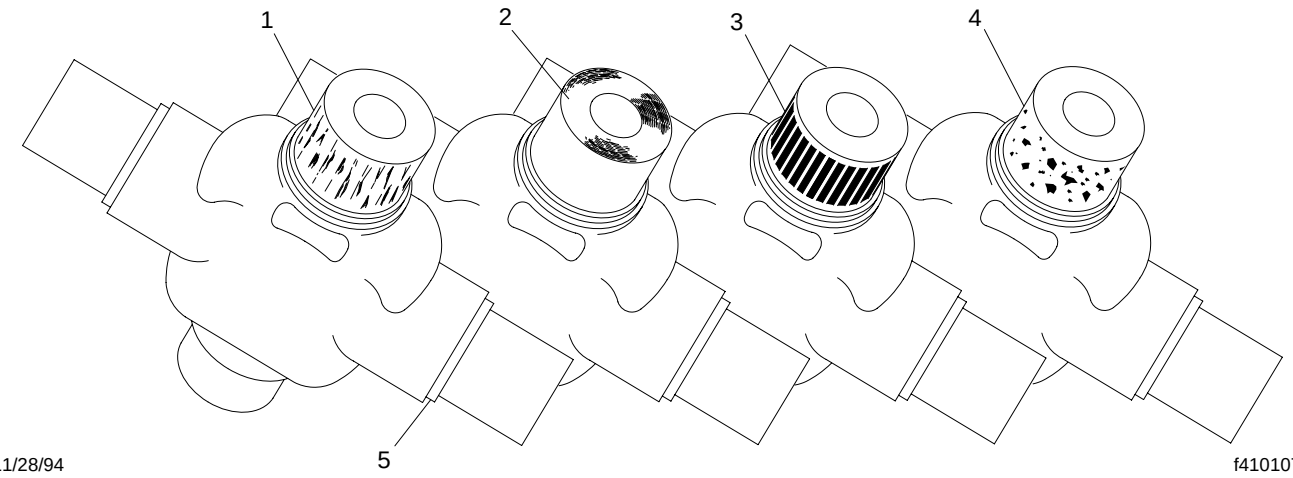
A. Use fine emery cloth on this surface.

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



1. Spalling
2. End Galling
3. Brinelling
4. Pitting
5. Slinger

Fig. 8, Damaged U-Joint Crosses

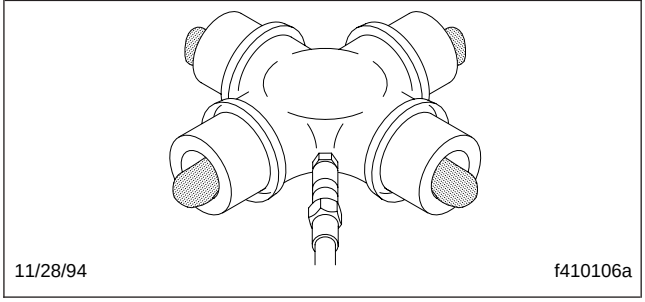
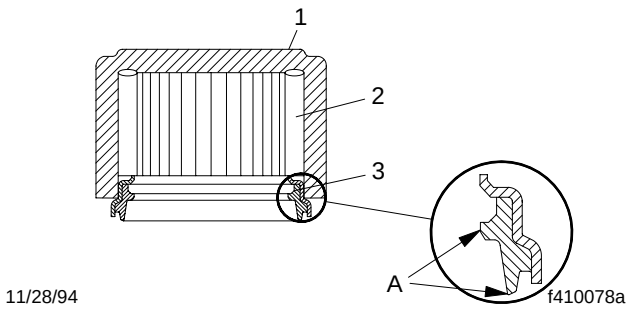


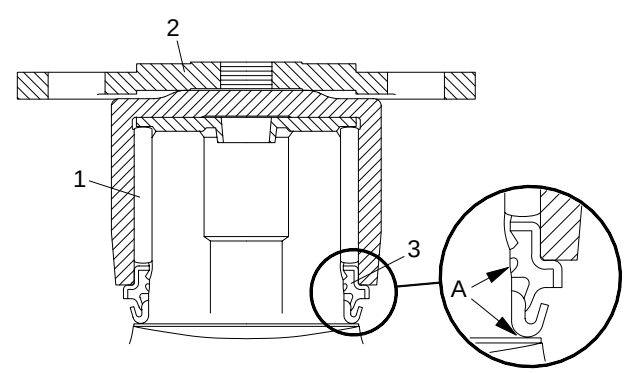
Fig. 9, Forcing Out Old Lubricant From a U-Joint Cross



A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

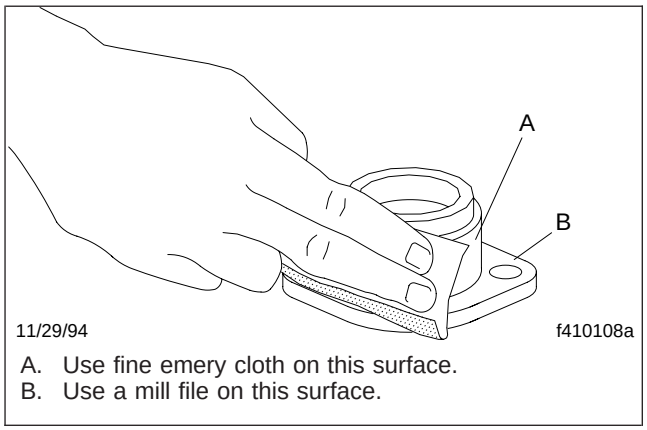
Fig. 10, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup



A. Lubricate seal lips here.

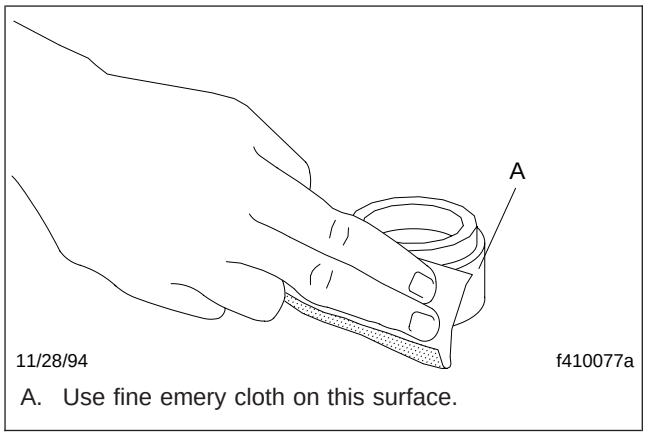
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 11, Sectional View of a Full-Round Yoke U-Joint Bearing Cup



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



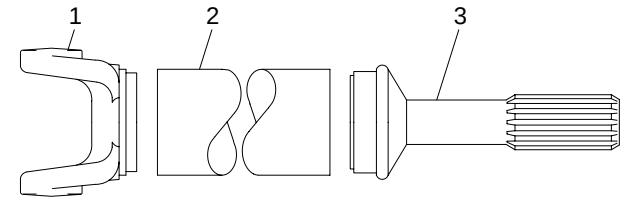
A. Use fine emery cloth on this surface.

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 (see **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

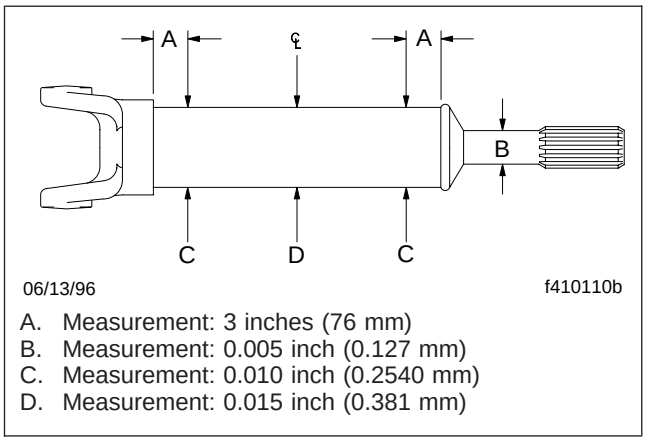
Runout limits for a new (rebuilt) driveshaft (see **Fig. 2**) are:

- 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 or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

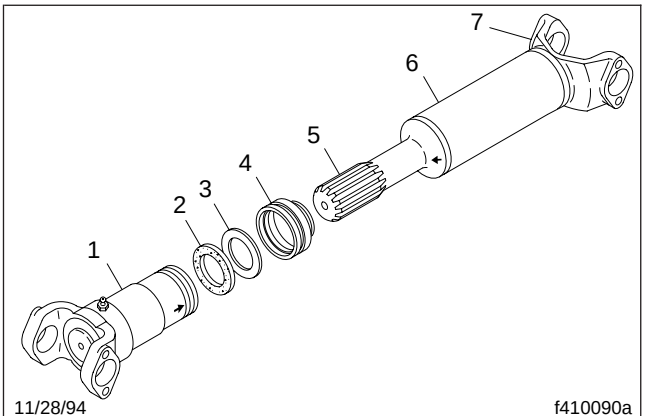


A. Measurement: 3 inches (76 mm)
B. Measurement: 0.005 inch (0.127 mm)
C. Measurement: 0.010 inch (0.2540 mm)
D. Measurement: 0.015 inch (0.381 mm)

Fig. 2, Runout Specifications for a Rebuilt (or New) Driveshaft

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**.
2. Coat the splines of the shaft with multipurpose chassis grease.

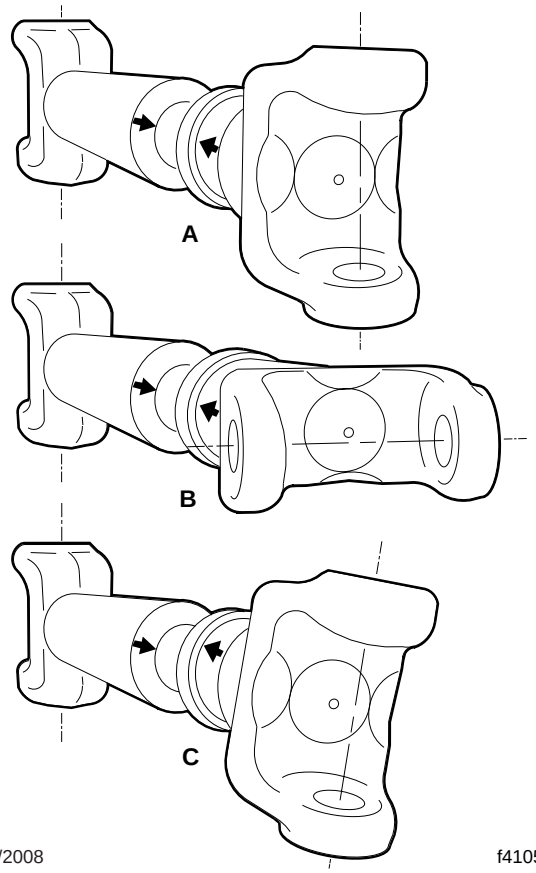


1. Sleeve-Yoke
2. Cork Seal
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

Fig. 3, Slip-Joint Components

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**.

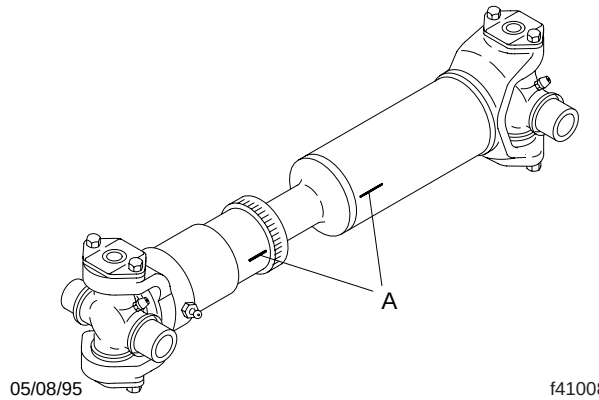


A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

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.

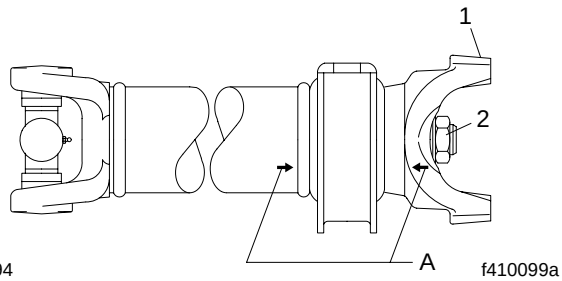
1. Place the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.

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, as follows: 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**.

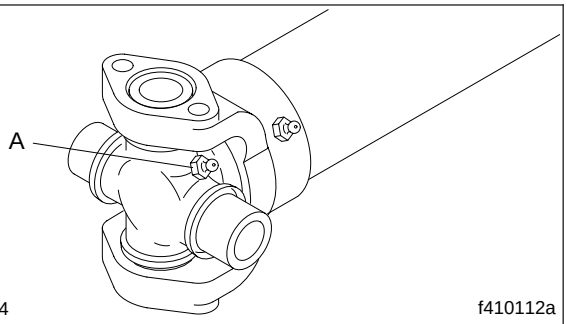
IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Inspect and lubricate the U-joint; see **Subject 140**.
4. Install the U-joint cross and bearing assemblies in the yoke, as follows:

   4.1 Position the U-joint cross in the driveshaft yoke so one grease fitting points toward

Driveline Component Replacement or Installation/ Assembly

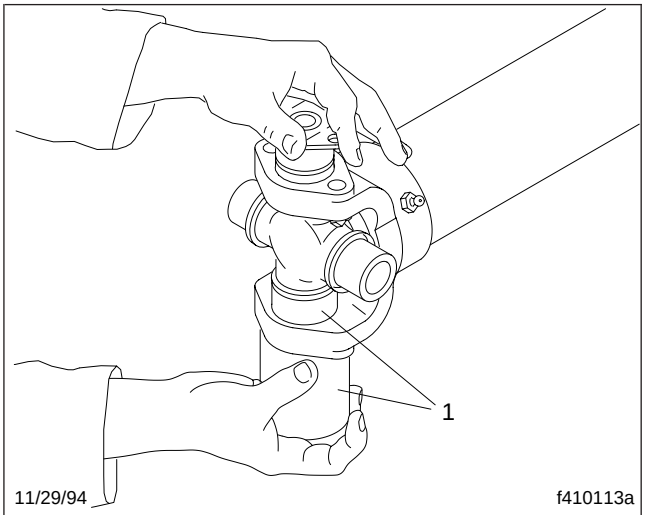
the driveshaft, and aligns with the grease fitting on the sleeve-yoke (if so equipped). See **Fig. 7**.



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 (see **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**.



NOTE: Sleeve-yoke shown.

1. Trunnion Locator

Fig. 8, Using 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**.

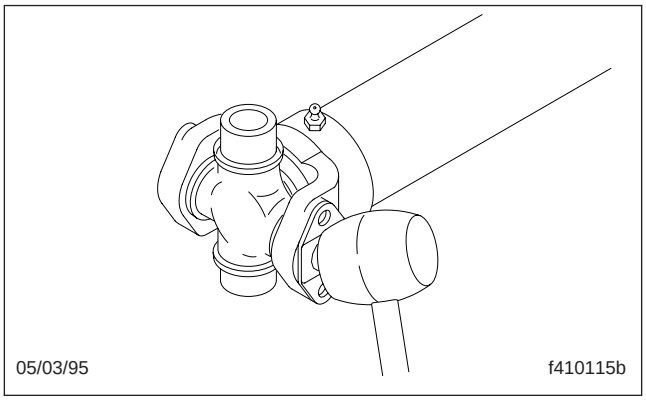


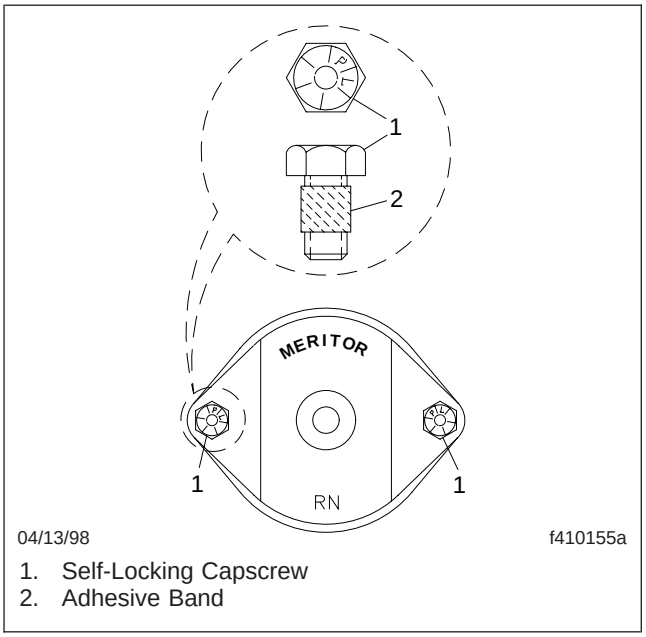
Fig. 9, Seating a U-Joint Bearing Cup In a Full-Round Yoke

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 60 lbf·in (680 N·cm), 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 if they have been disassembled and removed from a driveshaft.

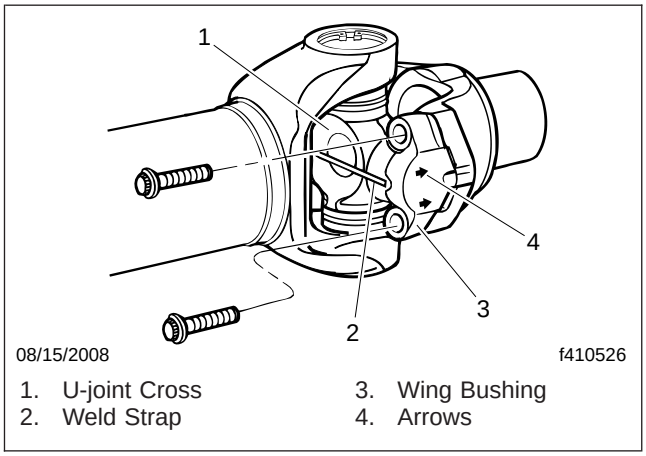
1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

   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

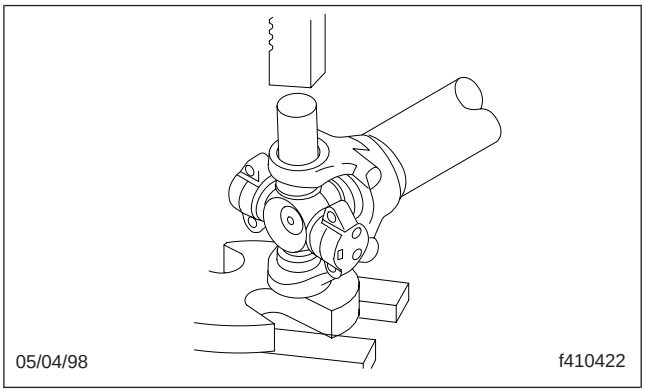
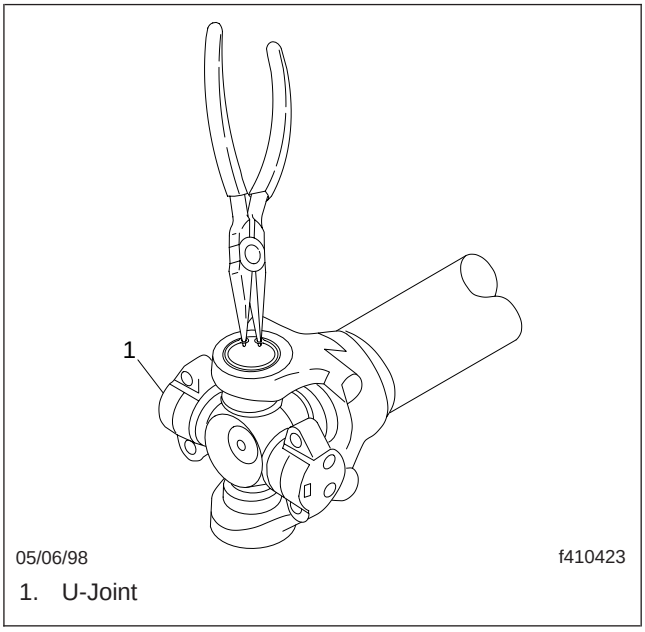


Fig. 12, Installing Bearing Cups, RPL Series U-Joint



1. U-Joint

Fig. 13, Installing the Snap Rings

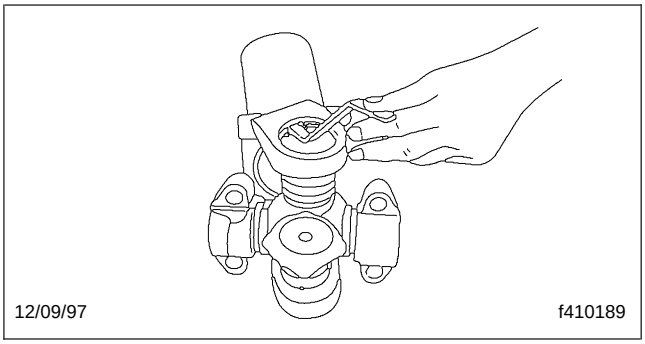
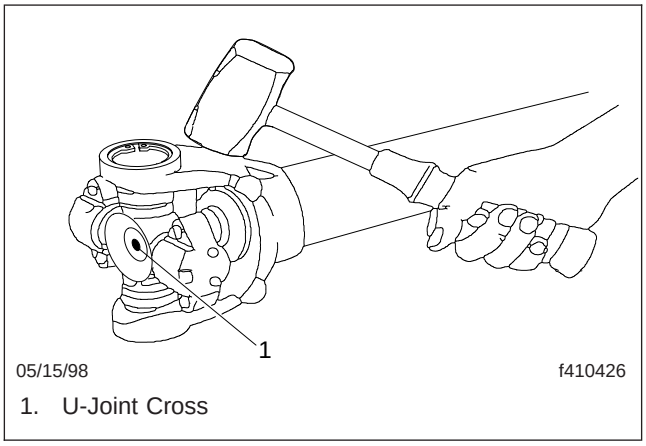


Fig. 14, Checking Snap Ring Installation

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**.

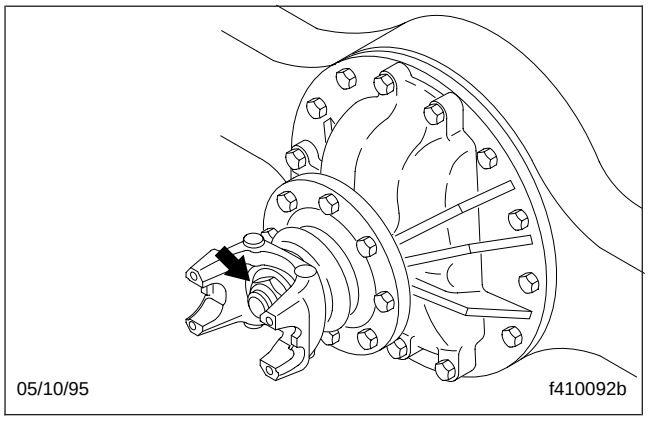


Fig. 16, Axle End-Yoke Locknut

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 DANA Customer Support for OEMs at, 1-888-242-7253, or visit their web site at:

www.dana.com

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

Or you can visit their web site at:

www.otctools.com

End-Yoke Puller (for removing end-yokes from transmission output 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

Or you can visit their web site at:

www.otctools.com

Universal Joint Puller

To order the universal joint puller, Tiger Tool 10102: Call Tiger Tool Company's customer service center at 800-661-4661, or visit their website at:

www.tigertool.com

Driveline Angularity

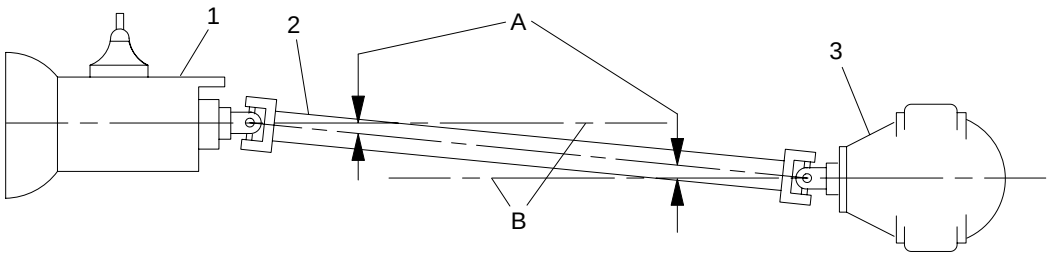
The most important consideration of driveline angularity is the U-joint working angle. A U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component to which the U-joint connects. See **Fig. 1**. Because the action 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 (see **Fig. 1**), or an intersecting arrangement (see **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 that bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 3**.



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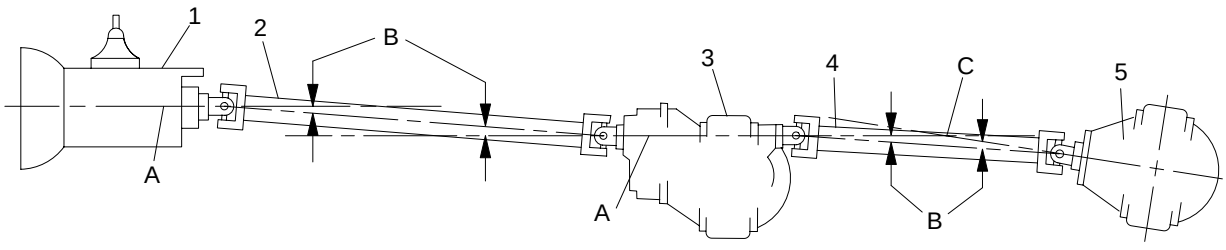
A. Equal U-Joint Working Angles
B. Parallel Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Rear Axle

Fig. 1, Parallel Arrangement for Single-Drive Vehicles



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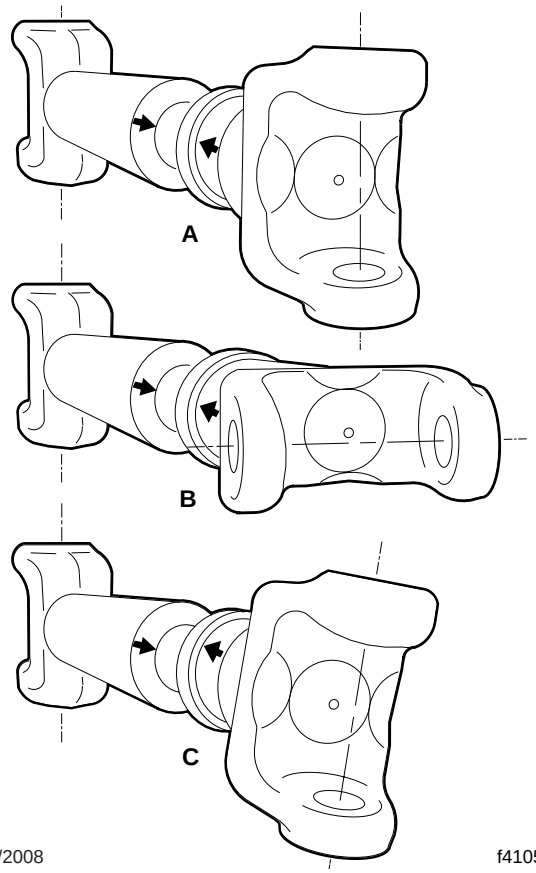
A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Intersecting Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 2, Intersecting Planing Arrangements for Dual-Drive Vehicles

General Information

NOTE: Some driveshafts are designed and phased with their end yokes clocked 90 degrees from each other. This is referred to as cross phasing.



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.

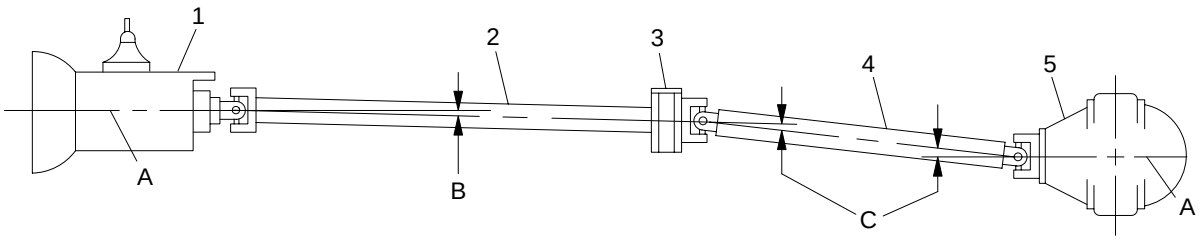
A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds that exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Loose end-yoke nuts, loose midship bearing 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.



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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

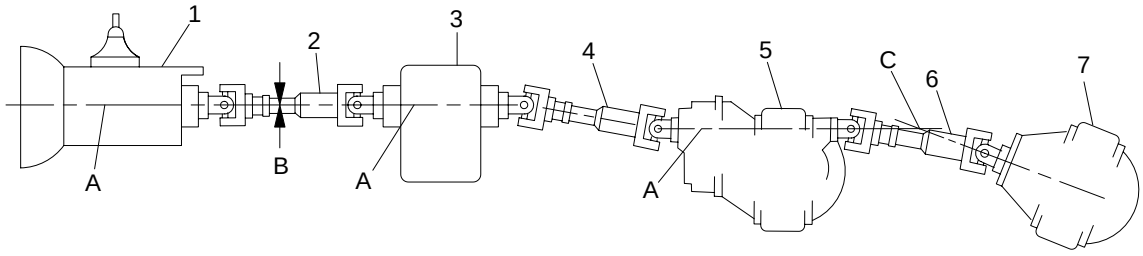
Fig. 4, Midship Bearing in a Single-Drive Vehicle

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 (see **Fig. 1**) or an intersecting arrangement (see **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



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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

rearmost 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**, that 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**.

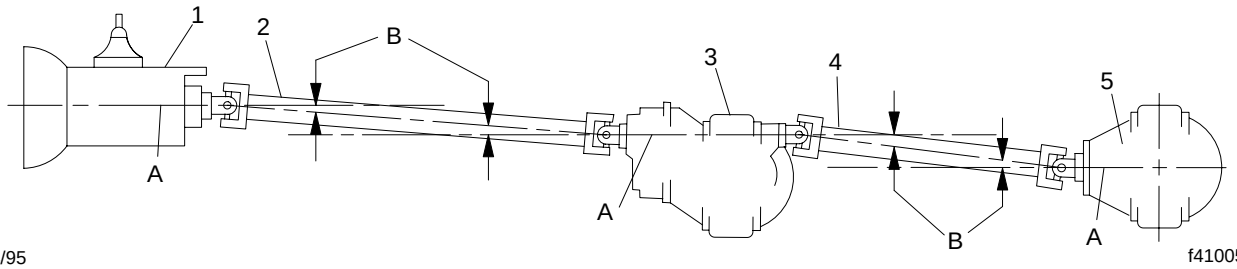
However, some axle spacings, axle models, and suspension designs allow additional axle movement or axle windup that requires additional clearances between the driveshaft and the frame or suspension components, or that creates other conditions that make the intersecting arrangement of the no. 3 driveshaft 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.

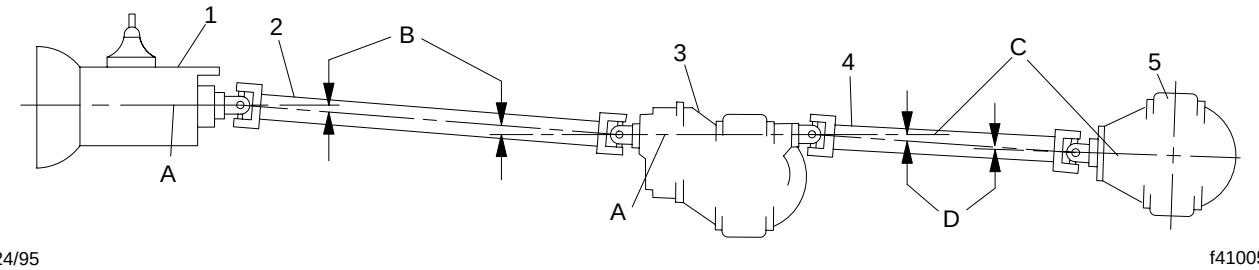
In the field, whenever axle or suspension components are changed, the axle pinion angles may also change. If this occurs, contact your district service manager for the correct axle pinion angle adjustment procedure.



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

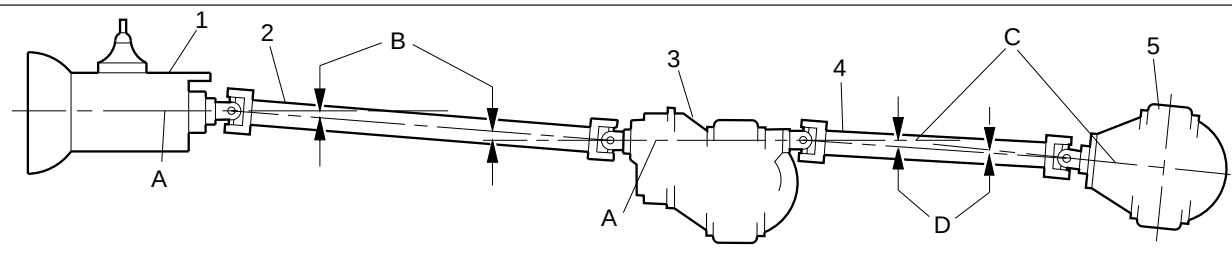
Fig. 6, Parallel Arrangement for Dual-Drive Vehicles



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.

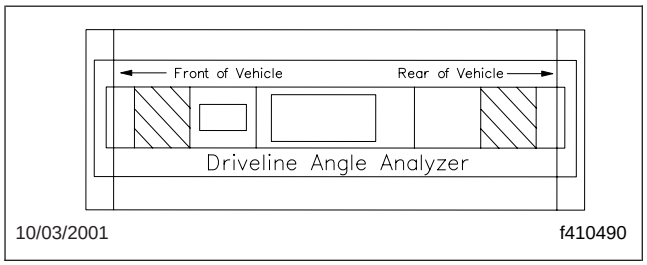
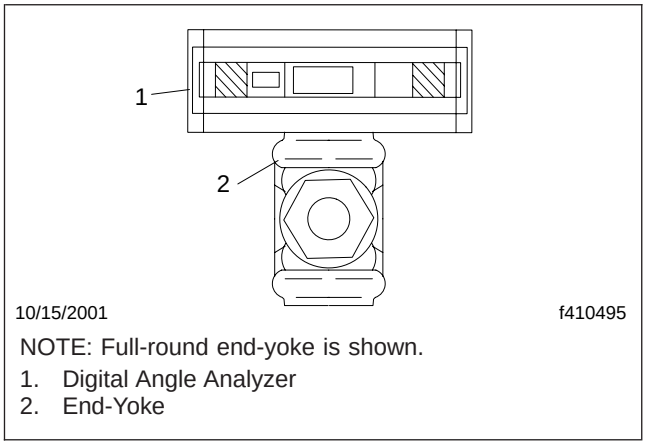


Fig. 1, Digital Angle Analyzer

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**.



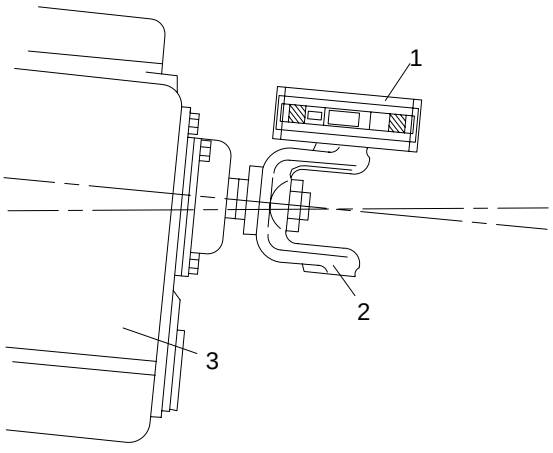
NOTE: Full-round end-yoke is shown.

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



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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.

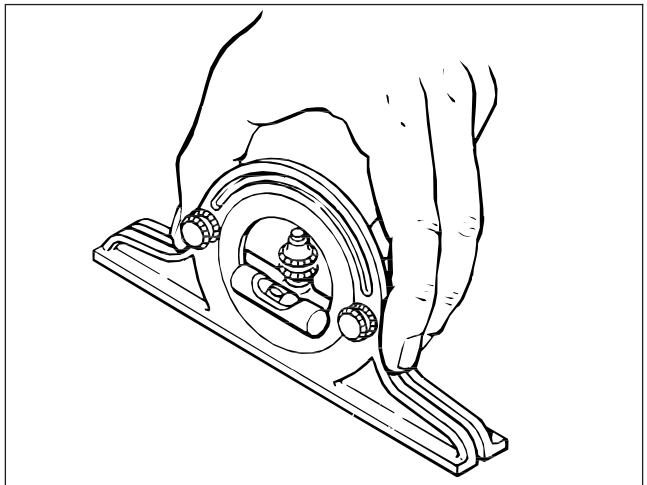

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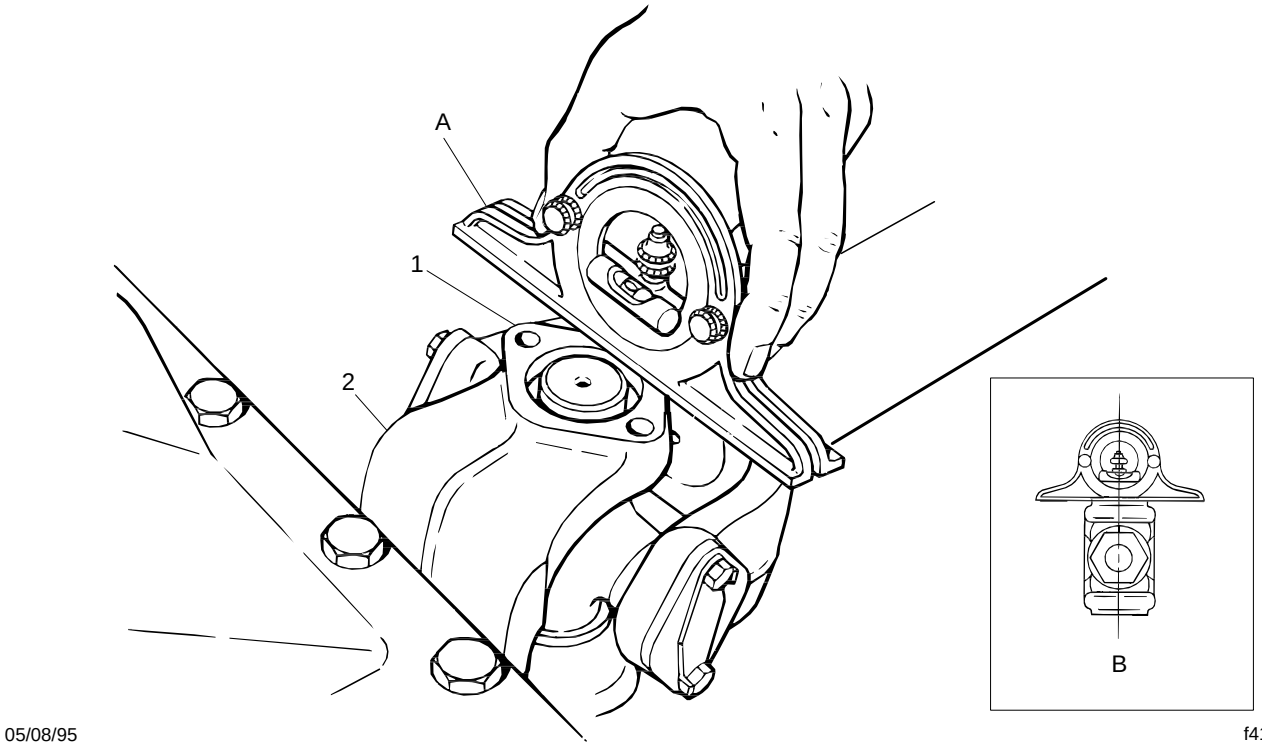
Fig. 4, Spirit Level Protractor

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.



NOTE: Full-round end-yoke is shown.

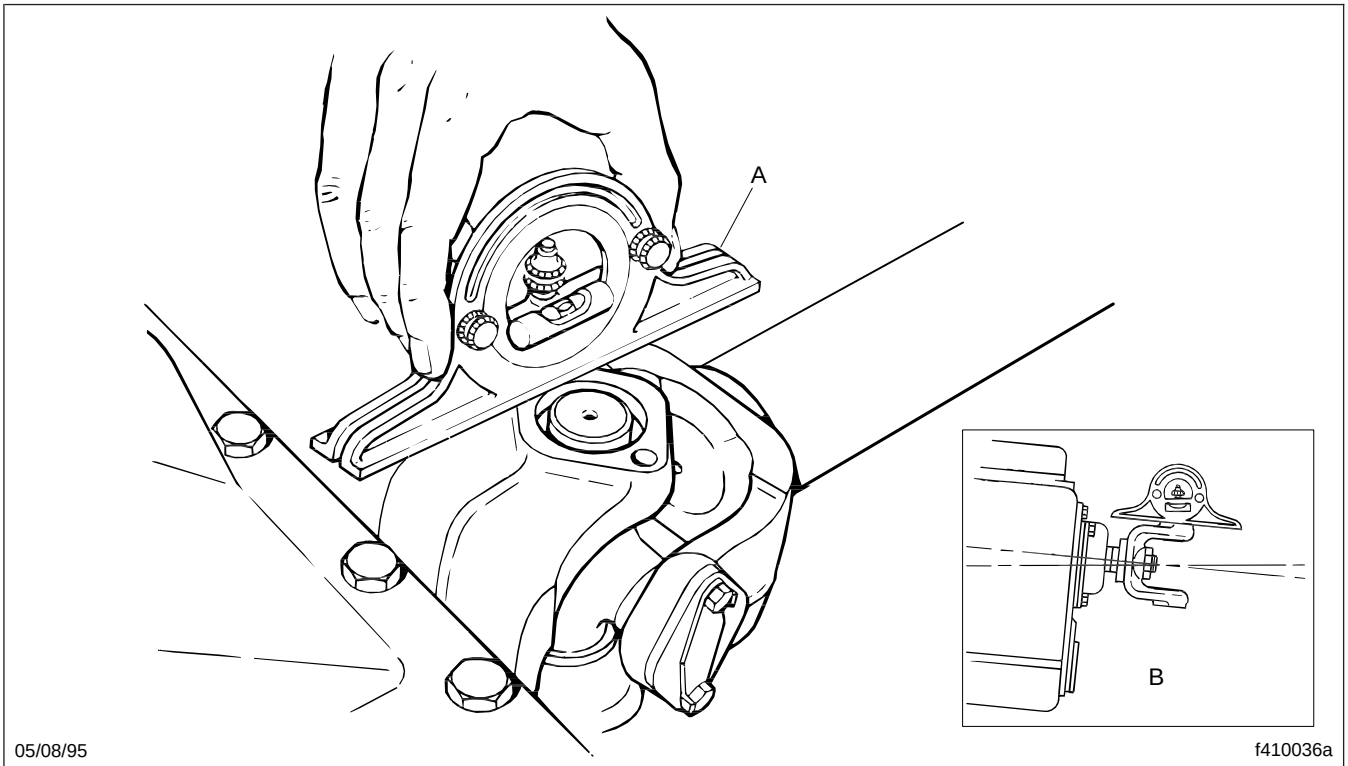
A. Protractor held at right angle to vehicle frame centerline.
B. End view of end-yoke.

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.

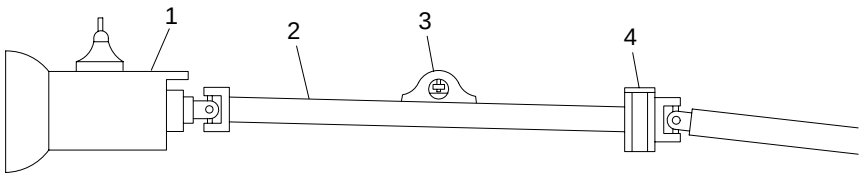
   If the rear axle pinion angle does not meet the above specification, contact your district service manager.
4. On dual-drive installations, measure the forward-rear-axle pinion angle (at the rear of the no. 2 driveline); for instructions, see **Subject 100**.

   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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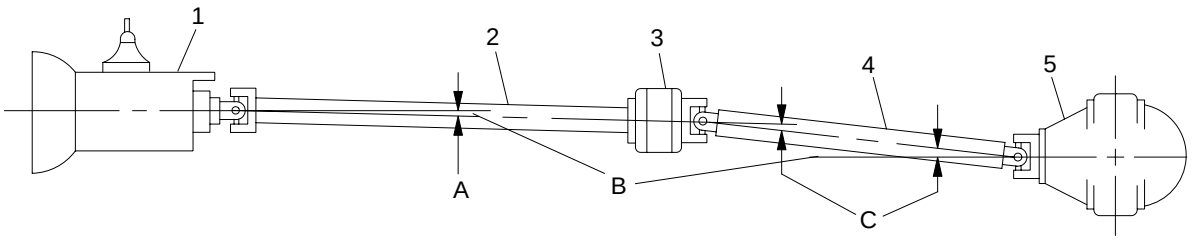
1. Transmission
2. Coupling Shaft
3. Protractor
4. Midship Bearing

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 Axles: Adjust axle pinion angles to the values in **Table 1**, ±1 degree.

Freightliner AirLiner Suspensions With Meritor RT–40 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 Axles

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.

Cascadia™ vehicles are equipped with a Meritor WABCO E-Version Antilock Braking System (ABS) with a cab-mounted electronic control unit (ECU).

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.

Cascadia™ 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

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.

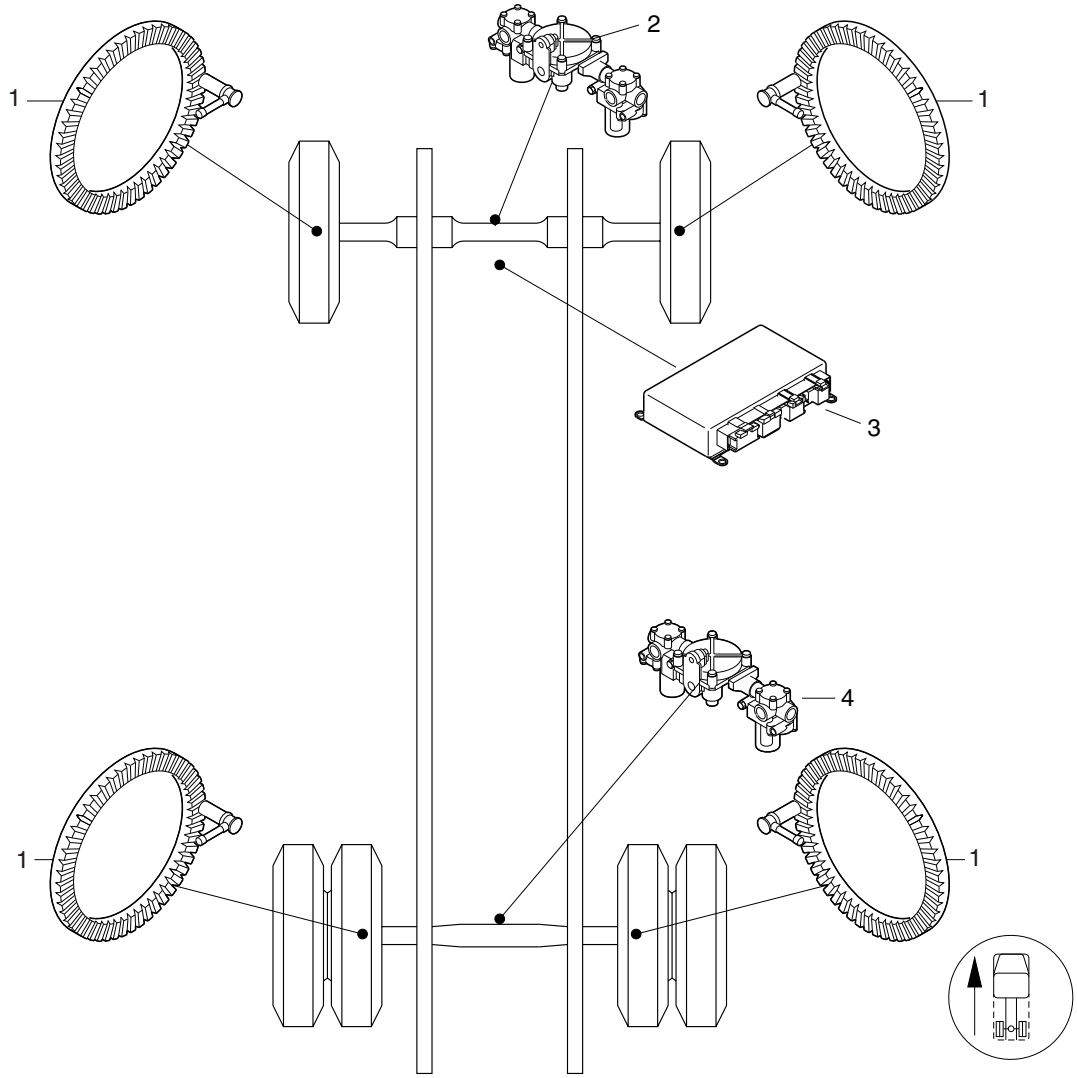
Electronic Control Unit (ECU)

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 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.

General Information



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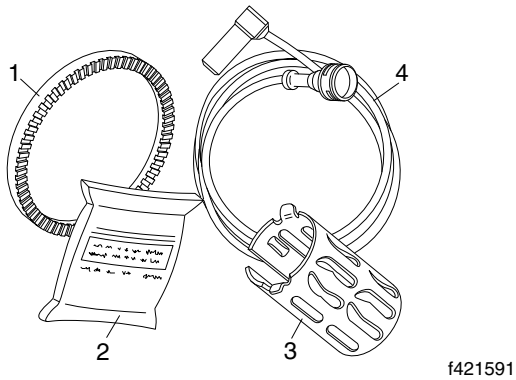
1. Tone Wheel and Sensor
2. Front Modulator Valve Assembly
3. Electronic Control Unit (ECU)
4. Rear Modulator Valve Assembly

Fig. 1, ABS Component Location (4-channel, 4S/4M system shown)

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 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.



1. Tone Wheel
2. Lubricant
3. Sensor Spring Clip
4. Sensor

Fig. 2, Wheel Speed Sensor Components

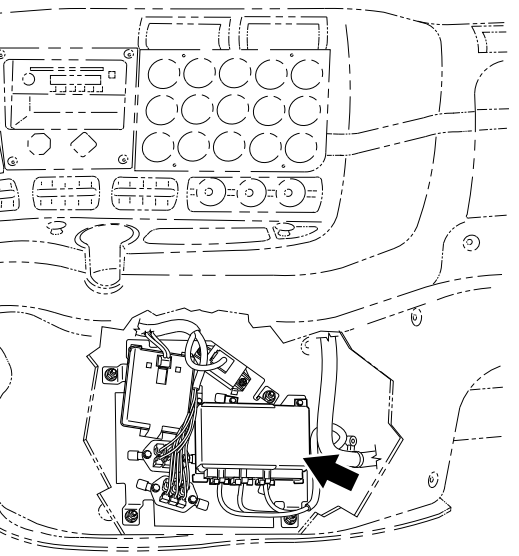


Fig. 3, ECU

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 above, repair the ABS/ATC system. See the *Cascadia™ Troubleshooting Manual* 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 TOOLBOX (recommended), ServiceLink or DiagnosticLink, 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.

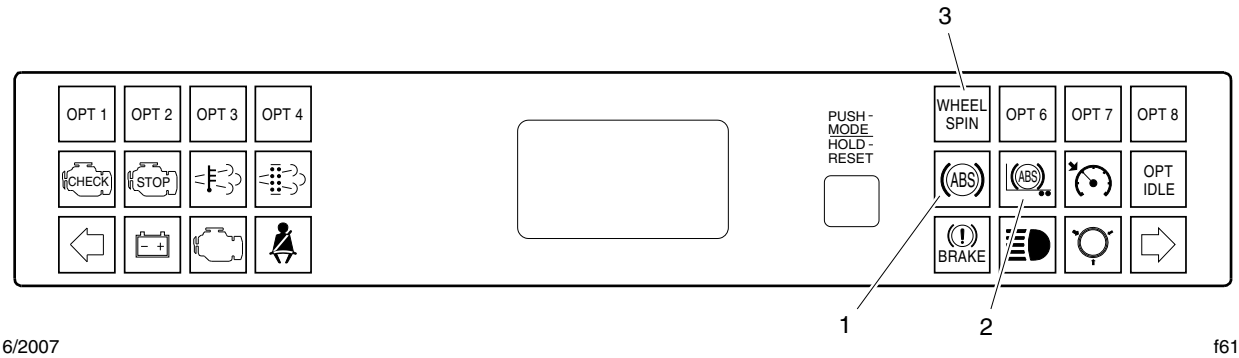
Modulator Valves

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.

General Information



1. Tractor ABS Warning Light
2. Trailer ABS Warning Light
3. Wheel Spin Warning Light

Fig. 4, ABS and Wheel Spin Lights

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

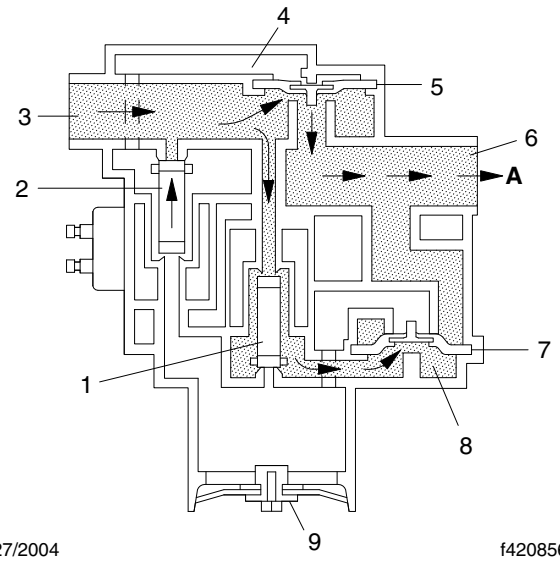
The normal brake function (without ABS control) operates as follows:

- 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.

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.



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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.

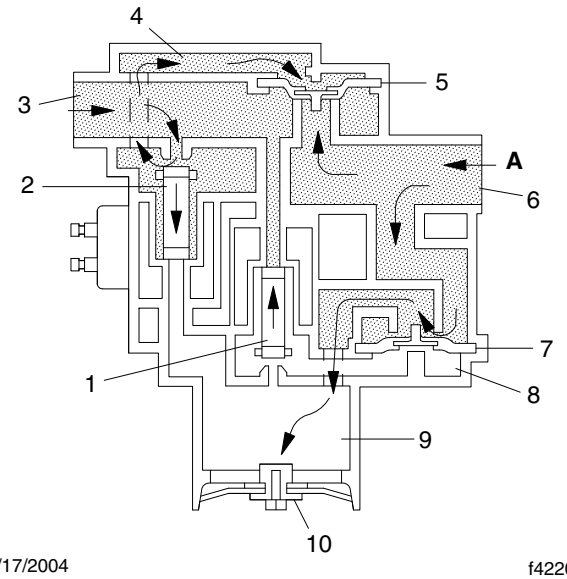
1. Exhaust Valve (closed)
2. Supply Valve (closed)
3. Supply Port
4. Supply Pilot Chamber
5. Supply Diaphragm (unseated)
6. Delivery Port
7. Exhaust Diaphragm (seated)
8. Exhaust Pilot Chamber
9. Exhaust Port

Fig. 5, Modulator Valve, Normal Brake Control (brake applied)

- 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.



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NOTE: Both solenoid valves are open.

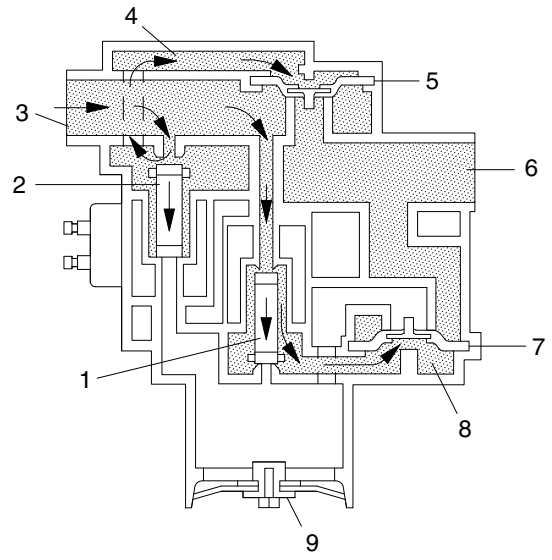
A. Air from brake chamber.

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)

- 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.

General Information



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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 Pilot Chamber
9. Exhaust Port

Fig. 7, Modulator Valve, Brake Hold Control

- The remaining air pressure in the brake chamber is held and remains constant for stopping the vehicle in the minimum distance.

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.

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.

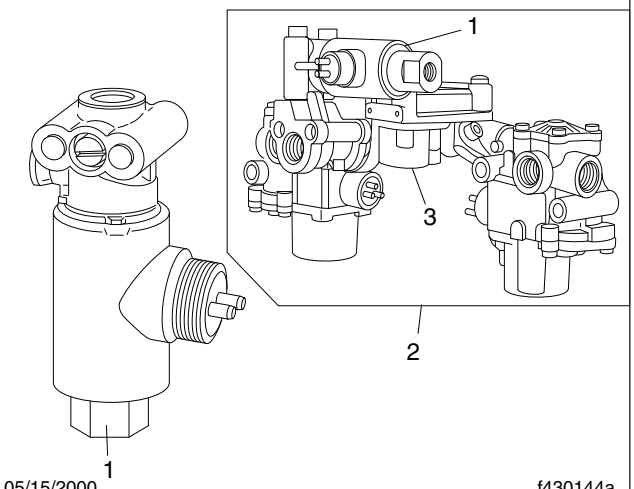
If a drive wheel starts to spin faster than the steer-axle wheels, the ATC system applies air pressure to brake that drive wheel. This transfers engine torque to the wheel or wheels that have better traction (differential braking). If two or more drive wheels spin, the ATC reduces the engine torque to 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.

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.

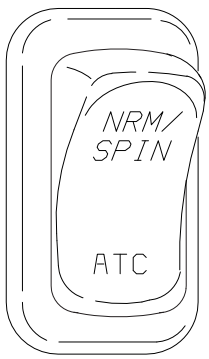
An ATC function switch on the dash allows the driver to select from two levels of drive-axle traction control (see **Fig. 9**):

- 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.



1. ATC Valve
2. Rear Modulator Valve Assembly
3. Service Relay Valve

Fig. 8, ATC Valve



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 (see **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.
- 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 Sensor 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

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**.

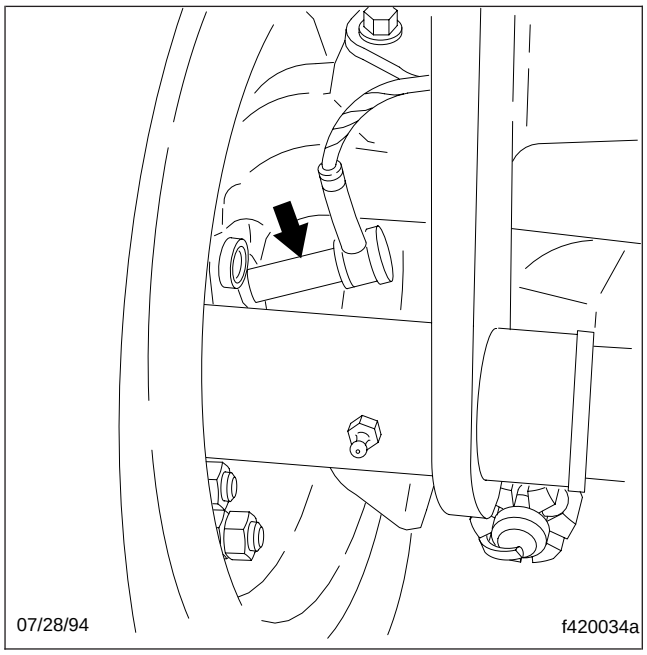


Fig. 1, Front Wheel Speed Sensor Removal

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.

Wheel Speed Sensor Replacement

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 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 group.
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 and lower the vehicle.

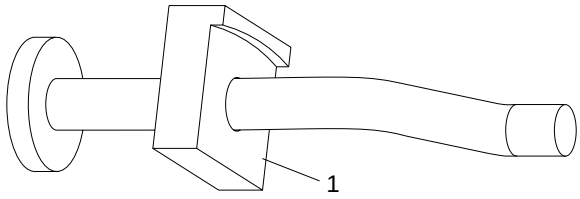
⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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.



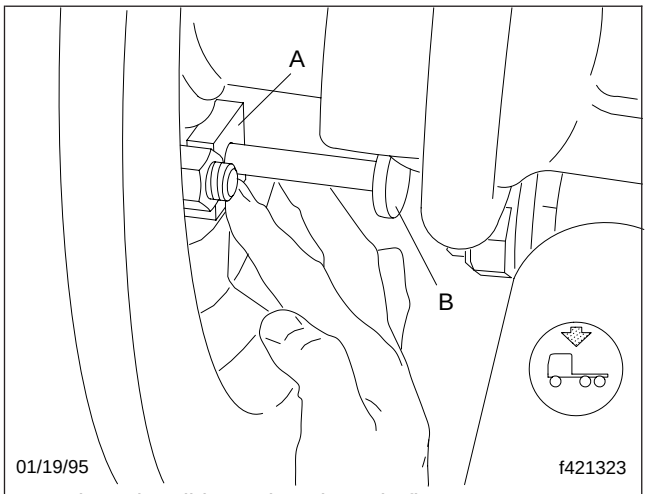
1. Adjustment Tool Slide

Fig. 1, ABS Sensor Adjustment Tool

2. Find the sensor access hole in the rear-axle flange, as follows.
   - 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**.



A. Place the slide against the axle flange.
B. Tap the handle with your hand.

Fig. 2, Positioning the Tool

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.

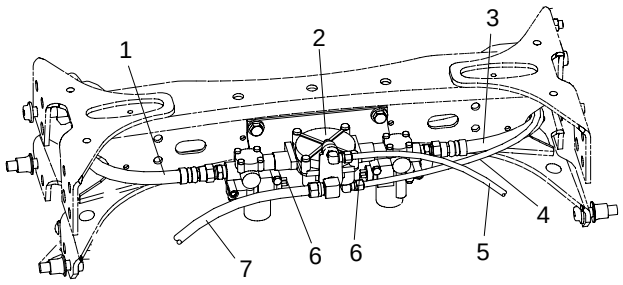
⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Removal

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.
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 that attach 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 the **Cascadia™ Troubleshooting Manual** 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.
6. Test drive the vehicle to verify that the ABS warning light is functioning correctly.

⚠ WARNING

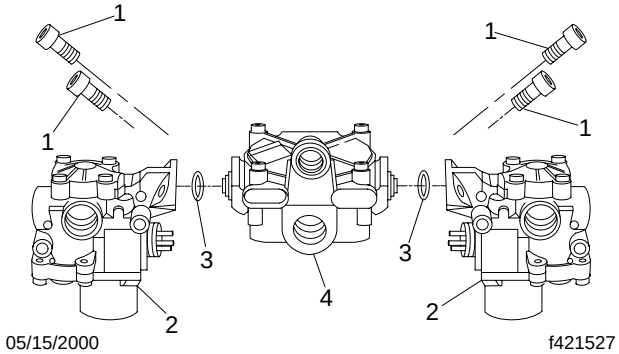
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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, as follows.

   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**.



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1. Capscrew, Allen-Head, M8
2. Modulator Valve
3. O-Ring
4. Service Relay Valve

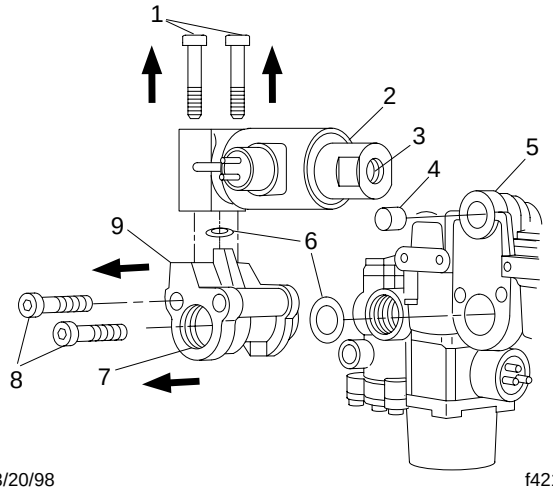
Fig. 1, Modulator Valve Assembly

   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, as follows. 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.



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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

   3.2 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.

   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, as follows.

   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).

Modulator Valve Disassembly and Assembly

1.3 Lubricate the replacement seal and install it in the control port (upper port) of the service relay valve.

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 (540 to 680 N·cm).

2. Install the modulator valves on the service relay valve, as follows.

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**.

ABS Tone Ring Installation on Service Hubs

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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

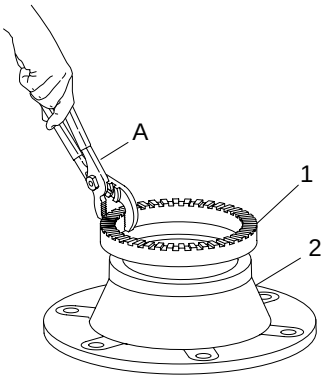
When installing an ABS system, special ABS hubs must be ordered. Machining older hubs to accommodate the installation of tone rings can cause problems due to insufficient hub bore wall thickness. Machining an older hub with insufficient hub bore wall thickness could result in cracking, causing bearing 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**.



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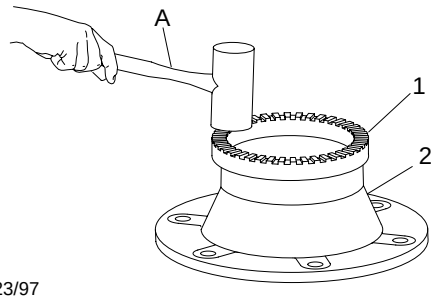
A. Use pliers to apply the ring.
1. Tone Ring 2. Hub

Fig. 1, Centering the Ring on the Hub



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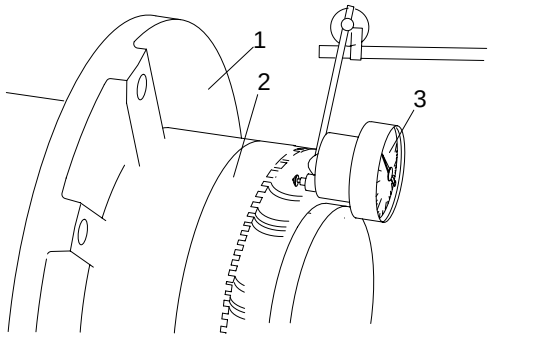
A. Use a rubber mallet.
1. Tone Ring 2. Hub

Fig. 2, Installing the Tone Ring

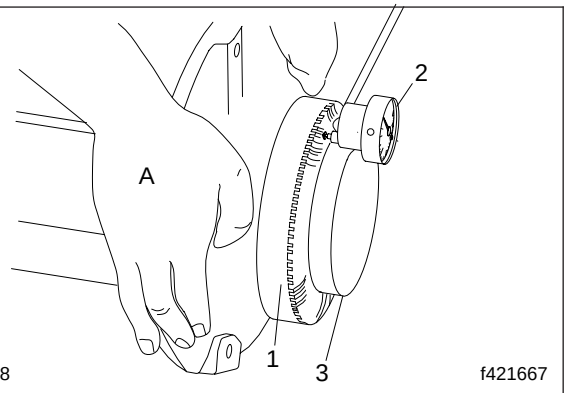
5. Rotate the hub and check the ring for runout. The runout should be less than 0.005 inch (0.13 mm). See **Fig. 4**.
6. Install the wheel. For instructions, see **Group 40**.

ABS Tone Ring Installation on Service Hubs



1. Hub
2. Tone Ring
3. Dial Indicator

Fig. 3, Positioning the Dial Indicator



A. Rotate the hub.

1. Tone Ring
2. Dial Indicator
3. Axle

Fig. 4, Checking Tone-Ring Runout

⚠ 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 at 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

This subject provides instructions for cleaning ABS tone rings on front and rear axles. ABS tone rings need to be cleaned when a hub oil seal has leaked or certain ABS fault codes are found. For more information about ABS fault codes, see **H01.01—ABS and Stability Control Systems** in the *Cascadia Troubleshooting Manual*.

Front Axle

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Using a suitable jack, raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
3. Remove the wheel and tire assembly. For instructions, see **Group 40**.

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.

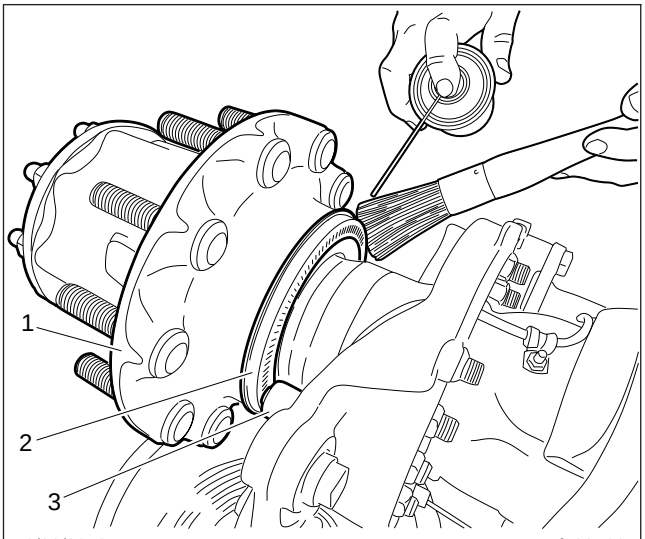
4. Do one of the following:
   - For drum brakes, remove the brake drum and shoes. See **Section 33.01, Subject 160** and **Section 42.01, Subject 110** for instructions.
   - For disc brakes, remove the brake caliper and hub. See **Section 42.21, Subject 120** and **Section 33.01, Subject 100** for instructions.

NOTICE

Do not use anything abrasive to clean an ABS tone ring. ABS tone rings can be scratched and damaged by abrasive contact.

NOTE: For disc brakes, the tone ring is located between the hub and brake rotor. On some vehicles, the brake rotor will need to be removed to access the tone ring.

5. Apply brake cleaner to the tone ring and remove any residue with a plastic-bristled brush. See **Fig. 1.**



NOTE: Rear axle hub with drum brakes shown. For disc brakes, the tone ring is located between the hub and brake rotor.

1. Hub
2. ABS Tone Ring
3. ABS Sensor Housing

Fig. 1, Cleaning an ABS Tone Ring

6. To ensure the ABS sensor is not stuck in the housing, push the sensor away from the tone ring and then back to it.
7. Do one of the following:
   - For drum brakes, install the brake shoes and drum. See **Section 42.01, Subject 110** and **Section 33.01, Subject 160** for instructions.
   - For disc brakes, install the hub and brake caliper. See **Section 33.01, Subject 100** and **Section 42.21, Subject 120** for instructions.
8. Install the wheel and tire assembly. For instructions, see **Group 40**.
9. Adjust drum brakes at the slack adjuster. For instructions, see **Section 42.01, Subject 130**.
10. Remove the safety stands, and lower the vehicle.

ABS Tone Ring Cleaning

Rear Axle

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Using a suitable jack, raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle.
3. Remove the wheel and tire assembly. For instructions, see **Group 40**.

⚠ 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. Do one of the following:
   - For drum brakes, remove the brake drum and shoes. See **Section 35.01, Subject 160** and **Section 42.01, Subject 110** for instructions.
   - For disc brakes, remove the brake caliper and hub. See **Section 42.21, Subject 120** and **Section 35.01, Subject 100** for instructions.

NOTICE

Do not use anything abrasive to clean an ABS tone ring. ABS tone rings can be scratched and damaged by abrasive contact.

NOTE: For disc brakes, the tone ring is located between the hub and brake rotor. On some vehicles, the brake rotor will need to be removed to access the tone ring.

5. Apply brake cleaner to the tone ring and remove any residue with a plastic-bristled brush. See **Fig. 1.**
6. To ensure the ABS sensor is not stuck in the housing, push the sensor away from the tone ring and then back to it.
7. Do one of the following:
   - For drum brakes, install the brake shoes and drum. See **Section 42.01, Subject 110** and **Section 35.01, Subject 160** for instructions.
   - For disc brakes, install the hub and brake caliper. See **Section 35.01, Subject 100** and **Section 42.21, Subject 120** for instructions.
8. Install the wheel and tire assembly. For instructions, see **Group 40**.
9. Adjust drum brakes at the slack adjuster. For instructions, see **Section 42.01, Subject 130**.
10. Remove the safety stands, and lower the vehicle.

Wiring Diagrams

For vehicle specific wiring diagrams, access EZWiring™ in ServicePro®.

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 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 displaced by either the outward 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.

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).

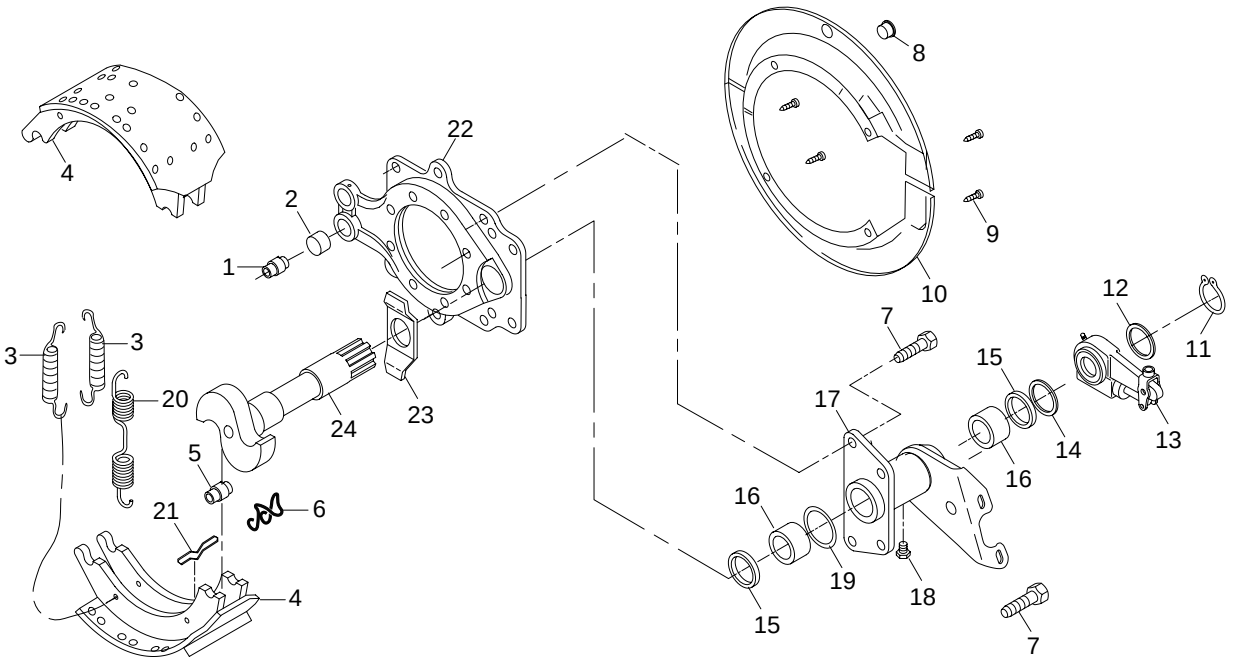
Principles of Operation

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



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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)

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.

Brake Shoe 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.

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

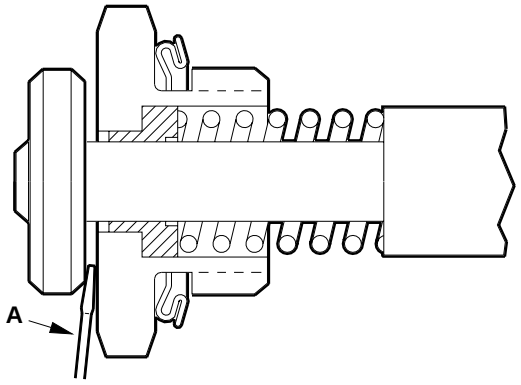
When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury or death.

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, as follows.
   - 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, and keep it there 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-pawl button out about 1/32 inch (0.8 mm).

Fig. 1, Pull-Pawl on Meritor Automatic Slack Adjusters

NOTE: On Haldex 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 the brake shoes are fully retracted and the drum clears the lining. See **Subject 130** for instructions.

Brake Shoe Removal and Installation

- On Meritor adjustors, turn the square adjusting nut clockwise (as if tightening a right-hand threaded fastener).
- On Haldex 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, as follows.

   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**.

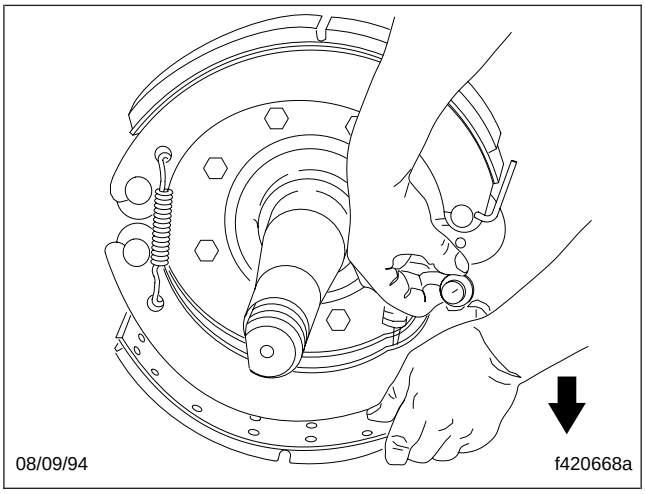


Fig. 2, Cam Roller Removal

   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.

9. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

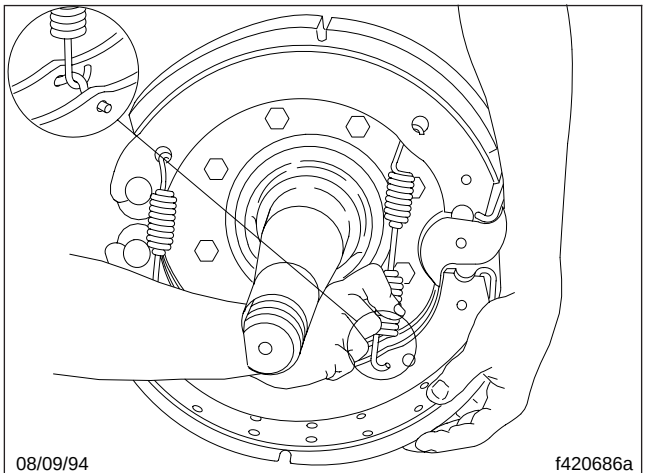


Fig. 3, Return Spring Removal/Installation, Straight Tie Bar

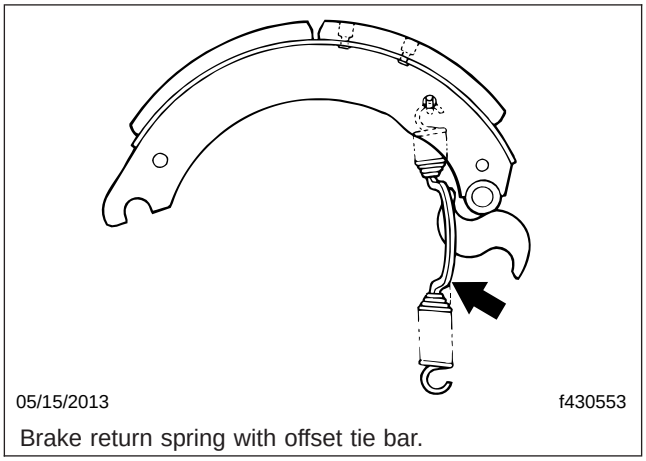


Fig. 4, Return Spring Removal/Installation, Offset Tie Bar

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.

NOTE: Springs, rollers, and anchor pins should be replaced when installing new brake linings.

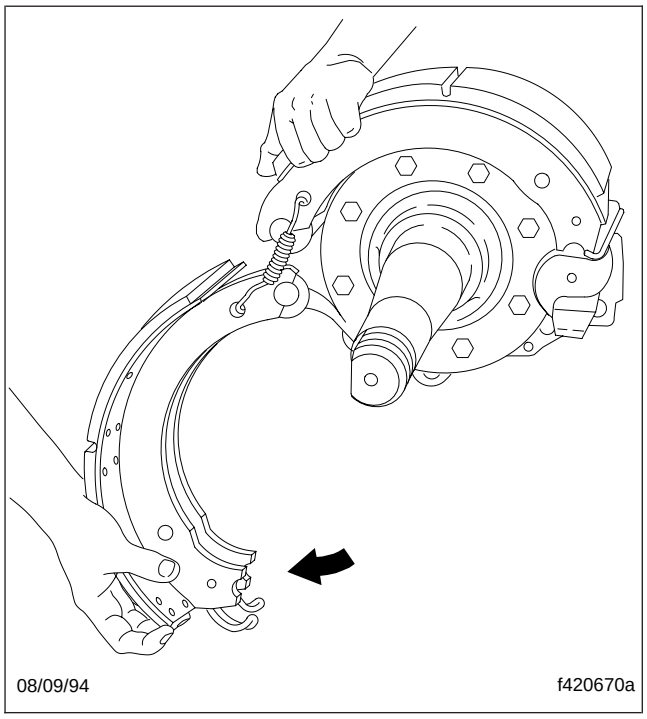


Fig. 5, Brake Shoe Removal

1. Install the brake shoes, as follows.

   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 multipurpose 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**.

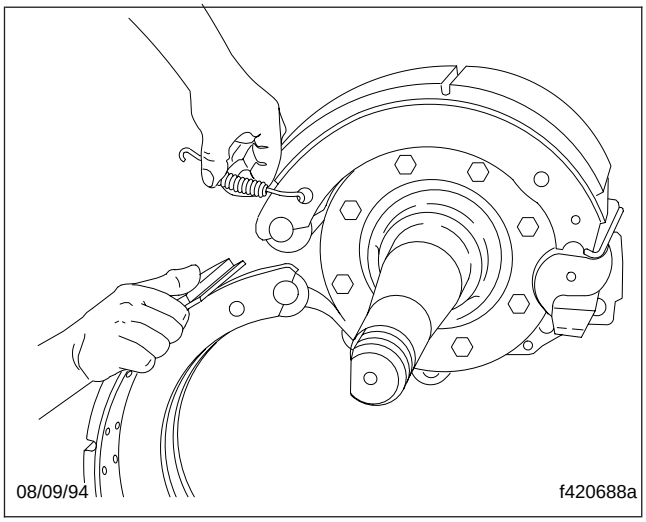


Fig. 6, Brake Shoe Retaining Spring Installation

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.

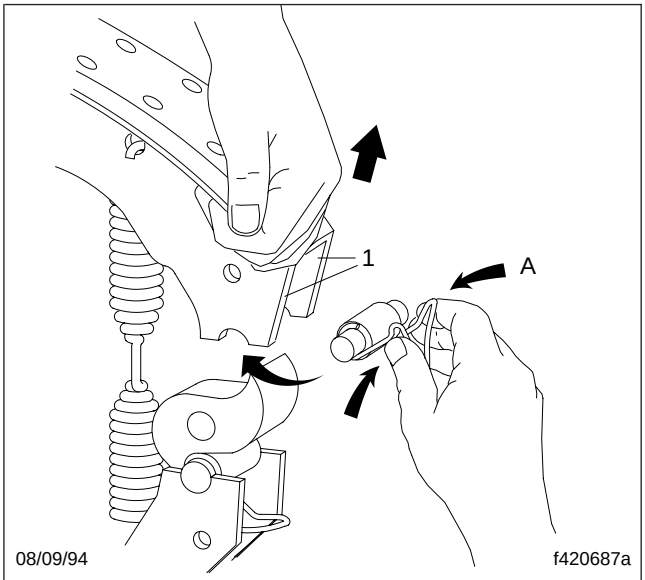
Squeeze the ears of the retainer clip together to fit between the brake shoe webs on the cam end of the brake shoes. See **Fig. 7**.

Push the retainer clips between the brake shoe webs until the ears lock in the holes in the webs. See **Fig. 8**.

1.5 Repeat substep 1.4, for the upper brake shoe.

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**.

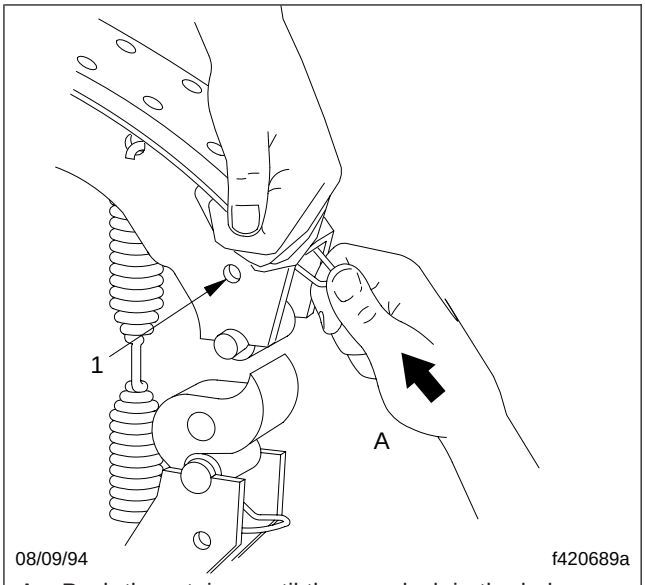
Brake Shoe Removal and Installation



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, and lower the vehicle.

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, as follows.
   - 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 show a lack of braking effort on those wheels.

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Inspection

1. Remove the brake shoes as needed to perform the followig inspections. Use the instructions in **Subject 110** for shoe removal.
2. Check the linings, as follows.

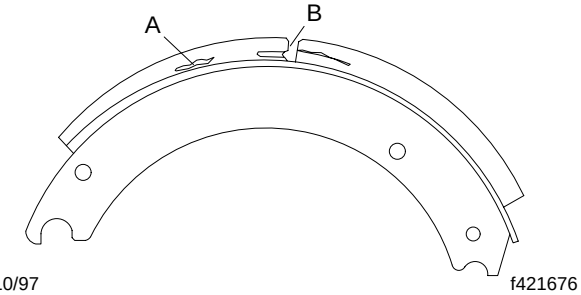
   2.1 If the linings are grease- or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.

   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 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**.



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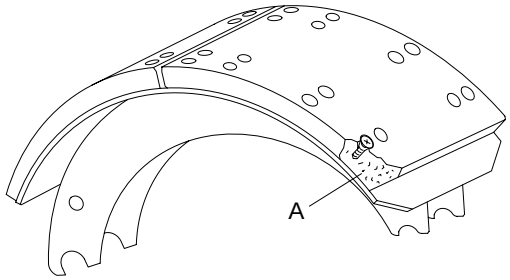
A. Cracks exceeding 1-1/2 inches (38 mm) in length.
B. Cracks or voids exceeding 1/16 inch (1.6 mm) in width.

Fig. 1, Cracks and Voids

   - Portions of the lining are missing exposing a rivet when viewed from the edge. See **Fig. 2**.



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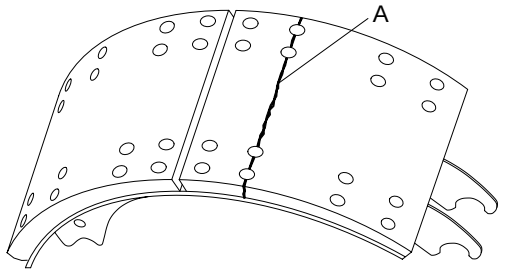
A. Exposed fastening device.

Fig. 2, Portions of Brake Lining Missing

   - Cracks extend across the lining face and through the lining edge, or the lining is loose on the shoe. See **Fig. 3**.



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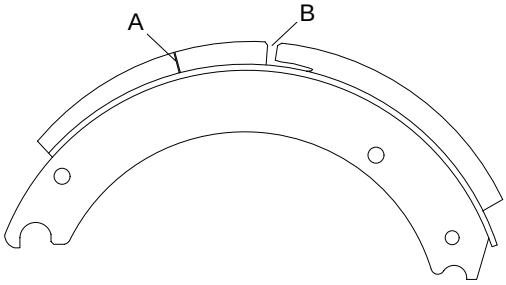
A. Cracks extending through the lining edge.

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 material and do not exceed 1/16 inch (1.6 mm) in width or 1-1/2 inches (38 mm) in length. See **Fig. 4**.
   - Corner portions of the lining are missing with no fastener exposed. See **Fig. 5**.

Brake Shoe and Lining Inspection



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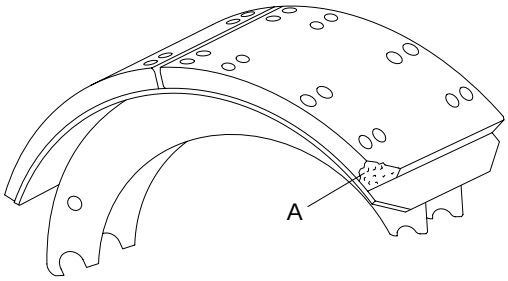
A. Cracks not exceeding 1-1/2 inches (38 mm) in length or 1/16 inch (1.6 mm) in width.
B. Voids under the lining not exceeding 1-1/2 inches (38 mm) in length or 1/16 inch (1.6 mm) in width.

Fig. 4, Cracks and Voids



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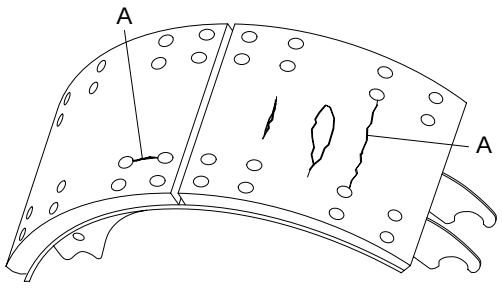
A. Corner segment is missing but no fastener is exposed.

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.
5. Check the diameter of the anchor pin holes. The anchor pin holes must not exceed 1.009 inch (25.6 mm). Replace the shoes if needed.



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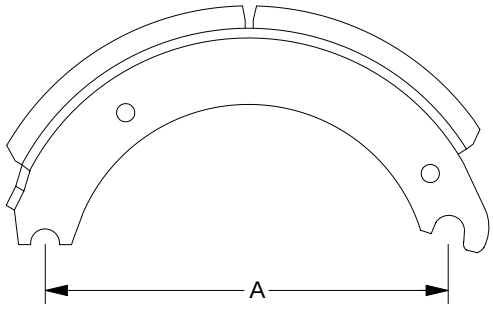
A. Cracks extending from hole to hole.

Fig. 6, Crack in the Brake Lining

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 shoes if needed. See **Fig. 7**.



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A. 12-7/8 inches (327 mm) maximum

Fig. 7, Measuring the Shoe Span

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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**.
- 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 42.11**, or **Section 42.12** for Haldex, or Meritor slack adjusters, respectively.

⚠ 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.

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. Measuring and adjusting the applied chamber stroke (fine adjustment).
2. Measuring and adjusting the free-stroke.
3. Adjusting the approximate brake chamber stroke using the manual adjusting nut on the slack adjuster (coarse 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)	
		New Brake Installation	In Service Brake
Long Stroke†			
16, 20, and 24	2 (51)	5/8 to 3/4 (16 to 19)	1/2 to 5/8 (13 to 16)
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

⚠ 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.

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, or there is no retaining clip, see **Section 42.12** for slack adjuster disassembly and inspection procedures.

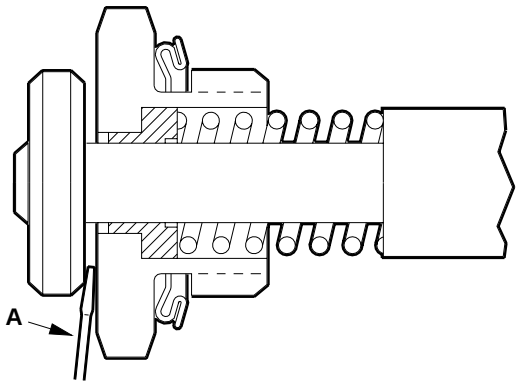
⚠ CAUTION

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), as follows. 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.



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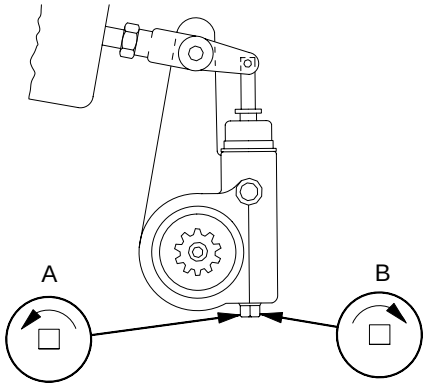
A. Insert screwdriver here.

Fig. 1, Disengaging the Pull-Pawl



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A. Shorten stroke. B. Lengthen stroke.

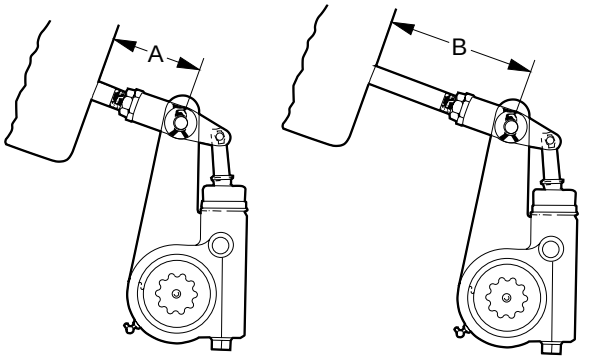
Fig. 2, Adjusting the Stroke

7. Measure and adjust the applied chamber stroke (fine adjustment), as follows.

   7.1 If system pressure is not already at 100 psi (689 kPa), start the engine and build air pressure, then shut down the engine.

   7.2 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. 3**.

   7.3 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. 3**, Ref. B. Record this measurement as dimension C.



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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 C. 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.

   7.5 The applied chamber stroke must not exceed the maximum value specified in **Table 1**.

   If the applied chamber stroke is within limits, as shown in **Table 1**, no further checking is necessary. Skip the rest of this step, and do not check free stroke.

   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.

   7.6 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.

8. Measure and adjust the free-stroke, as follows.
   - 8.1 Using a lever, move the slack adjuster until the brake linings contact the brake drum.
   - 8.2 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**.
   - 8.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.
   - 8.4 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. 2**. Then, measure the free-stroke again, and readjust it until it is correct.
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

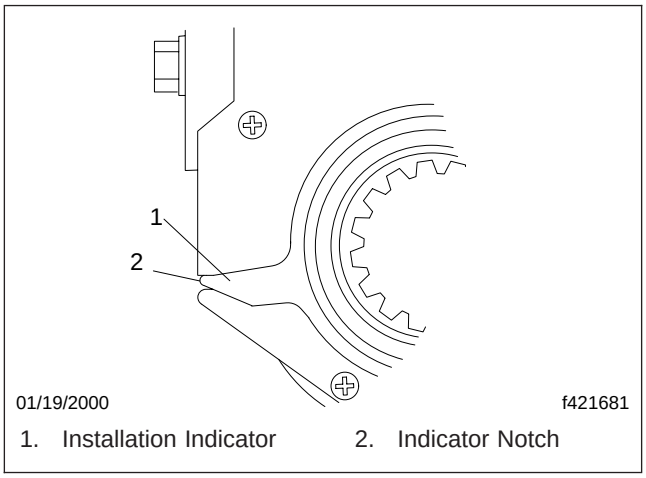
IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

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), as follows.
   - 5.1 Using a torque wrench and a 7/16-inch socket, 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.

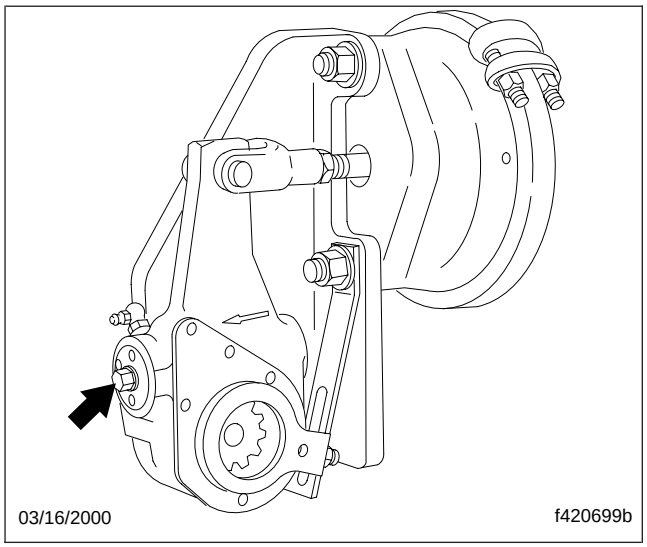


Fig. 5, Adjusting Hexnut

6. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment), as follows.

   6.1 Turn the adjusting nut clockwise until the brake linings contact the brake drum.

   6.2 Then, turn the adjusting nut counterclockwise 1/2 turn. You will hear a ratcheting sound.

7. Measure and adjust the applied chamber stroke (fine adjustment), as follows.

   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 far side of the clevis pin hole. See **Fig. 6**, 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 applied chamber stroke is within legal limits, no further checking is necessary. Skip the rest of this step, and do not check free stroke.

   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.

   7.5 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.

8. Measure and adjust the free-stroke, as follows.

   8.1 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.

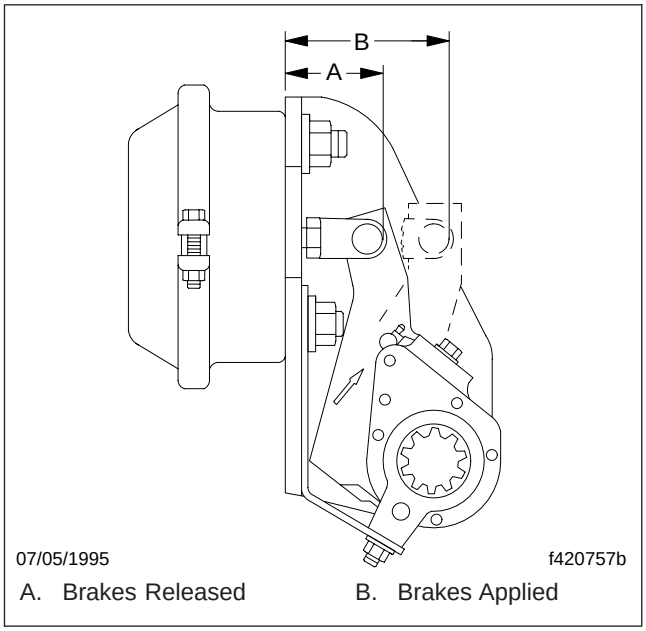


Fig. 6, Measuring the Stroke

   8.2 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.

   8.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

   8.4 The free-stroke for a new brake installation should be 5/8 to 3/4 inch (16 to 19

Brake Adjustment

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 in the required direction. Then, measure the free-stroke again and readjust it until it is correct.

9. 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.

10. Check for proper brake operation. For instructions, see **Subject 110**.

Brake Components Disassembly, Inspection, Cleaning, and Assembly

Disassembly and Inspection

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

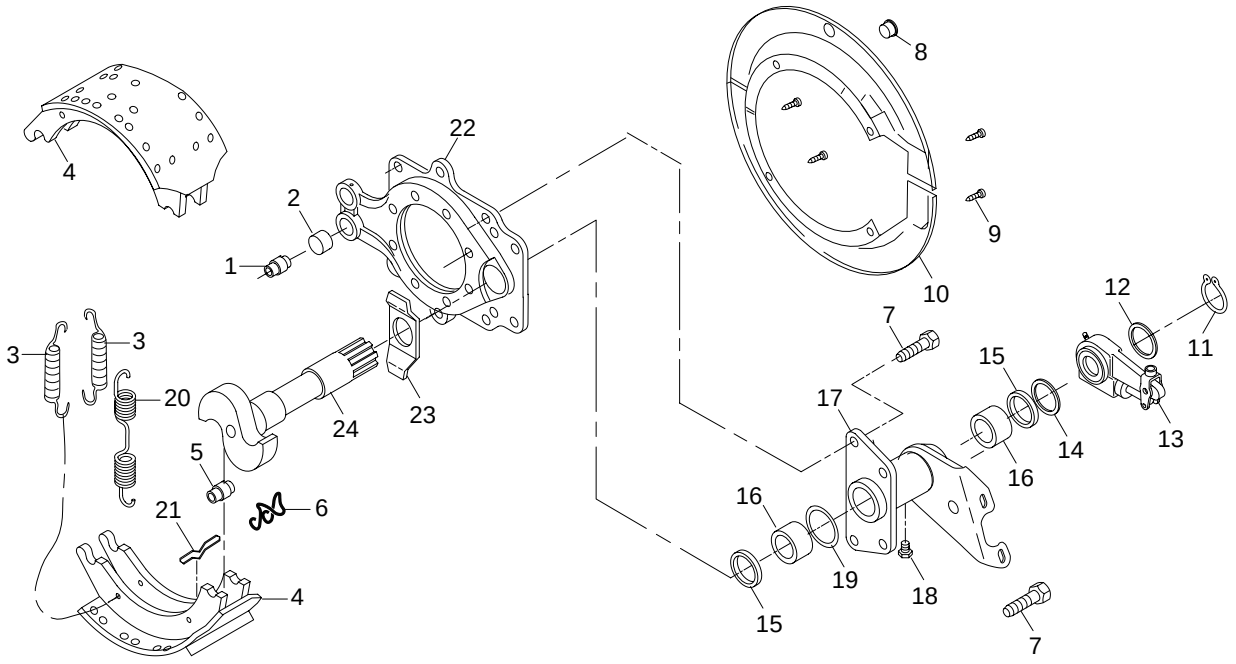
Three Q Plus brake assemblies are shown in the following figures:

- **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, as follows. 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



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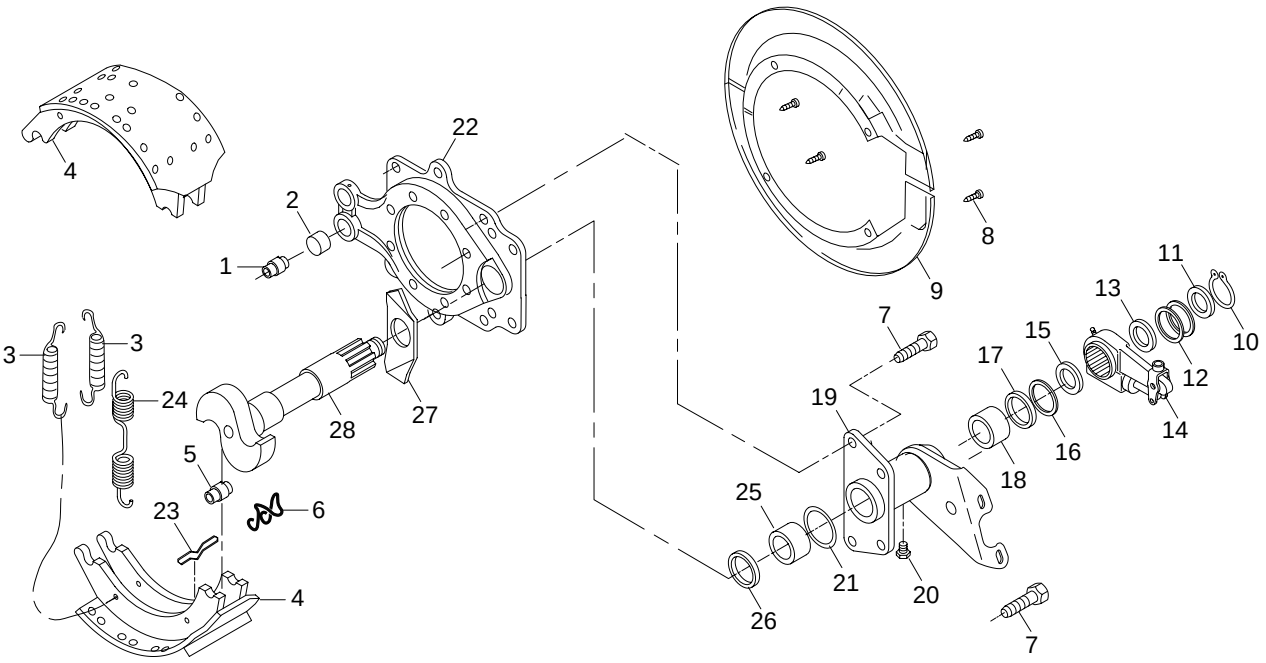
1. Anchor Pin
2. Anchor Pin Bushing
3. Retaining Spring
4. Brake Shoe and Lining Assembly
5. Cam Roller
6. Roller Retainer
7. Capscrew, Chamber Bracket
8. Plug
9. Capscrew, Dust Shield
10. Dust Shield
11. Camshaft Snap Ring
12. Washer (spacer)
13. Automatic Slack Adjuster
14. Washer (thick spacer)
15. 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



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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" i.d.
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" i.d.
26. Orange Camshaft Seal
27. Camhead Thrustwasher
28. S-Head Camshaft

Fig. 2, Q Plus MX500 Brake (with cast spider)

repaired. For detailed instructions, see **Section 33.01** or **Section 35.01**.

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, as follows. For detailed instructions, see **Section 42.11** for Haldex, or **Section 42.12** for Meritor automatic slack adjusters.

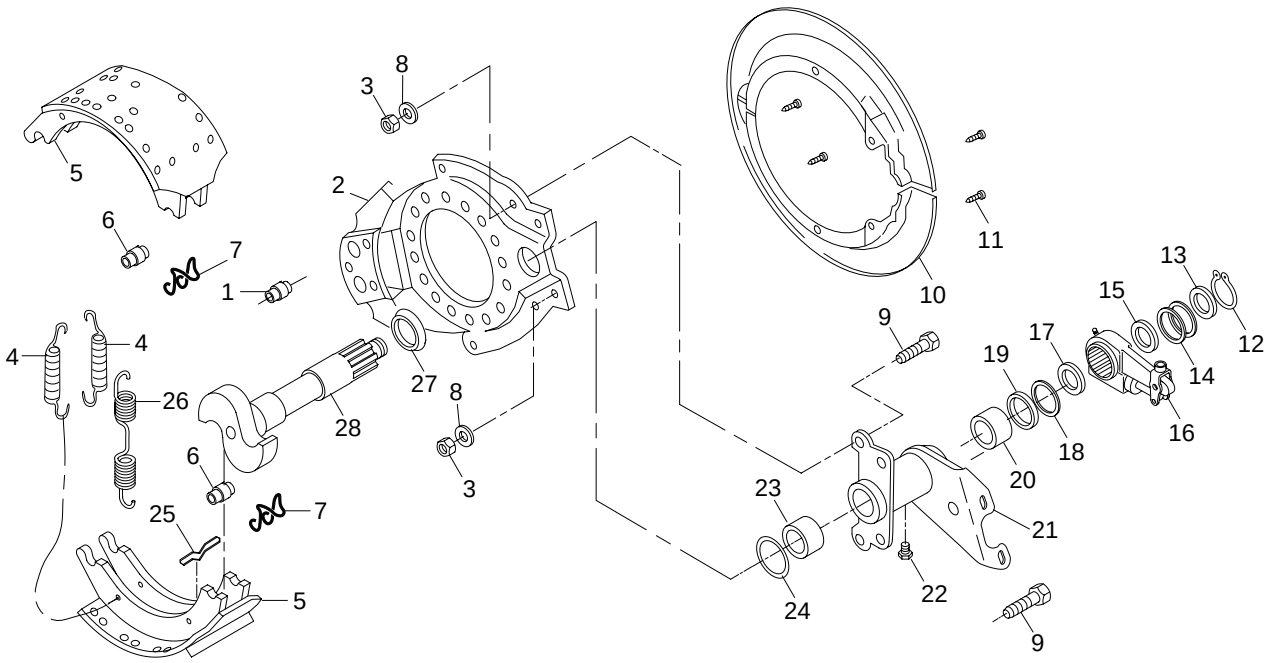
3.1 Remove the cotter pin from the clevis pin; remove the clevis pin. See **Fig. 5**.

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



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" i.d.
21. Camshaft-and-Chamber Bracket
22. Pipe Plug
23. Camshaft Bushing, 1-5/8" i.d.
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 adjusters, turn the adjusting hexnut counterclockwise. You will hear a ratcheting sound.

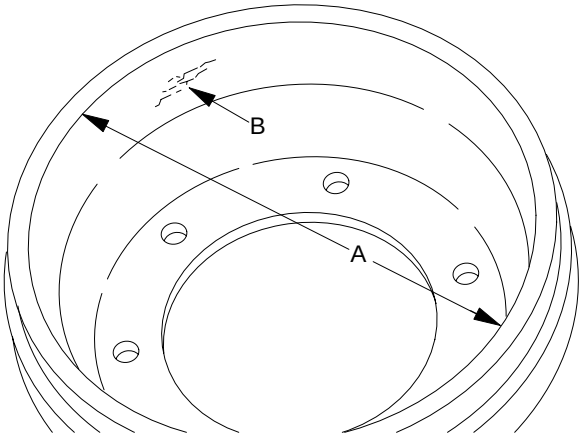
4. Check the camshaft radial free play, as follows. See **Fig. 7**.

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, as follows.

Brake Components Disassembly, Inspection, Cleaning, and Assembly



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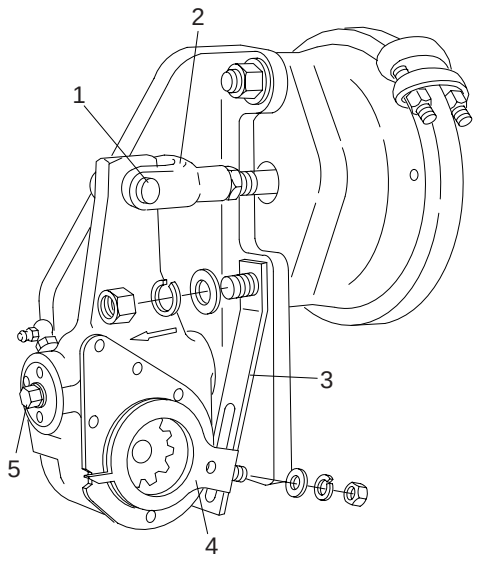
A. Check for diameter and out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 4, Brake Drum Inspection



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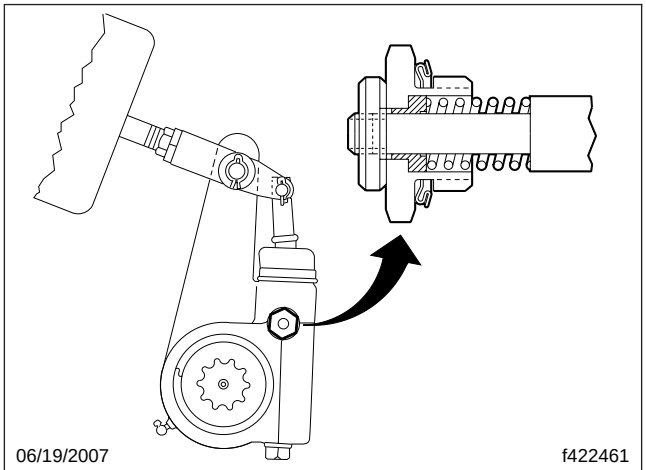
1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

Fig. 5, Disconnecting Slack Adjuster from Clevis



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A. Insert a screwdriver here to pry the pull-pawl out about 1/32 inch (0.8 mm).

Fig. 6, Meritor ASA Pull-Pawl Disengagement

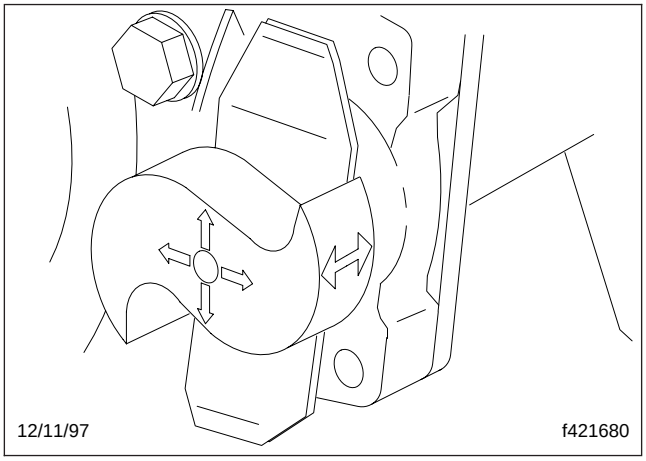

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Fig. 7, Checking Free Play

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, as follows.

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 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).

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.

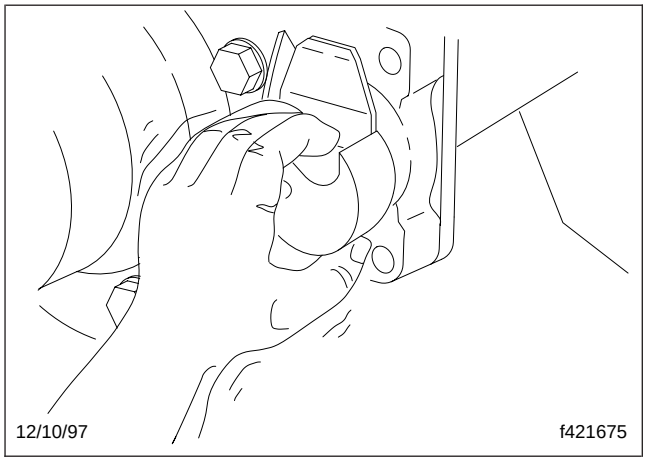


Fig. 8, Removing the Camshaft

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 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.
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, as follows.

Brake Components Disassembly, Inspection, Cleaning, and Assembly

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, as follows.

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.

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.

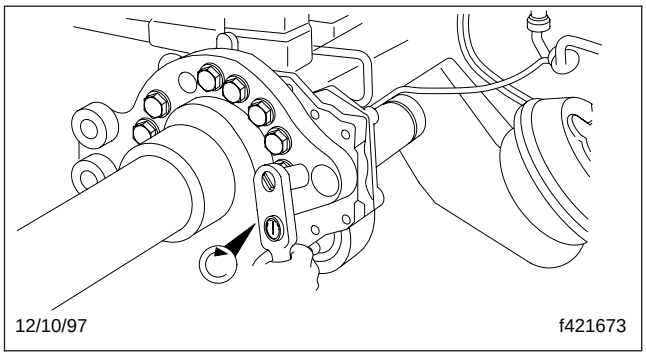


Fig. 9, Tightening the Brake Spider Fasteners

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, as follows.

Fastener		Torque Specification	
Description and Size	Grade	lbf·ft	N·m
Dust Shield Fasteners			
5/16–18	5	15–20	20–27
3/8–16	5	25–35	34–47
3/8–16	8	35–50	47–68
Brake Spider Fasteners			
7/16–20		60–75	81–102
1/2–20		85–115	115–156
9/16–18		135–165	183–224
5/8–18		180–230	244–312
Camshaft-and-Chamber Bracket Fasteners			
1/2–13 Capscrew (without nut)	5	65–85	88–116
1/2–13 Capscrew (without nut)	8	70–100	95–136
5/8–18 Bolt with Locknut		130–165	176–224
5/8–18 Bolt with Plain Hexnut		150–190	203–258

Table 1, Dust Shield, Spider, and Bracket Torque Specifications

Brake Components Disassembly, Inspection, Cleaning, and Assembly

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, lockwashers, and stud nuts.

4.3 Tighten the brake chamber fasteners to the specifications in **Table 2**.

Brake Chamber Torque Specifications: lbf·ft (N·m)		
Chamber Type (Size)	**MGM**	**Haldex**
16	35–40 (48–54)	100 (136)
20, 24, 30, 36	100–115 (136–156)	100 (136)
Spring Chamber	100–115 (136–156)	100 (136)

Table 2, Brake Chamber Torque Specifications

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, as follows. See **Fig. 12**.

6.1 Put the cam head thrustwasher on the camshaft with the bent flaps toward the brake spider.

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.

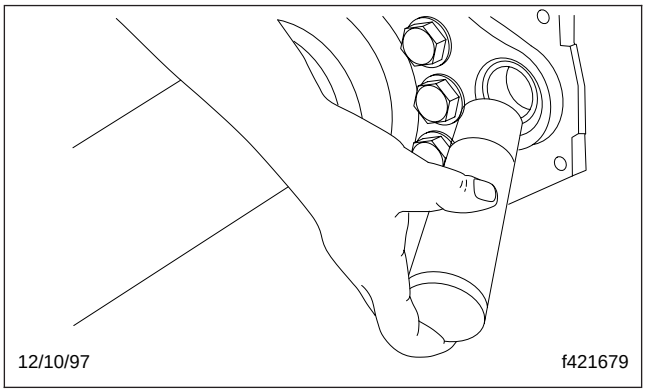
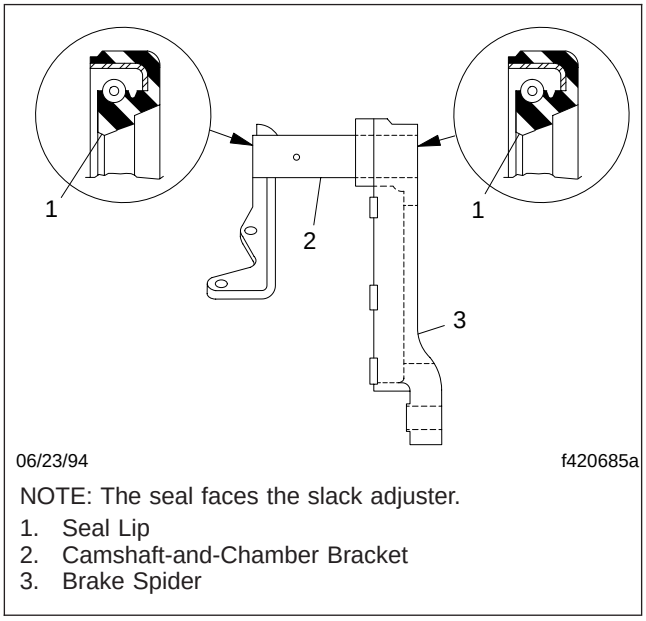


Fig. 10, Installing the Seals and Bushings



NOTE: The seal faces the slack adjuster.
1. Seal Lip
2. Camshaft-and-Chamber Bracket
3. Brake Spider

Fig. 11, Positioning the Seals

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.

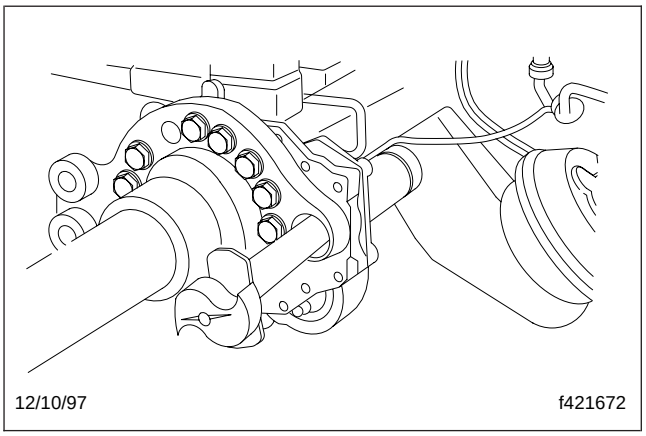


Fig. 12, Installing the Camshaft

7. Install the slack adjuster. For instructions, see **Section 42.11** for Haldex, or **Section 42.12** 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 vehicle's stopping distance could be reduced, which could result in personal injury or property damage.

8. For all Cam-Master Q Plus brakes except MX500, pressure lube the camshaft-and-chamber bracket bushings, as follows.

   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.

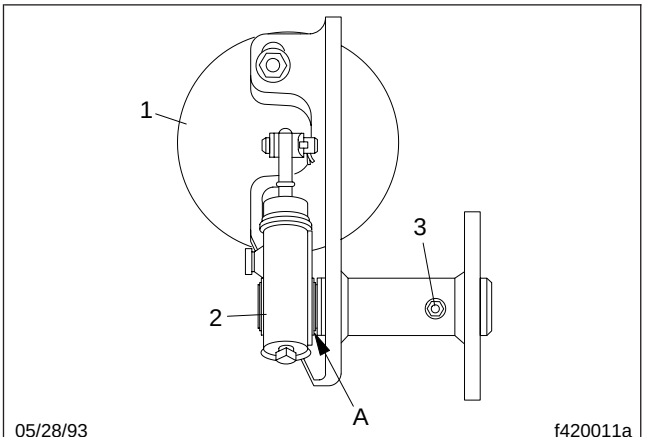
9. For MX500 brakes, when changing the brake linings at the service interval, lubricate the camshaft-and-chamber bracket and the automatic slack adjuster, as follows.

   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**.



A. Grease Exit

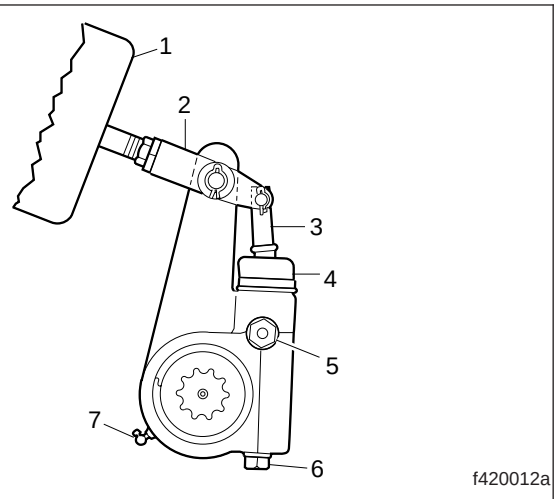
1. Brake Chamber
2. Slack Adjuster
3. Grease Fitting (or lube plug)

Fig. 13, Camshaft-and-Chamber Bracket Lubrication

   9.5 Using Meritor-approved NLGI grade 2 synthetic polyurea grease (EVO-LUBE TEK-615), lubricate the slack adjuster through

Brake Components Disassembly, Inspection, Cleaning, and Assembly

the grease fitting until new grease flows out of the pull-pawl or camshaft seal. See **Fig. 14**.



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**.

Specifications

Q Plus Brake Torque Specifications			
Fastener Description and Size	**Grade**	**lbf·ft**	**N·m**
Brake Shoe Lining Nuts			
1/4 in	5	80 to 100 lbf·in	900–1120 N·cm
3/8 in	5	18–23	24–31
Dust Shield Fasteners			
5/16–18	5	15–20	20–27
3/8–16	5	25–35	34–47
3/8–16	8	35–50	47–68
Brake Spider Fasteners			
7/16–20		60–75	81–102
1/2–20		85–115	115–156
9/16–18		135–165	183–224
5/8–18		180–230	244–312
Camshaft-and-Chamber Bracket Fasteners			
1/2–13 Capscrew (without nut)	5	65–85	88–116
1/2–13 Capscrew (without nut)	8	70–100	95–136
5/8–18 Bolt with Locknut		130–165	176–224
5/8–18 Bolt with Plain Hexnut		150–190	203–258

Table 1, Q Plus Brake Torque Specifications

Brake Chamber Torque Specifications: lbf·ft (N·m)		
Chamber Type (Size)	**MGM**	**Haldex**
16	35–40 (48–54)	100 (136)
20, 24, 30, 36	100–115 (136–156)	100 (136)
Spring Chamber	100–115 (136–156)	100 (136)

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)
O-637	1 and 2	Calcium Base	See Manufacturer's Specification
O-641	—	Anti-Seize	See Manufacturer's Specification

Specifications

Meritor Grease Specification			
Specification Number	**NLGI Grade**	**Grease Type**	**Outside Temperature: °F (°C)**
O-695	2	Synthetic Polyurea	–40 (–40)

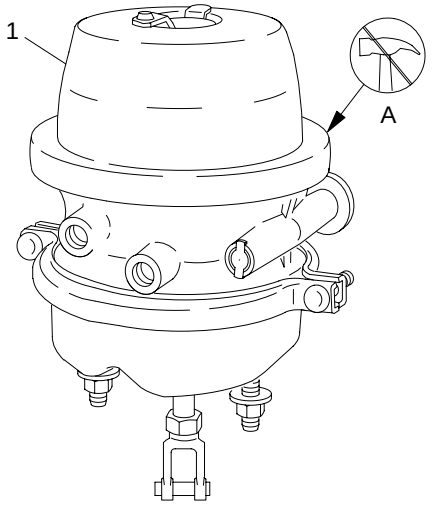
Table 3, Meritor Grease Specification

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

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.



02/22/2000 f421352

A. Do not remove the factory-sealed clamp ring.

1. Model TR Brake Chamber

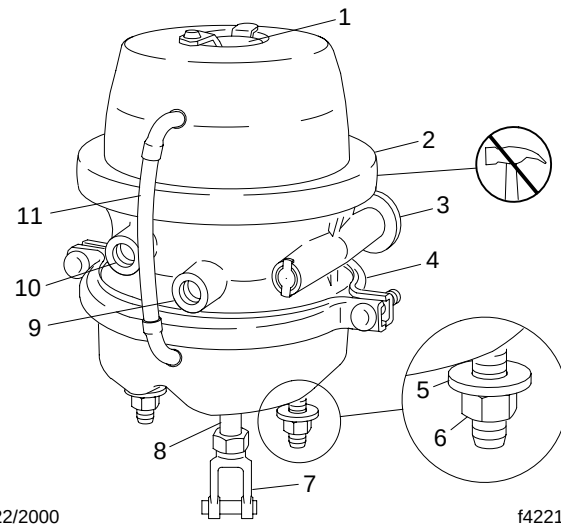
Fig. 1, Brake Chamber

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.



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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. Parking 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.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

- Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber piston rods and slack adjusters; the brakes may apply as air system 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.
- 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.

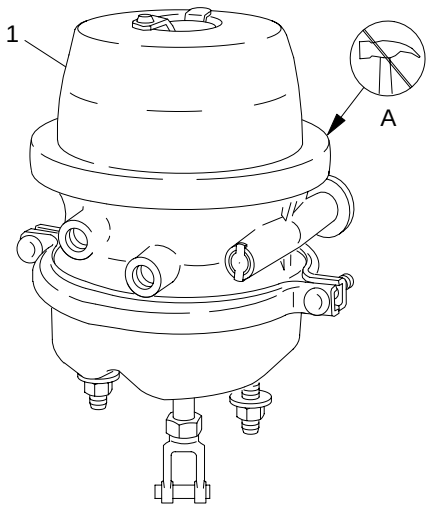
Manual Release of Spring Brake (Caging)

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

⚠ 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**.

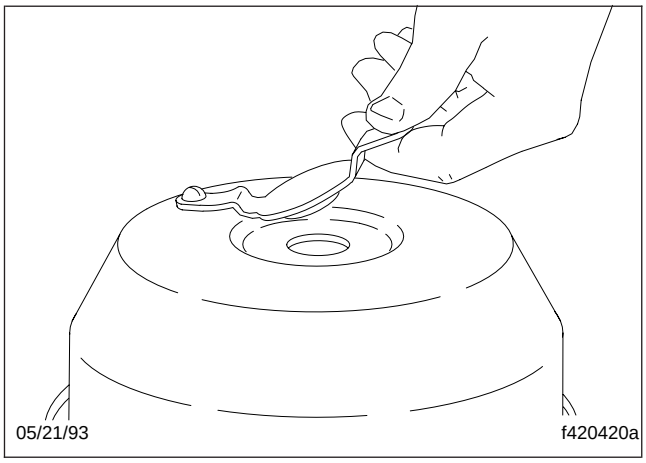

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Fig. 2, Removing the End-Cover Cap

⚠ 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. 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. 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.

4. Insert the release bolt in the center-hole into the chamber head. See **Fig. 4**. Insert the bolt until it bottoms out in the hole in the piston inside the chamber.

Manual Release of Spring Brake (Caging)

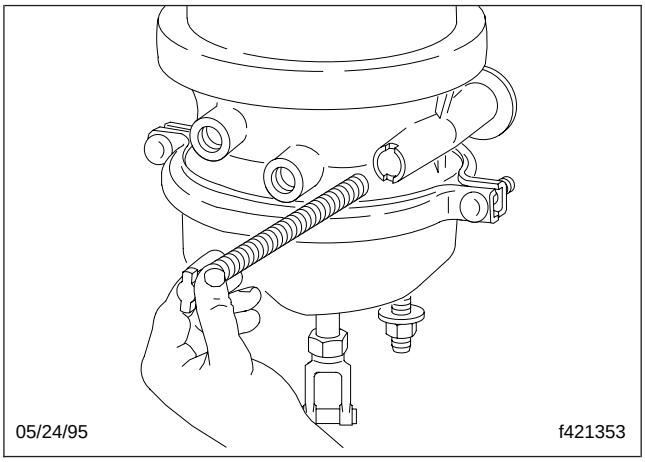


Fig. 3, Removing the Release Bolt

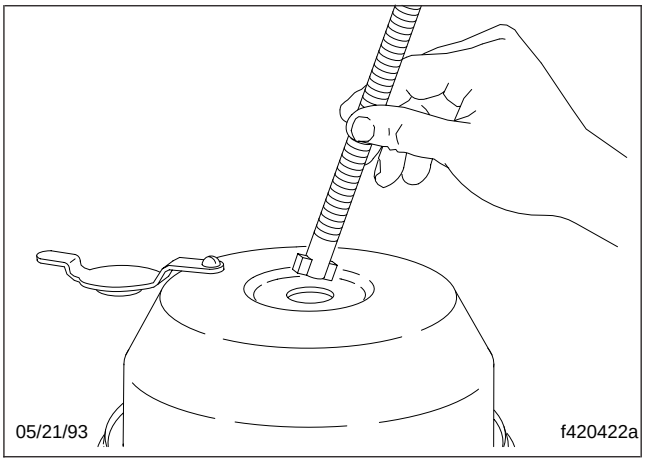


Fig. 4, Inserting the Release Bolt

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.

5. 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.

IMPORTANT: Don't exceed the designated length for the type of chamber used.

6. 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**.

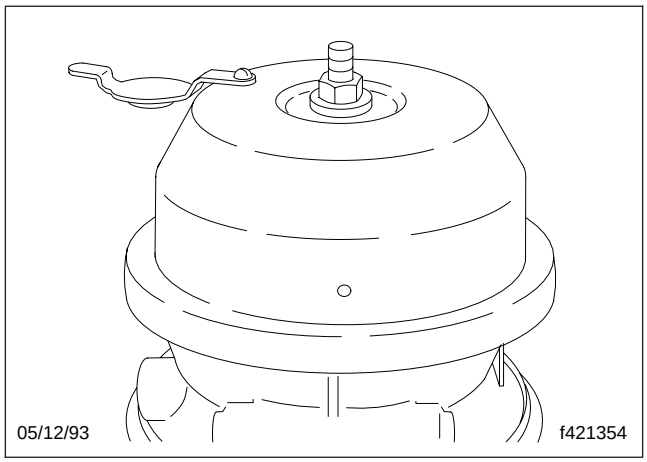


Fig. 5, Flatwasher and Release Nut Installed

⚠ CAUTION

Do not exceed 50 lbf·ft (68 N·m) torque on the release nut; and do not 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.

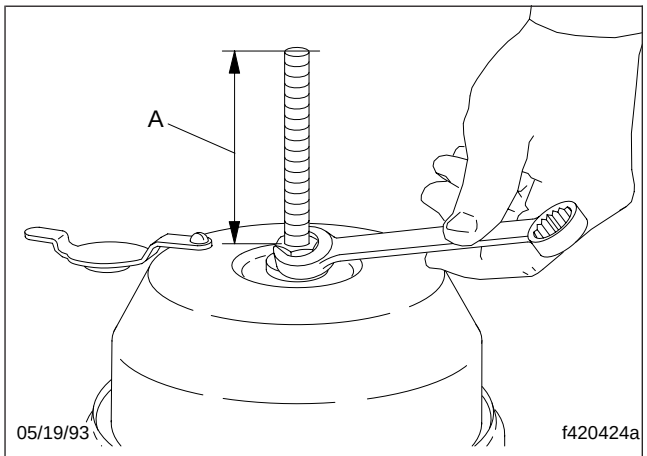
7. Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the bolt extends above the nut 3.25 inches (80 mm) on type 2430 and 3030 chambers and 4 inches (100 mm) on type 3036 and 3636 chambers. See **Fig. 6**.
8. Once the power spring has been caged, exhaust the compressed air from the parking brake.

Manual Reset (Parking Brake Reset)

1. Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

⚠ CAUTION

Do not exceed 50 lbf·ft (68 N·m) torque on the release nut; and do not use an impact wrench on



Don't exceed the designated length.
A. Measure this distance.

Fig. 6, Turning the Release Nut

this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

2. Use a hand wrench to turn the release nut *counterclockwise* until the bolt bottoms out in the unit.
3. Remove the nut and flatwasher.
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.
5. 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**.
6. 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.

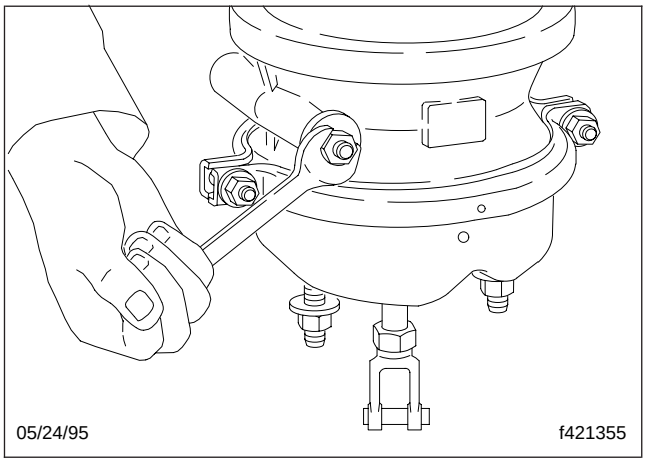


Fig. 7, Tightening the Release Nut

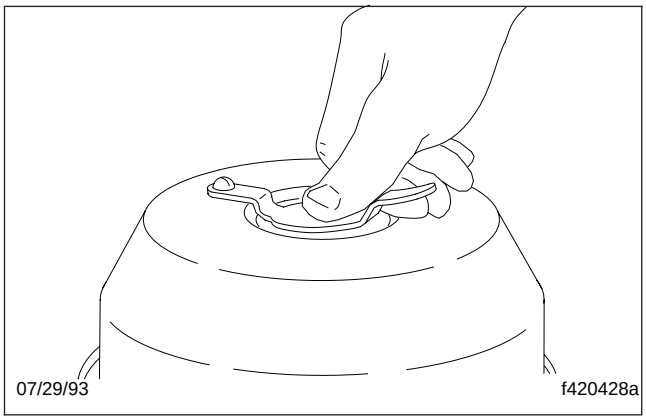


Fig. 8, Snapping the end-cover Cap in Place

7. Check the plastic end-cover cap periodically, and replace it with a new one at once if damaged or missing.

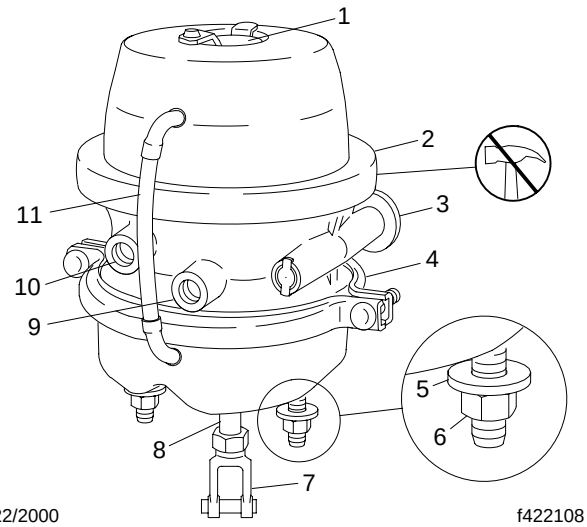
Service Brake Diaphragm Replacement

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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)

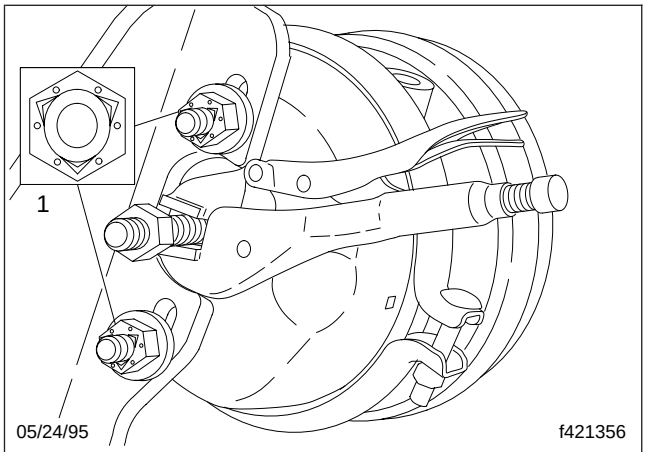
Fig. 1, Model TR-T (TR Series) Brake Chamber

Replacement

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, as follows.

   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, Locking the Piston Rod in Place

WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in Subject 110. 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 110.
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.

Service Brake Diaphragm Replacement

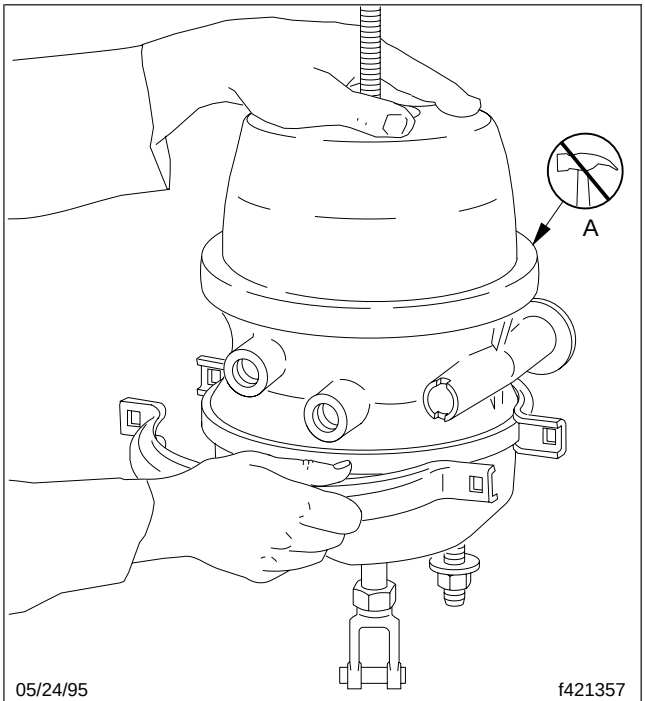
⚠ DANGER

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.

4. Remove the parking brake section from the service brake section, as follows.

   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**.



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A. Do not remove the factory-sealed clamp ring.

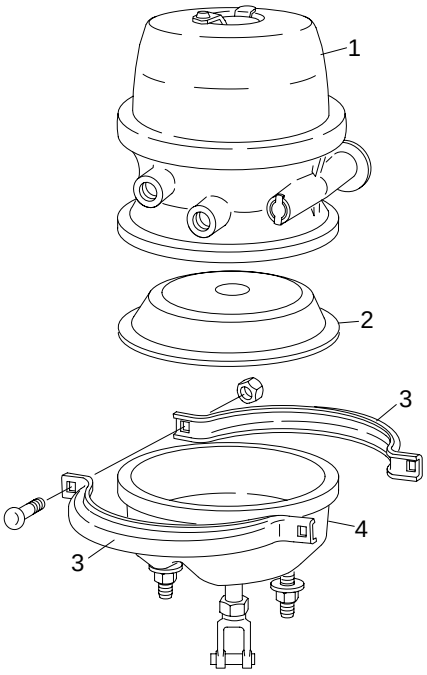
Fig. 3, Removing the Service Clamp Ring

5. Remove the service brake diaphragm from the bottom of the parking brake section.

6. Inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust.

7. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts with genuine MGM-engineered replacement parts.

8. Place the new service brake diaphragm in the bottom recess of the parking brake section. See **Fig. 4**.



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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

9. Install the (new, if needed) parking/emergency brake section, as follows.

   9.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

   9.2 Check that the release bolt is fully extended outward. For instructions, see **Subject 110**.

9.3 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.

10. Install the service brake clamp ring, as follows.

10.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

10.2 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.

10.3 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).

11. 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).

12. 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).

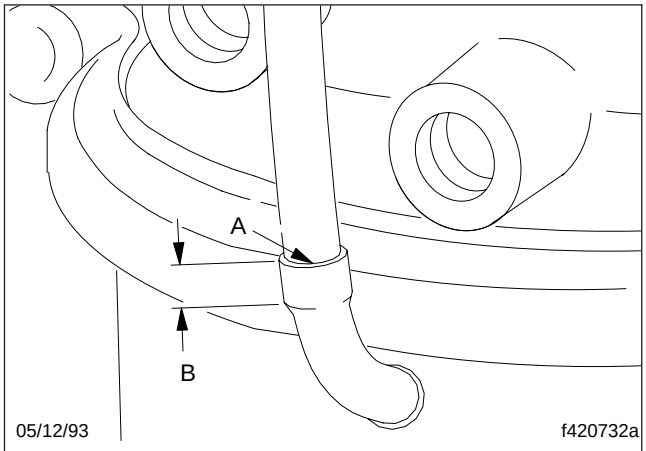
13. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

⚠ 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.

14. 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.

15. 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, Installing the External Breather Tube

16. 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 110**.

17. 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.

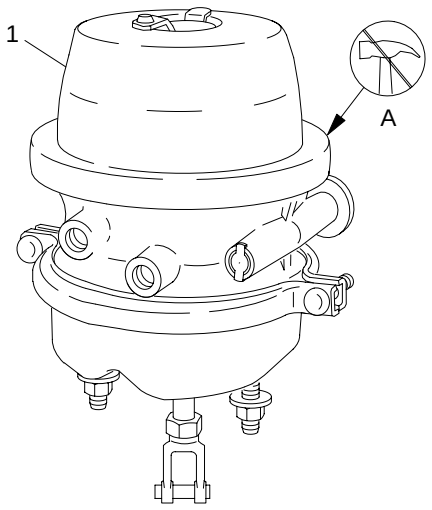
Combination Service and Parking Brake Chamber Removal and Installation

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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.



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A. Do not remove the factory-sealed clamp ring.
1. Model TR-T (TR Series) Brake Chamber

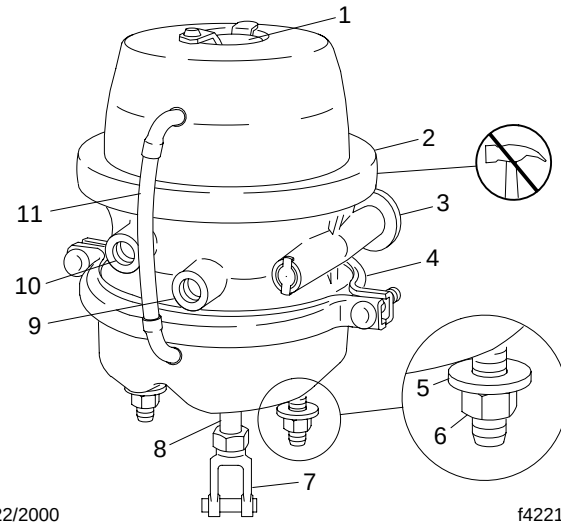
Fig. 1, Brake Chamber

Removal

Refer to **Fig. 2** for brake chamber parts identification.

WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in Subject 110. 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.



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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. Parking Brake Air Inlet
11. External Breather Tube (optional)

Fig. 2, Model TR-T (TR Series) Brake Chamber

1. Manually release the parking brake (cage the power spring). For instructions, see **Subject 110**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the cotter pins from the clevis pins, then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.
4. Make sure the parking brake has been released manually (the power spring has been caged). For instructions, see **Subject 110**. 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 (see **Fig. 4**) to exactly duplicate the "rod only" length *before* the clevis assembly is installed on the piston rod.

5. From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

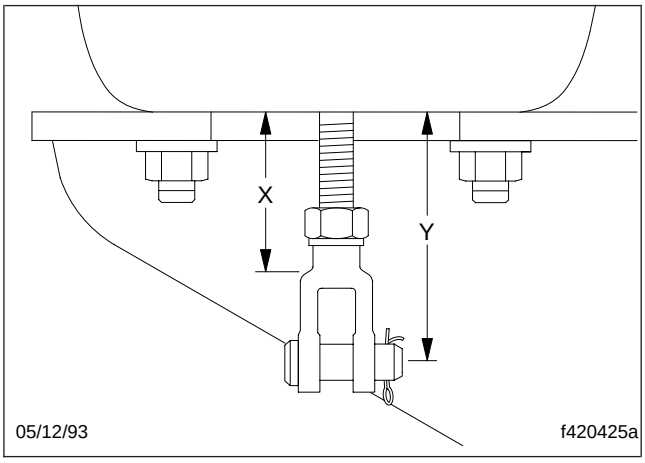


Fig. 3, Measuring X and Y

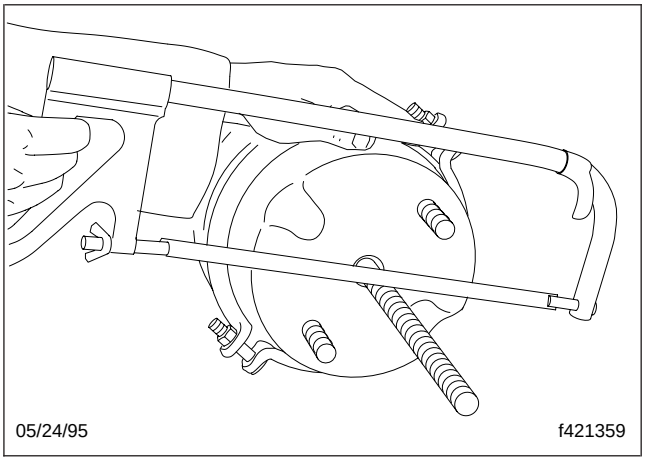


Fig. 4, Cutting the Service Piston Rod

Installation

Refer to **Fig. 2** for brake chamber parts identification.

1. If installing a new brake chamber unit, do the following:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 110** 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, as follows. 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 110**.

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.

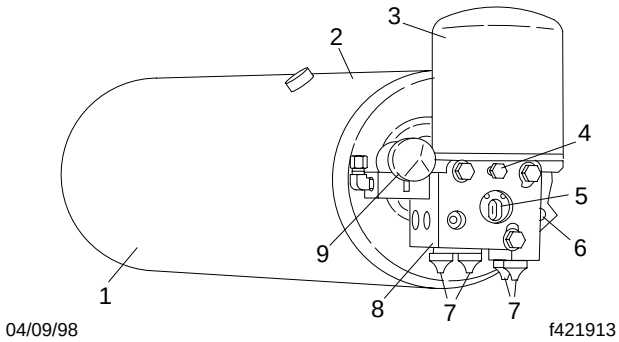
Specifications

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

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

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 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. 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 and 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

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.

General Information

The purge cycle lasts only a few seconds and is detected by an audible burst of air at the air dryer exhaust.

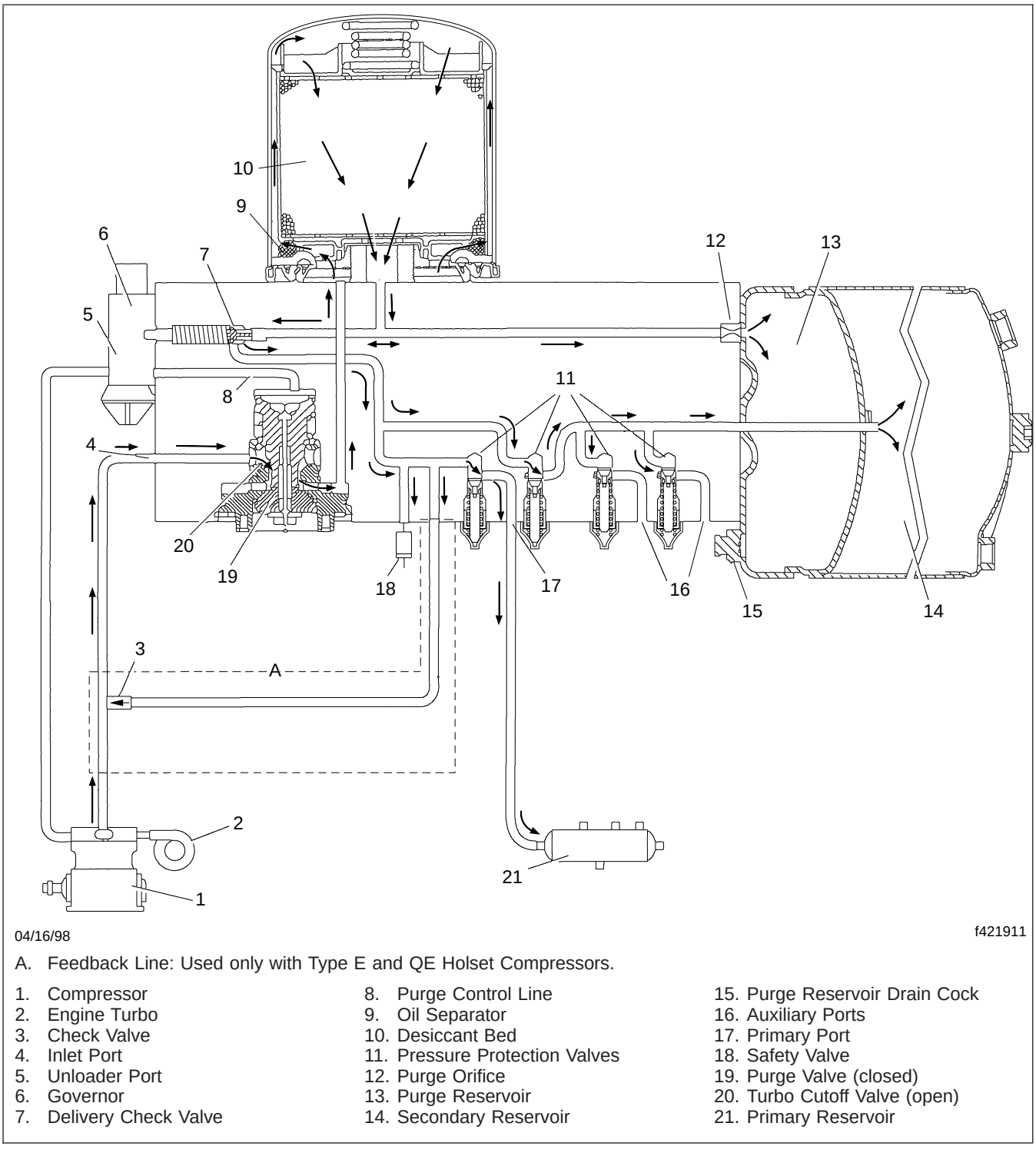
The reactivation of the desiccant drying bed begins as dry air flows from the purge reservoir, through the purge orifice, and into the desiccant bed. Pressurized air from the purge reservoir expands after passing through the purge orifice; its pressure is lowered and its volume is increased. The flow 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 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.

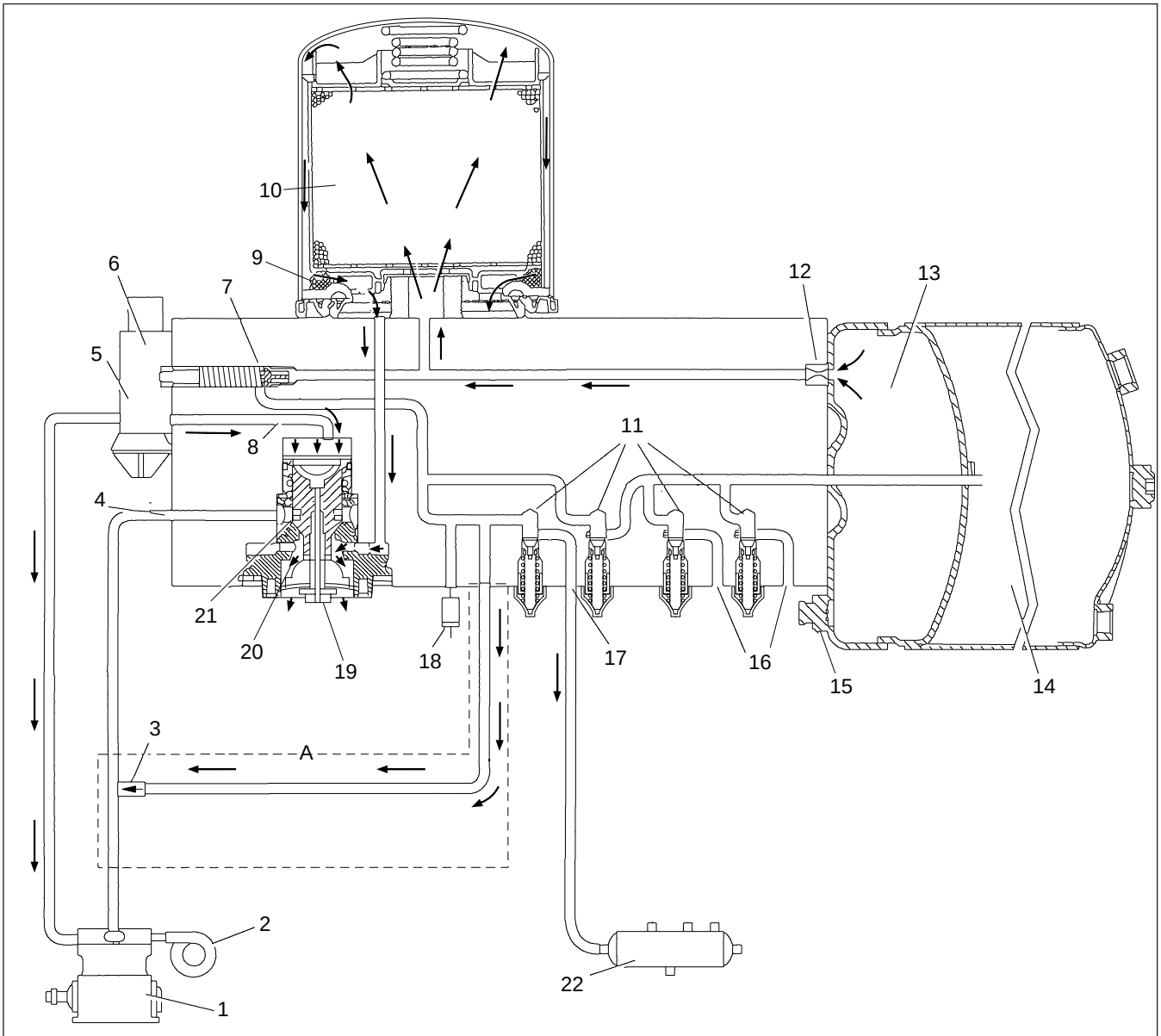


A. Feedback Line: Used only with Type E and QE Holset Compressors.

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

General Information



A. Feedback Line: Used only with Type E and QE Holset Compressors.

1. Compressor
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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. 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 pushrods 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.

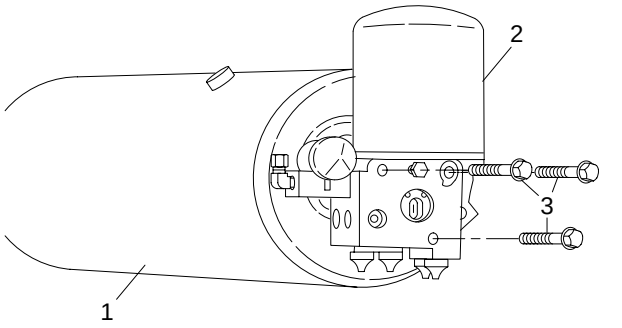
D. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

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, 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 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, DRM (air dryer capscrews shown)

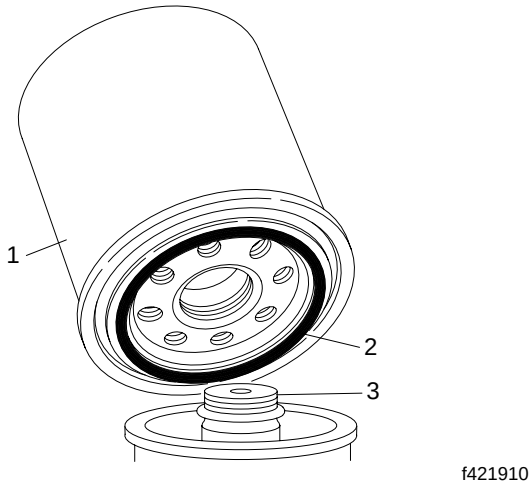
6. Remove the governor and delivery check valve from the air dryer. For instructions, see **Subject 130**.
7. Remove the desiccant cartridge. For instructions, see **Subject 120**.
8. Install the delivery check valve and governor onto the new air dryer. For instructions, see **Subject 130**.
9. If removed, 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**.

⚠ 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. 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.

Delivery Check Valve and Governor Replacement

⚠ WARNING

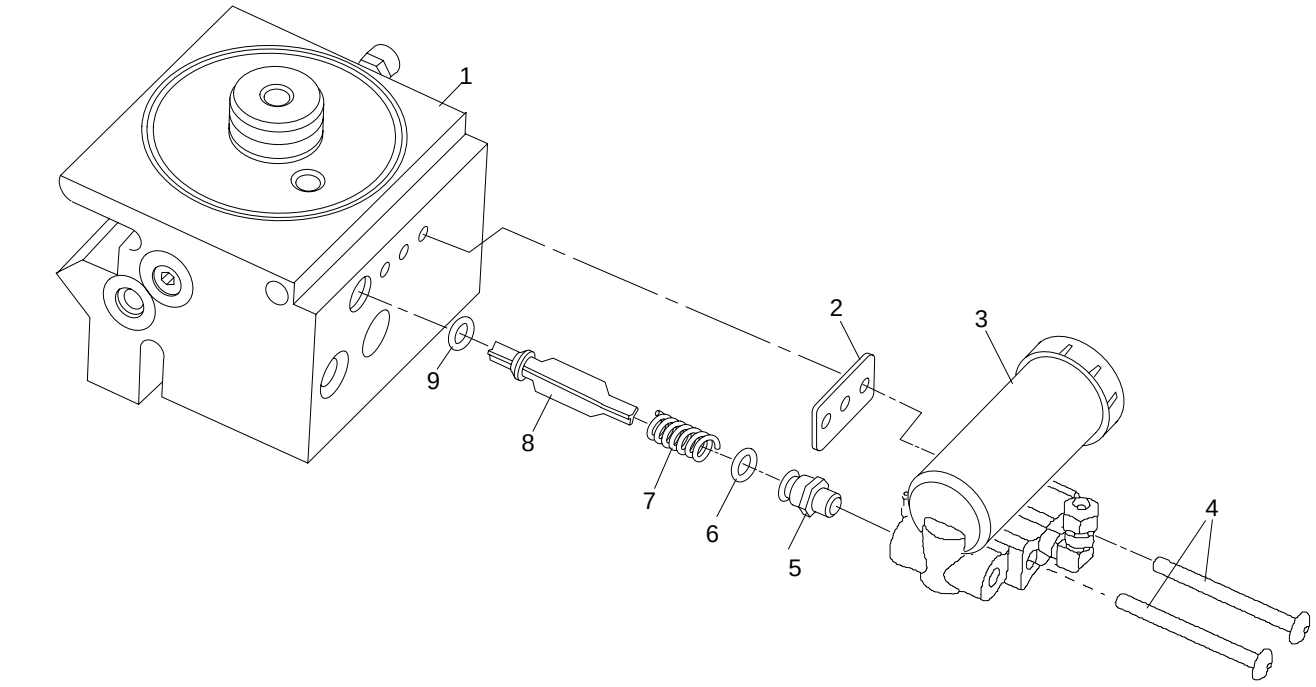
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

1. Park the vehicle on a level surface, shut down the engine, 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. 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.



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

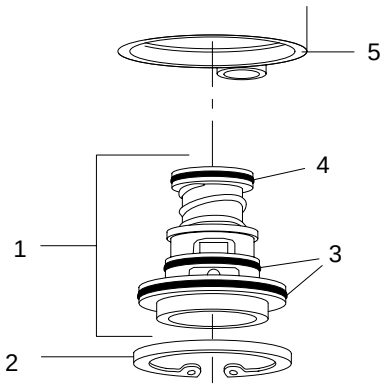
9. Install the adaptor fitting into the governor. Using the silicone grease, lubricate the remaining larger O-ring, and install it into the groove of the adaptor. Install the gasket supplied in the kit. Install the governor, and torque the capscrews 10 lbf·ft (14 N·m).
10. Perform the operational tests in **Subject 170**.

⚠ 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. Shut down the engine, apply the parking brake, and 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**.

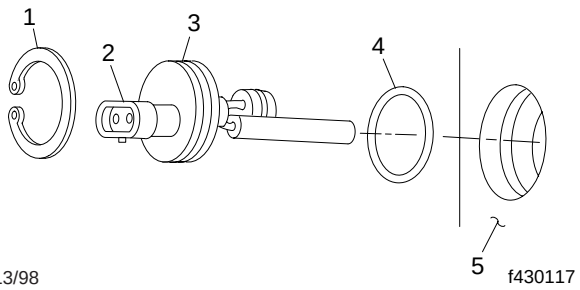
Heater and Thermostat Replacement

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. Shut down the engine, 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. See **Fig. 1.**



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.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

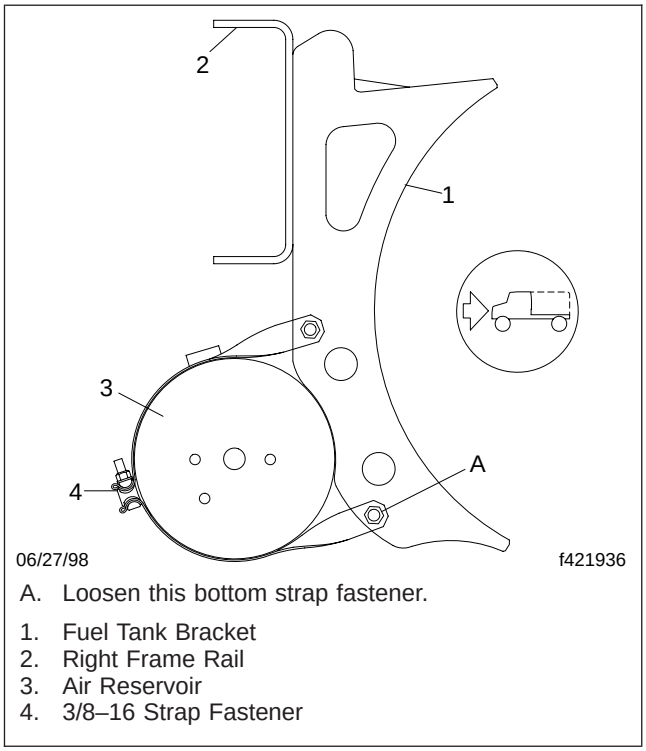
Replacement

1. 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.
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 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**.



A. Loosen this bottom strap 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

⚠ 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. 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, 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.

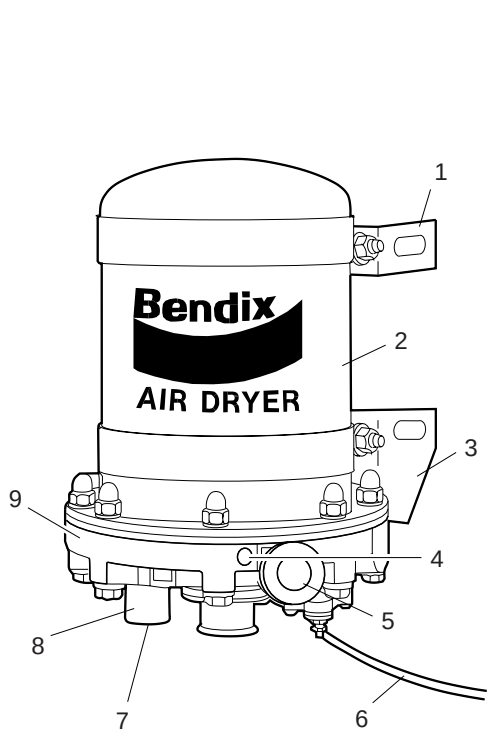
   Warm the thermostat and heater assembly to about 90°F (32°C) and check the resistance again. The resistance should exceed 1000 ohms. If the resistance values obtained are within the stated limits, the thermostat and heater assembly is operating properly. If the resistance values obtained are outside 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).

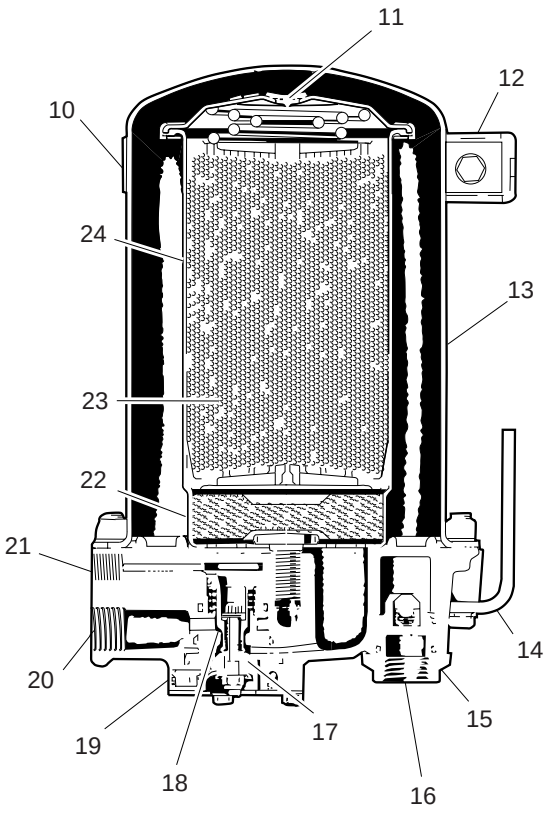
General Description

The function of the Bendix AD-9 air dryer (see **Fig. 1**) is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

purge valve housing assembly. The removable purge valve housing assembly features a purge valve mechanism and a turbocharger cutoff that are designed to prevent loss of engine turbocharger boost pressure during the purge cycle of the air dryer.

To ease servicing, the desiccant cartridge and dis-





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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. Turbocharger 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 bolts and nuts. The end cover contains a check valve assembly, a safety valve, three threaded air connections and the

charge 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-9 has three female pipe thread air connections; each is identified as follows in **Table 1**.

Air Dryer Port Identification	
Port I.D.	**Function/Connection**
4-CON	Control Port (purge valve control and turbocharger 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 Air Dryer (see **Fig. 2**):

  The standard air dryer uses a metal seat turbocharger 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 turbocharger 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

Figure 4 illustrates the AD-9 charge cycle.

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 temperature, 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.

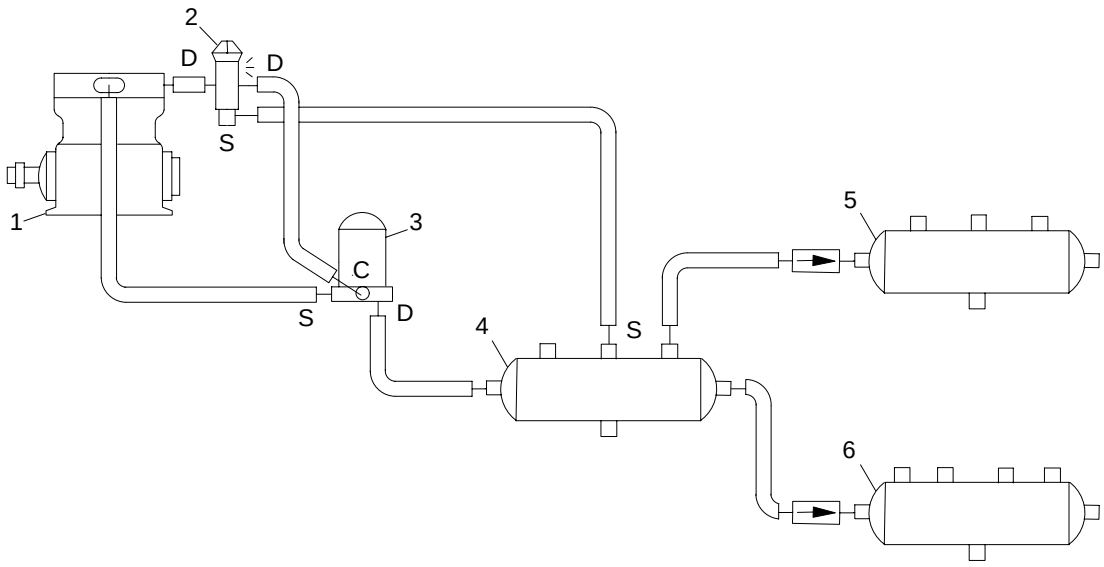
The air dryer remains in the charge cycle until air brake system pressure builds to the governor cutout setting.

Purge Cycle

Figure 5 illustrates the AD-9 purge cycle.

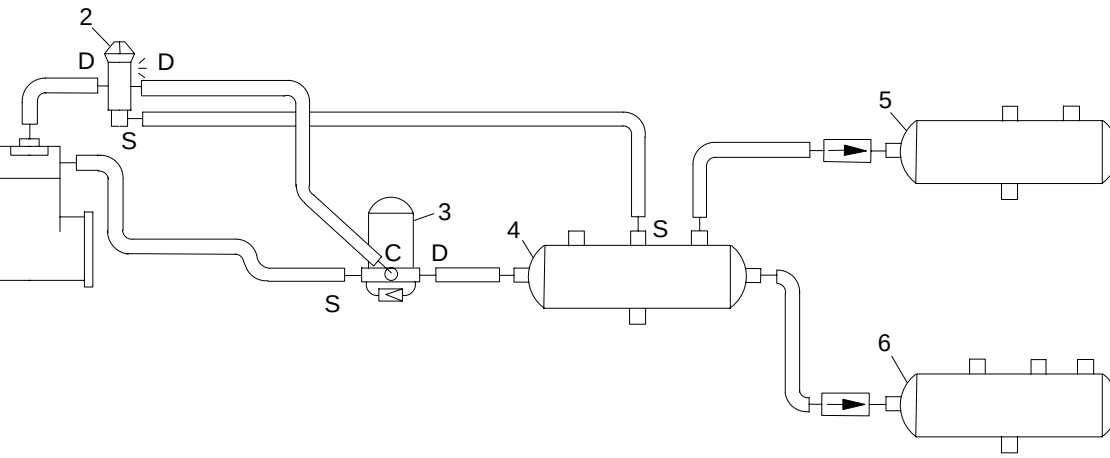
When the brake system pressure reaches the governor cutout setting, the compressor unloads (air compression stopped), and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the unloader mechanism and line connecting the governor unloader port to the AD-9 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 "Turbocharger 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.



C. Control
D. Delivery
S. Supply
1. Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply Reservoir
5. Primary Reservoir
6. Secondary Reservoir

Fig. 2, Standard Air Dryer Plumbing Diagram

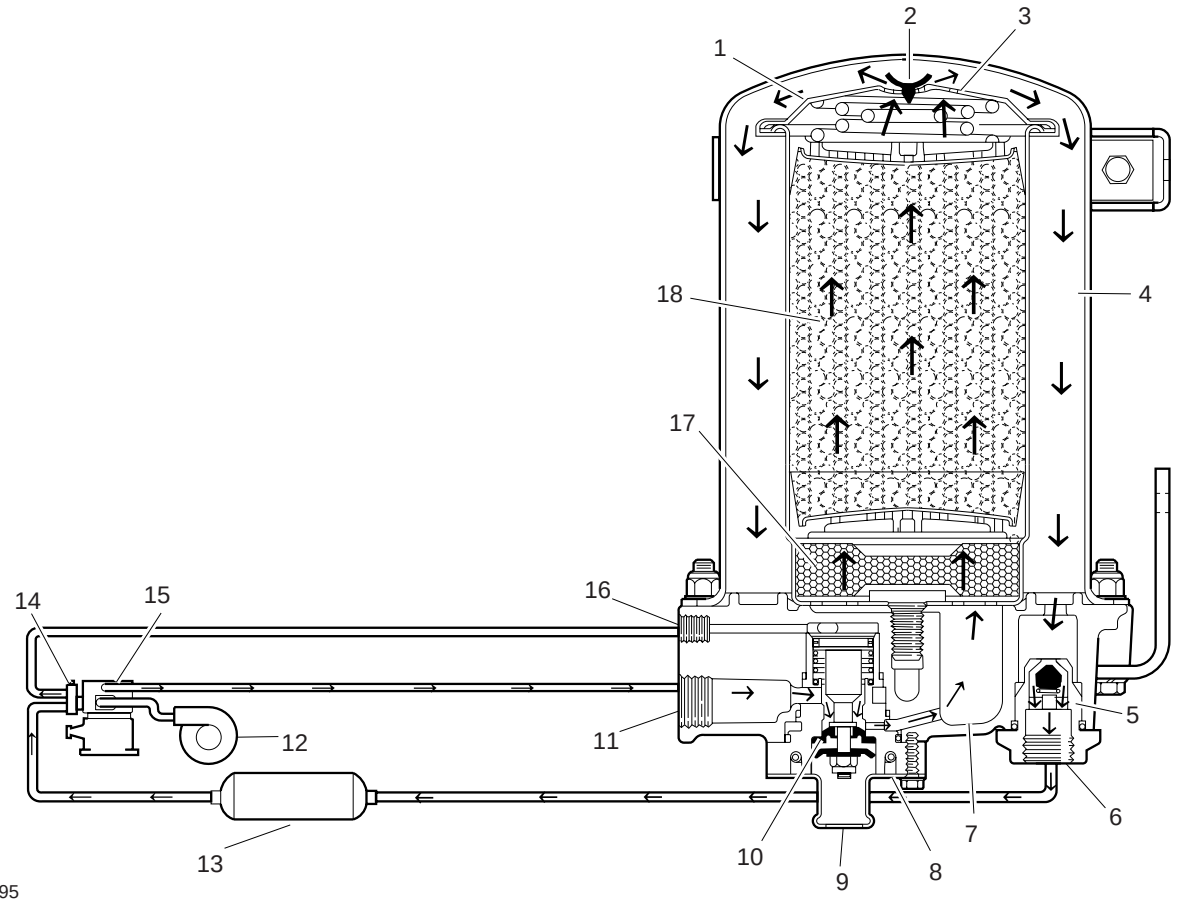


C. Control
D. Delivery
S. Supply
1. Holset or Cummins Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply Reservoir
5. Primary Reservoir
6. Secondary Reservoir

Fig. 3, Drop-In Style Air Dryer Plumbing Diagram (with Holset or Cummins air compressor)

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

General Information



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. Supply Port
12. Engine Turbocharger
13. Reservoir
14. Governor
15. Compressor
16. Control Port
17. Oil Separator
18. Desiccant Bed

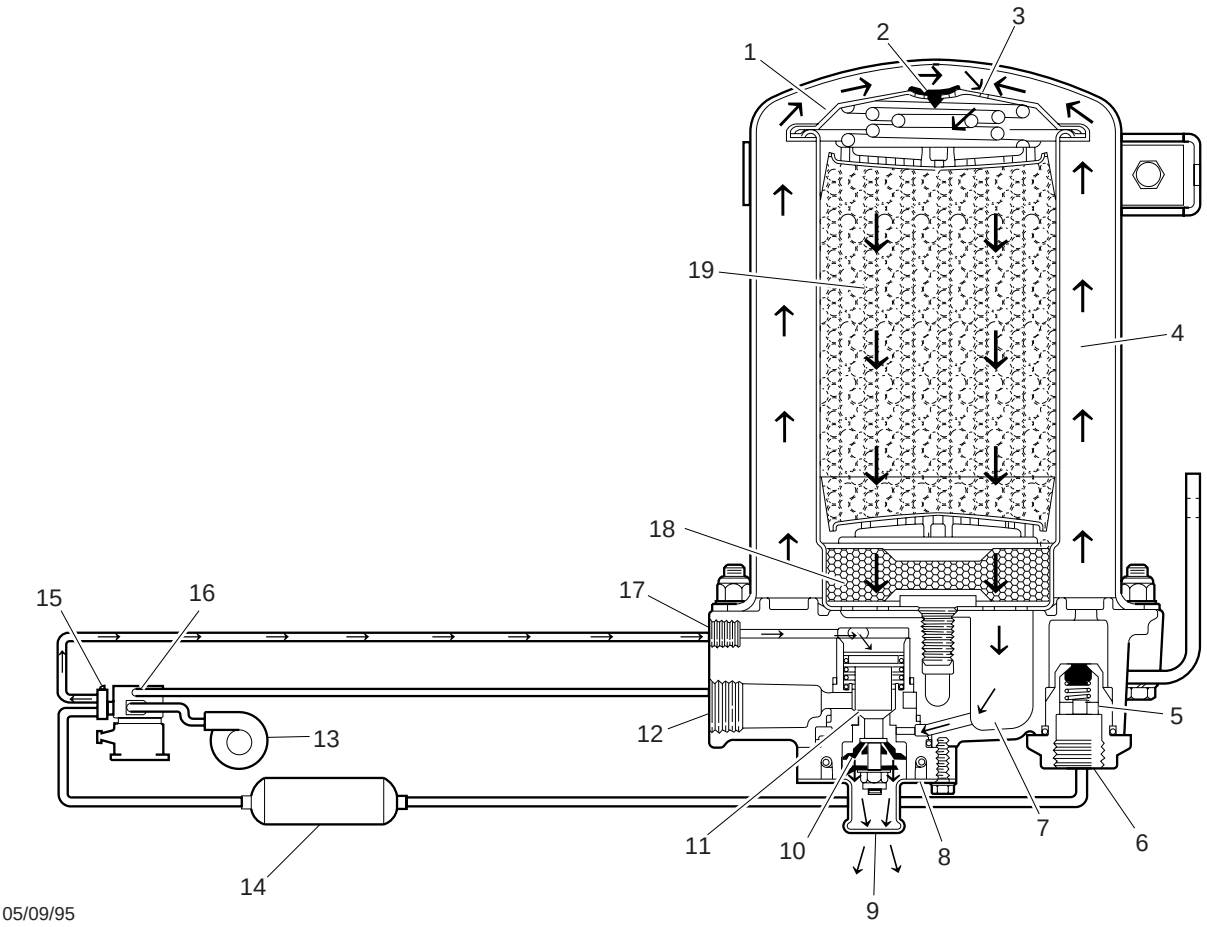
Fig. 4, AD-9 Charge Cycle

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 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 **Group 42** of the *Cascadia™ 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

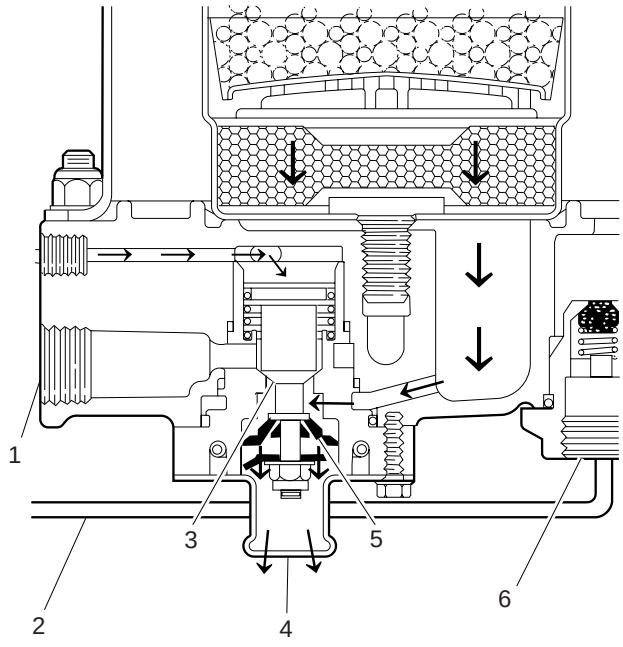
Turbocharger Cutoff Feature

Figure 6 shows the AD-9 turbocharger cutoff.

Primarily, the turbocharger 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 turbocharger 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 turbocharger cutoff valve (tapered portion of the purge piston) contacts its mating metal seat in the purge valve housing. With the turbocharger cutoff valve seated (closed position), air in the discharge line and AD-9 supply port is restricted from entering the air dryer. While the turbocharger cutoff *effectively* pre-

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 Turbocharger Cutoff

vents loss of turbocharger boost pressure to the engine, some seepage of air may be detected under certain conditions of compressor, 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 pushrods 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.

⚠ 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 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. See **Fig. 1**.
4. Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the exhaust cover.
5. Loosen the bolt that secures the upper bracket strap.
6. Remove, save, and mark the two end cover bolts, 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 bolts.)
7. Remove the air dryer from its mounting brackets.

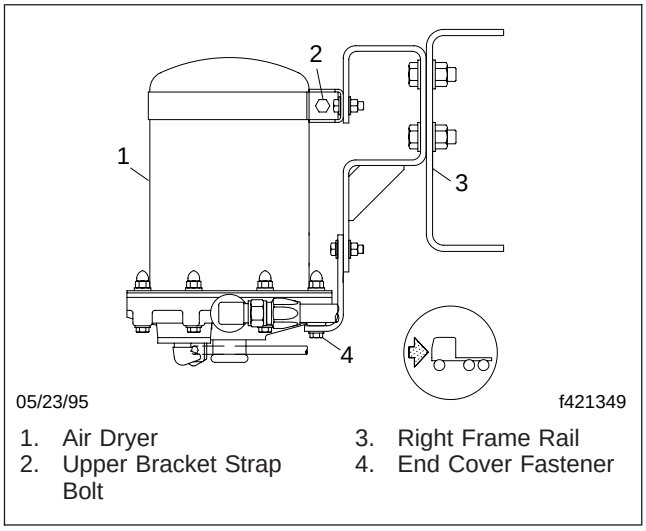
Installation

1. Position the air dryer up into the upper mounting bracket and strap. See **Fig. 1**. 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.
2. Using the two longest bolts, four special washers, and two locknuts, secure the air dryer to the lower bracket. Tighten the two remaining bolts 23 to 32 lbf·ft (31 to 43 N·m).
3. Tighten the capscrew and nut on the upper mounting bracket strap 48 lbf·in (540 N·cm).
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 the instructions in "Testing" below.

Testing

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.



1. Air Dryer
2. Upper Bracket Strap Bolt
3. Right Frame Rail
4. End Cover Fastener

Fig. 1, Air Dryer Mounting

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

Figure 1 shows an exploded view of the AD-9 air dryer.

⚠ CAUTION

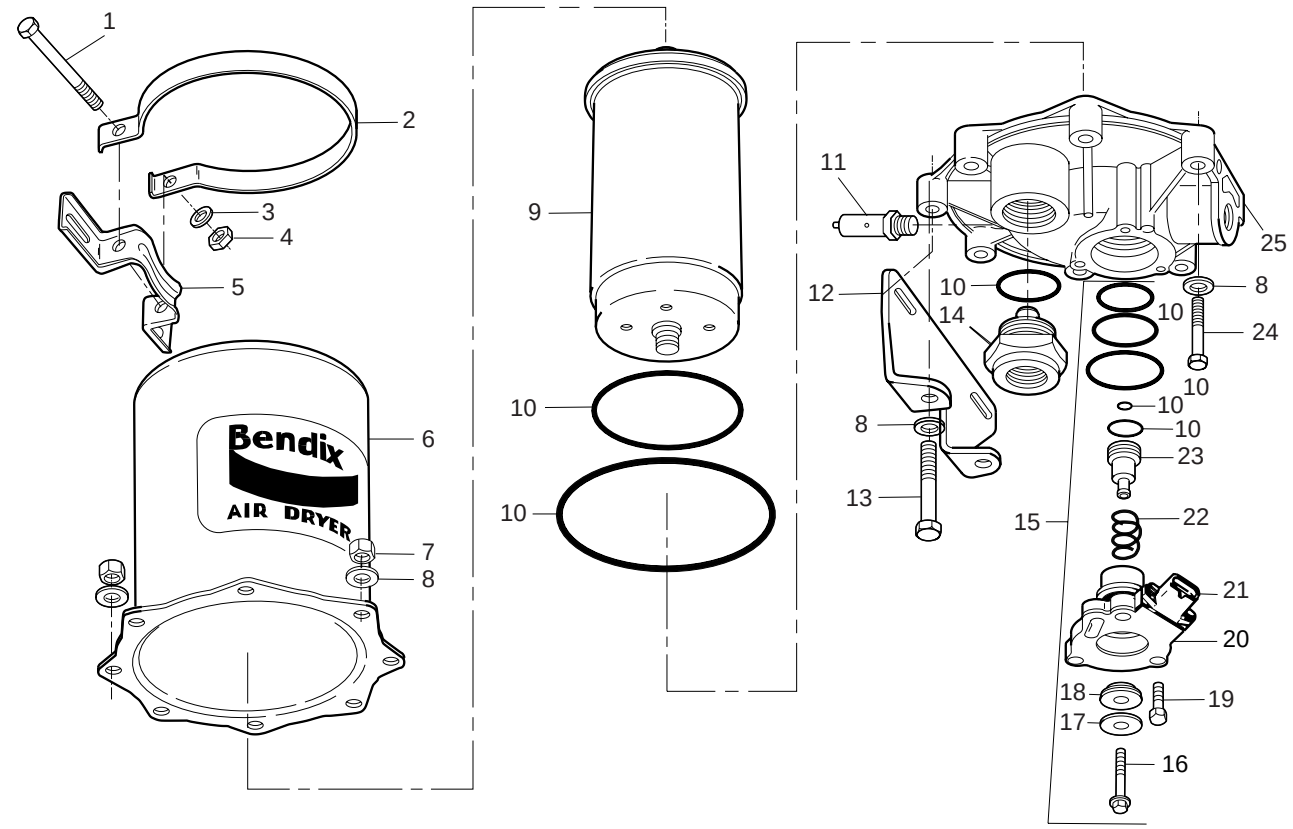
While servicing the air dryer, do not use a clamping device (vise, C-clamp, etc.) to hold any die-cast aluminum part, as damage may result. To hold the end cover, install a pipe nipple in the supply port, and clamp the nipple in a vise.

1. Remove the air dryer from the vehicle. See **Subject 110**.
2. Remove the check valve assembly and O-ring. Remove the O-ring from the check valve assembly.
3. Remove the purge valve housing assembly, as follows.
   - 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, as follows.
   - 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, as follows.
   - 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 capscrew 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).
6. Remove the remaining six bolts (Item 24), locknuts (Item 7), and twelve special washers (Item 8) that secure the end cover to the housing (Item 6). Separate the end cover and desiccant cartridge (Item 9) from the housing (Item 6).
7. Remove the end-cover-to-outer-housing O-ring.
8. Don't remove the safety valve (Item 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·cm). Make sure the drain hole (slot) is facing down.
9. Place a strap or chain wrench around the desiccant cartridge (Item 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.

Air Dryer Disassembly, Cleaning and Inspection, and Assembly



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1. 5/16-Inch x 4-1/2 Inch Upper Bracket Bolt
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 Bolt (Long)
14. Check Valve Assembly
15. Purge Valve Assembly
16. Purge Valve Capscrew
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 Bolt
25. End Cover

Fig. 1, AD-9 (exploded view)

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

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

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, as follows.
   - 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 (120 to 220 N·cm).
3. Assemble the purge-valve housing, as follows.
   - 3.1 Install the O-ring on the purge piston. Place the return spring in the purge-valve 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 capscrew. Torque the purge valve capscrew 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, as follows.
   - 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, as follows.

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

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 bolts, locknuts, and the twelve special washers, making sure they are positioned as referenced earlier. The two longer bolts will be used to secure the air dryer to its mounting bracket.

6.3 Tighten the six bolts and nuts in a star pattern (depending on lower bracket location) 23 to 32 lbf·ft (31 to 43 N·m). See **Fig. 2**.

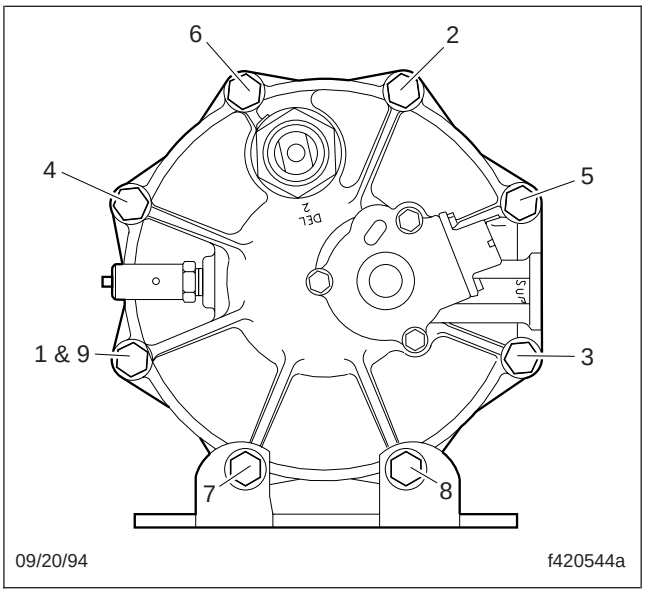

Fig. 2, End Cover to Housing Torque Pattern

NOTE: The two remaining bolt holes in the end cover and two 3/8-inch bolts must be the ones marked during removal to ensure correct orientation of the ports and adequate length of the bolts.

7. Connect the electrical connector to the heater and thermostat assembly.
8. Test the air dryer for proper operation. For instructions, see "Testing" below.

Testing

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.

The following diagrams are for general reference. For vehicle-specific plumbing diagrams, refer to EZWiring.

Figure 1 is a full view of the plumbing diagram for an air brake installation with two dash valves. (Freightliner diagram D12-22341). See **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6**, and **Fig. 7**, for partial views.

Figure 8 is a full view of the plumbing diagram for an air brake installation with one dash valve and a conventional air dryer (diagram D12-22343). See **Fig. 9**, **Fig. 10**, **Fig. 11**, **Fig. 12**, **Fig. 13**, and **Fig. 14**, for partial views.

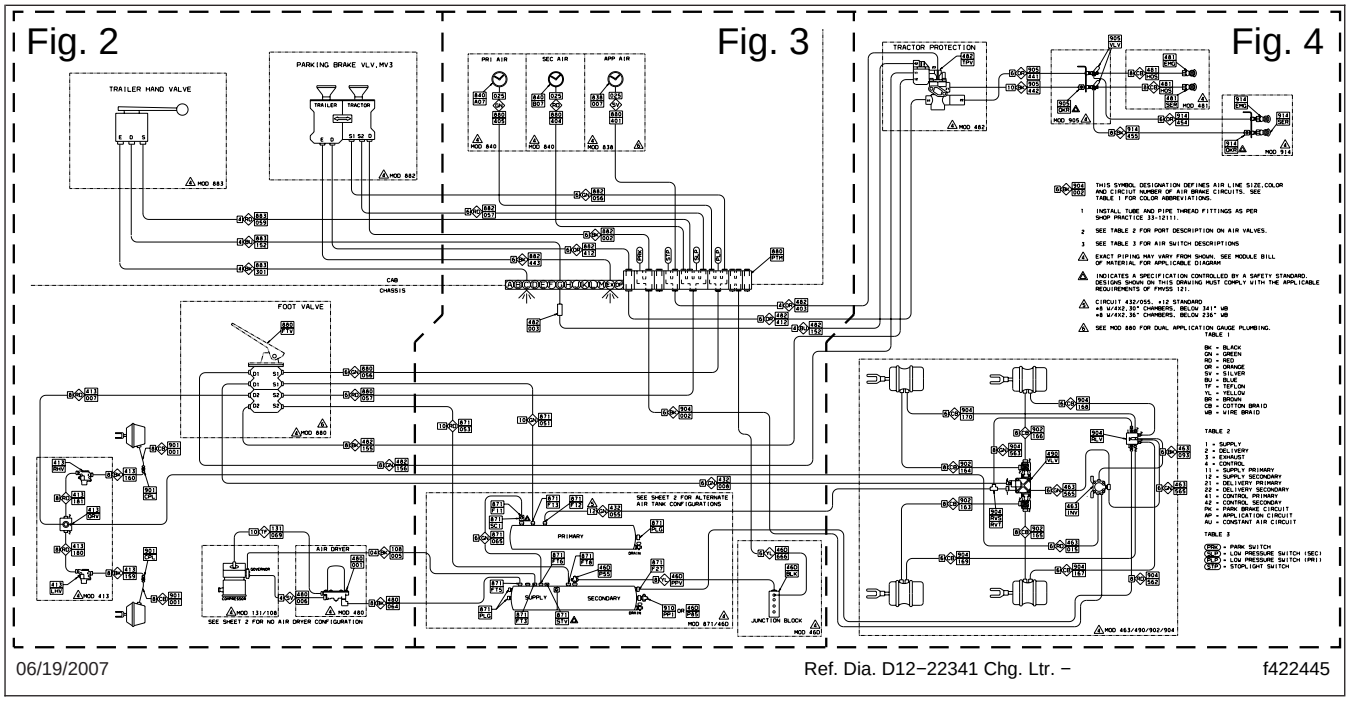

Fig. 1, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (full view)

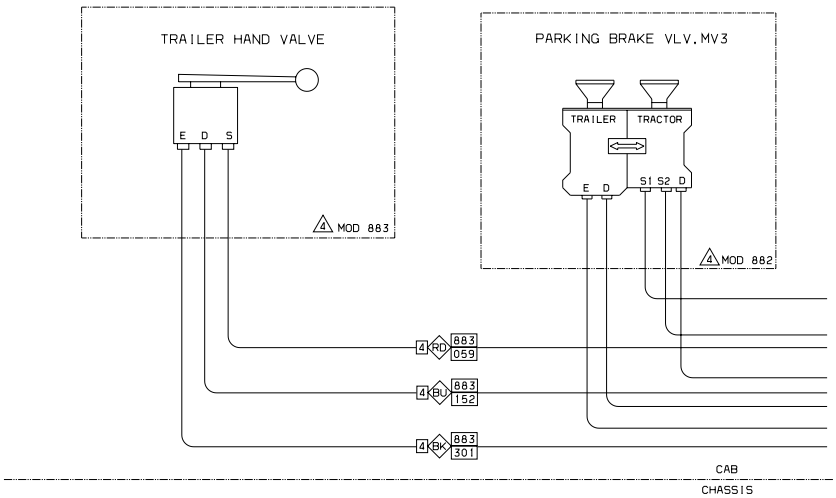

Fig. 3

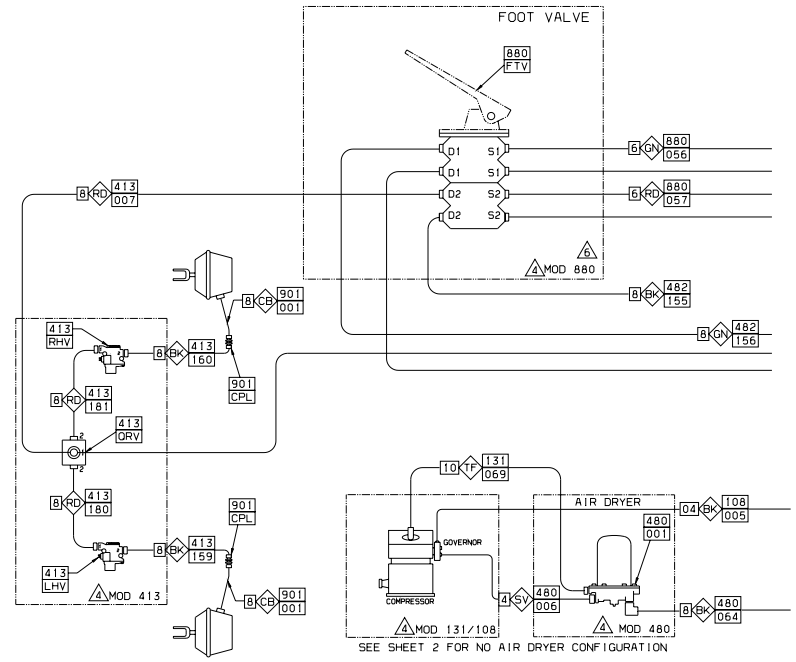

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Fig. 2, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

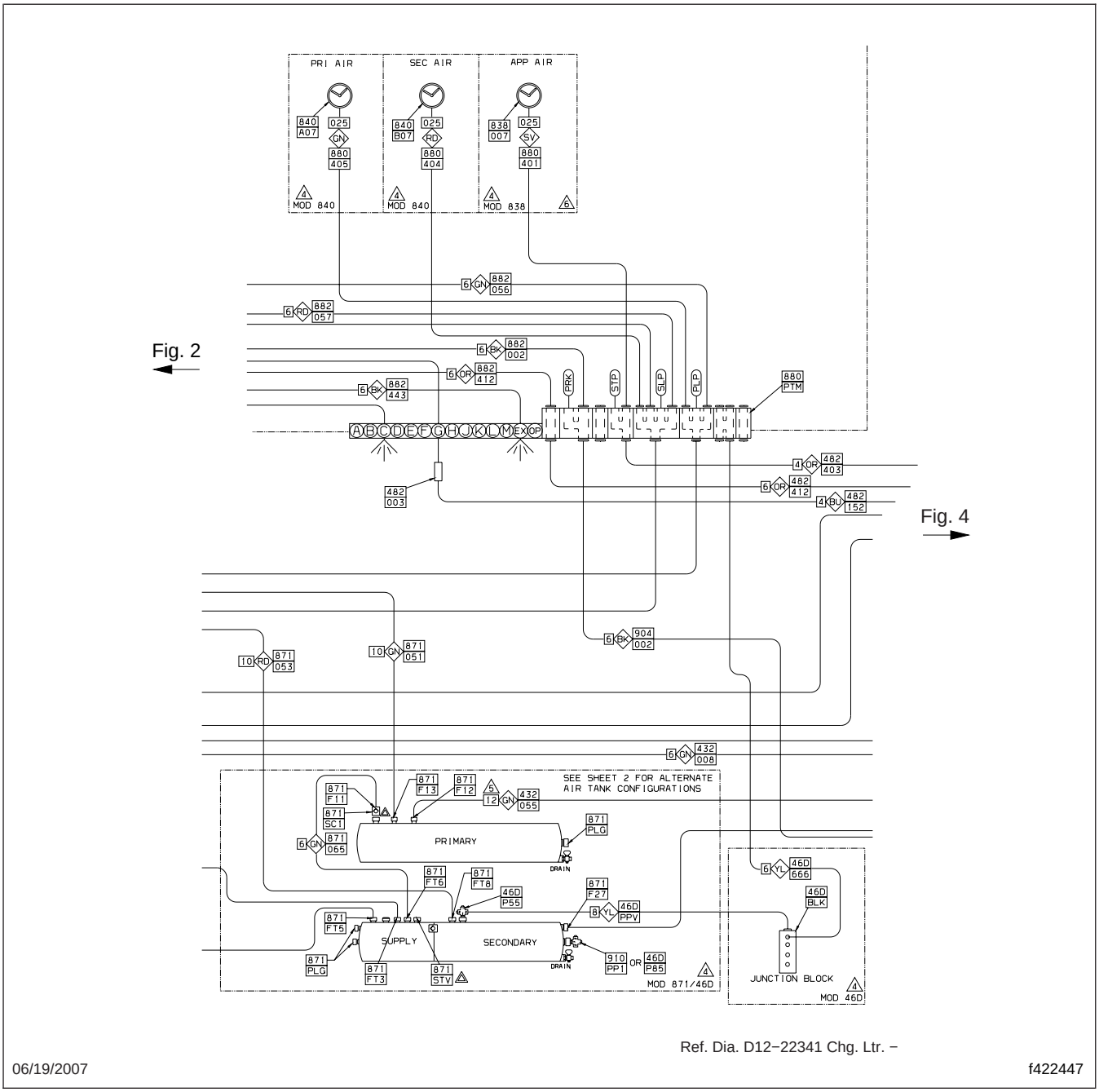

Fig. 3, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

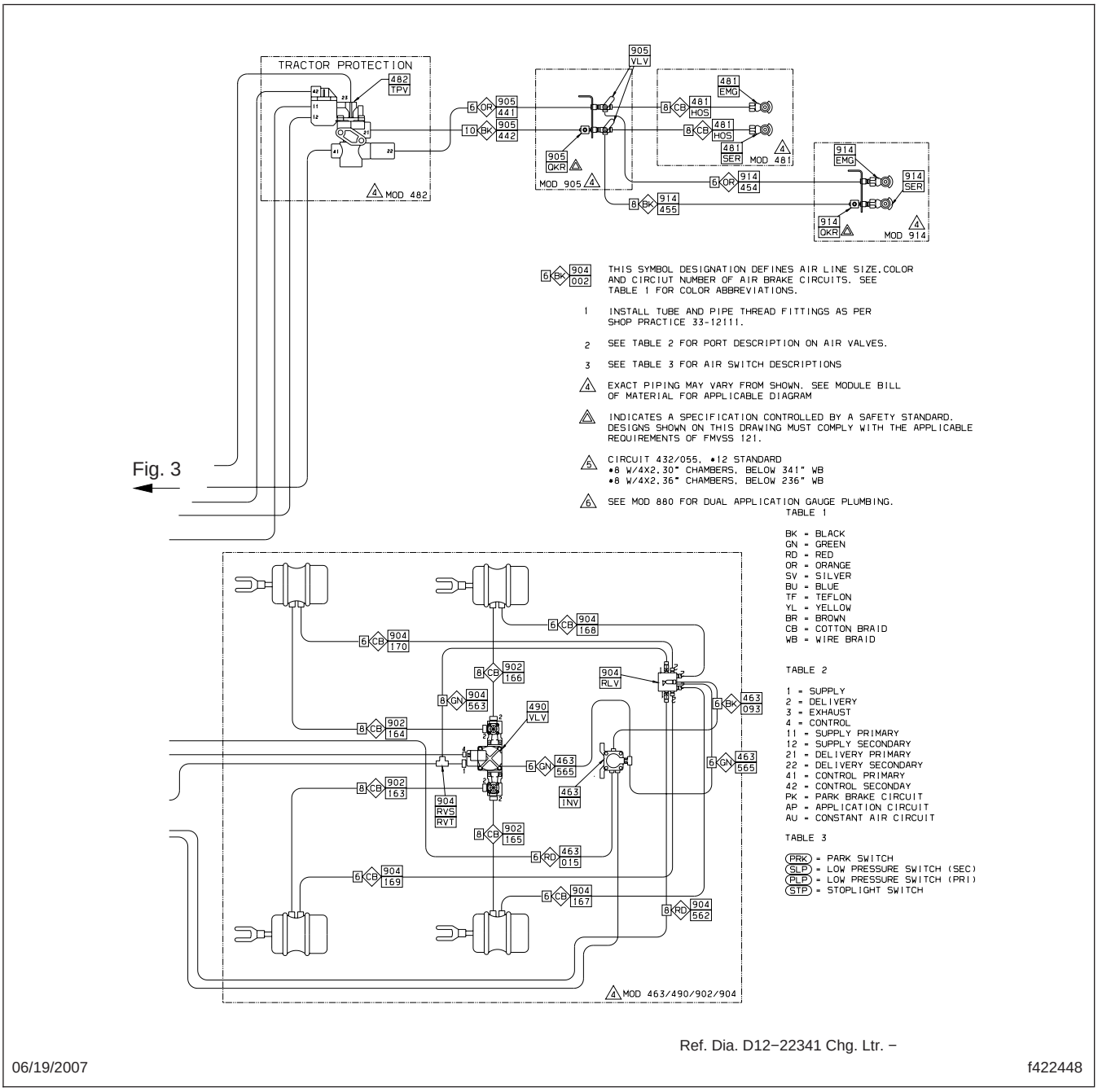

Fig. 4, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

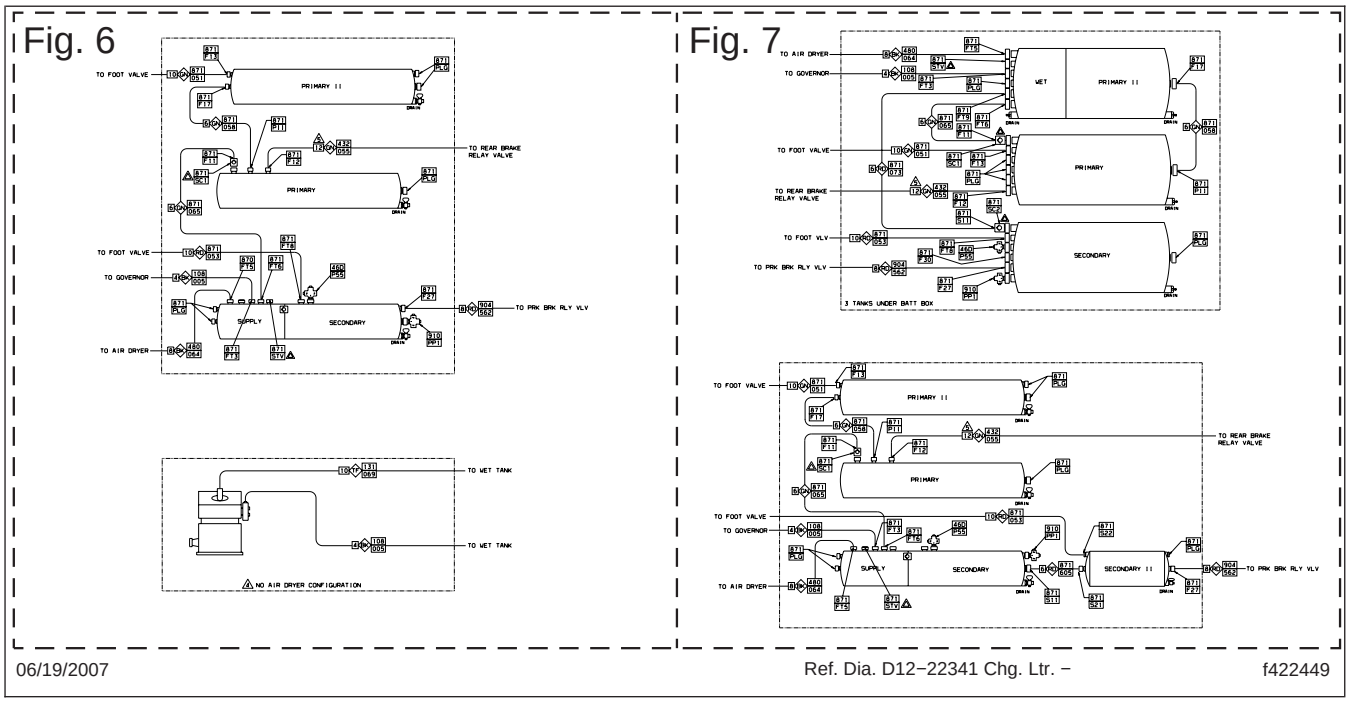

Fig. 5, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

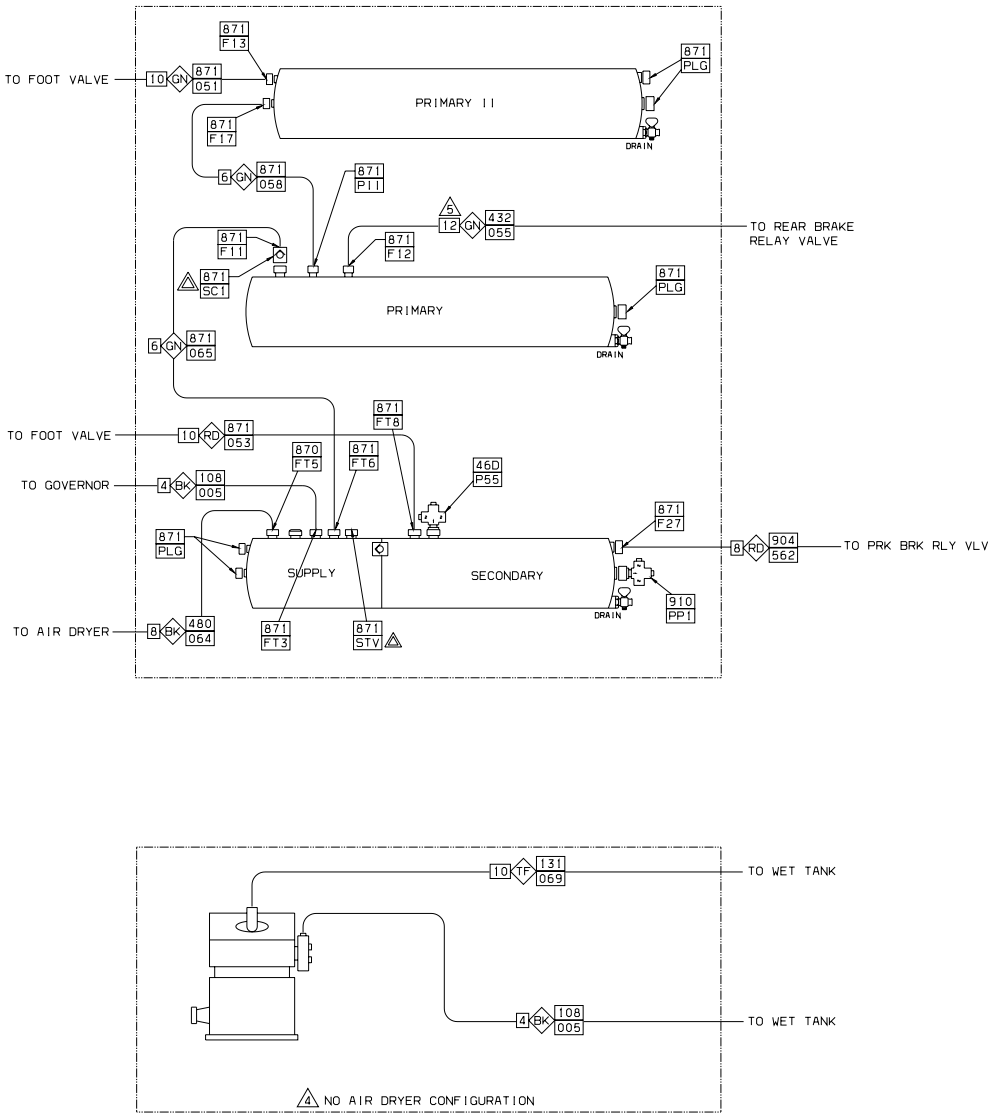

Fig. 6, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

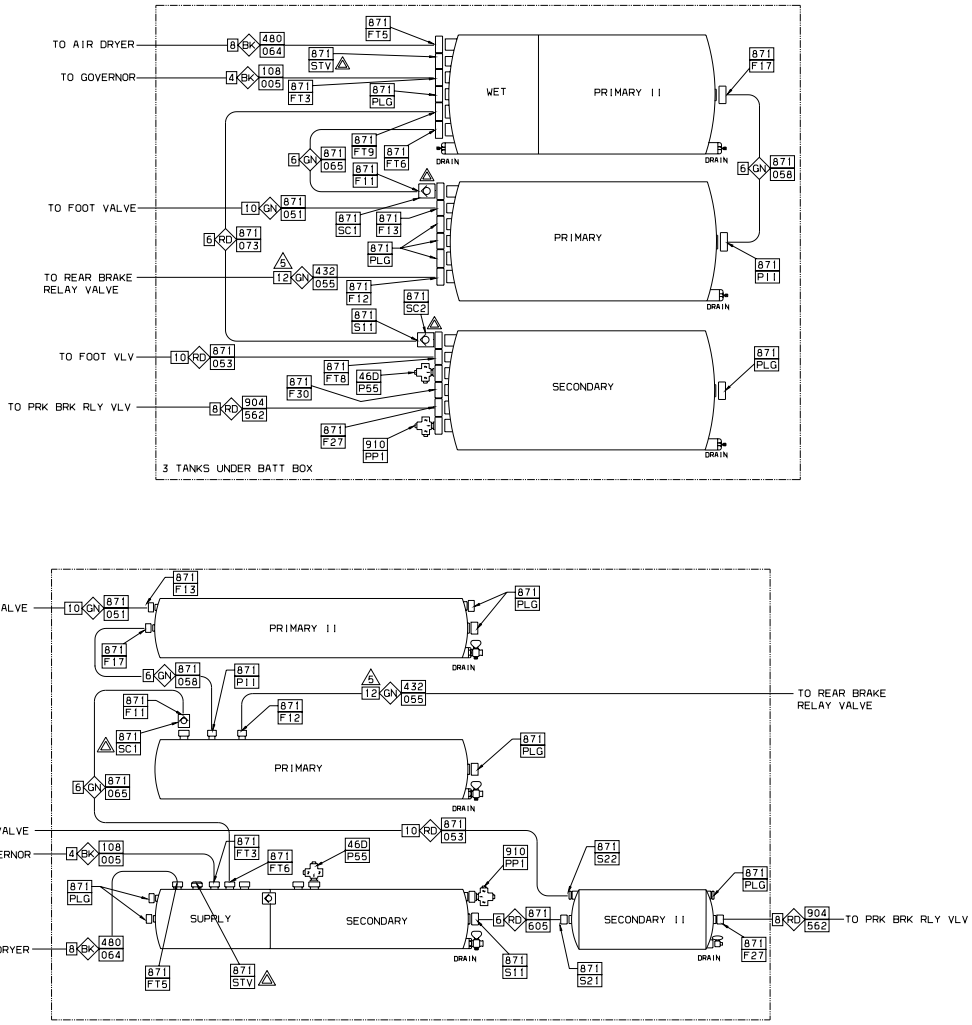

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Fig. 7, Air Brake Plumbing, Two Dash Valves/Conventional Air Dryer (partial view)

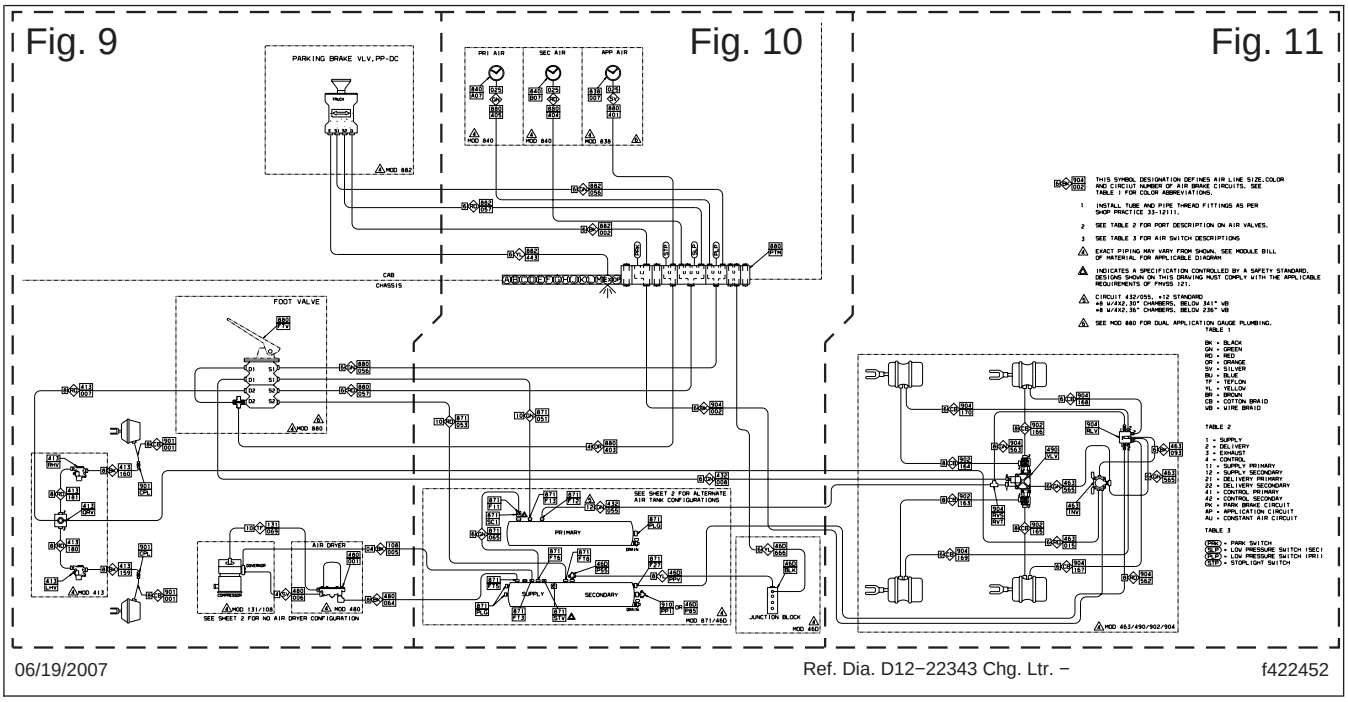

Fig. 8, Air Brake Plumbing, One Dash Valve/Conventional Air Dryer (full view)

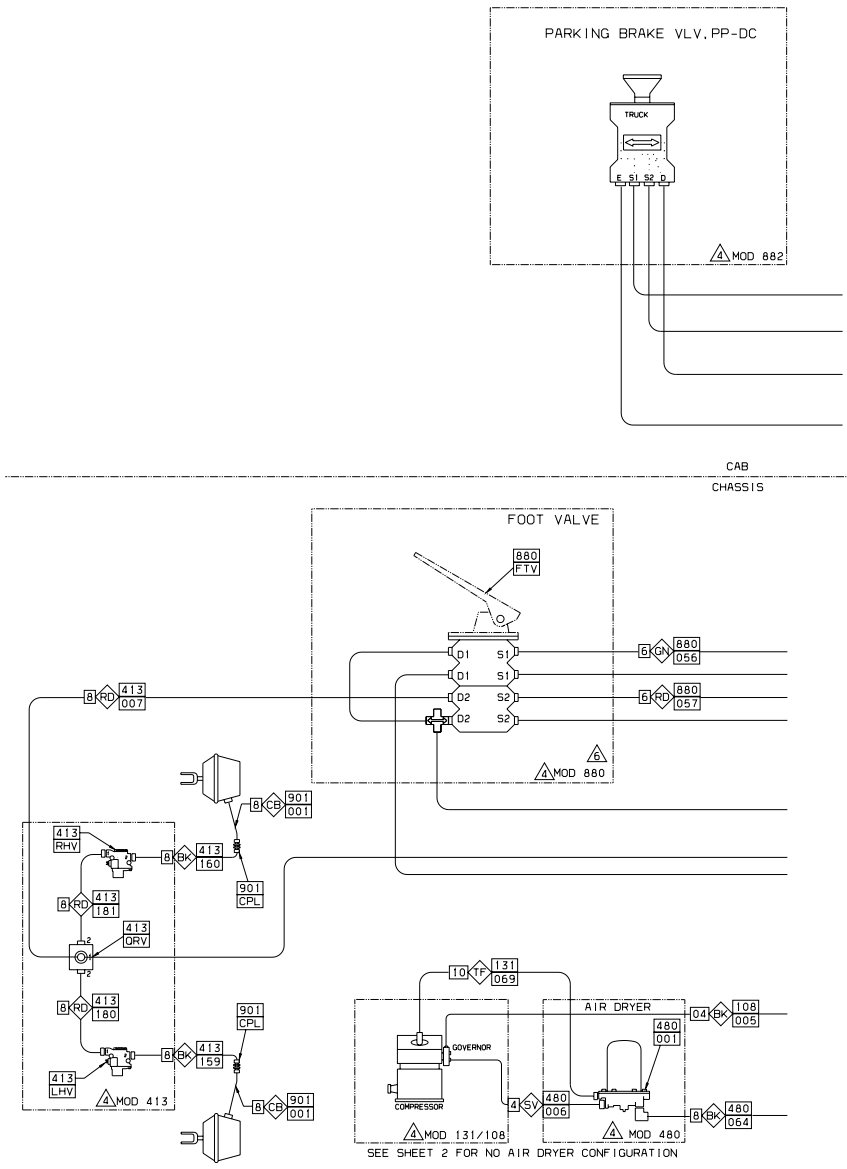

Fig. 10 →

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Fig. 9, Air Brake Plumbing, One Dash Valve/Conventional Air Dryer (Partial view)

Fig. 9

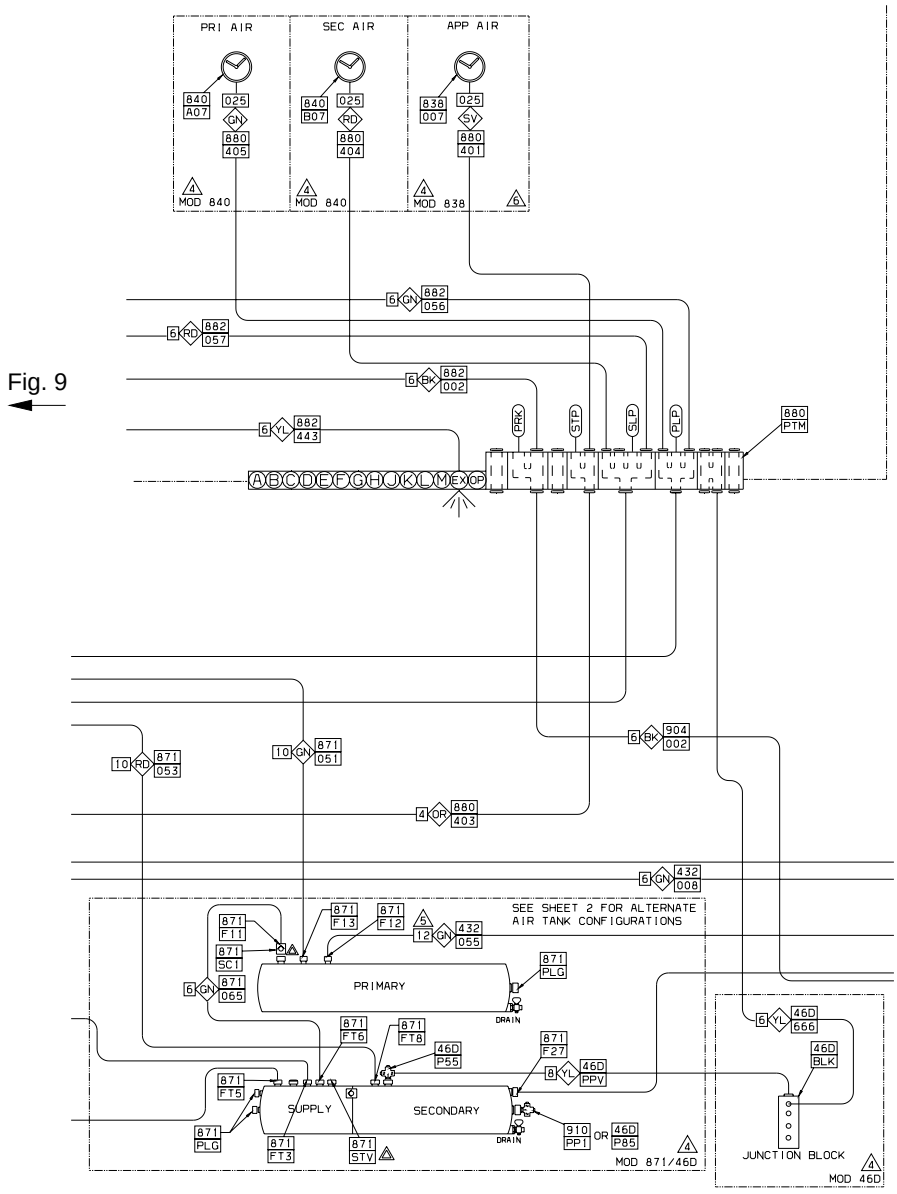

Fig. 11

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Fig. 10, Air Brake Plumbing, One Dash Valve/Conventional Air Dryer (Partial view)

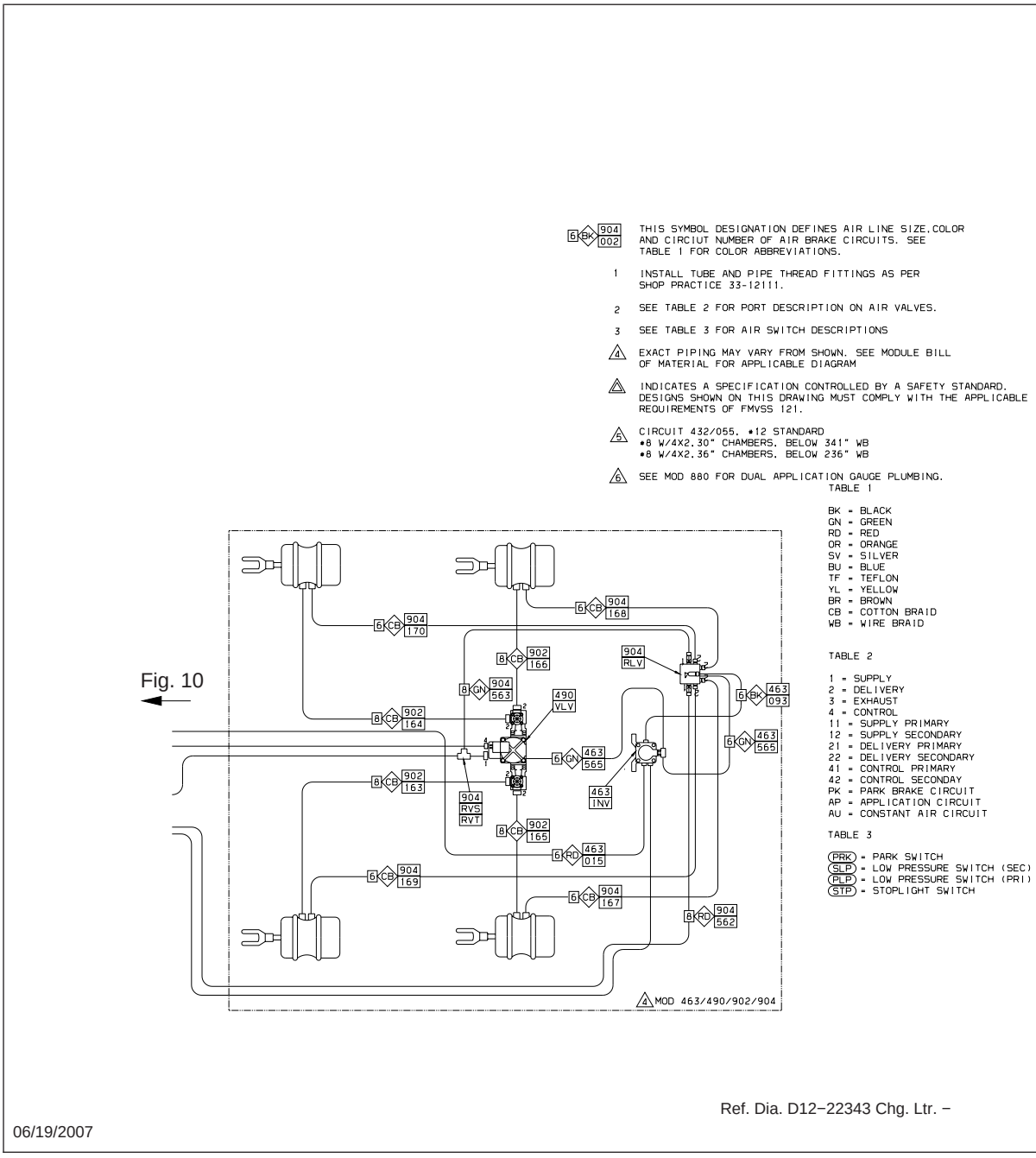

Fig. 11, Air Brake Plumbing, One Dash Valve/Conventional Air Dryer (Partial view)

General Information

Fig. 13

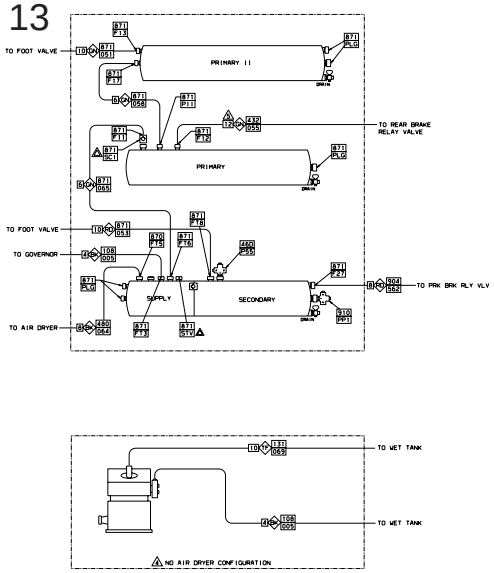

Fig. 14

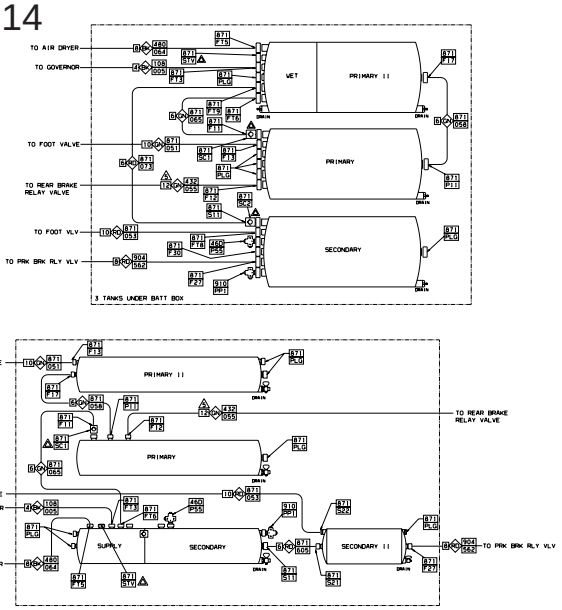

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Fig. 12, Air Brake Plumbing, One Dash Valve/Conventional Air Dryer (Partial view)

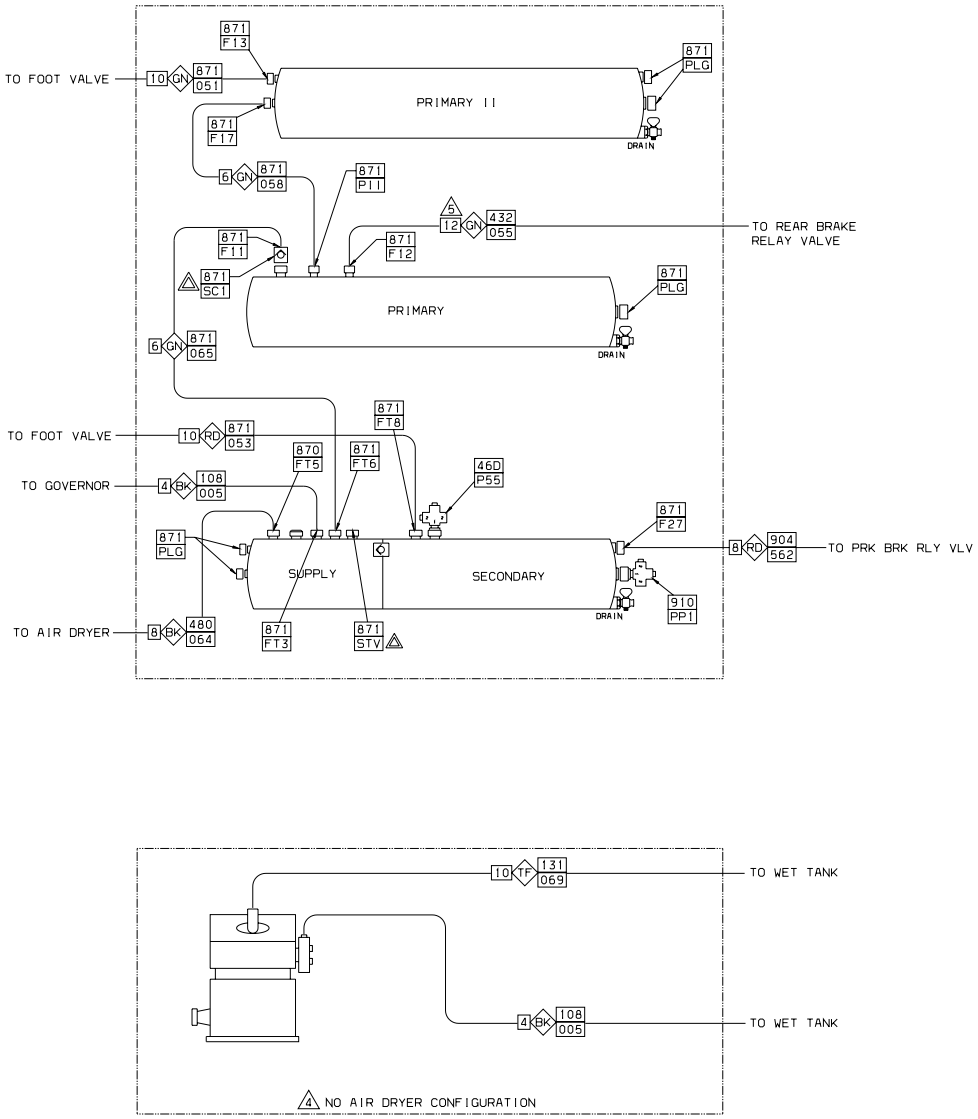

Fig. 13, Air Brake Plumbing, One Dash Valve/Conventional Air Dryer (Partial view)

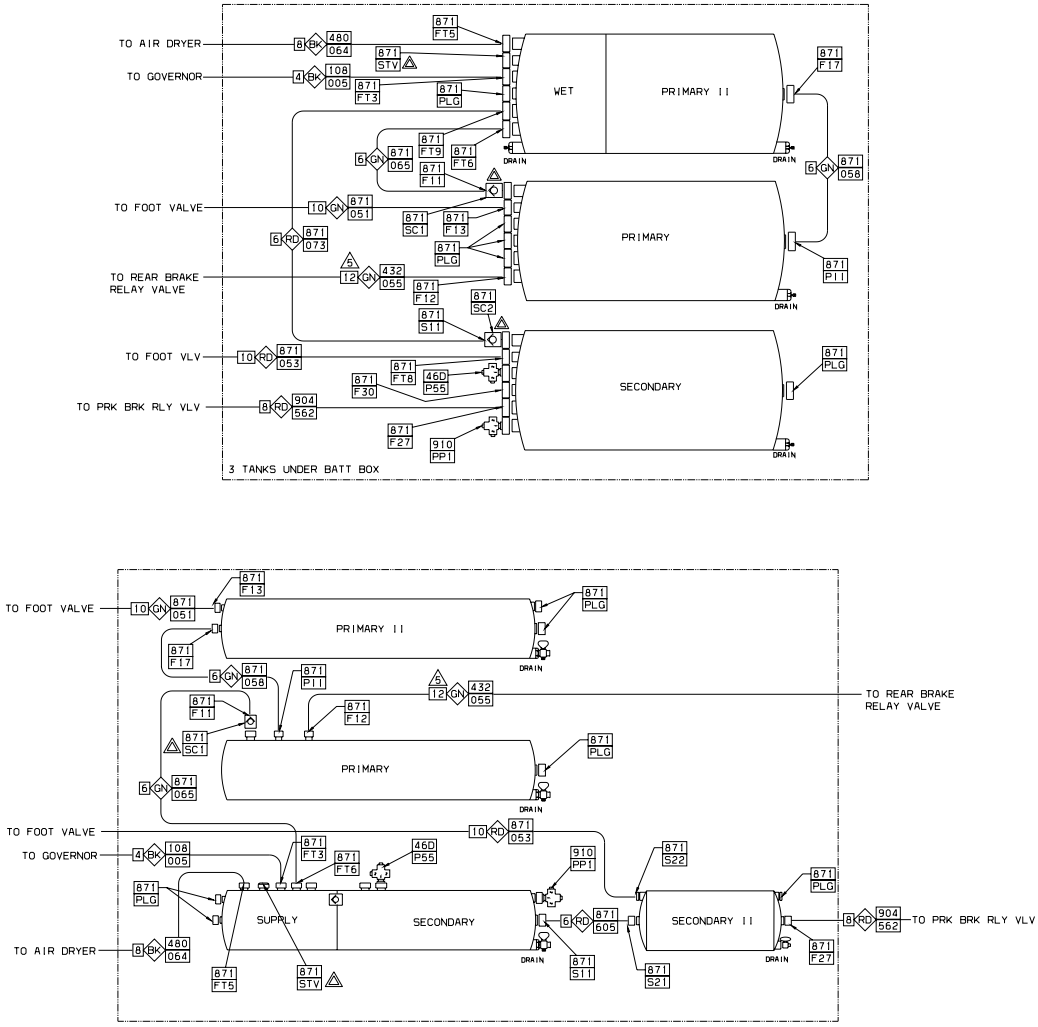

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Fig. 14, Air Brake Plumbing, One Dash Valve/Conventional Air Dryer (Partial view)

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 air seats, cab suspension, transmission shift, and rear suspension.
- 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.

In the supply reservoir is a safety valve that protects the air system against excessive air pressure buildup. 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. The first primary reservoir, plumbed to the supply tank is equipped with an in-line check valve. Other primary tanks plumbed to this first primary tank will not have check valves. 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.

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 pushrods 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. When working with compressed air, always wear safety glasses, and never exceed recommended air pressure.

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.

⚠ 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 and Leak Elimination

NOTE: If the vehicle is equipped with an automatic moisture-ejection valve, see **Section 42.14** 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.
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 buildup.

   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.

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

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.

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, as follows. 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.

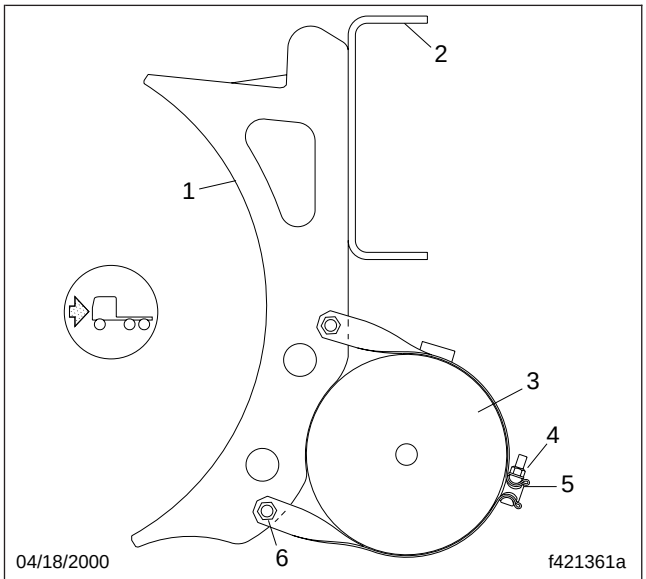
   NOTE: If the reservoir is mounted on the fuel tank bracket, loosen the bottom strap fastener first.

   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 lbf·ft (87 N·m).
   - Tighten the reaction joint clamp bolts 26 lbf·ft (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 42.07, Subject 100**.



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

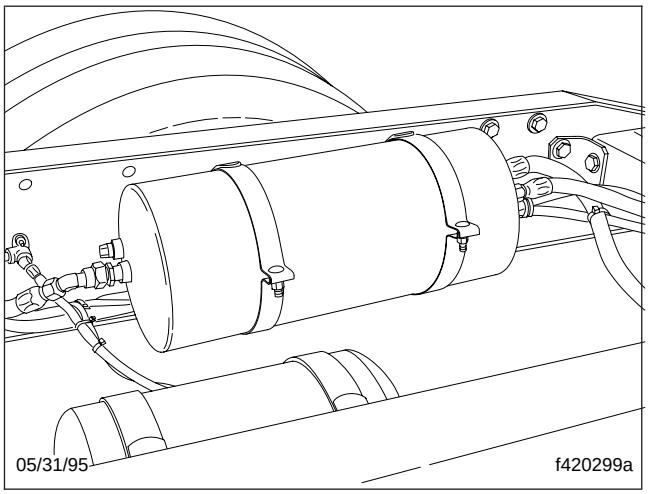


Fig. 2, Air Reservoir, Frame Rail Mounting

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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, then 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**.

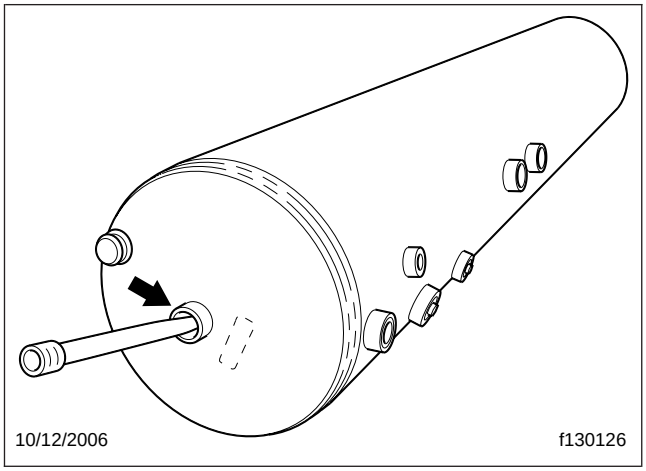
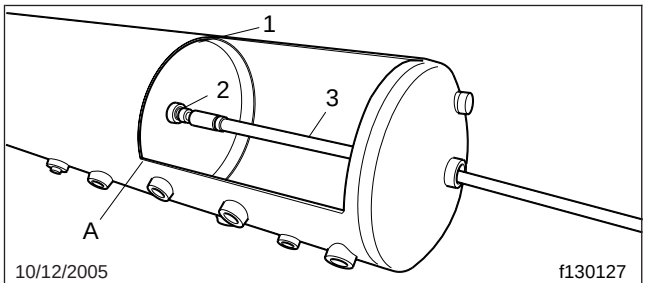


Fig. 1, Accessing the Internal Check Valve



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.

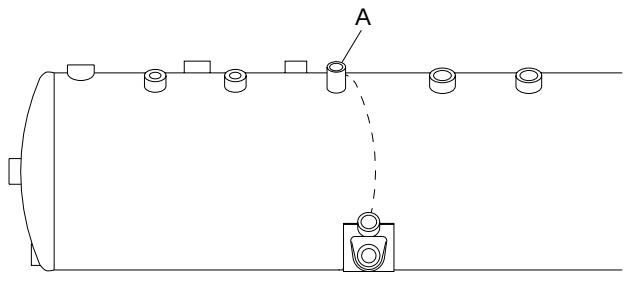
6. Install a new check valve.
7. Attach the pressure-protection valve and the 90-degree elbow.

Internal Check Valve Replacement

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.

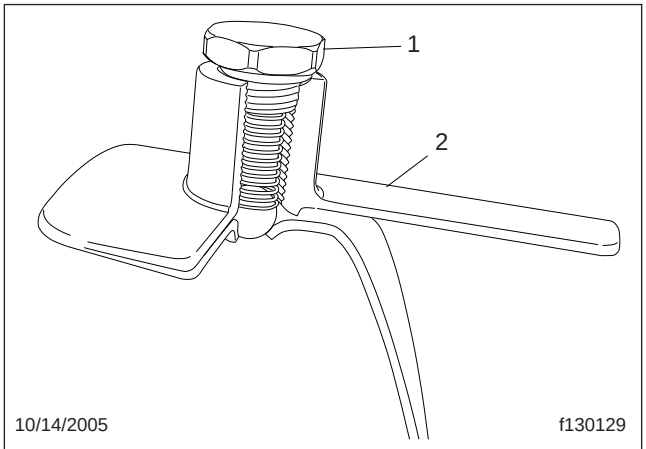
Fig. 3, Check Valve Location

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**.



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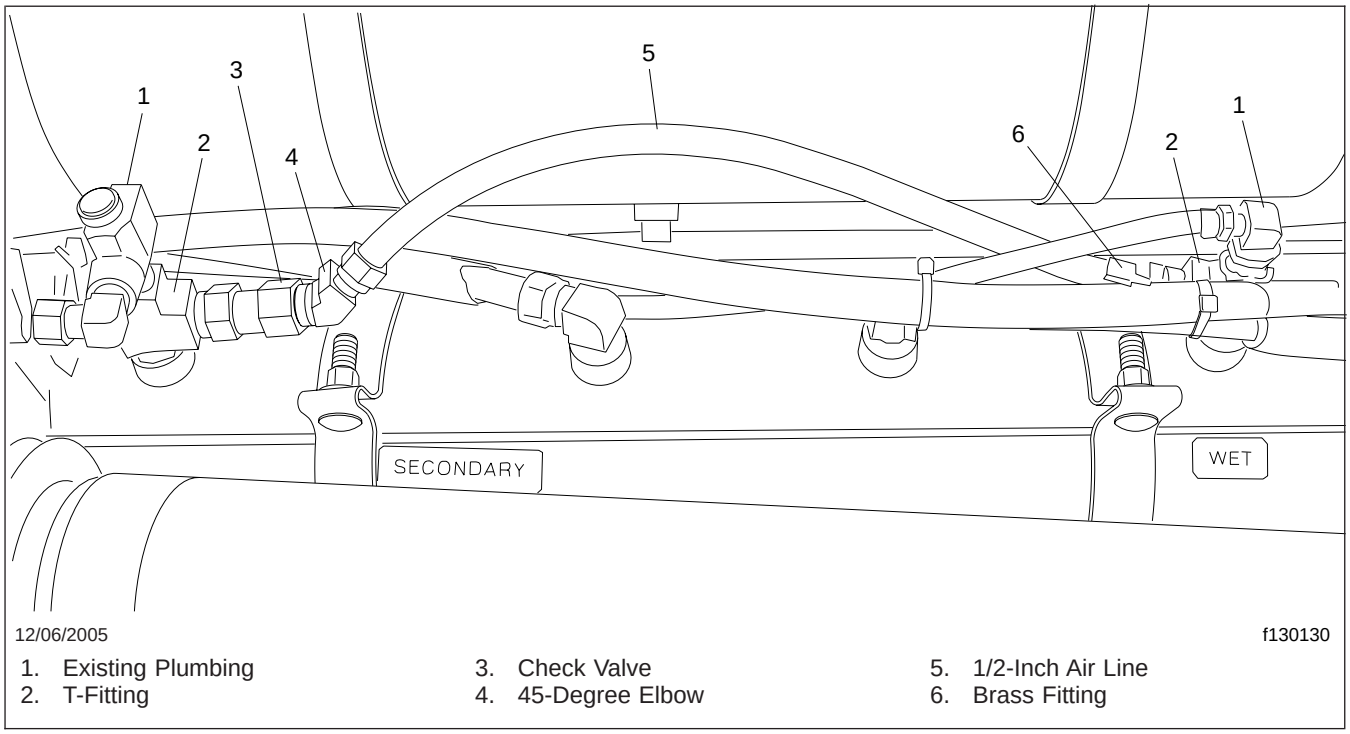
1. Check Valve
2. Tank Shell (cut away)

Fig. 4, Cutaway View of the Check Valve Installation

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.



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

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 pushrods 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.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Installing Air Lines

Nylon Tubes

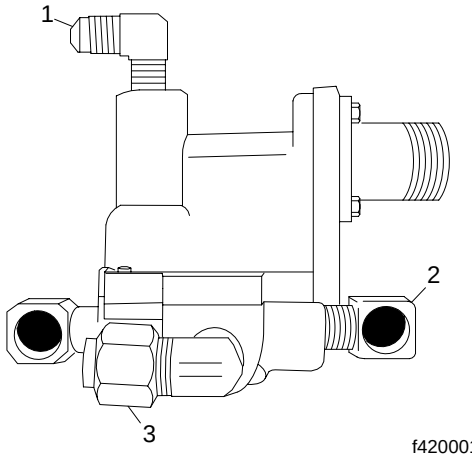
When installing a nylon tube, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate table in **Specifications 400**.

Figure 1 and Figure 2 show tubing and fittings used in the air system.

⚠ 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.



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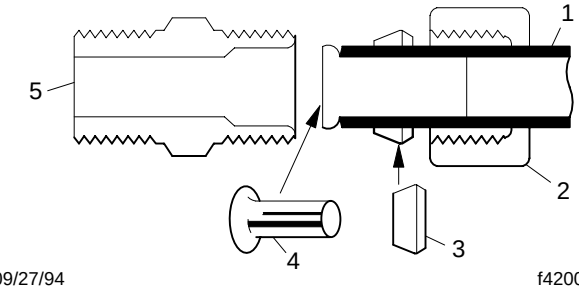
1. Wire Braid Hose Fitting
2. Pipe Fitting
3. Nylon Tube Fitting

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.



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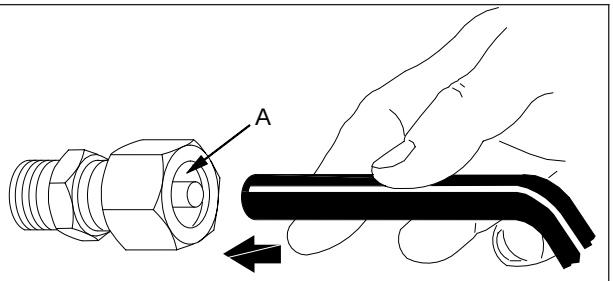
1. Nylon Tube
2. Nut
3. Sleeve
4. Brass Insert
5. Body

Fig. 2, Nylon Tube Fitting

3. Slide the nut onto the tubing.
4. Install a new sleeve in the nut, and a new brass insert in the end of the tubing.
5. Insert the squared end of the tubing in the fitting, until it bottoms in the body of the fitting. See **Fig. 3**.



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A. Tube end must bottom before tightening the nut.

Fig. 3, Installing Nylon Tubing

6. 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.

Wire Braid Hoses

When installing a wire braid hose, (**Fig. 1**) be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate tables in **Specifications 400**.

Installing Air Lines and Fittings

IMPORTANT: 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, tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.

Installing Fittings

Brass and Steel Pipe Fittings

For brass pipe fittings (see **Fig. 1)**, 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.

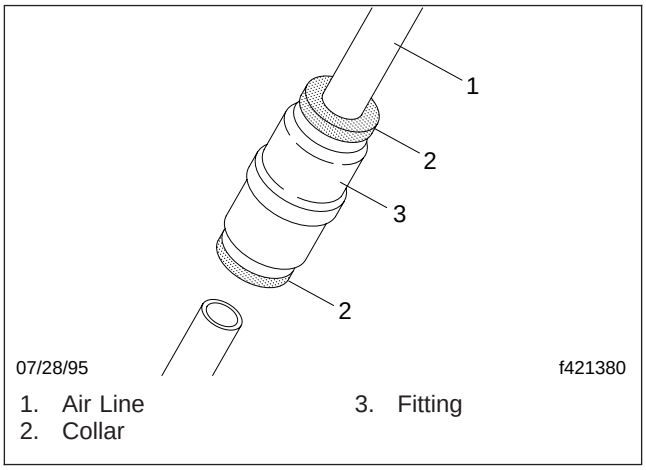
Copper Tube Fittings

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.



1. Air Line
2. Collar
3. Fitting

Fig. 4, Quick-Connect Fitting

Tube and Pipe Fittings on Plastic Components

For tightening specifications, refer to the table in **Specifications 400**.

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)
Pass Through Manifold w/ Metal Thread Inserts	1/8 NPT	50–60 (580–680)	—

* 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 Information

See **Fig. 1** for a sectional view of the Bendix E-6 Dual Circuit Foot Valve.

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.

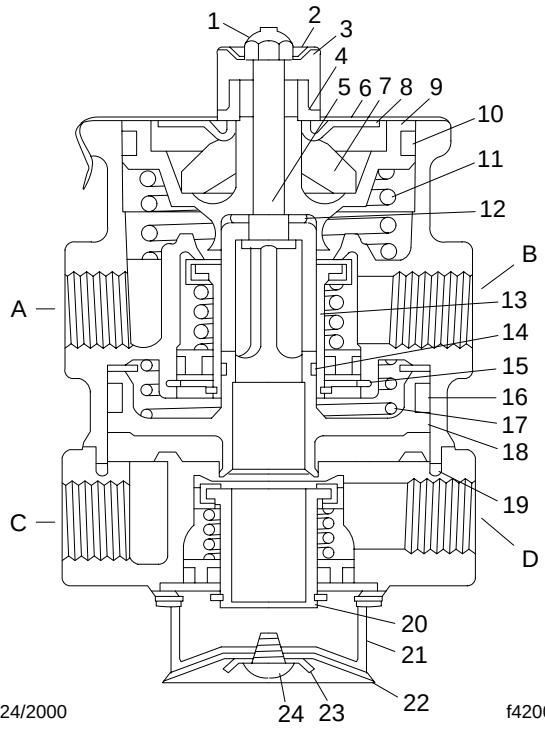
Holding

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 pushrod 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.



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 secondary 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 Screw

Fig. 1, Bendix E-6 Dual Circuit Foot Valve (sectional view)

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.

Removal

Figure 1 shows the E-6 brake valve mounting.

1. Park the vehicle on a level surface, shut down the engine, and chock the tires. Tilt the hood.

⚠ WARNING

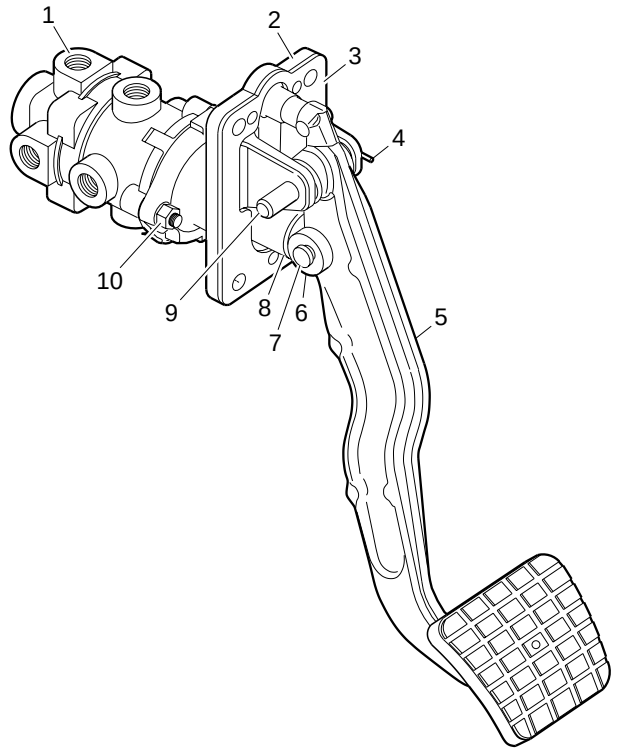
When draining the air system, do not look into the air lines/ports or direct them toward another person, because dirt or sludge particles may be in the airstream. Do not disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service 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 locknuts and washers that attach the brake valve to the mounting adaptor.
5. Remove the plunger from the mounting adaptor. Wipe off the old grease from the plunger and adaptor.
6. 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

⚠ WARNING

When applying sealant, make sure that excess sealant does not 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.



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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. Locknut and Washer

Fig. 1, Brake Valve Mounting

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.
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.

Brake Valve Removal and Installation

3. Using the locknuts and washers, attach the mounting adaptor to the brake valve. Tighten the capscrews 10 to 13 lbf·ft (14 to 18 N·m).
4. 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.
5. Return the hood to the operating position.
6. Perform the operating and leakage checks, as instructed in **Subject 130**.
7. Remove the chocks from the tires.
8. 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.

Brake Valve Disassembly, Cleaning and Inspecting, 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.

Disassembly

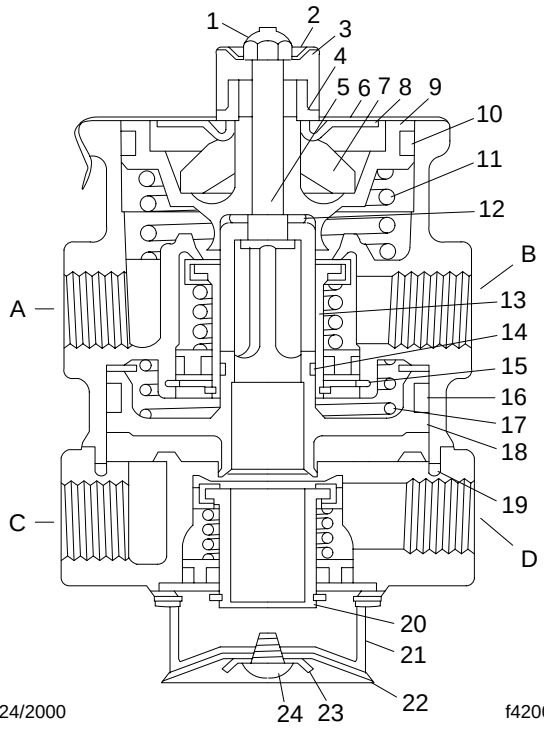
See **Fig. 1** for an exploded view of the Bendix E-6 valve.

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 locktabs 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 lbf (222 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.



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 secondary 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)

Brake Valve Disassembly, Cleaning and Inspecting, and Assembly

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. Turn the spring seat nut counterclockwise, and separate the spring seat nut, spring seat, and the rubber spring. Remove the primary piston O-ring.
12. Remove the small and large O-rings from the relay piston.
13. 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

NOTE: Keep the work area, tools, and brake valve parts clean during assembly.

1. Using Bendix BW 291126, or Dow Corning 55-M, or an equivalent pneumatic grease, 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 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 lbf (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 (Item 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 locktabs 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 (Item 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.

Brake Valve Disassembly, Cleaning and Inspecting, and Assembly

21. Install the brake valve. For instructions, see **Subject 110**.

⚠ WARNING

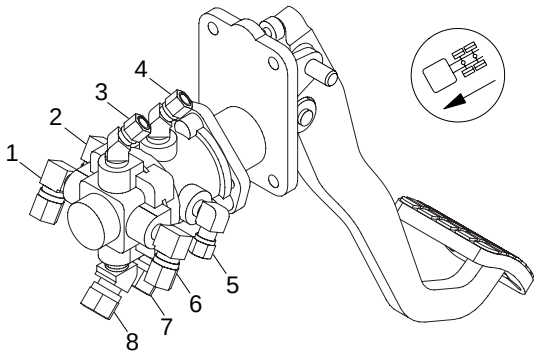
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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 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**.



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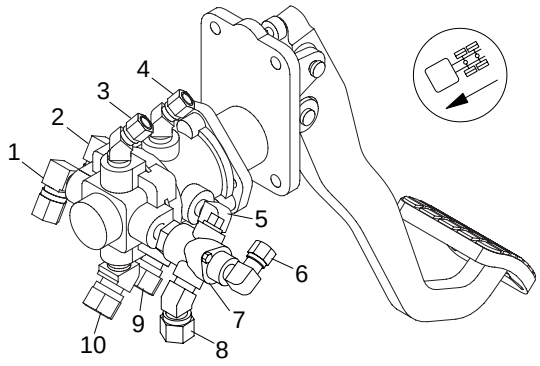
1. Secondary Delivery Circuit to Front Brake Valve
2. Delivery Circuit to Rear Brake Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Primary Delivery Circuit to Tractor Protection Valve
6. Secondary Delivery Circuit to Tractor Protection Valve (if not equipped 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



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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)

NOTE: When checking the delivery pressure of the primary and secondary circuits, use test gauges that are accurate.

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."

Brake Valve Operating and Leakage Checks

Leakage Check

1. Make and hold a pressure application of 80 psi (552 kPa).
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.

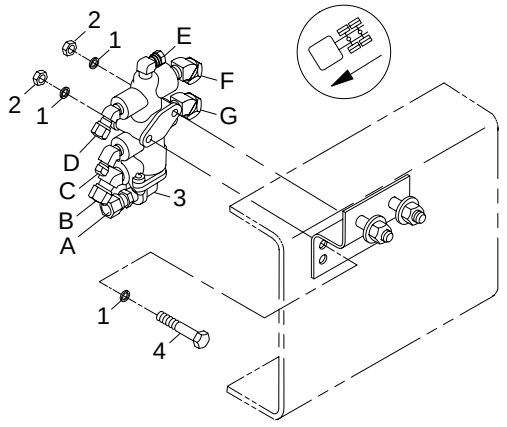
   If the brake valve does not function as described above, or if leakage is excessive, replace it with a new or remanufactured unit. Repeat the leakage test before placing the brake valve in service.

General Description

The 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**.



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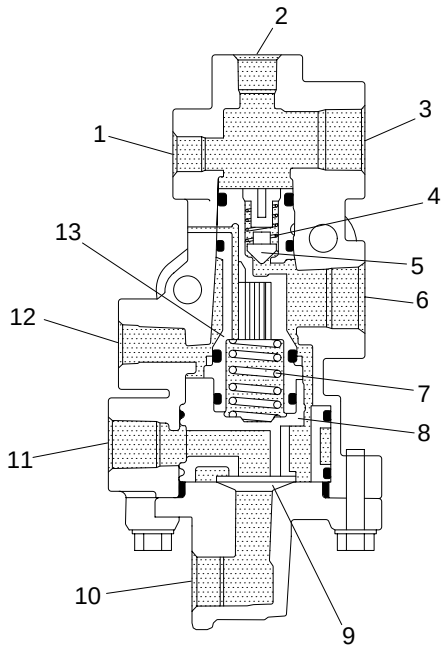
A. From service brake foot valve, primary circuit.
B. From service brake foot valve, secondary circuit.
C. To air manifold (stop lamp switch).
D. From trailer supply valve.
E. To proportioning relay (if installed).
F. To trailer emergency port.
G. To trailer service port.

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**.



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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

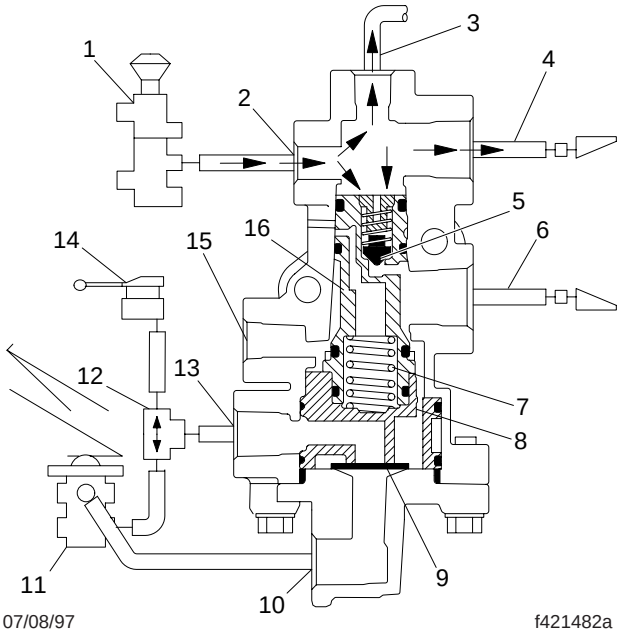
Principles of Operation

Initial Charge

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. See **Fig. 3**. 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

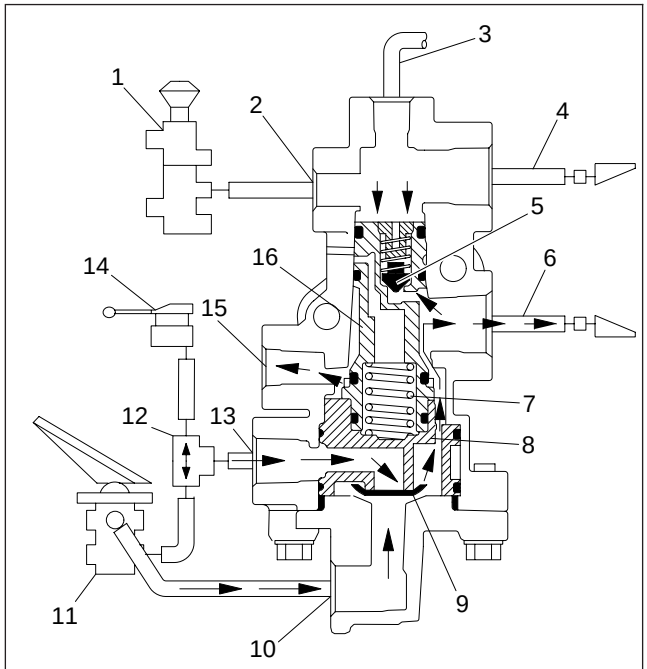
Fig. 3, Initial Charge

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

When the foot pedal is pressed, air flows to the TP–3DC valve tractor control primary and secondary ports. See **Fig. 4**. 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

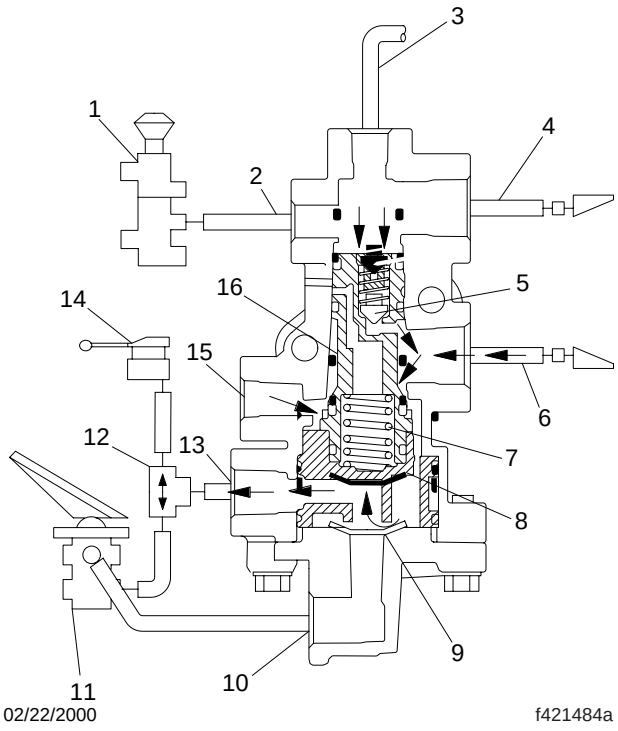
Inside the TP–3DC valve, the higher pressure (primary or secondary) moves the diaphragm to seal off the port at the lower pressure.

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

When the foot pedal is released, air stops flowing into the TP–3DC valve at the tractor control primary or secondary port. See **Fig. 5**. At the same time, air in the trailer control line returns to the valve, flowing back through the open inlet valve.



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

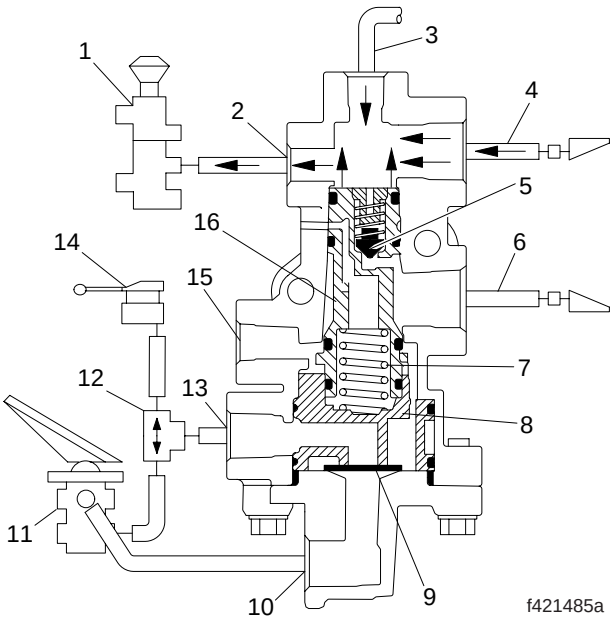
Fig. 5, Service Brake Release

Once the exhausting air has reached a sufficient flow level, a quick release valve located in-line between the trailer control line and the TP3-DC service brake port allows rapid exhausting.

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

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. See **Fig. 6**. 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.



1. Trailer Air Supply Valve
2. Tractor Supply Port
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5. Single Check Valve
6. Trailer Control Port
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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

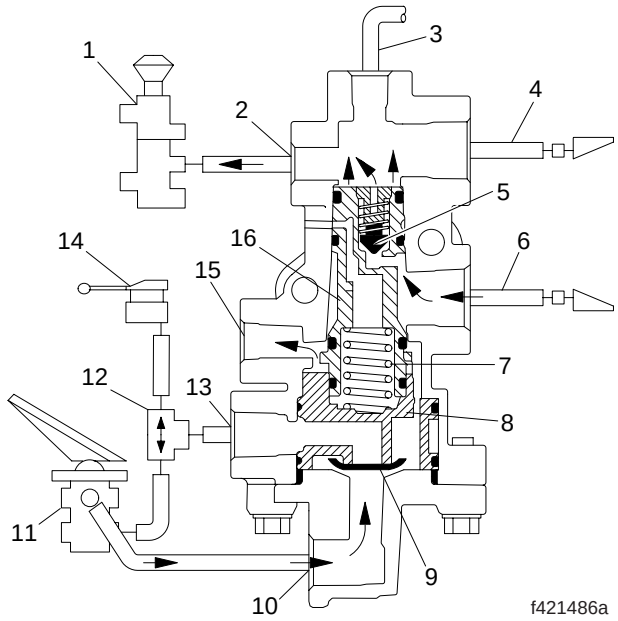
Fig. 6, Tractor Protection

General Information

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.

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. See **Fig. 7**. 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.



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 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.

⚠ 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. 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 that attach the TP–3DC valve to the vehicle, and remove the valve.

Installation

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.

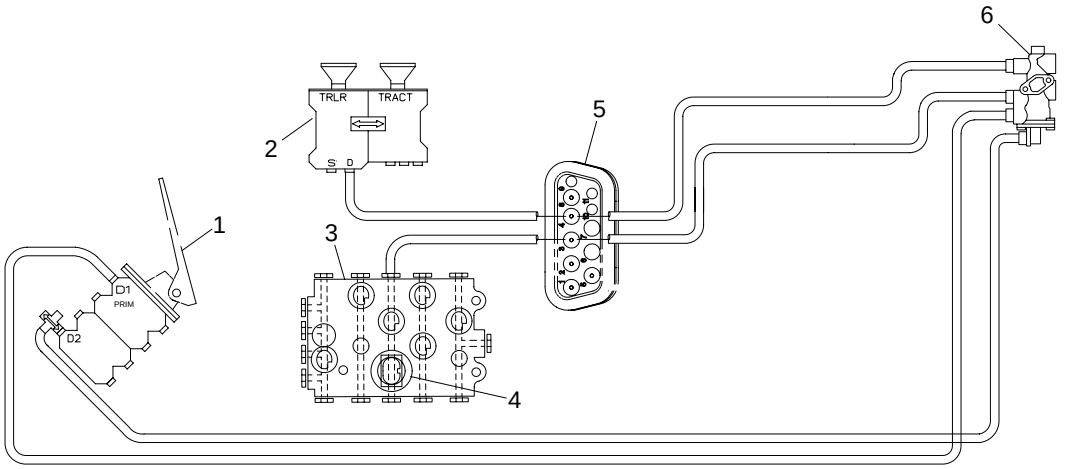
2. Remove the caps from the air lines, and, depending on the type of air hose, use the following instructions to connect the air hoses to the TP–3DC valve:

   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 130**.

Valve Removal and Installation



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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

Valve Disassembly, Cleaning and Inspection, and Assembly

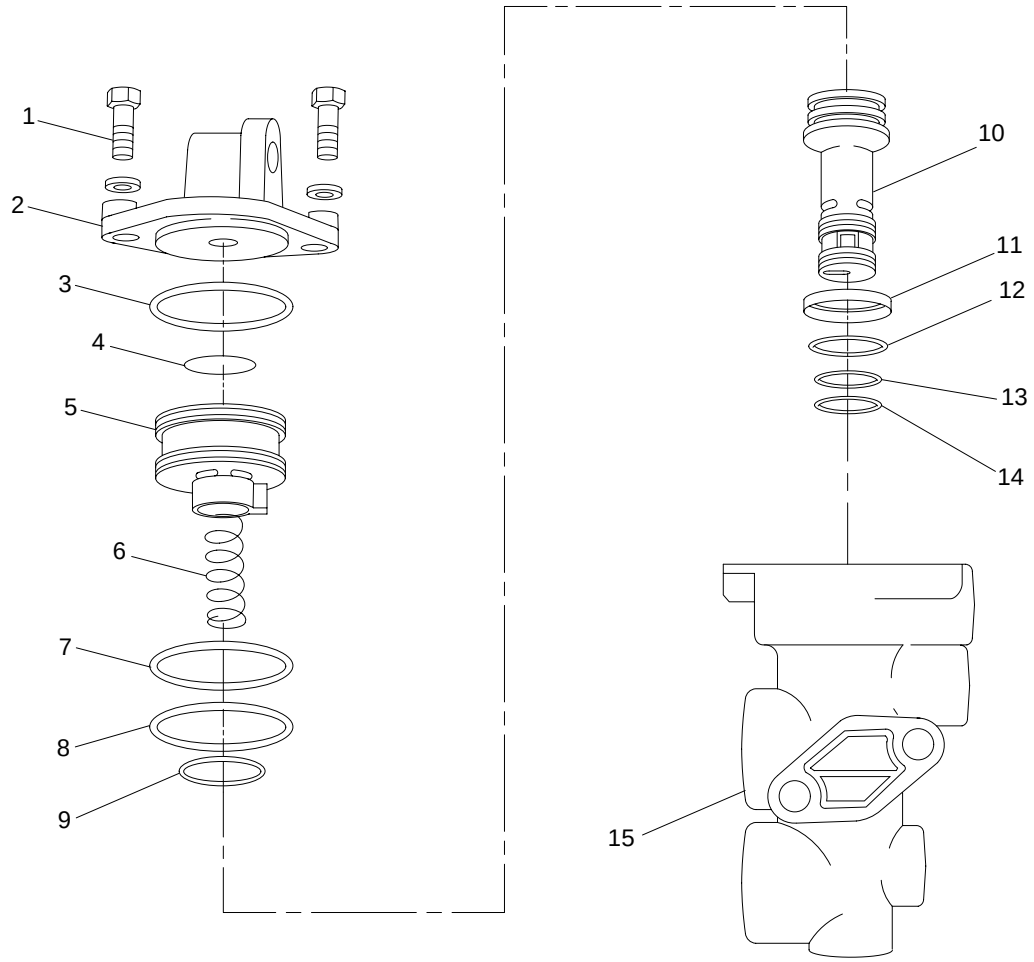
⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Disassembly

See **Fig. 1** for an exploded view of TP-3DC valve.

1. Remove the valve from the vehicle, retaining the mounting hardware. For instructions, see **Subject 110**.
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 that secure the valve cover to the valve body, and allow the



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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

Valve 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

⚠ 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

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 110**.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Operation and Leakage Test

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 soap-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 a 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.

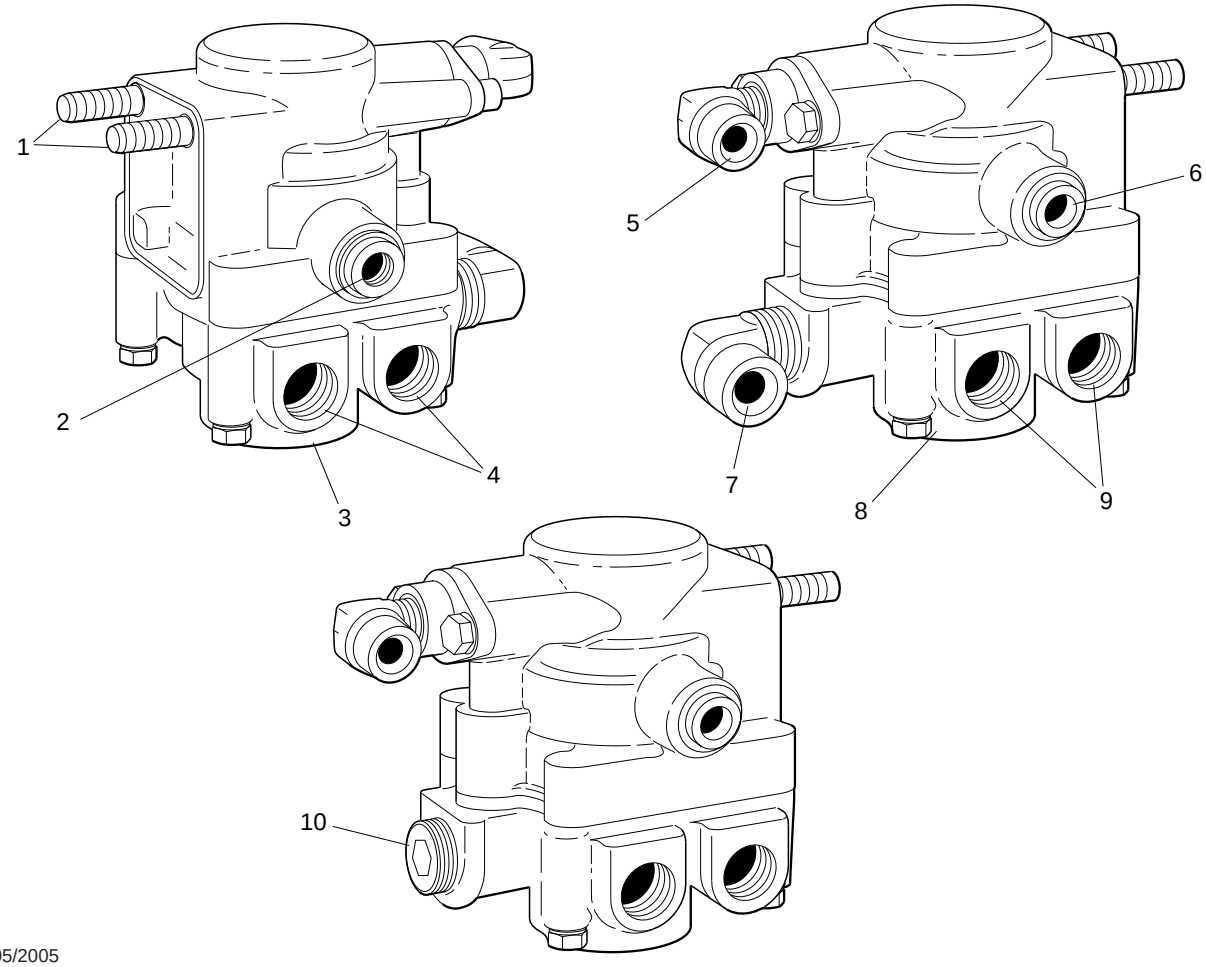
IMPORTANT: If the valve does not function as described, or if leakage is excessive, repair or replace the valve.

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. Depending on vehicle configuration, different numbers of delivery ports will be used. For instance, a 4x2 truck requires only two delivery ports be used. The remaining delivery ports would be plugged.



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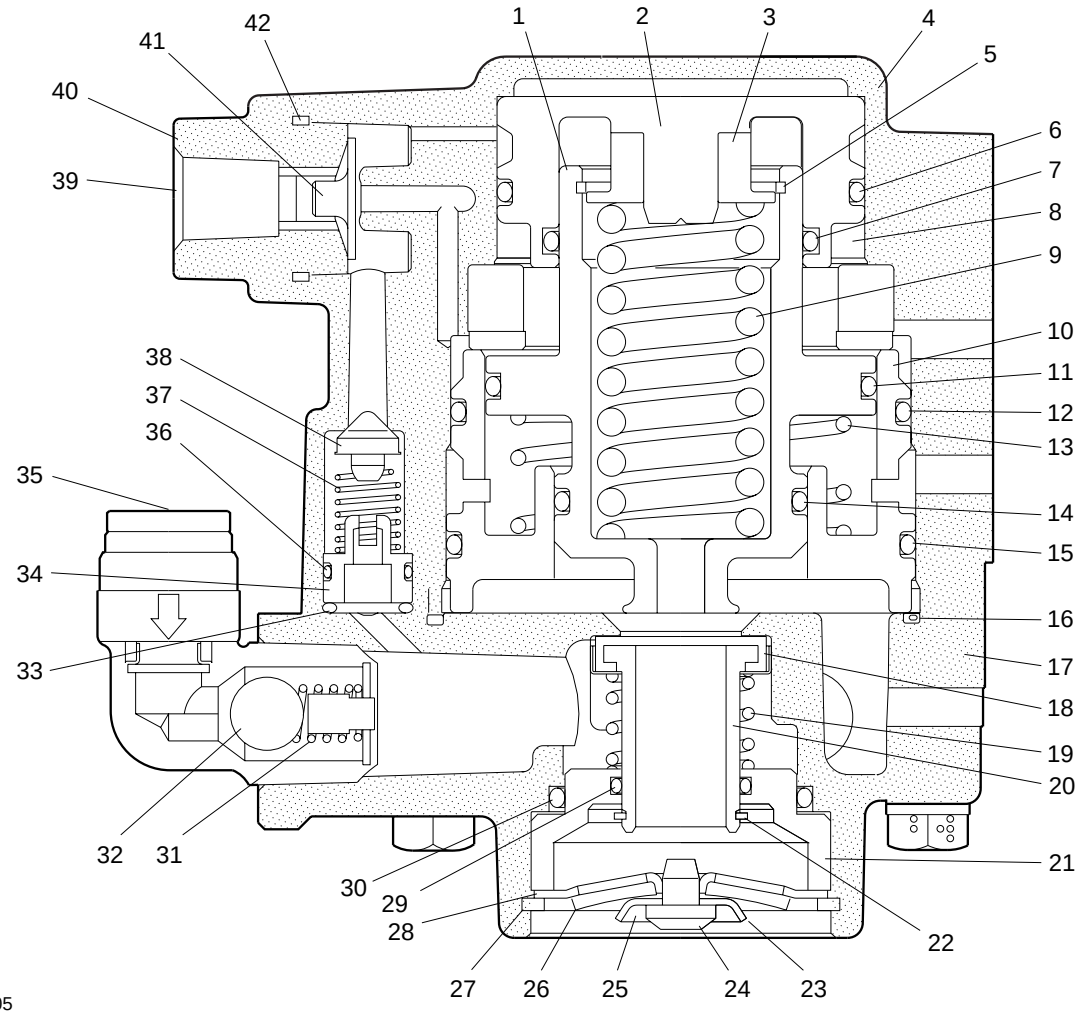
1. Mounting Studs
2. 42 Control Port
3. Exhaust
4. Delivery
5. 41 Park Control (from dash valve)
6. 41 Balance Port
7. Supply Port
8. Exhaust
9. Delivery
10. Pipe Plug (QRV applications only)

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)

The valve incorporates two mounting studs for mounting the valve to the frame rail or crossmember.

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)

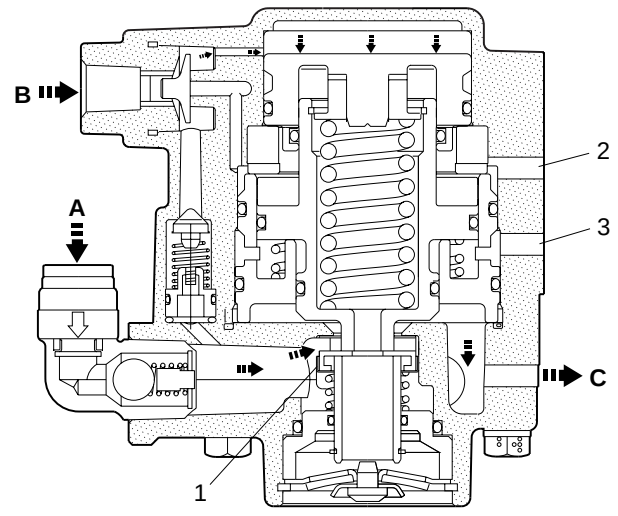
With the air brake system charged and the parking brakes released (by pushing in the dash valve button), air enters the park control port. This opens the SR-7 valve, to supply air pressure to the spring brake chambers. As illustrated, air pressure in the chambers is below 107 psi (737 kPa) (nominal). 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**.



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)

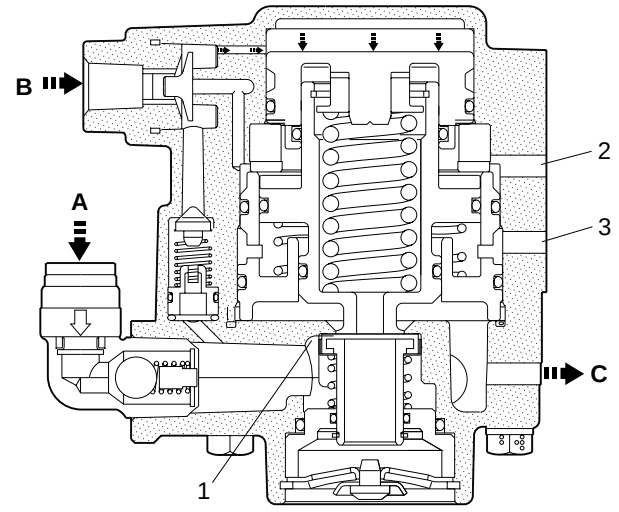
Parking

Actuating the parking 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



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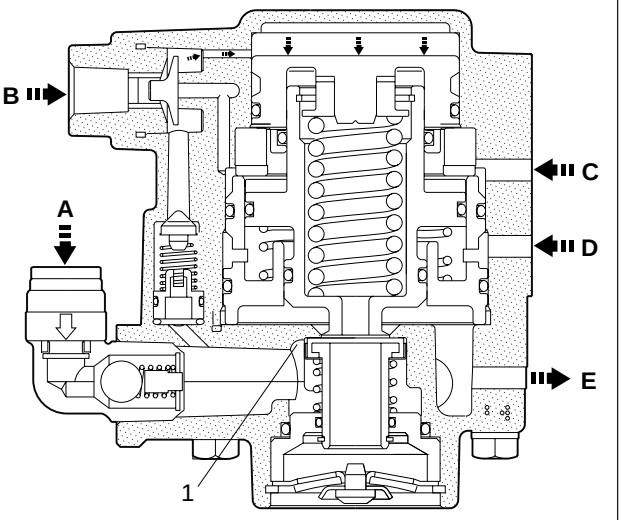
A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes

1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 4, Charging the Spring Brake Actuators Above 107 psi (737 kPa)



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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 Seated

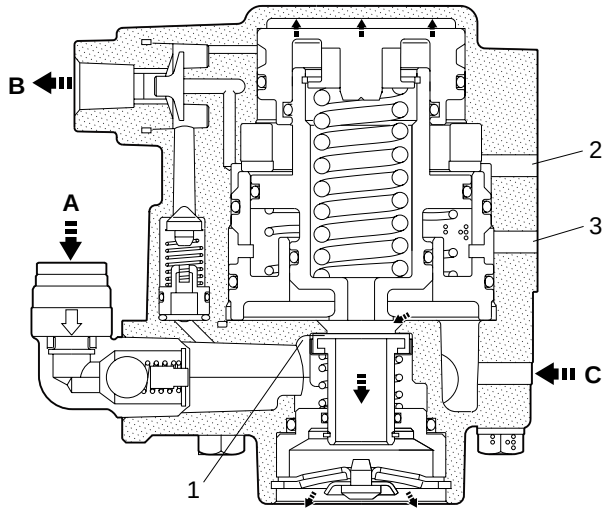
Fig. 5, Normal Service Application

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 parking 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**.



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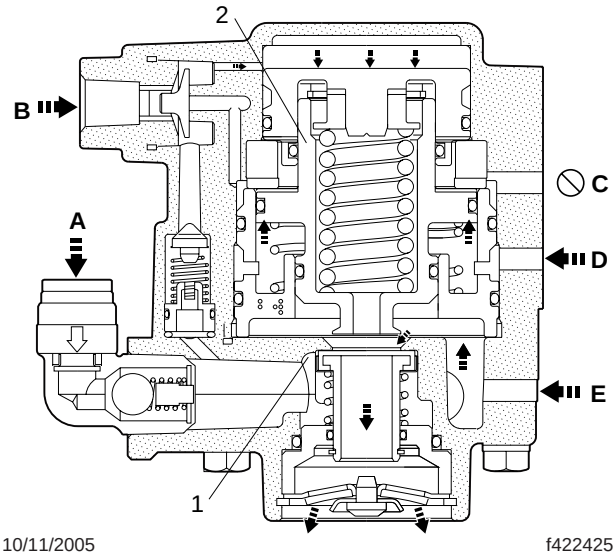
A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes

1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 6, Parking



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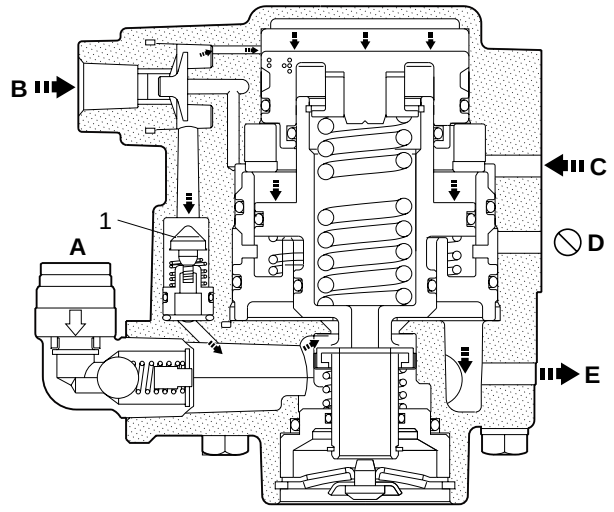
A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—loss of primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes

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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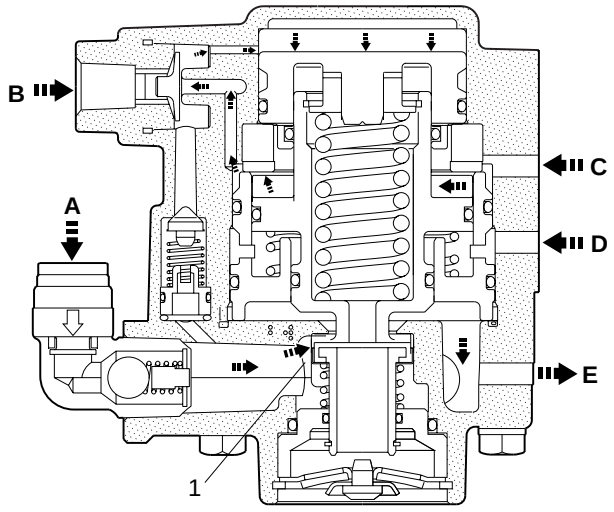
A. Secondary reservoir no pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—loss of secondary circuit pressure
E. Delivery to spring brakes

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.
- 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.
- The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.
- 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.
- To eliminate the possibility of component failure, used reservoirs must not be used as replacements.
- To prevent valve failure, safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured.
- Various actuators contain powerful internal springs that require special handling procedures. To avoid personal injury or property damage, note and be guided by the warning tags on such units.
- To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

Modulating Valve Removal and Installation

Removal

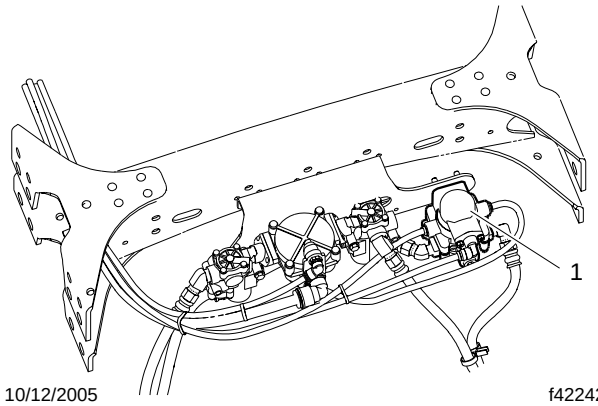
⚠ WARNING

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. With the vehicle parked on a level surface, set the parking brake, and shut down the engine. Chock the tires.
2. Drain the air system.
3. Identify all 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 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, then install and tighten the mounting nuts 15 to 18 lbf·ft (20 to 24 N·m).
3. Attach all 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, then 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.

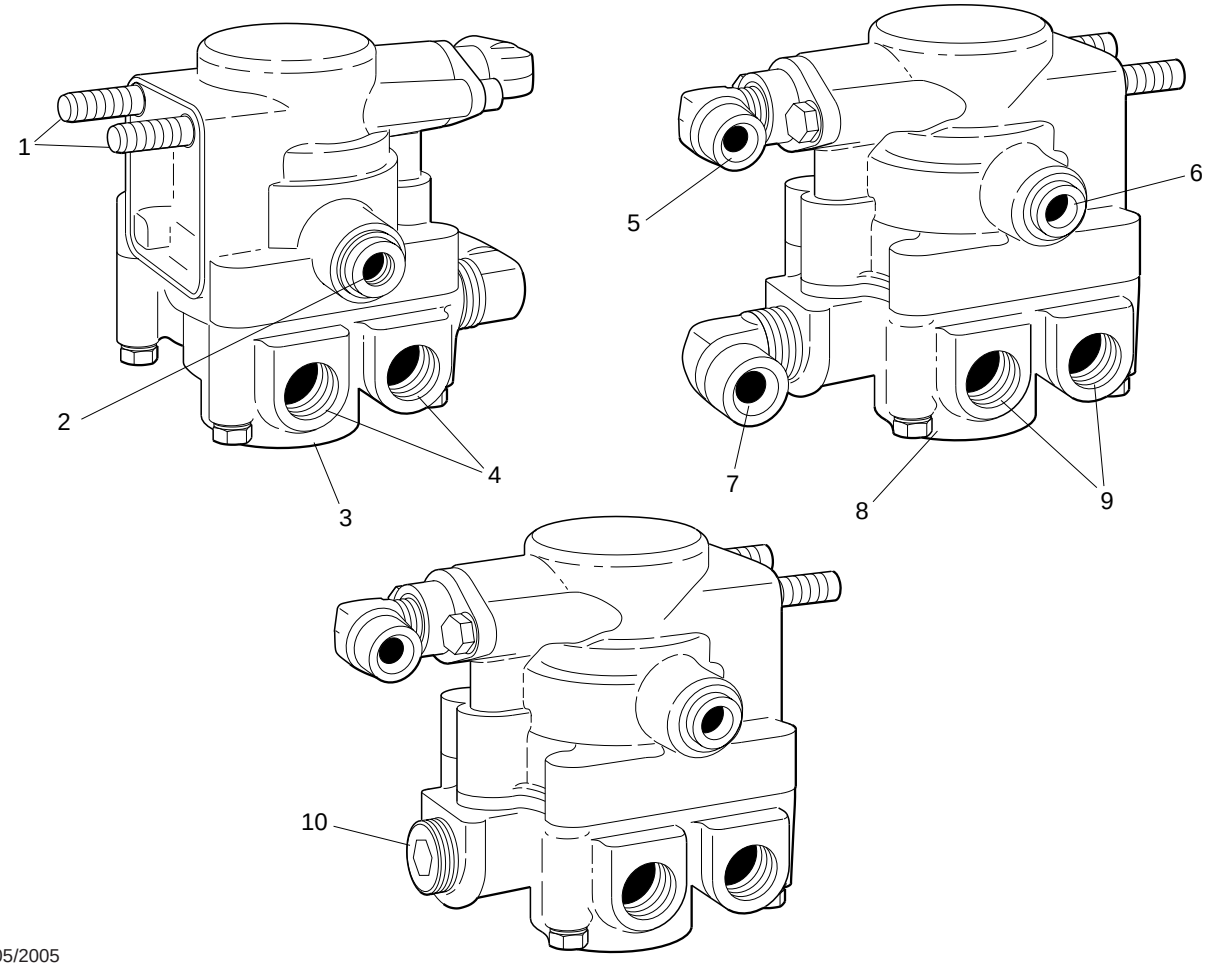
NOTE: The SR-7 valve is not serviceable. If the valve does not function as described, replace it.

Leakage Test

Place the parking 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



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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)

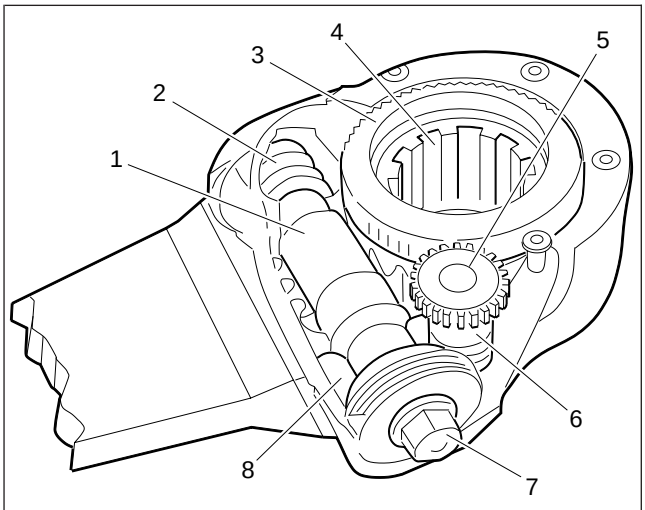
General Description

The Haldex (SAB) automatic slack adjuster, shown in **Fig. 1**, 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 indicator notch corresponds to the normal lining-to-drum clearance. As the brake application continues, the rack moves upward and rotates the one-way clutch, which slips in this direction.



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1. Wormshaft
2. Coil Spring
3. Control Disc
4. Worm Wheel
5. Regulator Gear
6. One-Way Clutch
7. Adjustment Hex
8. Clutch Wheel

Fig. 1, Haldex Slack Adjuster

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.

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 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.

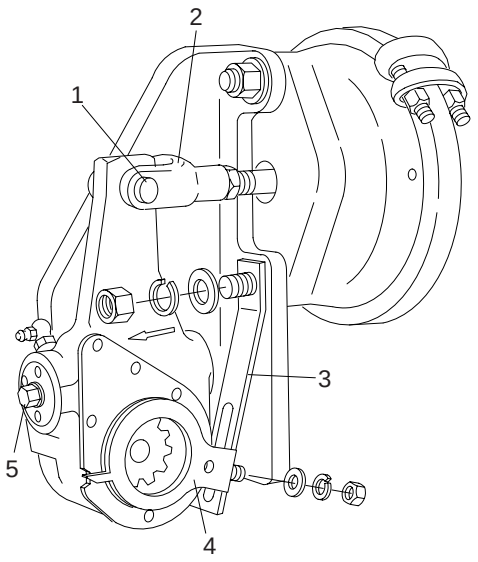
Slack Adjuster Removal and Installation, and Brake Adjustment

⚠ 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, set the parking brakes, and shut down the engine. Chock the front and rear 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**.



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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 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.

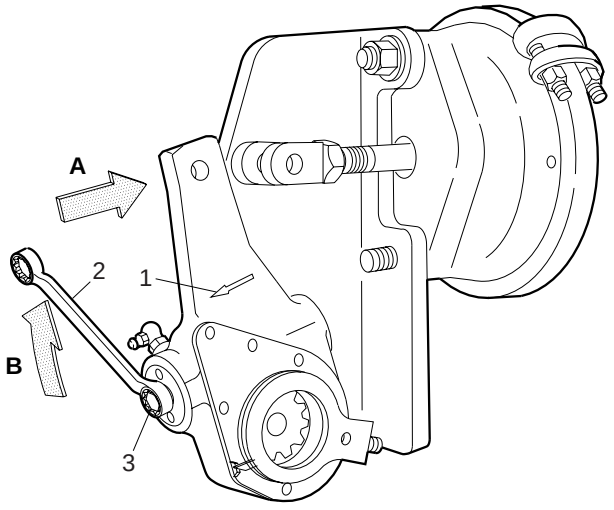
IMPORTANT: When correctly installed, the brake-chamber pushrod pushes in the direction of the arrow on the slack adjuster housing.

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. Box Wrench, 7/16 in
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.

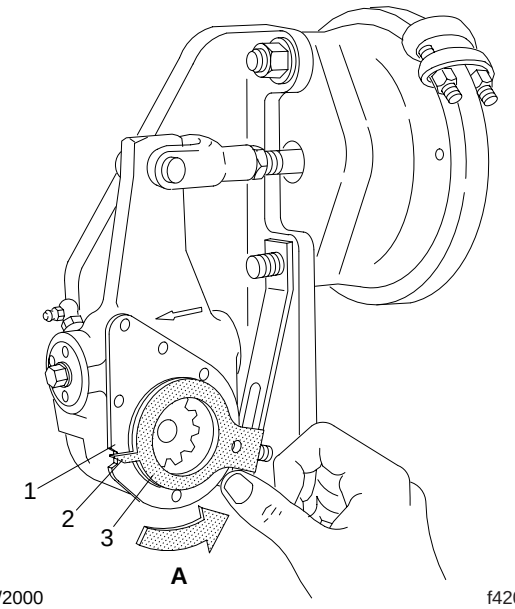
CAUTION

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, Aligning 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".

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 the *Cascadia™ Troubleshooting Manual*.

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

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**.

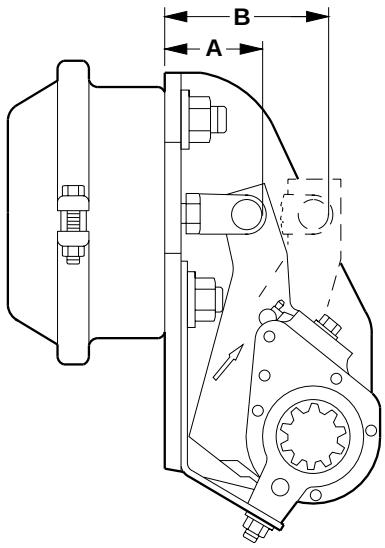
6.4 If the stroke varies or is greater than the maximum allowed length, refer to the *Cascadia™ Troubleshooting Manual*.

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.



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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

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

Specifications

Approved Lubricants	
Lubricants Type	**Lubricant Type**
Low Lube	Mobilgear SHC 460 Synthetic
Standard	Standard Chassis Grease

Table 1, Approved Lubricants

Brake Chamber Stroke Specifications			
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 2, Brake Chamber Stroke Specifications

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 pushrod 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 pushrod's return stroke to control the clearance and resets 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**.

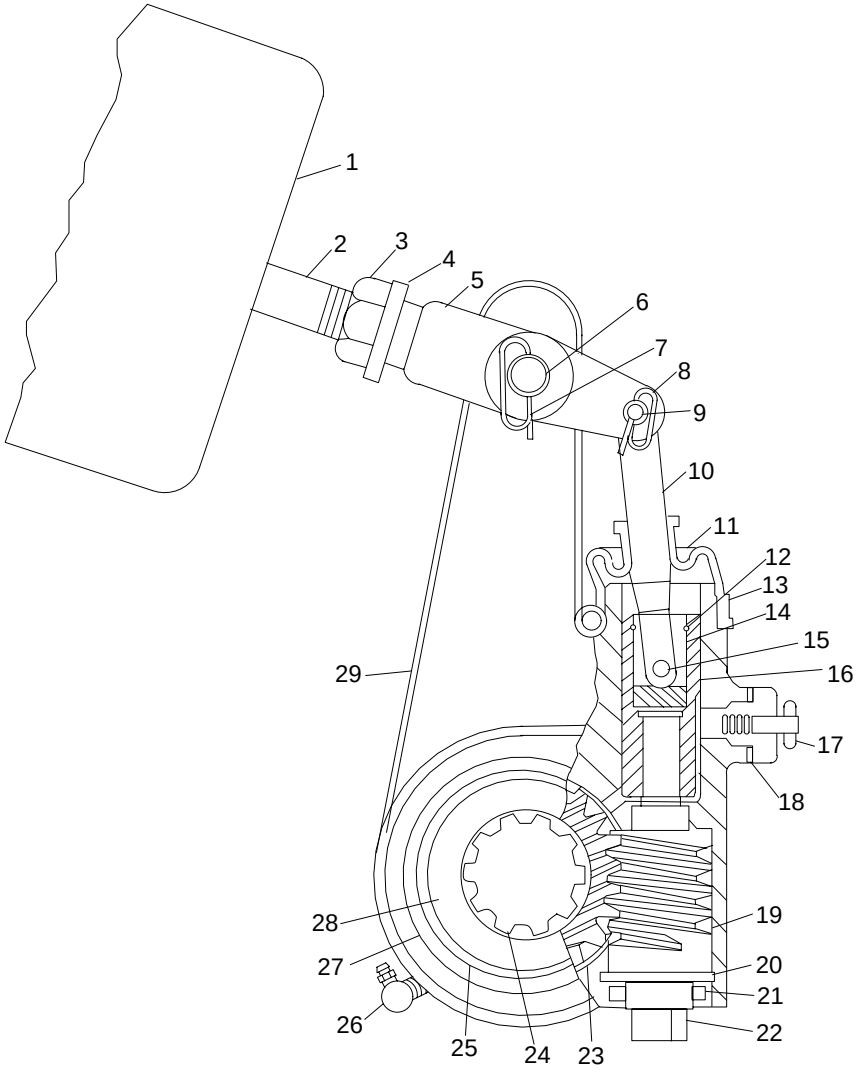
Inside the slack adjuster, the piston, actuator (adjusting sleeve), and pull-pawl work together to adjust the length of the pushrod stroke as the brake linings wear. The actuator has internal splines and angled serrations on the outside.

- The internal splines on the actuator mesh with the splined end of the worm so that any rotation 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 serrations 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 serration 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 automatically adjust the brake.

General Information



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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

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 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.

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. 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.

NOTICE

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.

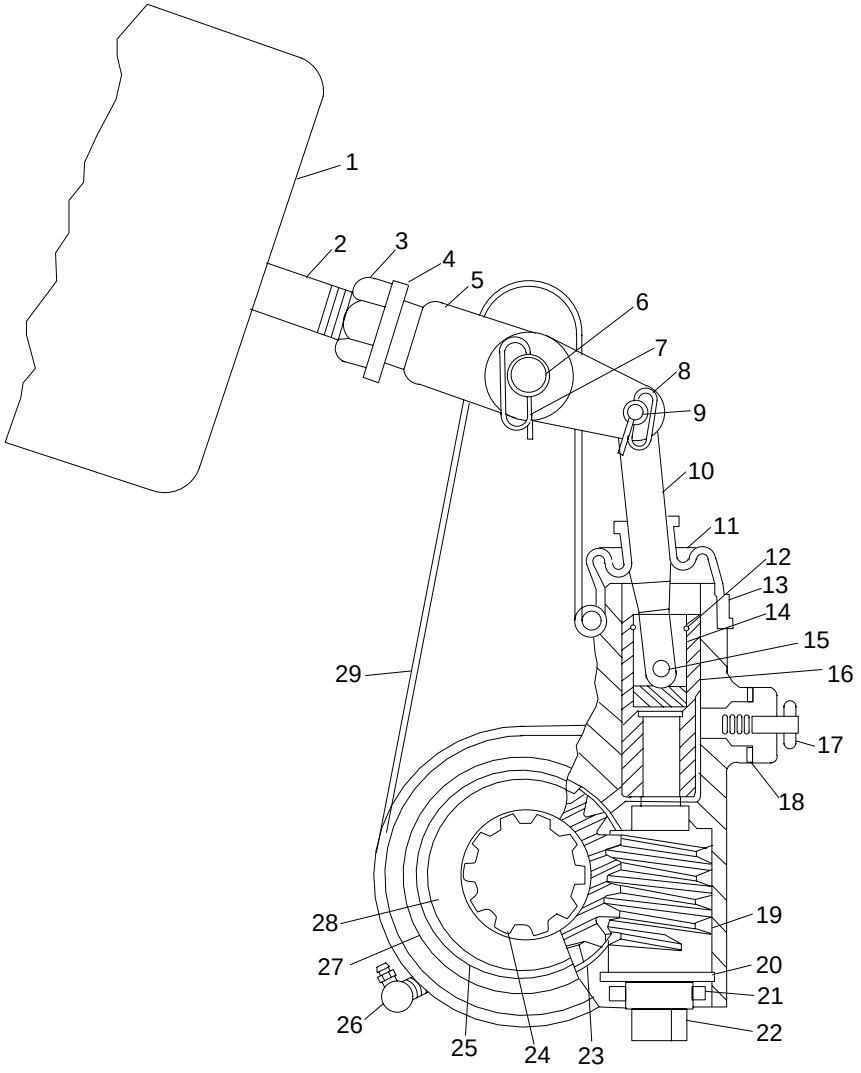
1. Inspect the parts and prepare the slack adjuster for installation.
2. Check the brake camshaft splines for wear or corrosion.

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.

Slack Adjuster Removal and Installation, and Brake Adjustment



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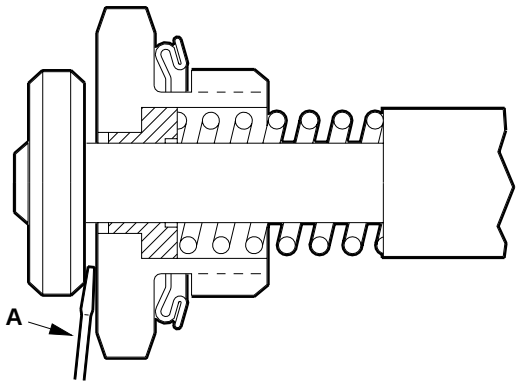
1. Brake Air Chamber
2. Brake Chamber Pushrod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Retainer Clip (large)
8. Retainer Clip (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
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

Slack Adjuster Removal and Installation, and Brake Adjustment



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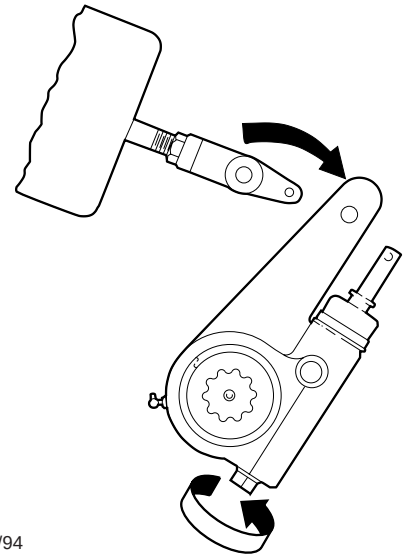
A. Insert screwdriver here.

Fig. 2, Disengaging the Pull-Pawl



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Turn the manual adjusting nut clockwise.

Fig. 3, Slack Adjuster Removal

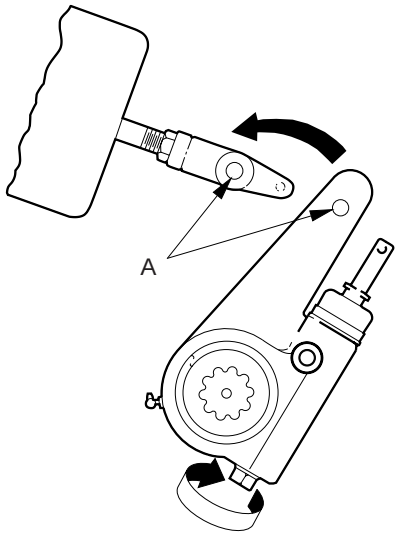
NOTICE

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.

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

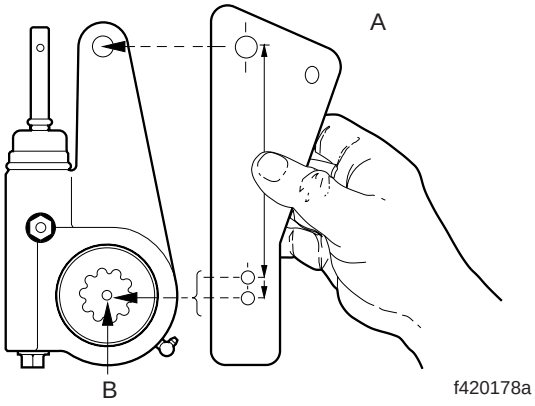
7. If installing a new slack adjuster:

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.

Slack Adjuster Removal and Installation, and Brake Adjustment



A. Using a template, measure the slack adjuster arm length.
B. Camshaft Center

Fig. 5, Slack Adjuster Measurement

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.

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).

NOTICE

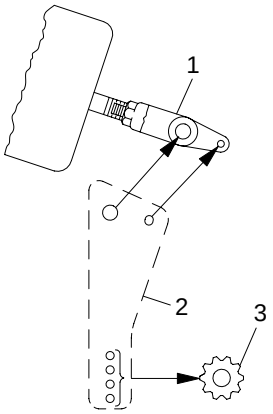
Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

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.

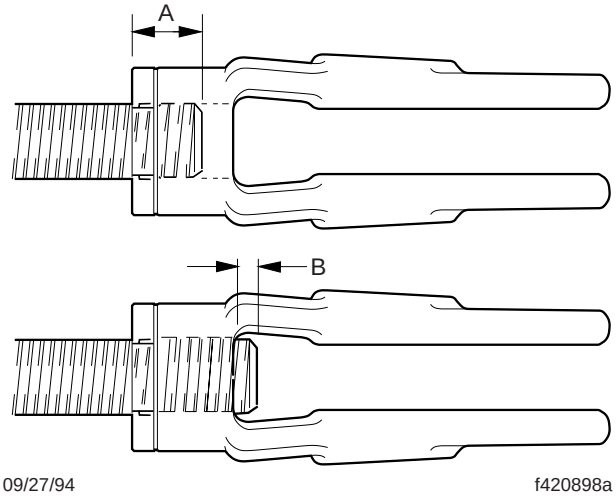
7.11 Make sure the small hole in the clevis is completely visible through the 1/8 inch hole at the top of the template.

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.



A. Minimum 1/2 inch (13 mm).
B. Maximum 1/8 inch (3 mm).

Fig. 7, Check Pushrod Engagement

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.

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).

NOTICE

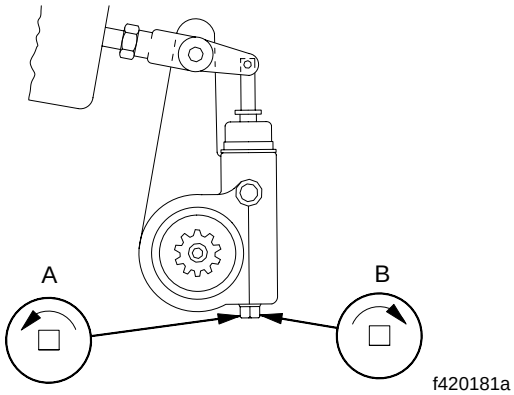
Before turning the manual adjusting nut on the slack adjuster, disengage the pull-pawl. Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

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.

NOTE: When the screwdriver is removed, the pull-pawl will engage automatically.

Slack Adjuster Removal and Installation, and Brake Adjustment

4. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment), as follows. See **Fig. 8**.



A. Shorten stroke. B. Lengthen stroke.

Fig. 8, Adjusting the Stroke

4.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.

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**.

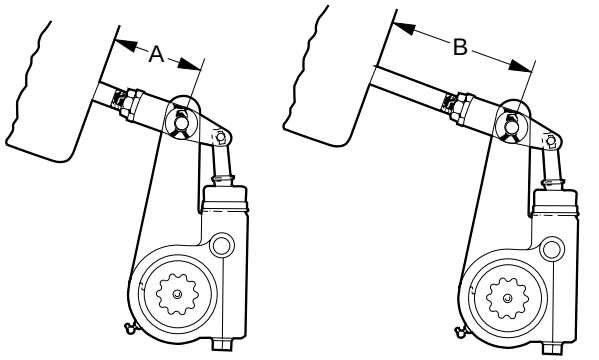
5.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

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.

6. Measure and adjust the applied chamber stroke (fine adjustment), as follows.

6.1 If system pressure is not already at 100 psi (690 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**.



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

6.3 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.

Slack Adjuster Removal and Installation, and Brake Adjustment

NOTICE

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**.

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 (552–621 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

Slack Adjuster Arm Length		
Chamber Size	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 Specifications	
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

Maximum Adjusted Brake Chamber Stroke		
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 (57) — *3-inch rated stroke*
30	2 (51)	2-1/2 (64)

Specifications

Maximum Adjusted Brake Chamber Stroke		
Chamber Size	Maximum Chamber Stroke: in (mm)	
	Standard Stroke	Long Stroke
36	2-1/4 (57)	—

Table 3, Maximum Adjusted Brake Chamber Stroke

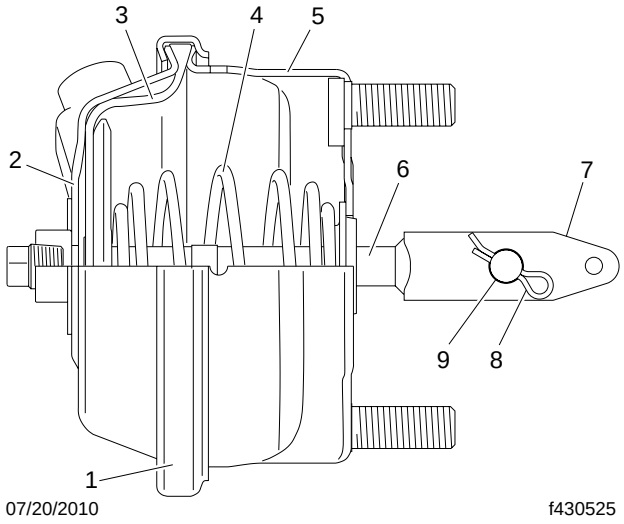
DANGER

Do not attempt to remove the sealed rolled-ring assembly on the brake chamber for any purpose at any time. The brake chamber is not intended to be serviced. Serious injury or death may result from the sudden release of the piston rod spring.

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. Rolled Ring Assembly (sealed)
2. Cover Assembly
3. Diaphragm
4. Piston Rod Spring
5. Body Assembly
6. Piston Rod Assembly
7. Welded Clevis Pushrod
8. Cotter Pin
9. Clevis Pin

Fig. 1, Brake Chamber (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.

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 Piston rods 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 they are 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.

Brake Chamber 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. Chock the tires.

⚠ WARNING

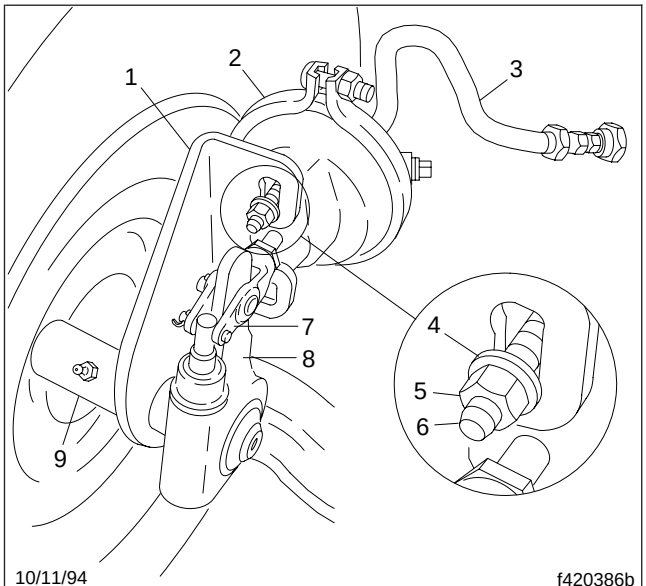
Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Do not direct the airstreams at other people. Do not disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result 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. See **Fig. 1**.
4. Remove the cotter pins from the clevis pins.
5. Remove the clevis pins from the slack adjuster.
6. From each mounting stud, remove any installed nuts and washers. Remove the brake chamber from the vehicle.

Installation

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. Attach the brake chamber to the mounting bracket, using a hardened flatwasher and prevailing torque locknut. See **Fig. 1**.
3. Tighten the locknuts. See **Specifications 400** for the correct torque value.
4. Connect the clevis pins to the slack adjuster.
5. Install and lock new cotter pin(s) to secure the clevis pin(s).



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
9. Camshaft Tube

Fig. 1, Brake Chamber Mounting

6. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this group.
7. Make sure the air line fittings are clean and free of debris.
8. Connect the air line to the brake chamber and tighten the nut finger-tight. Then, using a wrench, further tighten the nut until there is resistance, then tighten one-sixth turn more.

   Check that the hoses are properly supported and, if needed, clamped to provide good clearance.
9. Do both of the tests in **Subject 120**.

⚠ 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: For both of these tests, the air system must be pressurized to at least 80 psi (552 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 group.

Leakage Test

1. Apply the brakes and hold them on full line pressure of at least 80 psi (552 kPa).
2. Using a soap solution, coat the sealed clamp ring. Leakage is excessive if it produces a 1-inch (25-mm) bubble within five seconds.

   If leakage exceeds allowed amount, replace the brake chamber.

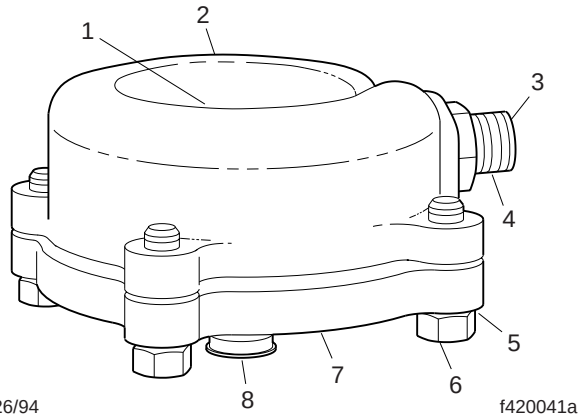
Specifications

Torque Values		
Description	**Chamber Size (all 5/8-inch Studs)**	**Torque: lbf·ft (N·m)**
Brake Chamber Mounting-Stud Locknuts	16	130–150 (176–203)
	20	
	24	
	30	

Table 1, Torque Values

General Description

The DV-2 automatic reservoir drain valve (see **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**.

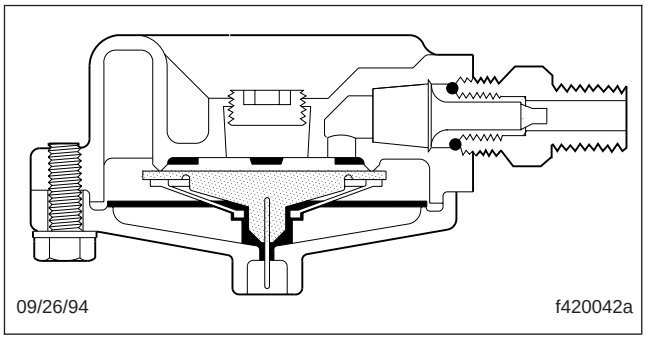


Fig. 2, No System Pressure

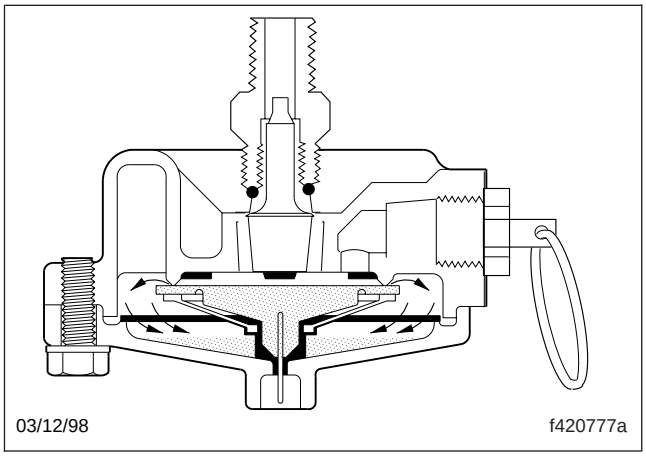


Fig. 3, Start of System Pressure Charging

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

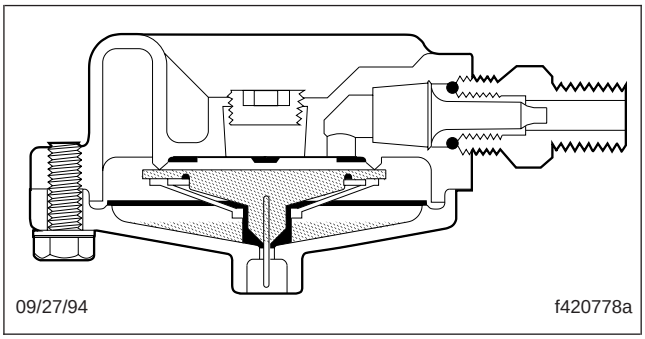


Fig. 4, System Pressure Rising

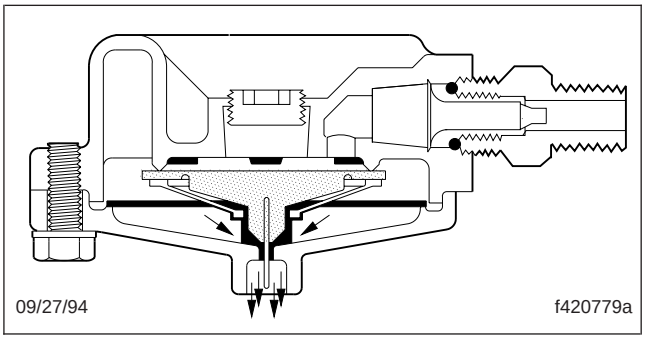


Fig. 5, Exhaust Cycle

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.

⚠ 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. Chock the tires, and drain the air system.
2. Remove the drain valve assembly from the end of the wet tank air reservoir.

Installation

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.
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 130**.

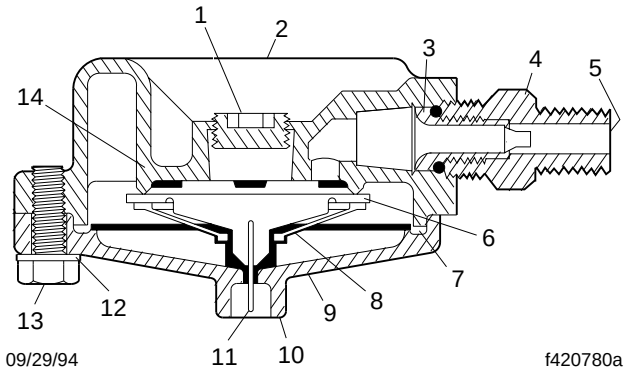
Drain Valve Disassembly, Cleaning and Inspection, and Assembly

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Disassembly

Refer to **Fig. 1** during drain valve disassembly and assembly.



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)

1. Remove the drain valve, following the instructions in **Subject 110**.
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

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.

NOTICE

Do not reassemble the drain valve with a dirty filter; to do so could result in failure of the drain valve in service.

Assembly

Before assembling the drain valve, apply a light film of grease on the inlet valve seat.

IMPORTANT: 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 95 to 130 lbf·in (1073 to 1469 N·cm).

Drain Valve Disassembly, Cleaning and Inspection, and Assembly

5. Install the hexhead nipple onto the valve body, and tighten it 65 to 95 lbf·in (734 to 1073 N·cm).
6. Install the drain valve on the wet tank, following the instructions in **Subject 110**.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Operating 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, 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.

Specifications

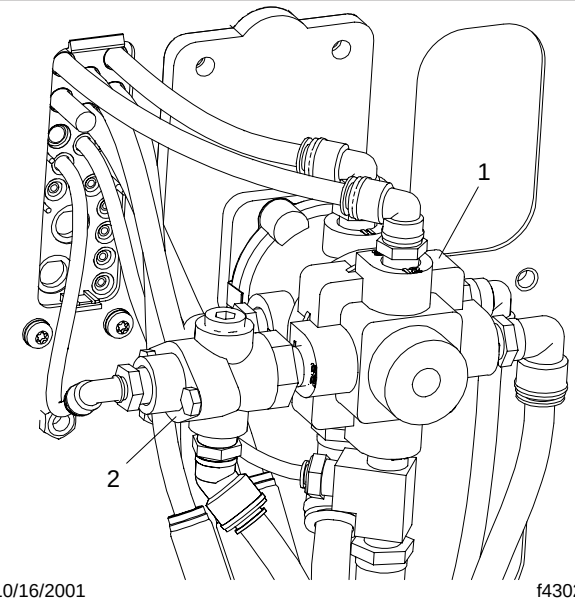
Torque Values	
Description	**Torque: lbf·in (N·cm)**
Valve Cover Capscrews	95–130 (1073–1469)
Hexhead Nipple (to valve body)	65–95 (734–1073)

Table 1, Torque Values

General Information

The Bendix DC-4 shuttle-type double check valve (see **Fig. 1**) 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.



1. Foot Brake Valve
2. Double Check Valve

Fig. 1, Brake Valve and Double Check Valve

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 pushrods 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 they are not correctly disassembled. Use only the correct tools, and observe all precautions regarding use of those tools.

Double Check Valve Removal and Installation

WARNING

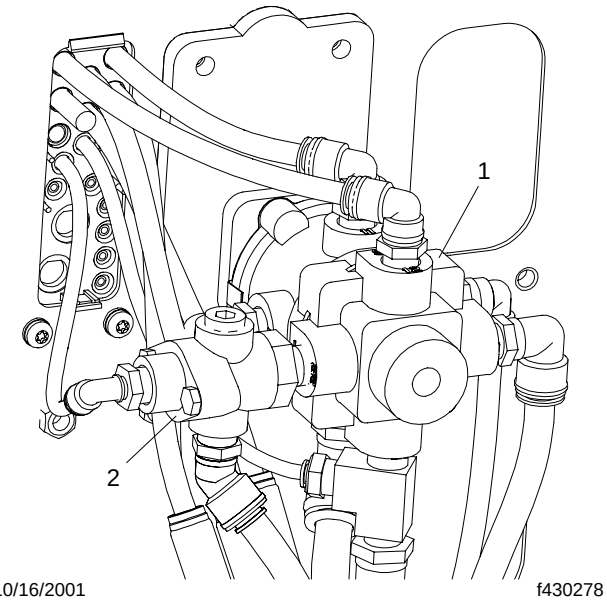
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Removal

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. Do not direct the air streams at other people. Do not 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. Mark the positions of the air lines on the valve, then disconnect them from the double check valve. See **Fig. 1**.



1. Foot Brake Valve
2. Double Check Valve

Fig. 1, Brake Valve and Double Check Valve Plumbing

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. Push the air lines firmly into the quick-connect fittings.

Double Check Valve 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.

Disassembly

See **Fig. 1** for a cross-sectional view of the check valve.

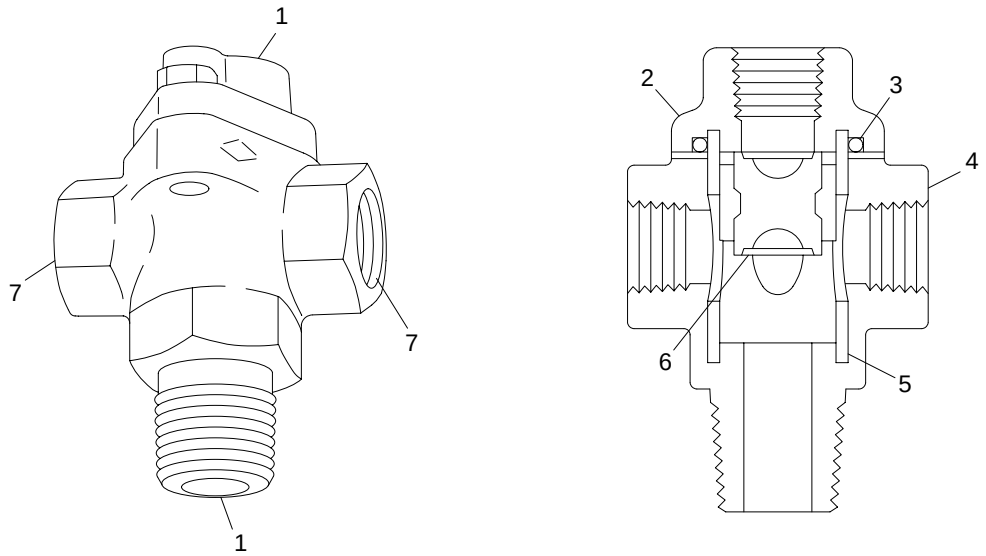
1. Remove the valve from the vehicle. For instructions, see **Subject 110**.
2. Remove the end cap from the valve.
3. Remove the O-ring.
4. Remove the shuttle valve and shuttle guide.

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 a new 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 110**.
6. Test the valve. For instructions, see **Subject 130**.



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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

Double Check Valve Operating and Leakage Test

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Operating and Leakage Test

On-Vehicle Testing

1. Push in and release the foot brake pedal while checking that the brakes apply and release on both the tractor and trailer.
2. Apply and release the trailer control valve while checking that only the trailer brakes apply and release.
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.
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 5 seconds is allowable.
5. If the double check valve does not function as described, or if the leakage is excessive, replace it. See **Subject 110** for instructions.

   If the valve cannot be replaced, repair it using Bendix parts. See **Subject 120** for instructions.
6. Connect the air line to the trailer control valve exhaust port.

Bench Testing

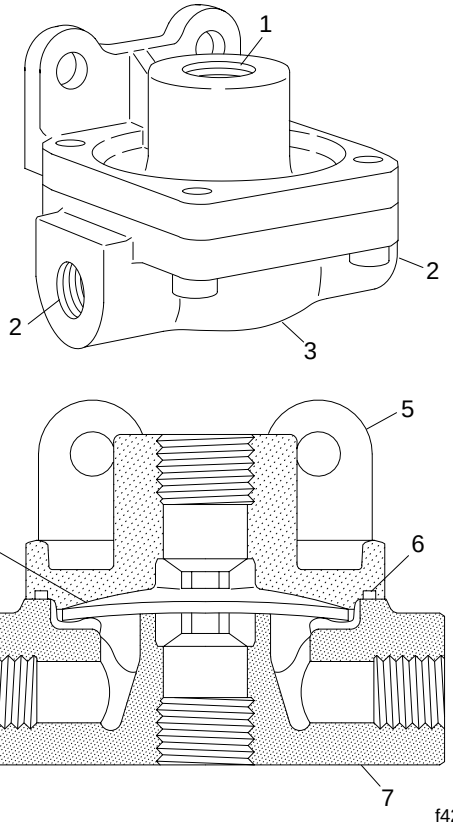
1. Connect two separately controlled air supplies to the inlet ports.
2. Apply and release air to one inlet port (foot brake pedal) while checking that the test gauge registers the application and release.
3. Apply and release air to the other inlet port (trailer control valve) while checking that the gauge registers the application and release.
4. 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.
5. If the double check valve does not function as described, or if the leakage is excessive, replace it. See **Subject 110** for instructions.

   If the valve cannot be replaced, repair it using Bendix parts. See **Subject 120** for instructions.

General Information

QR-1 Valve

The function of the QR-1 quick release valve (see **Fig. 1**) is to speed up the release of air pressure from the front service brake chambers. When the front brake chambers are equipped with a QR-1 valve, and a foot brake application is released, the exhaust port of the quick release valve opens and the air from the front brake chambers is exhausted through the quick release valve. This accelerates the release of the front brakes.



1. Supply Port
2. Delivery Port
3. Exhaust Port
4. Diaphragm
5. Valve Cover
6. O-Ring
7. Valve Body

Fig. 1, QR-1 Valve and Cross-Section

When the front brake chambers are equipped with a QR-1 valve, it is located on the forward face of the crossmember just aft of the transmission. A delivery line from the foot valve is connected to the port on top of the QR-1 quick release valve; the two side ports are for brake chamber connections, and the exhaust port is located at the bottom of the valve.

QR-1C Valve

The QR-1C quick release valve (see **Fig. 2**) is a dual function valve. Its primary function is to speed up the release of air pressure from the service brake chambers. Additionally, the valve works as an anti-compound device. The double check valve feature prevents a service and parking brake application from occurring at the same time.

The QR-1C valve is generally mounted on the axle and serves two spring brake actuators. A balance line from the relay valve delivery port 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. The air connections to the QR-1C are as follows:

1. The QR-1C delivery port is connected to the emergency port of the spring brake.
2. The QR-1C balance port is connected to the delivery of the relay valve.

NOTE: The QR-1C valve should be connected to the delivery side (not to the service or signal side) of the relay valve.

3. The QR-1C supply port is connected to the delivery of the park control valve.

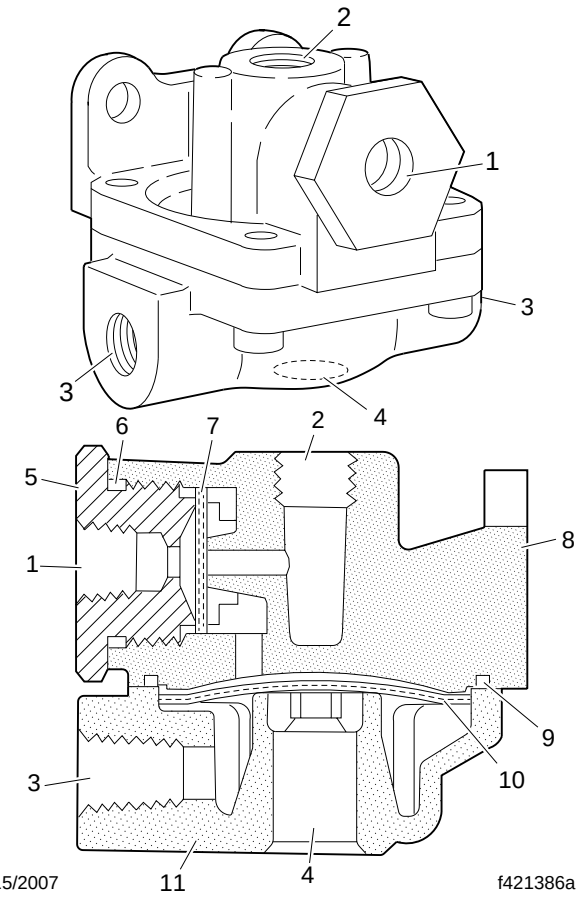
Principles of Operation

QR-1 Valve

When the foot brake control is applied, delivery air enters the brake valve port on the QR-1 quick release valve; the diaphragm moves down, sealing the exhaust port. At the same time, air pressure forces the edges of the diaphragm down, allowing air to flow out the brake chamber ports, filling the chambers and applying the front axle brakes.

When the brake chamber air pressure (beneath the diaphragm) equals the air pressure being delivered by the foot valve (above the diaphragm), the outer edge of the diaphragm will seal against the valve body seat. The exhaust port is still sealed by the

General Information



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Capnut
6. Sealing Ring
7. Double Check Diaphragm
8. Valve Body
9. O-Ring
10. Quick Release Diaphragm
11. Valve Cover

Fig. 2, QR-1C Valve and Cross-Section

center portion of the diaphragm. When the foot brake is released, the air above the diaphragm is released back through the foot brake valve exhaust, while the air beneath the diaphragm forces the diaphragm to rise, opening the exhaust port, and allowing air in the brake chambers to exhaust.

QR-1C Valve

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 balance port allowing the supply port to seal the balance and exhaust ports and keep the spring brakes released.

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 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 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.

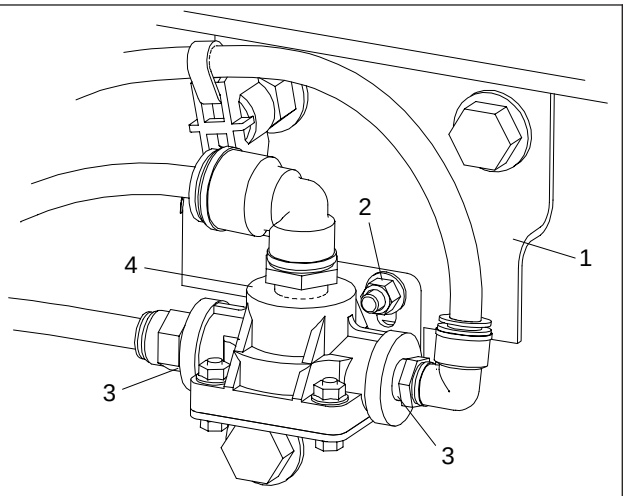
QR-1/QR-1C Removal and Installation

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 and shut down the engine. Chock the tires or hold the vehicle by means other than air brakes.
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. See **Fig. 1**.



1. Mounting Bracket
2. Mounting Nut and Bolt
3. Delivery Port
4. Supply Port

Fig. 1, Quick Release Valve Mounting (QR-1 valve shown)

Installation

1. Install the quick release valve with the exhaust port facing down. Securely tighten the mounting bolts.
2. Install the air lines to the quick release valve in the locations previously marked.
3. Perform the operating and leakage tests in **Subject 130**.

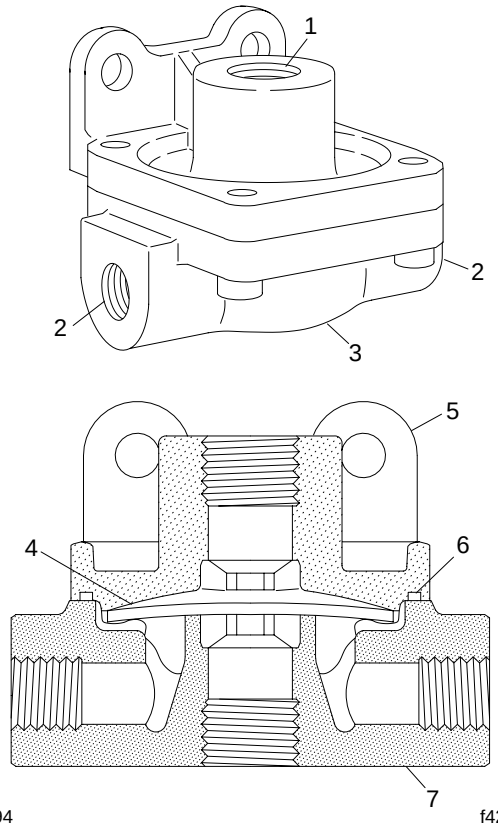
QR-1/QR-1C Disassembly, Cleaning and Inspection, and Assembly

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

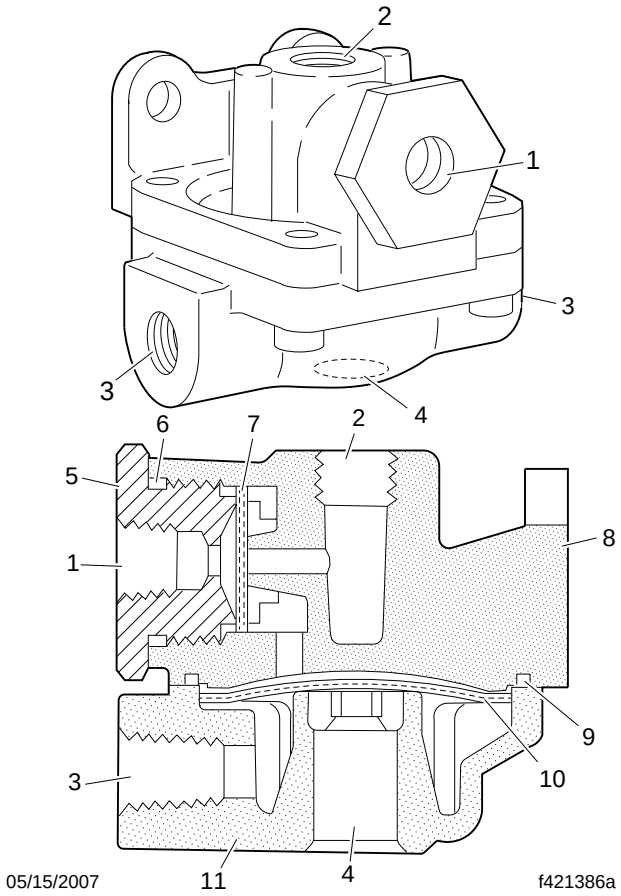
Refer to the following figures during these procedures:

- QR-1 Valve — **Fig. 1**.
- QR-1C Valve — **Fig. 2**.



1. Supply Port
2. Delivery Port
3. Exhaust Port
4. Diaphragm
5. Valve Cover
6. O-Ring
7. Valve Body

Fig. 1, QR-1 Valve and Cross-Section



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Capnut
6. Sealing Ring
7. Double Check Diaphragm
8. Valve Body
9. O-Ring
10. Quick Release Diaphragm
11. Valve Cover

Fig. 2, QR-1C Valve and Cross-Section

Disassembly

1. Remove the quick release valve from the vehicle, following the instructions in **Subject 110**.
2. Mark the valve body and valve cover for ease of installation.
3. For a QR-1C valve, remove the capnut at the supply port, then remove the sealing ring from the capnut.
4. For a QR-1C valve, remove the double check diaphragm.
5. Remove the four screws that hold the valve cover on the valve body.

QR-1/QR-1C Disassembly, Cleaning and Inspection, and Assembly

6. Separate the cover from the valve body, then remove the O-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. For a QR-1C valve, install the sealing ring on the cap nut.
2. For a QR-1C valve, install the double check diaphragm in the valve body.
3. For a QR-1C valve, install the cap nut, and tighten it 13 to 33 lbf·ft (18 to 45 N·m).
4. Install the quick release diaphragm in the cover.
5. Install the O-ring and 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 110**.
7. Do the operating and leakage test as instructed in **Subject 130**.

Operating and Leakage Tests

⚠ WARNING

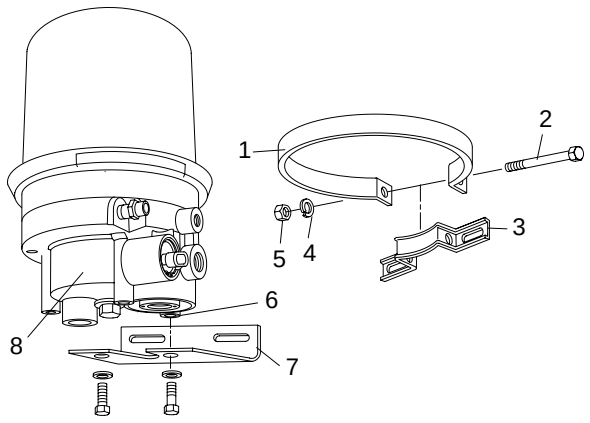
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

The following tests should be performed after repairing or replacing the quick release valve to ensure that it is functioning properly.

1. Park the vehicle on a level surface and set the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Release the parking brakes.
4. On QR-1C valves, remove the air line from the valve balance port. Build system air pressure to 120 psi (827 kPa). Coat the exhaust and balance ports with a soap solution; leakage of no greater than a 1-inch (2.5-cm) bubble in 5 seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes. Step on the foot brake; the valve should exhaust air at the exhaust port when the foot brake is released.
6. Drain the air system.
7. Remove the air line from the valve supply port. Build system air pressure to 120 psi (827 kPa). With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of no greater than a 1-inch (2.5-cm) bubble in 5 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.

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. Daily manual draining of the reservoirs is eliminated.



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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

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

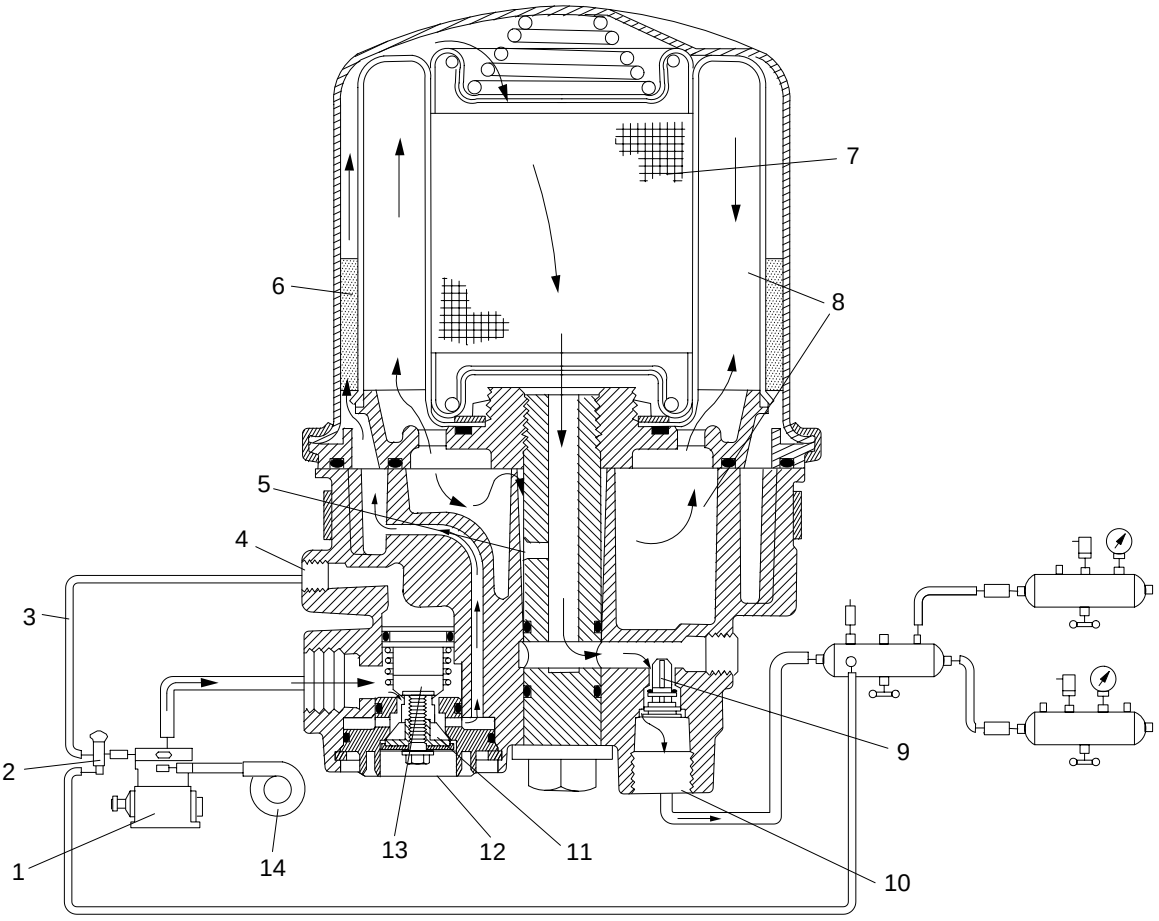
When the compressor is loaded (compressing air), compressed air, along with oil, oil vapor, water, and water vapor flows through the compressor discharge line to the supply port of the air dryer body.

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

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

drying bed. Air flowing down through the column of desiccant becomes progressively dryer as water 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.

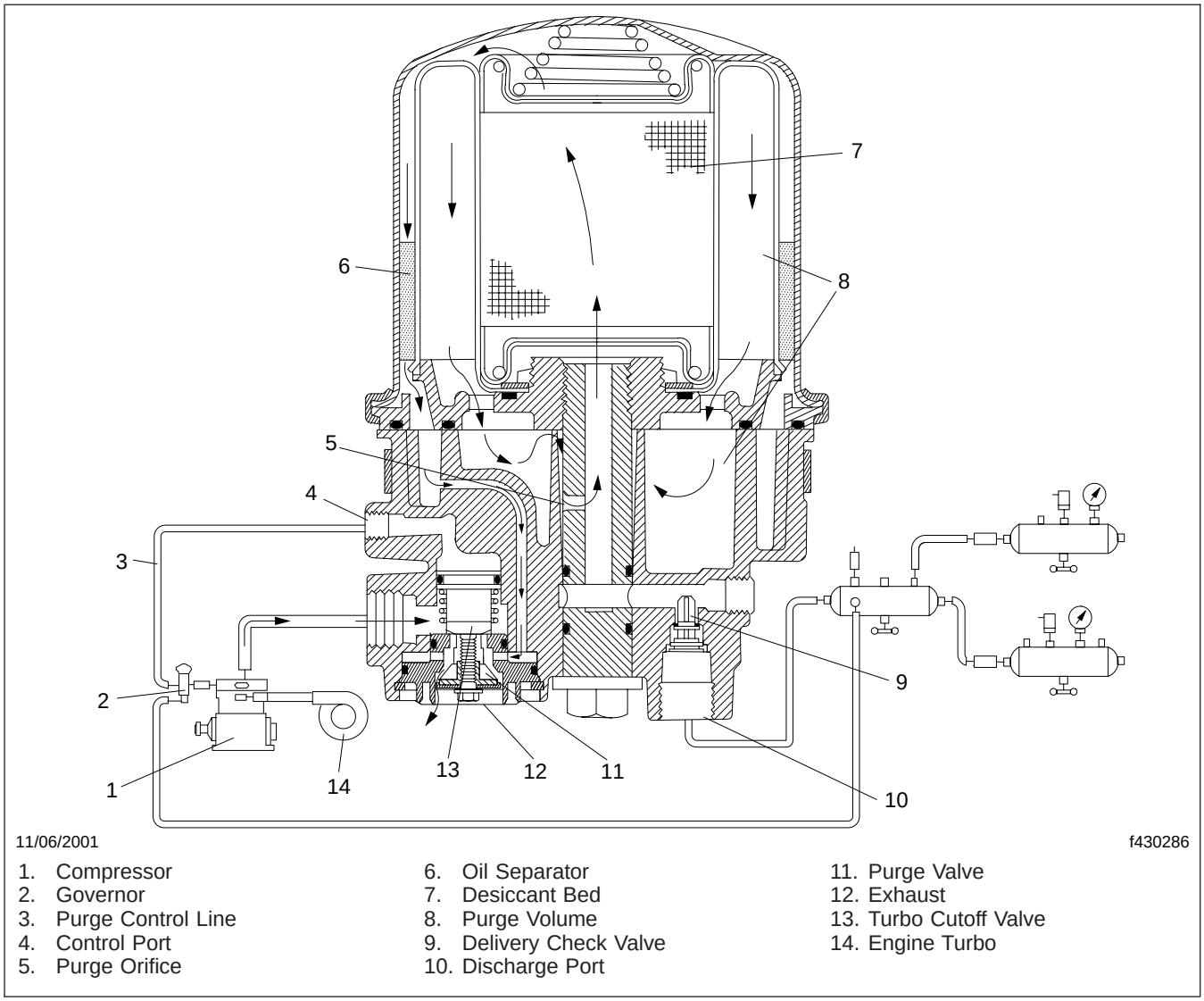
Dry air exits the bottom of the desiccant cartridge and flows through the center of the bolt used to secure the cartridge to the end cover. Air flows down the center of the desiccant cartridge bolt, through a cross-drilled passage and exits the air dryer delivery port through the delivery check valve.

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 cut-out 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 Cut-off 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

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.

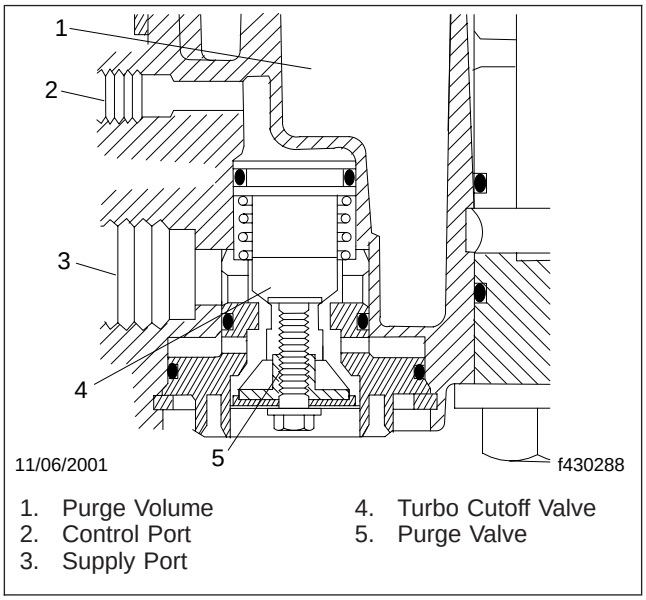
NOTE: The air dryer should be periodically checked for operation and tested for leaks. Refer to **Group 42** of the *Cascadia™ Maintenance Manual* for intervals and procedures.

Turbocharger Cutoff Feature

NOTE: The air compressor on the Cascadia™ 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.

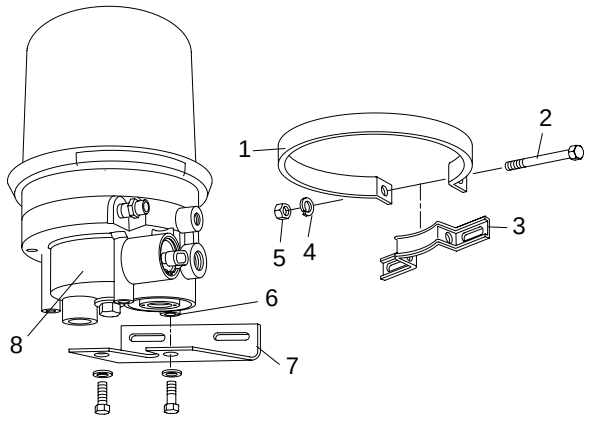
  Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.

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 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 *Cascadia™ 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

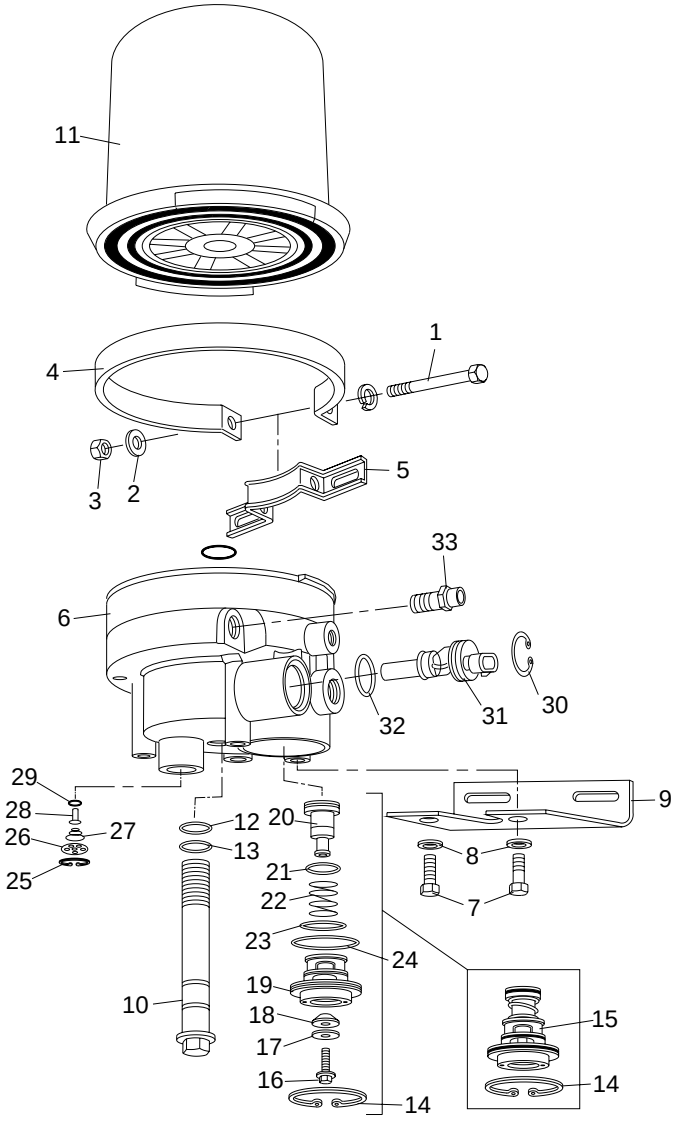
1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.

NOTE: Don't 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



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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

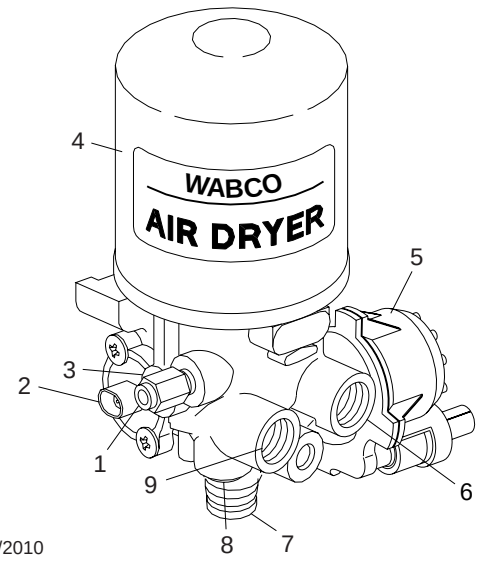
1. Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-base lubricant. See **Fig. 1** during assembly unless otherwise advised.
2. Install and center the exhaust diaphragm over the shoulder bolt, making certain that the diaphragm ID is over the bolt shoulder. 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 70 lbf·ft (95 N·m), to secure the desiccant cartridge to the end cover.
11. Install the air dryer. For instructions, see **Subject 110**.

General Information

The System Saver 1200 air dryer, shown in **Fig. 1**, is a desiccant air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the buildup of dirt and moisture in the vehicle air system.



1. Pressure Relief Valve
2. Heater/Thermostat Assembly
3. Governor Port (to air governor)
4. Desiccant Canister
5. Regeneration Valve Assembly
6. Outlet Port (to air supply reservoir)
7. Exhaust Port (Purge Valve Assembly)
8. Turbocharger Cutoff Valve
9. Inlet Port (from air compressor)

Fig. 1, WABCO System Saver 1200

The air dryer consists of a light weight aluminum and steel body. The desiccant cartridge is contained in a spinoff canister at the top of the air dryer.

The bottom half of the air dryer houses the following components.

- Pressure Relief Valve—this valve protects the air dryer from over pressurization. The valve is attached directly to the air dryer.
- Desiccant Canister—a cylindrical steel housing that contains the filter elements and the desiccant needed to filter and dry the air that passes through it.
- Heater/Thermostat Assembly—located in the air dryer base, this assembly is designed to prevent the collected moisture from freezing.
- Outlet Check Valve—this valve prevents air in the system from flowing back through the air dryer and escaping out the purge valve during the compressor unload cycle.
- Pressure-Controlled Check Valve—this valve is separate from the air dryer and is installed on the system air tank. The valve allows air to back flow from the system tank to the supply tank as long as air system pressure remains between the normal cut in and cut out range of the air governor.
- Purge Valve—this valve allows the collected moisture and contaminants to be expelled from the air dryer during the purge cycle.
- Regeneration Valve—this valve allows air from the supply and system tanks to bypass the outlet check valve and flow into the regeneration valve. Air then flows through an orifice where the air expands and back flushes moisture off of the desiccant. The air is then exhausted through the purge valve.
- Silencer (Muffler)—an optional component that is attached to the purge valve and used to eliminate most of the noise during the air dryer purge cycle.
- Turbocharger Cut-Off Valve—this valve closes the path between the air compressor and the air dryer purge valve to help maintain boost pressure for maximum engine horsepower during the compressor unload cycle.

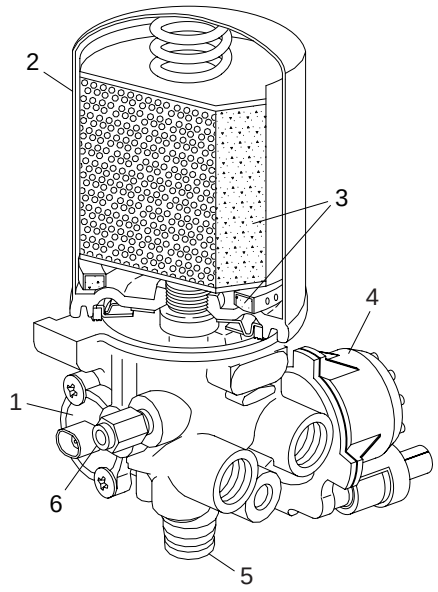
NOTE: The air compressor on the Cascadia™ is naturally aspirated; the air passes from the vehicle air filter directly to the air compressor intake.

Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and initially settle into the base of the dryer. The moisture-laden air also passes through the desiccant

General Information

bed, where any remaining moisture is retained by the desiccant. The clean air then passes through the air dryer outlet port to the supply reservoir. See **Fig. 2**.



1. Heater/Thermostat Assembly
2. Desiccant Canister
3. Filter
4. Regeneration Valve Assembly
5. Exhaust Port (Purge Valve Assembly)
6. Pressure Relief Valve

Fig. 2, Desiccant Canister Sectional View

When the compressor reaches 125 psi (862 kPa), the purge valve opens, allowing the initial decompression of the dryer, and expelling the water and contaminants collected in the base of the dryer. The regeneration valve, along with the pressure-controlled check valve, allows the system air to flow back through the dryer. This back flow dries the desiccant for the next cycle.

Safety Precautions

⚠ WARNING

When draining the air system, do not look into the air jets or direct them toward another person, as dirt or sludge particles may be in the air-stream. 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 cause personal injury.

When working on or around air brake systems and components, observe the following precautions.

1. Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Do not disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc., should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Do not attempt to repair parts by machining.
7. Never exceed recommended air pressure.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

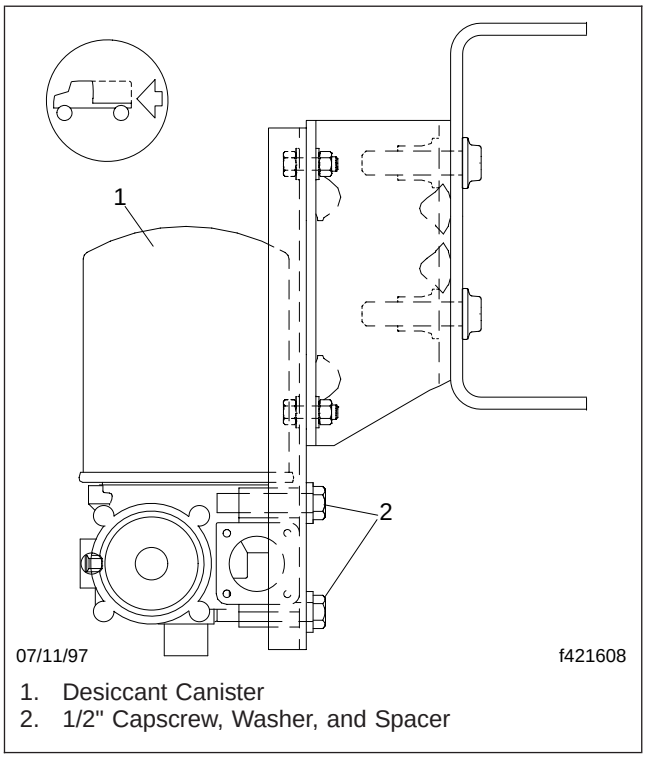
Refer to **Fig. 1** for removal and installation of the air dryer.

Removal

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.
4. Remove the capscrews, washers, and spacers that attach the air dryer to the mounting bracket.
5. Remove the air dryer.

Installation

1. Position the air dryer on the mounting bracket. Install the spacers, washers, and capscrews. Tighten them 22 to 30 lbf·ft (30 to 41 N·m).
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
4. Connect the air dryer wiring harness.



1. Desiccant Canister
2. 1/2" Capscrew, Washer, and Spacer

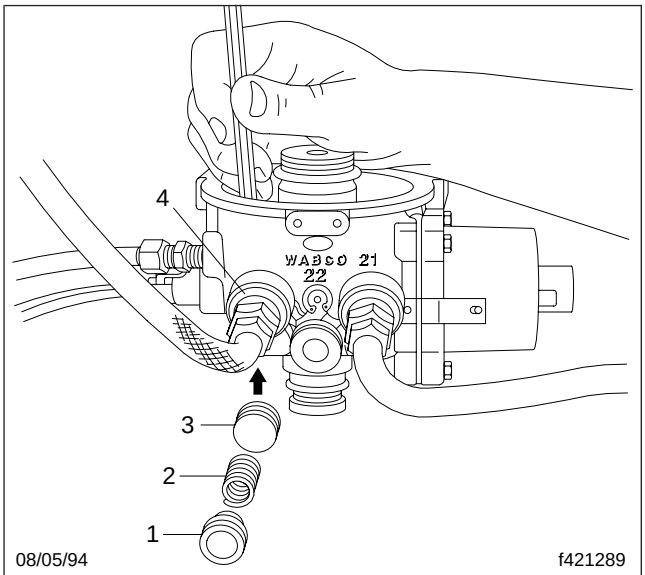
Fig. 1, Air Dryer Installation (outboard rail mounting shown)

⚠ 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. Drain the air system.
2. Remove the snap ring at the bottom of the valve assembly. The valve cover and spring may fall out of the cavity when the snap ring is removed. See **Fig. 1**.



1. Valve Cover
2. Spring
3. Piston
4. Inlet Port

Fig. 1, Pushing the Piston, Spring, and Cover out of the Valve Cavity.

3. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
4. If not already removed, use a wooden stick to push the piston, spring, and the cover out of the valve cavity.
5. Clean the valve cavity with a commercial cleaning solvent.
6. Install new O-rings on the piston and the cover.
7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
8. Install the new piston with its hollow side facing out.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

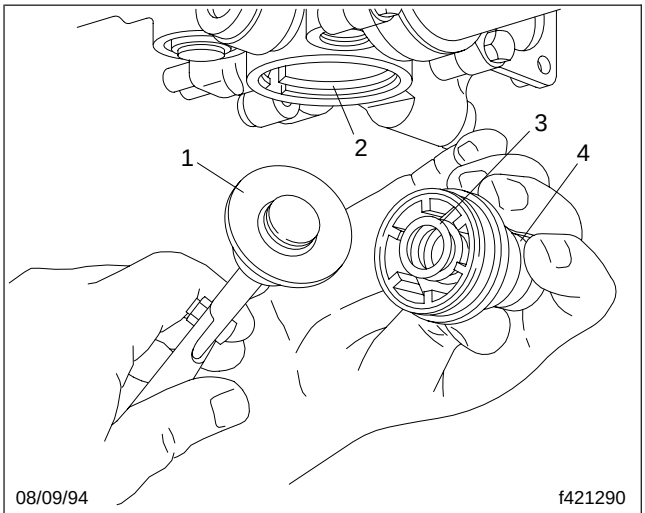
9. Install the new spring, cover, and snap ring to hold the components in place.
10. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not overtighten.

⚠ 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. Valve Assembly
2. Exhaust Port
3. Spring
4. Valve Head

Fig. 1, Removing the Valve Assembly

1. Drain the air system.
2. Remove the snap ring, valve head, and the spring from the exhaust port.
3. Pull the valve assembly out of the exhaust port.
4. Remove the O-ring from the base of the exhaust port.
5. Clean the purge valve cavity area with a commercial cleaning solvent.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the valve cavity and all of the new O-rings. Install the O-rings in the base of the exhaust port and on the valve head.
7. Position the new valve assembly in the valve cavity.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

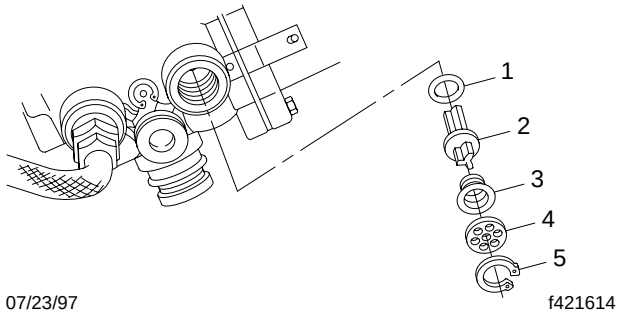
8. Install the spring in the valve head, and position them in the valve cavity.
9. Install the snap ring to secure the valve head in position.

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 valve replacement.



1. O-Ring
2. Valve Body
3. Spring
4. Washer
5. Snap Ring

Fig. 1, Outlet Check Valve Assembly

1. Drain the air system.
2. Disconnect the air line from the outlet port.
3. Remove the snap ring, washer, valve body, and the O-ring.
4. Clean the cavity area with a commercial cleaning solvent.
5. Install a new O-ring on the valve body.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the valve cavity.
7. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
8. Install the new spring with its small end around the Y-shaped fins on the valve body.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

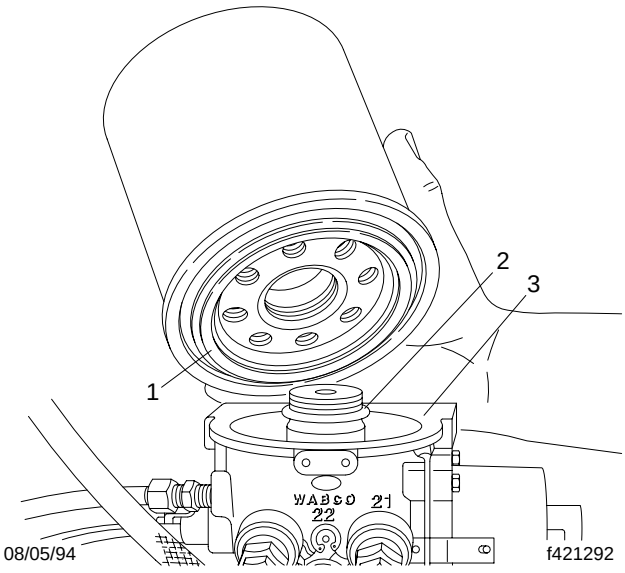
9. Install a new washer and snap ring to secure the assembly in the valve cavity.
10. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

⚠ 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 cartridge replacement.



1. Seal
2. O-Ring
3. Air Dryer Base

Fig. 1, Desiccant Cartridge Replacement

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
3. Remove and discard the O-ring.
4. Clean the top surface of the dryer base with a commercial cleaning solvent.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the dryer base. Install the O-ring.
6. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not overtighten.

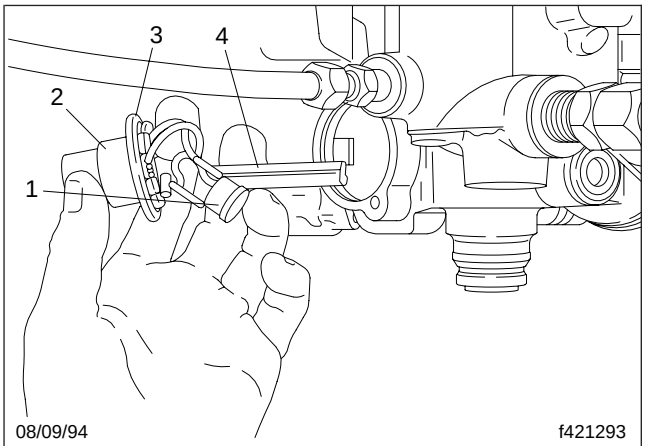
IMPORTANT: If the air dryer base is damaged, preventing a tight seal, replace the air dryer.

⚠ 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 heater/thermostat assembly replacement.



1. Thermostat
2. Receptacle
3. O-Ring
4. Element

Fig. 1, Heater/Thermostat Replacement

1. Drain the air system.
2. Disconnect the wiring harness.
3. Remove the screws that attach the heater/thermostat receptacle. Remove the receptacle and the O-ring.
4. Remove the retaining screw that holds the assembly in place. Remove and discard the heater/thermostat assembly.
5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Position the new heater/thermostat assembly in the cavity. Install the retaining screw.
7. Position the new receptacle and O-ring, and install the screws. Tighten the screws securely.
8. Connect the wiring harness.

⚠ 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 valve replacement.

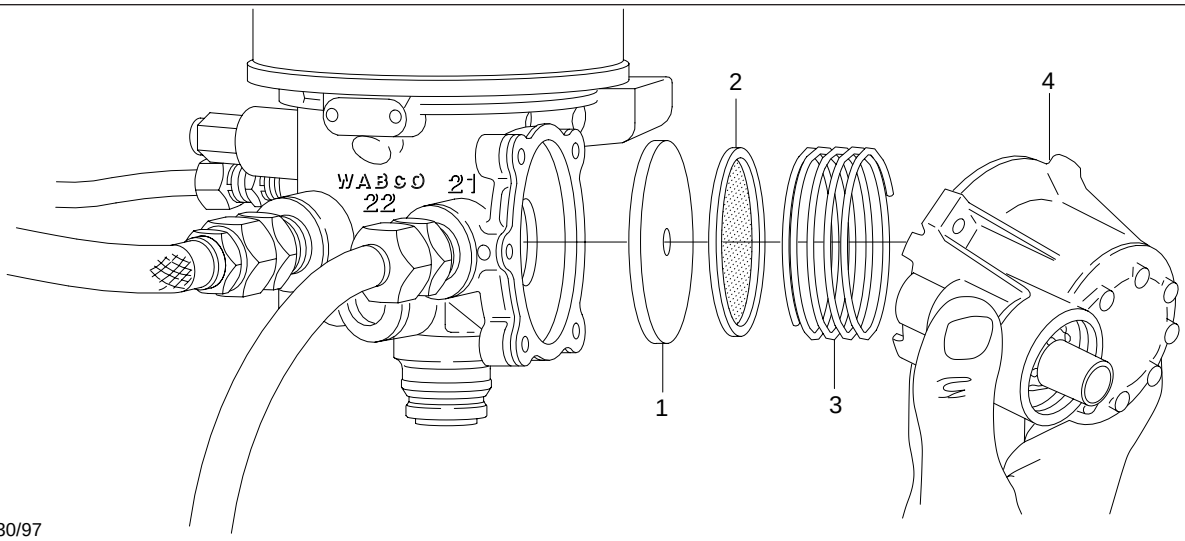
1. Drain the air system.

NOTE: When the valve housing is removed, the spring and the retainer will fall out of the housing.

2. Remove the four mounting bolts and remove the valve housing assembly.
3. Remove the rubber diaphragm.
4. Using a commercial cleaning solvent, clean the groove where the diaphragm lip fits.
5. Install a new diaphragm with its lip in the groove.

IMPORTANT: If the groove is damaged, preventing a tight seal, replace the air dryer.

6. Install the new spring and retainer (with the retainer lip facing out).
7. Position the valve housing on the air dryer. Install the bolts and tighten them to 53 lbf·in (600 N·cm).



1. Diaphragm
2. Retainer
3. Spring
4. Valve Housing Assembly

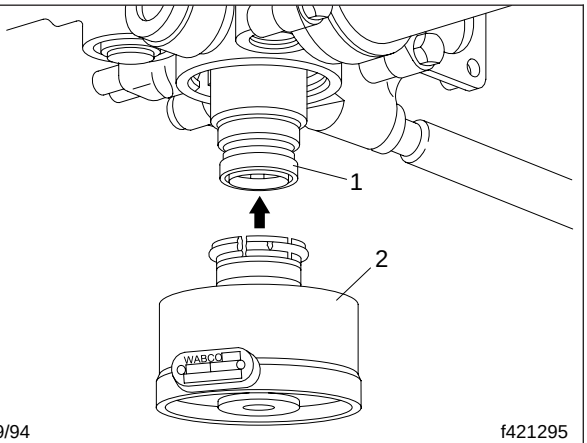
Fig. 1, Regeneration Valve Assembly

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

Refer to **Fig. 1** for silencer replacement.



1. Purge Valve Head
2. Silencer

Fig. 1, Silencer Replacement

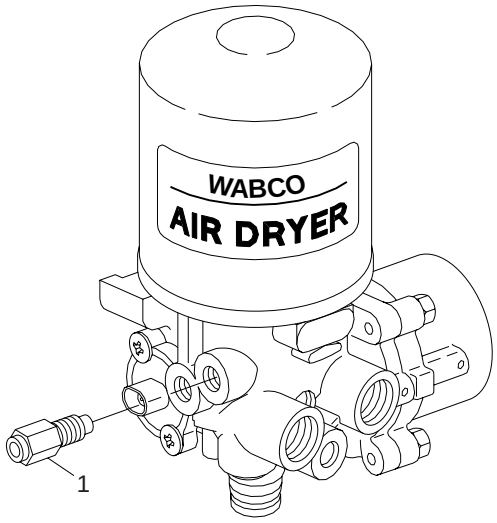
1. Using snap ring pliers, expand the snap ring and pull the silencer off of the purge valve head.
2. Push the new silencer onto the purge valve head until the silencer snaps into place.

⚠ 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 valve replacement.



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1. Pressure Relief Valve

Fig. 1, Pressure Relief Valve Replacement

1. Drain the air system.
2. Unscrew and remove the old valve from the dryer.
3. Screw the replacement valve into the dryer base. Do not exceed a torque of 30 lbf·ft (41 N·m) for a 3/8-inch thread, or 65 lbf·ft (88 N·m) for a 1/2-inch thread.

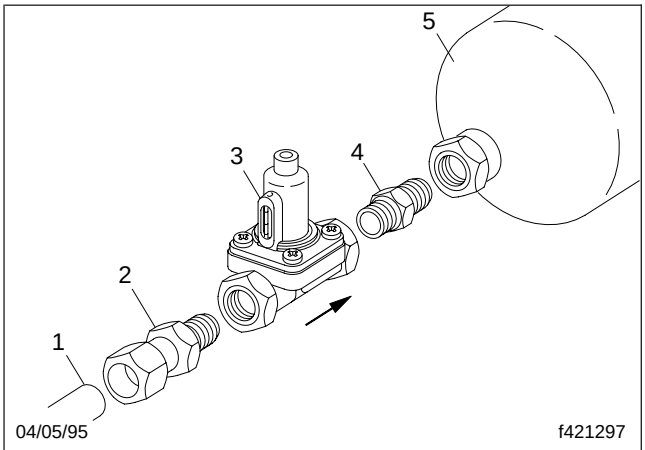
NOTE: The threads on the replacement pressure relief valve provided by WABCO are coated with sealant. They do not require any additional sealant.

⚠ 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 valve replacement.



1. Air Line
2. Nylon Tube Connector
3. Pressure-Controlled Check Valve
4. Hex Nipple Pipe Fitting
5. Air Tank

Fig. 1, Check Valve Assembly Replacement

1. Drain the air system.
2. Disconnect the air line from the pressure-controlled check valve.
3. Remove the valve and the hex nipple pipe fitting from the air tank.
4. Install the pipe fitting on the new valve.
5. Install the new valve on the air tank with the arrow on the valve pointing towards the tank.
6. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the air line fitting threads. Connect the air line to the valve. Tighten the air line securely.

NOTE: Always apply sealant to the external threads so that any excess will be scraped off externally rather than internally to the joint.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Operating Tests

Air Dryer Operating Check

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
3. When the compressor reaches the unload cycle, the air dryer purges, beginning regeneration of the air dryer.
4. During the purge cycle, which lasts about 10 to 15 seconds, the wet tank and system tank with pressure-controlled check valve will drop about 10 psi (69 kPa). Check the system air gauge in the cab dash panel.
5. If the gauge needle does not show a pressure drop of about 10 psi (69 kPa), one of the following problems may exist.
   - A pressure-controlled check valve is not installed.
   - The pressure-controlled check valve is installed in the wrong air tank.
   - The pressure-controlled check valve is installed on a one-way check valve, instead of in place of a one-way check valve.
   - There is an extra check valve located somewhere between the air dryer and the secondary air tank (usually at the wet tank).
   - The system air gauge is not plumbed to the correct air system.
6. If system air pressure drops 15 psi (103 kPa) or more during the purge cycle, and there are no other air-operated components in use, then there are air leaks or other system problems. Refer to the *Cascadia™ Troubleshooting Manual* for other possible causes.

Pressure-Controlled Check Valve Operating Check

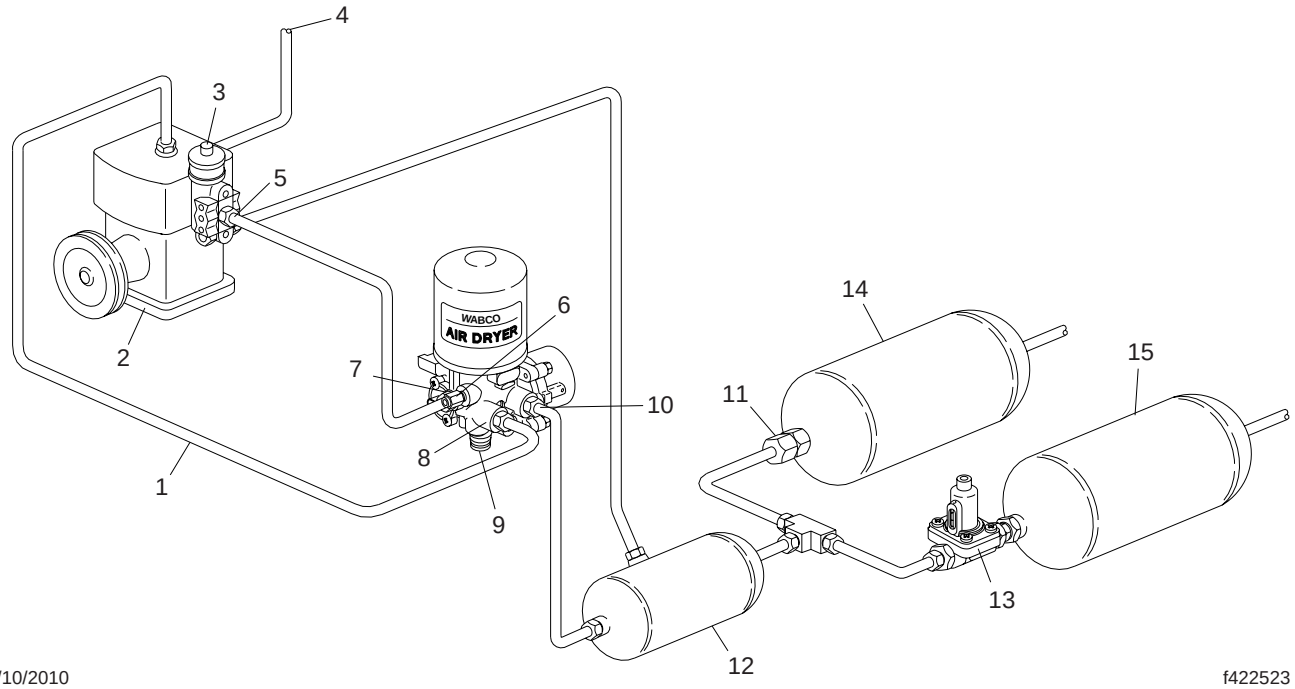
IMPORTANT: Install a calibrated air gauge (accurate to within 1 psi [7 kPa]) in the system air tank with the pressure-controlled check valve, to check the valve. Do not use the cab air gauges.

1. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
2. Stop the engine after the air compressor has unloaded.
3. Drain the opposite system air tank(s) down to about 80 psi (552 kPa).
4. Check the calibrated air gauge. It should read 95±5 psi (655±34 kPa).

   If the gauge reading is less that 85 psi (586 kPa), either the pressure-control check valve is installed backwards, it is damaged, or there are air leaks in the system tank air system.

   If the gauge reading does not change, or the reading does not fall below 105 psi (724 kPa), make the checks under "Air Dryer Operating Check." If none of those problems exist, replace the control valve.

See **Fig. 1** for the plumbing diagram.



1. Compressor Discharge Line
2. Air Compressor
3. Air Governor
4. Compressor Intake Line
5. Unloader Port
6. Pressure Relief Valve
7. Air Governor Port
8. Air Dryer Inlet
9. Purge Valve
10. Air Dryer Outlet
11. Check Valve
12. Supply Tank
13. Pressure-Control Check Valve
14. System Reservoir
15. System Reservoir

Fig. 1, Air Dryer Plumbing Diagram

General Description

The Bendix PP-DC parking brake air valve is installed on trucks with air brakes, and is used to control the rear axle parking brakes. It is a push-pull type of valve, and is mounted on the right side of the dash.

Principles of Operation

When the valve knob is pulled out, air is exhausted from the parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs, and compresses the springs, releasing the parking brakes.

The PP-DC has a double check valve feature. If the pressure drops 20 to 30 psi (138 to 207 kPa) in either air system (primary or secondary), the valve will automatically use air pressure from the system with the higher pressure for the parking brakes. This prevents the parking brakes from applying automatically unless pressure is lost from both systems.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

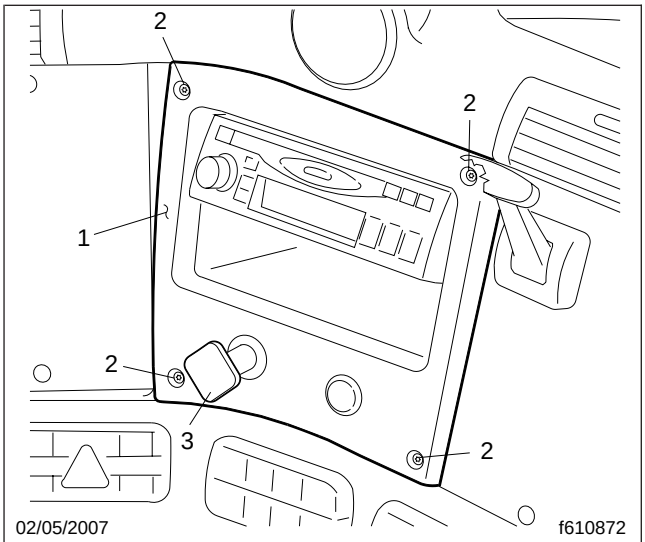
1. Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber pushrods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component 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.

Parking Brake Dash Valve 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.

Refer to **Fig. 1** and **Fig. 2** for parking brake dash valve removal and installation.



1. Dash Center Panel
2. Fastener
3. Parking Brake Hand Valve Knob

Fig. 1, Parking Brake Hand Valve

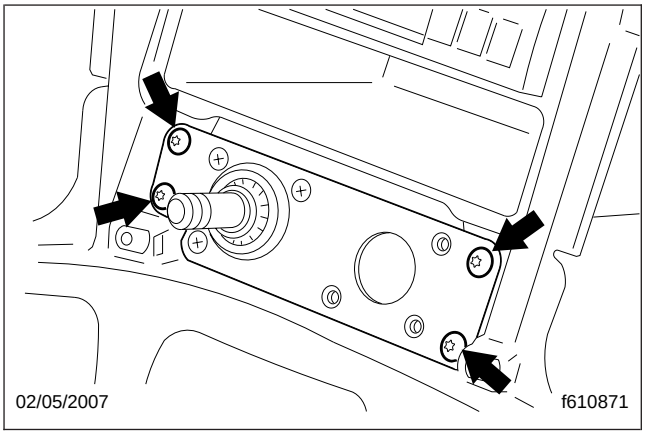


Fig. 2, Parking Brake Valve Mounting

Removal

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain the air tanks.
2. Turn the valve knob counterclockwise and remove it from the valve stem.
3. Remove the fasteners from the dash center panel and remove the panel.
4. Remove and save the mounting screws and washers from the corners of the cover plate.
5. With the valve and cover plate assembly pulled out slightly from the dash panel, mark the air lines for later reference, then disconnect them from the valve assembly.

NOTE: The primary supply line is green; the secondary supply line is red; the exhaust line is black and 1/2 inch (13 mm) in diameter; the delivery line is black and 3/8 inch (9.6 mm) in diameter.

6. Remove the valve.

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. Attach the knob onto the threaded stem of the spool, making sure that it is oriented correctly as noted during removal.
3. Leak test the fittings, as instructed in **Subject 130**.
4. Align the valve in the dash and install the mounting screws and washers into the corners of the cover plate.
5. Remove the knob.
6. Position the dash center panel and install the fasteners.
7. Attach the knob onto the threaded stem of the spool, making sure that it is oriented correctly as noted during removal.

Parking Brake Dash Valve Disassembly 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.

Refer to **Fig. 1** for valve disassembly and assembly.

Disassembly

1. Remove the valve assembly from the dash, as instructed in **Subject 110**.
2. Put the valve assembly in a soft-jawed or padded vise.
3. Remove the screws that attach the cover to the body. Remove the cover.
4. Pull the plunger stem and remove the plunger and guide spool from the body.
5. Remove and discard the plunger spring.
6. Using a screwdriver (if needed), carefully remove the check valve seat from the body. Use care to not damage either the check valve seat or the valve body.
7. Remove and discard the check valve seat O-rings.
8. Turn the body upside down and gently tap it on a flat surface to remove the check valve. Discard the check valve.
9. Remove the guide spool from the plunger. Remove and discard the O-ring.
10. Remove and discard the O-rings from the plunger. Also, remove and discard the exhaust seal.

Assembly

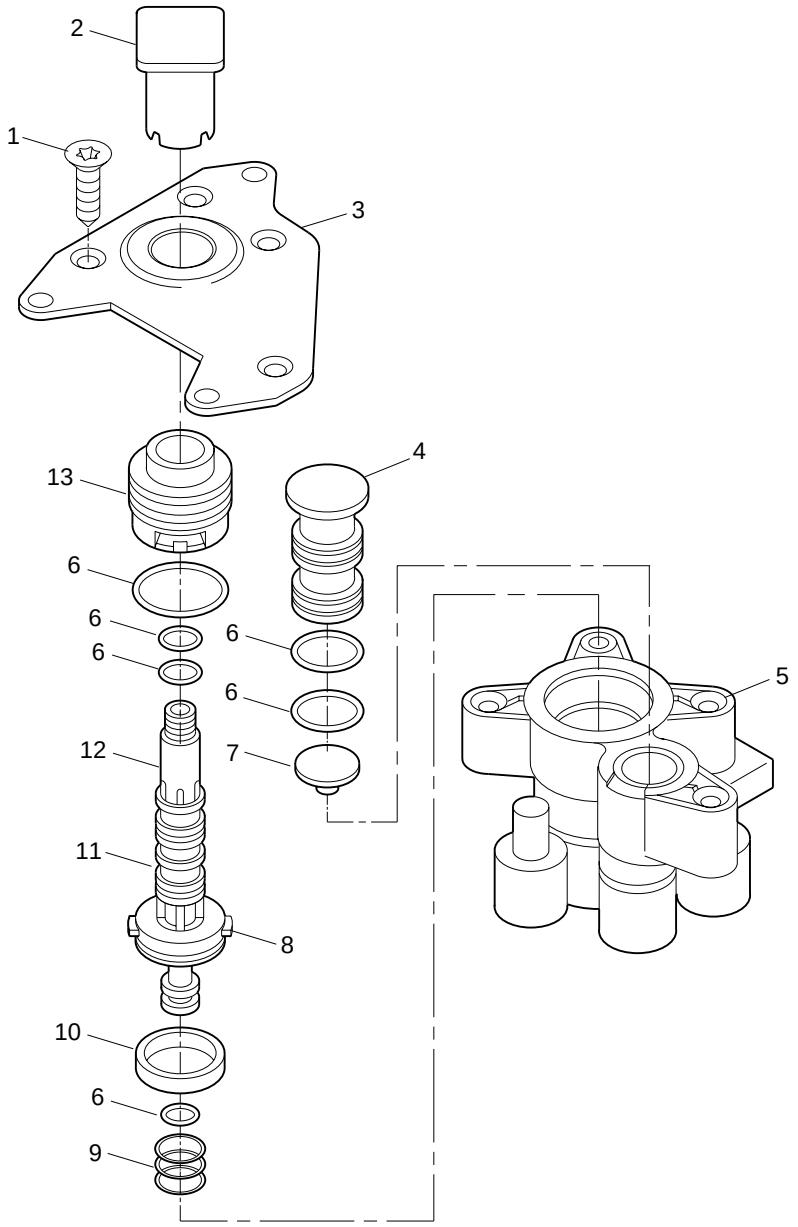
1. Clean and dry all the parts.
2. Check all the parts. Replace a part if any wear or damage is found.
3. Lightly grease all the parts—including the new parts from the maintenance kit—with Dow Corning 55 silicone pneumatic grease or equivalent.
4. Position the check valve in its seat in the body, with the flat surface of the valve facing up. If needed, reach into the body to make sure that the valve is seated evenly in the bore.
5. Install the O-rings on the check valve seat, and install the assembly into the body. Make sure that the check valve seat is even with the valve body surface.
6. Install the plunger spring into the body. Make sure that the spring is upright and seated properly in the body bore.

NOTE: The plunger spring should surround the protrusion or "lip" at the bottom of the body bore.

7. Install the O-rings onto the plunger, then install the plunger into the body.

   For ease of installation, line up the plunger's index tabs with the spaces in the body bore.
8. Install the O-ring on the guide spool. Install the spool over the plunger and into the body. Firmly press the guide spool into position.
9. Position the cover and install the screws that attach it to the body. Tighten the screws 35 lbf·in (400 N·cm).
10. Install the valve in the dash, then leak test it. Follow the instructions in **Subject 110** for installation, and in **Subject 130** for leak testing.

Parking Brake Dash Valve Disassembly and Assembly



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1. Screw
2. Valve Knob
3. Cover
4. Check Valve Seat
5. Valve Body
6. O-Ring
7. Check Valve
8. Index Tab
9. Plunger Spring
10. Exhaust Seal
11. Plunger
12. Plunger Stem
13. Guide Spool

Fig. 1, Bendix PP-DC Parking Brake Valve, Exploded View (typical)

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Refer to **Fig. 1** for valve disassembly and assembly.

Operating Test

1. Chock the tires.
2. Start the engine and build the air pressure to the normal operating level.
3. With the valve knob pulled out, supply either supply port with 120 psi (827 kPa) of pressure. Push the valve knob in. Air pressure should rise in the delivery line, and should equal supply line pressure.

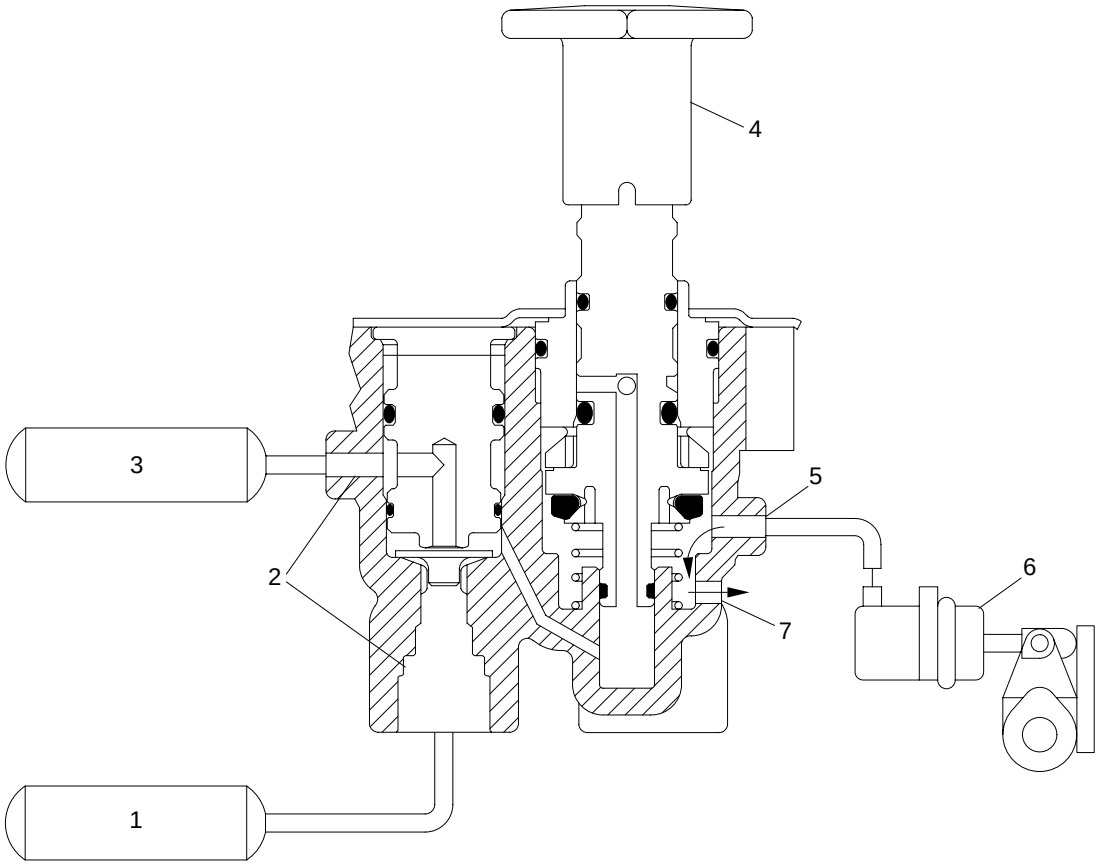
   Pull the valve knob out. Delivery pressure should exhaust to zero.
4. Build air pressure to each supply source to 120 psi (827 kPa). Decrease supply pressure at the secondary service reservoir supply port at a rate of 10 psi (69 kPa) per second.

   Primary supply pressure and delivery pressure should not drop below 100 psi (689 kPa). Repeat this step for decreasing primary service reservoir pressure.
5. Build air pressure to each supply source to 120 psi (827 kPa). Then decrease both supply pressures to below 20 to 30 psi (138 to 207 kPa). The valve knob should automatically pop out when the pressure is within that range.
6. If the valve does not work as described, repair the valve or replace it, as instructed in **Subject 120**.

Leak Testing

1. Chock the tires.
2. Supply the valve with 120 psi (827 kPa) from the primary reservoir supply port.
3. With the valve knob pulled out, coat the exhaust port and the plunger stem with a soapy solution. Leakage at either fitting should not exceed a 1-inch (2.5-cm) bubble every five seconds.There should be no leakage from the secondary reservoir supply port.
4. Supply the valve with 120 psi (827 kPa) from the secondary reservoir supply port. There should be no leakage from the primary reservoir supply port.
5. With the valve knob pushed in, coat the exhaust port and the plunger stem with a soapy solution. Leakage at the fittings should not exceed a 1-inch (2.5-cm) bubble every three seconds. If it does, replace or repair the valve, following instructions under **Subject 120**.

Parking Brake Dash Valve Tests



1. Primary Service Reservoir
2. Supply Port
3. Secondary Service Reservoir
4. Valve Knob
5. Delivery Port
6. Brake Chamber
7. Exhaust Port

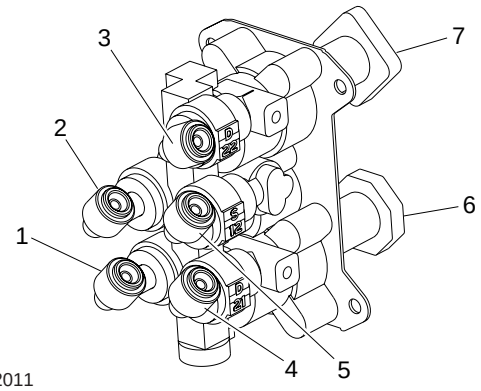
Fig. 1, Parking Brake Dash Valve (sectional view)

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.

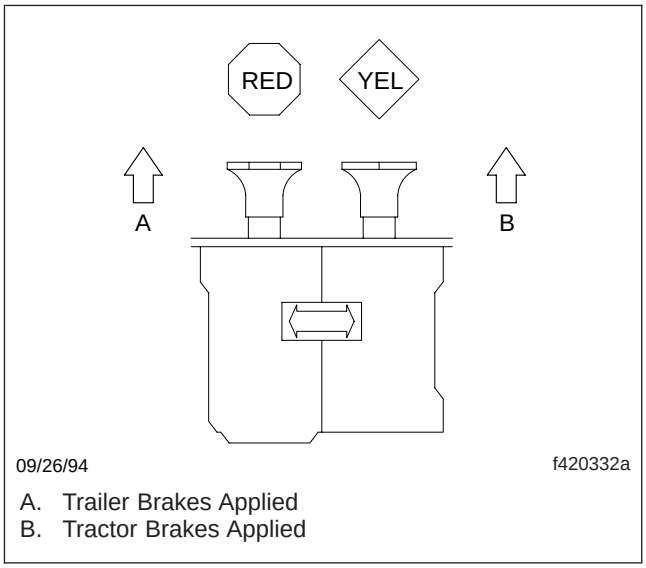


1. Exhaust
2. Primary Reservoir Supply
3. Delivery–Tractor Spring Brakes
4. Delivery–Trailer Supply
5. Secondary Reservoir Supply
6. Trailer Air Supply Knob
7. Parking Brake Control Valve Knob

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

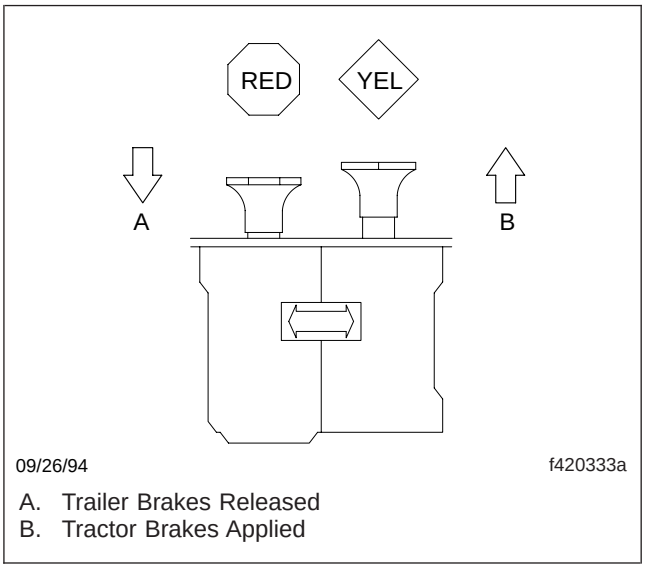
Initial Charge

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

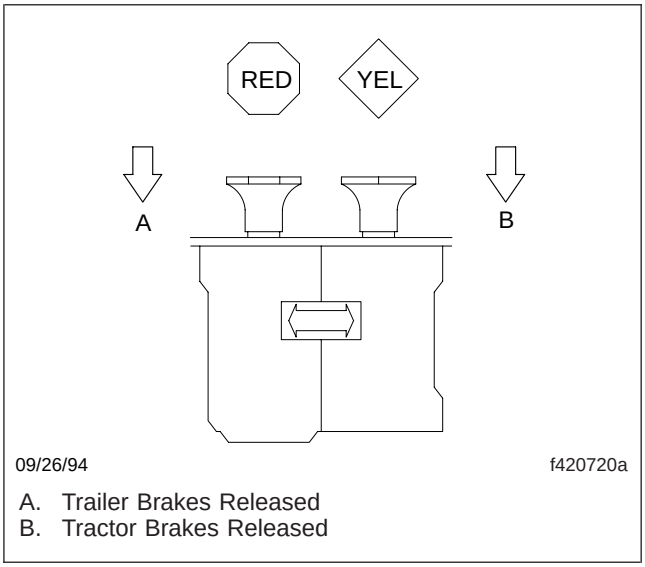
When both knobs are pushed in, air is supplied to the trailer and the tractor parking brakes; all parking brakes are released. See **Fig. 4**. This is the normal operating mode.

General Information



A. Trailer Brakes Released
B. Tractor Brakes Applied

Fig. 3, Trailer Parking Brakes Released (red control knob pushed in)

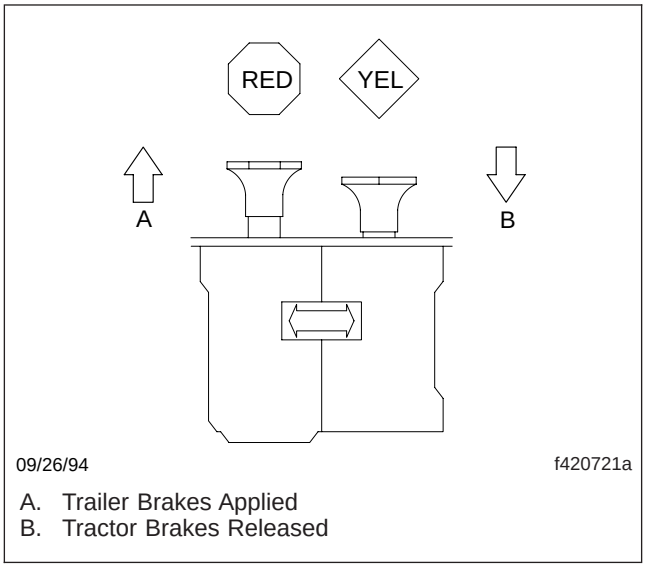


A. Trailer Brakes Released
B. Tractor Brakes Released

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).

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber pushrods 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.

Control Module 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.

Refer to **Fig. 1** and **Fig. 2** for control module removal and installation.

Removal

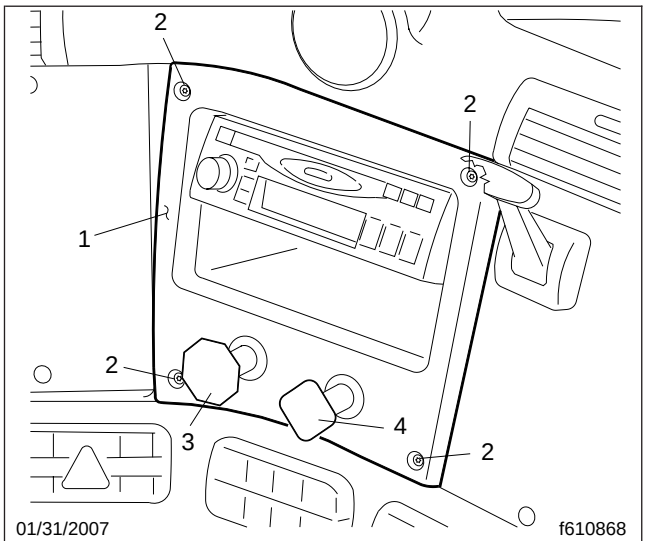
WARNING

Wear eye protection when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Do not direct the airstreams at anyone. Do not 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. Unscrew the red and yellow knobs from the stems of the spools on the MV-3 valve by turning them counterclockwise. Mark these knobs in relation to the valve for later reference.
3. Remove the fasteners from the radio trim panel and remove the panel.
4. Remove and save the four mounting screws and washers from the four corners of the cover plate.
5. 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.
6. 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. Attach the red and yellow knobs to the threaded stems of the spools, making sure that they are oriented correctly as noted during removal.
3. Leak test the fittings, as instructed in **Subject 130**.



1. Radio Trim Panel
2. Fastener
3. Parking Brake Knob (red)
4. Trailer Brake Knob (yellow)

Fig. 1, MV-3 Control Valve Mounting

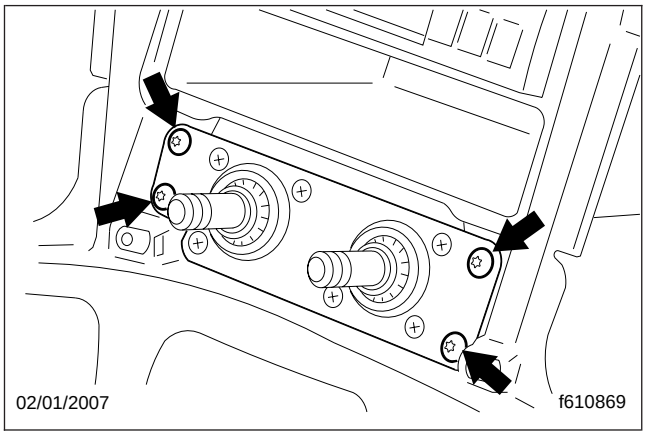


Fig. 2, MV-3 Control Valve Mounting

4. Align the valve in the dash, then install the four screws and washers into the corners of the cover plate.
5. Remove the red and yellow knobs.
6. Position the radio trim panel and install the fasteners.
7. Attach the red and yellow knobs to the threaded stems of the spools, making sure that they are oriented correctly as noted during removal.

Control Module 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.

Refer to **Fig. 1** for control module disassembly and assembly.

Disassembly

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 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 needlenose 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 (**Fig. 1**Item 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.

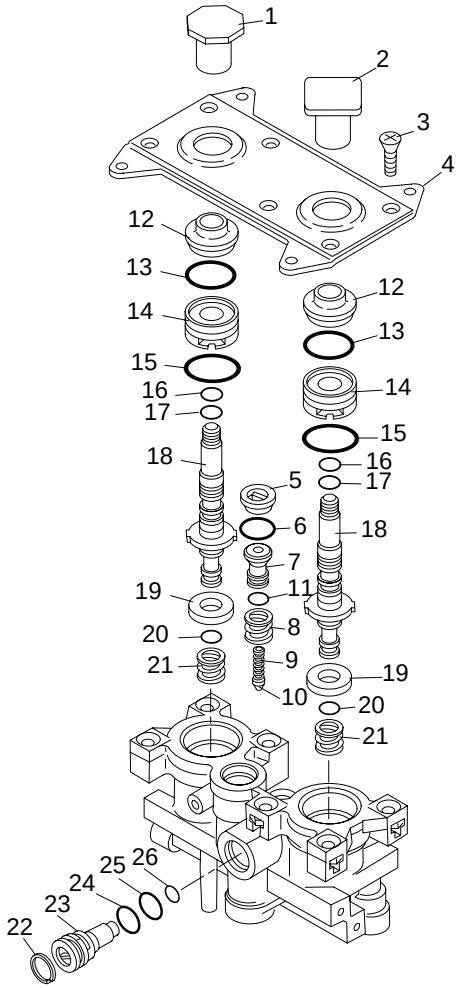
IMPORTANT: The exhaust seal (**Fig. 1**Item 19) must be installed so that its beveled surface mates with the beveled surface of the plunger.

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.
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. 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



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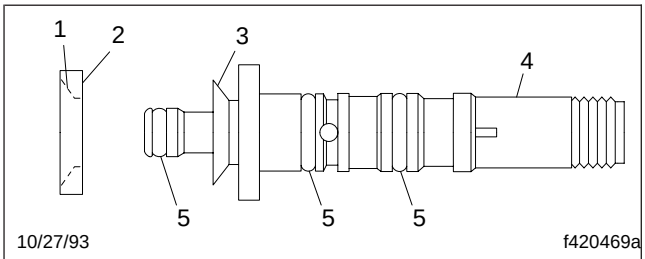
1. Red Knob
2. Yellow Knob
3. Screw
4. Cover Plate
5. Cap
6. O-Ring
7. Tripper Piston
8. Spring, Large Diameter
9. Spring, Small Diameter
10. Check Valve
11. O-Ring
12. Guide Cap
13. O-Ring
14. Guide Spool
15. O-Ring
16. O-Ring
17. O-Ring
18. Plunger
19. Exhaust Seal, Beveled
20. O-Ring
21. Spring
22. 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

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 the valve 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.



1. Inside Bevel
2. Exhaust Seal
3. Mating Exhaust Seal Bevel
4. Plunger
5. O-Rings

Fig. 2, Plunger Assembly

6. Attach the cover plate to the valve body using the six screws. Tighten them 25 lbf·in (280 N·cm).
7. Check the operation of the valve as instructed in **Subject 130**.

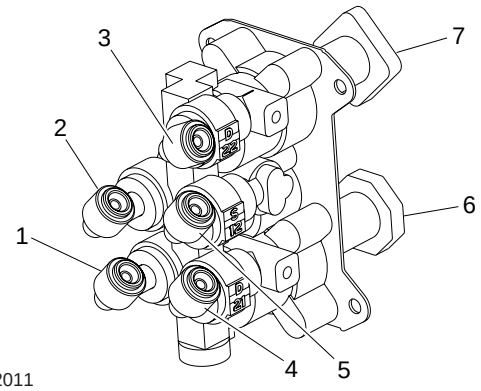
⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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.

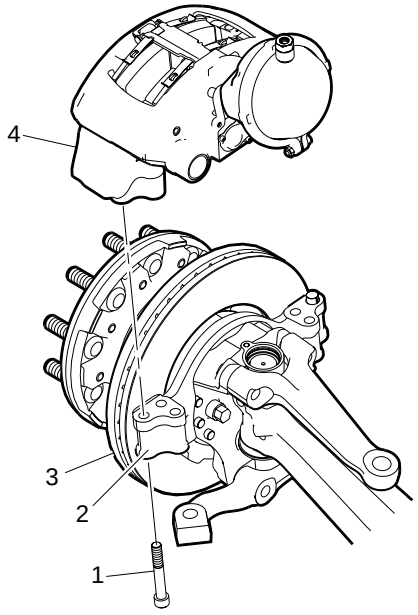
4. Hold the red knob in and continue to reduce pressure in all service reservoirs. Air must start to escape from the exhaust port when the trailer line pressure reaches 20 to 35 psi (138 to 241 kPa).
5. Release the red knob and rebuild the supply pressure to 120 psi (827 kPa). Push in the yellow knob; 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.

Control Module Operating Tests

11. If the MV-3 fails to operate as described, or leakage exceeds the limits stated, replace or repair it using genuine Bendix parts.

Description

Bendix air disc brakes use a floating caliper design to provide foundation braking on all axles. They are fitted with a standard brake chamber or a combination spring brake chamber, depending on the vehicle specification, and the position on the vehicle. The caliper-carrier and anchor plate are a proprietary design available only on Daimler vehicles. This design allows for easy removal and installation of the caliper/carrier assembly on all axles, without removing other major components. See **Fig. 1**.



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1. Capscrew
2. Anchor Plate
3. Rotor
4. Caliper/Carrier

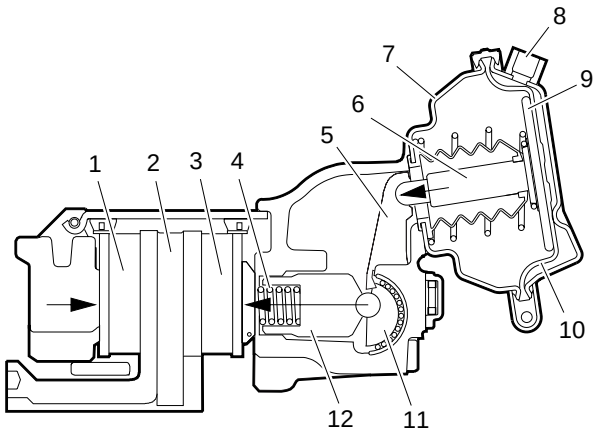
Fig. 1, Caliper/Carrier Installation

Operation

Bendix air disc brakes convert air pressure into braking force. See **Fig. 2**.

Brake Application

When the vehicle brakes are applied, air enters the service brake chamber through the supply port, applying pressure within the diaphragm. The pressure expands the diaphragm, applying force to the pressure plate and pushrod, and moving them forward.



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1. Outer Brake Pad
2. Rotor
3. Inner Brake Pad
4. Return Spring
5. Lever
6. Pushrod
7. Brake Chamber
8. Supply Port
9. Pressure Plate
10. Diaphragm
11. Eccentric Bearing
12. Bridge

Fig. 2, Brake Operation

The pushrod presses against a cup in the internal lever, which pivots on an eccentric bearing, moving the bridge. Moving against a return spring, the bridge transfers the motion to two threaded tubes and tappets, which move the inner brake pad. The inner brake pad (from its normal position of having a running clearance between it and the rotor) moves into contact with the brake rotor. Further movement of the bridge forces the caliper, sliding on two stationary guide pins, away from the rotor, which pulls the outer brake pad into the rotor. The clamping action of the brake pads on the rotor applies braking force to the wheel.

Brake Release and Adjustment

When the vehicle brakes are released, the air pressure in the service brake chamber is exhausted, and the return springs in the chamber and the bridge return the caliper to a neutral, non-braked position. To maintain the running clearance gap between the rotor and the brake pads over time, the non-braked position is mechanically adjusted by a mechanism in the caliper. The adjustment mechanism operates automatically whenever the brakes are activated, to compensate for rotor and brake pad wear and to keep the running clearance constant. During pad or

General Information

rotor maintenance, the technician manually sets the system's initial non-braked position. The total running clearance (sum of clearances on both sides of the rotor) should be between 0.024 to 0.043 in. (0.6 and 1.1 mm).

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 calipers, 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 particulate air (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.

Brake Pad Removal, Inspection, 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.

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.

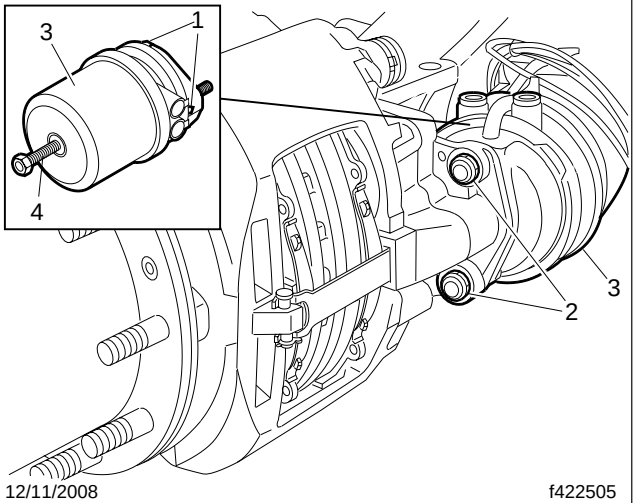
Removal

1. Shut down the engine. Chock the tires on the axle that is not being serviced.
2. If working on the drive axle, carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft (35 N·m) to release spring force on the pushrod. See **Fig. 1**.
3. Drain the air from the air system.
4. 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.
5. Remove the wheel(s). See **Group 40**.

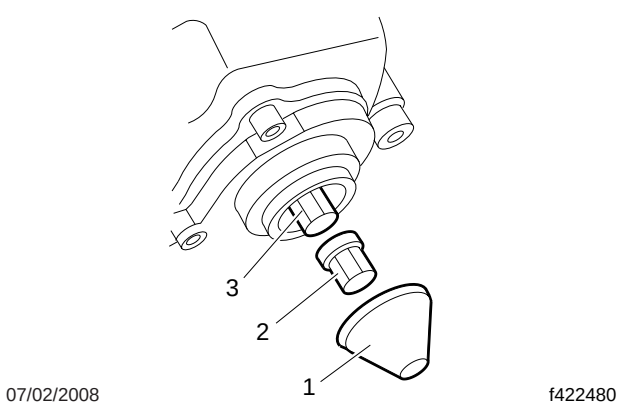
IMPORTANT: Before removing the brake pads, check the adjuster mechanism for proper operation.

6. Using the tab, pull off the adjuster cap, being sure to keep the shear adaptor in position on the adjuster. See **Fig. 2**.



1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

Fig. 1, Spring Brake Chamber Installation



1. Adjuster Cap
2. Shear Adaptor
3. Adjuster

Fig. 2, Shear Adaptor in Position

NOTICE

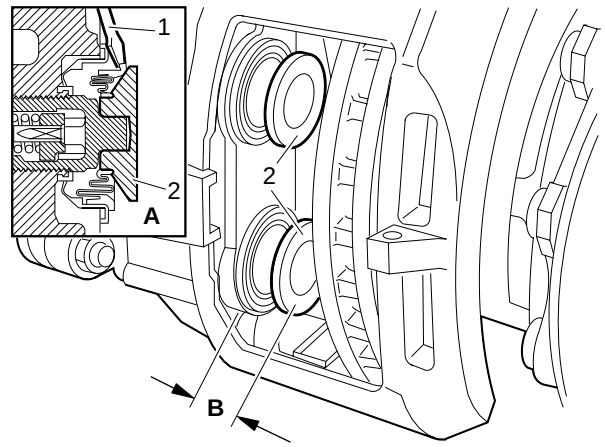
Do not use an open-ended wrench, as this may damage the adaptor.

IMPORTANT: Never turn the adjuster without the shear adaptor installed. The shear adaptor is a safety feature and is designed to prevent an excess of torque being applied to the adjuster. The shear adaptor will come loose if too much

Brake Pad Removal, Inspection, and Installation

torque is applied. If the shear adaptor fails, try again with a new adaptor. A second failure confirms that the adjustment mechanism is seized and the caliper/carrier assembly must be replaced.

7. Using a box-end wrench or socket, fully retract the tappet and boot assemblies by rotating the shear adaptor counterclockwise. See **Fig. 3**.



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A. Boot Location Ring
B. Extend less than 1.18 in (30 mm)

1. Boot Location Ring
2. Tappet and Boot Assembly

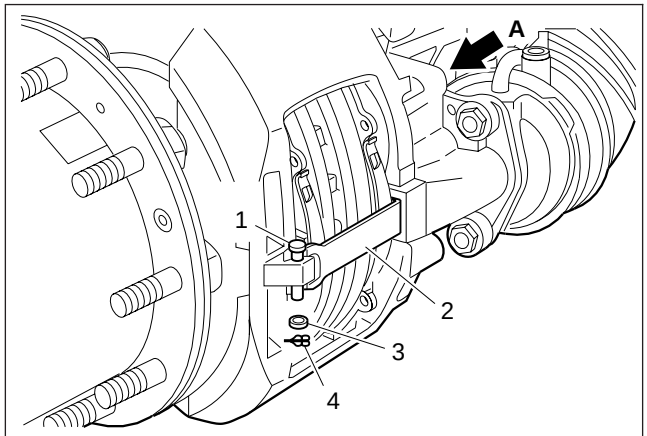
Fig. 3, Tappet and Boot Assembly

8. Remove the pad retainer clip and washer. See **Fig. 4**. Depress the pad retainer and remove the pad retainer pin. Discard all components that have been removed.
9. Slide the caliper to the outboard position. Remove the outer pad. See **Fig. 5**.
10. Slide the caliper to the inboard position. Remove the inner pad.

Inspection

Brake Pads

1. Measure the thickness of the friction material on the brake pad.



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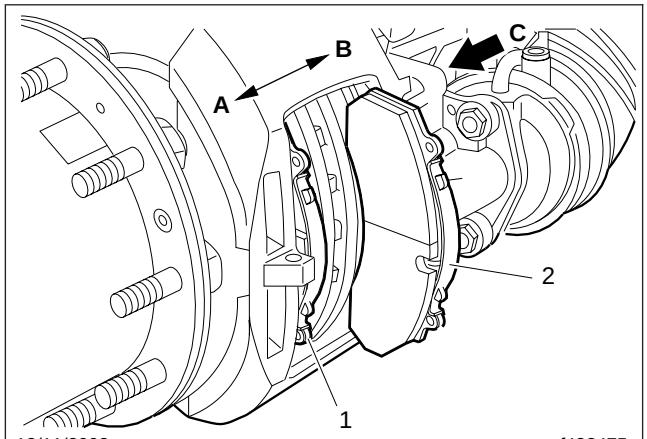
A. Shear Adjuster Location

1. Pad Retainer Pin
2. Pad Retainer
3. Washer
4. Clip

Fig. 4, Caliper Assembly



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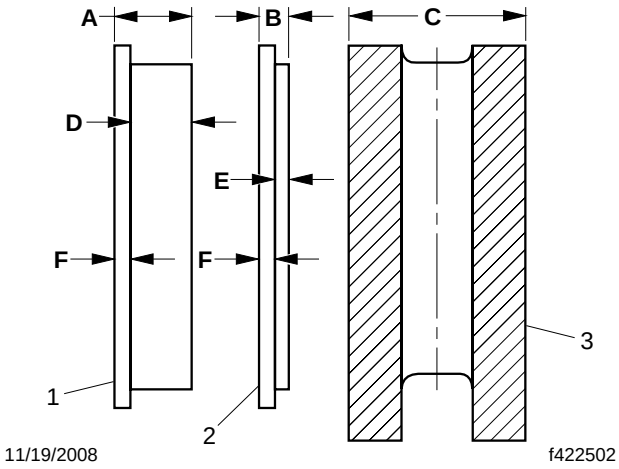
A. Outboard
B. Inboard
C. Area of Shear Adaptor

1. Outboard Brake Pad
2. Inboard Brake Pad

Fig. 5, Brake Pad Removal

If the thickness of the friction material is less than 0.079 in (2 mm) the pads must be replaced. See **Fig. 6**, Ref. E.

Most Bendix air disc brakes use 0.35 in (9 mm) backing plates. On a used brake pad, the combined pad and backing plate thickness should be no less than 0.43 in (11 mm).



1. New Pad
2. Used Pad
3. Rotor

A. New Pad Thickness 1.18 in (30 mm)
B. Used Pad Thickness 0.43 in (11 mm)
C. Rotor Thickness 1.77 (45 mm) to 1.46 (37 mm)
D. New Pad Friction Material Thickness
E. Used Pad Friction Material Thickness 0.079 in (2 mm) minimum
F. Backing Plate Thickness 0.35 in (9 mm) to 0.43 in (11 mm)

Fig. 6, Brake Pad Inspection

2. If the pad thickness is within the acceptable range, inspect the pad surface.

   Minor damage (small amount of brake material chipped) at the edges is permitted, but replace the pads if major damage (section damaged or missing) is found on the surface.

Rotors

1. Examine the rotor and measure the thickness at the thinnest point. Avoid measuring near the edge of the rotor as minor burrs may be present. Replace the rotors when the minimum thickness is 1.46 in (37 mm).

NOTE: It is recommended to replace the rotor with the same type that was originally installed on the vehicle and to replace the brake pads at the same time.

2. Inspect the rotor for grooves and cracks.

   Conventional rotors may be turned when changing pads, but is not normally necessary. In the case of severe grooving of the entire friction surface, then turning could be useful and may increase the load-bearing surface of the pads. To meet Bendix recommendations, the minimum rotor thickness after turning must be greater than 1.53 in (39 mm).

IMPORTANT: Always maintain air disc brake pads and rotors within specifications. Excessive pad or rotor wear will degrade optimum performance. When replacing rotors, be sure to adhere to Daimler Trucks North America (DTNA) recommended bolt tightening torques and sequence. See **Subject 130** for rotor replacement.

Installation

NOTE: When replacing brake pads, replace them as an axle set. Only use pads that have the same backing plate thickness as originally specified.

1. Install the outboard brake pad by sliding the caliper to the outboard position (be sure the brake lining material is facing the rotor).
2. Install the inboard pad by sliding the caliper to the inboard position.
3. Using a box-end wrench or socket, turn the shear adaptor clockwise until the pads come into contact with the rotor. Then turn the shear adaptor counterclockwise two clicks to set the initial running clearance.
4. Install the new pad retainer into the groove of the caliper. Depress the pad retainer, and install the new pad retainer pin so that it is pointing downward.
5. Install the new washer and spring clip to secure the pad retainer pin. See **Fig. 1**.

NOTE: The adjustment mechanism operates automatically whenever the brakes are activated, to compensate for rotor and brake pad wear and to keep the running clearance constant. During pad or rotor maintenance the technician is to manually set the systems' initial nonbraked position.

6. Set the total running clearance (sum of clearances on both sides of the rotor), between 0.024 to 0.043 in (0.6 to 1.1 mm). See **Fig. 7**.

Brake Pad Removal, Inspection, and Installation

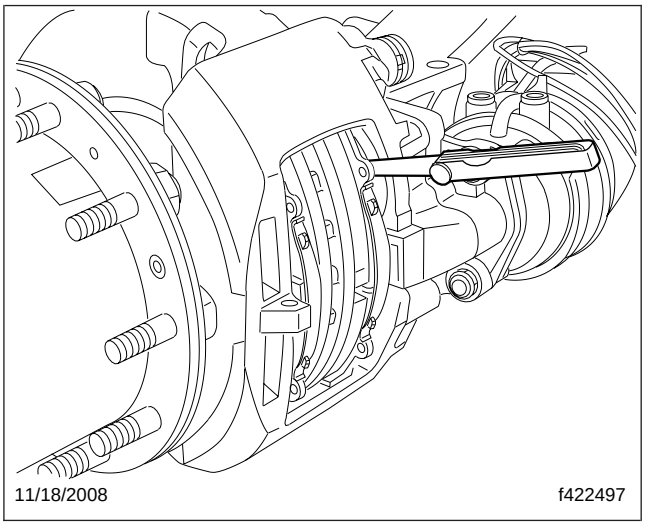


Fig. 7, Checking Brake Pad Running Clearance

7. Uncage the spring brake.
8. Apply and release the brake, then check that the hub turns easily by hand.
9. Using white lithium-based grease, lightly grease and install the adjuster cap.
10. Install the wheel(s). See **Group 40**.
11. Remove the safety stands and lower the vehicle.

Brake Caliper/Carrier Assembly 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.

NOTE: Replacement bolts are not supplied with the caliper, use only bolts of a grade and type specified by Daimler Trucks North America (DTNA).

Replacement caliper/carrier assemblies may be delivered with a plastic cap, adhesive tape, or a breakthrough diaphragm in the area where the actuator is mounted. Remove the cap or tape only after installing the replacement caliper. If the replacement caliper has the breakthrough diaphragm, it should be left in place. Refer to **Fig. 1** for front caliper/carrier removal and installation.

Front Caliper/Carrier Assembly Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheel. See **Group 40**.
5. Cut the zip ties holding the ABS harness to the brake hose as needed.

NOTE: If you are not replacing the caliper, it is not necessary to disconnect the air hose, if it can be safely supported out of the way while doing other work.

6. If replacing the caliper, disconnect the brake hose at the swivel connection at the frame rail, then remove the brake chamber from the caliper. See **Subject 150**.
7. With the caliper/carrier assembly securely supported, remove and discard the six bolts attaching the carrier to the anchor plate. Remove the caliper/carrier assembly.
8. Clean and inspect the anchor plate contact area. If damage is found, replace the anchor plate. See **Subject 140**.

Front Caliper/Carrier Assembly Installation

1. Position the carrier/caliper assembly, and attach it to the anchor plate with new bolts. Tighten 170 to 200 lbf·ft (230 to 271 N·m).
2. Install the brake pads, and brake pad shield, if equipped. See **Subject 110**.
3. Using new nuts, attach the brake chamber to the caliper/carrier assembly. Tighten 127 to 137 lbf·ft (172 to 186 N·m). See **Subject 150**.
4. Connect the brake hose.
5. Position the ABS harness, and install new zip ties to hold the harness to the brake hose. Leave room for movement.
6. Install the wheel. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

⚠ 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.

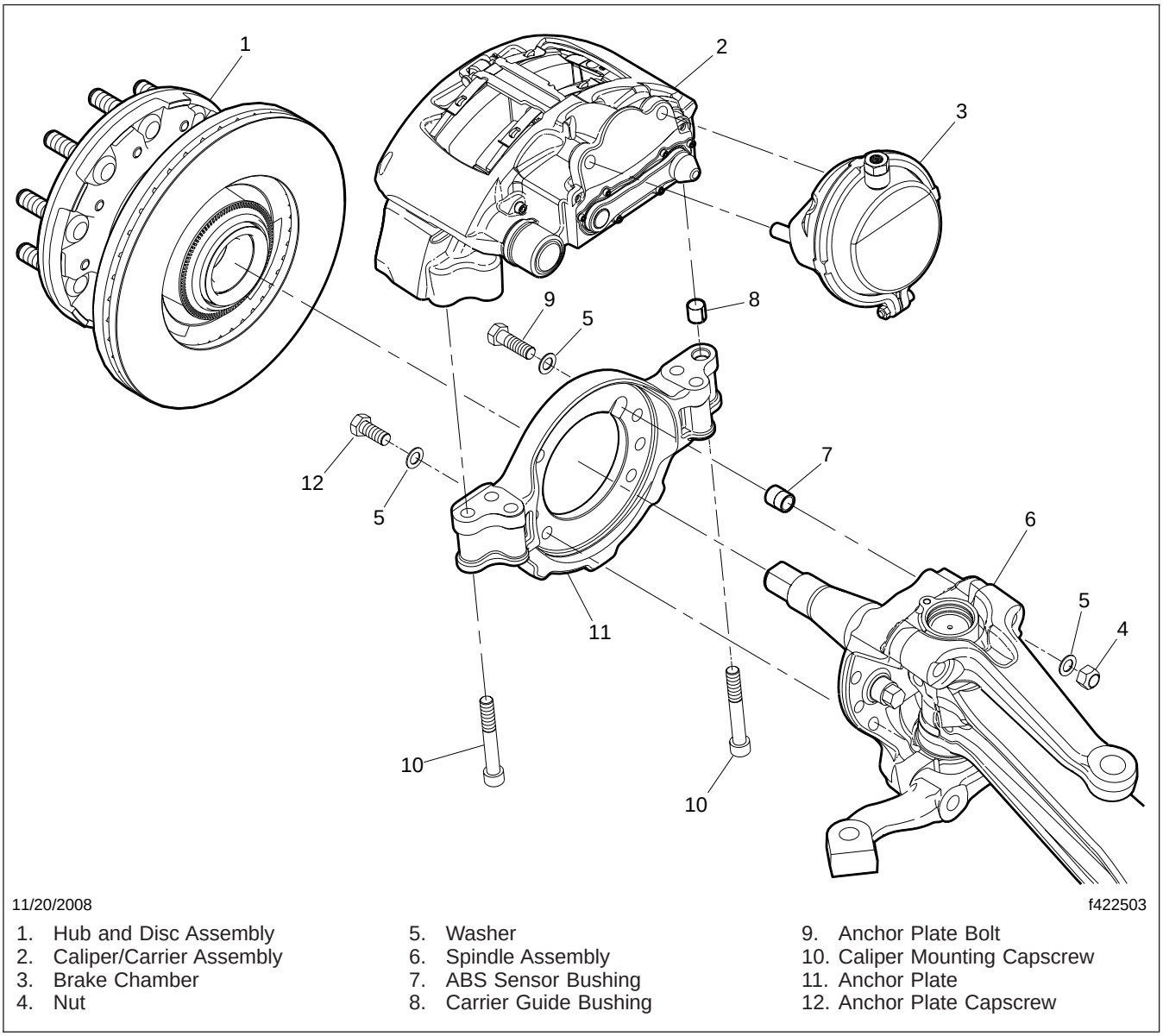
8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Rear Caliper/Carrier Assembly Removal

Refer to **Fig. 2** for rear caliper/carrier removal and installation.

1. Apply the brakes and chock the tires.

Brake Caliper/Carrier Assembly Removal and Installation



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1. Hub and Disc Assembly
2. Caliper/Carrier Assembly
3. Brake Chamber
4. Nut
5. Washer
6. Spindle Assembly
7. ABS Sensor Bushing
8. Carrier Guide Bushing
9. Anchor Plate Bolt
10. Caliper Mounting Capscrew
11. Anchor Plate
12. Anchor Plate Capscrew

Fig. 1, Front Caliper and Carrier Assembly Installation

2. Raise the axle being serviced, and support it with an appropriate jackstand.
3. Remove the wheels. See **Group 40**.

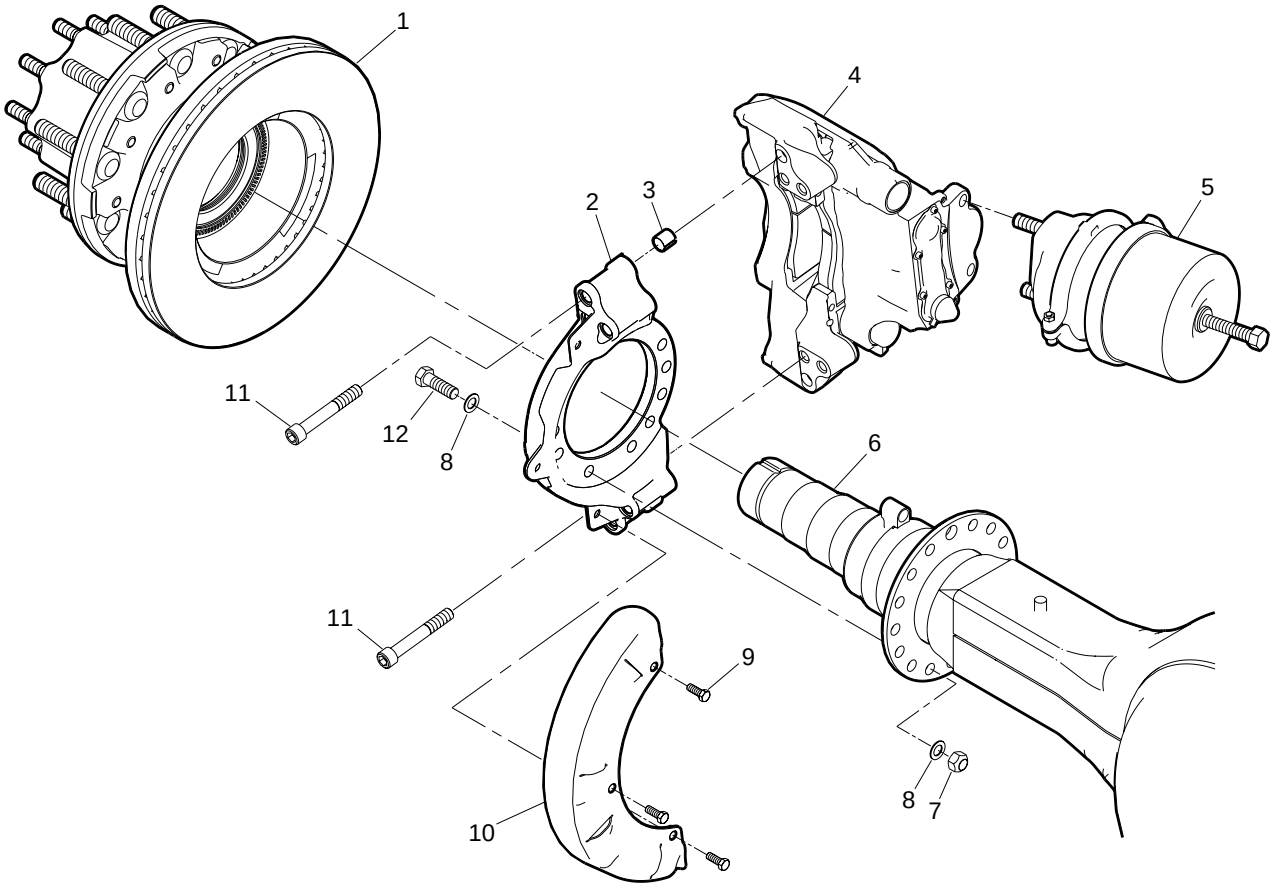
⚠ WARNING

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.

4. Carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft. (35 N·m) to release spring force on the pushrod. See **Fig. 3**.
5. Drain the air from the air system.

Brake Caliper/Carrier Assembly Removal and Installation



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1. Hub and Rotor Assembly
2. Anchor Plate
3. Carrier Guide Bushing
4. Caliper/Carrier Assembly
5. Spring Brake Chamber
6. Axle End
7. Nut
8. Washer
9. Rotor Shield Capscrew
10. Rotor Shield
11. Caliper Mounting Capscrew
12. Bolt

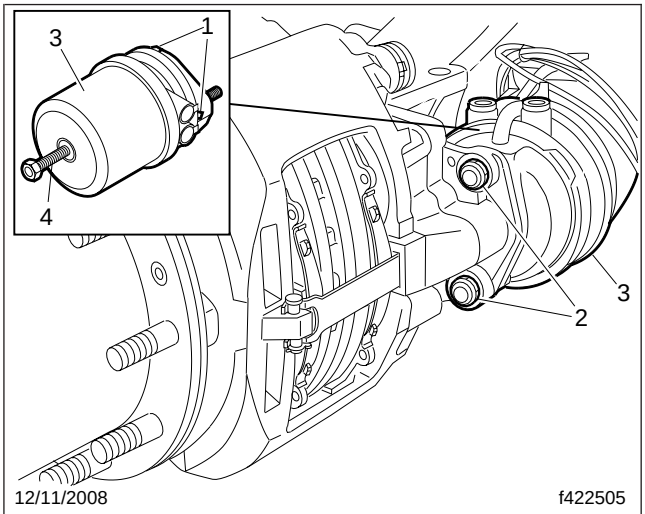
Fig. 2, Rear Caliper and Carrier Assembly Installation

6. Cut the zip ties holding the ABS harness to the brake hose as needed.
7. Remove the brake chamber from the caliper. See **Subject 150**.
8. Remove the rotor shield, if equipped.
9. With the caliper/carrier assembly securely supported, remove and discard the six bolts attaching the carrier to the anchor plate. Remove the caliper/carrier assembly.
10. Clean and inspect the anchor plate contact area. If damage is found, replace the anchor plate. See **Subject 140**.

Rear Caliper/Carrier Assembly Installation

1. Position the new carrier/caliper assembly, and attach it to the anchor plate with new bolts. Tighten 170 to 200 lbf·ft (230 to 271 N·m).

Brake Caliper/Carrier Assembly Removal and Installation



1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

Fig. 3, Spring Brake Chamber Installation

2. Install the brake pads, and brake pad shield, if equipped. See **Subject 110**.
3. Using new nuts, attach the brake chamber to the caliper/carrier assembly. Tighten 127 to 137 lbf·ft (172 to 186 N·m). See **Subject 150**.
4. Install the rotor shield, if equipped.
5. Uncage the spring brake chamber.
6. Install the wheels. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

⚠ 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, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 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 rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

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.

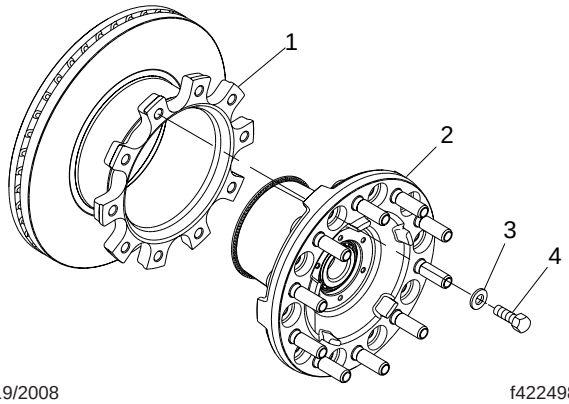
Brake Rotor Removal

1. Chock the wheels on an axle that is not being serviced.
2. Raise the axle end to be serviced, and secure it on a jackstand.
3. Remove the wheel(s). See **Group 40**.
4. Remove the brake caliper/carrier assembly. See **Subject 120**.
5. Remove the hub and rotor assembly. See **Group 33** for the front axles, or **Group 35** for the rear axle.

   If replacing the rotor, remove the capscrews from the hub, and remove the brake rotor. See **Fig. 1** for front axles, or **Fig. 2** for rear axles.

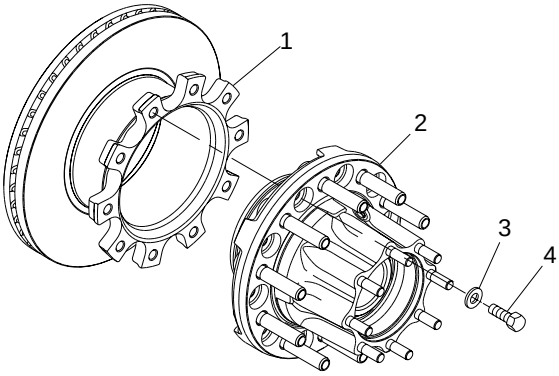
Brake Rotor Installation

1. If the rotor was removed from the hub, clean the mating surface of the hub and brake rotor as needed.



1. Rotor
2. Hub
3. Washer
4. Capscrew

Fig. 1, Front Rotor Installation



1. Rotor
2. Hub
3. Washer
4. Capscrew

Fig. 2, Rear Rotor Installation

NOTE: It may be necessary to install the hub prior to tightening the hub-to-rotor capscrews to their final torque setting.

2. If replacing the rotor, position the new rotor on the hub, and install the capscrews. See **Fig. 1** for front axles, or **Fig. 2** for rear axles. Tighten 190 to 210 lbf·ft (258 to 285 N·m) using the sequence shown in **Fig. 3**.
3. Install the hub and rotor assembly. See **Group 33** for the front axle, or **Group 35** for the rear axle.

Brake Rotor Removal and Installation

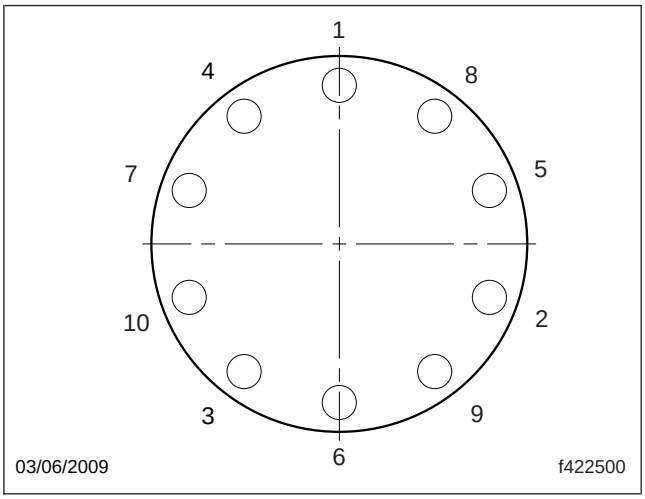


Fig. 3, Tightening Sequence

4. Install the brake caliper/carrier assembly. See **Subject 120**.
5. Install the wheel(s). See **Group 40**.
6. Remove the jackstand, and lower the vehicle.

⚠ 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, as follows, before you put the vehicle in service.
   - 7.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 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 rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Anchor Plate Removal, Cleaning and Inspection, 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.

Front Anchor Plate Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheel. See **Group 40**.
5. Remove the caliper/carrier assembly. See **Subject 120**.
6. Remove the hub and disc assembly. See **Subject 130**.
7. Pull the ABS sensor from its hole in the axle flange, and secure it in a safe place.
8. Remove the fasteners and remove the anchor plate. See **Fig. 1**.

Rear Anchor Plate Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheels. See **Group 40**.
5. Remove the rotor shield, if equipped. See **Fig. 2**.
6. Remove the caliper/carrier assembly. See **Subject 120**.
7. Remove the hub and disc assembly. See **Subject 130**.
8. Cut the zip ties holding the ABS sensor harness in place.
9. Disconnect the ABS sensor harness at its connection to the chassis harness, then feed it through the hole in the anchor plate and secure it in a safe manner.
10. Remove the fasteners and remove the anchor plate.

Anchor Plate Cleaning and Inspection

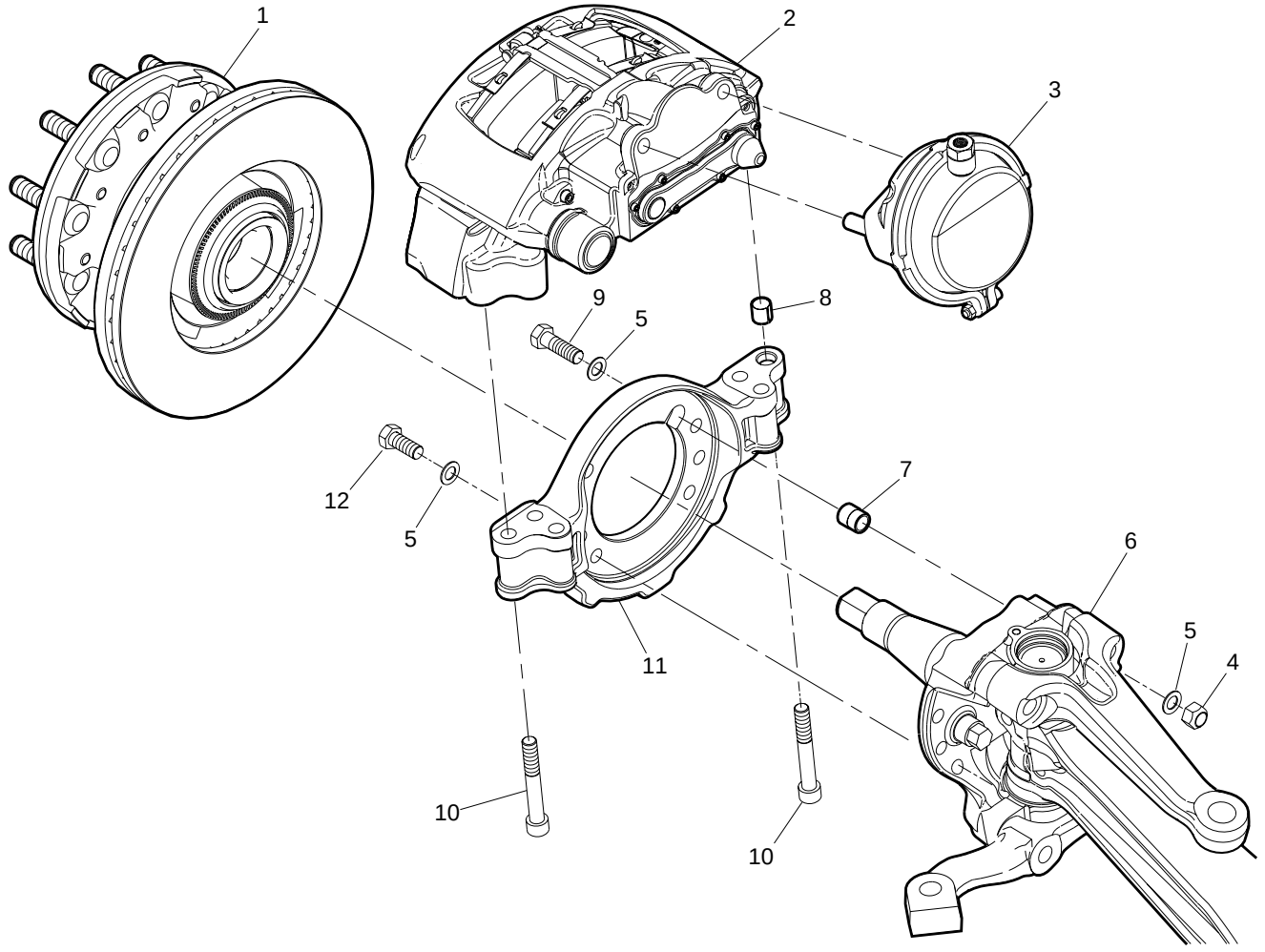
If replacing the anchor plate, it is not necessary to clean and inspect it. If the anchor plate will be reused, clean and inspect it as follows.

1. Clean the anchor plate with a brush and solvent.
2. Inspect the anchor plate for cracks or other damage. If damage is found, replace the anchor plate.
3. Inspect the carrier and axle flange mounting surface of the anchor plate. All surfaces must be clean and free of any rust or corrosion. Use a hand-held wire brush to clean these surfaces, if needed.
4. Check that the carrier bolt hole threads are clean and free of foreign matter, and that the carrier guide bushing is secure and properly seated.

Front Anchor Plate Installation

1. Position the anchor plate on the spindle flange with the caliper mounting bosses facing up, and the ABS sensor hole (larger) aligned with the uppermost forward hole on the axle flange.
2. Install the capscrews, washers, and nuts, as shown in **Fig. 1**.
   - 2.1 Install the 2-inch capscrew, washers, and nut, in the hole next to the ABS sensor hole.
   - 2.2 Then install the 1-1/2-inch capscrews that thread into the steering knuckle.
   - 2.3 Tighten the 2-inch capscrew 144 to 164 lbf·ft (195 to 222 N·m), and the 1-1/2-inch capscrews 168 to 188 lbf·ft (228 to 255 N·m) using the sequence shown in **Fig. 3**.
3. Install the hub and disc assembly. See **Subject 130**.
4. Install the ABS sensor. Push it in by hand, as far as it will go.
5. Install the caliper/carrier assembly. See **Subject 120**.
6. Install the wheel. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

Anchor Plate Removal, Cleaning and Inspection, and Installation



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1. Hub and Disc Assembly
2. Caliper/Carrier Assembly
3. Brake Chamber
4. Nut
5. Washer
6. Spindle Assembly
7. ABS Sensor Bushing
8. Carrier Guide Bushing
9. Anchor Plate Bolt
10. Caliper Mounting Capscrew
11. Anchor Plate
12. Anchor Plate Capscrew

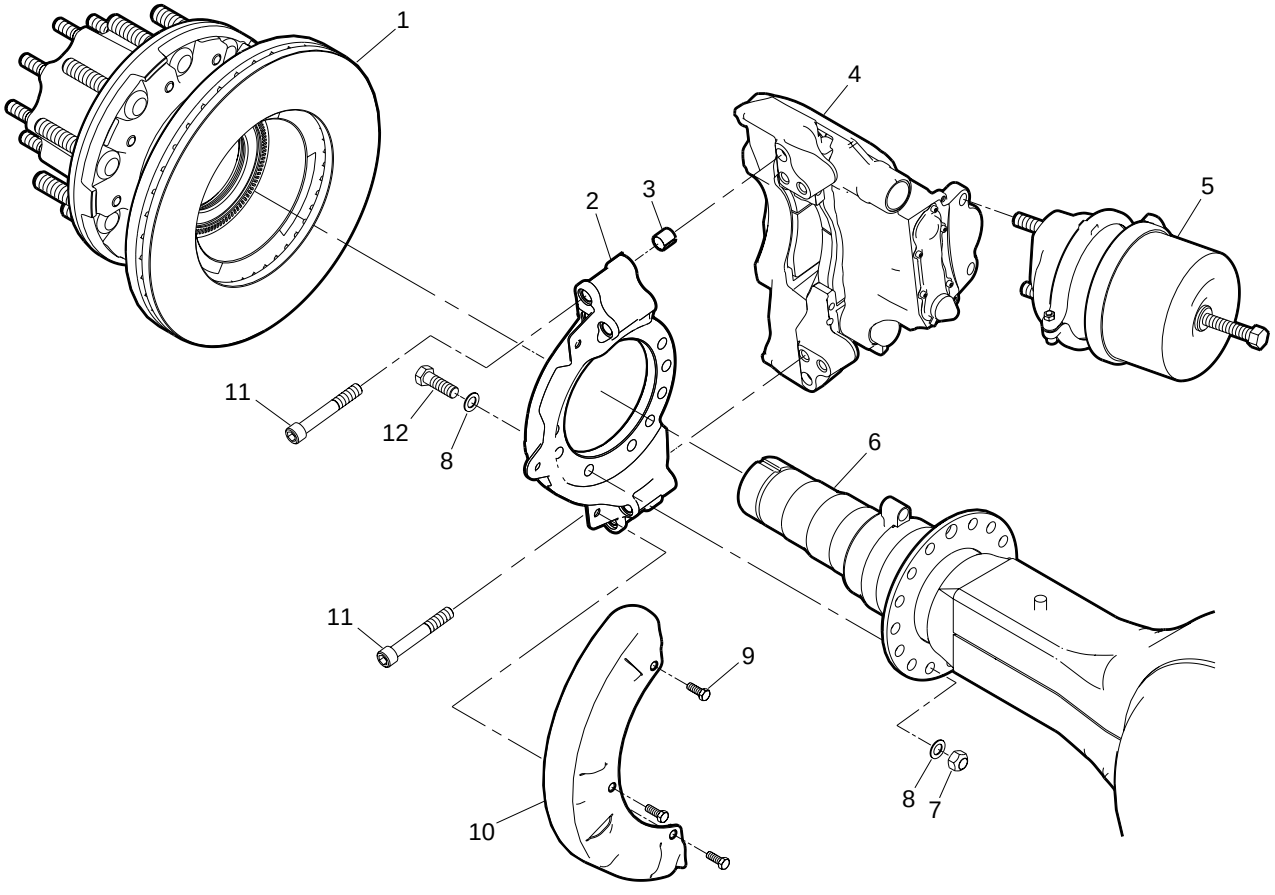
Fig. 1, Front Axle Anchor Plate Installation

⚠ 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, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

Anchor Plate Removal, Cleaning and Inspection, and Installation



1. Hub and Rotor Assembly
2. Anchor Plate
3. Carrier Guide Bushing
4. Caliper/Carrier Assembly
5. Spring Brake Chamber
6. Axle End
7. Nut
8. Washer
9. Rotor Shield Capscrew
10. Rotor Shield
11. Caliper Mounting Capscrew
12. Bolt

Fig. 2, Rear Axle Anchor Plate Installation

8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Rear Anchor Plate Installation

1. Position the anchor plate on the axle flange with the ABS sensor hole at the 12 o'clock position on the axle flange. Install the ten capscrews, washers, and nuts, leaving the holes at 1, 2, 3, and 9 o'clock positions empty. Tighten 144 to 164 lbf·ft (195 to 222 N·m), using the sequence shown in **Fig. 3**.
2. Feed the ABS sensor harness through the hole in the anchor plate, and connect it at the chassis harness. Secure it with zip ties as needed.
3. Install the hub and disc assembly. See **Subject 130**.
4. Install the caliper/carrier assembly. See **Subject 120**.
5. Install the rotor shield, if equipped.

Anchor Plate Removal, Cleaning and Inspection, and Installation

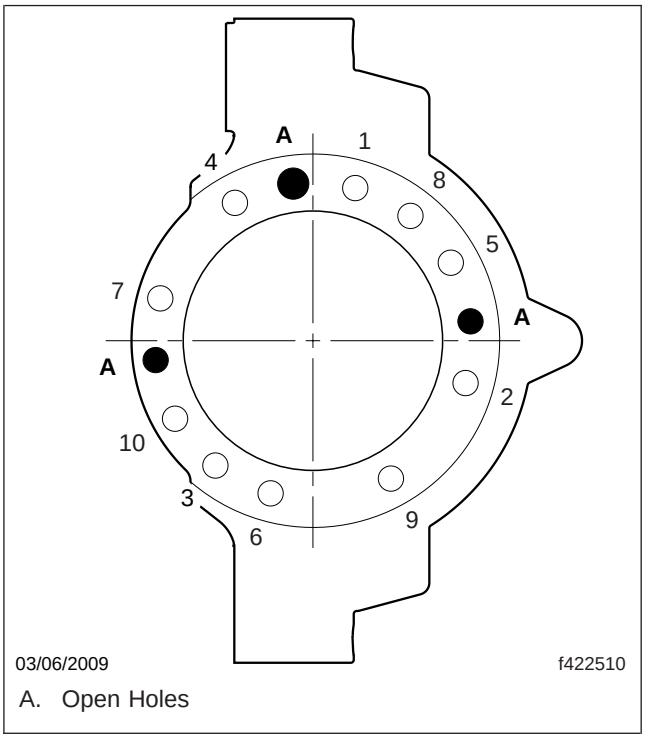


Fig. 3, Tightening Sequence

6. Install the wheels. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

⚠ 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, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 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 rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

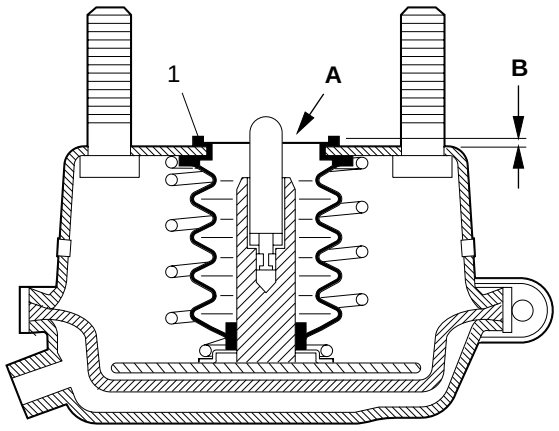
Brake Chamber, or Spring Brake Chamber, Removal and Installation

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

IMPORTANT: Replace the brake chamber, or spring-brake chamber, only with units that are the same as originally installed on the vehicle. Replacement with alternate equipment could compromise brake performance and the vehicle warranty. Do not use brake chambers with seals with a thickness less than 0.12 in. (3 mm). See Fig. 1. Use only brake chambers which are recommended by Daimler Trucks North America (DTNA).

NOTE: New brake chambers have drain hole plugs installed in all positions. After installation, remove whichever plug is at the lowest position. Be sure that all other drain holes remain plugged.



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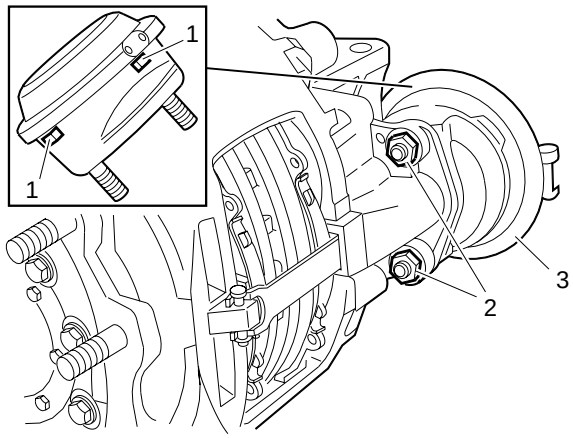
A. Pushrod Area
B. Do Not Use if Thickness is Less than 0.12 in (3 mm)

1. Seal

Fig. 1, Pushrod Area

Front Brake Chamber Removal

1. Apply the brakes and chock the tires.
2. Remove the wheels.
3. Drain the air from the air system.
4. Cut the zip ties holding the ABS wire to the air hose.
5. Disconnect the air hose at the frame rail connection.
6. Remove and discard the brake chamber mounting nuts. See Fig. 2.



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1. Drain Plugs
2. Brake Chamber Mounting Nuts
3. Brake Chamber

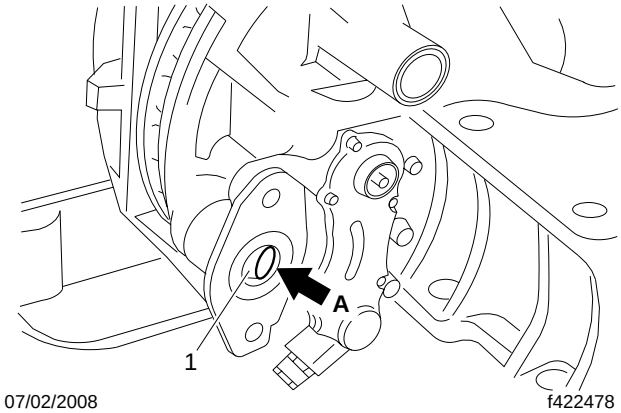
Fig. 2, Brake Chamber Installation

7. Remove the brake chamber.
8. If replacing the brake chamber, remove the air hose to use on the new one.

Front Brake Chamber Installation

1. If replacing the brake chamber, install the air hose from the old chamber.
2. Before installing the new brake chamber, clean and inspect the brake chamber flange for damage. See Fig. 3. The seal, as well as the pushrod area must be clean and dry. See Fig. 1.
3. Lubricate the spherical cup in the lever with white grease. Do not use grease containing molybdenum disulfate.

Brake Chamber, or Spring Brake Chamber, Removal and Installation



A. Actuator Flange
1. Spherical Cup in Lever

Fig. 3, Actuator Flange

4. Install the brake chamber using new self-locking nuts. Alternately tighten both nuts in increments to a final torque of 126 to 140 lbf·ft (170 to 190 N·m).
5. Connect the air hose. Be sure that the hose is not twisted, or in contact with moving vehicle components. The air hose routing must allow for full caliper travel.
6. Secure the ABS wire to the brake hose. Be sure to leave flex room.
7. Install the wheels.
8. Lower the vehicle.

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.

9. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 9.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 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 rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Spring Brake Chamber Removal

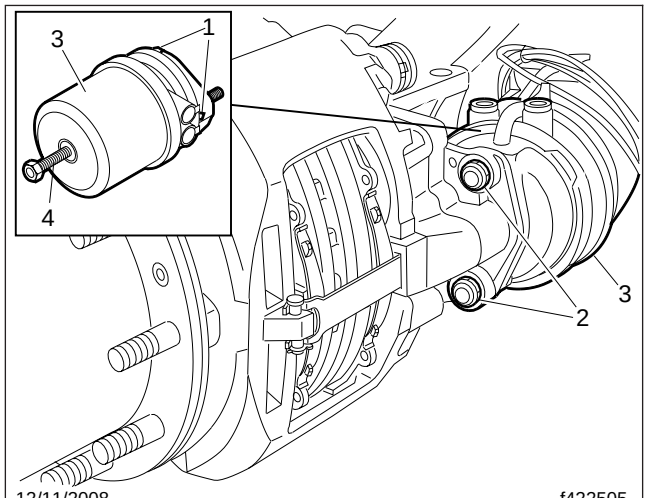
1. Set the brakes and chock the tires.
2. Remove the wheels.

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. Carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft. (35 N·m) to release spring force on the pushrod. See **Fig. 4**.



1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

Fig. 4, Spring Brake Chamber Installation

4. Drain all the air pressure from the air brake system.

5. Cut the zip ties holding the ABS wire to the air hose.
6. Disconnect the air hose at the frame rail connection.
7. While supporting the spring brake chamber in position, remove and discard brake chamber mounting nuts. Remove the brake chamber.
8. If replacing the brake chamber, remove the air hose to use on the new one.

Spring Brake Chamber Installation

IMPORTANT: Replace the brake chamber, or spring-brake chamber, only with units that are the same as originally installed on the vehicle. Replacement with alternate equipment could compromise brake performance and the vehicle warranty. Do not use brake chambers with seals with a thickness less than 0.12 in. (3 mm). See **Fig. 1**. Use only brake chambers which are recommended by DTNA.

NOTE: New brake chambers have drain hole plugs installed in all positions. After installation, remove whichever plug is at the lowest position. Be sure that all other drain holes remain plugged.

1. If replacing the brake chamber, install the air hose from the old chamber.
2. Before installing the new brake chamber, clean and inspect the brake chamber flange for damage. The seal, as well as the pushrod area must be clean and dry. See **Fig. 3**.
3. Lubricate the spherical cup in the lever with white grease. Do not use grease containing molybdenum disulfate. See **Fig. 3**.
4. Install the brake chamber using new self-locking nuts. Alternately tighten both nuts in increments to a final torque of 126 to 140 lbf·ft (170 to 190 N·m).
5. Connect the air hose. Be sure that the hose is not twisted, or in contact with moving vehicle components. The air hose routing must allow for full caliper travel.
6. Secure the ABS wire to the brake hose. Be sure to leave flex room.
7. Uncage the spring brake.
8. Install the wheels.
9. Lower the vehicle.

⚠ 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.

10. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
    - 10.1 Apply and release the brakes several times to check for air leaks and proper operation.
    - 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 rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Specifications

Bendix Air Disc Brake Fastener Torque Specifications	
Installation	**Torque: lbf·ft (N·m)**
Hub to Rotor	190–210 (258–285)
Anchor Plate to Axle Flange: 2-inch (front only)	144–164 (195–222)
Anchor Plate to Axle Flange: 1.5-inch (front)	168–188 (228–255)
Anchor Plate to Axle Flange (rear)	144–164 (195–222)
Caliper to Anchor Plate	170–200 (230–271)
Brake Chamber to Caliper	126–140 (170–190)
Rotor Shield to Anchor Plate	25–35 (34–47)

Table 1, Bendix Air Disc Brake Fastener Torque Specifications

General Information

The function of the Integrated Solution Air Dryer (AD-IS®) and reservoir system is to provide vehicles with an integrated air dryer, purge reservoir, governor, and a number of the charging valve components in a module. 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. 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 cut-out 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.

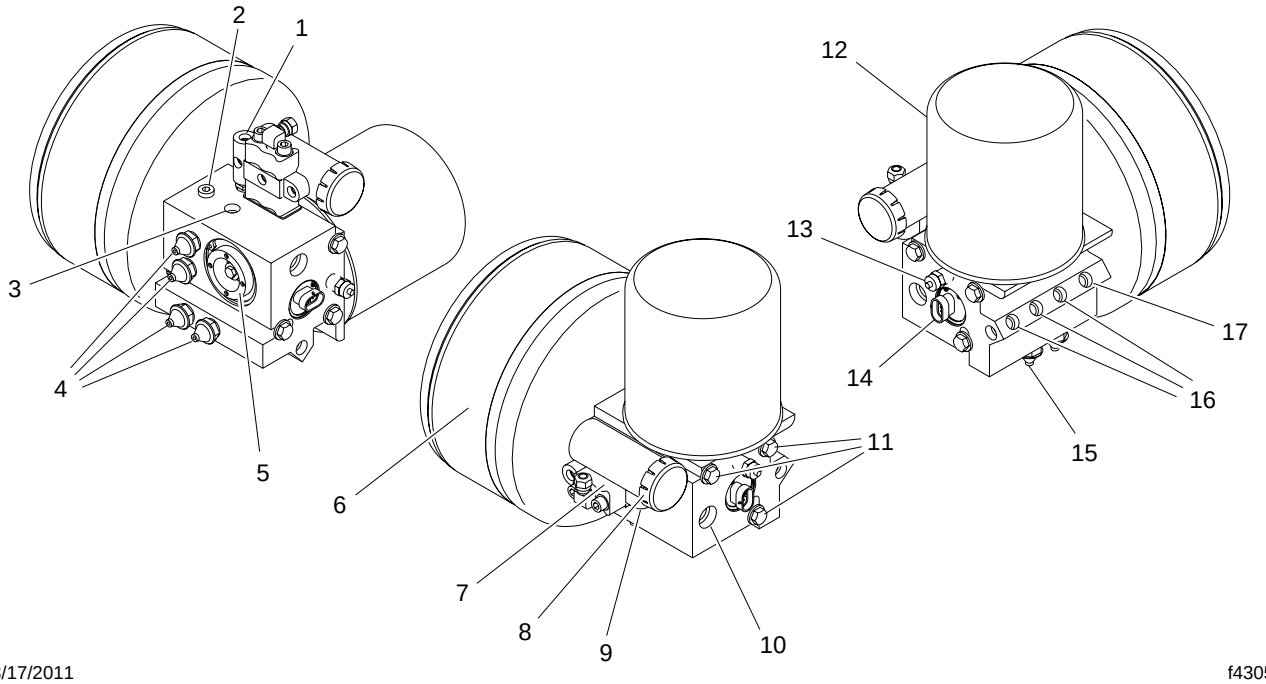
The delivery check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

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

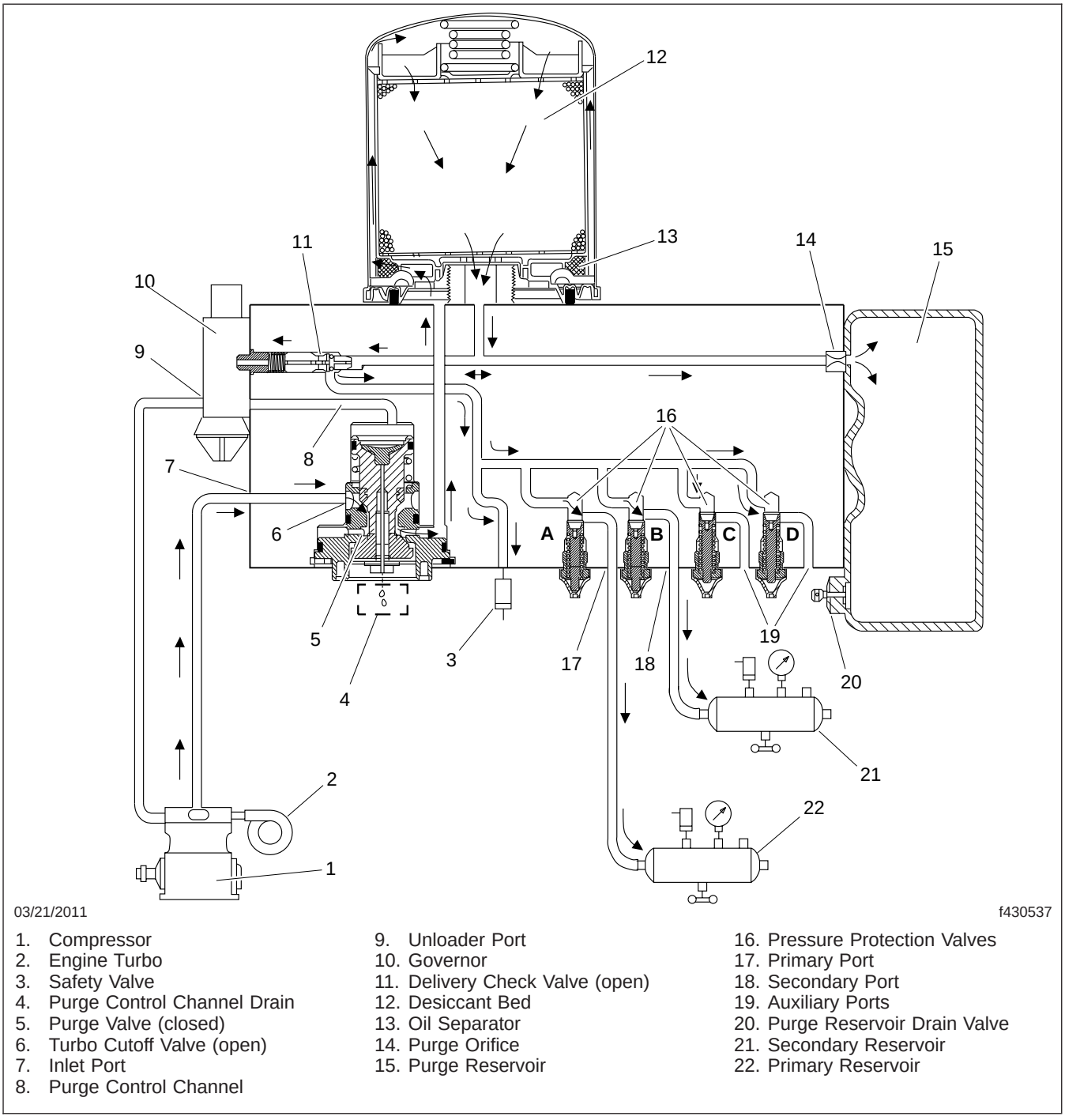
General Information



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

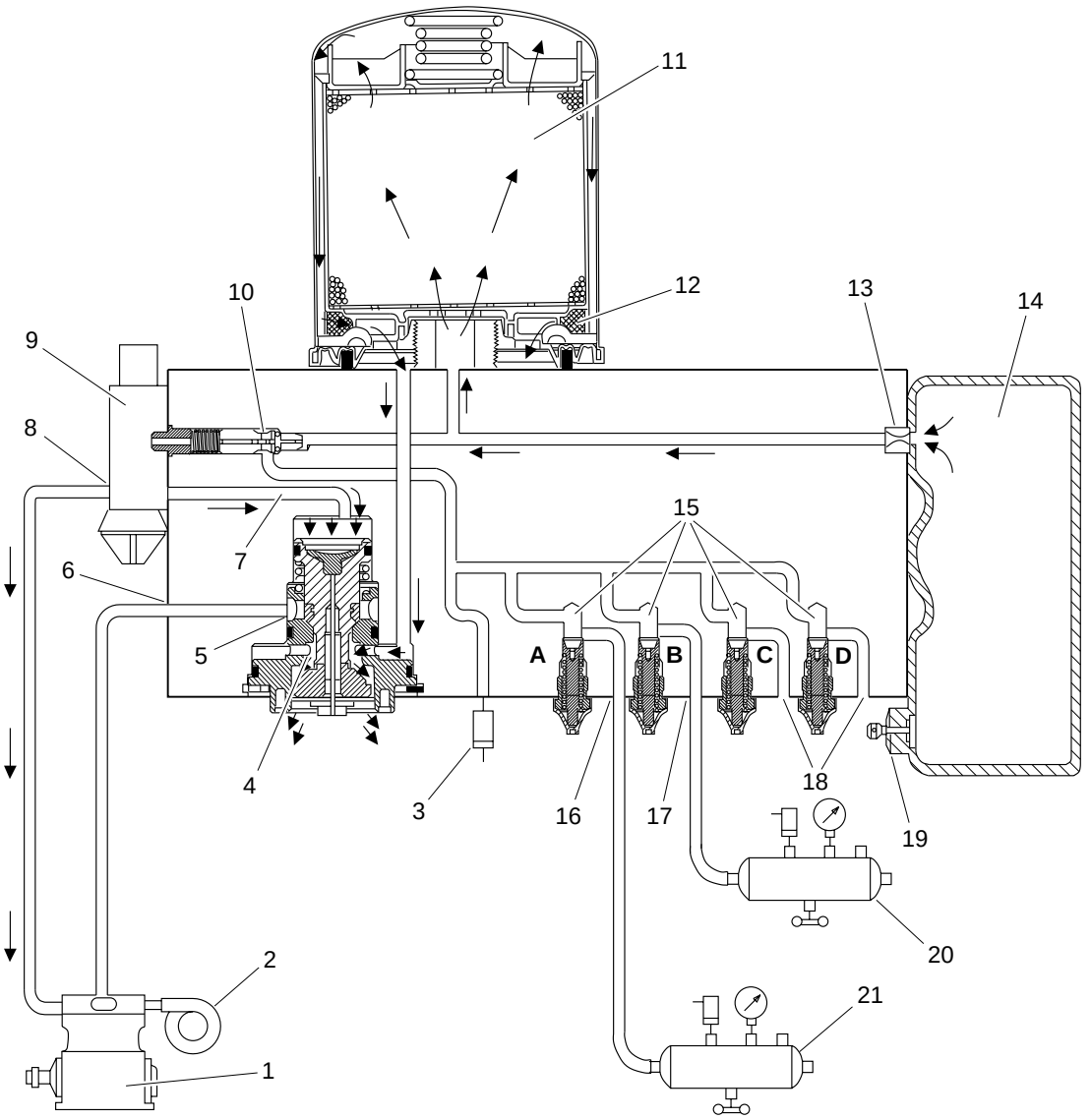
housing. With the turbo cutoff valve seated (closed position), air in the compressor discharge line and air dryer inlet port cannot enter the air dryer. This maintains turbocharger boost pressure to the engine.



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

General Information



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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.

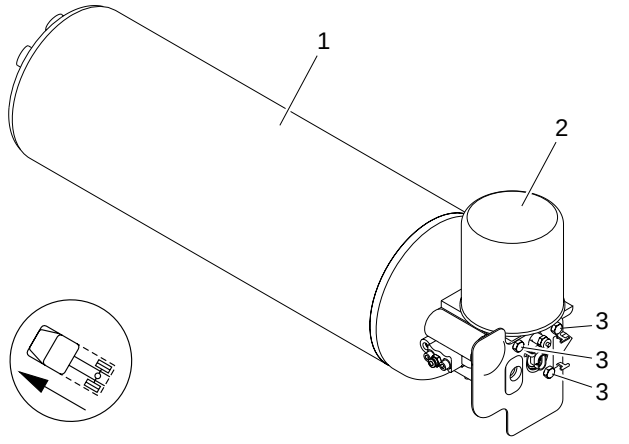
  Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

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, 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 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

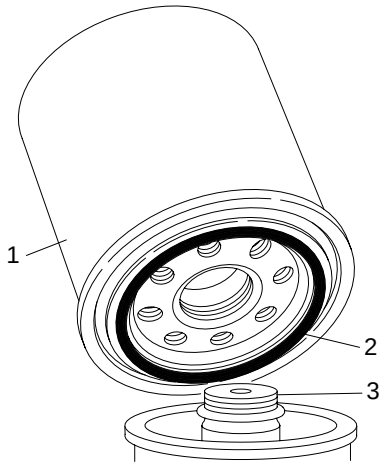
6. Remove the governor and delivery check valve from the air dryer. For instructions, see **Subject 130**.
7. Remove the desiccant cartridge. For instructions, see **Subject 120**.
8. Install the delivery check valve and governor onto the new air dryer. For instructions, see **Subject 130**.
9. If removed, 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**.

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. 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.

Delivery Check Valve and Governor Replacement

⚠ WARNING

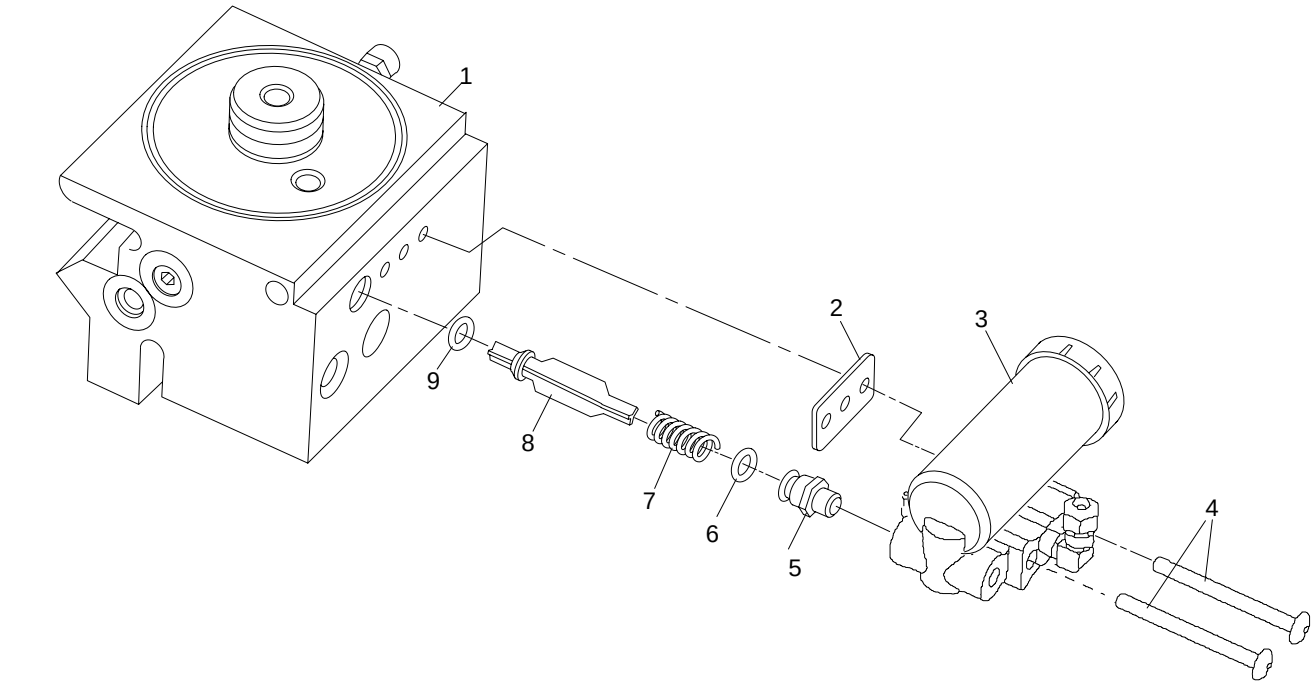
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

1. Park the vehicle on a level surface, shut down the engine, 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. 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.



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

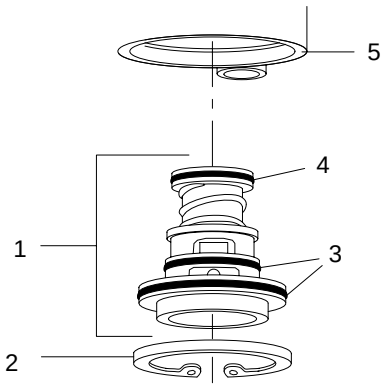
9. Install the adaptor fitting into the governor. Using the silicone grease, lubricate the remaining larger O-ring, and install it into the groove of the adaptor. Install the gasket supplied in the kit. Install the governor, and torque the capscrews 10 lbf·ft (14 N·m).
10. Perform the operational tests in **Subject 170**.

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. Shut down the engine, apply the parking brake, and 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.

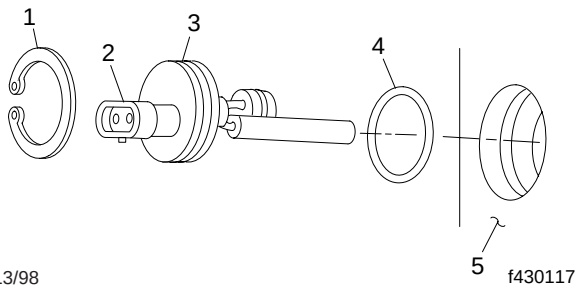
7. Install the two new O-rings on the purge valve housing cover, and the new quad-ring on the purge piston.
8. Install the new purge valve assembly in the end cover while making sure the purge valve housing is fully seated against the end cover.
9. Install the new retaining ring in its groove in the end cover.
10. Perform the operational tests in **Subject 170**.

⚠ 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. Shut down the engine, 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. See **Fig. 1**.



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.

WARNING

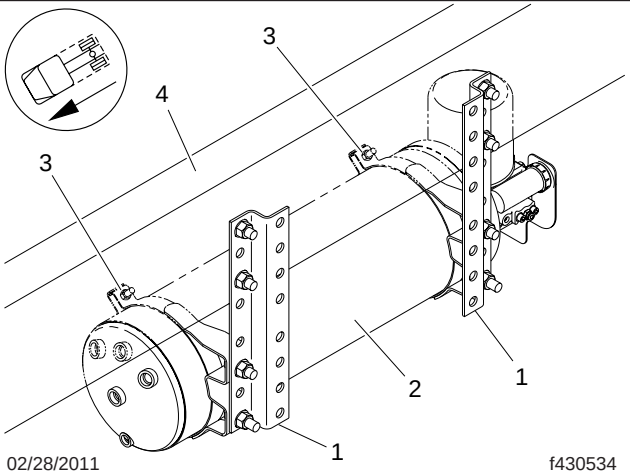
Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Replacement

1. Shut down the engine, apply the parking brake, 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.



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. 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, 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).

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.

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

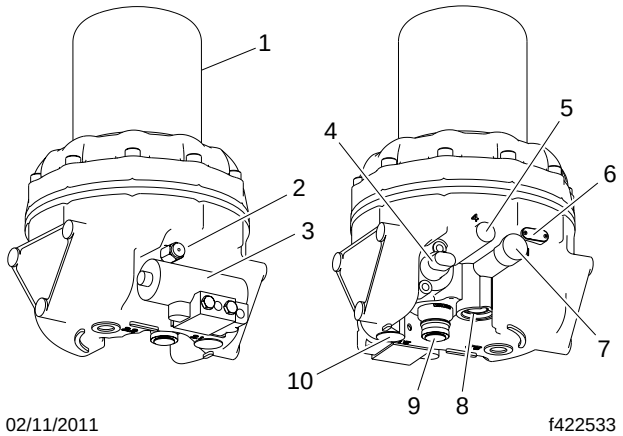
Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle	
Possible Cause	**Remedy**
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, 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 Information

The System Saver 1200 Plus air dryer, shown in **Fig. 1**, is a desiccant air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the buildup of dirt and moisture in the vehicle air system.



1. Desiccant Canister
2. Pressure Relief Valve
3. Governor
4. Heater/Thermostat Assembly
5. Control Port (to the air compressor unloader port)
6. Date Code Information (for the air dryer)
7. Air Dryer Inlet (from the air compressor discharge)
8. Turbocharger Cutoff Valve
9. Exhaust Port (Purge Valve Assembly)
10. Delivery/Outlet Port (to the air supply reservoir)

Fig. 1, WABCO System Saver 1200 Plus

The air dryer consists of a light weight aluminum and steel body. The desiccant cartridge is contained in a spinoff canister at the top of the air dryer.

The bottom half of the air dryer houses the following components.

- Pressure Relief Valve—this valve protects the air dryer from over pressurization. The valve is attached directly to the air dryer.
- Desiccant Canister—a cylindrical steel housing that contains the filter elements and the desiccant needed to filter and dry the air that passes through it.
- Heater/Thermostat Assembly—located in the air dryer base, this assembly is designed to prevent the collected moisture from freezing.
- Outlet Check Valve—this valve prevents air in the system from flowing back through the air dryer and escaping out the purge valve during the compressor unload cycle.
- Purge Valve—this valve allows the collected moisture and contaminants to be expelled from the air dryer during the purge cycle.
- Silencer (Muffler)—an optional component that is attached to the purge valve and used to eliminate most of the noise during the air dryer purge cycle.
- Turbocharger Cutoff Valve—this optional valve closes the path between the air compressor and the air dryer purge valve to help maintain boost pressure for maximum engine horsepower during the compressor unload cycle. A turbocharger cutoff valve is required with air compressors that use a turbocharged air intake.

NOTE: If the air compressor is naturally aspirated, the air passes from the vehicle air filter directly to the air compressor intake and **does not** require a turbocharger cutoff valve.

Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and initially settle into the base of the dryer. The moisture-laden air also passes through the desiccant bed, where any remaining moisture is retained by the desiccant. The clean air then passes through the air dryer outlet port to the supply reservoir.

When the compressor reaches 125 psi (862 kPa), the purge valve opens, allowing the initial decompression of the dryer, and expelling the water and contaminants collected in the base of the dryer.

Safety Precautions

⚠ WARNING

When draining the air system, do not look into the air jets or direct them toward another person, as dirt or sludge particles may be in the air-stream. 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 cause personal injury.

When working on or around air brake systems and components, observe the following precautions.

- Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air system pressure drops.
- Wear safety goggles.
- Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
- Do not disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
- Replacement hardware, tubing, hose, fittings, etc., should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace any components that have stripped threads or damaged parts. Do not attempt to repair parts by machining.
- Never exceed recommended air pressure.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

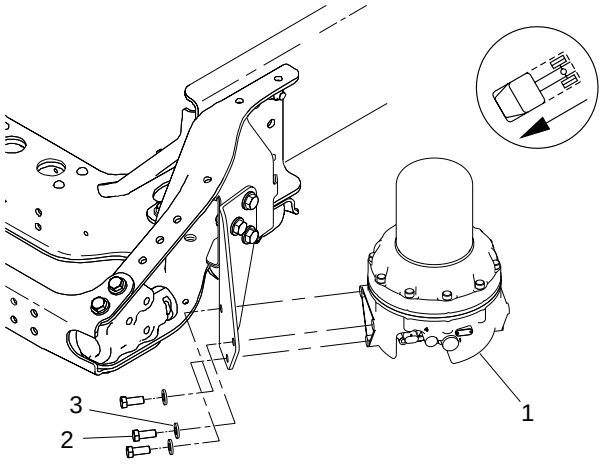
Refer to **Fig. 1** for removal and installation of the air dryer.

Removal

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.
4. Remove the mounting screws and washers that attach the air dryer to the mounting bracket.
5. Remove the air dryer.

Installation

1. Position the air dryer on the mounting bracket. Install the washers and capscrews. Tighten them 52±4 lbf·ft (71±4 N·m).
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
4. Connect the air dryer wiring harness.



1. Air Dryer
2. Mounting Screw
3. Washer

Fig. 1, Air Dryer Installation (left-hand forward frame mounting shown)

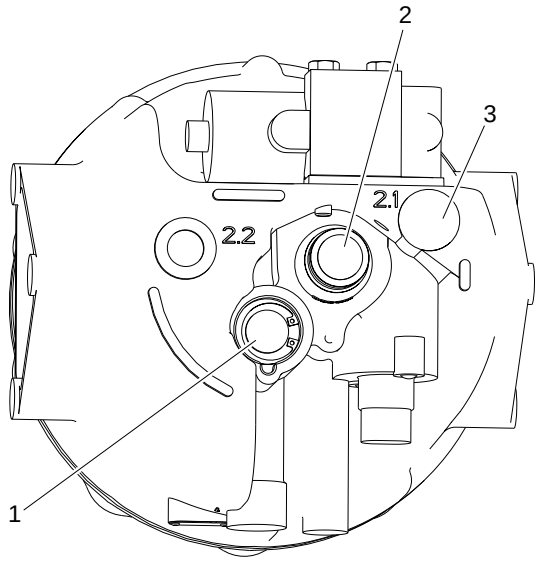
⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

IMPORTANT: The turbocharger cutoff valve is optional on the WABCO System Saver 1200 Plus air dryer.

Replacement

1. Drain the air system.
2. Remove the snap ring at the bottom of the valve assembly. See **Fig. 1** for the location of the turbocharger cutoff valve and **Fig. 2** for an example of the turbocharger cutoff valve assembly.



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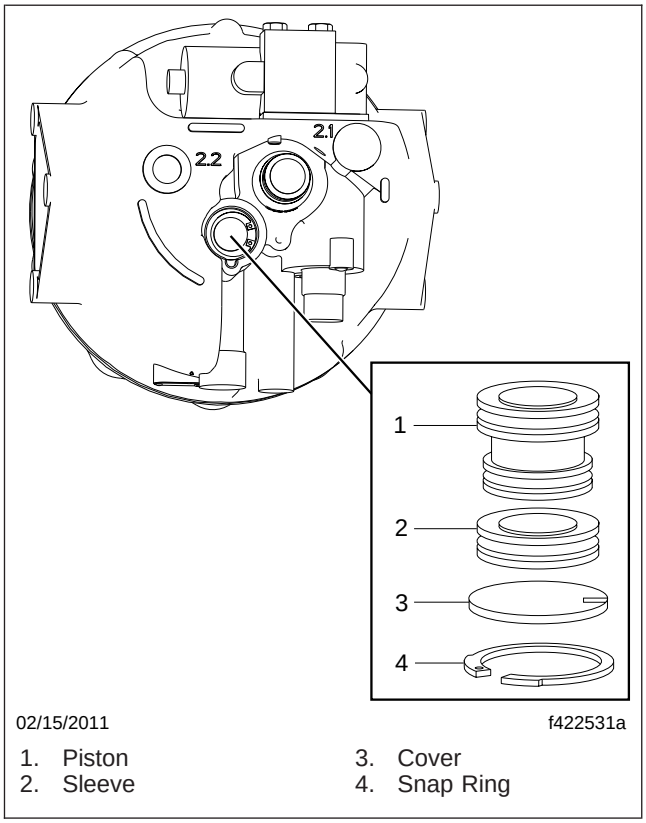
1. Turbocharger Cutoff Valve (has an orange cover)
2. Exhaust Port (Purge Valve Assembly)
3. Delivery/Outlet Port (to the air supply reservoir)

Fig. 1, Turbocharger Cutoff Valve

3. Clean the valve cavity with a commercial cleaning solvent.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer. See **Subject 110** for instructions.

4. Install new O-rings on the piston and the sleeve.



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1. Piston
2. Sleeve
3. Cover
4. Snap Ring

Fig. 2, Turbocharger Piston and Sleeve Assembly

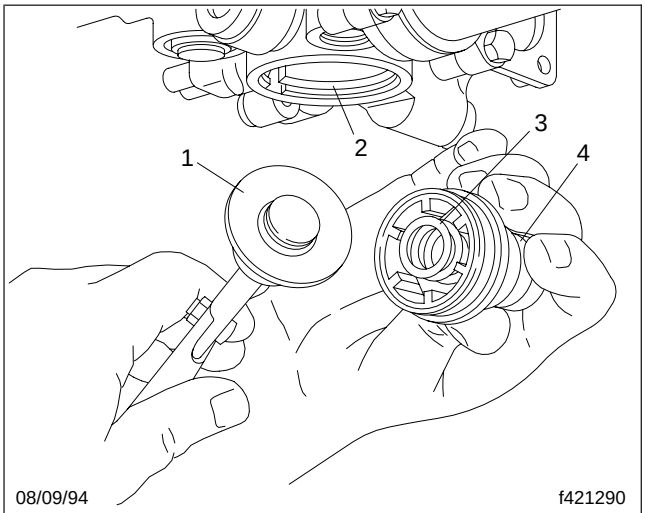
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
6. Press the piston into the sleeve.
7. Press the new piston and sleeve assembly into the air dryer.
8. Install the cover and snap ring to hold the components in place.

⚠ 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. Valve Assembly
2. Exhaust Port
3. Spring
4. Valve Head

Fig. 1, Removing the Valve Assembly

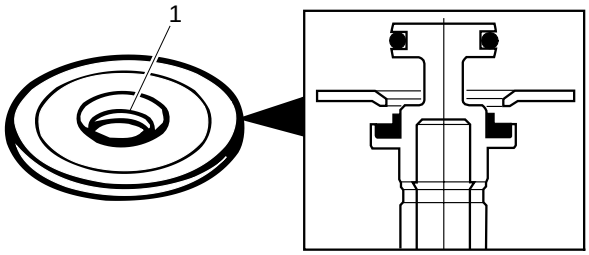
1. Drain the air system.
2. Remove the snap ring, valve head, and the spring from the exhaust port.
3. Pull the valve assembly out of the exhaust port.
4. Remove the O-ring from the base of the exhaust port.
5. Clean the purge valve cavity area with a commercial cleaning solvent.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the valve cavity and all of the new O-rings. Install the O-rings in the base of the exhaust port and on the valve head.
7. Install the new washer and O-ring in the dryer base and on the valve head.

NOTE: The lip on the washer must face the piston seat as shown in **Fig. 2**.

8. Assemble the piston assembly.
   - 8.1 Install the O-ring in the groove on the piston head.
   - 8.2 Install the piston seat in the groove on the piston base.
   - 8.3 Install the washer on the piston.
9. Position the new valve assembly in the valve cavity.



1. Lip

Fig. 2, Washer Lip Facing Piston Seat

10. Install the spring in the valve head, and position them in the valve cavity.
11. Install the snap ring to secure the valve head in position.

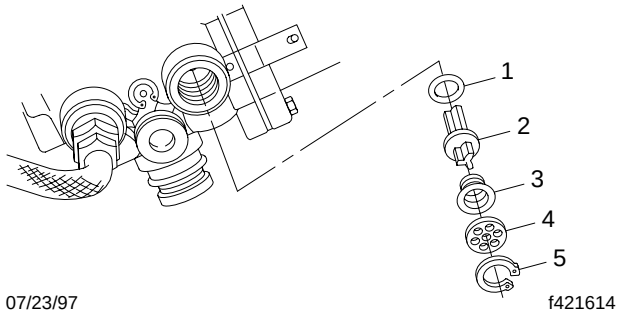
NOTE: Make certain the snap ring is fully seated or the assembly will leak from the purge valve.

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 valve replacement.



1. O-Ring
2. Valve Body
3. Spring
4. Washer
5. Snap Ring

Fig. 1, Outlet Check Valve Assembly

1. Drain the air system.
2. Disconnect the air line from the outlet port.
3. Remove the snap ring, washer, valve body, and the O-ring.
4. Clean the cavity area with a commercial cleaning solvent.
5. Install a new O-ring on the valve body.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the valve cavity.
7. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
8. Install the new spring with its small end around the Y-shaped fins on the valve body.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

9. Install a new washer and snap ring to secure the assembly in the valve cavity.
10. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

NOTICE

The WABCO System Saver 1200 Plus air dryer can use either a standard or oil coalescing desiccant cartridge. When replacing the desiccant cartridge, it is very important to use the same type of cartridge that was originally installed on the dryer. Oil coalescing cartridges can be used in any application, but require more frequent service intervals (every 1 to 2 years instead of every 2 to 3 years for a standard cartridge). Do not replace an oil coalescing cartridge with a standard cartridge, as this may result in contamination and malfunctioning of downstream air system components.

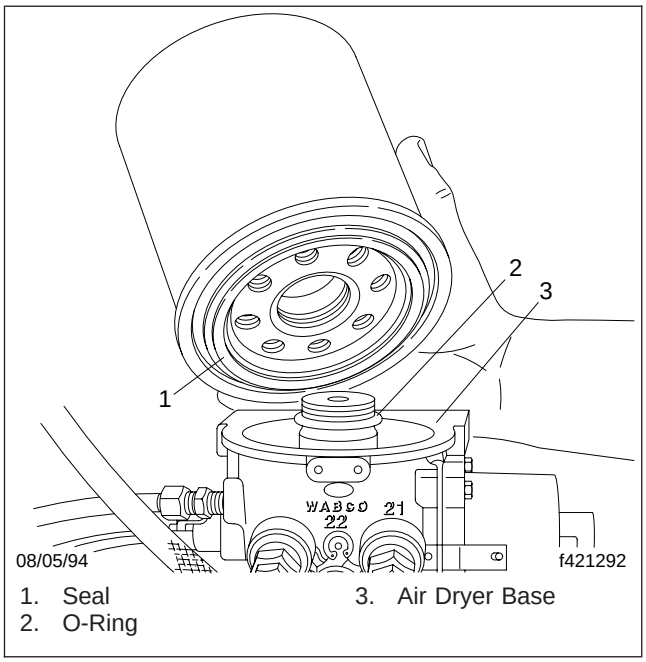
Replacement

Refer to **Fig. 1** for cartridge replacement.

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
3. Remove and discard the O-ring.
4. Clean the top surface of the dryer base with a commercial cleaning solvent.

IMPORTANT: If the air dryer base is damaged, preventing a tight seal, replace the air dryer.

5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the dryer base. Install the O-ring.
6. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not overtighten.



1. Seal
2. O-Ring
3. Air Dryer Base

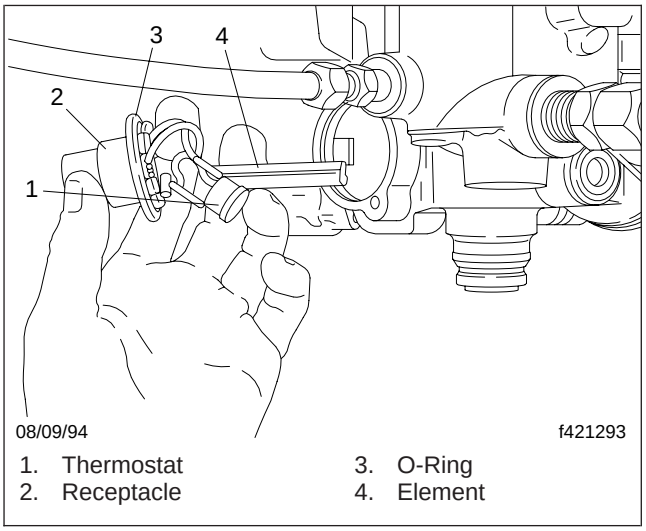
Fig. 1, Desiccant Cartridge Replacement

⚠ 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 heater/thermostat assembly replacement.



1. Thermostat
2. Receptacle
3. O-Ring
4. Element

Fig. 1, Heater/Thermostat Replacement

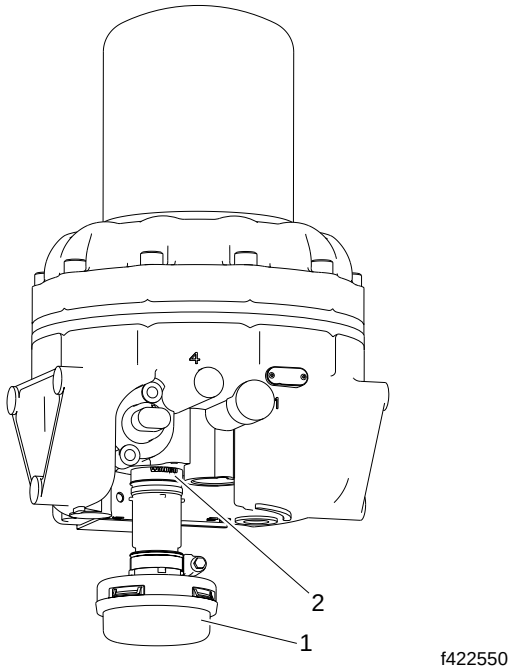
1. Drain the air system.
2. Disconnect the wiring harness.
3. Remove the screws that attach the heater/thermostat receptacle. Remove the receptacle and the O-ring.
4. Remove the retaining screw that holds the assembly in place. Remove and discard the heater/thermostat assembly.
5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Position the new heater/thermostat assembly in the cavity. Install the retaining screw.
7. Position the new receptacle and O-ring, and install the screws. Tighten the screws securely.
8. Connect the wiring harness.

⚠ 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 silencer replacement.



1. Silencer
2. Purge Valve Head

Fig. 1, Silencer Replacement

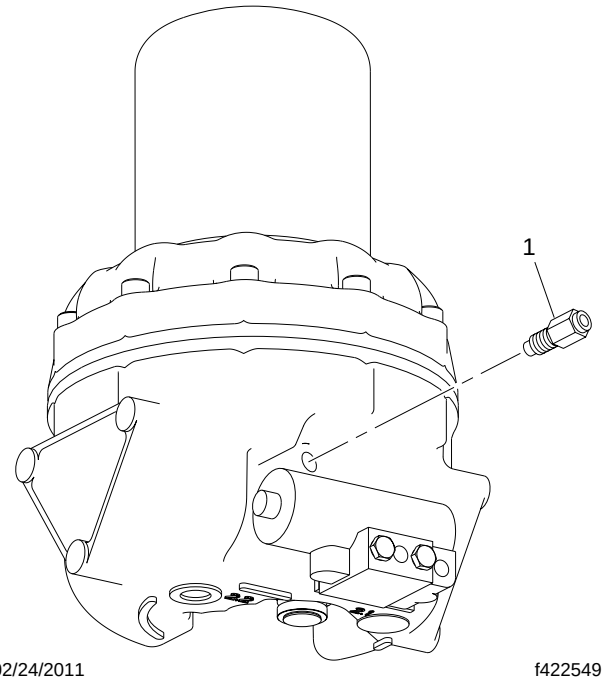
1. Using snap ring pliers, expand the snap ring and pull the silencer off of the purge valve head.
2. Push the new silencer onto the purge valve head until the silencer snaps into place.

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 valve replacement.



1. Pressure Relief Valve

Fig. 1, Pressure Relief Valve Replacement

1. Drain the air system.
2. Unscrew and remove the old valve from the dryer.
3. Screw the replacement valve into the dryer base. Do not exceed a torque of 30 lbf·ft (41 N·m) for a 3/8-inch thread, or 65 lbf·ft (88 N·m) for a 1/2-inch thread.

NOTE: The threads on the replacement pressure relief valve provided by WABCO are coated with sealant. They do not require any additional sealant.

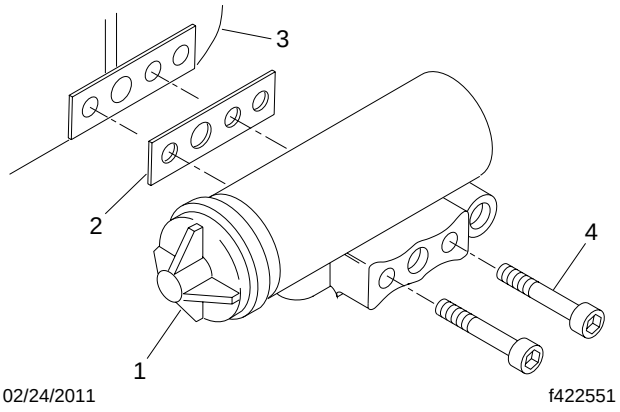
⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

IMPORTANT: When replacing the governor, use only the Meritor WABCO governor specified for use with the System Saver 1200 Plus air dryer.

Replacement

1. Remove the mounting bolts, governor and gasket as shown in **Fig. 1**. Discard the gasket.



1. Governor
2. Gasket
3. Air Dryer
4. Mounting Bolt

Fig. 1, Replacing the Governor

2. Place the new governor and gasket into position on the air dryer.
3. Using the mounting bolts, install the governor. Tighten the bolts 15 lbf·ft (20 N·m).

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Air Dryer Operating Tests

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
3. When the compressor reaches the unload cycle, the air dryer purges, beginning regeneration of the air dryer.
4. There should be no visible pressure drop on the vehicle dash gauges during regeneration. If there is a visible pressure drop, and there are no other air-operated components in use, then there are air leaks or other system problems. Refer to **Troubleshooting 300** for other possible causes.

Problem—Air Dryer Purges Too Often and Is Accompanied by Excessive Cycling of the Compressor

Problem—Air Dryer Purges Too Often and Is Accompanied by Excessive Cycling of the Compressor	
Possible Cause	**Remedy**
There is a leak in the line between the unloader port of the air compressor and dryer port 4.	Repair the air line.
There is a leak in the line between the supply tank and the delivery/outlet port.	Repair the air line.
Excessive air system leaks.	Repair all leaks.
Excessive air system demands.	Increase the air system capacity or reduce air demand.
The outlet check valve does not seal.	Inspect and replace the outlet check valve as needed.
There is a leak at the air governor gasket.	Replace the gasket.
The air governor has less than 16 psi (110 kPa) range.	Replace the air governor.
The air compressor's unloader(s) is leaking.	Inspect the air compressor and repair or replace it according to the manufacturer's instructions.

Problem—The Air Dryer Does not Purge When the Compressor Unloads (No Blast of Air from the Purge Valve)

Problem—The Air Dryer Does not Purge When the Compressor Unloads (No Blast of Air from the Purge Valve)	
Possible Cause	**Remedy**
The air line between the unloader port of the air compressor and air dryer port 4 is kinked or plugged.	Repair the air line.
The purge valve is stuck closed.	Replace the purge valve.
The air governor is not working properly.	Inspect the air governor and repair or replace it according to the manufacturer's instructions.
Cut-out pressure is never achieved by the air compressor.	Check for air leaks in the system and repair as needed. If no leaks are found, check the compressor output. Repair or replace the compressor according to the manufacturer's instructions.

Problem—There Is Rapid "Spitting" of Air from the Purge Valve in Small Amounts; Frequency Varies With Engine Speed

Problem—There Is Rapid "Spitting" of Air from the Purge Valve in Small Amounts; Frequency Varies With Engine Speed	
Possible Cause	**Remedy**
A Holset E-type compressor is being used, but a non-1200E air dryer is installed.	Replace the air dryer with an SS1200E air dryer.
The compressor does not completely unload when cut-out pressure is reached.	Inspect the compressor and repair or replace it according to the manufacturer's instructions.
This is normal for air dryers that are not equipped with an optional turbocharger cutoff valve.	Not applicable.

Troubleshooting

Problem—Air Leaks at the Turbo Cutoff Valve Vent; There Is a Hole Burned in the Piston

Problem—Air Leaks at the Turbo Cutoff Valve Vent; There Is a Hole Burned in the Piston	
Possible Cause	**Remedy**
The temperature of the air coming into the dryer is too high, and there is not enough cooling taking place before the air gets to the air dryer inlet.	Move the dryer farther from the compressor. Add additional compressor discharge line before the air dryer. Add a cooling coil or heat exchanger before the air dryer. NOTE: The inlet air temperature must not exceed 175°F (79°C).
The valve bore is worn excessively.	Inspect the valve bore for wear. If a new turbo cut-off valve does not seal in a clean, lubricated bore, replace the air dryer.
The piston is broken.	Replace the turbocharger cutoff valve. See **Subject 120**.

Problem—The Air Dryer Is Frozen (Water Collected in the Base of the Air Dryer Freezes)

Problem—The Air Dryer Is Frozen (Water Collected in the Base of the Air Dryer Freezes)	
Possible Cause	**Remedy**
There is no power to the heater connector.	Check for a blown fuse. Repair the heater circuit. NOTE: There must be power to the heater connector the entire time the vehicle's ignition is activated.
Low voltage to the heater connector.	Repair the cause of low voltage—poor electrical ground, bad connections, corroded wire splices, etc.
The heater assembly is not working.	Replace the heater assembly.
An incorrect voltage air dryer is being used (for example a 12V air dryer in a 24V system).	Replace with the correct voltage air dryer.

Problem—Air Pressure Will Not Build-Up in the System

Problem—Air Pressure Will Not Build-Up in the System	
Possible Cause	**Remedy**
The air dryer is not plumbed correctly.	Make certain the compressor discharge line is plumbed to air dryer port 1, and air dryer port 21 is connected to the vehicle's supply tank.
The wrong air line is connected to air dryer port 4.	Verify that the air dryer port 4 line is connected to the "UNL" port of the unloader port of the air compressor.
The air governor is not working properly.	Inspect the air governor and repair or replace it according to the manufacturer's instructions.
Air system components, such as the compressor discharge line, air dryer reservoirs, brake valves, or suspension valves leak.	Locate the leak(s) and repair as needed.
The air dryer leaks at the purge valve.	See *Air dryer purges too often and is accompanied by excessive cycling of the compressor* and *The air dryer leaks from the purge valve during a compressor loaded cycle (the leak may cause excessive compressor cycling or prevent the system from building air pressure).*

Problem—Water, Oil, or Sludge Is in the Air System Tanks

Problem—Water, Oil, or Sludge Is in the Air System Tanks	
Possible Cause	**Remedy**
Desiccant is contaminated with oil.	Replace desiccant. Inspect the compressor according to the manufacturer's instructions.

Problem—Water Is in the Air System Tanks

Problem—Water Is in the Air System Tanks	
Possible Cause	**Remedy**
The air dryer is not suitable for the vehicle.	Review the vehicle guidelines. Call the Meritor Customer Support Center for assistance at 1-800-535-5560.

Problem—The air dryer leaks from the purge valve during a compressor loaded cycle (the leak may cause excessive compressor cycling or prevent the system from building air pressure)

Problem—The air dryer leaks from the purge valve during a compressor loaded cycle. The leak may cause excessive compressor cycling or prevent the system from building air pressure.	
Possible Cause	**Remedy**
The purge valve is frozen open.	Check the heater, and repair or replace it if necessary. Make sure the air line between the unloader port of the air compressor and dryer port 4 is free of water and oil. Remove and inspect the purge valve, and clean any water or oil from the top of the piston.
Debris is under the purge valve seat.	Remove the purge valve and clean it. See **Subject 130** for instructions to remove the purge valve. Remove the desiccant cartridge and clean the dryer sump area. See **Subject 150** for instructions.
The purge valve washer is installed upside down.	Make certain the lip on the washer faces down, away from the air dryer.
The wrong air line is connected to air dryer port 4.	Verify that the dryer port 4 line is connected to the "UNL" port of the air compressor.
The purge valve snap ring is not fully seated in the groove.	Seat the snap ring fully into the groove.

Problem—The regeneration cycle is too long (more than 30 seconds), accompanied by loss of pressure in the supply tank

Problem—The regeneration cycle is too long (more than 30 seconds), accompanied by loss of pressure in the supply tank	
Possible Cause	**Remedy**
The outlet check valve is not seating.	Inspect the outlet check valve. Replace the valve if needed.

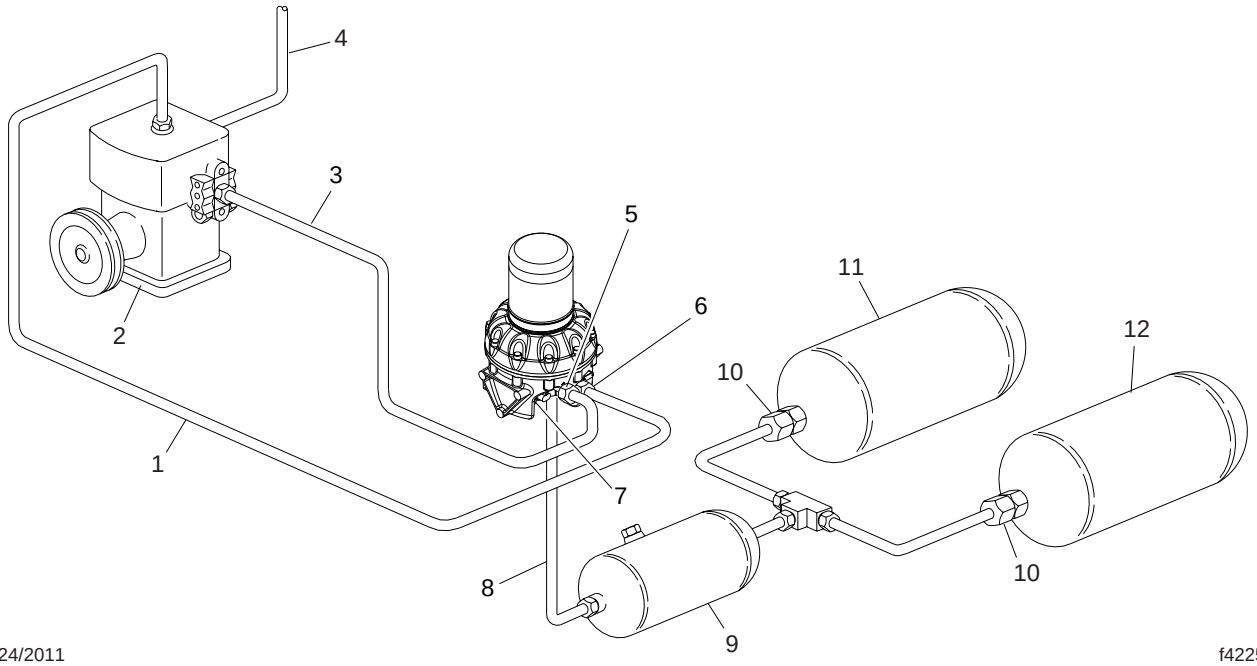
Problem—The regeneration cycle is too short (less than 20 seconds)

Problem—The regeneration cycle is too short (less than 20 seconds)	
Possible Cause	**Remedy**
There are high air system demands during a compressor unloaded cycle.	Increase the air system capacity or reduce air demands.

Troubleshooting

Problem—The regeneration cycle is too short (less than 20 seconds)	
Possible Cause	**Remedy**
The air governor is not working correctly.	Inspect the air governor and repair or replace it according to the manufacturer's instructions.

See **Fig. 1** for the plumbing diagram.



1. Compressor Discharge Line
2. Compressor
3. Signal Line
4. Compressor Intake Line (naturally aspirated or turbocharged)
5. Air Dryer Control Port
6. Air Dryer Inlet
7. Exhaust Port (Purge Valve Assembly)
8. Delivery Line (from the delivery/outlet port)
9. Supply Tank
10. Check Valve
11. System Reservoir
12. System Reservoir

Fig. 1, Air Dryer Plumbing Diagram

General Information

The ZF steering driveline is a ball-splined telescopic shaft that consists of a tube with internal splines and a special-pattern shaft with external splines. At the slip-end of the tube is a ball bearing cartridge with two rows of ball bearings that run in the splines and form a positive rotating link. This design ensures freedom from radial play but low-resistance axial displacement with an effective stroke of ±1.10 inches (±28 mm). The ball-splined telescopic shaft has a low rate of wear and needs no maintenance.

Steering I-Shaft Removal and Installation

Removal

WARNING

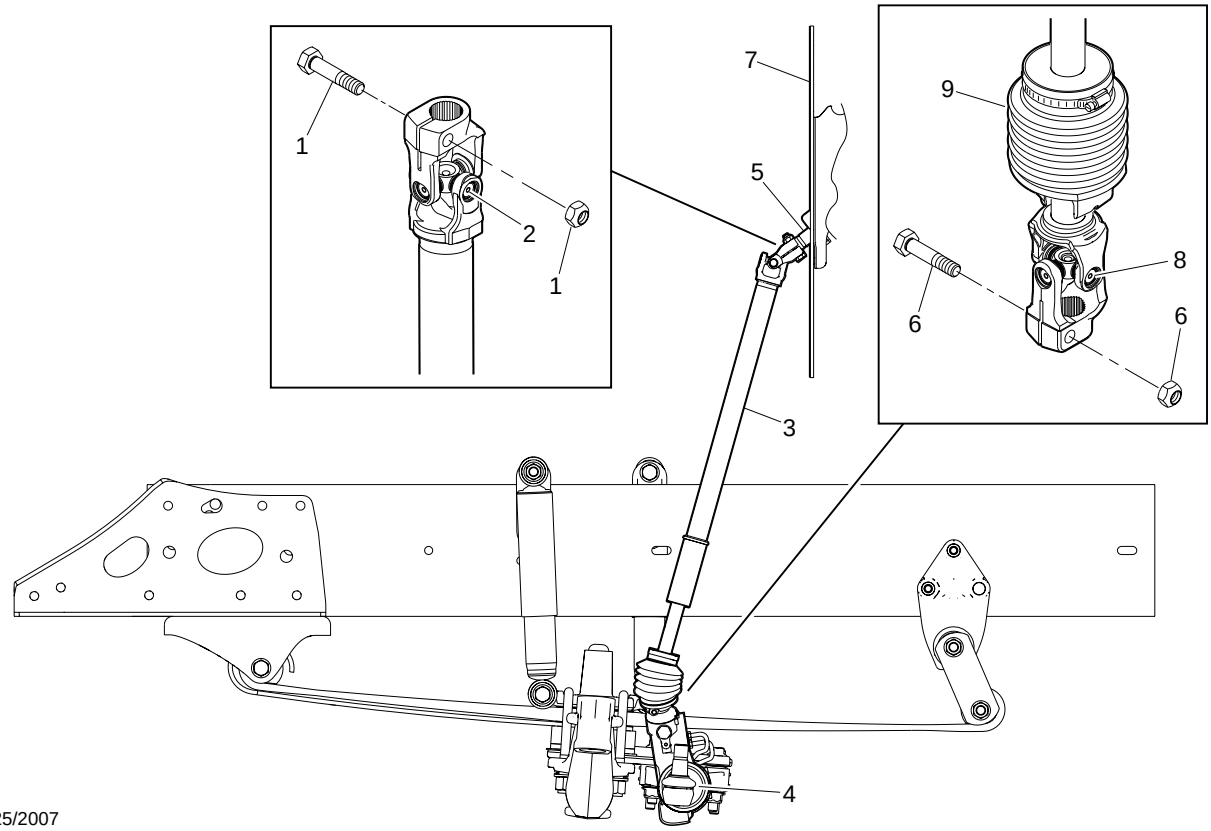
All steering mechanisms are essential to the safe operation of the vehicle. Follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause personal injury or property damage.

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 and discard the pinch bolt and nut from the lower end of the steering I-shaft. See **Fig. 1** and **Fig. 2**.
4. Remove and discard the pinch bolt and nut from the upper end of the steering I-shaft.
5. Remove the steering I-shaft.

Installation

1. Using a new M10 x 1.25 pinch bolt and nut, attach the steering I-shaft to the steering gear input shaft. Tighten the bolt 30 to 35 lbf·ft (41 to 47 N·m).
2. Using a new M10 x 1.25 pinch bolt and nut, attach the steering I-shaft to the steering column shaft end. Tighten the bolt 30 to 35 lbf·ft (41 to 47 N·m).
3. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and nuts.

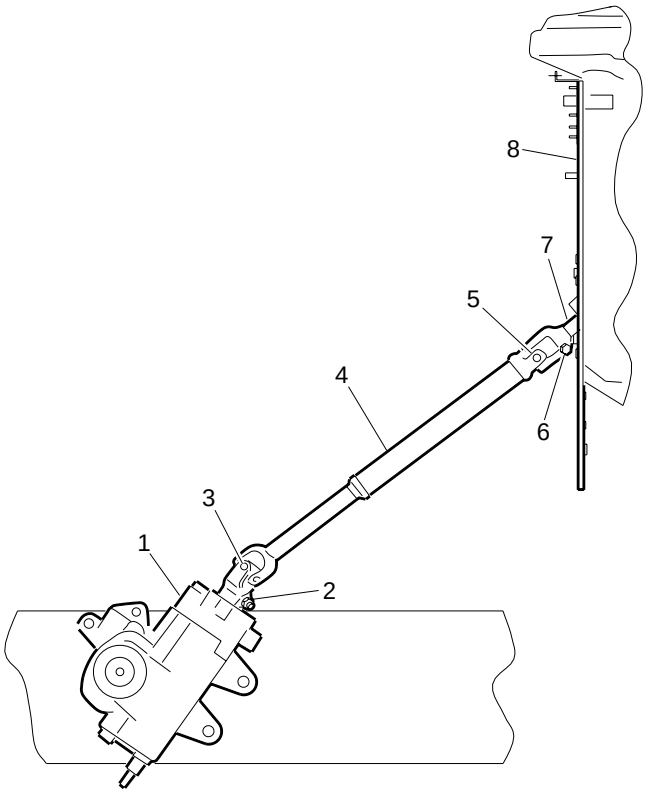
Steering I-Shaft Removal and Installation



1. Upper Pinch Bolt and Nut
2. Upper End Yoke
3. Steering I-Shaft
4. Rack and Pinion Steering Gear
5. Steering Column Shaft End
6. Lower Pinch Bolt and Nut
7. Frontwall
8. Lower End Yoke
9. Lower Yoke Boot

Fig. 1, I-Shaft, Rack and Pinion Steering Gear

Steering I-Shaft Removal and Installation



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1. Integral Steering Gear
2. Lower Pinch Bolt and Nut
3. Lower End Yoke
4. Steering I-Shaft
5. Upper End Yoke
6. Upper Pinch Bolt and Nut
7. Steering Column Shaft End
8. Frontwall

Fig. 2, I-Shaft, Integral Steering Gear

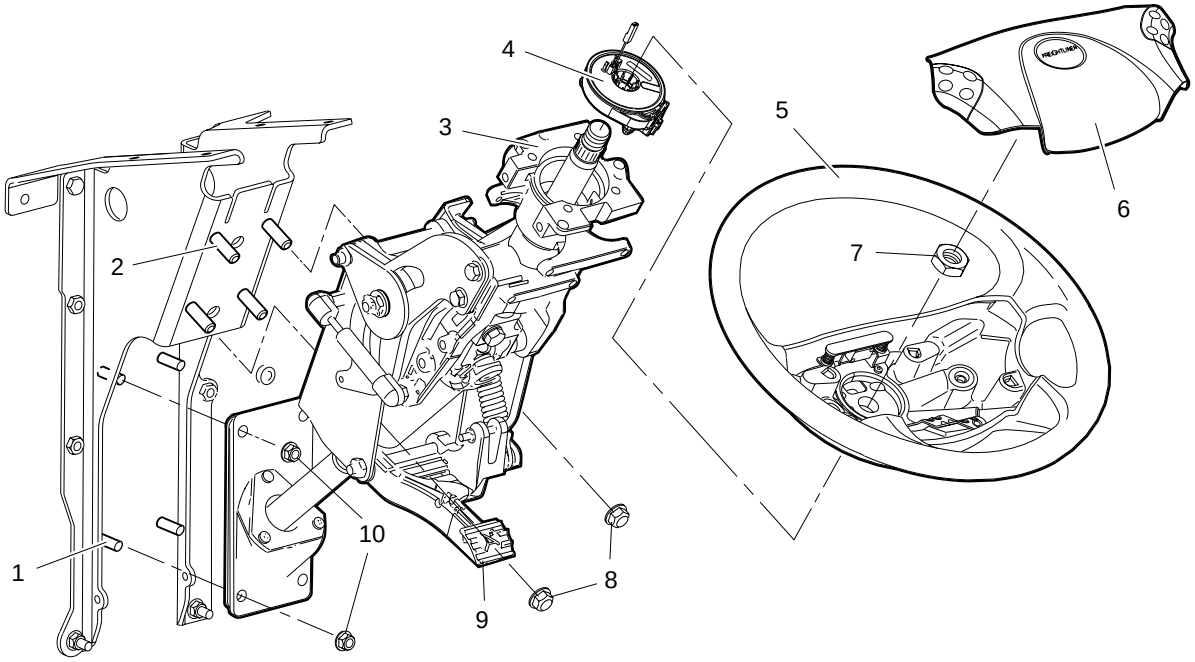
General Information

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**.

The removable steering wheel cover houses switch clusters and the horn button.

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.



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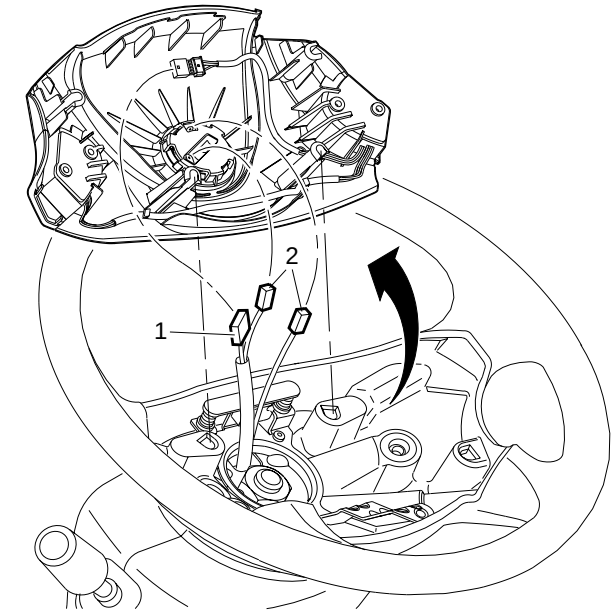
1. Frontwall Bearing Studs
2. Column Mounting Bracket Studs
3. Steering Column
4. Clockspring
5. Steering Wheel
6. Steering Wheel Cover Module
7. Steering Wheel Nut
8. M10 Nut
9. Column Position Adjustment Pedal
10. M8 Nut

Fig. 1, Steering Column Assembly, No Airbag

Steering Wheel with No Airbag

Removal

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Remove the steering wheel cover module by prying its corners away from the steering wheel and pulling the module out.
3. Disconnect the horn and steering wheel switch connectors. See **Fig. 1**.



1. Steering Wheel Switch Connector
2. Horn Button Connectors

Fig. 1, Steering Wheel Cover Module and Connectors, No Airbag

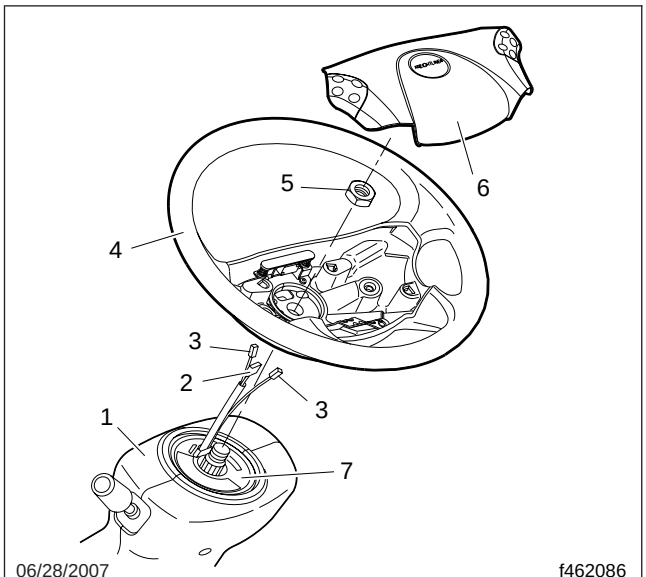
IMPORTANT: The steering wheel does not have threaded wheel-puller holes. The tapered fit between the steering wheel and the column is designed to be removed by hand.

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 that the steering gear is centered.

1. Thread the switch and horn wires through the hole above the center of the steering wheel, and set the steering wheel on the steering column; see **Fig. 2**.

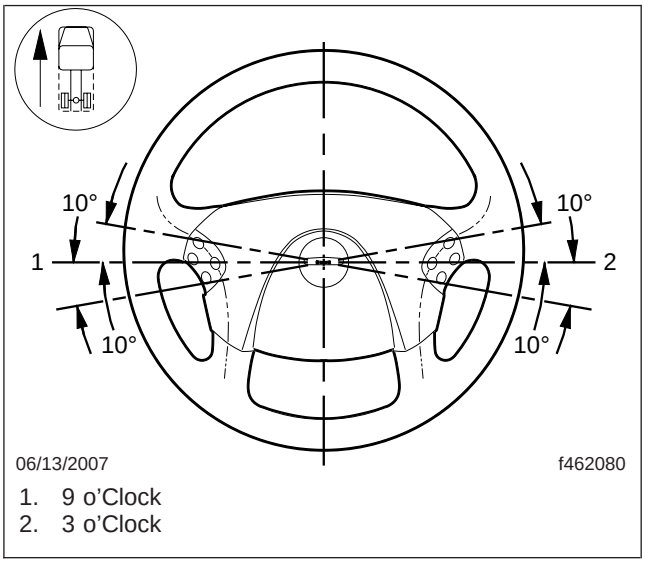


1. Steering Column
2. Steering Wheel Switch Connector
3. Horn Button Connectors
4. Steering Wheel
5. Steering Wheel Nut
6. Steering Wheel Cover Module
7. Clockspring

Fig. 2, Steering Wheel Cover Module and Connectors, No Airbag

2. Make sure that the steering wheel is within ±10 degrees of center as shown in **Fig. 3**.
3. Install a new steering wheel nut and tighten 33 to 41 lbf·ft (45 to 55 N·m).

Steering Wheel Removal and Installation



1. 9 o'Clock
2. 3 o'Clock

Fig. 3, Steering Wheel Position

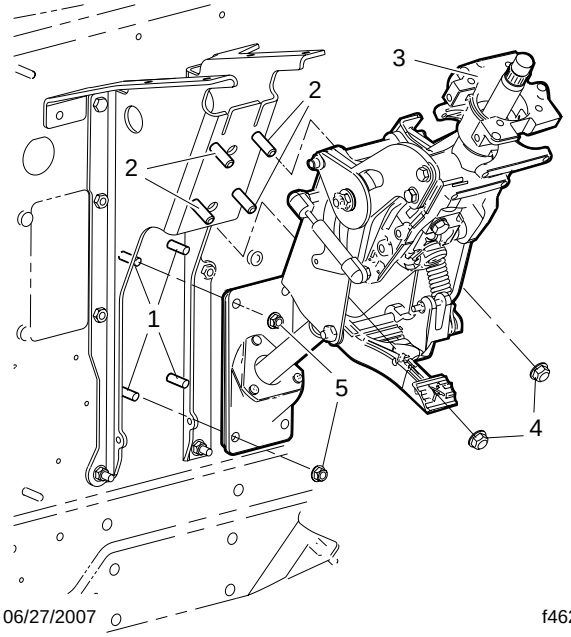
4. Connect the steering wheel switch and horn connectors to the steering wheel cover module.
5. Install the steering wheel cover module into the steering wheel.

Removal

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires. Open the hood.
2. Remove the steering wheel; see **Subject 100**.
3. Remove the fasteners that hold the dash knee bolster to the dash, then remove the bolster.
4. Remove the four column cover fasteners on the back and the two on the front of the column, and remove the covers.
5. Remove the turn signal wiring harness bracket from the column.
6. Disconnect the turn signal harness from the stalk switch by depressing the plastic retaining tabs on the connector body while detaching the harness.
7. Disconnect the SmartShift lever, and trailer brake assembly, if equipped.
8. 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.
9. Support the column, and remove the nuts that hold the column to the frontwall. See **Fig. 1**.
10. Remove the nuts that hold the column to the column mounting bracket, and remove the column. See **Fig. 2**.

Installation

1. Position the new 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 24 to 30 lbf·ft (32 to 40 N·m), and the frontwall bearing nuts 7 to 10 lbf·ft (9 to 13 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.



1. Frontwall Bearing Studs
2. Steering Column Mounting Bracket Studs
3. Steering Column
4. M10 Nut
5. M8 Nut

Fig. 1, Steering Column Installation

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.
7. Install the steering wheel. See **Subject 100**.

Steering Column Removal and Installation

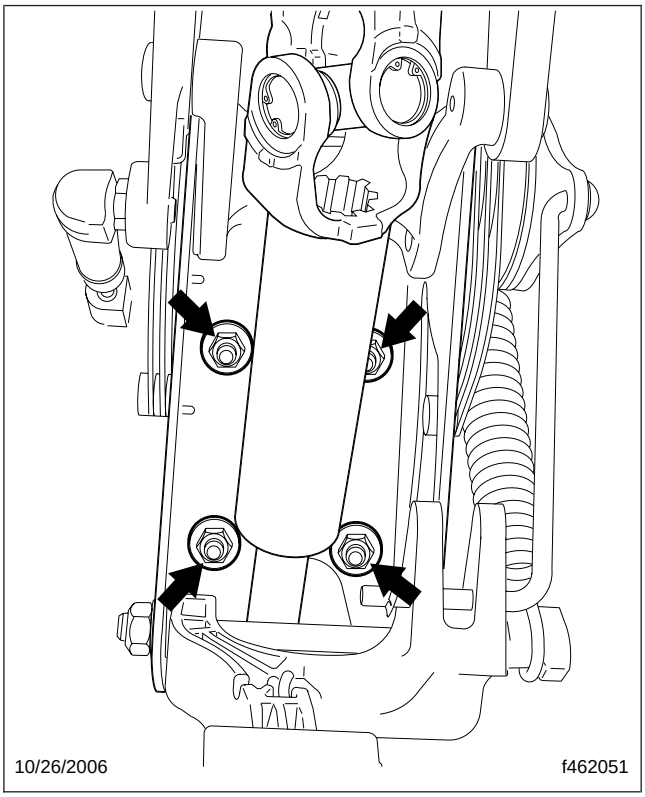
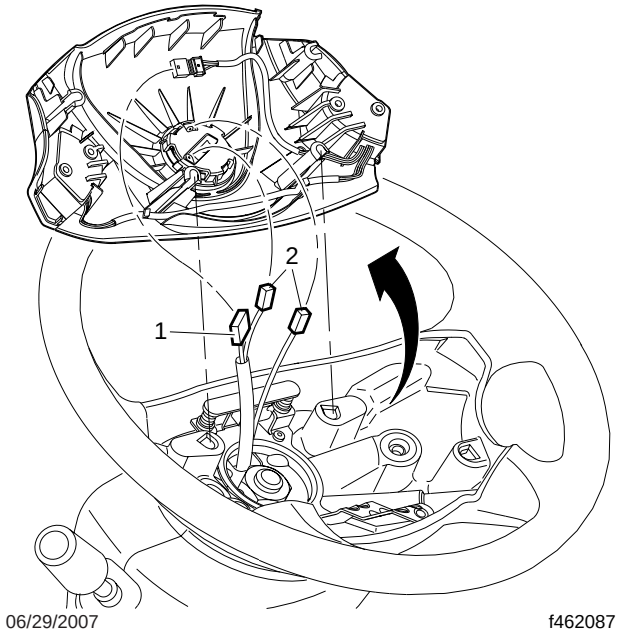


Fig. 2, Location of Column Mounting Bracket Fasteners

Replacement, No Airbag

1. Shut down the engine, set the parking brake, and chock the tires.
2. Remove the steering wheel cover module by prying its corners away from the steering wheel and pulling the module out.
3. Disconnect the horn and steering wheel switch connectors. See **Fig. 1**.



1. Steering Wheel Switch Connector
2. Horn Button Connectors

Fig. 1, Steering Wheel Cover Module and Connectors, No Airbag

4. Connect the steering wheel switch and horn connectors to the new steering wheel cover module.
5. Install the steering wheel cover module into the steering wheel.

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.

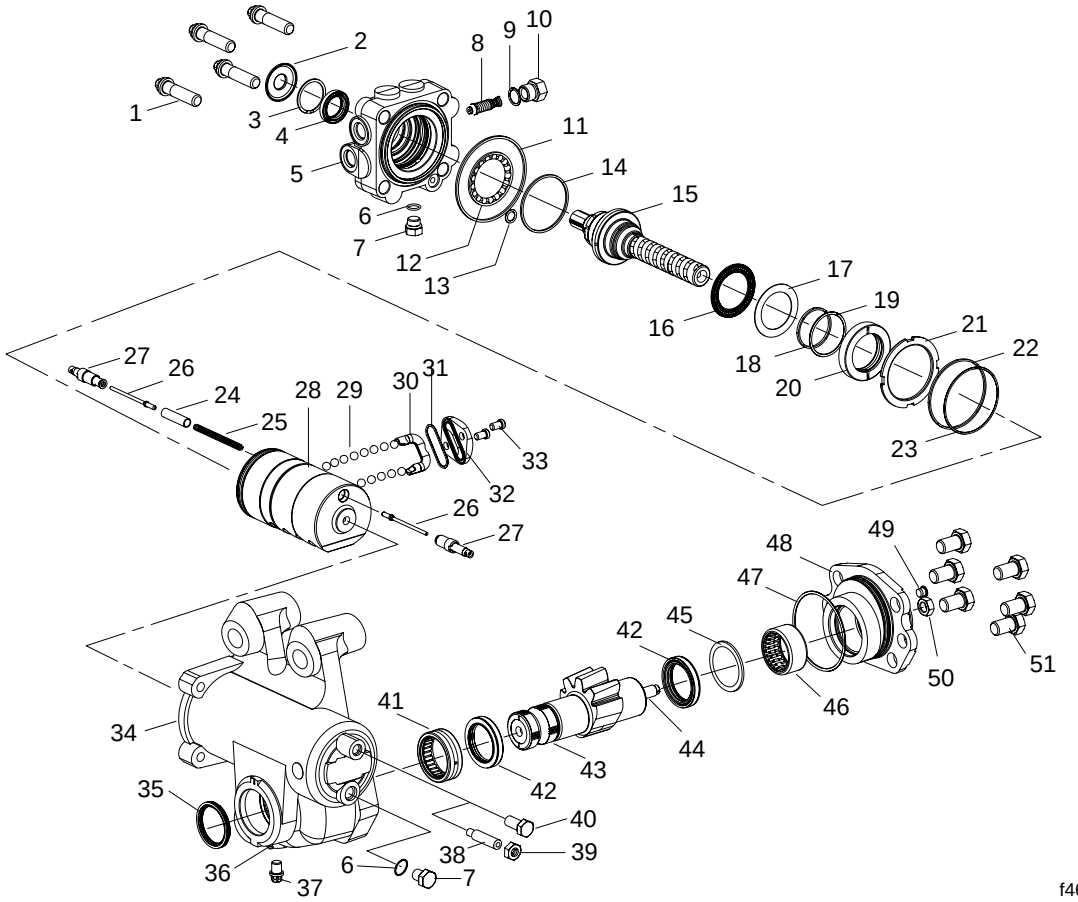
The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). 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



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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

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.

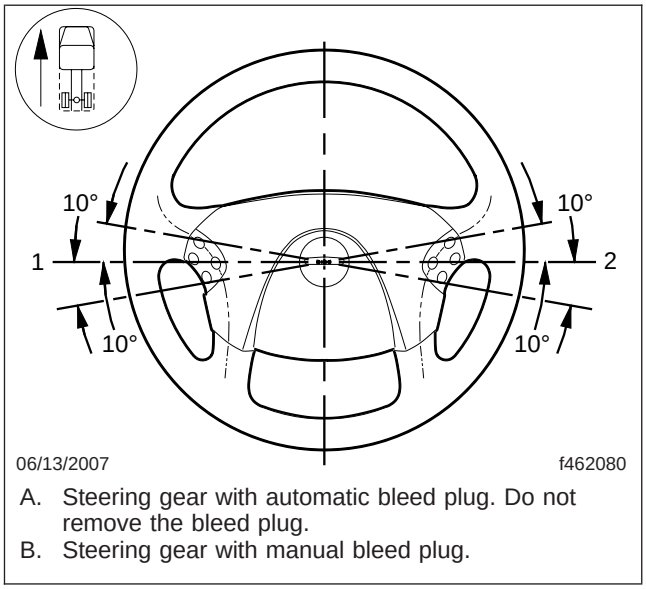
   Automatic bleed systems should now be free of trapped air.

   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).



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

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.

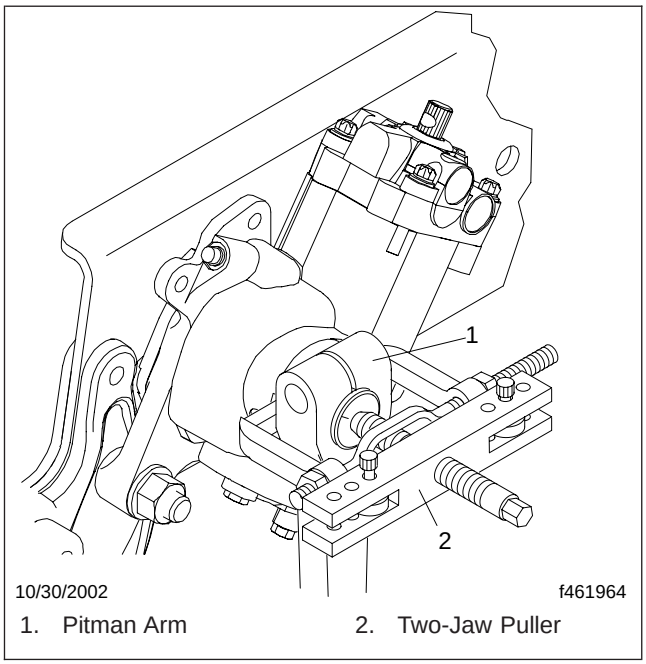


Fig. 1, Pitman Arm Removal

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.

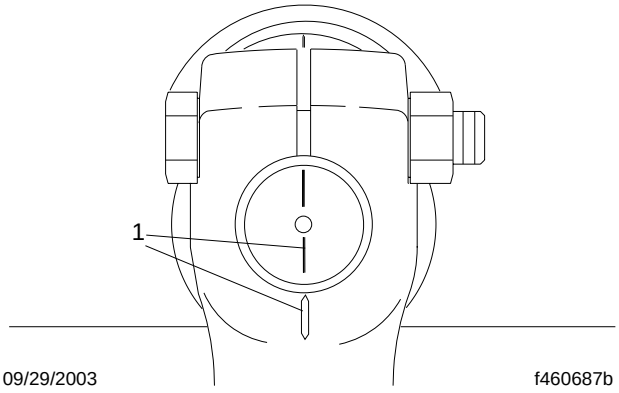
⚠ WARNING

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.

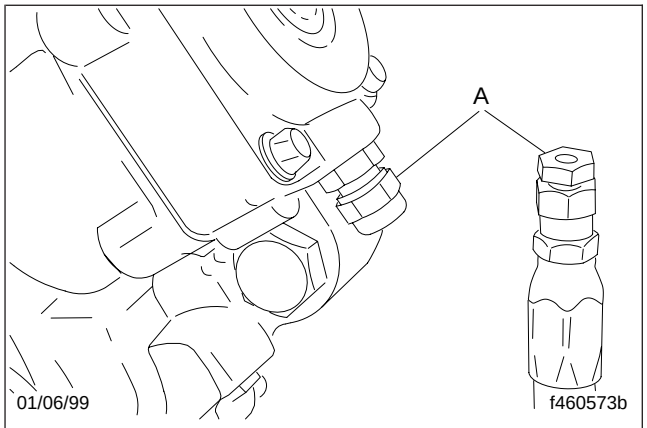
8. Fill and bleed the steering system. For instructions, refer to **Subject 110**.

9. Close the hood and perform the post-service checks in **Subject 150**.

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.



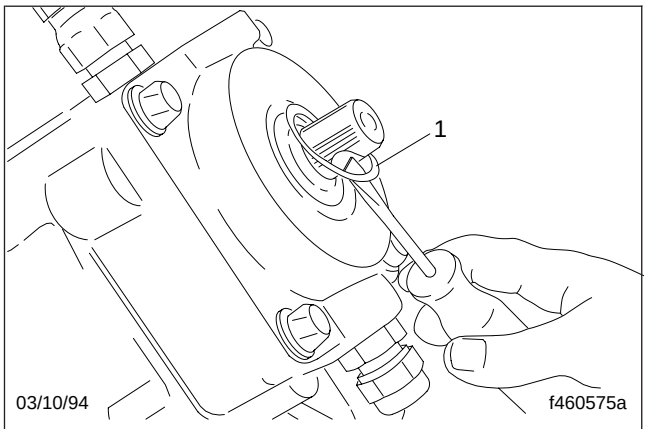
A. Cap the return line and the return port.

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.

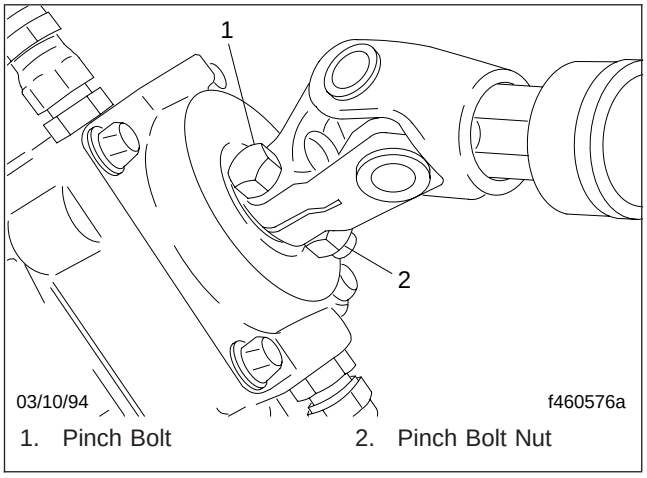
3. Disconnect the steering driveline from the steering gear input shaft.
4. Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove all grease from around the input shaft.
6. Using a screwdriver inserted into 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

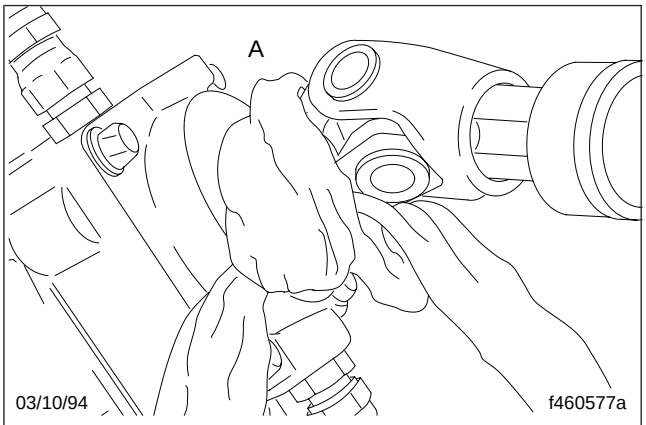
Fig. 3, Pinch Bolt Installation

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

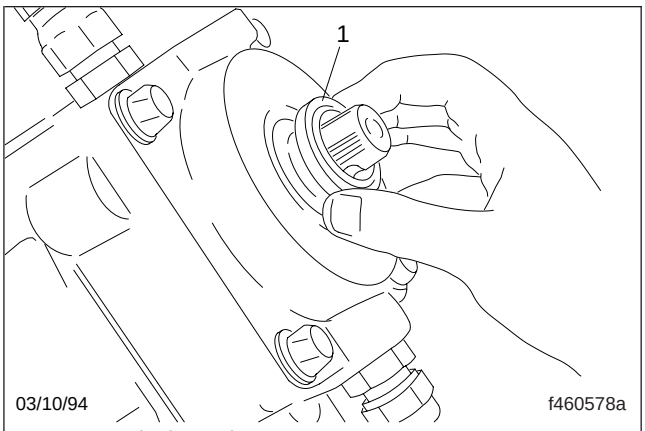


A. Cover the input shaft area.

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

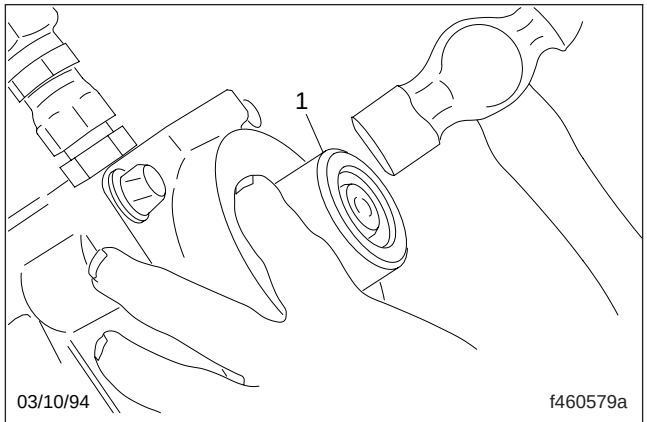
Fig. 5, Input Shaft Seal Removal

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.



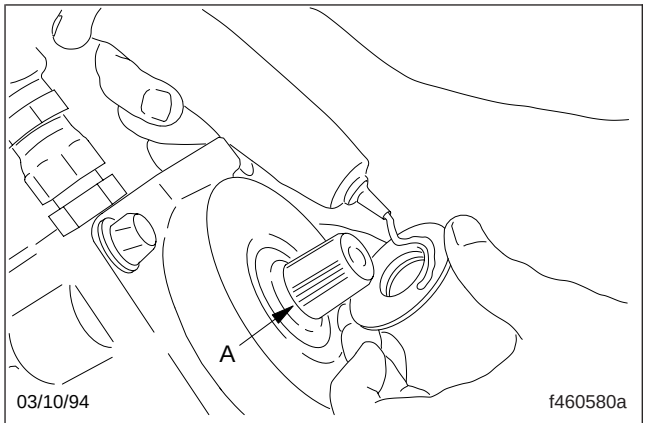
1. Seal Installer Tool

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**.

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:

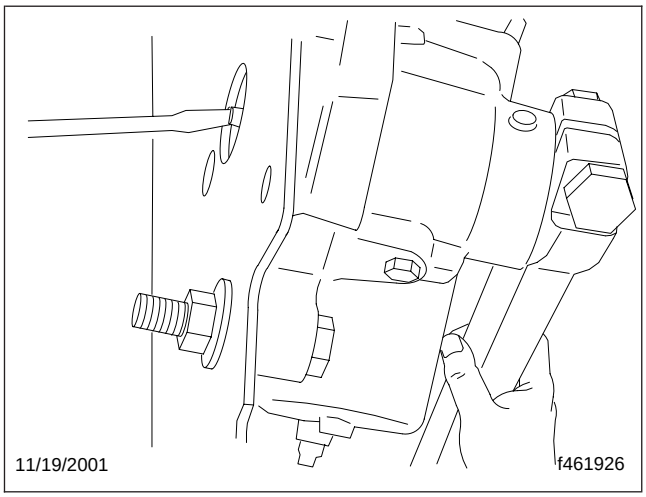


Fig. 1, Adjusting the Sector Shaft

- 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.

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**.

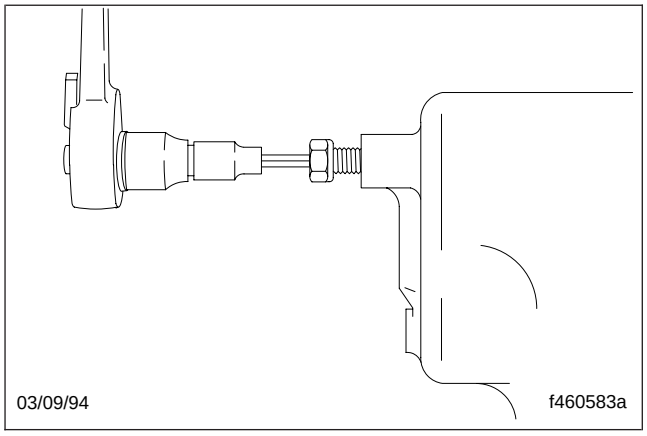


Fig. 1, Adjusting Screw and Nut Assembly

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

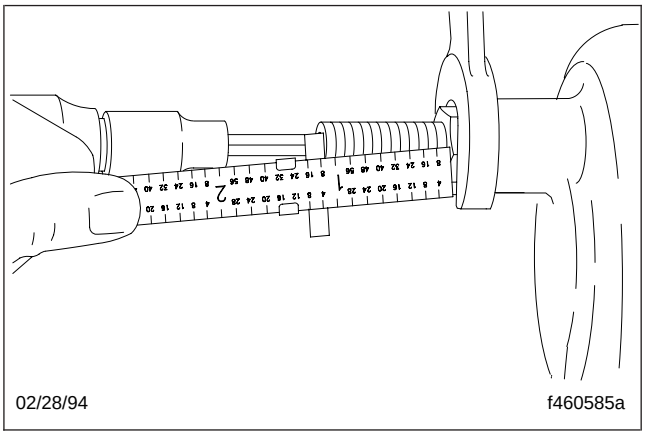


Fig. 2, Adjusting Screw Position

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**.

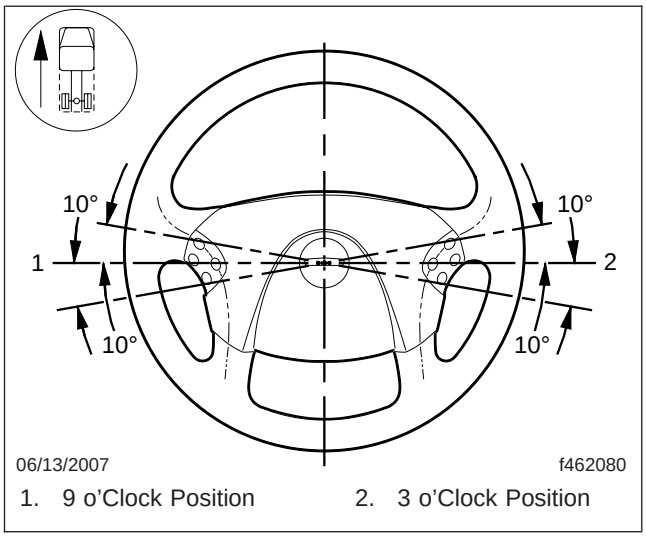


Fig. 1, Steering Wheel Centered

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

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.

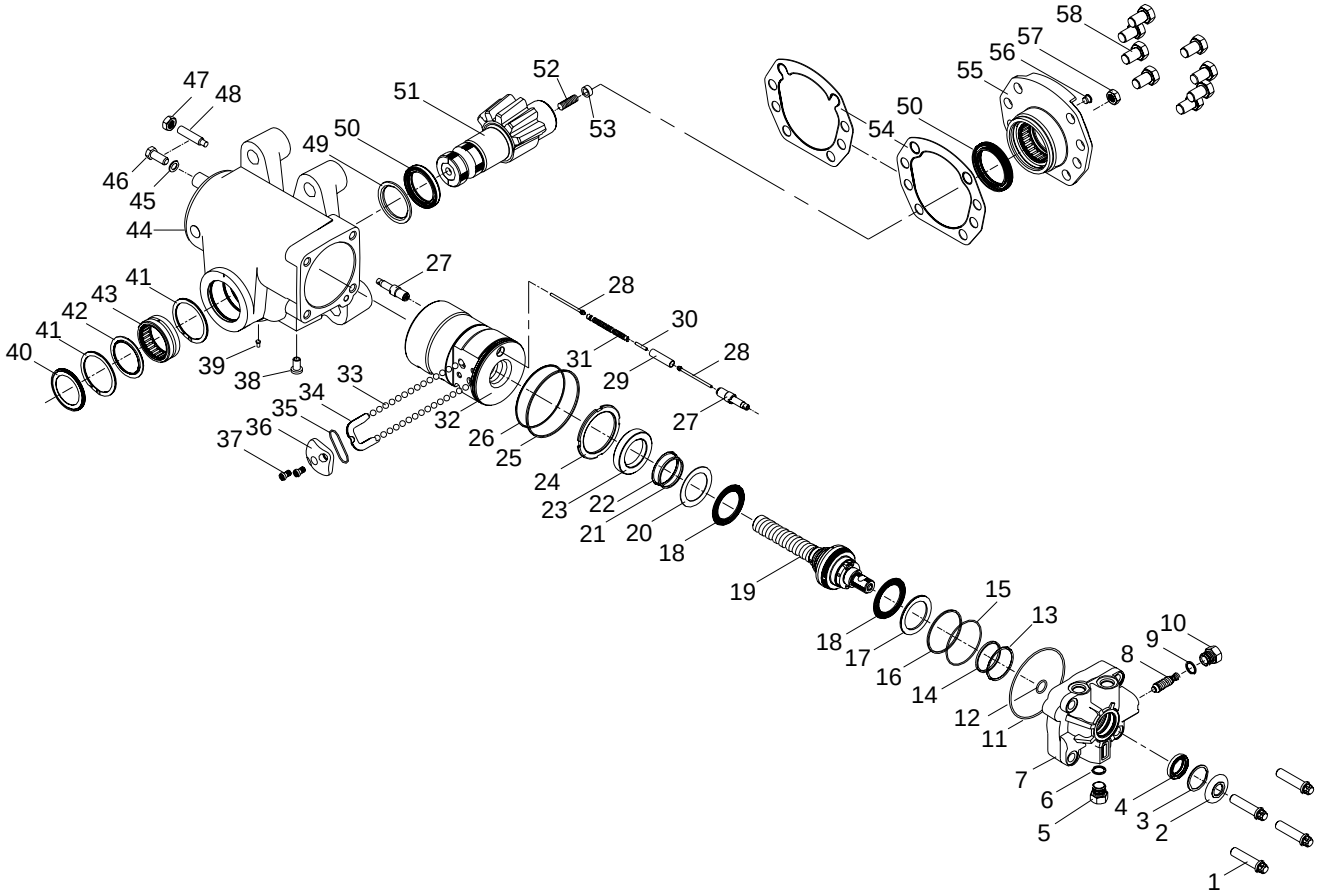
The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). 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



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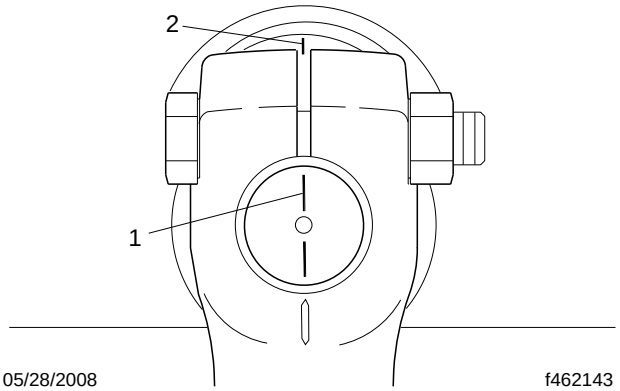
1. Bolts, Valve Housing
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Auxiliary Port Plug
6. O-Ring, Auxiliary Port Plug
7. Valve Housing
8. Relief Valve
9. O-Ring, Relief Valve
10. Relief Valve Cap
11. Seal Ring, Large
12. Seal Ring, Small
13. Seal Ring
14. O-Ring
15. Seal Ring
16. 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

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. 1**. Shut down the engine.



1. Housing Timing Mark
2. Sector Shaft Alignment Mark

Fig. 1, 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.

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. 2**. 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

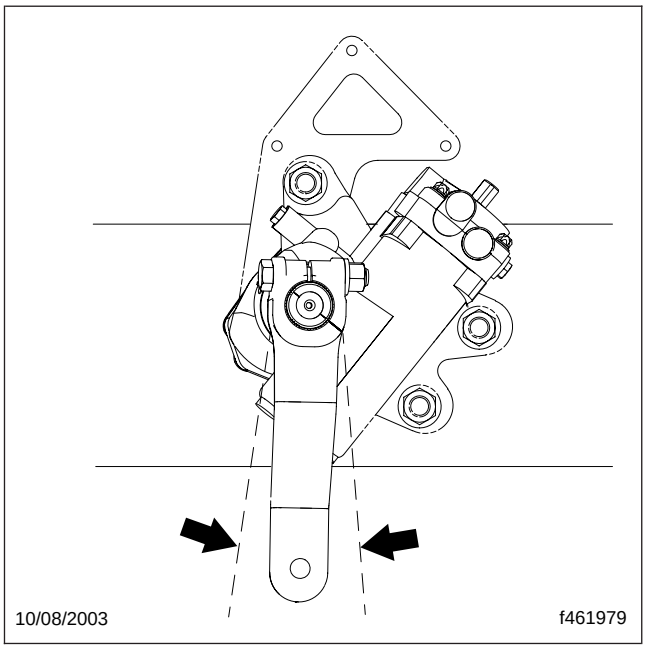


Fig. 2, Lash Check

counterclockwise until you feel lash at the sector shaft. See **Fig. 3**.

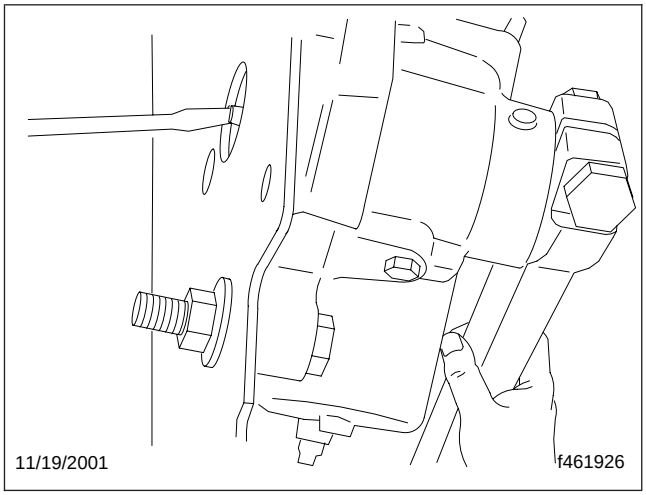


Fig. 3, Adjusting the Sector Shaft

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).

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. 4**.

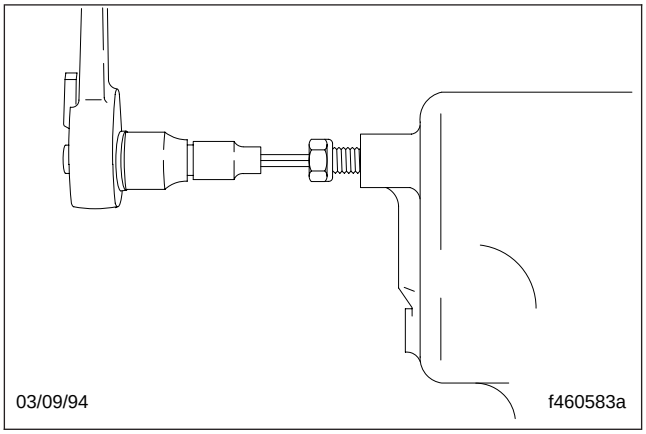


Fig. 4, Adjusting Screw and Nut Assembly

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.

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.
   - 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. 5**. Tighten the nut against the housing.
12. Set the lower poppet.
   - 12.1 Start the engine and let it idle.

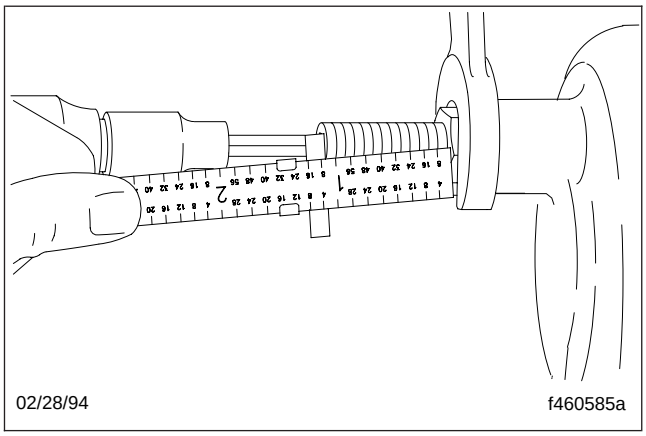


Fig. 5, Adjusting Screw Position

   - 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.

Steering Gear Adjustments

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.

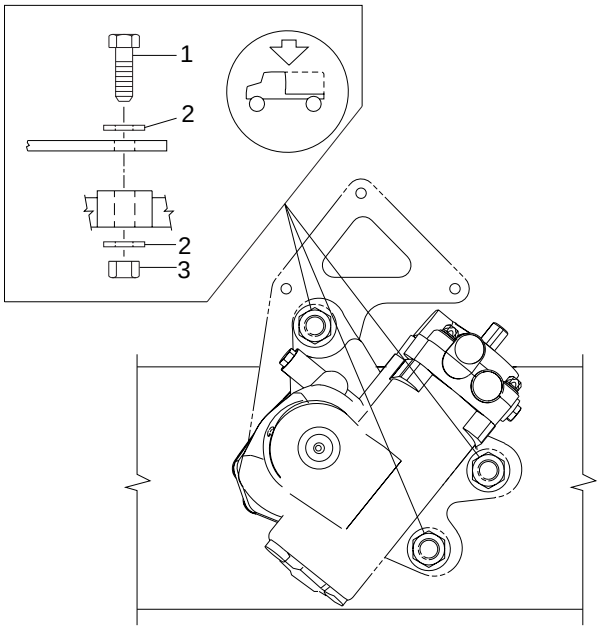
WARNING

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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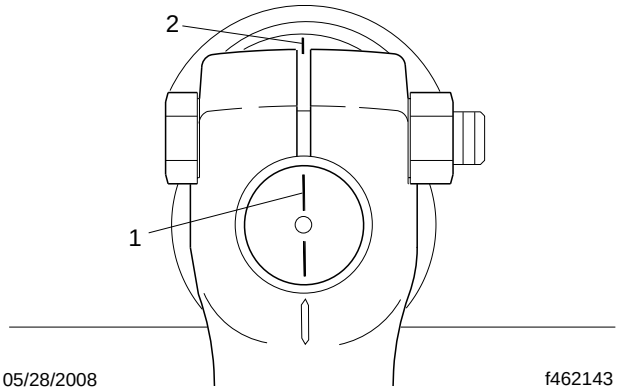
1. Bolt
2. Washer
3. Nut

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

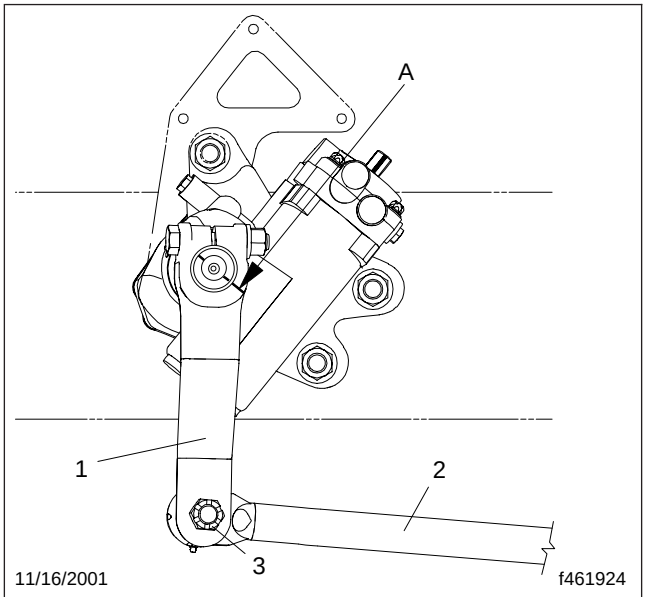
Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

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.

⚠ 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.

8.1 Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.

8.2 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.

8.3 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.

8.4 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.

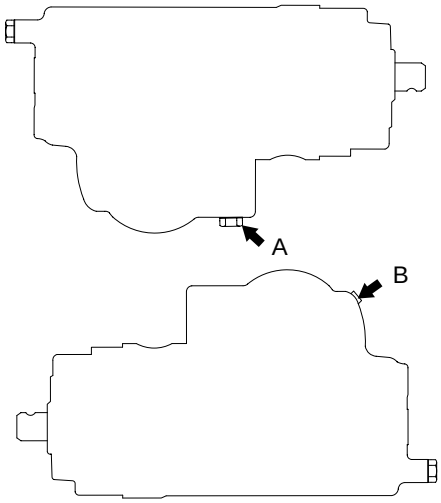
If the vehicle has a manual bleed system (**Fig. 4**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

8.5 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.

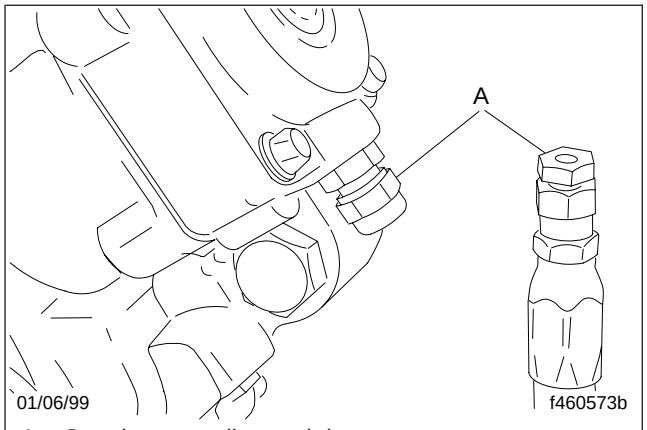
Fig. 4, Steering Gear Bleed Systems

9. Close the hood and perform the post-service checks in **Subject 130**.

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.

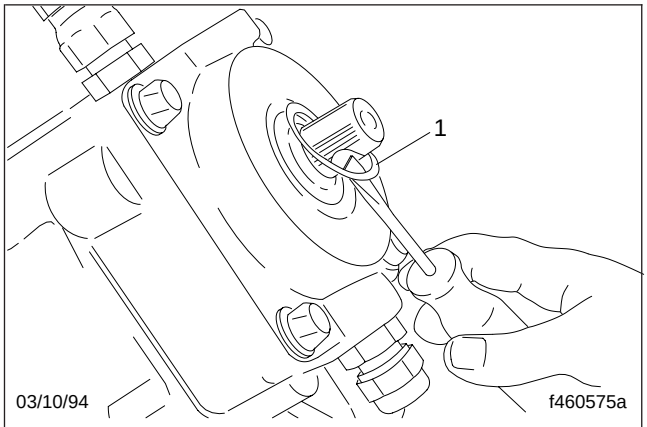
3. Disconnect the steering driveline from the steering gear input shaft.

   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.

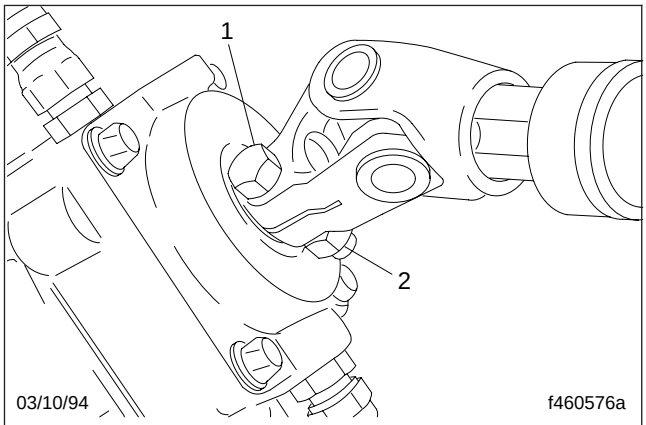
4. Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove all grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, remove the retaining ring. 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**.

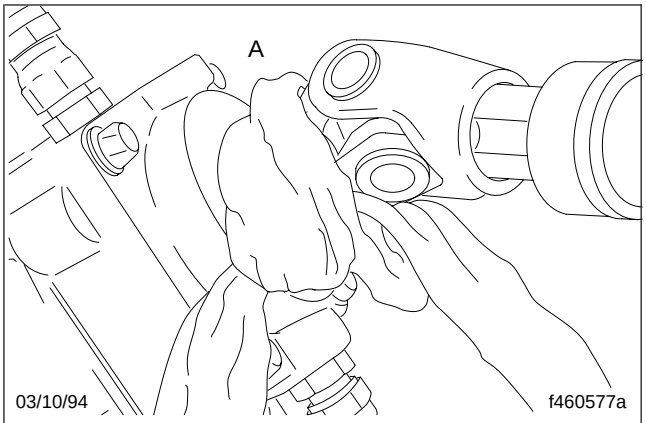


1. Pinch Bolt 2. Pinch Bolt Nut

Fig. 3, Pinch Bolt Installation

Input Shaft Seal Replacement

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**.



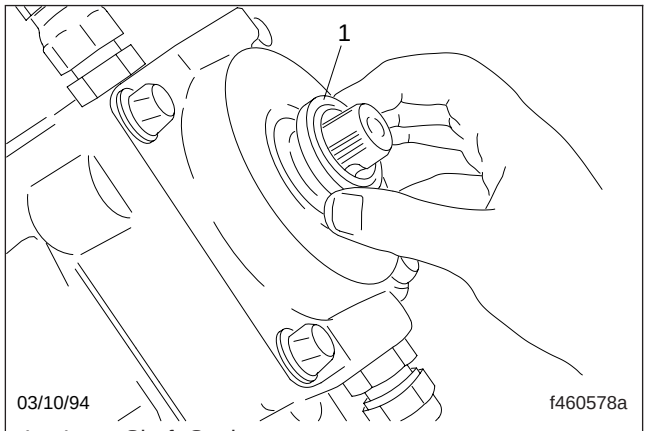
A. Cover the input shaft area.

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.



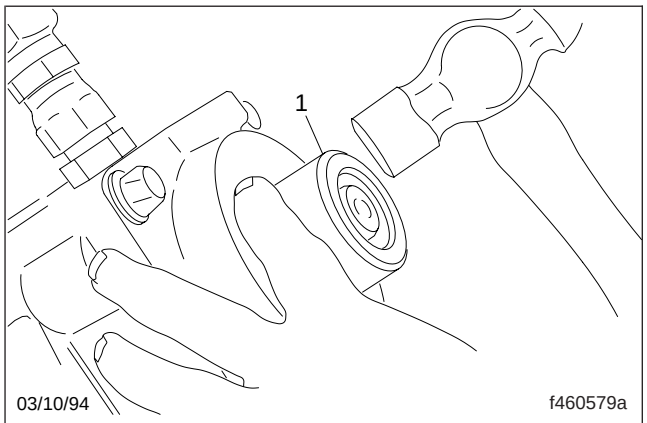
1. Input Shaft Seal

Fig. 5, Input Shaft Seal Removal

WARNING

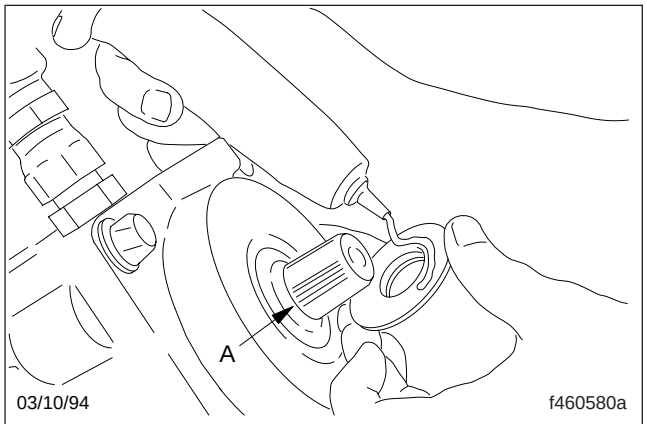
Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.

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 bleed the steering 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.

    20.1 Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.

    20.2 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.

    20.3 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.

    20.4 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 from trapped air.

    If the vehicle has a manual bleed system (**Fig. 8**), proceed to the next step.

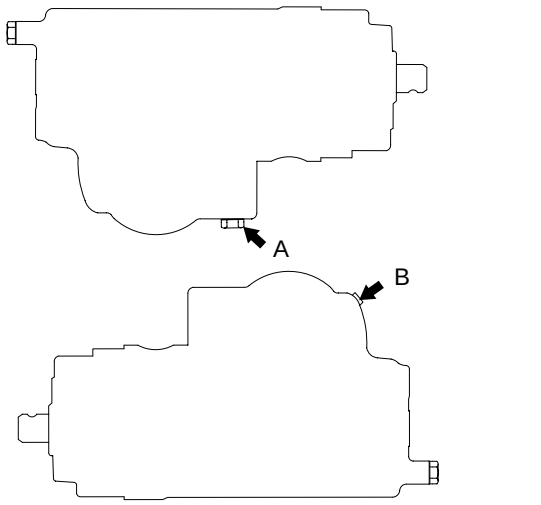
IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

Input Shaft Seal Replacement

20.5 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. 8, Steering Gear Bleed Systems

21. Perform the post-service checks in **Subject 130**.

Post-Service Checks

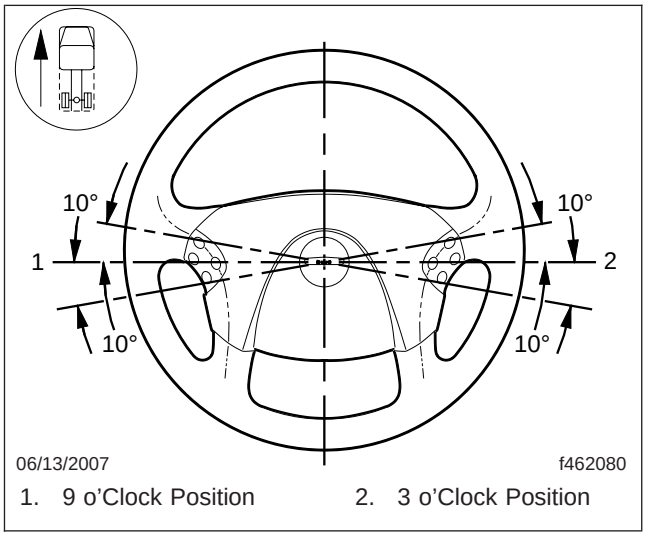
After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

⚠ 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 46.08**. 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

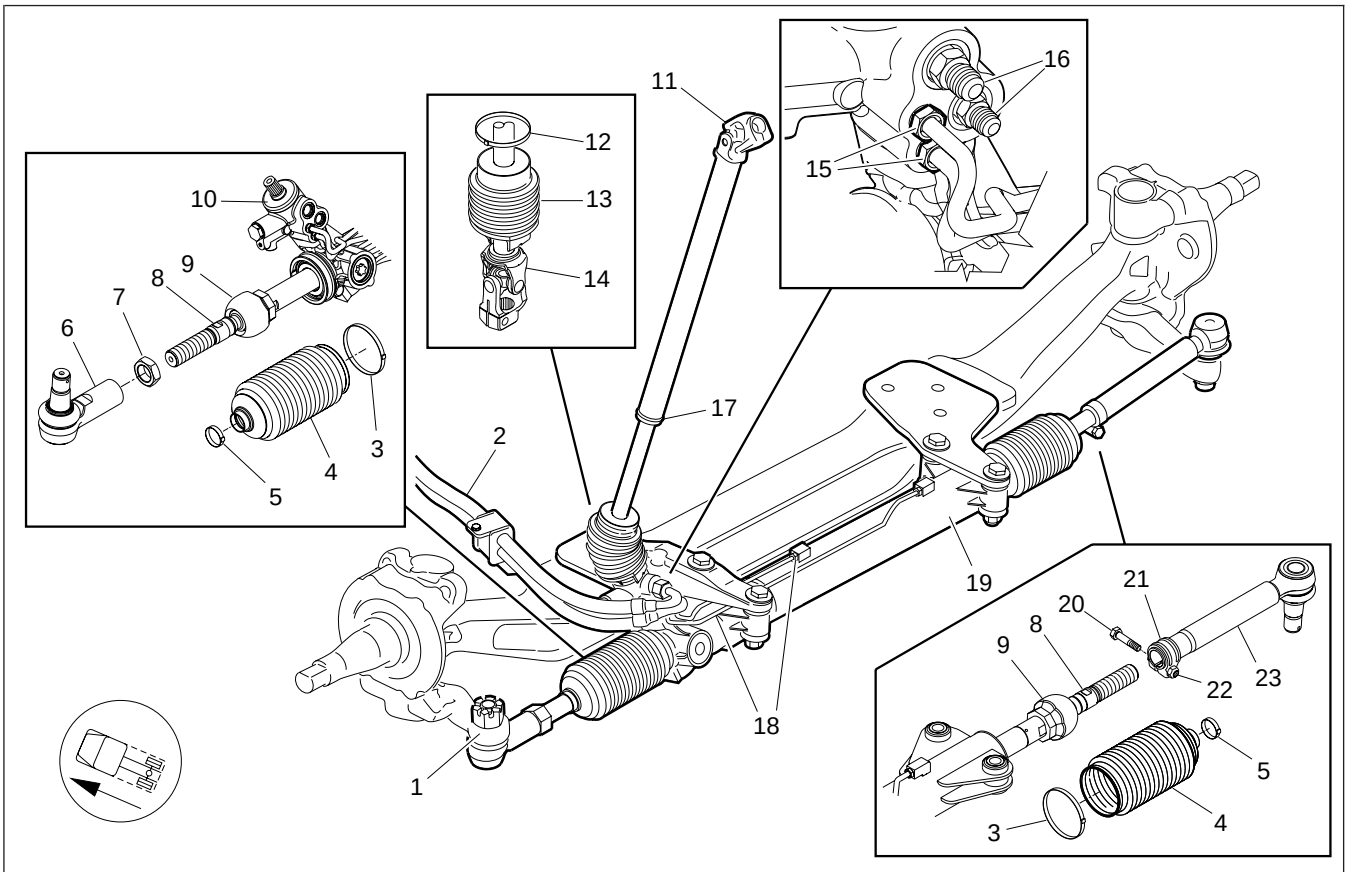
SPX Kent-Moore Tools	
Tool	**Part Number**
Bearing Adjuster Tool	J37070
Poppet Adjuster Seat Tool	J36452
Seal Installer Tool	J37073

Table 1, SPX Kent-Moore Tools

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



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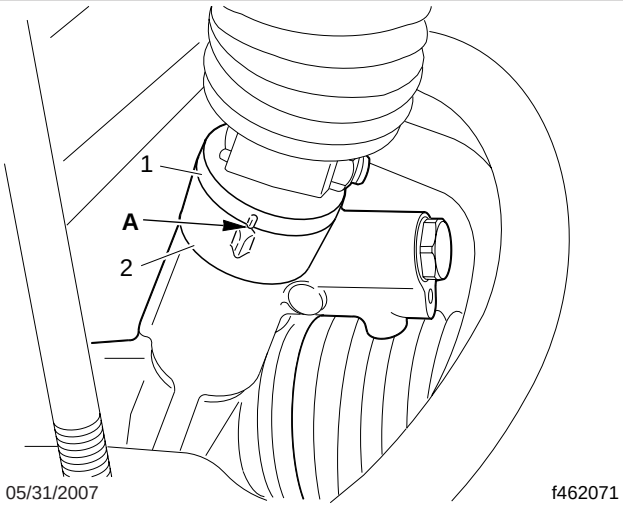
1. Steering Tie Rod Arm
2. Power Steering Fluid Lines
3. Large Bellows Clamp
4. Bellows
5. Small Bellows Clamp
6. Driver-Side Outer Tie Rod
7. Tie Rod Jam Nut
8. Inner Tie Rod Flat
9. Inner Tie Rod Ball Joint
10. Input Shaft Seal Cover
11. I-Shaft Upper Yoke
12. I-Shaft Lower Yoke Boot Clamp
13. I-Shaft 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.

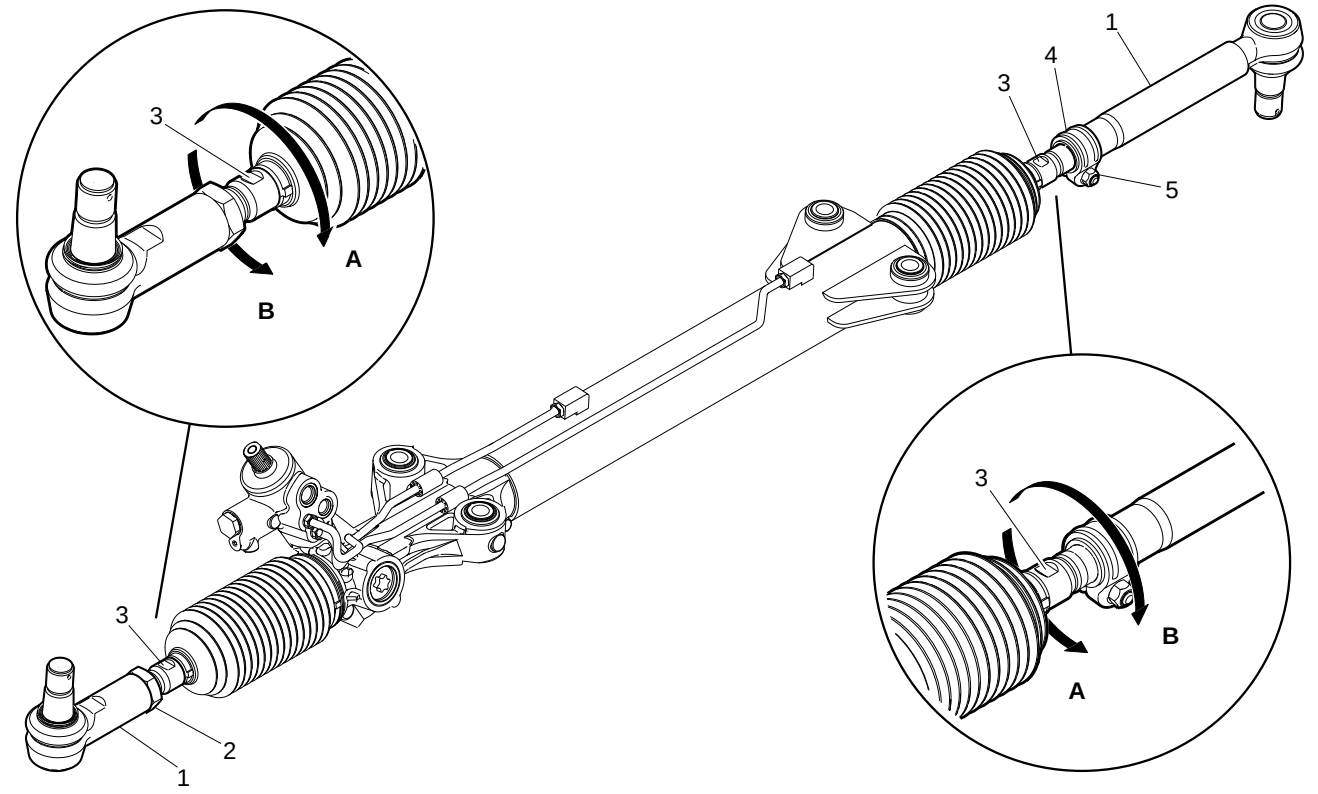
5. Turn the wheels as far right and left as possible to check for interference between the wheels/tires and other components. There must be at least 1/2 inch (13 mm) clearance from any fixed object, and 3/4 inch (19 mm) from any moving object.

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



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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.

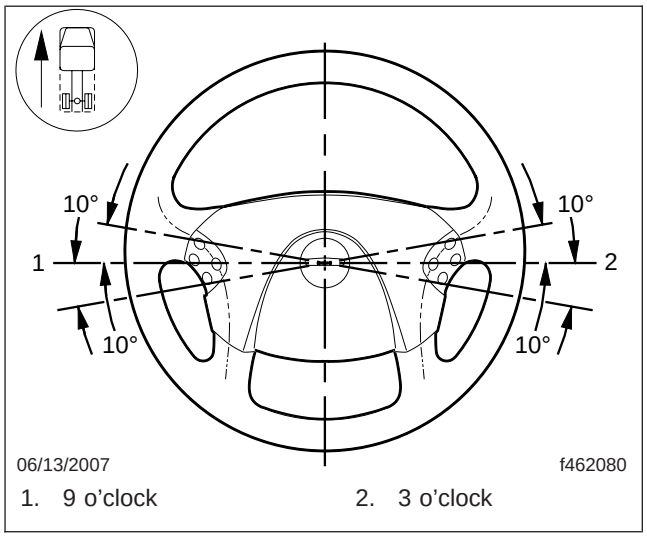


Fig. 3, Steering Wheel Centered

Rack and Pinion Removal and Installation

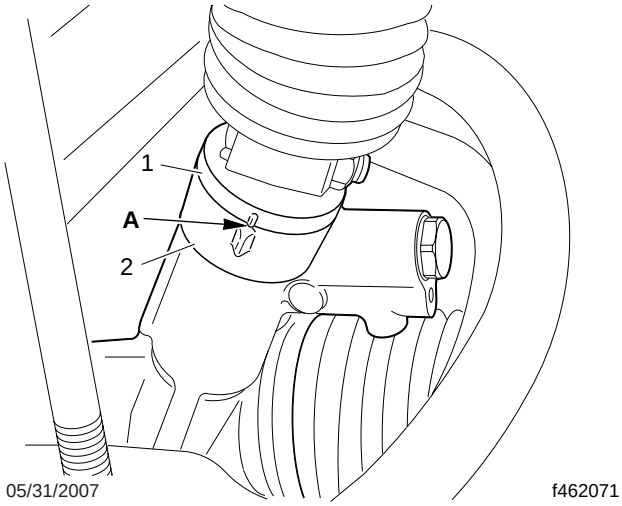
Removal

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

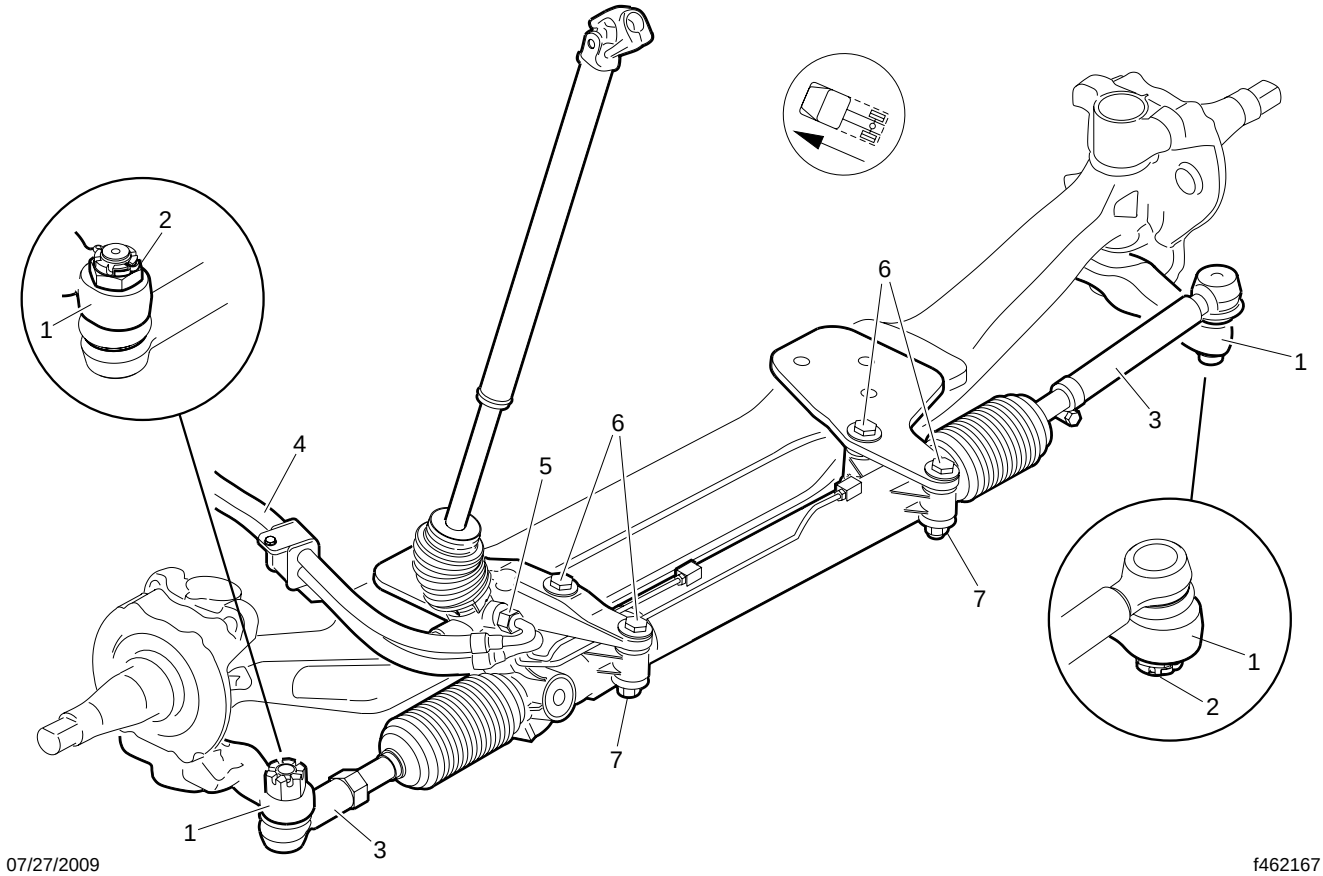
5. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and nut.
6. If needed, install power steering fluid line fittings (**Fig. 2**, Item 5) on the steering gear and tighten 30 to 35 lbf·ft (41 to 47 N·m).
7. Connect the power steering fluid lines to the fittings, ensuring that the hoses 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.

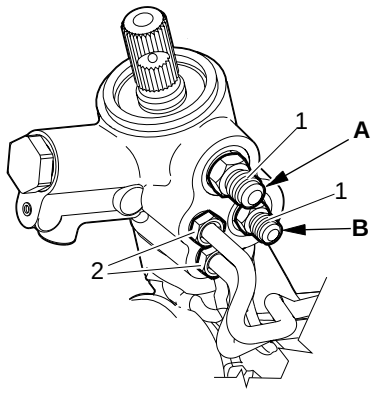
8.5 If the steering system needs additional bleeding, repeat the previous substep after the fluid in the reservoir has had time to release any air.

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.



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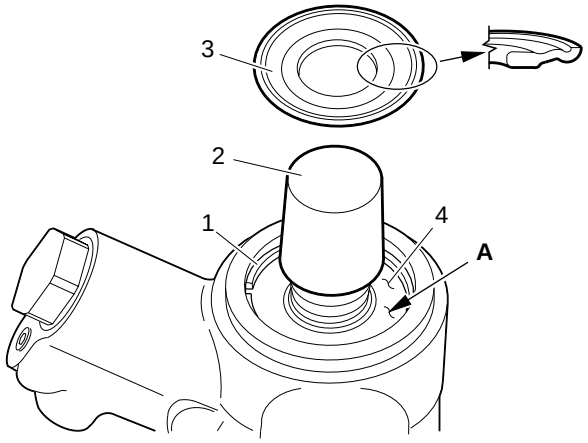
A. Apply air to the outlet port to remove the input shaft seal.
B. Seal the inlet port while applying air.

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**.



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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.

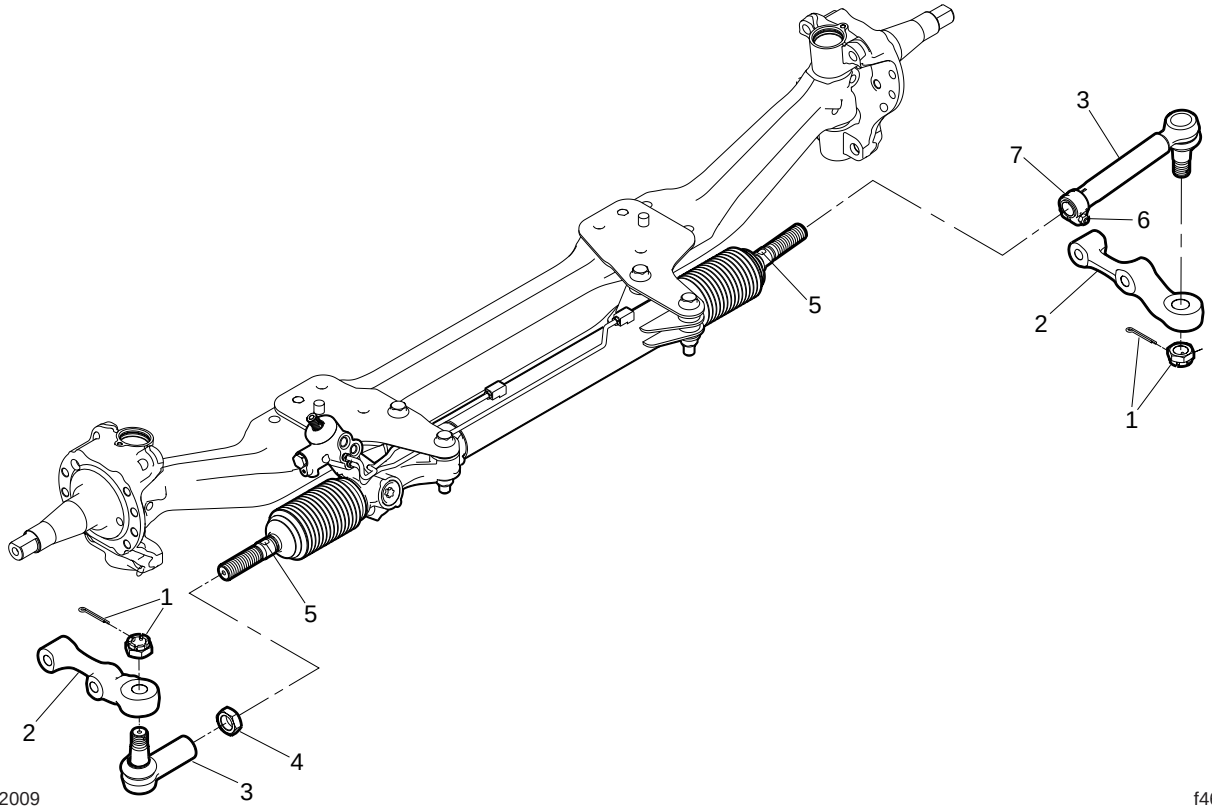
Replacement

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

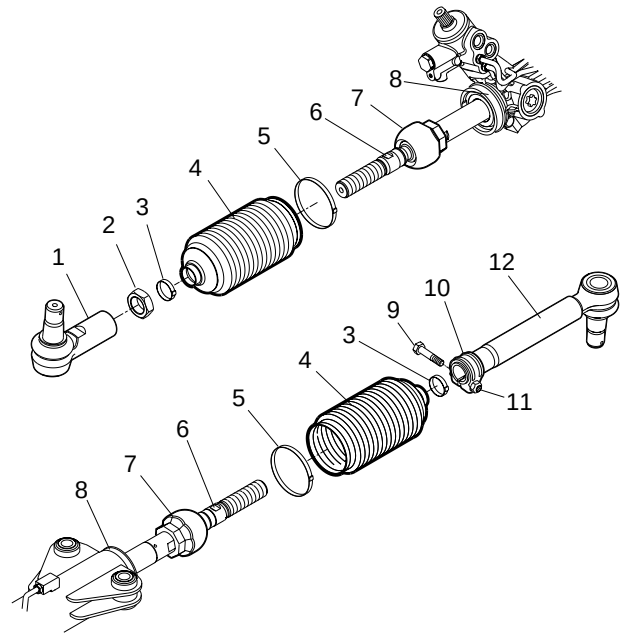


1. Castellated Nut and Cotter Pin
2. Steering Tie Rod Arm
3. Outer Tie Rod
4. Tie Rod Jam Nut
5. Inner Tie Rod Flat
6. Tie Rod Clamp Nut
7. Tie Rod Clamp

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.



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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).

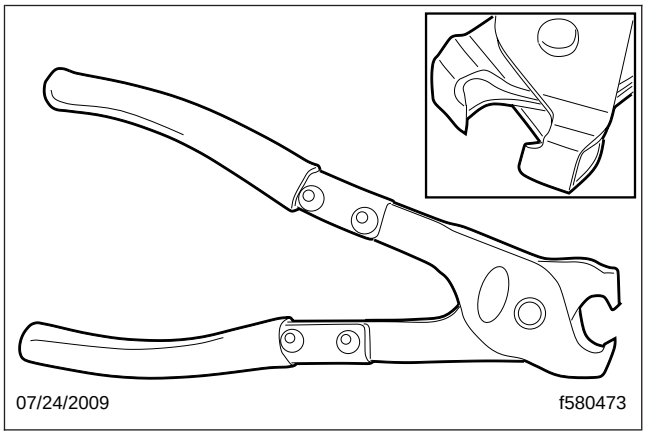

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Fig. 2, Oetiker Clamp Tool

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 Information

The TRW EV Series power steering pump supplies power steering fluid for the operation of the power steering gear. The EV Series power steering pump is a balanced, positive displacement, sliding-vane, two-line pump with an internal pilot-operated flow control and relief valve.

Principles of Operation

As the input shaft turns the rotor inside the cam ring, the centrifugal force pushes the vanes out toward the surface of the cam ring. The pumping element has two pumping pockets opposed 180 degrees from each other that balance the internal forces using the pressure generated by the pumping action. Fluid entering via the inlet port is forced by the vanes through the pumping pockets in the cam ring, and out through the outlet port, to the steering gear. Once through the steering gear, the fluid returns to the power steering reservoir, then back to the power steering pump.

The pump outputs a fixed volume for each revolution of the input shaft. This volume is determined by the internal contour of the cam ring.

The pump has a pilot-operated valve built into the pump housing that controls the amount of fluid that is output to the steering gear. This allows the output flow to remain within specification for almost any input speed variation.

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 and discard 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.
5. Pull the pump straight out from the engine. Keep it level to avoid spilling fluid.
6. Turn the pump upside down over the container and let the fluid drain out.
7. Discard the gasket from the pump mounting flange.

Installation

1. Install a new gasket on the pump mounting flange, then place the pump on the engine accessory drive mounting.
2. Install new 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 adapter. Tighten the adapter no more than 74 lbf·ft (100 N·m).
4. Connect the outlet hose from the power steering gear to the outlet port. Tighten the adapter no more than 37 lbf·ft (50 N·m).
5. Bleed the power steering system, as follows.
   - 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. See **Subject 400** for fluid specifications.
   - 5.5 Shut down the engine.

TRW EV Series pumps use ATF fluid that meets the TES-389 specification. The TRW part number is located as shown in **Fig. 1.** Pump specifications by TRW part number are listed in **Table 1.**

Specification Codes for Fourteen-Character TRW Part Number								
Character Position	**1, 2**	**3, 4**	**5, 6**	**7, 8**	**9**	**10**	**11, 12**	**13, 14**
Typical TRW Part Number	**EV**	**22**	**16**	**18**	**L**	**1**	**01**	**01**
Code Description								
Family Designation EV = EV Series Pump								
Displacement per Revolution 18 = 18 cc (1.10 cir) 22 = 22 cc (1.34 cir) 25 = 25 cc (1.53 cir) 28 = 28 cc (1.71 cir)								
Flow Control 12 = 12 lpm (3.17 gpm) 14 = 14 lpm (3.70 gpm) 16 = 16 lpm (4.23 gpm)								
Relief Setting 09 = 90 bar (1305 psi) 15 = 150 bar (2175 psi) 16 = 160 bar (2320 psi) 17 = 170 bar (2465 psi) 18 = 185 bar (2683 psi)								
Direction of Rotation R = clockwise rotation L = counterclockwise rotation								
Shaft Type 1 = 11 tooth 16/32 spline								
Housing 01 = SAE A Flange - JIC ports 02 = SAE A Flange - Metric ports								
Customer Version 01 = Freightliner								

Table 1, Specification Codes for Fourteen-Character TRW Part Number

Specifications

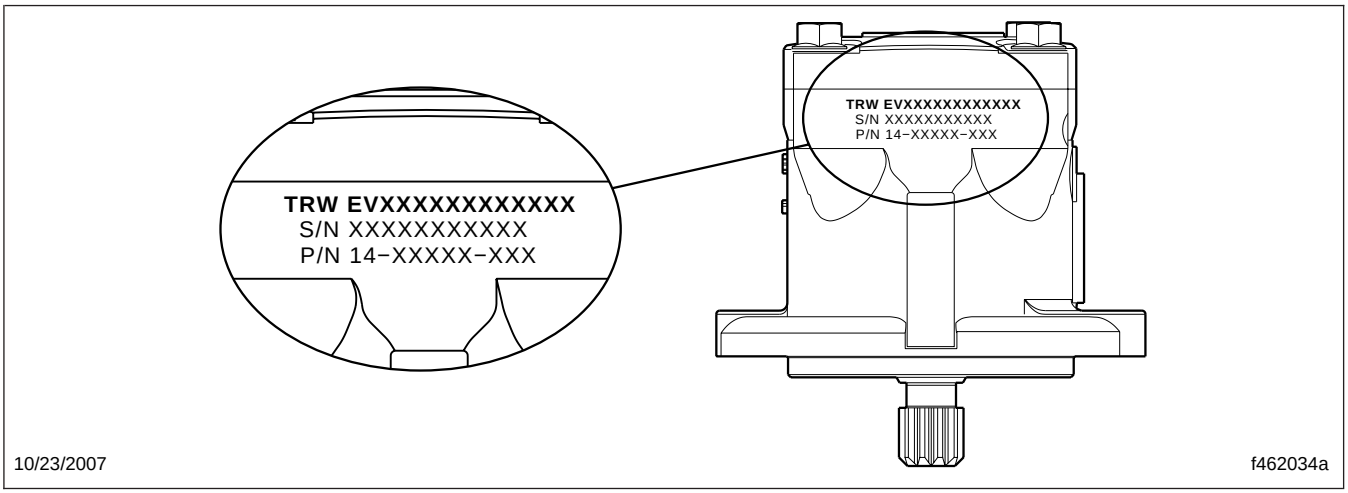
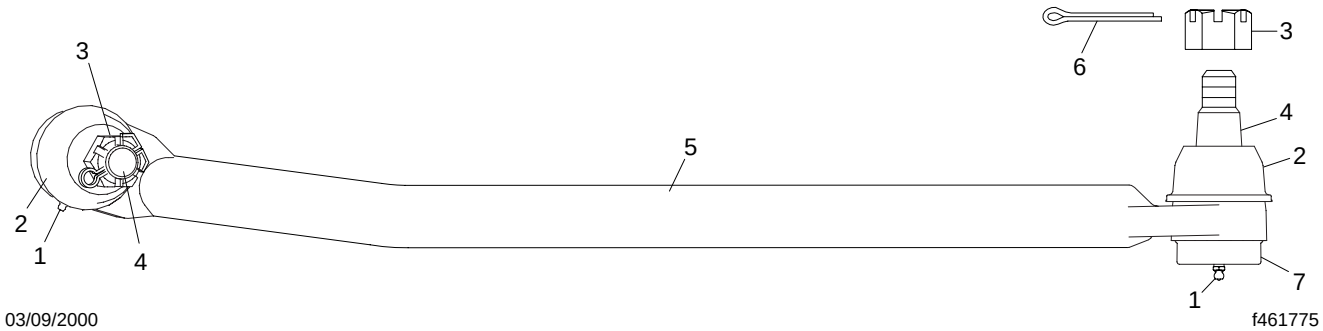


Fig. 1, Power Steering Pump Identification Numbers

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.**

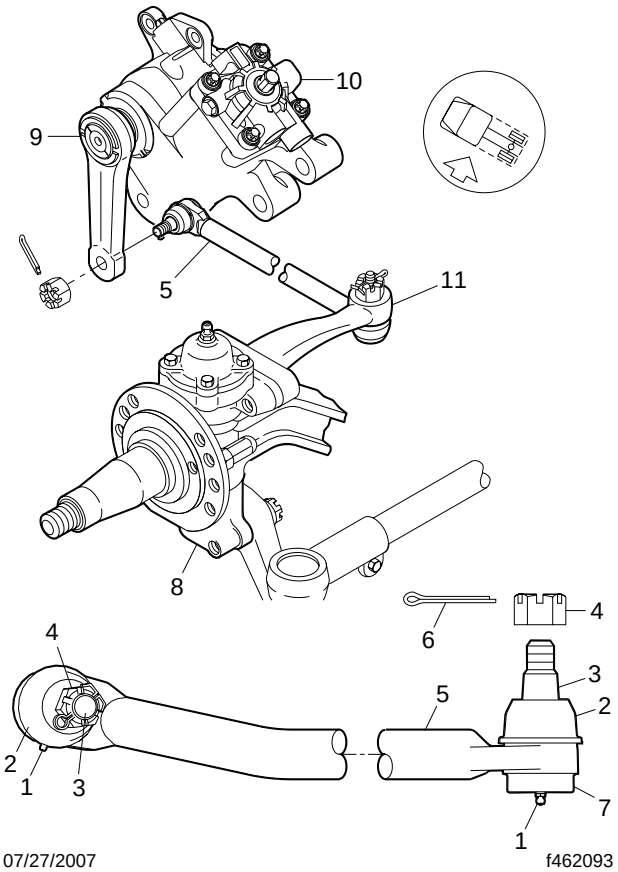
Installation

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.



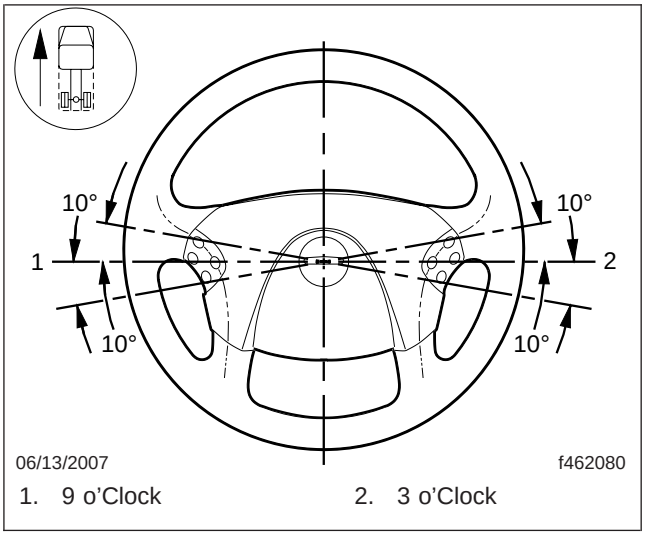
1. Grease Fitting
2. Ball Stud Cover
3. Tapered Ball Stud
4. Castle Nut
5. Drag Link
6. Cotter Pin
7. Dust Cap
8. Front Axle
9. Pitman Arm
10. Steering Gear (TRW THP-60 shown)
11. Axle Steering Arm

Fig. 1, Drag Link Installation

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.**

Drag Link Removal and Installation

7. Check the settings of the steering gear poppet valves. 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.



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 pin. Tighten the ball stud nut as follows (see **Table 1**):

Torque Values	
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. For instructions, see **Subject 100.**

NOTICE

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. See **Fig. 1.**
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.

NOTICE

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.

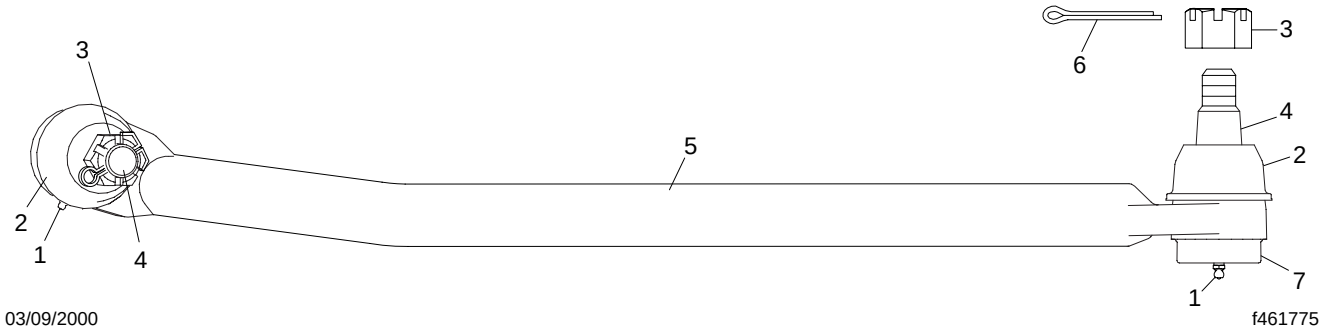
IMPORTANT: To install the stud cover, use a section of tubing that has an inside diameter as close as possible to the outside diameter of the stud cover. Also, make sure that the inside edge of the tube is chamfered (angled) to avoid cutting the rubber stud cover.

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.

NOTICE

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.**

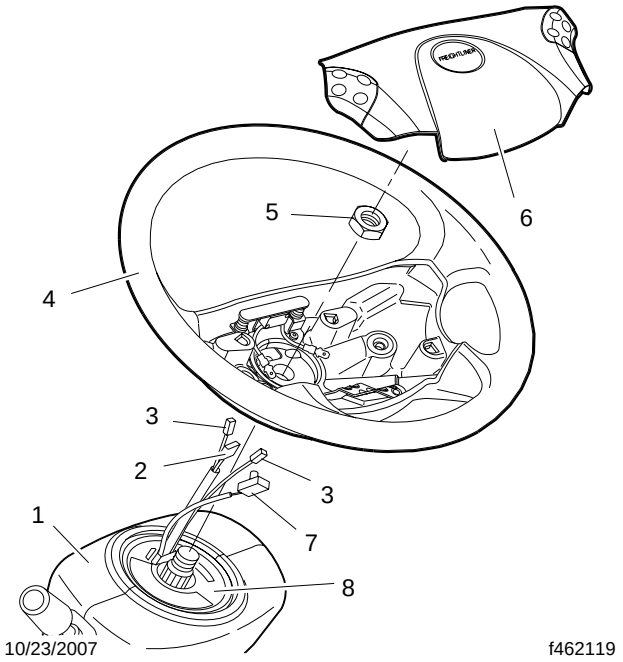


1. Grease Fitting
2. Ball Stud Cover
3. Castle Nut
4. Tapered Ball Stud
5. Drag Link
6. Cotter Pin
7. Dust Cap

Fig. 1, Drag Link Assembly

General Information

The air bag system, when used with seat belts, provides additional protection to the driver in severe frontal collisions. The air bag is located in the steering wheel cover module; see **Fig. 1**.



1. Steering Column
2. Steering Wheel Switch Connector
3. Horn Button Connectors
4. Steering Wheel
5. Steering Wheel Nut
6. Steering Wheel Cover Module
7. Air Bag Connector
8. Clockspring

Fig. 1, Steering Wheel Cover Module and Connectors

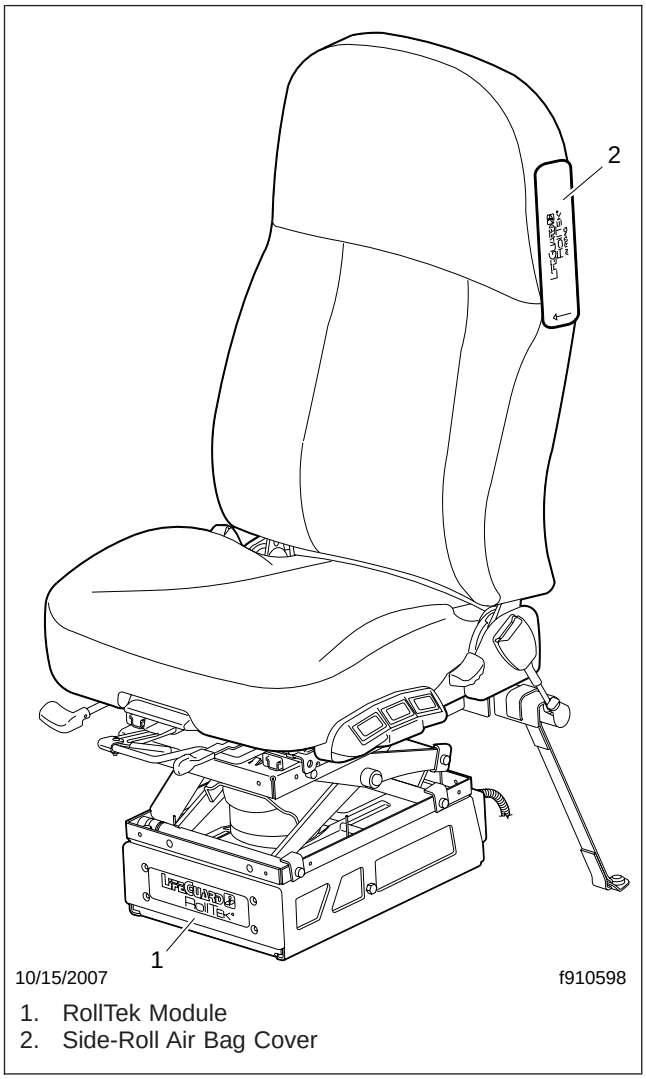
Some vehicles may be equipped with a RollTek Rollover Protection System, which includes a side air bag, in addition to a frontal airbag. For information on the RollTek Rollover Protection System, see **Section 91.03**.

IMPORTANT: To determine which type of supplemental protection system is installed in the vehicle, look at the driver's seat: RollTek Rollover Protection Systems are marked near the floor on the module, and on the upper door-facing side of the seat back, see **Fig. 2**.

⚠ 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.



1. RollTek Module
2. Side-Roll Air Bag Cover

Fig. 2, RollTek System Identifiers

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.**

Air Bag Removal and Installation

Removal

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 060. 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.

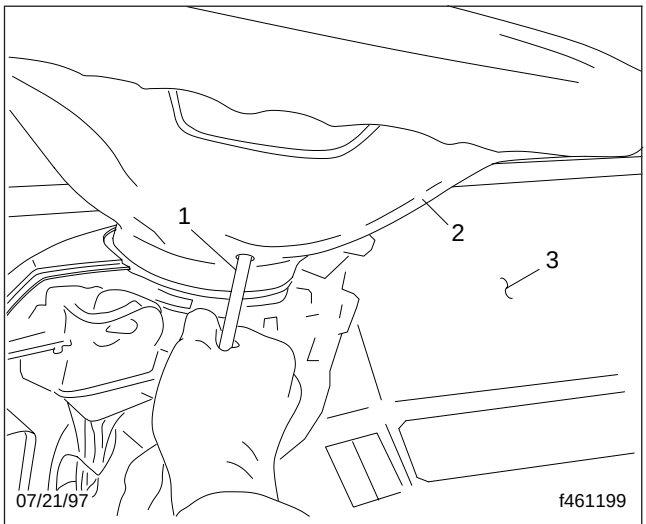
WARNING

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. Loosen the retainer screws underneath the steering wheel; see **Fig. 1**.
4. Carefully lift the air bag from the steering wheel, and disconnect the air bag connector and the steering wheel switch connector from the air bag; see **Fig. 2**. Disconnecting the horn wires is not necessary.
5. Remove the air bag.

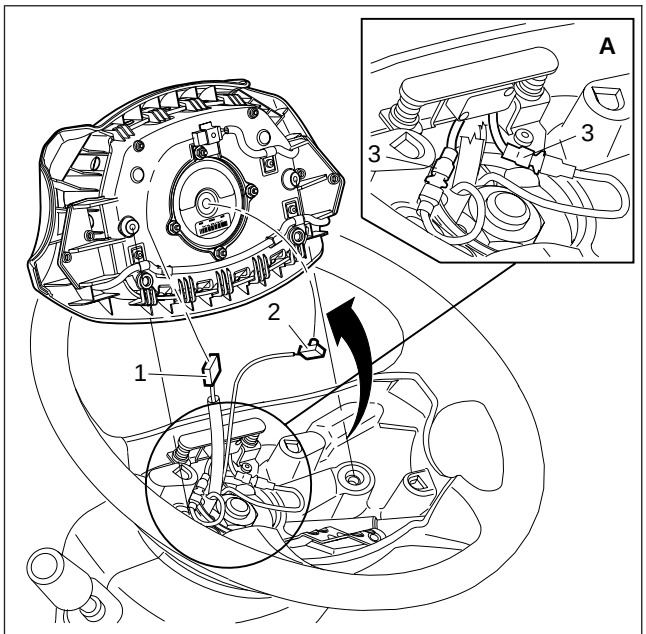
Installation

1. If the air bag was previously deployed, inspect the clockspring and clockspring connector. If there is any melting or damage, remove the steering wheel and replace the clockspring; see **Section 46.01, Subject 100**.
2. Connect the steering wheel 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.



1. Screwdriver
2. Steering Wheel
3. B-Panel of Dash

Fig. 1, Loosening the Air Bag Retainer Screws



A. Horn Wires Detail View

1. Steering Wheel Switch Connector
2. Air Bag Connector
3. Horn Wires

Fig. 2, Air Bag Module Connections

Air Bag Removal and Installation

3. Tighten the air bag retaining screws at the bottom of the steering wheel.
4. Make sure nobody is in the cab, then connect the batteries.
5. 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 *Cascadia Troubleshooting Manual*, 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

⚠ 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 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.

General Information

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.

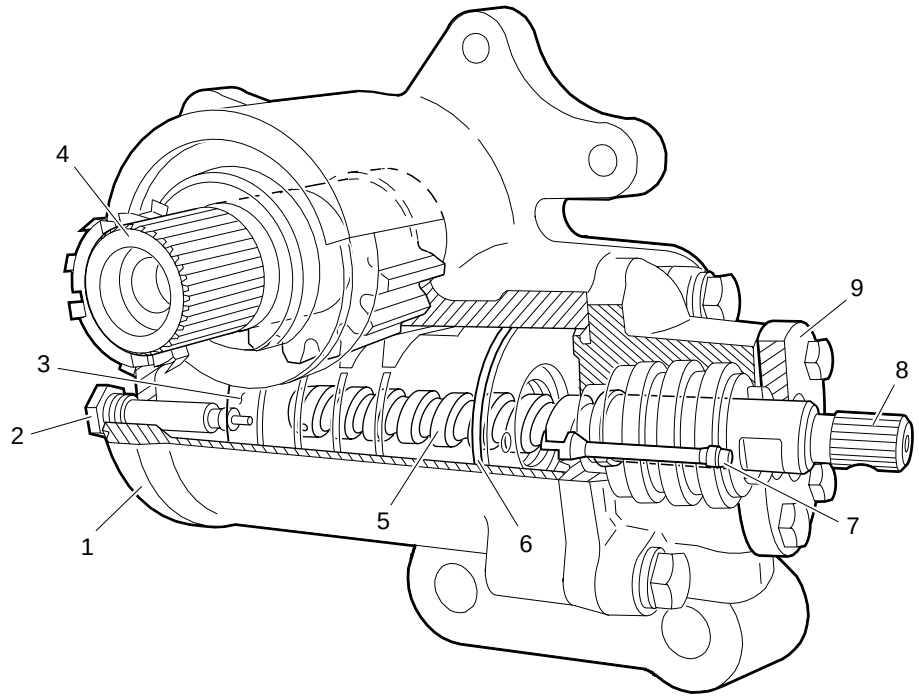
Principles of Operation

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 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 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.

General Information



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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

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.

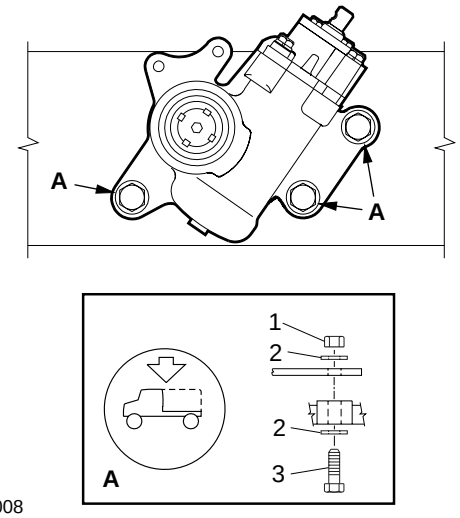
WARNING

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.

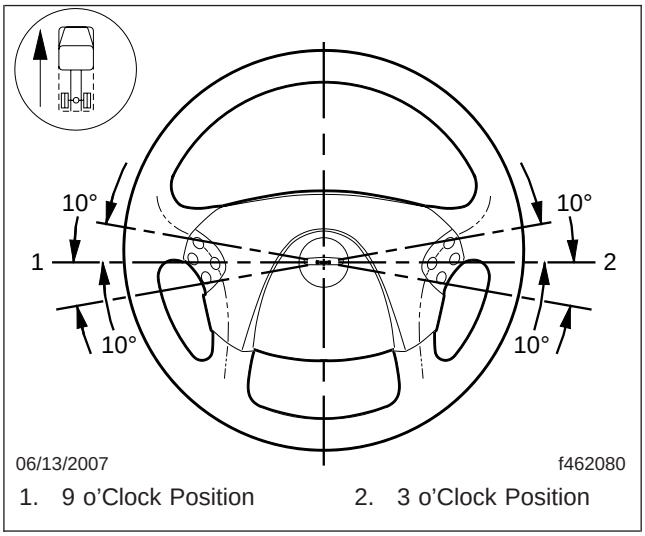
   4.1 Clean the steering gear input shaft and the inside of the steering driveline yoke.

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**.

Pitman Arm Removal and Installation

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.

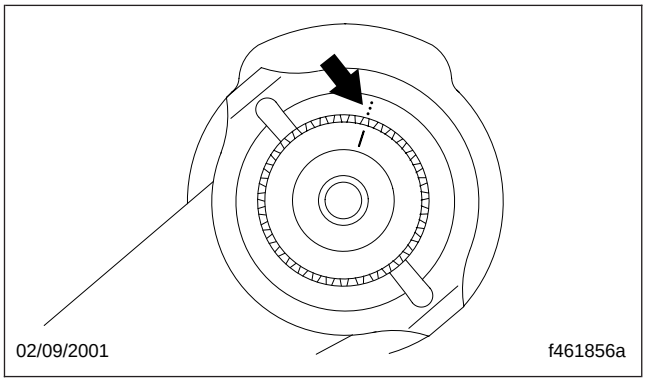


Fig. 1, Timing Mark Alignment

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.

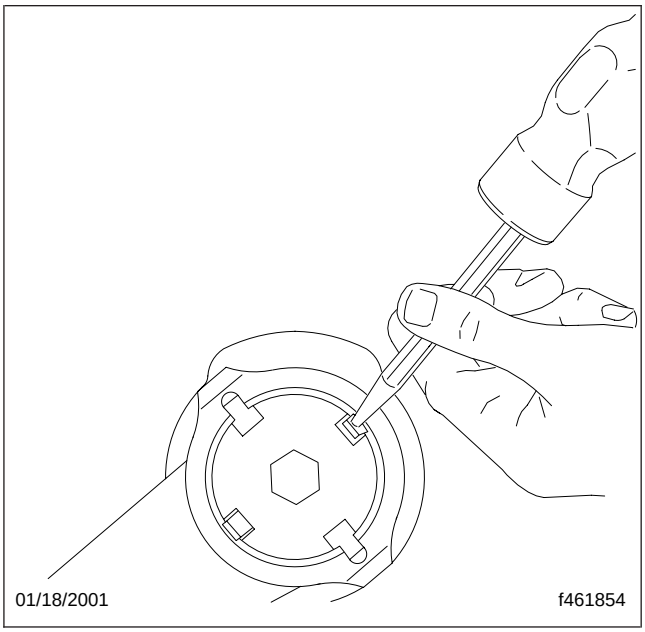


Fig. 2, Bending the Restraining Tabs

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.

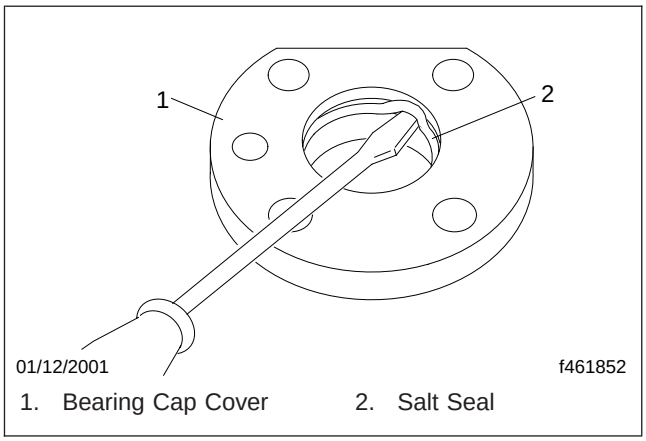


Fig. 1, Salt Seal Removal

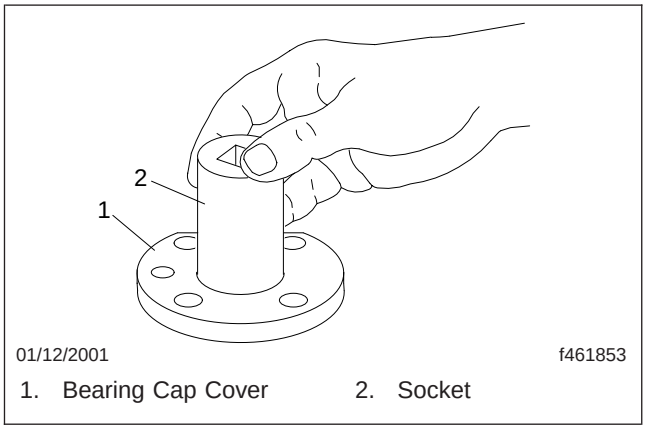


Fig. 2, Input Seal Removal

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

Seal Replacements

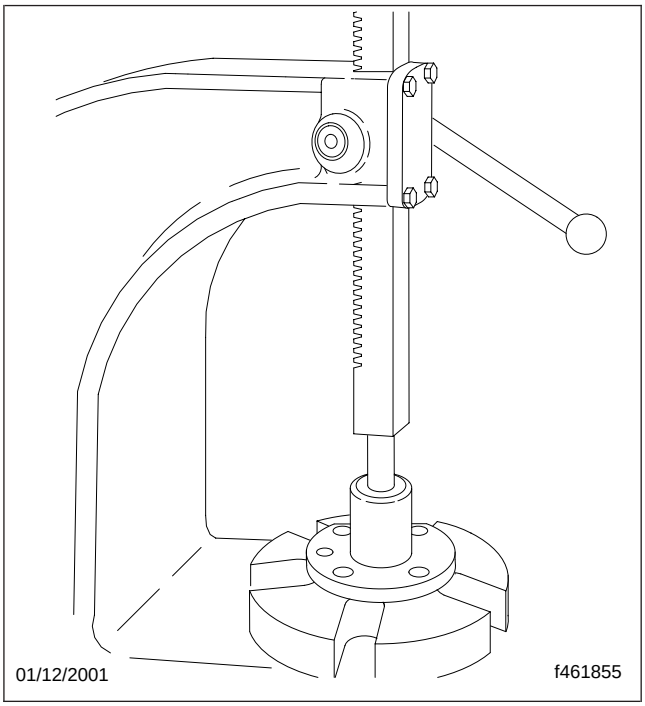


Fig. 3, Salt Seal Installation

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.

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. 5**. It may be necessary to tap on the sector shaft to properly seat it into the housing.

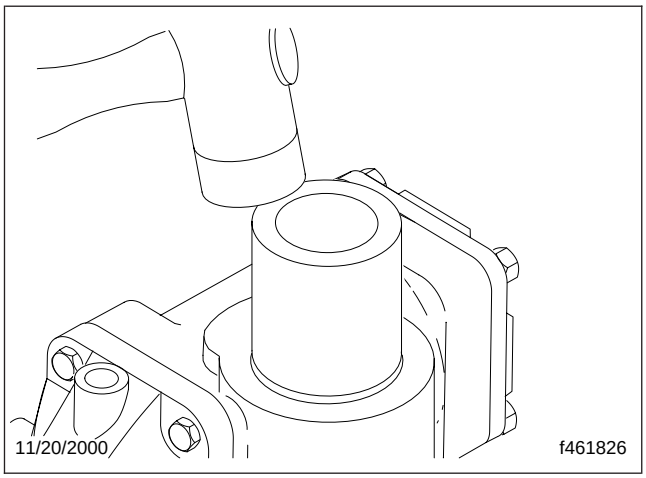
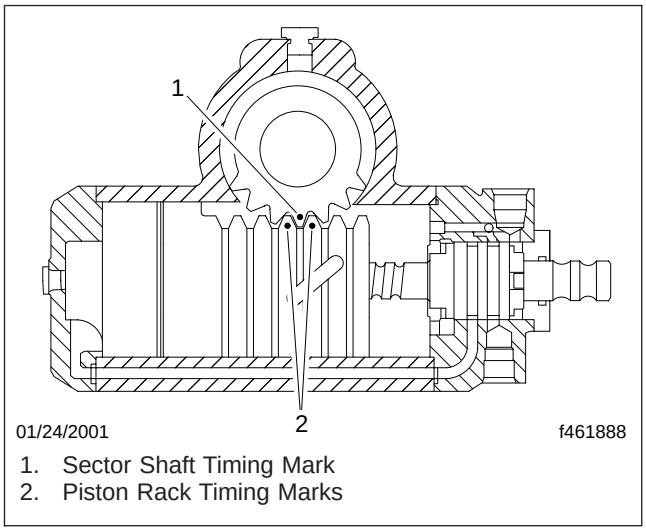


Fig. 4, Excluder Seal Installation



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.

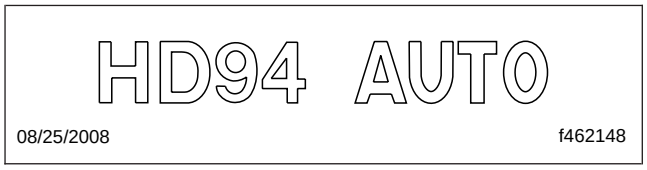


Fig. 1, Automatic Relief Plunger Identifier

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."

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.

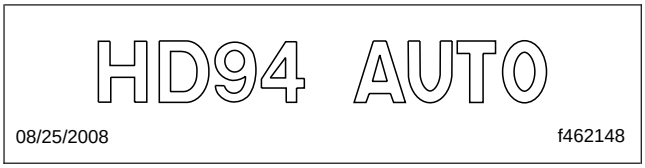


Fig. 1, Automatic Relief Plunger Identifier

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.

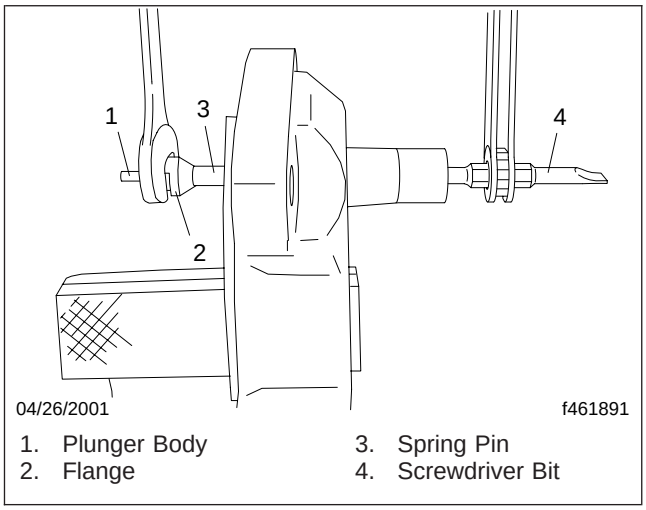


Fig. 2, Flange Removal

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

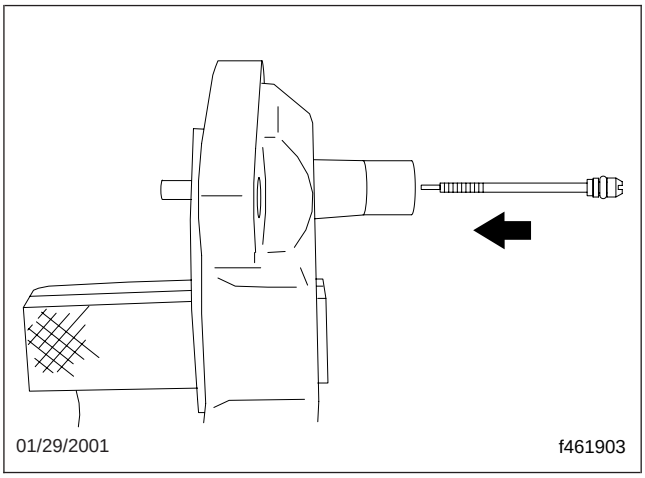


Fig. 3, Plunger Body Installation

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.

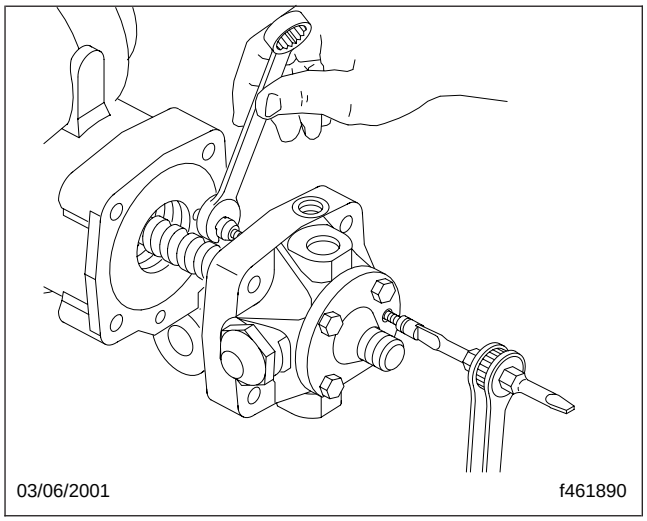


Fig. 4, Flange Removal

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).
15. Install the plastic cap on the plunger boss.
16. Connect the steering driveline to the steering input shaft. For instructions, see **Subject 100**.

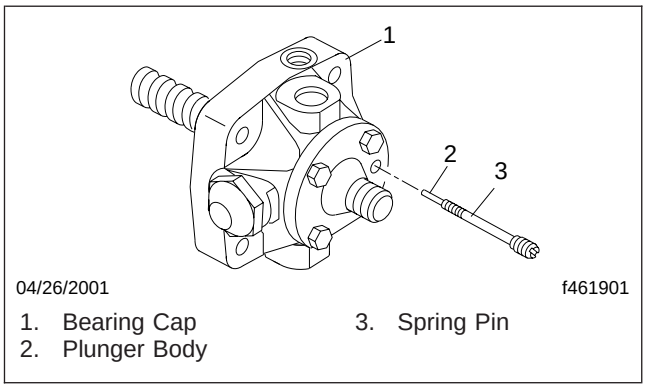


Fig. 5, Plunger Body Installation

⚠ 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**.

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 Information

The complete fuel system includes several components:

- the engine fuel system;
- the fuel tanks and tank mounting components;
- the fuel lines and shut-off valves.

NOTE: Fuel filters, fuel injectors, fuel transfer pumps, and fuel governors are considered to be parts of the **engine fuel system**. In this manual, the engine fuel system is considered to be a separate subsystem from the **vehicle fuel system**. For service and maintenance information on the engine fuel system, refer to the engine manufacturer's manuals.

The fuel tanks are held in their brackets by metal straps. A cab access step assembly, or an air fairing, may be attached to the fuel-tank straps and brackets.

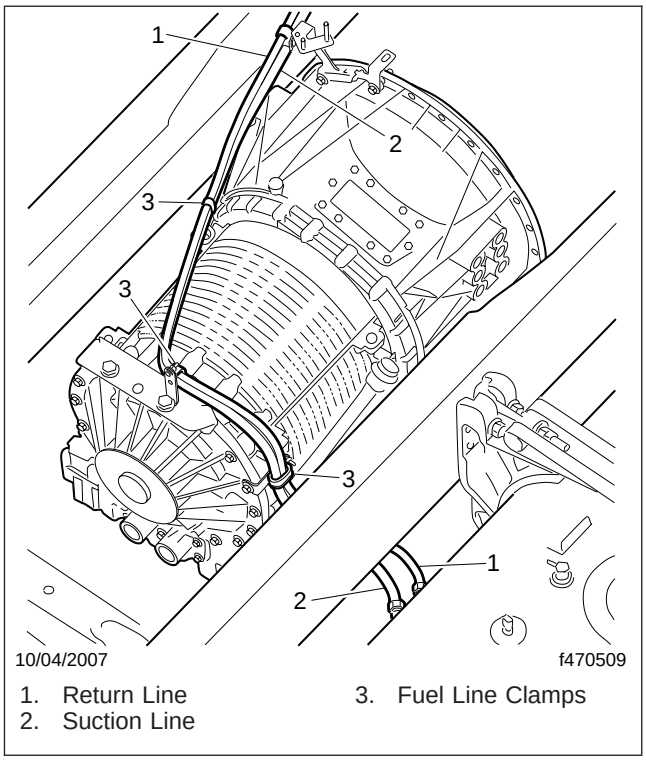
Flexible, reinforced fiber-braid fuel lines carry fuel from the tank to the engine, and return surplus fuel from the engine to the tank.

The EquiFlo® Inboard Fuel System is standard on all single-tank vehicles (see **Fig. 1**) and recommended for dual-tank systems. See **Fig. 2**. The EquiFlo 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 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; see **Fig. 3**.

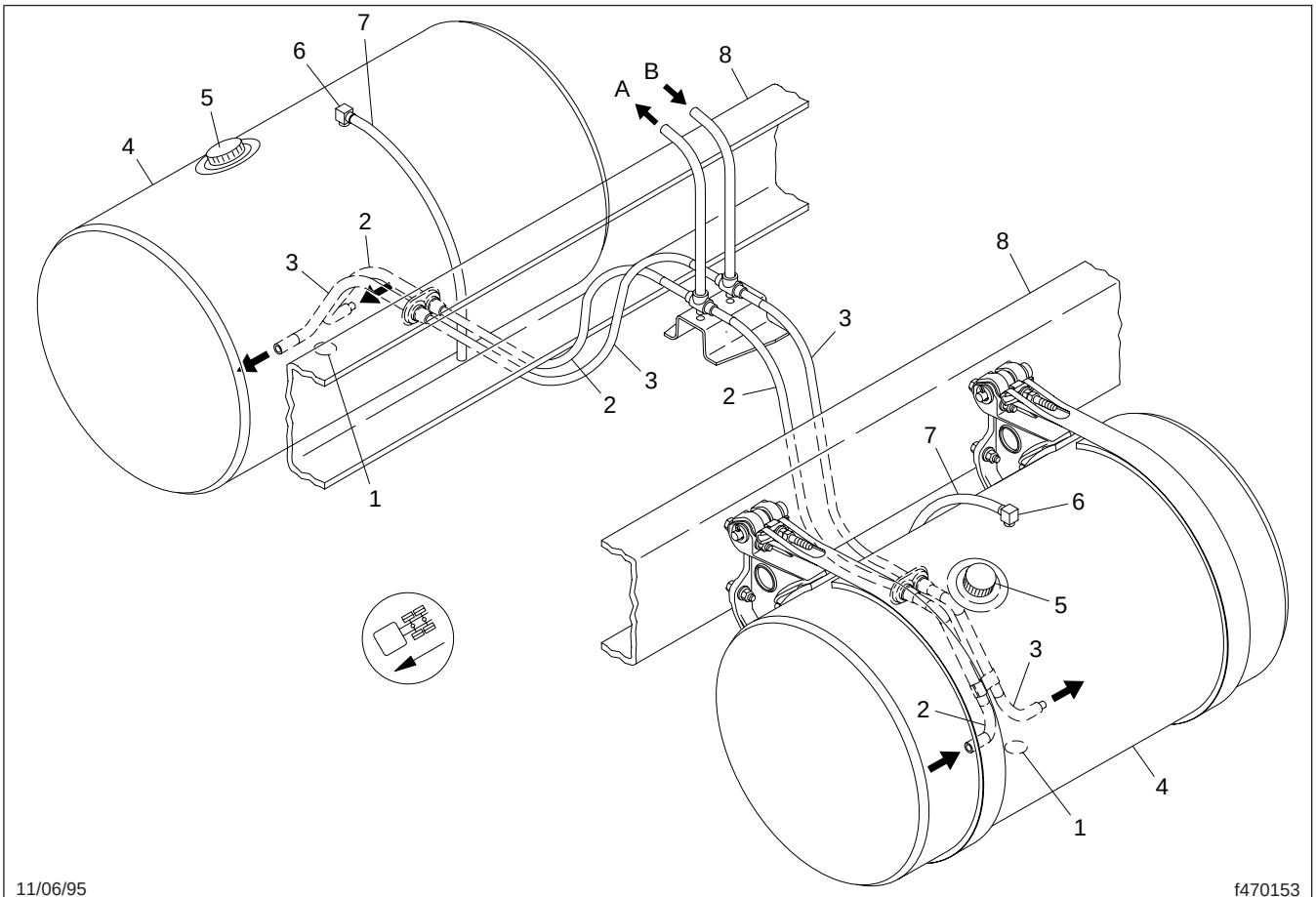
Fuel is drawn and returned equally from and to each tank, so that their levels remain equal. The suction and return fuel lines, although entering the fuel tank through the same opening, are designed to direct the fuel flow to the bottom of the tank. See **Fig. 2**. This ensures thorough mixing of the fuel before it is drawn up by the suction line, so that vapor can disperse, and so that warm fuel is not recirculated in electronically controlled engines.



1. Return Line
2. Suction Line
3. Fuel Line Clamps

Fig. 1, EquiFlo Single-Tank Fuel Lines

General Information



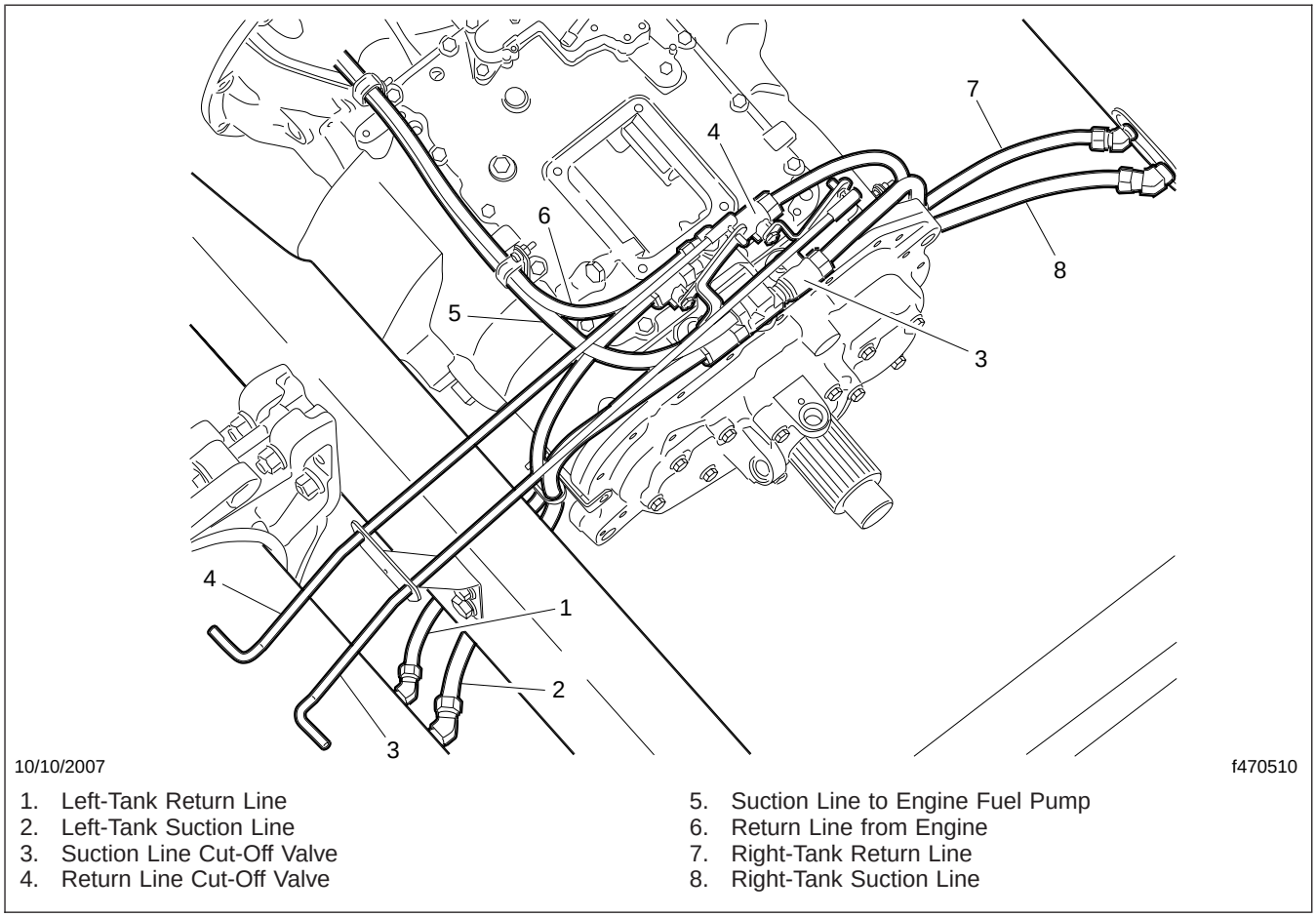
NOTE: Arrows indicate direction of flow.

A. To Fuel Pump

B. Return Line to Tanks

1 Drain
2. Suction Line
3. Return Line
4. Fuel Tank
5. Fuel Cap
6. Vent
7. Vent Line
8. Frame Rail

Fig. 2, EquiFlo Dual-Tank Inboard Fuel System



1. Left-Tank Return Line
2. Left-Tank Suction Line
3. Suction Line Cut-Off Valve
4. Return Line Cut-Off Valve
5. Suction Line to Engine Fuel Pump
6. Return Line from Engine
7. Right-Tank Return Line
8. Right-Tank Suction Line

Fig. 3, EquiFlo Dual-Tank Shut-Off Valves and Fuel Lines

Removal

If there is any damage to the fuel tank, replace it.

IMPORTANT: U.S. Federal Motor Carrier Safety Regulation 393.67 establishes standards relating to fuel tank strength, leakage, and venting. *Replacement fuel tanks must meet these same standards.*

⚠ WARNING

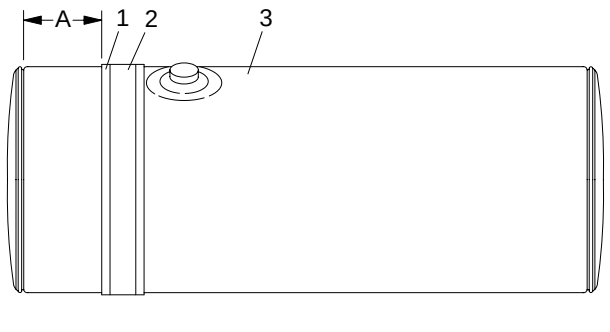
Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

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, big enough 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 covered, clean, and 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 and record 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 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.



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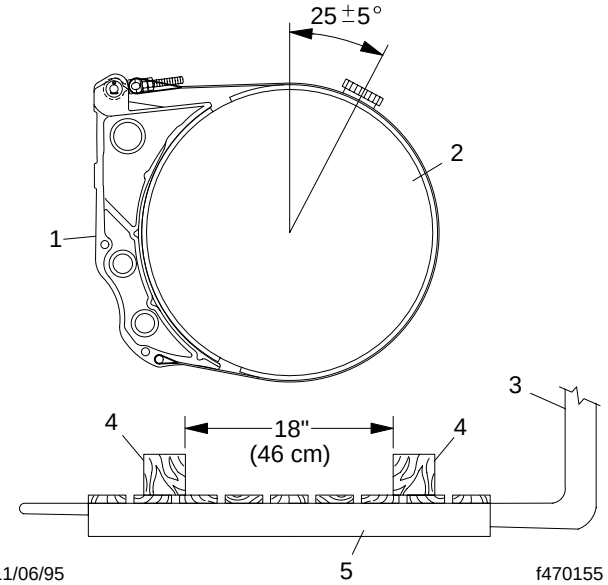
A. Measure the distance from the end of the tank to the edge of the band isolator.

1. Band Isolator
2. Fuel Tank Band
3. Fuel Tank

Fig. 1, Measuring the Band Installation Distance



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Make sure the tank is rotated so the vent is located at the top.

1. Fuel Tank Bracket
2. Fuel Tank
3. Lift-Truck Fork
4. 4 x 4 Wooden Block
5. Wooden Pallet

Fig. 2, Fuel Tank Orientation and Support

Removal and Installation

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 110** for bracket and band replacement procedures.

Installation

Note: The fuel filler neck should be oriented 25 degrees outboard of vertical on standard tanks under the main cabin. The filler neck should be oriented 30 degrees outboard of vertical on standard tanks under the sleeper.

Auxiliary fuel tank caps should be oriented 15 degrees outboard of vertical.

1. Using the fork lift and pallet, put 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.

   1.1 Holding the tank on the forklift, attach the band and isolator to the eye bolt.

   1.2 Install a hardened flatwasher and the inner 5/8–11 hexnut, but do not tighten yet.

2. 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 the center 2 inches (50 mm) 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.

3. Install the other tank band around the tank. Insert the isolators under the brackets so that the relief in each isolator aligns with the tank longitudinal weld seam. See **Fig. 3**.

⚠ CAUTION

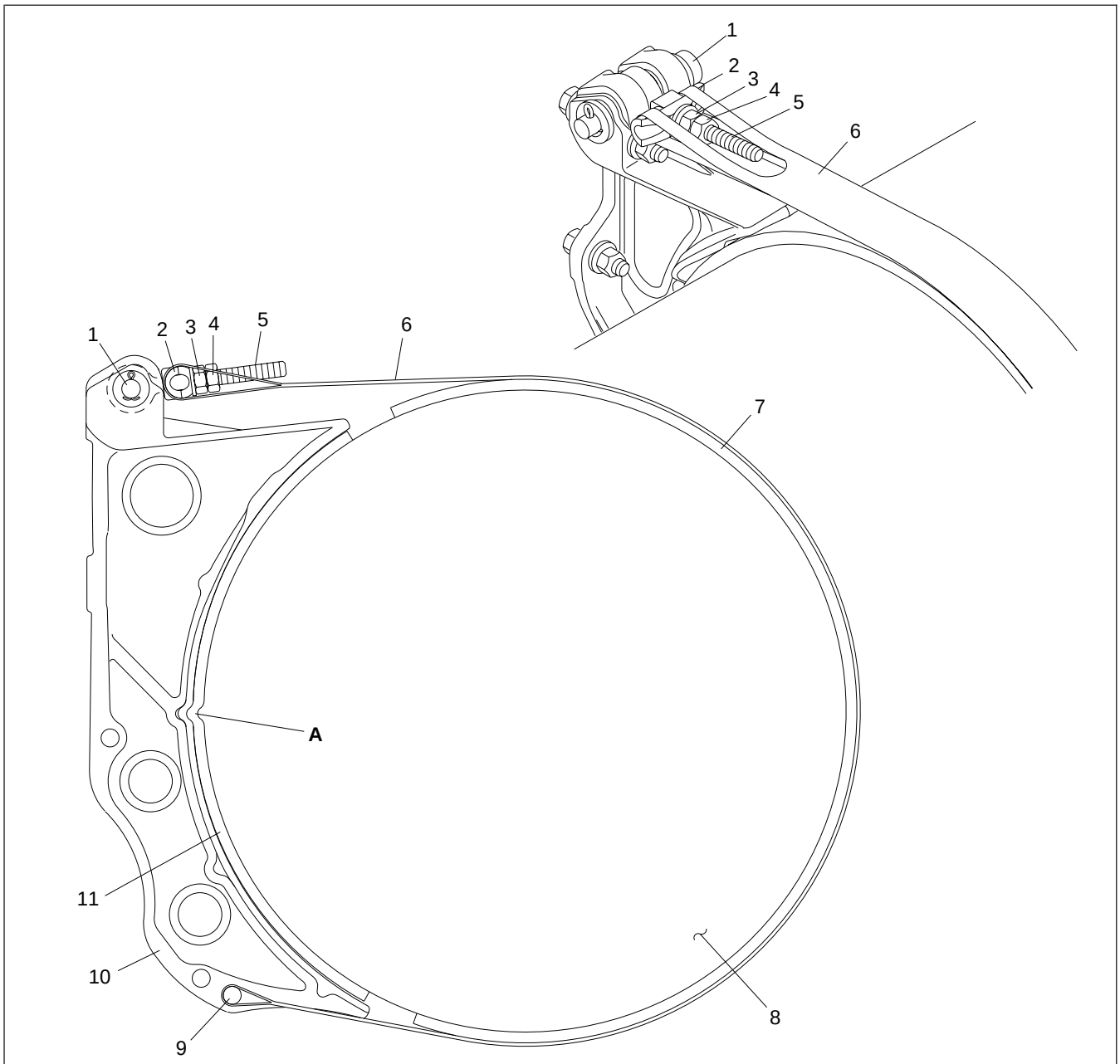
Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.

4. 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).
5. 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.

6. Install the chassis fairings. For instructions, refer to **Section 31.04, Subject 100**.
7. 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).

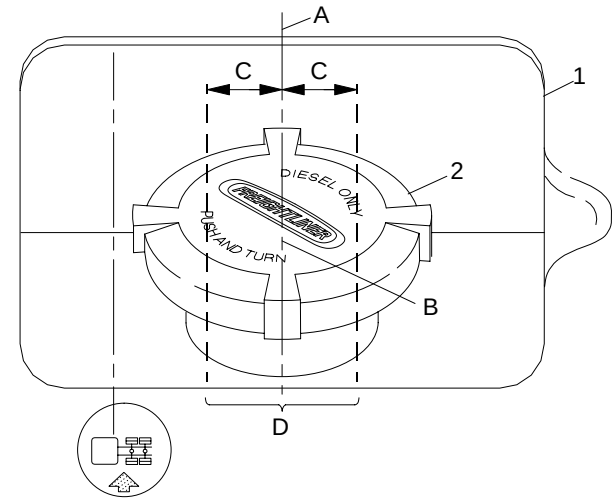


A. Tank Seam

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

Removal and Installation



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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

Fuel Tank Band 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 small clevis pin from the bottom end of the fuel tank bracket, to free the band.

   Remove the band from the fuel tank.
6. Install the band, as follows.

   6.1 Position the small end of the new band on the bottom edge of the fuel tank bracket.

   6.2 Install the small clevis pin with two hardened flatwashers onto the fuel tank bracket and band, and fasten it in place with a cotter pin.
7. Apply Alumilastic® or an 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 the 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, as follows:

   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 the jam nut 30 lbf·ft (41 N·m).
10. Repeat this procedure to replace the other bands. When the bands have been replaced, check the inner hexnuts and jam nuts for tightness.
11. Install the chassis fairings. For instructions, refer to **Section 31.04, Subject 100**.

Fuel Tank Bracket Replacement

1. Support the tank, and remove the fuel tank band from the bracket that is being replaced. See "Fuel Tank Band Replacement" 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, as follows.

   3.1 Apply Alumilastic®, or an equivalent substance, between the fuel tank bracket and the frame rail.

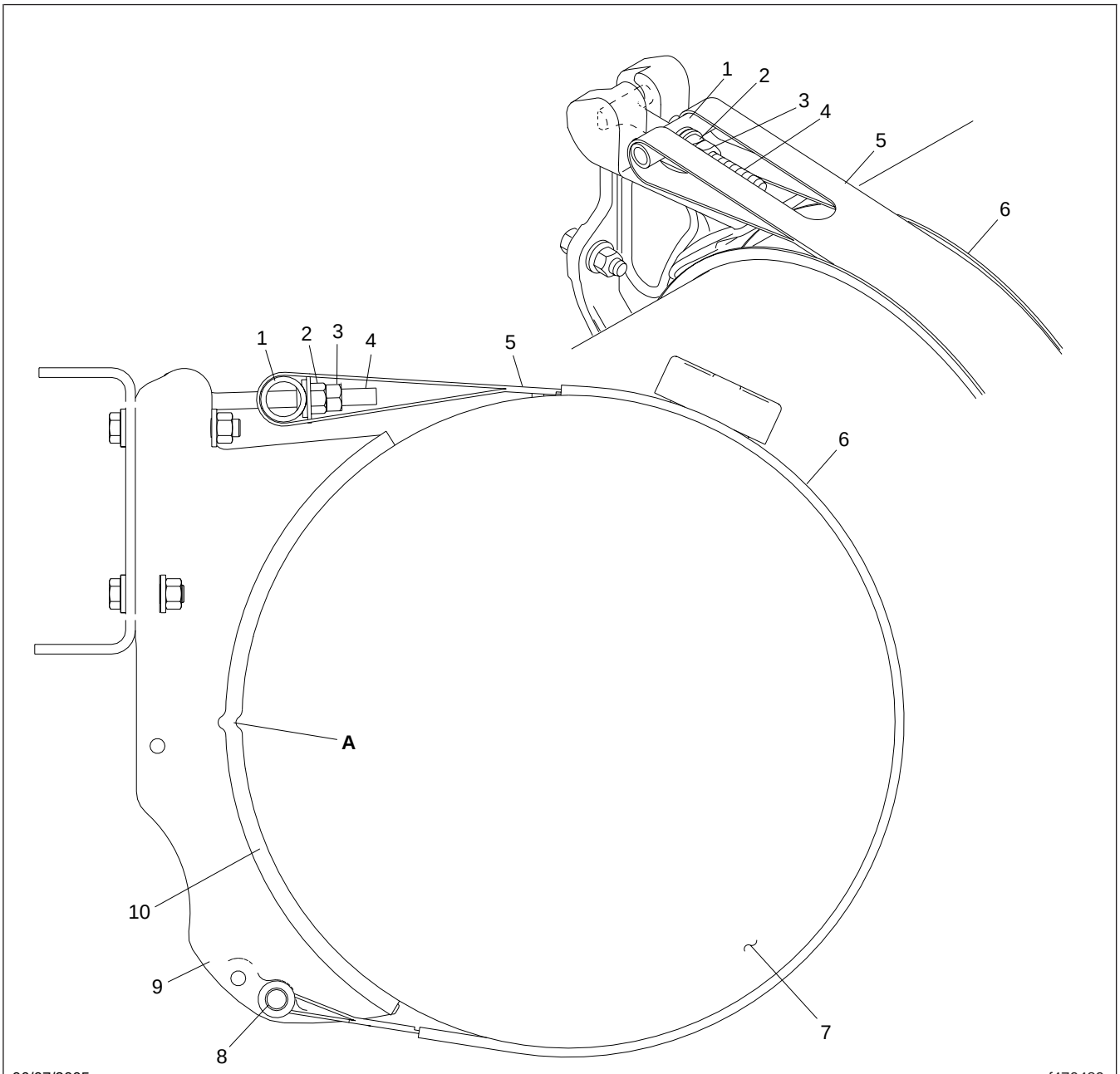
CAUTION

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 tank bracket against the outside of the frame rail. See **Fig. 1**.

   3.3 Insert two 5/8–11 x 4 bolts with washers through the top holes in the frame rail and bracket.

Fuel Tank Band and Bracket Replacement



A. Tank Seam

1. Large Clevis Pin
2. Hexnut, 5/8–11
3. Jam Nut, 5/8–11
4. Eye Bolt
5. Fuel Tank Band
6. Band Isolator
7. Fuel Tank
8. Small Clevis Pin
9. Fuel Tank Bracket
10. Bracket Isolator

Fig. 1, Fuel Tank Band Assembly

3.4 Insert two 5/8–11 x 2-1/4 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 "Fuel Tank Band Replacement" for instructions.

Fuel Shutoff Valve Replacement, EPA10 Engines

Replacement

NOTE: Fuel shutoff valves are only installed on vehicles with dual tanks.

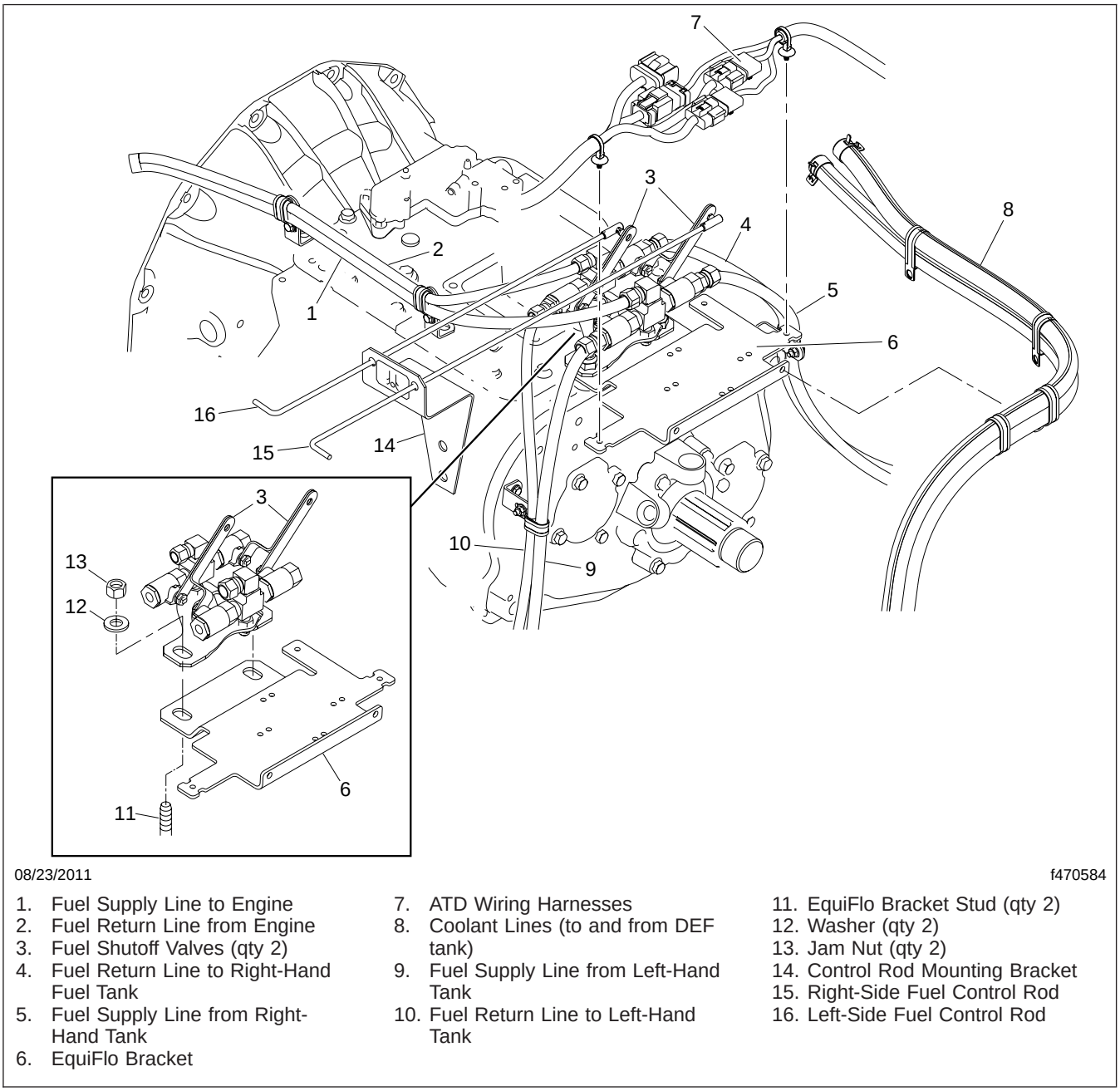
1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Put the transmission into high gear, chock the tires and open the hood.
2. Disconnect the fuel control rod(s) from the fuel shutoff valve lever(s). Swing the control rod(s) out of the way without removing them from the control rod mounting bracket. See **Fig. 1**.

⚠ 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, causing potentially serious burns or material damage. Wear appropriate protective gear when working around the ATD. Do not to let diesel from the fuel lines come into contact with the ATD.

3. Disconnect the driveline from the transmission output yoke. For instructions, see **Section 41.00, Subject 100** for uncoupling from a *half-round* end-yoke, or **Section 41.00, Subject 110** for uncoupling from a *full-round* end-yoke.
4. Disconnect the driveline midship bearing from the midship bearing bracket, and set the driveline out of the way.
5. Disconnect the aftertreatment device (ATD) wiring harnesses located on the EquiFlo bracket.
6. Disconnect the diesel exhaust fluid (DEF) coolant lines located on the EquiFlo bracket.
7. Disconnect the fuel lines from the tee fittings, then cap the lines.
8. In order to gain access to the fuel shutoff valves, it may be necessary to remove the standoff brackets that secure the DEF lines to the EquiFlo bracket, then move the lines aside. See **Fig. 1**.
9. Remove any remaining cables and brackets as needed to access the fuel shutoff valves.
10. Loosen the two jam nuts that secure the fuel shutoff valves and tee fittings to the EquiFlo bracket. Remove the tee fittings and valves as an assembly.
11. Remove the shutoff valves from the tee fittings, then install new shutoff valves.
12. Using two jam nuts, install the tee fitting and shutoff valve assembly on the EquiFlo bracket.
13. Install the fuel lines on the tee fittings and tighten the fittings.
14. If any ATD wiring harness standoff brackets were previously removed, install them on the EquiFlo bracket, then connect the wiring harnesses.
15. If any DEF line standoff brackets were previously removed, install them on the EquiFlo bracket.
16. Connect the DEF coolant lines.
17. Connect the ATD wiring harnesses.
18. Install any remaining cables and brackets that were previously removed.
19. Connect the driveline to the transmission output yoke. For instructions, see **Section 41.00, Subject 100** for coupling to a *half-round* end-yoke, or **Section 41.00, Subject 110** for coupling to a *full-round* end-yoke.
20. Connect the midship bearing to the midship bearing bracket.
21. Connect the control rod(s) to the fuel shutoff valve lever(s). Tighten the nuts 16 lbf·ft (22 N.m).
22. Start the engine and check for leaks.

Fuel Shutoff Valve Replacement, EPA10 Engines



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1. Fuel Supply Line to Engine
2. Fuel Return Line from Engine
3. Fuel Shutoff Valves (qty 2)
4. Fuel Return Line to Right-Hand Fuel Tank
5. Fuel Supply Line from Right-Hand Tank
6. EquiFlo Bracket
7. ATD Wiring Harnesses
8. Coolant Lines (to and from DEF tank)
9. Fuel Supply Line from Left-Hand Tank
10. Fuel Return Line to Left-Hand Tank
11. EquiFlo Bracket Stud (qty 2)
12. Washer (qty 2)
13. Jam Nut (qty 2)
14. Control Rod Mounting Bracket
15. Right-Side Fuel Control Rod
16. Left-Side Fuel Control Rod

Fig. 1, Fuel Shutoff Valve Assembly, Dual-Tank Vehicle

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**.
4. Thoroughly steam clean the inside of the tank until all water leaving the drain hole looks clean.
5. Install the 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 this fuel from the tank into a suitable container. 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

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.

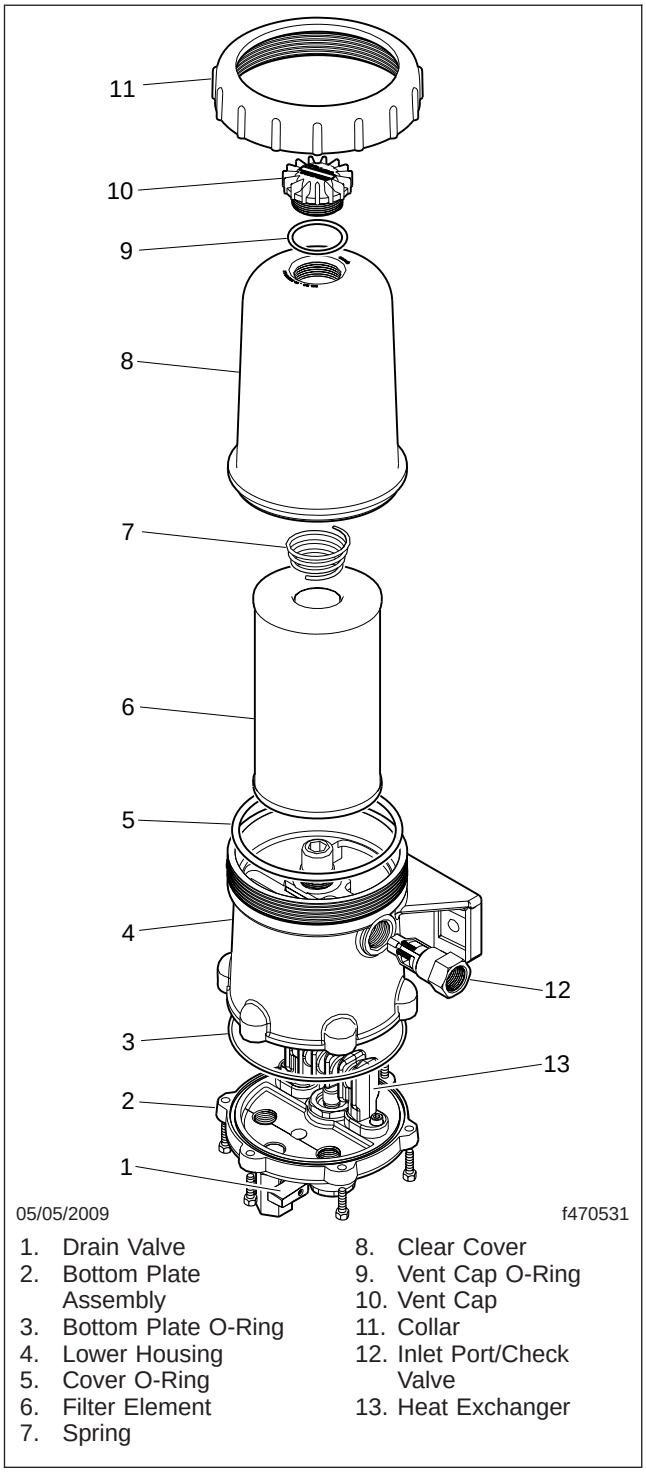
At the fuel/water separator inlet port, a check valve prevents the fuel from draining back to the fuel tank. Large pieces of dirt and water separate from the fuel in the lower housing, and collect in the bottom to be drained out when the drain valve is opened. From the lower housing, the fuel level rises 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.

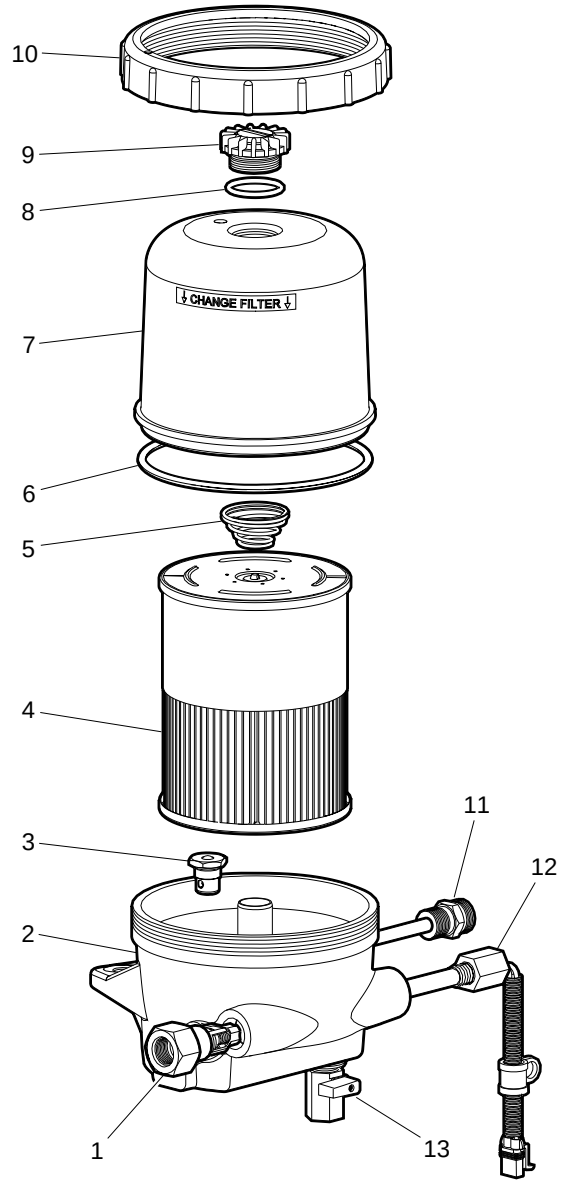
NOTE: The Daimler Trucks North America Learning Center (accessible through **www.AccessFreightliner.com**) and DAVCO (**www.DavcoTec.com**) offer excellent online resources for understanding, testing, and diagnosing fuel/water separator problems.



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



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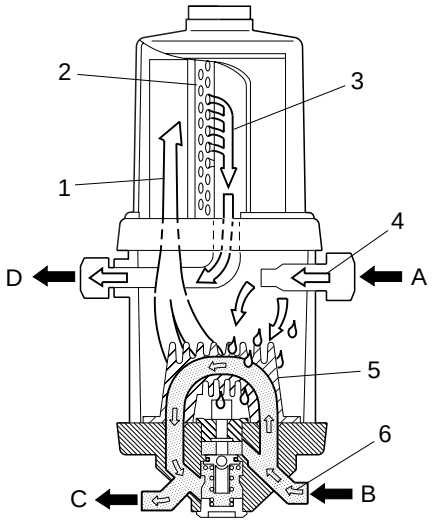
1. Inlet Port/Check Valve
2. Lower Housing
3. Bypass Valve
4. Filter Element
5. Spring
6. Cover O-Ring
7. Clear Cover
8. Vent Cap O-Ring
9. Vent Cap
10. Collar
11. 120VAC Pre-Heater
12. 12VDC Pre-Heater
13. Drain Valve

Fig. 2, DAVCO Fuel Pro 482



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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.

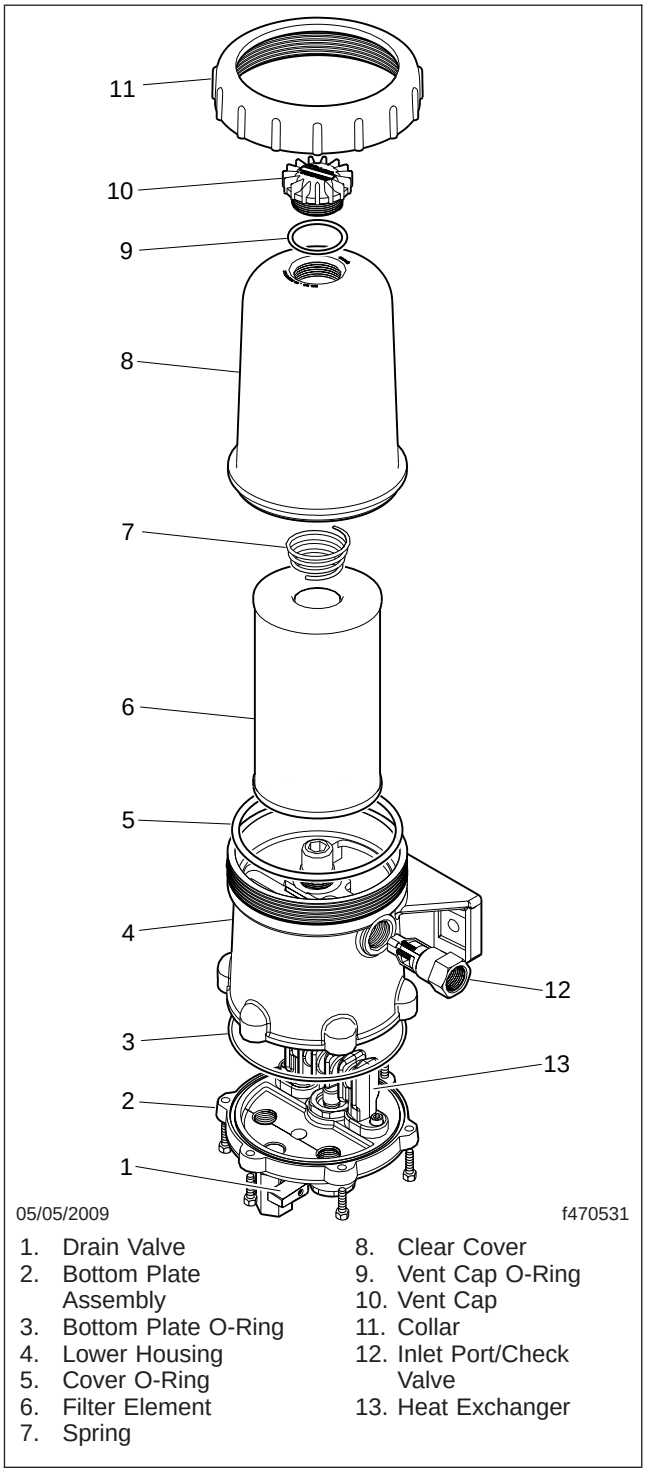
If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

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

Removal and Installation

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 may 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

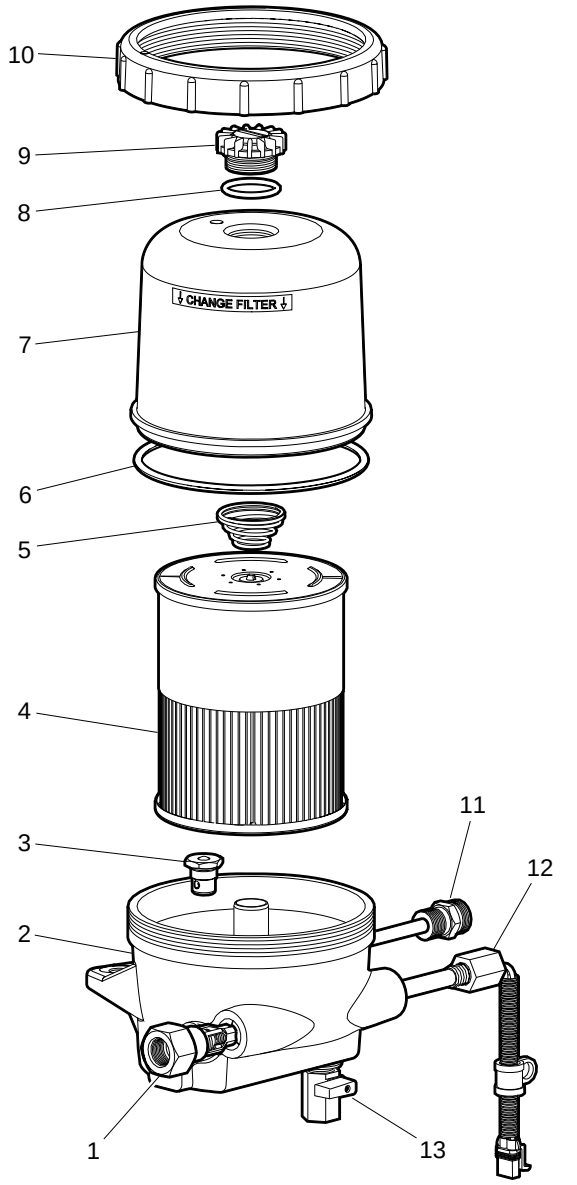
Removal

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.



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.

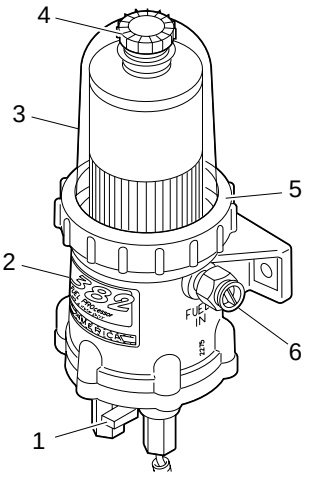
If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

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)

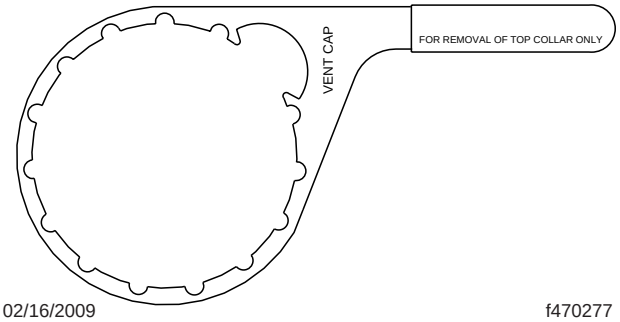

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Fig. 2, DAVCO Collar Wrench

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 Replacement

⚠ WARNING

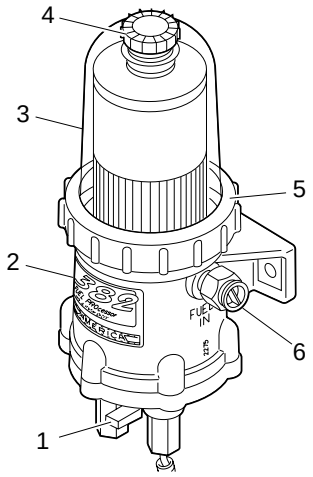
Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

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.



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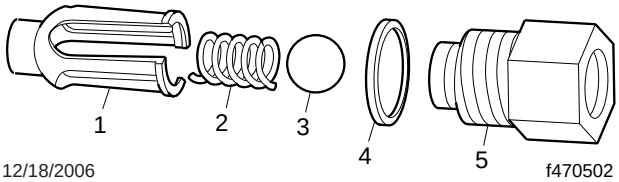
1. Drain Valve
2. Lower Housing
3. Clear Cover
4. Vent Cap
5. Collar
6. Inlet Port/Check Valve

Fig. 1, DAVCO Fuel/Water Separator (Fuel Pro 382 Shown)



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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.

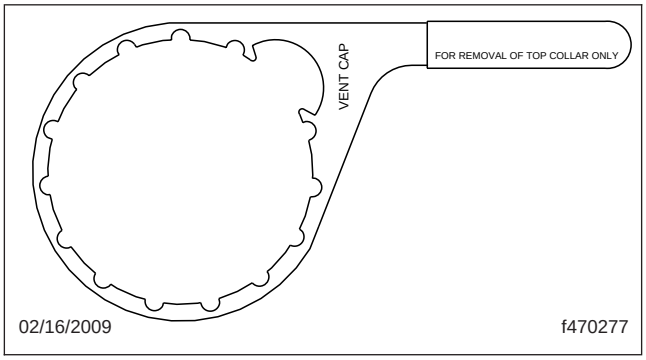


Fig. 3, DAVCO Collar Wrench

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.

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.

Electric Heater, Thermoswitch, and Fluid Heat Tests

Any one of several types of pre-heaters and thermoswitches may be fitted to DAVCO fuel/water separators. They include 12 VDC pre-heaters, 120 VAC pre-heaters, combination pre-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 pre-heater types, as specified:

- Electric Pre-Heater
- 12 VDC Thermoswitch
- Combination Pre-Heater Thermoswitch
- Fluid Heat

The following equipment is recommended to test DAVCO pre-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

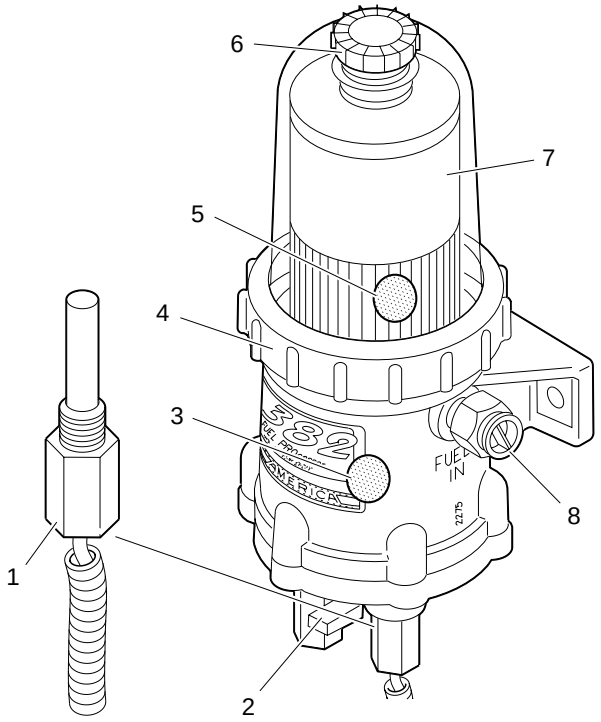
⚠ WARNING

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.

Electric Pre-Heater

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the pre-heater from the wiring harness, see **Fig. 1**.
3. Connect the ohmmeter leads to the pins of the pre-heater (for pre-heaters with one pin, connect to the pin and the bushing).
4. Read the resistance and use **Table 1** to determine whether the pre-heater is within the acceptable resistance range.
5. Connect the pre-heater wiring harness.



1. Electric Heating Element
2. Drain Valve
3. Housing
4. Collar
5. Filter Element
6. Vent Cap
7. Clear Cover
8. Inlet Port/Check Valve

Fig. 1, Fuel Pro 382 With Electric Heating Element

Electric Pre-Heater Test Paramaters		
Electric Pre-Heater	**Watts**	**Resistance Range: Ohms**
12 VDC (two pin)	250	0.6–0.8
12 VDC (single pin)	250	0.6–0.8

Electric Heater, Thermoswitch, and Fluid Heat Tests

Electric Pre-Heater Test Paramaters		
Electric Pre-Heater	**Watts**	**Resistance Range: Ohms**
12 VDC (single pin)	150	0.9–1.1
120 VAC	75	173–203
120 VAC	37	369–411

Table 1, Electric Pre-Heater Test Parameters

12 VDC Thermoswitch

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 and open the drain valve to drain the fuel completely, then close the drain valve.
4. Disconnect the thermoswitch wiring harness, see **Fig. 2**. Remove the thermoswitch from the fuel/water separator.

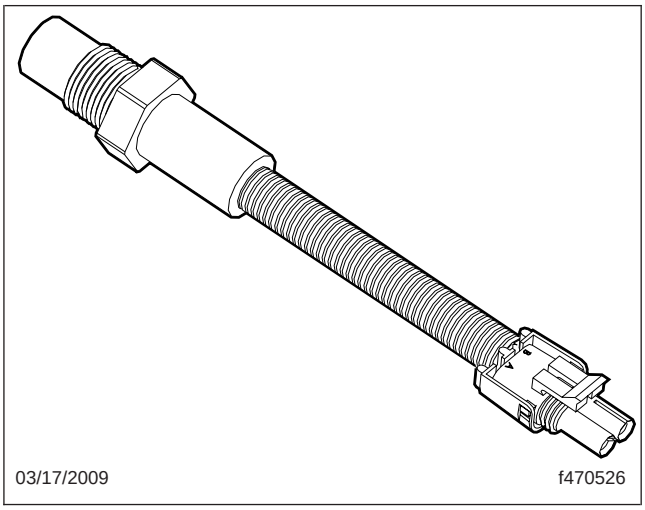


Fig. 2, 12 VDC Thermoswitch

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 or equal to 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 Pre-Heater Thermoswitch

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 and open the drain valve to drain the fuel completely, then close the drain valve.
4. Disconnect the pre-heater/thermoswitch unit from the wiring harness, see **Fig. 3**.

Electric Heater, Thermoswitch, and Fluid Heat Tests

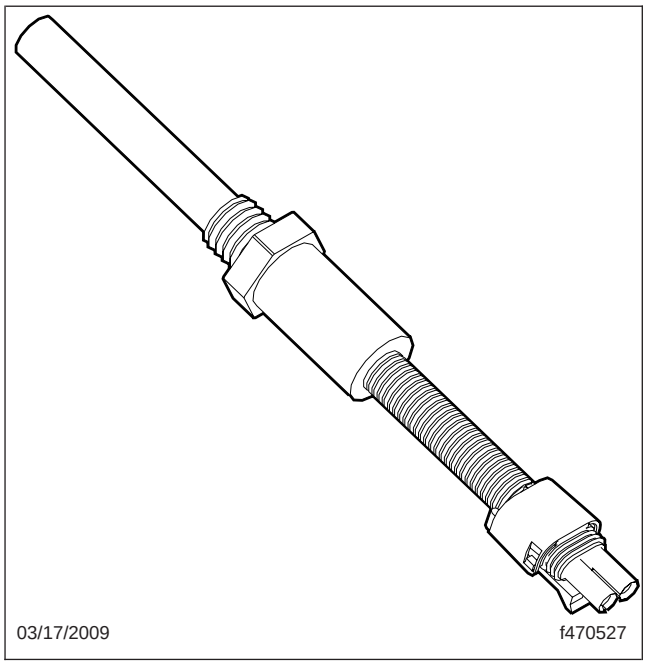


Fig. 3, Combination Pre-Heater Thermoswitch

5. Connect the ohmmeter leads to the pre-heater/thermoswitch pins.
6. Lower the pre-heater/thermoswitch unit temperature to below 40°F (4.4°C).

   The resistance shown on the ohmmeter should be:

   - 0.9 to 1.1 ohms for a 12 VDC 150 W unit
   - 0.6 to 0.8 ohms for a 12 VDC 250 W unit

7. Raise the pre-heater/thermoswitch unit temperature to above 70°F (21°C). The pre-heater/thermoswitch unit should show an open circuit.
8. Install the pre-heater/thermoswitch in the fuel/water separator. Connect the pre-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.

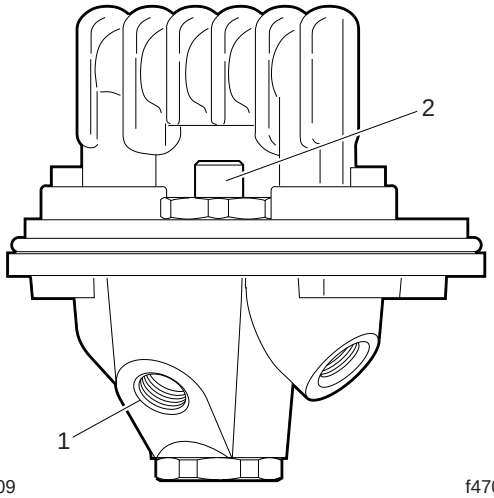
Fluid Heat, Fuel Pro 382

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. 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.
4. Remove the vent cap and open the drain valve to drain the fuel completely, then close the drain valve.
5. Remove the bottom plate and lower housing O-ring.
6. While looking into the fluid port of the bottom plate (**Fig. 4**), 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.

   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. 5**.
7. Replace the lower housing O-ring and install the bottom plate on the fuel/water separator. The

Electric Heater, Thermoswitch, and Fluid Heat Tests



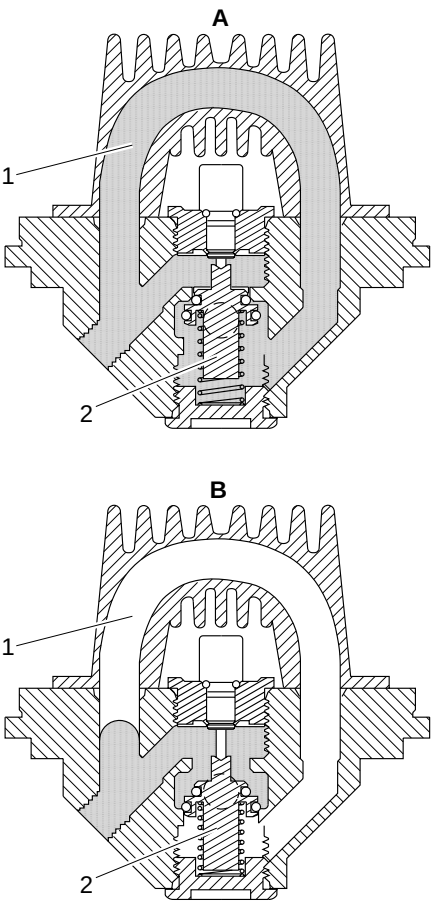
1. Fluid Port
2. Top of Thermovalve Spool

Fig. 4, Fluid Heat Thermovalve Test

fuel/water separator may have either a screw-assembled or locking-collar-assembled bottom plate.

- Locking-collar-assembled: Apply 2 to 3 drops of Loctite 406 to the bottom collar threads, then tighten 50 to 60 lbf·ft (68 to 81 N·m).
- Screw-assembled: 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
   - 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.



A. Fuel is Cold, Thermovalve Is Up
B. Fuel is Warm, Thermovalve is Down

1. Heater Loop
2. Thermovalve

Fig. 5, Heat Exchanger Fluid Flow

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.

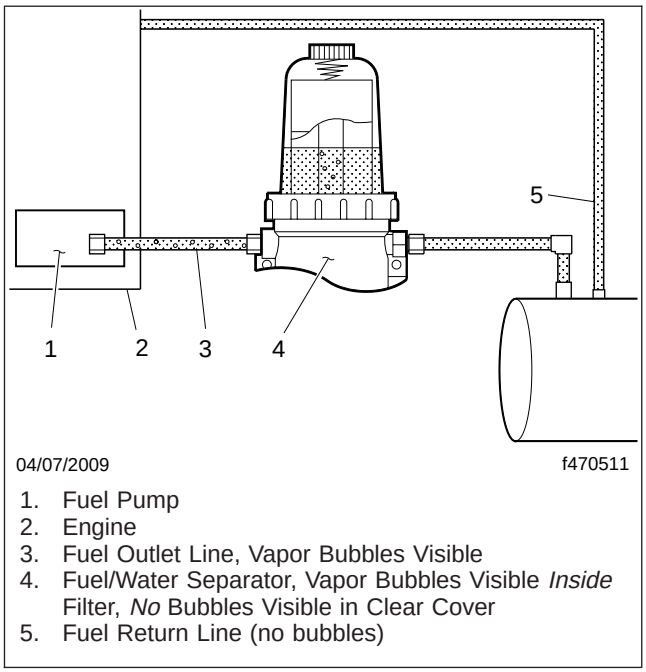
Identifying Bubble Types

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.



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

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.

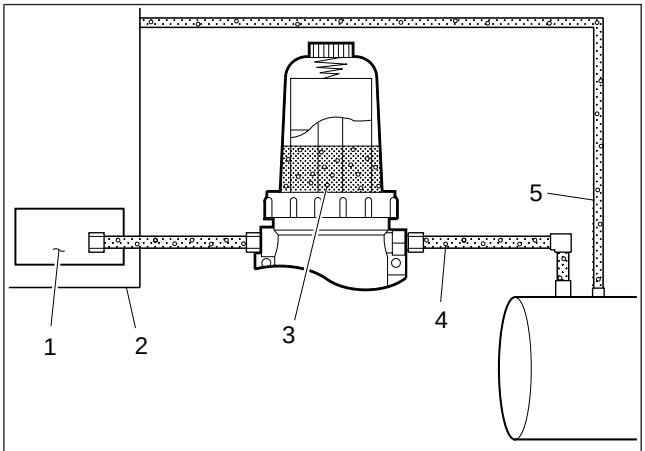
Air bubbles visible in the clear cover of a DAVCO fuel/water separator may indicate an air leak in the fuel system upstream of the bubbles, or in the fuel/water separator; see **Fig. 2**. If there are no bubbles visible in the clear cover but the engine runs rough, there may be an air leak at or between the fuel/water separator outlet port and the fuel pump inlet. These 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.
5. If the fuel level has risen to the top of the filter, replace the filter.

NOTE: A DAVCO fuel/water separator, properly assembled with the rubber grommet in the bottom of the fuel filter, does not restrict fuel flow until the fuel level has risen to the top of the filter.

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 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.

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 teflon pipe thread sealant, and reconnect the fuel connections and tighten them securely.

Air Pressure Testing

⚠ WARNING

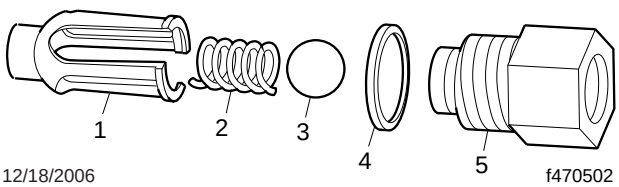
Wear goggles and skin protection when pressure-testing a fuel/water separator, and be careful not to perform this test near a source of possible ignition, such as an open flame. Never exceed the maximum pressure stipulated for the test, and do not perform this test if the clear cover appears to be damaged.

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 and open the drain valve to drain the fuel completely, then close the drain valve.
4. Remove the fuel/water separator from the chassis. For instructions, see **Subject 100**.
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 a leak is found, repair the fuel/water separator as needed.
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.
10. If no bubbles appear, the air leak is not in the fuel/water separator.

Check Valve Operation Test

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 (Diesel Pro® units only)
5. Check Valve Body

Fig. 3, Check Valve Assembly

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.

1. Shut down the engine, apply the parking brake, and chock the tires.

Troubleshooting

⚠ 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.

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 and open the drain valve to drain the fuel completely, 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 120**.
7. If the valve body and ball seat are not damaged, clean the threads on the check valve body, fuel inlet fitting, and the water separator housing.
8. Apply a teflon 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 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.

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.
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.

Conditions Visible Inside DAVCO Clear Filter Covers		
If You See:	**What to Do:**	**Comments:**
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 separtor outlet port and the fuel pump inlet. Check and tighten all fuel fittings in the area of the leak.	—
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

Specifications

Torque Values				
Component	Fuel Pro 382		Fuel Pro 482	
	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 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:

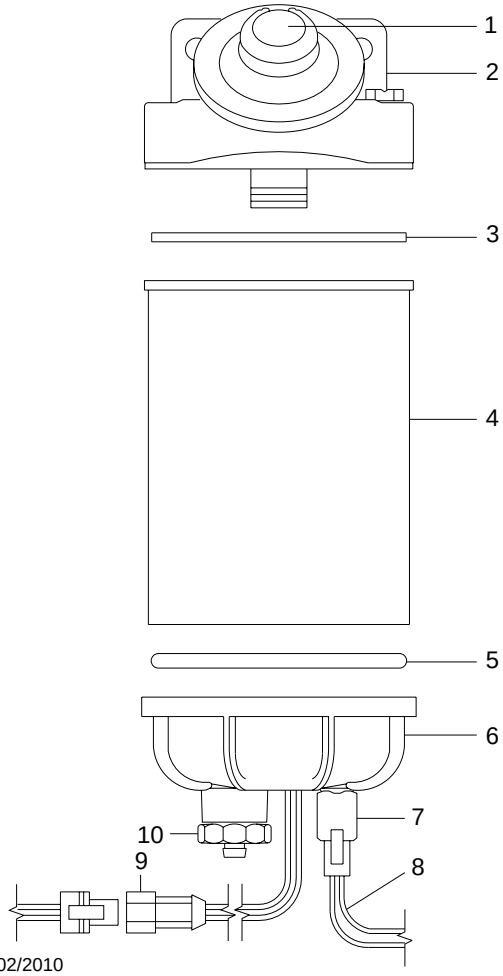
- Ignition-controlled heater to melt ice and wax in the fuel
- Water sensor probe to alert the operator to drain the sight bowl
- Manual priming pump to easily prime the fuel/water separator

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

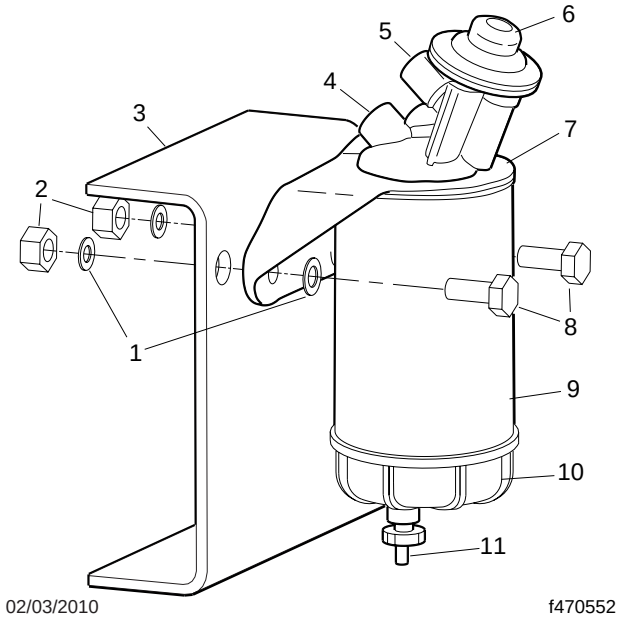
1. Shut down the engine, apply the parking brake, and chock the tires.

   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.

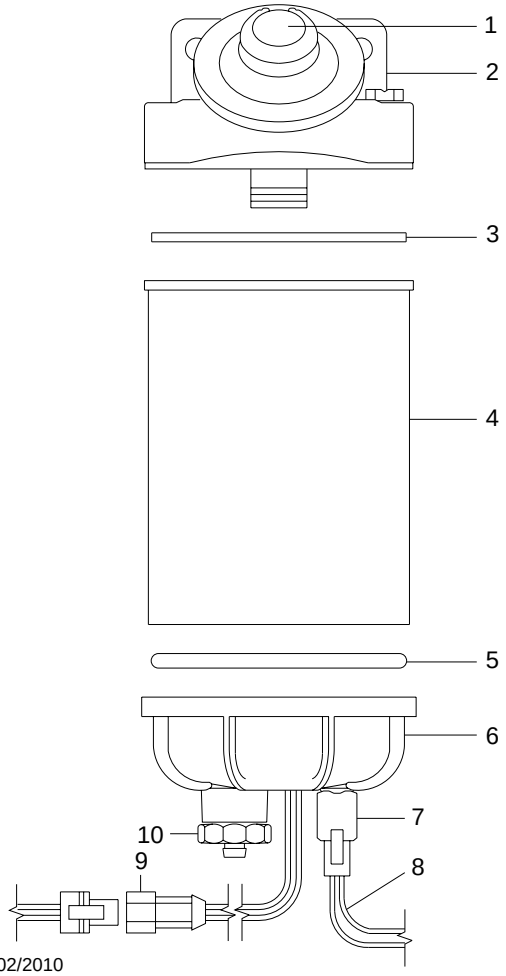
3. Turn the drain plug counterclockwise to open it. If equipped, operate the pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

⚠ 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.

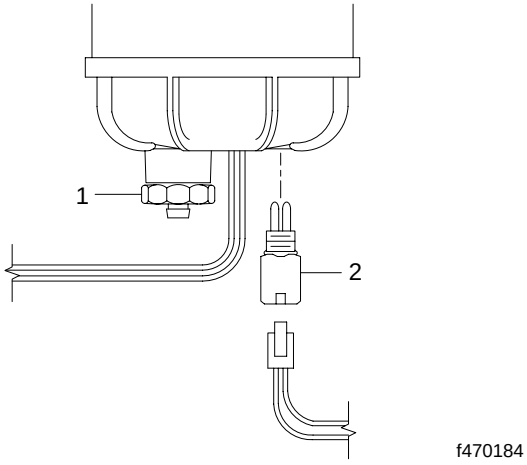
IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

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.

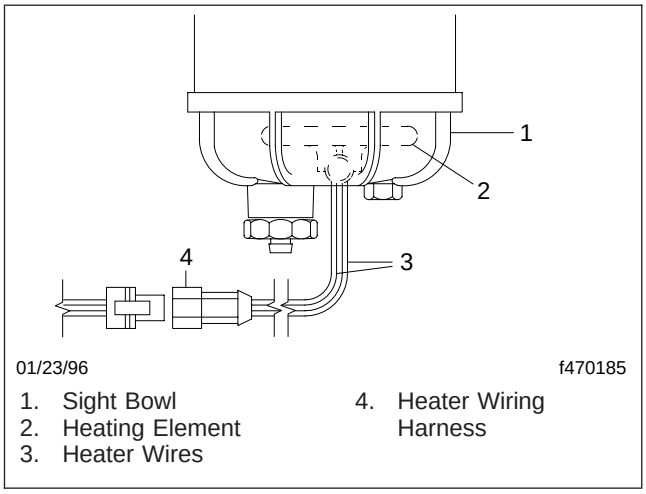
5. If equipped, disconnect the wiring harness from the water sensor probe. See **Fig. 1**.



1. Drain Plug
2. Water Sensor Probe

Fig. 1, Water Sensor Probe

6. Disconnect the heater wiring harness. See **Fig. 2**.



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.

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**.

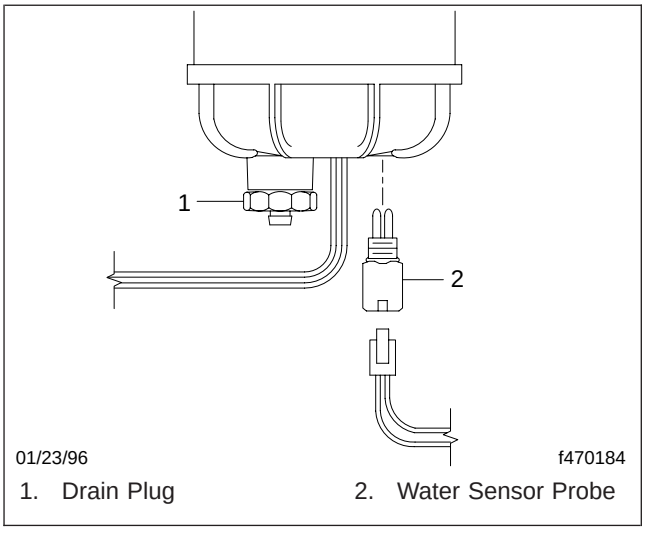


Fig. 1, Water Sensor Probe

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 Description

IMPORTANT: The liquefied natural gas (LNG) fuel system should be routinely inspected for gas leakage. Always use a natural gas detector, or an approved bubble solution, to check the fuel tank, fuel filtering and regulating mechanisms, and fuel lines. Repair or replace any lines, devices, or connections that are leaking.

LNG is created by condensing natural gas into a liquid by cooling it to approximately -259°F (-162°C). When vaporized at ambient temperatures, natural gas is less dense than air, and it will rise and disperse. Cold atmospheric conditions may prevent natural gas from disbursing quickly when released in large amounts.

Natural gas is nontoxic, but can cause asphyxiation at high enough concentrations simply by excluding adequate oxygen to sustain life.

For natural gas to burn, it must first vaporize, then mix with air in the proper proportions (flammable range is 5 to 15% by volume in air), and then be ignited.

The LNG fuel system consists of:

- A fuel tank that stores LNG at an extremely low temperature
- Pressure relief and manual fuel shutoff valves
- A vaporizer or heat exchanging device that changes LNG to gaseous form
- A filling connection with a check valve that prevents the gas from flowing back out of the fuel filling line
- A pressure control regulator that reduces the high fuel tank pressure to the lower pressure needed for the engine
- A gas-air mixer to produce a flammable mixture for the engine
- An economizer, or pressure control regulator, that opens at pressures above 120 psi (827 kPa) to reduce pressure in the fuel tank
- A dash-mounted fuel contents gauge that indicates the fuel supply in the tank

If a natural-gas-fueled vehicle is involved in an accident and the fuel tank is damaged, remove the tank from service and have it inspected and repaired by the tank manufacturer. Repair or replace any damaged or leaking fuel lines, fittings, or other components. Install parts and components in accordance with the manufacturer's instructions.

Related Information and Websites

Detailed LNG fuel system component repair, replacement, troubleshooting and safety information can be obtained from the following websites:

www.agilityfs.com.

Agility Fuel Systems
1815 E. Carnegie Ave.
Santa Ana, CA 92705
1-949-267-7738

www.westport.com.

Westport Global Headquarters
1750 West 75th Avenue, Suite 101
Vancouver, British Columbia, Canada V6P 6G2T
+1-604-718-2000

The National Fire Protection Association website provides additional information about LNG fuel systems: **www.nfpa.org**

Safety Precautions

⚠ DANGER

Natural gas vapors are highly flammable. Failure to observe the following safety precautions could lead to ignition of the natural gas, which could cause serious bodily injury or death.

⚠ WARNING

LNG is extremely cold, -200 to -240°F (-129 to -151 °C). Failure to use proper handling equipment and protective clothing may lead to cryogenic burns.

Liquefied natural gas (LNG) vapors are highly flammable. Whenever a leak is suspected, immediately shut off all engines and ignition sources. Avoid causing sparks, and stay away from arcing switches and equipment. Extinguish cigarettes, pilot lights, flames, and other sources of ignition in the area and adjacent areas. Immediately provide extra ventilation to the area. Do not start any equipment until the gas leak is corrected and the area cleared of LNG.

Natural gas is nontoxic, but can cause asphyxiation at high enough concentrations simply by excluding adequate oxygen to sustain life.

Periodic inspections of the LNG tank are required by law to ensure continued safety. Each fuel tank should be visually inspected at specified intervals for external damage and deterioration. See the vehicle *Maintenance Manual* for inspection schedule information.

If a tank receives an impact, or has deep scratches or gouges, it should be inspected before refilling. The inspection should be performed by a qualified person, in accordance with the tank manufacturer's established inspection criteria.

Always use a natural gas detector to test the system for leaks, whether an odor is present or not. A bubble solution can be used to pinpoint the exact location of leaks.

Servicing Precautions

Observe the following safety precautions when servicing LNG-powered vehicles:

- Depending on the type of service being preformed, do one of the following before proceeding.
  - Completely purge the fuel tanks and lines,

    The system can be purged by either transferring LNG in the fuel tank to an approved cryogenic rated container, or by running the vehicle until the tank is empty and the engine stops. Or,
  - Close the fuel tank shutoff valves and bleed the lines as needed before performing maintenance or repairs on the fuel system.

    Open the valves only if LNG is needed to operate the engine or to check for leaks.
- Repair work on an LNG fuel system should be performed only by qualified technicians trained in automotive LNG system repair.
- Always tighten fasteners and fuel connections to the required torque specification. Overtightening or undertightening could cause leaks.
- Cover eyes and exposed skin with cryogenic-rated protective devices when working on the fuel system or fueling the vehicle.

Workshop Precautions

Do not store an LNG vehicle indoors for any extended period of time. The LNG system will vent any excess pressure due to the heating and expanding of the LNG in the tanks.

Observe the following safety precautions when LNG vehicles are inside a workshop:

- Use only safety fluorescent extension shop lights when working around LNG fuel systems.
- Ensure the shop ceiling is equipped with a vent system that will allow gas to escape and dissipate.
- Ensure the shop is equipped with an alarm system that activates when gas concentration in the air becomes dangerous.
- Have CO_2 fire extinguishers (ABC minimum) located in a highly visible and easily accessible location.
- Permit no smoking or other ignition sources within thirty feet of an LNG vehicle.

- Avoid open flames or sparks near an LNG vehicle.
- Check the fuel tank pressure gauge periodically to ensure that pressure is within the normal range of 120 to 150 psi (827 to 1034 kPa). If the tank pressure exceeds 150 psi (1034 kPa) move vehicle outdoors. In the unlikely event that tank pressure exceeds 230 psi (1586 kPa) and the pressure relief valve does not open automatically, vent the tank outdoors immediately.

Major Repair and Replacement of Parts

If a natural-gas-fueled vehicle is involved in an accident, remove the fuel tank from service and have it inspected by a qualified technician. Replace any leaking or damaged fuel tanks and fuel lines; repair or replace leaking or damaged fittings. Install parts and components in accordance with the manufacturer's instructions.

Any and all replacement parts (valves, fittings, tubing, etc.) of the LNG fuel system must be designed specifically for LNG use, and must be approved for use by the fuel system manufacturer.

Install parts and components in accordance with the fuel system manufacturer's instructions.

Gas Detection System

A gas detection system is included on all Daimler trucks with factory installed LNG-fuel systems. The system has sensors located in the cab overhead console (zone 1), in the engine compartment on the frontwall (zone 2), and in the sleeper (zone 3) (if equipped); all of the sensors are situated in high areas to detect natural gas buildup as a result of leaks. The system is meant to serve as a supplemental warning only. It is not intended to replace standard safety practices that should be conducted around flammable gases.

IMPORTANT: To function properly, the gas detection system must be powered at all times. The gas detection system is directly powered by the batteries, and can only be powered off by disconnecting the batteries. When servicing a natural-gas-fueled vehicle, disconnect the batteries only when necessary, and do not leave the batteries disconnected for extended periods of time.

De-Fueling

⚠ WARNING

Liquefied natural gas (LNG) vapors are highly flammable. Refer to the safety precautions listed in Subject 100 before servicing the vehicle. Failure to observe these precautions could lead to ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

IMPORTANT: Follow all local, state, and federal guidelines regarding usage and venting of LNG.

Purging the fuel system and fuel tank can be done by either transferring LNG in the fuel tank to an approved cryogenic-rated container, or by running the vehicle until the tank is empty and the engine stops.

Detailed LNG tank de-fueling information and procedures can be obtained from the fuel system manufacturer: **www.nexgenfueling.com**.

Chart Inc.
1300 Airport Drive
Ball Ground, GA 30107
770-479-6531

Tank Filling

Tank filling can only be done at a certified facility.

IMPORTANT: Close all windows and doors during the fueling process. Keeping windows and doors closed allows for easier leak detection inside the cab after fueling.

1. Remove the fuel fill fitting dust cap. See **Fig. 1**.
2. Using compressed nitrogen or a wire brush, remove any dirt, debris, or water that may have collected in the fuel fill fitting and the station dispensing nozzle.
3. Connect the station fueling nozzle to the tank fuel fill fitting.
4. Connect an electrical ground clamp and cable to the fuel tank.

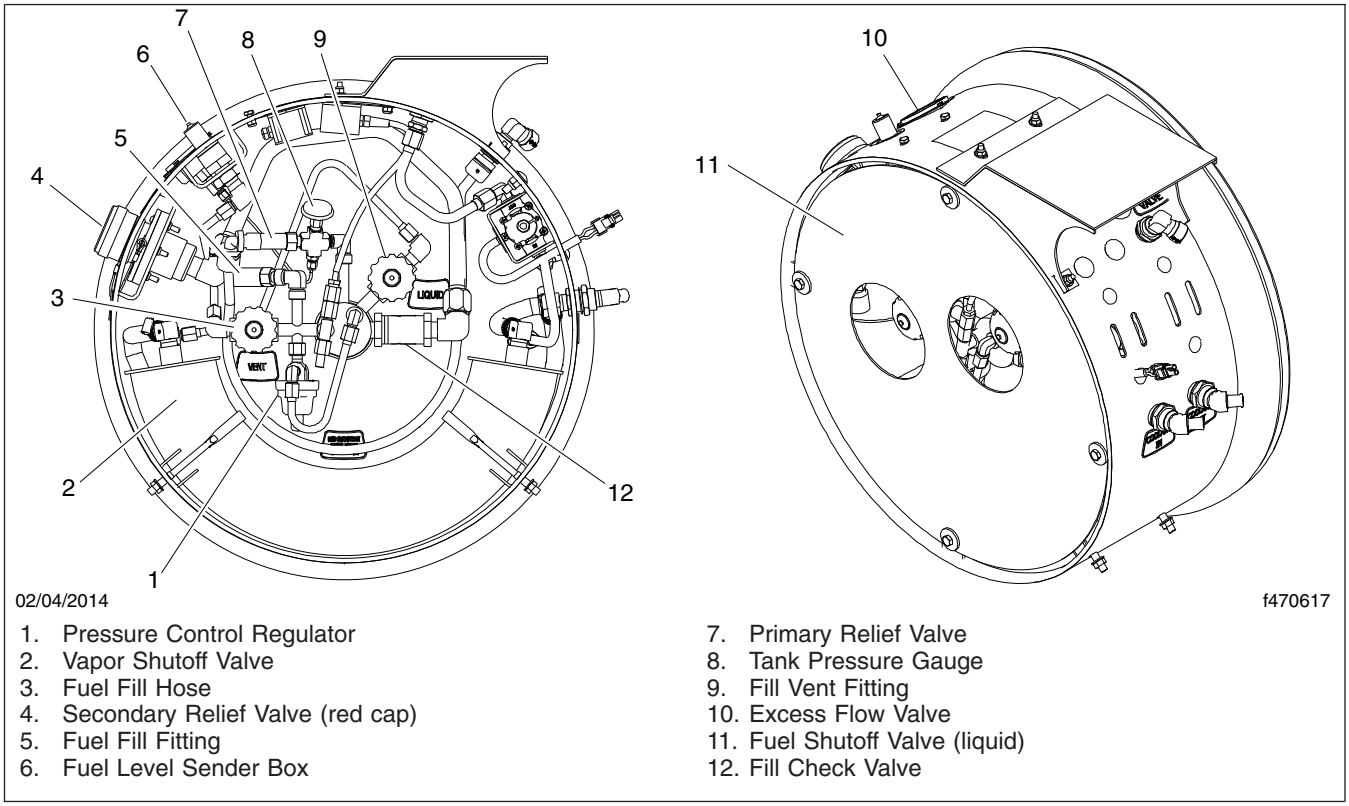
IMPORTANT: An LNG tank on a vehicle that has not been operated in approximately ten days may have had all the LNG fuel vented out of the tank. This tank state is called a "hot tank." When fueling a hot tank, LNG entering the tank will immediately vaporize, causing tank pressure to spike above 250 psi (1724 kPa) and automatically shutting down the station fuel pump. To prevent the pump from shutting down, connect a vent line to the fill vent fitting to capture escaping vapor, then open the shroud cover and open the vapor shutoff valve.

5. Open the station's fill valve, if equipped, and start fueling. Monitor the flow or line pressure as filling progresses.

IMPORTANT: When fueling a hot tank, initially put 5 to 10 gallons (19 to 37 liters) of LNG in the tank and manually stop the fueling process. Drive the vehicle for 15 to 20 minutes to cool the tank and reduce tank pressure, then continue fueling the tank to full.

6. When a rapid pressure rise or flow rate drop is observed, close the station's fill valve, if equipped.
7. Disconnect the station hose from the tank fuel fill fitting.
8. Disconnect the electrical ground clamp and cable from the fuel tank.
9. Install the dust cap on the tank fuel fill fitting.

Tank De-Fueling and Filling



1. Pressure Control Regulator
2. Vapor Shutoff Valve
3. Fuel Fill Hose
4. Secondary Relief Valve (red cap)
5. Fuel Fill Fitting
6. Fuel Level Sender Box
7. Primary Relief Valve
8. Tank Pressure Gauge
9. Fill Vent Fitting
10. Excess Flow Valve
11. Fuel Shutoff Valve (liquid)
12. Fill Check Valve

Fig. 1, LNG Fuel Tank

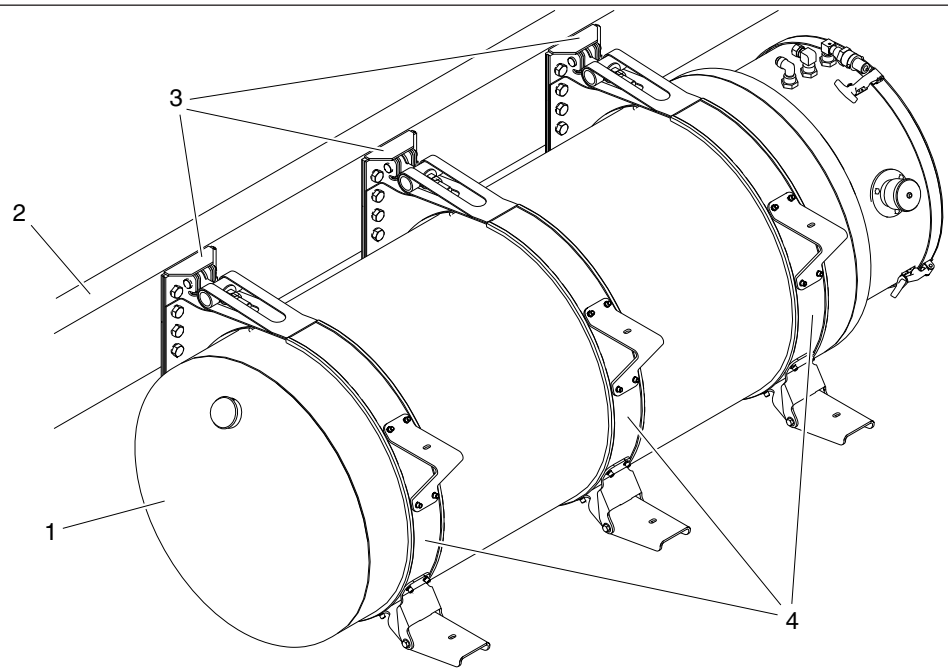
Removal

If there is any damage to the liquid natural gas (LNG) tank, replace 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.

Figure 1 shows a typical LNG tank installation.



1. LNG Tank
2. Frame Rail
3. Tank Mounting Bracket
4. Tank Straps

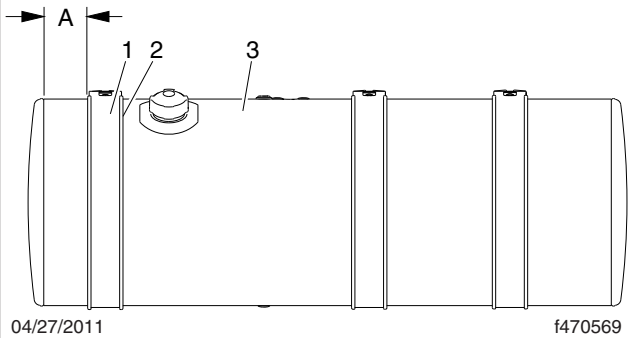
Fig. 1, LNG Tank Installation (left side shown)

1. Remove the access steps as needed.
2. Close the fuel shutoff valve on tanks that are not being removed.
3. De-fuel the tank to be removed. For more information, see **Subject 110**.
4. Disconnect the fuel lines from the tank. Cap or plug the open lines and fittings to prevent contamination.
5. Disconnect the electrical connectors from the tank.
6. Before removing the fuel tank bands, measure and record the distance from the forward edge of the fuel tank to the edge of the forwardmost band isolator. See **Fig. 2**.
7. To prevent the fuel tank from rolling during and after removal, nail 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. 3**.

   Move the fork lift and pallet into place to support the fuel tank.
8. Loosen the jam nut on each tank band eye bolt. Remove the jam nut, inner hexnut, and washer. See **Fig. 4**.

   Drop the tank bands and isolators. Leave the tensioner lug inside the band.
9. Remove the fuel tank.

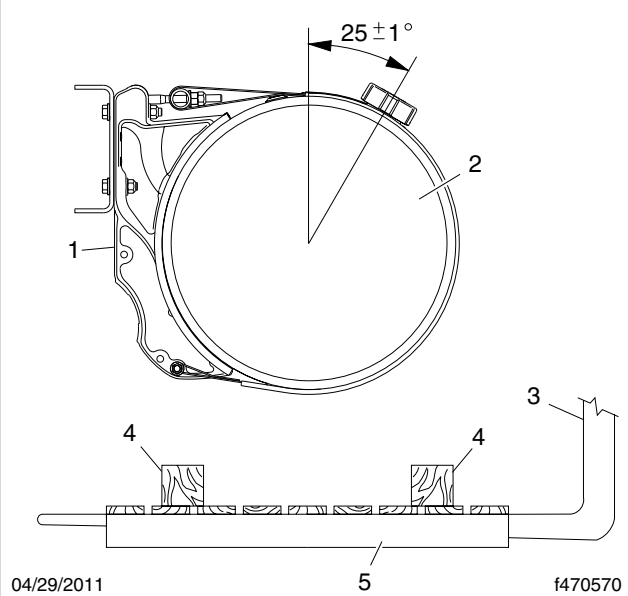
Tank Removal and Installation



A. Measure this distance.

1. Tank Band
2. Tank Band Isolator
3. Fuel Tank

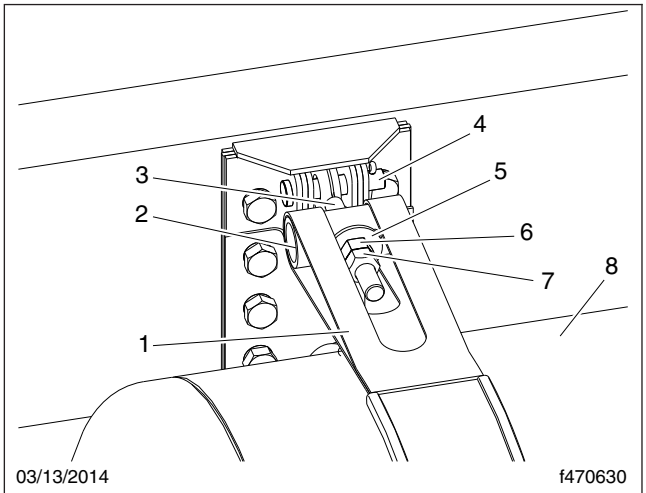
Fig. 2, Distance From Forward Edge of Fuel Tank to Isolator (diesel tank shown)



1. Fuel Tank Bracket
2. Fuel Tank
3. Fork Lift
4. Wooden Blocks
5. Wooden Pallet

Fig. 3, Fuel Tank Orientation and Support (diesel tank shown)

10. After removing the tank, inspect the tank bands, isolators, and brackets for damage. Replace worn or damaged parts with new parts.



1. Tank Strap
2. Tensioner Lug
3. Eye Bolt
4. Large Clevis Pin
5. Washer
6. Hexnut
7. Jam Nut
8. Fuel Tank

Fig. 4, Fuel Tank Band Assembly

Installation

1. Using the fork lift and pallet, put the fuel tank in its approximate installed position. See **Fig. 3**.
2. Install the forward tank band and band isolator loosely.
   - 2.1 Holding the tank on the forklift, attach the band and isolator to the eye bolt.
   - 2.2 Install a hardened flatwasher and the inner hexnut, but do not tighten it yet.
3. Adjust the tank position until the distance between the forward edge of the tank and the tank band is equal to the distance measured in **Fig. 2**.

NOTICE

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.

4. Install the other tank band around the tank. Insert the isolators under the brackets so that the relief in each isolator aligns with the tank longitudinal weld seam.

5. Tighten the inner hexnuts alternately in stages, until each is tightened 32 lbf·ft (44 N·m).
6. Install a jam nut on each hexnut, then tighten each jam nut 32 lbf·ft (44 N·m).
7. Make certain the fuel lines are clean, then install them on the fuel tank fittings.
8. Install the access steps.
9. Fill the fuel tank. For more information, see **Subject 110**.
10. Check for leaks. Repair as needed.

Welding

⚠ WARNING

Liquefied natural gas (LNG) vapors are highly flammable. Refer to the safety precautions listed in Subject 100 before servicing the vehicle. Failure to observe these precautions could lead to ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

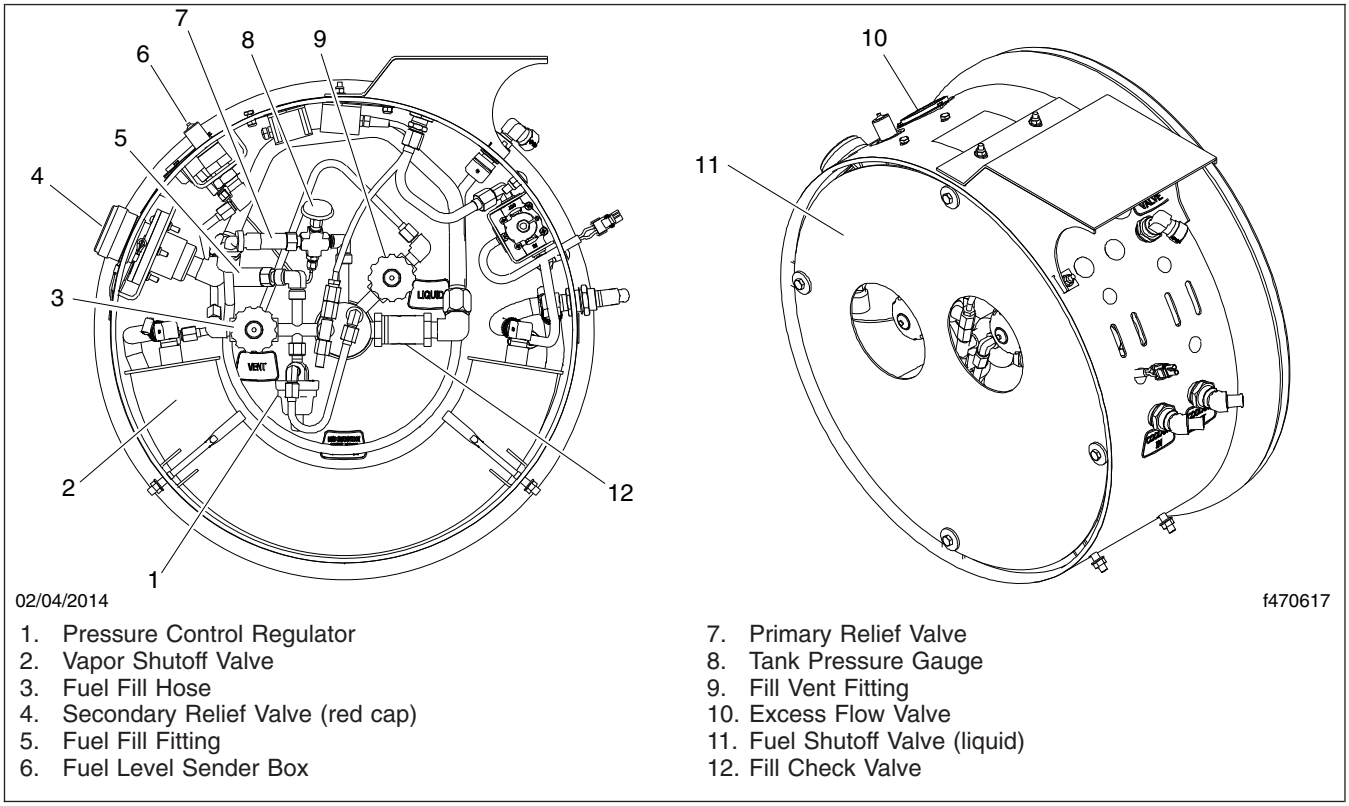
NOTICE

Welding an LNG fuel tank could damage the tank vacuum insulation and/or void the warranty. Consult the tank manufacturer (www.nexgenfueling-.com or 770-479-6531) before welding an LNG tank.

IMPORTANT: Follow all local, state, and federal guidelines regarding usage and venting of LNG.

1. Park the vehicle on a level surface, shut down the engine and set the parking brake. Chock the tires.
2. Ensure the vehicle is parked in a well-ventilated area. Do not park the vehicle in an area where natural gas can accumulate.
3. De-fuel the LNG tank. See **Subject 110** for more information.
4. Close the fuel shutoff and vapor shutoff valves. See **Fig. 1**.
5. Use a natural gas detector to test the area around the vehicle for natural gas.
6. Shut down all vehicle electrical systems.
7. Cover the LNG tank and fuel lines with a metal shield or welding blankets to prevent sparks or residue from falling on LNG equipment.
8. Complete all necessary welding, then remove the protective welding blankets or metal shield.
9. Start up the vehicle electrical systems.
10. Fill the LNG tank with fuel. For instructions, refer to **Subject 110**.
11. Open the fuel shutoff and vapor shutoff valves. See **Fig. 1**.

Welding an LNG Vehicle



1. Pressure Control Regulator
2. Vapor Shutoff Valve
3. Fuel Fill Hose
4. Secondary Relief Valve (red cap)
5. Fuel Fill Fitting
6. Fuel Level Sender Box
7. Primary Relief Valve
8. Tank Pressure Gauge
9. Fill Vent Fitting
10. Excess Flow Valve
11. Fuel Shutoff Valve (liquid)
12. Fill Check Valve

Fig. 1, LNG Tank Plumbing Components

General Description

IMPORTANT: The compressed natural gas (CNG) fuel system should be routinely inspected for gas leakage per the fuel management system (FMS) manufacturer's and the engine manufacturer's instructions. Use a natural gas detector to check fuel cylinders, fuel filtering and regulating mechanisms, and fuel lines. Replace or repair any component that is leaking per the manufacturer's procedures.

CNG is made by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. When vaporized at ambient temperatures, natural gas is less dense than air, and it will rise and disperse. Cold atmospheric conditions may prevent natural gas from disbursing quickly when released in large amounts.

Natural gas is nontoxic, but can cause asphyxiation at high enough concentrations simply by excluding adequate oxygen to sustain life.

Commercial CNG normally contains an odor-producing chemical. However, a natural gas detector, or an approved natural gas leak checking solution, is recommended for leak checking.

For natural gas to burn, it must first vaporize, then mix with air in the proper proportions (flammable range is 5 to 15% by volume in air), and then be ignited.

The CNG fuel system consists of:

- Fuel cylinders that store CNG at high pressure
- Pressure relief and manual fuel shutoff valves
- A filling connection with a check valve that prevents the gas from flowing back out of the fuel filling line
- A high-pressure fuel filter
- A pressure control regulator that reduces the high fuel cylinder pressure to the lower pressure needed for the engine
- A gas-air mixer to produce a flammable mixture for the engine
- A dash-mounted fuel contents gauge that indicates the available fuel supply in the cylinders

Related Information and Websites

Detailed CNG fuel system repair, replacement, and troubleshooting information can be obtained from the fuel system manufacturer.

Agility Fuel Systems
1815 E Carnegie Avenue
Santa Ana, CA 92705
949-267-7738

www.agilityfuelsystems.com

Agility Customer Support, 949-267-7745.

Information about Cummins CNG engines can be accessed at: Cummins Westport **http://www.cumminswestport.com**

The following documents and websites provide additional information about CNG and CNG fuel systems:

- NFPA 52 *Vehicular Gaseous Fuel Systems Code, 2010*: **www.nfpa.org**
- Society of Automotive Engineers *Recommended Practice for Compressed Natural Gas Vehicle Fuel*: **standards.sae.org/j1616_199402/**
- Compressed Gas Association: **www.cganet-.com**

Safety Precautions

⚠ WARNING

Compressed natural gas is highly flammable. Failure to observe the following precautions could lead to the ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

Whenever gas is smelled, immediately shut off all engines and ignition sources. Avoid causing sparks, and stay away from arcing switches and equipment. Extinguish cigarettes, pilot lights, flames, and other sources of ignition in the area and adjacent areas. Immediately provide extra ventilation to the area. Do not start any equipment until the gas leak is corrected and the area cleared of natural gas.

Periodic inspections of the compressed natural gas (CNG) fuel cylinders are required by law to ensure continued safety. Each fuel cylinder should be visually inspected at specified intervals for external damage and deterioration. See the *Cascadia Maintenance Manual* for inspection schedule information.

If the vehicle has an impact greater than 30 mph, of if a cylinder a cylinder receives an impact over five mph, or has deep scratches or gouges, it should be inspected before refilling. The inspection should be performed by a qualified person, in accordance with the manufacturer's established inspection criteria and Compressed Gas Association procedures.

Always use a natural gas detector or an approved natural gas leak checking solution to check for leaks.

Servicing Precautions

Observe the following safety precautions when servicing CNG-powered vehicles:

- Always purge the fuel lines before performing maintenance or repairs on a CNG fuel system. Do not transfer CNG from one vehicle to another without an appropriate natural gas transfer line, as a buildup of static electricity could cause a spark and ignite the fuel.
- Only vent CNG outdoors in a safe location.
- Close the fuel cylinder shutoff valves before performing maintenance and repairs. Open the valves only if CNG is needed to operate the engine or to check for leaks.
- Repair work on a CNG fuel system should be performed only by qualified technicians trained in automotive CNG system repair.
- Always tighten fasteners and fuel connections to the required torque specification. Overtightening or undertightening could cause leaks.
- Cover eyes and exposed skin when working on a CNG fuel system or fueling a CNG vehicle.

Workshop Precautions

Do not store a CNG vehicle indoors for any extended period of time.

Observe the following safety precautions when CNG vehicles are inside a workshop:

- Use only safety fluorescent extension shop lights.
- Ensure the shop ceiling is equipped with a vent system that will allow gas to escape and dissipate.
- Ensure the shop is equipped with an alarm system that activates when gas concentration in the air becomes dangerous.
- Have CO_2 fire extinguishers (ABC minimum) located in a highly visible and easily accessible location.
- Permit no smoking or other ignition sources within thirty feet of a CNG vehicle.
- Avoid open flames or sparks near a CNG vehicle.
- Close the fuel cylinder shutoff valves when storing the vehicle inside. Open the valves only if CNG is needed to operate the engine or to check for leaks.

Major Repair and Replacement of Parts

Replace any leaking or damaged fuel cylinders and fuel lines; repair or replace leaking or damaged fittings. Install parts and components in accordance with the manufacturer's instructions.

Any and all replacement parts (valves, fittings, hoses, etc.) of the CNG fuel system must be designed specifically for CNG automotive use, and must be offi-

cially approved and rated for the pressures and conditions that pertain.

Gas Detection System

A gas detection system is included on all Daimler Trucks CNG-fueled vehicles unless the customer specifically requests the system not be included. The system has sensors located in the cab overhead console (zone 1), in the engine compartment on the frontwall (zone 2), and in the sleeper (zone 3) (if equipped); all of the sensors are situated in high areas to detect natural gas buildup as a result of leaks. The system is meant to serve as a supplemental warning only. It is not intended to replace standard safety practices that should be conducted around flammable gases.

IMPORTANT: To function properly, the gas detection system must be powered at all times. The gas detection system is directly powered by the batteries, and can only be powered off by disconnecting the batteries. When servicing a natural-gas-fueled vehicle, disconnect the batteries only when necessary, and do not leave the batteries disconnected for extended periods of time.

Venting

⚠ WARNING

Compressed natural gas is highly flammable. Do not attempt to transfer compressed natural gas (CNG) from one vehicle to another with out an appropriate NG transfer line, as a buildup of static electricity could cause a spark and ignite the fuel, which could cause severe bodily injury, death, or property damage.

IMPORTANT: Only vent compressed natural gas (CNG) outdoors in a safe location.

The fuel cylinder shutoff valves are installed in line from top to bottom, and on the rear of the side mounted tanks. Closing a fuel cylinder shutoff valve will cut off the flow of CNG from that cylinder and all of the fuel cylinders positioned above it in the storage box.

Compressed natural gas can be vented from the fuel cylinders in two ways.

- Run the engine until it stops.
- Open the CNG bleed valve on the manifold.

If only one cylinder needs to be purged, close the fuel shutoff valves on the fuel cylinders positioned above it. Then, either run the engine until the cylinders are empty and the engine stops, or open the bleed valve and allow the CNG to vent. At this time, all CNG in the venting cylinder and the cylinders in line below it will have vented.

CNG System Depressurization and Pressurization

⚠ WARNING

Compressed natural gas is highly flammable. Refer to the safety precautions listed in Subject 100 before servicing the vehicle. Failure to observe these precautions could lead to the ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

Depressurization

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Turn the cylinder shut-off valves (one on each cylinder) clockwise to the “OFF/CLOSED” position. See **Fig. 1**.
3. Turn the manual shut off-valve to the “ON/OPEN” position. See **Fig. 2**.
4. Start the engine and run it until it stops.
5. Turn the ignition switch to "OFF".
6. Turn the manual shut off-valve to the “OFF/CLOSED” position. See **Fig. 2**.
7. Ensure that the proper vehicle lock-out procedures are followed.
8. Check the gauge on the fill panel to ensure that the system pressure is at or near zero. See **Fig. 2**.

NOTE: Some residual pressure will remain in parts of the system.

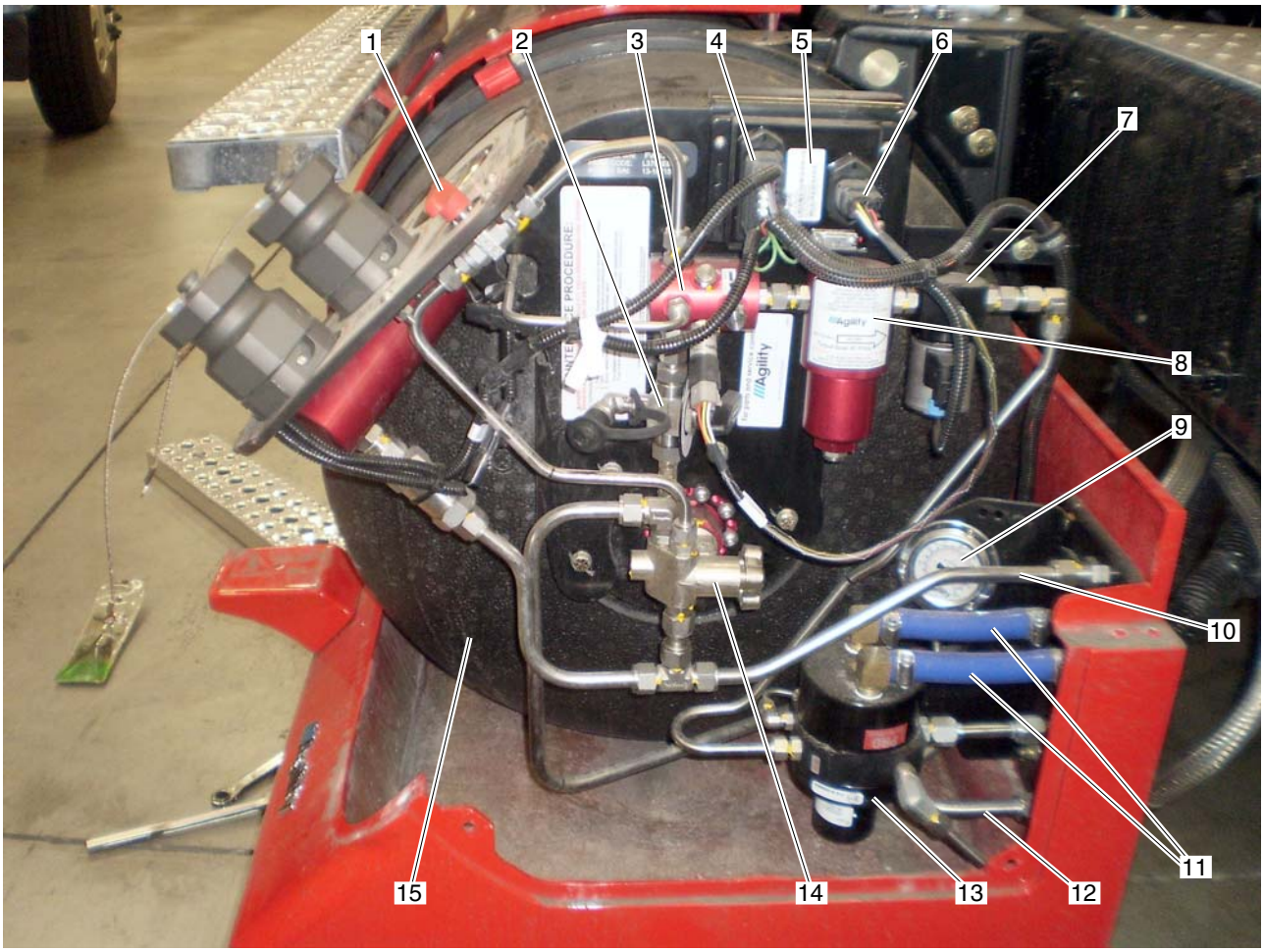
9. Relieve the remaining pressure by slowly opening the bleed valve (or, if so equipped, move the "Vent-Off-Defuel" valve to the "Vent" position), located inside the cover housing at the fuel management module (FMM). See **Fig. 1**. This vents pressure and gas into the atmosphere, so take appropriate safety precautions.

   The system is now depressurized up to the primary solenoid lock-off valve. There may be pressure remaining downstream of the solenoid valve. Be careful when loosening fittings for the first time because a small amount of gas may leak out of any fitting downstream of the solenoid lock-off valve. This is normal.

Pressurization

1. Ensure the ignition switch is turned to "OFF", and remove the keys from the ignition.
2. Close the bleed valve (or, if so equipped, move the "Vent-Off-Defuel" valve off the "Vent" position). See **Fig. 1**.
3. Turn the manual shut-off valve to the “ON/OPEN” position. See **Fig. 2**.
4. Slowly turn the cylinder shut-off valves (one on each cylinder) counterclockwise to the “ON/OPEN” position. See **Fig. 1**.
5. Start the engine.

CNG System Depressurization and Pressurization



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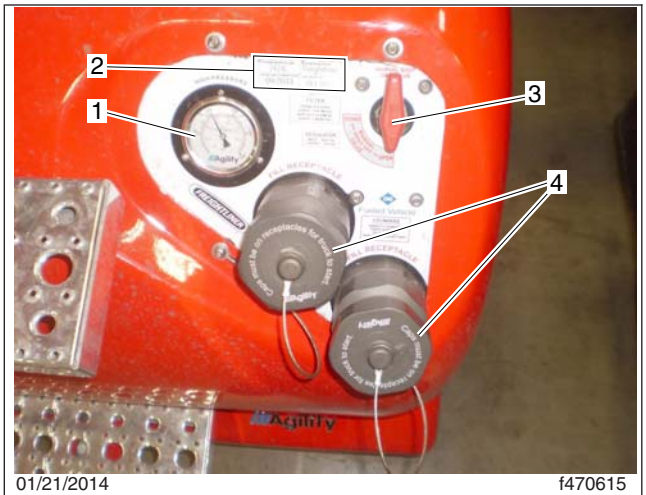
1. Manual Shut-Off Valve
2. Vent-Off-Defuel Valve
3. Manifold
4. ECU Connector
5. ECU
6. Fuel Level Sender Connector
7. Solenoid Valve
8. High-Pressure Filter
9. High-Pressure Gauge
10. Fuel Line to Other Tanks
11. Coolant Lines
12. Low-Pressure Fuel Line to Engine
13. Pressure Regulator
14. Cylinder Shut-Off Valve
15. CNG Tank

Fig. 1, CNG System Plumbing



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1. High-Pressure Gauge
2. Fuel Cylinder Information Sticker
3. Manual Shut-Off Valve
4. Fuel Fill Port

Fig. 2, Fill Panel (side tank shown)

CNG Fuel Tank Removal and Installation

⚠ WARNING

Compressed natural gas is highly flammable. Refer to the safety precautions listed in Subject 100 before servicing the vehicle. Failure to observe these precautions could lead to the ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

NOTE: The tanks can be removed with CNG present in the tanks. Tanks must be stored outdoors, or in an approved facility with proper ventilation, and a natural gas safety monitoring system.

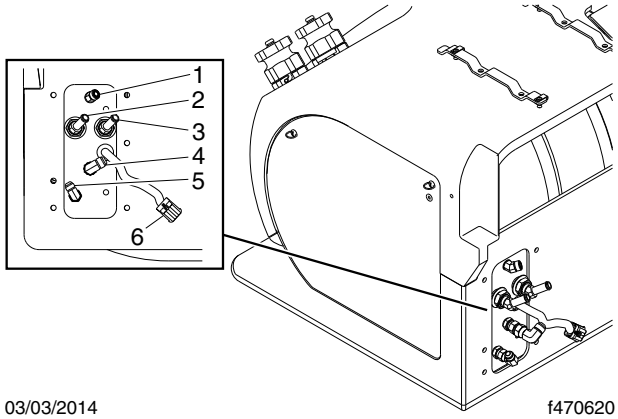
Frame-Rail-Mounted Tank Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Depressurize the CNG system. Follow the instructions in **Subject 120**.

IMPORTANT: Some residual pressure and gas from the low pressure side of the system may escape when loosening the fittings. Be prepared for this, and observe all safety precautions.

NOTE: Coolant hoses, CNG fuel lines, and wire harnesses are located on the bulkhead at the back of the left side tank assembly, on the inboard face near the fuel management module (FMM). See **Fig. 1**.

3. Disconnect the CNG fuel lines.
4. Cap or plug all open fuel lines and fittings to prevent system contamination.
5. Disconnect the vent line.
6. Disconnect the coolant hoses as follows.
   - 6.1 Crimp the rubber coolant hoses using the appropriate coolant hose crimping tools.
   - 6.2 Place a pan under the bulkhead to catch any coolant draining from the system when disconnecting the coolant hoses.
   - 6.3 Disconnect the coolant hoses.
   - 6.4 Cap or plug all open coolant fittings and hoses.
7. Disconnect the 8-pin wire harness.



1. High Pressure Fuel Connection
2. Coolant IN
3. Coolant OUT
4. Low Pressure Fuel Connection
5. Vent Stack
6. 8-Pin ECU Connector

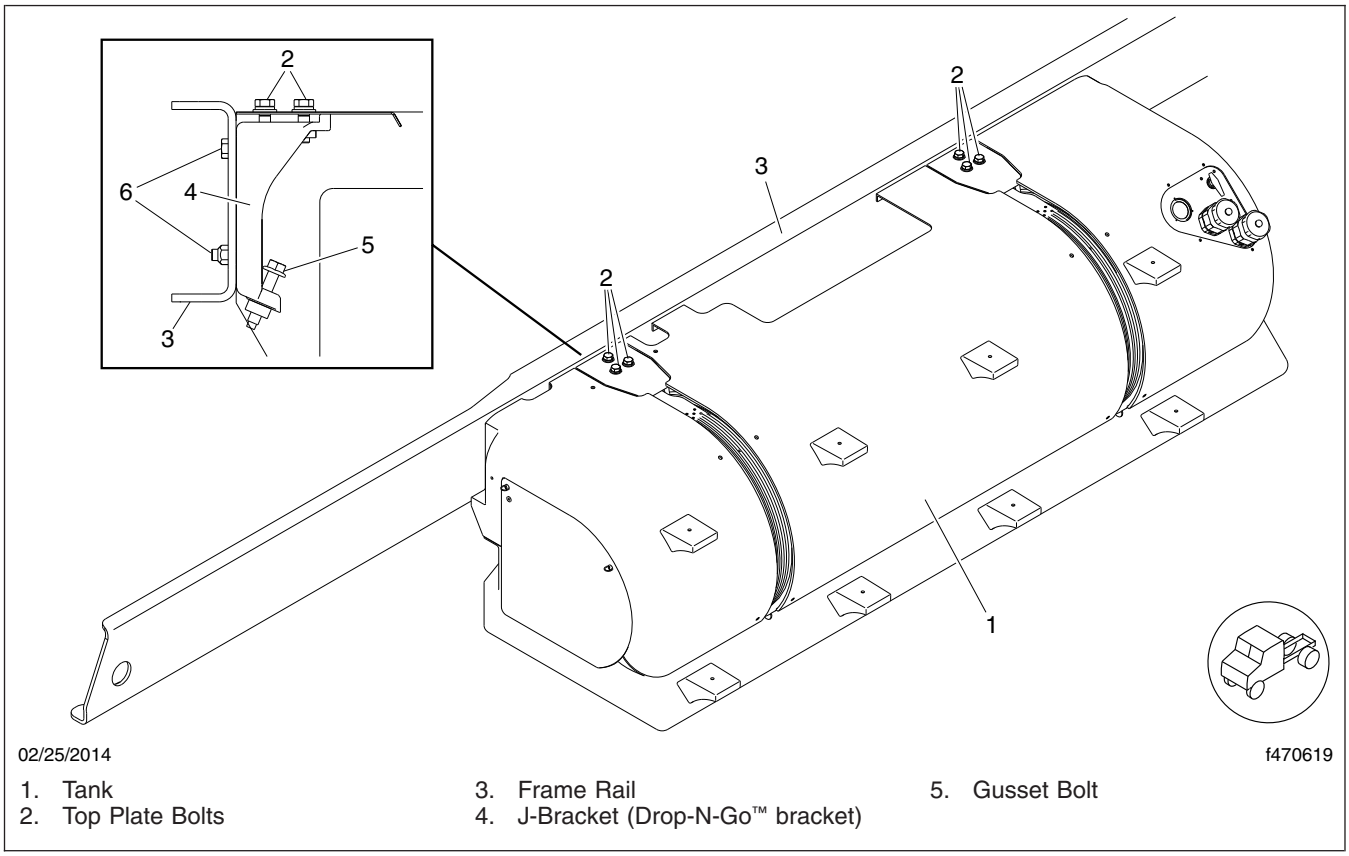
Fig. 1, Bulkhead Connections

NOTE: Each side-mounted tank has two Drop-N-Go™ brackets. This is a two-part subassembly. The first part mounts to the vehicle frame rail. The second part is a tapered, (P-shaped) bracket that mounts to the tank. See **Fig. 2**.

The Drop-N-Go bracket allows the tank assembly to "hang" on the chassis even when all fasteners are removed. A proper lifting device(s) should be positioned under the tank as a safety precaution.

8. Remove the two tank bracket top plates. See **Fig. 2**.
9. Position the lifting device under the tank.
10. Remove the gusset bolt. Access this bolt from the top, using a long extension bar to reach inside the cover assembly.
11. Using safe lifting procedures with a flat jack, forklift, etc., lift the tank up off the mounting pins, and out or backwards to clear the chassis.
12. Store the tank in a safe place.

CNG Fuel Tank Removal and Installation



1. Tank
2. Top Plate Bolts
3. Frame Rail
4. J-Bracket (Drop-N-Go™ bracket)
5. Gusset Bolt

Fig. 2, Frame-Rail-Mounted Tank Installation

Frame-Rail-Mounted Tank Installation

1. Using a proper lifting device, hang the tank on the Drop-N-Go brackets.
2. With the tank still supported with the lifting device, use a long extension bar to install the gusset bolt from the top. Tighten the gusset bolt 160 lbf·ft (217 N·m).
3. Remove the lifting device.
4. Install the two tank bracket top plates and tighten the bolts 160 lbf·ft (217 N·m).
5. Connect the coolant hoses.
6. Connect the CNG fuel lines. Tighten the fittings to the specifications shown in **Table 1**.

SAE Torque Specifications: O-Ring Boss Fittings	
Fitting Size	**Torque: lbf·ft (N·m)**
7/16-20	15 (20)
1/2-20	18 (24)
9/16-18	26 (35)
3/4-16	51 (69)
7/8-14	74 (100)
1-1/16-12	125 (169)

Table 1, SAE Torque Specifications: O-ring Boss Fittings

7. Connect the wiring harnesses.
8. Secure any mounting that was removed.
9. Pressurize the system. Follow the instructions in **Subject 120**.

10. Check for leeks per manufactures specifications. Repair any leaks as needed.

Back-of-Cab-Mounted Tank Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Depressurize the CNG system. Follow the instructions in **Subject 120**.

IMPORTANT: Some residual pressure and gas from the low pressure side of the system may escape when loosening the fittings. Be prepared for this, and observe all safety precautions.

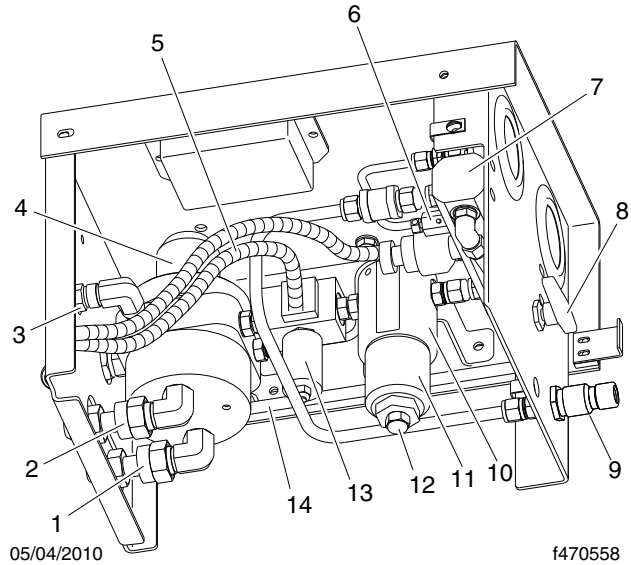
NOTE: The fuel management module (FMM), coolant hoses, natural gas fuel lines, and wire harnesses are located in the lower area of the cabinet on vehicles with only a back-of-cab installation. See **Fig. 3**.

On vehicles with side-mounted tanks, these components are located on the bulkhead at the back of the left-side mount tank assembly, near the FMM. See **Fig. 1**.

3. Disconnect CNG fuel lines.
4. Cap or plug all open fuel lines and fittings to prevent system contamination.
5. Position the lifting device as needed and connect the chain or sling to the eyelets on the top of the cabinet. Apply enough pressure to prevent the cabinet from tipping when loosened.
6. Remove the mounting bracket bolts. See **Fig. 4**.
7. Using safe lifting procedures with a forklift or hoist, lift the tank up off the frame rails and out or backwards to clear the chassis.

Back-of-Cab Mounted Tank Installation

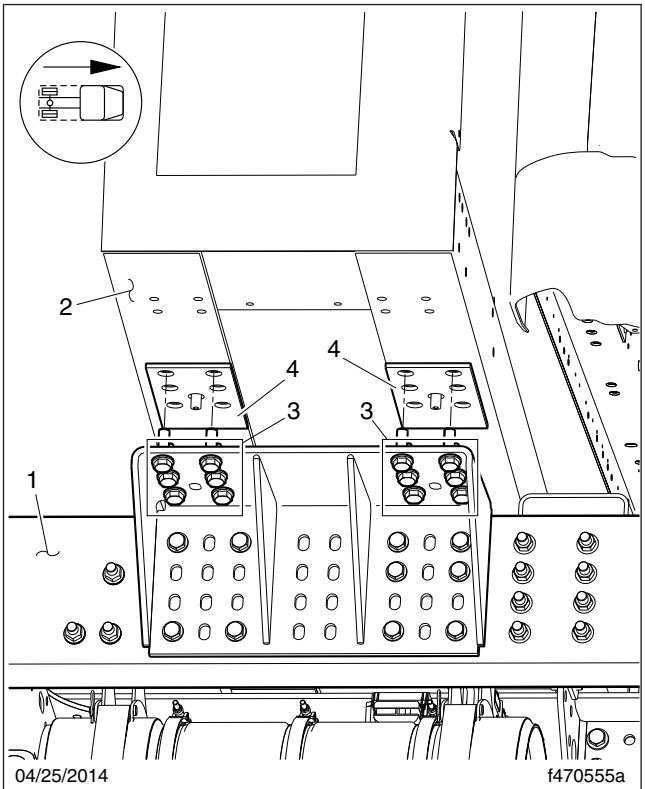
1. Position the rubber isolators on the mounting brackets.
2. Using an appropriate lifting device, position the cabinet on the frame rails and align the mounting bracket holes on the cabinet with the holes in the mounting brackets on the frame rails.
3. While still supported with the lifting device, install the mounting bolts, with washers, from the bottom, and install the washers and nuts from inside the cabinet. See **Fig. 4**.
4. Following the pattern shown in **Fig. 5**, sequentially tighten the bolts on each mounting bracket a minimum of three times, according to the following schedule.
   - 4.1 Tighten the bolts in the pattern shown 200 lbf·ft (270 N·m).
   - 4.2 Wait four hours.
   - 4.3 Tighten the bolts in the pattern shown 200 lbf·ft (270 N·m).
   - 4.4 Wait a minimum of four hours.



1. Coolant Inlet Port
2. Coolant Outlet Port
3. Pressure Relief Valve
4. Pressure Regulator
5. Wiring Harness
6. Manifold Bleed Valve
7. Manifold
8. Manual Fuel Shut-Off Valve
9. Fuel Fill Port
10. Filter Housing
11. Filter Bowl
12. Filter Drain Plug
13. Solenoid Valve
14. Fuel Line To Cylinders

Fig. 3, Back-of-Cab Plumbing and Wiring

CNG Fuel Tank Removal and Installation



1. Frame Rail
2. Cabinet
3. Mounting Bolts
4. Rubber Isolator

Fig. 4, Back-of-Cab Cabinet Installation

Fig. 5, Tightening Sequence (one side shown)

4.5 Tighten the bolts in the pattern shown 200 lbf·ft (270 N·m).

The minimum final torque after the rubber has settled is 159 lbf·ft (215 N·m).

5. Remove lifting device.
6. Connect the coolant hoses.
7. Connect the CNG fuel lines. Tighten the fittings to the specifications shown in **Table 1**.
8. Connect the wiring harnesses.
9. Secure any mounting that was removed.
10. Pressurize the system. Follow the instructions in **Subject 120**.
11. Check for leaks per manufactures specifications. Repair any leaks as needed.

⚠ WARNING

Compressed natural gas is highly flammable. Refer to the safety precautions listed in Subject 100 before servicing the vehicle. Failure to observe these precautions could lead to the ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

Welding

IMPORTANT: Follow all local, state, and federal guidelines regarding usage and venting of compressed natural gas (CNG).

1. Park the vehicle on a level surface, shut down the engine and set the parking brake. Chock the tires.
2. Depressurize the fuel system. Refer to **Subject 120**.

IMPORTANT: Some pressure may remain in the fuel system between the solenoid valve and the engine. Use caution when loosening fittings, as a small amount of gas may leak out.

3. Disconnect the wiring harness from the solenoid valve.
4. Use a remote 12-volt power source to activate the solenoid valve to drain any compressed natural gas remaining in the fuel system between the solenoid valve and the engine.

NOTICE

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 antilock braking system (ABS).

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.

5. Shut down all vehicle electrical systems and disconnect the battery.
6. Let the vehicle sit in a well-ventilated area for at least 10 minutes.

IMPORTANT: Do not weld in areas directly adjacent to CNG tanks. Avoid direct heat exposure on tanks.

7. Cover the CNG tanks and fuel lines with a metal shield or welding blankets to prevent sparks or residue from contacting CNG equipment.
8. Complete all necessary welding, then remove the protective welding blankets or metal shield.
9. Connect the electrical harness to the solenoid valve.
10. Start up the vehicle electrical system and connect the batteries.
11. Close the bleed valve on the manifold and open the manual fuel shutoff valve on the fuel panel.
12. Open the fuel cylinder shutoff valves.
13. Start the engine and check for gas leaks in the fuel system.

    Using a methane detector, or a an approved natural gas leak checking solution, leak test all fuel system components.

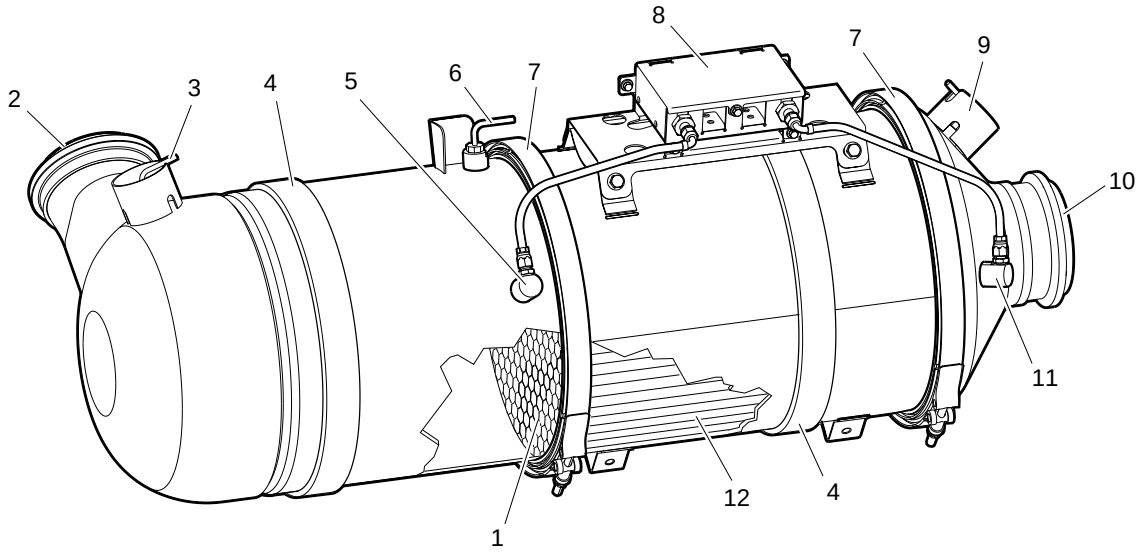
    Repair or replace any leaking components.
14. Install the access cover on the fill panel.

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).

ways 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 eventu-



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)

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 ally builds up, and the DPF must be removed and physically cleaned.

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

General Information

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.

NOTICE

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.

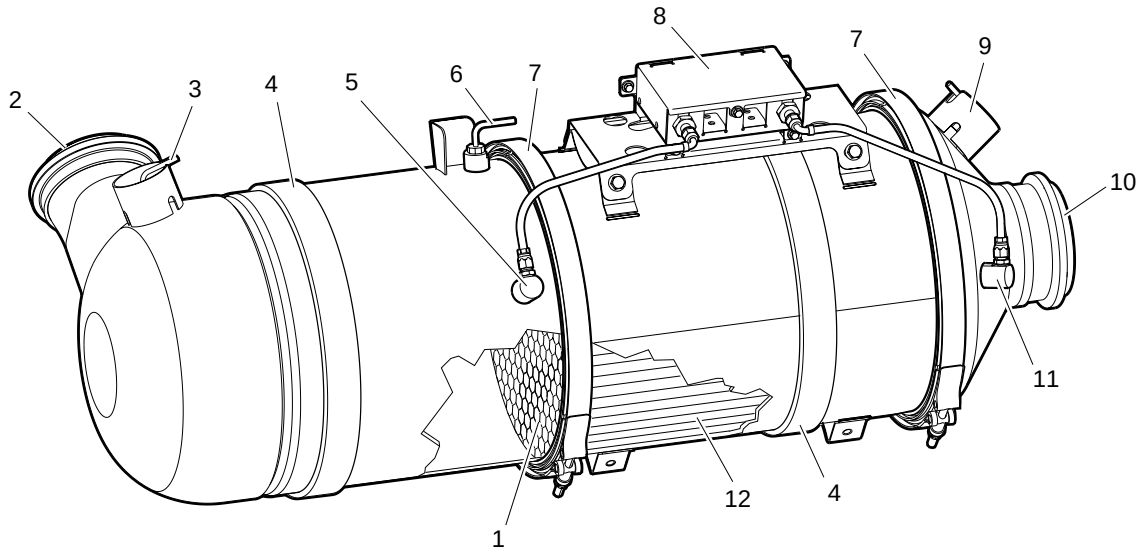
4. If the ATD is horizontally mounted, raise the ATD-handling device into place against it, so that the ATD is supported securely. If the ATD is vertically mounted, attach a shop crane or similar device to the lifting ears and take up the slack so that the lifting device is beginning to take the weight 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.

NOTICE

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.

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: It may be necessary to raise the vehicle, or remove heat shields or body panels, to remove the ATD.

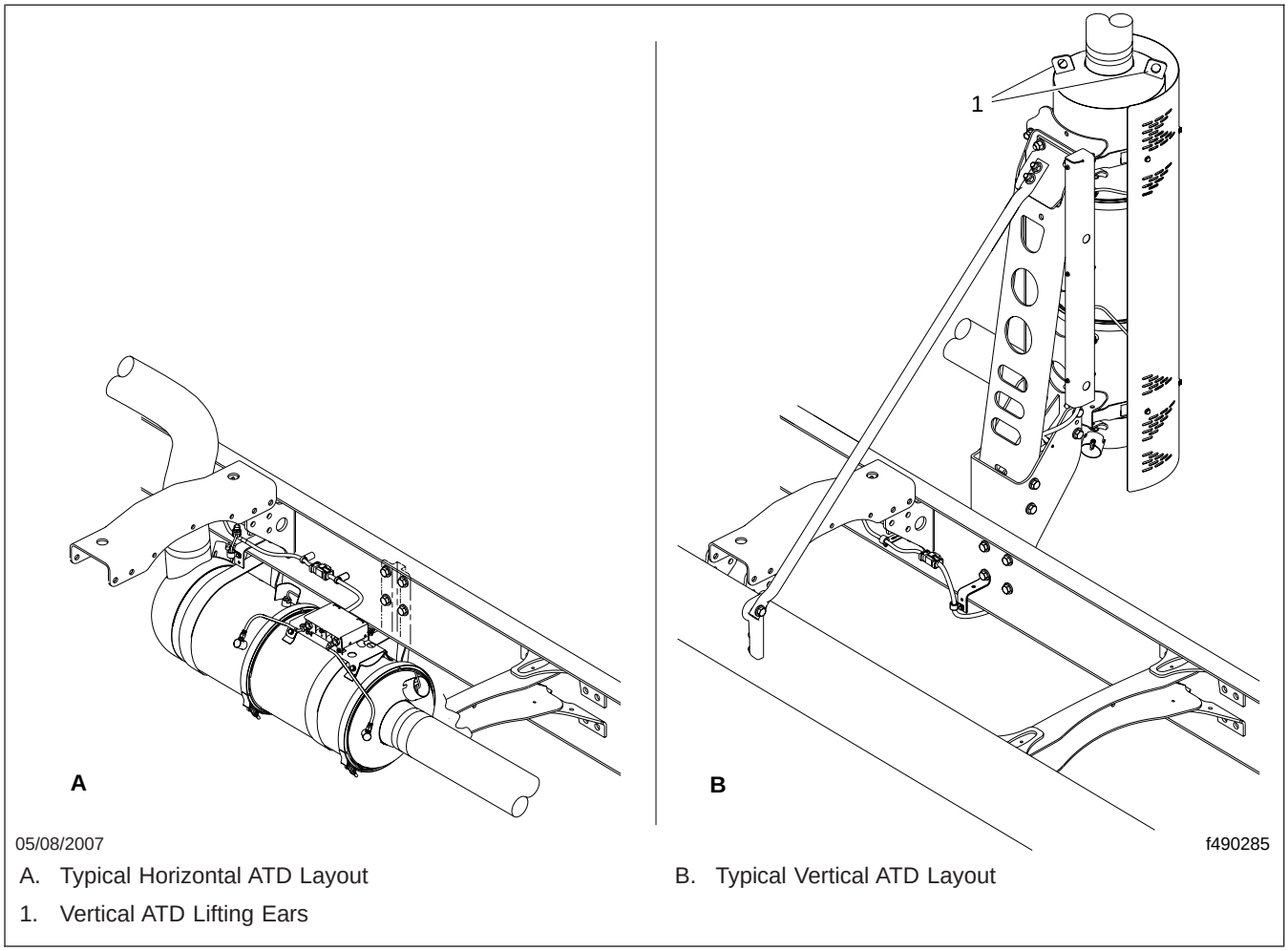
8. Move the ATD handling device slightly, so that the ATD positioning pin (see **Fig. 4**) clears its hole in the mounting bracket. Carefully remove the ATD from the vehicle.

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



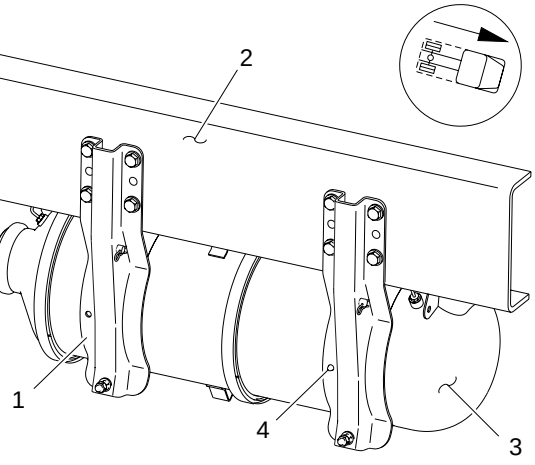
A. Typical Horizontal ATD Layout

B. Typical Vertical ATD Layout

1. Vertical ATD Lifting Ears

Fig. 2, ATD Mounting Options

EPA07 Aftertreatment Device Removal and Installation



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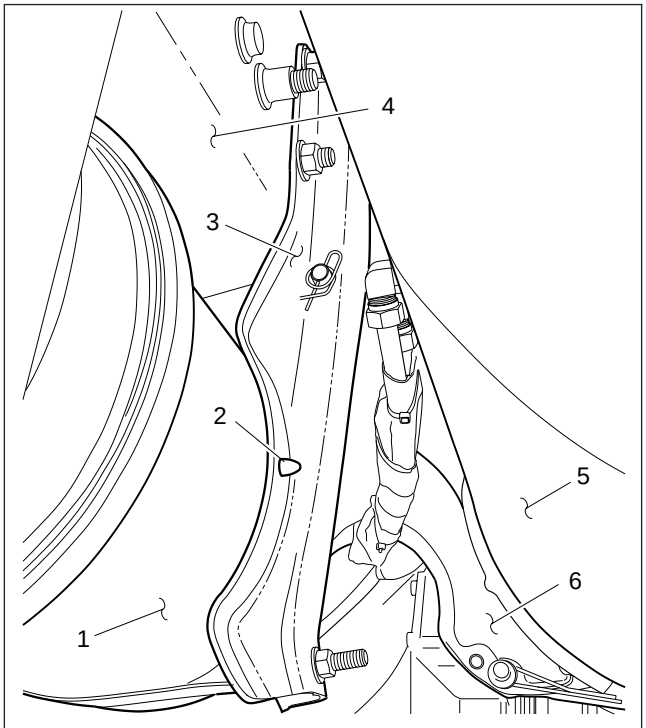
1. ATD Mounting Bracket
2. Chassis Frame Rail
3. ATD Inlet End
4. ATD Positioning Pin

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



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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

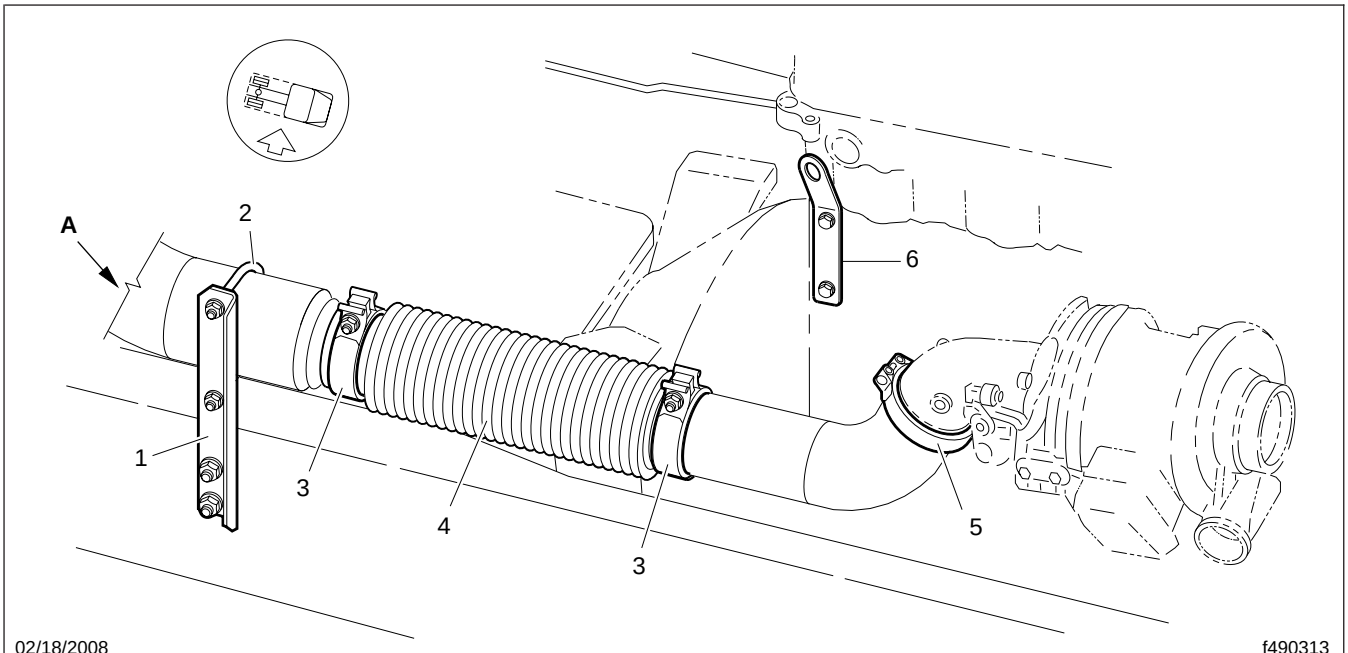
1. Open the hood.
2. Open the tool box under the passenger-side door, and remove the cover.
3. Remove the right quarter fender and mud flap. For instructions, see **Group 88**.
4. Remove the V-clamp (**Fig. 1**, Item 5) that holds the turbo outlet pipe to the turbocharger.
5. Remove the U-clamp that 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.

NOTICE

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**.

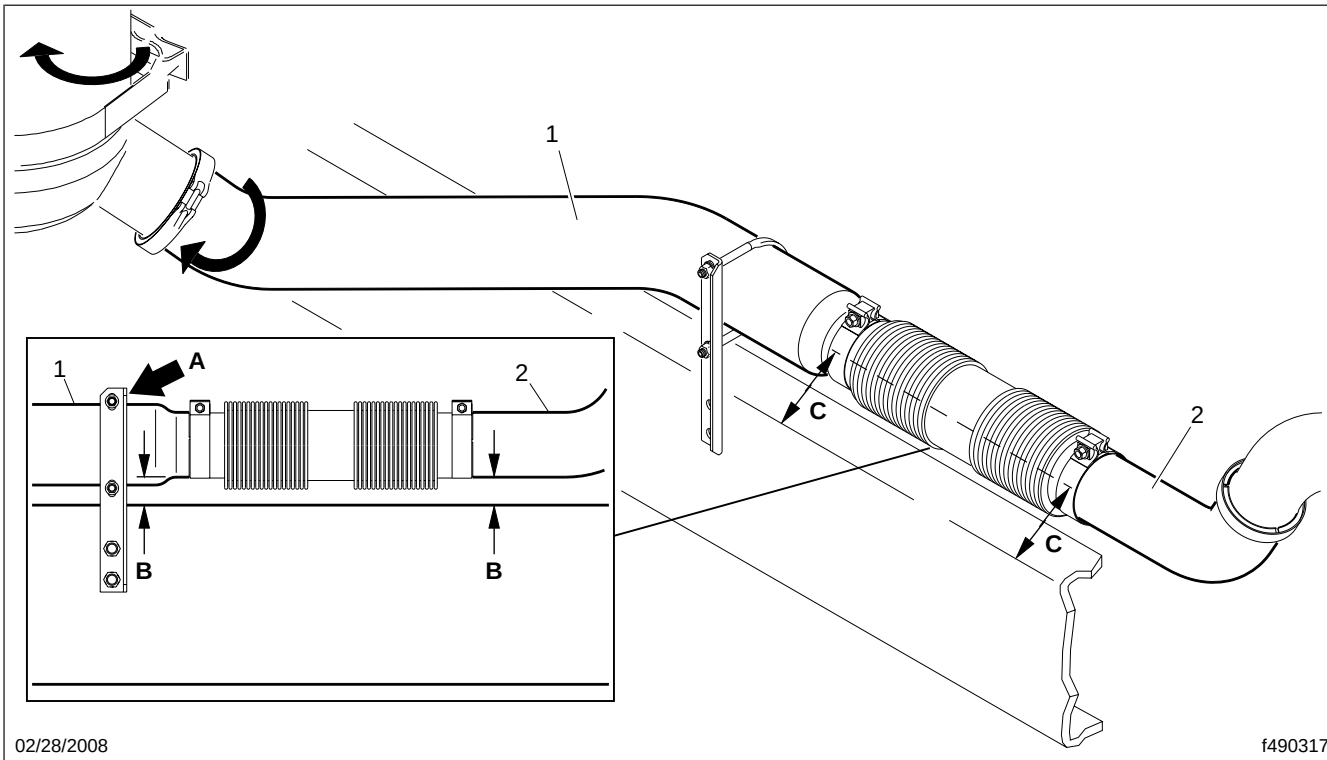
    The distance between the pipe ends is to be at least 14 inches (35.5 cm), but not more than 14-3/8 inches (36.5 cm).

    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.

EPA07 Aftertreatment System Bellows Replacement

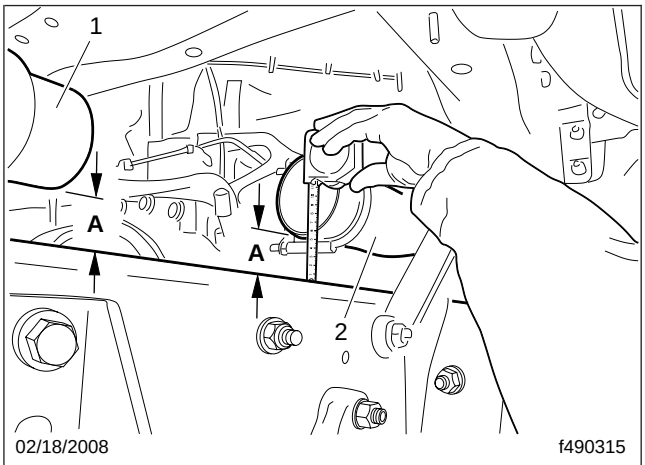


A. Up-and-down adjustment to be done at this bracket.
B. Vertical measurements to be the same.
C. Horizontal (in-and-out) measurements to be the same.
1. ATD Inlet Pipe
2. Turbo Outlet Pipe (support bracket not shown)

Fig. 2, Rotation and Adjustment Areas for Exhaust Pipe alignment (vertical ATD installation shown)

24. Start the engine and check for leaks. Shut down the engine, and tighten any clamps as needed.

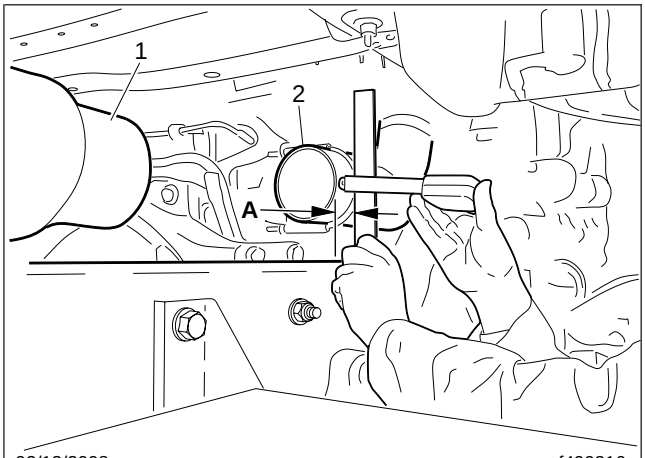
EPA07 Aftertreatment System Bellows Replacement



A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe 2. Turbo Outlet Pipe

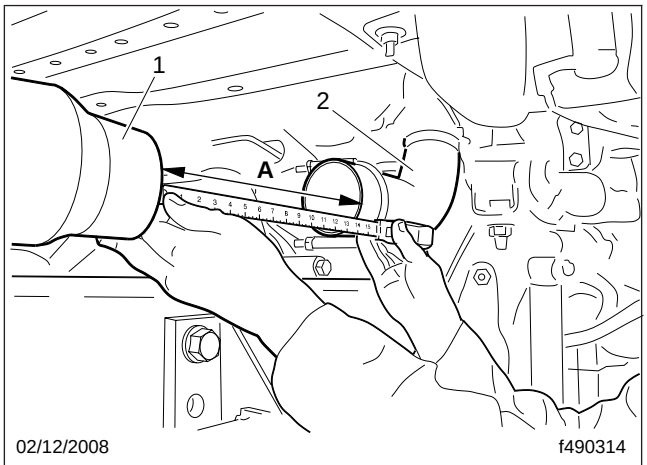
Fig. 3, Measuring the Vertical Distance



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



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 Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2009 must reduce the level of emissions exhausted by the engine to 0.2 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx).

To meet the EPA10 requirements, Daimler Trucks North America is using technology known as Selective Catalytic Reduction (SCR) in the exhaust aftertreatment system (ATS). The SCR process requires the introduction of diesel exhaust fluid (DEF) into the exhaust stream. DEF is colorless, non-toxic, and biodegradable.

IMPORTANT: The ATS is part of an integrated engine and emissions management system, controlled by the aftertreatment control module (ACM). Follow the engine manufacturer's procedures, and use the correct equipment when diagnosing or working on any part of the ATS.

The ATS is always chassis-mounted, but there are several different installation options available to fit any needed vehicle configuration. ATS exhaust piping is stainless steel. The EPA10 aftertreatment system (ATS) includes all the piping and equipment between the turbocharger outlet and the tip of the exhaust pipe. It includes an aftertreatment device (ATD), an SCR catalyst, a DEF tank, tank header unit, pump, metering unit, DEF, aftertreatment control module (ACM), coolant, and air lines that run between each component. See **Fig. 1** for system components and function. Monitoring and operation of the ATS is controlled by an electronic control module (ACM).

EPA10 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. Inside the ATD, the exhaust first passes through the diesel oxidation catalyst (DOC) where combustion gasses are chemically broken down to water and carbon dioxide, then through the DPF, where solid particles are trapped. The soot is reduced to ash during regeneration, and the ash is collected in the DPF until the DPF is full, at which time the DPF must be removed and cleaned. The DPF needs to be removed and cleaned of ash at specific cleaning intervals. For DPF maintenance and repair information, see the specific engine manufacturer's service literature.

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.

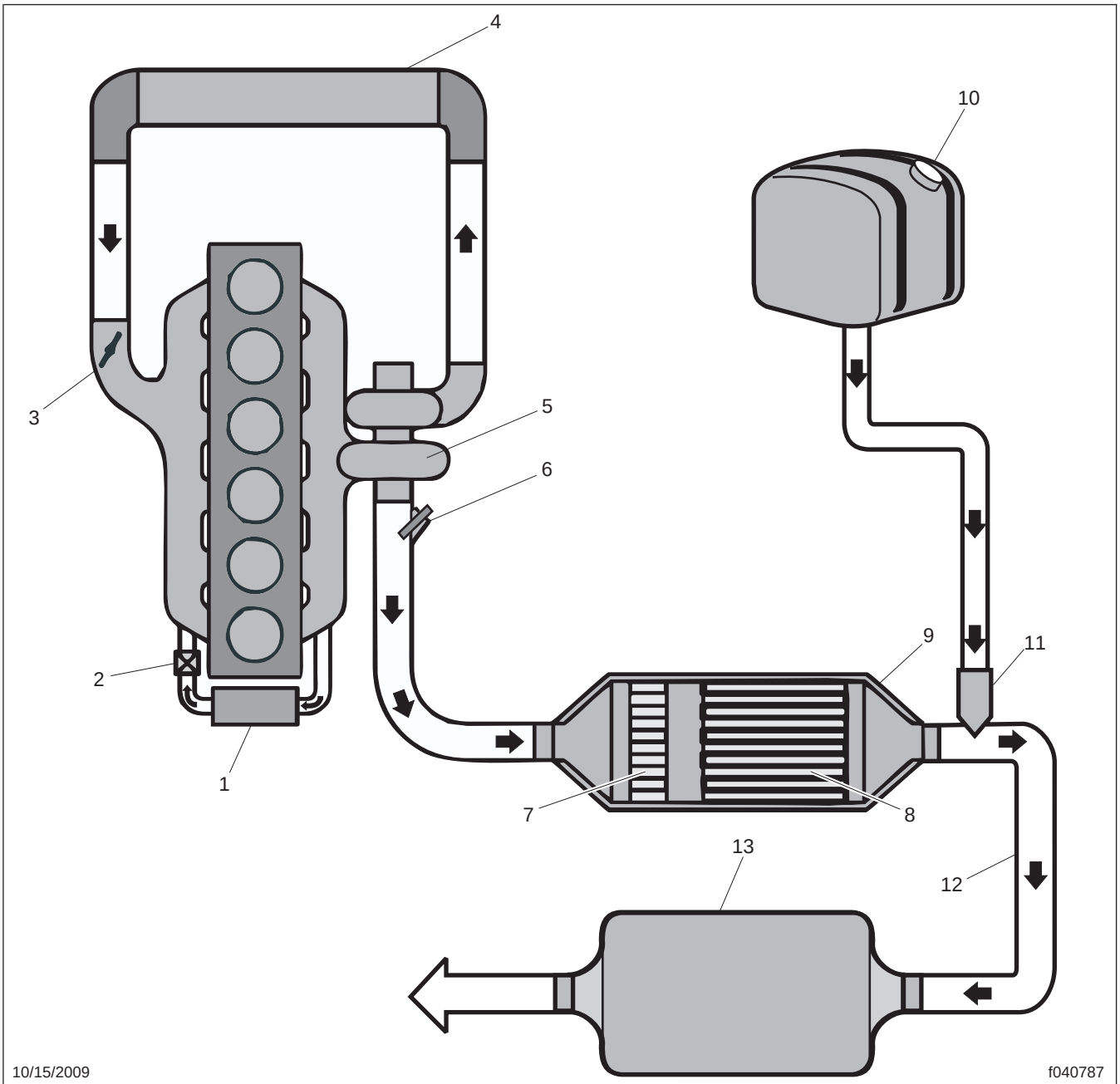
After exhaust gases leave the ATD, a controlled quantity of diesel exhaust fluid (DEF) is injected into the exhaust stream. DEF is colorless, non-toxic, and biodegradable. In the presence of heat, DEF is converted to ammonia gas, which reacts with NOx in the SCR chamber to yield nitrogen and water vapor, which exit through the tailpipe.

EPA10 compliant DTNA vehicles are equipped with an additional tank to carry the DEF necessary for the SCR process. The DEF tank will require filling a minimum of every second diesel refuel, dependant on the DEF tank capacity. DEF consumption will vary depending on ambient conditions and vehicle application.

IMPORTANT: All EPA10 compliant DTNA vehicles require the use of ULSD fuel with a maximum sulfur content of 15 parts per million (PPM). In addition, DTNA vehicles require the use of CJ-4 engine oils with less than 1% ash. See the specific engine manufacturer's literature for additional information.

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 ATS components.

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. Diesel Oxidation Catalyst (DOC)
8. Diesel Particulate Filter (DPF)
9. Aftertreatment Device (ATD)
10. Diesel Exhaust Fluid Tank
11. DEF Injector
12. Mixing Tube
13. SCR Catalyst Chamber

Fig. 1, Aftertreatment System (typical)

Bellows Replacement, Cummins and Detroit® TC Engines

Replacement

NOTE: For the bellows replacement procedure on vehicles with a Detroit Axial Turbine engine, see **Subject 105**.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

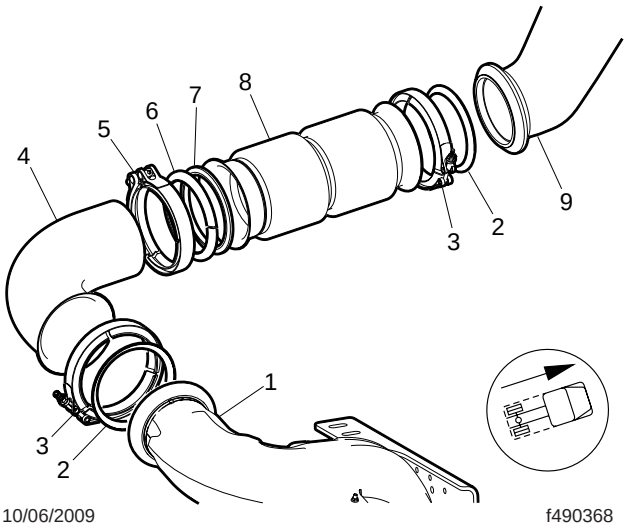
⚠ WARNING

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.**

2. Allow the exhaust system to cool before working on it.
3. Remove the inner fender/splash shield.
4. Remove and discard the spherical clamp and gasket at the turbocharger outlet. See **Fig. 1**.
5. Remove and discard the spherical clamp and gasket at the ATD inlet.
6. On DD13 engines only, complete the following substeps.
   - 6.1 Remove the turbocharger-outlet-pipe support bracket clamp, if equipped. See **Fig. 2**. Save the clamp for reuse.
   - 6.2 Remove the ATD-inlet-pipe support bracket clamp, if equipped. Save the clamp for reuse.
   - 6.3 If additional clearance is necessary, remove the ATD-inlet-pipe support bracket from the frame rail.
7. Remove the bellows and ATD inlet pipe as an assembly.

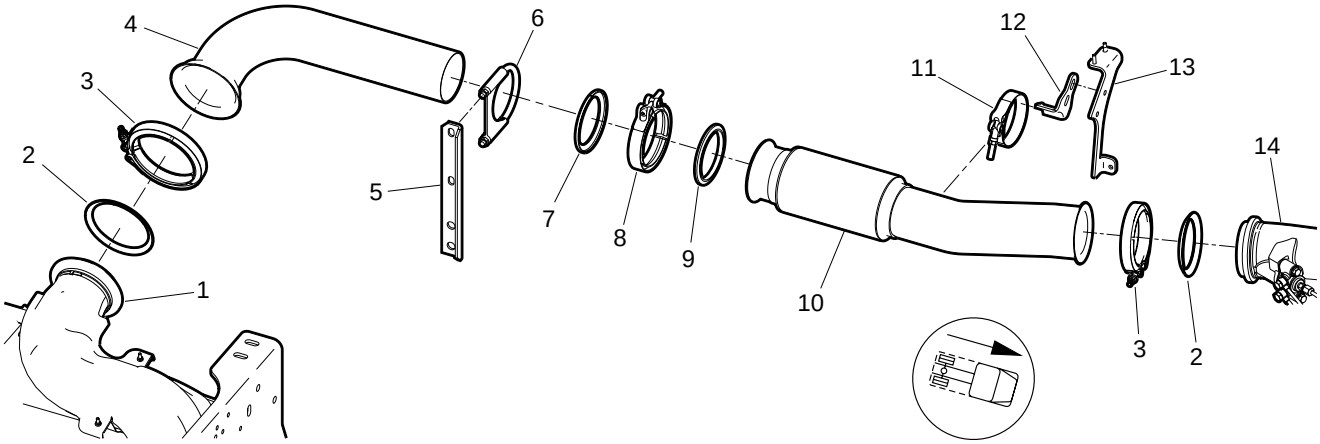


1. ATD
2. Spherical Clamp Gasket
3. Spherical Clamp
4. ATD Inlet Pipe
5. Slip-Joint Clamp
6. Compression Gasket
7. Conical Gasket
8. Bellows
9. Turbocharger Outlet

Fig. 1, Exhaust Bellows Installation (typical DD15TC shown)

8. On the workbench, replace the bellows as follows.
   - 8.1 Remove and discard the slip-joint clamp and gaskets between the bellows and the ATD inlet pipe.
   - 8.2 Slide the new slip-joint clamp, then the two new gaskets, onto the ATD inlet pipe in the order shown in **Fig. 1**.
   - 8.3 Slide the new bellows onto the ATD inlet pipe.
   - 8.4 Position the slip-joint clamp over the gaskets but do not tighten it.
9. Position the bellows and ATD inlet pipe assembly on the vehicle.
10. Slide the ATD inlet pipe in or out of the bellows to align it with the ATD inlet.
11. Install but do not tighten the new spherical clamp and gasket at the ATD inlet.
12. Install but do not tighten the new spherical clamp and gasket between the bellows and the turbocharger outlet pipe.

Bellows Replacement, Cummins and Detroit® TC Engines



1. ATD Inlet
2. Spherical Clamp Gasket
3. Spherical Clamp
4. ATD Inlet Pipe
5. Bracket
6. Clamp
7. Compression Gasket
8. Slip-Joint Clamp
9. Conical Gasket
10. Bellows
11. Bellows Pipe Support Clamp
12. L-Bracket
13. Bellows Pipe Support Bracket
14. Turbocharger Outlet Pipe

Fig. 2, Exhaust Bellows Installation (DD13 engine shown)

13. On DD13 engines only, complete the following substeps.
    - 13.1 Install but do not tighten the new spherical clamp and gasket at the turbocharger-outlet-pipe to turbocharger connection.
    - 13.2 Install the ATD-inlet-pipe support bracket on the frame rail.
    - 13.3 Install but do not tighten the turbocharger-outlet-pipe support bracket clamp.
    - 13.4 If previously removed, install but do not tighten the ATD-inlet-pipe support bracket clamp.
14. Using a straight edge, align the bellows, the ATD inlet pipe, and the turbocharger outlet pipe. Check from at least two positions about 90 degrees apart. All three components should from a straight line through the connections.
15. Tighten the spherical clamps at each end of the bellows assembly 9.5 to 10.5 lbf·ft (13 to 14 N·m).
16. On DD13 engines only, complete the following substeps.
    - 16.1 Tighten the turbocharger-outlet-pipe support bracket clamp 14 to 16 lbf·ft (19 to 22 N·m).
    - 16.2 Tighten the ATD-inlet-pipe support bracket clamp 20 to 26 lbf·ft (27 to 35 N·m).
17. Tighten the slip-joint clamp between the ATD inlet and the bellows 15 lbf·ft (20 N·m).
18. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.
19. Install the inner fender/splash shield.

Bellows Replacement, Detroit® AT Engines

Replacement

NOTE: For the bellows replacement procedure on vehicles with a Cummins engine or a Detroit Turbo Compounder engine, see **Subject 100**.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

⚠ WARNING

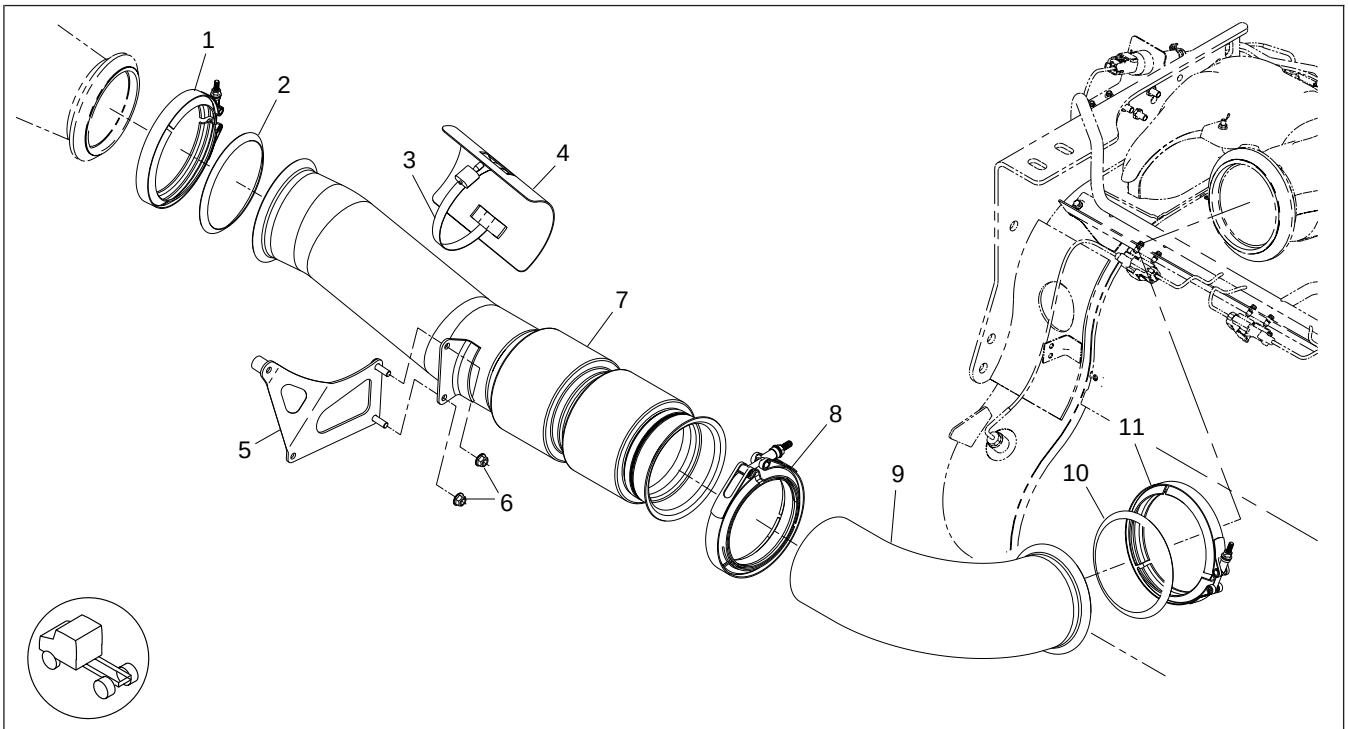
Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.

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.**

2. Allow the exhaust system to cool before working on it.
3. Remove the inner fender/splash shield.
4. Remove and discard the spherical clamp and gasket at the turbocharger outlet. See **Fig. 1**.
5. Remove and discard the spherical clamp and gasket at the ATD inlet.
6. Remove and discard the two hexnuts that secure the bellows assembly to the bellows support bracket. See **Fig. 1**.
7. Remove the bellows and ATD inlet pipe as an assembly.
8. On the workbench, replace the bellows as follows.
   - 8.1 Remove and discard the slip-joint clamp and gaskets between the bellows and the ATD inlet pipe.
   - 8.2 Slide the new slip-joint clamp, then the two new gaskets onto the ATD inlet pipe.
   - 8.3 Slide the new bellows onto the ATD inlet pipe.
   - 8.4 Position the slip-joint clamp over the gaskets but do not tighten it.
9. Position the bellows and ATD inlet pipe assembly on the vehicle.
10. Slide the ATD inlet pipe in or out of the bellows to align it with the ATD inlet.
11. Install but do not tighten the new spherical clamp and gasket at the ATD inlet.
12. Install but do not tighten the new spherical clamp and gasket between the bellows and the turbocharger outlet.
13. Align the bellows assembly so it lines up with the bellows support bracket. See **Fig. 1**.
14. Using a straight edge, align the bellows, the ATD inlet pipe, and the turbocharger outlet. Check from at least two positions about 90 degrees apart. All three components should form a straight line through the connections.
15. Tighten the two hexnuts that secure the bellows to the bellows support bracket 9 to 10 lbf·ft (12 to 14 N·m).
16. Tighten the spherical clamps at each end of the bellows assembly 9.5 to 10.5 lbf·ft (13 to 14 N·m).
17. Tighten the slip-joint clamp between the ATD inlet and the bellows 15 lbf·ft (20 N·m).
18. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.
19. Install the inner fender/splash shield.

Bellows Replacement, Detroit® AT Engines



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1. Spherical Clamp, Turbo Outlet
2. Spherical Clamp Gasket
3. Heat Shield Hose Clamp
4. Heat Shield
5. Bellows Support Bracket
6. Bellows Support Bracket Hexnuts
7. Bellows
8. Slip-Joint Clamp
9. ATD Inlet Pipe
10. Spherical Clamp Gasket
11. Spherical Clamp, ATD Inlet

Fig. 1, Exhaust Bellows Installation (typical DD15AT shown)

DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation

Removal

NOTICE

Under normal circumstances, the two top, and the forward ATD mounting brackets, should not be removed during one-box understep ATD removal. If the brackets must be removed for any reason, mark their exact location with spray paint or with some other method before removing the brackets. Improper alignment of the ATD during installation can lead to unnecessary component failure. Warranty does not cover parts that are damaged due to improper installation.

1. Shut down the engine, set the parking brakes, and chock the tires.

⚠ 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.**

2. Allow the exhaust system to completely cool before working on the aftertreatment system.
3. Remove the eight bolts that mount the steps to the mounting brackets on the ATD housing, and remove the steps.
4. Remove the inner splash shield.

NOTE: The exhaust piping from the turbocharger outlet to the ATD inlet will vary depending on vehicle configuration and engine installation.

5. Remove the clamp at the ATD inlet. See **Fig. 1** for DD13 engines, and **Fig. 2** for DD15/16 engines.
6. Remove the cover from the DEF metering unit. Disconnect the DEF supply and return lines, and the control wiring connectors, from the metering unit. See **Fig. 3**.
7. Disconnect the wiring harness from the sensor box.

NOTE: Exhaust piping downstream from the ATD will vary depending on vehicle configuration.

8. Disconnect the exhaust pipe from the SCR catalyst outlet pipe as needed.
9. Position the ATD jack, with the one-box understep attachment, under the ATD and strap the ATD to the jack. **Figure 4** shows the jack and attachment.
10. Remove the four nuts and bolts that attach the ATD to the upper mounting brackets. See **Fig. 5**.
11. On the forward ATD mounting bracket, remove the four bolts that fasten the ATD to the frame rail mounting bracket. Leave the mounting bracket attached to the frame rail. See **Fig. 6**.
12. On the rear ATD mounting bracket remove the three bolts that fasten the ATD mounting bracket to the frame rail. See **Fig. 7**.
13. Move the ATD away from the frame rail a few inches, then lower it to the floor.

Installation

NOTICE

Be careful not to bump the probe on the back side of the ATD when positioning the ATD on the frame rail. The probe could be damaged.

1. Using the ATD jack, lift the ATD and position it on top of the upper ATD mounting brackets.
2. Install the four bolts into the forward frame rail mounting bracket and tighten the bolts 10 lbf·ft (14 N·m).
3. Install the four bolts (two on each bracket) into the upper ATD mounting brackets and tighten the bolts 10 lbf·ft (14 N·m).
4. Align the rear frame rail mounting bracket to the frame rail, install the three bolts and tighten the bolts 10 lbf·ft (14 N·m).

DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation

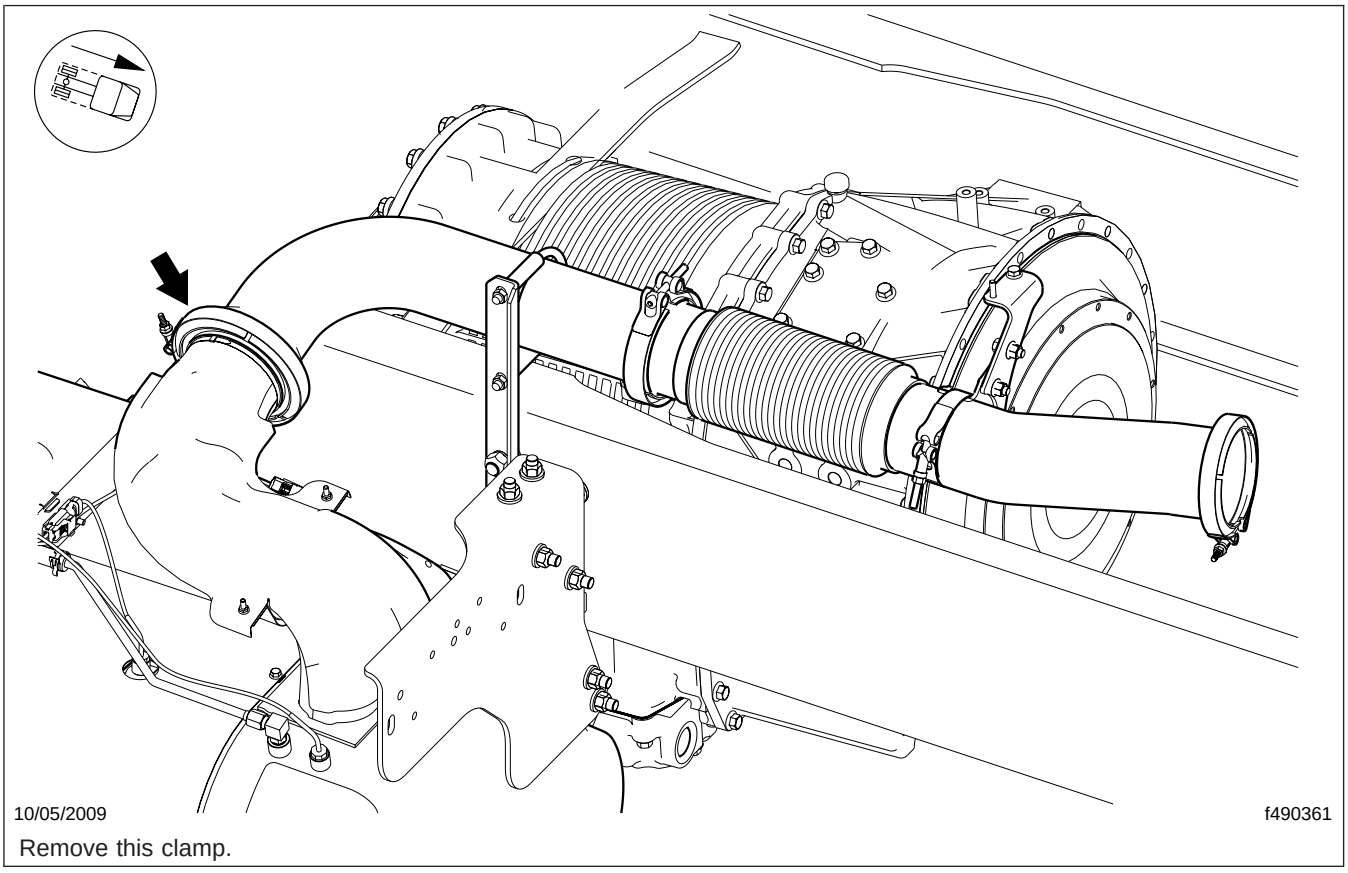


Fig. 1, Disconnecting the ATD from the Exhaust Piping, DD13

5. Loosen the four bolts on the rear ATD mounting bracket.

NOTICE

Follow the tightening sequence shown in Fig. 8 for the following steps. Improper tightening will put potentially damaging stresses on the installation.

6. Tighten the four bolts on the forward ATD mounting bracket 50 lbf·ft (68 N·m).
7. Tighten the four bolts (two on each bracket) on the upper ATD mounting brackets 50 lbf·ft (68 N·m).
8. Tighten the four bolts on the rear ATD mounting bracket 50 lbf·ft (68 N·m).
9. Tighten the three bolts on the rear frame rail mounting bracket 50 lbf·ft (68 N·m).
10. Remove the ATD jack.
11. Connect the wiring harness to the sensor box.
12. Connect the DEF supply and return lines, and the control wiring connectors, to the metering unit. Install the cover.
13. Install the spherical clamp and gasket at the ATD inlet. See **Fig. 1** and **Fig. 2**. Tighten 126 to 138 lbf·in (1425 to 1560 N·cm).
14. If disconnected, connect the exhaust pipe to the SCR catalyst outlet pipe. Tighten 45 to 60 lbf·ft (60 to 80 N·m).
15. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.
16. Install the inner splash shield.
17. Install the steps.

DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation

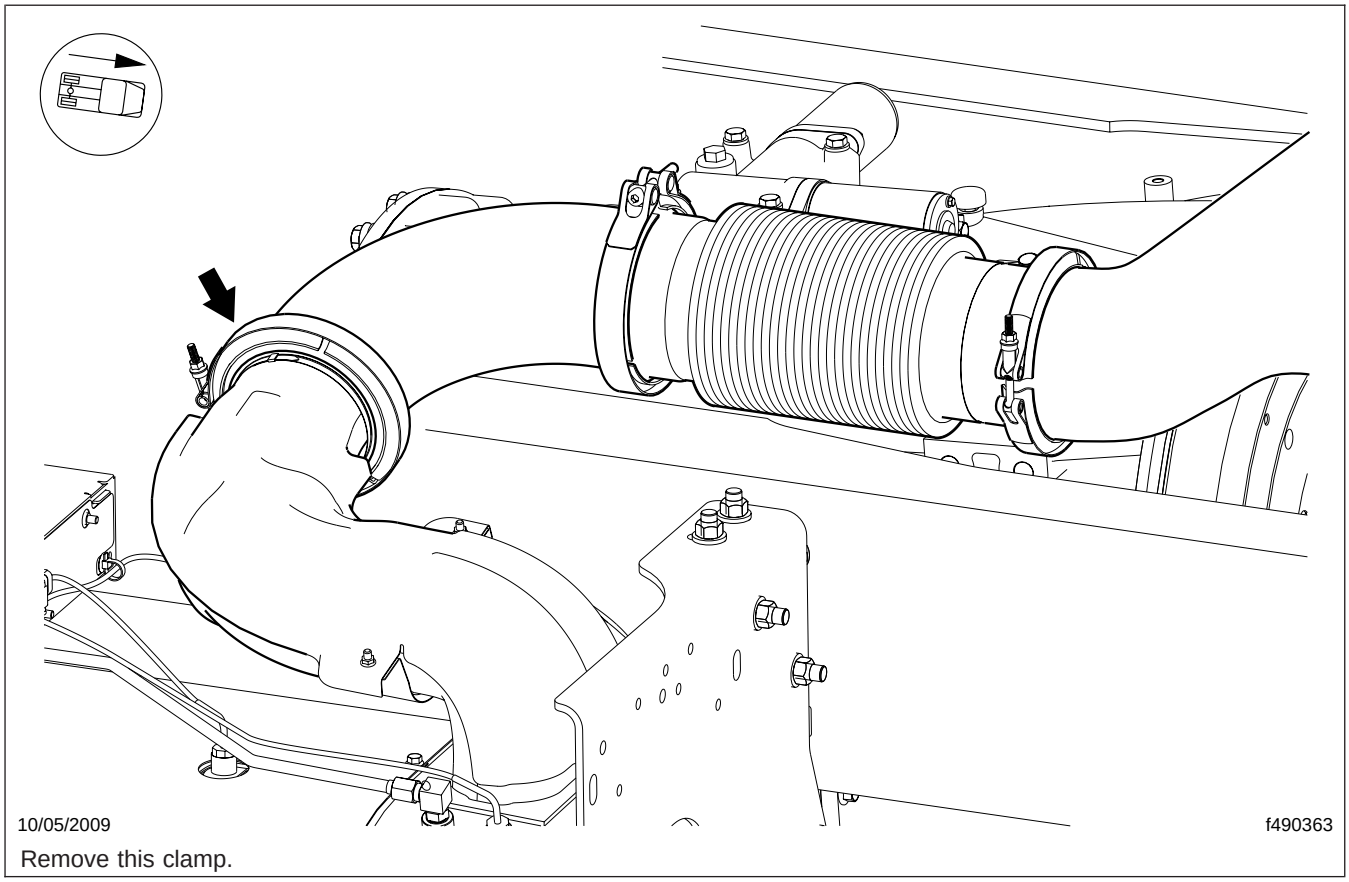
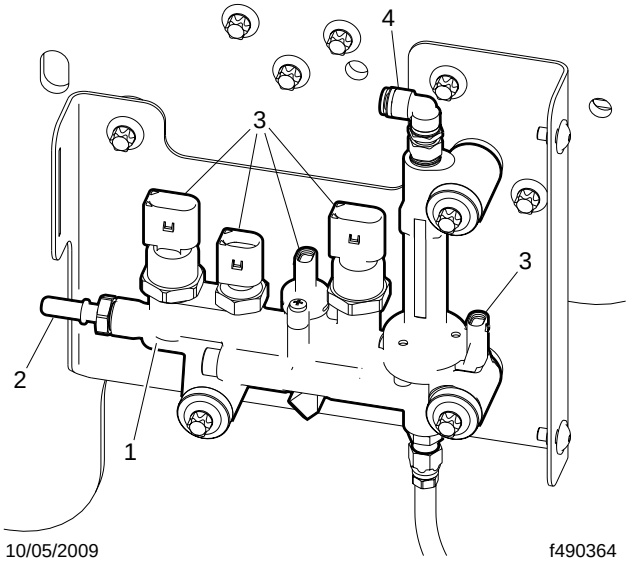


Fig. 2, Disconnecting the ATD from the Exhaust Piping, DD15/16

DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation



1. Metering Unit
2. Metering Unit Air Line
3. Wiring (controls, sensors, and heaters)
4. Metering Unit DEF Supply Line

Fig. 3, DEF Metering Unit Installation (cover removed for clarity)

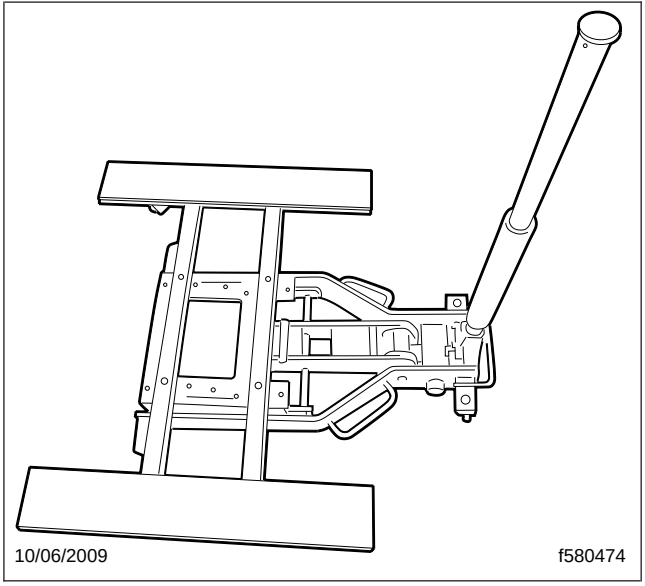


Fig. 4, ATD Jack (with "one-box" attachment)

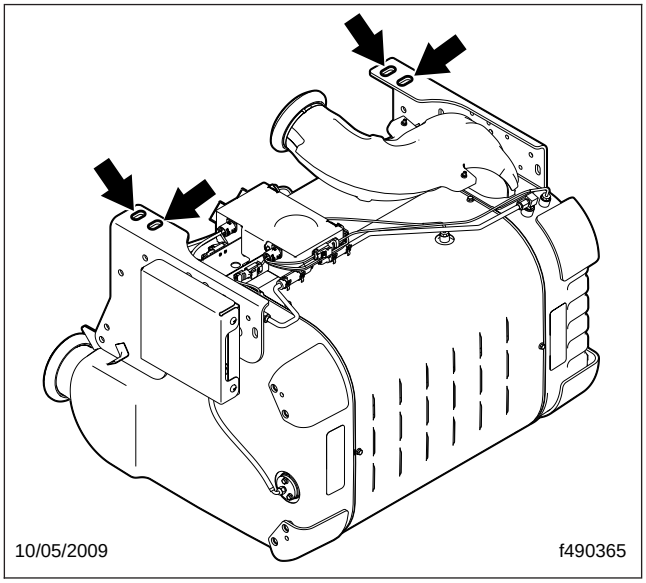


Fig. 5, Upper ATD Mounting Brackets

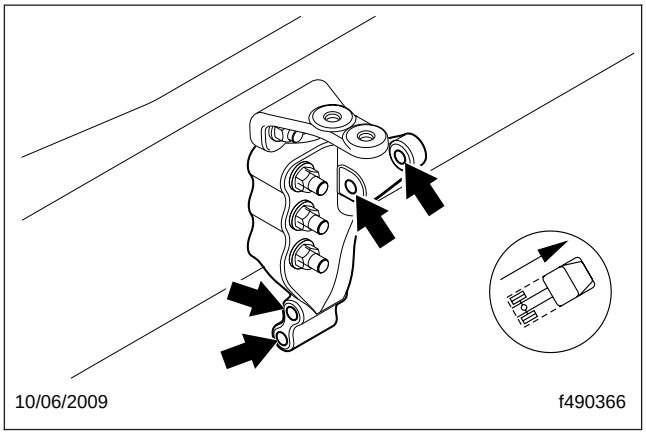


Fig. 6, Forward ATD Mounting Bracket

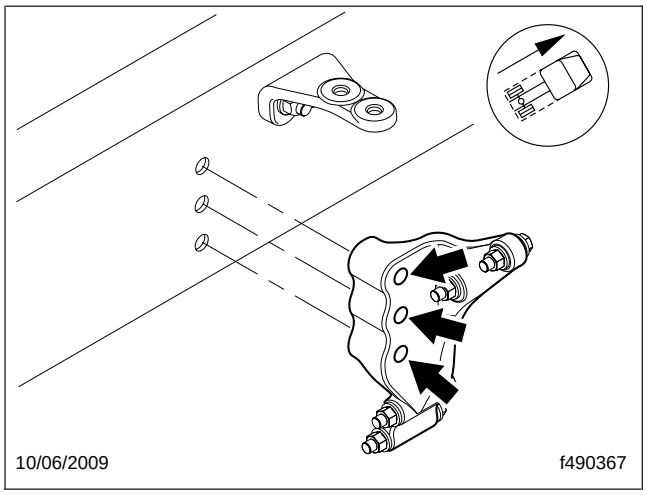


Fig. 7, Rear ATD Mounting Bracket

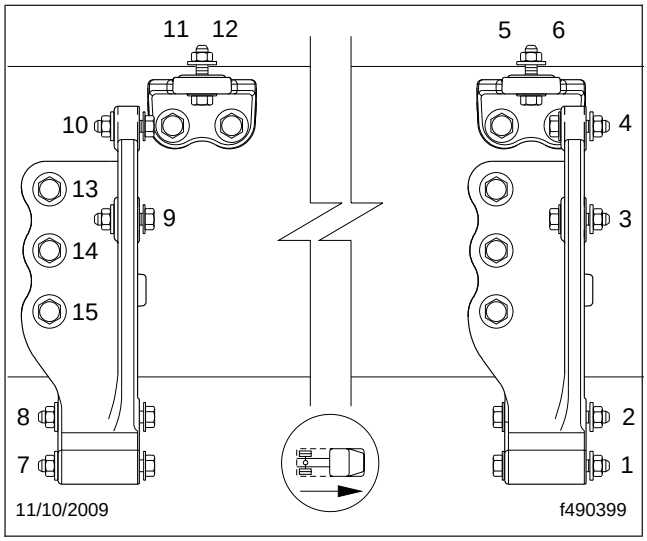


Fig. 8, Mounting Bolt Tightening Sequence

DDC 2V2 ATD and SCR Catalyst Removal and Installation

General Information

Removing the DDC 2V2 ATD and SCR catalyst as a unit is the quickest, and easiest, way to remove it from the vehicle. The ATD or the SCR catalyst can be removed separately. When removing the components separately, mark all parts to assist in proper assembly. Daimler Trucks North America LLC does not recommend disassembling the ATD on the vehicle. Remove the component following the instructions below, and then disassemble it on a workbench following the instructions in the engine manufacturer's service literature.

⚠ 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.**

ATD and SCR Catalyst Removal and Installation

Removal

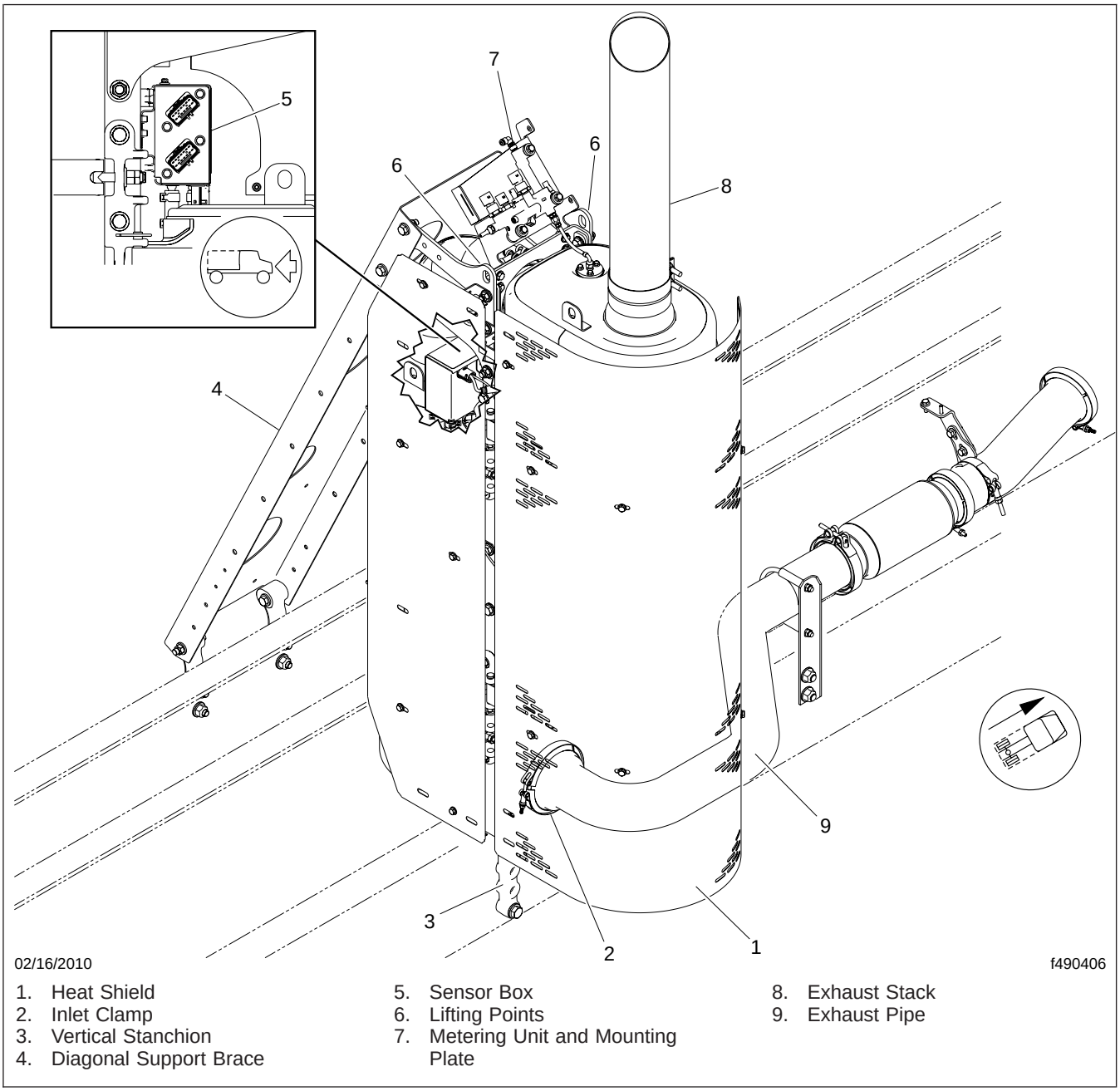
Refer to **Fig. 1** for the following procedure.

1. Shut down the engine and chock the tries.
2. Allow the ATS time to cool.
3. Remove the heat shield.
4. Remove the exhaust stack from the SCR catalyst.
5. Disconnect the two 14-pin connectors at the sensor box.
6. Disconnect the wiring connectors from the metering unit.
7. Disconnect the air lines from the metering unit.
8. Disconnect and cap/plug the DEF lines from the metering unit.
9. Remove the metering unit mounting plate with the metering unit attached.
10. Loosen the lower fasteners on the diagonal support brace. Disconnect the diagonal support brace from the lifting bracket that attaches to the vertical stanchion and swing it out of the way. Secure it as needed.
11. Disconnect the exhaust pipe at the intake to the ATD. Support it as needed so there is no stress on the bellows.
12. Position the overhead lifting device over the vertical stanchion and connect the hooks at the lifting points. Apply enough pressure to the lift points to prevent the unit from dropping when loosened.
13. Remove the four mounting fasteners that attach the vertical stanchion to the frame rail.
14. Lower the unit away from the vehicle.

Installation

1. Using the overhead lifting device, position the unit at the frame rail, and install the mounting fasteners. Tighten 159 to 201 lbf·ft (212 to 268 N·m).
2. Position the diagonal support brace and install the mounting fasteners. Tighten the upper and lower fasteners 49 to 63 lbf·ft (66 to 86 N·m).
3. Connect the two 14-pin connectors at the sensor box.
4. Install the metering unit and mounting plate.
5. Connect the wiring connectors to the metering unit.
6. Connect the air lines to the metering unit.
7. Connect the DEF lines to the metering unit.
8. Using a new seal, connect the exhaust pipe to the ATD. See **Fig. 2** for proper installation. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
9. Install the exhaust stack. Tighten the clamp 27 to 37 lbf·ft (37 to 50 N·m).

DDC 2V2 ATD and SCR Catalyst Removal and Installation



1. Heat Shield
2. Inlet Clamp
3. Vertical Stanchion
4. Diagonal Support Brace
5. Sensor Box
6. Lifting Points
7. Metering Unit and Mounting Plate
8. Exhaust Stack
9. Exhaust Pipe

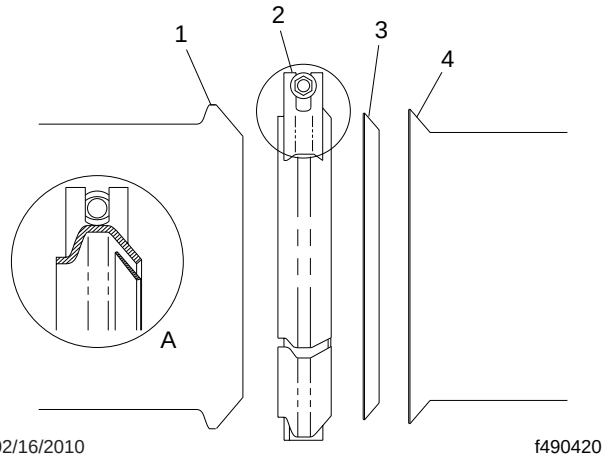
Fig. 1, 2V2 ATD and SCR Catalyst Installation

10. Install the heat shield. Tighten 13 to 17 lbf·ft (18 to 22 N·m).
11. Start the engine and check for leaks. Tighten any connections as needed.

ATD Removal and Installation

Refer to **Fig. 3** for the following procedure.

DDC 2V2 ATD and SCR Catalyst Removal and Installation



NOTE: Clamp and seal are directional.

A. Correct Clamp and Seal Installation

1. ATD
2. Clamp
3. Gasket
4. Exhaust Pipe

Fig. 2, Spherical Clamp Installation

NOTICE

Alignment is essential. Mark every component's position prior to disassembling it on the truck. Improper assembly may result in leaks or damage to the ATS.

Removal

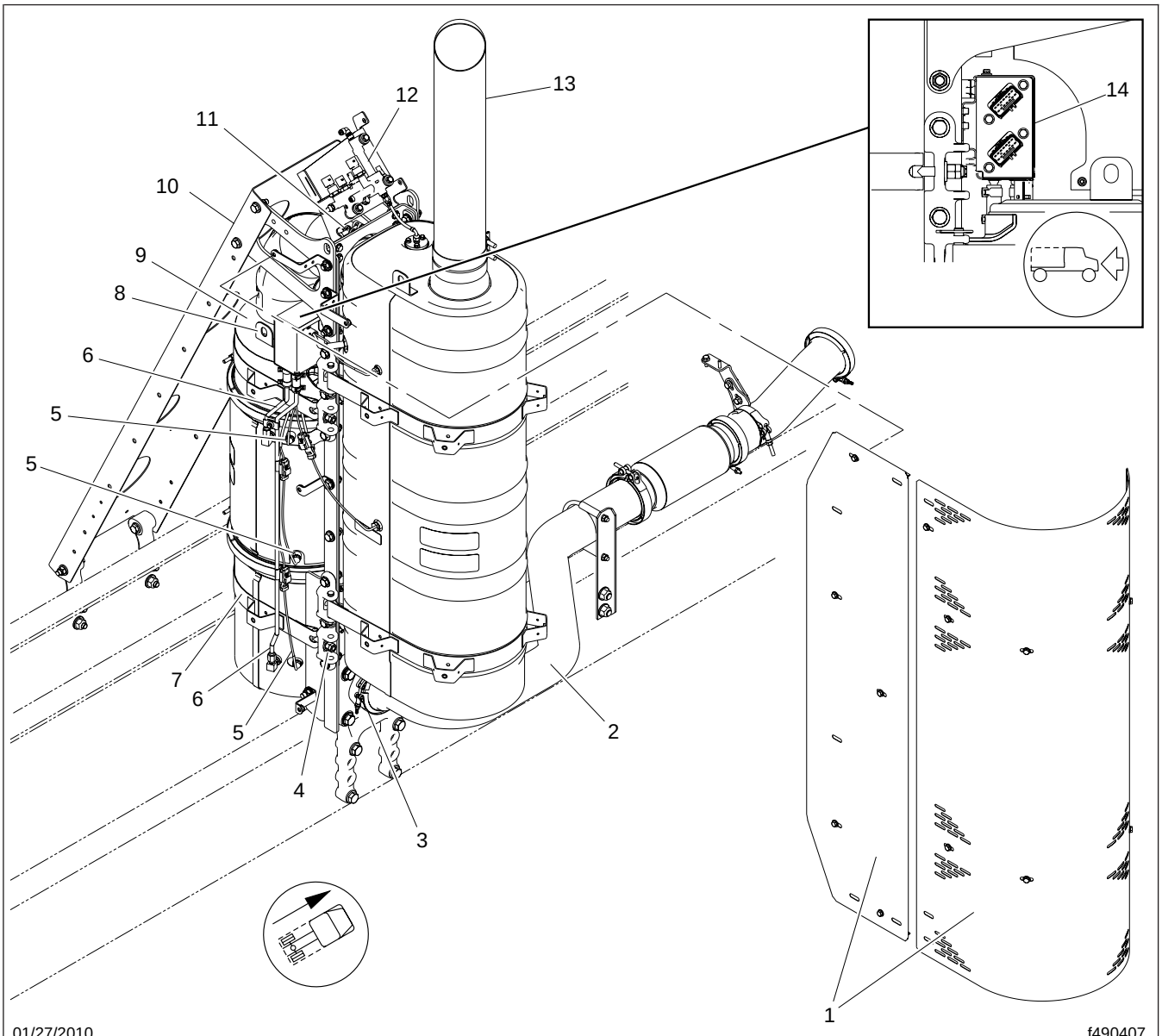
1. Shut down the engine and chock the tries.
2. Allow the ATS time to cool.
3. Remove the heat shield.
4. Disconnect the two pressure tubes at the connection to the ATD.
5. Disconnect the three temperature sensors on the ATD.
6. Disconnect the two 14-pin connectors at the sensor box.
7. Disconnect the wiring connectors from the metering unit.
8. Disconnect the air lines from the metering unit.
9. Disconnect and cap/plug the DEF lines from the metering unit.
10. Remove the metering unit mounting plate with the metering unit attached.
11. Loosen the lower fasteners on the diagonal support brace. Disconnect the diagonal support brace from the vertical stanchion, and swing it out of the way. Secure it as needed.
12. Remove the intake and outlet clamps from the ATD. Support the turbo outlet pipe as needed so there is no stress on the bellows.
13. Position the overhead lifting device over the ATD and connect the hooks at the lifting points. Apply enough pressure to the lift points to prevent the unit from dropping when loosened.
14. Remove the mounting clamps.
15. Lift the ATD away from the vehicle.

Installation

1. Using the overhead lifting device, position the ATD on the vertical stanchion, and secure it in position with the mounting clamps. Do not tighten the straps at this time.
2. Align the connection with the SCR catalyst, and using a new seal, install the clamp. See **Fig. 2** for proper installation. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
3. Align the connection with the exhaust pipe from the turbocharger, and, using a new seal, install the clamp. See **Fig. 2** for proper installation. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
4. Check all alignment marks, and tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).

   Install the jam nuts. Using a back-up wrench, tighten 30 lbf·ft (40 N·m).
5. Connect the two pressure tubes.
6. Connect the three temperature sensors.
7. Position the diagonal support brace and install the mounting fasteners. Tighten the upper and lower fasteners 49 to 63 lbf·ft (66 to 86 N·m).
8. Connect the two 14-pin connectors at the sensor box.
9. Install the metering unit and mounting plate.
10. Connect the wiring connectors to the metering unit.

DDC 2V2 ATD and SCR Catalyst Removal and Installation



1. Heat Shield
2. Exhaust Pipe
3. Intake Clamp
4. Clamping Strap Nuts
5. Temperature Sensor
6. Pressure Tube
7. Clamping Strap
8. Lifting Points
9. ATD
10. Diagonal Support Brace
11. Outlet Clamp
12. Metering Unit and Mounting Plate
13. Exhaust Stack
14. Sensor Box

Fig. 3, 2V2 ATD Installation

11. Connect the air lines to the metering unit.
12. Connect the DEF lines to the metering unit.
13. Install the heat shield.
14. Start the engine and check for leaks. Tighten any connections as needed.

SCR Catalyst Removal and Installation

Refer to **Fig. 4** for the following procedure.

Removal

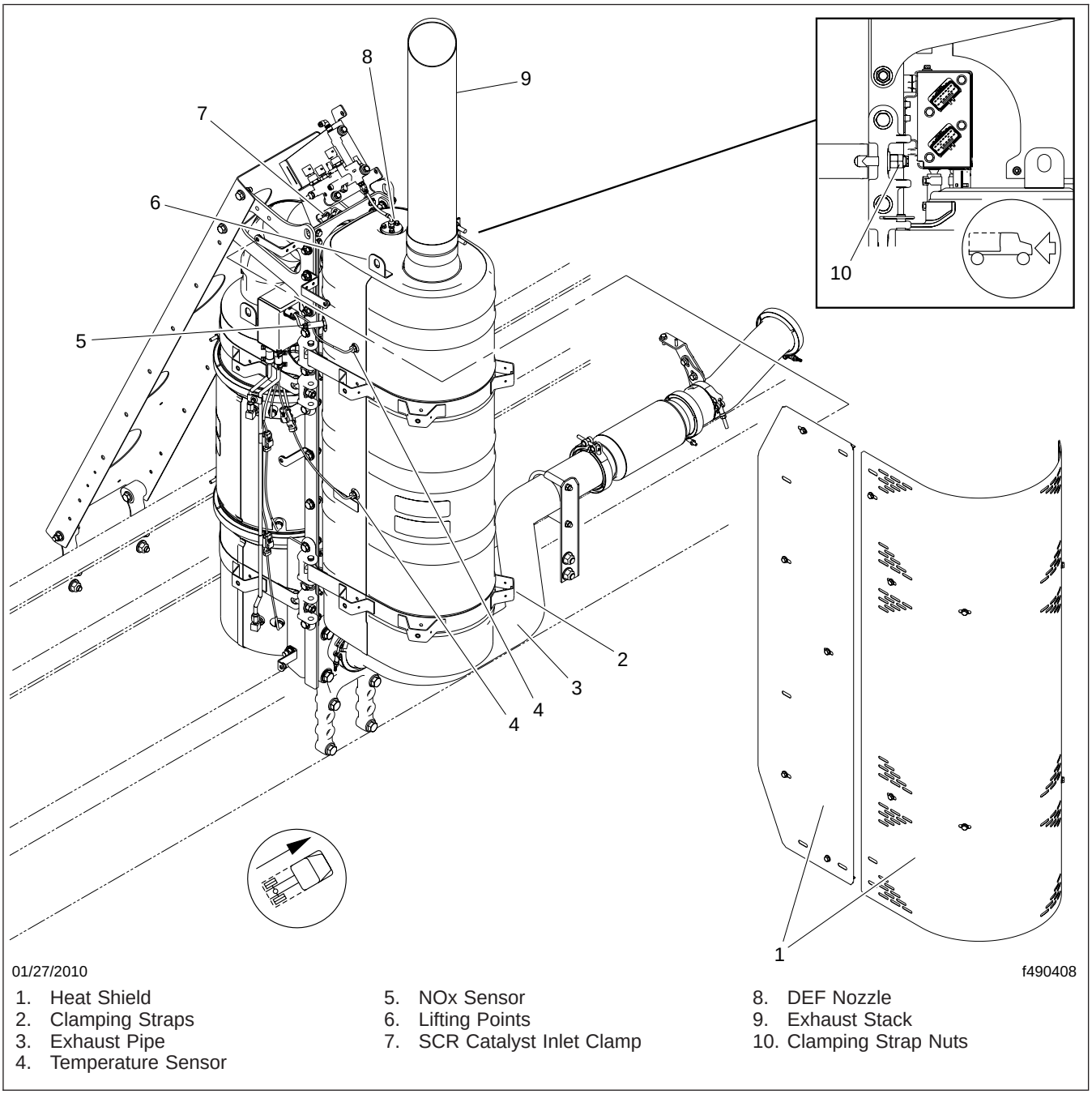
1. Shut down the engine and chock the tries.
2. Allow the ATS time to cool.
3. Remove the heat shield.
4. Remove the exhaust stack from the SCR catalyst.
5. Remove the SCR catalyst inlet clamp.
6. Disconnect the two temperature sensors and the NOx sensor.
7. Disconnect the DEF nozzle.
8. Position the overhead lifting device over the SCR catalyst and connect the hooks at the lifting points. Apply enough pressure to the lift points to prevent the unit from dropping when loosened.
9. Remove the clamping strap nuts.
10. Lift the SCR catalyst away from the vehicle.

Installation

1. Using the overhead lifting device, position the SCR catalyst on the vertical stanchion, and secure it in position with the mounting clamps. Do not tighten the straps at this time.
2. Align the connection with the ATD, and using a new seal, install the clamp. See **Fig. 2** for proper installation. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
3. Check all alignment marks, and tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).

   Install the jam nuts. Using a back-up wrench, tighten 30 lbf·ft (40 N·m).
4. Connect the two temperature sensors and the NOx sensor.
5. Connect the DEF nozzle.
6. Install the exhaust stack. Tighten the clamp 27 to 37 lbf·ft (37 to 50 N·m).
7. Install the heat shield. Tighten 13 to 17 lbf·ft (18 to 22 N·m).
8. Start the engine and check for leaks. Tighten any connections as needed.

DDC 2V2 ATD and SCR Catalyst Removal and Installation



1. Heat Shield
2. Clamping Straps
3. Exhaust Pipe
4. Temperature Sensor
5. NOx Sensor
6. Lifting Points
7. SCR Catalyst Inlet Clamp
8. DEF Nozzle
9. Exhaust Stack
10. Clamping Strap Nuts

Fig. 4, 2V2 SCR Catalyst Installation

DDC 2HV ATD and SCR Catalyst Removal and Installation

⚠ 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.**

NOTICE

Alignment is essential. Mark every component's position prior to disassembling it on the truck. Improper assembly may result in leaks or damage to the ATS.

ATD Removal and Installation

Daimler Trucks North America LLC does not recommend disassembling the ATD on the vehicle. Remove the component following the instructions below, and then disassemble it on a workbench following the instructions in the engine manufacturer's service literature.

Removal

Refer to **Fig. 1** for this procedure.

1. Shut down the engine, set the parking brakes, and chock the tires.
2. Remove the spherical clamps connecting the ATD inlet and outlet pipes to the ATD.
3. Disconnect the electrical harnesses going to the ATD sensor box.
4. Make alignment marks on the ATD and the mounting brackets to assist in proper assembly.
5. Position the ATD jack under the ATD and secure it to the jack with a strap.
6. Remove the clamping strap nuts from the two clamping straps holding the ATD to the mounting brackets. Remove and discard the clamping straps and hardware.
7. Lower the ATD from the truck.

Installation

1. Using the ATD jack, raise ATD into mounting brackets.
2. Install the new clamping straps, and tighten the clamping strap nuts just enough to hold the ATD in place.
3. Align the ATD fore and aft to match the ATD inlet and outlet pipes, then install the two spherical clamps. Do not tighten at this time. See **Fig. 2** for proper installation.

NOTICE

Do not allow the clamping strap to twist while tightening it. A twisted strap could lead to a strap failure and possible damage to the ATS.

4. Check all alignment marks, and tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).
5. Tighten the spherical clamps 114 to 126 lbf·in (1290 to 1425 N·cm).
6. Connect the electrical harnesses to the ATD sensor box.
7. Start the engine and check for leaks. Tighten any connections as needed.

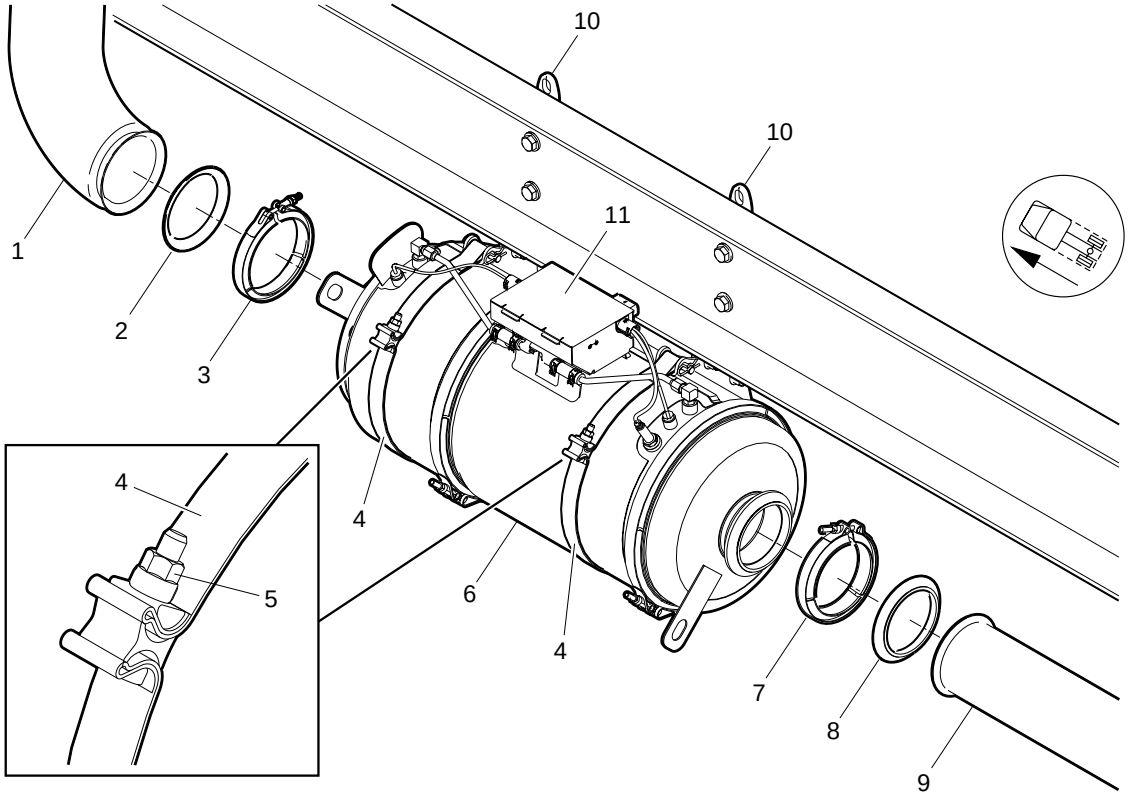
SCR Catalyst Removal and Installation

Refer to **Fig. 3** for this procedure.

Removal

1. Shut down the engine, set the parking brakes, and chock the tires.
2. Remove the six fasteners holding the SCR catalyst heat shield in place.
3. Remove the stack.
4. Disconnect the two temperature sensors and the NOx sensor.

DDC 2HV ATD and SCR Catalyst Removal and Installation



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1. ATD Inlet Pipe
2. Gasket
3. Spherical Clamp
4. Clamping Strap
5. Clamping Strap Nut
6. ATD
7. Spherical Clamp
8. Gasket
9. ATD Outlet Pipe
10. ATD Mounting Brackets
11. Sensor Box

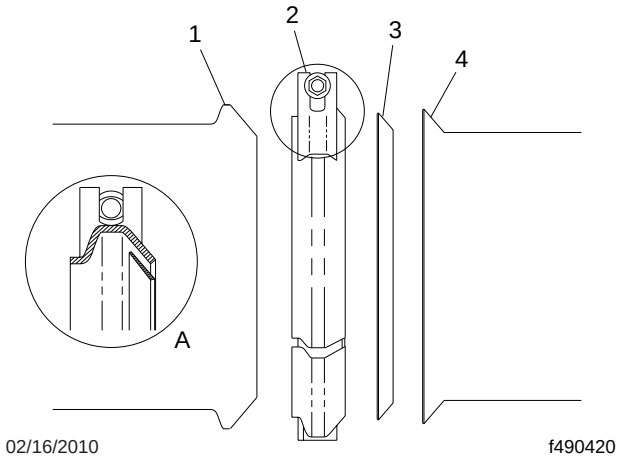
Fig. 1, ATD Installation

5. Disconnect the DEF nozzle supply line.
6. Remove the spherical clamp at the SCR catalyst inlet.
7. Disconnect the electrical harness from the SCR catalyst.
8. Make alignment marks on all parts to assist in proper assembly.
9. Position the overhead lifting device over the SCR catalyst and connect the hooks at the lifting points. Apply enough pressure to the lift points to prevent the unit from dropping when loosened.
10. Remove the two mounting straps from the SCR catalyst.
11. Move the SCR catalyst outboard away from the truck horizontally until the inlet clears the vertical mounting bracket. Then lift the SCR catalyst away from the truck.

Installation

1. Using the overhead lifting device, lower the SCR catalyst vertically until the inlet aligns vertically with the hole in the mounting bracket. Then move the SCR catalyst horizontally until the SCR catalyst is up against the mounting bracket and the inlet is through the mounting bracket hole.
2. Install the two mounting straps. Do not tighten at this time.

DDC 2HV ATD and SCR Catalyst Removal and Installation



NOTE: Clamp and seal are directional.

A. Correct Clamp and Seal Installation

1. ATD
2. Clamp
3. Gasket
4. Exhaust Pipe

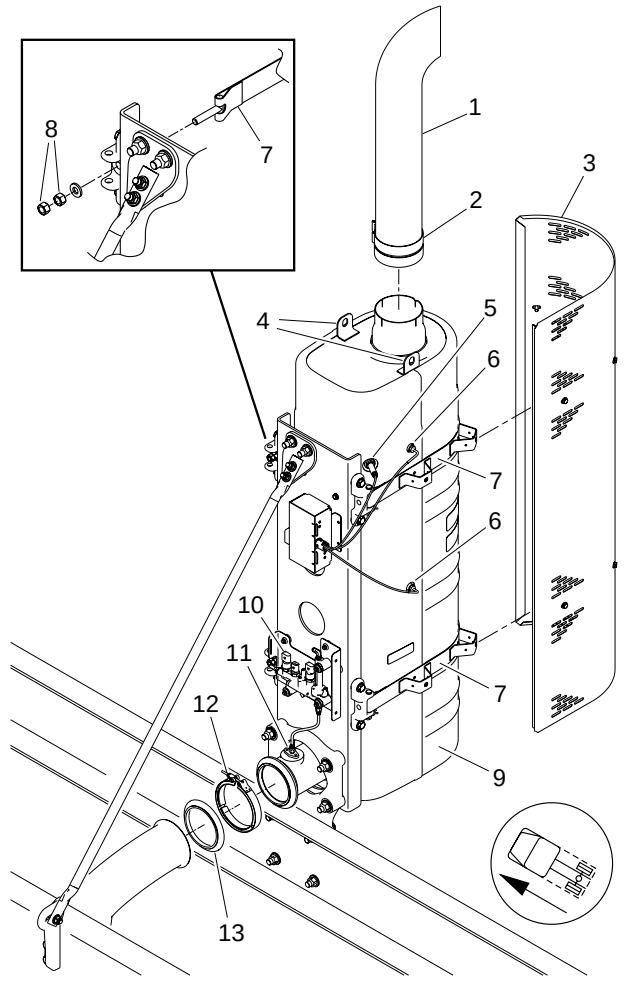
Fig. 2, Spherical Clamp Installation

3. Align the SCR catalyst inlet to the exhaust pipe, and install the spherical clamp. Do not tighten at this time. See **Fig. 2** for proper installation.

NOTICE

Do not allow the clamping strap to twist while tightening it. A twisted strap could lead to a strap failure and possible damage to the ATS.

4. Check all alignment marks, and tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).
5. Tighten the spherical clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
6. Connect the two temperature sensors and the NOx sensor.
7. Connect and tighten the DEF nozzle supply line.
8. Install the stack. Align the outlet 45 degrees out from the back of the cab. Tighten the clamp 27 to 37 lbf·ft (37 to 50 N·m).
9. Install the six bolts that attach the heat shield to the SCR catalyst. Tighten 13 to 17 lbf·ft (18 to 22 N·m).
10. Start the engine and check for leaks. Tighten any connections as needed.



1. Stack
2. Clamp
3. Heat Shield
4. Lifting Points
5. NOx Sensor
6. Temperature Sensor
7. Clamping Strap
8. Clamping Clamp Nuts
9. SCR Catalyst
10. DEF Metering Unit
11. DEF Nozzle
12. Spherical Clamp
13. Gasket

Fig. 3, SCR Catalyst Installation

Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation

⚠ 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.**

NOTICE

Alignment is essential. Using a paint pen, mark every component's position prior to disassembling it on the truck. Improper assembly may result in leaks or damage to the ATS.

ATD and SCR Catalyst Assembly Removal and Installation

Daimler Trucks North America LLC does not recommend disassembling the ATD on the vehicle. Remove the component following the instructions below, and then disassemble it on a workbench following the instructions in the engine manufacturer's service literature.

Removal

Refer to **Fig. 1** for this procedure.

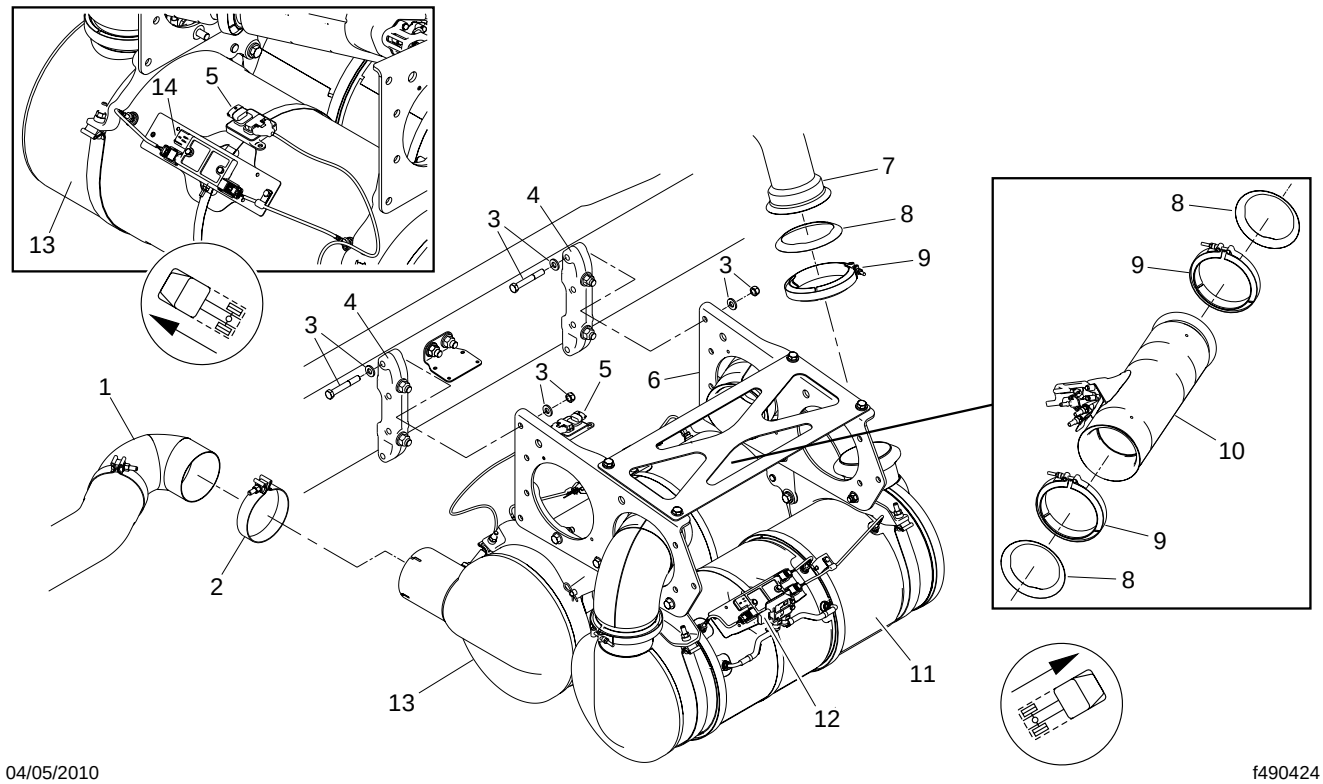
1. Shut down the engine, set the parking brakes, and chock the tires.
2. Allow the ATS time to cool.
3. Raise the hood.
4. Remove the right side steps and fairing.
5. Remove the step mounting bracket, brace, and step rails. See **Fig. 2**.
6. Remove the spherical clamp connecting the ATD inlet pipe to the ATD.
7. Disconnect the SCR catalyst outlet pipe from the SCR catalyst.
8. Disconnect the wiring harnesses from the ATD sensor box.
9. Mark the clocking of the mixer tube to both elbows in several places. Disconnect the mixer tube from the elbows at both ends of the mixer tube, and secure the mixer tube on top of the frame rail.
10. Disconnect the wiring harness from the NOx sensor module.
11. Disconnect the wiring harness from the temperature sensor module.
12. Cut any zip ties as necessary, and free the harness from the ATS.
13. Remove the NOx sensor module from the mounting bracket on the frame rail, and secure it to the ATS.
14. Position an ATD jack, with a "one box" attachment, under the ATS and secure it to the jack with a strap. See **Fig. 3**.
15. Remove the eight bolts and nuts that attach the ATS mounting frame to the mounting brackets on the frame rail.
16. Lower the ATS from the vehicle.

Installation

NOTE: The ATD mounting frame attaches to the forward face of the mounting brackets.

1. Using the jack, raise the ATS into position.
2. Install the eight bolts and nuts that attach the ATS mounting frame to the mounting brackets on the frame rail. Tighten the nuts 50 lbf·ft (68 N·m).
3. Position the wiring harness on the ATS. Install new zip ties as needed.
4. Install the NOx sensor module on the mounting bracket on the frame rail. Connect the wiring harness.
5. Connect the wiring harnesses to the ATD sensor box.
6. Connect the wiring harness to the temperature sensor module.

Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation



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1. SCR Catalyst Outlet Pipe
2. Narrow Band Clamp
3. ATS Frame Fasteners (8)
4. ATS Mounting Brackets
5. NOx Sensor Module
6. ATS Mounting Frame
7. ATD Inlet Pipe
8. Gasket
9. Spherical Clamp
10. Mixer Tube
11. ATD
12. ATD Sensor Box
13. SCR Catalyst
14. Temperature Sensor Module

Fig. 1, ATS Installation

7. Connect the SCR catalyst outlet pipe to the SCR catalyst. Tighten the clamp 37 to 45 lbf·ft (50 to 60 N·m).
8. Using a new gasket, install the spherical clamp connecting the ATD inlet pipe to the ATD. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
9. Position the mixer tube, and using a new gaskets install the spherical clamps that connect the mixer tube to the ATD outlet elbow and the SCR inlet elbow. Align the mixing tube using the paint pen marks applied during disassembly, then tighten the clamps 114 to 126 lbf·in (1290 to 1425 N·cm).
10. Start the engine and check for leaks. Tighten any connections as needed.
11. Install the step mounting bracket, brace, and step rails.
12. Install the steps and fairing.

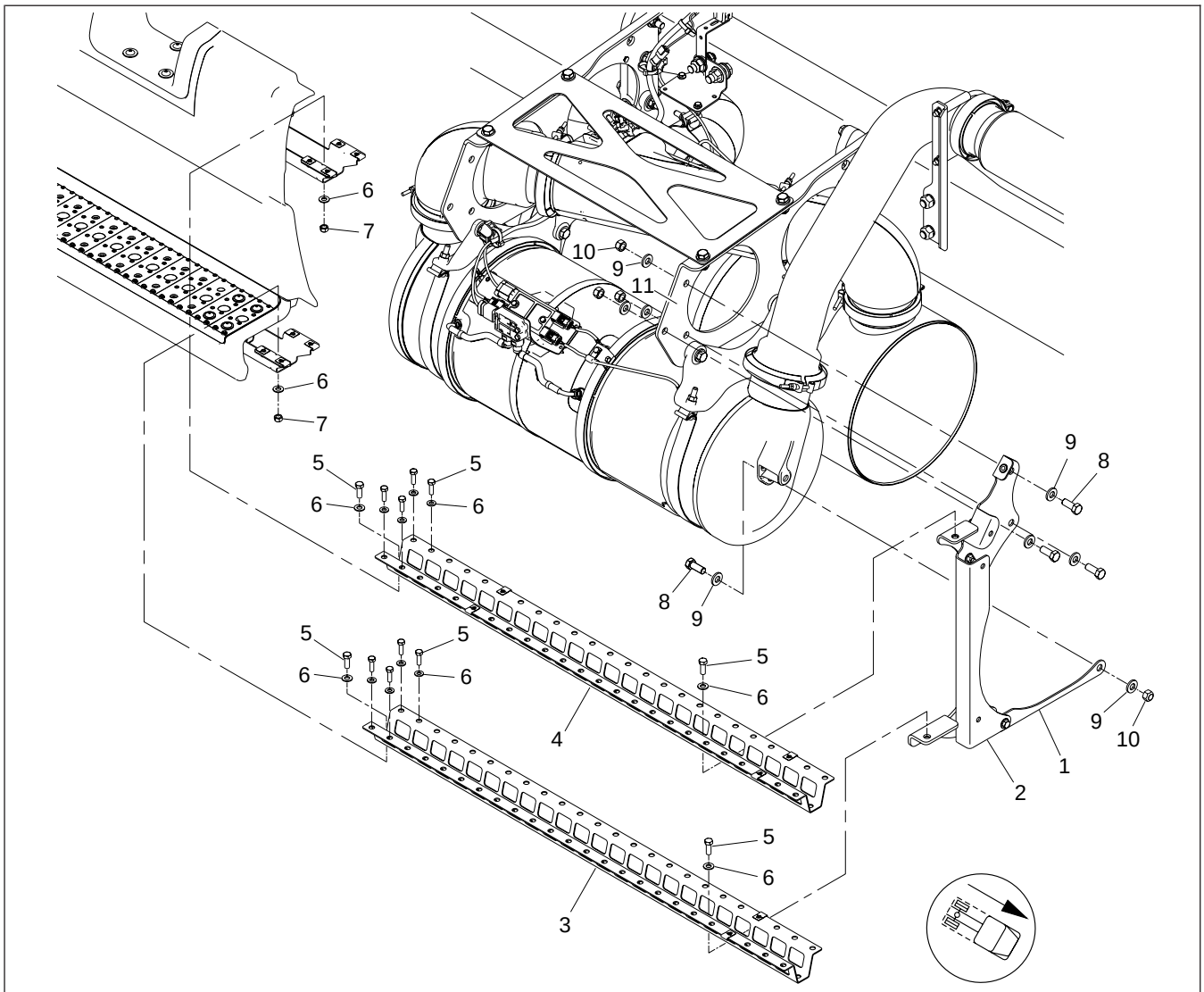
ATD Removal and Installation

Daimler Trucks North America LLC does not recommend disassembling the ATD on the vehicle. Remove the component following the instructions below, and then disassemble it on a workbench following the instructions in the engine manufacturer's service literature.

Removal

Refer to **Fig. 4** for this procedure.

Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation



1. Step Mounting Bracket
2. Step Mounting Bracket Brace
3. Lower Step Rail
4. Upper Step Rail
5. Bolt
6. Washer
7. Nut
8. Bolt
9. Washer
10. Nut
11. ATS Mounting Frame

Fig. 2, Step Mounting Bracket and Step Rail Installation

1. Shut down the engine, set the parking brakes, and chock the tires.
2. Allow the ATS time to cool.
3. Raise the hood.
4. Remove the right side steps and fairing.
5. Remove the step mounting bracket, brace, and step rails. See **Fig. 2**.
6. Remove the spherical clamp connecting the ATD inlet pipe to the ATD.
7. Remove the spherical clamp connecting the ATD inlet pipe to the mixer tube elbow.

Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation

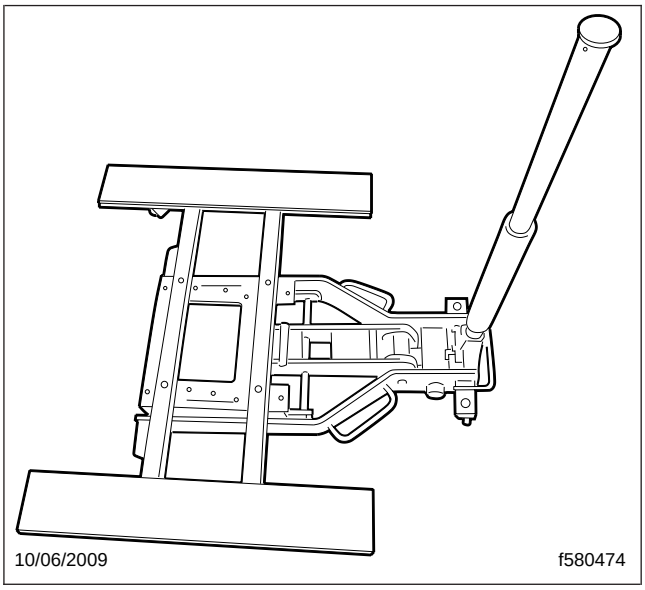


Fig. 3, ATD Jack (with "one-box" attachment)

8. Disconnect the wiring harnesses from the ATD sensor box.
9. Cut any zip ties as necessary to free the harness from the ATD.
10. Mark the clocking of the ATD on both mounting frames in several places for later installation.
11. Position an ATD jack, with single unit cradles, under the ATD and secure it to the jack with a strap.
12. Remove the nuts from the ATD clamping straps. Remove the straps, and discard the straps and hardware.
13. Lower the ATD from the truck.

Installation

IMPORTANT: Always use new gaskets when installing exhaust system components.

1. Using the ATD jack, raise the ATS into position.

NOTICE

The ATD may rotate while tightening the clamps. It is important that this is prevented. Check the alignment during and after the clamping procedure and make adjustments as needed. Improper installation may lead to component failure.

2. Install new clamping straps. Do not tighten at this time. Allow room to align the ATD in the mounting frame and with the inlet and mixer tubes.
3. Align the ATD in the mounting frame using the paint pen marks applied during disassembly.
4. Align the mixer tube elbow with the ATD outlet, then using a new gasket install the spherical clamp. Do not tighten at this time.
5. Align the ATD inlet pipe to the ATD, then using a new gasket, install the spherical clamp. Do not tighten at this time.
6. Check all alignment marks on the ATD, then tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).
7. Tighten the spherical clamps at the ATD inlet and the mixer tube elbow 114 to 126 lbf·in (1290 to 1425 N·cm).
8. Connect the wiring harnesses to the ATD sensor box.
9. Start the engine and check for leaks. Tighten any connections as needed.
10. Install the step mounting bracket, brace, and step rails.
11. Install the steps and fairing.

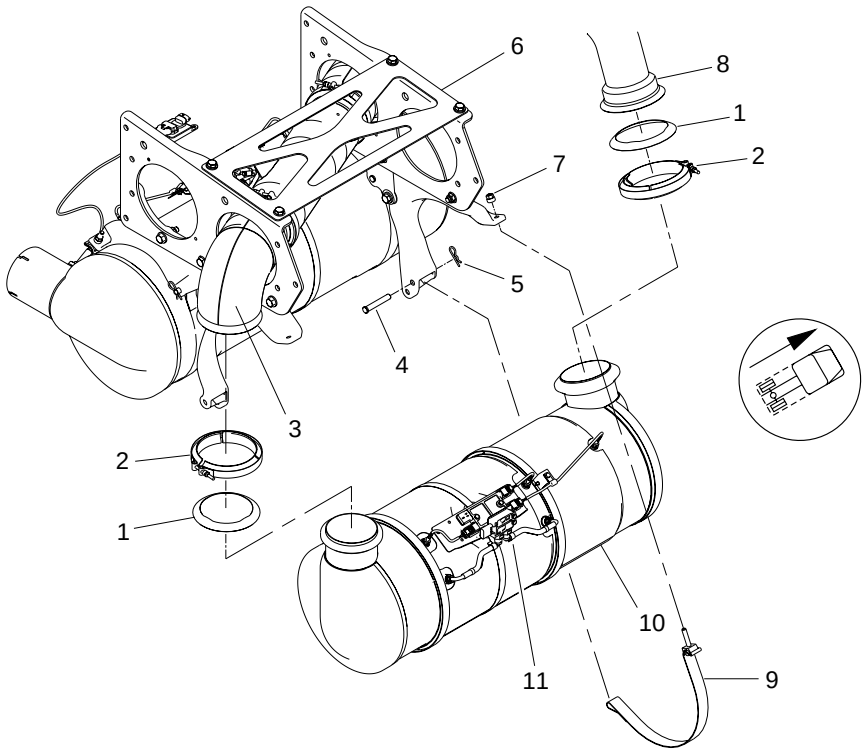
SCR Catalyst Removal and Installation

Removal

Refer to **Fig. 5** for this procedure.

1. Shut down the engine, set the parking brakes, and chock the tires.
2. Allow the ATS time to cool.
3. Raise the hood.
4. Remove the right side splash shield.
5. Remove the right side steps and fairing.
6. Remove the step mounting bracket, brace, and step rails. **Fig. 2**.
7. Mark the clocking of the SCR catalyst on both mounting frames in several places for later installation.
8. Remove the marmon clamp connecting the SCR catalyst inlet to the mixer tube elbow.

Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation



1. Gasket
2. Spherical Clamp
3. ATD to Mixer Tube Elbow
4. Clamping Strap Pin
5. Retaining Pin
6. ATS Mounting Frame
7. Clamping Strap Nut
8. ATD Inlet Pipe
9. Clamping Strap
10. ATD
11. Sensor Box

Fig. 4, ATD Installation

9. Remove the narrow band clamp connecting the SCR catalyst outlet pipe to the SCR catalyst.
10. Disconnect the wiring harness from the NOx sensor module.
11. Disconnect the wiring harness from the temperature sensor module.
12. Cut any zip ties as necessary, and free the harness from the SCR catalyst.
13. Remove the NOx sensor module from the mounting bracket on the frame rail, and secure it to the SCR catalyst.
14. Position an ATD jack, with single unit cradles, under the SCR catalyst and secure it to the jack with a strap.
15. Remove the nuts from the SCR catalyst clamping straps. Remove the straps, and discard the straps and hardware.
16. Lower the SCR catalyst from the truck.

Installation

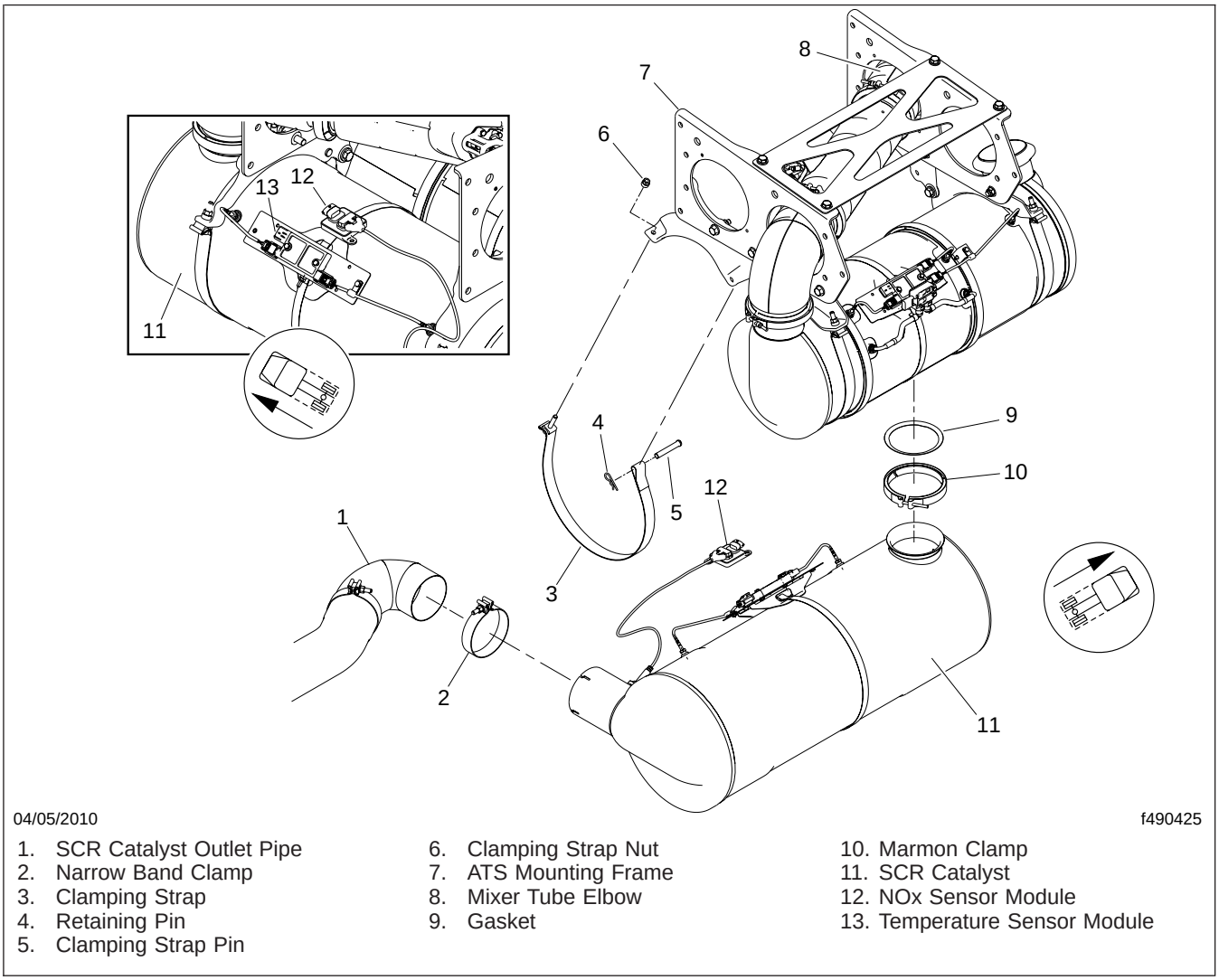
IMPORTANT: Always use new gaskets when installing exhaust system components.

1. Using the jack, raise the SCR catalyst into position.

NOTICE

The SCR catalyst may rotate while tightening the clamps. It is important that this is prevented. Check the alignment during and after the clamp-

Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation



1. SCR Catalyst Outlet Pipe
2. Narrow Band Clamp
3. Clamping Strap
4. Retaining Pin
5. Clamping Strap Pin
6. Clamping Strap Nut
7. ATS Mounting Frame
8. Mixer Tube Elbow
9. Gasket
10. Marmon Clamp
11. SCR Catalyst
12. NOx Sensor Module
13. Temperature Sensor Module

Fig. 5, SCR Catalyst Installation (typical)

ing procedure and make adjustments as needed. Improper installation may lead to component failure.

2. Install new clamping straps. Do not tighten at this time. Allow room to align the SCR catalyst in the mounting frame and mixer tube and outlet pipe.
3. Align the SCR catalyst in the mounting frame using the paint pen marks applied during disassembly.
4. Align the mixer tube elbow to the SCR catalyst inlet, then using a new gaskets, install the marmon clamp. Do not tighten at this time.
5. Align the SCR catalyst outlet pipe to the SCR catalyst, then install the clamp. Do not tighten at this time.
6. Check all alignment marks on the SCR catalyst, and tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).
7. Check the alignment on the mixer tube, then tighten the clamp 12 to 13 lbf·ft (16 to 17 N·m).
8. Tighten the SCR catalyst outlet pipe clamp 37 to 45 lbf·ft (50 to 60 N·m).

9. Position the wiring harness on the ATS. Install new zip ties as needed.
10. Install the NOx sensor module on the mounting bracket on the frame rail. Connect the wiring harness.
11. Connect the wiring harness to the temperature sensor module.
12. Start the engine and check for leaks. Tighten any connections as needed.
13. Install the step mounting bracket, brace, and step rails.
14. Install the steps and fairing.
15. Install the splash shield.

Cummins 2HH ATD and SCR Catalyst Removal and Installation

⚠ 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.**

NOTICE

Alignment is essential. Using a paint pen, mark every component's position prior to disassembling it on the truck. Improper assembly may result in leaks or damage to the ATS.

ATD Removal and Installation

Refer to **Fig. 1** for removal and installation of the ATS components.

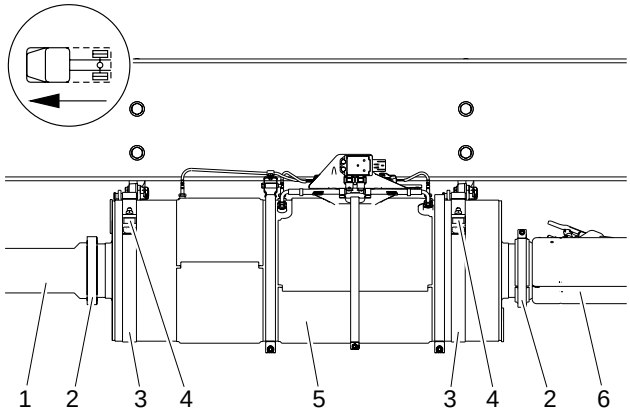
Removal

1. Shut down the engine and chock the tires.
2. Allow the ATS to cool before working on it.

NOTICE

Component alignment is critical to proper installation of ATS components. Before removing any components, put alignment marks (use both clocking and longitudinal marks where applicable) on all ATS components. This will aid in faster and more accurate alignment during assembly. Failure to accurately align all of the components of the ATS may result in component damage.

3. Make alignment marks on all of the components to be removed.



1. ATD Inlet Pipe
2. Spherical Clamp
3. Clamping Strap
4. Clamping-Strap Bolt and Nut
5. Aftertreatmment Device (ATD)
6. Mixer Tube

Fig. 1, ATD Installation

4. Disconnect the wire harness to the control module on the ATD.
5. Remove the spherical clamp and gasket that connects the ATD inlet pipe to the ATD. Discard the clamp and gasket.
6. Remove the spherical clamp and gasket that connects the ATD to the mix-tube. Discard the clamp and gasket.
7. Position the jack and cradle under the assembly and secure it with straps.
8. Remove the clamping bolts and nuts from the clamping straps.
9. Lower the unit.
10. Remove and discard the clamping straps and hardware.

Installation

1. Position the assembly in the jack cradle and secure it with straps.
2. Slide the unit under the vehicle and raise it into position.
3. Install the new clamping straps.

Cummins 2HH ATD and SCR Catalyst Removal and Installation

4. Position the assembly in the clamping straps, then install the clamping bolts and nuts. Do not tighten at this time.

IMPORTANT: Always use new gaskets when installing exhaust system components.

5. Connect the ATD to the ATD inlet pipe and install the new spherical clamp and gasket. Do not tighten at this time.
6. Connect the ATD outlet to the mix tube and install the new spherical clamp and gasket. Do not tighten at this time.
7. Recheck the alignment of all components. Make adjustments to the clamping straps as needed, then incrementally tighten the bolts 15 lbf·ft (20 N·m), them 30 lbf·ft (41 N·m).
8. Tighten the spherical clamps at the connections to the ATD inlet pipe and the mix tube 126 to 138 lbf·in (1425 to 1560 N·cm).
9. Connect the wiring harnesses to the control module on the ATD.
10. Remove the jack and cradle.
11. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.

SCR Catalyst Removal and Installation

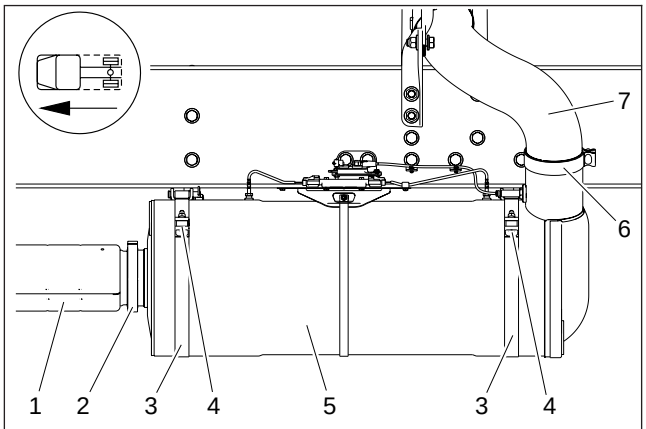
Refer to **Fig. 2** for removal and installation of the ATS components.

Removal

1. Shut down the engine and chock the tires.
2. Allow the ATS to completely cool before working on it.

NOTICE

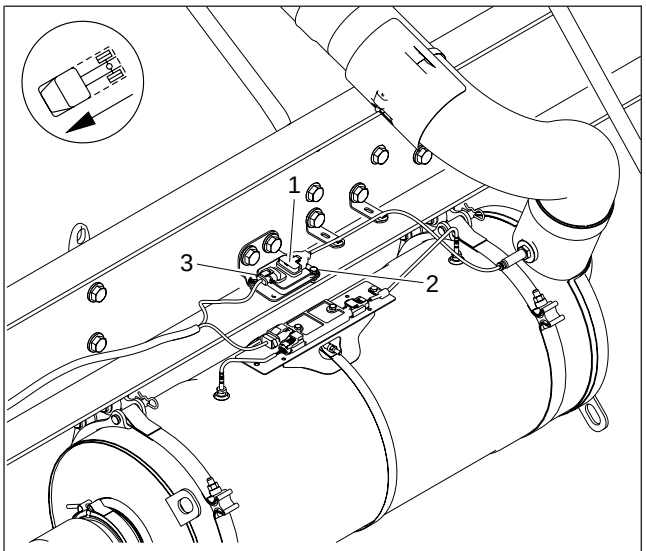
Component alignment is critical to proper installation of ATS components. Before removing any components, put alignment marks (use both clocking and longitudinal marks where applicable) on all ATS components. This will aid in faster and more accurate alignment during assembly. Failure to accurately align all of the components of the ATS may result in component damage.



1. Mixer Tube
2. Marmon Clamp
3. Clamping Strap
4. Clamping-Strap Bolt and Nut
5. SCR Catalyst
6. Wide-Band Clamp
7. Exhaust Pipe

Fig. 2, SCR Catalyst Installation

3. Make alignment marks on all components to be removed.
4. Disconnect the wire harness to the NOx sensor.
5. Remove the NOx sensor module from the frame rail bracket and secure it to the SCR catalyst. See **Fig. 3**.
6. Disconnect the wire harness to the control module on the SCR catalyst.
7. Remove the marmon clamp that connects the SCR catalyst to the mixer tube. Discard the clamp.
8. Remove the wide-band clamp that connects the SCR catalyst to the exhaust pipe. Discard the clamp.
9. Position the jack and cradle under the assembly and secure it with straps.
10. Remove the bolts and nuts from the four clamping straps.
11. Remove and discard the clamping straps and hardware.
12. Lower the unit.



1. NOx Sensor Module
2. Mounting Bolts and Nuts
3. Chassis Harness Connector

Fig. 3, NOx Sensor Module Installation

Installation

1. Position the assembly in the jack cradle and secure it with straps.
2. Install the new clamp straps.
3. Slide the unit under the vehicle and raise it into position.
4. Position the assembly in the clamping straps, and install the clamping bolts and nuts. Do not tighten at this time.

IMPORTANT: Always use new gaskets when installing exhaust system components.

5. Connect the SCR catalyst to the mixer tube and install the new marmon clamp and gasket. Do not tighten at this time.
6. Connect the SCR catalyst to the exhaust outlet pipe and install the new wide-band clamp. Do not tighten at this time.
7. Recheck the alignment of all components. Make adjustments to the clamping straps as needed then tighten the bolts 15 lbf·ft (20 N·m), then 30 lbf·ft (41 N·m).
8. Tighten the marmon clamp at the connection of the SCR catalyst and the mixer tube 12 to 13 lbf·ft (16 to 17 N·m).
9. Install the NOx sensor module on the bracket on the frame rail, then connect it to the chassis harness.
10. Connect the wiring harness to the control box on the SCR catalyst.
11. Remove the jack and cradle.
12. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.

General Description

The Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2009 must reduce the level of emissions exhausted by the engine to 0.2 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx).

To meet the EPA10 requirements, Daimler Trucks North America is using technology known as Selective Catalytic Reduction (SCR) in the exhaust aftertreatment system (ATS). See **Fig. 1**.

The SCR process requires the introduction of diesel exhaust fluid (DEF) into the exhaust stream. DEF is colorless, non-toxic, and biodegradable. In the ATS, the exhaust gases pass through the ATD, then are treated with precisely-controlled quantities of DEF, and then pass into the SCR catalyst. DEF consumption is dependent on ambient conditions and vehicle operation.

DEF is drawn from the tank by the DEF pump. The DEF is then filtered and, from the pump, transported through the DEF lines to the metering unit. The metering unit measures the correct amount of DEF, which is then injected into the hot exhaust flow after exhaust gases have passed through the ATD. In the presence of heat, DEF is converted to ammonia gas, which reacts with NOx in the selective catalyst chamber to yield harmless nitrogen and water vapor, which exit out the tailpipe.

DEF causes mild discoloration to aluminum, but will not affect its strength or structure. White crystals may be noticeable around components that come into contact with DEF. The crystals can be easily removed using water.

DEF freezes to a slush consistency at 12°F (-11°C). Because DEF can freeze, the DEF lines and metering unit are designed to purge whenever the engine is shut down to prevent damage. Complete purging of the DEF lines requires approximately five minutes after the engine is shut down.

DEF in the tank is allowed to freeze while the vehicle is non-operational. The DEF temperature sensor detects when the temperature of the DEF in the tank is approaching its freezing point. After the engine has been started and the engine coolant reaches a certain temperature, the coolant valve opens, allowing the coolant to flow through the coolant lines inside the DEF tank. The lines transfer heat, causing any frozen DEF in the tank to thaw and preventing liquid DEF from freezing during operation in cold weather. After flowing through the tank, the coolant is redirected back to the engine.

DEF will degrade over an extended period of time; shelf life is between twelve and eighteen months in standard operating conditions and temperatures. As DEF begins to degrade, it is usable but may be consumed at a slightly higher rate than normal.

A minor engine derate (approximately 25%) will occur when the DEF level registers below 5% on vehicles with Detroit Diesel engines, or 2.5% on vehicles with Cummins engines. If the DEF tank is empty, a major engine derate (vehicle speed is limited to 5 mph) will occur after an engine shut down and restart if the diesel tank has been refueled and the DEF tank is not refilled.

There are also safety controls that derate the engine if a contaminant has been introduced into the DEF tank. When a contaminant is detected, a minor engine derate will occur. When the vehicle has operated for 20 hours or 1000 miles with a contaminated tank, the vehicle will experience a major engine derate once the system determines that the vehicle is in a safe situation. Once the DEF tank has been filled with clean DEF, engine performance will return to normal.

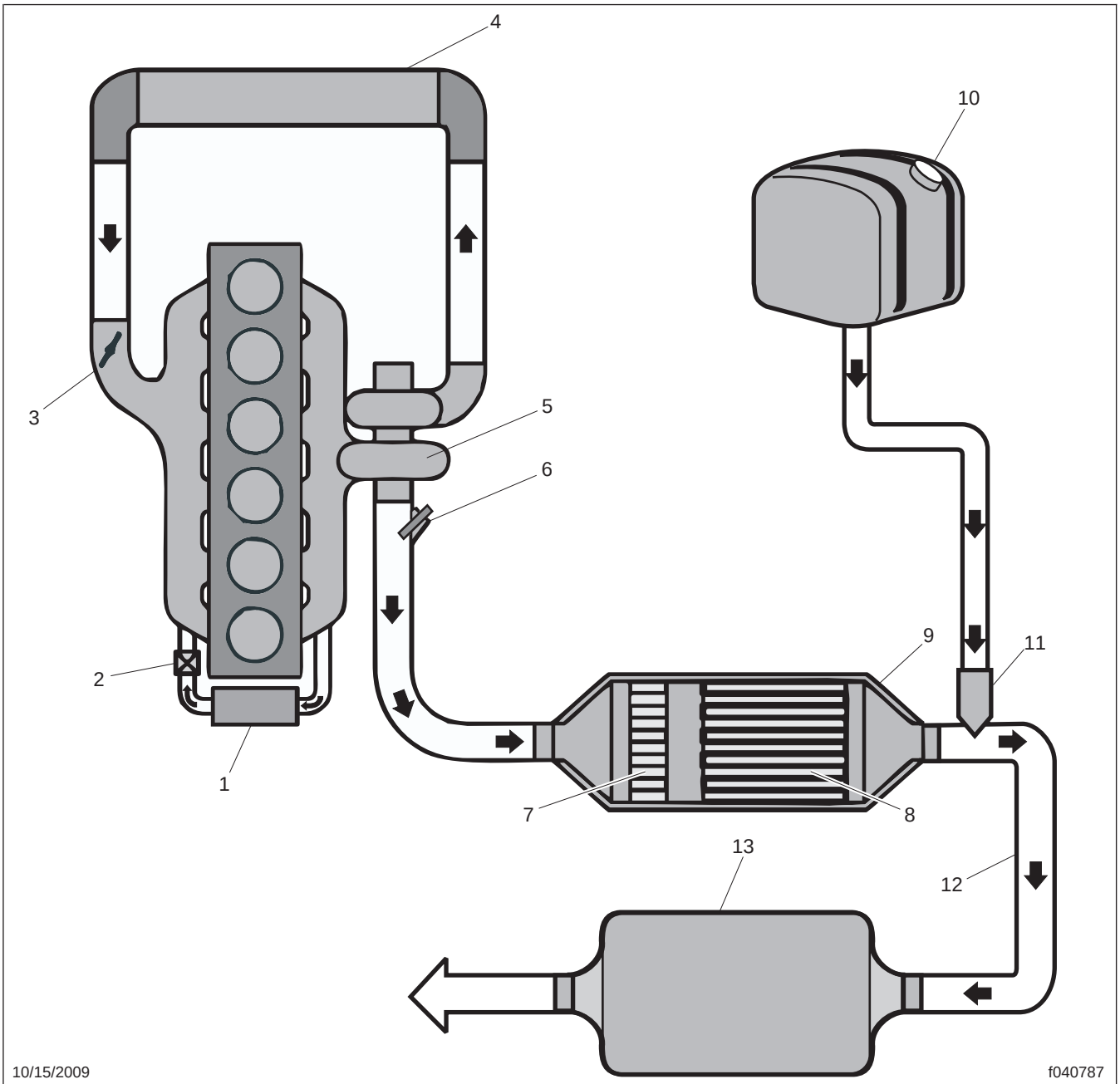
DTNA-covered components of the DEF system include the DEF tank, tank header unit, pump, and coolant, DEF, and air lines between these components. See the engine manufacturer's service literature for information regarding other DEF system components such as the metering unit and injector, and DEF system maintenance instructions and intervals.

For additional operating information, see the *Cascadia Driver's Manual*.

For additional information on and definitions for EPA10-compliant systems and components, see **Section 01.02**, EPA07/EPA10 Engine Information.

For additional information on the ATS, see **Section 49.01**, Aftertreatment System, EPA10.

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 Diesel Oxidation Catalyst (DOC)
8. Diesel Particulate Filter (DPF)
9. Aftertreatment Device (ATD)
10. DEF Tank
11. DEF Injector
12. Mixing Tube
13. SCR Catalyst Chamber

Fig. 1, EPA10 Aftertreatment System

Daimler Trucks North America vehicles carry diesel exhaust fluid (DEF) tanks in three sizes: 6 gallons, 13 gallons, or 23 gallons.

NOTE: DEF creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

6-Gallon Tank

Removal

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood.
3. Drain the coolant from the cooling system. For instructions, see **Group 20**.
4. Place a clean drain pan underneath the tank to catch draining DEF. Uncontaminated DEF may be reused.

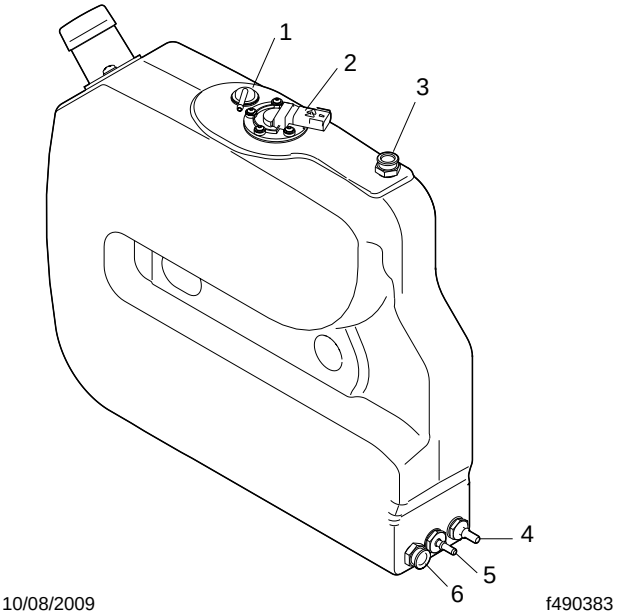
IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the DEF lines. Complete purging of the DEF lines requires approximately five minutes after the engine is shut down.

5. Disconnect the DEF line heater wiring harnesses from the DEF lines at the tank.

NOTICE

To disconnect a DEF line, push the line coupling in towards the male connector to move the holding clip to the unlocked position, then compress the prongs of the holding clip and pull the line off of the male connector. Failure to properly remove a DEF line can result in damage to a line coupling or DEF fitting.

6. Disconnect the DEF lines from the supply and return ports and let the DEF drain into the drain pan. See **Fig. 1** or **Fig. 2**.
7. Disconnect the wiring harness from the tank header unit.



1. Vent
2. DEF Level and Temperature Sensor Wiring Harness
3. Coolant Inlet
4. DEF Outlet
5. DEF Inlet
6. Coolant Outlet

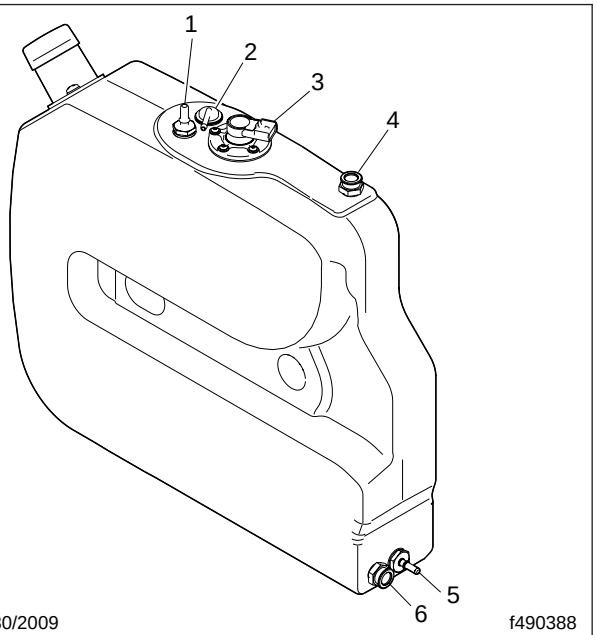
Fig. 1, 6-Gallon Tank Ports (Detroit Diesel shown)

8. Disconnect the coolant lines from the supply and return ports.
9. Disconnect the vent line.
10. If another chassis-mounted component is located directly aft of the DEF tank, check to see if the component is mounted close enough to prevent the tank from sliding off the mounting studs. If so, remove the nuts, bolts, and washers that secure the tank assembly to the frame casting, and remove the assembly from the frame casting.
11. Remove the two capscrews that secure the tank and retaining washers on the mounting studs. See **Fig. 3**.
12. Remove the two tank retaining washers from the tank mounting studs.
13. Slide the tank off of the mounting studs.

Installation

1. Slide the tank onto the mounting studs.

Tank Removal and Installation

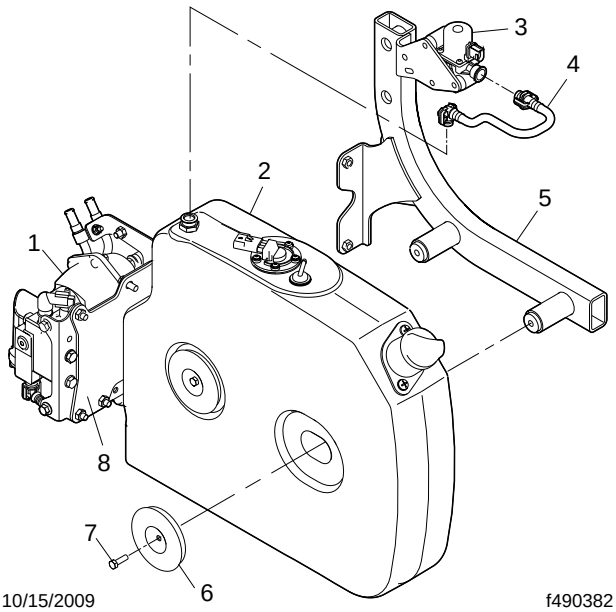


1. DEF Inlet
2. Vent
3. DEF Level and Temperature Sensor Wiring Harness
4. Coolant Inlet
5. DEF Outlet
6. Coolant Outlet

Fig. 2, 6-Gallon Tank Ports (Cummins shown)

2. Install two tank retaining washers on the tank mounting studs.
3. Install two capscrews onto the mounting studs, securing the tank and retaining washers on the tank mounting studs. Tighten the capscrews 11 to 18 lbf·ft (15 to 25 N·m).
4. If the tank assembly was previously removed from the frame casting, install the tank assembly on the frame casting. Tighten the four tank assembly mounting bolts 112 lbf·ft (152 N·m).
5. Connect the vent line.
6. Connect the coolant supply and return lines to the coolant ports on the tank.
7. Remove any white DEF crystals from the DEF ports on the tank and the DEF line couplings.

IMPORTANT: To connect a DEF line, push the line coupling onto the DEF port male connector, then pull back gently on the coupling to engage the holding clip in the locked position.



1. DEF Pump
2. DEF Tank
3. Coolant Valve
4. Coolant Supply Line
5. Tank Mounting Bracket
6. Tank Retaining Washer (Qty 2)
7. Capscrew (Qty 2)
8. Pump Mounting Bracket

Fig. 3, 6-Gallon Tank Mounting Assembly

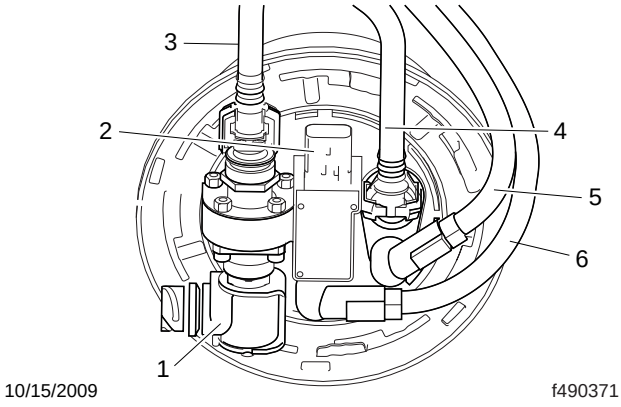
8. Connect the DEF supply and return lines to the DEF ports on the back of the tank.
9. Connect the DEF line heater wiring harnesses to the DEF lines at the tank.
10. Connect the wiring harness to the tank header unit.
11. Fill the DEF tank.
12. Fill the cooling system and check for leaks. For instructions, see **Group 20**.
13. Close the hood.

13- or 23-Gallon Tank

Removal

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood.
3. Drain the coolant from the cooling system. For instructions, see **Group 20**.
4. Remove the beauty cover, if equipped.
5. Using a siphon, empty the DEF from the tank into a clean container. Uncontaminated DEF may be reused.
6. Place a drain pan underneath the tank to catch any remaining DEF or coolant that drains out.
7. Disconnect the coolant valve and DEF level and temperature sensor wiring harnesses from the tank header unit. See **Fig. 4**.



1. Coolant Valve Wiring Harness
2. DEF Level and Temperature Sensor Wiring Harness
3. Coolant Return Line
4. Coolant Supply Line
5. DEF Return Line
6. DEF Supply Line

Fig. 4, DEF Tank Header Unit (Detroit Diesel shown)

8. Disconnect the coolant lines from the tank header unit.

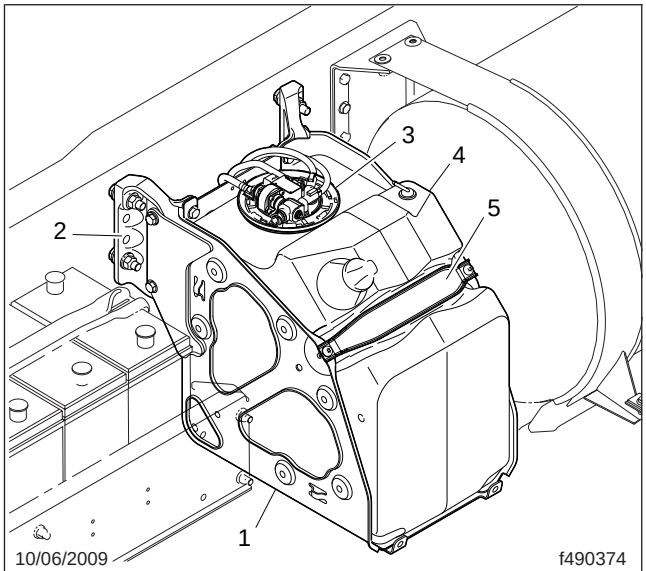
IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the DEF lines. Complete purging of the DEF lines requires approximately five minutes after the engine is shut down.

9. Disconnect the DEF line heater wiring harnesses from the DEF lines at the tank.

NOTICE

To disconnect a DEF line, push the line coupling in towards the male connector to move the holding clip to the unlocked position, then compress the prongs of the holding clip and pull the line off of the male connector. Failure to properly remove a DEF line can result in damage to a line coupling or DEF fitting.

10. Disconnect the DEF lines from the tank header unit.
11. Disconnect the vent line.
12. Remove the two nuts that secure the tank retaining bracket to the tank mounting cage and remove the retaining bracket. See **Fig. 5**.



1. Mounting Cage
2. Mounting Support Bracket
3. Tank Header Unit
4. Tank
5. Tank Retaining Bracket

Fig. 5, 13- or 23-Gallon DEF Tank Mounting Assembly

13. Remove the tank from the mounting cage.

Installation

1. Install the tank into the mounting cage.

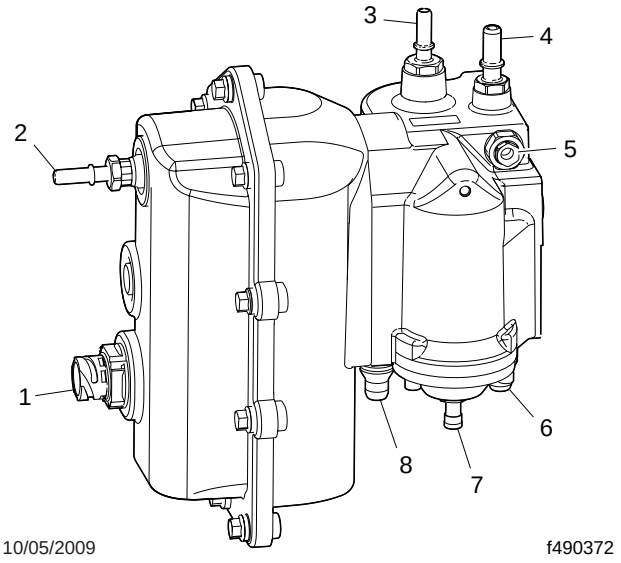
Tank Removal and Installation

2. Install the tank retaining bracket on the tank mounting cage studs. Install two nuts on the tank retaining bracket and tighten the nuts 12 lbf·ft (16 N·m).
3. Connect the vent line.
4. Remove any white DEF crystals from the DEF ports on the header unit and the DEF line couplings.

IMPORTANT: To connect a DEF line, push the line coupling onto the DEF port male connector, then pull back gently on the coupling to engage the holding clip in the locked position.

5. Connect the DEF supply and return lines to the tank header unit.
6. Connect the DEF line heater wiring harnesses to the DEF lines at the tank.
7. Connect the coolant lines to the tank header unit.
8. Connect the coolant valve and DEF level and temperature sensor wiring harnesses to the tank header unit.
9. Fill the DEF tank.
10. Install the beauty cover, if equipped.
11. Fill the cooling system and check for leaks. For instructions, see **Group 20**.
12. Close the hood.

EPA10-compliant vehicles have a diesel exhaust fluid (DEF) pump module (**Fig. 1**) mounted in a protective box to the back of the DEF tank.



1. Wiring Harness Connector
2. DEF Inlet Port
3. DEF Outlet Port (to metering unit)
4. DEF Outlet Port (to tank)
5. Compressed Air Port
6. Coolant Outlet Port
7. Air Bladder Fill Valve
8. Coolant Inlet Port

Fig. 1, DEF Pump (Detroit Diesel shown)

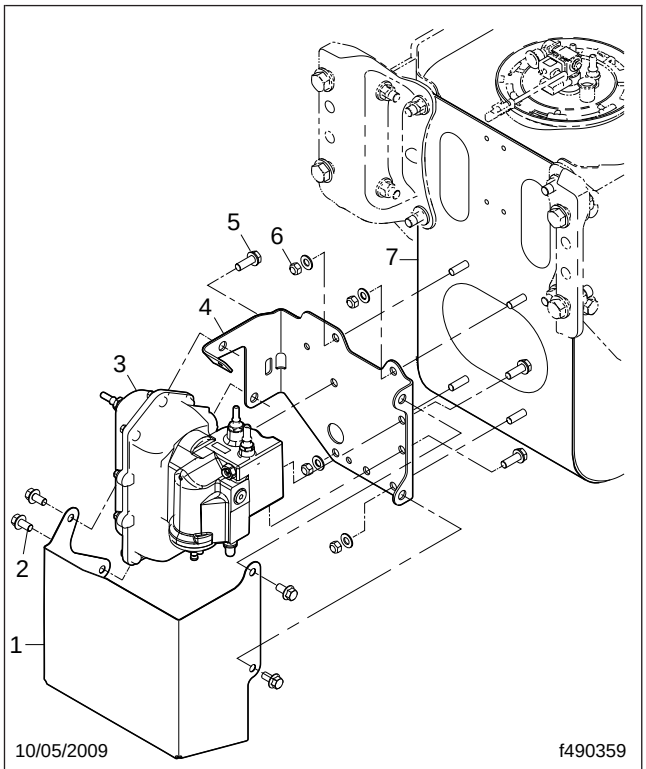
The DEF pump module filters and supplies DEF to the metering unit. The only serviceable components of the pump module are the air bladder and the filter. See the engine manufacturer's service literature for maintenance instructions and intervals.

NOTE: DEF creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

Removal

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood.
3. Drain the air system.
4. On a vehicle equipped with a Detroit Diesel engine, drain the coolant from the cooling system. For instructions, see **Group 20**.
5. Place a drain pan underneath the pump to catch any DEF or remaining coolant that drains out.
6. Remove the four mounting bolts that secure the protective cover over the pump. Remove the cover. See **Fig. 2**.



1. Protective Cover
2. Protective Cover Mounting Fasteners
3. DEF Pump
4. Pump Mounting Bracket
5. Pump Mounting Fasteners
6. Mounting Bracket Fasteners
7. DEF Tank Mounting Cage

Fig. 2, DEF Pump Removal and Installation

7. Disconnect the wiring harness from the pump.

Pump Removal and Installation

8. Disconnect the coolant lines and air line, if equipped, from the pump.

IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the DEF lines. Complete purging of the DEF lines requires approximately five minutes after the engine is shut down.

9. Disconnect the DEF line heater wiring harnesses from the DEF lines at the pump.

NOTICE

To disconnect a DEF line, push the line coupling in towards the male connector to move the holding clip to the unlocked position, then compress the prongs of the holding clip and pull the line off of the male connector. Failure to properly remove a DEF line can result in damage to a line coupling or DEF fitting.

10. Disconnect the DEF lines from the pump.
11. Loosen and remove the four nuts that secure the pump mounting bracket to the tank mounting cage.
12. Remove the DEF pump and mounting bracket.
13. Remove the three fasteners that secure the pump to the mounting bracket, and remove the pump from the bracket.

Installation

1. Using the three pump mounting fasteners, secure the pump to the pump mounting bracket. Tighten the fasteners 26 lbf·ft (35 N·m).
2. Install the four nuts that secure the pump mounting bracket to the DEF tank mounting bracket. Tighten the nuts 23 lbf·ft (31 N·m).
3. Remove any white DEF crystals from the DEF ports on the pump and the DEF line couplings.

IMPORTANT: To connect a DEF line, push the line coupling onto the DEF port male connector, then pull back gently on the coupling to engage the holding clip in the locked position.

4. Connect the DEF supply and return lines to the three DEF ports on the pump.
5. Connect the DEF line heater wiring harnesses to the DEF lines at the pump.
6. Connect the air line and coolant lines, if equipped, to the pump.
7. Connect the wiring harness to the pump.
8. Place the protective cover over the pump and install the four mounting bolts that secure the protective cover to the pump mounting bracket. Tighten the bolts 37 lbf·ft (50 N·m).
9. On a vehicle equipped with a Detroit Diesel engine, fill the cooling system and check for leaks. For instructions, see **Group 20**.
10. Fill the air system.
11. Close the hood.

NOTE: Diesel exhaust fluid (DEF) creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

Replacement

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the battery ground cable. Disconnecting the battery ground cable too soon will prevent purging of the DEF lines after the engine is shut down.

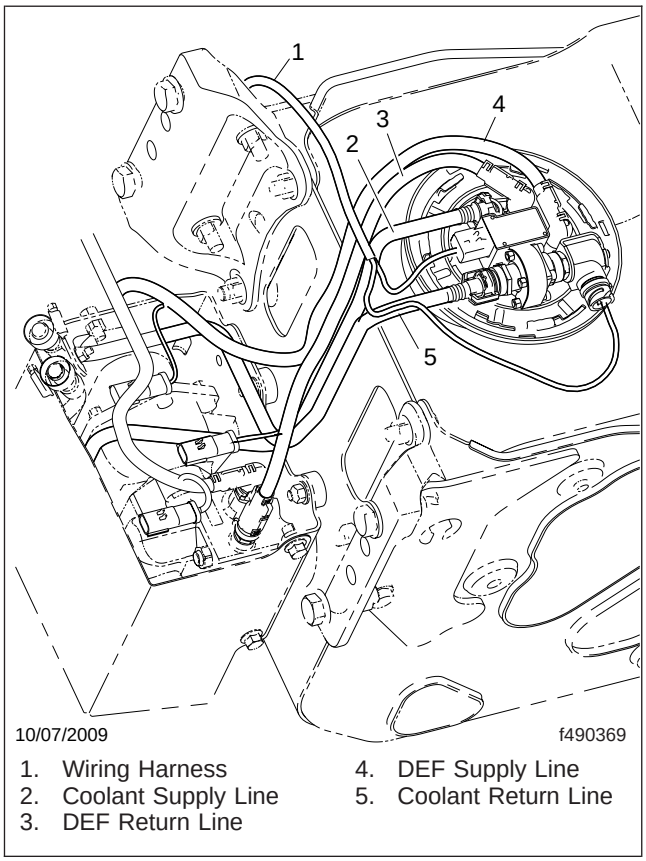
2. Disconnect the batteries.
3. Place drain pans underneath the DEF pump and the DEF metering unit to catch any draining DEF.
4. Disconnect the DEF line heater wiring harnesses from the DEF lines at the tank, pump, and metering unit.

NOTICE

To disconnect a DEF line, push the line coupling in towards the male connector to move the holding clip to the unlocked position, then compress the prongs of the holding clip and pull the line off of the male connector. Failure to properly remove a DEF line can result in damage to a line coupling or DEF fitting.

5. Disconnect the DEF lines between the DEF pump and the tank. See **Fig. 1**.
6. Disconnect the DEF lines between the pump and the metering unit.
7. Discard the lines.
8. Ensure the new DEF lines are undamaged and free of dirt or debris.
9. Remove any white DEF crystals from the DEF ports on the tank, pump, and metering unit.

IMPORTANT: To connect a DEF line, push the line coupling onto the DEF port male connector, then pull back gently on the coupling to engage the holding clip in the locked position.



1. Wiring Harness
2. Coolant Supply Line
3. DEF Return Line
4. DEF Supply Line
5. Coolant Return Line

Fig. 1, DEF Pump Line Connections

10. Install new DEF lines between the DEF pump and the tank.
11. Install new DEF lines between the DEF pump and the metering unit.
12. Connect the DEF line heater wiring harnesses to the DEF lines at the tank, pump, and metering unit.
13. Connect the batteries.

NOTE: DEF creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

Replacement, 6-Gallon Tank

The DEF header unit on vehicles with a 6-gallon DEF tank is secured to the top of the tank, and contains the DEF level sensor and the DEF temperature sensor.

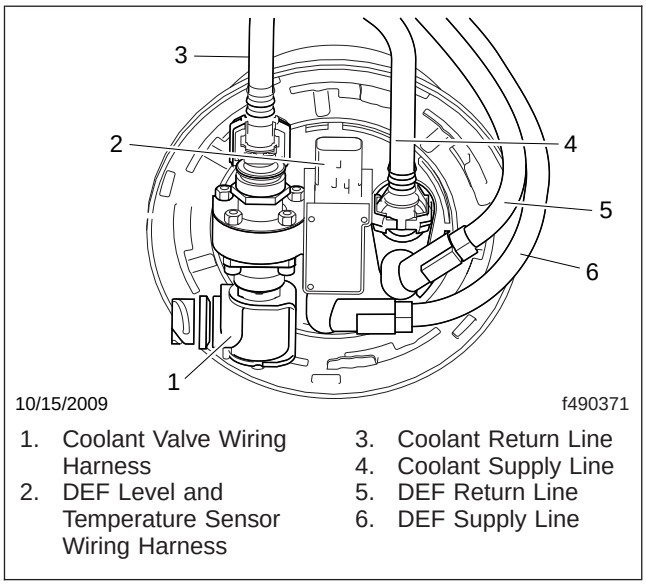
IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Remove the tank from the vehicle. See **Subject 100** for instructions.
3. Remove the header unit mounting capscrews and washers that secure the header to the tank.
4. Remove the header unit from the tank.
5. Install a new header unit into the tank.
6. Ensure that the header unit is situated securely on the raised lip of the tank, and is not tilted to the side.
7. Install the mounting capscrews and washers to secure the header unit to the tank. Tighten the capscrews 5 lbf·ft (7 N·m).
8. Connect the DEF level and temperature sensor wiring harness.
9. Install the DEF tank on the vehicle. See **Subject 100** for instructions.

Replacement, 13- or 23-Gallon Tank

The DEF header unit on vehicles with a 13- or 23-gallon DEF tank is secured to the top of the tank, and contains the engine coolant lines that run through the tank, the coolant valve, the DEF level sensor, and the DEF temperature sensor. See **Fig. 1**.

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.



1. Coolant Valve Wiring Harness
2. DEF Level and Temperature Sensor Wiring Harness
3. Coolant Return Line
4. Coolant Supply Line
5. DEF Return Line
6. DEF Supply Line

Fig. 1, DEF Tank Header Unit (Detroit Diesel shown)

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Remove the tank from the vehicle. See **Subject 100** for instructions.
3. Rotate the header lockring counter-clockwise to loosen it, then remove the lockring.
4. Remove the header unit from the tank by pulling the assembly straight up, then tilting it to pull the horizontal end clear of the tank; see **Fig. 2**.
5. Install a new header unit by tilting it to insert the horizontal end into the tank. Once the horizontal segment is inside the tank, tilt the header unit back to vertical to settle the bracket on top of the tank.
6. Ensure that the header unit is situated securely on the raised lip of the tank, and is not tilted to the side.
7. Install the header lockring and rotate it clockwise to secure it to the tank.
8. Remove any white DEF crystals from the DEF ports on the header unit and the DEF line couplings.
9. Install the DEF tank on the vehicle. See **Subject 100** for instructions.

Tank Header Unit Replacement

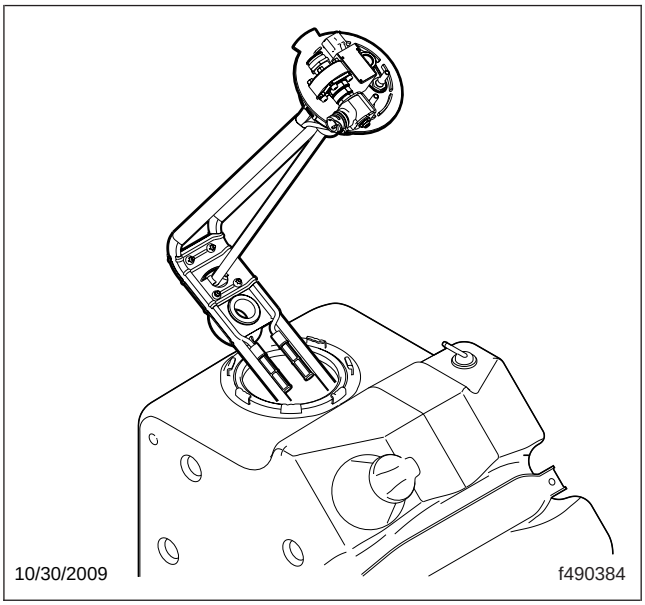


Fig. 2, Header Unit Tilt

NOTE: Diesel exhaust fluid (DEF) creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

Periodic maintenance of the DEF pump filter is required. For instructions and intervals, see the engine manufacturer's service literature.

Replacement

Detroit Diesel

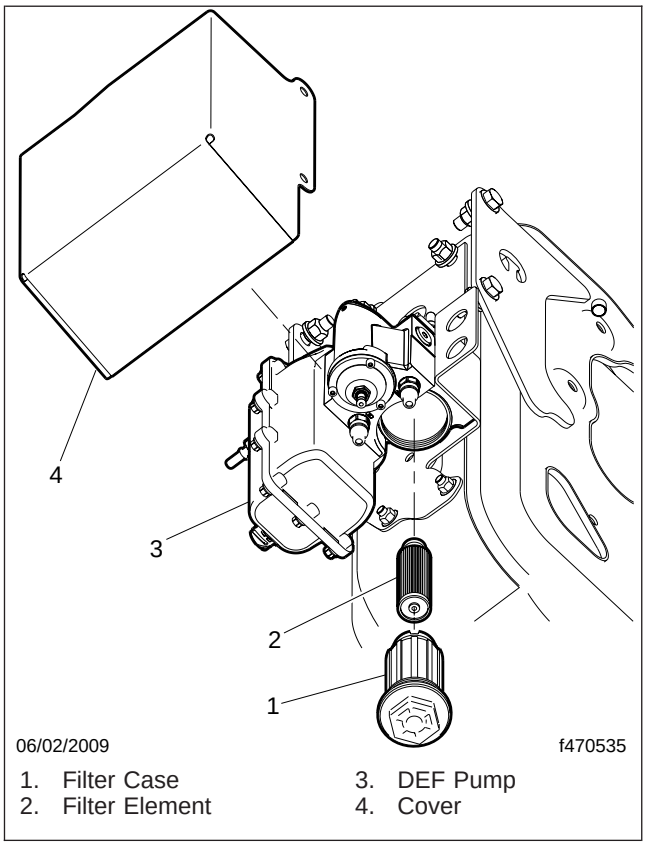
IMPORTANT: Discard contaminated DEF in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the battery ground cable. Disconnecting the battery ground cable too soon will prevent purging of the DEF lines after the engine is shut down.

2. Disconnect the batteries.
3. Remove the four mounting bolts that secure the protective cover over the pump. Remove the cover. The pump is located next to, or inboard of, the DEF tank.
4. Unscrew the filter cartridge; see **Fig. 1**. The cartridge includes both the filter case and the filter element, which are replaced as a unit. Verify that the filter element was removed with the case. If the filter element was not removed, use a suitable tool to remove it from the pump.

   Discard the filter element and case.
5. Lubricate the O-rings with clean DEF.
6. Check the new filter cartridge to ensure that the O-ring end of the filter element is facing out of the cartridge. Install the cartridge into the DEF pump. Tighten the filter cartridge 22 to 25 lbf·ft (30 to 34 N·m).
7. Place the protective cover over the pump and install the four mounting bolts that secure the protective cover to the pump mounting bracket. Tighten the bolts 37 lbf·ft (50 N·m).



1. Filter Case
2. Filter Element
3. DEF Pump
4. Cover

Fig. 1, DEF Filter Replacement, Detroit Diesel Engine

8. Connect the batteries.

Cummins

IMPORTANT: Discard contaminated DEF in accordance with EPA regulations.

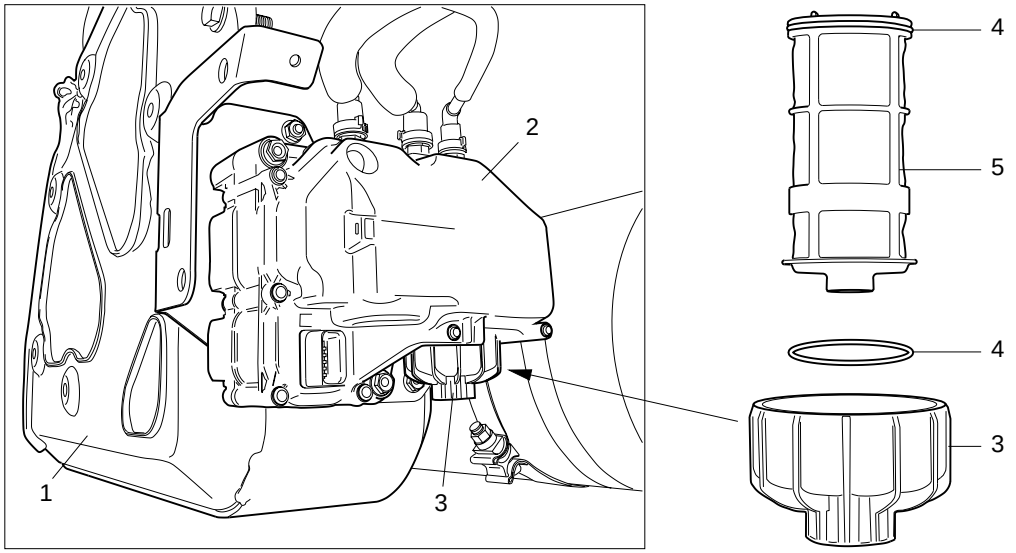
1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the battery ground cable. Disconnecting the battery ground cable too soon will prevent purging of the DEF lines after the engine is shut down.

2. Disconnect the batteries.
3. Remove the four mounting bolts that secure the protective cover over the pump. Remove the cover. The pump is located inboard of the DEF tank.

Pump Filter Replacement

4. Unscrew the filter cap, then remove and discard the filter element. See **Fig. 2**.
5. Install the new filter element into the DEF pump with the O-ring end facing into the pump.
6. Install the filter cap. Tighten the cap 15 to 18 lbf·ft (20 to 25 N·m).
7. Place the protective cover over the pump and install the four mounting bolts that secure the protective cover to the pump mounting bracket. Tighten the bolts 37 lbf·ft (50 N·m).
8. Connect the batteries.



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1. DEF Tank
2. DEF Pump
3. Filter Cap
4. O-Ring
5. Filter Element

Fig. 2, DEF Filter Replacement, Cummins Engine

If a contaminant has been introduced into the diesel exhaust fluid (DEF) system and the engine has been started, the following DEF components must be replaced:

- Tank
- Pump
- Header unit
- Metering unit
- Injector

See the other subjects in this section for tank, pump, and header unit replacement.

See the engine manufacturer's service literature for other component replacement instructions.

Flushing

If a contaminant has been introduced to the DEF tank, but the engine has not been started, complete the following steps.

1. Apply the parking brake and chock the tires.
2. Place a suitable container underneath the DEF tank to catch any draining DEF.

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

3. Remove the DEF and contaminant from the tank.

   On vehicles with a 6-gallon DEF tank, disconnect the DEF line from the DEF outlet port and let the DEF drain into the drain pan.

   On vehicles with a 13- or 23-gallon DEF tank, use a siphon to empty the DEF from the tank.
4. Remove the DEF tank. See **Subject 100** for instructions.
5. Thoroughly flush the tank with water until the tank is free of all contaminants.
6. Install the DEF tank. See **Subject 100** for instructions.

General Information

The SAM Cab is an integrated electronic control unit (ECU). The SAM Cab is the vehicle power distribution module that manages the cab electrical functions. The SAM Cab communicates with the other ECUs in the Cascadia using the CAN databus.

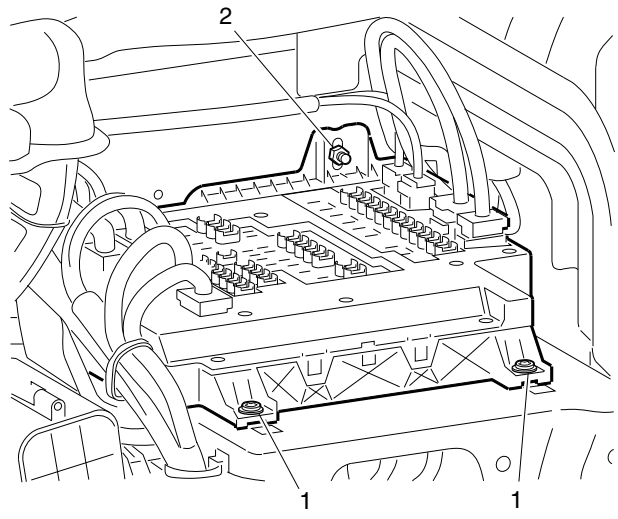
Fuses and relays are located on the top side of the SAM Cab inside the vehicle. Access is achieved by removing the glove compartment and the protective shields.

When a SAM Cab is replaced it must be reprogrammed with the specific parameters for the vehicle in which it is being installed. Use ServiceLink or DiagnosticLink to download and program the parameters for the SAM Cab.

All the ECUs on the CAN databus must be at compatible versions of software for data communication to occur properly. When a SAM Cab is replaced, use ServiceLink or DiagnosticLink to determine if the SAM Chassis, MSF, and CGW are all communicating at compatible versions of software. Use ServicePro® to get the current service bulletin information for any updates to Cascadia software versions.

Removal

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. On the passenger-side of the vehicle on the upper frontwall, gently pull the rain tray drain tube from the rain tray.
4. Reach up into the area behind the HVAC ducting and disconnect the 4 lever lock connectors from the "nosepiece" of the SAM cab.
5. Disconnect the positive and negative power cables from the SAM.
6. From inside the cab, remove the lower dash panel and the glove box. Refer to **Section 60.06**.
7. Carefully remove the drip shields. Avoid flexing the joint on the large drip shield covering the SAM cab.
8. Disconnect the four connectors on the lower side, and all the connectors on the upper side of SAM Cab. Mark these to insure proper installation.
9. Remove the three fasteners that secure the SAM Cab to the mounting plate. See **Fig. 1**.



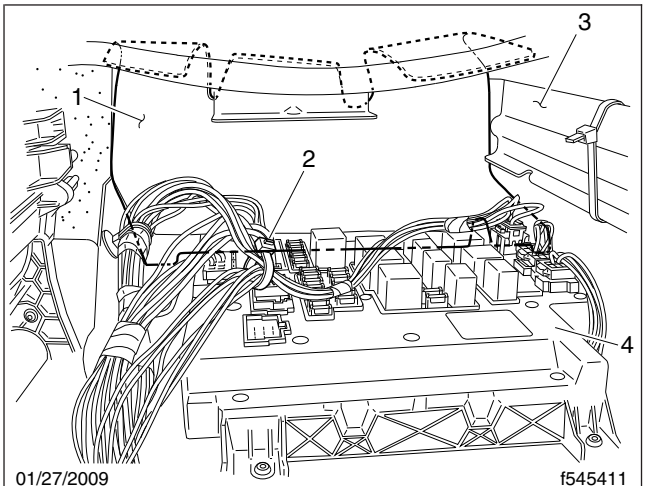
1. Forward Mounting Bolts
2. Rear Mounting Bolt

Fig. 1, SAM Cab Mounting Bolts

10. Slide the SAM Cab forward, then up and out of the vehicle.

Installation

1. Transfer any relays from the old SAM Cab.
2. Slide the new SAM cab in the glove compartment opening and align the mounting tabs into the bracket.
3. Check that no wires are pinched between the SAM and the frontwall. Then, install the three mounting fasteners to secure the SAM cab.
4. Position the drip shield on the forward edge of the SAM cab. Make sure the lower edge is forward of the connector area of the SAM cab See **Fig. 2**.

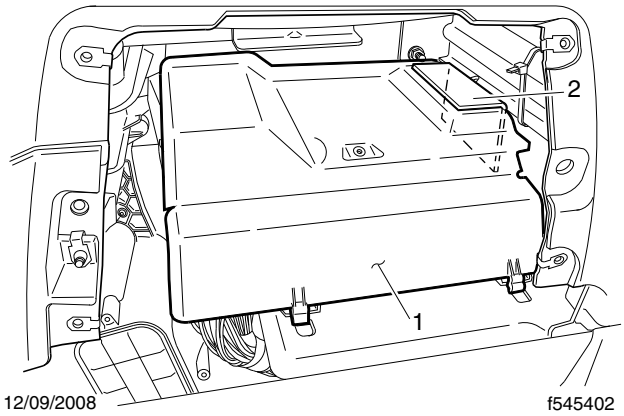


1. Plastic Drip Shield
2. Tie Strap
3. Dash Support Bracket
4. SAM Cab

Fig. 2, Drip Shield Installation

5. Connect the connectors in the SAM. Shape the drip loops in the harnesses on the right side of the SAM so the lower part of the loop is below the right edge of the SAM. The drip loops are tucked between the SAM and the side wall of the cab.
6. Install the SAM cover shield and the angle shield on the right edge of the cover shield. See **Fig. 3**. Make sure that any wiring such as antenna cables are routed above these shields.

Removal and Installation



1. Drip Shield
2. Angle Shield

Fig. 3, Drip Shield Installed

7. Install the glove compartment and the lower dash panel. Refer to **Section 60.06** .
8. From the engine compartment, install the positive and negative power cables and the four leverlock connectors.
9. Install the rain tray drain tube.
10. Connect the batteries.
11. Remove the chocks from the tires

NOTE: The SAM Cab must be programmed (updated) whenever it is removed from the vehicle and then reinstalled.

12. Flash the SAM Cab with the parameters applicable to the vehicle. Refer to **Subject 110** for more information.

Programming the SAM Cab

When the SAM Cab is programmed, both the application software and parameters are updated in the SAM Cab.

In most cases it is only necessary to update the SAM Cab as a last resort if the SAM Cab is suspected of being faulty. This is to confirm that the problem is hardware-related.

In all other situations, it is only necessary to "Reset Parameters."

Using ServiceLink

Programming

The SAM Cab can be programmed in ServiceLink using the SAM Cab "Flashing" Tab. See the for more information.

Reset Parameters

SAM Cab parameters can be reset in ServiceLink using the SAM Cab "Parameters" tab. Selecting "Reset to Current Host" applies the appropriate parameters to the SAM Cab for the affected vehicle.

If the SAM Cab is still programmed with the original software version, it is also possible to select "Reset to Factory Settings."

NOTE: Pay particular attention to the first "NOTICES" screen when opening ServiceLink. This screen contains details about flashing, and applying reference parameters to the SAM Cab.

Using DiagnosticLInk

Programming

The SAM Cab can be programmed in DiagnosticLink using the "Program Device" tab. Select "Update Device Software."

Reset Parameters

SAM Cab parameters can be reset in DiagnosticLink using the "Program Device" tab. Select "Replace Device Settings with Server Configuration." Selecting "Latest" settings applies the appropriate parameters to the SAM Cab for the affected vehicle.

If the SAM Cab is still programmed with the original software version, it is also possible to select "Reset to Factory Settings."

Refer to in the for more information.

General Information

The SAM Chassis is an integrated electronic control unit (ECU). The SAM Chassis is the vehicle power distribution module that manages many of the chassis electrical functions. The SAM Chassis communicates with the other ECUs using the CAN databus.

Fuses and relays are located behind a cover on the engine side of the SAM Chassis.

When a SAM Chassis is replaced, it must be programmed with the specific parameters for the vehicle in which it is being installed. Use ServiceLink or DiagnosticLink to download and program the parameters for the SAM Chassis.

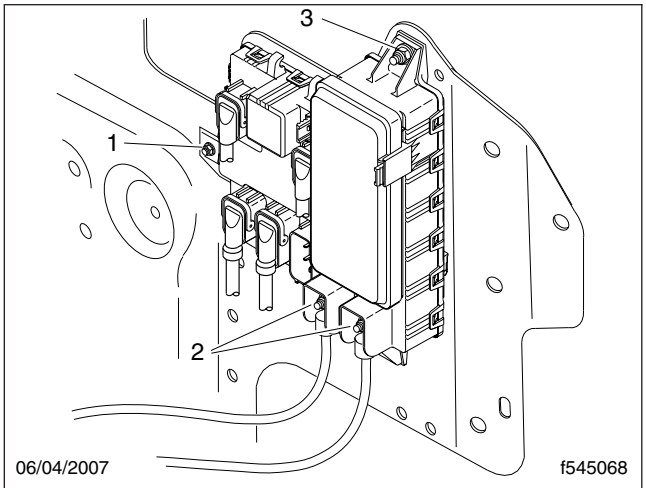
All the ECUs on the CAN databus must be at compatible versions of software for data communication to occur properly. When a SAM Chassis is replaced, use ServiceLink to determine if the SAM Cab, MSF, and CGW are all communicating at compatible versions of software. Use ServicePro® to get the current service bulletin information for any updates to Cascadia software versions.

Removal

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Disconnect the batteries.
4. From inside the cab, remove the driver-side kick panel and the door step plate.
5. Carefully push the frontwall insulation aside and disconnect the SAM Chassis electrical connectors. Remove the ground wires connected to the stud located below the electrical connectors.
6. On the frontwall, disconnect all wiring connectors, and the positive and negative battery cables, from the SAM Chassis.
7. To allow enough side-to-side movement for the SAM Chassis to be removed from the frontwall, loosen the hydraulic clutch control, if equipped.

   7.1 Remove the four T40 screws that secure the clutch control to the frontwall.

   7.2 Move the clutch control to the side. Use care to avoid stressing the hydraulic line.
8. Remove the three nuts that secure the SAM Chassis to the frontwall. See **Fig. 1**. Remove the SAM Chassis.



1. Mounting Nut (side)
2. Battery Cables
3. Mounting Nut (upper)

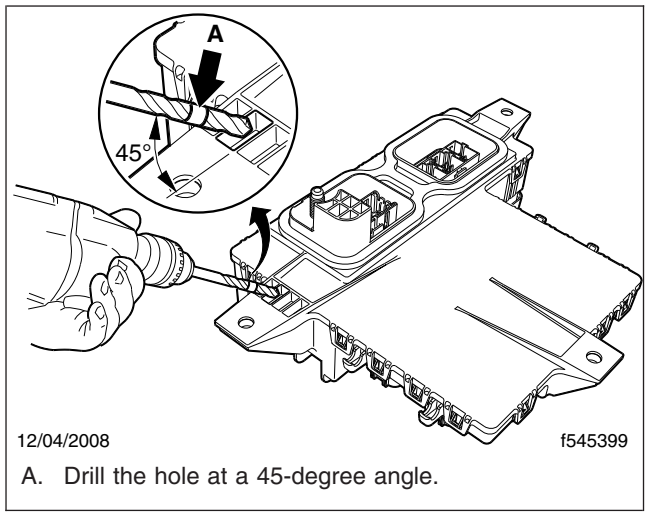
Fig. 1, SAM Chassis

Installation

1. Inspect the SAM Chassis for a hole in the lower mounting flange. If there is no hole, prepare the new SAM chassis by drilling a hole in the lower mounting flange.

   1.1 Mark a 1/4-inch (6-mm) drill bit with tape at 1 inch (25 mm) from the end. See **Fig. 2**.

   1.2 With the SAM Chassis on a workbench, drill a drain hole in the lower mounting flange of the SAM chassis, as shown in **Fig. 2**. Drill the hole at a 45-degree angle. Drill only to a depth of 1 inch (25 mm). *Do not drill any further*.



A. Drill the hole at a 45-degree angle.

Fig. 2, Drilling the Hole in the Lower Mounting Flange

   1.3 Transfer any fuses and relays from the old SAM Chassis to the new one, and install the cover.

   NOTE: The lower latch of the SAM Chassis should be securely attached before attaching the upper latch.

   1.4 Confirm the lower and upper latches of the cover are securely in place.
2. Position the SAM Chassis on the front wall and install the three mounting nuts.
3. Connect the wiring connectors to the SAM Chassis.

Removal and Installation

4. Connect the positive and negative battery cables to the SAM Chassis.
5. Install the hydraulic clutch control, if equipped.
   - 5.1 Position the clutch control on the frontwall.
   - 5.2 Install the four T40 clutch control mounting screws, and tighten the screws 11 to 15 lbf·ft (15 to 20 N·m).
6. From inside the cab, install the driver-side kick panel and the door step plate.
7. Connect the batteries.
8. Using ServiceLink or DiagnosticLink, program the SAM Chassis with the software and parameters appropriate for the vehicle.
9. Close the hood and remove the chocks from the tires.

Programming the SAM Chassis

When the SAM Chassis is programmed, its application software is updated only if needed, and parameters for the vehicle are applied.

Programming in ServiceLink is done in the SAM Chassis "Flashing" screen. Programming in DiagnosticLink is done in the "Program Device" screen. For more information, see the diagnostic tool's user documentation.

NOTE: Pay particular attention to the first "NOTICES" screen when opening ServiceLink. This screen contains details about flashing, and applying reference parameters to the SAM Chassis.

Refer to **G02.05—SAM Chassis** in the *Cascadia Troubleshooting Manual* for more information.

General Information

The Common Powertrain Controller (CPC) is an ECU used with Detroit Diesel and Mercedes-Benz engines. The CPC is the interface between the Motor Control Module (MCM) and the vehicle electronics system, acting as a gateway.

Electrical devices inside the cab that are used to control the engine are translated through the CPC. The accelerator pedal and cruise control switches are two examples of CPC function.

All J1939 and J1587/J1708 datalink communication from the engine to the vehicle electronics occurs with the CPC. The CPC then communicates with the MCM via a proprietary communication protocol.

The CPC has three 18-pin connectors and one 21-pin connector, and it's located behind the dash, to the right of the auxiliary panel.

Replacement

The CPC is located in the upper center of the dash console, and is accessed through the auxiliary dash panel opening. See **Fig. 1**.

1. Chock the tires.

NOTE: It may be helpful to loosen the screws that retain the panel around the radio trim plate and air valves before removing the auxiliary panel.

2. Remove the four T25 screws that secure the auxiliary panel to the dash assembly.
3. Pull the auxiliary panel forward to access the CPC.
4. Place masking tape along the edges of the auxiliary panel to prevent it from scratching dash components.
5. Remove any tie straps that assist retention of the CPC.
6. Remove the four electrical connectors.
7. Remove the CPC.
8. Install the new CPC in the dash.
9. Connect the four electrical connectors to the CPC.
10. Install new tie straps as necessary.
11. Remove any masking tape applied to the auxiliary panel before the CPC was removed.
12. Position the auxiliary panel on the dash and install the four T25 screws.
13. If necessary, tighten the screws that retain the radio trim plate and air valves.

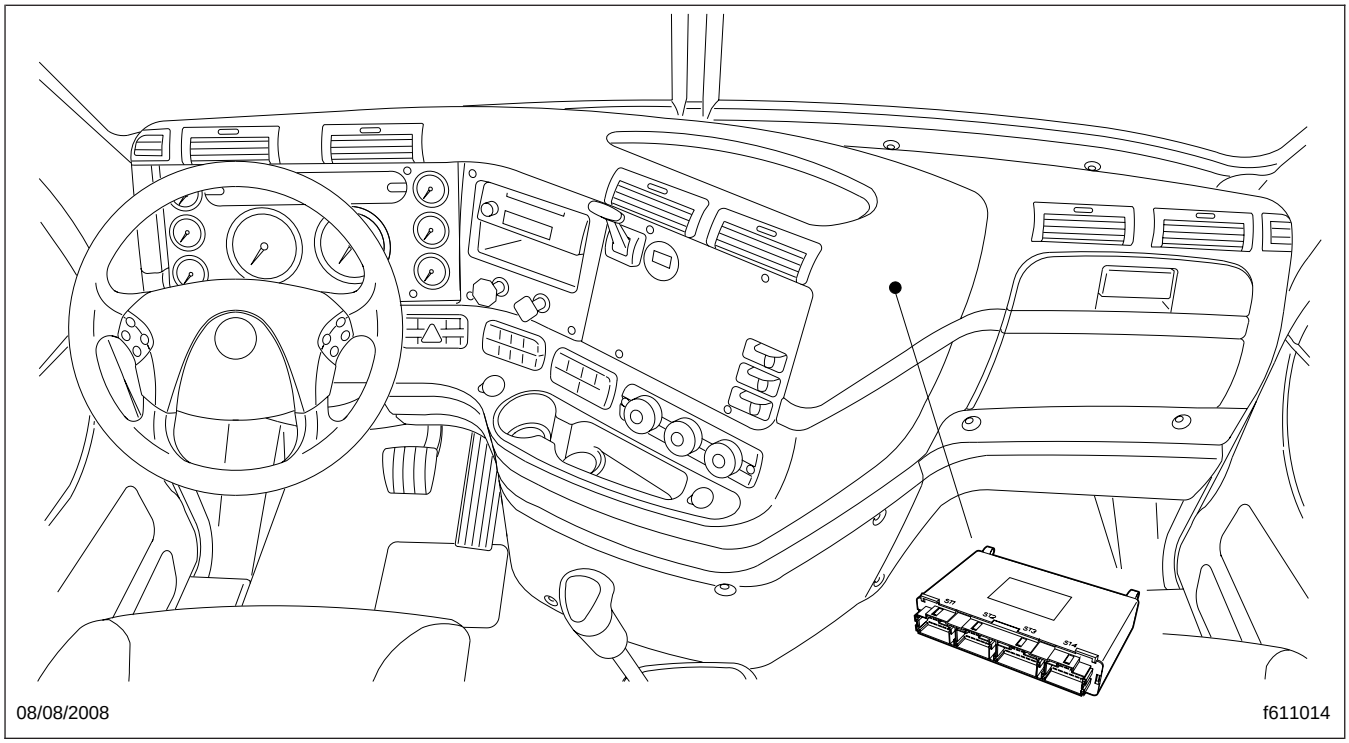


Fig. 1, Common Powertrain Controller Location

General Description

For detailed troubleshooting information about the ICU3, refer to subject **C01.01 — ICU3 Instrument Cluster** in the *Cascadia Troubleshooting Manual*.

For detailed troubleshooting information about the ICU4/ICU4M, refer to subject **C01.02 — ICU4/ICU4M Instrument Cluster** in the *Cascadia Troubleshooting Manual*.

ICU3

The 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 microcomputer and displayed on electronic gauges driven by stepper motors. Only air gauges operate mechanically.

The following gauges are standard:

- Speedometer
- Tachometer
- Engine Oil Pressure
- Coolant Temperature
- Fuel Level
- Primary Air System Pressure
- Secondary Air System Pressure

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.

ICU3 can drive gauges located in the B panel.

ICU4/ICU4M

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. 2**.

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.

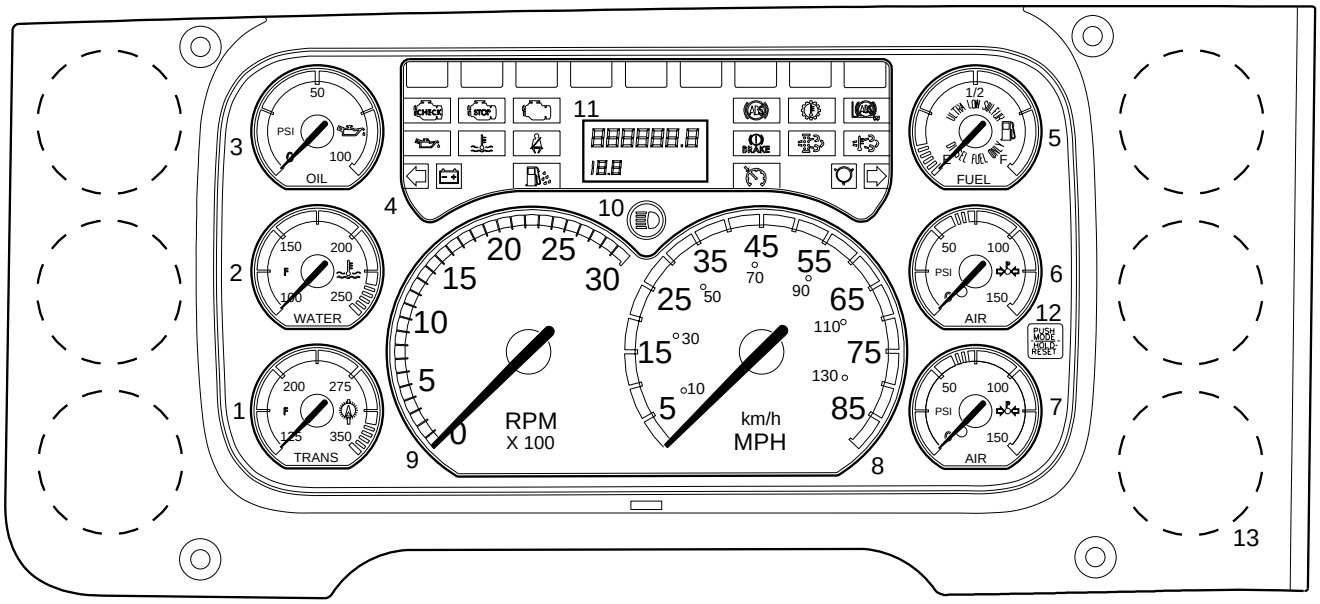
The ICU4 dash message center includes a set of 24 warning and indicator lights, and a message display screen in the center.

The ICU4M is an individual-gauge cluster with an intelligent light bar (ILB) and a "Quick Info" switch located on the B-panel which provides additional menu navigation capabilities on the light bar. See **Fig. 3**.

ICU4Me

The ICU4Me instrument cluster is an individual-gauge cluster with 18 standard and 8 optional telltales. See **Fig. 4**. The air gauges are driven by two transducers installed in the back of the ICU. There can be up to 14 removable gauges on the driver's instrument panel. The ICU4Me can also drive gauges located on the auxiliary instrument panel.

General Information



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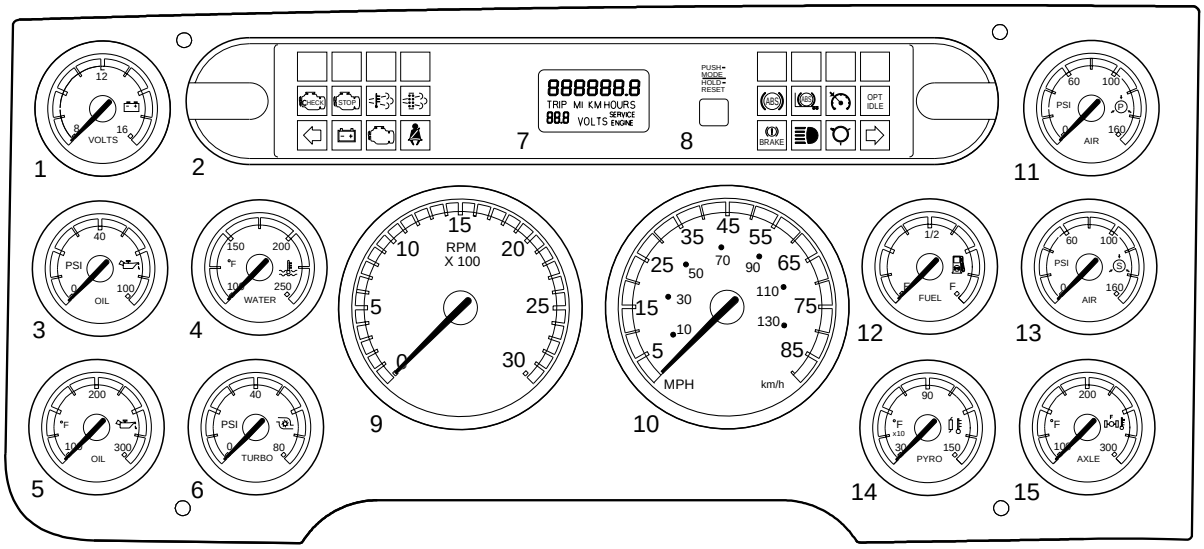
1. Transmission Temperature Gauge
2. Engine Coolant Temperature Gauge
3. Engine Oil Pressure Gauge
4. Driver Message Display
5. Fuel Gauge
6. Primary Air Pressure Gauge
7. Secondary Air Pressure Gauge
8. Speedometer
9. Tachometer
10. High Beam Indicator
11. Driver Display Screen
12. Mode/Reset Switch
13. Satellite Gauges

Fig. 1, ICU3 Instrument Cluster



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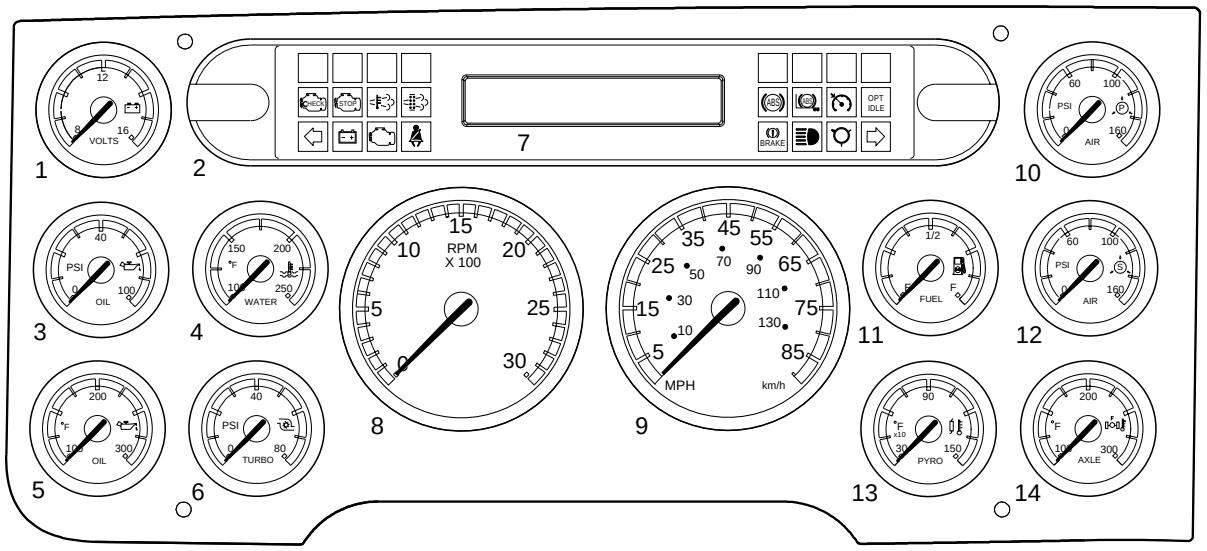
1. Battery Voltage Gauge
2. Lightbar
3. Engine Oil Pressure Gauge
4. Coolant Temperature Gauge
5. Engine Oil Temperature Gauge
6. Turbo Boost Air Pressure Gauge
7. Driver Message Display
8. Mode/Reset Switch
9. Tachometer
10. Speedometer
11. Primary Air Pressure Gauge
12. Fuel Level Gauge
13. Secondary Air Pressure Gauge
14. Pyrometer
15. Axle Temperature Gauge

Fig. 2, ICU4 Instrument Cluster

General Information



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1. Battery Voltage Gauge
2. Lightbar
3. Engine Oil Pressure Gauge
4. Coolant Temperature Gauge
5. Engine Oil Temperature Gauge
6. Turbo Boost Air Pressure Gauge
7. Dash Message Center
8. Tachometer
9. Speedometer
10. Primary Air Pressure Gauge
11. Fuel Level Gauge
12. Secondary Air Pressure Gauge
13. Pyrometer
14. Rear Axle Temperature Gauge

Fig. 3, ICU4M Instrument Cluster

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1. Engine Oil Temperature Gauge
2. Front Axle Temperature Gauge
3. Rear Axle Temperature Gauge
4. Speedometer and Coolant Temperature Gauge
5. Fuel/DEF Level Gauge
6. Tachometer and Engine Oil Pressure Gauge
7. Primary Air Pressure Gauge
8. Secondary Air Pressure Gauge
9. Transmission Oil Temperature Gauge
10. Driver Message Center

Fig. 4, ICU4Me Instrument Cluster

Removal

The instrumentation control unit, ICU3 is a self-contained one-piece unit, including housing, gauges, and the dash message center.

Air pressure gauges and light bulbs are the only components that are replaceable in the field. For air pressure gauge replacement, see **Subject 130**. For light bulb replacement, see **Subject 150**.

1. Drain both primary and secondary air systems.
2. Remove the four fasteners from the corners of the ICU3 bezel. Fasteners used on the ICU3 are T25 Torx®-head screws.

NOTICE

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.

3. Pull the ICU away from the dash.
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.

CAUTION

Drain all air pressure from the compressed air tanks before removing the air hoses. Failure to do so can cause the hoses to move uncontrollably when disconnected, possibly causing personal injury or equipment damage.

   - 4.2 Disconnect all air hoses.
5. Remove the ICU3.

Installation

1. Position the ICU3 on the dash.
   - 1.1 Connect the air hoses to the air gauges as marked on removal.
   - 1.2 Connect the two electrical connectors, as removed.
   - 1.3 Place the new ICU3 in the dash and install the fasteners.
2. Turn on the ignition and test the operation of the new ICU3. 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.

NOTE: Mechanical (air) gauges do not make a sweep.

Removal

To replace the individual components, see the subject listed below for procedures.

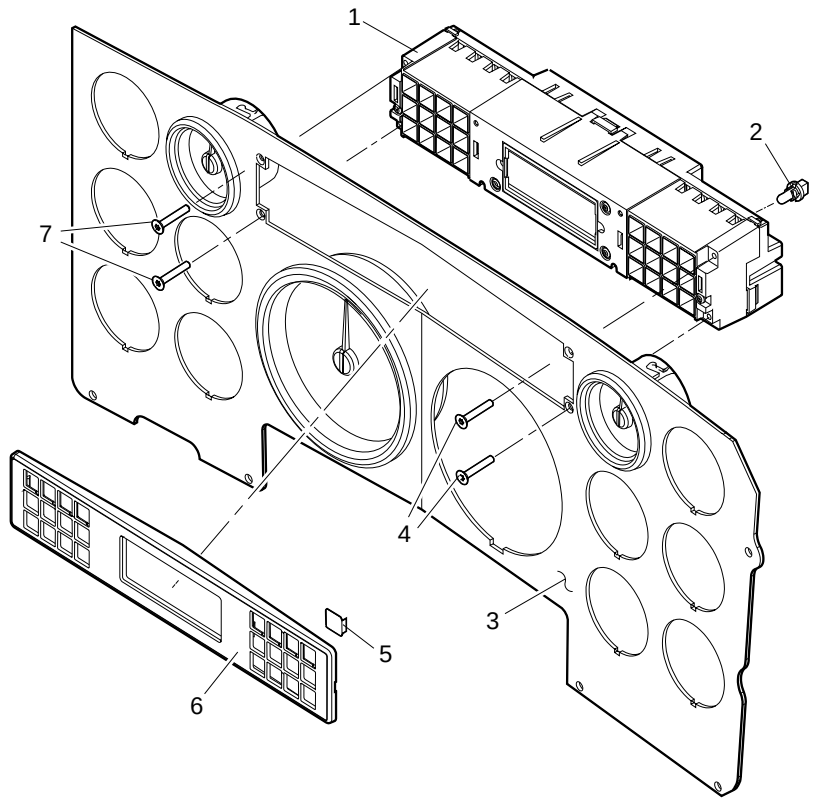
- Individual gauges, see **Subject 130**
- Light bar, see **Subject 140**
- Light bulbs, see **Subject 150**

1. Remove the fasteners that secure the ICU4M housing to the dash. Fasteners used on the ICU4M are T-25 Torx screws. See **Fig. 1**.
2. Remove the center dash trim panel, if necessary.
3. Place tape around the ICU4M edges to prevent it from scratching surfaces around the dash.
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.

CAUTION

Drain all air from the compressed air tanks before removing the air hoses. Failure to do so can cause the hoses to move uncontrollably when disconnected, possibly causing personal injury or equipment damage.

5. After bleeding all air pressure from the system, disconnect all air gauge hoses.



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1. Light Bar
2. Light Bulb
3. ICU4M Housing
4. Lightbar Screws
5. Telltale Lens
6. Light Bar Faceplate
7. Lightbar Screws

Fig. 1, ICU4M Dash Panel Installation

Removal and Installation, ICU4/ICU4M

6. When all fasteners and connections between the ICU housing and the dash have been disconnected, remove the old ICU from the dash. See **Fig. 1**.

Installation

1. Place the ICU4M close to its installed position and connect the air hoses to the air gauges.
2. 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.
3. Remove the tape around the edges of the ICU4M.
4. Install the fasteners that secure the ICU4M housing to the dash.
5. Turn on the ignition and test the operation of the ICU4M:
    - all gauges controlled by the ICU4M sweep to full scale and return
    - the buzzer sounds for 3 seconds
    - the fasten seat belt warning light illuminates for 15 seconds
    - the battery voltage and parking brake warning lights illuminate, and then turn off.

Removal

To replace the gauges, see **Subject 130**.

NOTE: The telltales on the ICU4Me are illuminated by LEDs in the circuit board. If the telltales do not illuminate, the ICU must be replaced.

1. Remove the 4 fasteners that secure the ICU housing to the dash. See **Fig. 1**. Pull the housing assembly out of the dash.
2. Place tape around the edges of the ICU to prevent it from scratching surfaces around the dash.

CAUTION

Drain all air from the compressed air tanks before removing the air hoses. Failure to do so can cause the hoses to move uncontrollably when disconnected, possibly causing personal injury or equipment damage.

3. Disconnect the electrical harness and air line connectors from the back of the ICUMe. These include the 56-pin wiring harness connector, the two 6-pin gauge databus connectors, and the two air transducers.
4. Remove the two mounting brackets from the back of the ICU4Me by removing the mounting screws. See **Fig. 2**.
5. Pull the ICU4Me forward and out of the ICU housing assembly.

1. ICU4Me Housing
2. ICU4Me
3. Mounting Fasteners

Fig. 1, ICU4Me Assembly

Installation

1. Slide the ICU4Me in to the housing assembly, then position the two mounting brackets on the ICUMe and install the screws. See **Fig. 2**.
2. Connect all remaining electrical harnesses and air lines to the back of the ICUMe. These include the 56-pin wiring harness connector, the two 6-pin gauge databus connectors, and the two air transducers.

Removal and Installation, ICU4Me

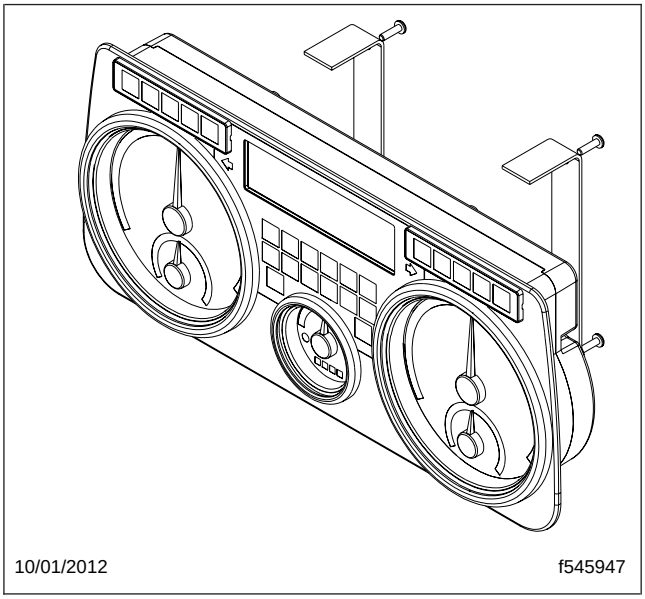


Fig. 2, ICU4ME Dash Panel Installation

3. Remove the tape around the edges of the ICU.
4. Position the ICU housing in the dash, and install the 4 fasteners. Tighten the fasteners securely.
5. Turn on the ignition and test the operation of the ICU4Me:
    - all gauges controlled by the ICU4Me sweep to full scale and return
    - the buzzer sounds for 3 seconds
    - the fasten seat belt warning light illuminates for 15 seconds
    - all functioning telltales will illuminate, and then turn off.

Refer to **Subject 100** for instructions on removing the ICU3. Refer to **Subject 110** for instructions on removing the ICU4/ICU4M. Refer to **Subject 120** for instructions on removing the ICU4Me.

Air Pressure Gauge Replacement, ICU3

The only replaceable gauges on the ICU3 are the air pressure gauges. If any other gauge in the cluster fails, the cluster must be replaced.

1. Drain the primary and secondary air tanks.
2. Remove the ICU3 from the dash, including disconnecting the electrical connectors and the air lines. For detailed instructions, see **Subject 100**.

NOTE: Be careful not to damage the ribbon electrical connector or the air gauge needles when removing the air gauge module. The gauge needles are exposed once the module is removed. A thin-ribbon electrical connector connects the air gauge module and the ICU3 housing. Once the fasteners that secure the air gauge module are removed, take care in separating the module from the ribbon electrical connector.

3. Carefully place the ICU3 face down on a smooth surface and remove the three T-8 capscrews that secure the air gauge module to the ICU. Do not remove the air gauge module cover.
4. Separate the air gauge module slightly from the ICU to allow access to the electrical ribbon that connects the module to the ICU. See **Fig. 1**.
5. Remove the electrical connection ribbon from the ICU, not from the air gauge module. Grip the ribbon firmly and lift out, then remove the air gauge module. See **Fig. 2**.
6. Place the air gauge module close to the opening it belongs in and connect the electrical ribbon connector in its slot. Gripping the ribbon end firmly at the edge, place the ribbon end into the slot and push it straight in until it stops.
7. Place the air gauge module into its opening in the ICU3. Make sure the rubber cup for the mode/reset button lines up with the matching alignment receptacle in the air gauge module when placing the module in the ICU.

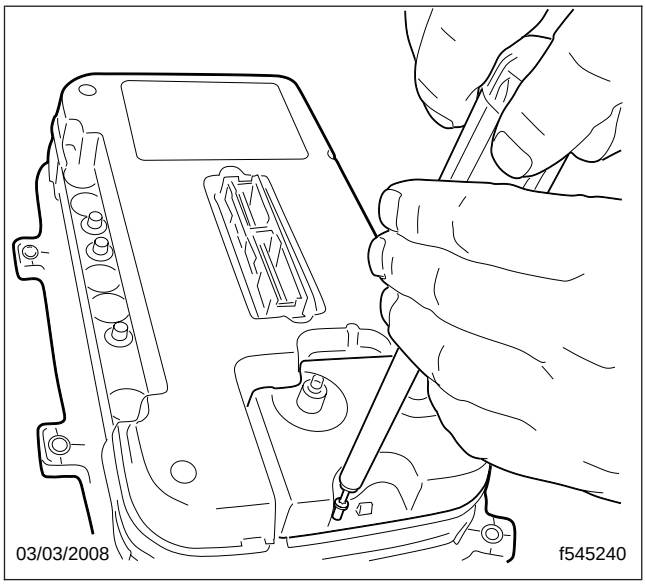


Fig. 1, Removing the Mounting Screws

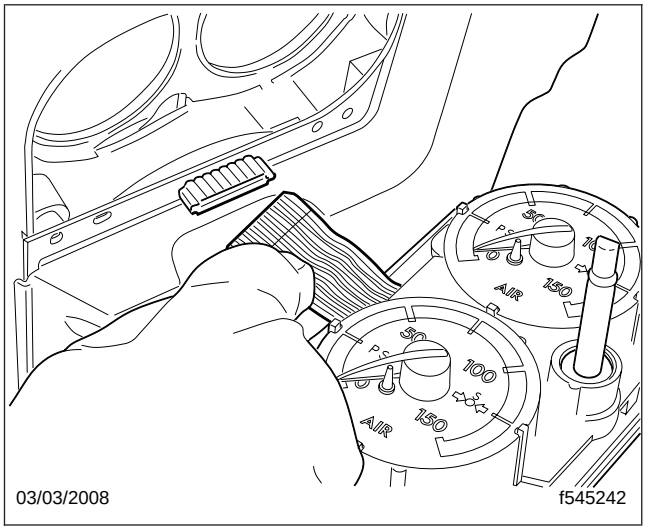


Fig. 2, Disconnecting the Ribbon Electrical Connector

NOTE: Insure the slack of the ribbon cable is folded and tucked inside the gauge module cover.

8. Install the three Torx capscrews and tighten them to secure the air gauge module.
9. Test the operation of the mode/reset button to insure it is not sticking or binding.
10. Install the ICU3. For detailed instructions, see **Subject 100**.

Gauge Replacement

11. After installing the ICU3, including the electrical connectors and the air lines, start the engine and verify the proper operation of the air gauge module as the air pressure builds.

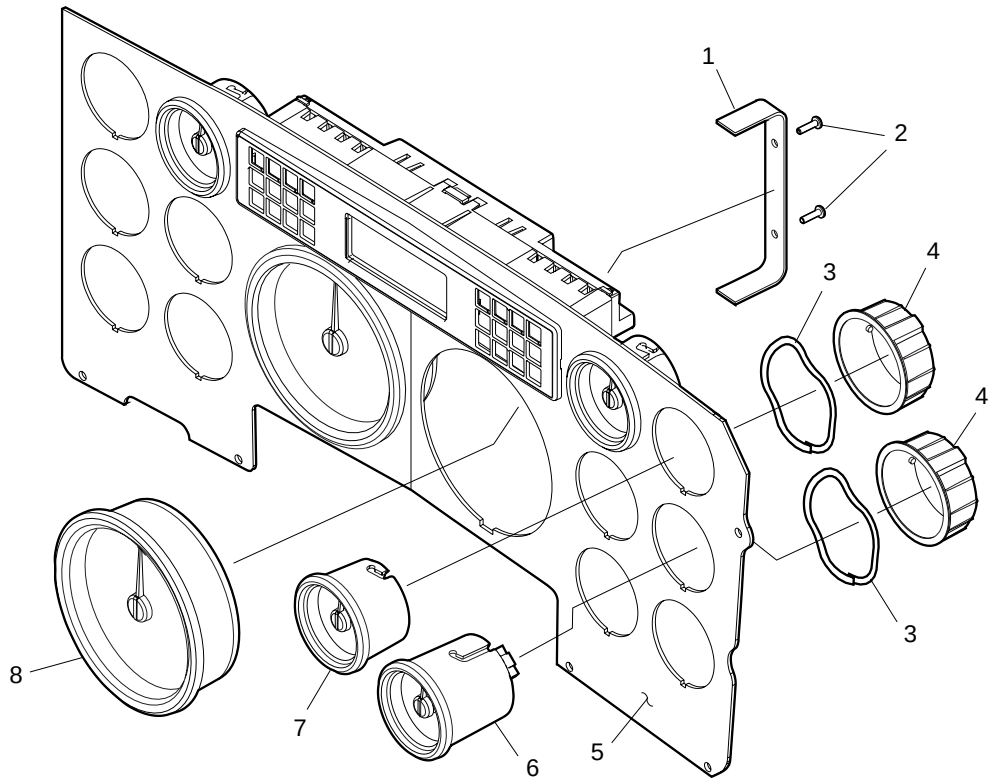
Speedometer and Tachometer, ICU4/ICU4M/ICU4Me

1. Disconnect the electrical harness connectors from the back of the gauge.
2. Remove the two Torx screws that secure the mounting bracket and the gauge to the ICU4M housing. See **Fig. 3**.
3. Remove the old gauge.
4. 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 screws.
5. Connect both wire harnesses to the back of the gauge.

Air Pressure Gauges, ICU4/ICU4M/ICU4Me

IMPORTANT: Bleed off all air before removing the air hoses.

1. Unplug both wire harnesses from the back of the gauge.



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1. Large Gauge Mounting Bracket
2. Large Gauge Mounting Screws
3. Wave Ring
4. Small Gauge Mounting Collar
5. ICU4M Housing
6. Air Pressure Gauge
7. Small Gauge
8. Large Gauge (speedometer or tachometer)

Fig. 3, Gauge Replacement (ICU4M shown)

NOTE: If multiple gauges are being replaced, note the location of each gauge before removal.

2. Remove the gauge from the ICU housing.
   - 2.1 Push in and give the gauge mounting collar (made of black plastic) a slight counterclockwise twist until the collar unlocks from the gauge.
   - 2.2 Remove the collar and wave ring from the back of the ICU housing.
   - 2.3 Lift up the ICU housing and remove the gauge through the front of the ICU housing.
3. Install the new gauge in the ICU housing.
   - 3.1 Locate the replacement gauge in the correct gauge opening.
   - 3.2 Insert the tab on the gauge into the slot in the ICU housing until the gauge is flat against the front of the housing.
   - 3.3 Place the wave ring and collar on the back of the gauge. 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.

NOTE: The telltales on the ICU4Me are illuminated by LEDs in the circuit board. If the telltales do not illuminate, the ICU must be replaced.

Light Bar Replacement, ICU4/ICU4M

1. Remove the ICU from the dash. See **Subject 110**.
2. Remove the light bar faceplate. Place a small flat blade under each end near the center and carefully pry it forward to release the locking tabs.
3. Remove the light bar from the back by removing its four screws from the front of the ICU4M housing.
4. Install the replacement light bar.
   - 4.1 From the back of the ICU4M housing, insert the light bar into the opening in the ICU4M housing.
   - 4.2 From the front, install four Torx screws, as removed.

NOTE: The ICU4 has a Mode/Reset button that passes through the faceplate. Insure the Mode/Reset button is in place before installing the faceplate.

5. Install the light bar faceplate. Place it over the front of the light bar, then carefully press it on until its end tabs lock in place.
6. Turn on the ignition and test the operation of the ICU4M:
   - all gauges controlled by the ICU4M sweep to full scale and return
   - the buzzer sounds for 3 seconds
   - the fasten seat belt warning light illuminates for 15 seconds
   - the Mode/Reset button operates freely without binding
   - the battery voltage, low air pressure, and parking brake warning lights illuminate, and then turn off.

NOTE: The telltales on the ICU4Me are illuminated by LEDs in the circuit board. If the telltales do not illuminate, the ICU must be replaced.

Light Bulb Replacement, ICU3

NOTE: The only bulbs that are replaceable on the ICU3 are those along the top row of the ICU. No hoses or connectors need to be disconnected in order to access these bulbs.

1. Remove the four screws attaching the ICU3 to the dash.
2. Tilt the ICU forward to access the bulbs.
3. Remove the burned-out light bulb(s). Use a small screwdriver to twist out the bulb base behind the affected light.
4. Install the new light bulb(s). Insert the bulb base into the slot and use a screwdriver to tighten it.
5. Position the ICU on the dash, and install the four mounting screws.
6. Turn on the ignition switch. Check all bulbs for correct operation.

Light Bulb Replacement, ICU4/ICU4M

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.

1. Loosen the center dash trim panel.
2. Remove the fasteners that secure the ICU4M housing to the dash.
3. Carefully pull the ICU4/ICU4M panel forward to gain access to the light bar from behind the panel.
4. Twist the burned-out bulb about 1/8-turn counterclockwise and pull it out from the back of the light bar.
5. 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.
6. Install the fasteners that secure the ICU4M housing to the dash.
7. Install the center dash trim panel.
8. Turn on the ignition and test the operation of the ICU4M:
    - all gauges controlled by the ICU4M sweep to full scale and return to zero. After 1 second they will travel to the measured value.
    - the buzzer sounds for 3 seconds
    - the fasten seat belt warning light illuminates for 15 seconds
    - the battery voltage, low air pressure, and parking brake warning lights illuminate, and then turn off unless there is low voltage, low air pressure, or the park brake is applied where the light will remain on.

Driver Side Footwell Light Replacement

1. Use a small flat-tip screwdriver to release the retaining tab on the end of the lamp assembly, then pry downward.
2. Remove the socket from the light assembly by turning counterclockwise.
3. Remove the push-in bulb from the socket.
4. Install a new bulb in the socket.
5. Attach the socket to the light assembly.
6. Snap the light assembly in the upper footwell panel.
7. Test the bulb for proper operation.

Passenger Side Footwell Light Replacement

1. Use a small flat-tip screwdriver to release the retaining tab on the end of the lamp assembly, then pry downward.
2. Remove the light socket from the footwell light assembly.
3. Replace the bulb.
4. Install the light socket in the footwell light assembly.
5. Snap the light assembly into the footwell panel.
6. Test the bulb for proper operation.

Dome/Map Light Replacement

1. Pry the lens from the light assembly using the two forward tab slots.
2. Push, then turn the bulb counterclockwise.
3. Install a new bulb.
4. Snap the lens back into place.
5. To remove the light assembly, pry the light assembly from the overhead console. The retaining tabs are at each end.
6. Disconnect the electrical connector and remove the light assembly.
7. Connect the electrical connector to a new light assembly.
8. Push the light assembly into the overhead console.
9. Test the bulb for proper operation.

Sleeper Cabinet Lamp

1. Reach above the light assembly in the sleeper cabinet and push down to gain access to the electrical connector.
2. Disconnect the electrical connector and remove the light assembly. See **Fig. 1**.

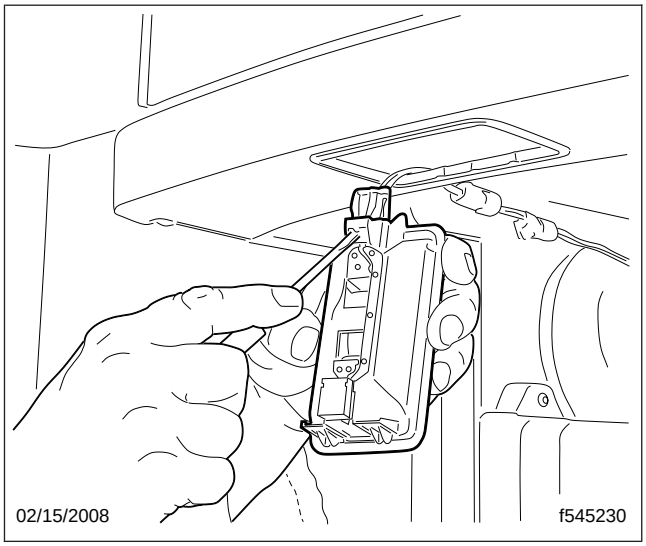


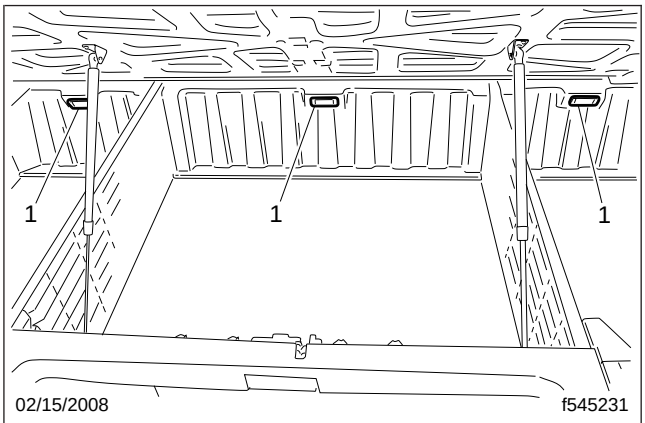
Fig. 1, Removing the Electrical Connector

3. Remove the lens by releasing the tab and popping the hinges.
4. Replace the bulb.
5. Install the lens.
6. Connect the electrical connector.
7. Install the light assembly in the sleeper cabinet.
8. Test the bulb for proper operation.

Storage Compartment Lights

1. Open up the bunk to gain access to the storage compartment lights. See **Fig. 2**.

Interior Light Replacement



1. Compartment Lights

Fig. 2, Storage Compartment

2. Use a small flat-tip screwdriver to release the retaining tab on the end of the light assembly, then pry downward.
3. Turn the socket counterclockwise to remove it from the light assembly.
4. Install a new light.
5. Snap the light assembly in place.
6. Test the bulb for proper operation.

Sleeper Dome and Bunk Reading Lights

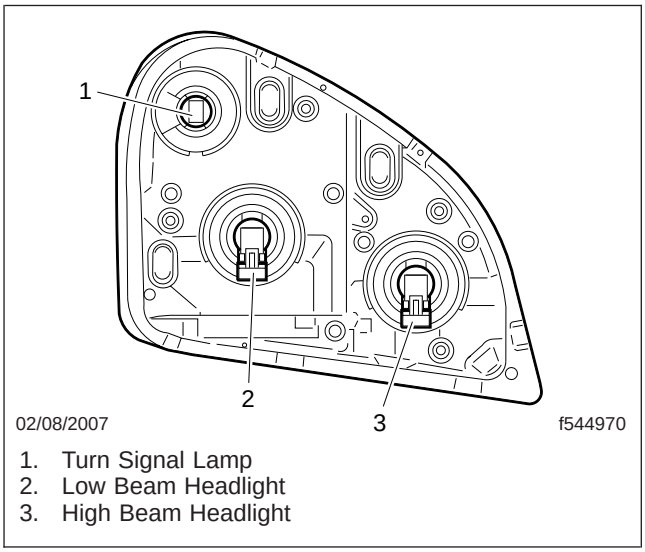
1. Pry the lens from the light assembly.
2. Replace the bulb.
3. Snap the lens on the light assembly.
4. Test the bulb for proper operation.

Door Entry Lights

1. Use a small flat-tip screwdriver to release the retaining tab on the end of the lamp assembly, then pry downward.
2. Push and turn the socket counterclockwise for removal.
3. Replace the bulb.
4. Install the lamp socket.
5. Snap the light assembly back into the door panel.
6. Test the bulb for proper operation.

Headlights

There are three bulbs housed in the headlight bucket assembly. See **Fig. 1**. Each bulb can be replaced using the same procedure.



1. Turn Signal Lamp
2. Low Beam Headlight
3. High Beam Headlight

Fig. 1, Headlight Bulbs

1. From the headlight assembly, remove the electrical connector for the bulb that is being changed. See **Fig. 2**.
2. Twist the bulb counterclockwise a quarter turn and remove the bulb. See **Fig. 3**.
3. Install a new bulb.
   - 3.1 Position the new bulb in the headlight.
   - 3.2 Twist the bulb a quarter turn clockwise until it locks into place.
4. Connect the electrical connector to the bulb.
5. Test the bulb for proper operation.

Fog/Road Lamps

1. Remove the nut and washer that secures the cover to the back of the fog lamp, and remove the cover. See **Fig. 4**.
2. Disconnect the electrical connector by prying the tabs at the back of the connector.
3. Twist the bulb counterclockwise a quarter turn and remove the bulb.

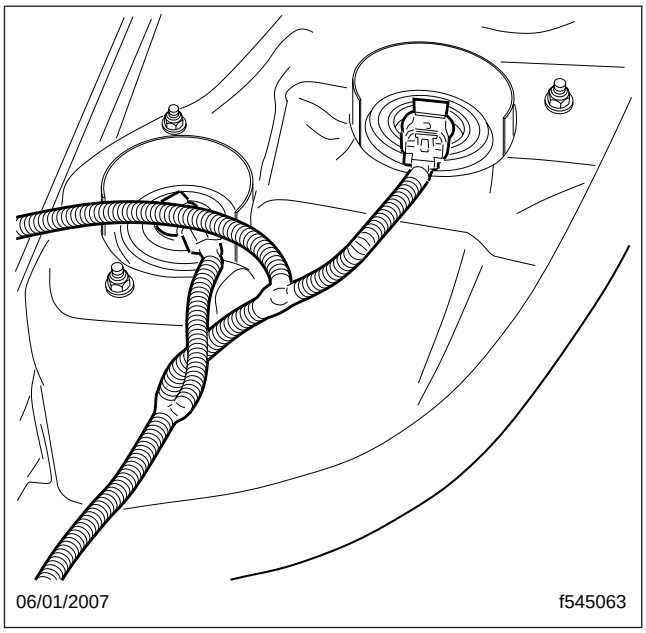


Fig. 2, Electrical Connectors

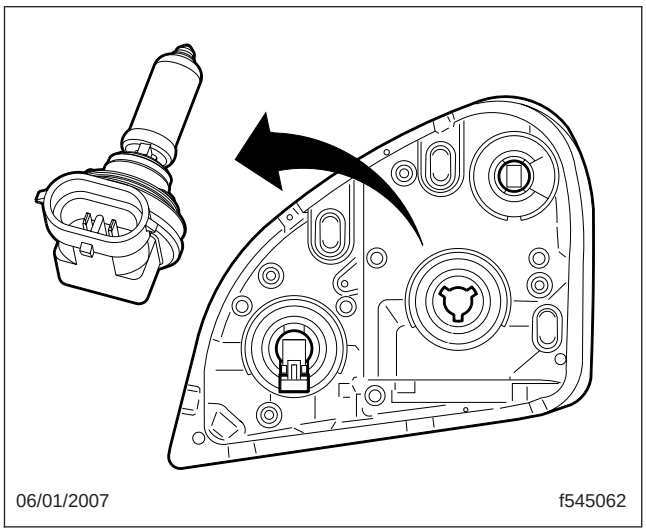
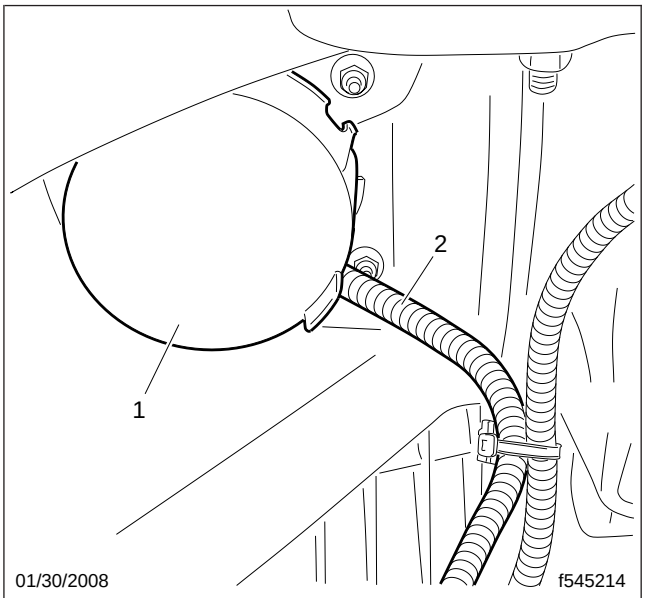


Fig. 3, Bulb Removal

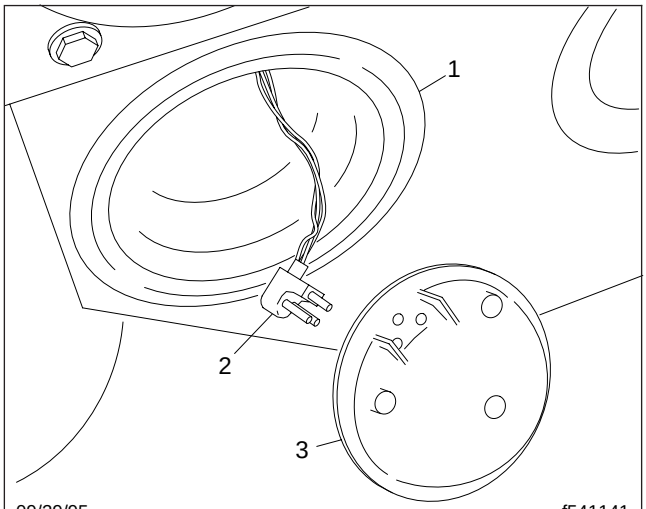
4. Position a new bulb in the fog lamp.
5. Twist the bulb a quarter turn clockwise until it locks into place.
6. Connect the electrical connector to the bulb.
7. Position the back cover on the fog lamp, and install the nut and washer.
8. Test the bulb for proper operation.

Exterior Light Replacement



1. Fog Lamp Cover
2. Electrical Connector

Fig. 4, Fog Lamp Cover



1. Gasket
2. Electrical Connector
3. Tail/Stop Light

Fig. 5, Taillight Assembly

Tail/Stop Lights

1. Press outward on the rear of the taillight until it comes out of the gasket. See **Fig. 5**.
2. Pull the tab on the electrical connector and remove it from the back of the taillight.
3. Press a new sealed taillight unit into the gasket until it is firmly seated.
4. Attach the electrical connector and tug gently on it to make sure the tab on the connector is seated.
5. Test the bulb for proper operation.

Side Marker Bulb Replacement

1. Remove the two Torx screws.
2. Disconnect the connector.
3. Replace the marker light.
4. Connect the electrical connector.
5. Install the two mounting screws.
6. Test the bulb for proper operation.

IMPORTANT: Before checking or adjusting the headlight aim, do the following.

- Check that the hood is completely closed, and latched.
- 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.
- With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.
- Clean the headlight lenses. Clean by hand only, using a flannel cloth with mild, non-caustic soap or detergent, and water.

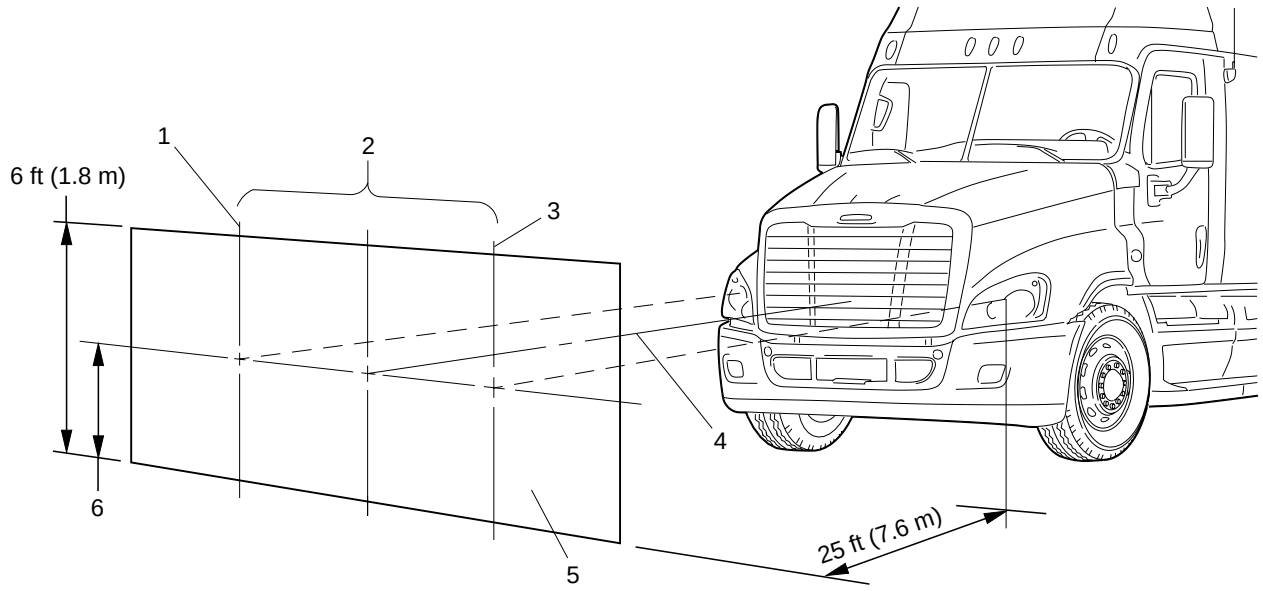
Headlight Aiming

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**.
2. On each headlight, find the low beam 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.
    - 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

The adjusting screw is located on the lower outside corner of the headlight assembly. See **Fig. 4**. Turn the adjusting screw clockwise to raise the beam and counterclockwise to lower it, until the beam pattern meets the acceptable standard in **Fig. 3**.

Headlight Aiming



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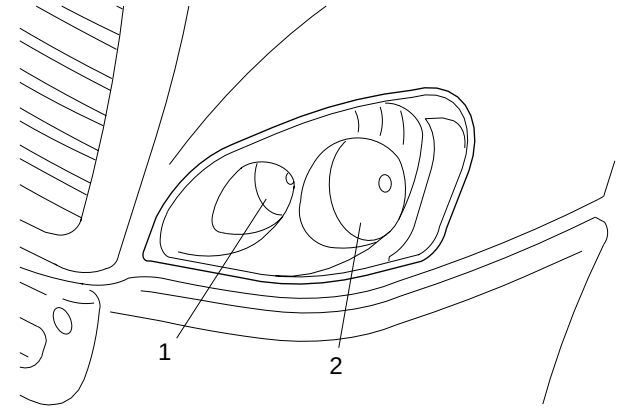
1. Vertical Centerline of Right Headlight
2. Distance Between Headlights
3. Vertical Centerline of Left Headlight
4. Projected Vehicle Centerline
5. Screen or Wall
6. Height of Lamp Centers

Fig. 1, Headlight Aiming Screen or Wall



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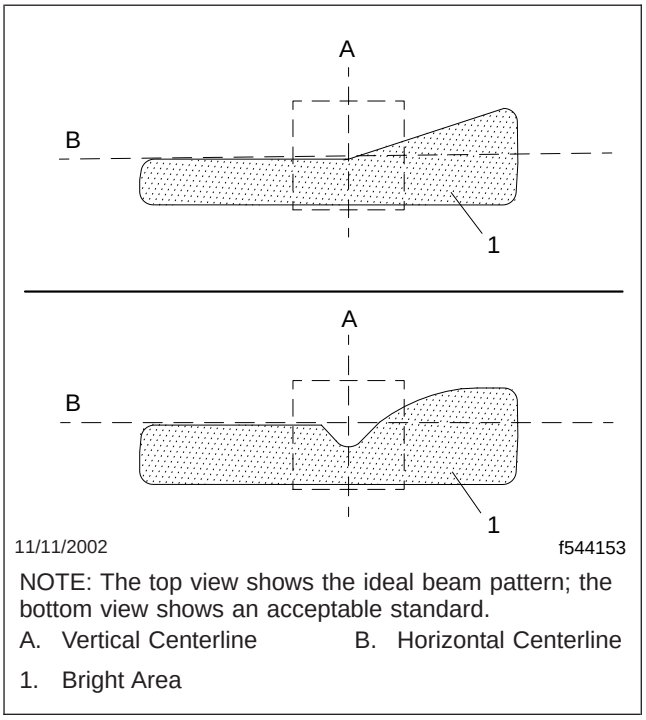
Measure beam height from the ground to the center of the low beam bulbs.

1. High-Beam Headlight
2. Low-Beam Headlight

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

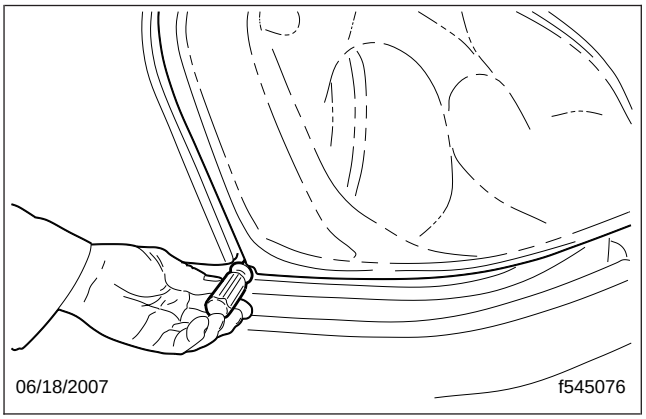


Fig. 4, Headlight Adjusting

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.

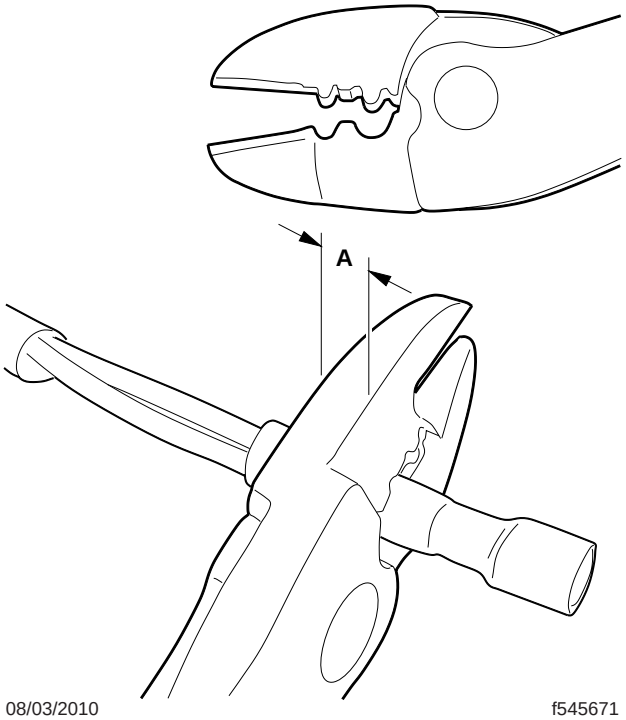
Wiring Repair Using Phillips STA-DRY® Solderless Connectors

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).



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 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**.

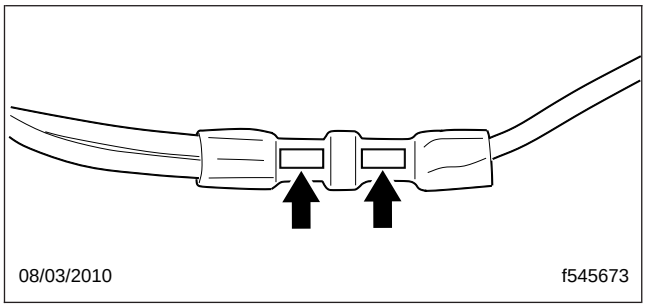


Fig. 2, Properly Crimped Splice

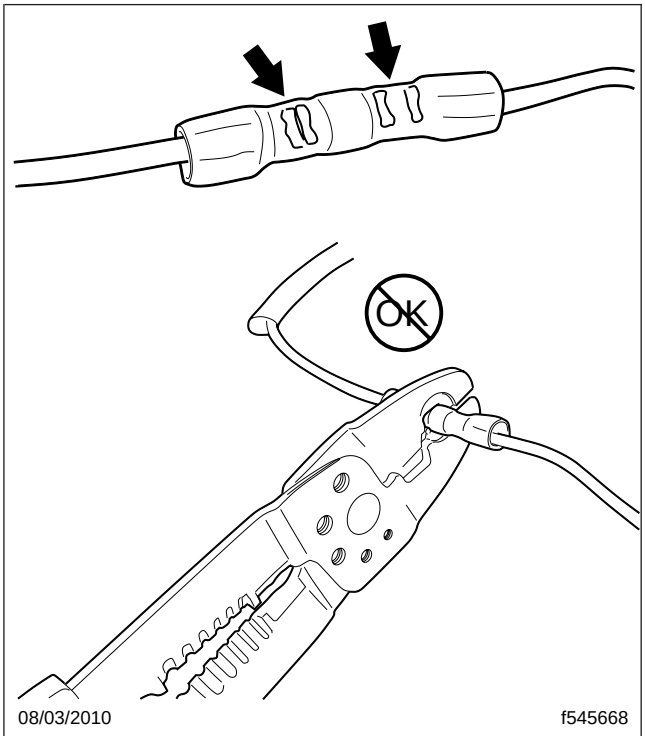
3. Pull test the wires by hand to ensure the crimp is mechanically solid.
4. A crimp tool that is too narrow will leave excessive air gaps in the crimp. The connection will not have the required amount of mechanical strength and the solder will not bond the wire to the connector. **Figure 3** shows an 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**.
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**.
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.

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



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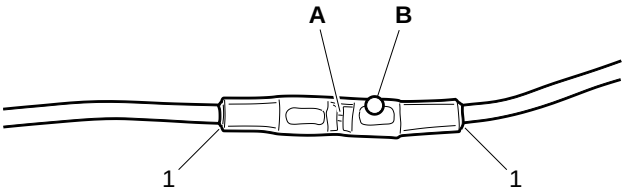
NOTE: Even with two crimps, there is too much air gap; the solder will not bond.

Fig. 3, Wrong Tool Being Used and a Crimp That Will Fail



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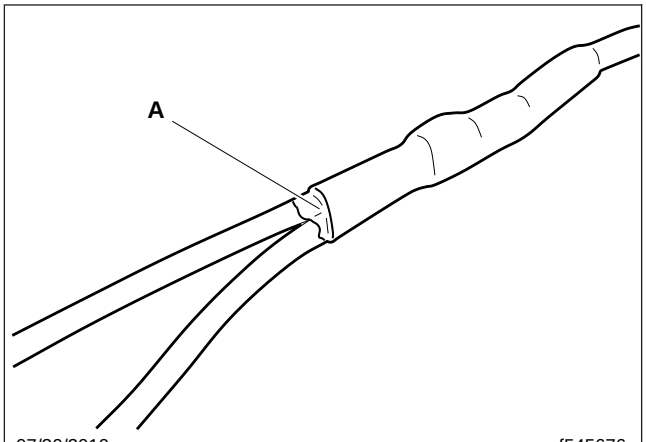
A. The solder band is completely melted.
B. Insulation rupture; gently shake off the solder bead.

1. Adhesive Fillet

Fig. 4, Solder Bead Rupture



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A. The fillet of adhesive at the ends of the shrink tube indicate a complete seal.

Fig. 5, Completed Three-Wire Tap Splice

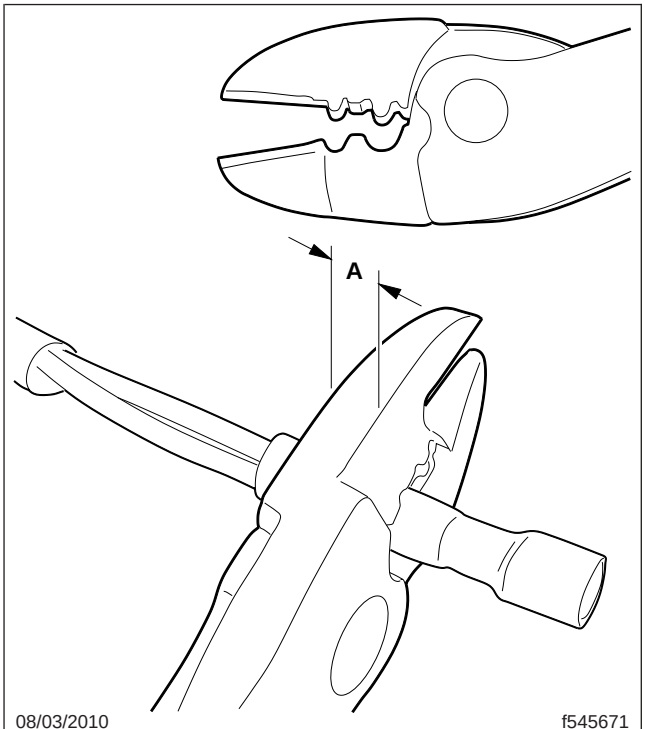
Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404

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).



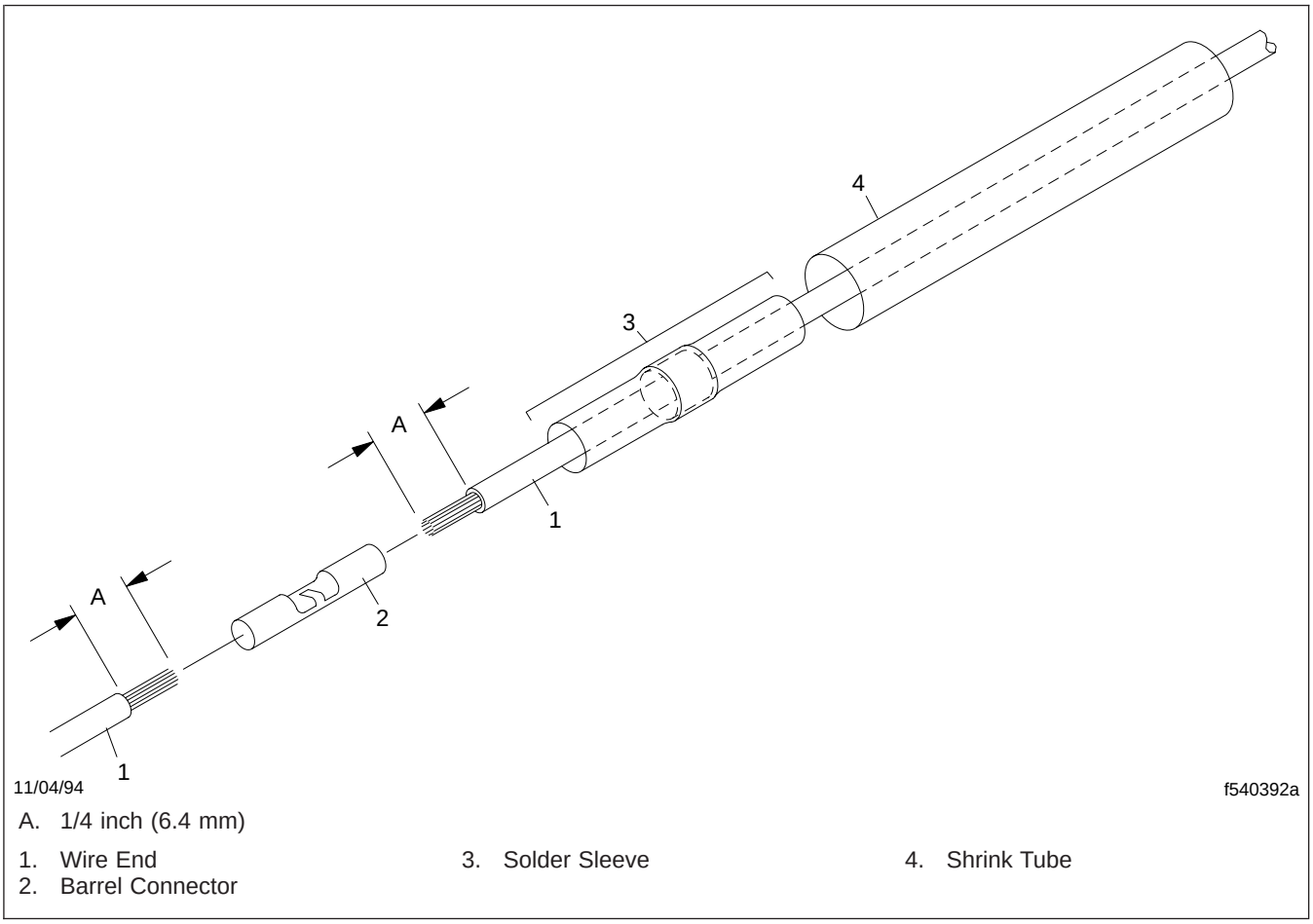
A. Minimum 3/16 inch width.

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.

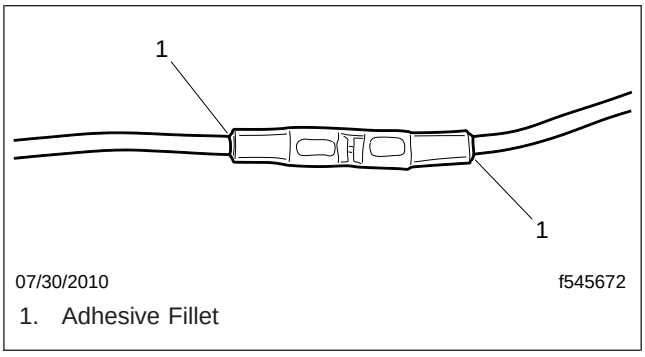
Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404



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



1. Adhesive Fillet

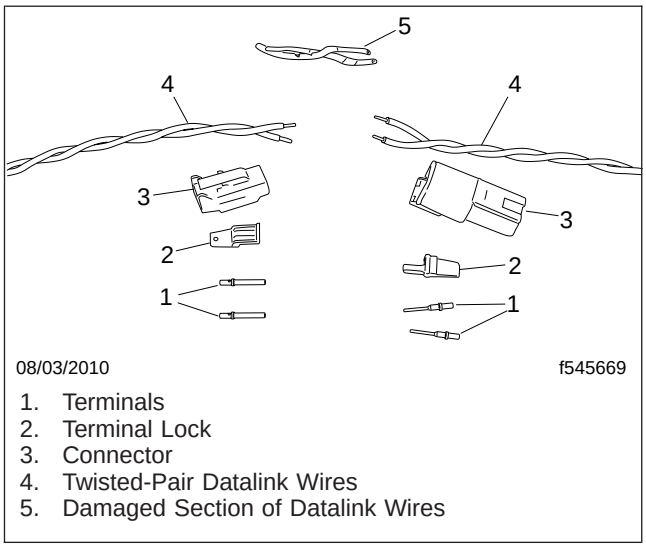
Fig. 3, Heated Solder Sleeve with Solder Band Melted into the Splice

Parts

Twisted-pair datalink wires may be spliced using a mating connector set. See **Table 1** for a typical set of datalink connector parts.

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

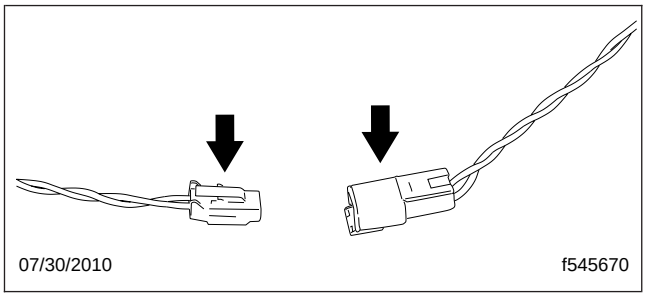


Fig. 2, Datalink Connectors

Datalink 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

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

Specifications

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

Specifications

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

Specifications

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	—

Specifications

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

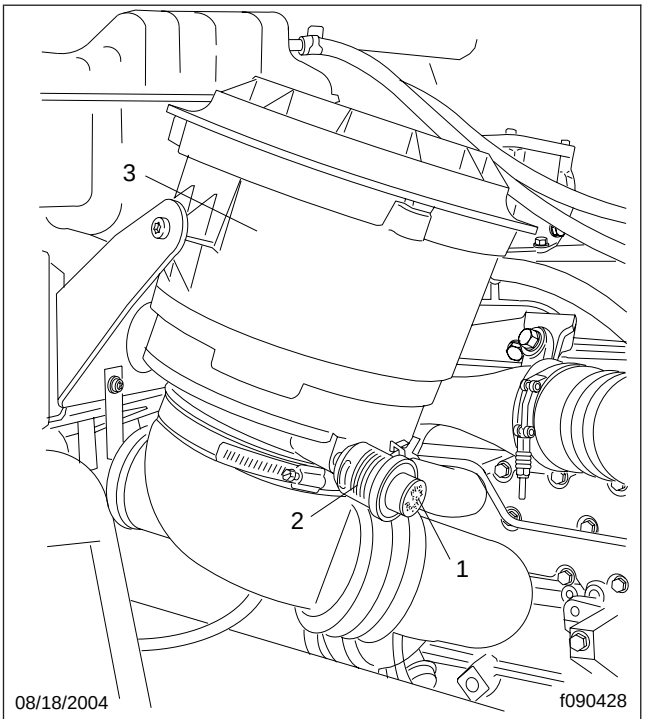
The intake air restriction indicator indicates how much air filter capacity has been used and how much remains. The indicator registers the actual maximum restriction of the filter element when the engine is operating at full load. The indicator retains the reading so that the remaining capacity can be read after the engine is shut down.

The intake air restriction indicator is mounted under the hood on the intake air piping, or in the cab on the dash panel. See **Fig. 1** and **Fig. 2**.

Do not open the air cleaner assembly until the indicator registers maximum restriction. When maximum restriction occurs, the air cleaner element needs to be serviced.

The intake air restriction indicator and the fitting may become plugged with moisture or engine vapors, possibly causing an incorrect reading.

NOTE: Most engine degreasers are harmful to the polycarbonate (Lexan) plastic that is used in the intake air restriction indicator. When cleaning the engine or other components, avoid getting degreaser on the indicator.



1. Reset Button
2. Intake Air Restriction Indicator
3. Air Cleaner Assembly

Fig. 1, Intake Air Restriction Indicator Mounted Under the Hood

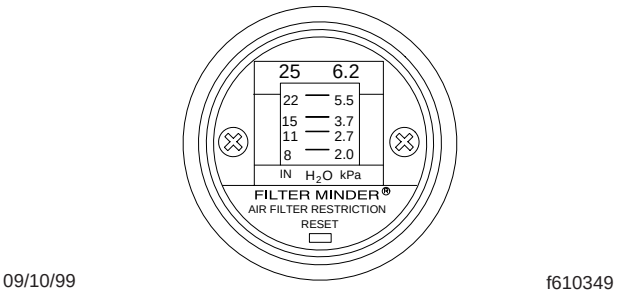


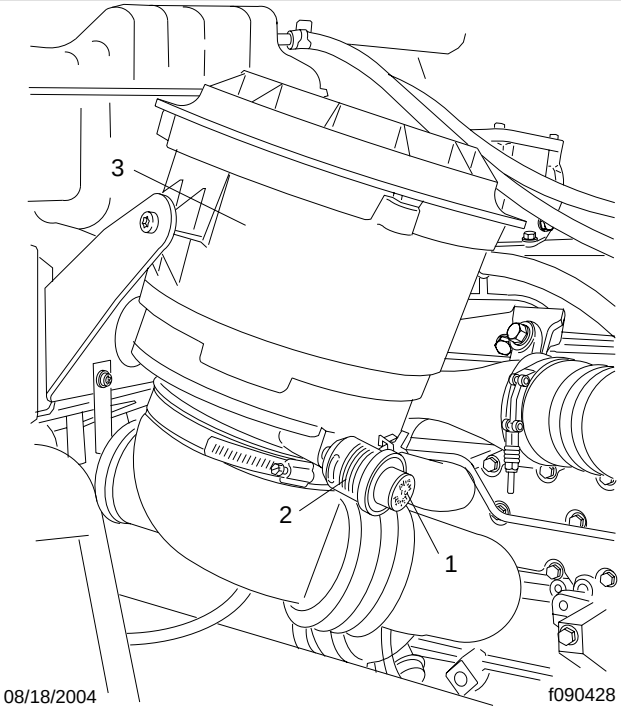
Fig. 2, Intake Air Restriction Indicator Mounted in the Cab

Intake Air Restriction Indicator Removal and Installation

Indicator Mounted Under the Hood

Removal

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Using a wrench, remove the intake air restriction indicator from the intake air piping. See **Fig. 1**.



1. Reset Button
2. Intake Air Restriction Indicator
3. Air Cleaner Assembly

Fig. 1, Indicator Mounted Under the Hood

Installation

1. Install the indicator on the intake air piping.
2. Close the hood and remove the chocks from the tires.

Indicator Mounted in the Cab

Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the necessary dash panels to access the intake air restriction indicator. For instructions, see **Section 60.06, Subject 100**.
3. Remove the electrical connector from the indicator. See **Fig. 2**.

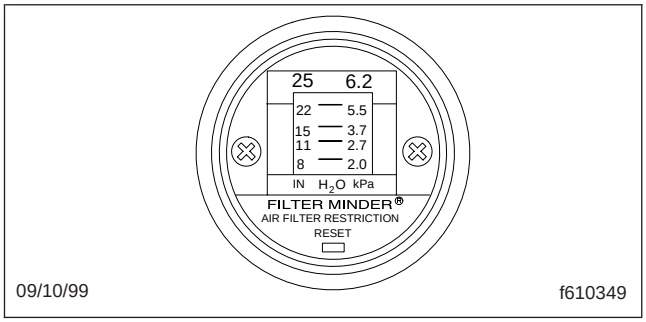


Fig. 2, Intake Air Restriction Indicator Mounted in the Cab

4. Remove the air line from the indicator.
5. Remove the screws that attach the indicator to the dash, and remove the indicator.
6. Using screws, attach a new indicator to the dash.
7. Attach the air line to the indicator.
8. Attach the electrical connector to the indicator.
9. Install the dash panels. For instructions, see **Section 60.06, Subject 100**.
10. Remove the chocks from the tires.

General Information

The turn signal switch operates the turn signals, the windshield wipers and washers, the high- and low-beam headlights, and the turn tip feature.

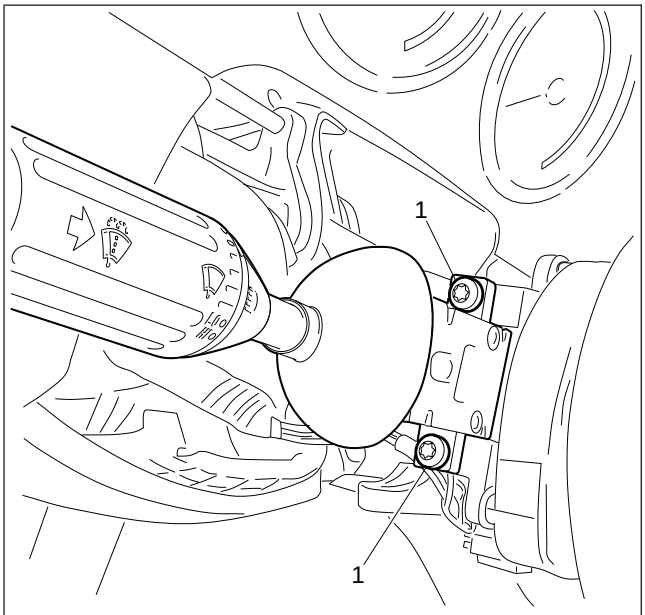
Moving the turn signal switch up or down activates the right or left turn signal lights respectively. There are three sets of turn signal lights on the vehicle: one in the headlight unit, one on the sides of the vehicle, and one at the rear closing crossmember.

When the turn tip feature is used, the turn signal lights flash a predetermined number of times. The number of times the turn signal lights flash is determined by a parameter. The turn tip feature is advantageous in lane change situations when the steering wheel does not travel far enough to cancel a conventional turn signal request. After flashing for a number of times, the turn signal lights stop flashing; the driver does not have to manually cancel the turn signal switch. Activation of the turn tip feature is immediately canceled when a request for the turn signal in the opposite direction is made. In this situation the turn signal light in the opposite direction flashes.

Turn Signal Switch Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the four screws that secure the lower cover to the steering wheel column, and remove the cover.
3. Remove the two screws that secure the turn signal switch to the steering wheel assembly. See **Fig. 1**.



1. Mounting Screws

Fig. 1, Turn Signal Switch Assembly

4. Pull the turn signal switch out, and remove the electrical connector.

Installation

1. Attach the electrical connector to the turn signal switch.
2. Position the switch on the steering wheel column.
3. Install and securely tighten the switch mounting screws.
4. Position the lower steering column cover on the steering column. Install and securely tighten the four cover-mounting screws.
5. Remove the chocks from the tires.

General Information

Lead-Acid Batteries

Maintenance-free lead-acid batteries, both liquid-electrolyte batteries and gel cells, 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.

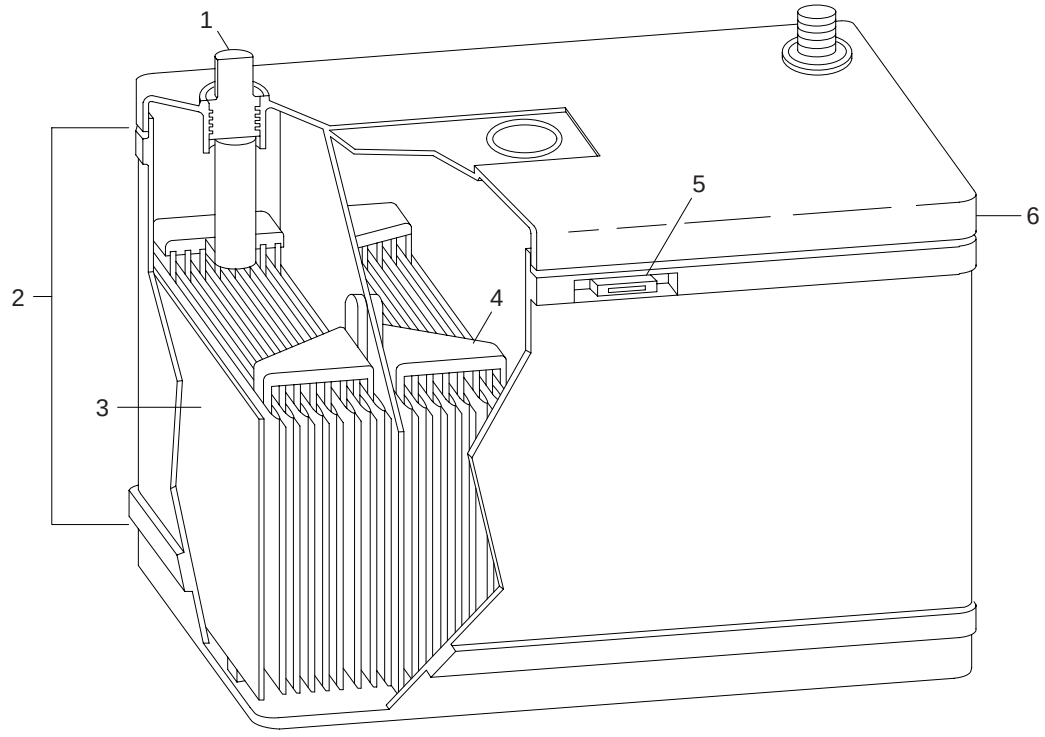
The modern automotive battery has three functions:

- To supply power to the starter and ignition system so the engine can be cranked and started.
- To stabilize the voltage in the electrical system by reducing temporary high voltages in the electrical system. These high transient voltages could damage other electrical components if they were not protected by the battery.
- To supply extra 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. See **Fig. 1**.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a solution of electrolyte (dilute sulfuric acid). In a gel cell battery, the electrolyte is a solid gel, not a liquid.

Maintenance-free wet cells use calcium rather than antimony to improve grid strength. Calcium reduces



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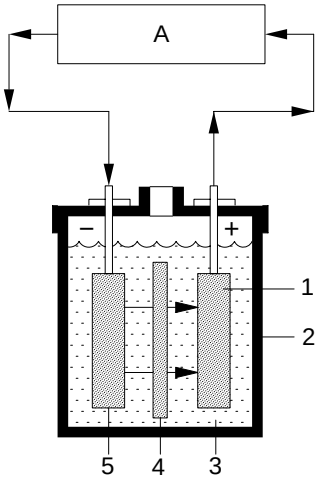
1. Terminal
2. Electrolyte Reservoir
3. Positive Plate Envelope
4. Intercell Connection
5. Vent Hole
6. Plastic Cover

Fig. 1, Typical Maintenance-Free 12-Volt Battery

General Information

the tendency for the battery to produce gas at normal charging voltages. Therefore, little water is lost, unless the battery has been charged at a very high rate. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents allow the escape of gases produced in the battery.

Electrical energy is produced in each cell by chemical changes in the plates (and in the electrolyte whenever a battery is discharged). See **Fig. 2**. A battery produces maximum electrical energy only when the cells are fully charged. As the cells discharge, chemical changes in the plates gradually reduce the potential electrical energy available. Recharging the battery with an opposite flow of direct current reverses the chemical changes within the cells and restores them to their active state. See **Fig. 3**.



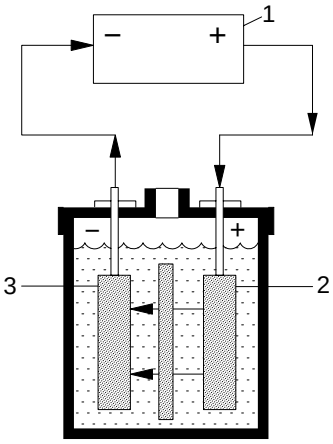
A. External electrical load (such as a starter).

1. Positive Plate
2. Battery Case
3. Electrolyte
4. Separator
5. Negative Plate

Fig. 2, Discharging 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.

In standard installations with single fuel tanks, the batteries are contained in a side-rail battery box, long side to rail. The batteries are mounted behind the



1. Charger
2. Positive Plate
3. Negative Plate

Fig. 3, Charging the Battery

vehicle access steps. The steps are removed by turning a twist handle on the step assembly.

Only good care can ensure long battery life. Proper testing will indicate the battery condition. For more information, see **Subject 140**.

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 good 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 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.

As more electronic content is installed, parasitic drain issues become more prevalent. The reserve capacity (RC) rating multiplied by 0.6 gives the approximate available ampere-hours (AH) from full charge to complete drain. Between full charge and complete battery drain there is a point where some of the electrical accessories still operate but the vehicle will not start.

NOTE: When there is bodybuilder-added equipment, contact the bodybuilder to get their specifications for parasitic draw and add it to the following numbers where appropriate.

Using up approximately 40 percent of the total available ampere-hours will usually take fully charged batteries to a no-start condition at moderate temperatures of 77° F (25°C). For typical batteries in a storage situation, depleting the available ampere-hours by 20 to 325 (depending on the number of batteries) will result in a no-start condition.

The recommendation for maximum parasitic drain is approximately 325 mA (0.325 amps). A typical 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.

A vehicle with a 325 mA drain and a fully charged 70 RC battery will last between five and six days. But if the batteries are at only 65 percent of full-charge, they are going to last only two days before causing a no-start condition.

IMPORTANT: If the batteries begin storage at 90 percent of full charge, reduce the available ampere-hours accordingly.

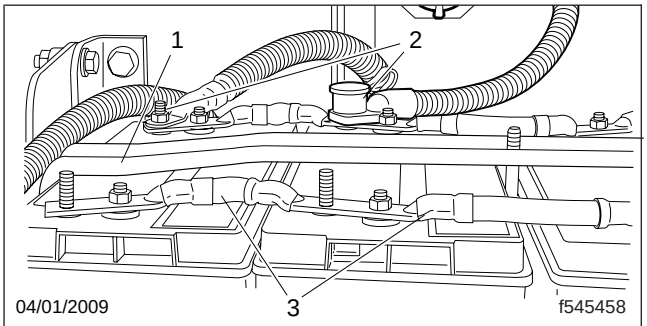
Battery Box Removal, Cleaning, Inspection, and Installation

Removal

Before working on any battery box, make sure all electrical loads (lights, ignition, accessories) are turned off.

Under-Cab Battery Box (EPA07)

1. Depressurize the air from the air tanks.
2. Remove 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. See **Fig. 1**.



1. Retainer Bar
2. Positive Battery Cables
3. Negative Battery Inerconnect Cable

Fig. 1, Battery Assembly

4. Remove the battery retainer bar. Remove the batteries from the battery box assembly.
5. Disconnect the air lines from the three air tanks mounted on the bottom of the battery box. The air lines are located on the inboard side of the air tanks, under the vehicle. See **Fig. 2**.
6. Place a jack under the battery box/air tank assembly. See **Fig. 3**.
7. Remove the bolts that secure the battery box to the brackets on the frame rail. See **Fig. 4**.
8. Lower the battery box/air tank assembly to the floor.
9. Support the assembly on the floor and remove the step and cover mounting hardware.
10. Remove the air tank supporting straps and brackets.

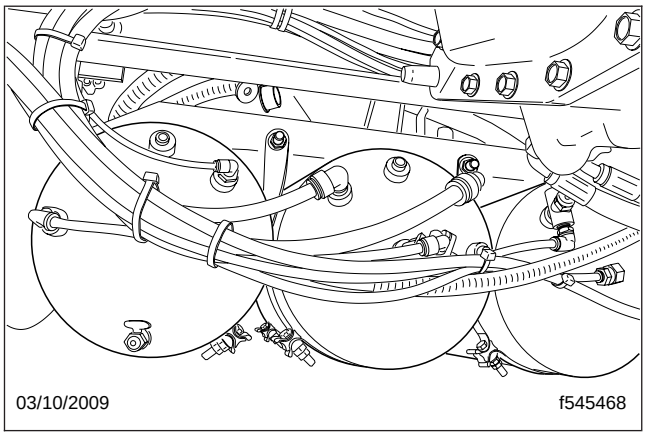


Fig. 2, Air Lines (inboard view of the air tanks)

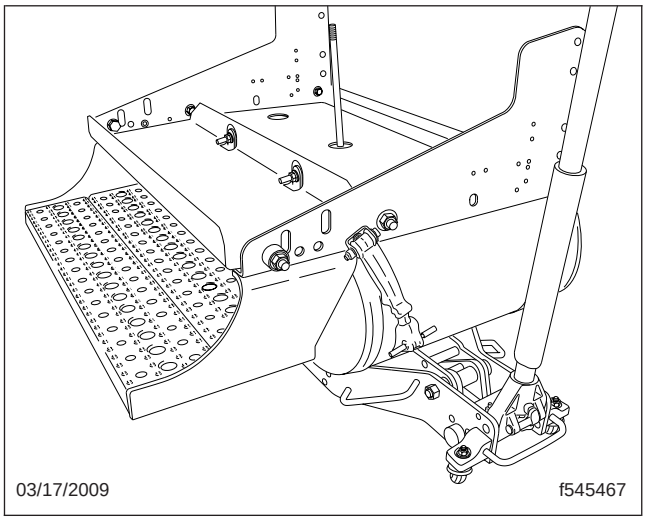


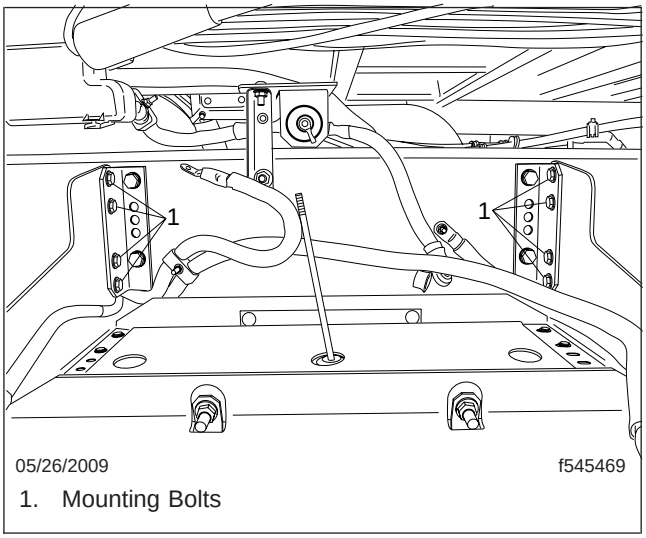
Fig. 3, Placing a Jack Under the Battery Box

11. Remove the three air tanks from the step assembly.

Between-Rail Battery Box

1. Remove the battery box cover.
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. 5**.
   - 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.

Battery Box Removal, Cleaning, Inspection, and Installation



1. Mounting Bolts

Fig. 4, Battery Box (mounted)

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.
5. Remove the battery box.

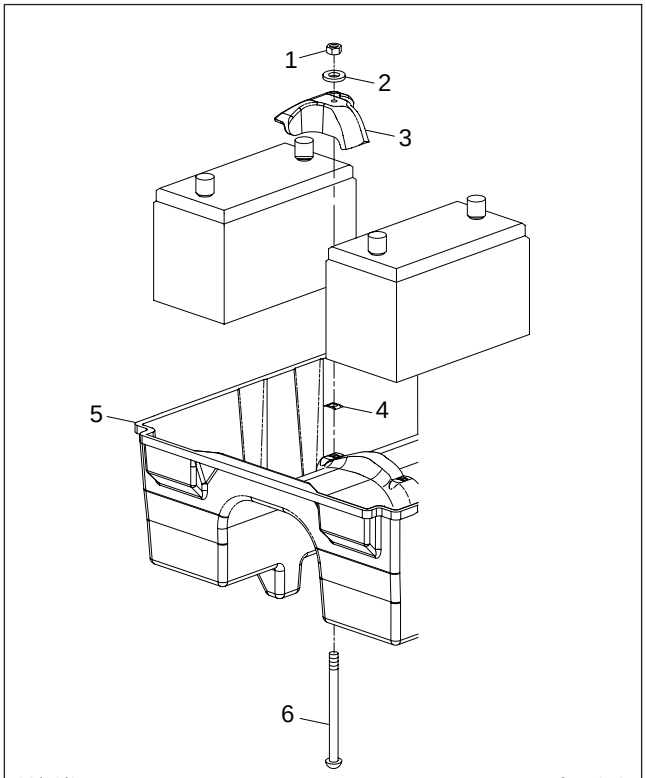
5.1 From underneath the battery box, remove the 3/8–16 hexnut and flatwasher from the keeper assembly. Retain the keeper and spring.

5.2 Remove the battery box from the vehicle.

6. Remove the bracket from the frame rail. The plastic washers are attached to the bracket with pressure-sensitive adhesive and come off with the bracket.

Under Cab Battery Box (EPA10)

1. Remove the driver-side step assembly by turning the locking handle and pulling the assembly away from the vehicle.
2. Remove the battery box cover.
3. Remove the three bolts that secure the side shield to the battery box and remove the side shield. See **Fig. 6**.



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. 5, Battery Hold-Downs

4. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components. Remove the battery cables.
5. Remove the battery retainers. Remove the batteries from the battery box.

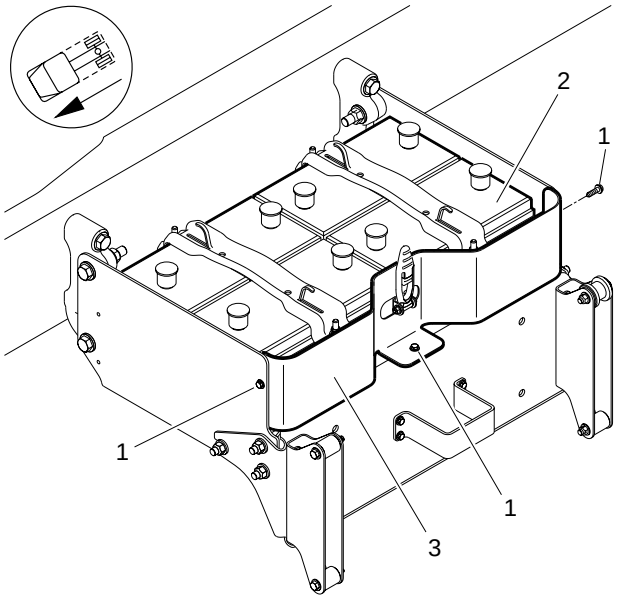
Under-Seat Battery Box (EPA10)

NOTE: The passenger seat folds up, providing access to the batteries. The seat can remain installed if only the batteries are being removed.

1. Remove the passenger-side seat.

1.1 On each side of the passenger seat, remove the two capscrews that attach the

Battery Box Removal, Cleaning, Inspection, and Installation



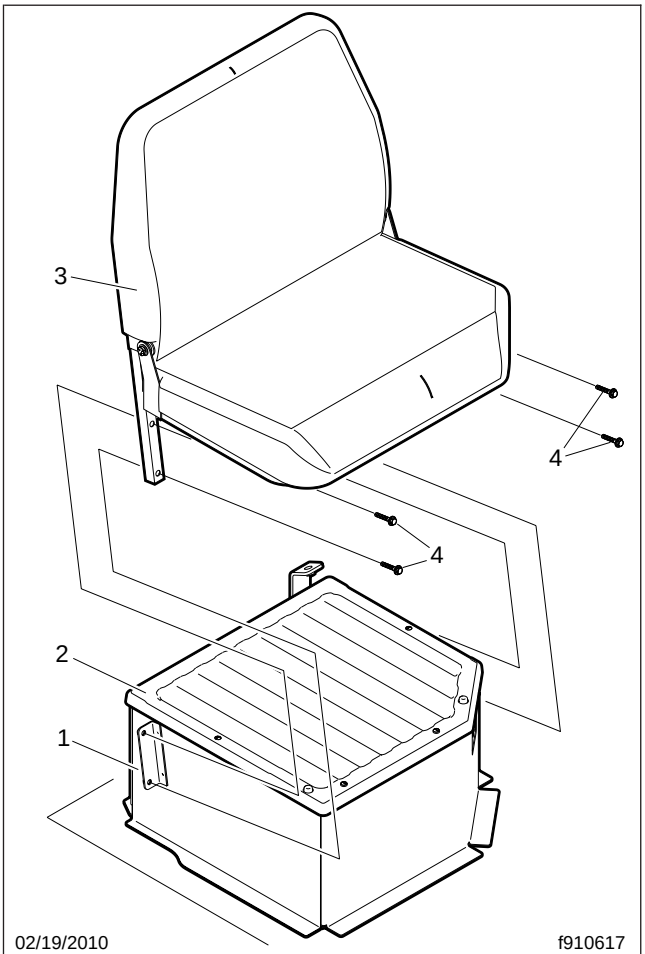
1. Side Shield Retaining Fasteners
2. Batteries
3. Side Shield

Fig. 6, Side-Rail Battery Box Assembly

seat to the bracket on the battery box. See **Fig. 7**.

1.2 Remove the seat, letting the seat belt buckle slip out between the seat and back cushions.

2. Remove the bolts that secure the seat belt bracket to the battery box.
3. Remove the battery box cover.
4. Disconnect the battery cables from the battery terminals and move the cables out of the way.
5. Remove the vinyl tubing from the ventilation ports on the batteries. See **Fig. 8**, ref. 3 and 4.
6. Remove the forward and rear battery retainers. See **Fig. 9**.
7. Remove the batteries from the vehicle. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components.
8. Remove the battery box.



1. Battery Box
2. Battery Box Cover
3. Seat
4. Capscrew

Fig. 7, Under-Seat Battery Box

8.1 Remove the eight nuts and bolts securing the battery box to the cab floor.

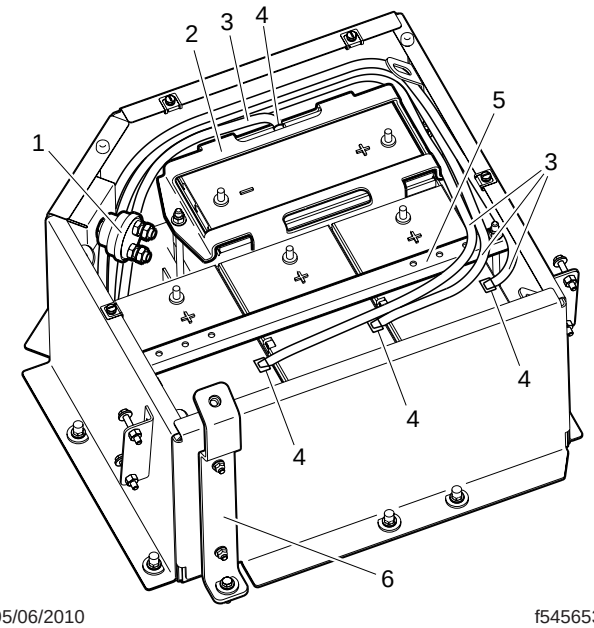
8.2 Remove the nuts and bolts that secure the seat belt bracket to the battery box.

8.3 Remove the battery box from the vehicle.

Cleaning and Inspection

1. Inspect the battery cables and replace any that are damaged. Clean the cable connector terminals with a wire brush.
2. Inspect the retainer assembly (or battery hold-downs) and battery box. Replace worn or dam-

Battery Box Removal, Cleaning, Inspection, and Installation



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1. Battery Cutoff Switch
2. Forward Battery Retainer
3. Vinyl Ventilation Tubing
4. Ventilation Ports
5. Rear Battery Retainer
6. Seat Belt Bracket

Fig. 8, Under-Seat Battery Installation

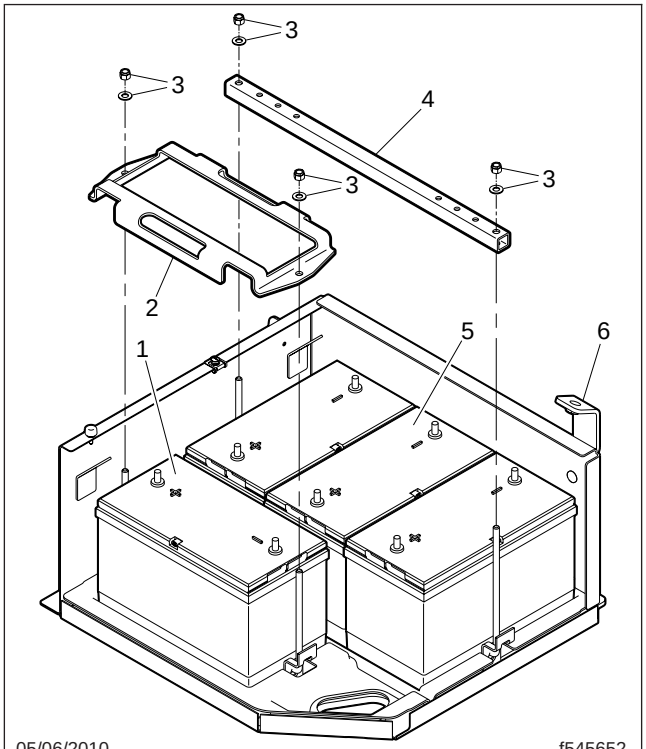
aged parts. Remove any corrosion with a wire brush, and wash with a weak solution of baking soda and water. Rinse with clean water, and dry. Paint the retainer assembly, if needed, to prevent rusting.

3. Be sure foreign objects or road debris are removed from the battery box.

Installation

Under Cab Battery Box (EPA07)

1. Attach the air tank straps and brackets to the step assembly.
2. Mount the air tanks and perform any necessary alignment.
3. Attach the step and cover attaching or fairing attaching hardware.
4. Move the jack under the battery box/air tank assembly.



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1. Forward Battery
2. Forward Battery Retainer
3. Nut and Washer
4. Rear Battery Retainer
5. Rear Batteries
6. Seat Belt Bracket

Fig. 9, Battery Retainers

5. Lift the assembly and position it on the brackets mounted on the frame rail.
6. Install the mounting bolts and tighten them 128 lbf·ft (173 N·m).
7. Attach the air lines to the air tanks.
8. Be sure that the battery to be installed has a sufficient capacity to cover the electrical needs of the vehicle.

NOTICE

Using an under-capacity battery will result in poor performance and premature battery failure, resulting in damage or reduced life of the starter.

9. Be sure the battery is at full charge when installed.

10. Place the batteries in the battery box assembly with the positive terminals toward the inboard side. The batteries should rest level in the carrier.
11. Install the battery retainers and tighten 9 to12 lbf·ft (12 to 16 N·m).

NOTICE

Do not overtighten the battery retainer assembly. Overtightening could damage the batteries.

12. Connect the battery cables to the batteries.
    - 12.1 Install the battery cable interconnectors.
    - 12.2 Tighten the battery cables to the torque specifications listed on the battery, generally 10 to 15 lbf·ft (14 to 20 N·m).
    - 12.3 Connect the vehicle harness battery cables, connecting the ground cables last.
    - 12.4 Coat the connections with dielectric grease.

NOTICE

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

    - 12.5 Check for correct polarity with respect to the vehicle.
13. Start the engine, and check the operation of the charging system.
14. Install the battery box cover.

Between-Rail Battery Box

1. Install the battery box.
    - 1.1 Line up the holes in the bottom of the battery box with the holes in each bracket.
    - 1.2 Install four keeper assemblies and springs through the holes in the battery box and brackets.
    - 1.3 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).
2. 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.
3. Install the battery hold-downs. See **Fig. 5**.
    - 3.1 Install a hold-down on each battery.
    - 3.2 Insert a rib-neck bolt up through each hold-down and thread onto it a 5/16–18 hold-down locknut and washer.

NOTICE

Do not overtighten the battery hold-downs. Overtightening could damage the batteries.

    - 3.3 Tighten each locknut 10 lbf·ft (14 N·m).
4. Connect the battery cables to the batteries.
    - 4.1 To provide corrosion protection, apply pumpable dielectric grease liberally to the terminal pads.
    - 4.2 Install the battery cable interconnectors.
    - 4.3 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.
    - 4.4 Check for correct polarity with respect to the vehicle.

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

5. Start the engine, and check the operation of the charging system.
6. Install the battery box cover and the deck plates.

Under Cab Battery Box (EPA10)

1. Install the batteries in the battery box assembly, and install the battery retainers.
2. Connect the battery cables to the batteries.
    - 2.1 To provide corrosion protection, apply dielectric grease liberally to the terminal pads.
    - 2.2 Install the battery cable interconnectors.
    - 2.3 Tighten the battery cables to the torque specifications listed on the battery, gener-

Battery Box Removal, Cleaning, Inspection, and Installation

ally 10 to 15 lbf·ft (14 to 20 N·m). Connect the ground cable last.

NOTICE

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

2.4 Check for correct polarity with respect to the vehicle.

3. Position the side shield on the battery box, and install the three bolts that secure the side shield to the battery box.
4. Install the battery box cover.
5. Install the step assembly.

Under-Seat Battery Box (EPA10)

1. Position the battery box in the cab and install the eight nuts and bolts that secure the battery box to the cab floor. Tighten the bolts 16 to 18 lbf·ft (21 to 24 N·m).
2. Install the nuts that secures the seat belt bracket to the battery box. Tighten the nuts 16 to 18 lbf·ft (21 to 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 forward and rear battery retainers, and install the washers and nuts. Tighten the nuts 5 to 6 lbf·ft (6 to 8 N·m).

NOTICE

Do not overtighten the battery retainer assembly. Overtightening could damage the batteries.

5. Connect the battery cables to the batteries.
   - 5.1 To provide corrosion protection, apply dielectric grease liberally to the terminal pads.
   - 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.

NOTICE

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

5.4 Check for correct polarity with respect to the vehicle.

CAUTION

Ensure the vent tubes are connected to battery and cab vent ports, and ensure the vent tubes are free of cuts or punctures. Failure to properly install the vent tubes could result in hydrogen gas leaking into the vehicle.

6. Install the vinyl ventilation tubing.
7. Start the engine, and check the operation of the charging system.

NOTICE

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.

8. Install the battery box cover.
9. Install the passenger-side seat.
   - 9.1 Position the seat on the battery box.
   - 9.2 From the back of the seat, push the seat belt buckle in between the seat and the back cushions.
   - 9.3 On each side of the seat, install the two capscrews that attach the seat to the bracket on the battery box. Tighten the capscrews 10 to 12 lbf·ft (13 to 16 N·m).

EPA07 Power Distribution

Battery power is fused at standard and optional locations on the Cascadia. The Mega Fuse Junction Block (MFJB) is the primary power distribution center for the vehicle. At the MFJB, battery power is routed to the alternator, the SAM Cab, SAM Chassis, powertrain PDM, and other optional loads. The in cab auxiliary PDM and chassis PDM are optional. At the MFJB, battery power may also be routed to an inverter and a trailer cable.

The Cascadia is equipped with a load disconnect switch that disconnects the MFJB from the batteries. Battery cables connecting the starter and emergency power circuits remain live even when the load disconnect switch is off. See **Fig. 1**.

EPA10 Power Distribution

The Powernet Distribution Box (PNDB) is the primary power distribution center for the vehicle. At the PNDB, battery power is routed to the alternator, the SAM Cab, SAM Chassis, powertrain PDM, and other keep-alive circuits. The in-cab auxiliary PDM and chassis PDM are optional. The PNDB can be controlled with a cab load disconnect switch (CLDS). The CLDS triggers the PNDB to disconnect power to the three high-amperage midi fuses that source power to the SAMs and the powertrain PDM (power distribution module).

Power Distribution Modules

Powertrain PDM

The powertrain PDM provides battery and ignition power to the engine, aftertreatment device, and transmission, in addition to optional powertrain-related circuits. The powertrain PDM is mounted above the driver-side inner fender. See **Fig. 2**.

In-Cab Auxiliary PDM

The optional in-cab auxiliary PDM is installed in one of two locations. On 113 BBC vehicles, the PDM is mounted on an HVAC duct in the dash, and accessed by removing the auxiliary dash panel. On 125 BBC vehicles, the PDM is mounted on the engine tunnel inside the cab next to the central gateway. Battery power to the in-cab auxiliary PDM is protected by a 30-amp inline fuse located near the SAM chassis in the engine compartment.

Chassis PDM

The optional chassis PDM is mounted on a bracket forward of the between-rail battery box, or inside the between-rail battery box. When mounted outside the battery box, there may be additional relays and an inline fuse on the lower side of the mounting bracket.

SAM Cab

The SAM cab contains the electronic controls and the fuses and relays for cab electrical systems. It is located in the passenger side of the dash and accessed by removing the glove compartment. The shields covering the SAM cab must be re-installed after the SAM is accessed. See **Section 54.01** for coverage of the SAM cab.

SAM Chassis

The SAM chassis contains the electronic controls and the fuses and relays for most of the chassis electrical system. It is located on the driver side of the frontwall in the engine compartment. The cover over the SAM chassis fuse and relay area must be completely latched into place after they are accessed. See **Section 54.02** for coverage of the SAM chassis.

Powernet Distribution Box

The Powernet Distribution Box (PNDB), installed on EPA10 vehicles, provides 4 circuits that are always powered, and three high amperage circuits that are switched on and off with the optional cab load disconnect switch (CLDS). A flashing LED on the PNDB or the CLDS indicates an error with the system.

General Information

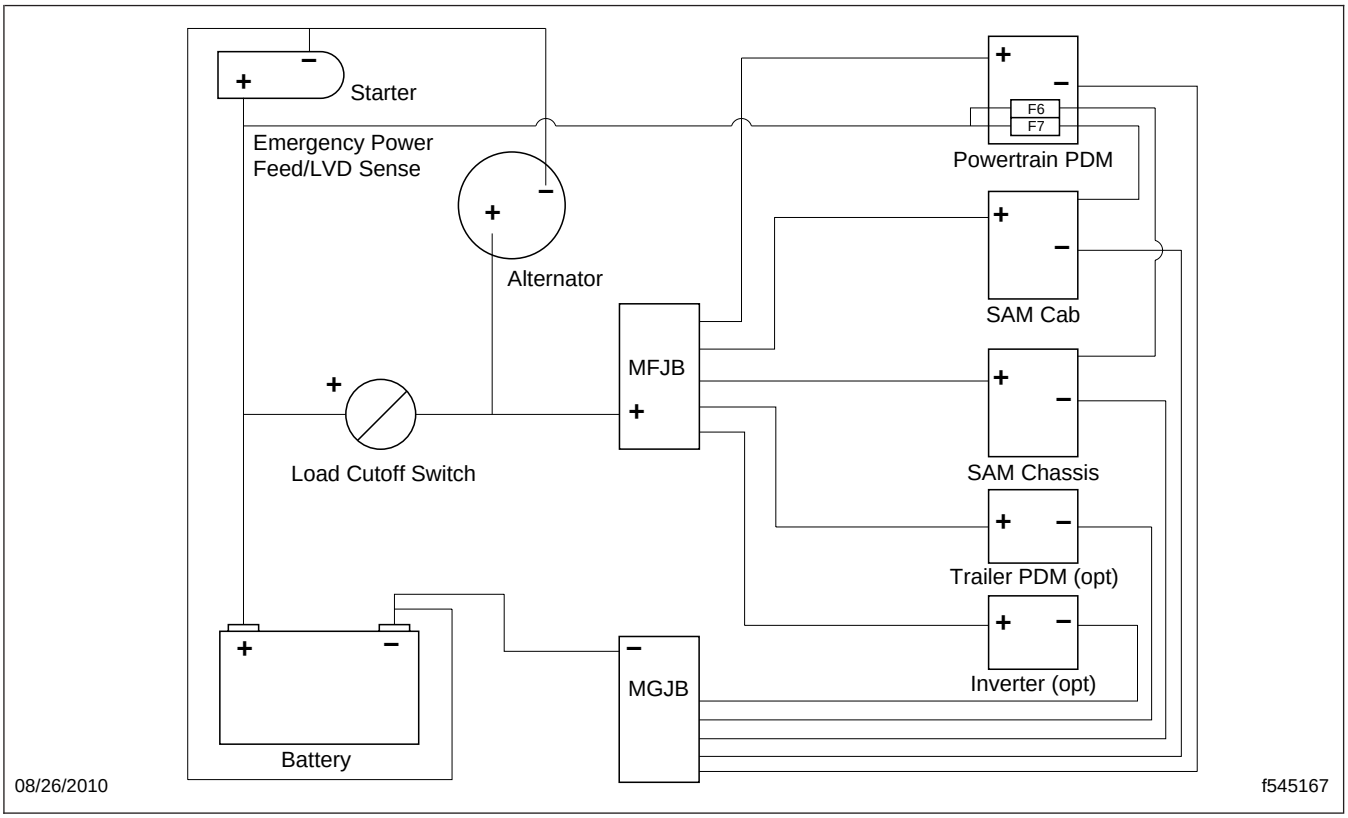
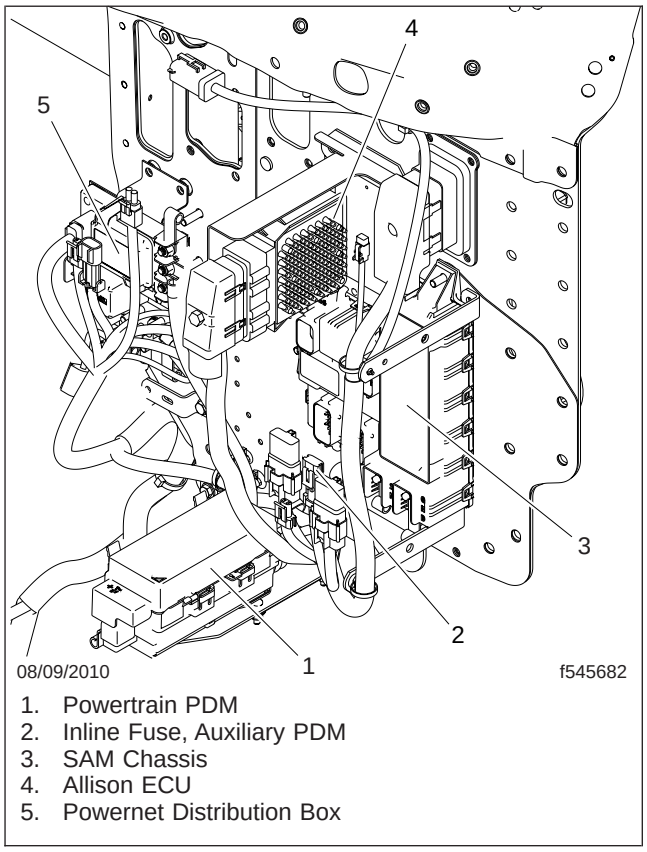


Fig. 1, EPA07 Power Distribution System Design



1. Powertrain PDM
2. Inline Fuse, Auxiliary PDM
3. SAM Chassis
4. Allison ECU
5. Powernet Distribution Box

Fig. 2, Cascadia Power Distribution

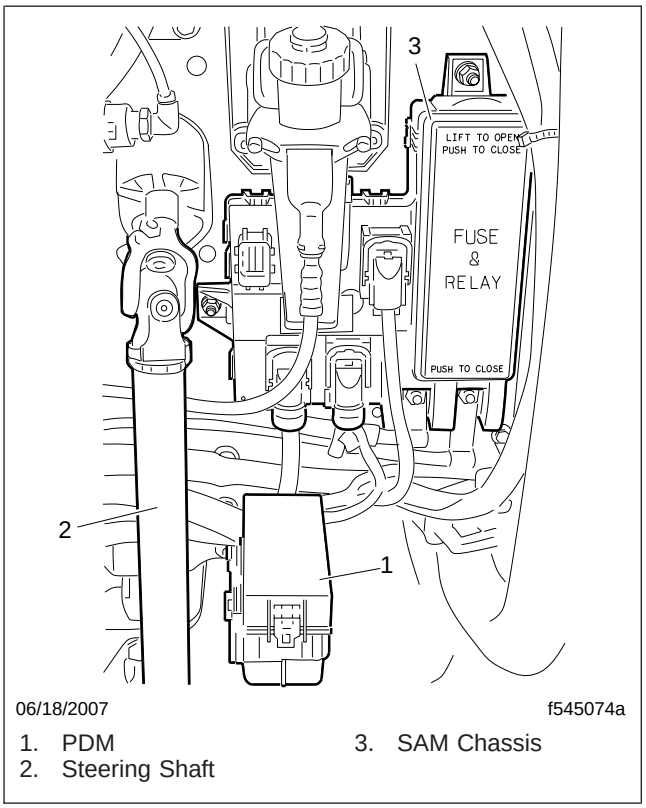
EPA07 Powertrain PDM

Removal

1. Disconnect the negative leads from the batteries.

NOTE: The powertrain power distribution module (PDM) is mounted in the engine compartment next to the left front inner fender. See **Fig. 1**.

2. Using a screwdriver, release the support tabs that secure the PDM to the mounting bracket. See **Fig. 2**. Remove the PDM from the bracket.
3. Remove the top cover from the PDM.
4. Remove the fuses and relays from the top of the PDM, noting the location of each fuse and relay before removal.
5. Remove the terminal locks. See **Fig. 3**.



1. PDM
2. Steering Shaft
3. SAM Chassis

Fig. 1, Power Distribution Module

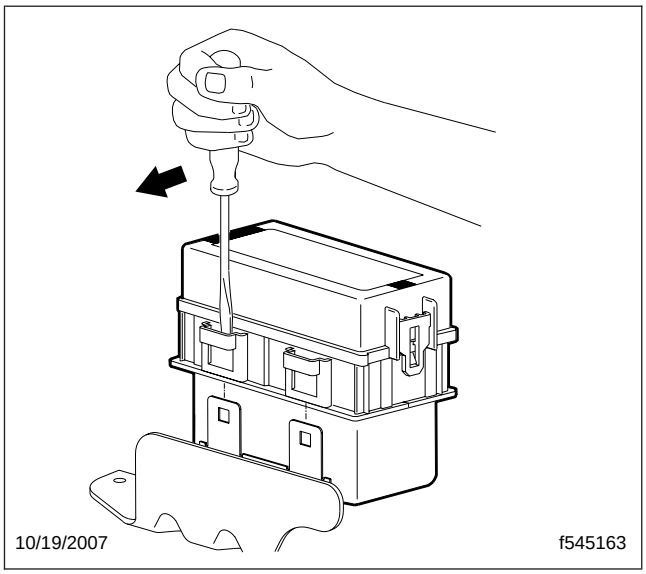
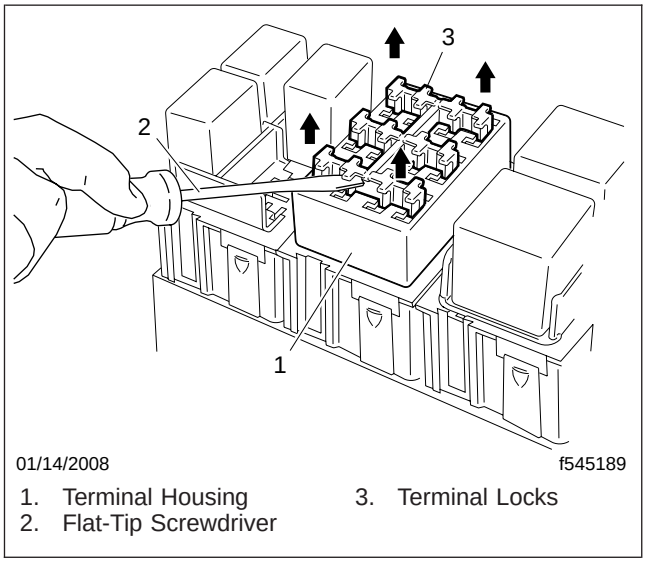


Fig. 2, PDM Removal

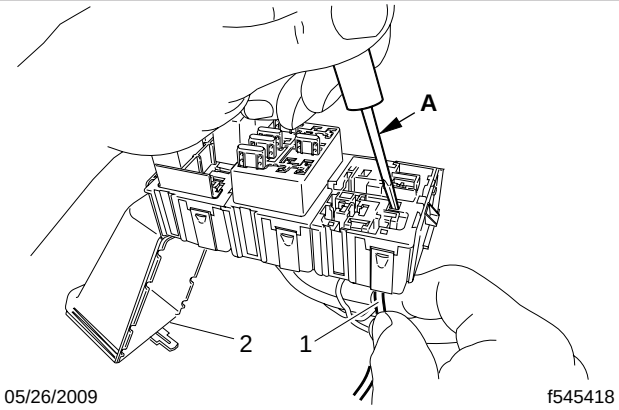


1. Terminal Housing
2. Flat-Tip Screwdriver
3. Terminal Locks

Fig. 3, Removing the Terminal Locks

6. Release the bottom cover using the tab on the end of the PDM where the wires exit. The cover will hinge open.
7. Mark each wire for reassembly.
8. Remove the wires under the PDM by pressing each terminal lock with a pick tool. See **Fig. 4**.
9. Remove the PDM from the vehicle.

Powertrain PDM Removal and Installation



A. Press each terminal lock with the pick tool to remove.

Fig. 4, Removing the Wire with a Pick Tool

Installation

1. Attach all wires to the bottom of the PDM. The terminals will click into place when inserted correctly.

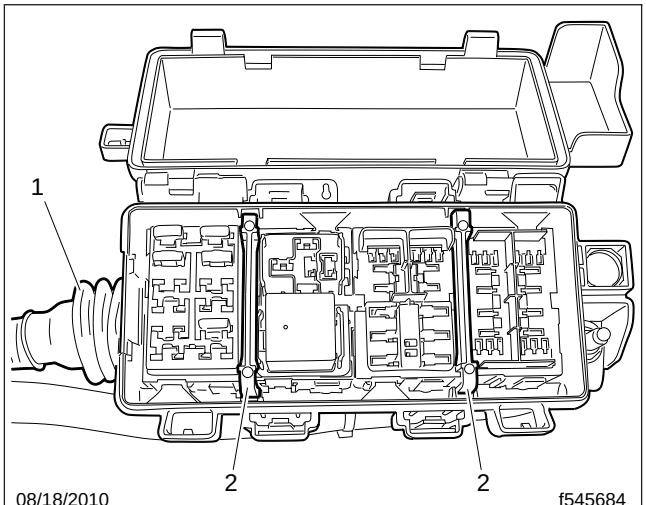
NOTE: If the terminals are inserted backward, the lock will not press into place.

2. Install the terminal locks.
3. Install the fuses and relays, using the locations noted earlier.
4. Install the bottom cover.
5. Position the PDM on the mounting bracket, and push down until the support tabs snap into place.
6. Install the PDM top cover. Use a wire tie to secure the cover, if necessary.
7. Connect the batteries.

EPA10 Powertrain PDM

Removal

1. Disconnect the batteries at the negative terminals.
2. In some installations, the PDM housing may be left attached to the mounting bracket. If it is necessary to remove it, insert a small flat screwdriver into the openings between the mounting bracket and the side of the PDM, then release the tabs. See **Fig. 2**.
3. Open the cover and remove the two retaining clips. See **Fig. 5**.



1. Connector Boot
2. Retaining Clips

Fig. 5, EPA10 PDM

4. Lift the PDM block assembly out from the housing. The power feed circuits can be disconnected from the bus when the block assembly is about half way out of the housing.
5. Identify the positions and values of the fuses and relays, then remove them.
6. Lift the terminal locks up and out of the PDM. See **Fig. 3**.
7. Label all the wires before removing them from the PDM. Remove the wires.
8. Use a Delphi pick tool to release the tab on the terminal then remove it from the bottom side.
9. Remove the PDM from the vehicle.

Installation

1. Insert each circuit into the bottom of the PDM block assembly. If the terminal is backward, the lock will not seat into place. See **Fig. 6**.
2. Install the terminal locks and the fuses and relays, as previously noted.
3. Place the PDM block assembly into the housing, and connect the power feed circuits to the buss bar.

4. Gently squeeze the PDM housing and install the two retaining clips. See **Fig. 7**.

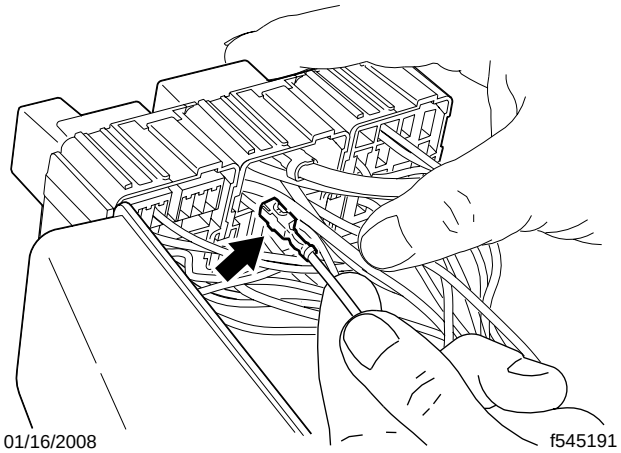
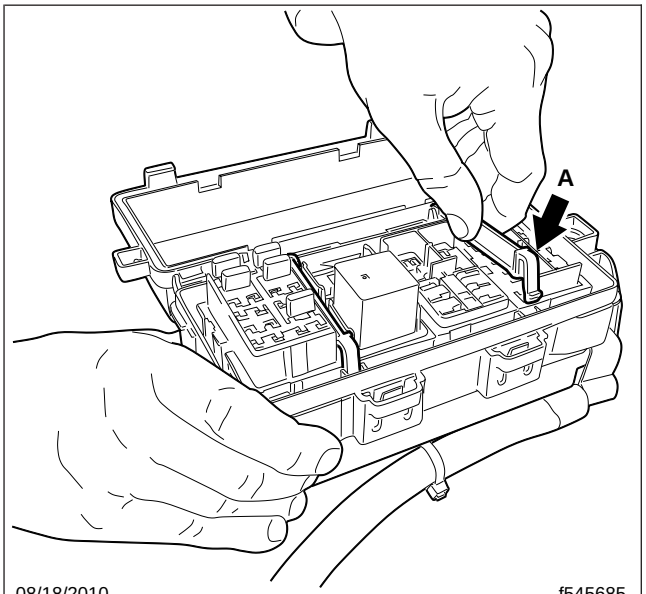


Fig. 6, Inserting Circuits in to the PDM



A. Squeeze the housing of the PDM when installing the retaining clips.

Fig. 7, Installing the Retaining Clips

5. Close the PDM cover.
6. Install the PDM housing onto the bracket, if it was removed.
7. Connect the batteries and close the hood.

Auxiliary PDM Removal and Installation

On 113 BBC vehicles, the in cab auxiliary PDM is located on the HVAC duct behind the center dash panel and is accessed by removing the auxiliary dash panel. See **Fig. 1**. On 125 BBC vehicles, the PDM is mounted on the engine tunnel inside the cab, next to the central gateway. See **Fig. 2**.

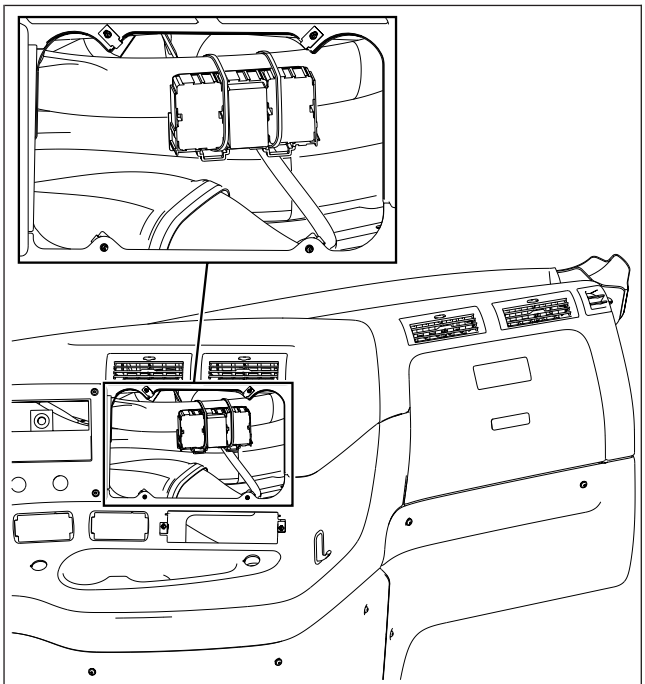
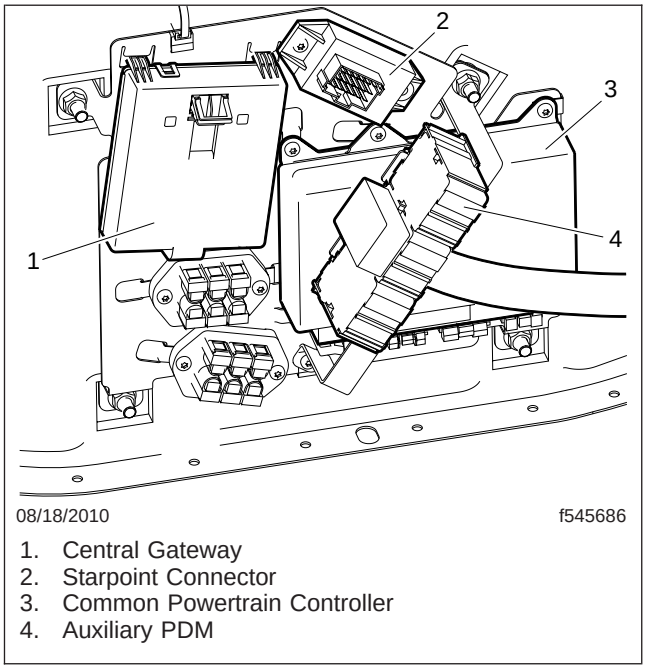


Fig. 1, Auxiliary PDM (113 BBC Installation)

Removal

1. Disconnect the batteries at the negative terminals.
2. On 113 BBC vehicles, remove the auxiliary dash panel. On 125 BBC vehicles, remove the center footwell panel.
3. On 113 BBC vehicles, remove the wire ties that secure the PDM to the HVAC duct.
4. On 125 BBC vehicles, remove the PDM from the mounting bracket.
5. Remove the top cover from the PDM.
6. Remove the fuses and relays from the top of the PDM, noting the location of each fuse and relay before removal.
7. Remove the terminal locks.



1. Central Gateway
2. Starpoint Connector
3. Common Powertrain Controller
4. Auxiliary PDM

Fig. 2, Auxiliary PDM (125 BBC Installation)

8. Release the bottom cover using the tab on the end of the PDM where the wires exit. The cover will hinge open.
9. Mark each wire for reassembly.
10. Remove the wires under the PDM by pressing each terminal lock with a pick tool.
11. Remove the PDM from the vehicle.

Installation

1. Attach all wires into the bottom of the PDM. The terminals will click into place when inserted correctly.

NOTE: If the terminals are inserted backward, the lock will not press into place.

2. Install the terminal locks.
3. Install the fuses and relays, using the locations noted earlier.
4. Install the bottom cover.
5. Install the PDM top cover.
6. On 113 BBC vehicles, attach the PDM to the HVAC duct with wire ties, then install the auxiliary dash panel.

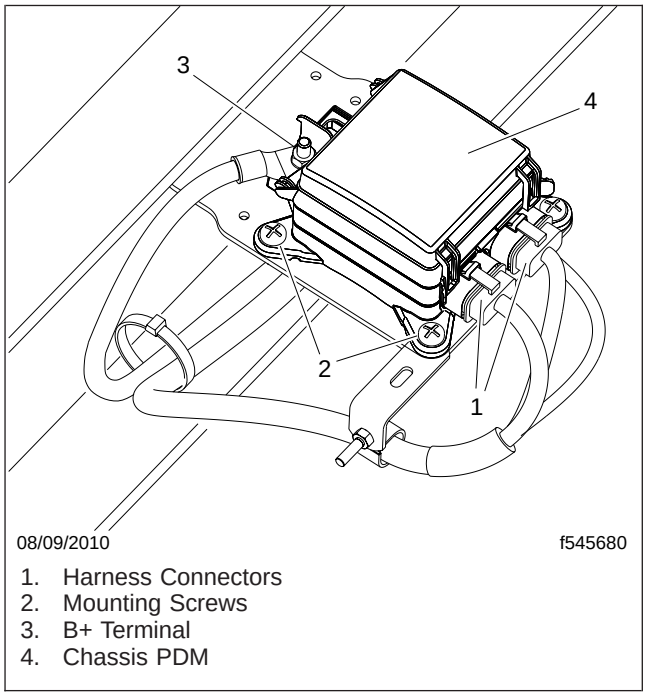
Auxiliary PDM Removal and Installation

7. On 125 BBC vehicles install the PDM on the mounting bracket, then install the center footwell panel.
8. Connect the batteries.

Chassis PDM Removal and Installation

Removal

The chassis PDM is either mounted on a bracket forward of the between-rail battery box, or inside the between-rail battery box. See **Fig. 1** and **Fig. 2**.



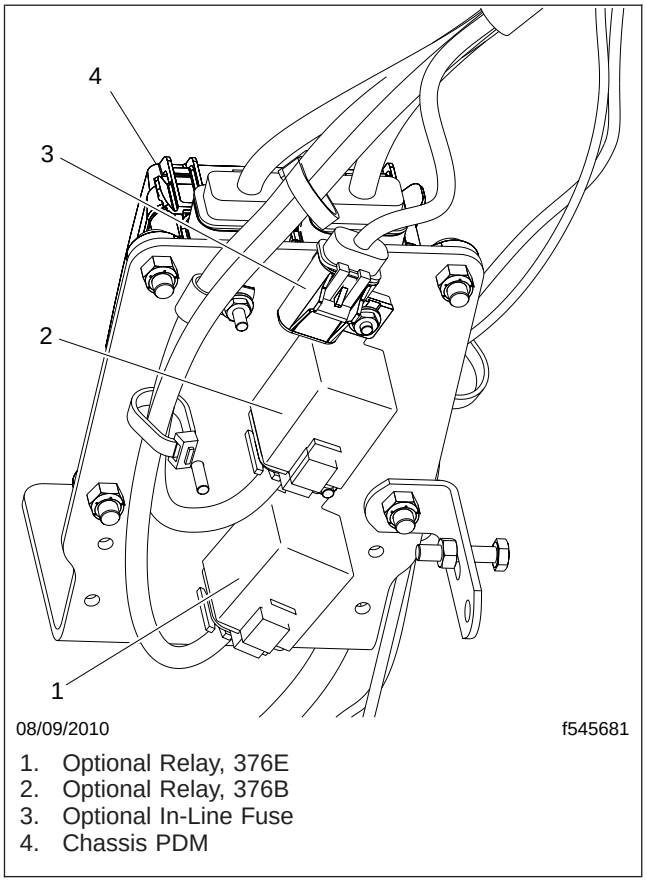
1. Harness Connectors
2. Mounting Screws
3. B+ Terminal
4. Chassis PDM

Fig. 1, Chassis Power Distribution Module

1. Disconnect the batteries at the negative terminals.
2. Disconnect the battery B+ cable at the PDM.
3. Disconnect the harness connectors from the PDM.
4. Remove the four nuts and bolts that attach the PDM to the mounting plate.
5. Remove the PDM.

Installation

1. Connect the harness connectors to the PDM.
2. Position the PDM on the mounting plate and install the four bolts and nuts. Torque the nuts 13 to 15 lbf·ft (17 to 20 N·m).



1. Optional Relay, 376E
2. Optional Relay, 376B
3. Optional In-Line Fuse
4. Chassis PDM

Fig. 2, Chassis Power Distribution Module (bottom view)

3. Attach the battery B+ cable to the B+ terminal. Protect this connection with dielectric red enamel..
4. Connect the batteries.

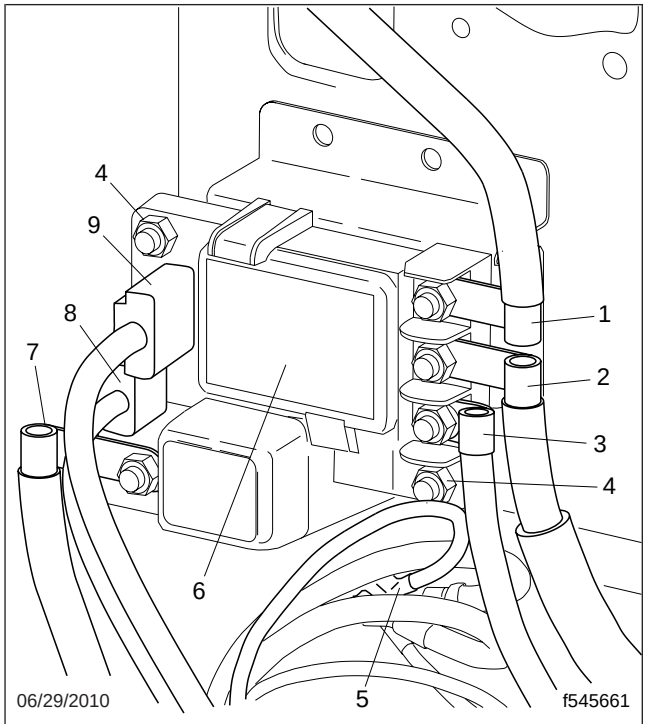
Powernet Distribution Box Removal and Installation

Removal

1. Disconnect the batteries.
2. Open the hood.

NOTE: The powernet distribution box (PNDB) is located on the cab frontwall, above the main ground junction block. See **Fig. 1**.

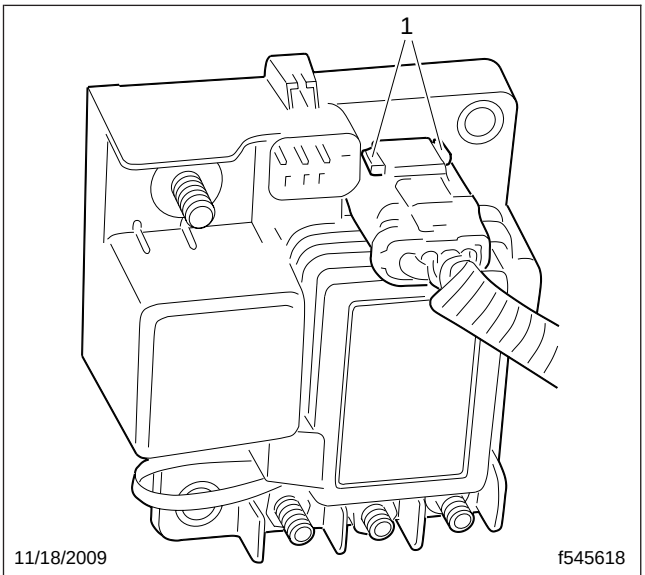
3. Disconnect the battery and power cables from the PNDB.
4. Disconnect the cab load disconnect switch (CLDS) connecter, if equipped.
5. Disconnect the keep-alive circuit connector from the PNDB.
   - 5.1 Using a flat-head screwdriver, push the red locking tab up.



1. SAM Cab Power
2. SAM Chassis Power
3. Powertrain PDM Power
4. Mounting Nut
5. MGJB Ground
6. Fuse Cover
7. Power (B+)
8. Disconnect Switch (CLDS) Connector
9. Keep-Alive Circuit Connector

Fig. 1, Powernet Distribution Box

   - 5.2 Press and release the tab, then remove the connector. See **Fig. 2**.



1. Circuit Connector Locking Tab

Fig. 2, Removing the Circuit Connector

6. Remove the two mounting nuts.
7. Remove the PNDB from the vehicle.

Installation

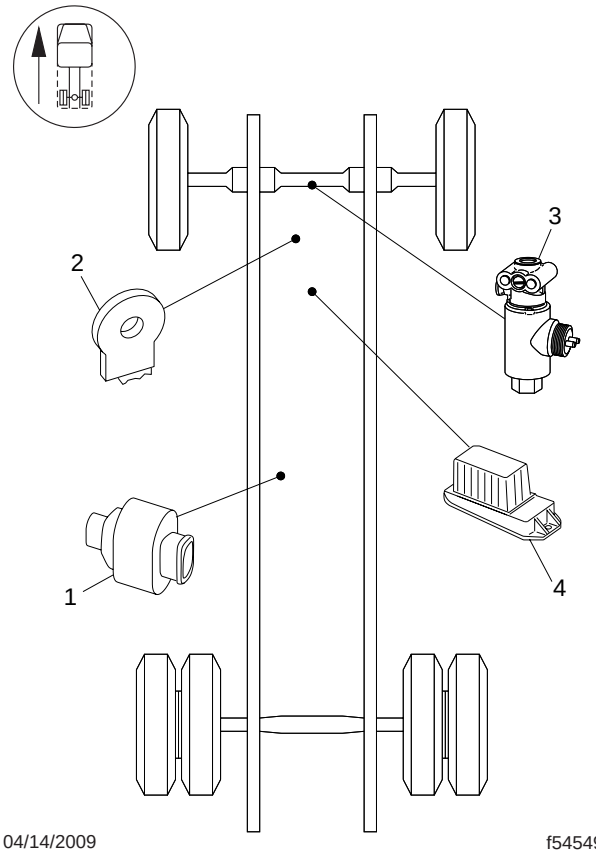
1. Position the PNDB on the frontwall, and attach the two mounting nuts.
2. Connect the battery and power cables.
3. Attach the keep-alive circuit connector and the CLDS connector.
4. Connect the keep-alive circuit.
5. Connect the batteries.
6. Close the hood.

General Information

The Roll Stability Control (RSC) system is an electronic system that passively monitors wheel speed and lateral acceleration. The system controls drive axle and trailer axle braking while decreasing engine torque and applying engine retarder (if equipped) in emergency roll over situations. As a result, the driver has full control over the vehicle until the ABS Electronic Control Unit (ECU) detects a potential rollover, and intervenes accordingly.

When active, tractor rear brakes are applied using the ATC solenoid valve while the trailer brakes are applied by the RSC solenoid valve. This is the same process used for the ATC, that is connected between the pneumatic brake system foot valve and the rear relay brake valve. The RSC valve is connected between the foot valve and the tractor protection valve. In normal operation, the roll stability control valve is inactive and allows control of the trailer brakes from the foot valve. If a rollover is about to occur, the valve opens the air supply from the secondary air tank to the tractor protection valve, that activates the trailer brakes. See **Fig. 1**.

The Electronic Stability Control (ESC) system is an RSC system that offers the additional capability of complete directional stability (yaw control) in oversteer and understeer conditions, such as the ability to reduce the likelihood of drift-out or jackknife. The ESC system includes an additional solenoid valve for front axle braking, a brake pressure sensor, a Steering Angle Sensor (SAS), and an Electronic Stability Control ECU (ESC module) with an integrated yaw rate sensor. The additional sensors allow the ECU to determine where the driver is attempting to steer the vehicle and how much brake demand is required in order to more precisely control the vehicle in an emergency situation. The additional front solenoid valve allows for individual wheel braking on the steering axle to provide yaw control.



1. Brake Demand Pressure Sensor
2. Steering Angle Sensor
3. Front Axle Solenoid Valve
4. ESC Module

Fig. 1, Electronic Stability Control Components

Electronic Stability Control Module

The ECU is mounted under the cab on the crossmember located behind the transmission. See **Fig. 2** and **Fig. 3**.

The ESC module has two sensors: an accelerometer and a yaw rate sensor. An accelerometer is used to measure lateral acceleration. During cornering, lateral acceleration causes a force directed at the vehicles center of gravity, and if high enough, can cause a vehicle to roll. The yaw rate sensor provides rotational sensing that can be used to detect and help prevent vehicle spinout or jackknife. The ESC module has one 4-pin connector that is used to communicate with the ABS ECU.

General Information

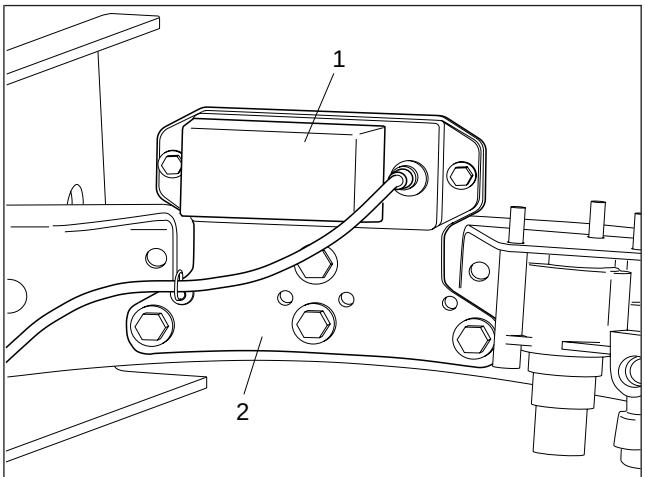


Fig. 2, Electronic Stability Control Module, Extended Cab Mounting

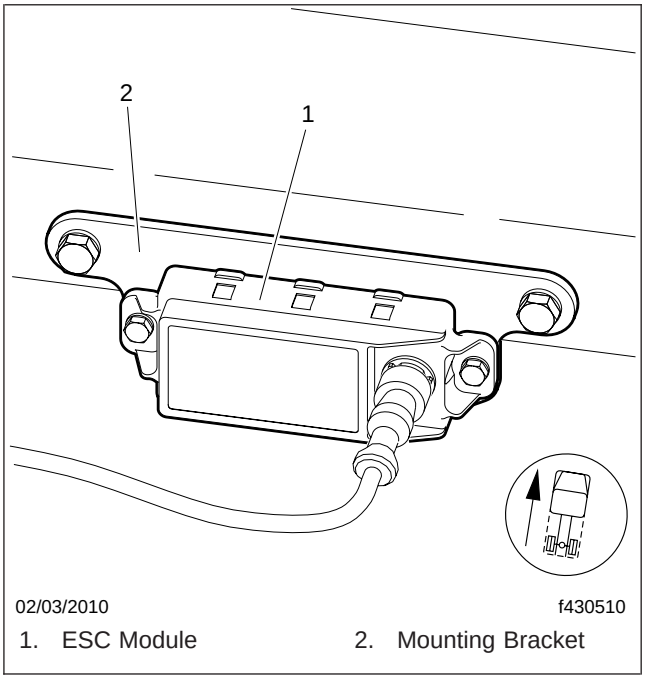


Fig. 3, Electronic Stability Control Module, Day Cab Mounting

ESC Module Removal and Installation

Removal

1. Shut down the engine and chock the tires.
2. Disconnect the electrical connector.
   - 2.1 Turn the collar on the connector counter-clockwise until it stops.
   - 2.2 Disconnect the connector.
3. Remove the two screws from each side of the ESC module.
4. Remove the ESC module.

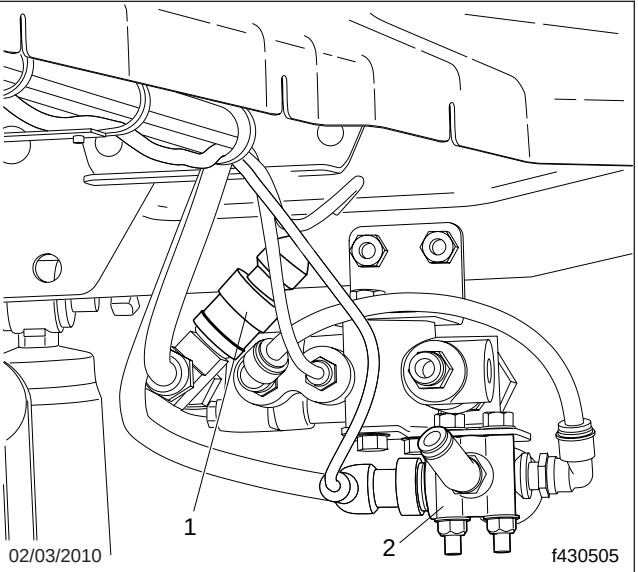
Installation

1. Position the ESC module on the crossmember and install two screws and nuts. Tighten the screws 16 lbf·ft (22 N·m).
2. Connect the electrical connector.

RSC Valve Removal and Installation

Removal

1. Shut down the engine and chock the tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the electrical connector from the roll stability control (RSC) valve. See **Fig. 1**.



1. Brake Demand Pressure Sensor
2. Roll Stability Control Valve

Fig. 1, Pressure Sensor (mounted on trailer protection valve)

   3.1 Turn the collar on the connector counterclockwise until it stops.

   3.2 Disconnect the connector.

4. Disconnect the air lines.
5. Remove the two mounting screws and nuts.
6. Remove the RSC valve.

Installation

1. Position the RSC valve on the crossmember and install two mounting screws and nuts. Tighten the screws 13 lbf·ft (18 N·m).
2. Connect the air lines.
3. Connect the electrical connector to the RSC valve. Hand-tighten only.
4. Verify operation of the RSC valve.

   4.1 Connect the blue gladhand to a 50 cubic inch (819 cubic cm) air tank.

   4.2 Start the vehicle and allow the air reservoirs to fully charge.

   4.3 Shut down the engine.

   4.4 Turn the ignition to ON. Verify that the ATC/RSC/ESC indicator lamp operates correctly.

   4.5 Activate the RSC valve using the Meritor WABCO PC Diagnostics tool, TOOLBOX.

   4.6 Check for air leaks at the RSC valve. If the RSC valve leaks, make the necessary repairs.

   4.7 If the RSC valve fails to cycle, turn off the ignition and make sure the electrical connections are tight. Turn the ignition switch on and check the valve again. If the RSC valve still fails to cycle, check for fault codes. Refer to **H01.01 — ABS and Stability Control Systems** in the *Cascadia Troubleshooting Manual* for fault code identification.

Front Solenoid Valve Removal and Installation

Removal

1. Shut down the engine and chock the tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the electrical connector from the front solenoid valve.
   - 3.1 Turn the collar on the connector counterclockwise until it stops.
   - 3.2 Disconnect the connector.
4. Disconnect the air lines.
5. Remove the two mounting screws and nuts.
6. Remove the front solenoid valve.

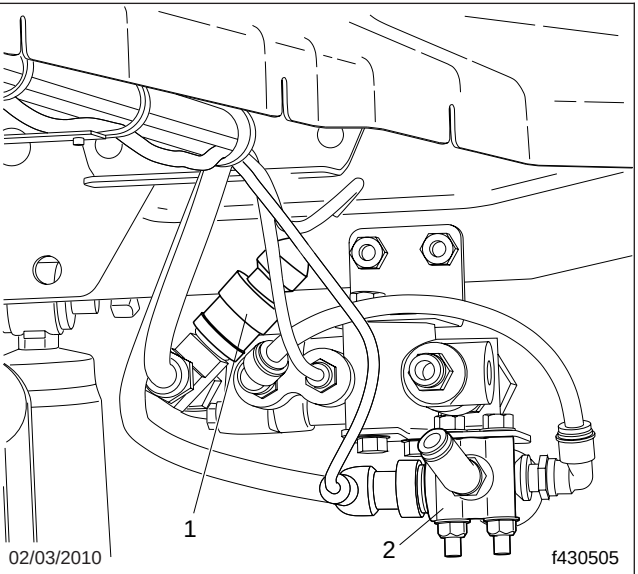
Installation

1. Mount the new solenoid valve and install the two screws and nuts. Tighten the nuts to 8 lbf·ft (11 N·m).
2. Connect the air lines to the front solenoid valve.
3. Connect the electrical connector to the front solenoid valve. Hand-tighten only.
4. Verify the operation of the solenoid valve.
   - 4.1 Start the vehicle and allow the air reservoirs to fully charge.
   - 4.2 Shut down the engine.
   - 4.3 Apply the brakes and check for air leaks at the front solenoid valve.
   - 4.4 Turn the ignition to ON. Verify that the ATC/RSC/ESC indicator lamp operates correctly.
   - 4.5 Activate the front solenoid valve using the Meritor WABCO PC Diagnostics tool, TOOLBOX.
   - 4.6 Check for air leaks at the front solenoid valve. If valve leaks, make necessary repairs.
   - 4.7 If front solenoid valve fails to cycle, turn off the ignition and make sure the electrical connections are tight. Then, turn the ignition switch on and check the valve again. If the front solenoid valve still fails to cycle, check for fault codes. Refer to **H01.01 — ABS and Stability Control Systems** in the *Cascadia Troubleshooting Manual* for fault code identification.

Pressure Sensor Removal and Installation

Removal

1. Shut down the engine and chock the tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the pressure sensor. See **Fig. 1**.



1. Brake Demand Pressure Sensor
2. Roll Stability Control Valve

Fig. 1, Pressure Sensor

   3.1 Turn the flange on the connector counterclockwise until it stops.

   3.2 Disconnect the connector.

4. Disconnect the pressure sensor.

Installation

1. Install the new air pressure sensor. Make sure that the pressure sensor is secured; the connector end should be higher than the threaded end to prevent freezing water from disabling the sensor.
2. Connect the electrical connector to the pressure sensor. Hand-tighten only.
3. Verify operation of the pressure sensor.

   3.1 Connect the blue gladhand to a 50 cubic inch (819 cubic cm) air tank.

   3.2 Start the engine and allow the air reservoirs to fully charge.

   3.3 Shut down the engine.

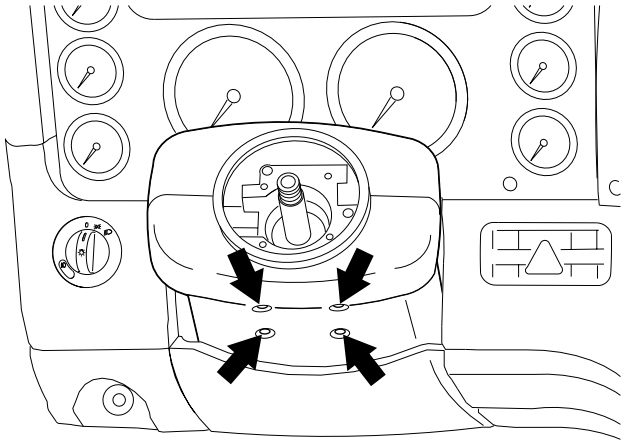
   3.4 Apply the brakes and check the pressure sensor fitting for leaks.

   3.5 Test drive the vehicle to verify that the ATC/RSC/ESC indicator lamp operates correctly.

Steering Angle Sensor Removal and Installation

Removal

1. Shut down the engine and chock the tires.
2. Remove the knee bolster panel, located below the steering column. Remove the four fasteners. See **Fig. 1**.



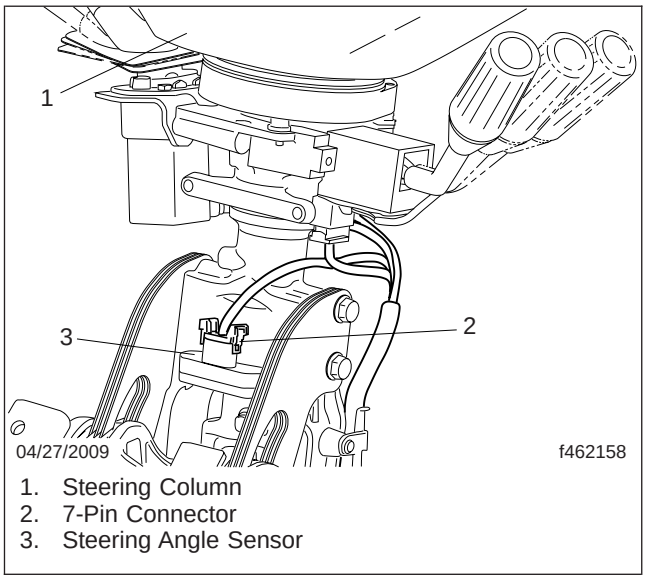
A. Steering wheel not shown for clarity.

Fig. 1, Lower Steering Column Cover Fasteners

3. Remove the steering column.
   - 3.1 Remove the pinch bolt and nut from the upper end yoke on the steering column shaft. Discard the pinch bolt and nut.
   - 3.2 Slide the upper-end yoke off the splines on steering column shaft.
4. Remove the 7-pin connector from the steering angle sensor. See **Fig. 2**.
5. Remove the 3 screws (two upper, one lower) holding the steering angle sensor to the steering column. See **Fig. 3**. Discard the 3 T20 screws and remove the steering angle sensor.

Installation

1. Apply a small amount of grease to the tab in the middle of the steering angle sensor opening, and to the groove of the steering shaft.
2. Place the new steering angle sensor on the steering shaft, making sure to align the guide pin on the steering angle sensor into the grooved slot on the steering shaft. Make sure the steering angle sensor is facing the same direction as originally installed.

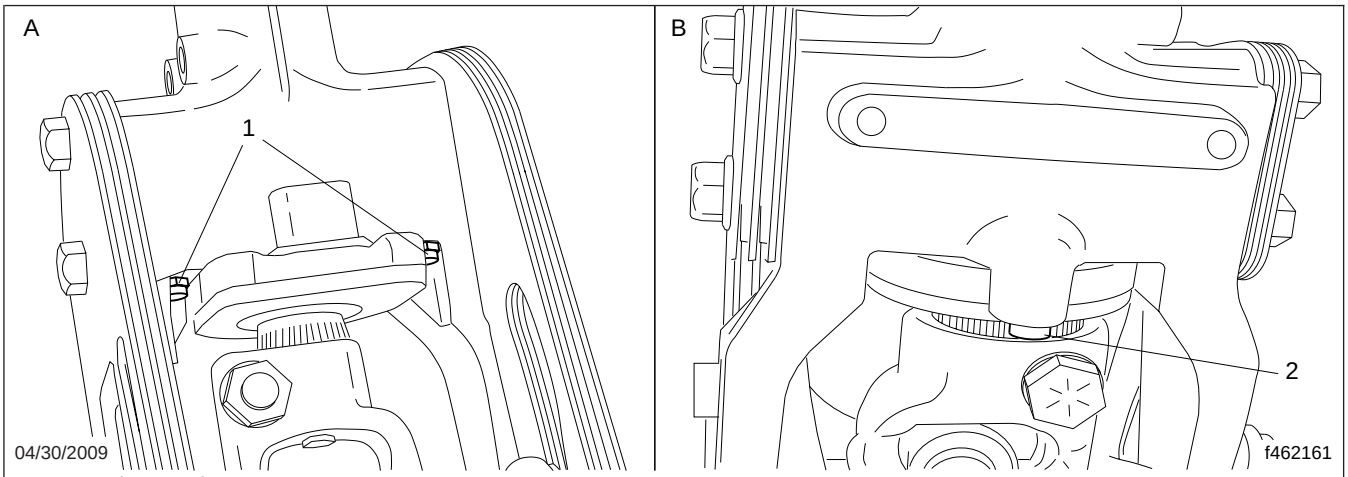


1. Steering Column
2. 7-Pin Connector
3. Steering Angle Sensor

Fig. 2, Steering Column Assenmbly

3. Secure the steering angle sensor onto the steering column using three new T20 screws.
4. Using a new pinch bolt and nut, attach the upper end yoke to the steering column shaft. Tighten the bolt 30 to 35 lbf·ft (41 to 47 N·m).
5. Connect the 7-pin connector onto the new steering angle sensor.
6. Install the steering column.
   - 6.1 Slide the upper-end yoke on to the splines on steering column shaft.
   - 6.2 Install the pinch bolt and nut on the upper end yoke on the steering column shaft.
7. Install the knee bolster. Tighten the four screws 26 to 34 lbf·in (295 to 385 N·cm).
8. Install the steering column upper and lower covers. Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm).

Steering Angle Sensor Removal and Installation



A. Steering Angle Sensor, Front
B. Steering Angle Sensor, Back

1. Upper Mounting Screws
2. Lower Mounting Screw

Fig. 3, Steering Angle Sensor

General Information

The Virtual Technician (VT) ECU generates diagnostic information to aid Detroit Diesel and the technician diagnose complex engine control issues. The system creates sensor log files, captures fault codes, and sends alert messages and other advanced diagnostic information to the *Detroit Diesel Customer Support Center* (CSC). The ECU utilizes GPS navigation, GSM (cellular telephone) communication, and a J1939 connection for databus monitoring. Virtual Technician does not require any driver input to function. The ECU is located behind the sunglass holder on the passenger side of the overhead console, and is mounted to a bracket with hook and loop tape. See **Fig. 1** and **Fig. 2**. The ECU can safely be removed from the mount while remaining wired into the vehicle for visual diagnostic purposes.

There are three modes of operation for the Virtual Technician ECU:

- **Registration Mode**: The vehicle identification number (VIN), engine serial number, and GPS ID are gathered at the manufacturing facility in this mode. Registration mode also occurs when a new unit is installed at the dealership.
- **Normal Operation Mode**: This mode occurs after electronic registration of the unit. In this mode, the ECU gathers fault codes, ring buffer files, and GPS data. This mode monitors the databus for general information and fault codes. Transmission of this information to Detroit Diesel generally occurs within 4 minutes of collection depending on GSM network availability. Normal mode also allows for over-the-air updates of VT firmware.
- **Dormant Mode**: In dormant mode, activity and data usage is minimized or eliminated. This mode is activated only by remote modification of the firmware settings by the CSC. This may occur if the VT subscription ends.

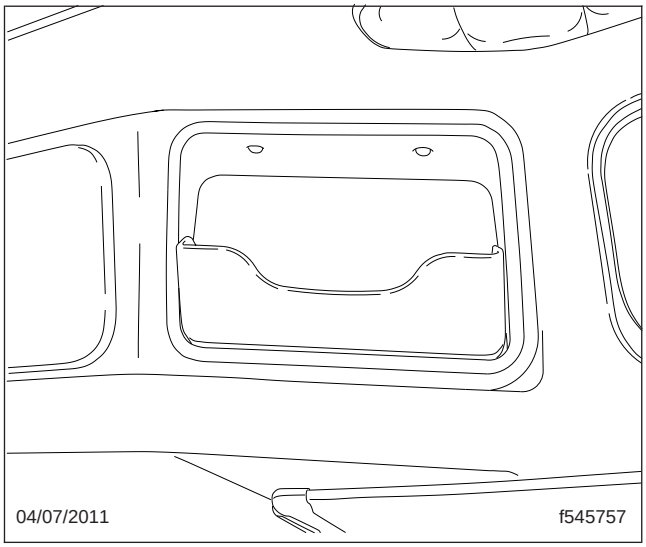
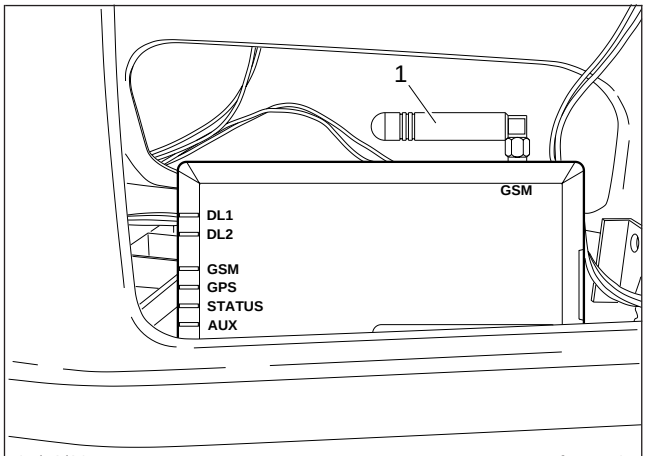


Fig. 1, Sunglass Holder



1. GSM Antenna

Fig. 2, Virtual Technician ECU

Virtual Technician ECU Removal and Installation

The Virtual Technician ECU is located behind the sunglass holder on the passenger side of the Cascadia overhead console.

Removal

1. Park the vehicle and shut down the engine.
2. Remove the sunglass holder from the overhead console by removing the two mounting screws. See **Fig. 1**.

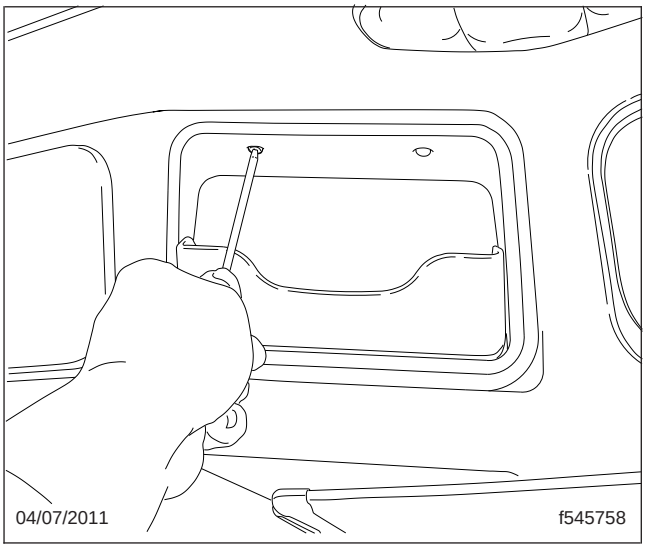
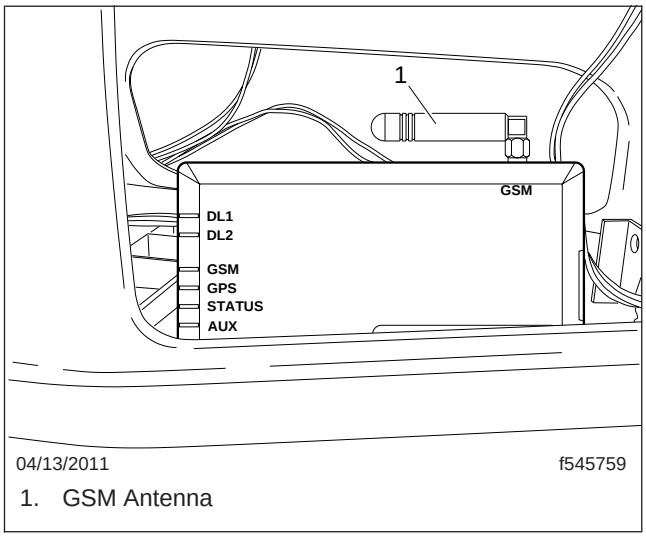


Fig. 1, Sunglass Holder Removal

3. Remove the hook and loop tape mounting of the Virtual Technician ECU to view LEDs for diagnostic information. See **Fig. 2**. The LEDs are located on the left side of the ECU.
4. Refer to **P04.02 — Virtual Technician** in the *Cascadia Troubleshooting Manual* for diagnostic information. If the Virtual Technician ECU needs to be replaced, call the *Detroit Diesel Customer Support Center*.
5. Remove the ECU from the vehicle.

Installation

1. Position the new Virtual Technician ECU in the overhead console.
2. Fasten the hook and loop tape mounting to the ECU.
3. Verify the operation of the ECU.



1. GSM Antenna

Fig. 2, Virtual Technician ECU

3.1 Start the vehicle and drive to an open area, at least 40 feet (12 meters) away from any buildings. Park the vehicle and keep the ignition in the ON position. Apply the parking brake.

3.2 Call the *Detroit Diesel Customer Support Center*. Make sure to have the vehicle serial number and the Virtual Technician serial number available so that the new ECU can be registered.

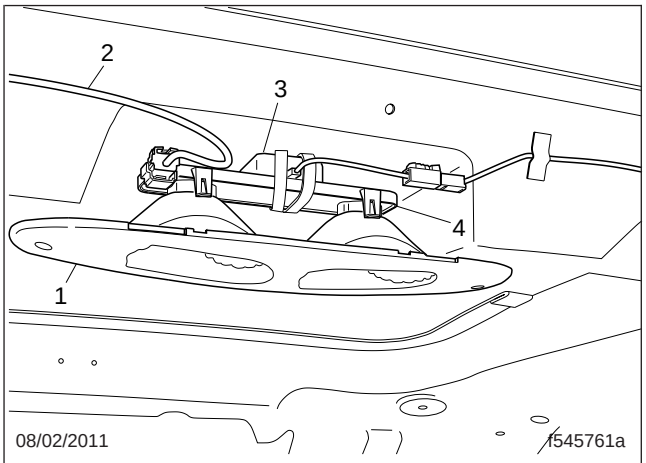
3.3 Install the sunglass holder.

Replacement

NOTE: Before removing the GPS antenna, call the *Detroit Diesel Customer Support Center* for diagnosis of the problem and instructions for repair. On sleepers, the GPS antenna is located in the headliner, and is attached to the right-hand interior lamp. On daycabs, the GPS antenna is mounted externally to the rear of the cab.

Sleepers

1. Park the vehicle, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the right-hand sleeper dome light.
3. Disconnect the GPS antenna from the antenna cable. See **Fig. 1**.



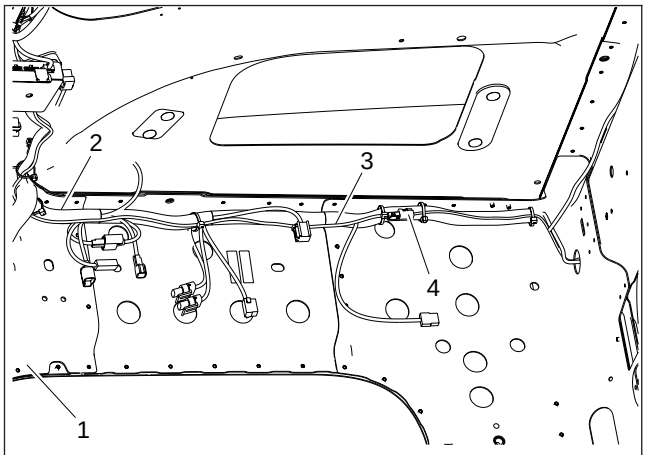
1. Right-Hand Sleeper Dome Light
2. Interior Wiring
3. GPS Antenna
4. Dome Light Mounting Bracket

Fig. 1, Dome Light Connections

4. Remove the cable ties that secure the antenna to the dome light mounting bracket, then remove the antenna.
5. Remove the antenna from the vehicle.
6. Secure the new antenna to the dome light mounting bracket with two cable ties in a cross pattern.
7. Connect the new antenna to the antenna cable.
8. Install the right-hand sleeper dome light.

Daycabs

1. Park the vehicle, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the headliner.
3. Disconnect the antenna pigtail from the antenna cable. See **Fig. 2**.

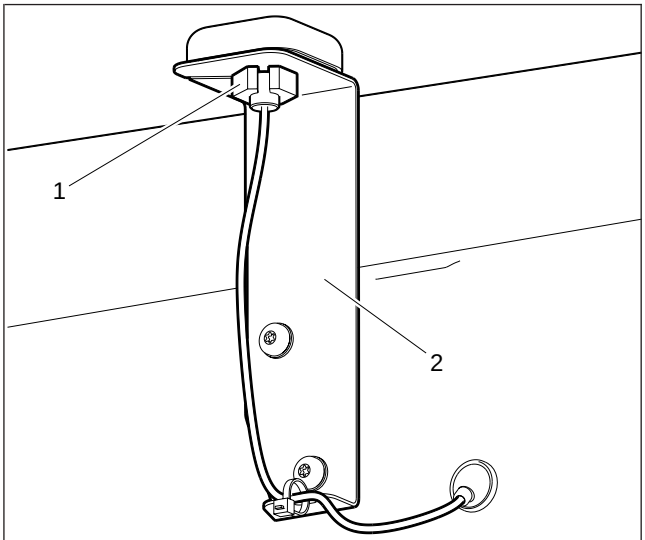


1. Passenger-Side Cab Door
2. Overhead Commodity Harness
3. Antenna Cable
4. Antenna Pigtail Connector

Fig. 2, Antenna Connector (daycab)

4. Loosen the nut securing the antenna to the mounting bracket on the rear exterior of the cab, and remove the antenna. See **Fig. 3**.
5. Remove the rubber grommet and pigtail from the cab.
6. Mount the new antenna to the mounting bracket and tighten the mounting nut.
7. Run the new pigtail into the cab, and secure the attached rubber grommet over the insertion hole.
8. Connect the antenna pigtail to the antenna cable.
9. Install the headliner.

GPS Antenna Replacement



1. Antenna Mounting Nut
2. Antenna Bracket

Fig. 3, External Antenna (daycab)

General Information

The OnGuard collision safety system uses forward-looking radar to measure the distance between the vehicle and any moving object in front of the vehicle. At speeds greater than 15 mph (24 km/h), OnGuard sends audible and visual warnings through the display unit located on the dash to alert the driver to take corrective action when the following distance is too short. The warning ends when speed is decreased and the following distance is increased. The following distance alert is disabled when the driver's vehicle speed is below 15 mph (24 km/h).

When cruise control is set, OnGuard provides engine throttle and retarder control, as well as foundation brake activation to maintain safe following distances. The automatic braking is intended only to provide early braking. The driver must also apply the brakes in response to the collision warning.

If there is a fault with the OnGuard system, the display will change to a red background and show the suspect parameter number (SPN) and failure mode identifier (FMI). When a fault is detected, the OnGuard system and the vehicle cruise control system will be disabled. Only active fault codes are displayed. Fault codes may be displayed during service procedures on other electrical components.

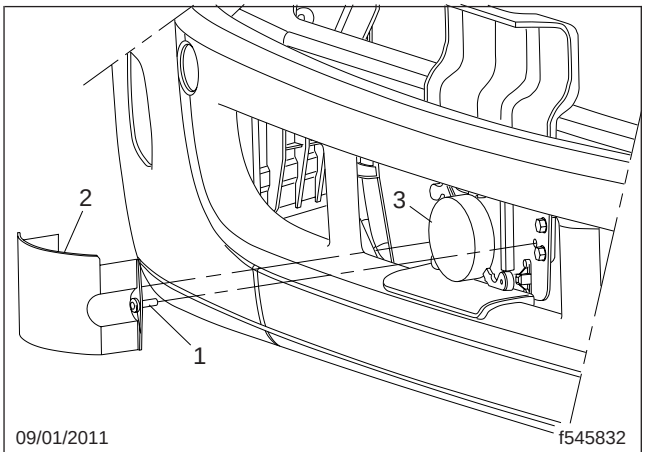
Principles of Operation

The radar unit, located at the front bumper, measures the distance to the moving object forward of the vehicle. This distance is broadcast on the J1939 data bus. The display unit is typically located on the dash auxiliary panel.

When no vehicle is within range, the OnGuard display background is blue. When a vehicle is being tracked and no action is being taken by OnGuard, the background turns to green. The background turns yellow, and an audible tone will sound when the driver is following too closely behind another vehicle. This alert ends when the driver's vehicle speed drops below the lead vehicle speed and the following distance is increased.

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Remove the two fascia attaching bolts and remove the fascia from in front of the radar antenna. See **Fig. 1**.



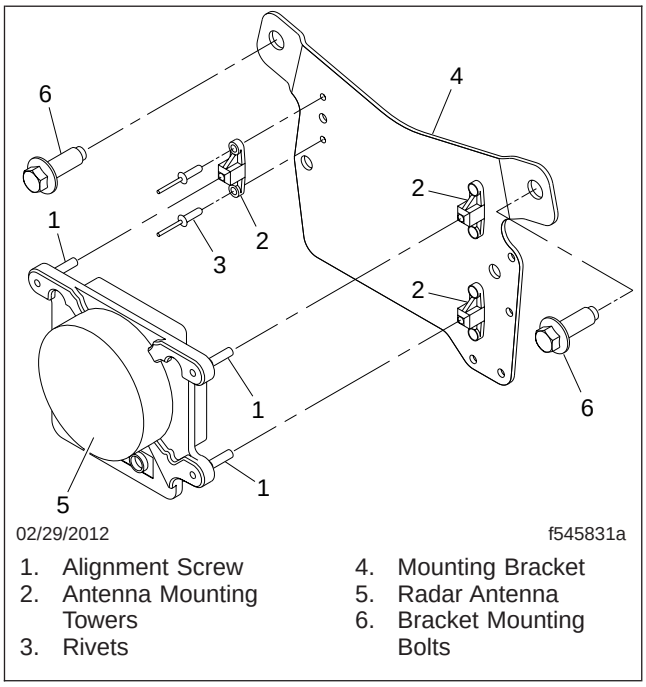
1. Fascia Cover
2. Mounting Bolts
3. Radar Antenna

Fig. 1, Radar Antenna Fascia Cover

3. Disconnect the radar antenna connector by depressing the lock tabs on both sides of the radar connector.
4. Remove the three alignment screws from the antenna mounting towers and remove the radar antenna. See **Fig. 2**. The alignment screws will remain in the ball socket clip attached to the antenna.

Installation

1. Inspect the radar antenna mounting bracket. Insure that it is not bent and that it is securely fastened to the bumper.
2. Inspect the mounting towers are and their attachment to the bracket. Insure that the mounting towers are not cracked and that the head of the attaching rivets are tight to the tower.



1. Alignment Screw
2. Antenna Mounting Towers
3. Rivets
4. Mounting Bracket
5. Radar Antenna
6. Bracket Mounting Bolts

Fig. 2, Radar Antenna Mounting Assembly

3. Insert the three ball socket clips and alignment screws into the new antenna. Refer to **Subject 130** in this section for instructions.
4. Connect the antenna electrical connector by pushing on the connector until it snaps into the radar antenna. Slide the rubber boot over the connector until the connector is completely covered by the boot.

NOTE: Make sure the harness is not crimped or pinched, and that it routes behind the mounting bracket.

5. Align the radar antenna. Refer to **Subject 140** in this section for instructions.
6. Install the fascia cover.

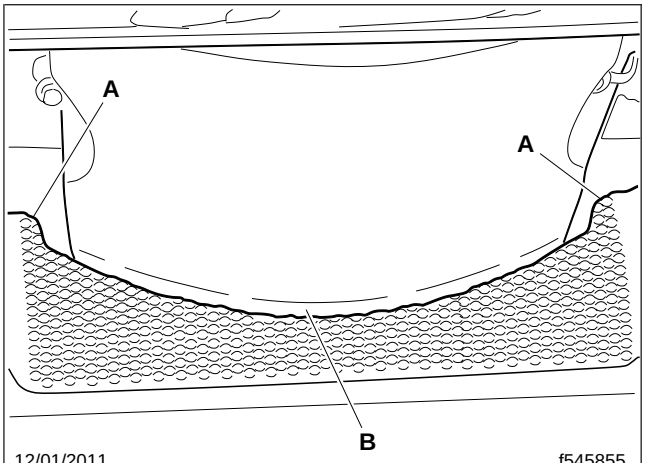
Antenna Installation Checklist

OnGuard system performance depends on proper antenna installation. Use the following checklist to verify that the antenna is mounted properly and free from obstruction.

1. Make sure that there is a consistent gap between the antenna, fascia, and the bumper step

Radar Antenna Removal and Installation

plate. The fascia should not be touching the antenna or the step plate. See **Fig. 3**



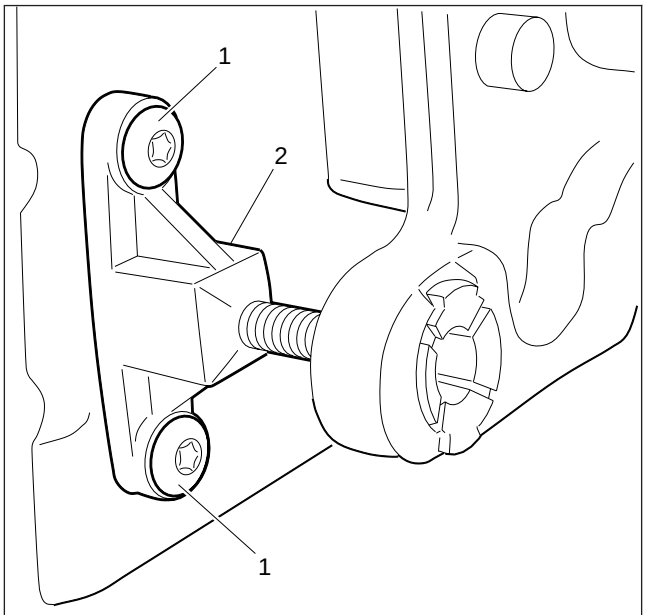
A. There should be two small ears on each side of the step plate to show that the cutout is correct.
B. There should be a consistent gap between the antenna fascia and the bumper step plate.

Fig. 3, Correct Antenna Installation

2. Make sure the towers and rivets are not broken or missing. See **Fig. 4**.
3. Make sure that the antenna harness is routed between, and not over, the ribs of the bumper step plate.

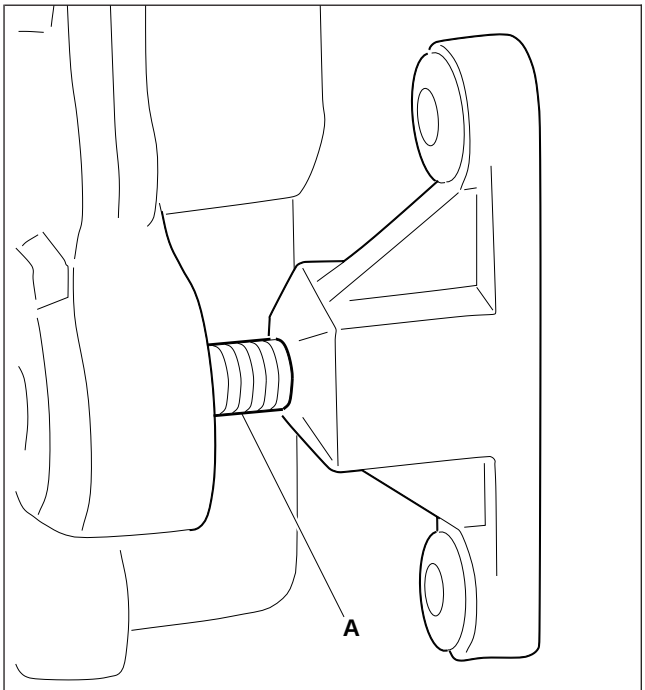
IMPORTANT: Remove the antenna fascia before performing the following checks.

4. Make sure that the antenna is the correct distance from the mounting towers. There should be four to seven threads showing on each adjustment screw. See **Fig. 5**.
5. Make sure that the adjustment screw is properly engaged in the mounting socket.
6. Make sure the ball socket clips are not broken and that all four "ear" tabs are present. See **Fig. 6**. Grab the antenna and push, then pull gently. If the joint is loose, the ball socket clip may be broken.



1. Rivets
2. Mounting Tower

Fig. 4, Rivet and Mounting Tower Installation



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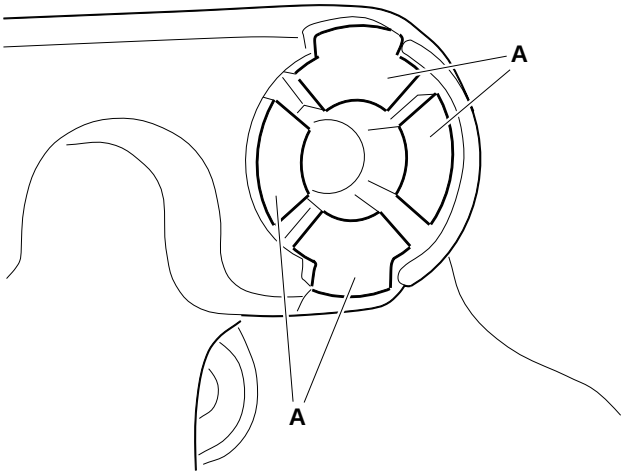
A. There should be four to seven threads showing on each adjustment screw.

Fig. 5, Correct Antenna Alignment



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A. Make sure all four ear tabs are present on each ball socket clip.

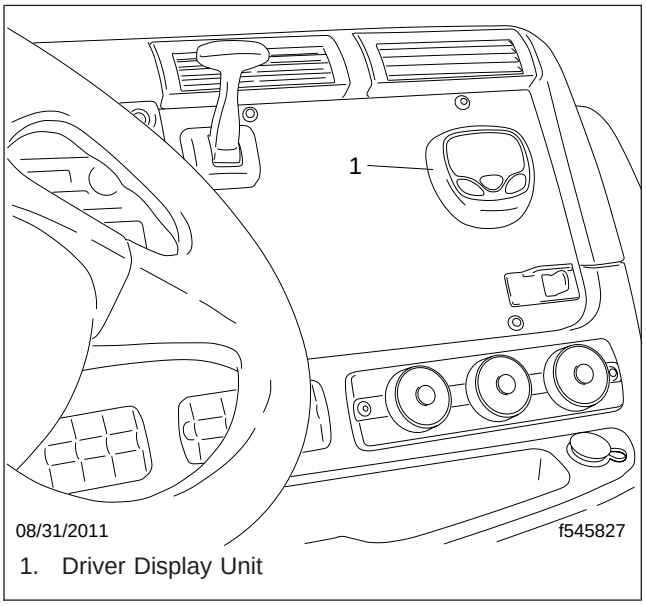
Fig. 6, Antenna Mounting Socket Tabs

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.

NOTE: The display unit is located on the right-hand dash panel, next to the trailer parking brake. See **Fig. 1**.

2. Remove the four bolts from the right-hand dash panel and remove the panel.



1. Driver Display Unit

Fig. 1, OnGuard Display Unit Mounting Location

3. Unplug the 6-pin harness connector from the back of the display unit.
4. Remove the nuts from the display unit mounting studs and remove the display unit.

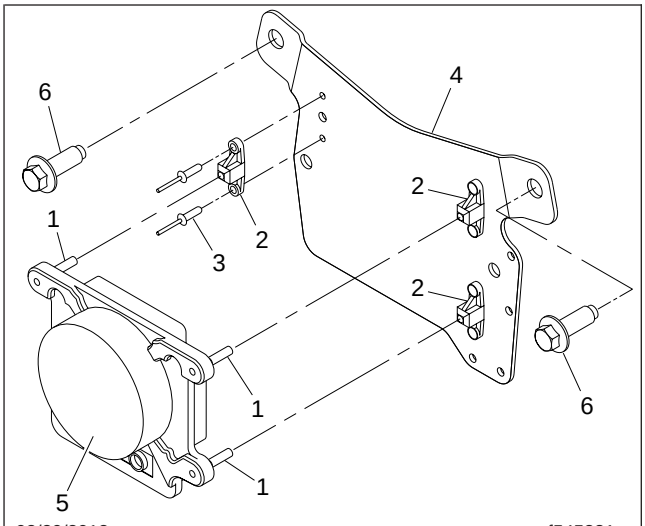
Installation

1. Insert the OnGuard display unit on the right hand instrument panel.
2. Install nuts on the mounting studs and torque the nuts 8 to 9 lbf·in (90 to 100 N·cm).
3. Attach the 6-pin harness connector to the back of the display unit.
4. Install the right hand instrument panel.

Radar Antenna Mounting Bracket and Towers Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Remove the radar antenna. Refer to **Subject 100** in this section for instructions.
3. If applicable, remove the front grille to access the bracket mounting bolts.
4. Remove the radar antenna mounting bracket. See **Fig. 1**.



1. Alignment Screw
2. Antenna Mounting Towers
3. Rivets
4. Mounting Bracket
5. Radar Antenna
6. Bracket Mounting Bolts

Fig. 1, Radar Antenna Mounting Assembly

5. If replacing the mounting towers, drill out the tower mounting rivets to remove the towers from the mounting bracket.

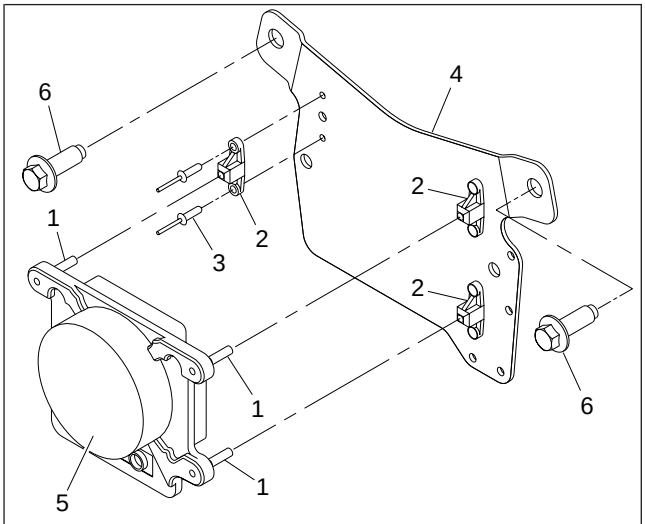
Installation

1. If replacing the mounting towers, secure new tower(s) on the mounting bracket with new rivets.
2. Position the radar antenna mounting bracket on the vehicle, and install the two mounting bolts. Torque the nuts 56 to 71 lbf·ft (77 to 97 N·m).
3. Install the front grille, if removed.
4. Install the radar antenna. Refer to **Subject 100** in this section for instructions.
5. Perform the radar antenna alignment procedure. Refer to **Subject 140** in this section for instructions.
6. Install the fascia cover.

Ball Socket Clips and Alignment Screws Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Remove the two fascia mounting bolts and remove the fascia from in front of the radar antenna. See **Fig. 1**.



1. Alignment Screw
2. Antenna Mounting Towers
3. Rivets
4. Mounting Bracket
5. Radar Antenna
6. Bracket Mounting Bolts

Fig. 1, Radar Antenna Mounting Assembly

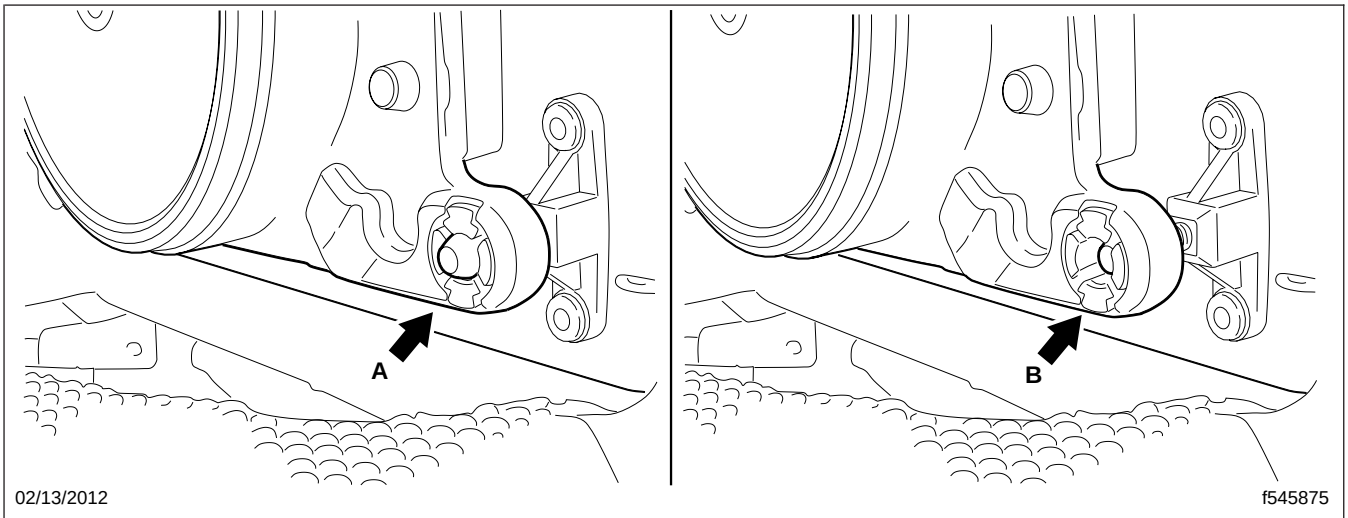
3. Disconnect the radar antenna connector by depressing the lock tabs on both sides of the radar connector.
4. With the radar antenna still mounted on its bracket, release the alignment screws from the ball socket clips by gently tapping on the radar antenna ears.
5. Remove the alignment screws from the radar antenna mounting towers.
6. Remove the radar antenna from the vehicle.
7. With pliers, pinch the tabs on the ball socket clips and push from the rear of the radar antenna ears to remove the clips.

Installation

1. Push the new ball socket clips into the front side of the radar antenna ears until they are flush with the top surface of the ears.
2. Mount the radar antenna on the bracket. Walk the antenna onto the bracket by rotating each screw about three rotations, each with multiple passes until the back of the radar antenna is about 3/4 inches (19 mm) from the radar bracket and is approximately parallel to the bracket.
3. Wedge a small wrench handle between the radar antenna and the bracket near each ball screw socket. Gently pull on the wrench until the alignment screw ball head pops into the ball socket clip. When seated properly, no motion should occur between the bracket and the radar antenna.
4. Turn the alignment screws in until the gap between the back of the radar antenna and the mounting bracket is approximately 1/4 inch (6.35 mm). This gap should be the same at each alignment screw location.
5. Connect the antenna connector by pushing on the connector until it snaps on the radar antenna. Slide the rubber boot over the connector until it is completely covered by the boot.
6. Align the radar antenna. Refer to **Subject 140** in this section for instructions.
7. Install the fascia cover.

Radar Antenna Alignment

Check the radar unit to verify that it is properly mounted. A frontal impact can dislodge the radar antenna from the mounting sockets. If there are no damaged parts, the radar antenna can be "popped" back into the mounting towers. Place a tool between the back of the radar antenna and the mounting bracket, and gently pry the radar antenna away from the mounting bracket until the ball socket engages with the adjustment screw. See **Fig. 1**.



A. Incorrect ball and socket engagement is indicated when the adjusting screw head is dislodged from the mounting socket.

B. The antenna is properly mounted when the adjusting screw is seated in the mounting socket.

Fig. 1, Correct Ball and Socket Engagement

Ensure that there is at least a 1/4-inch (6.35-mm) clearance between the radar antenna and the bracket. Attempt to wiggle the radar antenna by hand to make sure there is no movement. Adjust, repair, or replace mounting towers, adjustment screws, or the ball sockets clips as necessary. See **Fig. 2**.

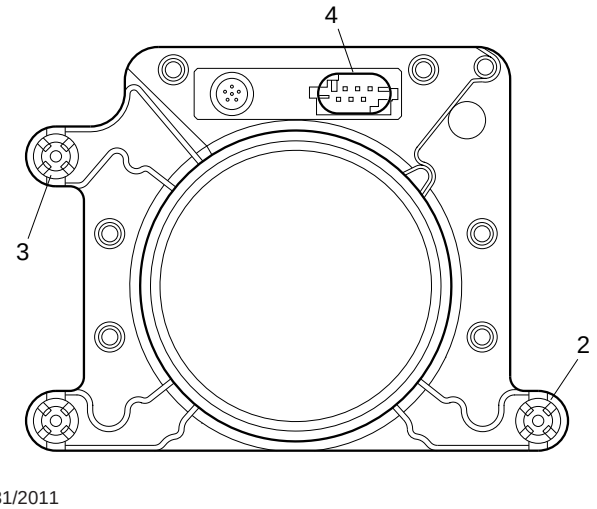
Vertical Alignment

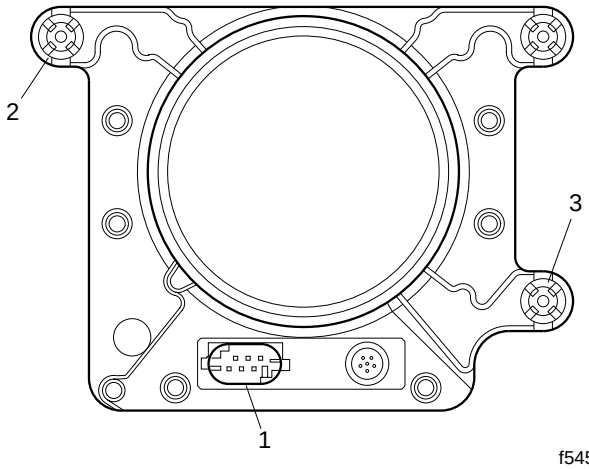
1. Park the vehicle, shut down the engine, and set the parking brake. Chock the tires.

IMPORTANT: The vehicle must be unloaded before the vertical alignment can be tested.

2. Check the springs for sagging or broken leaves. The suspension must be at a standard ride height (air system fully charged for air-suspension vehicles).
3. Check the suspension for proper functioning of the leveling mechanism. On cabs with air suspensions, make sure that the height is properly adjusted.
4. With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.
5. Remove the two fascia mounting bolts and remove the radar antenna fascia. See **Fig. 3**.
6. Set the vertical alignment using a digital level.
   - 6.1 Calibrate the digital level by placing it on the surface where the vehicle is parked. Zero the digital level.
   - 6.2 Position the digital level on the outside metal surface of the radar antenna. See **Fig. 4**.
   - 6.3 Adjust the vertical adjustment screw until the digital level indicates that the radar antenna is perpendicular with the surface that the tires are on within +/- 0.1 degrees.

Radar Antenna Alignment





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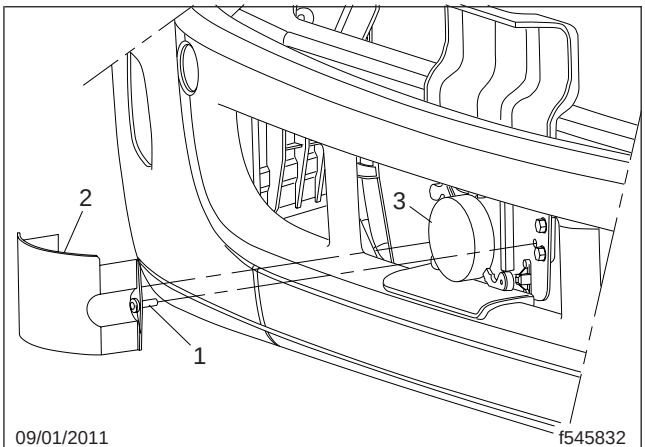
1. Radar Connector (bottom)
2. Horizontal Adjustment Screw
3. Vertical Adjustment Screw
4. Radar Connector (top)

Fig. 2, Ball Socket and the Adjustment Screw



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1. Fastener
2. Fascia Cover
3. Antenna

Fig. 3, Radar Antenna Fascia

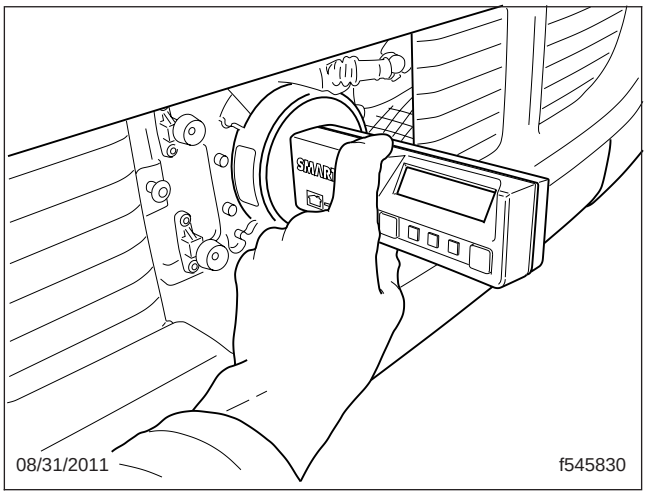

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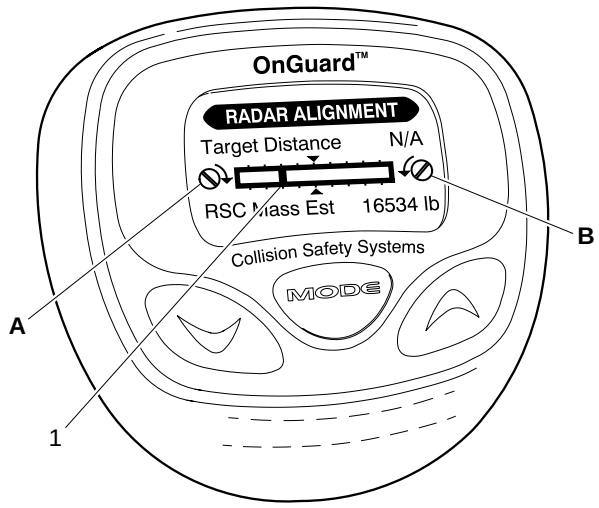
Fig. 4, Digital Level Positioned on the Radar Antenna

Horizontal Alignment

1. Start the engine and press "MODE" twice on the OnGuard driver display unit to select the radar alignment screen. See **Fig. 5**.

NOTE: The following conditions must be met before using the displayed sliding bar for adjustment:

- Drive the vehicle on a smooth, level and straight road.
- Follow another vehicle with a distance of at least 300 feet (91 meters).
- Drive a steady speed above 15 miles an hour.
- The vehicle stays centered in the lane.
- The alignment screen on the display unit stays **green**.



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A. Turn the horizontal adjustment screw clockwise when the sliding bar is to the left.
B. Turn the horizontal adjustment screw counterclockwise if the sliding bar is to the right.

1. Sliding Bar (at two tic marks from the center)

Fig. 5, OnGuard Driver Display Unit

2. Allow several seconds for the slider bar to settle into a position before noting the position for adjustment. Each tic mark represents one full turn of the adjustment screw. The horizontal adjustment screw should be turned in the direction indicated on either end of the scale, depending on which side of the center mark the sliding bar is on.
3. Park the vehicle in a safe location and turn the horizontal adjustment screw one full turn counterclockwise or clockwise for each mark counted. Repeat the procedure until the slider bar is within ± 1 mark of the center arrows on the OnGuard Radar alignment screen.

IMPORTANT: Do not make adjustments based on the sliding bar position when tracking a vehicle less than 300 feet (91 meters) away. If the radar does not track a vehicle out to at least 300 feet (91 meters), it indicates that the radar is misaligned. It may be necessary to adjust the vertical alignment.

4. Attach the fascia and verify that the radar alignment is tracking to 350 to 400 feet (106 to 121 meters) on a smooth, level, and straight road.

General Information

The Central Gateway (CGW) is located behind the doghouse cover on the passenger-side engine tunnel. See **Fig. 1**.

The CGW translates data between four vehicle data busses:

- Diagnostic CAN
- Cabin CAN
- J1939
- J1708/1587

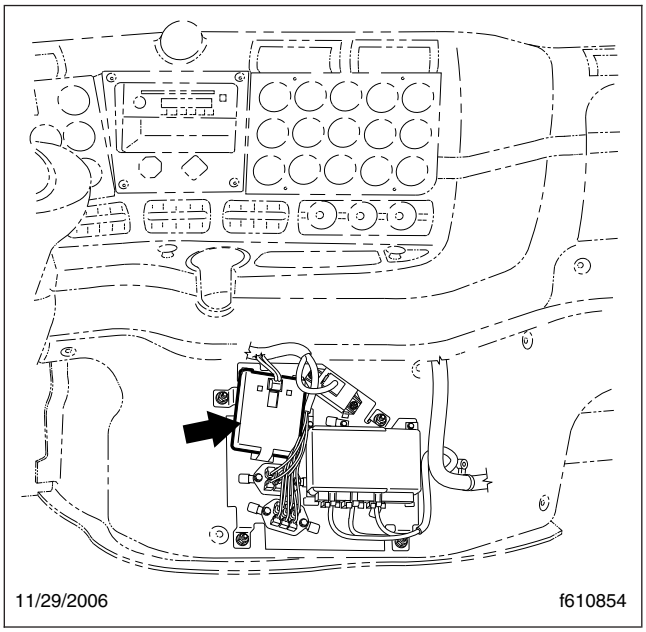


Fig. 1, Central Gateway

See **Fig. 2** for a diagram of CGW data translation.

The CGW receives battery power and ground from the SAM Cab; power comes through fuse F20 (2A) and out connector X3, pin 18 on the SAM Cab.

General Information

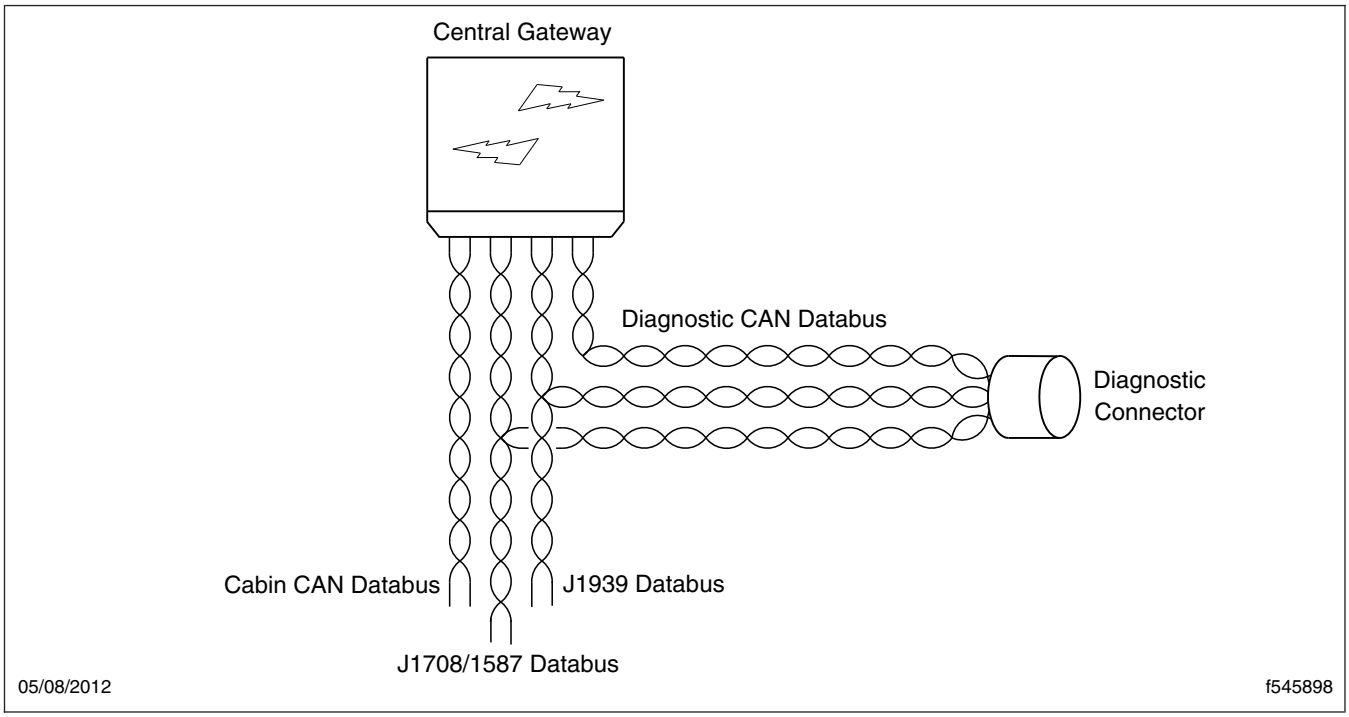


Fig. 2, Central Gateway Data Translation

Removal

The central gateway is located behind the doghouse cover, and mounted on the passenger-side engine tunnel. See **Fig. 1**.

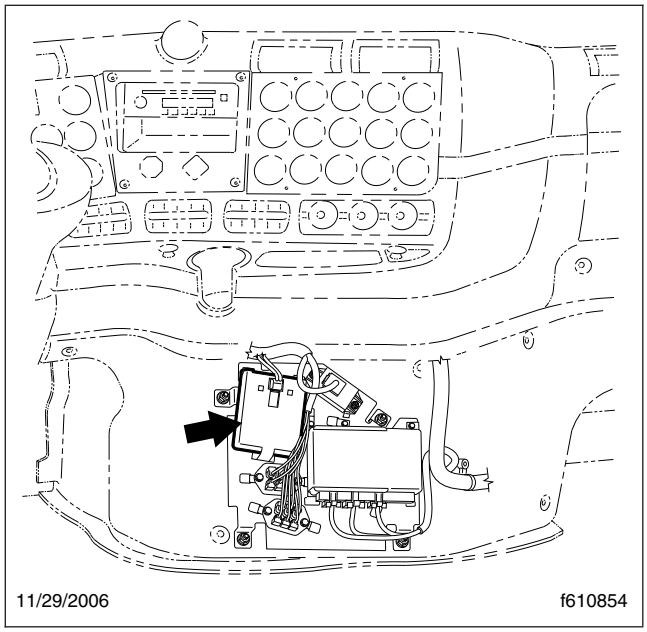


Fig. 1, Central Gateway

1. Park the vehicle, shut down the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the batteries.
3. Remove the lower center dash panel.
4. Disconnect the gateway connector by pushing in on the lock button then releasing the lever. The connector will disengage.
5. Press the tab on the lower side of the central gateway module and lift it from the bracket.

Installation

1. Place the upper end of the CGW into the bracket then gently press the lower tab into the slot.
2. Place the connector into the receptacle on the module and engage the lever until it is completely locked.
3. Connect the batteries.
4. Using ServiceLink or DiagnosticLink, program the CGW with the software and parameters appropriate for the vehicle.
5. Disconnect the diagnostic tool, then wait 10 seconds and connect again. All the CAN ECUs and communications functions will be restored.
6. Use ServiceLink or DiagnosticLink to select the faults tab and clear fault history for all communications protocols.
7. Disconnect the diagnostic tool.
8. Install the lower center dash panel.

General Information

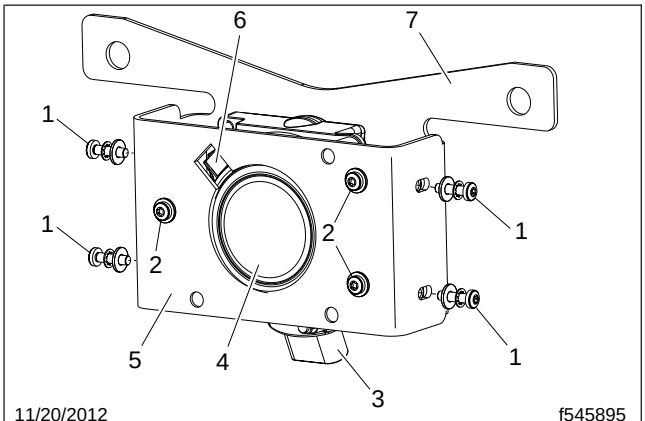
The Bendix™ VORAD® VS–400 is an adaptive cruise control and collision warning system. It consists of forward looking radar (FLR), a driver interface unit, and optional side-object detection with a side sensor display. The VS–400 provides warning information to the driver using auditory and visual alerts about objects ahead, or on the side of the vehicle that are potential collision hazards.

Refer to the *Bendix VORAD VS-400 Radar System Troubleshooting Guide* at **bendix.com** for more information.

The Bendix Help Desk can be contacted at **1-800-247-2725** for technical or troubleshooting questions.

Replacement

1. Park the vehicle on a level surface, shut down the engine (ignition switched off), and set the parking brake. Chock the tires.
2. Remove the bumper. Refer to **Section 31.02, Subject 100** in this manual for instructions.
3. Remove the four locking screws on the side of the radar housing. See **Fig. 1**, ref 1.



1. Locking Screws
2. Alignment Screws
3. Electrical Connector
4. VS-400 Forward-Looking Radar
5. Radar Housing
6. Mirror
7. Mounting Bracket

Fig. 1, VS-400 Module, Mounted on the Forward Frame Rail

4. Remove the three alignment screws on the front of the radar housing.
5. Remove the housing from the vehicle.
6. Disconnect the electrical connector from the bottom of the radar.
7. Remove the three screws on the back of the radar, then remove the radar from the radar housing.
8. Remove the protective cover from the the diamond-shaped mirror on the front of the new VS-400 radar.
9. Position the VS-400 radar in the housing, then install the three screws on the back of the module that secure it to the bracket. Torque to 4 lbf·ft (5 N·m).
10. Position the module on the forward frame rail, then install the four locking screws. Do not torque the screws until the radar is calibrated. See **Fig. 1**, ref 1.
11. Install the three alignment screws on the front of the radar housing.
12. Adjust the horizontal and vertical alignment of the radar. Refer to **Subject 110** in his section for instructions.
13. Install the bumper. Refer to **Section 31.02, Subject 100** in this manual for instructions.

Radar Antenna Alignment

Vertical Alignment

CAUTION

The alignment of the forward-looking radar is critical to the correct operation of the Bendix™ VORAD® VS-400 system. Improper alignment can cause the system to improperly detect objects in the vehicle's path. Take care to ensure that the VS-400 system alignment, both horizontal and vertical, is correct.

Alignment of the forward-looking radar (FLR) is a repetitive process of adjusting the vertical and horizontal axis using the bracket screws. The vertical alignment must be completed with a digital level. The horizontal alignment is achieved by referencing the FLR against fixed positions on the bumper, and by using a digital level. The horizontal alignment is completed by performing a calibration procedure with ACOM diagnostic software while driving the vehicle equipped with the VS-400 system.

NOTE: The vehicle must be parked on a level surface. If the vehicle is on an angled surface, then level compensation must be made to ensure proper alignment.

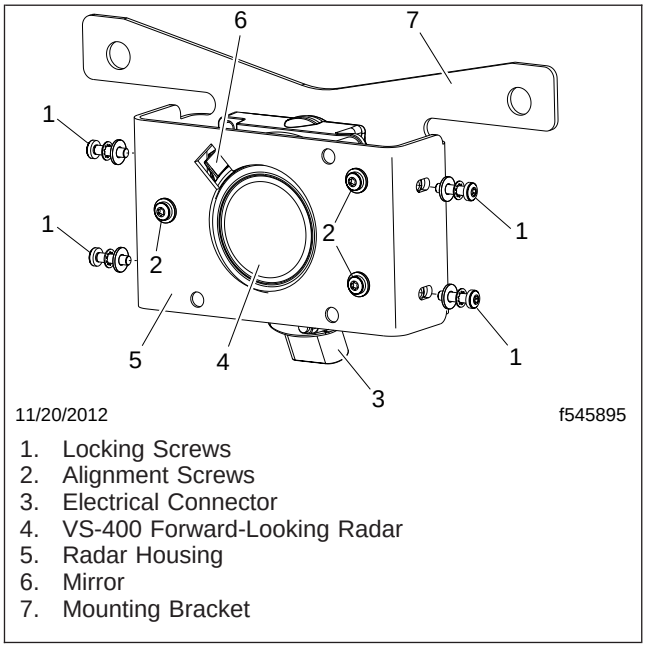
1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

IMPORTANT: The vehicle must be unloaded before the vertical alignment can be tested.

2. Check the springs for sagging or broken leaves. The suspension must be at a standard ride height (air system fully charged for air-suspension vehicles).
3. Check the suspension for proper functioning of the leveling mechanism. On cabs with air suspensions, make sure that the height is properly adjusted.
4. With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.

NOTE: Failure to loosen both locking screws **will** result in damage to the alignment bracket.

5. Loosen the four locking screws on the sides of the radar housing. See **Fig. 1**.



1. Locking Screws
2. Alignment Screws
3. Electrical Connector
4. VS-400 Forward-Looking Radar
5. Radar Housing
6. Mirror
7. Mounting Bracket

Fig. 1, VS-400 Module, Mounted on the Forward Frame Rail

6. Set the vertical alignment using a digital level. See **Fig. 2**.

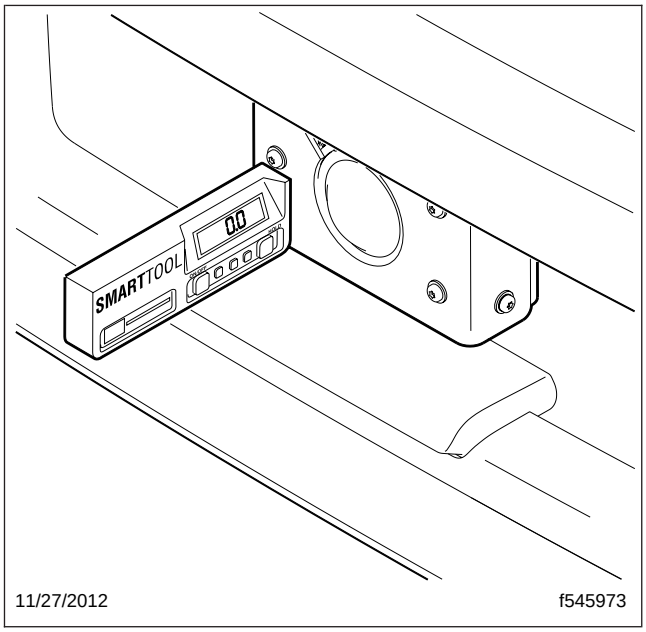


Fig. 2, Vertical Alignment Using a Digital Level

6.1 Calibrate the digital level by placing it on the surface where the vehicle is parked. Zero the digital level.

6.2 Position the digital level on the outside surface of the radar housing.

6.3 Adjust the alignment screws until the digital level reads 0°±.2°.

6.4 Tighten the locking screws.

Horizontal Radar Alignment

1. Center a 4- to 6-inch (1- to 2-meter) straight edge across a flat surface of the radar housing. See **Fig. 3**.

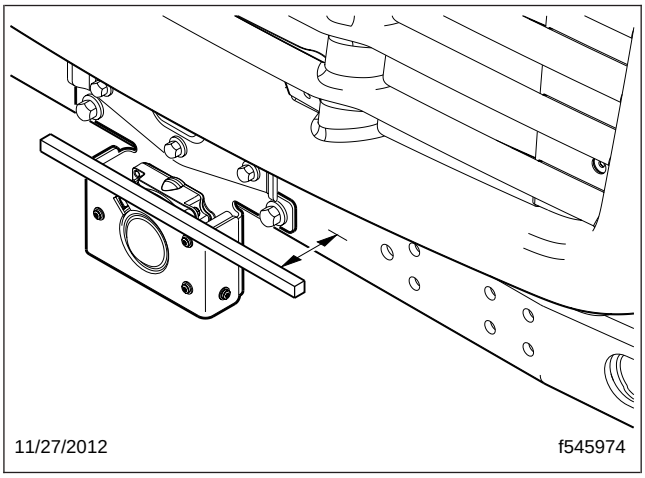


Fig. 3, Horizontal Alignment Using a Straight Edge

2. Measure the distance between the two reference points on the bumper and the face of the straight edge.
3. Use a 5/32-inch Allen wrench to loosen the locking screws.

NOTE: Failure to loosen both locking screws **will** result in damage to the alignment bracket.

4. Adjust the alignment screw until the two measurement points are equal within ± .1 inch (2.54 mm).
5. Once the measurements are equal for both of the reference points, tighten the locking screws.
6. Check both the vertical and horizontal alignment.

6.1 Measure the reference points to ensure they are equal.

6.2 Use the digital level to verify that the vertical alignment is still face down 0° from vertical ± .2°.

Calibrating the Horizontal Alignment

Calibration of the forward-looking radar is recommended once the horizontal alignment is complete. The calibration procedure requires two people.

⚠ DANGER

The person driving the vehicle must not perform the calibration procedure. Performing the calibration procedure while driving the vehicle could result in property damage, serious personal injury, and injury to others. The calibration procedure must only be performed by a passenger in the radar-equipped vehicle.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Connect the Nexiq adapter to the diagnostic connector, and start the engine.
3. Open Bendix ACOM Diagnostics 6.4, or newer.
4. Select the Vorad VS400 ECU and click "Start with ECU". See **Fig. 4**.

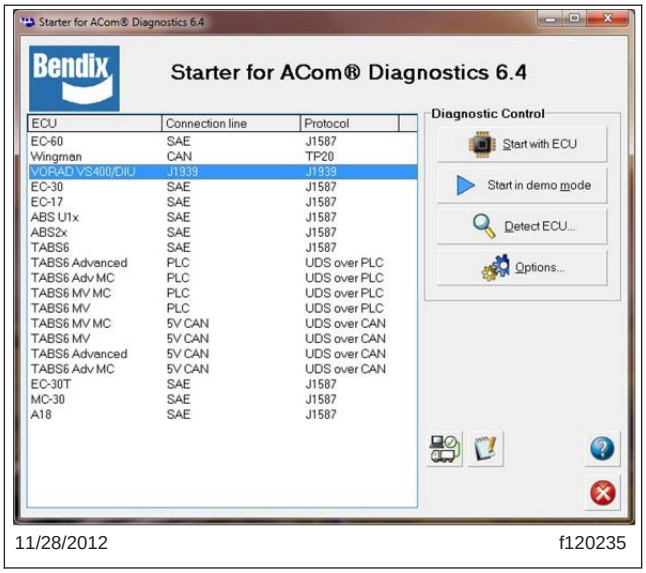


Fig. 4, Starter for ACOM Diagnostics 6.4

5. Click "Config". See **Fig. 5**.

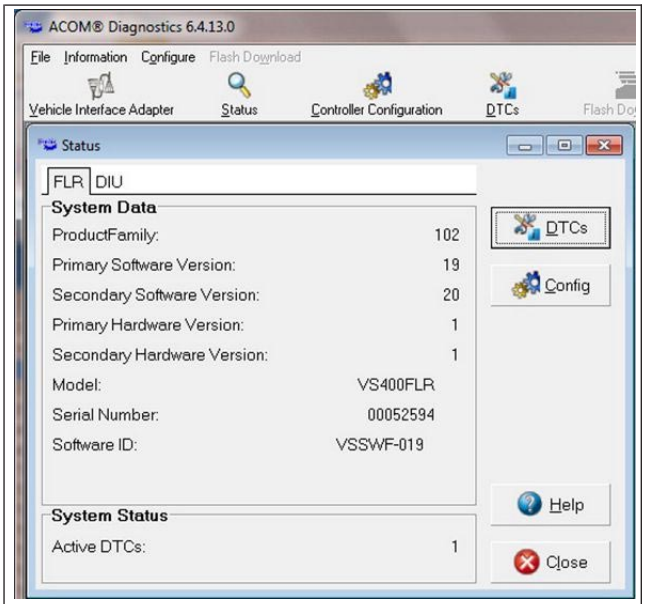


Fig. 5, Status Screen

6. Click "Alignment Test". See **Fig. 6**.
7. Click "Reset". See **Fig. 7**.
8. Click "Yes" when asked to reset to an uncorrected value. See **Fig. 8**.
9. Click "Start" to begin the horizontal alignment calibration. See **Fig. 9**.

Performing the Calibration Procedure

In order to perform the procedure, the vehicle must be traveling on a straight road at a speed above 30 mph (48 km) behind a target vehicle traveling in the same lane. The trailing vehicle should be in Smart-Cruise® mode. If the vehicle is not equipped with SmartCruise, position the vehicle 200 to 300 feet (60 to 90 meters) behind the target vehicle. At highway speeds, the distance can be approximated by the VORAD system displaying a following distance of 2 to 3 seconds.

NOTE: The azimuth reading may fluctuate 2-3 degrees when shifting or when the road surface causes the vehicle to pitch up and down.

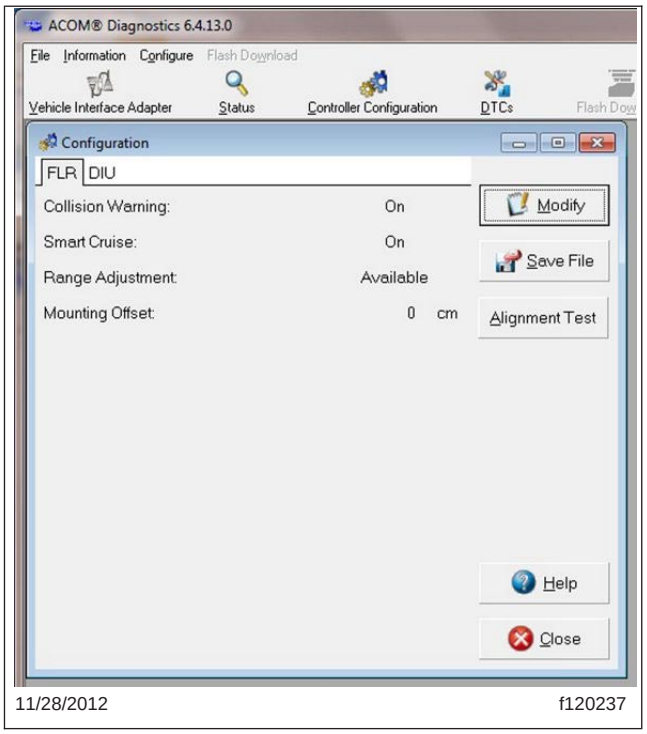


Fig. 6, Configuration Screen

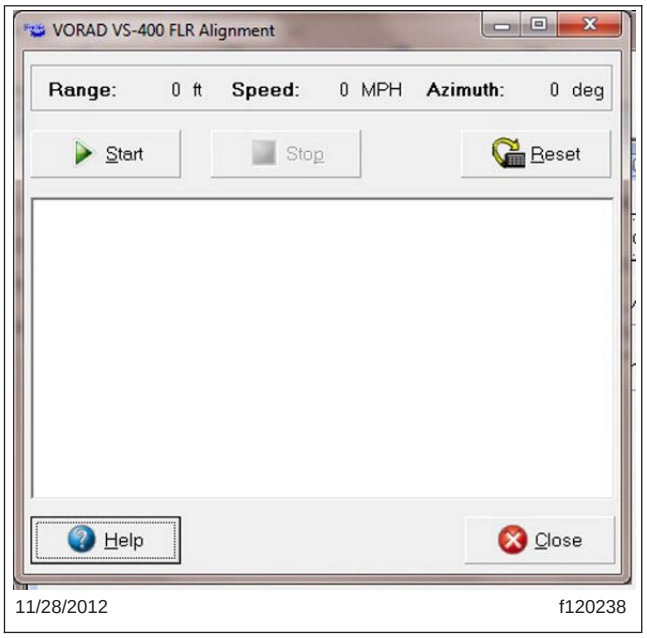


Fig. 7, Resetting the Alignment Process

Continue to run the vehicle for a period of 2 to 5 minutes, monitoring the azimuth value. As long as the

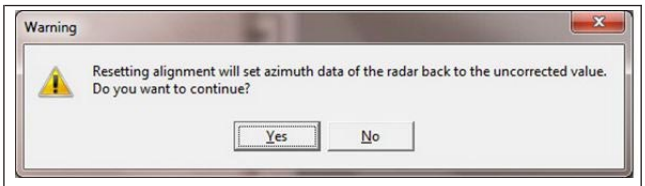


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Fig. 8, Reset Warning Dialogue Box

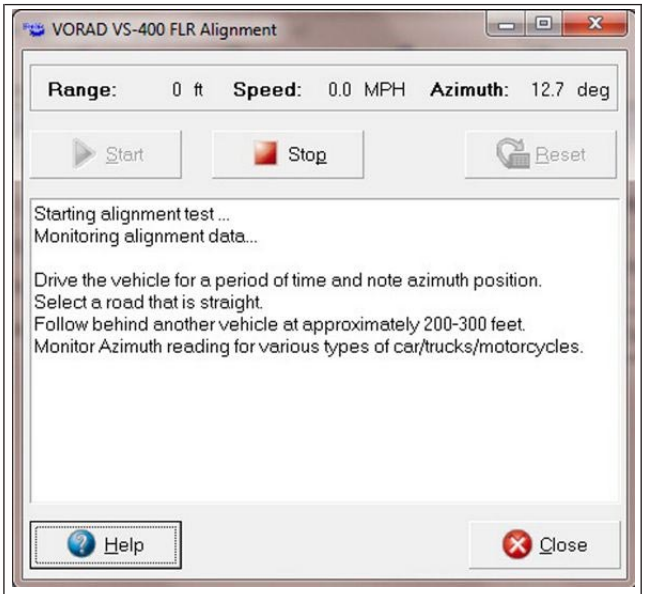

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Fig. 9, Starting Screen for the Alignment Test

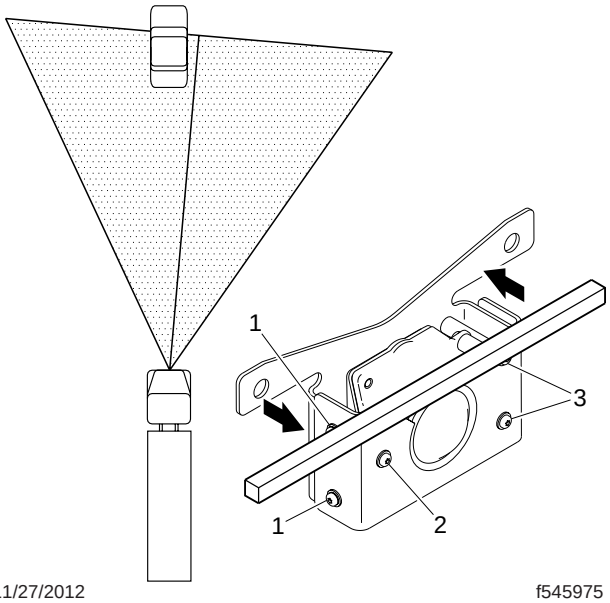
tracking vehicle is in the same lane, the azimuth position should be 0°; fluctuations in driving techniques may cause the vehicle to drift ± 0.3°. If this value cannot be consistently maintained, click the "Reset" button and monitor the azimuth position. If the position is consistently more than 0.5° or less than -0.5°, the radar horizontal alignment must be adjusted based on the azimuth position.

Azimuth Adjustment

NOTE: The azimuth is adjusted with the vehicle parked on a level surface, following the horizontal and vertical adjustment procedures.

Positive Azimuth Adjustment (radar too far to the right)

If the alignment function shows a negative value, then the radar is adjusted too far to the right when looked at from the driver's seat. The radar needs to be adjusted to the driver's left. To change the positive azimuth, adjust the horizontal alignment screw by turning it in a counter-clockwise direction. See **Fig. 10**. Each full rotation of the adjustment screw adjusts for approximately 0.2° of azimuth position from the alignment function. For example, if the azimuth position is -0.5°, the alignment screw should be adjusted 2 1/2 turns counter-clockwise.



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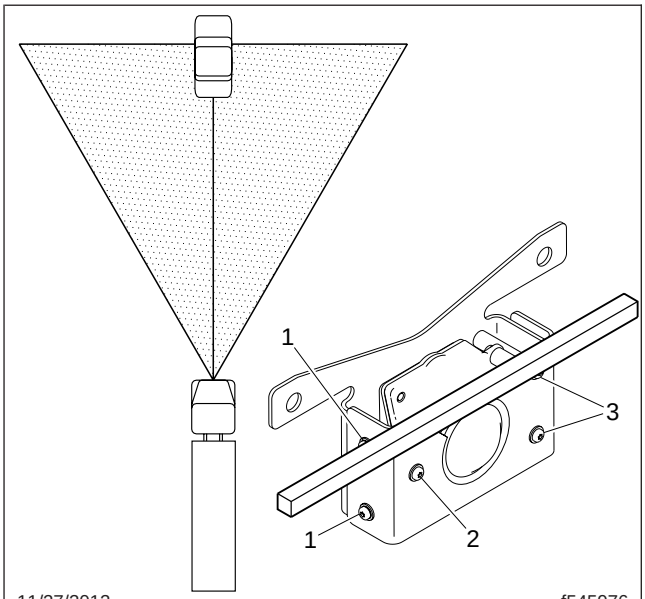
1. Locking Screws
2. Horizontal Alignment Screw
3. Vertical Alignment Screws

Fig. 10, Positive Azimuth Adjustment

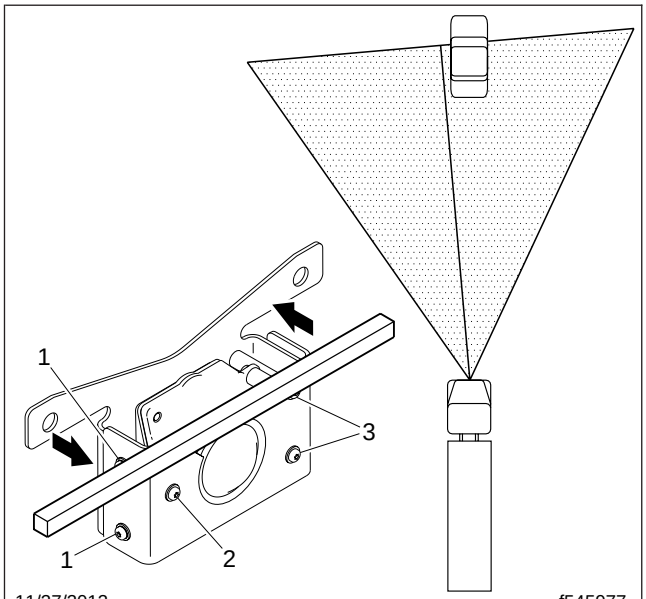
Center Radar Azimuth Position (radar aligned correctly)

If the alignment function consistently shows an azimuth value of 0° ± 0.5° when tracking a vehicle in the same lane, the radar is properly centered. See **Fig. 11** . If this is the case, the radar does not need any further adjustment.



1. Locking Screws
2. Horizontal Alignment Screw
3. Vertical Alignment Screws

Fig. 11, Positive Azimuth Adjustment



1. Locking Screws
2. Horizontal Alignment Screw
3. Vertical Alignment Screws

Fig. 12, Positive Azimuth Adjustment

Negative Azimuth Adjustment (radar too far to the left)

If the alignment shows a positive value, the radar is adjusted too far to the left when looked at from the driver's seat. The radar needs to be adjusted to the driver's right. To change the negative azimuth, adjust the horizontal alignment screw by turning it in a clockwise direction. See **Fig. 12**. Each full rotation of the adjustment screw adjusts for approximately 0.2° of azimuth position from the alignment function. For example, if the azimuth position is 0.5°, the alignment screw should be adjusted 2 1/2 turns counterclockwise.

General Information

The lane guidance lane departure warning system monitors the vehicle's position inside the roadway lane markings, and sounds a warning when the vehicle is about to stray outside its lane. The system includes a windshield-mounted camera, a central processing unit in the overhead console, and a stereo speaker above and behind each door that emits a sound similar to a rumble strip. The sound is made in the direction that the vehicle is straying, prompting the driver to respond and steer back into the correct lane.

On startup, the system performs a self-test, then sounds two chirps through the speakers to indicate that the system is ready. The rocker switch on the instrument panel turns the system on and off. Once the vehicle is started and the system is ready, the ON light at the bottom of the switch illuminates. Pushing the top of the rocker switch turns the system off, and pushing the switch again turns the system on. The top portion of the switch reads "LANE ALERT" and is backlit when the dash lights are on.

The "LANE SRCHNG" amber warning light illuminates when the system is not fully functional. When the warning light is on, the system audible alert may not indicate a lane departure. The warning light can come on if:

- the system is unable to detect lane markings;
- vehicle speed is less than 40 mph (64 km/h);
- lane width is greater than 13 feet (4 m);
- a dirty windshield or a similar problem is obscuring the camera, or;
- a system problem is detected.

While the system is capable of detecting a number of different types of lane markers, its performance may be compromised or degraded by:

- weather conditions such as snow, heavy rain, ice, or standing water;
- damaged, worn, or faded lane markings;
- broken pavement, dirt, sand, salt, gravel, or skid marks;
- poor lighting, such as heavy glare or an inoperable headlight, or;
- a cracked, dirty, or streaked windshield.

The lane guidance system is not meant for use in city traffic or in heavy highway traffic. System alerts are automatically disabled when vehicle speed drops below 40 mph (64 km/h), and when the turn signal is on. The system may be manually turned off with the instrument panel rocker switch if an unacceptable level of false alerts is reached.

Camera Mounting Bracket Installation

Installation

1. Park the vehicle on a level surface. Set the parking brake, and chalk the tires.
2. Using a digital level, take a level reading of the surface where the vehicle is parked. See **Fig. 1**.

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Fig. 1, Measuring the Level on the Surface where the Vehicle is Parked

3. Clean the windshield, and verify that the windshield temperature is above freezing.

NOTE: Do not remove the clear plastic liner that protects the lane guidance camera mounting bracket adhesive.

4. Warm the digital camera mounting bracket 100 to 150°F (38 to 65°C). See **Fig. 2**.
5. Install the camera mounting bracket. From the center of the mounting bracket, measure 7 inches (18 cm) from the windshield centerline, and 2 inches (5 cm) from the notch in the rim of the camera bracket and the top of the windshield. See **Fig. 3**.
6. Peel the clear protective liner down to the perforation line, exposing two tabs of adhesive at the top of the bracket. See **Fig. 4**.
7. Crease the liner along the perforation. Avoid contact with the exposed adhesive tabs.
8. Affix the digital level to the sensor-side of the bracket using two small rubber bands hooked to the fingers of each of the alignment tabs. See **Fig. 5**.

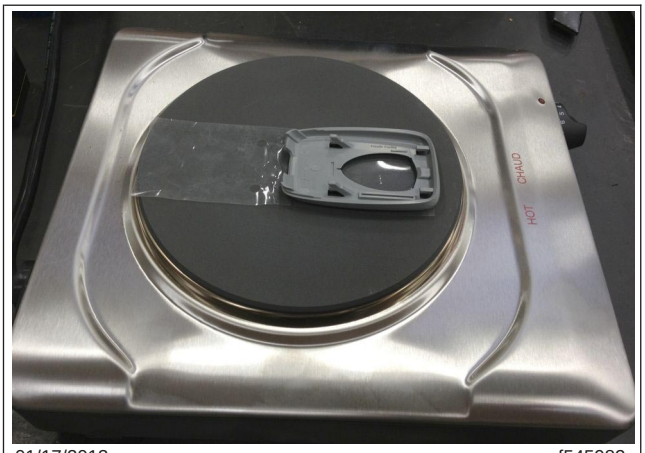

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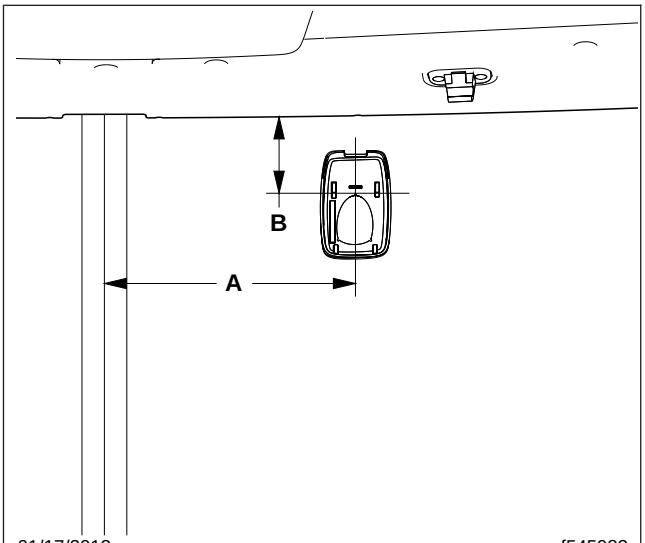
Fig. 2, Heating the Lane Guidance Camera Bracket



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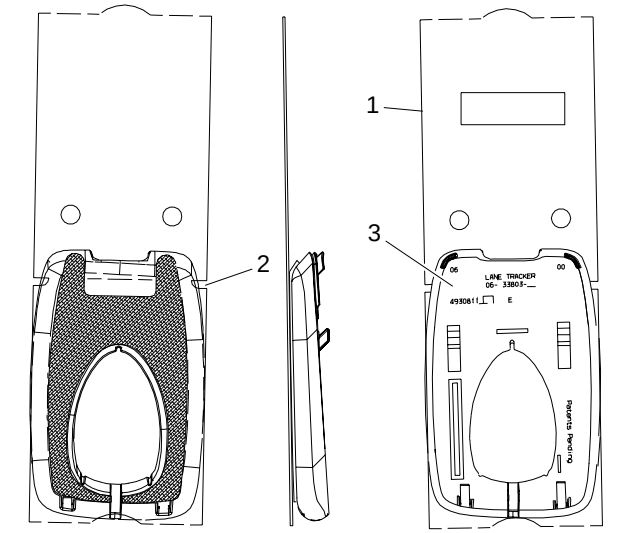
A. Horizontal orientation is 7 inches (18 cm) from the windshield centerline to the center of the bracket.
B. Vertical orientation is 2 inches (5 cm) from notch in the bracket to the top of the windshield.

Fig. 3, Mounting the Camera Mounting Bracket

9. Apply the bracket and level to the predetermined area of the windshield, keeping the protective liner in place. See **Fig. 6**.
10. Adjust the bracket until the level reading is identical to the reading for the parking surface.

IMPORTANT: Make sure that the level is held into the notches on the alignment tabs of the

Camera Mounting Bracket Installation



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1. Liner Perforation
2. Protective Liner
3. Bracket

Fig. 4, Clear Protective Liner

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Fig. 5, Digital Level Affixed to the Bracket

bracket. The bracket can be repositioned on the windshield until the level reflects the recorded value.

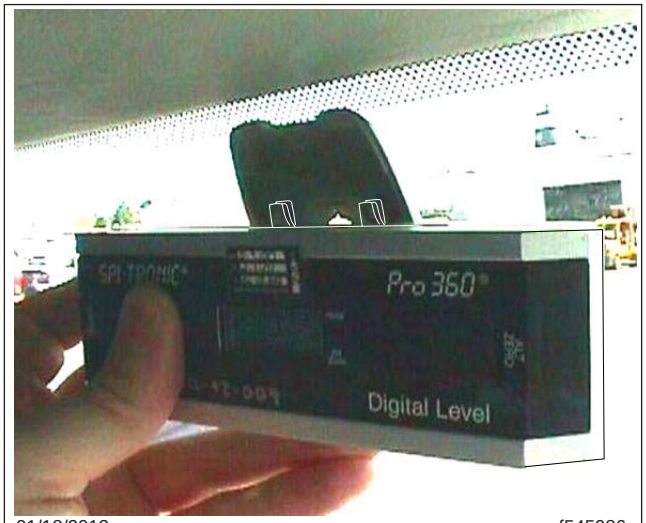

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Fig. 6, Checking the Position of the Bracket on the Windshield

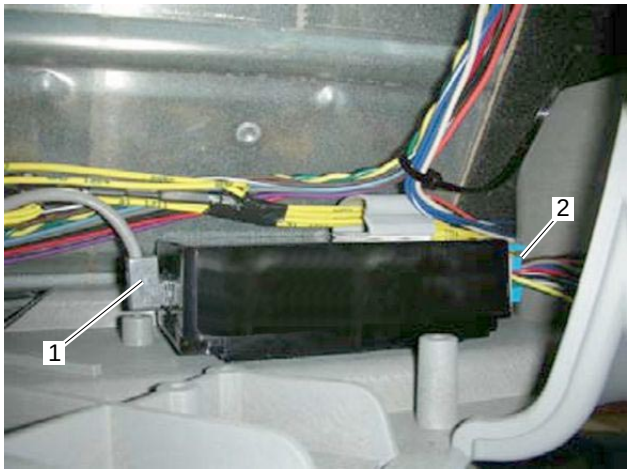
11. When the bracket has been positioned correctly (with the tabs sticking to the windshield), lift the bottom of the bracket slightly away from the windshield 1/2 to 1 inch (1.5 to 2.5 cm). Pull the lower liner tab, which should be hanging below the bracket. Pull it to remove the protective liner entirely, then gently press the bracket against the windshield. Take care to not damage any of the four camera holding hooks molded in the plastic. Hold the bracket in place for several seconds.
12. Verify the alignment of the bracket using the digital level.

Lane Guidance ECU and Digital Camera Replacement

Replacement

NOTE: The lane guidance ECU and the camera must be replaced together.

1. Remove the right-hand sunglass holder from the overhead console by removing the two mounting screws.
2. Remove the hook-and-loop tape that secures the lane guidance ECU.
3. Disconnect the harness and digital camera connectors from the ECU. See **Fig. 1**.



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1. Digital Camera Connector
2. Harness Connector

Fig. 1, Lane Guidance ECU

4. Remove the ECU from the overhead console.
5. Remove the digital camera from the windshield mounting bracket by pressing upward with both thumbs on the sensor body above the seam to the bracket. See **Fig. 2**.
6. Lower the overhead console enough to remove the camera cable and connector. Refer to **Section 60.07** in the *Cascadia Workshop Manual* for instructions.
7. Mount the new camera on the windshield mounting bracket.
8. Route the camera cable into the overhead console.

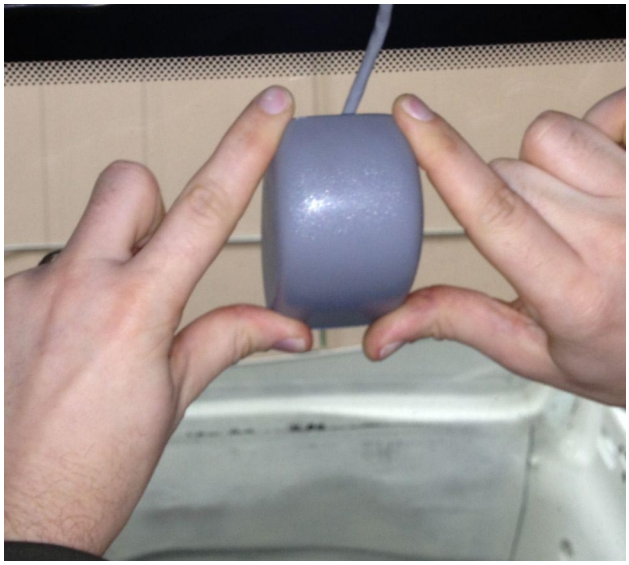

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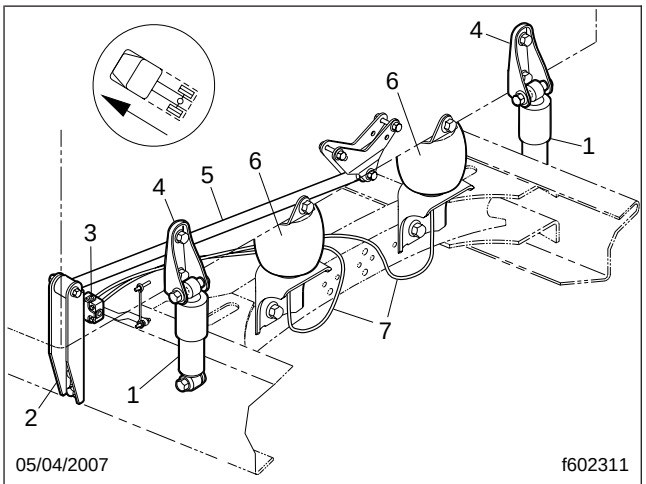
Fig. 2, Removing the Digital Camera

9. Secure the overhead console in place taking care not to pinch the camera cable.
10. Mount the lane guidance ECU in the overhead console with hook and loop tape behind the right hand sunglass holder, then connect the ECU and digital camera connectors.
11. Connect the harness and digital camera connectors to the lane guidance ECU.
12. Install the sunglass holder.

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**.

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.



1. Shock Absorber
2. Control Rod Mounting Bracket
3. Cab Height-Control Valve
4. Upper Shock Absorber Bracket
5. Lateral Control Rod
6. Air Spring
7. Air Lines

Fig. 1, Cab Air Suspension Installation

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 the 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 valve. It mounts on the control rod bracket, which is attached to the frame rail. Attached to the height-control valve is a horizontal control lever. The outboard end of the control lever is connected to a vertical linkage, which 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 which 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. One end of the control rod is attached to a bracket on the frame rail, the other to a bracket on the cab underbody.

General Information

Shock Absorbers

The shock absorbers control the air spring and cab suspension movement, and reduce the amount of oscillation in the cab suspension system. They are attached to the rear of the cab and to the outboard edge of each frame rail. In addition to absorbing road shock, the shock absorbers limit upward motion of the rear of the cab, and help support the cab.

Fitting Leakage Repair

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. Place blocks between the frame and the bottom of the cab to keep the cab in position when the air spring is deflated.
3. Drain all air from the air tanks.

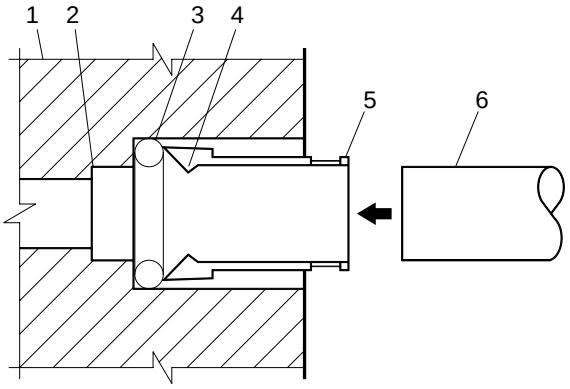
⚠ WARNING

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.
5. Rotate and hold the control lever up until all air is exhausted from the air spring.
6. Push the collar of the quick-connect fitting into the fitting body with a 1/4-inch (7-mm) open-end wrench; see **Fig. 1**. With the collar pushed into the fitting, pull the tubing from the fitting. The fitting should easily release the tubing.

NOTE: Find the mark on the tubing, about 1/4 inch (7 mm) from the end, where the collar clamped the tubing; see **Fig. 2**. If this mark is less than 1/4 inch (7 mm) from the end of the tubing, the fitting was not assembled correctly and could have caused an air leak.

7. Inspect the end of the tubing for paint or debris that could prevent full insertion of the tubing into the fitting. Remove any dirt from the tubing and fitting.
8. Check that the end of the tubing is cut square. If the tubing is cut at an angle, the fitting will not seal correctly; cut the end of the tubing at an angle of 90 degrees.
9. Insert the squared end of the tubing into the fitting. An initial resistance is felt when the tubing touches the clamping ring section of the collar. Push the tubing past this resistance another 1/4 inch (7 mm) or so until the tubing is fully seated against the shoulder.



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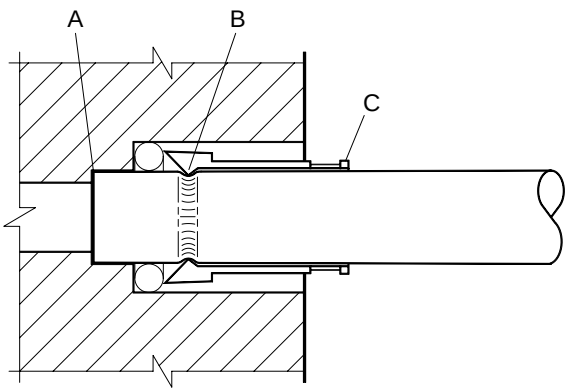
1. Fitting Body
2. Shoulder
3. Release Ring
4. Clamping Ring
5. Collar
6. Nylon Tube

Fig. 1, Parts of the Quick-Connect Fitting



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A. Square end of the tube against the shoulder.
B. The collar clamps the tube here.
C. Push the collar to release the tube.

Fig. 2, Correctly Installed Quick-Connect Fitting

Quick-Connect Fittings

10. Tug on the air tubing to ensure the tubing is clamped in the collar.
11. Align the vertical linkage with the control lever, and install the washer and nut.
12. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Check for air leaks.
13. Remove the blocks that were installed to support the cab.
14. Remove the chocks.

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 Cascadia 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.

NOTICE

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 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

⚠ 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 this Barksdale height-control valve test kit.

1. If not already done, park the vehicle on a level surface and chock the tires.

NOTE: Do not set the parking brake for this procedure. If the parking brake is set, release it. Having the parking brake set may put a strain on parts of the suspension system, and affect the test results.

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 vs. inlet pressure.

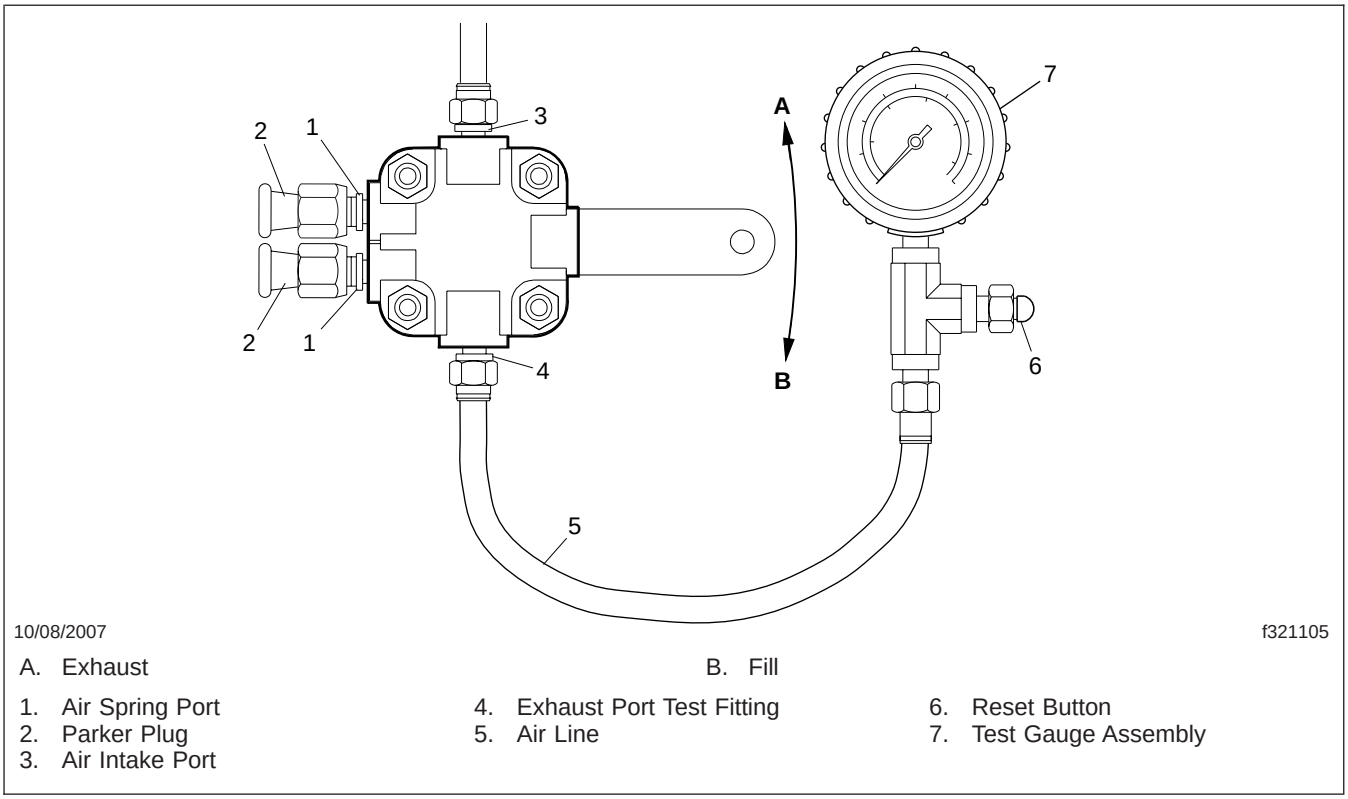
    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    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.

Height-Control Valve Checking



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

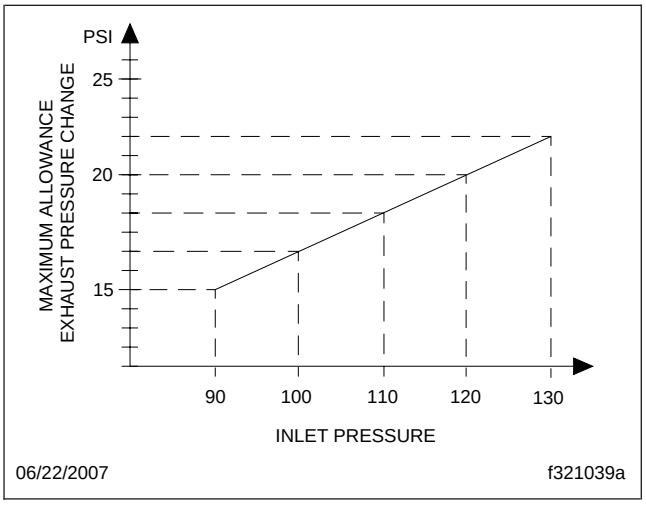


Fig. 2, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

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 vs. 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.

Height-Control Valve Replacement

IMPORTANT: Before replacing the height-control valve, perform the steps in **Subject 110** to see if the height-control 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. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the air springs are deflated.
3. Drain all air from the air tanks.

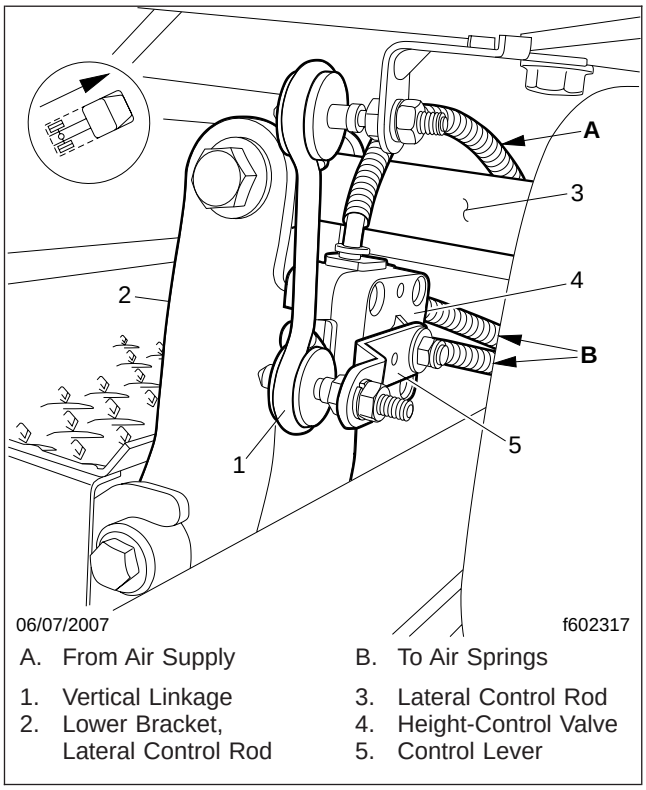
⚠ WARNING

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 attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. Mark the air tubing to the height-control valve for later reference, then disconnect the tubing.

NOTICE

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.



A. From Air Supply
B. To Air Springs
1. Vertical Linkage
2. Lower Bracket, Lateral Control Rod
3. Lateral Control Rod
4. Height-Control Valve
5. Control Lever

Fig. 1, Cab Height-Control Valve

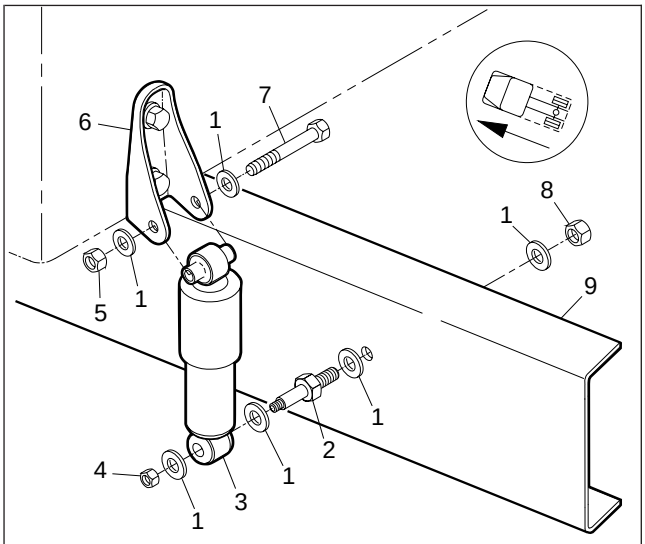
7. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
8. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and torque to 95 lbf·in (1100 N·cm). Do not overtighten.
9. Connect the air tubing to the height-control valve.
10. Align the vertical linkage with the horizontal control lever and install the washer and nut.
11. Start the engine and run it until air pressure builds to at least 100 psi (690 kPa).
12. Check all air tubing and fittings for leaks.

Height-Control Valve Replacement

13. Remove the cab supports.

Shock Absorber 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 hexnut, washers, and bolt that attach the shock absorber to the upper bracket; see **Fig. 1**.



1. Washer
2. Shock Absorber Mounting Stud
3. Shock Absorber
4. Hexnut, 7/16–20
5. Hexnut, 1/2–13
6. Shock Absorber Upper Bracket
7. Bolt, 1/2–13 x 4
8. Hexnut, 5/8–11
9. Frame Rail

Fig. 1, Cab Suspension Shock Absorber

4. Remove the nut and washers that attach the shock absorber to the mounting stud on the frame rail. 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.
6. Position the upper end of the shock absorber in the upper bracket and install the bolt, washers, and hexnut.
7. Tighten the upper shock absorber hexnut 35 to 45 lbf·ft (47 to 61 N·m). Tighten the lower hexnut 22 to 32 lbf·ft (30 to 44 N·m).
8. Remove the cab supports.
9. Remove the chocks.

Air Spring Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

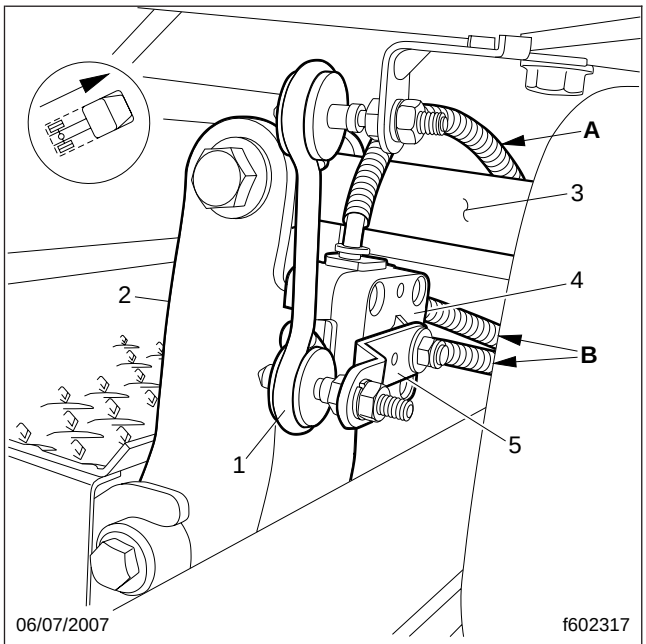
Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the air spring is deflated.
3. Drain all air from the air tanks.

⚠ WARNING

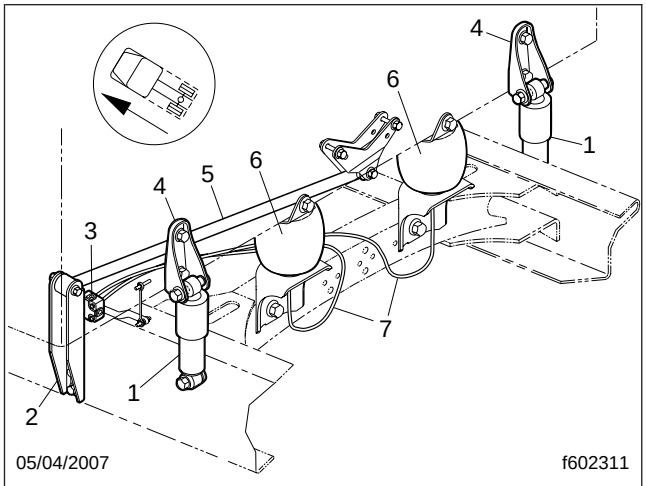
Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

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. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. Disconnect the supply air tubing from the bottom of the air spring; see **Fig. 2**. If the new air spring will not be installed immediately, cover the open end of the air tubing to prevent dirt or other foreign material from entering.
7. Using a screwdriver inserted between the top of the air spring and the upper mounting bracket, pry the air spring away from the bracket, and pop the air spring tangs loose. Repeat for the bottom of the air spring.
8. Install the new air spring by snapping the bottom of the air spring into the lower air spring bracket, then snapping the top of the air spring into the top bracket.
9. Remove the cover from the air tubing, then connect it to the bottom of the new air spring.



A. From Air Supply
B. To Air Springs
1. Vertical Linkage
2. Lower Bracket, Lateral Control Rod
3. Lateral Control Rod
4. Height-Control Valve
5. Control Lever

Fig. 1, Cab Height-Control Valve



1. Shock Absorber
2. Control Rod Mounting Bracket
3. Cab Height-Control Valve
4. Upper Shock Absorber Bracket
5. Lateral Control Rod
6. Air Spring
7. Supply Air Tubing

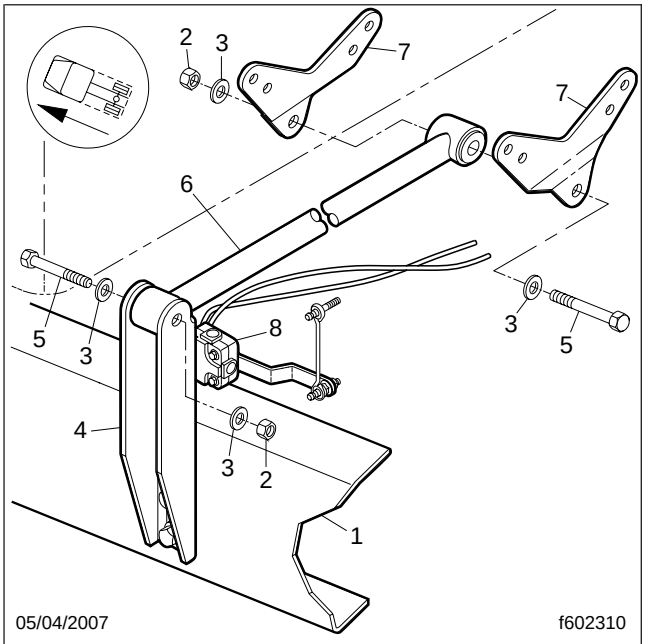
Fig. 2, Cab Air Suspension

Air Spring Replacement

10. Align the vertical linkage with the control lever and install the washer and nut.
11. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air spring.
12. Remove the cab supports.
13. Remove the chocks.

Lateral Control Rod 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 lateral control rod is removed.
3. Remove the nut, washers, and bolt that attach the lateral control rod to the cab-mounted brackets. See **Fig. 1**.
4. Remove the nut, washers, and bolt that attach the lateral control rod to the frame-mounted lower bracket. Remove the lateral control rod.



1. Frame Rail
2. Hexnut, 5/8–11
3. Washer
4. Lateral Rod Lower Bracket
5. Bolt, 5/8–11 x 3.75
6. Lateral Control Rod
7. Cab-Mounted Bracket

Fig. 1, Lateral Control Rod Installation

5. Install the new lateral control rod in the frame-mounted lower bracket. Install the bolt, washers, and nut.
6. Position the upper end of the lateral control rod between the cab-mounted brackets. Install the bolt, washers, and nut.
7. Remove the cab supports.
8. Remove the chocks.

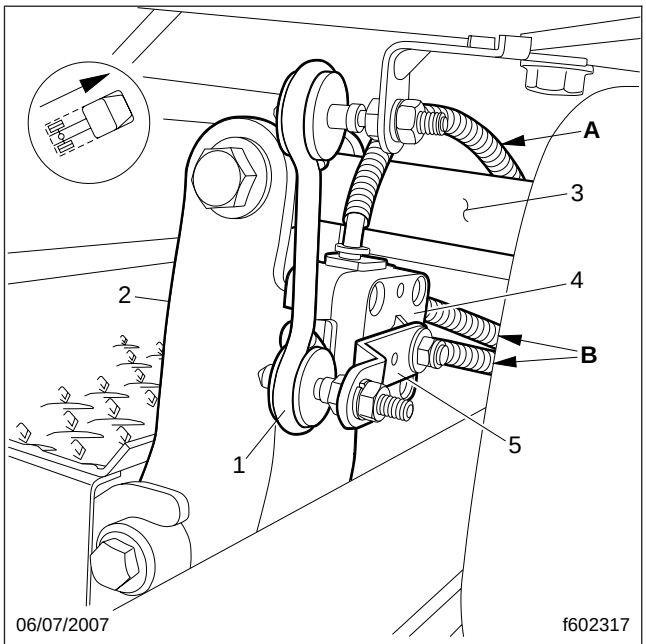
Vertical Linkage Replacement

1. With the vehicle parked 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), then shut off the engine.

⚠ WARNING

Do not disconnect the vertical linkage in the cab suspension system without first blocking the cab securely and inserting a pin in the neutral-position hole of the height-control valve and the horizontal control lever. If the cab is not securely blocked, dislodging the pin and moving the control lever could cause the cab to fall or rise abruptly, possibly resulting in serious injury.

3. Place blocks between the frame and the bottom of the cab or use jack stands to keep the cab in position.
4. Insert a 5/32-inch (4-mm) pin or drill bit into the neutral-position hole of the height-control valve and horizontal control lever.
5. Remove the nut and washer that attaches the vertical linkage to the cab-mounted air spring bracket. See **Fig. 1**.
6. Remove the nut and washer that attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever.
7. Align the new vertical linkage between the upper shock-mount bracket and the control lever. Attach the lower end of the vertical linkage to the control lever with the washer and nut.
8. Attach the upper end of the vertical linkage to the cab-mounted air spring bracket with the washer and nut.
9. Remove the drill bit or pin from the height-control valve.
10. Remove the cab supports.
11. Remove the chocks.



A. From Air Supply
B. To Air Springs
1. Vertical Linkage
2. Lower Bracket, Lateral Control Rod
3. Lateral Control Rod
4. Height-Control Valve
5. Control Lever

Fig. 1, Cab Height-Control Valve

Torque Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.01**.

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.

NOTICE

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.

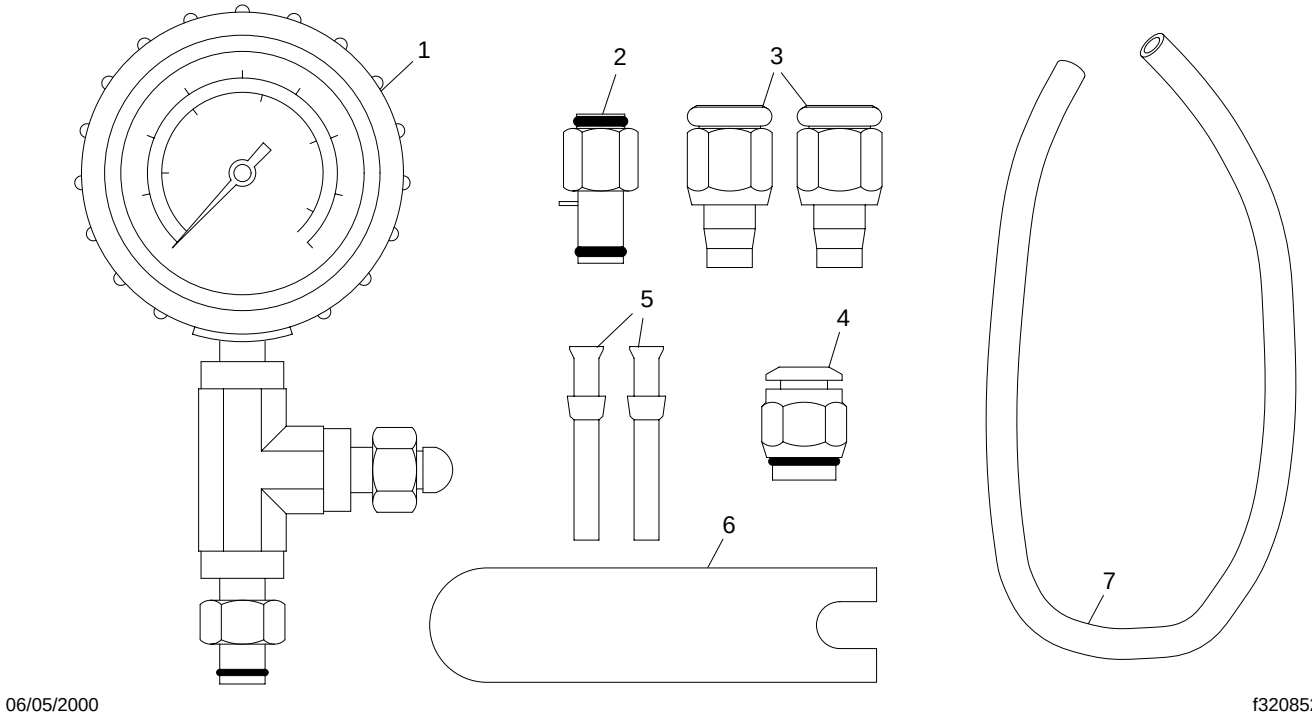
Torque Specifications				
Fastener Description	**lbf·ft**	**N·m**	**lbf·in**	**N·cm**
Shock Absorber Upper Nut, 1/2–13	35–45	47–61	—	—
Shock Absorber Lower Nut, 7/16–20	22–32	30–44	—	—
Shock Absorber Stud Nut, 5/8–11	54–92	73–125	—	—
Height-Control Valve Housing Bolts, 1/4–20*†	—	—	45	500
Height-Control Valve Mounting Locknuts, 1/4–20*†	—	—	95	1100
Control Lever Screw	—	—	45–50	500–560

* Grade 8 bolts with phosphate- and oil-coated threads, and cadmium-plated, wax-coated grade C locknuts; both used with hardened washers.

† See the cautionary statements below.

Table 1, Torque Specifications

Specifications

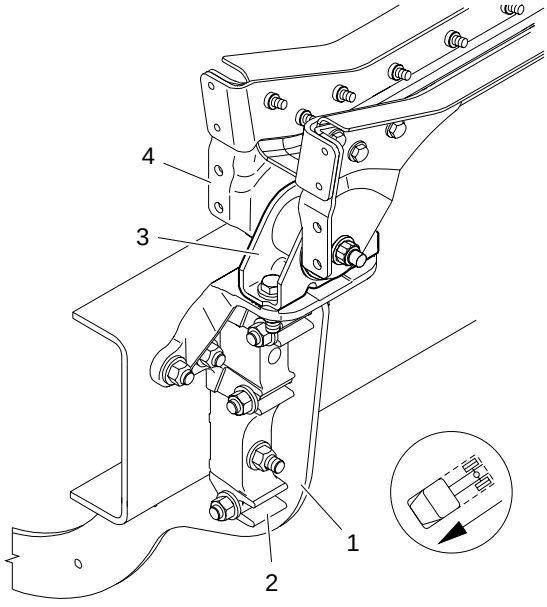


1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 1, Barksdale Height-Control Valve Test Kit BKS KD2264

General Information

The forward part of the cab is attached to the frame rails with two cab mount isolators; see **Fig. 1**. Each forward cab mount isolator is made of hard rubber, surrounded by a steel bracket. The isolator is attached to a frame rail bracket and the cab underbody.



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1. Underslung Crossmember
2. Frame-Mounted Bracket
3. Cab Mount Isolator
4. Cab-Mounted Bracket

Fig. 1, Left Forward Cab Mount Installation

Forward Cab Mount Replacement

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Remove the front wheel splash shield, as follows.
   2.1 Remove the Torx® screw and washer that attach the cowl side panel to the splash shield; see **Fig. 1**.

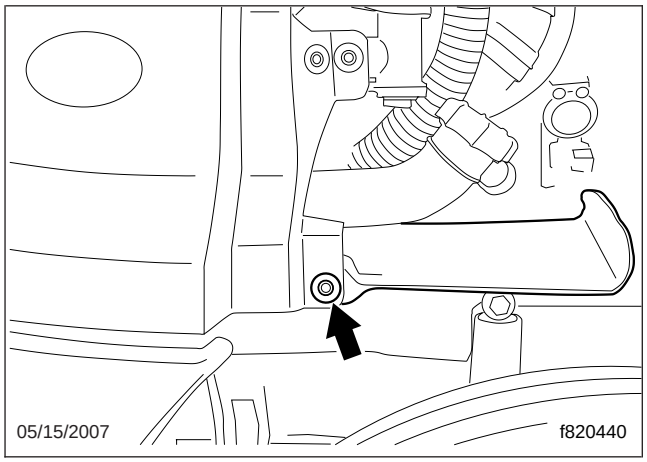


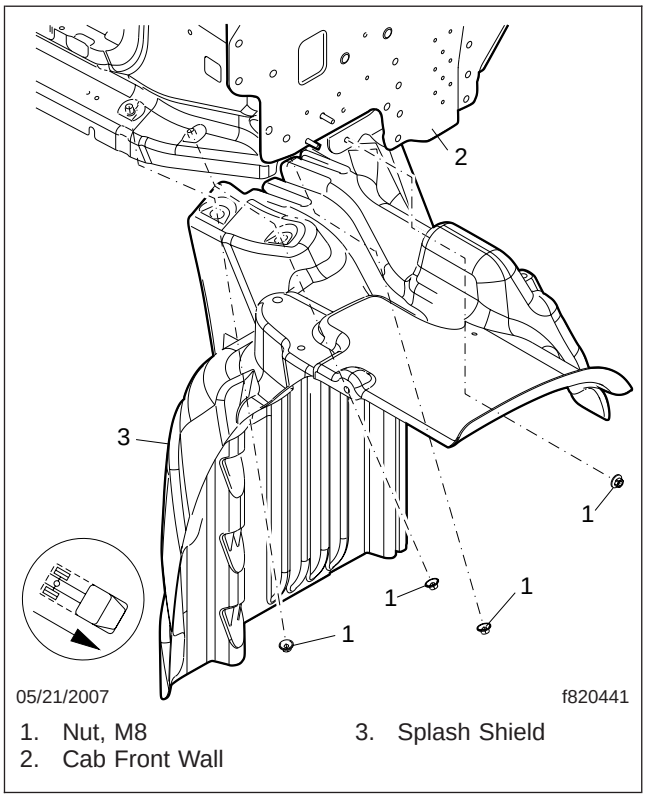
Fig. 1, Cowl Side Panel Torx Screw and Washer

   2.2 From underneath the splash shield, remove the four M8 nuts that attach it to studs on the cab; see **Fig. 2**.
   2.3 Pull the splash shield off the studs.
3. Using a jack, lift up the front of the cab just enough to loosen the isolator bolt. Support the cab with jack stands.

⚠ WARNING

Do not work under the cab when it is supported only by a jack. Use safety stands or other suitable means to firmly support the cab. Jacks can slip, causing the cab to fall, which could result in serious injury or death.

4. Remove the isolator bolt, nut, and washers; see **Fig. 3**.
5. Remove the bolts, nuts, and washers that attach the cab mount isolator to the frame-mounted bracket. Remove the isolator.

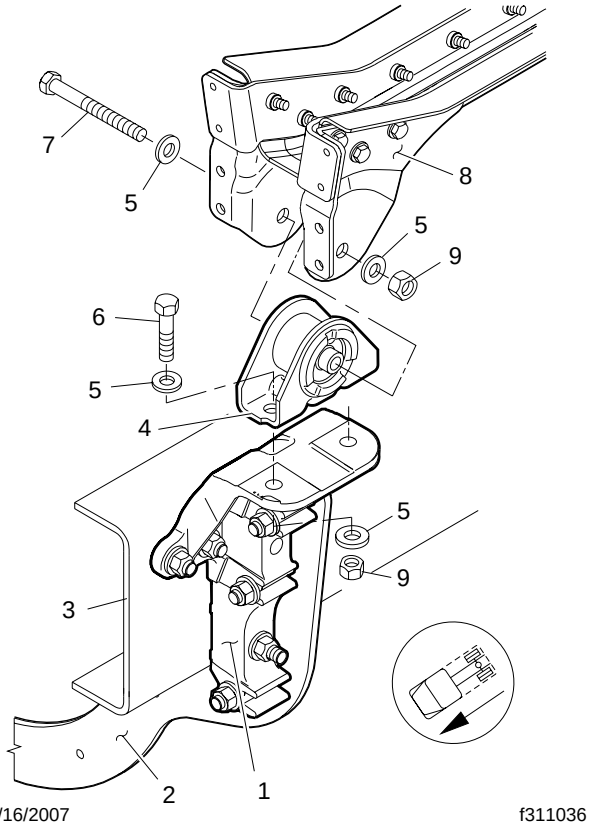


1. Nut, M8
2. Cab Front Wall
3. Splash Shield

Fig. 2, Splash Shield Installation

6. Place a new cab mount isolator on the frame-mounted bracket, between the ears of the bracket on the cab underbody. Make sure that the stamped word "OUTSIDE" is facing outboard.
7. Attach the cab mount isolator to the bracket on the cab underbody with the isolator bolt, washers, and nut, inserting the bolt from the inboard side. Hand-tighten the nut.
8. Carefully lower the cab.
9. Install the bolts, nuts, and washers that attach the cab mount isolator to the frame-mounted bracket.
10. Tighten the isolator-bolt nut.
11. Install the front wheel splash shield, as follows.
    11.1 Position the splash shield on the studs.
    11.2 Attach the splash shield to the cab with four M8 nuts. Tighten the nuts 11 lbf·ft (14 N·m).

Forward Cab Mount Replacement



1. Frame-Mounted Bracket
2. Underslung Crossmember
3. Frame Rail
4. Cab Mount Isolator
5. Washer
6. Bolt, 5/8–11 x 2.25
7. Isolator Bolt, 5/8–11
8. Cab Underbody
9. Hexnut, 5/8–11

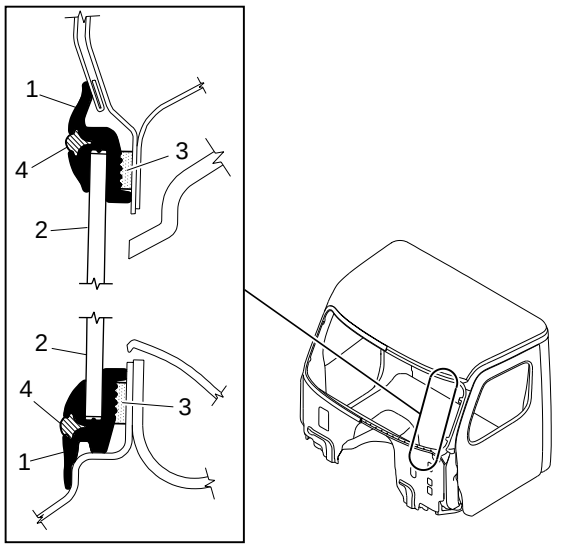
Fig. 3, Forward Cab Mount Installation

11.3 Attach the splash shield to the cowl side panel with a Torx screw and washer.

12. Remove the chocks.

General Information

The two-piece roped-in bonded windshield installation has the seal held in place on the windshield mask by a bead of urethane adhesive/sealant. The glass is inserted into a channel in the seal, then a lockstrip is inserted to secure the glass in place; see **Fig. 1**. Glass replacement is easier in a roped-in bonded installation than in an encapsulated installation, as only the lockstrip has to be pulled out to loosen the glass in the seal.



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1. Seal and Flange
2. Windshield Glass
3. Urethane Adhesive/Sealant
4. Lockstrip

Fig. 1, Roped-In Bonded Windshield Installation, Cross-Sectional View

If the windshield is cracked, carefully inspect the glass, seal, and 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.

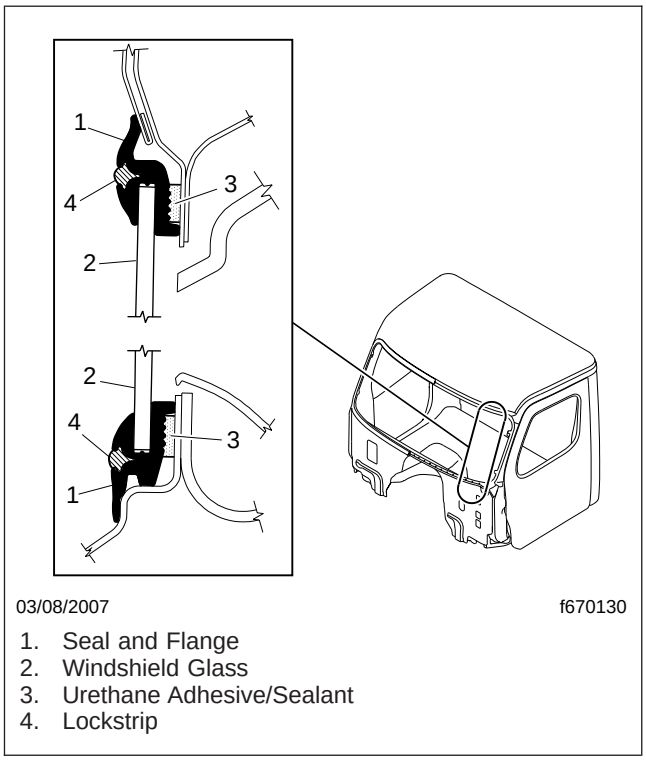
Roped-In Bonded Windshield

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the windshield wiper arms; see **Section 82.00, Subject 100**.
4. Protect the paint finish and instrument panel by taping paper around the inside and outside of the windshield opening.
5. Pull the center post locking strip out.
6. Find the end of the perimeter locking strip, at the base or top of the windshield center post. Pull the strip out around the glass to be replaced; see **Fig. 1**.

⚠ 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.

7. Using a windshield pick (**Fig. 2**), go around the perimeter to separate the glass from the seal.
8. From inside the cab, gently push the upper outboard corner of the glass out of the seal channel. Use care not to push with force enough to separate the seal from the windshield mask.
9. Use the windshield pick to slip the outboard edge of the glass out of the seal.
10. Pull the outboard edge of the glass away from the windshield mask. Slide the glass away from the center seal, and pull the glass outward until it is released from the perimeter seal. Remove the glass.
11. Inspect the seal to make sure that removing the glass did not separate the seal from the windshield mask. If necessary, bond the separated seal to the windshield mask.
12. Lubricate the seal with a soap-and-water solution or foaming window cleaner.
13. Insert the inboard corners of the new windshield glass into the seal channel, then push the glass inboard into the center seal; see **Fig. 3**.



1. Seal and Flange
2. Windshield Glass
3. Urethane Adhesive/Sealant
4. Lockstrip

Fig. 1, Roped-In Bonded Windshield Installation, Cross-Sectional View

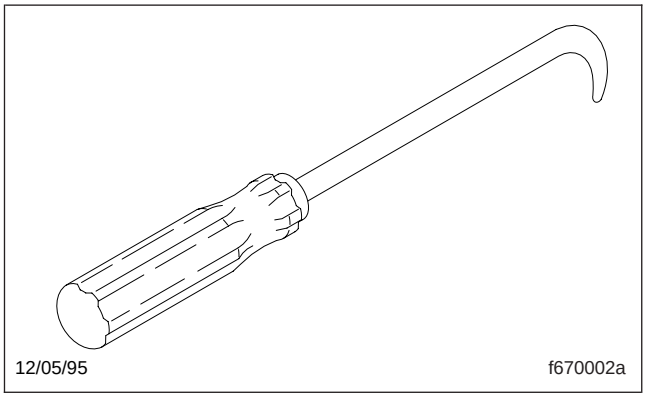
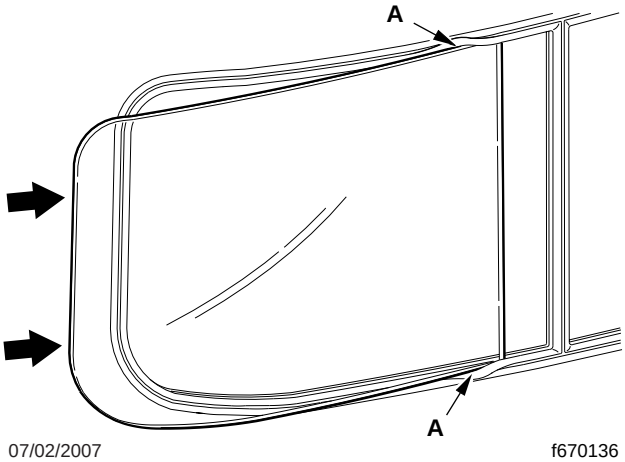


Fig. 2, Typical Windshield Pick

Windshield Replacement



A. Insert the inboard corners of the glass into the seal channel.

Fig. 3, Inserting Windshield Glass Into the Seal Channel

14. Work the lip of the seal over the edge of the windshield glass.
15. Install the center seal locking strip, using a bead spreader; see **Fig. 4** and **Fig. 5**. Insert the bead spreader into the center post seal, near the bottom. Feed the end of the lock strip through the bead spreader into the seal channel, pushing it to the bottom end of the center post seal. Move the bead spreader up the center post seal, feeding the lock strip into the channel. Make sure the lock strip does not twist in the channel; it should lay flat. Cut off any excess lockstrip and tuck the end into the channel.
16. Install the perimeter seal locking strip, using a bead spreader. Insert the locking strip into the bead spreader, then insert the bead spreader into the seal channel. Move the bead spreader around the perimeter seal, feeding the lock strip into the channel. Make sure the lock strip does not twist in the channel; it should lay flat. Cut off any excess lockstrip and tuck the end into the channel.
17. Install the windshield wiper arms; see **Section 82.00, Subject 100**.
18. Clean both sides of the new windshield glass.
19. Remove the protective coverings from the inside and outside of the windshield opening.

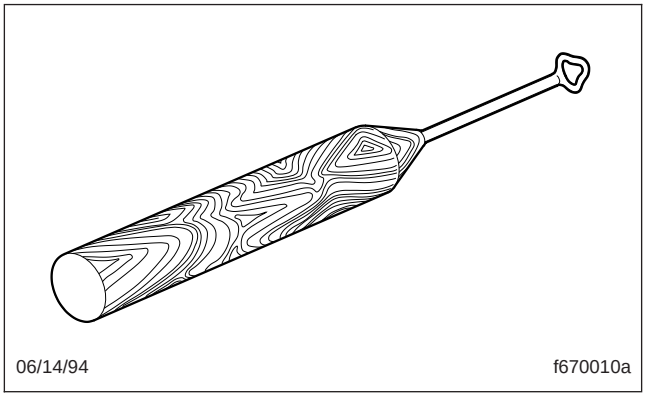


Fig. 4, Typical Bead Spreader

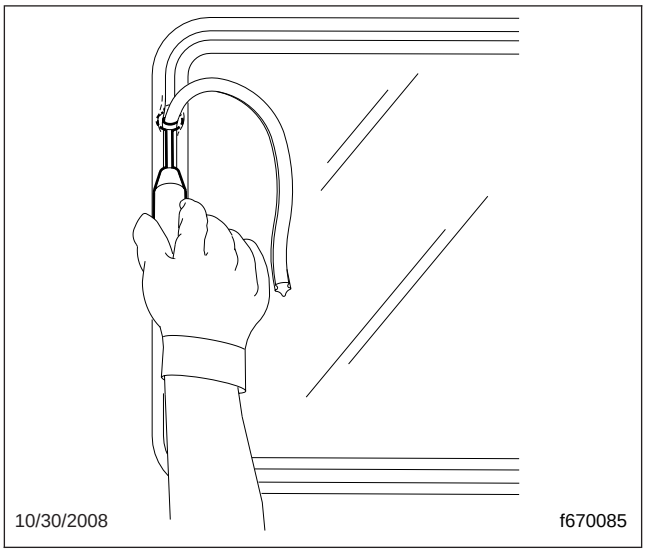


Fig. 5, Inserting Locking Strip Using Bead Spreader

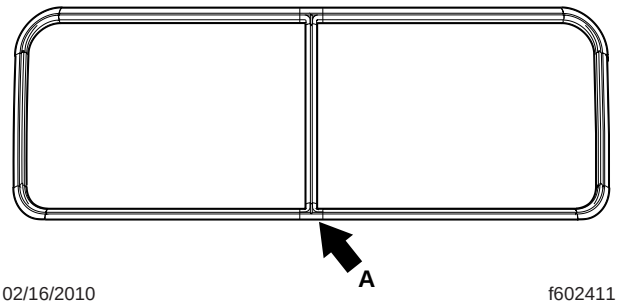
Roped-In Bonded Windshield Seal Replacement

NOTE: To replace the glass only for a roped-in bonded windshield, see **Subject 100**.

Seal Replacement

A treated seal has superseded the old untreated seal in production. The treated seal has the part number "A18-66173-000" or "A18-64181-000" molded into the seal at the bottom center "T" section, on the cab-facing side. See **Fig. 1**.

When installing a treated seal with part number "A18-66173-000" or "A18-64181-000" molded on the seal, DTNA recommends using the Sika or Dow Essex products listed in **Specifications 400**. Do not use Lord Chemlok® 7701 in the installation of the treated seal.



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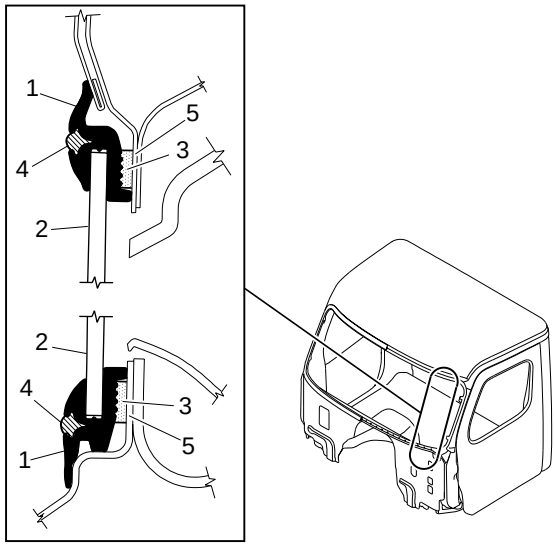
A. The part number is molded into the cab-facing side of the seal here.

Fig. 1, Location of Part Number on Treated Seal

The procedure below specifies Sika adhesives and primers. 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.

IMPORTANT: Do not perform this procedure at temperatures lower than 50°F (10°C).

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.
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. Protect the windshield glass from breakage and separation during removal by applying masking tape in a cross pattern on both the inside and outside surfaces of both pieces of glass.
7. Pull the center post lockstrip out, and discard it.
8. Find the end of the perimeter lockstrip, at the top or base of the windshield center post. Pull the lockstrip out around the entire perimeter of the seal and discard it. See **Fig. 2**.



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NOTE: Typical installation shown. The seal and flange may vary in design.

1. Seal and Flange
2. Windshield Glass
3. Urethane Adhesive/Sealant
4. Lockstrip
5. Windshield Mask

Fig. 2, Roped-In Bonded Windshield Installation, Cross-Sectional View

⚠ WARNING

Work in a well-ventilated space and wear appropriate protective gloves and safety glasses when replacing windshield glass or using the chemicals required for windshield seal replacement.

Roped-In Bonded Windshield Seal Replacement

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. Some of the materials used in the procedure may cause skin, eye, or respiratory irritation. Inhalation of vapors may be harmful.

9. Cut the seal off the glass to minimize the chance of breaking the glass. Remove the glass. Repeat for the other side.

NOTE: When cutting the seal from the windshield opening, a cutting tool with a depth control gauge is recommended to prevent damage to painted surfaces.

10. Using a pneumatic cutting tool equipped with a depth control blade (**Fig. 3**) cut the seal from the windshield opening. Leave a thin layer of adhesive, no more than 3/64 to 6/64 inch (1 to 2 mm), in place around the windshield opening for a good base for the new adhesive. Discard the seal. If any bare metal is present on the windshield mask (pinch weld) due to corrosion or loosened adhesive, remove the loosened adhesive. Scuff any visible corrosion to leave a bare metal surface. Lightly scuff the mask surface where any loose adhesive was removed. Clean any loose debris off the windshield mask with a clean, dry towel.

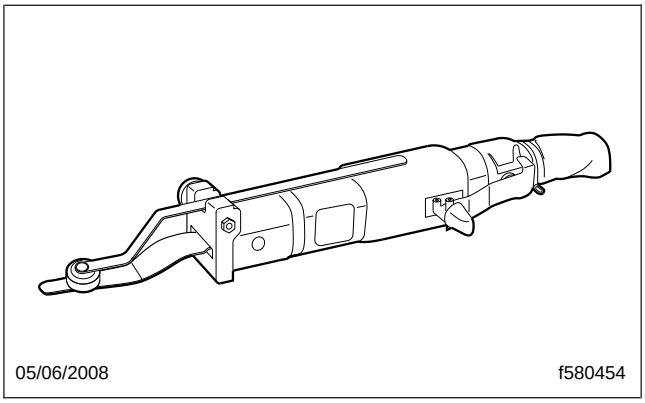


Fig. 3, Pneumatic Cutting Tool With Depth Control Blade

NOTE: When installing the windshield, first install the glass in the seal. Do not attempt to attach the seal to the windshield mask without both the left- and right-side glass installed in the seal.

11. Install the left- and right-side glass in the new seal. Start by pushing the inboard edge of the glass into the centerpost channel, then work the seal over the edge of the glass; see **Fig. 4**. Make sure that both glass panes are seated in the centerpost channels.

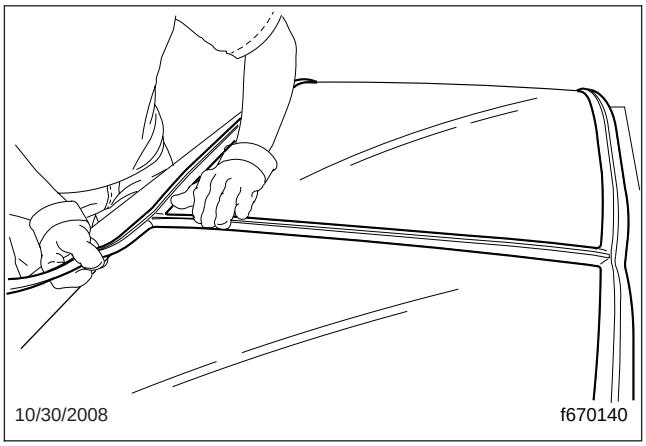


Fig. 4, Installing Glass in Seal

IMPORTANT: If the new seal has the part number "A18-66173-000" or "A18-64181-000" molded into the seal at the bottom center "T" section, on the cab-facing side, it is a treated seal. Do not use Lord Chemlok® 7701 when installing a treated seal.

If the part number molded on the seal is anything other than "A18-66173-000" or "A18-64181-000," or if the part number is missing, it is an untreated seal, and Lord Chemlok 7701 must be applied to the seal. When applying Lord Chemlok 7701 always use clean paper towels. Replace them frequently and expect to use multiple towels, even if using an ultra-absorbent product.

12. *If the new seal is a treated seal*, with the part number "A18-66173-000" or "A18-64181" molded into the seal (**Fig. 1**), do not use Lord Chemlok 7701. Go to the next step.

    If the new seal is an untreated seal, using clean paper towels moistened with Lord Chemlok 7701, apply the Chemlok to the entire width of the bond surface of the rubber seal. Chemlok 7701 chemically etches the surface of the seal,

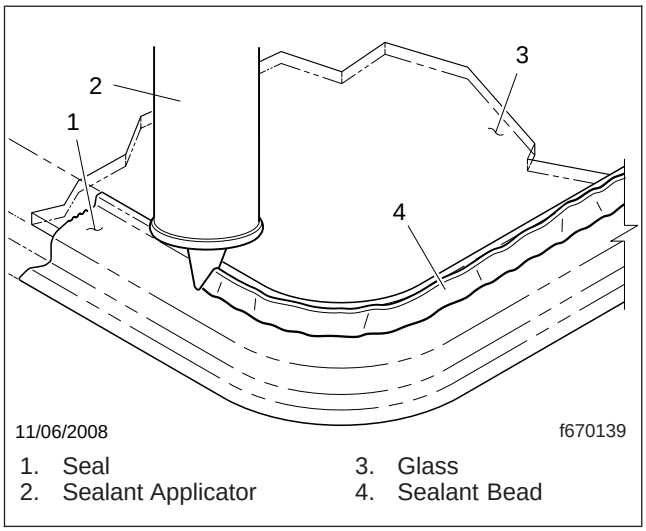
creating a stronger bond with the rubber. Allow to dry for at least 5 minutes before applying Sika®-Aktivator.

13. Using clean, lint-free paper towels, apply Sika®-Aktivator to any areas previously scuffed on the mask and the entire bond surface of the rubber seal that will be in contact with the new adhesive. Apply sparingly in one direction (not back and forth), then wipe off with a clean, dry towel. Allow to dry for at least 10 minutes, but not more than two hours, before applying adhesive.

NOTE: Do not allow Sika®-Aktivator, or any alcohol-based cleaner, to come in contact with wet urethane adhesive/sealant.

14. On any bare metal scratches or bare areas present on the windshield mask, use a brush to lightly apply Sika®-Primer 206 G+P on top of the previously applied Sika®-Aktivator. Allow to dry for at least 10 minutes, but not more than two hours, before installing the windshield.
15. Attach appropriate suction cup devices to the exterior surface of the windshield glass. The suction cups need to be of sufficient strength to support the glass, and to have good hand-holds for the two technicians required to position the glass/seal assembly in the windshield opening. Turn the windshield over, facing the interior surface of the windshield up.
16. Apply a triangular bead of SikaTack®-Ultrafast or SikaTack®-ASAP urethane adhesive/sealant to the rubber seal. Both are hot-applied single-part urethanes that come in standard caulking tubes and must be preheated to 170 to 180°F (75 to 80°C) before dispensing. Cut the applicator tip to produce a triangular bead approximately 9/16-inch (14-mm) tall and 1/2-inch (12-mm) wide. Apply a consistent bead of adhesive to the rubber seal; see **Fig. 5**. A cordless electric caulking gun is recommended for best results. Expect to heat cartridges for 1 hour in a Sika cartridge oven. Otherwise, verify adhesive temperature before dispensing it.

IMPORTANT: SikaTack Ultrafast and ASAP are not appropriate for use in a workspace that is colder than 50°F (10°C) for this application. Open time is decreased in cool ambient temperatures, and less time is available to install the windshield after dispensing the adhesive.



1. Seal
2. Sealant Applicator
3. Glass
4. Sealant Bead

Fig. 5, Applying Sealant/Adhesive to Windshield Seal

17. Using care, place the glass/seal assembly on the windshield mask; see **Fig. 6**. Make sure the bottom of the glass/seal assembly sits on the front-wall nose beam as shown in **Fig. 2**.

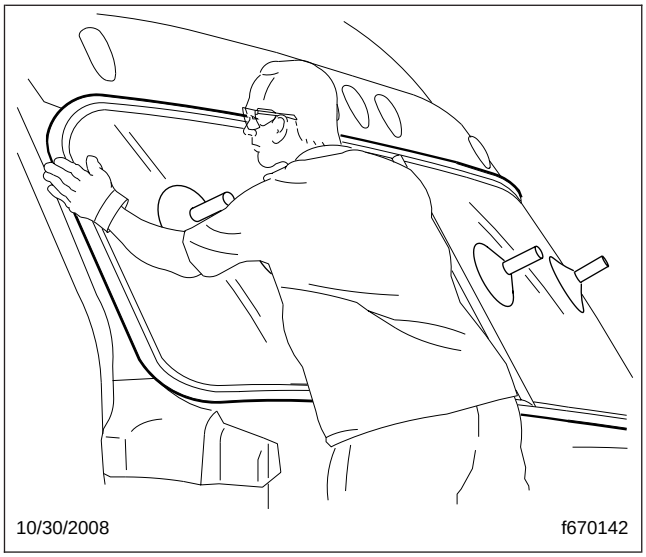


Fig. 6, Positioning Glass/Seal Assembly in Windshield Opening

18. Remove the glass-holding fixture, then press the windshield into place. Allow 15 minutes for the sealant to set before installing the lockstrips.
19. Using a bead spreader, install a new perimeter seal lockstrip; see **Fig. 7** and **Fig. 8**. Insert the

Roped-In Bonded Windshield Seal Replacement

lockstrip into the bead spreader, then insert the bead spreader into the perimeter seal channel below the mid-point of the passenger-side glass. Move the bead spreader around the perimeter seal, feeding the lockstrip into the channel. Make sure the lockstrip does not twist in the channel; it should lay flat. Cut off any excess lockstrip and tuck the end into the channel.

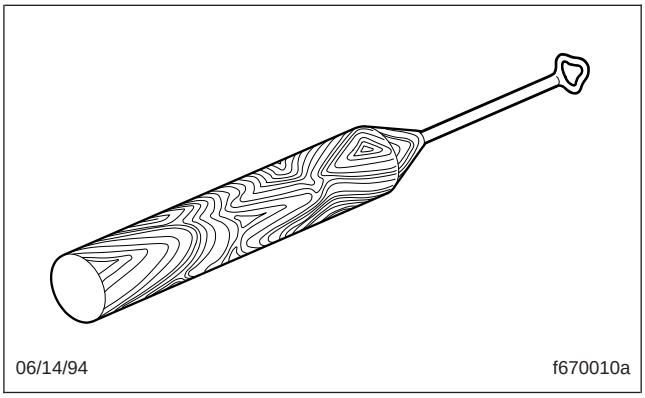


Fig. 7, Typical Bead Spreader

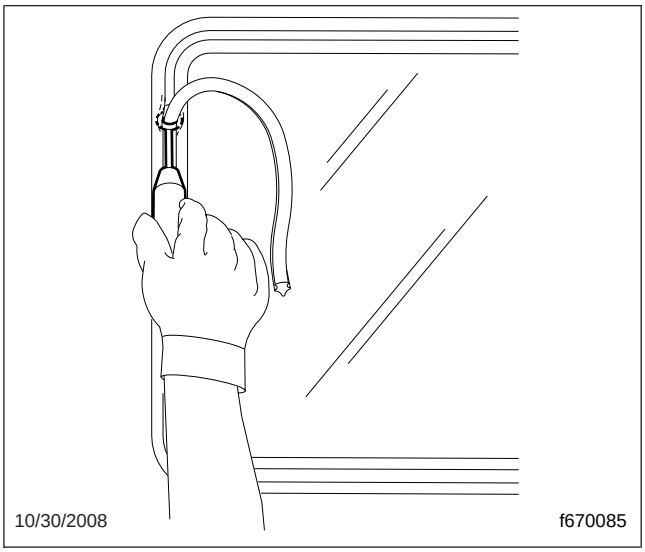
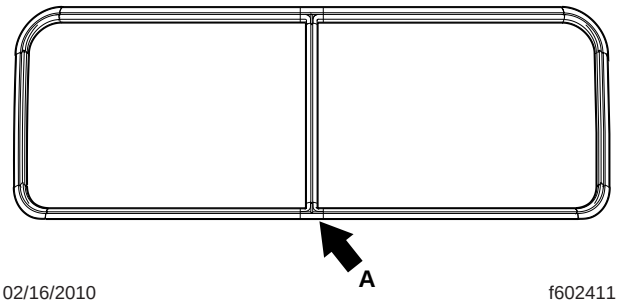


Fig. 8, Inserting Lockstrip Using Bead Spreader

20. Install a new centerpost lockstrip, starting at the top. Feed the end of the lockstrip through the bead spreader into the seal channel, pushing it to the top end of the center post seal. Move the bead spreader down the center post seal, feeding the lockstrip into the channel. Make sure the lockstrip does not twist in the channel; it should lay flat. Cut off any excess lockstrip and tuck the end into the channel.
21. Install the windshield wiper arms; see **Section 82.00, Subject 100**.
22. Clean both sides of the new windshield glass.
23. Remove the protective coverings from the inside and outside of the windshield opening.

For a new treated seal: see **Table 1** for the materials and tools recommended by DTNA to replace a roped-in bonded windshield seal with a new treated seal stamped with the part number "A18-66173-000" or "A18-64181-000" in the center "T" section. See **Fig. 1** for the location of the part number.

For a new untreated seal: see **Table 2** for the materials and tools recommended by DTNA to replace a roped-in bonded windshield seal with a new seal not stamped with a part number, or stamped with a part number other than "A18-66173-000" or "A18-64181-000."



A. The part number is molded into the cab-facing side of the seal here.

Fig. 1, Location of Part Number on Treated Seal

Materials Required for Roped-In Bonded Windshield Seal Replacement, New Treated Seal (part number A18-66173-000 or A18-64181-000)		
Description	**Purpose**	**Drying/Preparation Time**
Sika®-Aktivator	Cleaning and Preparation of Surfaces in Contact with Adhesive	10 Minutes to 2 Hours
Sika®-Primer 206 G+P	Priming of Bare Metal Surfaces to Improve Adhesion of Adhesive	10 Minutes to 2 Hours
SikaTack®-Ultrafast or SikaTack®-ASAP	Adhesive and Sealant	Varies Depending on Temperature and Humidity; Tack-Free in Approximately 10 Minutes (Ultrafast) or 8 Minutes (ASAP)
or		
Dow Betaclean™ GC-800 Glass Cleaner	Cleaning of Surfaces in Contact with Adhesive	Refer to Guidelines Supplied by Dow
Dow Betaprime™ 5404A	Priming of Bare Metal Surfaces to Improve Adhesion of Adhesive	
Dow Betaseal™ U-418HV or Betaseal™ Express	Adhesive and Sealant	

Table 1, Materials Required for Roped-In Bonded Windshield Seal Replacement, New Treated Seal (part number A18-66173-000 or A18-64181-000)

Materials Required for Roped-In Bonded Windshield Seal Replacement, New Untreated Seal (part number other than A18-66173-000 or A18-64181-000)		
Description	**Purpose**	**Drying/Preparation Time**
Sika®-Aktivator	Cleaning and Preparation of Surfaces in Contact with Adhesive	10 Minutes to 2 Hours
Sika®-Primer 206 G+P	Priming of Bare Metal Surfaces to Improve Adhesion of Adhesive	10 Minutes to 2 Hours
SikaTack®-Ultrafast or SikaTack®-ASAP	Adhesive and Sealant	Varies Depending on Temperature and Humidity; Tack-Free in Approximately 10 Minutes (Ultrafast) or 8 Minutes (ASAP)

Specifications

Materials Required for Roped-In Bonded Windshield Seal Replacement, New Untreated Seal (part number other than A18-66173-000 or A18-64181-000)		
Description	**Purpose**	**Drying/Preparation Time**
LORD Chemlok® 7701	Chemical Etching of Rubber Surface to Allow Stronger Bond with Rubber	5 to 30 Minutes

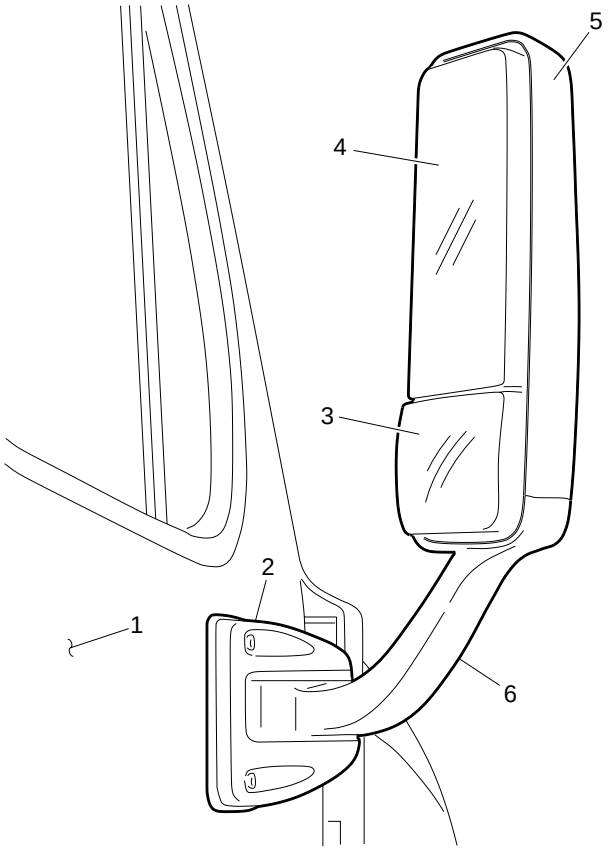
Table 2, Materials Required for Roped-In Bonded Windshield Seal Replacement, New Untreated Seal (part number other than A18-66173-000 or A18-64181-000)

General Information

The Cascadia cab mirror is a unit mounted on a fold-away pedestal arm, which is attached to the door with four Torx screws. The mirror head consists of a flat upper mirror and a convex lower mirror; see **Fig. 1**. The mirror plates are bonded to glass carriers, which can be adjusted for the best viewing angle. A cover is mounted on the back of the mirror head.

The flat and convex mirrors are both electrically heated. An indicator on the dash panel alerts the driver that the heating element in the mirror is on.

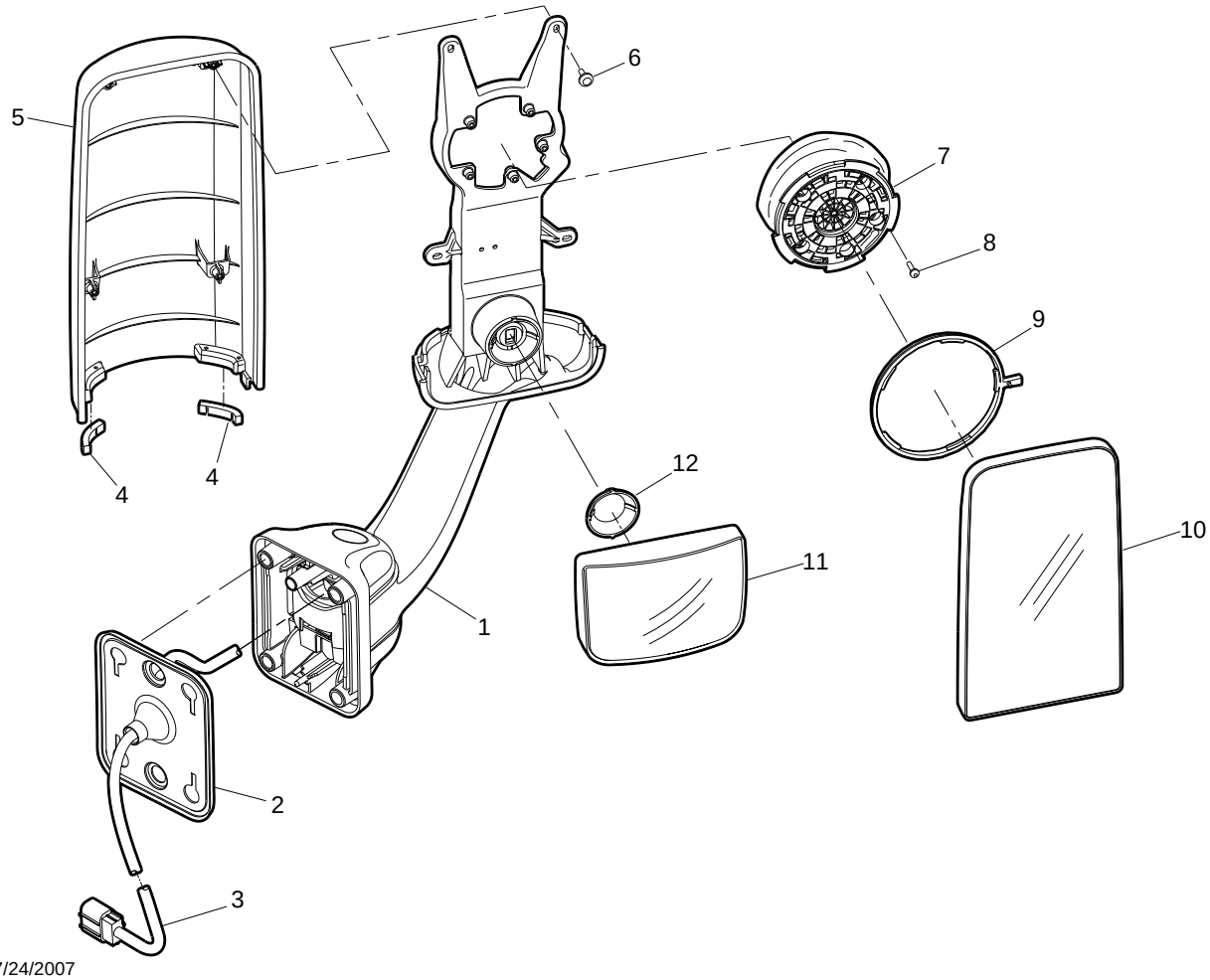
The flat mirror is remotely controlled, and is powered by an actuator with dual electric motors (one for vertical movement, and one for horizontal movement). The flat mirror carrier is mounted on the actuator, which is mounted on the mirror arm; see **Fig. 2**. The actuator is equipped with a clutch to prevent damage in case of binding. The convex mirror is manually actuated. All the wiring is hidden within the mirror arm and between the glass carriers and back cover.



1. Cab Door
2. Mirror Bracket
3. Convex Mirror
4. Flat Mirror
5. Back Cover
6. Mirror Arm

Fig. 1, Cab Mirror (RH shown)

General Information



1. Mirror Arm
2. Mirror Arm Gasket
3. Mirror Wiring Harness
4. Cover Gasket
5. Back Cover
6. Torx Screw, Back Cover
7. Actuator
8. Torx Screw, Actuator
9. Retainer Ring
10. Flat Glass Plate and Carrier
11. Convex Glass Plate and Carrier
12. Middle Sphere

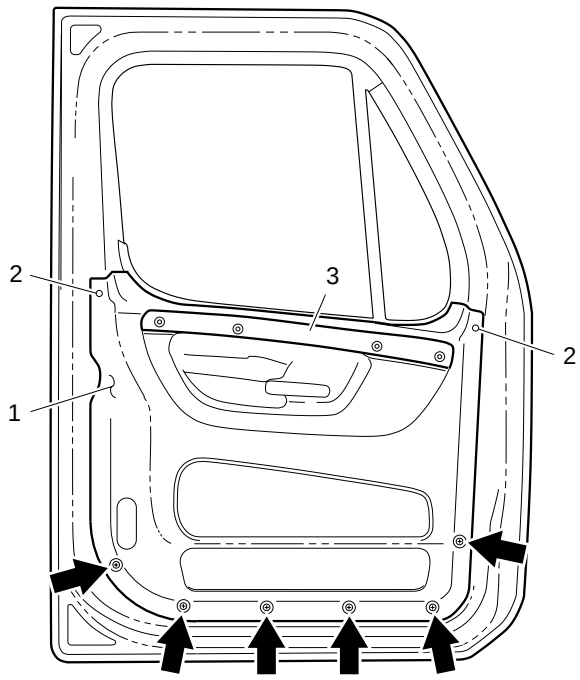
Fig. 2, Mirror Assembly (exploded)

Mirror Assembly Removal and Installation

For many procedures, the mirror assembly does not have to be removed from the vehicle door.

Removal

1. Apply the parking brakes and chock the tires.
2. Open the door, and remove the pull handle by removing the four Torx screws that attach it to the door cassette; see **Fig. 1**.



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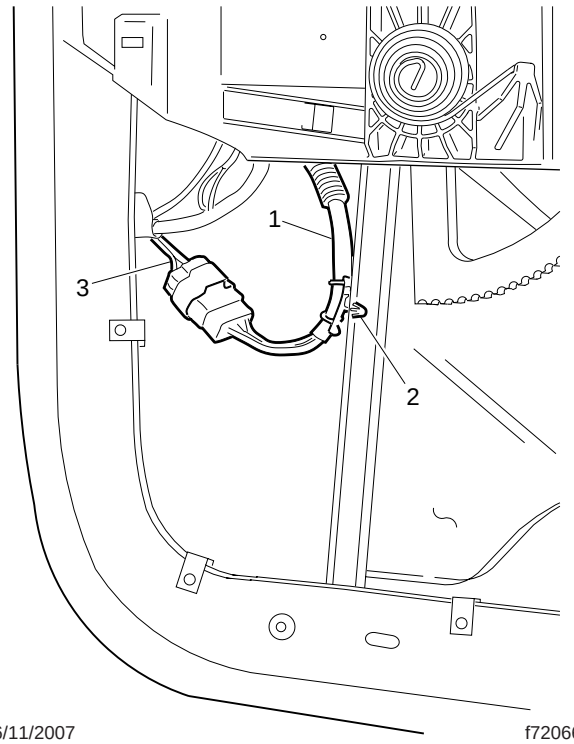
1. Door Interior Trim Panel
2. Christmas-Tree Fastener
3. Pull Handle

Fig. 1, Door Interior Trim Panel Screws (arrows)

3. Remove the door interior trim panel, as follows.
   - 3.1 Remove the six Torx screws that attach the door interior trim panel to the door.
   - 3.2 Remove the two Christmas-tree fasteners that attach the top corners of the trim panel to the door.
   - 3.3 Pull the panel away from the door to un-clip it from the door cassette.
   - 3.4 Disconnect the courtesy light electrical connector.
   - 3.5 Remove the panel by raising it over the lock knob and control switches.
4. Disconnect the mirror electrical connector from the door wiring harness. See **Fig. 2**.



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1. Mirror Wiring Harness
2. Clip
3. Door Wiring Harness

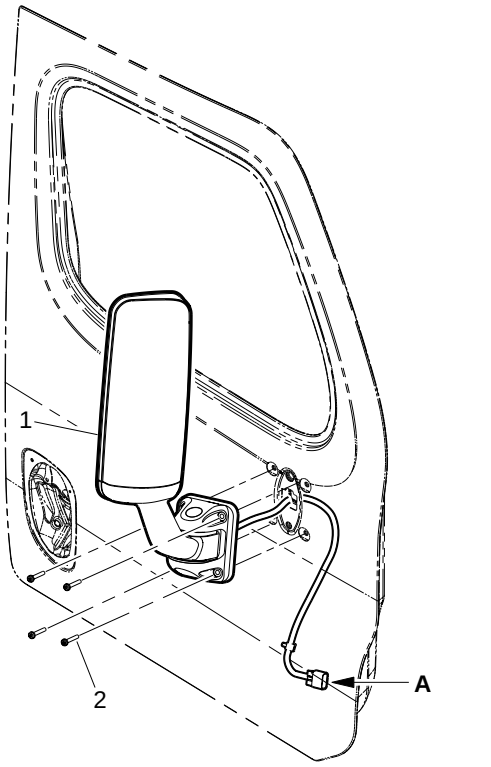
Fig. 2, Mirror Wiring Harness Connector

5. Loosen the wiring clip from the glass channel.
6. Close the door, then remove the four Torx screws that attach the mirror mounting bracket to the door. See **Fig. 3**. Support the mirror so as not to damage the door finish.
7. Remove the mirror and the rubber gasket, and pull the mirror wiring harness out through the opening in the door panel.

Installation

1. With the vehicle tires chocked, push the mirror wiring through the opening into the door, and

Mirror Assembly Removal and Installation



A. Mirror wiring is fed between the window cassette mechanism and the door outer panel structure.

1. Mirror Assembly
2. Torx Screw

Fig. 3, Mirror Assembly Installation

feed it down between the window cassette and the door outer panel structure. Make sure that the wiring does not bind up in the window mechanism. See **Fig. 3**.

2. Position the mirror and the rubber gasket on the door, supporting it while installing the four Torx screws. Tighten the screws 11 lbf·ft (15 N·m).
3. Open the door, and connect the mirror wiring to the door wiring harness. See **Fig. 2**.
4. Attach the mirror wiring clip to the glass channel.
5. Install the door interior trim panel, as follows.
   - 5.1 Lower the panel over the lock knob and control switches, and connect the courtesy light electrical connector.
   - 5.2 Push the panel into position on the door cassette to engage the backside clips that hold it in place.
   - 5.3 Using two Christmas-tree fasteners, attach the top corners of the trim panel to the door; see **Fig. 1**.
   - 5.4 Attach the bottom of the panel to the door assembly with six Torx screws. Tighten the screws 40 to 50 lbf·in (450 to 550 N·cm).
6. Install the pull handle on the door, using four Torx screws. Install the forward screw first, then the rear screw, then the two middle screws. Tighten the screws 54 to 71 lbf·in (600 to 800 N·cm).
7. Remove the chocks.

Mirror Glass Carrier Removal and Installation

NOTE: The following procedures can be performed with the mirror installed on the vehicle.

Flat Glass Carrier

Removal

1. Apply the parking brakes and chock the tires.
2. Actuate the flat mirror as far left as possible.
3. To unlock the flat glass carrier, support the glass carrier while pushing up the retainer ring locking tab, located behind the right-hand edge of the glass carrier; see **Fig. 1**. Use care in removing the glass carrier, as the heater wires are still attached.

NOTE: The retainer ring locking tab is located on the right-hand side on both the left-hand and right-hand mirrors.

4. Disconnect the mirror heater wires from the back of the flat glass carrier.

Fig. 1, Flat Glass Carrier Locking Tab

Installation

1. With the vehicle tires chocked, connect the mirror heater wires to the back of the flat glass carrier. Note that the heater is not polarity sensitive.
2. Make sure that the circular foam pad is in place on the back of the glass carrier.
3. With the actuator rotated as far left as possible, carefully align the flat glass carrier on the actuator. Apply light pressure on the glass to hold it in place, and pull down the retainer ring locking tab. See **Fig. 1**. Make sure that the glass carrier is securely locked in place.
4. Remove the chocks.

Convex Glass Carrier

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the flat glass carrier; see the procedure under "Flat Glass Carrier".
3. Remove the mirror back cover, as follows.
   - 3.1 Remove the four Torx screws that attach the back cover to the mirror arm; see **Fig. 2**.
   - 3.2 Lift the cover up to remove it from the mirror arm. Note that there are two gaskets that fit into the recesses on the bottom edge of the cover.
4. Using a pair of pliers, release the convex glass carrier by pulling and rotating (90 degrees) the white locking tab on the back of the convex mirror; see **Fig. 3**. Note that the middle sphere, located between the glass carrier and the mirror arm, may come loose.
5. Disconnect the mirror heater wires from the back of the convex glass carrier.

Installation

1. With the vehicle tires chocked, connect the mirror heater wires to the back of the convex glass carrier.
2. Position the middle sphere between the convex glass carrier and the mirror arm, making sure that it is correctly aligned.

Mirror Glass Carrier Removal and Installation

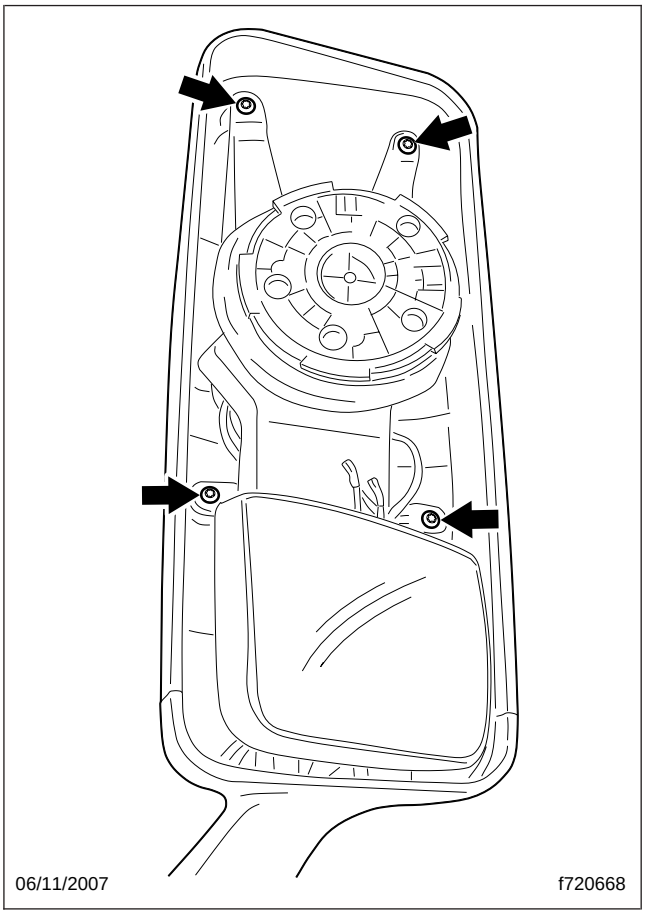


Fig. 2, Back Cover Fasteners

3. Push the convex glass carrier in place, passing the locking tab through the rectangular hole in the mirror arm. Using a pair of pliers, pull and rotate the locking tab 90 degrees to lock the glass carrier in place. See **Fig. 3**.
4. Install the back cover on the mirror arm, as follows.
   - 4.1 Place the two mirror cover gaskets over the posts on the mirror arm.
   - 4.2 Slide the cover down on the mirror arm. The gaskets should fit into the recesses on the bottom edge of the cover.
   - 4.3 Make sure that the cover is tightly seated on the mirror arm, then attach it to the arm with four Torx screws; see **Fig. 2**. Tighten the screws 13 to 17 lbf·in (145 to 190 N·cm).

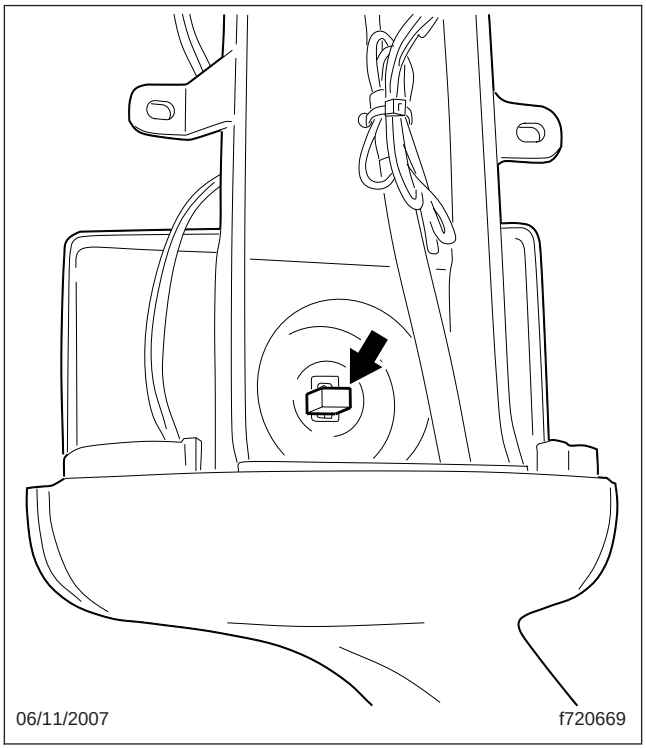


Fig. 3, Convex Mirror Plate Locking Tab

5. Install the flat glass carrier; see the procedure under "Flat Glass Carrier".
6. Remove the chocks.

Mirror Actuator Replacement

NOTE: The following procedure can be performed with the mirror installed on the vehicle.

Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the flat glass carrier; see **Subject 110**.
3. Remove the mirror back cover, as follows.
   - 3.1 Remove the four Torx screws that attach the back cover to the mirror arm; see **Fig. 1**.
   - 3.2 Lift the cover up to remove it from the mirror arm. Note that there are two gaskets that fit into the recesses on the bottom edge of the cover.
4. Disconnect the mirror wiring harness from the actuator; see **Fig. 2**.
5. Remove the actuator assembly by removing the five Torx screws that attach it to the mirror arm.
6. Attach a new actuator to the mirror arm with the five screws. Tighten the screws 13 to 17 lbf·in (145 to 190 N·cm).
7. Connect the mirror wiring harness to the actuator, as shown in **Fig. 2**.
8. Install the back cover on the mirror arm, as follows.
   - 8.1 Place the two mirror cover gaskets over the posts on the mirror arm.
   - 8.2 Slide the cover down on the mirror arm. The gaskets should fit into the recesses on the bottom edge of the cover.
   - 8.3 Make sure that the cover is tightly seated on the mirror arm, then attach it to the arm with four Torx screws; see **Fig. 1**. Tighten the screws 13 to 17 lbf·in (145 to 190 N·cm).
9. Install the flat glass carrier; see **Subject 110**.
10. Remove the chocks.

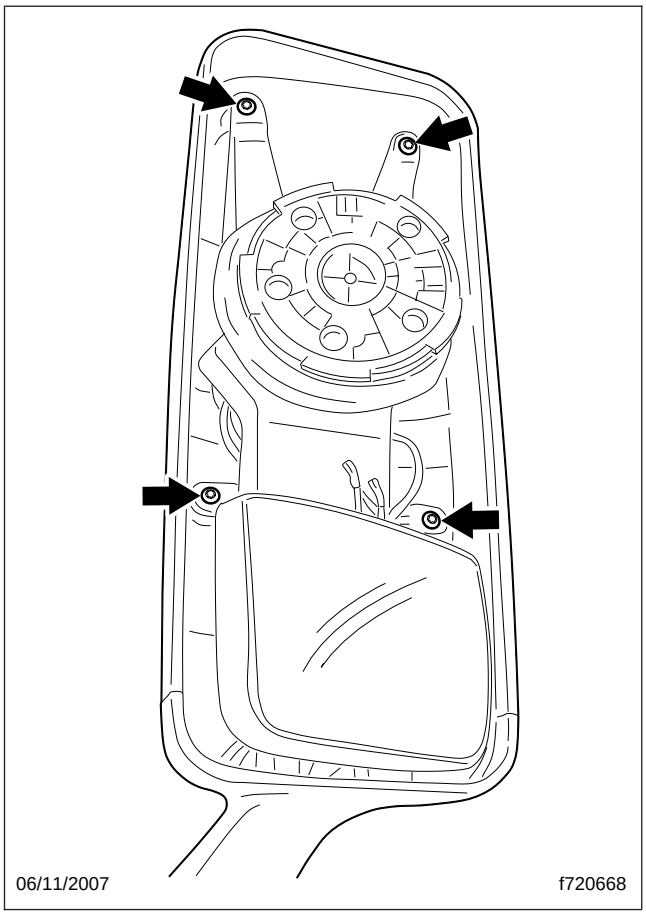


Fig. 1, Back Cover Fasteners

Mirror Actuator Replacement

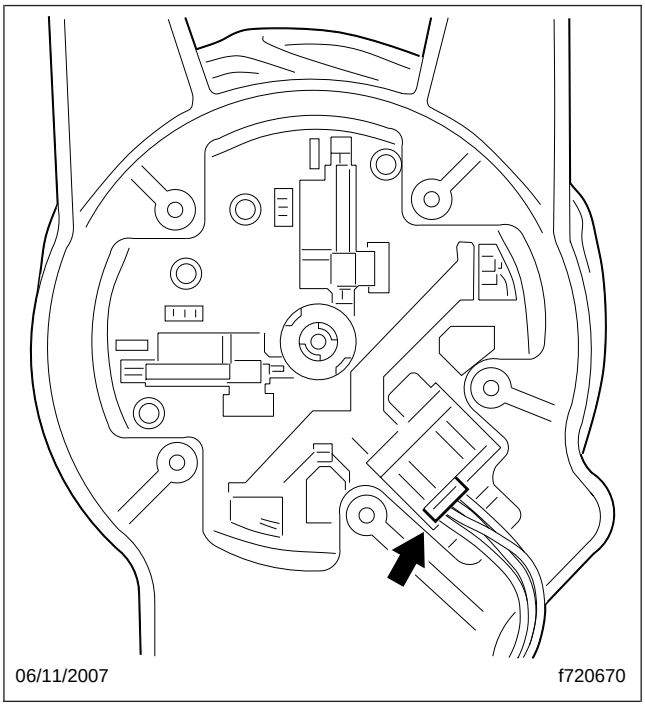


Fig. 2, Actuator Wiring Connector

Mirror Wiring Harness Replacement

Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the main and convex glass carriers, and the back cover; see **Subject 110**.
3. Remove the mirror from the cab door; see **Subject 100**.
4. Disconnect the mirror wiring harness from the actuator; see **Fig. 1**.

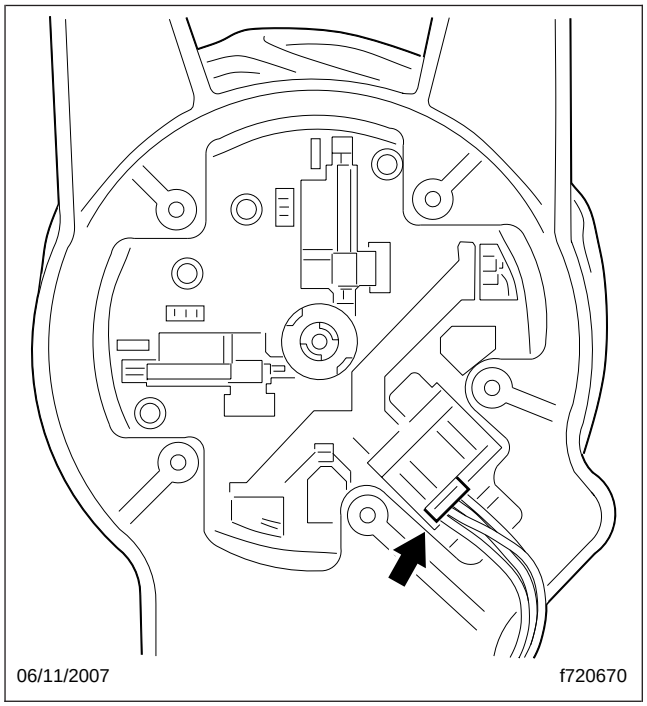
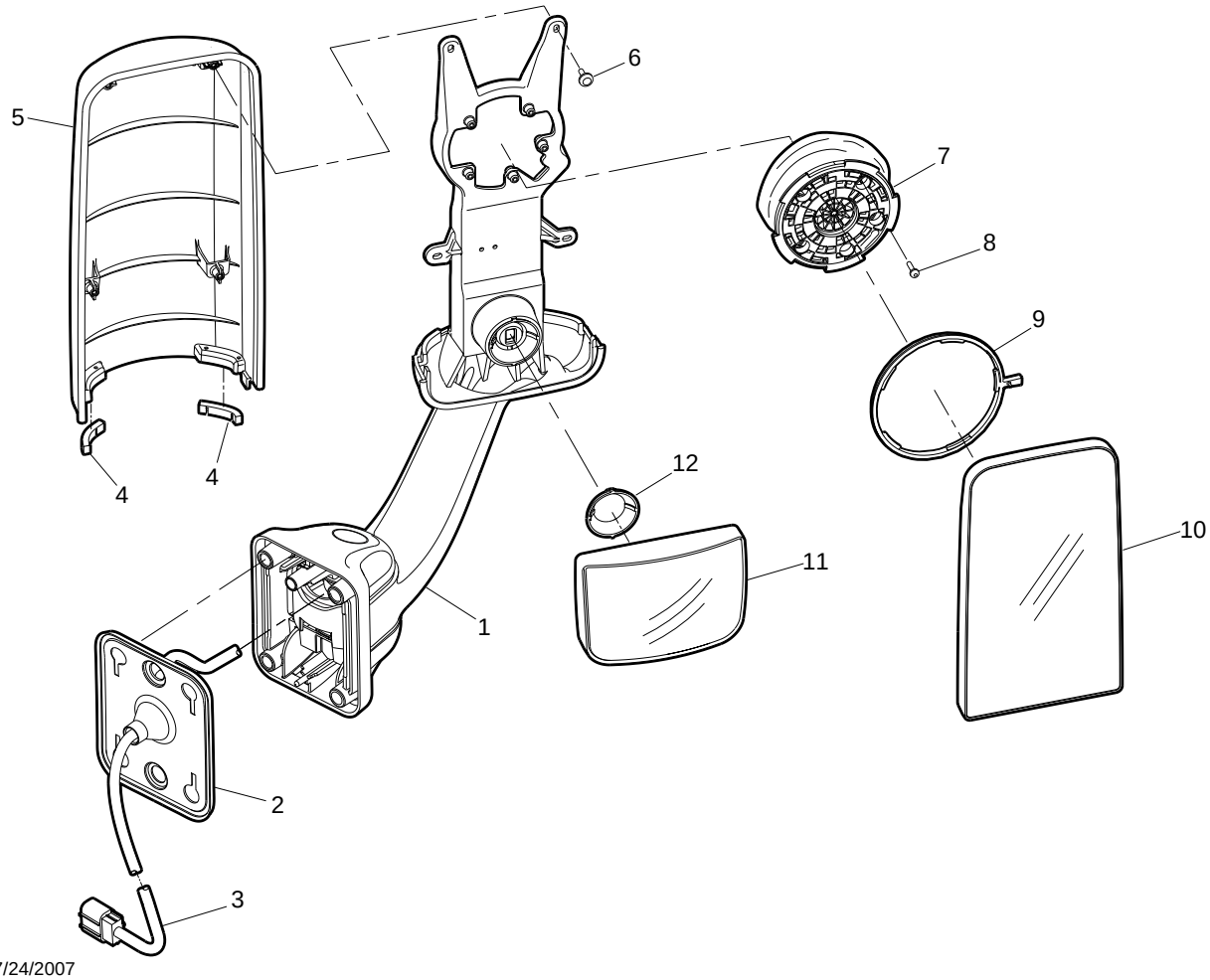


Fig. 1, Actuator Wiring Connector

5. Remove the mirror arm gasket from the lower end of the mirror arm; see **Fig. 2**.
6. Detach the wiring clamp from the lower end of the mirror arm.
7. Using care, pull the mirror wiring out through the lower end of the mirror arm.
8. Insert a new mirror wiring harness into the mirror arm through the opening in the lower end of the arm; see **Fig. 3**.
9. Feed the wiring through the arm, then carefully pull it through the upper opening far enough to connect to the mirror heater elements and the actuator.
10. Feed the wiring harness through the hole on the lower end of the mirror shell, as shown in **Fig. 4**.
11. Connect the wiring harness to the actuator; see **Fig. 1**.
12. Install the wiring clamp at the lower end of the mirror arm.
13. Install the rubber gasket on the mirror arm.
14. Install the mirror on the cab door; see **Subject 100**.
15. Install the main and convex glass carriers, and the back cover; see **Subject 110**.
16. Remove the chocks.

Mirror Wiring Harness Replacement



1. Mirror Arm
2. Mirror Arm Gasket
3. Mirror Wiring Harness
4. Cover Gasket
5. Back Cover
6. Torx Screw, Back Cover
7. Actuator
8. Torx Screw, Actuator
9. Retainer Ring
10. Flat Glass Plate and Carrier
11. Convex Glass Plate and Carrier
12. Middle Sphere

Fig. 2, Mirror Assembly (exploded)

Mirror Wiring Harness Replacement

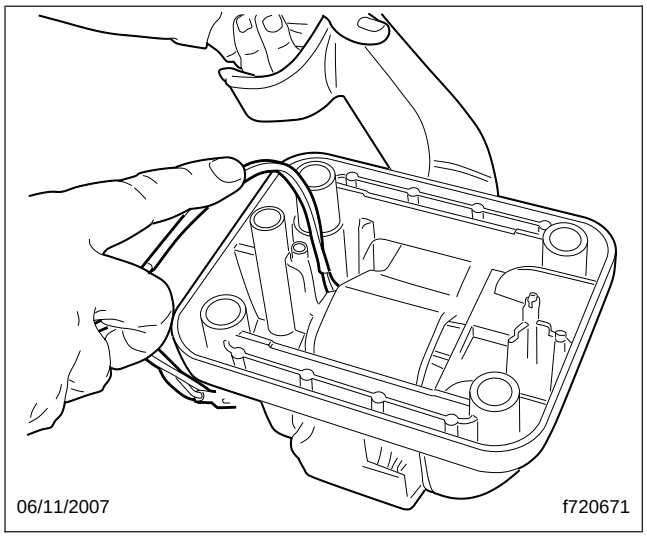
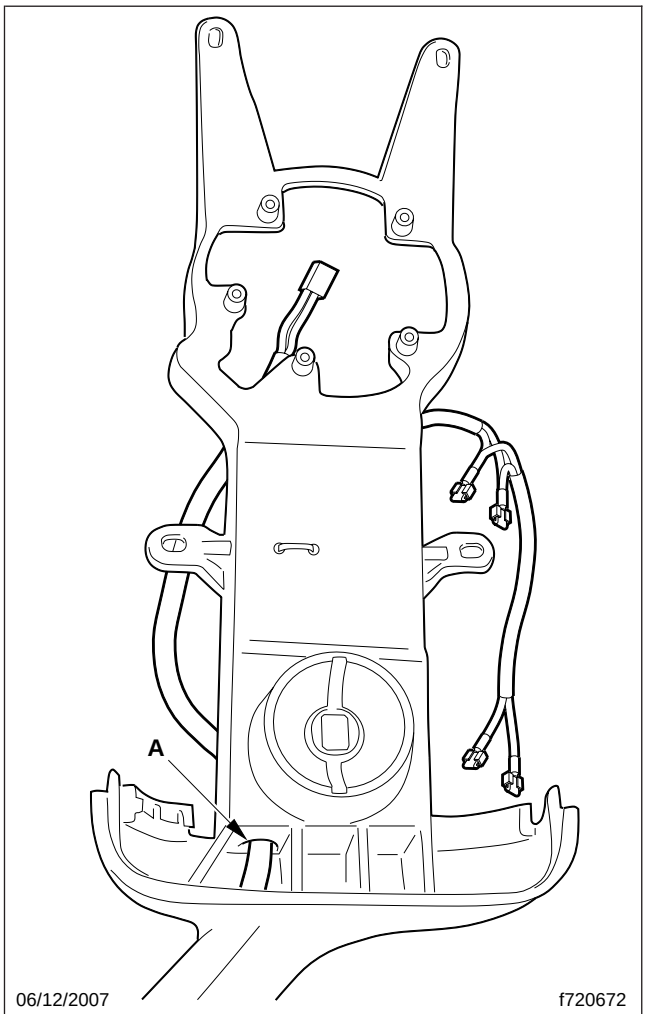


Fig. 3, Feeding Wiring Into Mirror Arm



A. Feed wiring harness through hole to the backside of the mirror arm.

Fig. 4, Mirror Wiring Routing

Specifications

For fastener torque values, see **Table 1**.

Torque Values	
Description	**Torque**
Mirror Assembly Mounting Screws	11 lbf·ft (15 N·m)
Door Interior Trim Panel Screws	40–50 lbf·in (450–550 N·cm)
Door Pull Handle Screws	54–71 lbf·in (600–800 N·cm)
Mirror Back Cover Mounting Screws	13–17 lbf·in (145–190 N·cm)
Mirror Actuator Mounting Screws	13–17 lbf·in (145–190 N·cm)

Table 1, Torque Values

Safety Precautions

⚠ 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

The vehicle is equipped with electronic control units. Serious damage to ECUs and components may result when welding unless the following precautions are taken.

- **Never allow an electronic component to be situated between the ground electrode and the weld site.**
- **Never lay welding cables on, near, or across any electronic component or wiring.**
- **Protect electronic components and wiring near the weld site from heat and splatter.**

1. Apply the parking brakes and chock the tires.
2. From the batteries, disconnect all negative cables first, then the positive cables, and prevent them from making connection with the frame or any other electrically conductive surface.
3. If a supplemental restraint system (SRS) is installed, disconnect it.
4. Disconnect all wiring from electronic control modules near the weld site, including any installed by the customer.
5. Attach the ground electrode as close as possible to the weld site (within 18"). Remove paint, rust, and grease to provide a clean, bare-metal connection for the ground electrode.
6. After welding work is completed, apply touch-up paint to protect the parts.

Cab Water-Leak Detection

If water has been detected inside the cab, use the following procedure to help determine points of entry into the cab. If a leak is not suspected, this method should not be used to locate points of potential water entry, as high pressure air will escape through passages where water will not enter.

1. Apply the parking brakes and chock the 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 seal perimeter (especially the upper and lower outboard corners)
    - front wall to A-pillar interface
    - marker lights
    - roof deflector mounts (if so equipped)
    - coach joint
    - sleeper roof side windows (if present)
7. Mark areas of suspected leaks.

NOTE: Bubbles around door seals, baggage doors, and along the vehicle side walls will likely not cause water intrusion issues. Bubbles forming at the mirror arm do not indicate a water leak path to the cab interior.

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.

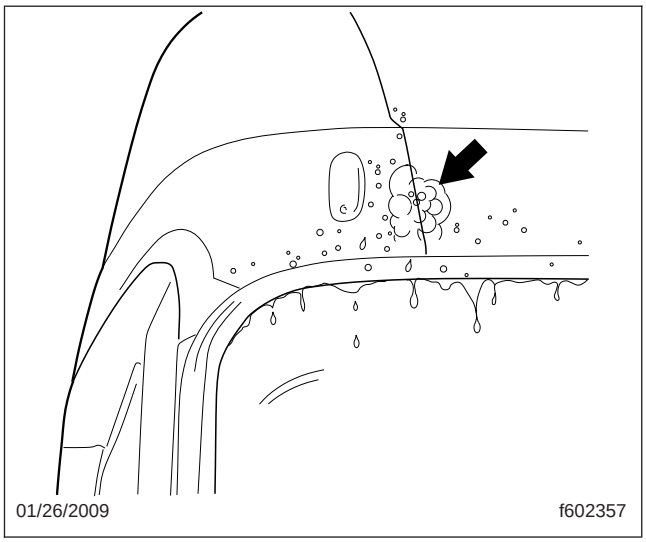


Fig. 1, Cab Water-Leak Detection with Wash Solution

10. Remove the tape from the cab exhausters.

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 Seal

Repair leaks in the windshield seal using the approved method and adhesive. Refer to **Section 60.02** for instructions on windshield seal repair.

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.

General Information

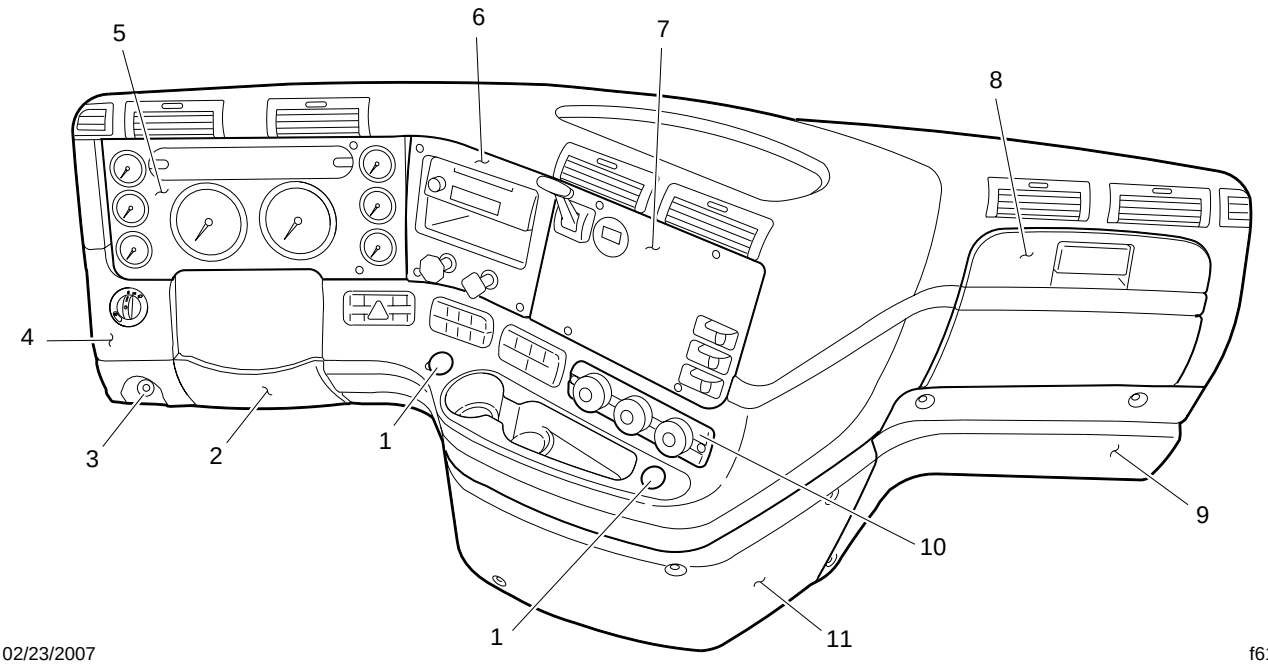
The dash is a one-piece bonded assembly with removable dash panels for easy access to instruments and wiring; see **Fig. 1**. The dash panel fasteners are exposed for easy accessibility. There are no overlapping trim pieces to hinder panel removal. Each dash panel can be independently removed for ease of access behind the dash.

The glovebox can be removed to access the cab signal detection and activation module (SAM).

The lower cover can be removed to access the ABS module, the J1939, and the central gateway (CGW).

The auxiliary instrument panel can be removed to access the vehicle control unit (VCU), attached to the inside of the dash.

On the lower right, the HVAC cover can be removed to access the HVAC unit.



1. Power Outlet
2. Driver's Knee Bolster
3. Ignition Switch
4. Headlamp Switch Cover
5. Driver Instrument Panel
6. Radio Trim Panel
7. Auxiliary Instrument Panel
8. Glovebox
9. HVAC Cover
10. HVAC Control Panel
11. Lower Cover

Fig. 1, Dash Panels

Dash Panels Removal and Installation

NOTE: All dash panels can be independently removed and installed; see **Fig. 1**. To replace a damaged lower fascia panel, follow the procedure in **Subject 120**. To remove and install the other panels, see the procedures below.

NOTICE

The dash surface can be scratched during dash panel removal. Protect the dash surface with masking tape or a cover before removing dash panels.

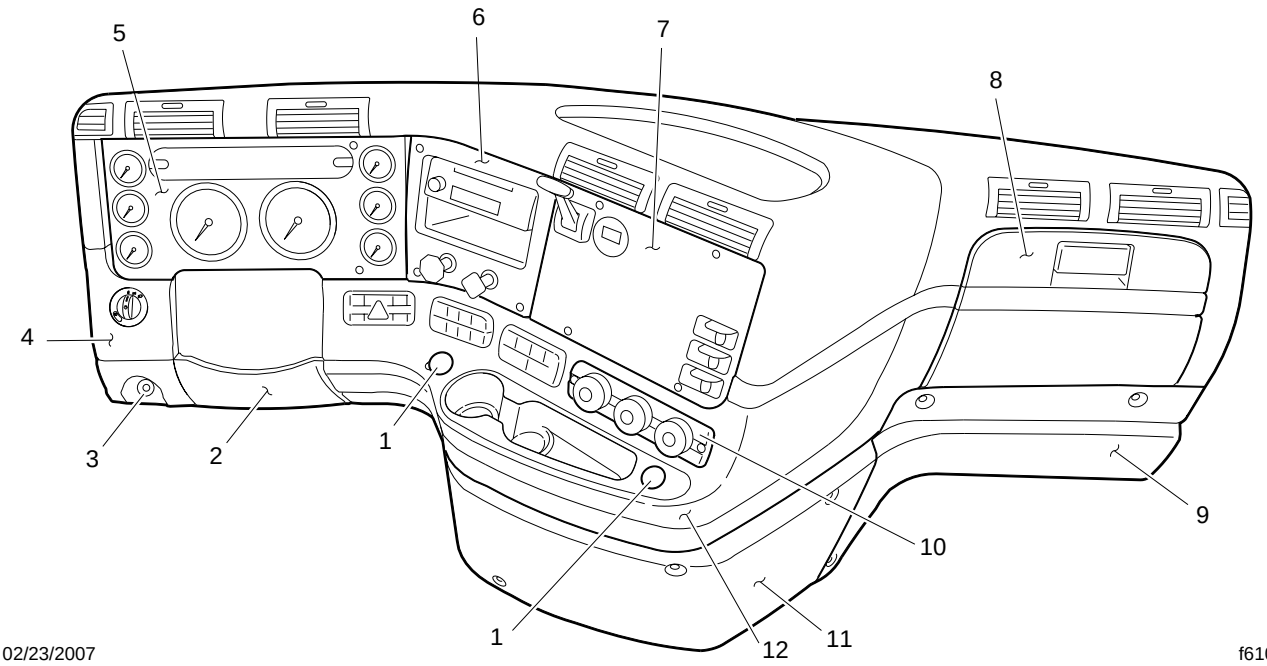
Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. If removing the ICU, 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. Disconnect the batteries.
4. Remove the dash lower cover by removing the four Torx screws, and the lower left Torx screw on the HVAC cover.
5. Remove the driver's knee bolster by removing the four Torx screws.
6. Remove the HVAC cover on the passenger side by removing five Torx screws (four Torx screws, if the dash lower cover has been removed). Disconnect the electrical connector from the footwell light at the back of the panel.



1. Power Outlet
2. Driver's Knee Bolster
3. Ignition Switch
4. Headlamp Switch Cover
5. Driver Instrument Panel
6. Radio Trim Panel
7. Auxiliary Instrument Panel
8. Glovebox
9. HVAC Cover
10. HVAC Control Panel
11. Lower Cover
12. Lower Fascia Panel

Fig. 1, Dash Panels

Dash Panels Removal and Installation

7. Remove the glove box assembly by removing the four Torx screws; see **Fig. 2**.

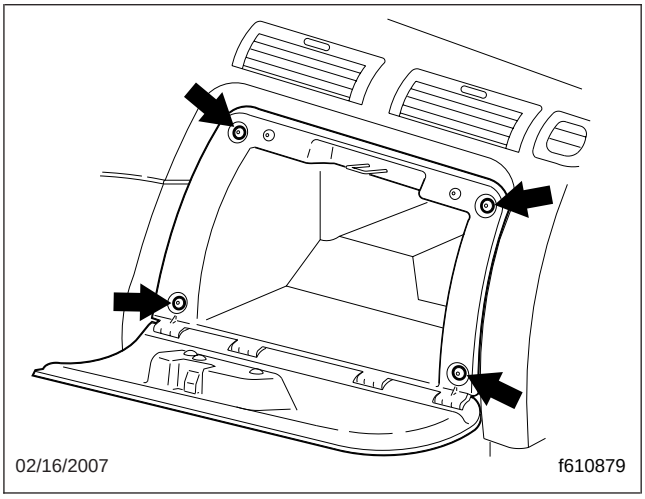


Fig. 2, Glovebox Assembly Fasteners

8. Remove the driver instrument panel by removing the four Torx screws. Disconnect the two electrical connectors and the two air lines from the back of the ICU.
9. Pull off the parking brake knob and the trailer air supply knob.
10. Remove the radio trim panel by removing the four Torx screws.
11. Remove the auxiliary instrument panel. Disconnect the air lines and electrical connectors on the back.

NOTE: Depending on the instrument panel configuration, other gauges and switches may need to be disconnected before the panel can be removed.

12. Remove the parking brake valve, by removing the four Torx screws. Mark and disconnect the air lines on the back of the valve.
13. Remove the radio from the radio housing, using the tools supplied with the unit.
14. Remove the headlamp switch cover by pulling it straight back from the dash.

Installation

1. Clip the headlamp switch cover onto the dash.
2. Install the radio into the radio housing.
3. Connect the air lines to the back of the parking brake valve. Attach the parking brake valve to the dash with four Torx screws. Tighten the screws 25 to 40 lbf·in (280 to 450 N·cm).
4. Connect the air lines and/or electrical connectors to the back of the auxiliary instrument panel. Install the panel on the dash with four Torx screws. Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm).
5. Install the radio trim panel on the dash with four Torx screws.
6. Install the parking brake knob and the trailer air supply knob.
7. Connect the two air lines and the two electrical connectors to the back of the ICU.
8. Install the driver instrument panel on the dash with four Torx screws. Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm).
9. Attach the glove box assembly to the dash with four Torx screws; see **Fig. 2**. Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm).
10. Connect the electrical connector to the footwell light on the back of the HVAC cover on the passenger side.
11. Attach the HVAC cover to the dash with five Torx screws (four Torx screws, if the dash lower cover is not installed). Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm).
12. Install the driver's knee bolster, using four Torx screws. Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm).
13. Install the dash lower cover, using five Torx screws (including the lower left screw on the HVAC cover). Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm).
14. Connect the batteries.

Removal

1. Apply the vehicle parking brakes and chock the tires.
2. If removing the ICU, drain all air from the air tanks.
3. Disconnect the batteries.
4. Remove the dash panels; see **Subject 100**.
5. Remove the steering column covers, as follows.

   5.1 Remove the four screws on the lower cover; see **Fig. 1**.

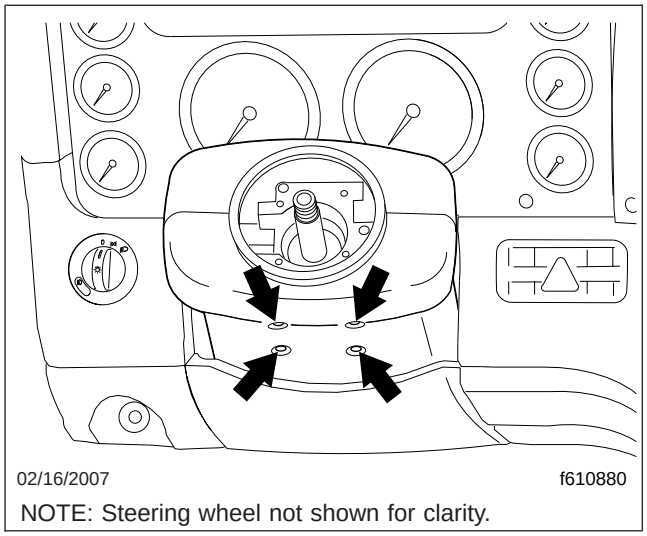


Fig. 1, Lower Steering Column Cover Fasteners

   5.2 Remove the two screws on the top cover.

6. Remove the steering column, to make room for dash removal; see **Group 46**.
7. Remove the headlight switch, by removing the two Torx screws; see **Fig. 2**.
8. Remove the ignition switch, by removing the nut on the outside.
9. Disconnect the driver-side footwell light.
10. Disconnect vehicle control unit (VCU) wiring, and pull the VCU loose from the inside of the dash; see **Fig. 3**.
11. Disconnect and remove the power outlets; see **Fig. 4**.

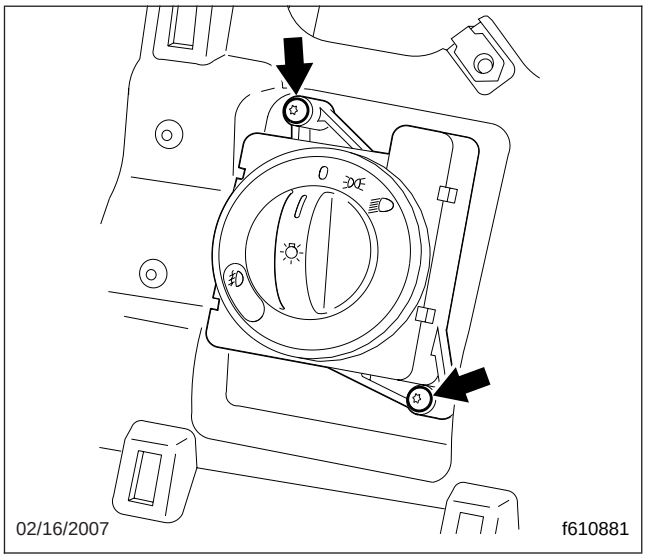


Fig. 2, Headlight Switch Fasteners

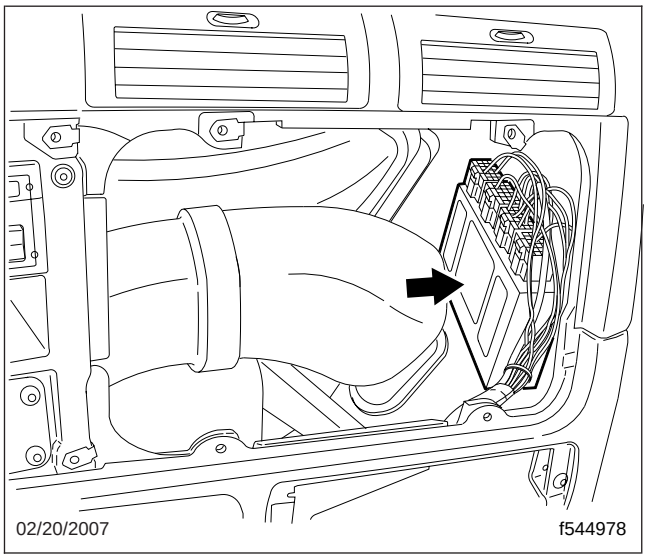


Fig. 3, Vehicle Control Unit (VCU)

12. Remove the dash front trim panels along the windshield.
13. Remove the five Torx screws and washers at the front of the dash, along the windshield.
14. From underneath, remove the four screws that attach the antenna multiplier plate, on top of the steering column, to the dash. Remove the plate and the antenna multiplier; see **Fig. 5**.

Dash Removal and Installation

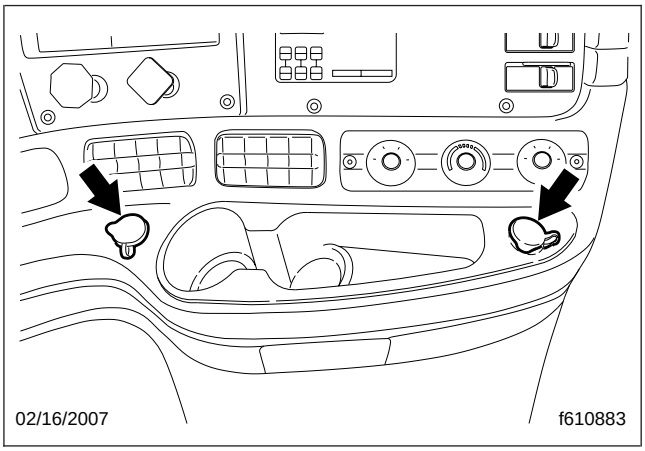


Fig. 4, Power Outlets

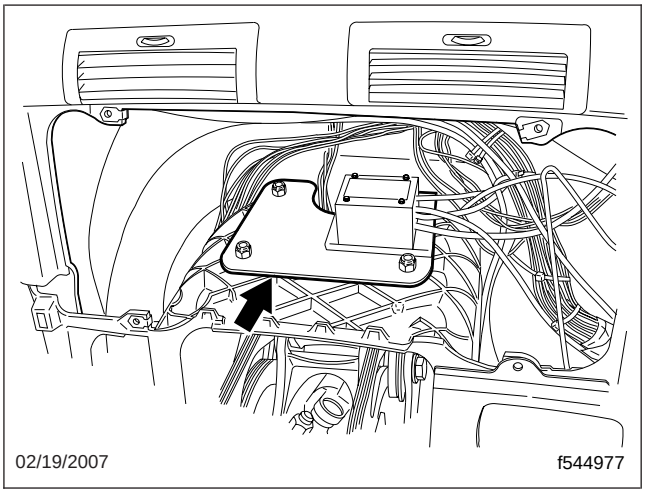
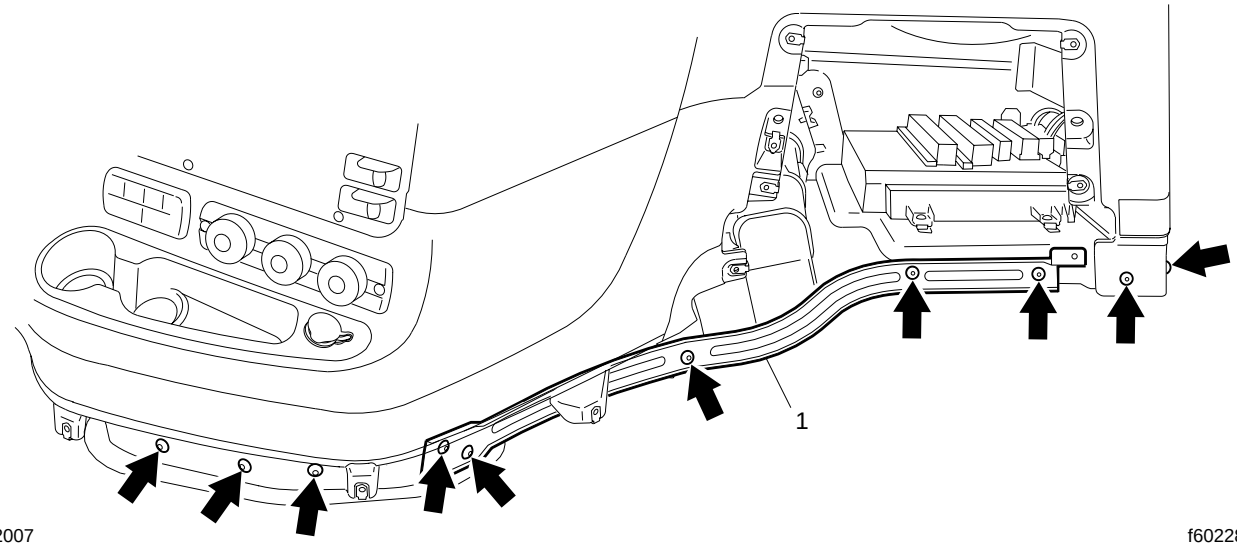


Fig. 5, Antenna Multiplier Plate

15. Remove the ten Torx screws along the center and right bottom of the dash. Remove the right-hand dash brace; see **Fig. 6**.
16. Remove the dash.

Installation

1. Position the dash in the cab.
2. Install the dash with ten Torx screws, along with the right-hand dash brace; see **Fig. 6**. Tighten the screws 32 to 50 lbf·in (360 to 565 N·cm).
3. Install the antenna multiplier plate inside the dash, above the steering column, with four screws; see **Fig. 5**.
4. Install the five Torx screws in the front of the dash, along the windshield. Tighten the screws 32 to 50 lbf·in (360 to 565 N·cm).
5. Install the dash front trim panels along the windshield.
6. Connect the power outlets; see **Fig. 4**.
7. Connect and install the VCU inside the center section of the dash; see **Fig. 3**.
8. Connect the driver-side footwell light.
9. Install the ignition switch. Tighten the nut on the outside.
10. Install the headlight switch with two Torx screws; see **Fig. 2**. Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm). Do not overtorque.
11. Install the steering column; see **Group 46**.
12. Install the four screws on the lower steering column cover and install the upper and lower steering column covers; see **Fig. 1**. Tighten the screws 26 to 34 lbf·in (295 to 385 N·cm).
13. Install the dash panels; see **Subject 100**.
14. Connect the batteries.
15. Remove the chocks.



1. Right-Hand Dash Brace

Fig. 6, Lower Dash Fasteners

Lower Fascia Panel Replacement

NOTICE

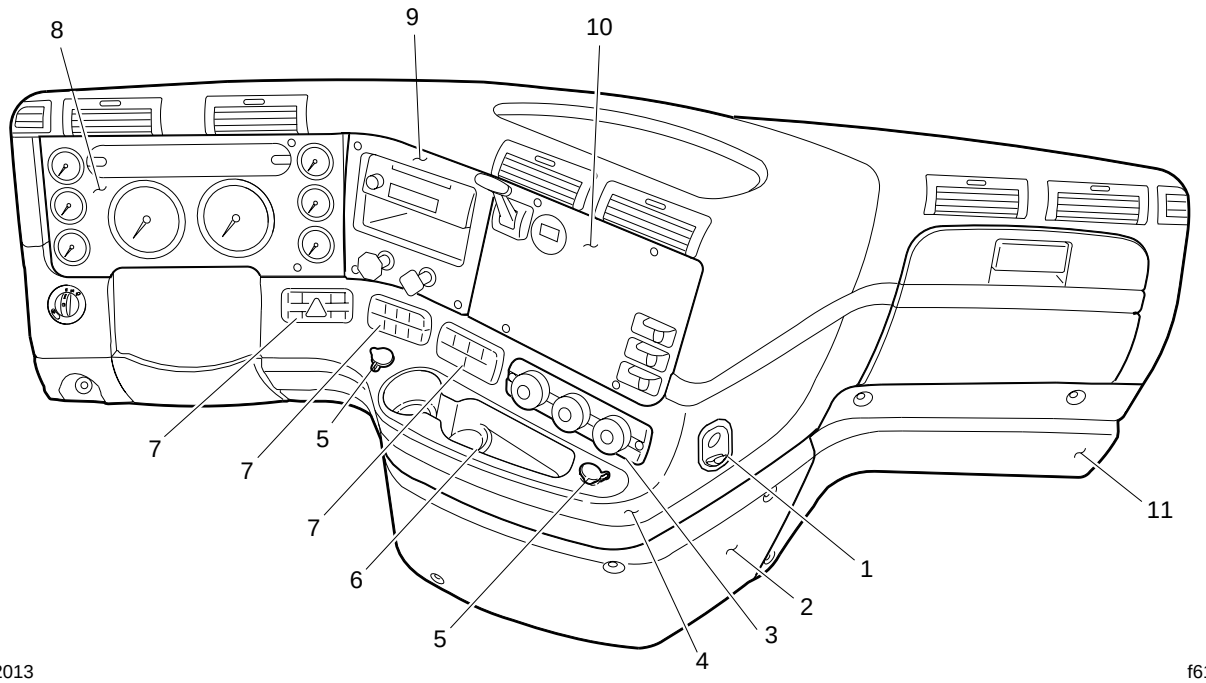
The dash surface can be scratched during dash panel removal. Protect the dash surface with masking tape or a cover before removing dash panels.

Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the batteries.
3. Remove the lower cover by removing the four Torx screws, and the lower left Torx screw on the HVAC cover. See **Fig. 1**.
4. Loosen, but do not remove, the driver instrument panel by removing the four Torx screws.
5. Remove the auxiliary instrument panel.
6. Disconnect and remove the power outlets.
7. From underneath the dash, remove the four screws that attach the dash cup holder to the lower fascia panel. See **Fig. 2**. Remove the cup folder.
8. Remove the HVAC control panel and the switch panels.
9. Remove the two screws that attach the utility hook to the lower fascia panel, then remove the hook.
10. Starting on the driver's side, pull at the lower fascia panel, detaching the panel from the heat-staked attachment points.

NOTICE

Use care when drilling through the fiberglass panel to avoid damaging components on the other side.



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1. Utility Hook
2. Lower Cover
3. HVAC Control Panel
4. Lower Fascia Panel
5. Power Outlet
6. Cup Holder
7. Switch Panel
8. Driver Instrument Panel
9. Radio Trim Panel
10. Auxiliary Instrument Panel
11. HVAC Cover

Fig. 1, Dash Panels and Components

Lower Fascia Panel Replacement

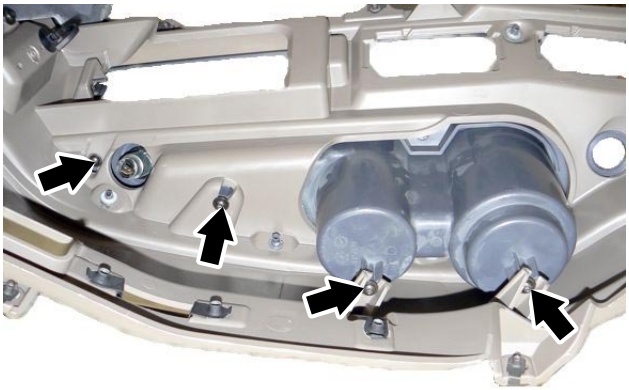

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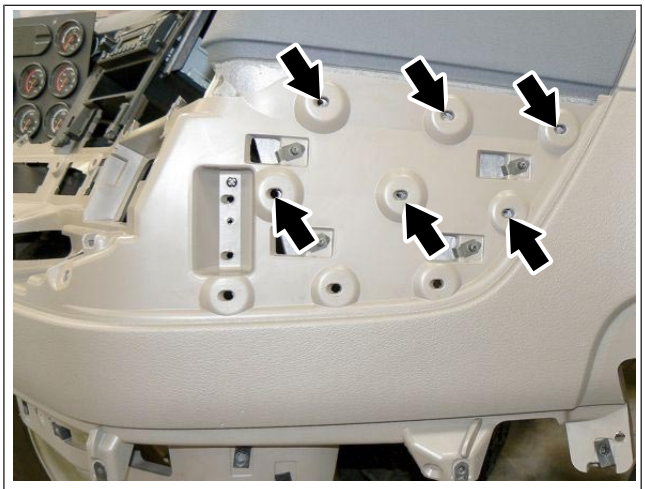
Fig. 2, Cup Holder Screws

11. Locate the six top holes on the passenger's side of the dash wing. Using a 1/4-inch drill bit and the existing holes as pilot holes, drill through the backing fiberglass panel. Use care to drill only through the fiberglass panel and no farther. See **Fig. 3**.



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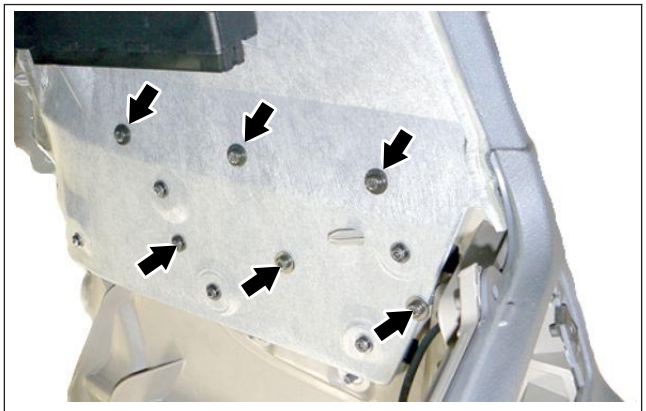
Using a 1/4-inch drill bit, drill through the backing fiberglass panel at the indicated holes.

Fig. 3, Lower Fascia Attachment Holes

12. Position a new lower fascia panel on the dash. Install six #10 self-tapping flanged screws (no longer than 1/2 inch) through the drilled holes. See **Fig. 4**. Tighten the screws only until the head touches the fiberglass panel; do not overtighten.



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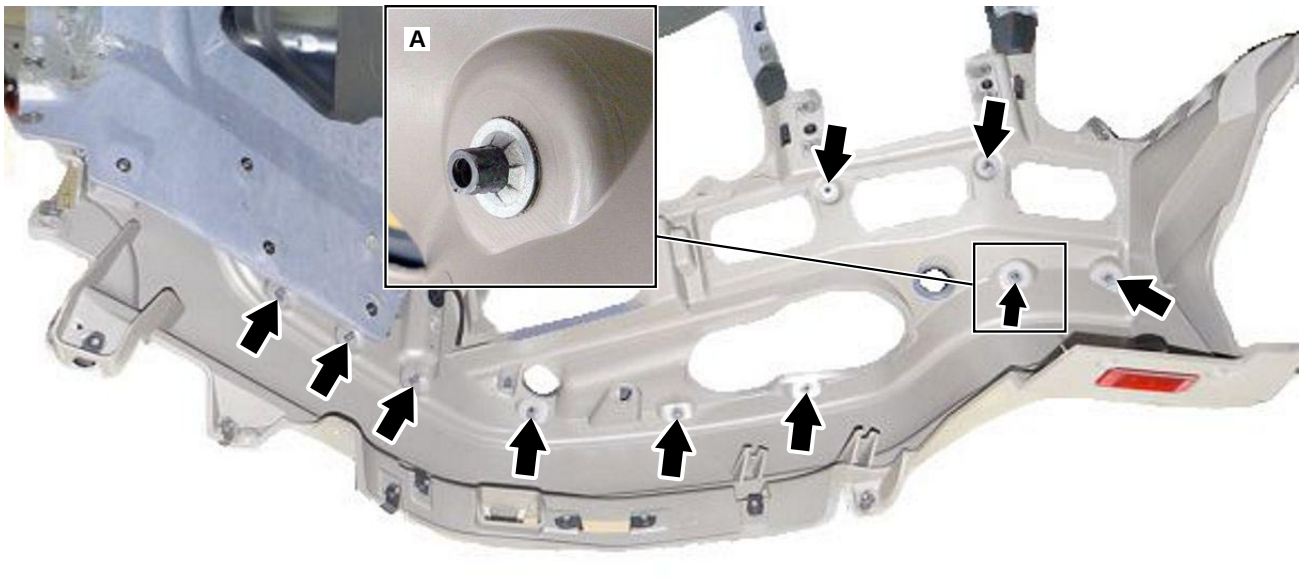
NOTE: View from the driver's position.

Fig. 4, Self-Tapping Flanged Screw Locations

13. From underneath the dash, install ten 1/4-inch push nuts on the heat-stake studs. See **Fig. 5**.
14. Install the utility hook.
15. Install the primary instrument panel.
16. Install the auxiliary instrument panel.
17. Install the HVAC control panel and the switch panels.
18. Attach the cup holder to the fascia panel with four screws. See **Fig. 2**.
19. Connect and install the power outlets.
20. Install the lower cover.
21. Connect the batteries.



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NOTE: View from underneath the dash.

A. Installed push nut

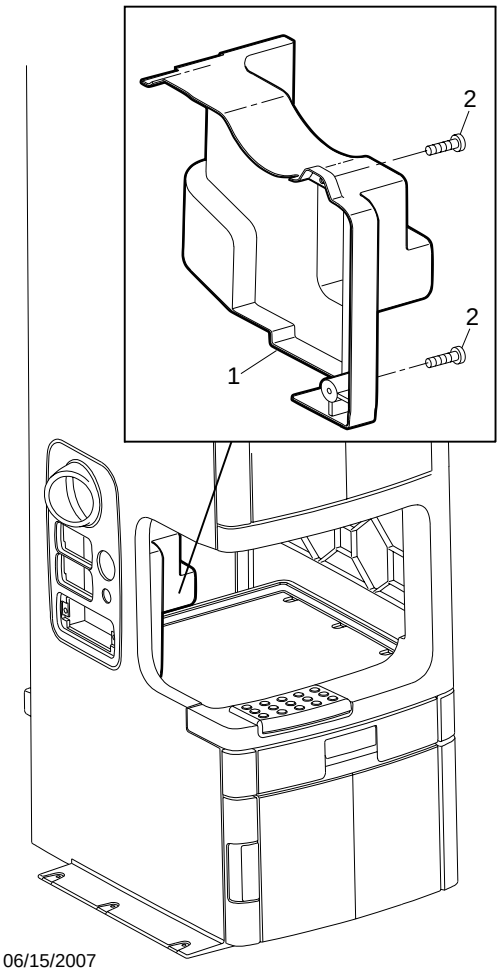
Fig. 5, Push Nut Locations

Storage Cabinet Removal and Installation

NOTE: The right-side and left-side storage cabinets are slightly different, but the procedures are similar.

Removal

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Remove the passenger seat to make room for the cabinet removal; see **Section 91.00**.
3. Fold up the upper bunk.
4. Lift up the lower bunk.
5. Remove the refrigerator, if so equipped.
6. Remove the sleeper switch panel wiring cover, if so equipped, from inside the cabinet by removing the two Torx screws that attach it to the cabinet assembly; see **Fig. 1**.
7. Remove the sleeper switch panel, if present. Disconnect the auxiliary HVAC, lights, and radio control from the back of the switch panel.
8. Pull the sleeper control panel wiring down through the hole between the compartments into the bottom compartment, and place it out of the way, in the lower compartment.
9. Remove the seat belt on the affected side, as follows.
   - 9.1 Disconnect the seat belt (if attached to the seat) from the seat intermediate-connecting-point threaded rod; see **Fig. 2**.
   - 9.2 Remove the cover from the seat belt retractor.
   - 9.3 Detach the retractor from the B-pillar interior panel and the cab wall by removing the screw at the bottom of the retractor cover.
   - 9.4 Remove the two screws that attach the upper seat belt mount to the B-pillar panel and the cab wall; see **Fig. 3**.
10. Remove the grab handle by removing the fasteners that attach the grab handle to the B-pillar cover and the cab wall.
11. Remove the tread plate by removing the three screws that attach it to the door frame.
12. Remove the interior B-pillar cover, as follows.



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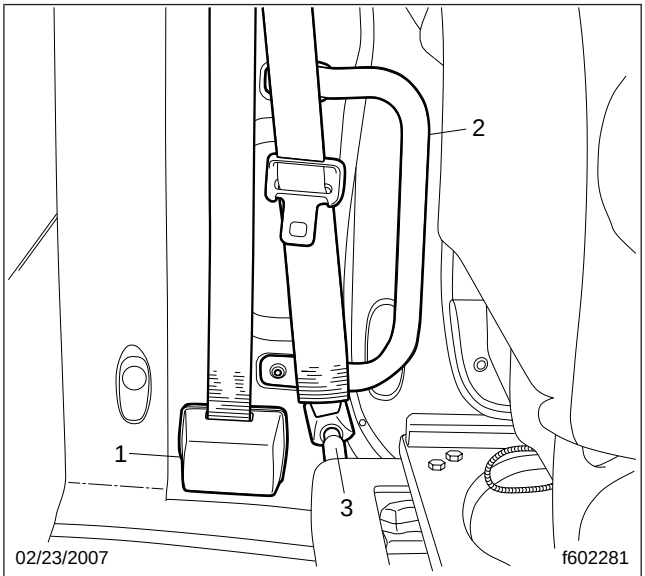
1. Switch Panel Wiring Cover
2. Torx Screw

Fig. 1, Sleeper Switch Panel Wiring Cover

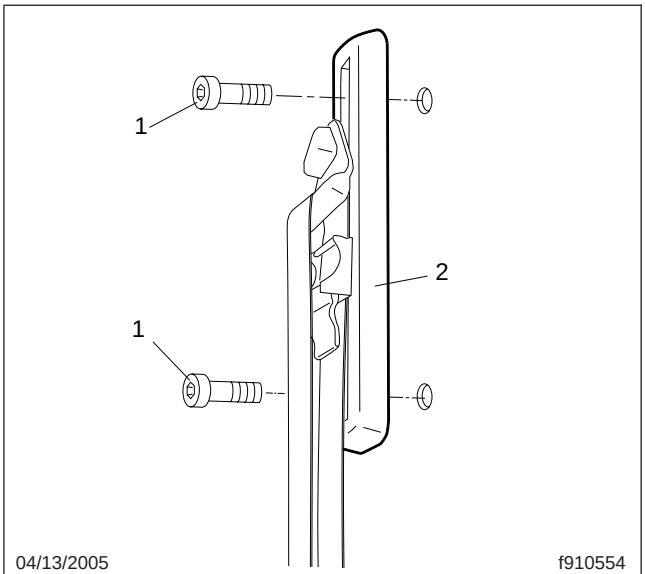
   - 12.1 Remove the screw that attaches the interior B-pillar cover to the bottom of the door opening.
   - 12.2 Remove the Christmas-tree fasteners that attach the cover to the B-pillar.
   - 12.3 Pull the cover off the B-pillar.
13. Remove the two Torx screws and washers that attach the brackets at the top of the cabinet to the sleeper roof; see **Fig. 4**.

Storage Cabinet Removal and Installation



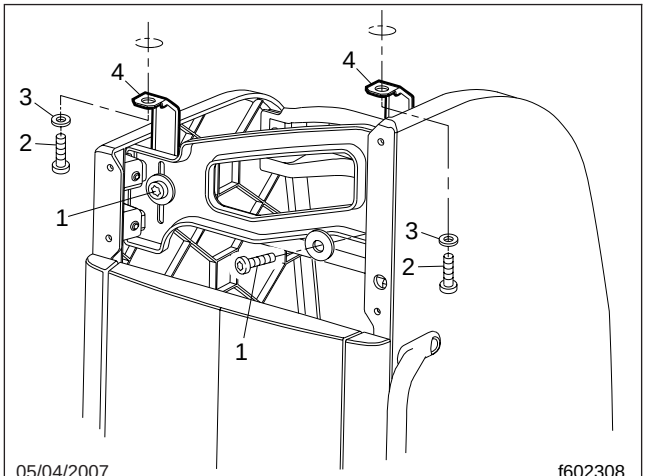
1. Seat Belt Retractor
2. Grab Handle
3. Intermediate-Connecting-Point Threaded Rod

Fig. 2, Grab Handle and Seat Belt Installation



1. Torx Capscrew
2. Upper Seat Belt Mount

Fig. 3, Upper Seat Belt Mount



1. Upper Bracket Screw
2. Torx Screw
3. Washer
4. Upper Bracket

Fig. 4, Upper Cabinet Fasteners

14. Loosen the screws that attach the brackets to the cabinet assembly, and slide the brackets down.
15. Remove the two screws and washers that attach the cabinet to the cab side wall behind the seat; see **Fig. 5**.
16. Inside the cabinet, remove the screws and washers that attach the cabinet to the sleeper wall; see **Fig. 6**.
17. Remove the upper cabinet from the lower cabinet or the auxiliary HVAC housing, as applicable.

    To remove the upper cabinet from the lower cabinet, remove the six screws and washers from inside the upper cabinet.

    To remove the upper cabinet from the auxiliary HVAC housing, remove the three screws from inside the upper cabinet, and the three screws aft, outside the cabinet; see **Fig. 7** and **Fig. 8**.
18. As applicable, remove the lower cabinet or auxiliary HVAC housing. The lower cabinet is attached to the cab floor with four screws and washers. The auxiliary HVAC housing is attached to the cab floor with five screws and washers, and to the cab wall with two screws and washers.

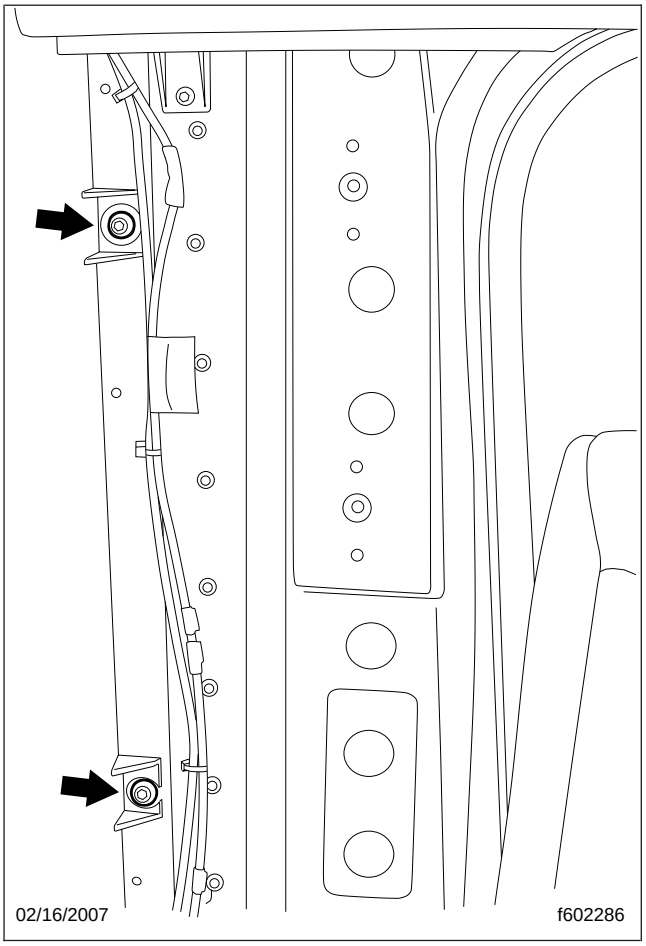


Fig. 5, Cabinet-to-Side Wall Fasteners Behind Seat

Installation

1. With the vehicle tires chocked, install the lower cabinet or auxiliary HVAC housing, as applicable. The lower cabinet is attached to the cab floor with four screws and washers. The auxiliary HVAC housing is attached to the cab floor with five screws and washers, and to the cab wall with two screws and washers.
2. Install the upper cabinet on top of the lower cabinet or auxiliary HVAC housing, as applicable. To attach the upper cabinet to the lower cabinet, install the six screws and washers inside the upper cabinet. To install the upper cabinet to the auxiliary HVAC housing, install the three screws inside the upper cabinet, and the three screws aft, outside the cabinet; see **Fig. 7** and **Fig. 8**.

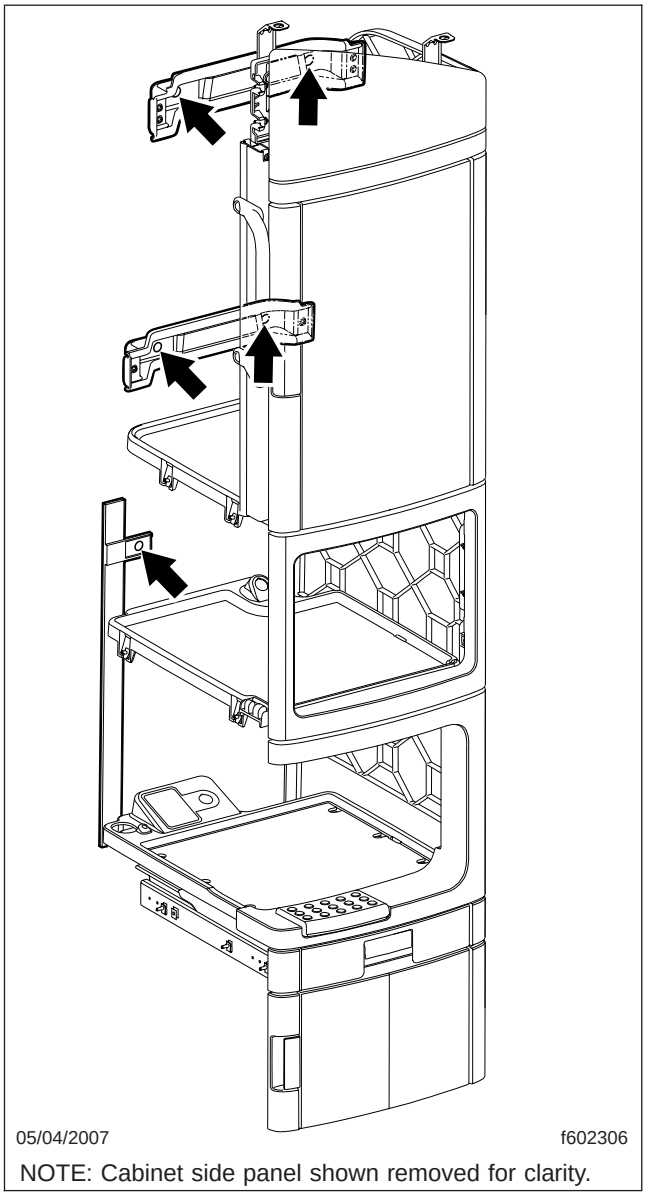


Fig. 6, Cabinet-to-Sleeper Wall Fasteners Inside Cabinet

3. Inside the cabinet, install the screws and washers that attach the cabinet to the sleeper wall; see **Fig. 6**.
4. Install the two screws and washers that attach the cabinet to the cab wall behind the seat; see **Fig. 5**.

Storage Cabinet Removal and Installation

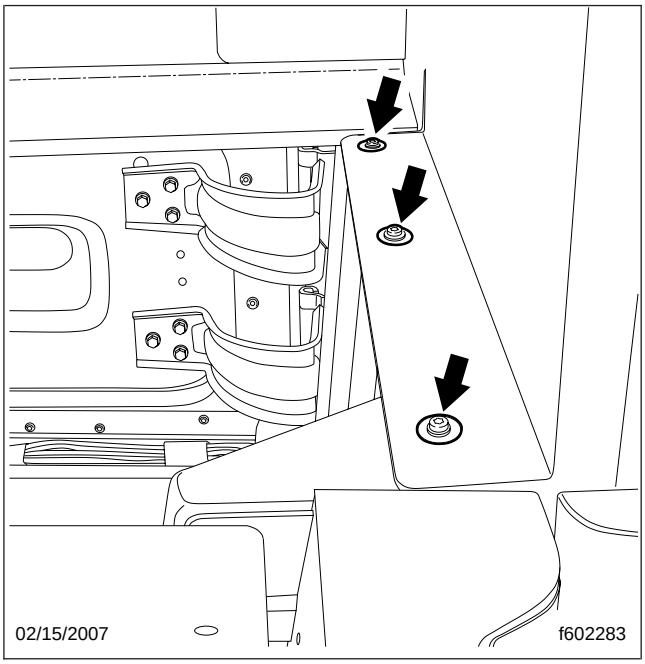


Fig. 7, Cabinet-to-Auxiliary HVAC Housing Fasteners, Aft Side

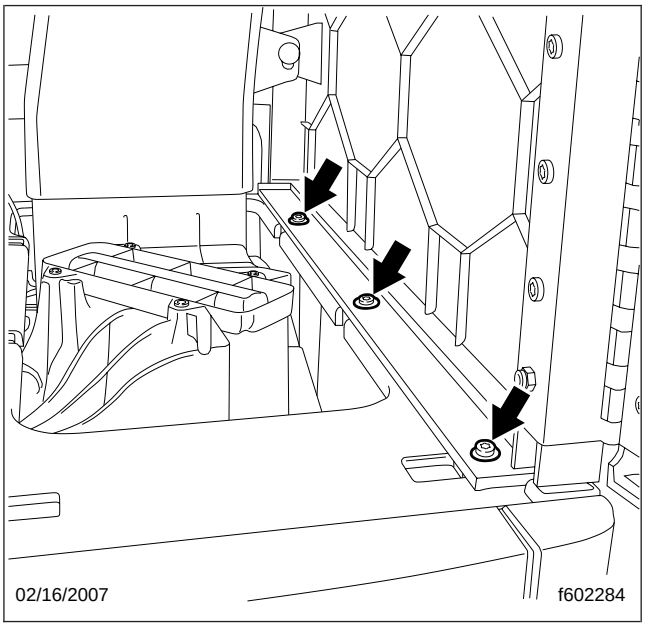
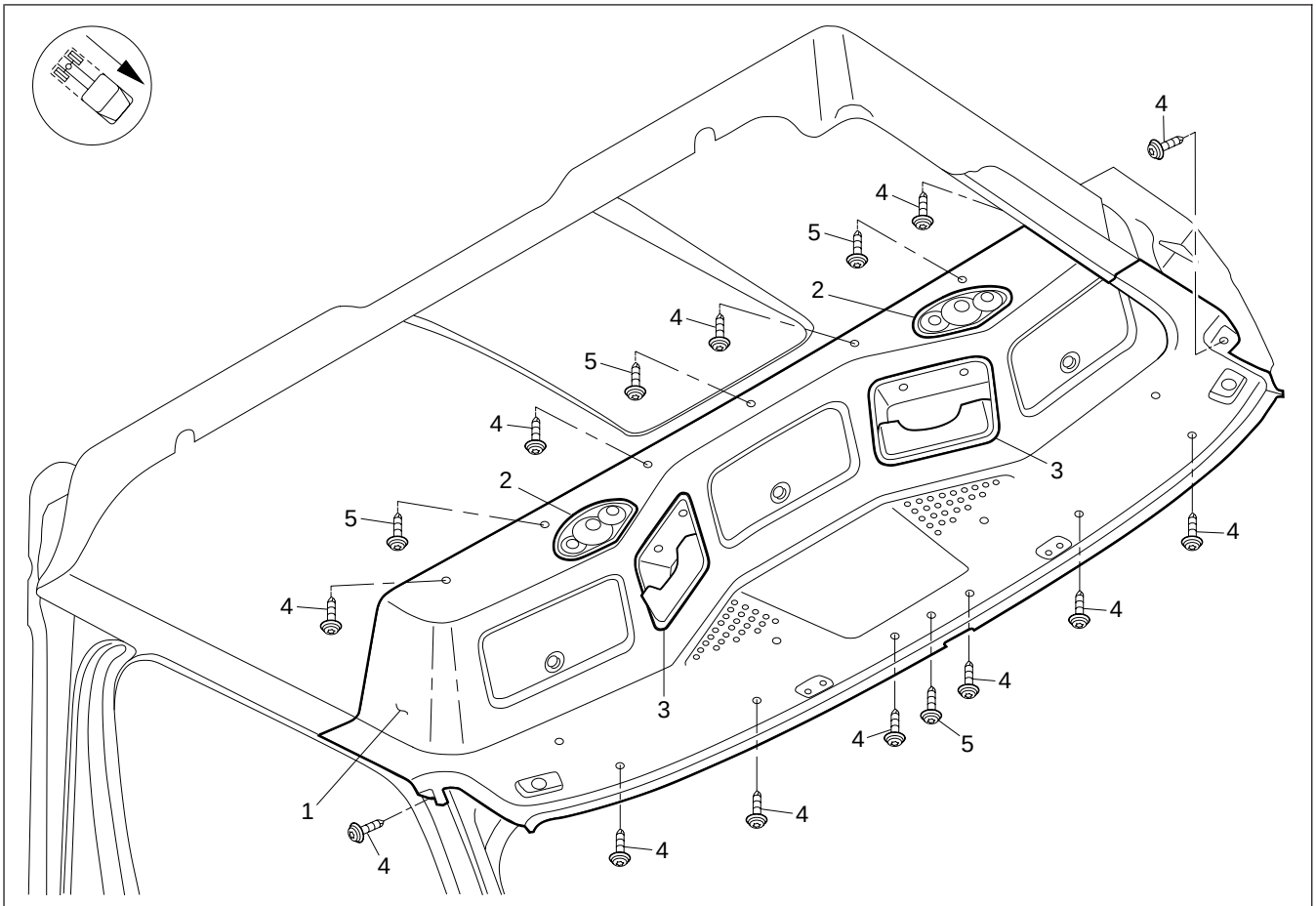


Fig. 8, Upper Cabinet-to-Auxiliary HVAC Housing Fasteners, Inside Cabinet

5. Slide up the two brackets at the top of the cabinet, and using the screws and washers, attach them to the sleeper roof; see **Fig. 4**.
6. Tighten the screws that attach the two brackets to the cabinet assembly.
7. Install the B-pillar cover, as follows.
   - 7.1 Position the B-pillar cover on the side wall.
   - 7.2 Attach the cover to the B-pillar with Christmas-tree fasteners.
   - 7.3 Attach the B-pillar cover to the bottom of the door opening with a screw.
8. Attach the tread plate to the bottom of the door opening with three screws.
9. Attach the grab handle, using two screws, to the B-pillar cover and the cab side wall; see **Fig. 2**.
10. Install the seat belt on the affected side, as follows.
    - 10.1 Install the upper seat belt mount on the B-pillar cover and the cab wall with two screws.
    - 10.2 Attach the seat belt retractor to the bottom of the B-pillar cover and the cab wall.
    - 10.3 Install the cover on the seat belt retractor.
    - 10.4 If the seat is installed, connect the seat belt to the intermediate-connecting-point threaded rod.
11. Pull the sleeper switch panel wiring back through the hole between the compartments up into the main compartment.
12. Connect the wiring to the back of the sleeper switch panel. Attach the control panel to the cabinet.
13. Attach the sleeper switch panel wiring cover to the inside of the cabinet with two Torx screws; see **Fig. 1**.
14. Install the refrigerator, if so equipped.
15. Lower the lower bunk.
16. Install the passenger seat; see **Section 91.00**.
17. Remove the chocks.

Overhead Console Removal and Installation

To gain access to the air horn mechanism and the marker light wiring, the overhead console has to be removed. Removal of the overhead storage bins requires removal of the console as well; see **Fig. 1**.



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NOTE: Some right-hand structure not shown for clarity.

1. Overhead Console
2. Overhead Light
3. Sunglasses Pocket
4. Torx Screw
5. Speed-Clip Torx Screw

Fig. 1, Overhead Console Installation

Removal

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Remove the Torx® screws that attach the curtain tracks to the overhead console and sidewall covers above the doors. Remove the curtain tracks and curtains.
3. Snap the two overhead lights from the console, and disconnect the wiring.
4. Remove the two overhead sunglasses pockets by removing the two Torx screws located at the top of each pocket.
5. Remove the sun visors from the overhead console by removing the four Torx screws that attach each sunvisor to the console.

Overhead Console Removal and Installation

6. Remove the two Torx screws that attach each sunvisor clip to the overhead console.
7. Pull the driver-side A-pillar cover loose from the A-pillar. The cover is held in place with clips, and at the bottom with a tab that fits into a slot on the A-pillar; see **Fig. 2**.

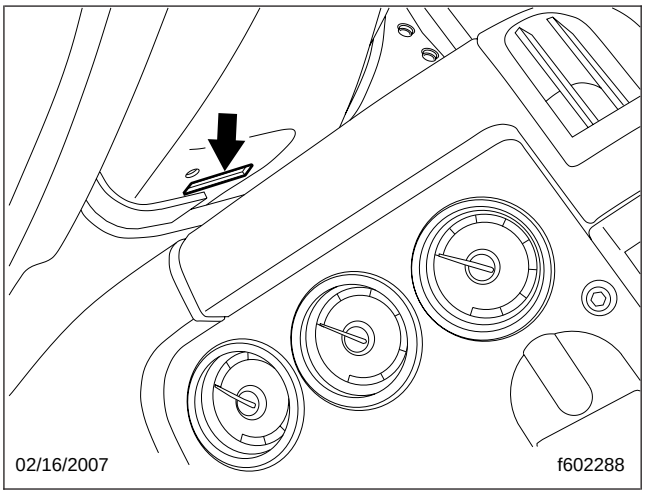


Fig. 2, A-Pillar Slot

8. Remove the grab handle from the passenger-side A-pillar cover by removing the two screws that attach it to the A-pillar.
9. Through the storage pocket openings, disconnect the antenna cable and any electrical connectors.
10. With an assistant helping to hold the console in place, remove the 16 Torx screws that attach the console to the roof; see **Fig. 1**.
11. Using care, twist the top of the passenger-side A-pillar cover enough to allow the lip of the console to be slipped from under it. Remove the console from the vehicle.

Installation

1. With the tires chocked, and with the help of an assistant, position the console in place. The top of the loosened passenger-side A-pillar cover has to be carefully twisted out of the way to allow the lip of the console to fit under it.
2. With the assistant helping to hold the console in place, make sure that the wiring and antenna connectors will be accessible after the console is installed, then position the console into place.
3. Install the speed-clip Torx screws first for alignment; see **Fig. 1**.
4. Install the remaining Torx screws that attach the console to the roof.
5. Connect any electrical connectors and the antenna.
6. Install the driver-side A-pillar cover, making sure that the tab on the bottom edge is engaged in the slot on the A-pillar panel; see **Fig. 2**. Attach the cover to the A-pillar with the Torx screws.

NOTE: Make sure that the door seal is not folded under the edge of the A-pillar cover. If it is, pull it out so it folds over the edge of the cover.

7. Install the grab handle on the passenger-side A-pillar cover with the two Torx screws.
8. Attach the sunvisor clips to the overhead console with two Torx screws each.
9. Attach the sunvisors to the overhead console with four Torx screws each.
10. Install the two sunglasses pockets in the overhead console. Attach them to the console with two Torx screws each.
11. Connect the overhead light wiring, and clip the light fixtures to the overhead console.
12. Install the curtain tracks and curtains in the vehicle. Attach the curtain tracks to the overhead console and sidewall covers with Torx screws.
13. Remove the chocks.

General Information

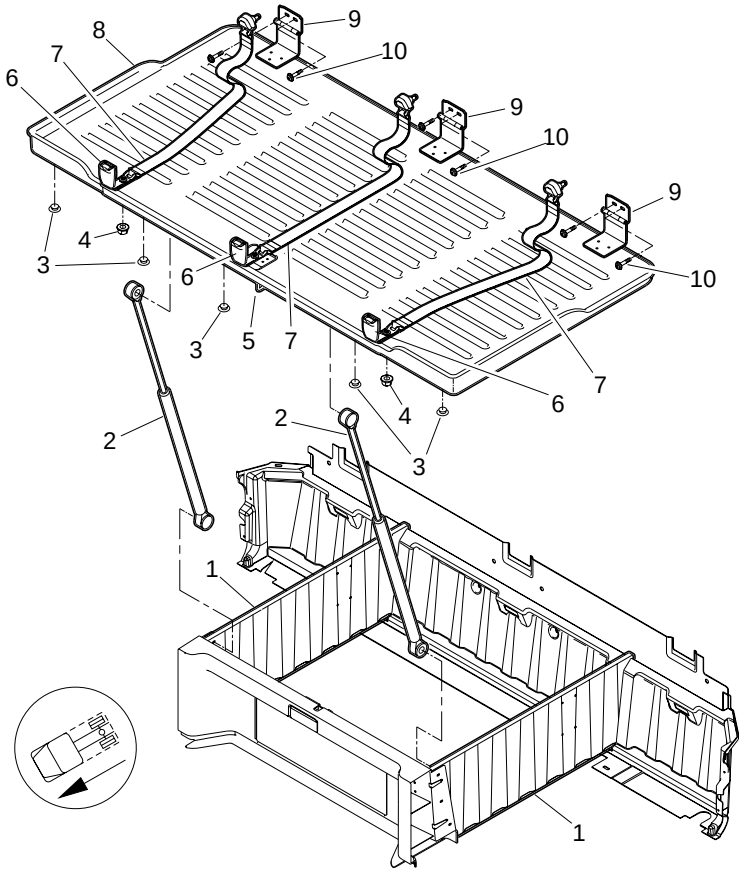
The sleeper bunks are manufactured of molded plastic. The lower bunk rests on top of the sleeper storage compartment, and can be folded up to access the storage. Three hinges attach the lower bunk to the back wall. Gas struts mounted underneath the bunk help lift the bunk to the folded position.

The upper bunk, if so equipped, rests on the "halo" trim that wraps around the side and back walls of the interior. Struts are mounted at both ends of the bunk, and two strikers secure the folded-up bunk against the back wall. In lieu of an upper bunk, an optional fixed (non-foldable) upper storage shelf is available for some sleeper cabs.

Lower Bunk Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Unbuckle the bunk restraint netting, and position it out of the way.
3. Remove the mattress.
4. Remove the three bunk restraint straps, as follows; see **Fig. 1**.
   - 4.1 Tilt the bunk up, and remove the bolts and nuts that attach the restraint buckles to the bunk.
   - 4.2 Lower the bunk, and remove the capscrews and spacers that attach the straps to the back wall. Remove the straps.
5. To make room to maneuver the bunk out of the cab, remove the two dividers in the luggage compartment. The forward ends of the dividers are attached to the bunk forward support with two Torx screws.
6. Tilt the bunk up. While supporting the bunk, use a flat-tip screwdriver to unclip the retainer from the upper ball-joint of each support strut; see **Fig. 2**. Pop the struts loose from the ball studs on the underside of the bunk.



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1. Storage Compartment Divider
2. Support Strut
3. Bumper
4. Nut
5. Striker
6. Restraint Buckle
7. Restraint Strap
8. Lower Bunk
9. Hinge
10. Capscrew

Fig. 1, Lower Bunk Installation

Lower Bunk Removal and Installation

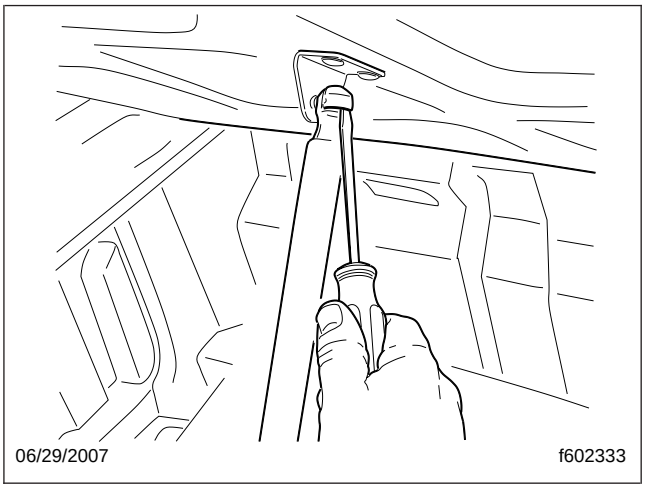


Fig. 2, Removing Strut Retaining Clip

7. Lower the bunk, and remove the two Torx screws that attach each bunk hinge to the back wall.

NOTE: Cover the dash and door with protective cloth to prevent damage when removing the bunk. Move the seats all the way back, and swing the arm rests to an upright position.

8. Remove the bunk from the cab.

Installation

1. With the vehicle tires chocked, place the bunk in position.
2. Attach the bunk hinges to the back wall with Torx screws; see **Fig. 1**.
3. While supporting the bunk in a raised position, attach the struts to the ball studs on the underside of the bunk. Push the retaining clips on the ball joints.
4. Install the two luggage compartment dividers, using Torx screws to attach them to the bunk forward support.
5. Install the three bunk restraint straps, as follows.
   - 5.1 Lower the bunk, and attach the straps to the back wall with the capscrews and spacers. Tighten the capscrews 35 to 45 lbf·ft (48 to 61 N·m).

⚠ CAUTION

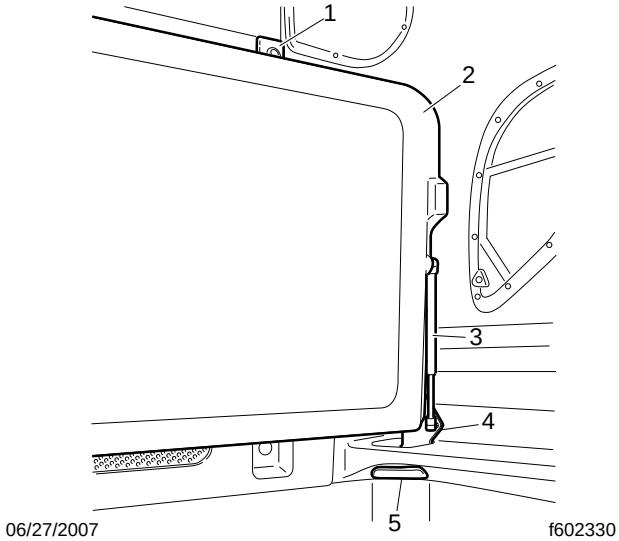
Do not overtighten the fasteners that attach the bunk restraint buckles to the bunk. Overtightening the fasteners can crush the molded plastic shell of the bunk.

   - 5.2 Tilt the bunk up, and attach the straps to the bunk with the bolts and nuts. Tighten the nuts 10 to 20 lbf·ft (14 to 27 N·m).
6. Place the mattress on the bunk.
7. Move the restraint netting back into position.
8. Remove the chocks.

Upper Bunk Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the mattress from the upper bunk pan.
3. Unbuckle the bunk restraint, if so equipped, and move it out of the way.
4. Tilt the upper bunk up, and latch it securely.
5. Remove the bunk lights (if so equipped) from the "halo" trim panel corners, as follows; see **Fig. 1**.



1. Striker
2. Upper Bunk Pan
3. Strut
4. Hinge Bracket
5. Bunk Light

Fig. 1, Upper Bunk (shown folded up)

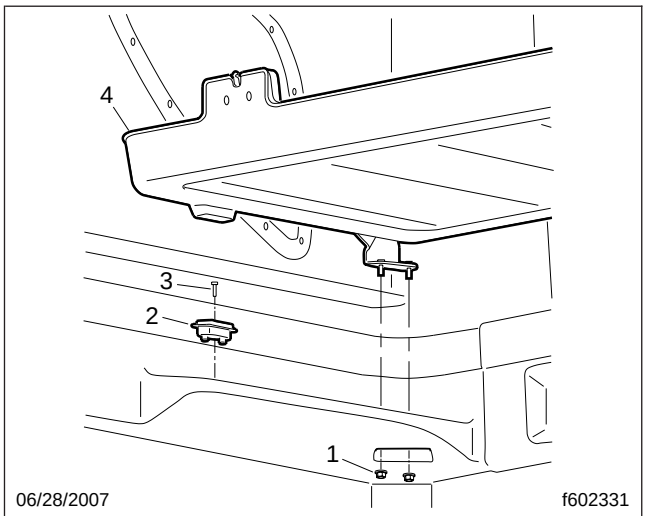
5.1 Snap off the lens from the light fixture.

5.2 Remove the light fixture from the trim panel.

5.3 Disconnect the electrical wiring from the light fixture.

NOTE: If there is no light fixture under the upper bunk bracket, pop off the plastic plug.

6. Through the light-fixture opening, remove the nuts and washers that attach the bunk to the bracket at each end of the bunk; see **Fig. 2**.
7. Cover the brackets, studs, and latches on the bunk with protective cloth, and remove the bunk from the cab.



1. Flanged Nut
2. Bumper
3. Screw
4. Upper Bunk Pan

Fig. 2, Upper Bunk Installation

Installation

1. With the vehicle tires chocked, place the upper bunk in the sleeper, remove the protective cloth, and make sure that the studs on the bunk hinge brackets are positioned through the holes in the support brackets. Latch the bunk strikers to the back wall.
2. Through the light-fixture opening, install the washer and nut on the stud, one at each end of the bunk; see **Fig. 2**.
3. Install the light fixtures, if so equipped, as follows; see **Fig. 1**.

3.1 Connect the electrical wiring to the light fixture.

3.2 Install the light fixture in the opening.

3.3 Snap the lens on the light fixture.

NOTE: If there is no light fixture, install the plastic plug in the opening.

4. Unlatch and lower the bunk.
5. Place the mattress on the bunk.
6. Remove the chocks.

Specifications

For fastener torque values, see **Table 1**.

Torque Values	
Description	**Torque**
Bunk Restraint Strap-to-Back Wall Capscrews	35–45 lbf·ft (48–61 N·m)
Bunk Restraint Strap-to-Bunk Nuts	10–20 lbf·ft (14–27 N·m)

Table 1, Torque Values

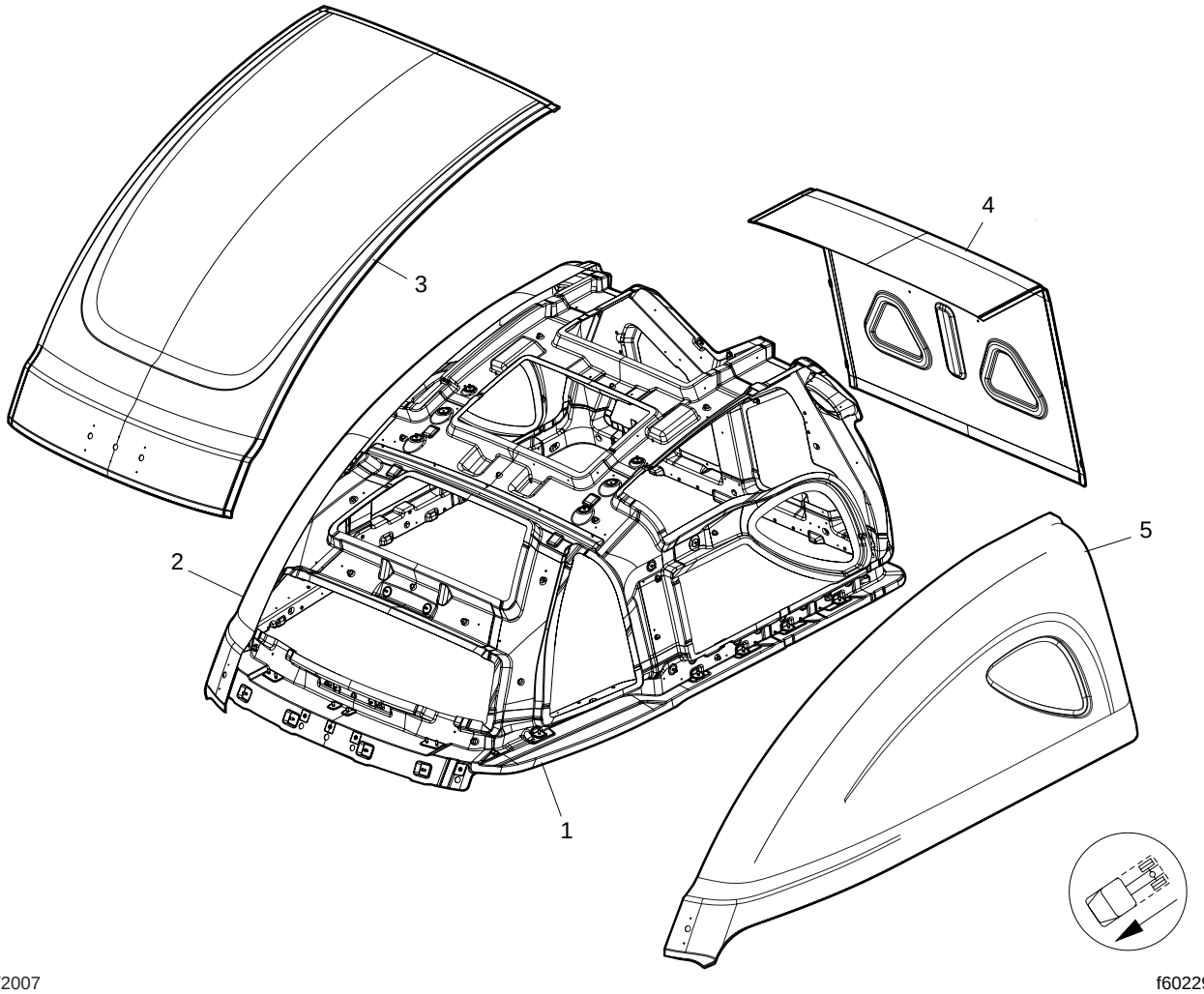
General Information

The raised roof cap exterior panels are attached to a framework of inner reinforcements; see **Fig. 1**. Insulation panels are installed in the open spaces between the inner reinforcement members; see **Fig. 2**. The soft interior trim panels are removable to access roof cap wiring.

Exterior Panel Manufacture

The exterior panels are made of glass fiber reinforced plastic (FRP) materials. FRP panels are manufactured using both male and female molds.

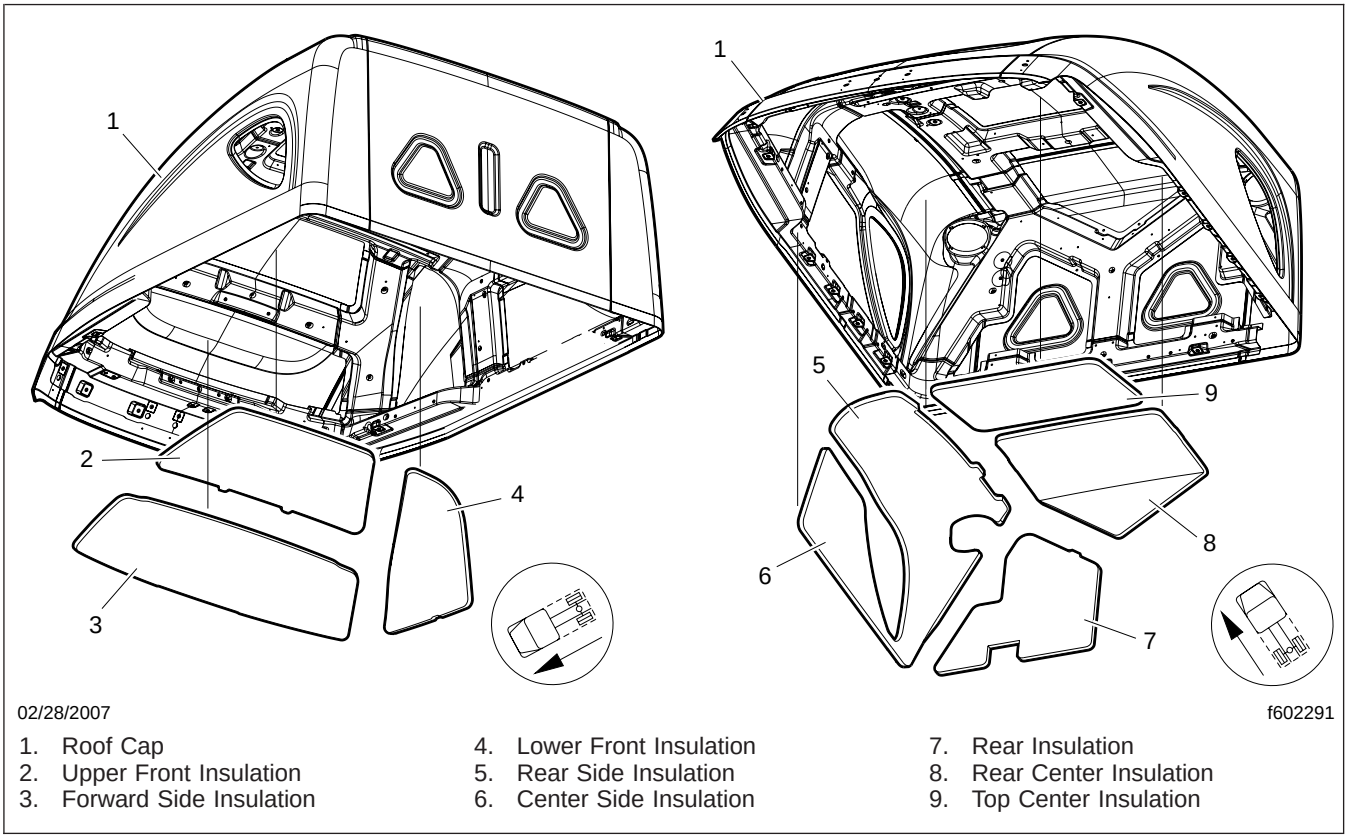
Initially, the mold halves are coated with a release agent to permit part removal after the resin hardens. Next, a glass reinforcing fabric is laid onto the male mold half. Then the resin is catalyzed and poured onto the male mold half. The mold halves are then



1. Inner Reinforcement Assembly
2. Side Panel, RH
3. Top Panel
4. Rear Panel
5. Side Panel, LH

Fig. 1, Raised Roof Cap Assembly

General Information



1. Roof Cap
2. Upper Front Insulation
3. Forward Side Insulation
4. Lower Front Insulation
5. Rear Side Insulation
6. Center Side Insulation
7. Rear Insulation
8. Rear Center Insulation
9. Top Center Insulation

Fig. 2, Raised Roof Cap Assembly

nested together, but with a gap between them in order to produce the specified thickness in the finished panel.

Heat and pressure are applied to the mold in order to cure (solidify) the resin. At the end of the process an in-mold coating is injected onto the part to prepare it for painting. 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, some holes or cutouts that were not molded are added. Remaining holes are drilled after assembly to maintain tighter tolerances.
2. All parts are cleaned and then sanded.
3. A two-part urethane adhesive is applied to the mating surfaces.
4. The panels and reinforcements 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.

If it is damaged, the cap can be repaired by following the procedures in **Subject 100**.

Inner Reinforcement Manufacture

The inner reinforcement members are molded using the SMC process. SMC, which stands for sheet molding compound, is a fiberglass and thermosetting polyester material. 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.

Repair Safety 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 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 fiberglass repair materials, wear old clothing, since the resin may damage the garment material. Wash the clothing before wearing it again.
4. Most of the liquids involved in fiberglass 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

Do fiberglass repairs in a safe workshop area to prevent 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 throwaway type or one with 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 fiberglass 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

⚠ WARNING

Before starting any raised roof repair procedure, read the safety precautions in Subject 100. Failure to be aware of the hazards in using fiberglass repair materials could result in serious and long-term health problems.

Surface damage refers to scratches, chips, or nicks on the exterior roof cap panels; see **Fig. 1**. Use the following instructions to repair surface damage.

1. Inspect the damaged area. If there are cracks which go all the way through the panel, refer to "Structural Damage Repair" for instructions.
2. Clean the area with xylene, acetone, 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. Clean the area with dry compressed shop air.
5. Apply Ashland Pliogrip 7775L self-leveling urethane adhesive 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**.

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**.

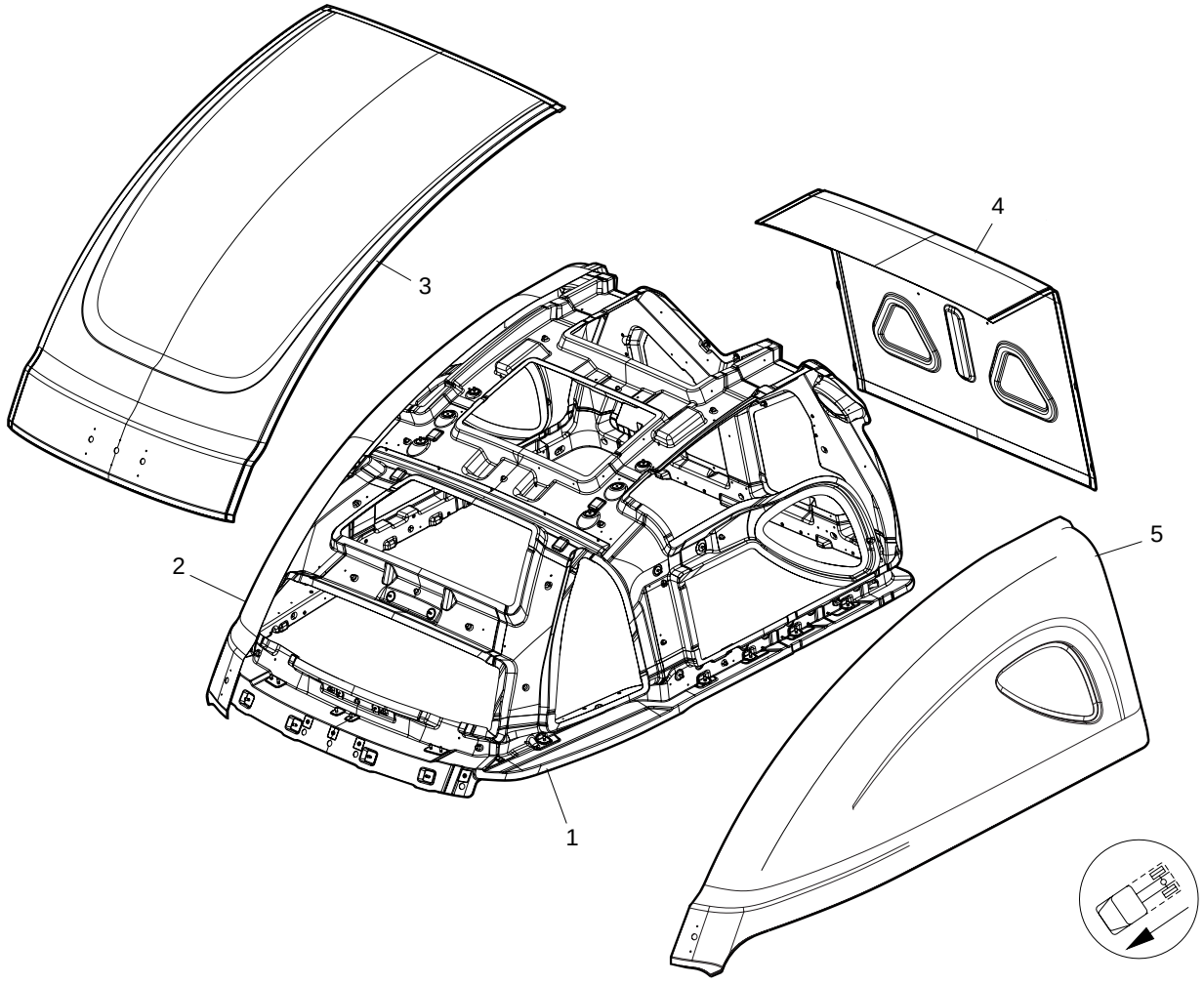
1. Examine the damage to the roof cap assembly. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, 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.
10. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip® 7775 urethane adhesive.

NOTE: When dispensing Ashland Pliogrip 7775, discard the first few inches of discolored adhesive. Apply the adhesive when a continuous bead of uniform size and color is produced.

11. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.
12. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a

Raised Roof Cap Repairs



1. Inner Reinforcement Assembly
2. Side Panel, RH
3. Top Panel
4. Rear Panel
5. Side Panel, LH

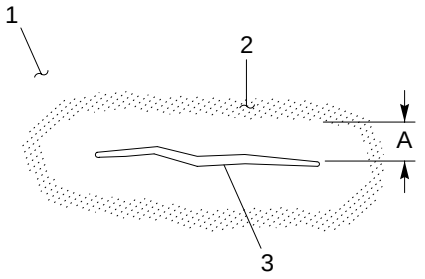
Fig. 1, Raised Roof Cap Assembly

fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.

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.



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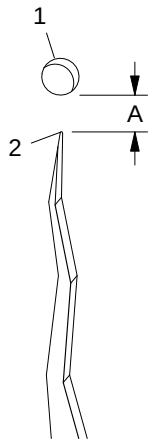
A. Remove paint and primer 1-1/2 inches (4 cm) around the damaged area. Use 220-grit or finer sandpaper.

1. Paint
2. Primer
3. Scratch

Fig. 2, Damaged Area With Paint Removed



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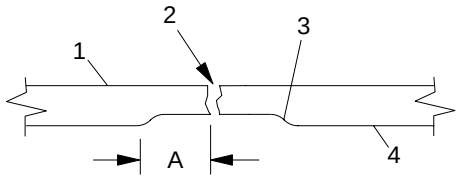
A. Drill a 1/8-inch hole, 1/8 inch (3 mm) away from the end of a crack.

1. 1/8-Inch Hole
2. End of Crack

Fig. 3, Crack Prevention

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."



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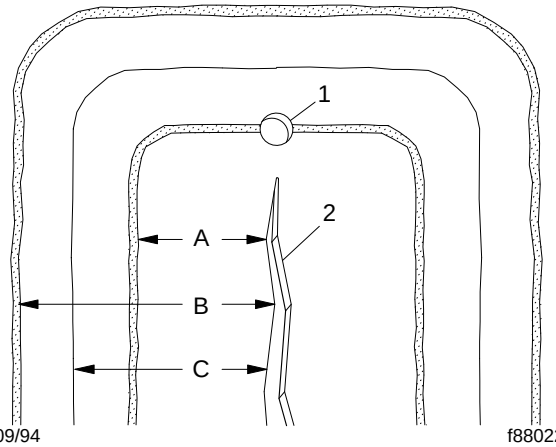
A. Grind a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Roof Panel
2. Crack
3. Slight Taper
4. Underside of Panel

Fig. 4, Recessed Area (cross-sectional view)



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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

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

Raised Roof Cap Repairs

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.

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.

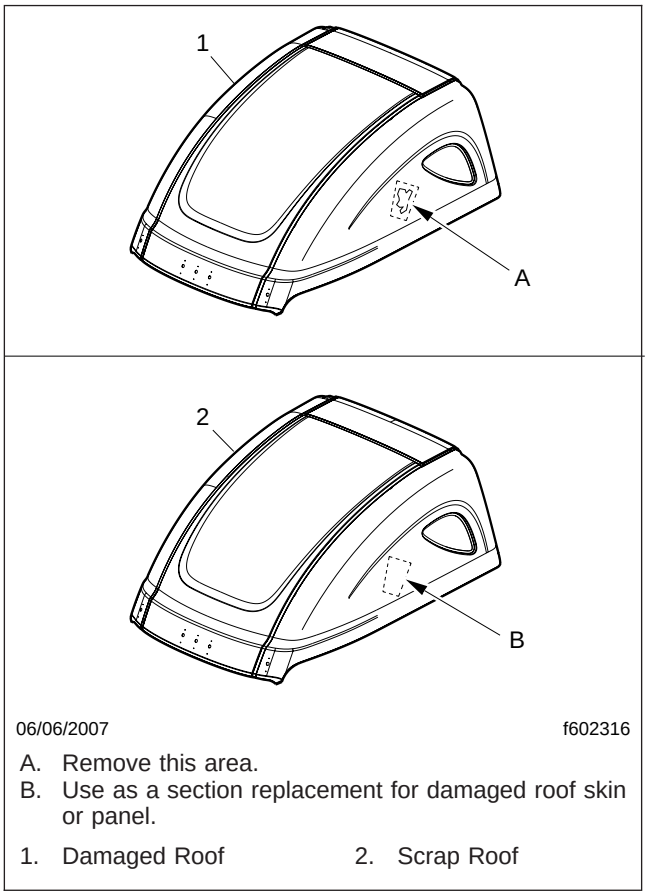
⚠ WARNING

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.



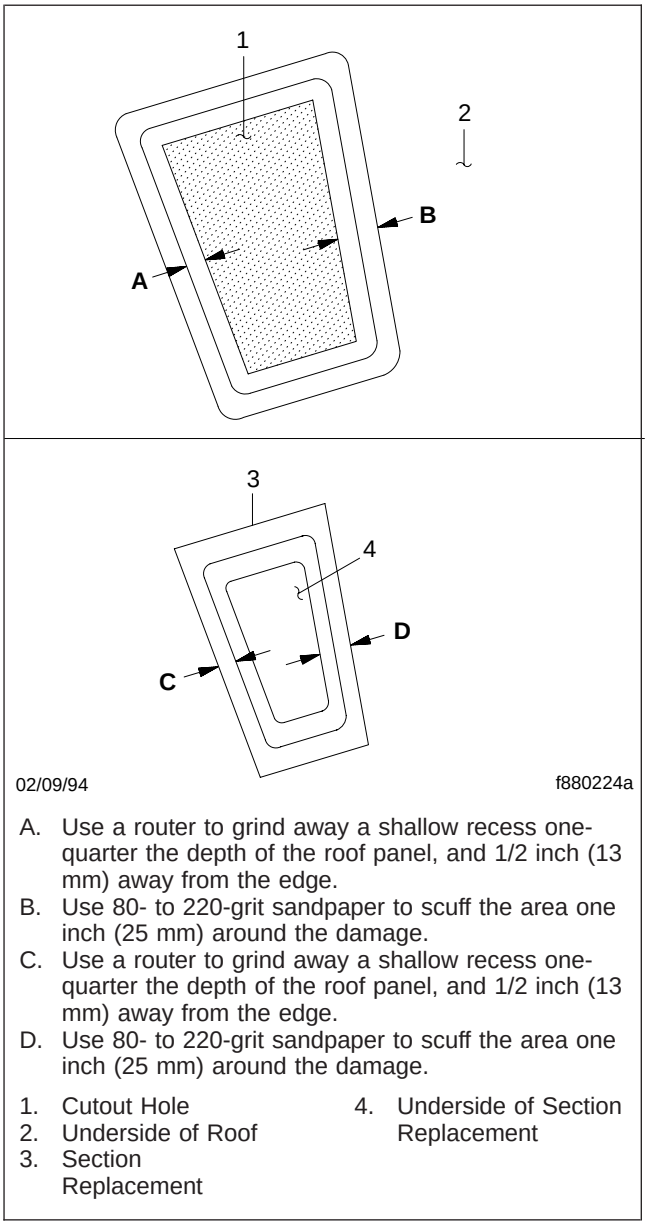
A. Remove this area.
B. Use as a section replacement for damaged roof skin or panel.

1. Damaged Roof
2. Scrap Roof

Fig. 6, Section Replacement of a Damaged Fiberglass Roof

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



A. 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. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
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.
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

it can stick. Be sure to completely sand off any undercoating sprayed on these areas.

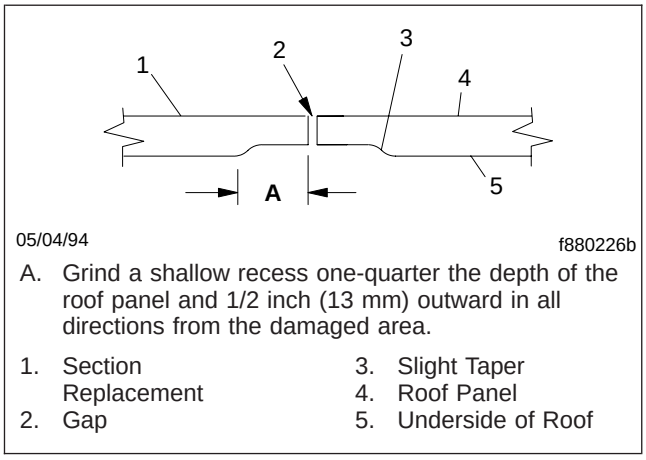
9. On the outer sides of both the cutout and the section replacement, bevel the edges about 45 degrees; see **Fig. 9**.

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.

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**.

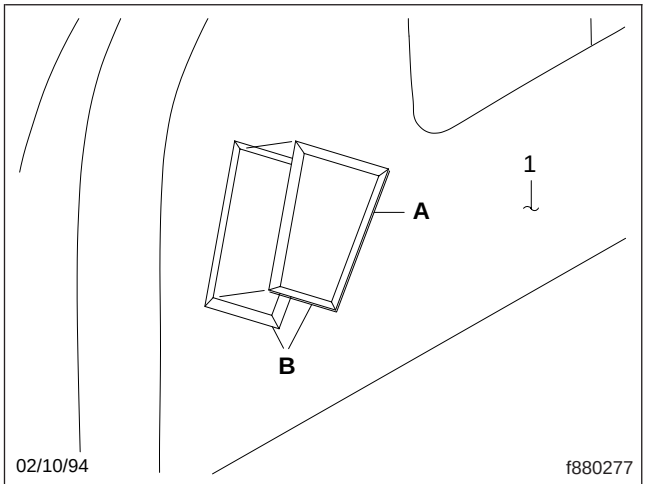
    12.1 Cut some scrap FRP into strips. Make enough strips to hold the section replace-



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)

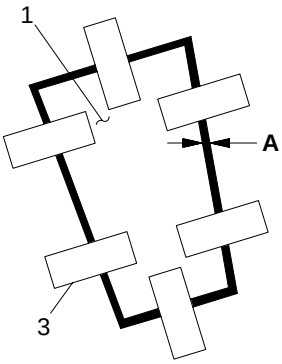


A. Insert section replacement.
B. Bevel outer surface edges on all sides.

1. Exposed Side of Roof

Fig. 9, Areas to be Beveled

Raised Roof Cap Repairs



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

ment 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.

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.

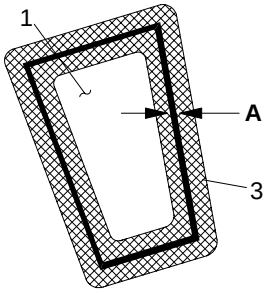
12.4 Holding the section replacement in position, bond the strips to both roof and replacement panels in the area already scuffed. Use Ashland Pliogrip 7773 to bond the strips.

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**.



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

14. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

NOTE: When dispensing Ashland Pliogrip 7775L, discard the first few inches of discolored adhesive. Apply the adhesive when a continuous bead of uniform size and color is produced.

15. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.

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.
2. Scuff the surfaces of the outer FRP panels with 80- to 220-grit sandpaper.
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. There should be enough clamps to hold the panel in place and keep the bonding surfaces together, or at least one clamp every 12 to 18 inches (30 to 45 cm). Remove the part for application of bonding agent.
5. Use the Pliogrip urethane cartridge materials 7773 or 7779, or equivalents, to bond panels together.

NOTE: When dispensing Ashland Pliogrip 7773 or 7779, discard the first few inches of discolored adhesive. Apply the adhesive when a continuous bead of uniform size and color is produced.

6. Within four minutes after applying the bead, align the part on the roof assembly and clamp it firmly in place. Tighten the clamps 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 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 7 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 1 hour. If no heat is applied, leave the bonded parts clamped together for 24 hours.

NOTE: Do not use a heat gun in excess of 180°F (82°C) when working with Ashland Pliogrip adhesive.

9. If necessary, prime and paint the repair area using the instructions under "Surface Damage Repair."

General Information

The Cascadia is available with optional side extenders and trim tabs. In the event of an accident, the side extender brackets are designed to break away to minimize damage to the cab skin.

Rubber flex extenders are attached to the trailing edges of the side extenders and trim tabs.

Flex Extender Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.

NOTE: Vehicles equipped with 20-inch side extenders and trim tabs have a retaining screw near the bottom of the flex extender.

2. Remove the flex extender from the side extender by pushing the bottom end of the flex extender inboard until it detaches from the side extender flange, then pulling the loosened end up and out.
3. Remove the flex extender from the trim tab, if so equipped, by pushing the bottom end of the flex extender inboard until it detaches from the trim tab flange, then pulling the loosened end up and out.

Installation

1. Apply soapy water to the side extender and trim tab to make installation easier.
2. With the tires chocked, install the flex extender on the side extender flange. Starting at the bottom, push the flex extender onto the side extender flange. Then, while pressing on the flex extender from the outboard side, work a windshield pick or screwdriver upward on the inboard side, folding the edge of the flex extender onto the flange; see **Fig. 1**. Support the flex extender upright while working upward from the bottom.

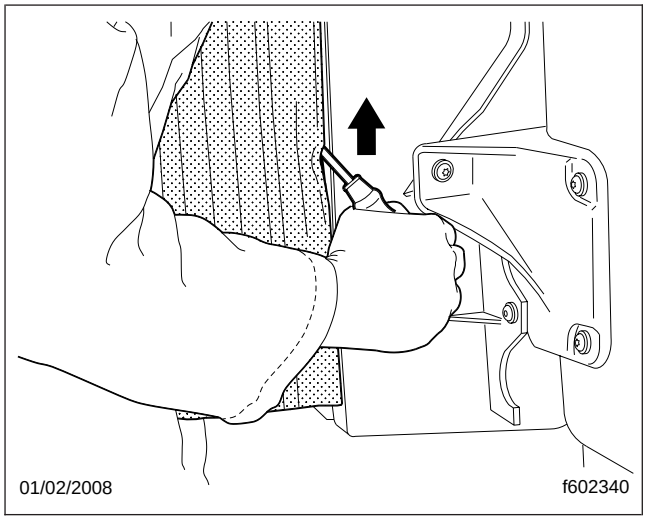


Fig. 1, Installing the Flex Extender

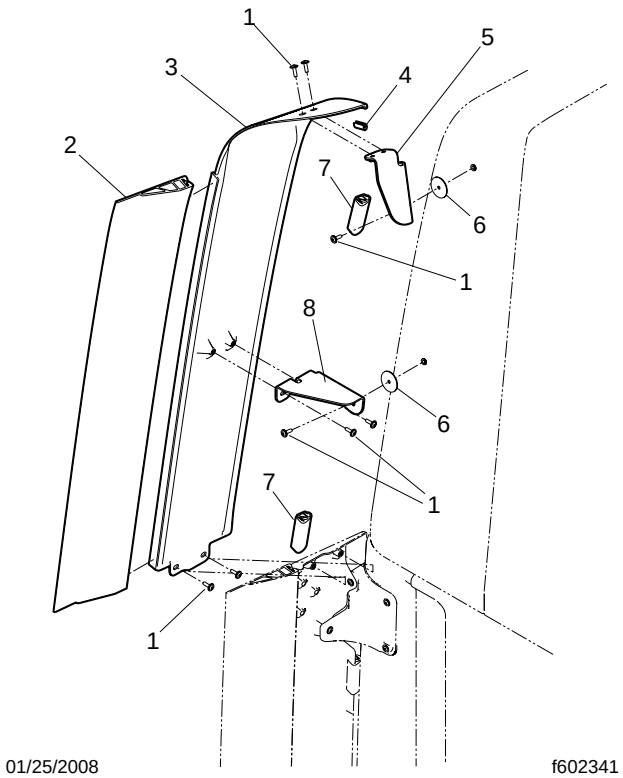
NOTE: Use care not to damage painted surfaces when using the tool to install the flex extender.

3. If the vehicle is equipped with trim tabs, slip the trim tab flex extender onto the trim tab flange at the top, then pull it down to the stop at the bottom.
4. Remove the chocks.

Trim Tab Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the two M6 x 12 screws that attach the bottom of the trim tab to the side extender; see **Fig. 1**.



NOTE: LH trim tab shown.

1. Torx Screw, M6 x 12
2. Flex Extender
3. Trim Tab
4. Edge Trim
5. Upper Trim Tab Bracket
6. Seal
7. Standoff Bumper
8. Lower Trim Tab Bracket

Fig. 1, Trim Tab Installation

3. Remove the two M6 screws that attach the trim tab brackets to the cab roof. Remove the trim tab.
4. If replacing the trim tab, remove the rubber flex extender from the trim tab; see **Subject 100**.

Installation

1. If replacing the trim tab, attach the rubber flex extender, brackets, standoff bumpers, and edge trim to the new trim tab, as follows; see **Fig. 1**.
   - 1.1 Install the flex extender on the trim tab; see **Subject 100**.
   - 1.2 Install the upper and lower trim tab brackets on the inboard surface of the new trim tab, using M6 x 12 screws. Tighten the screws 75 to 105 lbf·in (530 to 720 N·cm).
   - 1.3 Press two rubber standoff bumpers onto the forward edge of the trim tab.
   - 1.4 Press an edge trim bumper onto the forward edge at the top of the trim tab.
2. Attach the trim tab brackets to the cab roof with M6 x 12 screws. Tighten the screws 75 to 105 lbf·in (530 to 720 N·cm).
3. Attach the bottom edge of the trim tab to the side extender with two M6 x 12 screws. Tighten the screws 75 to 105 lbf·in (530 to 720 N·cm).
4. Remove the chocks.

Side Extender Removal and Installation

NOTE: Cascadia side extender replacements require mid-span support. If the vehicle is not equipped with middle brackets, they must be installed with the new side extenders.

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the rubber flex extender; see **Subject 100**.
3. Remove the bolts, nuts, and washers that attach the exterior utility lamp (**Fig. 1**) to the side extender. Remove the lamp.

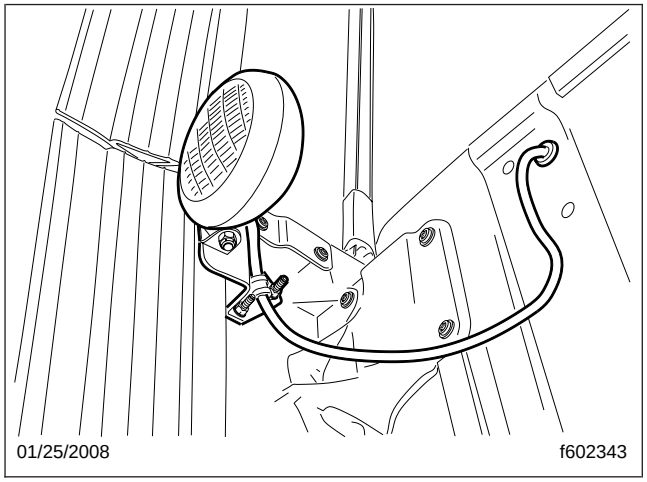
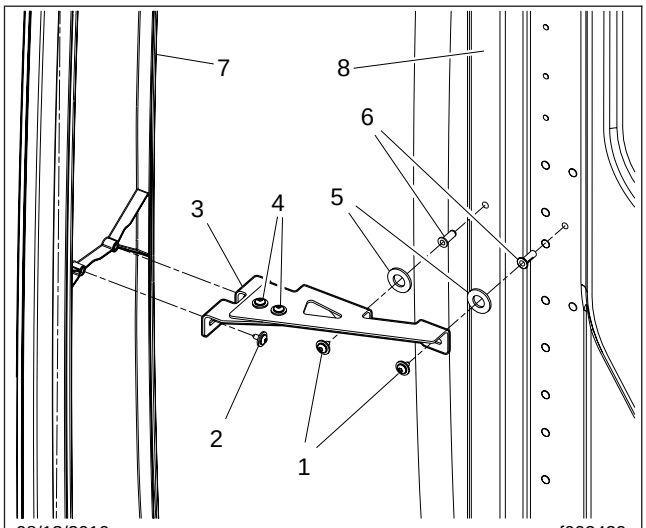


Fig. 1, Exterior Utility Lamp

4. Remove the two screws that attach the side extender to the middle bracket (if equipped). See **Fig. 2**.
5. Remove the M6 x 20 screws that attach the side extender to the upper and lower brackets; see **Fig. 3** or **Fig. 4**.
6. If the vehicle is equipped with a trim tab, remove the two M6 x 12 screws that attach the side extender to the bottom of the trim tab.
7. If necessary, remove the upper and lower side extender mounting brackets by removing the three M6 x 12 screws that attach each bracket to the cab.
8. If necessary, remove the middle bracket by removing the two M6 x 1.0 x 16 screws that attach the bracket to the cab back wall.



NOTE: Sleeper cab LH shown.

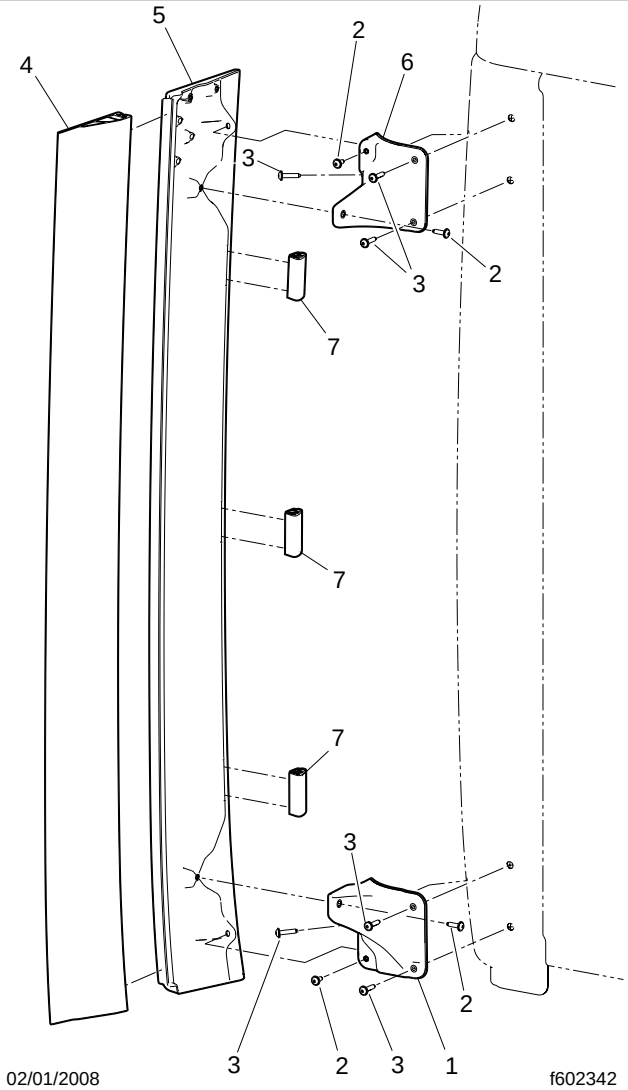
1. Screw, M6 x 1.0 x 16
2. Screw, M6 x 1.0 x 12
3. Middle Bracket Assembly
4. Adjustment Screws
5. Neoprene Washer Seal
6. Nutsert
7. Side Extender
8. Cab Back Wall

Fig. 2, Middle Bracket Installation (typical)

Installation

1. If necessary, install the upper and lower side extender brackets on the cab, using three M6 x 12 screws; see **Fig. 3** and **Fig. 4**. Tighten the screws 65 to 80 lbf·in (720 to 880 N·cm).
2. Using two M6 x 12 screws, loosely attach the top of the side extender to the trim tab.
3. If necessary, loosely attach the side extender to the middle bracket.
4. Loosely attach the side extender to upper and lower brackets brackets with M6 x 20 screws.
5. Loosen the adjustment screws on the middle bracket. See **Fig. 2**.
6. Loosely attach the side extender to the middle bracket.
7. Tighten the screws that secure the side extender as follows, making sure it is not prestressed in installation.

Side Extender Removal and Installation

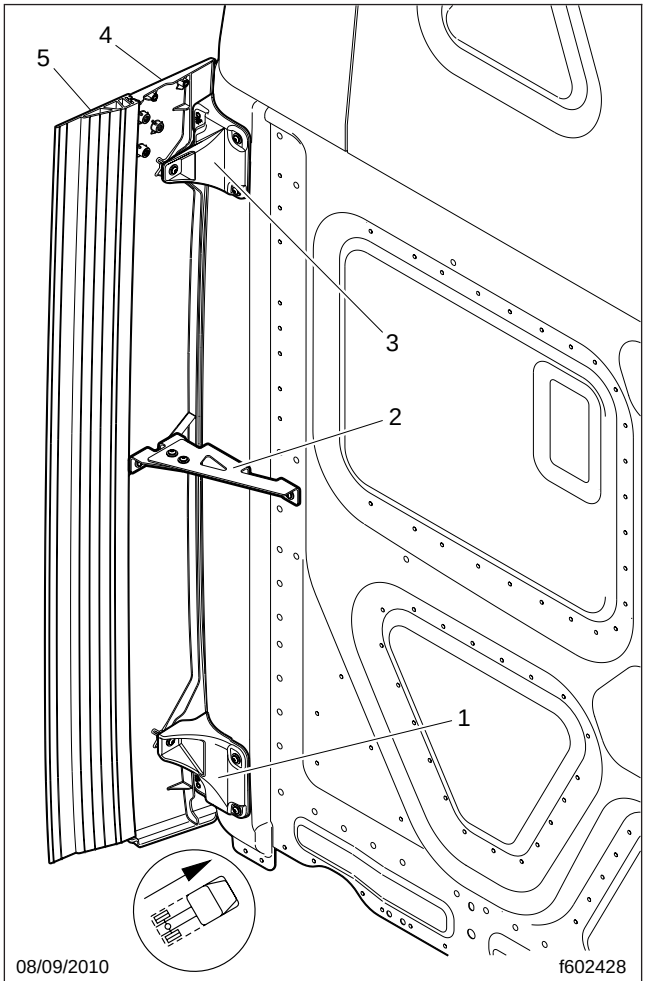


NOTE: LH side extender shown.

1. Lower Bracket Assembly
2. Side Extender Mounting Screw, M6 x 20
3. Bracket Mounting Screw, M6 x 12
4. Flex Extender
5. Side Extender
6. Upper Bracket Assembly
7. Standoff Bumper

Fig. 3, Side Extender Installation (without middle bracket)

7.1 Tighten the screws that attach the top of the side extender to the trim tab 75 to 105 lbf·in (530 to 720 N·cm).



NOTE: LH side extender shown.

1. Lower Mounting Bracket
2. Middle Bracket
3. Upper Mounting Bracket
4. Side Extender
5. Flex Extender

Fig. 4, Side Extender with Middle Bracket

7.2 Tighten the screws that attach the side extender to the upper, lower, and middle brackets 65 to 80 lbf·in (720 to 880 N·cm).

7.3 If necessary, tighten the screws that attach the middle bracket to the cab back wall 64 to 78 lbf·in (720 to 880 N·cm).

7.4 Tighten the two adjustment screws on the middle bracket.

8. Attach the exterior utility lamp (**Fig. 1**) to the side extender with the bolts, nuts, and washers.
9. Install the flex extender on the side extender; see **Subject 100**.

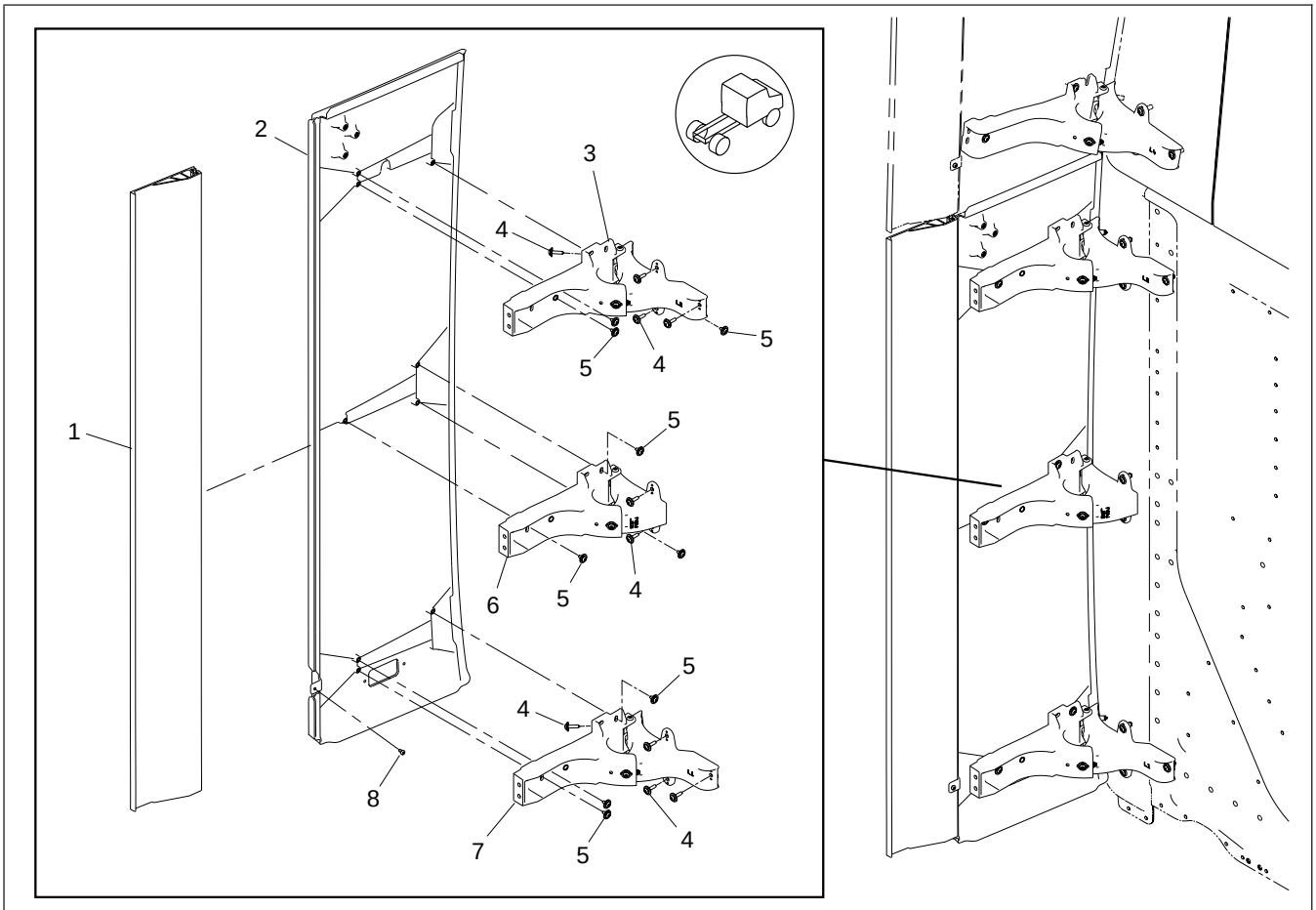
20-Inch Side Extender Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. If it is necessary to remove the lower flex extender, remove the retaining screw (**Fig. 1**, item 8) near the lower bracket, then remove the flex extender; see **Subject 100**.

NOTE: Before the lower flex extender can be removed, it may be necessary to remove the upper flex extender from the trim tab.

3. Remove the M6 x 12 screws that attach the side extender to the brackets. Remove the side extender.
4. If necessary, remove the side extender mounting brackets by removing the four M6 x 20 screws that attach each bracket to the cab.



NOTE: LH side shown.

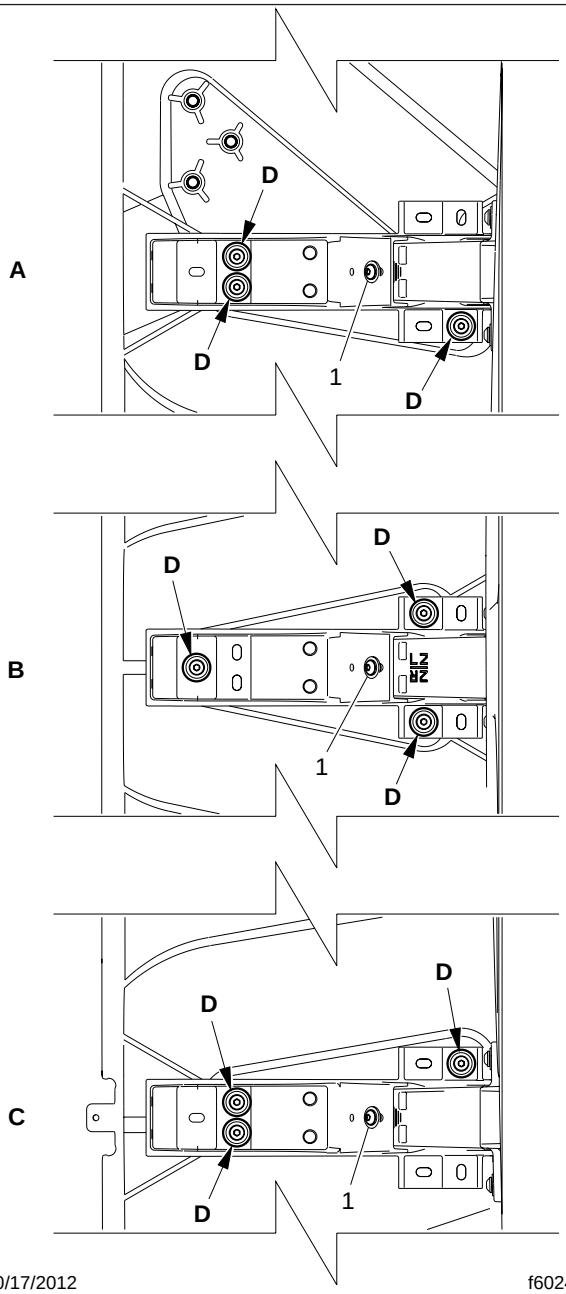
1. Lower Flex Extender
2. Side Extender
3. Upper Bracket
4. Screw, M6 x 20
5. Screw, M6 x 12
6. Middle Bracket
7. Lower Bracket
8. Retaining Screw

Fig. 1, 20-Inch Side Extender Installation

20-Inch Side Extender Removal and Installation

Installation

1. If removed, install the upper and lower side extender mounting brackets on the cab, using four M6 x 20 screws each. Tighten the screws 70 lbf·in (800 N·cm). Do not install the middle bracket yet.
2. Attach the side extender to the brackets, using three M6 x 12 screws each. See **Fig. 2** for fastener locations; note that the fastener locations are different for each bracket. Tighten the screws 70 lbf·in (800 N·cm).
3. If removed, install the middle bracket on the cab, using two M6 x 20 screws. Tighten the screws 70 lbf·in (800 N·cm).
4. Ensure that the middle bracket set screw is loose, then pivot it against the side extender. Using three M6 x 12 screws, attach the bracket to the side extender. See **Fig. 2** for fastener locations. Tighten the screws 70 lbf·in (800 N·cm).
5. If removed, install the lower flex extender on the side extender; see **Subject 100**.
6. If applicable, secure the flex extender with the retaining screw (**Fig. 1**, item 8).
7. If removed, install the upper flex extender on the trim tab, and secure it with the retaining screw.
8. Ensure that the set screws on all three brackets are loose, then adjust the angle of the side extender so that the adjustment feature on the upper bracket is set to the middle (longest) mark; see **Fig. 3**. Tighten all set screws 70 lbf·in (800 N·cm).



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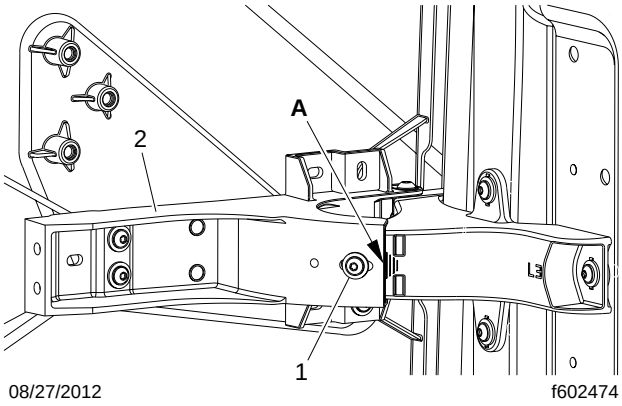
A. Upper Bracket
B. Middle Bracket
C. Lower Bracket
D. Install M6 x 12 screws at these locations only. LH shown, RH opposite.

1. Set Screw

Fig. 2, Side Extender Fastener Locations

20-Inch Side Extender Removal and Installation



A. Align to the center (longest) mark.

1. Set Screw
2. Upper Bracket

Fig. 3, Side Extender Adjustment

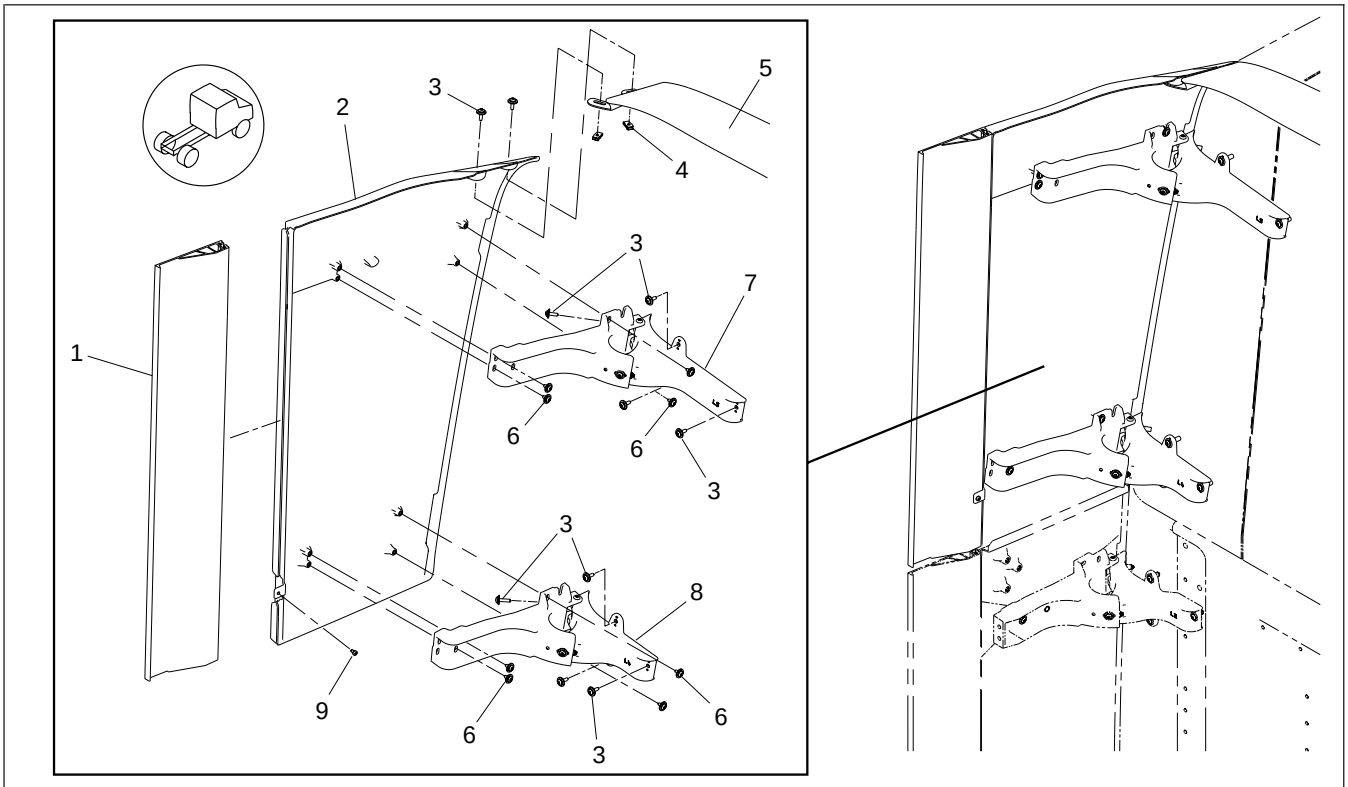
20-Inch Trim Tab Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. If it is necassary to remove the upper flex extender, remove the retaining screw (**Fig. 1**, item 9) near the lower bracket, then remove the flex extender as shown in **Subject 100**.
3. Remove the two M6 x 20 screws that attach the trim tab to the spoiler.
4. Remove the four M6 x 12 screws that attach each bracket to the trim tab. Remove the trim tab.
5. If necessary, remove the trim tab mounting brackets by removing the four M6 x 20 screws that attach each bracket to the cab.

Installation

1. If removed, install the trim tab mounting brackets on the cab, using four M6 x 20 screws each. Tighten the screws 80 lbf·in (920 N·cm).
2. Attach the trim tab to the brackets, using four M6 x 12 screws each. See **Fig. 2** for fastener locations; note that the fastener positions are different for each bracket. Tighten the screws 80 lbf·in (920 N·cm).



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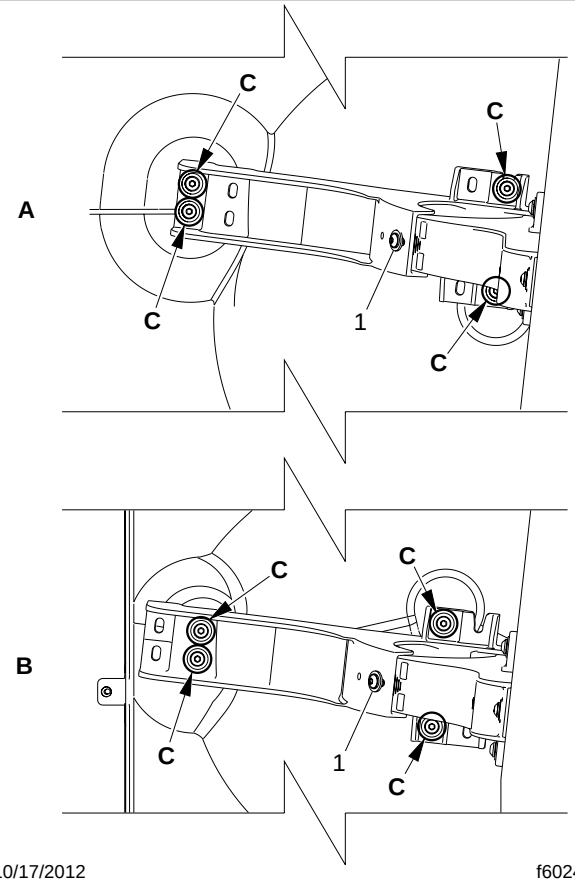
NOTE: LH shown.

1. Upper Flex Extender
2. Trim Tab
3. Screw, M6 x 20
4. J-Clip
5. Spoiler
6. Screw, M6 x 12
7. Upper Bracket
8. Lower Bracket
9. Retaining Screw

Fig. 1, 20-Inch Trim Tab Installation

20-Inch Trim Tab Removal and Installation



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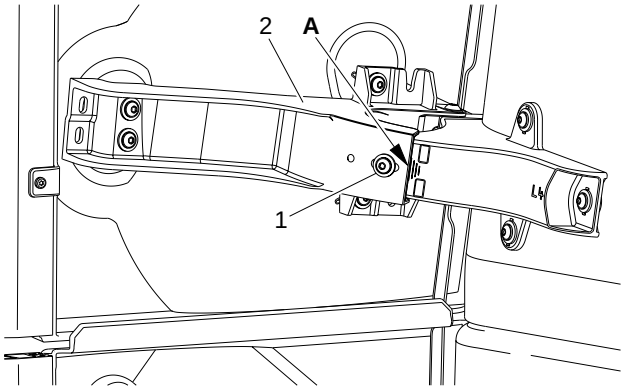
A. Upper Bracket
B. Lower Bracket
C. Install M6 x 12 screws at these locations only. LH shown, RH opposite.

1. Set Screw

Fig. 2, Trim Tab Fastener Locations

3. If removed, install the upper flex extender on the trim tab; see **Subject 100**.
4. If applicable, secure the flex extender with the retaining screw (**Fig. 1**, item 9).
5. Ensure that the set screws on both brackets are loose, then adjust the angle of the trim tab so that the adjustment feature on the lower bracket is set to the middle (longest) line; see **Fig. 3**. Tighten the set screws 80 lbf·in (920 N·cm).
6. Using two M6 x 20 screws, attach the trim tab to the spoiler. Tighten the screws 80 lbf·in (920 N·cm).



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A. Align to the center (longest) mark.

1. Set Screw
2. Lower Bracket

Fig. 3, Trim Tab Adjustment

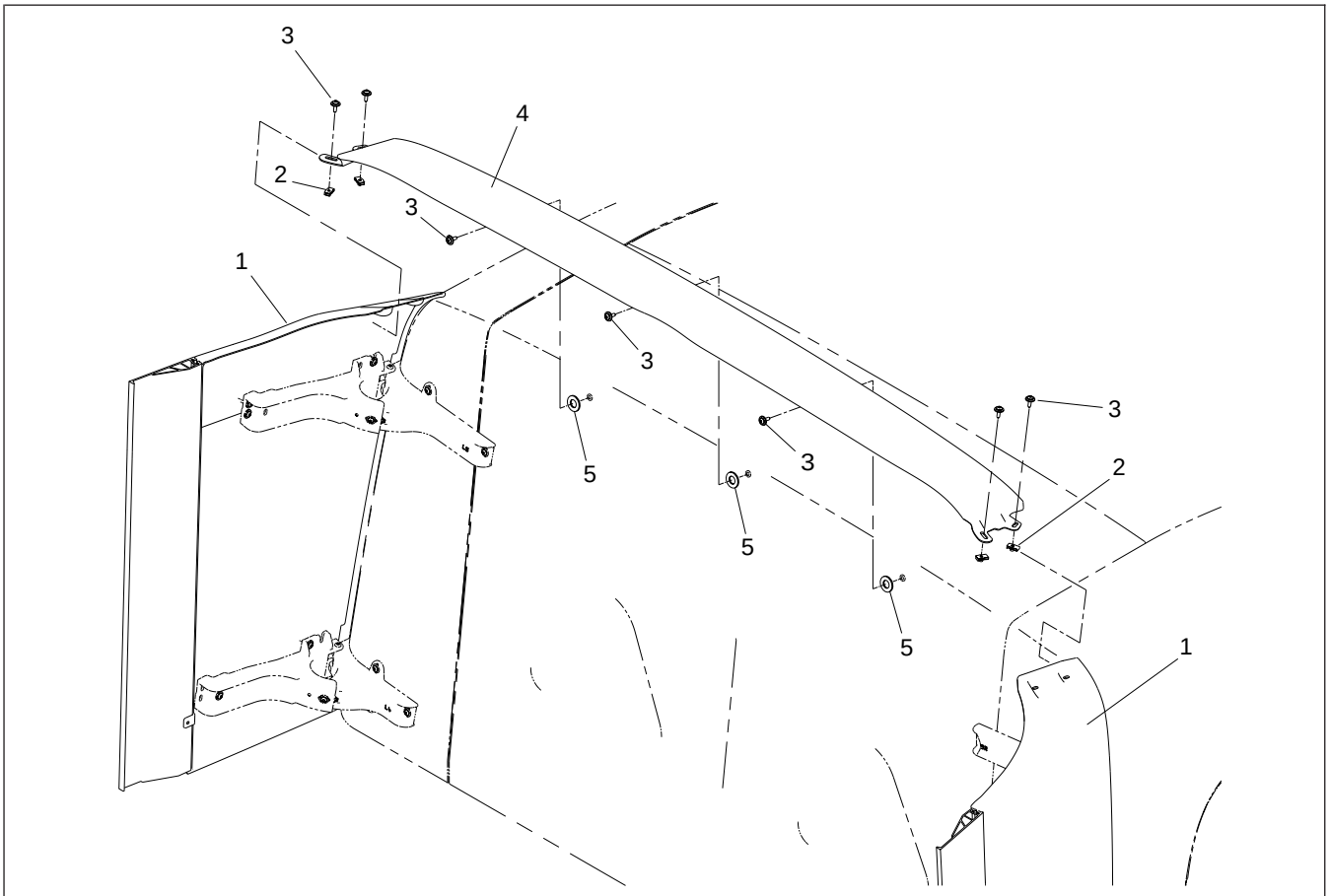
Spoiler Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the two M6 x 20 screws that attach the spoiler to each trim tab. See **Fig. 1**.
3. Remove the three M6 x 20 screws that attach the spoiler to the cab. Remove the spoiler.

Installation

1. Using three M6 x 20 screws, attach the spoiler to the cab. Tighten the screws 80 lbf·in (920 N·cm). See **Fig. 1**.
2. Using two M6 x 20 screws, attach the spoiler to each trim tab. Tighten the screws 80 lbf·in (920 N·cm).



1. Trim Tab
2. J-Clip
3. Screw, M6 x 20
4. Spoiler
5. Seal

Fig. 1, Spoiler Installation

Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.01**.

Torque Specifications		
Fastener Description	**lbf·in**	**N·cm**
Short Side Extenders and Trim Tabs		
Trim Tab Bracket Screws, M6 x 12	75–105	530–720
Trim Tab-to-Side Extender Screws, M6 x 12	75–105	530–720
Side Extender Bracket Mounting Screws, M6 x 12	65–80	720–880
Side Extender Mounting Screws, M6 x 20	65–80	720–880
20-Inch Side Extenders and Trim Tabs		
Side Extender Bracket Mounting Screws, M6 x 20	70	800
Side Extender Mounting Screws, M6 x 12	70	800
Trim Tab Bracket Mounting Screws, M6 x 20	80	920
Trim Tab Mounting Screws, M6 x 12	80	920
Spoiler		
Spoiler Mounting Screws	80	920
Spoiler-to-Trim Tab Screws	80	920

Table 1, Torque Specifications

General Information

Sleeper Compartment Exit Doors

Access to the sleeper compartment is provided by one or two optional exit doors, in addition to the walk-through opening inside the cab. The sleeper compartment exit door, located above the baggage door, is a round-cornered, double-paneled door, set flush with the exterior side panel of the sleeper.

The striker is attached to the interior panel of the door, and a latch is attached to the interior panel of the sleeper compartment, aft of the door opening. A door release cable, with a release handle inside the cab door opening, is connected to the latch. A seal is installed in the door opening.

Baggage Doors

On vehicles with sleeper compartments, the baggage doors allows access to the storage compartment under the sleeper bunk. The baggage door is a round-cornered, double-paneled door, set flush with the exterior side panel of the sleeper.

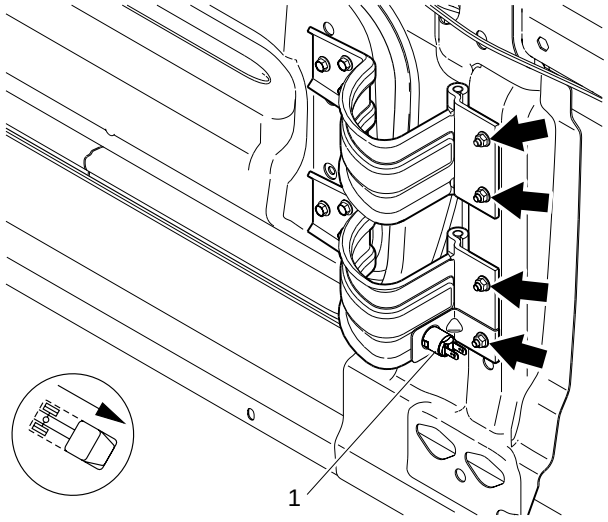
The striker is attached to the interior panel of the door, and a latch is attached to the interior panel of the baggage compartment, aft of the door opening. A door release cable, with a release handle inside the cab door opening, is connected to the latch. A seal is installed in the door opening.

Sleeper Compartment Exit and Baggage Door Adjustment

NOTE: The adjustment procedure for the baggage doors and sleeper exit doors is similar.

Adjustment

1. Chock the tires.
2. Open the sleeper compartment exit (or baggage) door being adjusted.
3. Loosen the flanged nuts that attach the hinges to the inside cab wall, just enough to adjust the door with gentle force; see **Fig. 1**. Note that the lower nut of the baggage door hinges also secures the light switch bracket. Adjust the door forward or aft, and up or down, as needed, to provide a uniform gap to the cab skin around the door.



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NOTE: Left-hand storage cabinet or auxiliary HVAC cover, as applicable, not shown.

1. Light Switch

Fig. 1, Hinge Mounting Nuts (baggage door shown)

4. Loosen and adjust the striker as needed; see **Fig. 2**. Make sure the striker is horizontal and the striker pin is centered between the latch jaws. The striker knob should be positioned at equal distance between the latch ratchet and the door seal; see **Fig. 3**.

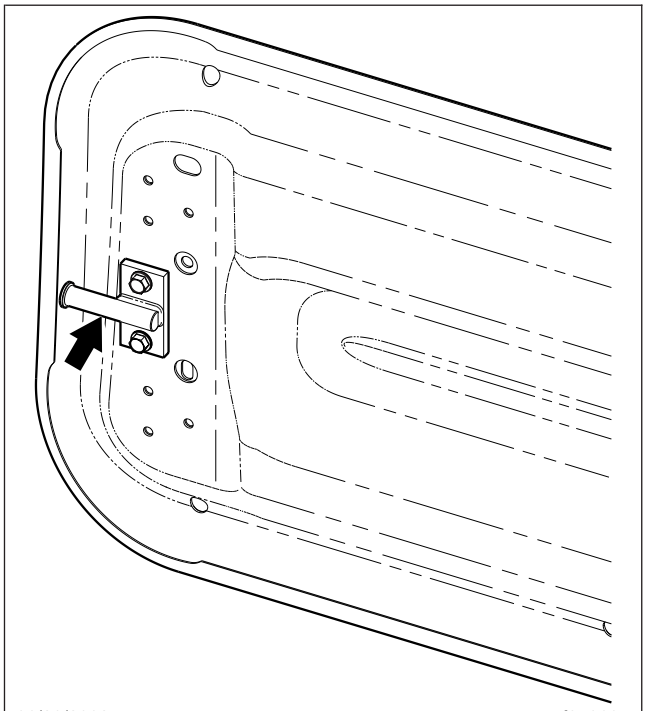

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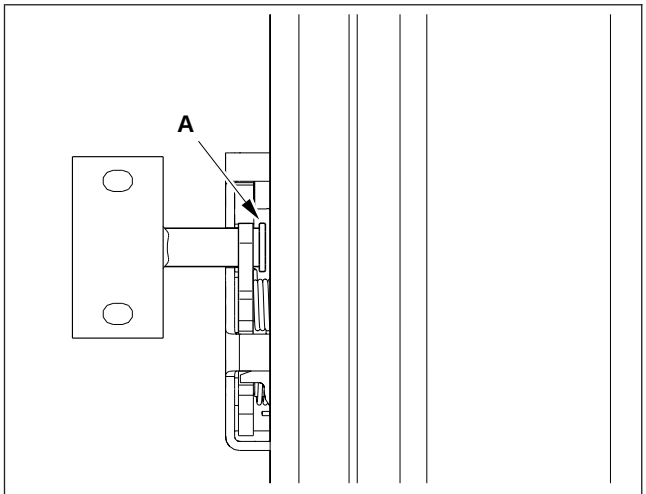
Fig. 2, Striker (baggage door shown)



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NOTE: View from outside. Door panels omitted for clarity.

A. Striker knob should be positioned at equal distance between the latch ratchet and the door seal.

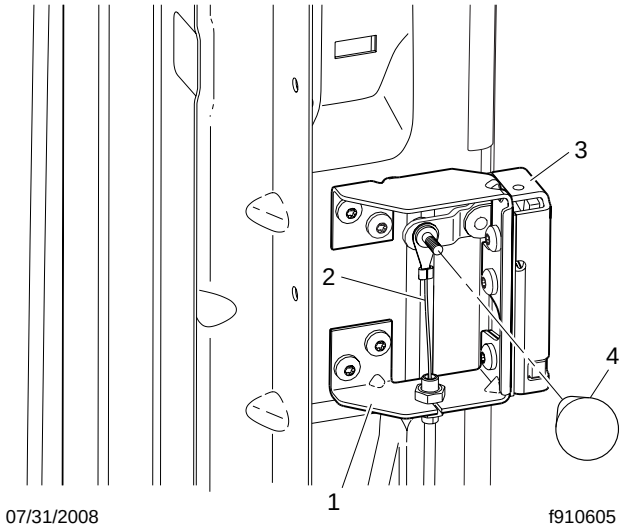
Fig. 3, Striker Adjustment

Sleeper Compartment Exit and Baggage Door Adjustment

5. Close the door. Make sure the striker is fully engaged in the latch. If the striker contacts the seal, adjust the striker forward.
6. Remove the chocks.

Latch Replacement, Sleeper Compartment Exit Door

1. Chock the tires.
2. Open the sleeper compartment exit door.
3. Remove the upholstery panel below the door surround.
4. Remove or loosen the side upholstery panel forward of the door, to access the Christmas-tree fasteners at the edge of the door surround.
5. Unscrew the latch release knob from the latch stud; see **Fig. 1**.



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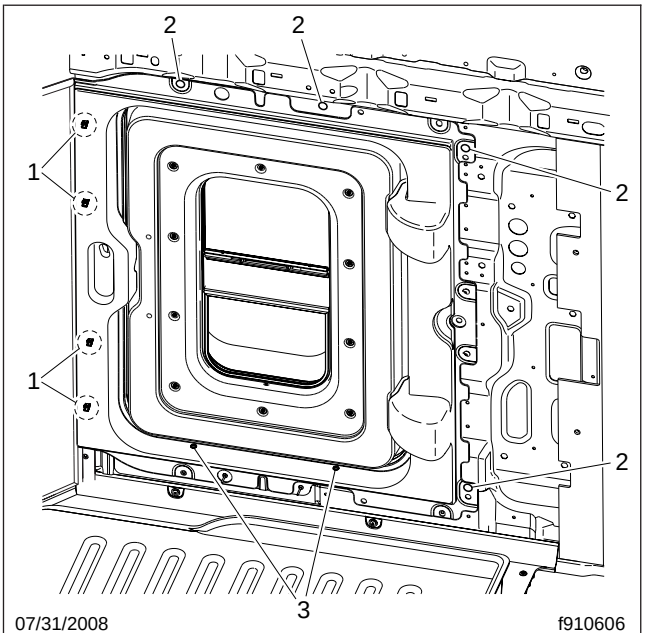
NOTE: Door surround not shown for clarity.

1. Latch Mounting Bracket
2. Release Cable
3. Latch Assembly
4. Release Knob

Fig. 1, Sleeper Compartment Exit Door Latch Installation

6. Remove the door surround. It is attached to the cab with four spring clips, two Torx screws, and four Christmas-tree fasteners; see **Fig. 2**.
7. Remove the push-on clip from the latch stud, then slide the cable eyelet from the stud.
8. Remove the four Torx screws that attach the latch mounting bracket to the cab wall. Remove the latch and bracket assembly.



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1. Spring Clips (on the backside of the surround)
2. Christmas-Tree Fastener
3. Torx Screws

Fig. 2, Door Surround Fasteners

9. Remove the three Torx screws that attach the latch assembly to the latch mounting bracket.
10. Attach the new latch assembly to the latch mounting bracket, using the three Torx screws; see **Fig. 1**.
11. Attach the latch and bracket assembly to the cab wall, using four Torx screws.
12. Position the release cable in place and slide the cable eyelet onto the latch stud. Install the push-on clip on the stud to secure the cable.
13. Install the door surround, pushing the spring clips along the aft edge into the holes on the cab wall. Install the Christmas-tree fasteners and Torx screws to secure the top, bottom, and forward edges of the surround; see **Fig. 2**.

NOTE: When installing the door surround, make sure the inner flap of the door seal is pulled over the edge of the surround opening.

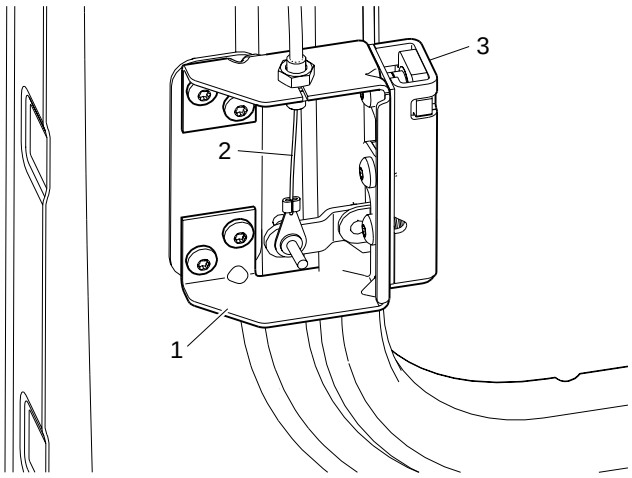
14. Install the latch release knob on the latch stud.
15. Push the side upholstery panel into place.

Latch Replacement

16. Install the uphostery panel below the door surround.
17. Close the door. Make sure the striker is fully engaged in the latch. If necessary, adjust the door and striker; see **Subject 100**.
18. Remove the chocks.

Latch Replacement, Baggage Door

1. Chock the tires.
2. Open the baggage door.
3. Remove the four Torx screws that attach the latch mounting bracket to the cab wall. Remove the latch and bracket assembly; see **Fig. 3**.



1. Latch Mounting Bracket
2. Release Cable
3. Latch Assembly

Fig. 3, Baggage Door Latch Installation

NOTE: It may be necessary to cut the interior panel over the latch to access the mounting screws. The plastic panel is scored above and below the latch; see **Fig. 4**. Cut the panel and peel it back.

4. Remove the push-on clip from the latch stud, then slide the cable eyelet from the stud.
5. Remove the three Torx screws that attach the latch assembly to the latch mounting bracket.

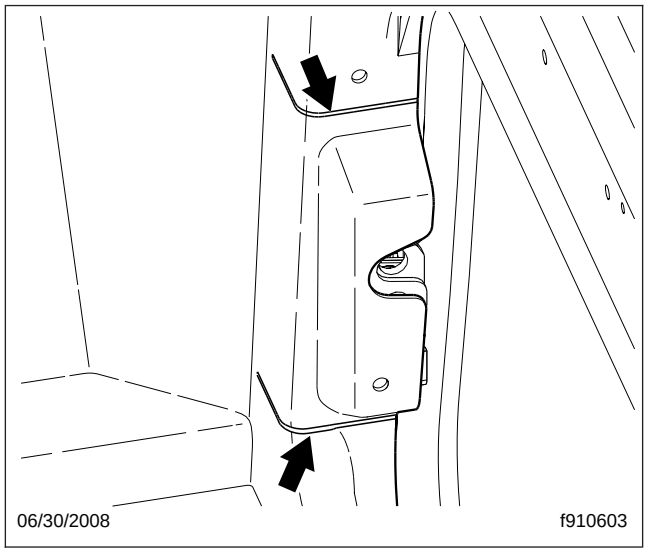


Fig. 4, Interior Panel Scores Above and Below the Latch

6. Attach the new latch assembly to the latch mounting bracket, using the three Torx screws.
7. Attach the latch and bracket assembly to the cab wall, using four Torx screws.
8. Position the release cable in place and slide the cable eyelet onto the latch stud. Install the push-on clip on the stud to secure the cable.
9. Close the door. Make sure the striker is fully engaged in the latch. If necessary, adjust the door and striker; see **Subject 100**.
10. Remove the chocks.

General Information

The bulkhead-style cab door is composed of fully stamped aluminum inner and outer panels, with large internal reinforcements at the hinge/A-pillar, waist, and mirror mount. The primary door seal is mounted on the door assembly. A secondary seal is mounted on the cab around the door opening frame.

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 opens on two discreet, hidden hinges that require no maintenance. The door hinges allow a 70-degree opening. The one-arm, pedestal-style mirror is mounted on the door, which is reinforced at the mount area.

The wiring for the window, mirror, and courtesy light is routed through an opening on the hinge side of the door.

The modular door mechanism cassette, which can be removed and serviced as a single assembly, consists of the window glass, carrier, run channels, regulator motor, window control module, wiring, door latch, and interior handle.

Most service operations can be done with the door attached to the vehicle. To reduce work time, do not remove the door unless necessary.

⚠ 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.

⚠ CAUTION

Before performing any electric welding on or near the door, read and comply with the welding precautions in Section 60.04, and disconnect the door wiring harness behind the inner trim panel.

Electric currents produced during electric welding can damage various electronic components on the vehicle.

Removal

1. Apply the parking brakes and chock the tires.
2. Lower the window glass.
3. Open the hood.
4. Disconnect the batteries.
5. Remove the door pull handle and interior trim panel; see **Subject 160**.
6. Remove the cowl side panel, as follows.

   6.1 Remove the two Torx screws and washers at the forward edge of the cowl side panel; see **Fig. 1**.

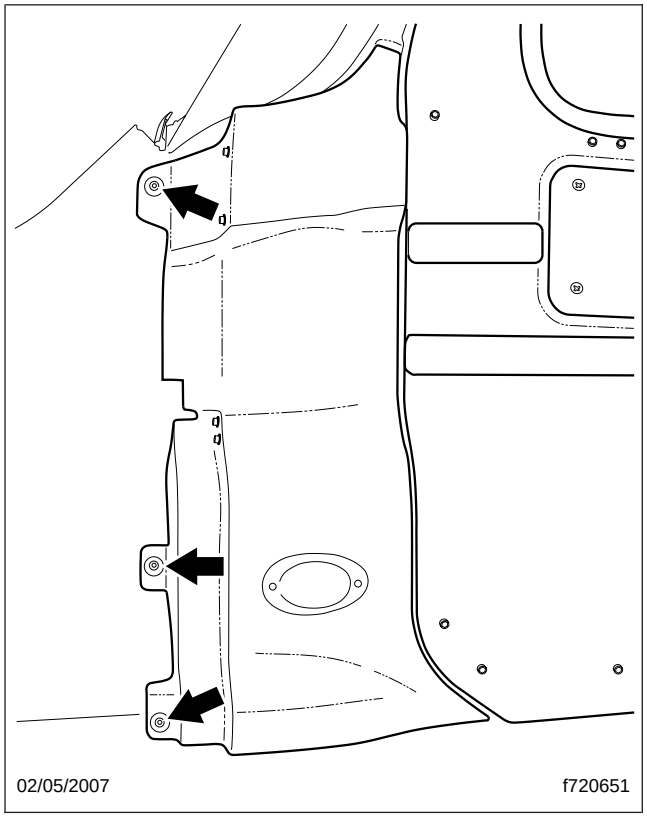


Fig. 1, Cowl Side Panel Forward Fasteners

   6.2 Remove the bolt, nut, and two washers that attach the lower front corner of the cowl side panel to the hood rear support.

   6.3 Remove the four Torx screws and washers that attach the cowl side panel to the door frame; see **Fig. 2**.

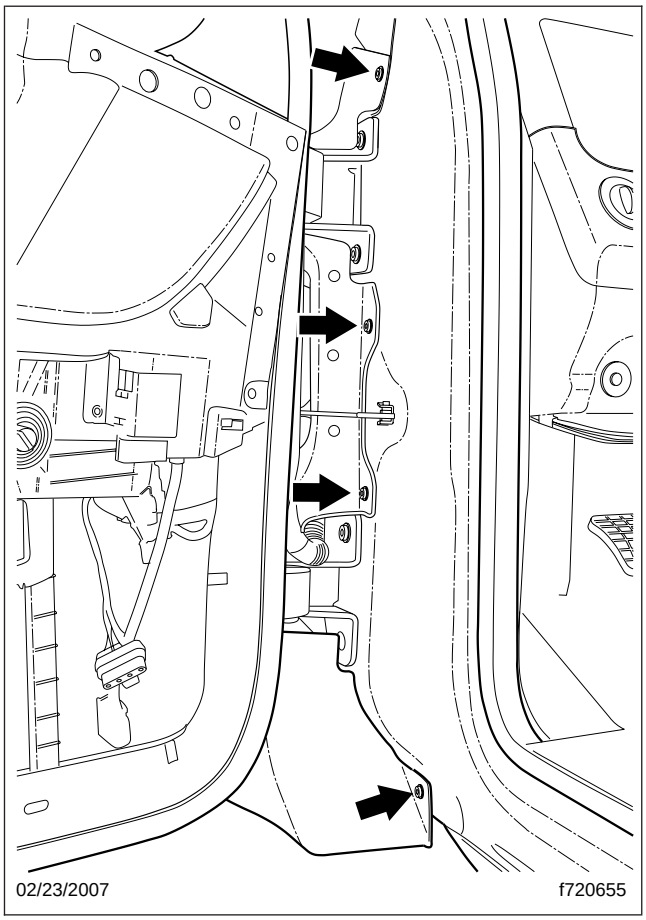
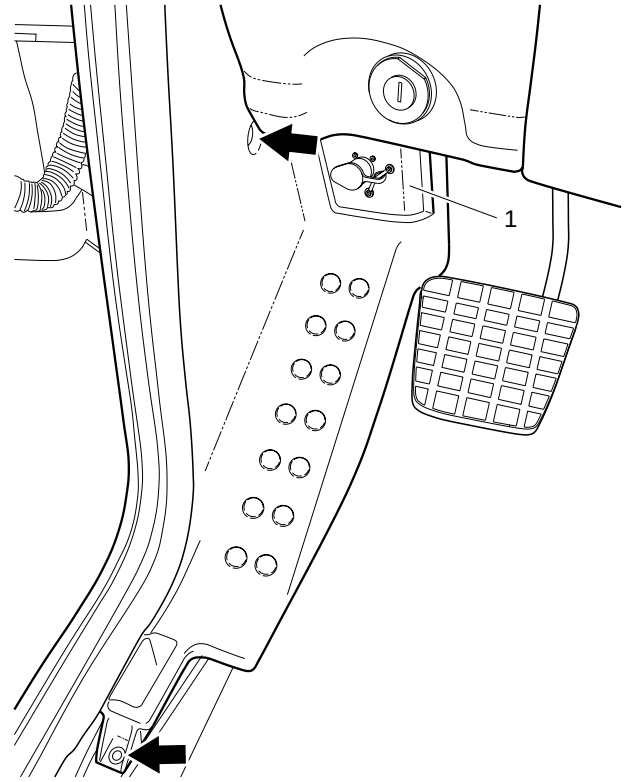


Fig. 2, Cowl Side Panel Rear Fasteners

   6.4 Disconnect the wiring to the auxiliary side turn indicator lamp, then remove the cowl side panel.

7. Remove the door tread plate by removing the three screws that attach it to the bottom of the door opening.
8. Detach the diagnostic connector plate (driver side only) from the A-pillar lower trim panel by removing the Christmas-tree fastener at the top of the plate and unhooking the bottom tab; see **Fig. 3**. Push the plate behind the trim panel through the opening.
9. Remove the two screws that attach the A-pillar lower trim panel to the door frame and the cab side wall; see **Fig. 3**.

Door Removal and Installation



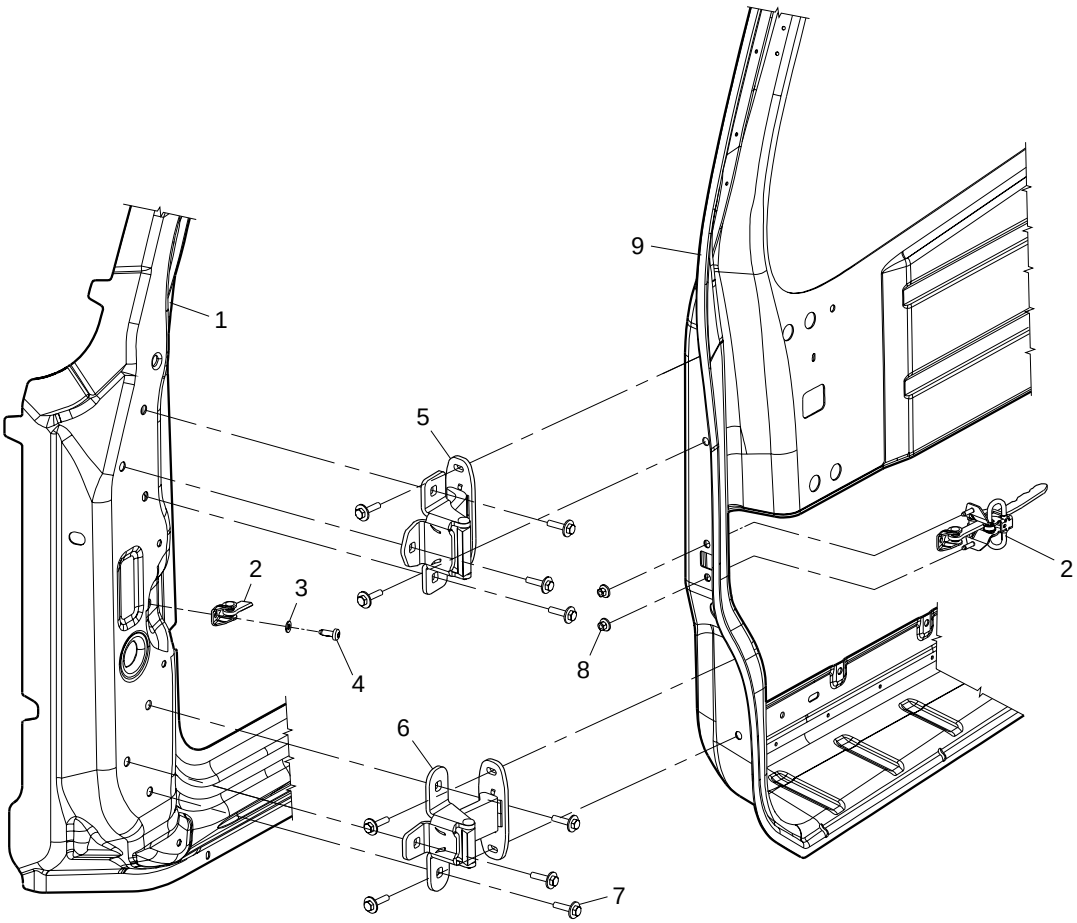
1. Diagnostic Connector Plate (driver side only)

Fig. 3, A-Pillar Lower Trim Panel Fasteners

10. Disconnect the three connectors of the door wiring harness. Do not disconnect the diagnostic connector (driver side only).
11. Pull the disconnected wiring harness out through the opening in the cab side wall, and then through the opening in the forward edge of the door.
12. Remove the door check assembly, as follows; see **Fig. 4**.
    - 12.1 Remove the Torx screw that attaches the door-check clevis bracket to the cab.
    - 12.2 Remove the two nuts that attach the door check to the edge of the door.
    - 12.3 Remove the door check assembly from the door.
13. Using a suitable hoist to support the door at its balancing point, remove the fasteners that attach the hinges to the cab.
14. Remove the door from the vehicle.

Installation

1. With the tires chocked, position the door alongside the vehicle, and align the holes in the hinges with those in the cab.
2. Install the hinge fasteners; see **Fig. 4**. Tighten the capscrews 15 to 18 lbf·ft (20 to 24 N·m).
3. Close the door and check for alignment. Adjust the door, if needed; see **Subject 130**.
4. Install the door check assembly, as follows.
    - 4.1 Install the door check into the forward edge of the door. Tighten the nuts 7 to 9 lbf·ft (9 to 12 N·m).
    - 4.2 Attach the door-check clevis bracket to the cab with a Torx screw.
5. Push the door wiring harness connectors out through the opening in the forward edge of the door, and then into the cab through the opening in the cab side wall.
6. Carefully snap the three wire harness grommets in place, without twisting the harness. The grommets are installed into the holes at the forward edge of the door, and outside and inside the A-pillar. Make sure the grommets are fully seated to ensure a good seal.
7. Connect the three electrical connectors inside the cab.
8. Pull the diagnostic connector plate (driver side only) through the opening in the A-pillar lower trim panel. Insert the tab on the bottom of the plate into the trim panel, and install the Christmas-tree fastener at the top of the plate.
9. Attach the trim panel to the door frame and the cab side wall with two screws; see **Fig. 3**.
10. Attach the door tread plate to the bottom of the door opening with three screws.
11. Install the cowl side panel, as follows.
    - 11.1 Connect the wiring to the auxiliary side turn indicator lamp, then position the cowl side panel in place and attach it to the



NOTE: Door skin omitted for clarity.

1. Door Frame
2. Door Check Assembly
3. Washer
4. Torx Screw, M8 x 30-mm Long
5. Upper Hinge Assembly
6. Lower Hinge Assembly
7. Capscrew
8. Nut with Washer, M6 x 1
9. Door Assembly

Fig. 4, Door Hinge and Door Check Installation

door frame with four Torx screws and washers; see **Fig. 2**.

11.2 Install the bolt, nut, and two washers that attach the lower front corner of the cowl side panel to the hood rear support; see **Fig. 1**.

11.3 Install the two Torx screws and washers at the forward edge of the cowl side panel.

12. Install the door interior trim panel and the pull handle; see **Subject 160**.
13. Connect the batteries.
14. Close the hood.

Door Cassette Removal and Installation

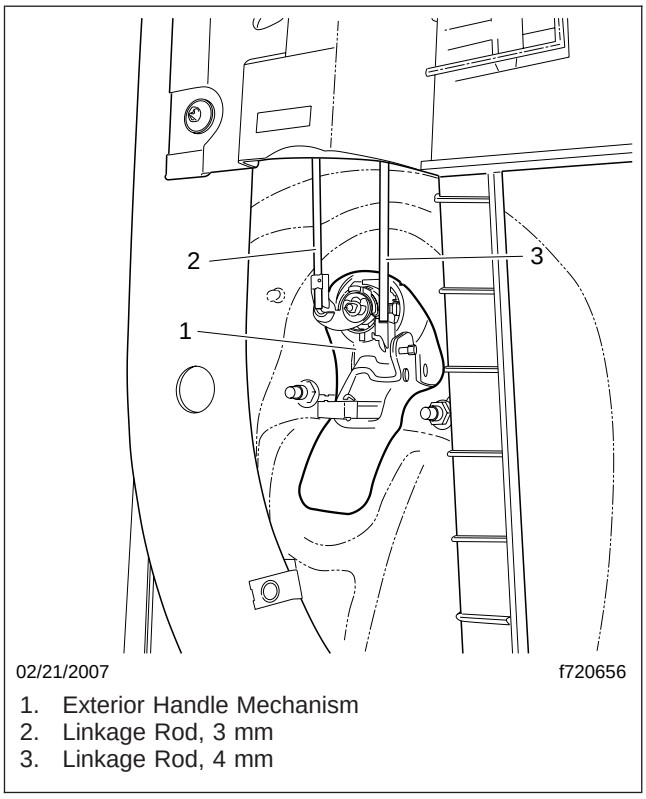
Removal

NOTE: To replace the window glass, the door cassette must first be removed.

To remove the door cassette, the cowl side panel and A-pillar lower trim panel must be removed in order to disconnect the door wiring harness. The wiring harness and connectors must then be pulled out through the openings on the cab side wall and door assembly.

To access the window regulator motor, the window control module, or the exterior handle, only the door interior trim panel need be removed.

1. Apply the parking brakes and chock the tires.
2. Fully lower the window glass.
3. Open the hood.
4. Disconnect the batteries.
5. Remove the door pull handle and interior trim panel; see **Subject 160**.
6. Disconnect the two linkage rods from the door exterior handle assembly; see **Fig. 1**.
7. Remove the cowl side panel, as follows.
   - 7.1 Remove the two Torx screws and washers at the forward edge of the cowl side panel; see **Fig. 2**.
   - 7.2 Remove the bolt, nut, and two washers that attach the lower front corner of the cowl side panel to the hood rear support.
   - 7.3 Remove the four Torx screws and washers that attach the cowl side panel to the door frame; see **Fig. 3**.
   - 7.4 Remove the cowl side panel.
8. Remove the door tread plate by removing the three screws that attach it to the bottom of the door opening.
9. Detach the diagnostic connector plate (driver side only) from the A-pillar lower trim panel by removing the Christmas-tree fastener at the top of the plate and unhooking the bottom tab; see **Fig. 4**. Push the plate behind the trim panel through the opening.



1. Exterior Handle Mechanism
2. Linkage Rod, 3 mm
3. Linkage Rod, 4 mm

Fig. 1, Exterior Handle Linkage Rods

10. Remove the two screws that attach the A-pillar lower trim panel to the door frame and the cab side wall; see **Fig. 4**.
11. Disconnect the three connectors of the door wiring harness. Do not disconnect the diagnostic connector (driver side only).
12. Pull the disconnected wiring harness out through the opening in the cab side wall, and then through the opening in the forward edge of the door.
13. Disconnect the mirror electrical connector, and unhook the wire harness from the forward glass run channel.
14. Remove the six Torx screws that attach the door cassette to the door assembly; see **Fig. 5**.
15. Remove the three Torx screws that attach the door latch to the door assembly.
16. Remove the two Torx screws that attach the glass run channels to the bottom of the door assembly.

Door Cassette Removal and Installation

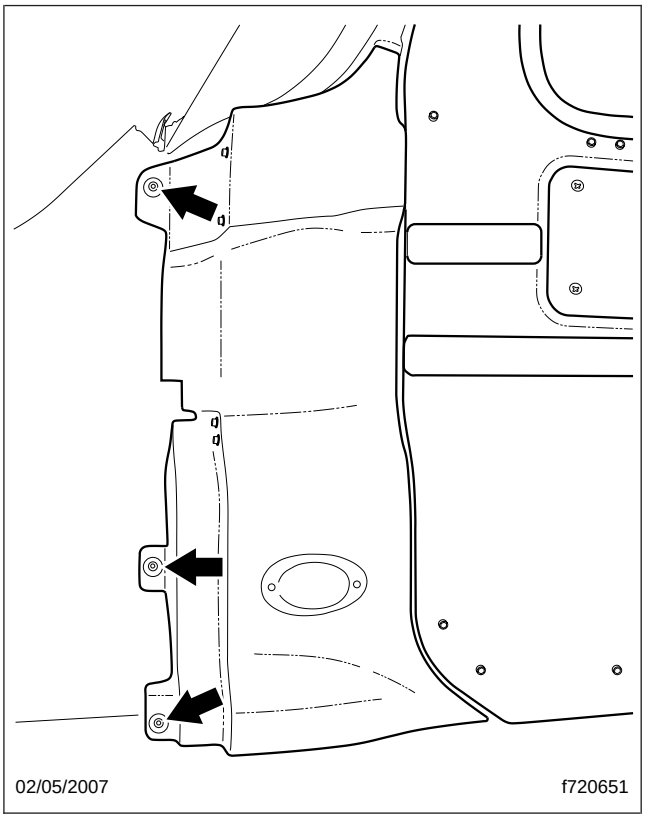


Fig. 2, Cowl Side Panel Forward Fasteners

NOTICE

Use care when twisting the forward run channel by the wing window; it can break if twisted too far. Remove the door cassette carefully, to avoid breaking the latch attachment bracket, or bending the connecting rods while pulling them up from the door assembly.

17. Twist the forward run channel by the wing window slightly to release the window glass from the run channel, then move the cassette forward to clear the latch from the door assembly. Lift the cassette up to pull the latch connecting rods up clear of the door assembly, and remove the cassette.

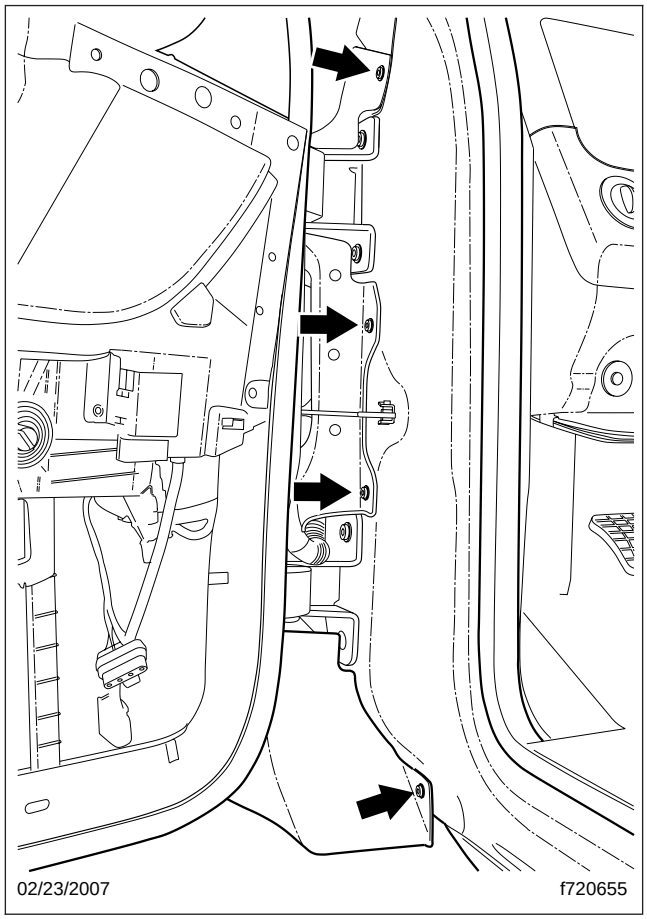


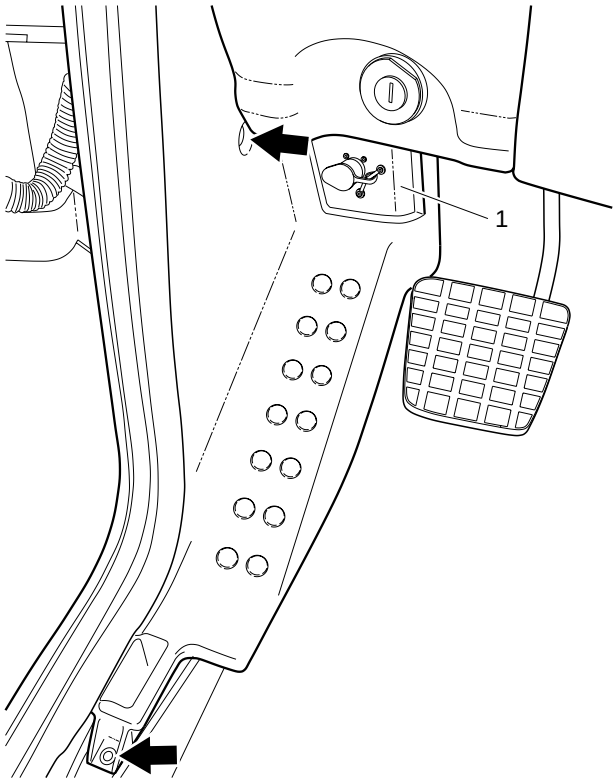
Fig. 3, Cowl Side Panel Rear Fasteners

Installation

NOTICE

Use care when twisting the forward run channel by the wing window; it can break if twisted too far. Install the door cassette carefully, to avoid breaking the latch attachment bracket, or bending the connecting rods while lowering them into the door assembly.

1. With the tires chocked, lower the door cassette assembly, directing the latch connecting rods into the door assembly. Then move the cassette to position the door latch against the inside of the door edge. Twist the forward run channel by the wing window slightly to allow the edge of the window glass to be set into the run channel.



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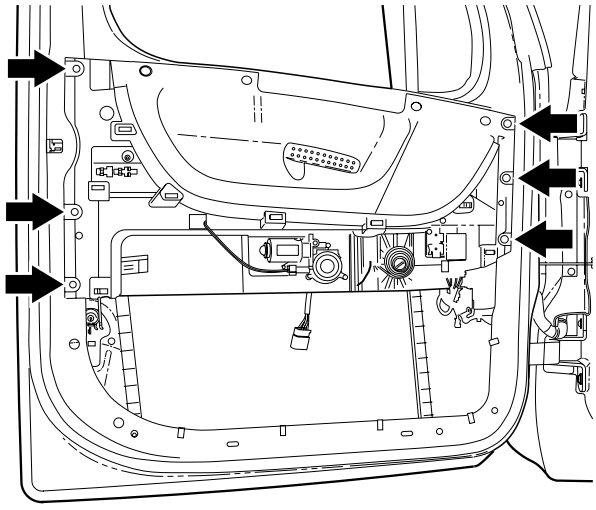
1. Diagnostic Connector Plate (driver side only)

Fig. 4, A-Pillar Lower Trim Panel Fasteners

2. Attach the door cassette to to door assembly, installing the Torx screws in the order following; see **Fig. 5**.
   - 2.1 Install the upper rear screw first.
   - 2.2 Install the upper front screw.
   - 2.3 Install the three Torx screws that attach the door latch to the door assembly.
   - 2.4 Install the remaining four screws.
   - 2.5 Tighten the screws 54 to 71 lbf·in (600 to 800 N·cm).
3. Install the two Torx screws that attach the glass run channels to the bottom of the door assembly.
4. Connect the mirror electrical connector, and hook the wiring harness on the forward run channel.



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NOTE: Latch fasteners not shown.

Fig. 5, Door Cassette Fasteners

5. Push the door wiring harness connectors out through the opening in the forward edge of the door, and then into the cab through the opening in the cab side wall.
6. Carefully snap the three wire harness grommets in place, without twisting the harness. The grommets are installed into the holes at the forward edge of the door, and outside and inside the A-pillar. Make sure the grommets are fully seated to ensure a good seal.
7. Connect the three electrical connectors inside the cab.
8. Pull the diagnostic connector plate (driver side only) through the opening in the A-pillar lower trim panel. Insert the tab on the bottom of the plate into the trim panel, and install the Christmas-tree fastener at the top of the plate.
9. Attach the trim panel to the door frame and the cab side wall with two screws; see **Fig. 4**.
10. Attach the door tread plate to the bottom of the door opening with three screws.
11. Install the cowl side panel, as follows.
    - 11.1 Position the cowl side panel in place and attach it to the door frame with four Torx screws and washers; see **Fig. 3**.

Door Cassette Removal and Installation

11.2 Install the bolt, nut, and two washers that attach the lower front corner of the cowl side panel to the hood rear support; see **Fig. 2**.

11.3 Install the two Torx screws and washers at the forward edge of the cowl side panel.

12. Connect the two linkage rods to the door exterior handle assembly; see **Fig. 1**.
13. Install the door interior trim panel and the pull handle; see **Subject 160**.
14. Connect the batteries.
15. Close the hood.
16. Test the window, mirror, and door latch mechanisms.

Forward Window Glass Replacement

NOTE: The forward window glass is also available as part of the window seal assembly. To replace the window seal assembly, complete with the forward window glass, follow steps 1–7 and 10–15 of the procedure below.

Replacement

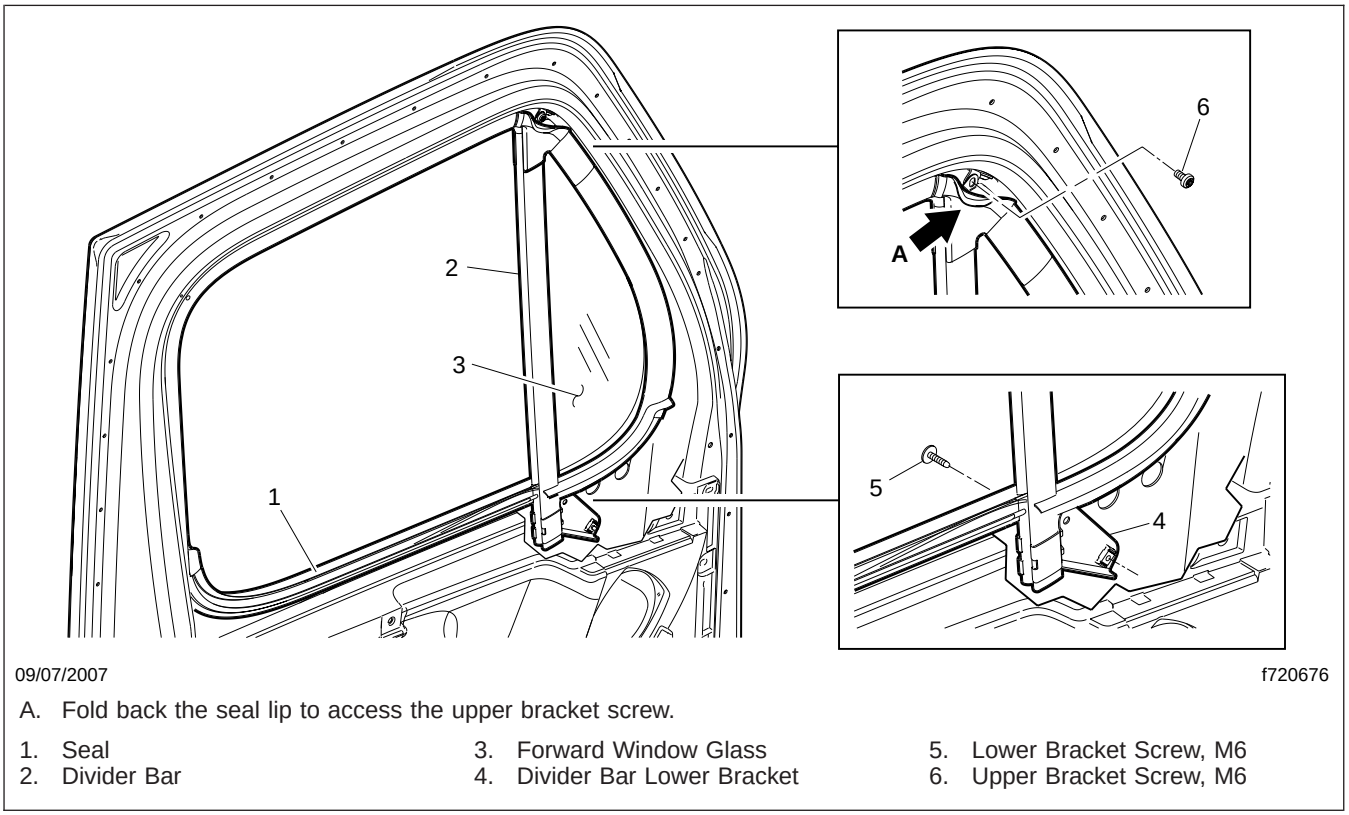
1. Apply the parking brakes and chock the tires.
2. Lower the window, and open the door.
3. Remove the door pull handle and interior trim panel; see **Subject 160**.
4. Remove the door-mounted mirror; see **Section 60.03, Subject 100**.
5. Fold back the seal lip to access the M6 Torx® screw that attaches the upper bracket of the forward window to the door. Remove the screw; see **Fig. 1**.
6. Through the exterior access hole at the mirror mount, remove the M6 Torx screw that attaches the divider bar lower bracket to the door.
7. Remove the rubber seal and the forward window assembly, both together, from the window opening.

   If replacing the complete window seal assembly, go to step 10.

⚠ WARNING

Wear protective gloves and safety glasses when replacing window 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.

8. Fold back the seal lip, and remove the glass. Start at the bottom, then, using care, pull the top of the glass out of the apex of the sail mold.



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A. Fold back the seal lip to access the upper bracket screw.

1. Seal
2. Divider Bar
3. Forward Window Glass
4. Divider Bar Lower Bracket
5. Lower Bracket Screw, M6
6. Upper Bracket Screw, M6

Fig. 1, Forward Window Glass and Seal

Forward Window Glass Replacement

NOTE: Soapy water may help both removal and installation of the glass.

9. Carefully push the top of the glass into the apex of the sail mold. To ensure that the bracket holes line up for the fasteners, seat the top of the glass fully into the apex of the mold. Twist the lip of the seal over the glass until the glass is seated in the seal.
10. Position the forward window and window molding assembly into the window opening. Starting with the forward window, seat the seal in the window opening, making sure that the holes at the top and bottom brackets line up, then seat the rest of the seal in place around the window opening.
11. From outside, install the M6 Torx screw through the opening on the door exterior panel, attaching the divider bar lower bracket to the door. Tighten the screw 53 to 71 lbf·in (600 to 800 N·cm).
12. Install the M6 Torx screw that attaches the upper bracket of the forward window to the door. Tighten the screw 53 to 71 lbf·in (600 to 800 N·cm).
13. Install the door-mounted mirror; see **Section 60.03, Subject 100**.
14. Install the door interior trim panel and the pull handle; see **Subject 160**.
15. Raise the window to make sure it seats into the seal and the divider bar.

General Information

A newly installed door assembly must be adjusted for correct up-and-down, fore-and-aft, and in-and-out position 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 and water leaks at the door opening frame
- premature wear of the door seal
- hard closing or opening of the door

Loosening the bolts that attach the hinges to the cab (**Fig. 1**) allows the door to be adjusted up or down, and forward or aft within the door frame. Loosening the bolts that attach the hinges to the door (**Fig. 2**) allows the front edge of the door to be adjusted in or out.

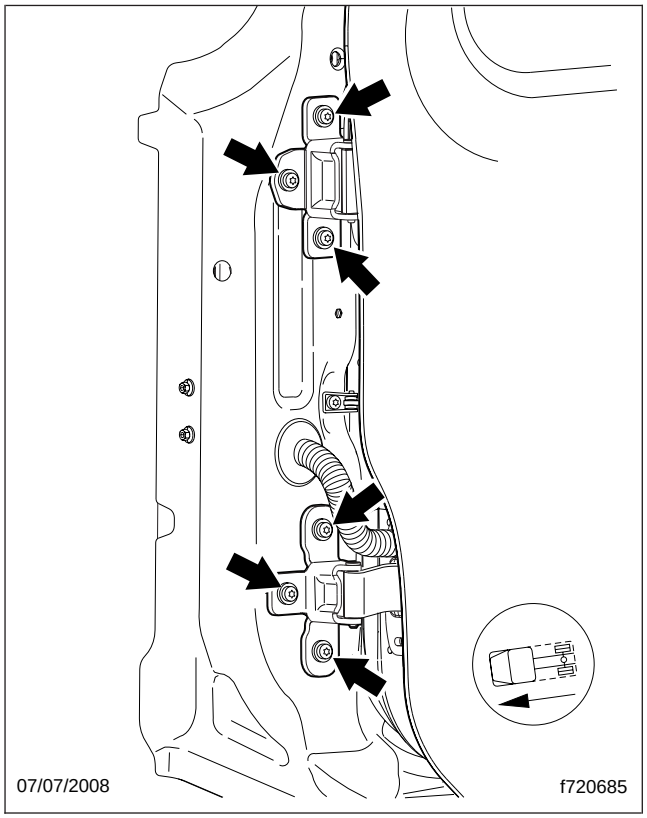


Fig. 1, Fore-and-Aft and Up-and-Down Adjusting Bolts on the Cab

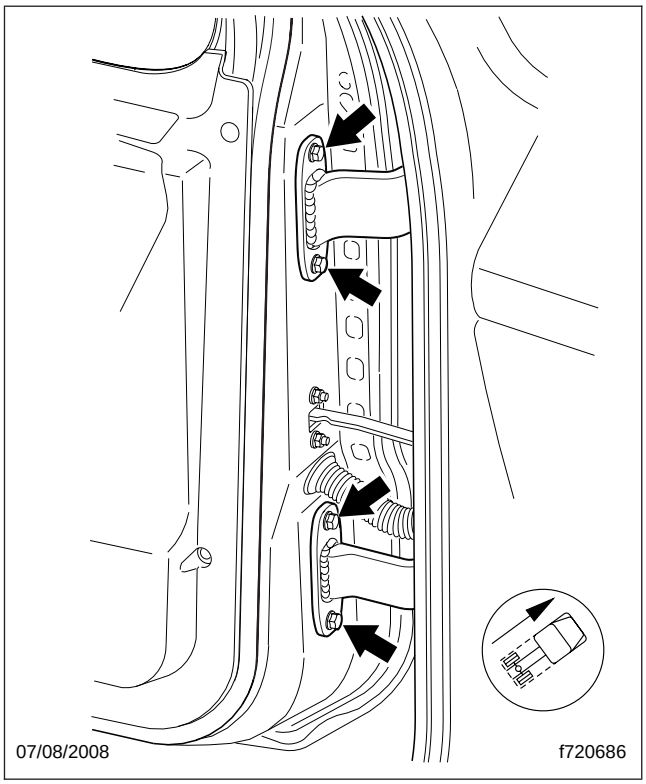


Fig. 2, In-and-Out Adjusting Bolts on the Door

Up-and-Down, Fore-and-Aft Adjustment

From outside the cab, check the alignment of the door within the door opening. The gaps at the top and rear edge of the door should be about 1/4 inch (7 mm), and the gap at the front edge of the door should be about 5/16 inch (8 mm). If the gaps are not correct, adjust the door.

1. Apply the parking brakes and chock the tires.
2. Remove the cowl side panel, as follows.
   - 2.1 Remove the two Torx screws and washers at the forward edge of the cowl side panel; see **Fig. 3**.
   - 2.2 Remove the bolt, nut, and two washers that attach the lower front corner of the cowl side panel to the hood rear support.
   - 2.3 Remove the four Torx screws and washers that attach the cowl side panel to the door frame; see **Fig. 4**.

Door Adjustment

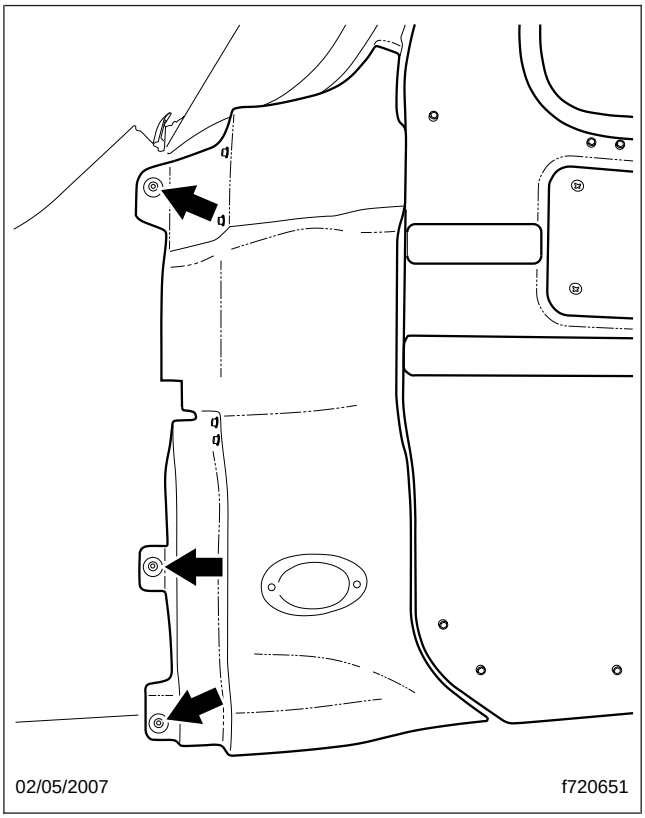


Fig. 3, Cowl Side Panel Forward Fasteners

2.4 Disconnect the wiring to the auxiliary side turn indicator lamp, then remove the cowl side panel.

3. Mark both the vertical and horizontal positions of the latch striker and the hinges before loosening them for adjustment. This will greatly simplify the procedure.
4. Loosen the striker (**Fig. 5**), then tighten it just enough to prevent unintentional movement.
5. Loosen the bolts that attach the door hinges to the cab, but keep them tight enough to prevent unintentional movement; see **Fig. 1**.
6. Loosely install the cowl panel to check the alignment gaps.
7. Carefully close the door, then move it fore-and-aft and up-and-down until the gaps at the top and rear edge of the door are about 1/4 inch (7 mm), and the gap at the front edge of the door is about 5/16 inch (8 mm).

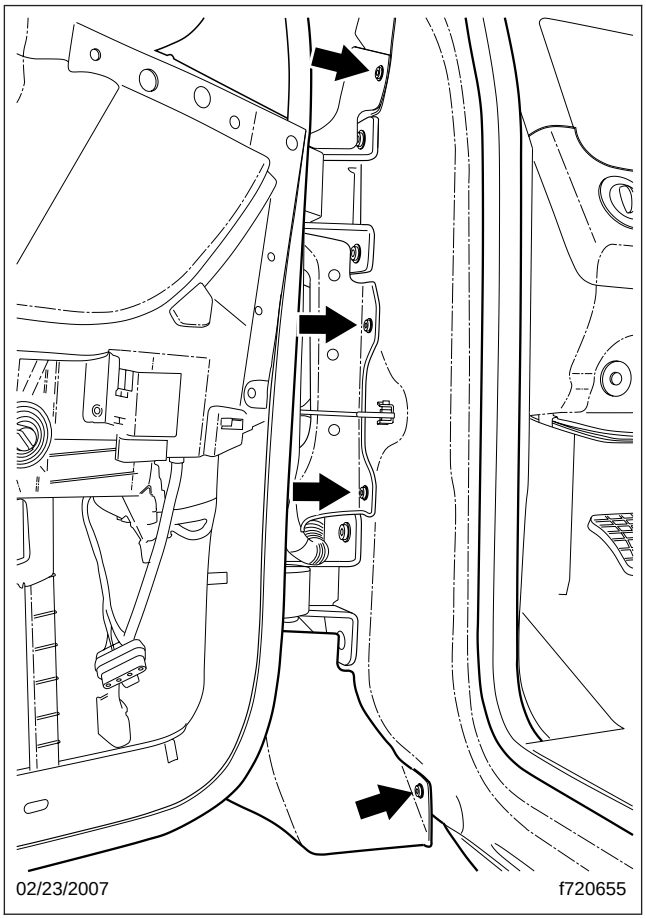


Fig. 4, Cowl Side Panel Rear Fasteners

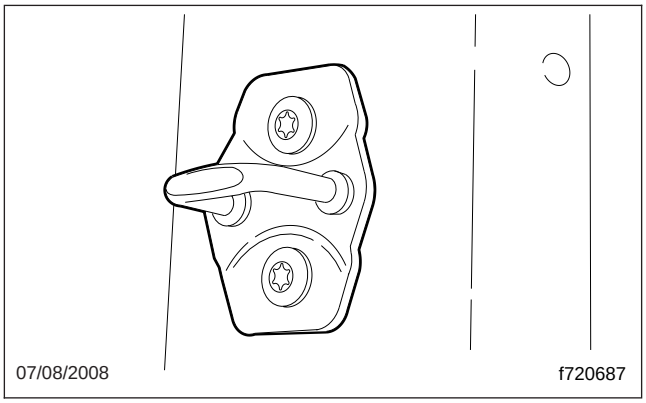


Fig. 5, Striker

⚠ CAUTION

Do not modify the holes in the hinge to allow for extra adjustment. This could affect the strength of the hinge and damage can result.

8. Remove the cowl panel, then carefully open and support the door, making sure that the positions of the hinges and striker are undisturbed. Tighten the hinge bolts 15 to 18 lbf·ft (20 to 24 N·m).
9. 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. Be sure the striker will be horizontal and centered in the latch jaw when the door is closed. If needed, reposition the striker; see "Striker Adjustment" below.
10. Install the cowl side panel, as follows.
    - 10.1 Connect the wiring to the auxiliary side turn indicator lamp, then position the cowl side panel in place and attach it to the door frame with four Torx screws and washers; see **Fig. 4**.
    - 10.2 Install the bolt, nut, and two washers that attach the lower front corner of the cowl side panel to the hood rear support; see **Fig. 3**.
    - 10.3 Install the two Torx screws and washers at the forward edge of the cowl side panel.
11. Check the gaps. If necessary, remove the cowl side panel to adjust the door.
12. The door surface should be flush with the cowl and cab body. Follow the instructions in “In-and-Out Adjustment” to adjust the door flush with the cab body panels, if necessary. Otherwise, go to “Striker Adjustment”.

In-and-Out Adjustment

The exterior surface of the door should appear to be flush with the surface of the cab skin at both its front and rear edges. If either edge is noticeably offset from the cab skin, adjust the door.

Door Front Edge Adjustment

1. If the front edge of the door needs adjusting, with the tires chocked, mark the vertical and horizontal positions of the hinges before loosening them for adjustment. This will greatly simplify the procedure.
2. Loosen the bolts that attach the hinges to the door assembly (**Fig. 2**), but keep them tight enough to prevent unintentional movement.
3. Carefully close the door, then move the front edge in or out until its surface appears to be flush with the surface of the cab skin. Be careful not to disturb the up-and-down adjustment.
4. Without disturbing the positions of the hinges, carefully open and support the door, then tighten the hinge bolts 15 to 18 lbf·ft (20 to 24 N·m).

Door Rear Edge Adjustment

1. If the rear edge of the door needs adjusting, with the tires chocked, mark the vertical and horizontal positions of the striker (**Fig. 5**) before loosening it for adjustment.
2. Loosen the striker, then tighten it enough to prevent unintentional movement.
3. Carefully close the door, then move the rear edge of the door in or out until the outer panel of the door appears to be flush with the cab side panel. Be careful not to disturb the up-and-down adjustment.
4. Without disturbing the position of the striker, carefully open the door, then tighten the striker screws 9 to 12 lbf·ft (12 to 16 N·m).

NOTE: The striker must be horizontal when tightened.

5. Close the door and check the door adjustment.
6. Follow the instructions in “Striker Adjustment” to correctly adjust the striker, if necessary.

Striker Adjustment

For secure door closure, check the alignment of the latch and striker even if the striker was not loosened.

1. With the tires chocked, from outside the cab, partially close the door and make sure that the striker (**Fig. 5**) is centered in relation with the latch jaws. Only the center of the striker should contact the latch jaws.
2. Close the door. It should not move up or down as the latch jaws engage the striker.

Door Adjustment

3. Make sure that the latch jaws will just clear the striker head when the door is closed. If necessary, loosen the striker, then reposition it.
4. Repeat the above steps, as needed, until the striker is correctly positioned. Tighten the striker screws 9 to 12 lbf·ft (12 to 16 N·m).

NOTE: The striker must be horizontal when tightened.

5. 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 position of the door.
6. Remove the chocks.

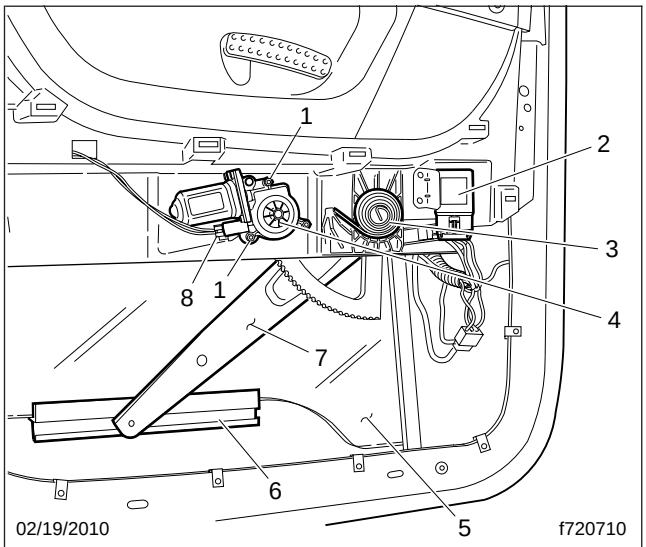
Replacement

1. Apply the parking brakes and chock the tires.
2. Lower the window all the way down, and open the door.
3. Remove the door pull handle and interior trim panel; see **Subject 160**.

WARNING

Remove the window motor only with the glass installed in the door cassette, and the door cassette installed on the vehicle. The weight of the glass keeps the counterbalance spring in place. Removing the motor with the window glass or door cassette removed could release the counterbalance spring, possibly causing personal injury.

4. Remove the three nuts that secure the window motor to the door cassette. See **Fig. 1**.
5. Pull the motor off the mounting studs.
6. Install the new motor on the mounting studs.
7. Install the nuts on the mounting studs. Tighten the nuts 31 to 58 lbf·in (350 to 650 N·cm).
8. Test the window glass operation.
9. Install the door interior trim panel and the pull handle; see **Subject 160**.



1. Motor Mounting Nuts
2. Express Down Module (driver-side door)
3. Counterbalance Spring
4. Window Motor
5. Window Glass
6. Glass Lift Channel
7. Regulator Arm
8. Motor Electrical Connector

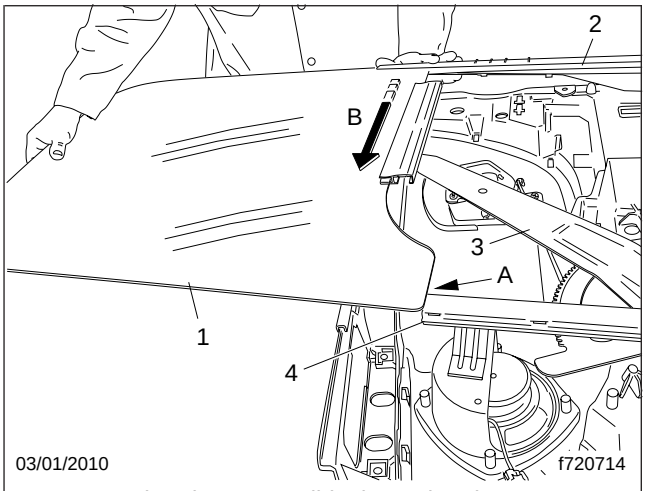
Fig. 1, Door Window Components

Replacement

1. Apply the parking brakes and chock the tires.
2. Lower the window all the way down, and open the door.
3. Remove the door pull handle and interior trim panel; see **Subject 160**.
4. Disconnect the door wiring from the vehicle.
5. Remove the door cassette from the door; see **Subject 110**.
6. Place the cassette down on a large flat surface, inboard side facing down.
7. Connect the door wiring to the vehicle.

NOTE: At this point it is not necessary to route the wiring through door frame and A-pillar.

8. With the help of an assistant holding the glass, power the glass up until it clears the shorter (forward) glass run channel. See **Fig. 1**.



A. Power the glass up until it clears the shorter (forward) glass run channel.
B. Slide the glass forward until it clears the regulator arm tab.

1. Glass
2. Glass Run Channel, Rear
3. Regulator Arm
4. Glass Run Channel, Forward

Fig. 1, Removing Glass

9. Slide the glass forward until the glass lift channel clears the tab on the end of the regulator arm.
10. Install the new glass, inserting the tab on the end of the regulator arm into the glass lift channel. See **Fig. 2**. Slide the glass back until the rear edge is seated in the rear glass run channel.

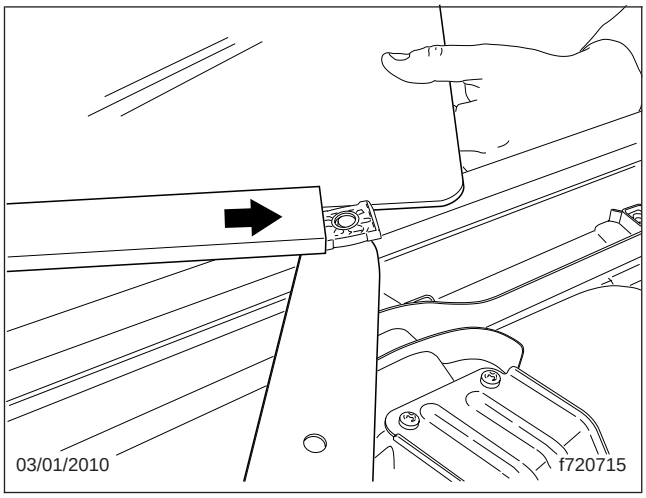


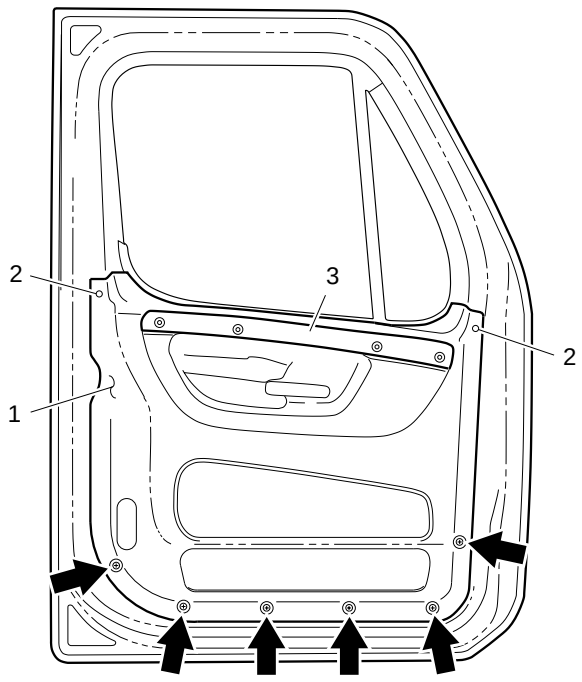
Fig. 2, Inserting Regulator Arm Tab in Glass Lift Channel

11. With the help of an assistant, power the glass all the way down, supporting it until it is well seated in both run channels.
12. Disconnect the door wiring from the vehicle.
13. Install the door cassette on the door; see **Subject 110**.
14. Install the door interior trim panel and the pull handle; see **Subject 160**.

Interior Trim Panel Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the pull handle by removing the four Torx screws that attach it to the door cassette; see **Fig. 1**.



1. Door Interior Trim Panel
2. Christmas-Tree Fastener
3. Pull Handle

Fig. 1, Door Interior Trim Panel Screws

3. Remove the control switch bezel from the top of the door interior trim panel.
4. Remove the six Torx screws that attach the door interior trim panel to the door.
5. Remove the two Christmas-tree fasteners that attach the top corners of the trim panel to the door.
6. Pull the panel away from the door to unclip it from the door cassette.
7. Disconnect the courtesy light electrical connector.

NOTICE

Use care not to damage the control switches when removing the interior trim panel. The switches contain small parts that can break off, making them inoperable.

8. Remove the panel by raising it over the lock knob and control switches.

Installation

1. With the vehicle tires chocked, lower the panel over the lock knob and control switches, using care not to damage the switches. Connect the courtesy light electrical connector.
2. Push the panel into position on the door cassette to engage the backside clips that hold it in place.
3. Using two Christmas-tree fasteners, attach the top corners of the trim panel to the door; see **Fig. 1**.
4. Attach the bottom of the panel to the door assembly with six Torx screws. Tighten the screws 35 to 53 lbf·in (400 to 600 N·cm).
5. Snap the control switch bezel in place on top of the trim panel.
6. Install the pull handle on the door, using four Torx screws. Install the forward screw first, then the rear screw, then the two middle screws. Tighten the screws 35 to 53 lbf·in (400 to 600 N·cm).

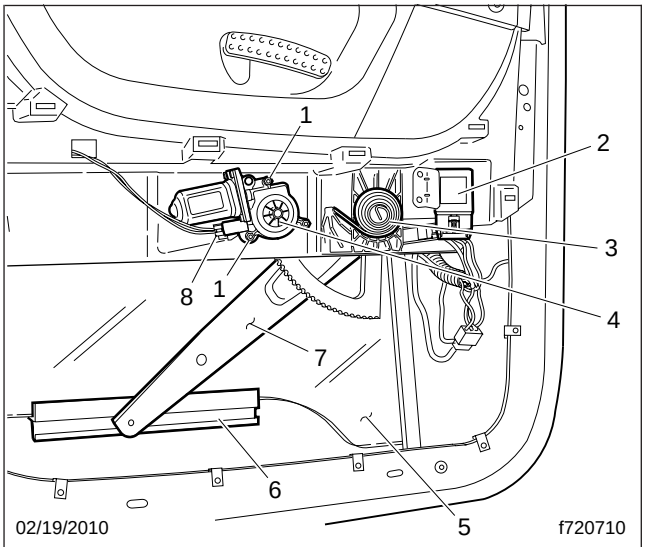
Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the door pull handle and the interior trim panel. See **Subject 160**.
3. Open the door and raise the window all the way up.

⚠ WARNING

Wear eye and hand protection when removing or installing the counterbalance spring. When installed, the spring is under tension, which can be released suddenly if not handled with care, possibly resulting in personal injury.

4. Remove the counterbalance spring (**Fig. 1**, item 3) as follows:



NOTE: LH door shown.

1. Motor Mounting Nut
2. Express Down Module (driver-side door)
3. Counterbalance Spring
4. Window Motor
5. Window Glass
6. Glass Lift Channel
7. Regulator Arm
8. Motor Electrical Connector

Fig. 1, Door Window Components

4.1 Firmly clamp small locking pliers on the straight section of the spring, between the coil and the hook.

4.2 Insert a sturdy flat-blade screwdriver in the jaw opening, as shown in **Fig. 2**.

4.3 While holding onto both the pliers and the screwdriver, carefully unhook and unwind the spring.

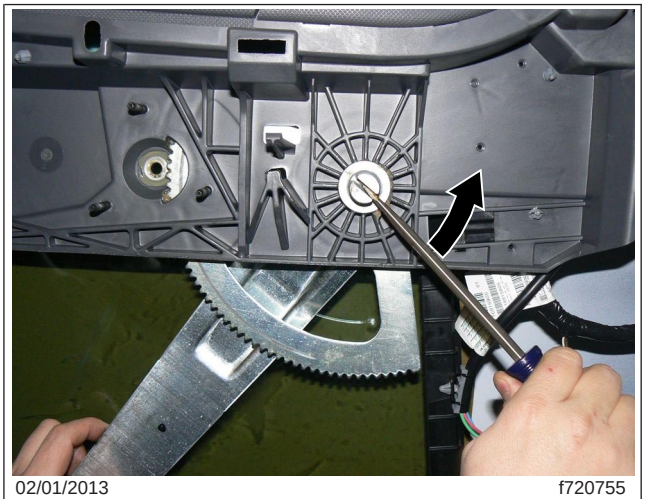
4.4 Remove the spring, leaving the locking pliers clamped onto it.

NOTE: LH door shown.

Fig. 2, Unhooking and Unwinding the Counterbalance Spring

5. Lower the window all the way down, then up about 1/4 inch (6 mm).
6. Disconnect the motor wiring.
7. Remove the three nuts that secure the window motor to the door cassette.
8. Pull the motor off the mounting studs.
9. Using a flat-blade screwdriver, unlock the regulator pivot stud by rotating it approximately 60 degrees (counterclockwise for the LH door, or clockwise for the RH door). Note the orientation of the slot in the head of the stud for installation. See **Fig. 3**.
10. Make sure the regulator gear is as far toward the rear of the door as possible, then remove the pivot stud. See **Fig. 4**.

Window Regulator Replacement



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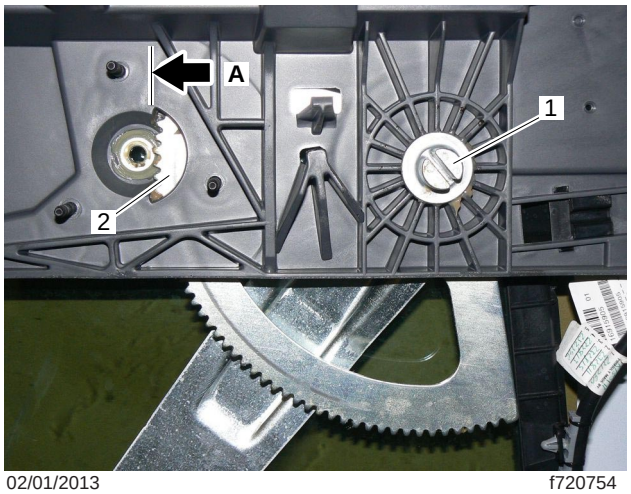
NOTE: LH door shown.

Fig. 3, Unlocking the Regulator Pivot Stud



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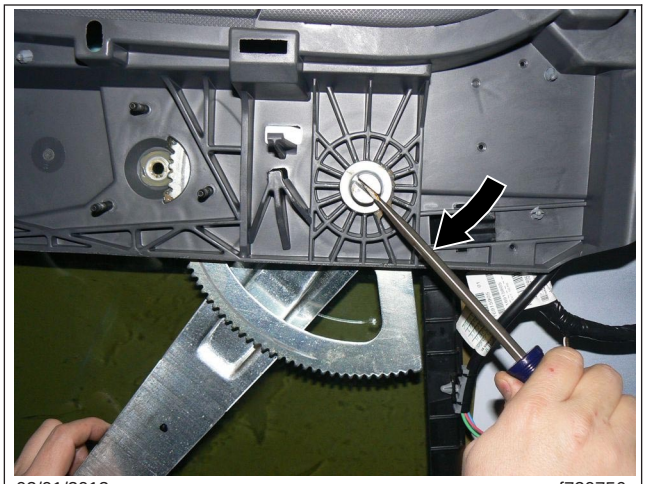
NOTE: LH door shown.

A. Move the regulator assembly as far toward the rear of the door as possible.

1. Pivot Stud
2. Regulator Gear

Fig. 4, Moving the Regulator Assembly for Pivot Stud Removal

11. Remove the regulator assembly, sliding the regulator arm tab out of the glass lift channel.
12. Grease the new regulator gear teeth, both sides of the gear surface, and the pivot stud, using medium-weight synthetic grease.
13. Install the new regulator assembly, sliding the regulator arm tab into the glass lift channel, with the gear positioned to engage the motor gear, as shown in **Fig. 4**.
14. Position the regulator with the pivot stud hole aligned with the hole in the panel. Install the pivot stud, with the slot aligned in the position noted when removed.
15. Using a flat-blade screwdriver, lock the pivot stud by rotating it approximately 60 degrees (clockwise for the LH door, or counterclockwise for the RH door). See **Fig. 5**.



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NOTE: LH door shown.

Fig. 5, Locking the Regulator Pivot Stud

16. Install the motor on the mounting studs.
17. Install the nuts on the mounting studs. Tighten the nuts 31 to 58 lbf·in (350 to 650 N·cm).
18. Connect the motor wiring.
19. Raise the window all the way up.
20. Install the counterbalance spring on the pivot stud, then using the locking pliers and the screwdriver, wind the spring and hook it on the stop.
21. Test the window operation.
22. Install the door interior trim panel and the pull handle. See **Subject 160**.

Specifications

For fastener torque values, see **Table 1**.

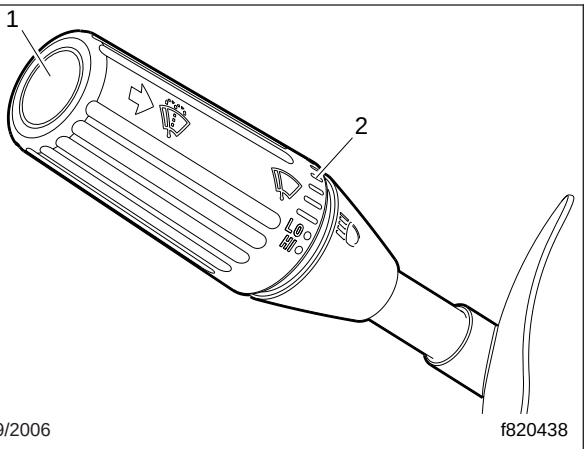
Torque Specifications				
Fastener Description	**lbf·ft**	**N·m**	**lbf·in**	**N·cm**
Hinge Capscrews, M8	15–18	20–24	—	—
Door Check Assembly Nuts, M6	7–9	9–12	—	—
Striker Mounting Screws, M8	9–12	12–16	—	—
Door Interior Trim Panel Torx Screws	—	—	35–53	400–600
Door Pull Handle Torx Screws	—	—	35–53	400–600
Door Cassette Torx Screws	—	—	53–71	600–800
Forward Window Mounting Screws	—	—	53–71	600–800
Window Motor Mounting Screws	—	—	31–58	350–650

Table 1, Torque Specifications

General Information

The windshield wipers and washer pump controls are located on the end of the stalk switch mounted on the steering column. To turn the windshield wipers on, rotate the end of the stalk switch to an intermittent, low, or high speed; see **Fig. 1**.

The windshield washer is operated by pressing the windshield washer button on the end of the windshield wiper switch. When the button is pressed, there is a short delay before the washer pump operates. When the washer button is pressed momentarily, the wiper operates one full, dry cycle. When the washer button is held on, the washer pump delivers washer fluid to the windshield, and the windshield wipers will operate at low speed until the button is released.



1. Windshield Washer Button
2. Windshield Wiper Control

Fig. 1, Windshield Wiper and Washer Controls

The windshield wipers have two wiper arms and two wiper blades. A single wiper motor powers both wipers. The wiper linkage and motor are located in the engine compartment, mounted on the cab front wall under the rain tray. The electric wiper motor is a sealed unit with a weather seal and motor lever. The wiper motor is not serviceable.

The windshield washer reservoir is located under the cab, on the right-hand side of the vehicle. The pump and an optional fluid level sensor are located at the back of the reservoir. A purge mechanism empties the lines after use to prevent fluid from freezing in the lines in cold weather.

The windshield washer nozzles are clipped to the wiper arms. On each wiper, the washer fluid tube is attached to the wiper arm with two clips. The washer fluid tubes connect to fittings on the rain tray.

Wiper Linkage Removal and Installation

Removal

1. With the vehicle parked on a level surface, 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. Remove the center section of the rain tray by removing the fasteners that attach it to the windshield support and to the left-side and right-side sections of the rain tray; see **Fig. 1**.

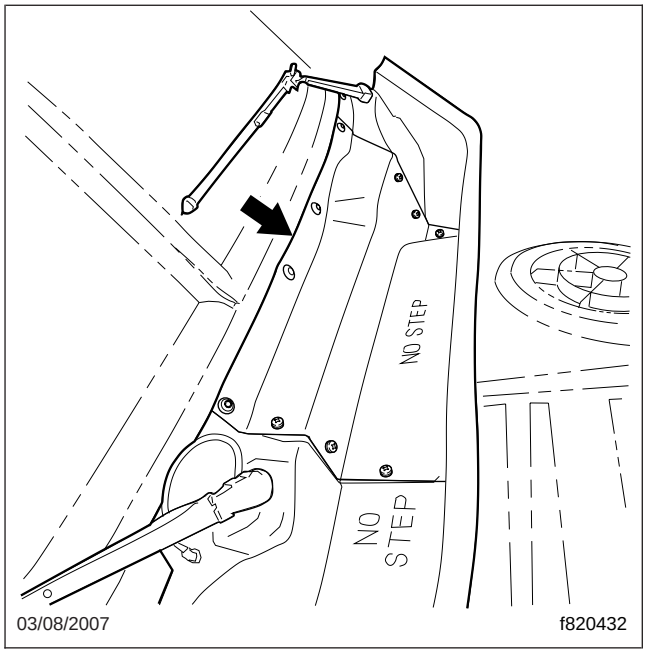


Fig. 1, Rain Tray, Center Section

5. 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.

6. Remove each wiper arm and disconnect the washer hoses, as follows.

6.1 Disconnect the windshield washer hose of the wiper arm from the fitting on the rain tray; see **Fig. 2**.

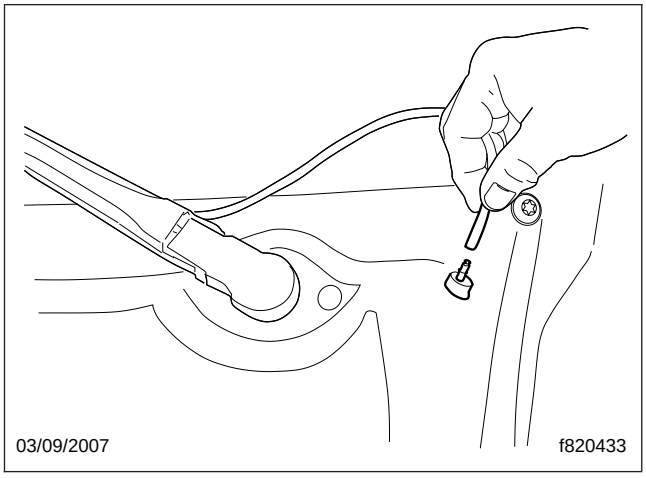


Fig. 2, Disconnecting Wiper Arm Washer Hose

6.2 With the wiper arm pulled away from the windshield, pull up the locking tab near the pivot end of the wiper arm; see **Fig. 3**. Remove the wiper arm from the wiper shaft.

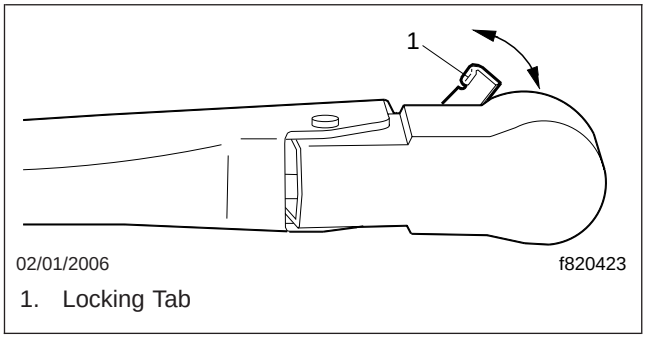


Fig. 3, Wiper Arm Lock

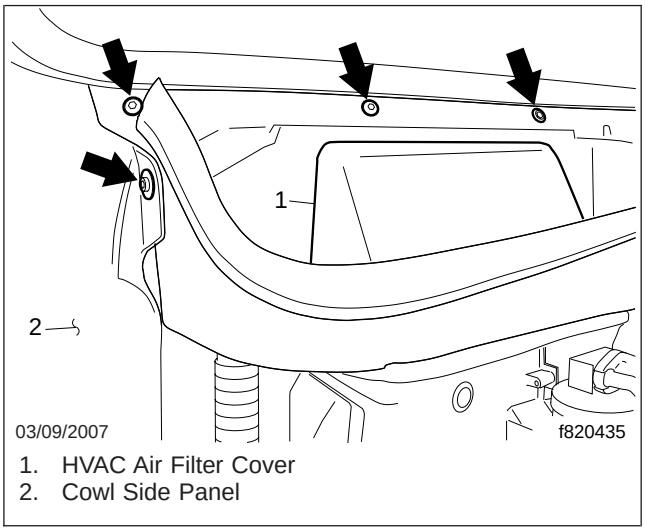
7. Remove the right-hand rain tray, as follows.

7.1 Detach the drain tube from the neck of the washer reservoir fill tube.

7.2 Remove the HVAC air intake filter cover by removing the two screws that attach it to the inside bottom of the right-hand rain tray; see **Fig. 4**.

7.3 Remove the screw that attaches the right-hand rain tray to the cowl side panel.

Wiper Linkage Removal and Installation



1. HVAC Air Filter Cover
2. Cowl Side Panel

Fig. 4, Right-Hand Rain Tray Fasteners

7.4 Remove the three screws that attach the right-hand rain tray to the windshield support. Pull the washer tube fitting loose from the bottom of the rain tray. Remove the tray.

8. Remove the left-hand rain tray, as follows.

8.1 Detach the drain tube from the left-hand splash shield.

8.2 Remove the screw that attaches the left-hand rain tray to the cowl side panel; see **Fig. 5**.

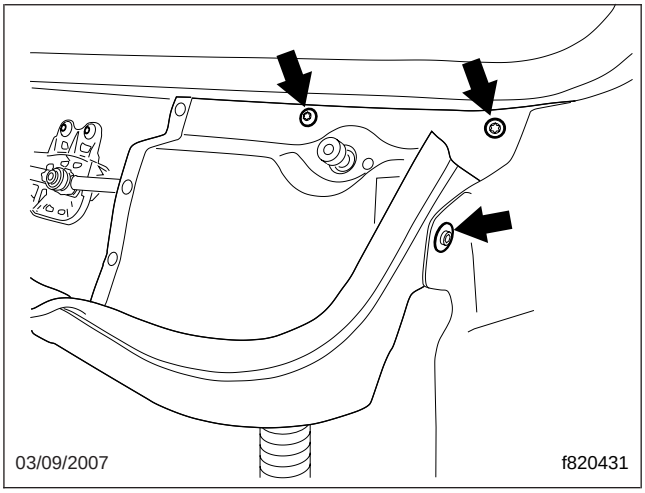


Fig. 5, Left-Side Rain Tray Fasteners

8.3 Remove the two screws that attach the left-hand rain tray to the windshield support. Pull the washer tube fitting loose from the bottom of the rain tray. Remove the tray.

9. Disconnect the washer fluid feeder line from the tee fitting at the linkage.
10. Cut the tie clips to remove the washer fluid tube from the wiper linkage.
11. Remove the Torx® screws that attach the wiper linkage to the cab. There are two screws at the wiper motor bracket and one at each end of the linkage; see **Fig. 6**.
12. Remove the nut that attaches the motor lever to the motor shaft; see **Fig. 7**.
13. Remove the motor from the linkage by removing the three screws that attach the motor to the mounting bracket.

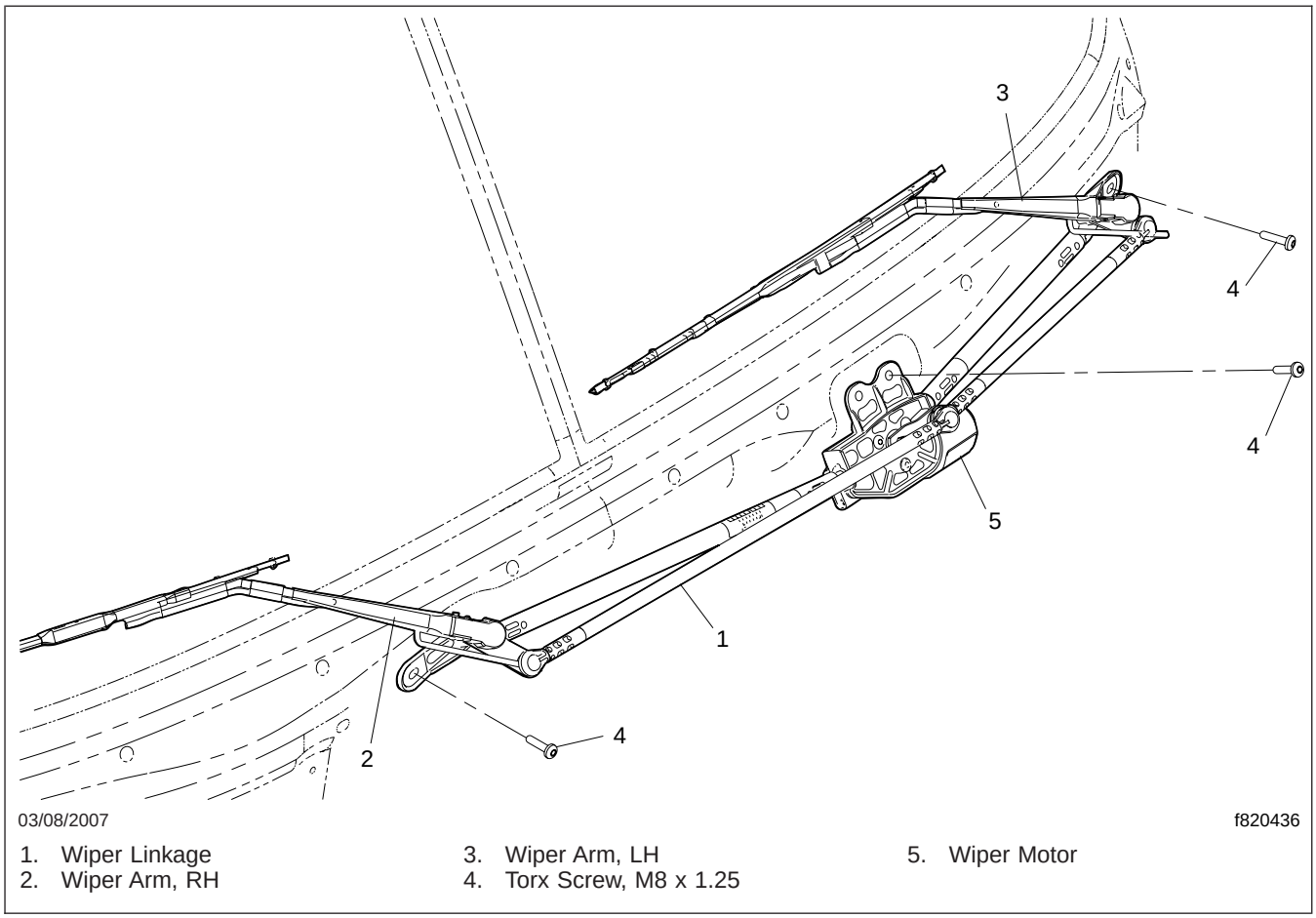
Installation

1. Attach the wiper motor to the mounting bracket on the linkage with three screws; see **Fig. 7**. Tighten the screws 8 to 11 lbf·ft (11 to 15 N·m).
2. With the linkage in park position, as shown in **Fig. 7**, install the nut that attaches the motor lever to the motor shaft. Tighten the nut 15 to 18 lbf·ft (20 to 24 N·m).
3. Attach the linkage to the cab front wall with two Torx screws at the wiper motor bracket and one at each end of the linkage; see **Fig. 6**.
4. Secure the washer tube to the linkage with new tie clips.
5. Connect the washer fluid feeder line to the tee on the washer tube.

NOTE: Replace the foam tape if damaged during removal of the rain tray.

6. Install the left-hand rain tray, as follows.

6.1 Push the washer tube fitting into the hole in the left-hand the rain tray. Attach the rain-tray to the windshield support with two screws; see **Fig. 5**. Tighten the screws 8 to 12 lbf·ft (11 to 16 N·m). Ensure that the tray seals evenly with the windshield support, with no gaps or bumps.



1. Wiper Linkage
2. Wiper Arm, RH
3. Wiper Arm, LH
4. Torx Screw, M8 x 1.25
5. Wiper Motor

Fig. 6, Wiper Linkage Installation

6.2 Secure the cowl side panel to the left-hand rain tray with a screw. Tighten the screw 4 to 6 lbf·ft (6 to 8 N·m).

6.3 Attach the drain tube to the left-hand splash shield.

NOTE: Replace the foam tape if damaged during removal of the rain tray.

7. Install the right-hand rain tray, as follows.

7.1 Push the washer tube fitting into the hole in the right-hand rain tray. Attach the rain-tray to the windshield support with three screws; see **Fig. 4**. Tighten the screws 8 to 12 lbf·ft (11 to 16 N·m). Ensure that the tray seals evenly with the cab, with no gaps.

7.2 Secure the cowl side panel to the right-hand rain tray with a screw. Tighten the screw 4 to 6 lbf·ft (6 to 8 N·m).

7.3 Attach the HVAC air filter cover to the inside of the right-hand rain tray with two screws.

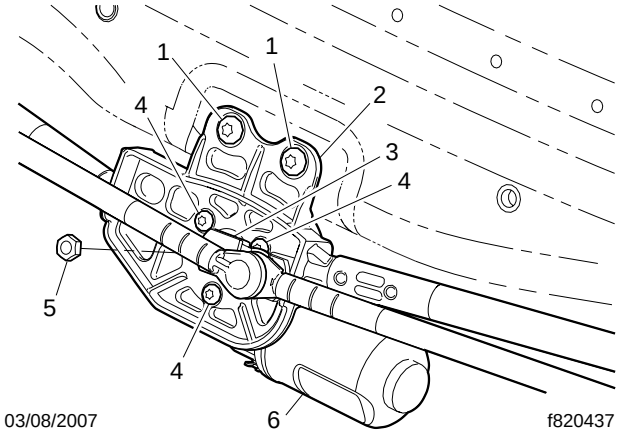
8. Attach the drain tube to the neck of the washer reservoir fill tube.

9. Install each wiper arm, as follows.

9.1 Push the wiper arm onto the wiper shaft. Make sure that it is parked in the correct position on the windshield.

9.2 Pull the wiper away from the windshield to lock the tab.

Wiper Linkage Removal and Installation



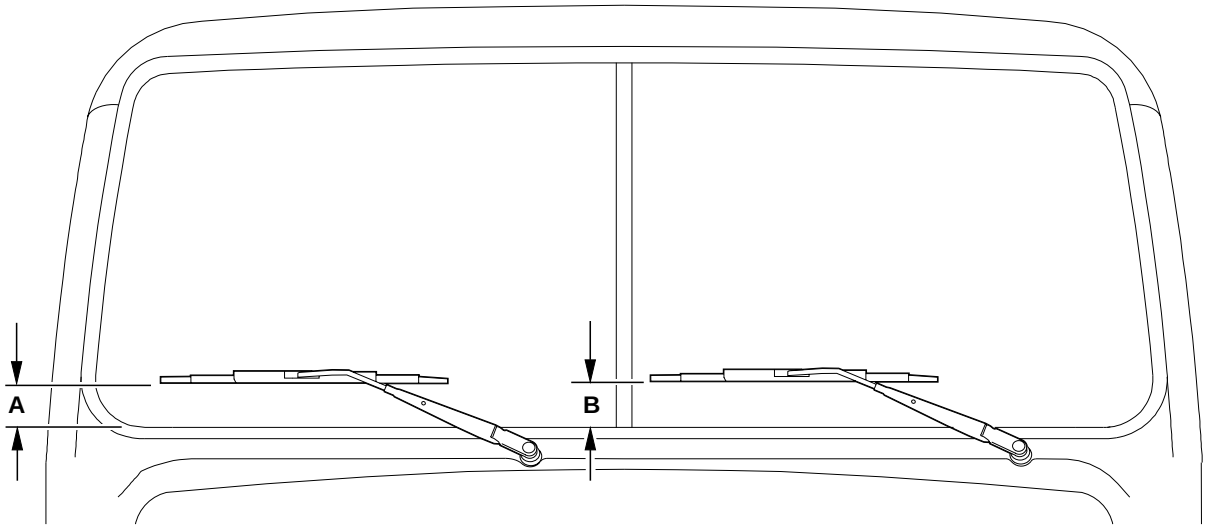
1. Bracket Mounting Screw
2. Mounting Bracket
3. Motor Lever
4. Motor Mounting Screw
5. Locknut
6. Wiper Motor

Fig. 7, Wiper Motor Installation

9.3 Connect the windshield washer hose of the wiper arm to the fitting on the rain tray; see **Fig. 2**.

10. Connect the wiper motor electrical connector.
11. Install the center section of the rain tray by attaching it with the fasteners to the windshield support and to the left-side and right-side sections of the rain tray; see **Fig. 1**. Tighten the screws that attach the rain tray to the windshield support 8 to 12 lbf·ft (11 to 16 N·m). Ensure that the tray seals evenly with the cab, with no gaps.
12. Inspect the hood seal before installation and replace if the sealing bulb is worn through. Make sure that the hood seal is fully pressed down onto the edge of the rain tray along its entire length.
13. 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 windshield, and that the wipers park as shown in **Fig. 8**. In the parked position, the end of the right-hand wiper blade should be 2-1/16 inches (53 mm) above the bottom edge of the windshield, and the end of the left-hand wiper blade should be 1-15/16 inches (49 mm) above the bottom edge of the windshield.
14. Close the hood.
15. Remove the chocks.

Wiper Linkage Removal and Installation



A. Measurement: 2-1/16 in (53 mm)
B. Measurement: 1-15/16 in (49 mm)

Fig. 8, Windshield Wiper Park Position

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the center section of the rain tray by removing the fasteners that attach it to the windshield support and to the left-side and right-side sections of the rain tray; see **Fig. 1**.
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 nut that attaches the motor lever to the motor shaft; see **Fig. 2**.
6. Remove the three screws that attach the motor to the mounting bracket. Remove the motor.

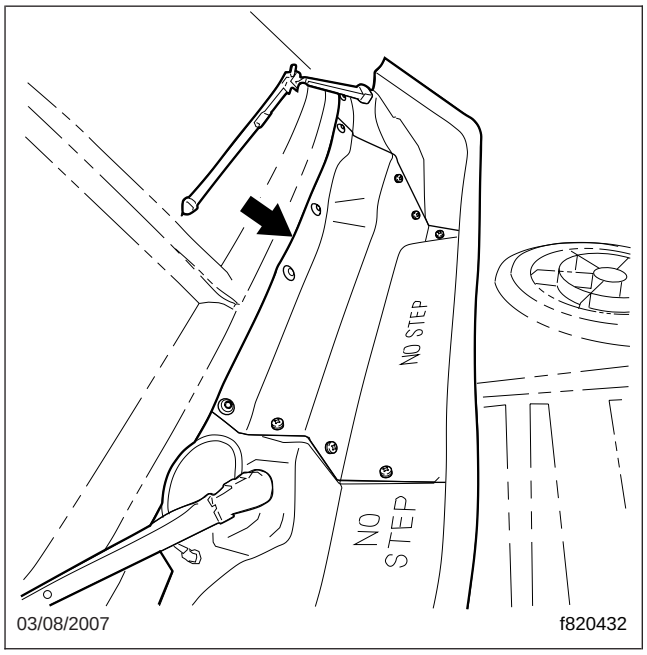
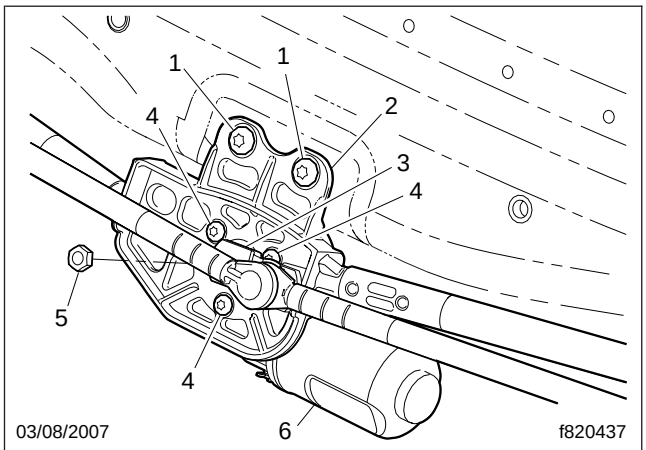


Fig. 1, Rain Tray, Center Section



1. Bracket Mounting Screw
2. Mounting Bracket
3. Motor Lever
4. Motor Mounting Screw
5. Locknut
6. Wiper Motor

Fig. 2, Wiper Motor Installation

7. Attach the new motor to the mounting bracket with three screws. Tighten the screws 8 to 11 lbf·ft (11 to 15 N·m).
8. With the linkage in park position, as shown in **Fig. 2**, install the nut that attaches the motor lever to the motor shaft. Tighten the nut 15 to 18 lbf·ft (20 to 24 N·m).
9. Connect the wiper motor electrical connector.

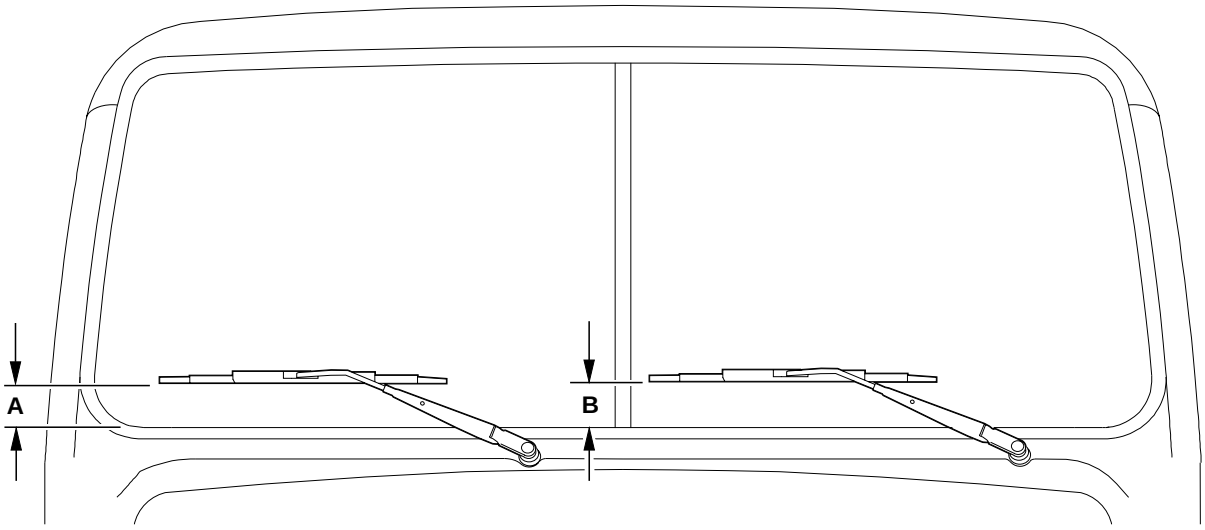
NOTE: Replace the foam tape if damaged during removal of the rain tray.

10. Install the center section of the rain tray by attaching it with the fasteners to the windshield support and to the left-side and right-side sections of the rain tray; see **Fig. 1**. Tighten the screws that attach the rain tray to the windshield support 8 to 12 lbf·ft (11 to 16 N·m). Ensure that the tray seals evenly with the cab, with no gaps.
11. Inspect the hood seal before installation and replace if the sealing bulb is worn through. Make sure that the hood seal is fully pressed down onto the edge of the rain tray along its entire length.
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 windshield, and that the wipers park as shown in **Fig. 3**. In the parked position, the end of the right-hand wiper blade should be 2-1/16

Wiper Motor Replacement

inches (53 mm) above the bottom edge of the windshield, and the end of the left-hand wiper blade should be 1-15/16 inches (49 mm) above the bottom edge of the windshield.

13. Close the hood.
14. Remove the chocks.

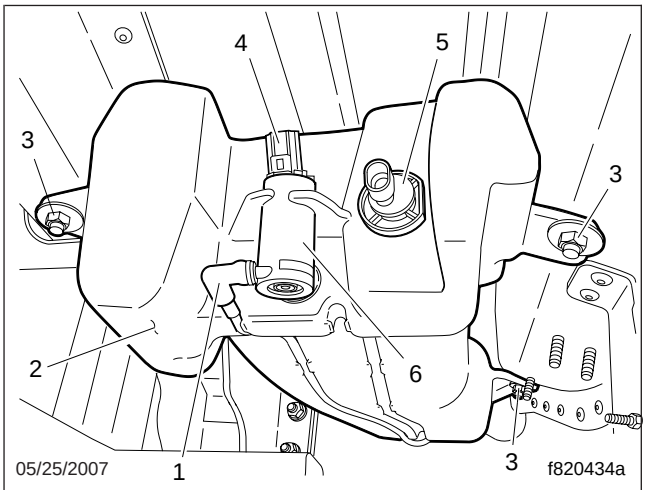


A. Measurement: 2-1/16 in (53 mm)
B. Measurement: 1-15/16 in (49 mm)

Fig. 3, Windshield Wiper Park Position

Replacement

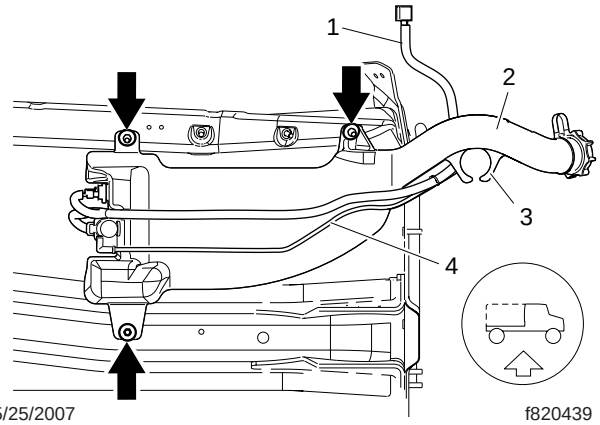
1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the front wheel splash shield. Refer to **Section 88.01, Subject 100** in this manual for instructions.
4. Disconnect the wiring from the pump and, if so equipped, the fluid level sensor; see **Fig. 1**.



1. Outlet Tube
2. Washer Reservoir
3. Reservoir Fasteners
4. Pump Electrical Connector
5. Level Sensor (optional)
6. Pump

Fig. 1, Washer Reservoir

5. Drain the washer reservoir, if necessary, by placing a container under it, and replacing the washer hose from the pump with one leading to a container.
6. Remove the pump, collecting the fluid from the reservoir in the container.
7. Place tape over the tank outlet to keep the tank from dripping.
8. Detach the rain tray drain tube from the collar on the reservoir filler tube.
9. Cut the tie clips, and remove the wiring and hose from the filler neck.
10. Remove the cap from the tank filler neck.
11. Remove the M8 nuts that attach the reservoir tank to the cab underbody; see **Fig. 2**. Remove the tank.



NOTE: Viewed from below.

1. Pump Wiring Harness
2. Reservoir Filler Tube
3. Rain Tray Drain-Tube Collar
4. Outlet Tube

Fig. 2, Washer Reservoir Fasteners (arrows)

12. Remove the fluid level sensor from the tank.
13. Install the fluid level sensor on the new tank.
14. Install the reservoir tank on the cab underbody with the M8 nuts; see **Fig. 2**. Tighten the nuts 11 lbf·ft (15 N·m).
15. Using tie clips to secure them to the filler neck, push the wiring and hose into the recessed channels on the bottom of the tank, routing them to the back.
16. Attach the rain tray drain tube to the collar on the reservoir filler neck.
17. Remove the tape from the tank outlet, and install the pump; see **Fig. 1**.
18. Connect the washer hose to the pump.
19. Connect the wiring to the pump, and if so equipped, the fluid level sensor.
20. Fill the washer reservoir with fluid.
21. Install the cap on the filler neck.
22. Test the washer operation.

Washer Reservoir Replacement

23. Install the front wheel splash shield. Refer to **Section 88.01, Subject 100** in this manual for instructions.
24. Close the hood.

Specifications

For fastener torque values, see **Table 1**.

Torque Values	
Description	**Torque**
Wiper Motor Mounting Screws	8–11 lbf·ft (11–15 N·m)
Wiper Motor Lever Nut	15–18 lbf·ft (20–24 N·m)
Washer Reservoir Mounting Nuts	11 lbf·ft (15 N·m)
Rain Tray Screws	8–12 lbf·ft (11–16 N·m)
Cowl Side Panel-to-Rain Tray Screws	4–6 lbf·ft (6–8 N·m)

Table 1, Torque Values

General Information

The vehicle heater, ventilation, and air conditioning (HVAC) system consists of the following major components:

- refrigerant compressor
- condenser
- receiver-drier
- cab heater and air conditioner assembly
- sleeper heater and air conditioner assembly (if equipped)
- high-side pressure transducer

The cab heater and air conditioner assembly is mounted behind the passenger dash panels and contains the following major components:

- blower motor
- evaporator
- heater core
- recirculation filter
- fresh air filter (on plenum on outside of front wall)
- four stepper motors (electric actuators)
- defrost, floor, blend, and recirculation doors
- thermal expansion valve
- two temperature sensors

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 *Cascadia™ Driver's Manual* for operating instructions.

Description of Components

Blower Motor

The 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.

Stepper Motor

The stepper motor is an electric actuator. It is a combined motor and gearbox, and is used to rotate the doors within the HVAC assembly. Movement of the doors is controlled by the settings on the climate control panel. There are four stepper motors on the HVAC assembly; they operate the defrost door, floor door, blend door, and recirculation door.

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 located downstream of the evaporator. The temperature sensor disengages the compressor to prevent the evaporator from freezing due to, for example, an expansion valve that is stuck open.

Duct Temperature Sensor

The temperature of the blended air leaving the heater core is monitored by the duct temperature sensor. The duct temperature sensor is located downstream of the heater core. The temperature sensor controls the blend door to maintain the desired output temperature.

Thermal Expansion Valve

The thermal 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 thermal expansion valve and moves into the low-pressure area of the

evaporator. A thermal 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 thermal 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.

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, the 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.

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 that 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-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 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.

General Information

psig Gauge pressure relative to the local atmosphere. At sea level, 0 psig is about 14.7 psia, which is standard atmospheric pressure. But in Denver, which is at about 5000 feet altitude, standard atmospheric pressure and 0 psig are about 12.5 psia. It is possible to have a negative gauge pressure, indicating a vacuum.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Recovery Removal of the refrigerant from the 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.

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.

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 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).

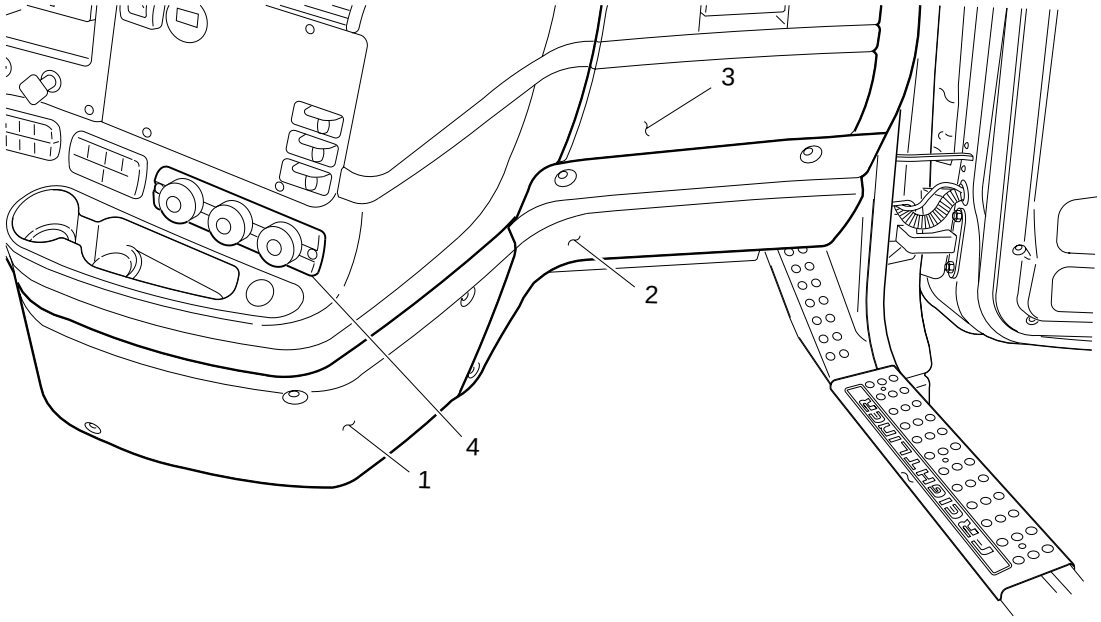
On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following guidelines:

- 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. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative cables.
3. Remove the dash access panels and supports listed below. See **Fig. 1** and **Fig. 2**. See **Section 60.06** for instructions.
   - HVAC cover
   - lower cover
   - glove box
   - glove box brace
4. If not already done, drill a 1/4-inch hole in the dash tab to gain access to the upper right-side floor duct fastener. See **Fig. 3** for the approximate location of the hole.
5. Remove the right-side floor duct. See **Fig. 4**.
6. Remove the windshield wiper arms. See **Section 82.00, Subject 100**.
7. Remove the HVAC fresh-air intake screen. See **Fig. 5**.
8. Remove the rain tray. See **Section 82.00, Subject 100**.
9. Place a drain pan under the vehicle, clamp the coolant lines to prevent excessive drainage from the cooling system, then disconnect the coolant lines from the heater core. Allow the heater core to completely drain into the pan. See **Fig. 6**.
10. If the heater core has not previously been replaced, use a razor knife to cut around the perimeter of the cutout panel, and discard the panel. See **Fig. 7**.

    If the heater core has previously been replaced, remove the fasteners and the cover.
11. Remove the heater core from the housing. Note the position of the "guide ear" next to the hose connections.



1. Lower Cover
2. HVAC Cover
3. Glove Box Assembly
4. HVAC Control Module

Fig. 1, Dash Panels

IMPORTANT: Make sure the "guide ear" on the heater core is properly aligned. Do not force the heater core into the housing. Forcing an improp-

Heater Core Replacement

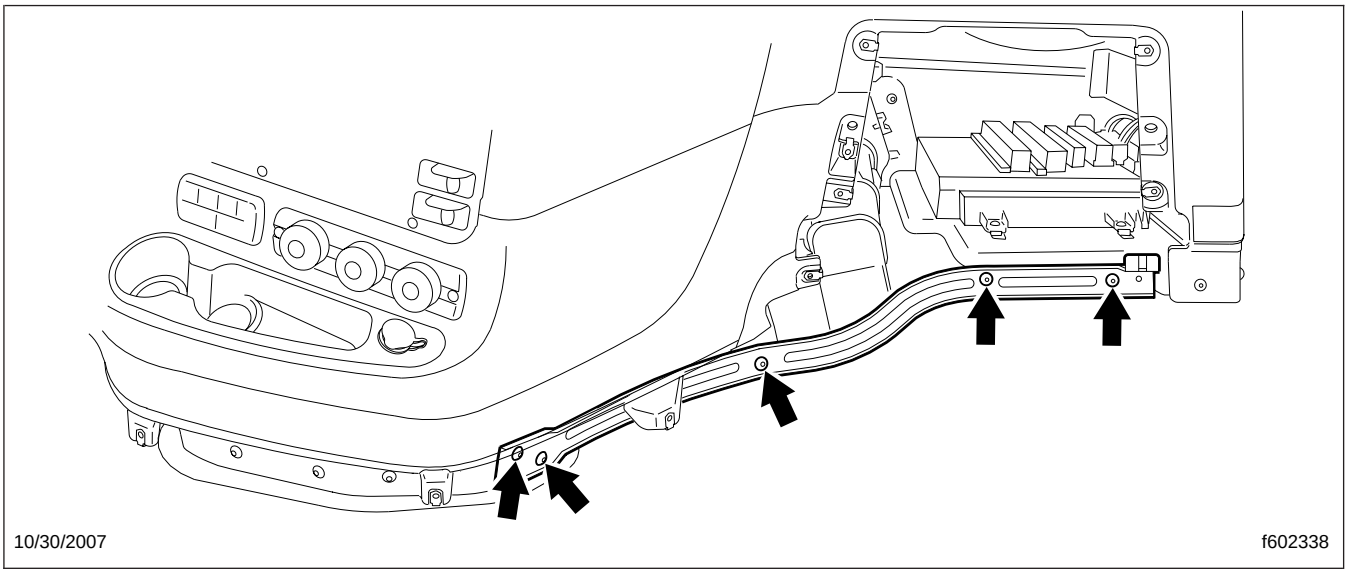
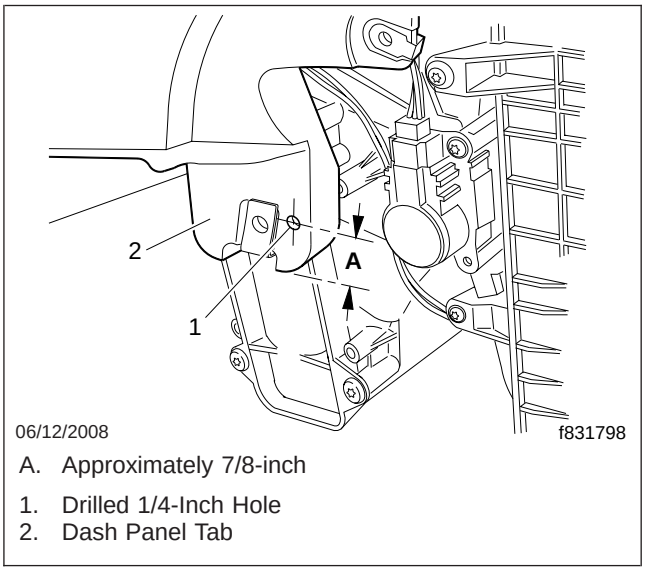


Fig. 2, Glove Box Brace Fasteners



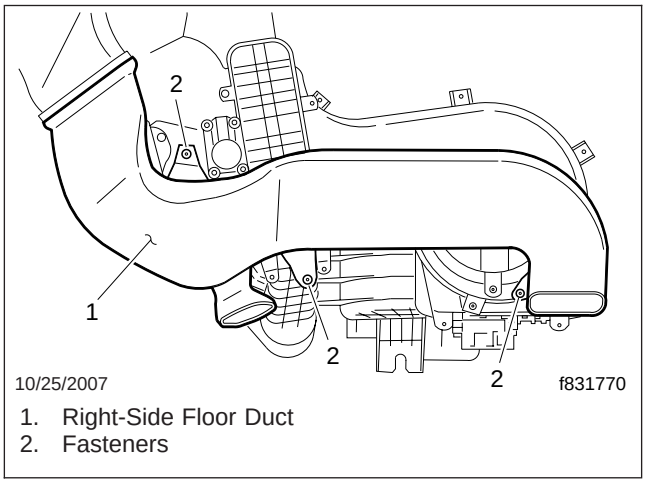
A. Approximately 7/8-inch

1. Drilled 1/4-Inch Hole
2. Dash Panel Tab

Fig. 3, New Hole Location

erly aligned heater core into the housing will break the "guide ear", and may cause the heater core to leak. It may be necessary to manipulate the core from both inside and outside the vehicle to get it into place without damaging it.

12. Orient the "guide ear" on the new heater core to the left, and slide the heater core in the housing.



1. Right-Side Floor Duct
2. Fasteners

Fig. 4, Right-Side Floor Duct Removal

NOTE: The new heater core comes with a replacement cover, and fasteners, for the one that was cut out.

13. Install the cover.

NOTE: When installing the right-side floor duct, it may be necessary to use needlenose pliers, or some other method, to aid in the installation of the upper fastener.

14. Install the right-side floor duct.

15. Install the glove box brace.

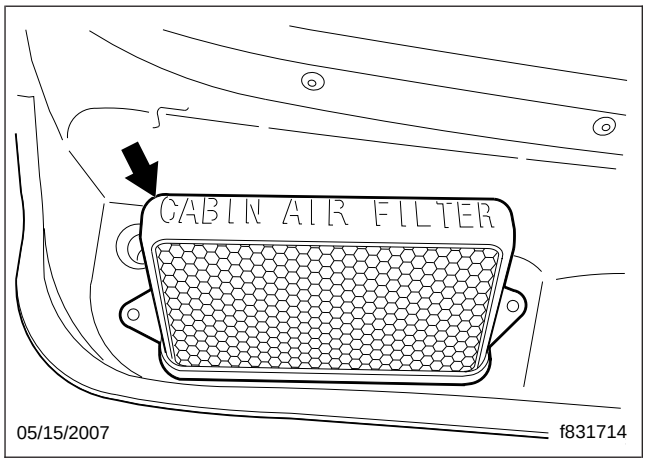


Fig. 5, Fresh-Air Intake Screen

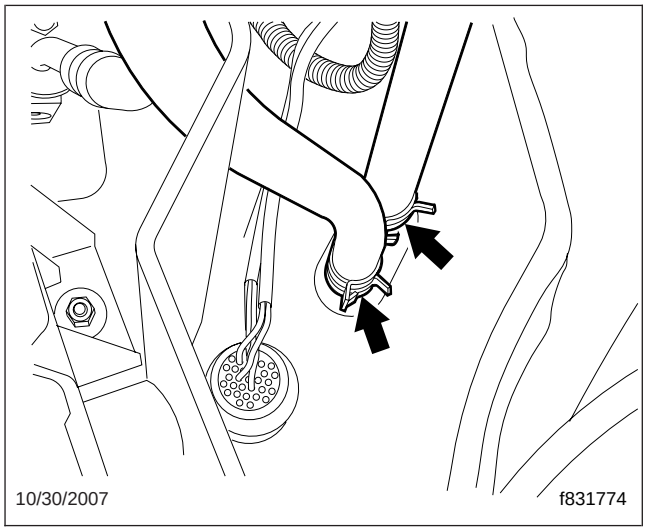


Fig. 6, Coolant Line Clamps

16. Install the dash panels.
17. Connect the coolant lines.
18. Install the rain tray.
19. Install the windshield wiper arms. See **Section 82.00, Subject 100**.
20. Install the HVAC fresh-air intake screen. See **Fig. 5**.
21. Connect the batteries.
22. Add coolant to the cooling system as needed. See **Group 20** for instructions.

Heater Core Replacement

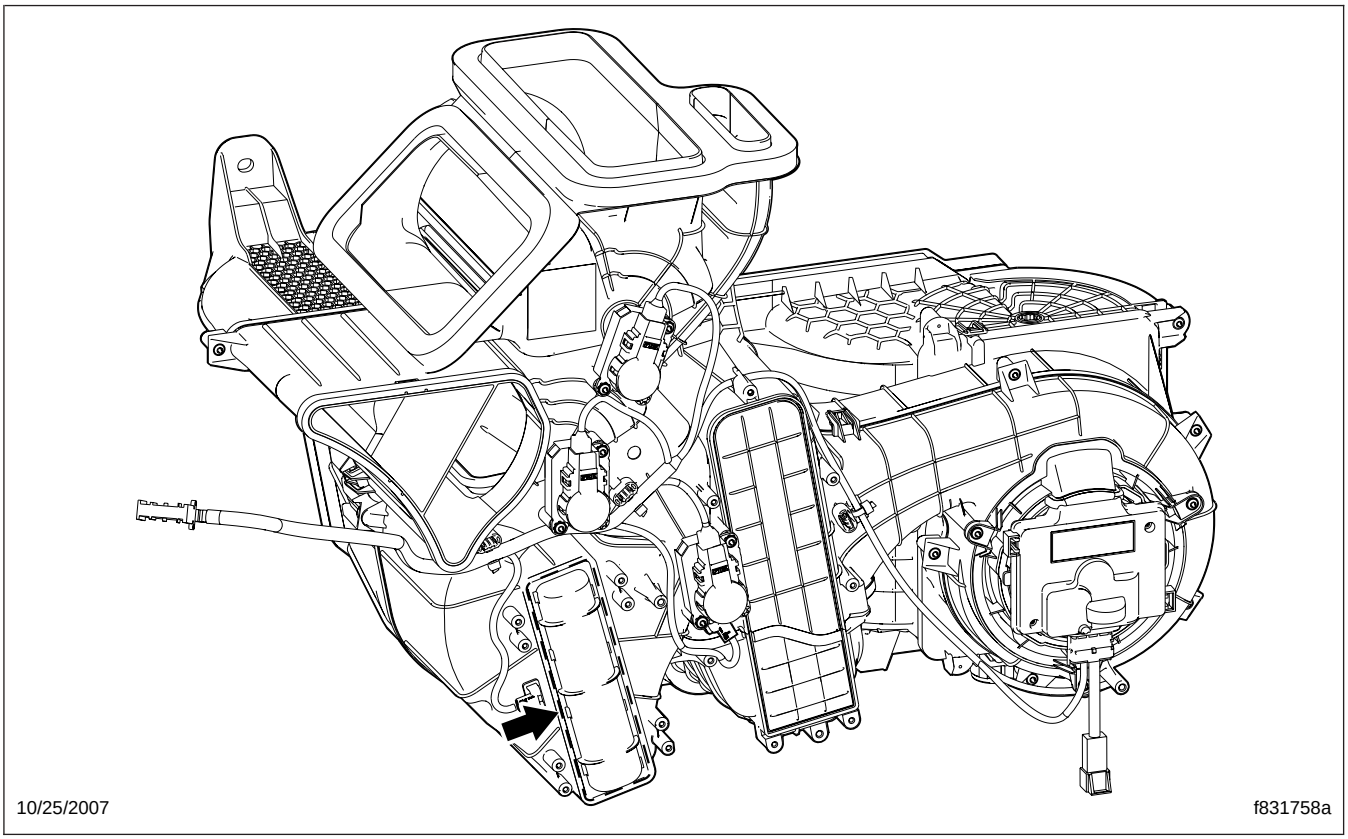


Fig. 7, Heater Core Cutout Panel

Evaporator Replacement

⚠ 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.

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative cables.
3. Recover the refrigerant from the air conditioning system. See **Subject 220** for instructions.
4. Remove the dash access panels and support listed below. See **Fig. 1** and **Fig. 2**. See **Section 60.06** for instructions.
    - HVAC cover
    - center cover
    - glove box
    - glove box brace
5. If not already done, drill a 1/4-inch hole in the dash tab to gain access to the upper right-side floor duct fastener. See **Fig. 3** for the approximate location of the hole.
6. Remove the right-side floor duct. See **Fig. 4**.
7. Remove the windshield wiper arms. See **Section 82.00, Subject 100**.
8. If the evaporator has not previously been replaced, use a razor knife to cut around the perimeter of the cutout panel, and discard the panel. If the evaporator has previously been replaced, remove the fasteners and the cover.
9. Remove the HVAC fresh-air intake screen. See **Fig. 5**.
10. Remove the rain tray. See **Section 82.00, Subject 100**.
11. Remove the nuts and bolts that hold the J-block to the HVAC intake duct. See **Fig. 6**.

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).

12. Disconnect the refrigerant lines from the thermal expansion valve, and cap the lines immediately to prevent contamination of the system.
13. Remove the evaporator from the housing. See **Fig. 7**.
14. If the new evaporator did not come with a new expansion valve, remove the thermal expansion valve from the old evaporator, and using new seals, install it on the new one. Tighten the valve 35 lbf·in (395 N·cm).
15. Install the new evaporator in the housing.
16. Using new seals, connect the refrigerant lines to the thermal expansion valve. Tighten the lines 11 to 15 lbf·ft (15 to 20 N·m). See **Fig. 8**.
17. Install the nuts and bolts that hold the J-block to the HVAC intake duct.
18. Add refrigerant oil to the compressor to replace that which is lost when the evaporator is replaced, and when the system is recovered. See **Section 83.02, Subject 120** for instructions.

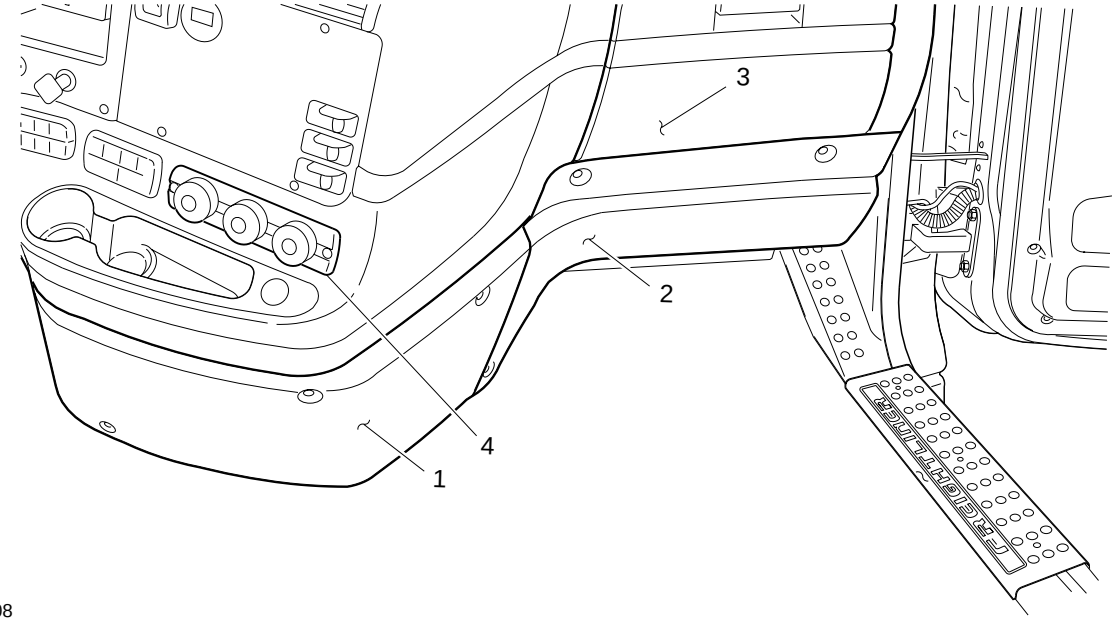
NOTE: The new evaporator comes with a replacement cover and fasteners for the one that was cut out.

19. Install the new cover.

NOTE: When installing the right-side floor duct, it may be necessary to use needlenose pliers, or some other method, to aid in the installation of the upper fastener.

20. Install the right-side floor duct.
21. Install the glove box brace.
22. Install the dash panels.
23. Install the rain tray.
24. Install the windshield wiper arms. See **Section 82.00, Subject 100**.
25. Install the HVAC fresh-air intake screen.
26. Connect the batteries.
27. Evacuate and charge the refrigerant system. See **Subject 220** for instructions.

Evaporator Replacement



1. Lower Cover
2. HVAC Cover
3. Glove Box Assembly
4. HVAC Control Module

Fig. 1, Access Panels

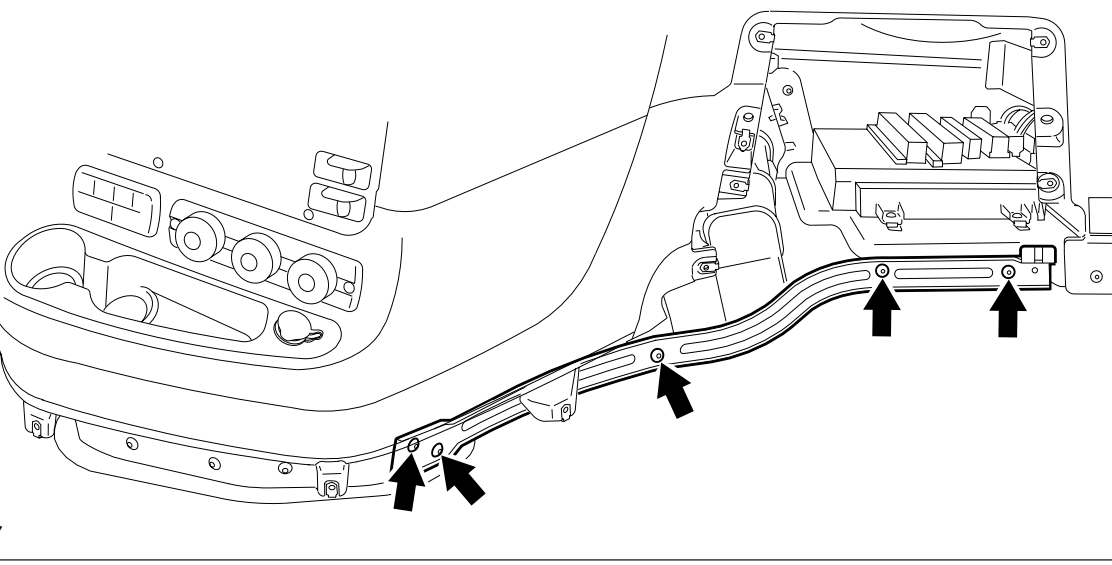
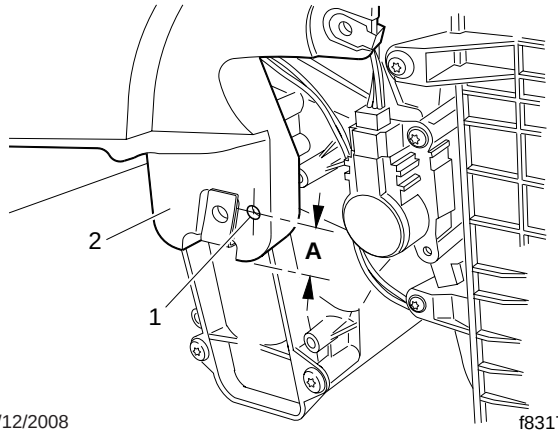


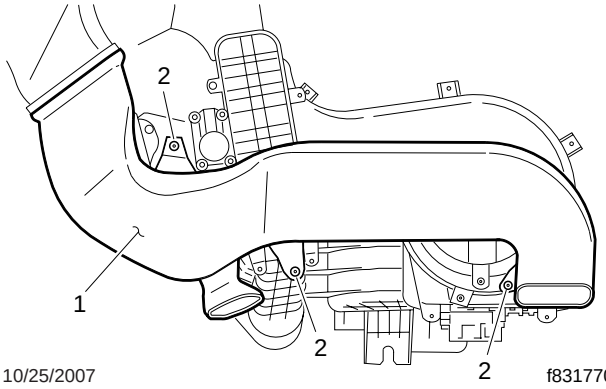
Fig. 2, Glove Box Brace Fasteners



A. Approximately 7/8-inch

1. Drilled 1/4-Inch Hole
2. Dash Panel Tab

Fig. 3, New Hole Location



1. Right-Side Floor Duct
2. Fasteners

Fig. 4, Right-Side Floor Duct Removal

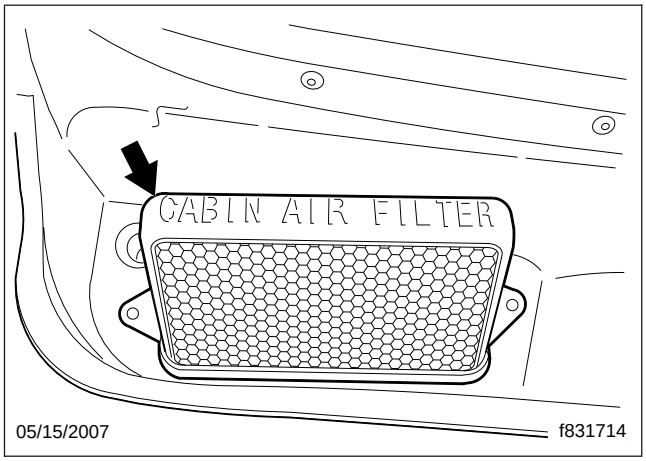
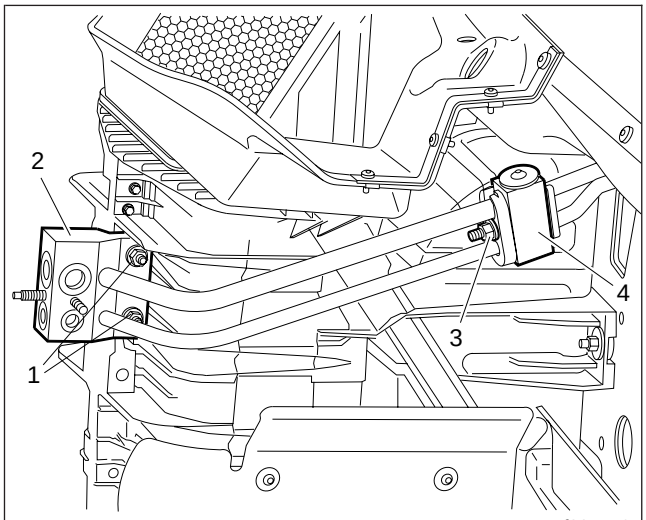


Fig. 5, Fresh-Air Intake Screen



1. J-Block Mounting Nuts and Bolts
2. J-Block
3. Thermal Expansion Valve Nut, Washer, and Stud
4. Thermal Expansion Valve

Fig. 6, Junction Block and Thermal Expansion Valve

Evaporator Replacement

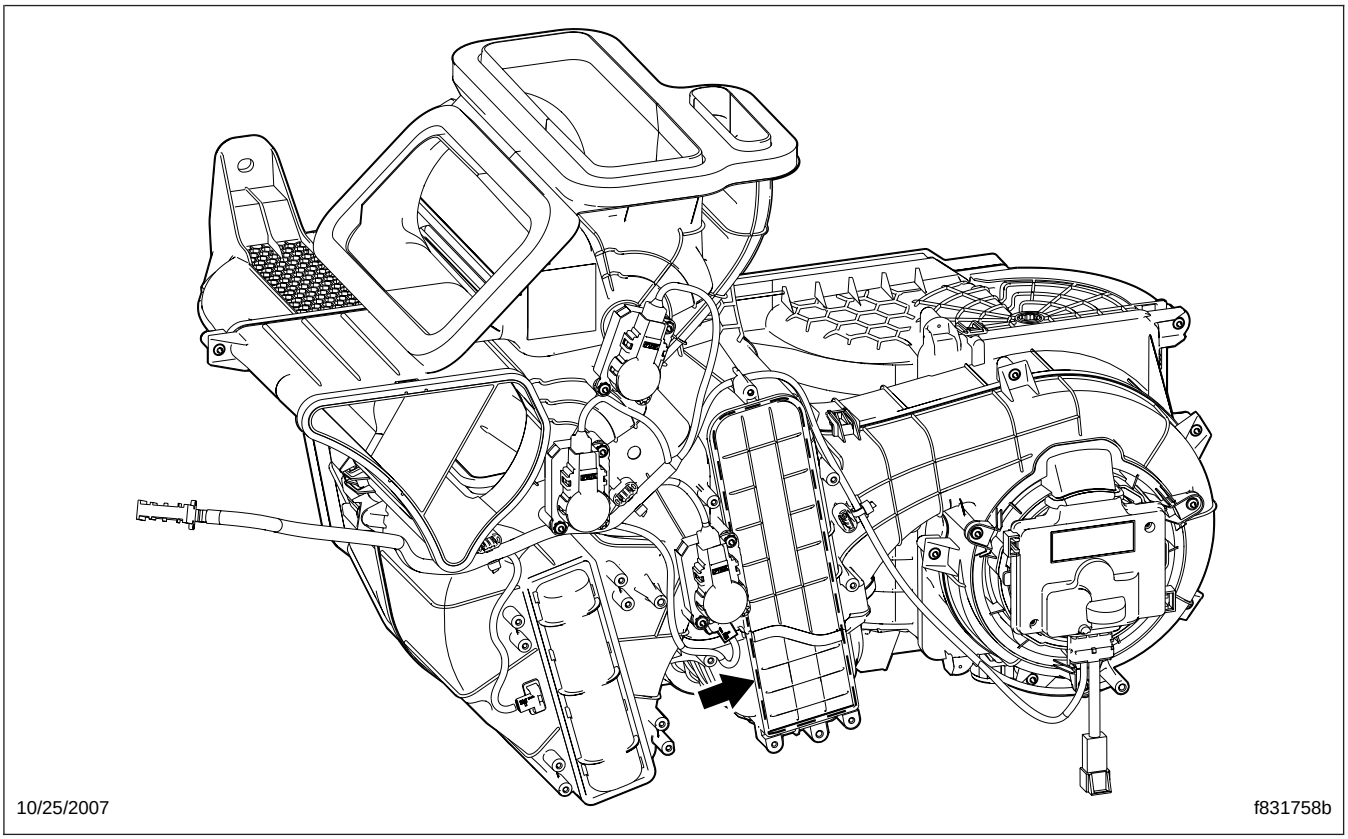
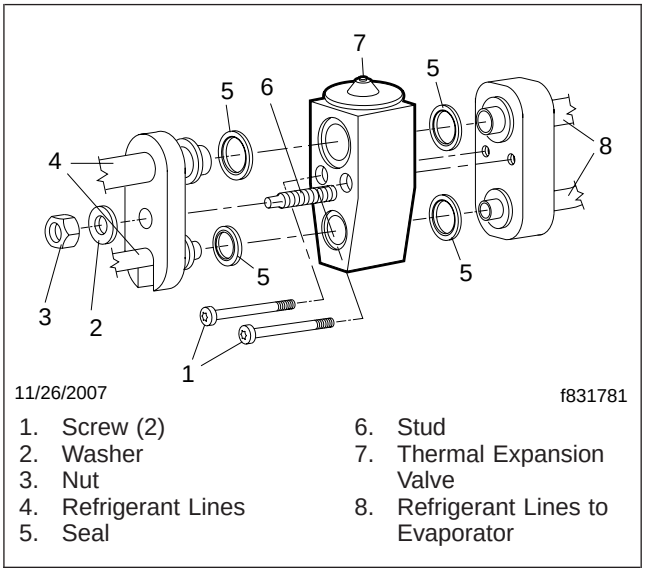


Fig. 7, Evaporator Installation



1. Screw (2)
2. Washer
3. Nut
4. Refrigerant Lines
5. Seal
6. Stud
7. Thermal Expansion Valve
8. Refrigerant Lines to Evaporator

Fig. 8, Thermal Expansion Valve Installation

Temperature Sensor Replacement

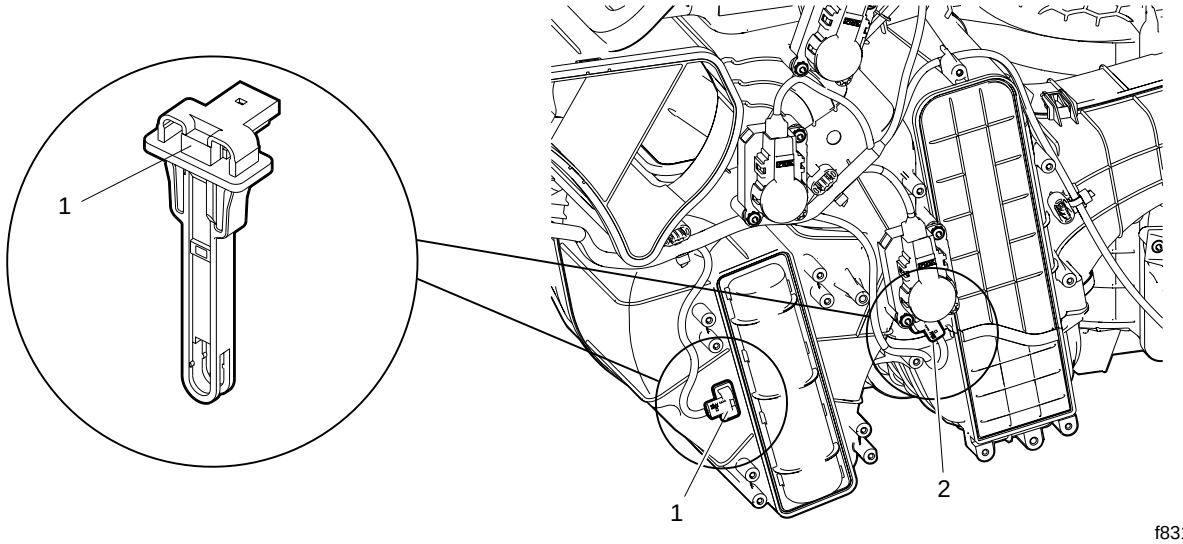
There are two temperature sensors on the cab HVAC unit. See **Fig. 1** for their locations. Both sensors install the same way, but they are **not** interchangeable. When replacing a sensor, make sure that you have the correct part. There is a slight difference in the guide tab on the two sensors, to prevent them from being reversed.

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative cables.
3. Remove the dash access panels and supports listed below. See **Fig. 2** and **Fig. 3**. See **Section 60.06** for instructions.
    - HVAC cover
    - lower cover
    - glove box
    - glove box brace
5. Remove the right-side floor duct. See **Fig. 5**.
6. Disconnect the wiring harness from the temperature sensor.
7. Pull the sensor out of the housing.
8. Install the new sensor in the housing.
9. Attach the wiring harness.

NOTE: When installing the right-side floor duct, it may be necessary to use needlenose pliers, or some other method, to aid in the installation of the upper fastener.

10. Install the right-side floor duct.
11. Install the glove box brace.
12. Install the dash panels.
13. Connect the batteries.

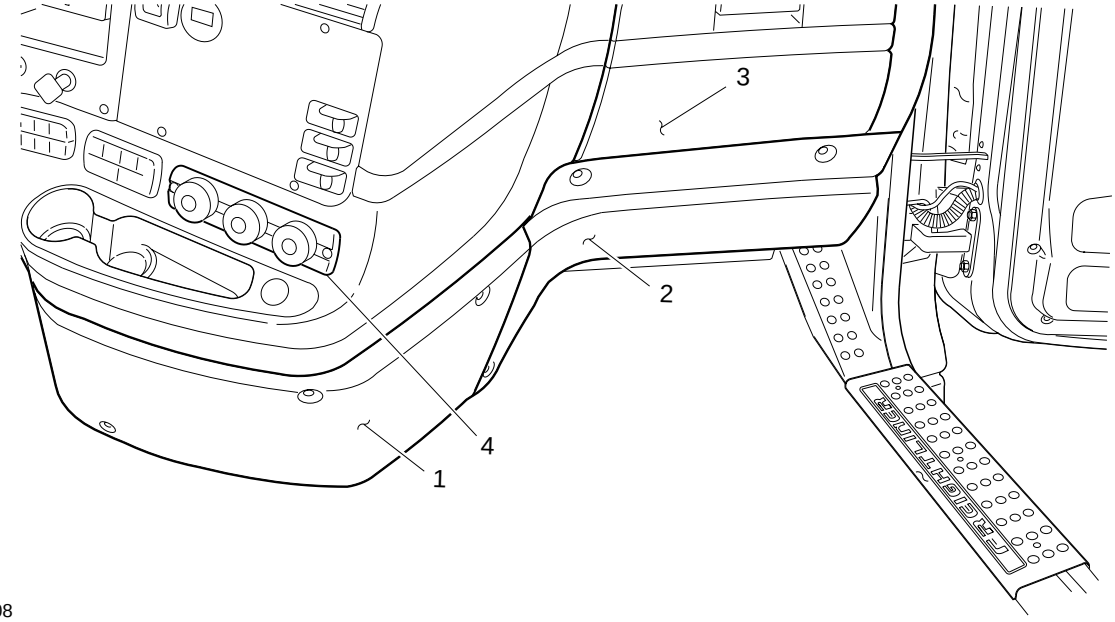


1. Heater Core Sensor
2. Evaporator Sensor

Fig. 1, Temperature Sensor Locations

4. If not already done, drill a 1/4-inch hole in the dash tab to gain access to the upper right-side floor duct fastener. See **Fig. 4** for the approximate location of the hole.

Temperature Sensor Replacement



1. Lower Cover
2. HVAC Cover
3. Glove Box Assembly
4. HVAC Control Module

Fig. 2, Access Panels

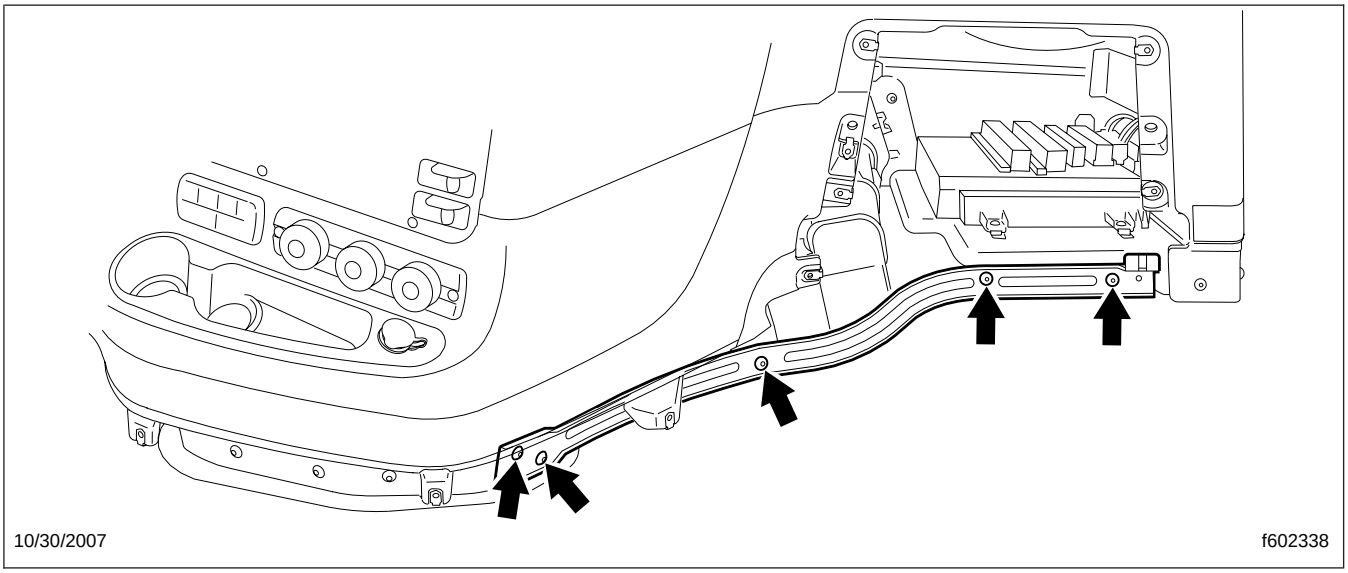
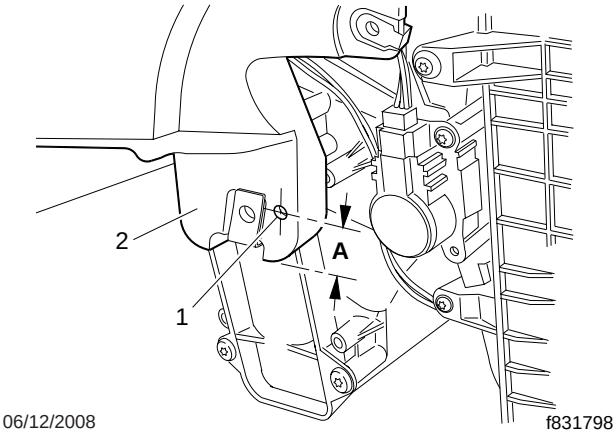


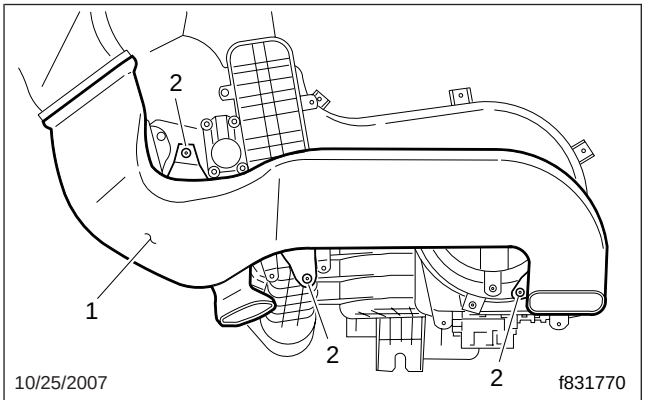
Fig. 3, Glove Box Brace Fasteners



A. Approximately 7/8-inch

1. Drilled 1/4-Inch Hole
2. Dash Panel Tab

Fig. 4, New Hole Location



1. Right-Side Floor Duct
2. Fasteners

Fig. 5, Right-Side Floor Duct Installation

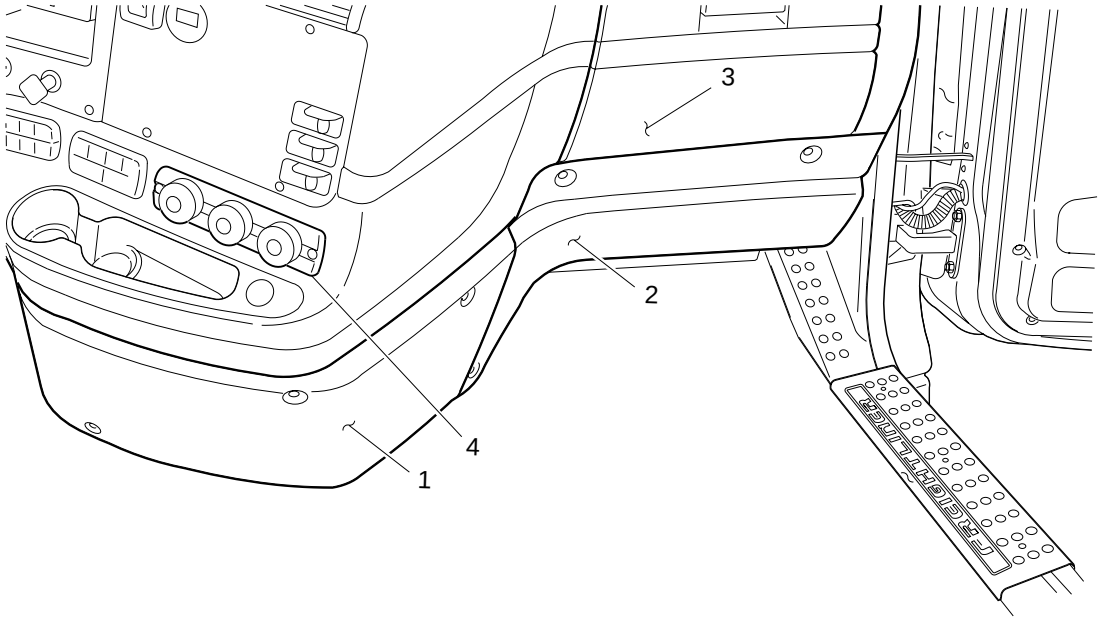
Blower Motor Replacement

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative cables.
3. Remove the dash access panels and supports listed below. See **Fig. 1** and **Fig. 2**. See **Section 60.06** for instructions.
    - HVAC cover
    - lower cover
    - glove box
    - glove box brace
4. If not already done, drill a 1/4-inch hole in the dash tab to gain access to the upper right-side floor duct fastener. See **Fig. 3** for the approximate location of the hole.
5. Remove the right-side floor duct. See **Fig. 4**.
6. Disconnect the electrical wires from the blower motor.
7. Remove the fasteners, and pull the blower motor out of the housing. See **Fig. 5**.
8. Position the new motor in the housing and install the fasteners.
9. Connect the wires.

NOTE: When installing the right-side floor duct, it may be necessary to use needlenose pliers, or some other method, to aid in the installation of the upper fastener.

10. Install the right-side floor duct.
11. Install the glove box brace.
12. Install the dash panels.
13. Connect the batteries.



1. Lower Cover
2. HVAC Cover
3. Glove Box Assembly
4. HVAC Control Module

Fig. 1, Access Panels

Blower Motor Replacement

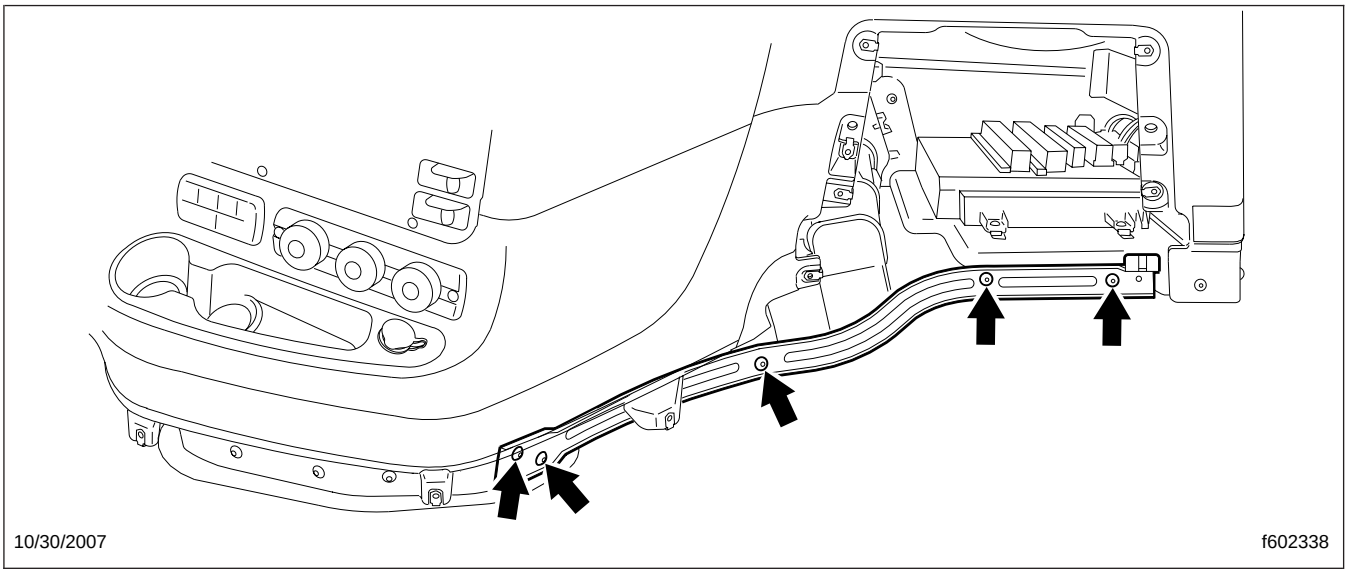
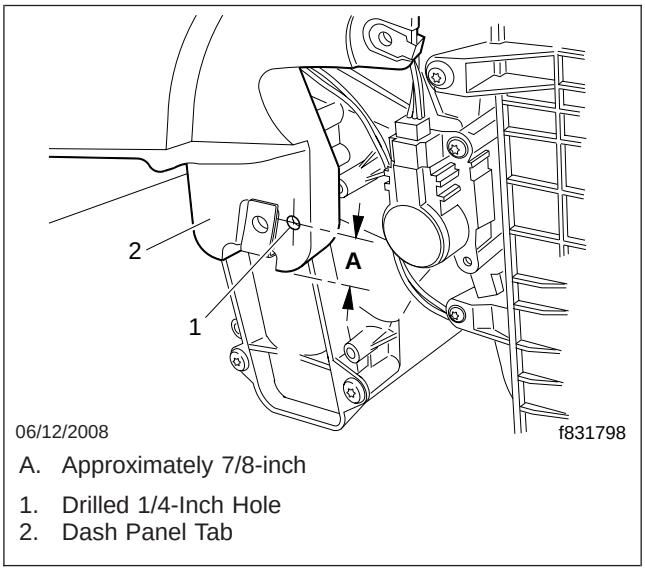


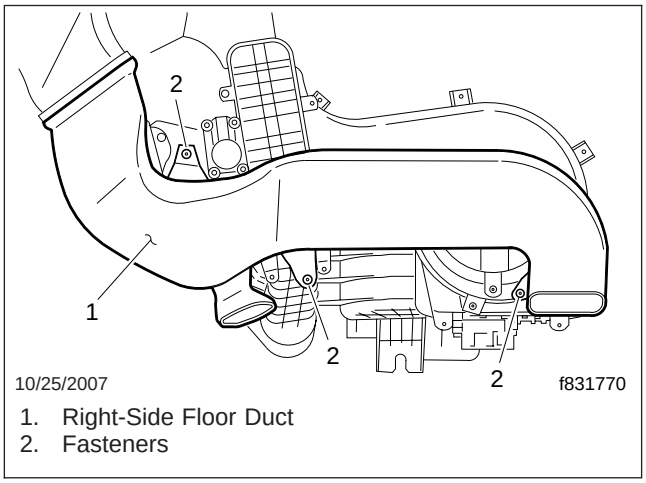
Fig. 2, Glove Box Brace Fasteners



A. Approximately 7/8-inch

1. Drilled 1/4-Inch Hole
2. Dash Panel Tab

Fig. 3, New Hole Location



1. Right-Side Floor Duct
2. Fasteners

Fig. 4, Right-Side Floor Duct Installation

Blower Motor Replacement

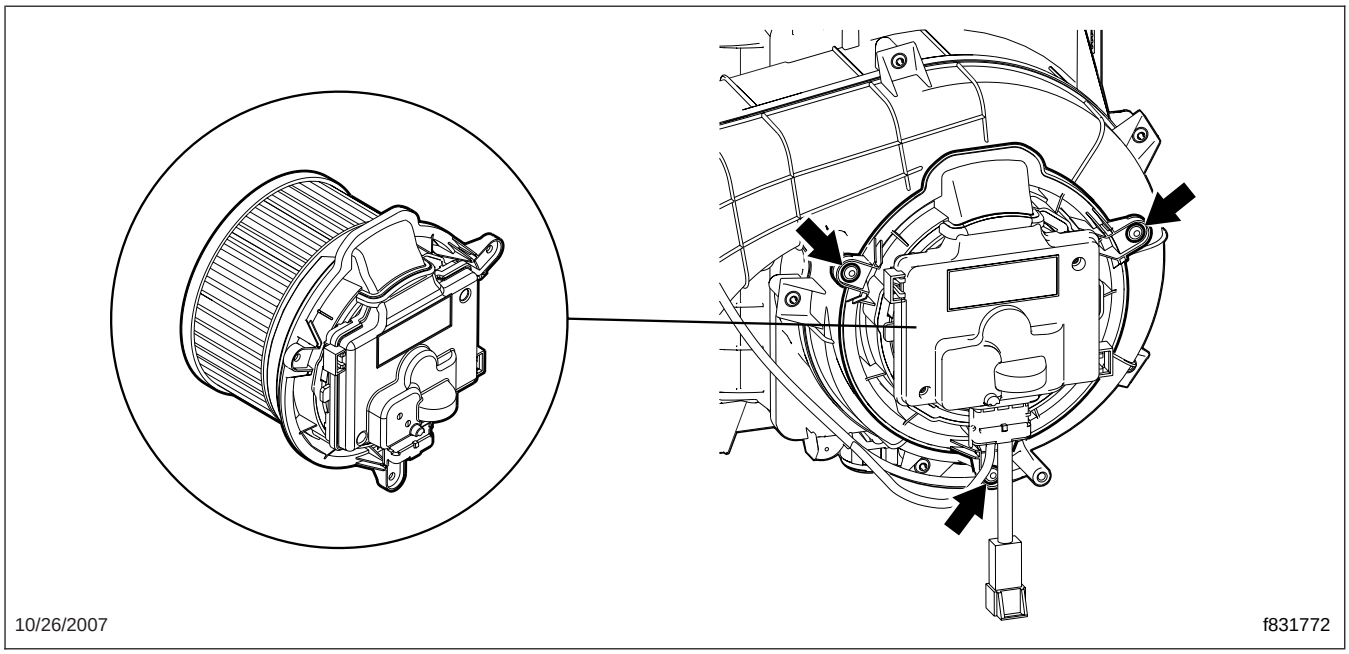


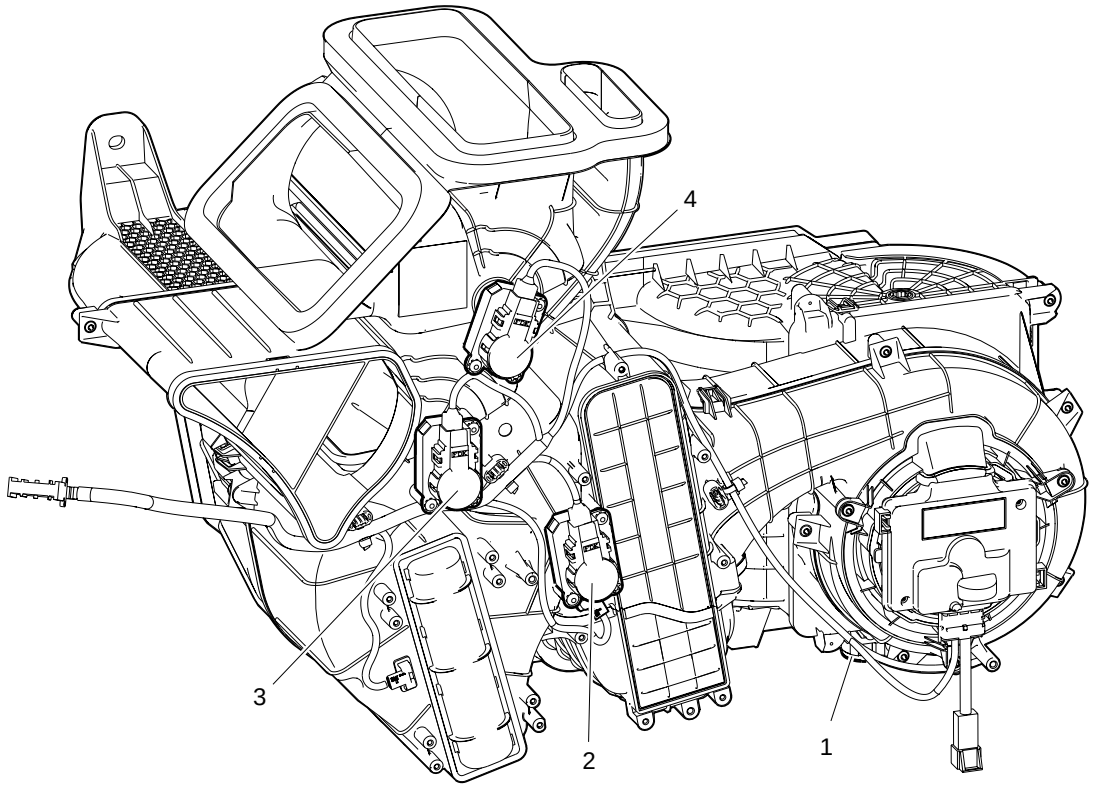
Fig. 5, Blower Motor Installation

Replacement

There are four identical stepper motors that operate the HVAC doors. See **Fig. 1** for stepper motor locations.

Stepper Motor Replacement, Recirculation Door and Blend Door

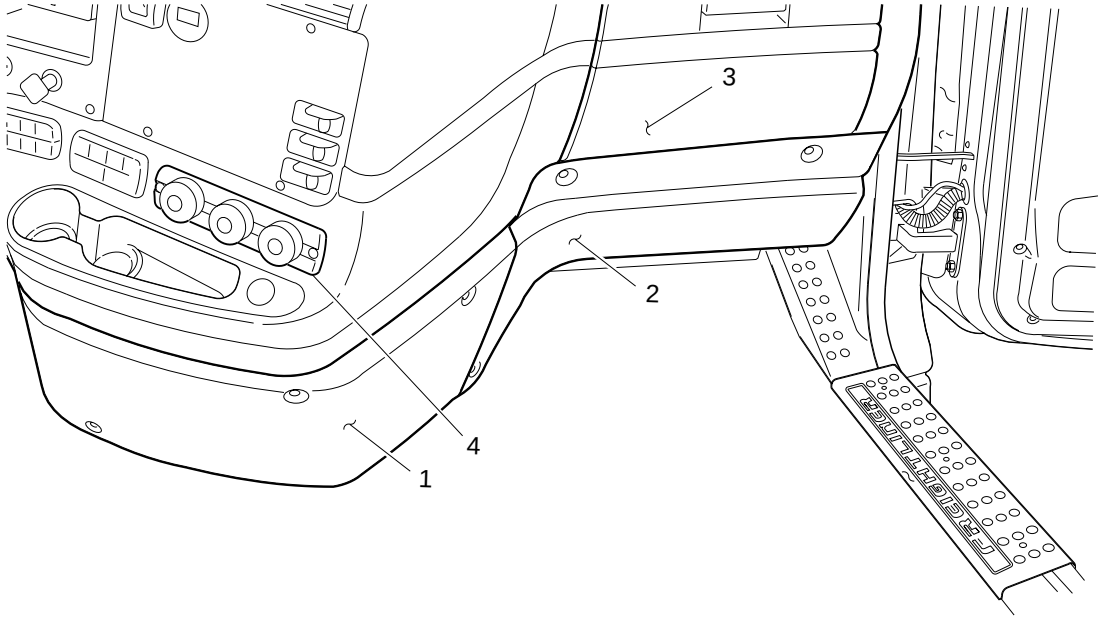
1. Park the vehicle on a level surface, turn off the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the batteries at the negative cables.
3. Remove the HVAC cover panel. See **Fig. 2**. See **Section 60.06** for instructions.
4. If replacing the blend door actuator, remove the glove box brace.
5. Disconnect the wire connector from the stepper motor.
6. Remove the two screws, and pull the motor straight out off the guide pin.
7. Install the new stepper motor.
   - 7.1 Carefully turn the output shaft on the new stepper motor to the same position as that of the door drive socket.
   - 7.2 Position the motor on the guide pin, then push it into place.
   - 7.3 Install the screws; do not overtighten.
8. Connect the wire harness to the motor.



1. Recirculation Door
2. Blend Door
3. Floor Door
4. Defrost Door

Fig. 1, Stepper Motor Locations

Stepper Motor Replacement



1. Lower Cover
2. HVAC Cover
3. Glove Box Assembly
4. HVAC Control Module

Fig. 2, Access Panels

9. If removed, install the glove box brace.
10. Install the HVAC cover panel.
11. Connect the batteries.
12. The HVAC unit will automatically recalibrate when the batteries are connected, or you can follow the steps under "Manual Calibration Mode" below.

Stepper Motor Replacement, Defrost Door and Floor Door

1. Park the vehicle on a level surface, turn off the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the batteries at the negative cables.
3. Remove the dash access panels and supports listed below. See **Fig. 2** and **Fig. 3**. See **Section 60.06** for instructions.
   - HVAC cover
   - lower cover
   - glove box
   - glove box brace
4. Remove the Cab HVAC control module, and disconnect the wire harness.

NOTE: The upper steering column clamshell panel is attached to a "skirt" that is permanently attached to the dash panel.

5. Remove the steering column bolster panel, and clamshell. See **Fig. 4**.
6. Remove the dash throttle pedal cover (if applicable.)

⚠ WARNING

Do not allow the weight of the steering column to hang unsupported on the frontwall bearing. The bearing, or bearing housing, could be damaged. A severely damaged steering driveline support at the frontwall could cause a loss of vehicle control, which could lead to personal injury or property damage.

7. Remove the fasteners that hold the steering column in place, and lower the column to rest on

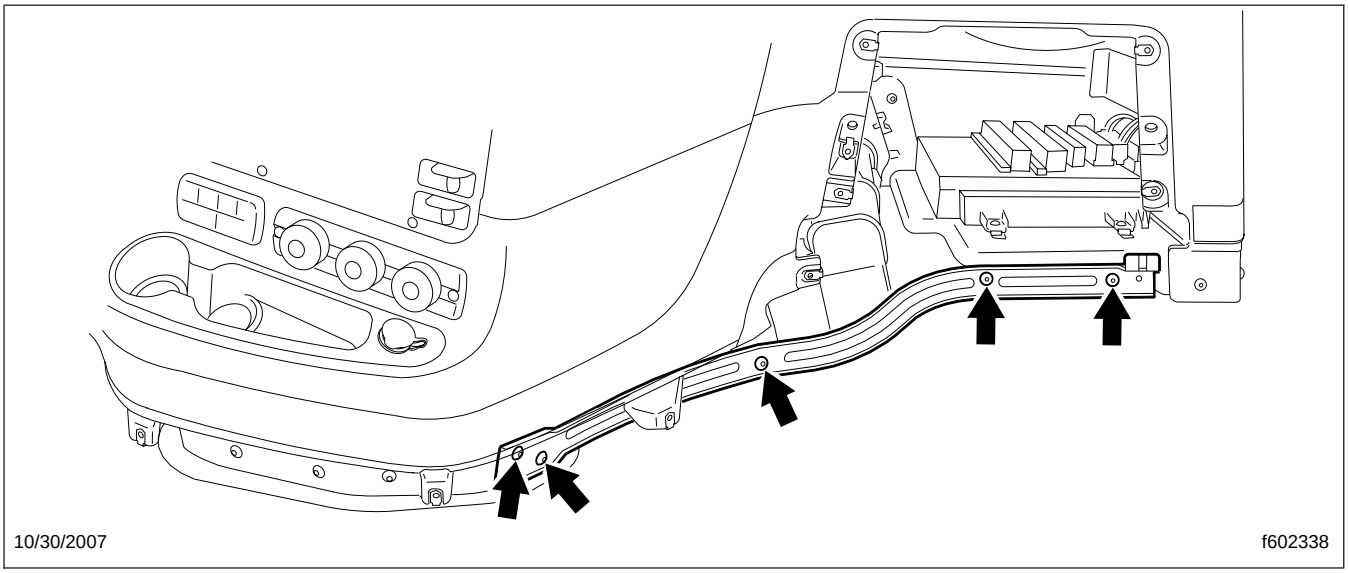
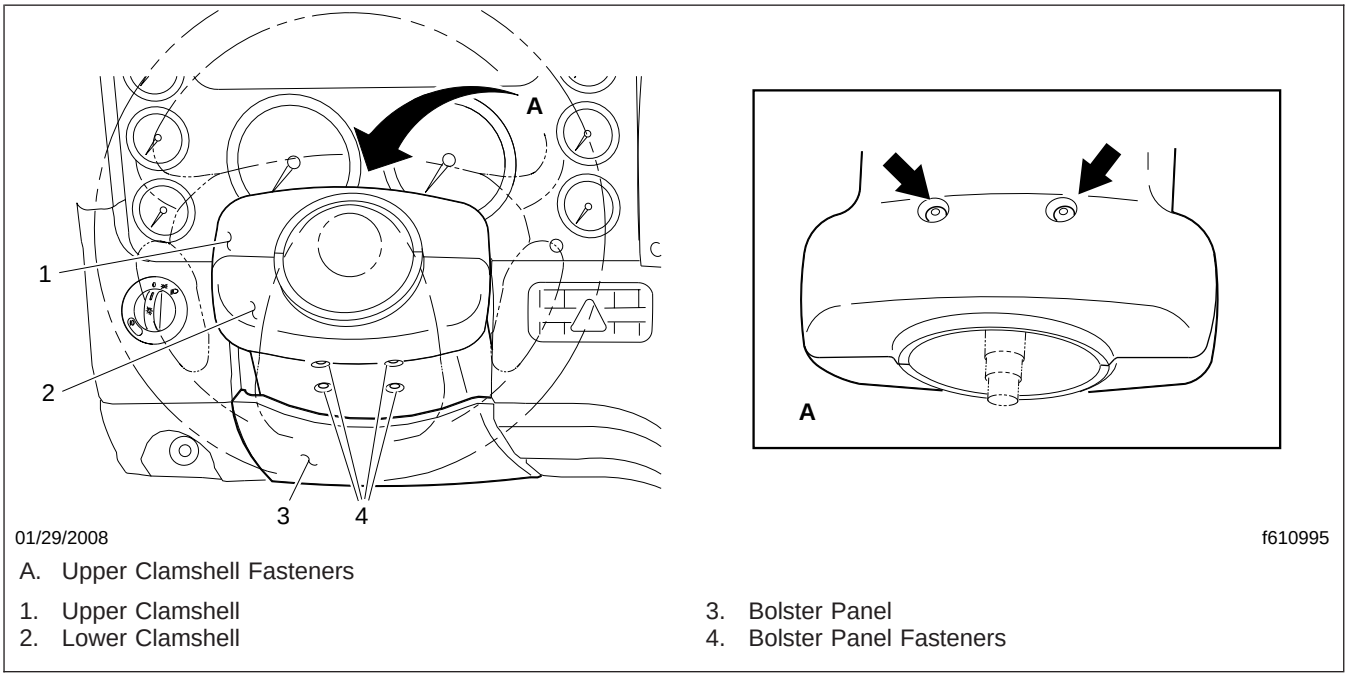


Fig. 3, Glove Box Brace Fasteners



A. Upper Clamshell Fasteners

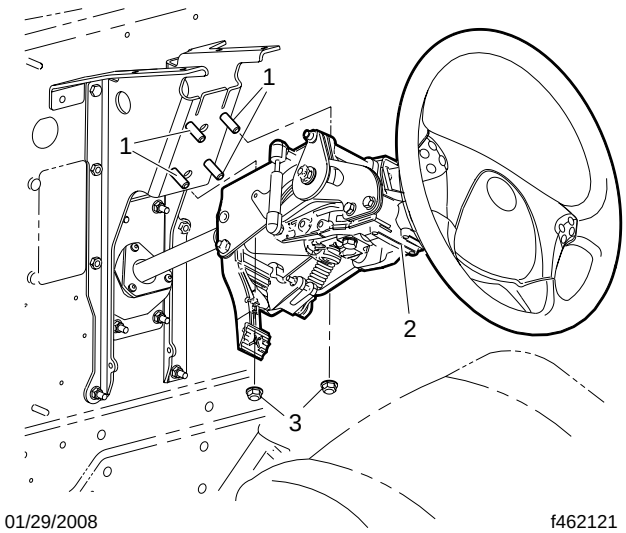
1. Upper Clamshell
2. Lower Clamshell
3. Bolster Panel
4. Bolster Panel Fasteners

Fig. 4, Removing the Steering Column Trim Panels

the driver's seat. See **Fig. 5**. See **Group 46** for the procedure.

8. Remove the A-pillar covers.
9. Remove the passenger side door opening tread-plate.
10. Remove the trim panel between the top of the dash and the windshield. See **Fig. 6**.
11. Remove the dash panel above the accelerator pedal (if applicable).

Stepper Motor Replacement



1. Upper Steering Column Mounting Studs
2. Steering Column Assembly
3. Upper Steering Column Mounting Nuts (4)

Fig. 5, Lowering the Steering Column

14. Remove the right-hand lower A-pillar cover panel.
15. Remove the right side floor duct. See **Fig. 8**.
16. Remove the floor distribution duct.
17. Disconnect the wire connector from the stepper motor.
18. Remove the two screws, and pull the motor straight out off the guide pin.
19. Carefully turn the new stepper motor output shaft to the same position as that of the door drive socket, position the motor on the guide pin, then push it into place.
20. Install the screws; do not overtighten.
21. Connect the wire connector.
22. Install the floor distribution duct.

NOTE: When installing the right-side floor duct, it may be necessary to use needlenose pliers, or some other tool, to aid in the installation of the upper fastener.

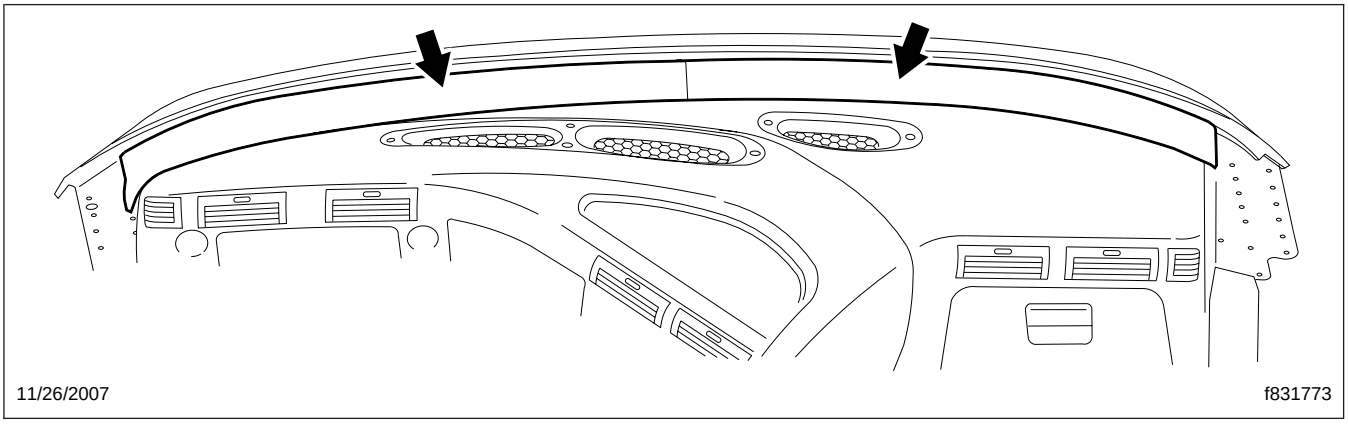


Fig. 6, Upper Dash Trim Panel

NOTE: Look for additional wires that may need to be unplugged to allow dash movement due to routing differences and options.

12. Remove the fasteners that hold the dash in place.
13. Raise the dash enough to provide clearance, and suspend it securely out of the way. See **Fig. 7**. See **Section 60.06** for instructions.
23. Install the right-side floor duct.
24. Lower the dash, and secure it in position.
25. Install the dash trim panels.
26. Install the steering column. See **Group 46** for the procedure.
27. Install the steering column clamshell and bolster panel.
28. Install the glove box brace.

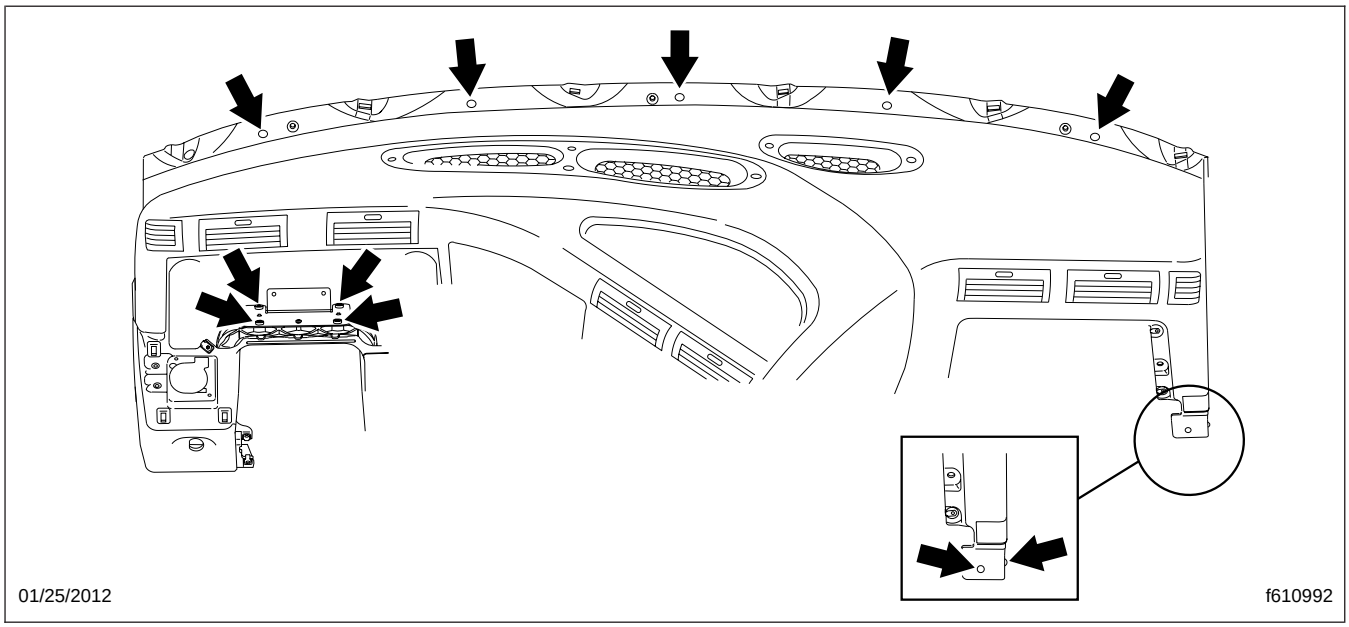
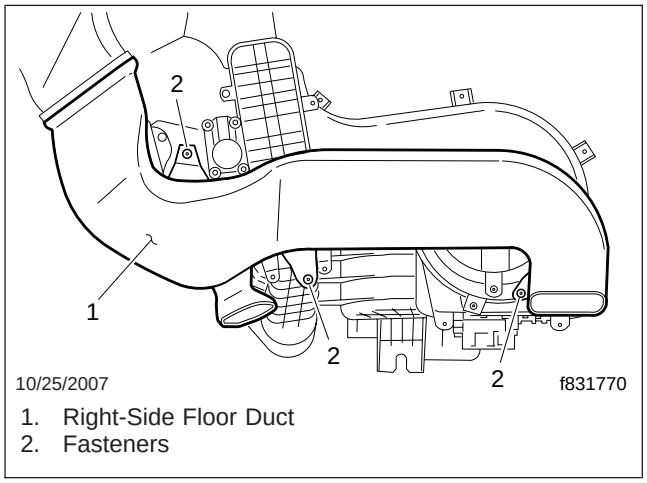


Fig. 7, Dash Fasteners



1. Right-Side Floor Duct
2. Fasteners

Fig. 8, Right-Side Floor Duct Installation

29. Install the dash panels.
30. Install the controller.
31. Connect the batteries.
32. Calibrate the actuators; see "Manual Calibration Mode" below.

Manual Calibration Mode

It is necessary to calibrate the actuators if they are removed or replaced. To enter calibration mode, perform the following steps.

1. Turn the ignition ON (engine OFF).
2. Set the blower speed control to OFF.
3. Set the temperature control knob to the full clockwise position (HOT).
4. Set the mode control knob to the full counterclockwise position (FACE).
5. Press the A/C and RECIRC buttons simultaneously until the A/C and RECIRC indicators begin flashing simultaneously.

   The calibration process will begin and will continue until the A/C and RECIRC indicators stop flashing.

Heater and Air Conditioner Housing Assembly Replacement

Replacement

1. Park the vehicle on a level surface, turn off the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the batteries at the negative cables.
3. Raise the hood.
4. Recover the refrigerant from the air conditioning system. See **Subject 220** for instructions.
5. Remove the dash access panels and supports listed below. See **Fig. 1** and **Fig. 2**. See **Section 60.06** for instructions.
   - HVAC cover panel
   - lower cover panel
   - glove box
   - glove box brace
6. Remove the Cab HVAC control module, and disconnect the wire harness.

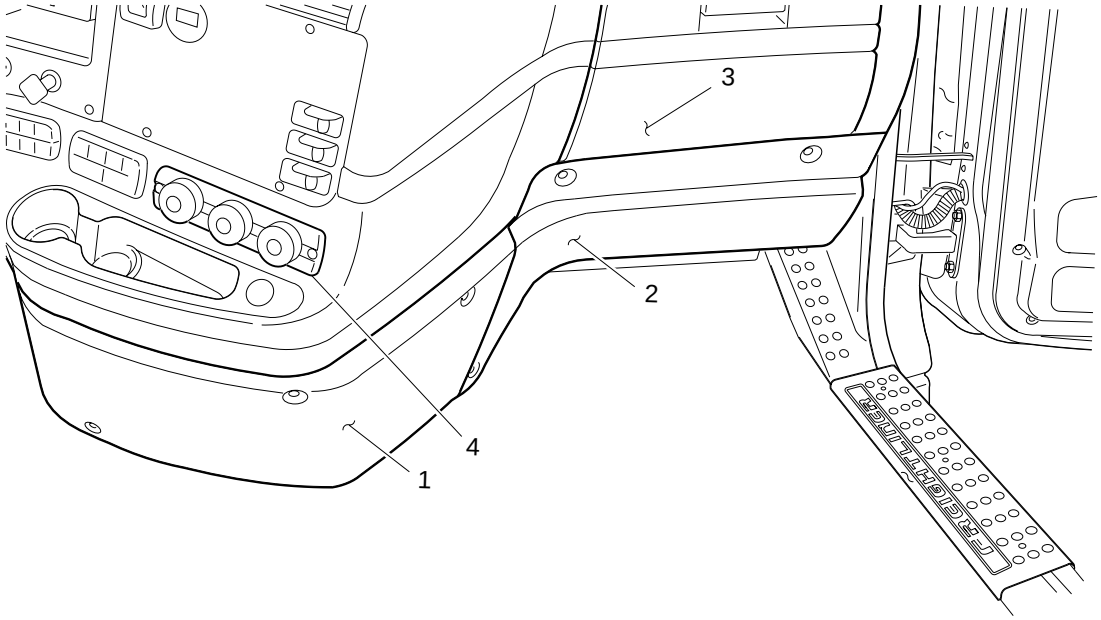
NOTE: The upper steering column clamshell panel is attached to a "skirt" that is permanently attached to the dash panel.

7. Remove the steering column bolster panel, and clamshell. See **Fig. 3**.
8. Remove the dash panel above the accelerator pedal (if applicable).

WARNING

Do not allow the weight of the steering column to hang unsupported on the frontwall bearing. The bearing, or bearing housing, could be damaged. A severely damaged steering driveline support at the frontwall could cause a loss of vehicle control, which could lead to personal injury or property damage.

9. Remove the fasteners that hold the steering column in place, and lower the column to rest on the driver's seat. See **Fig. 4**. See **Group 46** for the procedure.
10. Remove the A-pillar covers.



1. Lower Cover Panel
2. HVAC Cover Panel
3. Glove Box Assembly
4. Control Module

Fig. 1, Access Panels

Heater and Air Conditioner Housing Assembly Replacement

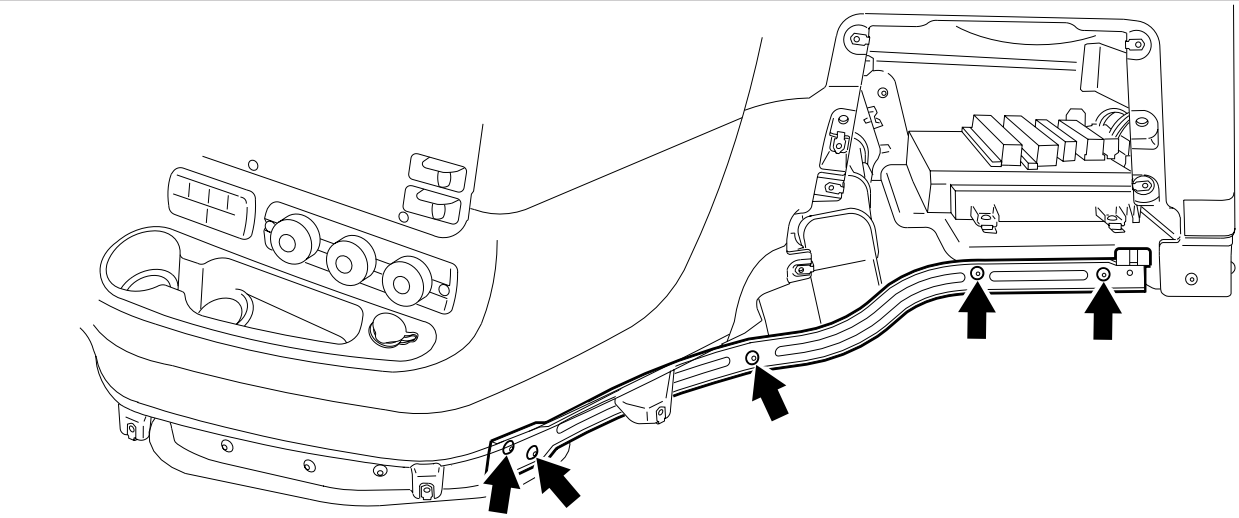
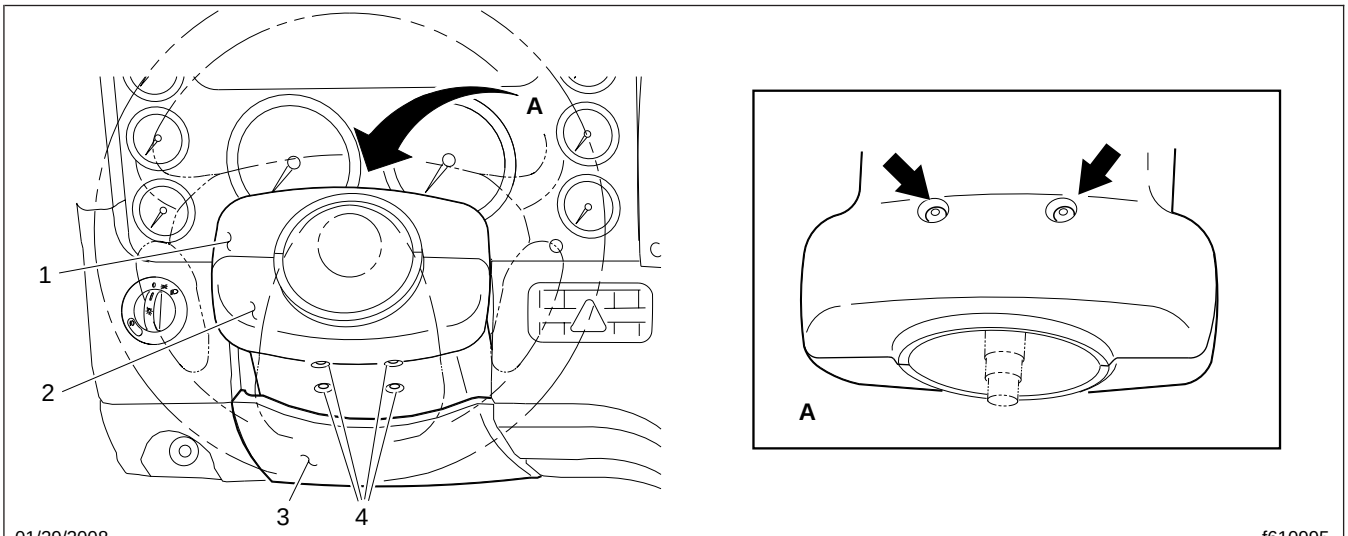


Fig. 2, Glove Box Brace



A. Upper Clamshell Fasteners

1. Upper Clamshell
2. Lower Clamshell
3. Bolster Panel
4. Bolster Panel Fasteners

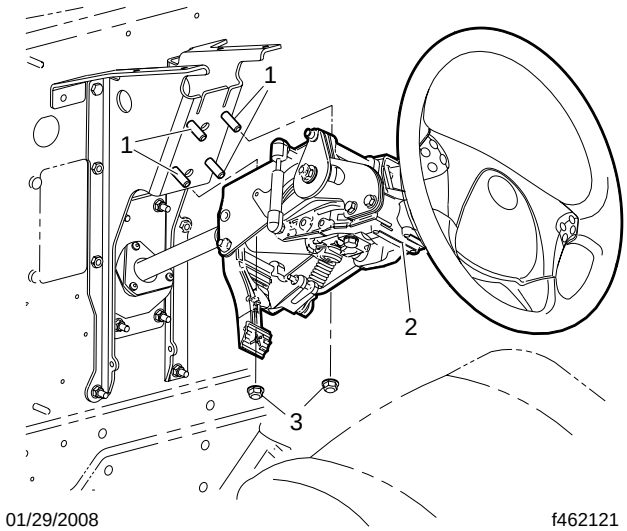
Fig. 3, Removing the Steering Column Trim Panels

11. Remove the passenger side door opening tread-plate.
12. Remove the trim panel between the top of the dash and the windshield. See **Fig. 5**.

NOTE: Look for additional wires that may need to be unplugged to allow dash movement due to routing differences and options.

13. Remove the fasteners that hold the dash in place.

Heater and Air Conditioner Housing Assembly Replacement



1. Upper Steering Column Mounting Studs
2. Steering Column Assembly
3. Upper Steering Column Mounting Nuts (4)

Fig. 4, Lowering the Steering Column

19. Remove the HVAC fresh-air intake screen. See **Fig. 7**.
20. Remove the rain tray. See **Section 82.00, Subject 100**.
21. Place a drain pan under the vehicle, clamp the coolant lines to prevent excessive drainage from the cooling system, then disconnect the coolant lines from the heater core. Allow the heater core to completely drain into the pan. See **Fig. 8**.
22. Remove the nuts and bolts that hold the J-block to the HVAC intake duct. See **Fig. 9**.

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).

23. Disconnect the refrigerant lines from the thermal expansion valve, and cap the lines immediately to prevent contamination of the system. See **Fig. 10**.

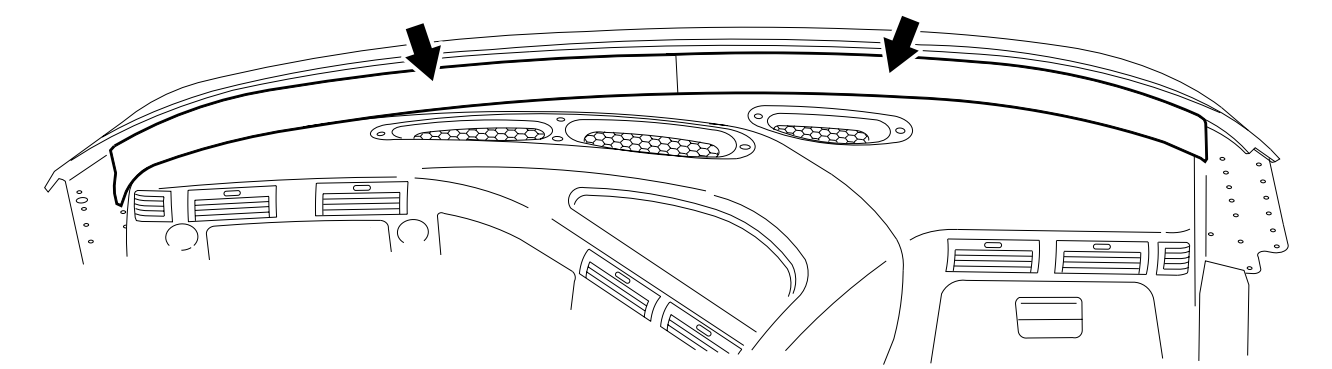


Fig. 5, Upper Dash Trim Panel

14. Raise the dash enough to provide clearance, and suspend it securely out of the way. See **Fig. 6**.
15. Remove the right-hand lower A-pillar cover panel.
16. Remove the right side floor duct.
17. Remove the floor distribution duct.
18. Remove the windshield wiper arms. See **Section 82.00, Subject 100**.
24. Disconnect the wiring harness from the assembly. See **Subject 210**.
25. Remove the intake duct.
26. Remove the wire harness connections from the SAM cab, and cut the tie straps to allow the harness to be moved.
27. Remove the six nuts (three inside and three outside) that hold the assembly in position on the frontwall. See **Fig. 11**.

Heater and Air Conditioner Housing Assembly Replacement

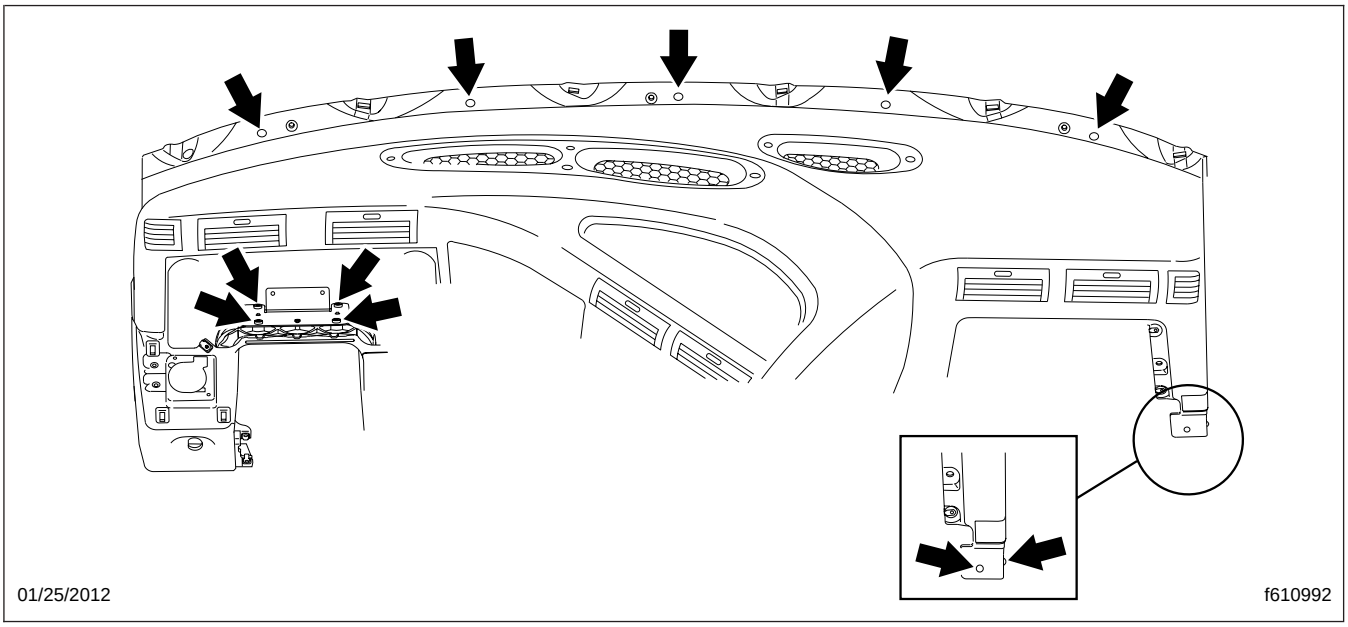


Fig. 6, Dash Fasteners

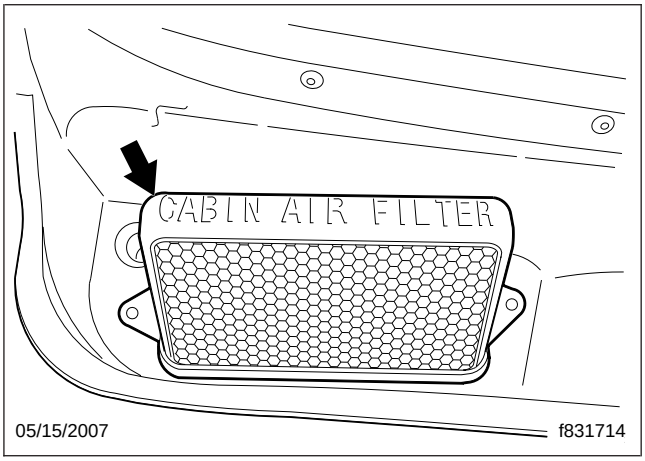


Fig. 7, Fresh-Air Intake Screen

28. Remove the assembly from the frontwall.
29. Position the new assembly on the frontwall, and install the nuts. Tighten 10 to 12 lbf·ft (14 to 16 N·m).
30. Connect the coolant lines.
31. Install the intake duct.
32. Using new seals, connect the refrigerant lines to the thermal expansion valve. Tighten 11 to 15 lbf·ft (15 to 20 N·m).

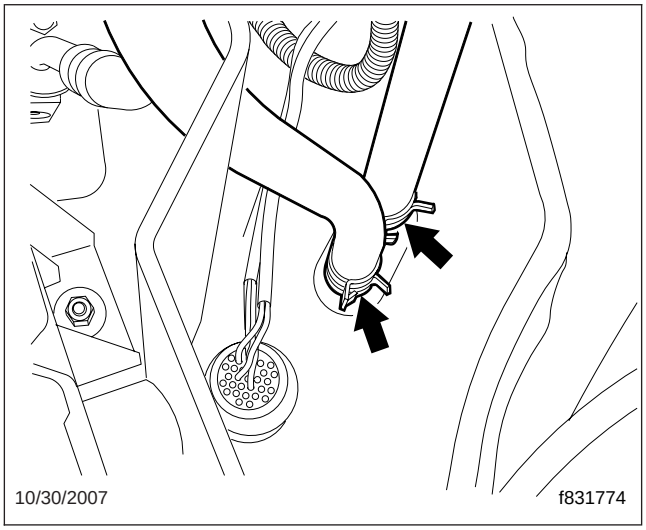
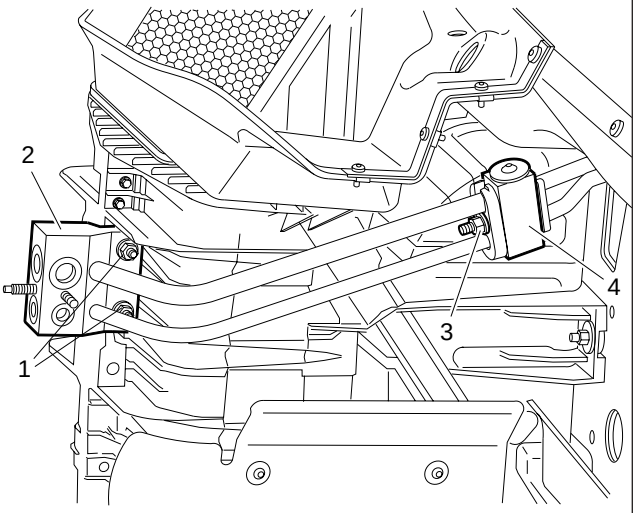


Fig. 8, Coolant Lines

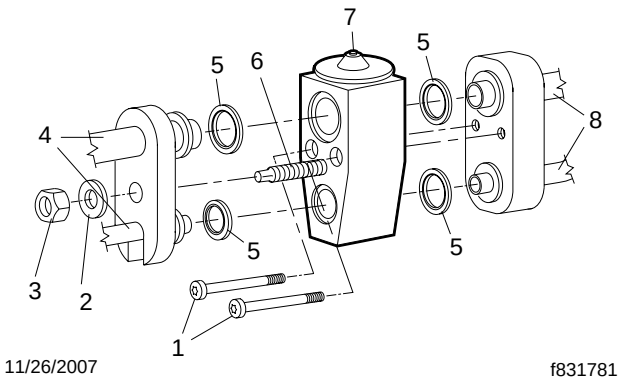
33. Connect the wiring harness.
34. Add refrigerant oil to the system to replace that which is lost when the components in the unit are replaced, and the system is recovered. See **Section 83.02, Subject 120**.
35. Start the evacuation. Evacuate and charge the refrigerant system. See **Subject 220**.
36. Install the defrost and right-hand foot well ducts.

Heater and Air Conditioner Housing Assembly Replacement



1. J-Block Mounting Nuts and Bolts
2. J-Block
3. Thermal Expansion Valve Connecting Nut and Bolt
4. Thermal Expansion Valve

Fig. 9, Junction Block and Thermal Expansion Valve

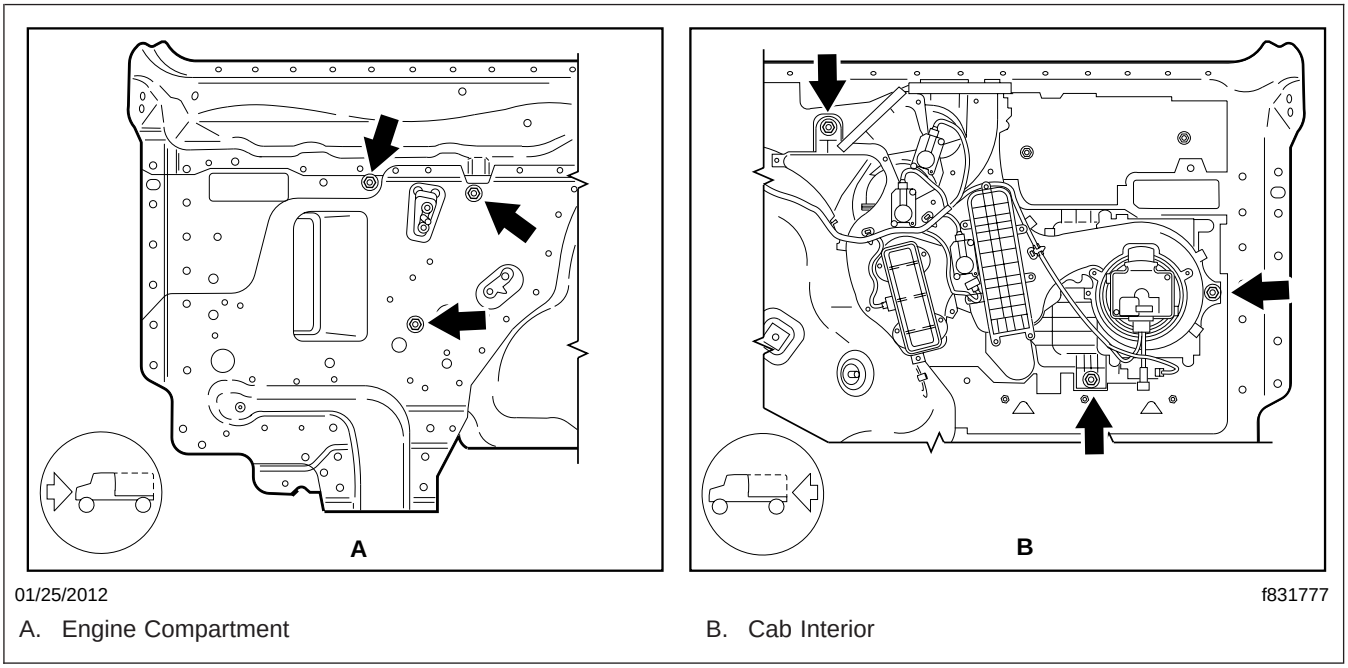


1. Screw (2)
2. Washer
3. Nut
4. Refrigerant Lines to J-Block
5. Seal
6. Stud
7. Thermal Expansion Valve
8. Refrigerant Lines to Evaporator

Fig. 10, Thermal Expansion Valve Installation

37. Install the right-hand lower A-pillar cover and tread plate.
38. Install the dash. See **Section 60.06**.
39. Install the steering column. See **Group 46** for the procedure.
40. Install the steering column clamshell and bolster panel.
41. Connect the main harness to the SAM cab and secure it.
42. Install the glove box brace.
43. Install the dash panels. See **Fig. 1**.
44. Install the controller.
45. Install the rain tray.
46. Install the windshield wiper arms. See **Section 82.00, Subject 100**.
47. Install the HVAC fresh-air intake screen.
48. Connect the batteries.
49. Check the coolant level, and add coolant as needed.
50. Leak check the refrigerant connections that were disconnected during the service.

Heater and Air Conditioner Housing Assembly Replacement



A. Engine Compartment

B. Cab Interior

Fig. 11, HVAC Mounting Nut Locations

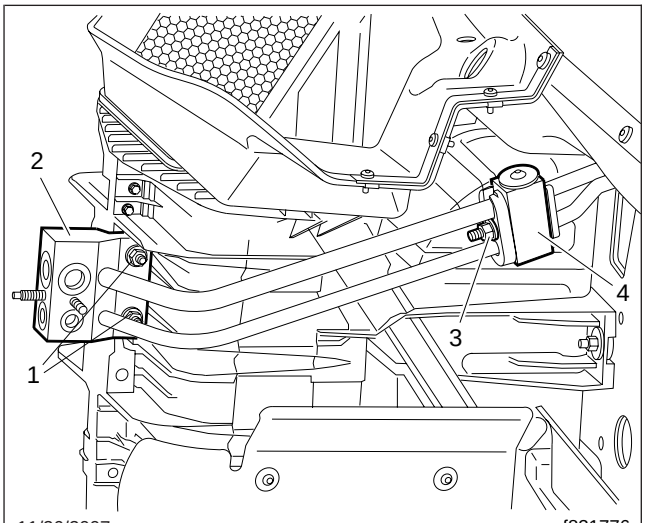
Thermal Expansion Valve Replacement

⚠ 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.

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative cables.
3. Raise the hood.
4. Recover the refrigerant from the air conditioning system. See **Subject 220** for instructions.
5. Remove the nuts and bolts that hold the J-block to the HVAC intake duct. See **Fig. 1**.



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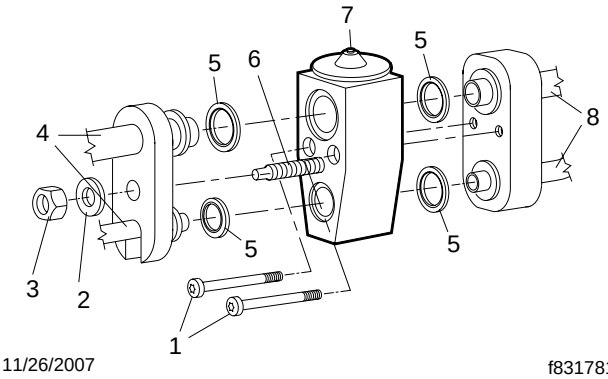
1. J-Block Mounting Nuts and Bolts
2. J-Block
3. Thermal Expansion Valve Connecting Nut and Washer
4. Thermal Expansion Valve

Fig. 1, J-Block and Thermal Expansion Valve Installation

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).

6. Disconnect and immediately cap the refrigerant lines from the thermal expansion valve.
7. Remove the two fasteners and thermal expansion valve from the plate on the evaporator lines. See **Fig. 2**.



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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. 2, Thermal Expansion Valve Installation

8. Using new seals, install a new thermal expansion valve on the plate on the evaporator lines. Tighten 35 lbf·in (395 N·cm).
9. Using new seals, connect the refrigerant hardlines to the thermal expansion valve. Tighten 11 to 15 lbf·ft (15 to 20 N·m).
10. Fasten the J-block to the intake duct.
11. Add refrigerant oil to the compressor to replace that which is lost when the system is recovered. See **Subject 83.02, Subject 120** for instructions.
12. Evacuate and charge the refrigerant system. See **Subject 220** for instructions.
13. Connect the batteries.

Receiver-Drier Replacement

⚠ 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.

Replacement

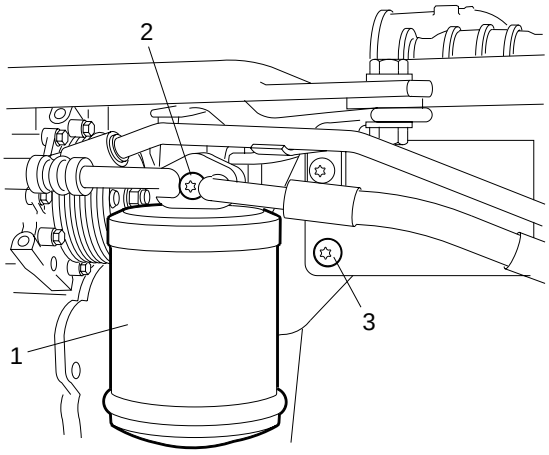
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. See **Subject 220** for instructions.

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 capscrew that attaches the retaining plate and refrigerant lines to the receiver-drier. Disconnect the refrigerant lines from the receiver-drier, then remove and discard the seals. Quickly cap the refrigerant lines. See **Fig. 1**.
5. Remove the mounting bracket fasteners, and 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. Position the new receiver-drier, and install the fasteners.
7. Uncap the refrigerant lines.
8. Using new seals, attach the refrigerant lines and retaining plate to the receiver-drier. Tighten 11 to 15 lbf·ft (15 to 20 N·m).



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1. Receiver-Drier
2. Refrigerant Line Fastener
3. Mounting Bracket Fastener

Fig. 1, Receiver-Drier

9. Drill a hole in the bottom of the receiver-drier, and drain the oil from it into a clean container. Measure the amount of oil recovered to determine how much to add back into the system.
10. Add refrigerant oil to the compressor to replace that which is lost when the receiver-drier is replaced, and when the system is recovered. See **Section 83.02, Subject 120** for instructions.
11. Evacuate and charge the air conditioning system with refrigerant. See **Subject 220** for instructions.

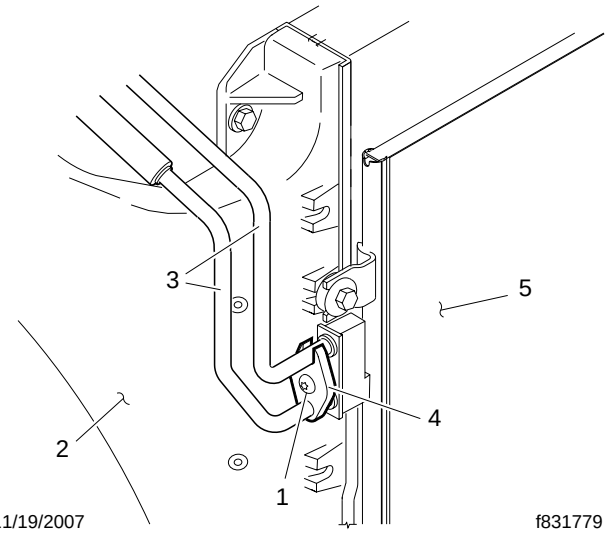
Condenser Removal and Installation

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.

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. See **Subject 220** for instructions.
4. Disconnect the refrigerant lines from the condenser and remove and discard the seals. Quickly cap the condenser inlet and outlet ports, if the condenser will be reinstalled, and plug the fittings. See **Fig. 1**.



1. Fastener
2. Charge Air Cooler
3. Refirgerant Lines
4. Connector Plate
5. Condenser

Fig. 1, Condenser Connection

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 charge air cooler, and remove the condenser.

Installation

1. Place the condenser on the charge air cooler. 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 new seals, connect the refrigerant lines to the condenser. Tighten the fastener on the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).
4. Add refrigerant oil to the compressor to replace that which is lost when the condenser is replaced, and when the system is recovered. See **Section 83.02, Subject 120** for instructions.
5. Evacuate and charge the air conditioning system with refrigerant. See **Subject 220** for instructions.

Climate Control Panel (Front Control Unit) Replacement

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative cables.
3. Remove the fasteners from the face of the control panel. See **Fig. 1**.

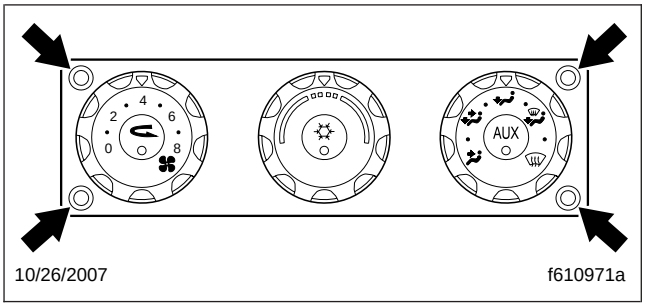


Fig. 1, Climate Control Panel

4. Pull the control panel out of the dash.
5. Disconnect the wiring harness.
6. Connect the wiring harness to the new controller.
7. Position the controller in the dash and install the fasteners.
8. Connect the batteries.

Replacement

1. Park the vehicle on a level surface, turn off the engine, and set the parking brakes. Chock the tires.
2. Disconnect the batteries at the negative cables.
3. Remove the dash access panels and supports listed below. See **Fig. 1** and **Fig. 2**. See **Section 60.06** for instructions.
   - HVAC cover
   - center cover
   - glove box
   - glove box brace
4. Remove the cab HVAC control module, and disconnect the wire harness.

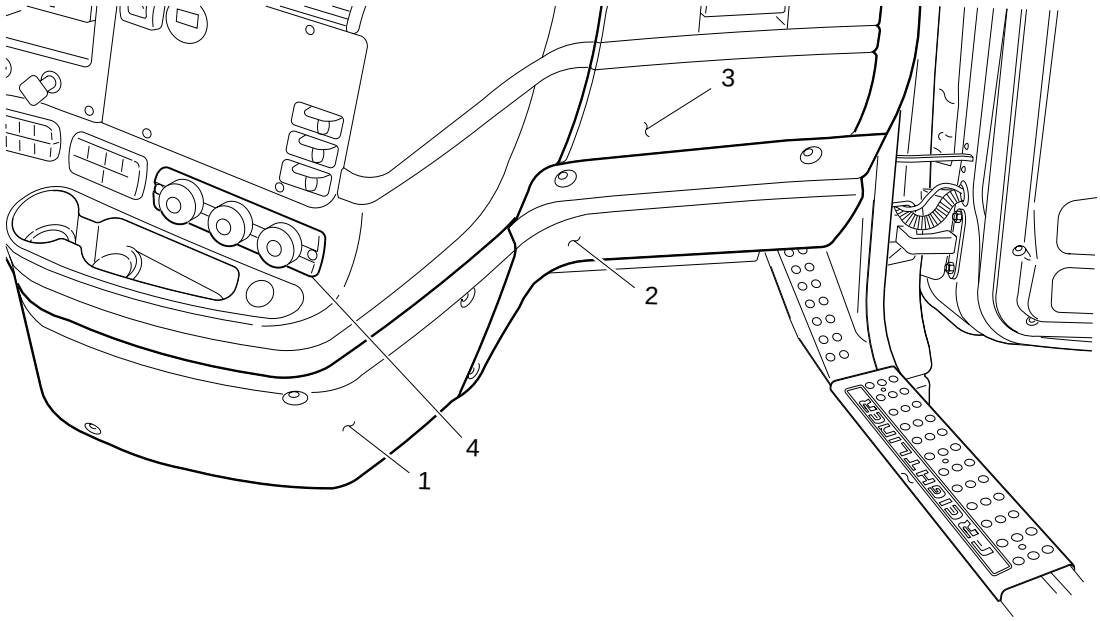
NOTE: The upper steering column clamshell panel is attached to a "skirt" that is permanently attached to the dash panel.

5. Remove the steering column bolster panel, and clamshell. See **Fig. 3**.
6. Remove the dash panel above the accelerator pedal (if applicable).

⚠ WARNING

Do not allow the weight of the steering column to hang unsupported on the frontwall bearing. The bearing, or bearing housing, could be damaged. A severely damaged steering driveline support at the frontwall could cause a loss of vehicle control, which could lead to personal injury or property damage.

7. Remove the fasteners that hold the steering column in place, and lower the column to rest on the driver's seat. See **Fig. 4**. See **Group 46** for the procedure.
8. Remove the A-pillar covers.
9. Remove the passenger side door opening treadplate.
10. Remove the trim panel between the top of the dash and the windshield. See **Fig. 5**.



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1. Lower Cover
2. HVAC Cover
3. Glove Box Assembly
4. Control Module

Fig. 1, Access Panels

HVAC Harness Replacement

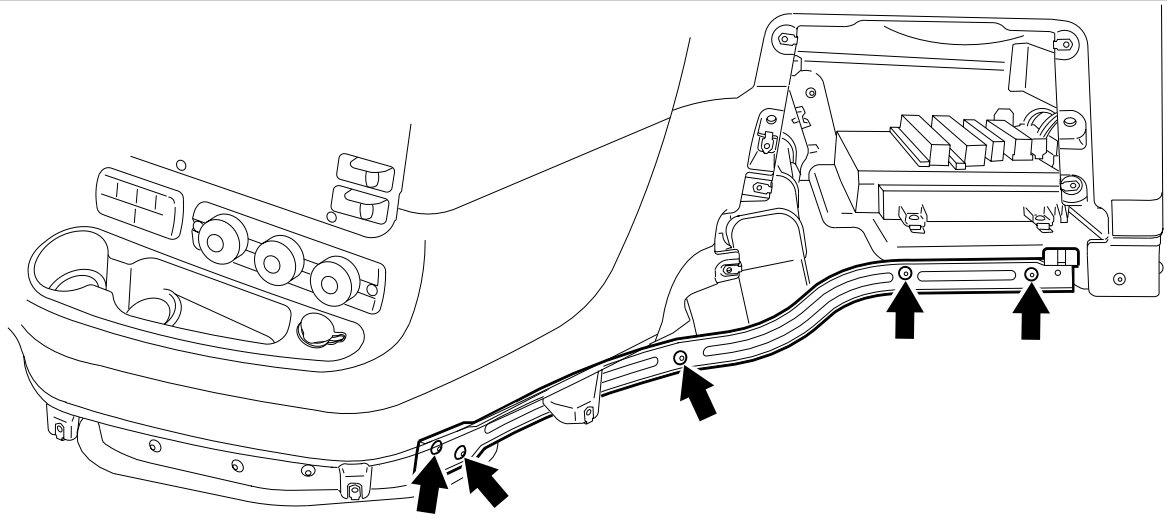
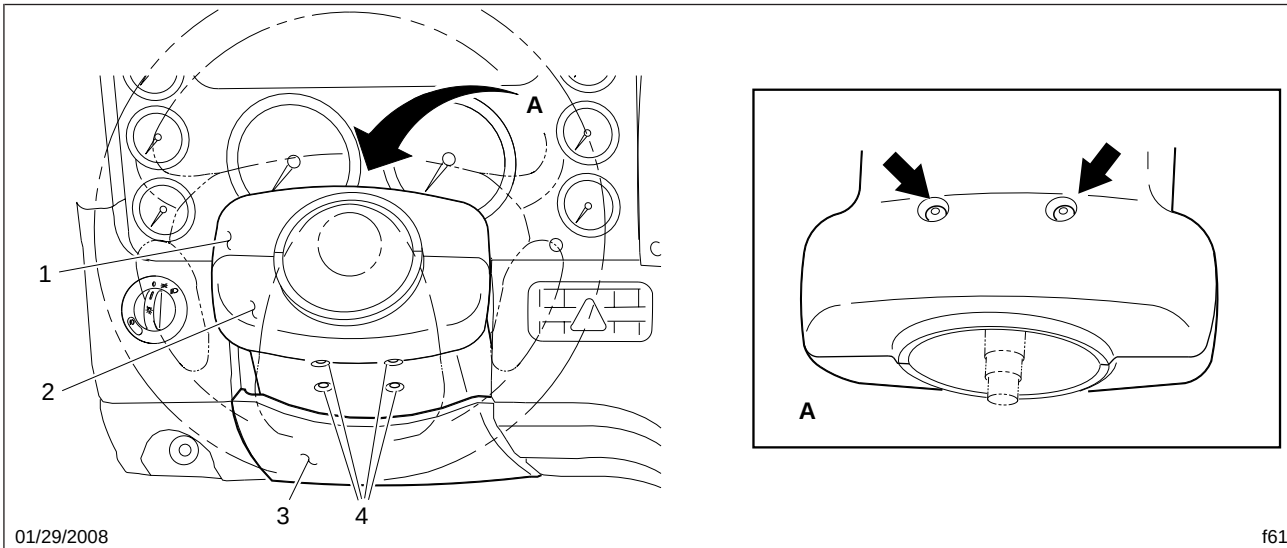


Fig. 2, Glove Box Brace



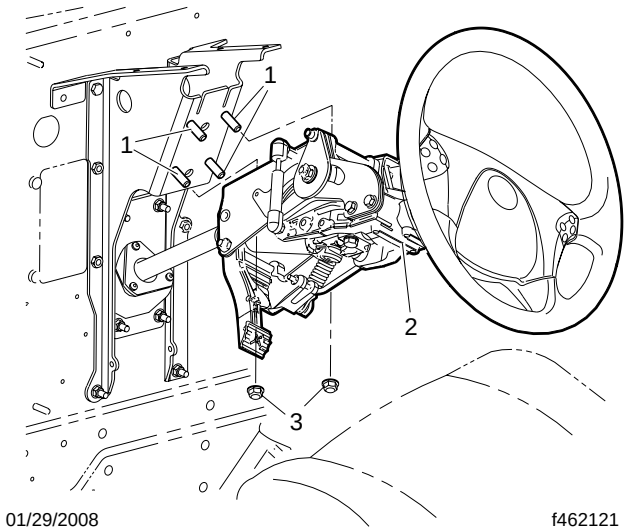
A. Upper Clamshell Fasteners

1. Upper Clamshell
2. Lower Clamshell
3. Bolster Panel
4. Bolster Panel Fasteners

Fig. 3, Removing the Steering Column Trim Panels

NOTE: Look for additional wires that may need to be unplugged to allow dash movement due to routing differences and options.

11. Remove the fasteners that hold the dash in place.
12. Raise the dash enough to provide clearance, and suspend it securely out of the way. See **Fig. 6**. See **Section 60.06** for instructions.
13. Remove the right-hand lower A-pillar cover panel.



1. Upper Steering Column Mounting Studs
2. Steering Column Assembly
3. Upper Steering Column Mounting Nuts (4)

Fig. 4, Lowering the Steering Column

20. Install the right side floor duct.
21. Lower the dash, and secure it in position.
22. Install the dash trim panels.
23. Install the steering column. See **Group 46** for the procedure.
24. Install the steering column clamshell and bolster panel.
25. Install the glove box brace.
26. Install the dash panels.
27. Install the controller.
28. Connect the batteries.

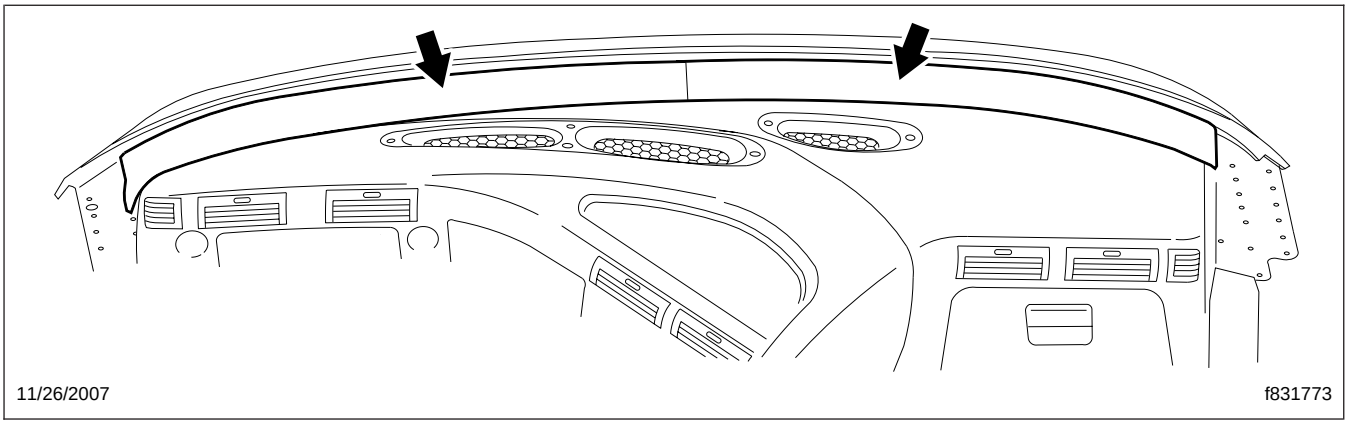


Fig. 5, Upper Dash Trim Panel

14. Remove the right side floor duct. See **Fig. 7**.
15. Remove the floor distribution duct.
16. Cut the zip ties that hold the harness in place.
17. Disconnect all of the connectors, and remove the harness. See **Fig. 8**.
18. Position the new harness and connect all the connectors.
19. Using zip ties, secure the harness in its original position.

HVAC Harness Replacement

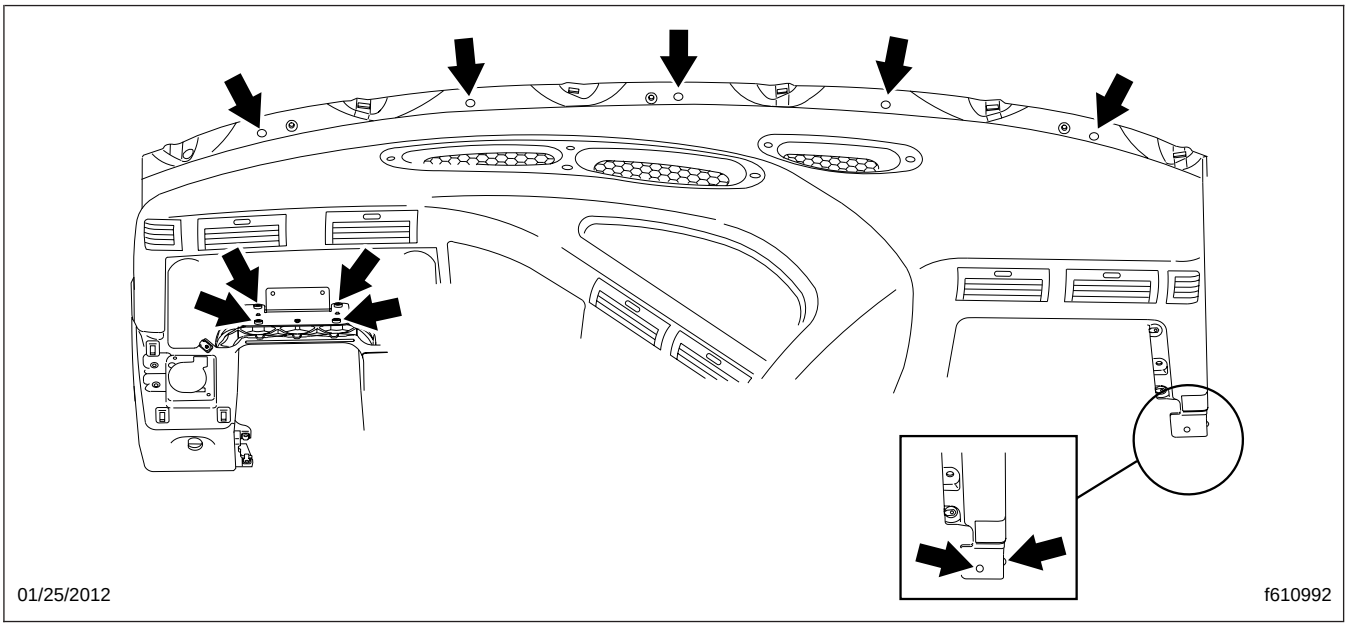
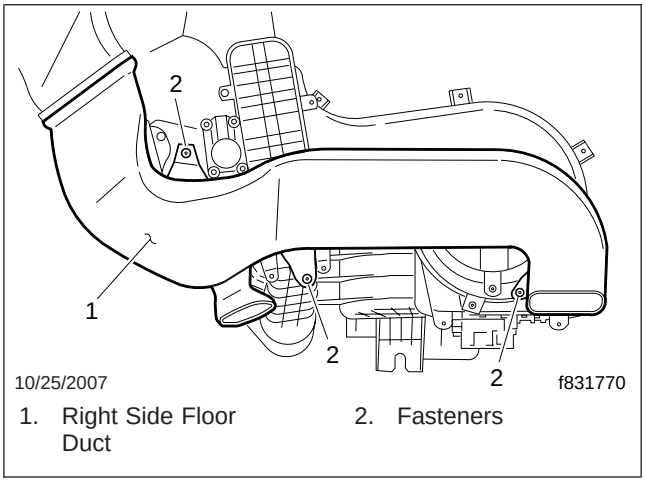


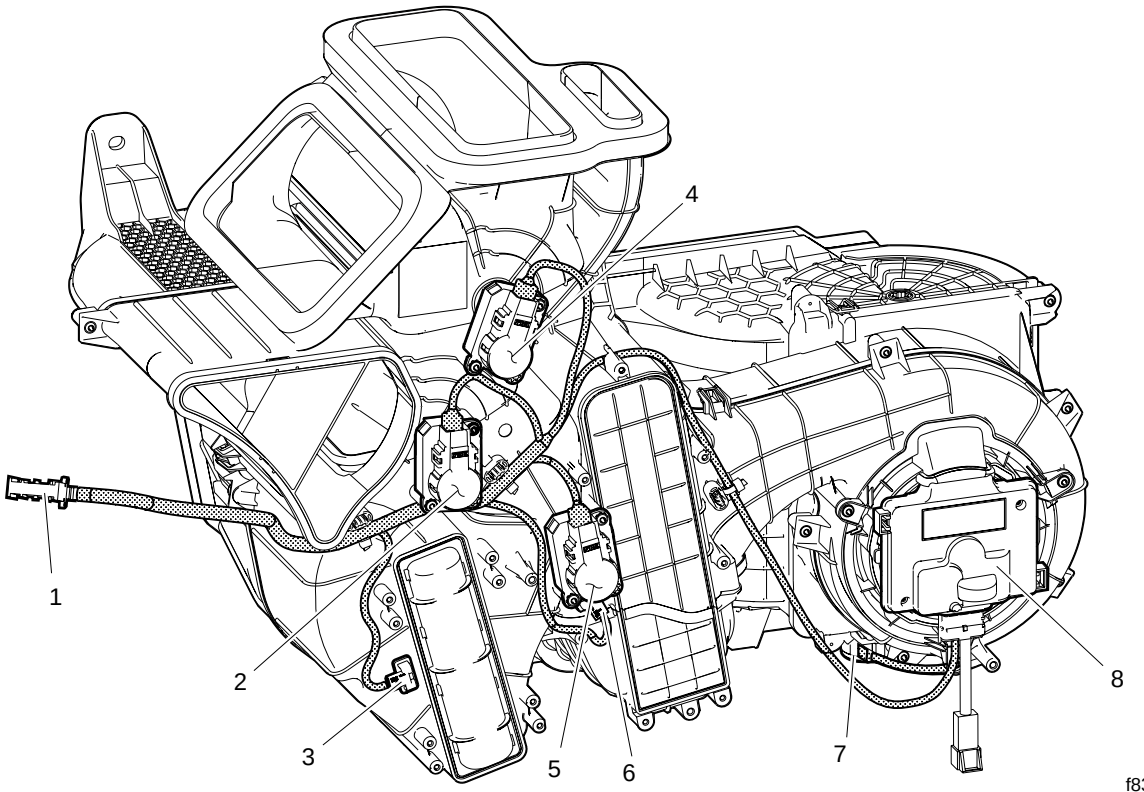
Fig. 6, Dash Fasteners



1. Right Side Floor Duct
2. Fasteners

Fig. 7, Right Side Floor Duct Removal

HVAC Harness Replacement



1. Main Harness Connector
2. Floor Door Stepper Motor
3. Heater Core Temperature Sensor
4. Defrost Door Stepper Motor
5. Blend Door Stepper Motor
6. Evaporator Temperature Sensor
7. Recirculation Door Stepper Motor
8. Blower Motor

Fig. 8, HVAC Harness Installation

⚠ 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.

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

IMPORTANT: Always use a refrigerant identifier before hooking up any equipment to the refrigerant system. This practice will protect your tools and ensure that you are not held responsible for an improper repair.

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

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. 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. 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.

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.

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

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. The only approved flushing agent is R134a refrigerant.

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.

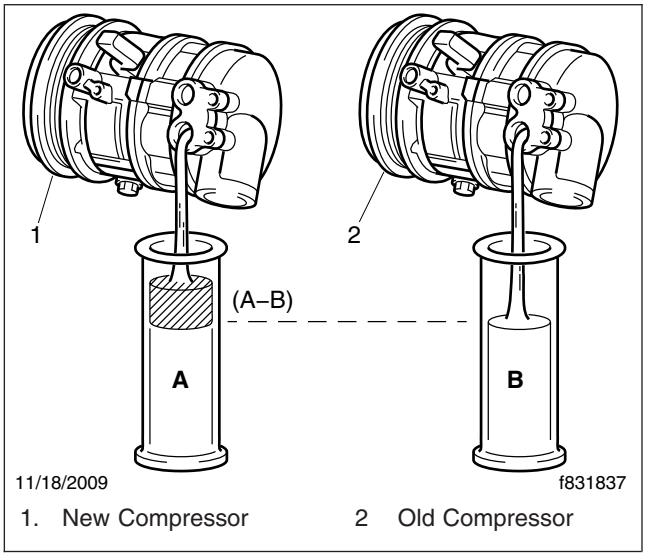
Tubing, funnels, or other equipment used to transfer the oil must be very clean and dry. When handling refrigerant oil:

- 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. Refer to the workshop manual for the specific compressor on the vehicle being serviced for details about how the total system volume is determined. 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**.



1. New Compressor 2 Old Compressor

Fig. 1, 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 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 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)
Major Leak at Connector Only	2 (59)

Table 1, Refrigerant Oil Quantities for Replaced Components

Charging

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.
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 **C02.01** in the *Cascadia™ Troubleshooting Manual*. If the operating pressures are not acceptable, see **C02.01** in the *Cascadia™ Troubleshooting Manual*, 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

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. A technician should not attempt to perform leak detection without reading and understanding the owner's 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" in **Specifications, 400** contains the qualifying leak rates for the components used on these 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-Stato seals that connect the components together are specified separately. Additionally, due to the possible difficulty of distinguishing between two minor leaks at a multiport connection, the leak rate for two Mini-Stato seals

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.

IMPORTANT: Refrigerant oil residue on a part may be an indication of a refrigerant leak in that area, but it is not an acceptable method of determining if a part is defective.

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 the 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, 400**, 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 the leak.
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, 400**.

Specifications

⚠ 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.

Refrigerant recovery/charge stations can be purchased from:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
1-800-328-6657

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

The sleeper heater and air conditioner assembly is mounted on the floor, in the cabinet tower, behind the driver's seat, and contains the following major components:

- blower motor
- evaporator
- heater core
- recirculation filter
- stepper motor
- blend door
- thermal expansion valve
- evaporator temperature sensor

Figure 1 shows the locations of the major components.

The heating, air conditioning, and ventilating functions of the sleeper heater and air conditioner system are controlled by the auxiliary control panel mounted on the cabinet behind the driver's seat. See the *Cascadia™ Driver's Manual* for operating instructions.

Description of Components

Blower Motor

The blower motor forces air through the HVAC assembly, and through the duct work.

Blend Door

The blend door controls the flow of air coming through the heater core and the evaporator, to regulate the temperature of the air coming from the HVAC assembly. The door is actuated by a stepper motor.

Stepper Motor

The stepper motor is an electric actuator, it is a combined motor and gearbox, and is used to rotate the door within the HVAC assembly. Movement of the doors is controlled by the settings on the climate control panel. There is one actuator on the sleeper HVAC assembly, it operates the blend door.

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 on the outlet side of the evaporator; it measures the temperature of the air leaving 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.

Thermal Expansion Valve

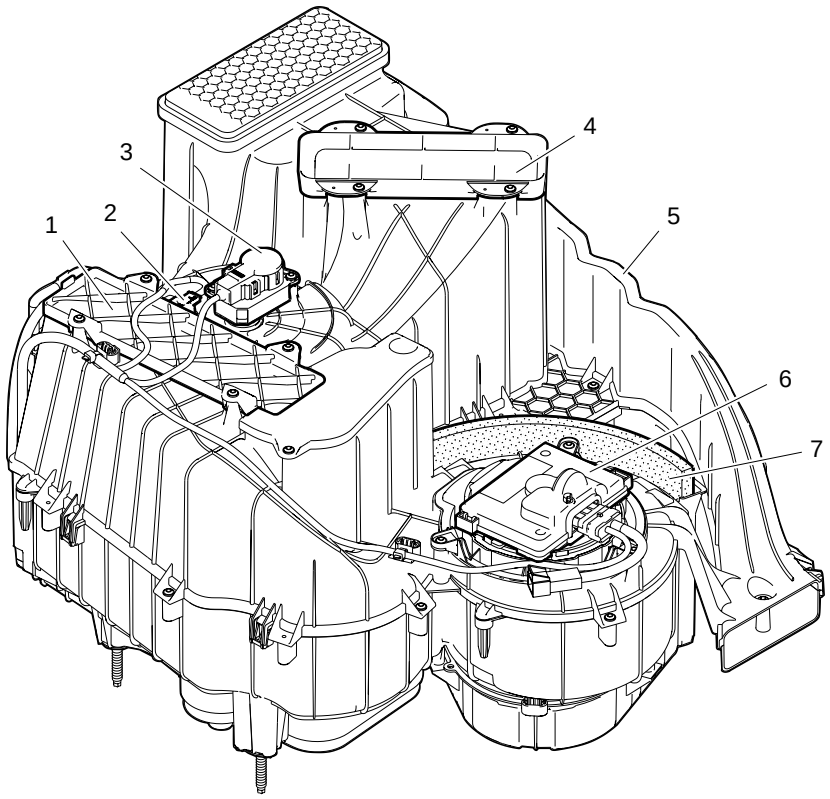
The thermal expansion valve (TXV) is a dividing point between the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the condenser passes through the thermal expansion valve, and moves into the low-pressure area of the evaporator.

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 thermal 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.

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.

General Information



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1. Evaporator
2. Evaporator Temperature Sensor
3. Stepper Motor
4. Heater Core
5. Auxiliary HVAC Unit Housing
6. Blower Motor
7. Filter

Fig. 1, Auxiliary HVAC Components

Recirculation Filter

The recirculation filter cleans air that is drawn into the HVAC assembly from the sleeper area, preventing the evaporator and heater core fins from becoming clogged with dust and debris.

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.

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 that 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-pressure condition.

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 thermal 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.

General Information

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 Gauge pressure relative to the local atmosphere. At sea level, 0 psig is about 14.7 psia, which is standard atmospheric pressure. But in Denver, which is at about 5000 feet altitude, standard atmospheric pressure and 0 psig are about 12.5 psia. It is possible to have a negative gauge pressure, indicating a vacuum.

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.

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.

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.

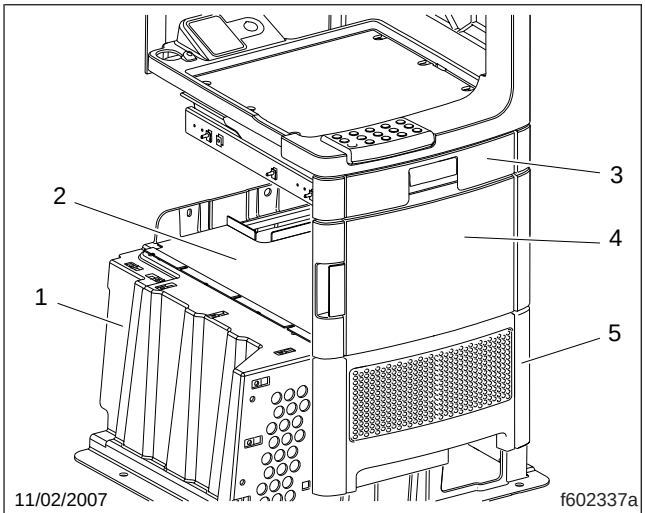
Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

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

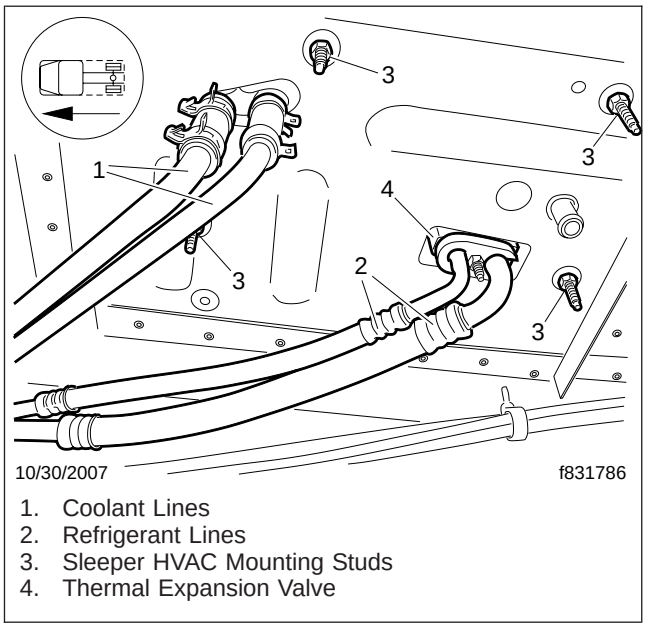
1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the left side fairing behind the steps, if equipped.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.



1. HVAC Compartment
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel

Fig. 1, Sleeper Cabinet Stack

5. Remove the drawer.
6. Place a drain pan under the coolant lines, at the connection to the heater core, under the cab.
7. Disconnect the coolant lines, and plug them to prevent further drainage of coolant from the lines. Let the heater core completely drain into the pan. See **Fig. 2**.
8. If the heater core has not previously been replaced, use a razor knife to cut around the perimeter of the cutout panel and discard the panel. If the heater core has been previously replaced, remove the fasteners and remove the cover. See **Fig. 3**.



1. Coolant Lines
2. Refrigerant Lines
3. Sleeper HVAC Mounting Studs
4. Thermal Expansion Valve

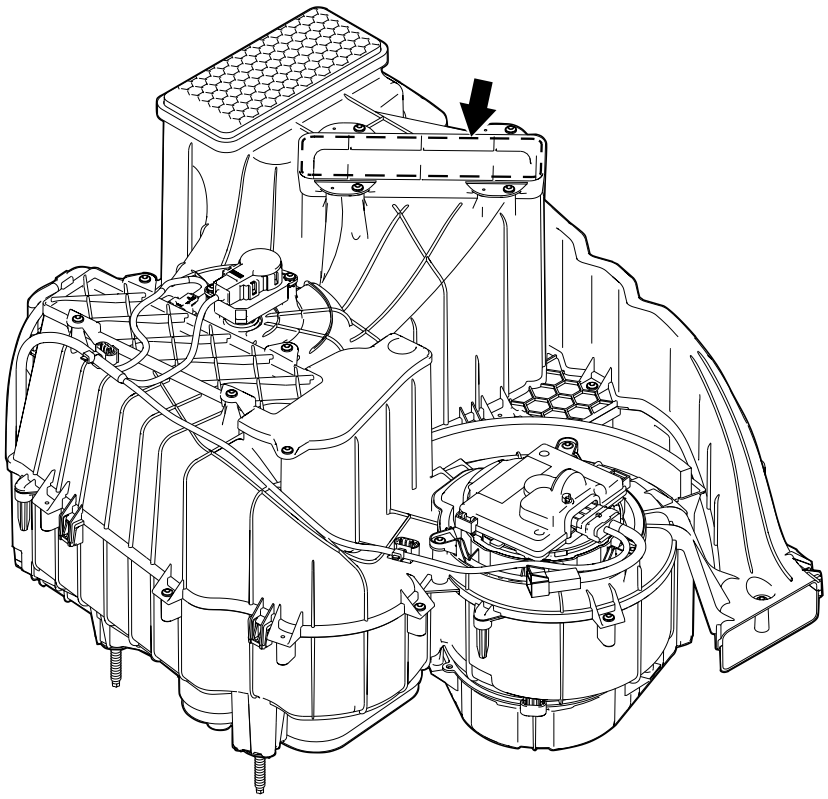
Fig. 2, Under-Cab View

9. Remove the heater core from the housing.
10. Install a new heater core in the housing.

NOTE: The new heater core comes with a replacement cover and fasteners for the one that was cut out.

11. Install the cover.
12. Install the panel on the bottom of the lower storage compartment.
13. Install the drawer, and close the door.
14. Connect the coolant lines.
15. Add coolant to the cooling system as needed. For instructions, see **Group 20**.
16. Connect the batteries.
17. Install the side fairing.

Heater Core Replacement



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Cut out the heater core panel.

Fig. 3, Heater Core Panel

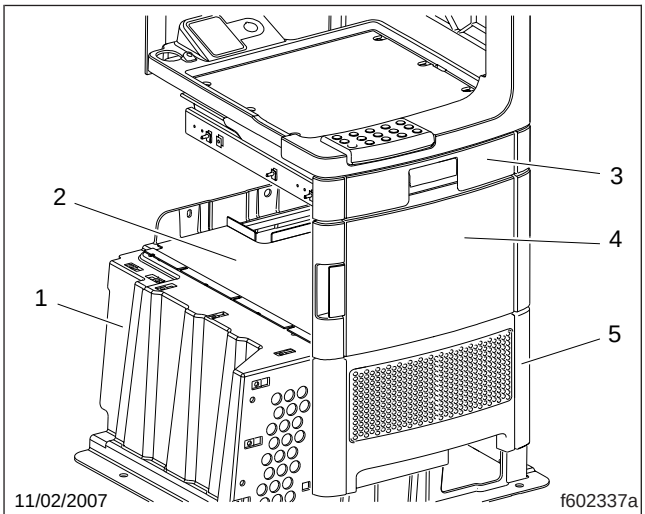
Evaporator Replacement

⚠ 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.

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Raise the hood.
4. Recover the refrigerant from the air conditioning system. See **Section 83.00, Subject 210**for instructions.
5. Remove the left side fairing behind the steps, if equipped.
6. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.



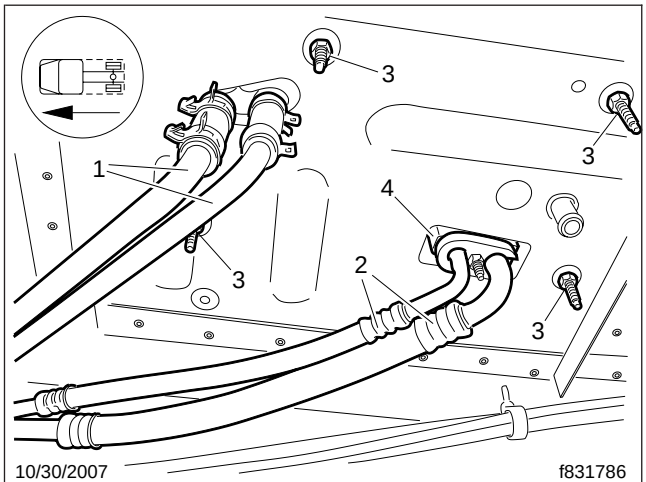
1. HVAC Compartment
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel

Fig. 1, Sleeper Cabinet Stack

7. Remove the drawer.
8. Remove the perforated panel on the front of the HVAC compartment.

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. Disconnect the refrigerant lines from the thermal expansion valve, and cap the lines immediately to prevent contaminants from entering the system. See **Fig. 2**.

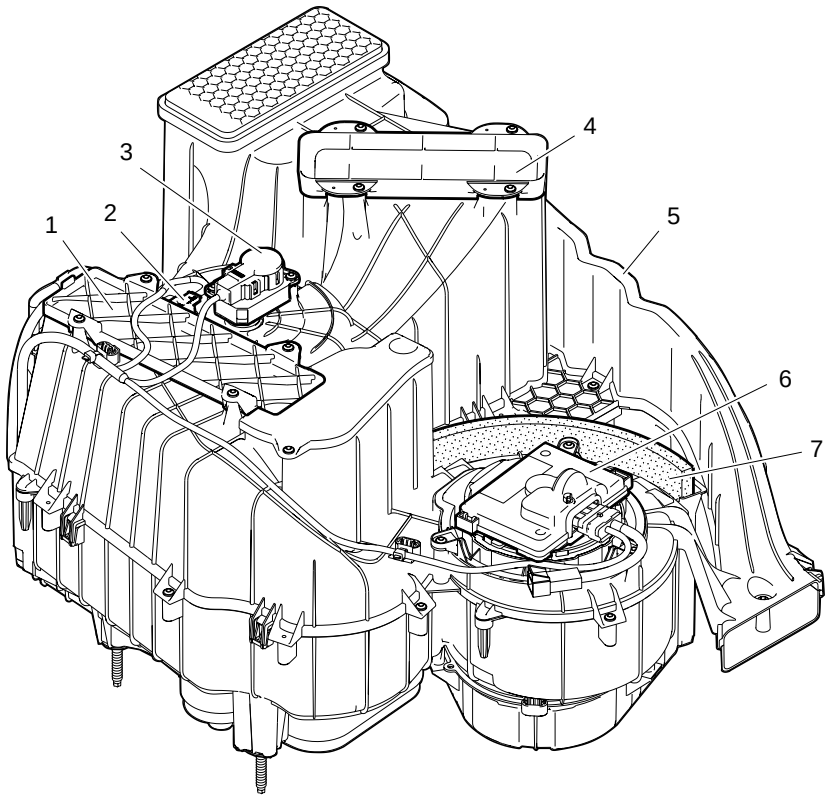


1. Coolant Lines
2. Refrigerant Lines
3. Sleeper HVAC Mounting Studs
4. Thermal Expansion Valve

Fig. 2, Under-Cab View

10. Disconnect the harness from the stepper motor and the probe.
11. Remove the evaporator cover; see **Fig. 3** for the location.
12. Remove the evaporator and thermal expansion valve from the housing.
13. Remove the thermal expansion valve from the old evaporator, and install it on the new one. Tighten to 35 lbf·in (400 N·cm).
14. Install the new evaporator and thermal expansion valve in the housing.

Evaporator Replacement



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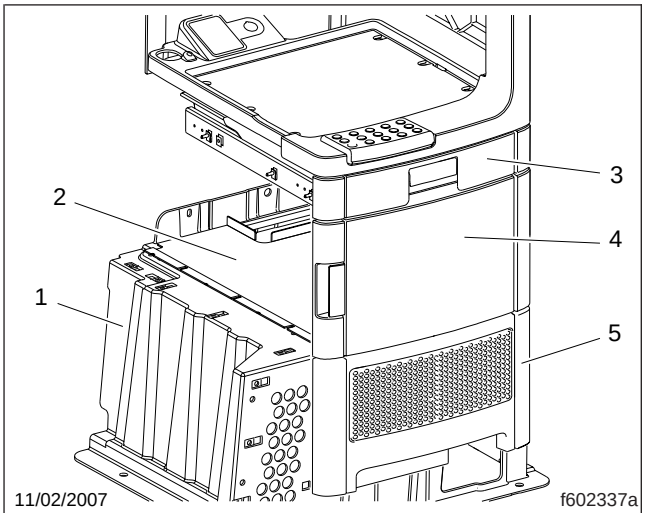
1. Evaporator Cover
2. Temperature Sensor
3. Stepper Motor
4. Heater Core Cover
5. Auxiliary HVAC Unit Housing
6. Blower Motor
7. Filter

Fig. 3, Auxiliary HVAC Component Locations

15. Install the cover.
16. Install the perforated panel on the front of the HVAC compartment.
17. Install the panel on the bottom of the lower storage compartment.
18. Install the drawer, and close the door.
19. Connect the refrigerant lines to the thermal expansion valve. Tighten 11 to 15 lbf·ft (15 to 20 N·m).
20. Evacuate and charge the refrigerant system. See **Section 83.00, Subject 210**.
21. Connect the batteries.
22. Return the hood to the operating position.
23. Install the side fairing.

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.



1. HVAC Compartment
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel

Fig. 1, Sleeper Cabinet Stack

4. Remove the harness connector. See **Fig. 2**.
5. Rotate the probe one quarter turn counterclockwise and pull it out of the housing.
6. Install a new probe. Make sure it snaps into position.
7. Connect the harness connector.
8. Install the panel on the bottom of the lower storage compartment, and close the door.
9. Connect the batteries.

Temperature Sensor Replacement

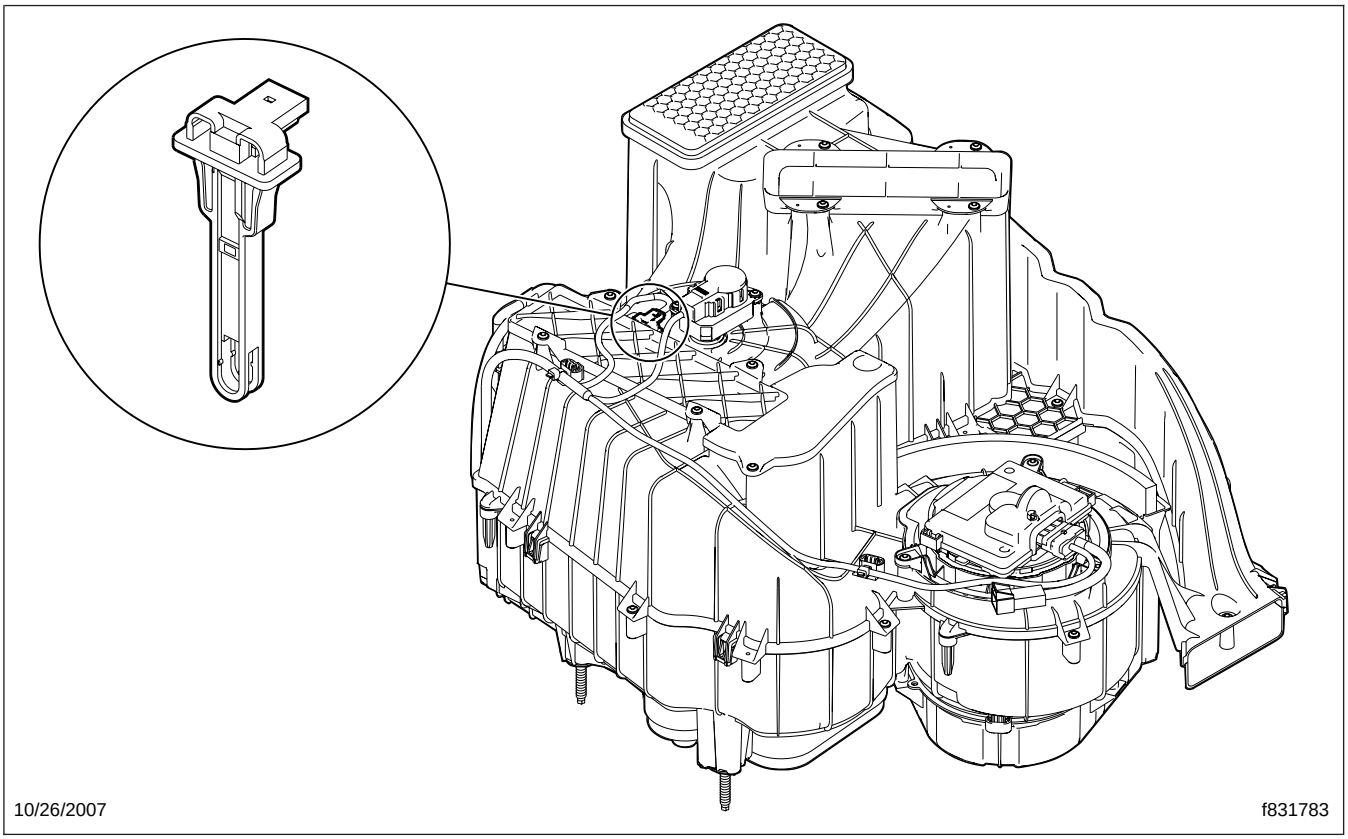
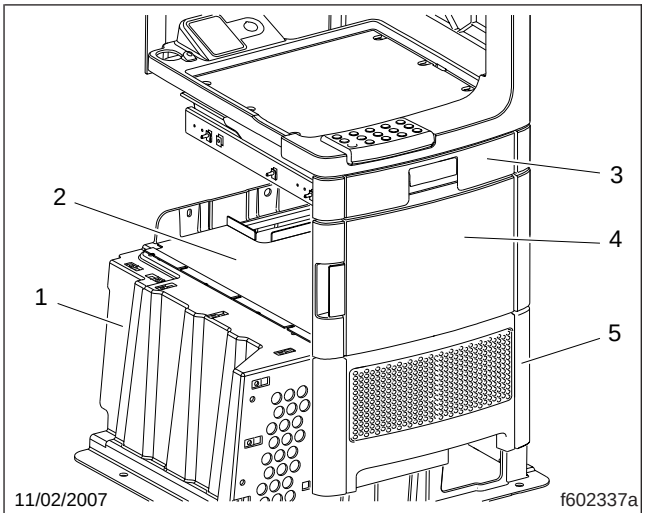


Fig. 2, Temperature Sensor Installation

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.



1. HVAC Compartment
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel

Fig. 1, Sleeper Cabinet Stack

4. Remove the drawer.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Disconnect the wire harness connector from the blower motor.
7. Remove the fasteners, and lift the blower assembly out of the housing. See **Fig. 2**.
8. Position the new blower assembly in the housing and install the fasteners.
9. Connect the wire harness connector to the blower motor.
10. Install the perforated panel on the front of the HVAC compartment.
11. Install the panel on the bottom of the lower storage compartment.
12. Install the drawer, and close the door.
13. Connect the batteries.

Blower Motor Replacement

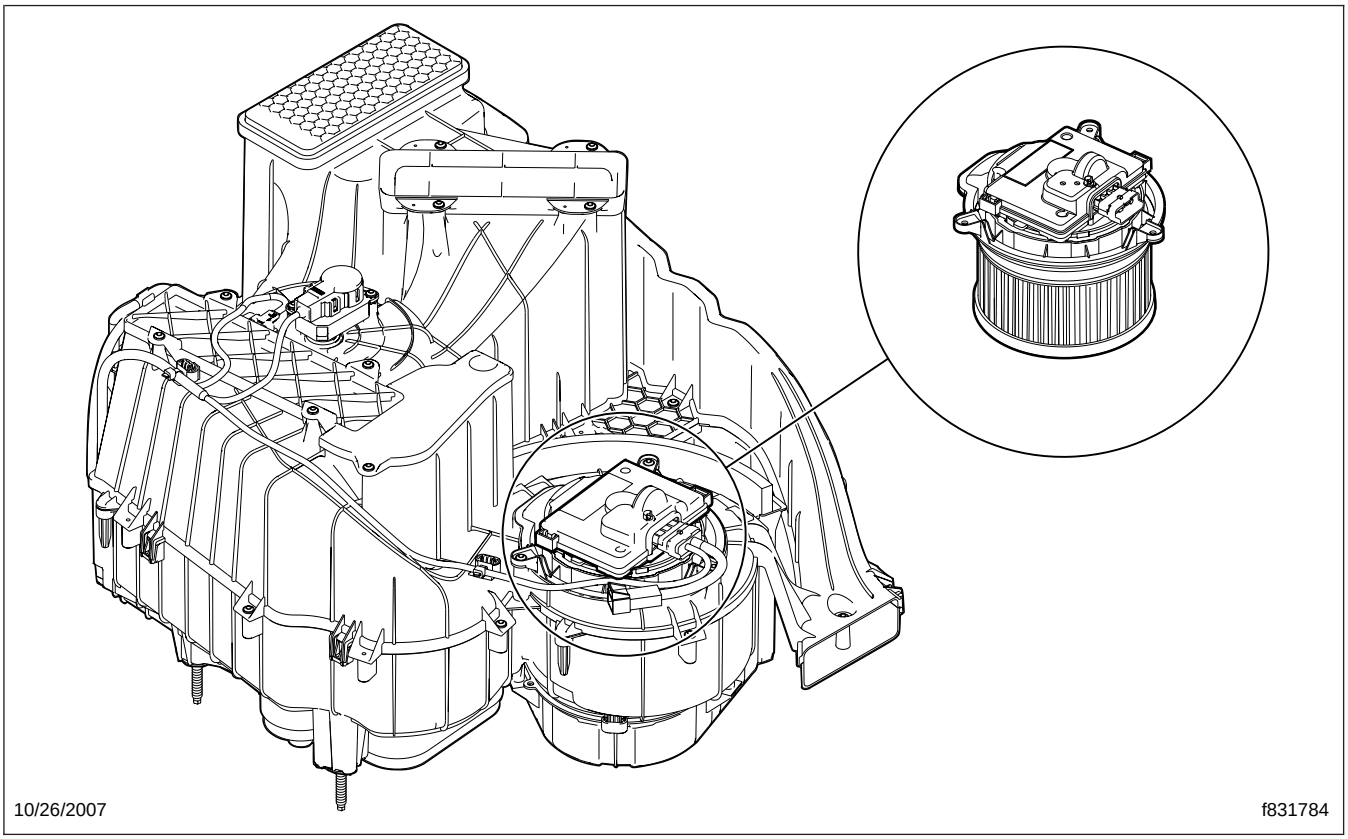
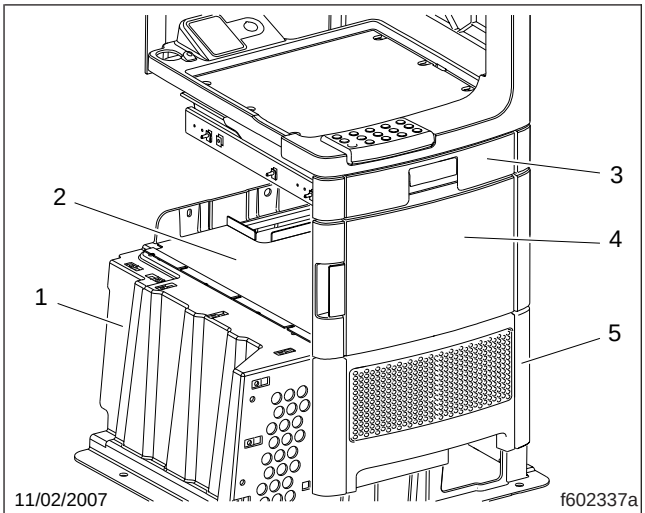


Fig. 2, Blower Motor Assembly Installation

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.



1. HVAC Compartment
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel

Fig. 1, Sleeper Cabinet Stack

4. Remove the drawer.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Disconnect the wire harness connector from the stepper motor. See **Fig. 2**.
7. Remove the fasteners, and lift the stepper motor up off the guide pin.
8. Carefully turn the new stepper motor output shaft to the same position as that of the old motor, position the motor on the guide pin, then push it into place. Install the screws; do not overtighten.
9. Connect the wire harness connector to the stepper motor.
10. Install the perforated panel on the front of the HVAC compartment.
11. Install the panel on the bottom of the lower storage compartment.
12. Install the drawer, and close the door.
13. Connect the batteries.

Stepper Motor Replacement

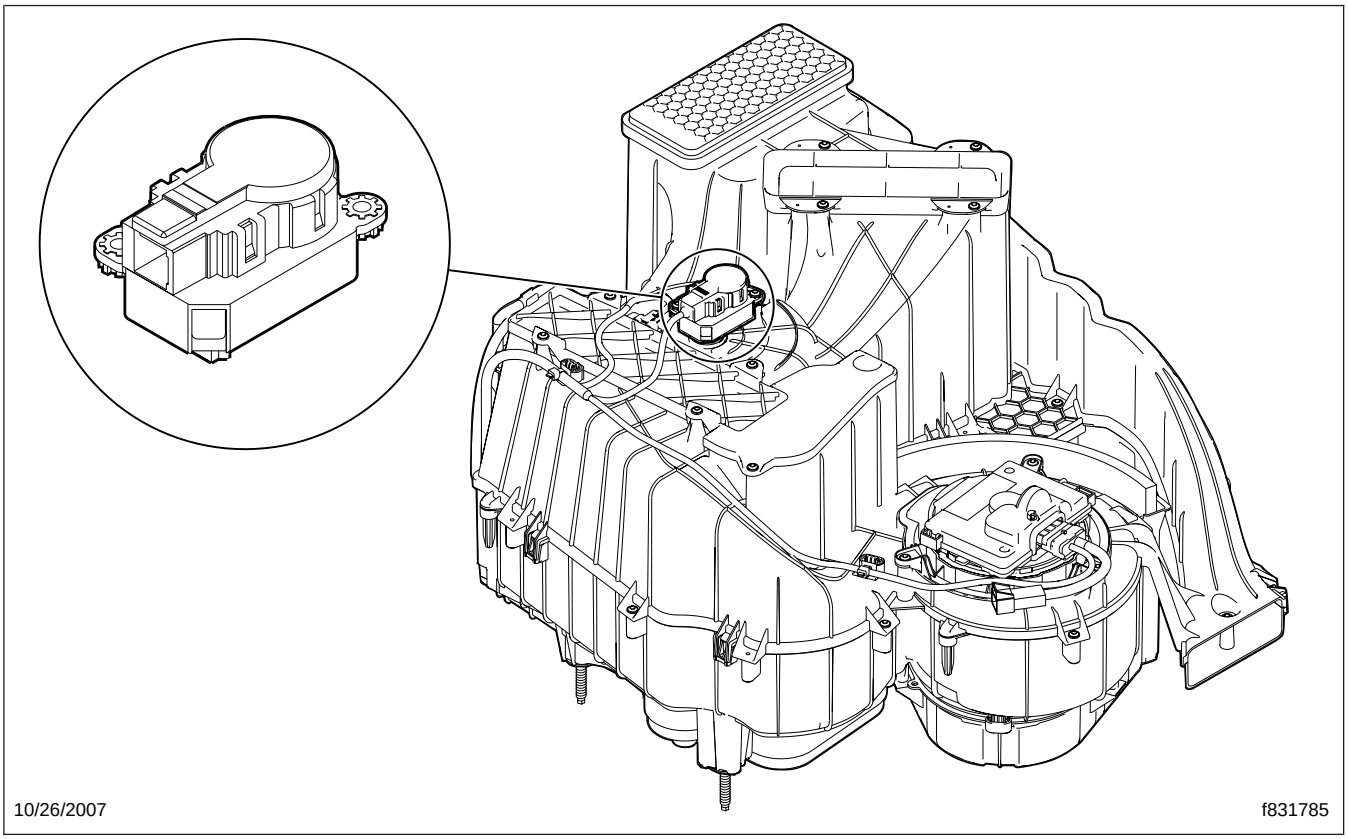


Fig. 2, Stepper Motor Assembly Installation

Auxiliary HVAC Unit Removal and Installation

⚠ WARNING

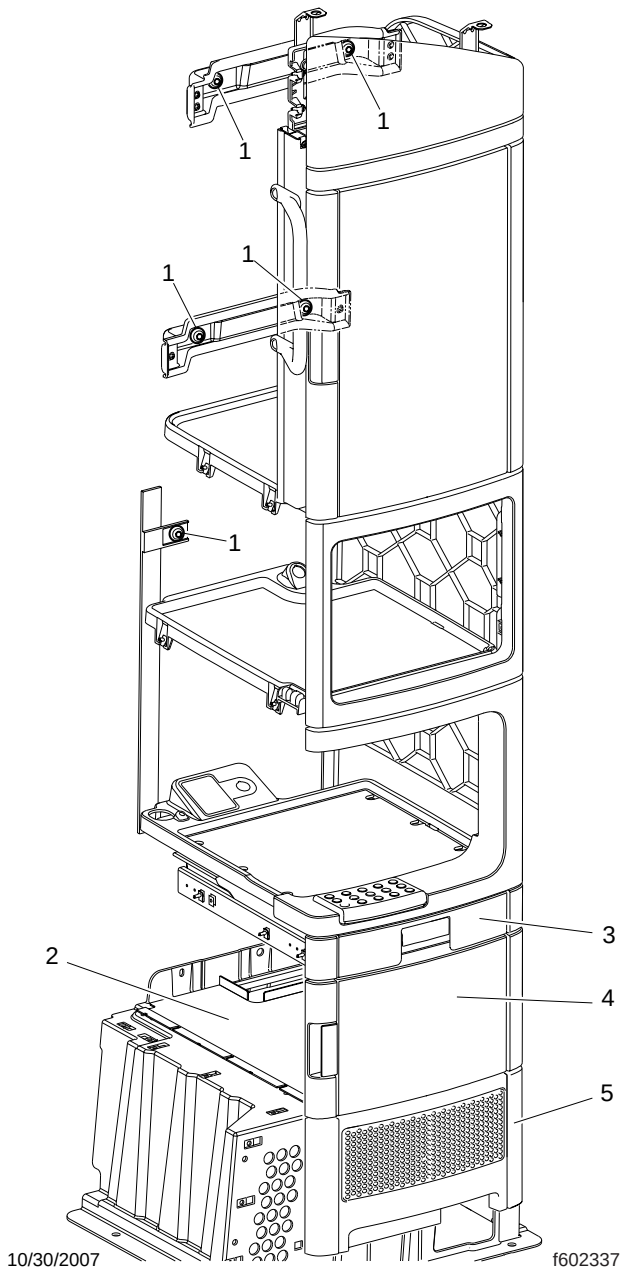
Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Removal

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Raise the hood.
4. Recover the refrigerant from the air conditioning system. See **Section 83.00, Subject 210**for instructions.
5. Remove the left side fairing behind the steps, if equipped.
6. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.
7. Remove the perforated panel on the front of the HVAC compartment.
8. Remove the cabinet stack. See **Group 60** for instructions.
9. Raise and secure the upper bunk.
10. Remove the lower bunk mattress, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
11. Remove the lower bunk front panel and any dividers under the bunk.
12. Remove the HVAC cabinet.

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).

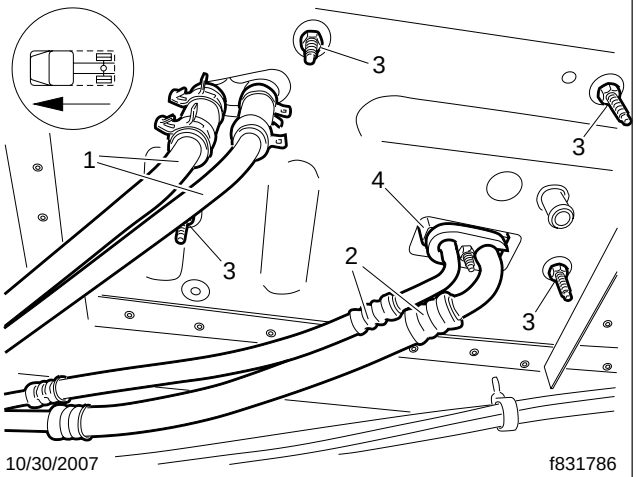
13. Disconnect the refrigerant lines from the thermal expansion valve, and cap the lines immediately to prevent contaminants from entering the system. See **Fig. 2**.



1. Cabinet Fasteners
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel

Fig. 1, Sleeper Cabinet Stack

Auxiliary HVAC Unit Removal and Installation



1. Coolant Lines
2. Refrigerant Lines
3. Sleeper HVAC Mounting Studs and Nuts
4. Thermal Expansion Valve

Fig. 2, Under-Cab View

14. Place a drain pan under the coolant lines, at the connection to the heater core, under the cab. Disconnect the coolant lines, and plug them to prevent further drainage of coolant from the lines. Let the heater core completely drain into the pan.
15. Remove the mounting nuts from the bottom of the HVAC unit.
16. Disconnect the harness at the controller and the main power connectors.
17. Lift the unit out.

Installation

1. Position the unit and install the mounting nuts.
2. Using new seals, connect the refrigerant lines to the thermal expansion valve. Tighten 11 to 15 lbf·ft (15 to 20 N·m).
3. Connect the coolant lines.
4. Evacuate and charge the refrigerant system. See **Section 83.00, Subject 210** for instructions.
5. Connect the batteries.
6. Add coolant to the cooling system as needed. For instructions, see **Group 20**.
7. Install the side fairing.
8. Install the HVAC cabinet.
9. Install the lower bunk front panel and any dividers under the bunk.
10. Install the cabinet stack. See **Group 60** for instructions.
11. Lower the bunk, and install the mattress.

Thermal Expansion Valve Replacement

WARNING

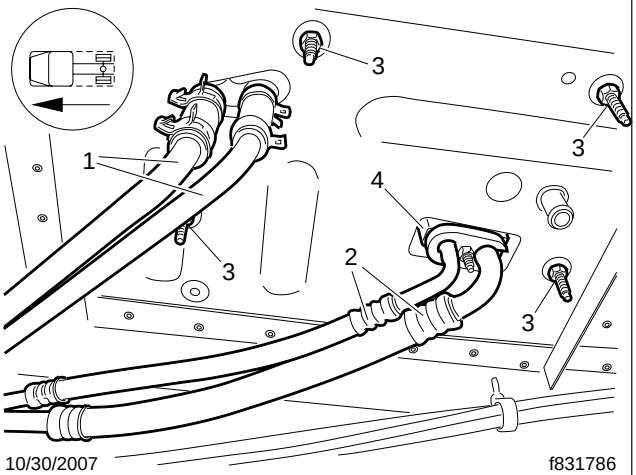
Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Raise the hood.
4. Recover the refrigerant from the air conditioning system. See **Section 83.00, Subject 210**for instructions.
5. Remove the left side fairing behind the steps, if equipped.

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).

6. Disconnect the refrigerant lines from the thermal expansion valve, and cap the lines immediately to prevent contaminants from entering the system. See **Fig. 1**.
7. Remove the two fasteners, and the thermal expansion valve, from the plate on the evaporator lines.
8. Using new seals, install a new thermal expansion valve on the plate on the evaporator lines. Tighten to 35 lbf·in (395 N·cm).
9. Using new seals, connect the refrigerant lines to the thermal expansion valve. Tighten 11 to 15 lbf·ft (15 to 20 N·m).
10. Evacuate and charge the refrigerant system. See **Section 83.00, Subject 210**for instructions.
11. Connect the batteries.
12. Return the hood to the operating position.
13. Install the side fairing.



1. Coolant Lines
2. Refrigerant Lines
3. Sleeper HVAC Mounting Studs
4. Thermal Expansion Valve

Fig. 1, Under-Cab View

Replacement

1. Remove the fasteners. See **Fig. 1**.

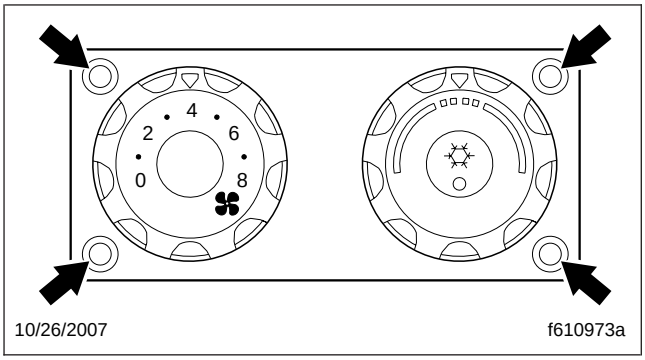


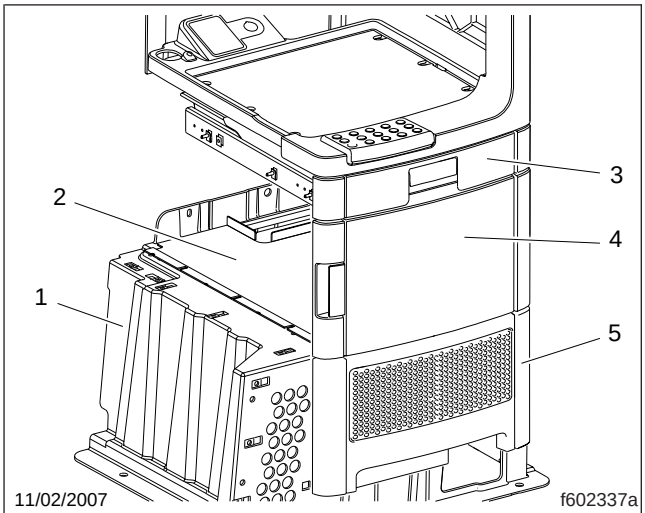
Fig. 1, Auxiliary Control Unit

2. Carefully pull the unit out, and disconnect the wiring harness.
3. Connect the wiring harness to the new unit.

   Position the unit in the panel and install the fasteners.

Replacement

1. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.



1. HVAC Compartment
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel

Fig. 1, Sleeper Cabinet Stack

4. Remove the drawer.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Cut the zip ties that secure the harness.
7. Disconnect the harness from all the connections.
   - blower motor
   - power supply
   - temperature probe
   - controller
   - stepper motor
8. Remove the harness.
9. Connect the new harness to all of the components.
10. Secure the harness with zip ties as needed.
11. Connect the batteries.
12. Install the perforated panel on the front of the HVAC compartment.
13. Install the panel on the bottom of the lower storage compartment.
14. Install the drawer, and close the door.

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, and charged. 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 more than 30 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 (drive belts)
- **never** mix PAG oil with other types of refrigerant oil

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. Park the vehicle on a level surface, turn off the engine, apply the parking brakes, and chock the tires.
2. Raise the hood.
3. Begin recovery of the refrigerant from the air conditioning system; for instructions, see **Section 83.00, Subject 210**.
4. Remove the drive belt. Do not pry or roll the belt off the pulleys.
5. Disconnect the wiring harness from the compressor.
6. After the refrigerant has been fully recovered, disconnect the discharge and suction lines from the compressor. Cap the discharge and suction ports and the refrigerant lines.

IMPORTANT: Under no circumstances should the ports on the compressor or 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).

7. Being careful not to spill any refrigerant oil, remove the capscrews and washers that attach the refrigerant compressor to the engine, and remove the compressor.

Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. The oil quantity is printed on a label attached to the compressor.

When installing a new compressor on the vehicle, gently release the nitrogen gas from the discharge side of the compressor.

1. Adjust the refrigerant oil level in the compressor; for instructions see, **Subject 120**.
2. Position the compressor on the mounting bracket and install the nuts and washers.
3. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
4. On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On refrigerant line connections that have Mini Stat-O-Seals, replace the seals. **Do not** lubricate the Mini Stat-O-Seals prior to installation. Use only a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.
5. Connect the refrigerant lines to the compressor.
6. Connect the wiring harness to the compressor.
7. Install the drive belt.
8. If installing a new compressor, or if the system was without any refrigerant pressure before repairs were started, replace the receiver-drier; for instructions, see **Section 83.00, Subject 180**.
9. Evacuate, charge, and leak test the refrigerant system; for instructions, see **Section 83.00, Subject 210**.
10. Return the hood to the operating position.

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 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 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.

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 83.00, Subject 210** for instructions.
3. Drain the recovered oil into the calibrated drain bottle of the recovery/recycle machine. Record the amount of oil recovered and properly dispose of the recovered oil.
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—indicates moisture in the system
   - grit or debris in the oil
5. 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 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 quanitites 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

6. 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.
7. Evacuate, charge, and leak test the refrigerant system. See **Section 83.00, Subject 210** 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.

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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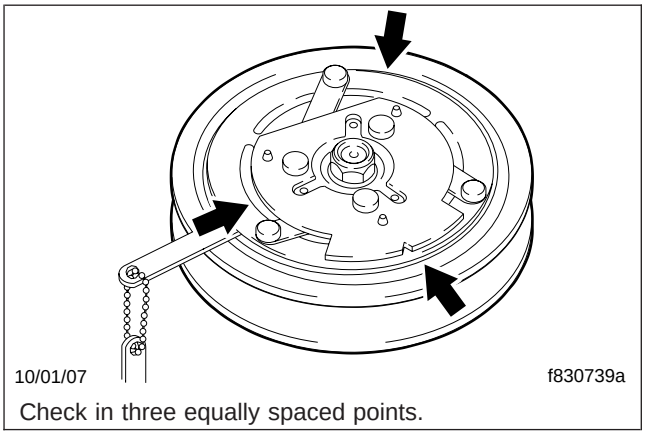
Fig. 1, Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

Clutch Assembly Removal, Inspection, and Installation

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.

The clutch should be replaced if it is worn. Before replacing the clutch, check the air gap. The air gap should be no greater than 0.030 inch (0.76 mm) at three equally spaced points around the perimeter. The gap must be greater than 0.030 inch (0.76 mm) at all three points for the clutch to need replacing. See **Fig. 1**.



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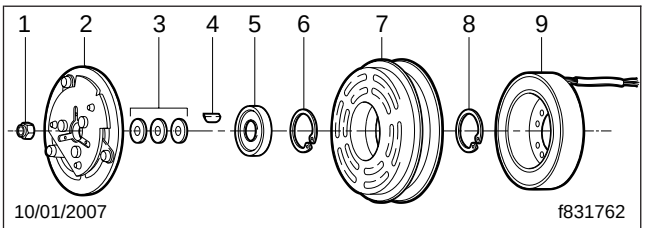
Check in three equally spaced points.

Fig. 1, Checking the Clutch Clearance

Removal

1. Remove the compressor from the vehicle. For instructions, see **Subject 110**.
2. Remove the bolts that attach the drive plate cover, and remove the cover. See **Fig. 2**.
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. 3**.
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. 4**.
5. Remove the pulley bearing dust cover (if equipped), the shaft key, and the clutch shims.



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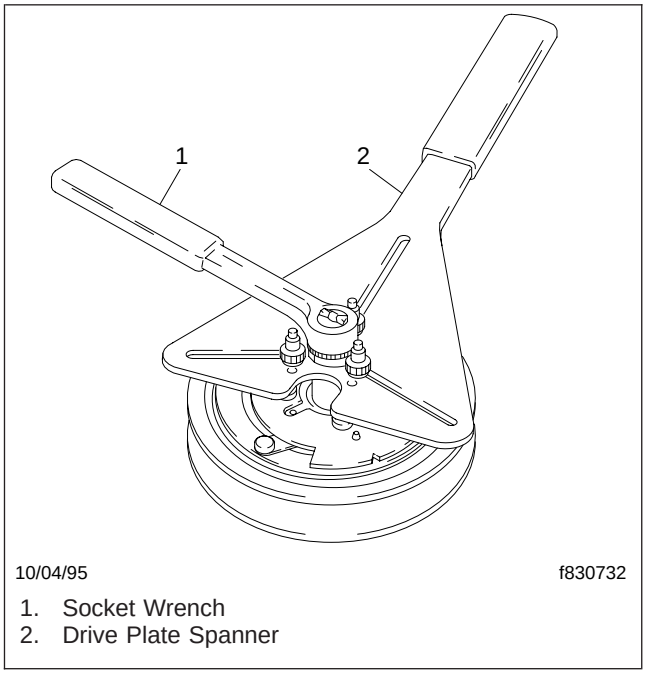
1. Shaft Nut
2. Drive Plate
3. Clutch Shims
4. Shaft Key
5. Pulley Bearing Dust Cover
6. Pulley Snap Ring
7. Pulley Assembly
8. Field Coil Assembly Snap Ring
9. Field Coil Assembly

Fig. 2, Refrigerant Compressor Clutch (exploded view)



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1. Socket Wrench
2. Drive Plate Spanner

Fig. 3, Remove the Retaining Nut

Use a slotted screwdriver and hammer to tap the shaft key loose. See **Fig. 5**.

6. Using external snap-ring pliers, remove the pulley assembly snap ring.
7. Remove the pulley assembly, as follows.

   7.1 Insert the lip of the pulley puller jaws into the snap ring groove. See **Fig. 6**.

   7.2 Place the puller shaft protector over the exposed shaft.

Clutch Assembly Removal, Inspection, and Installation

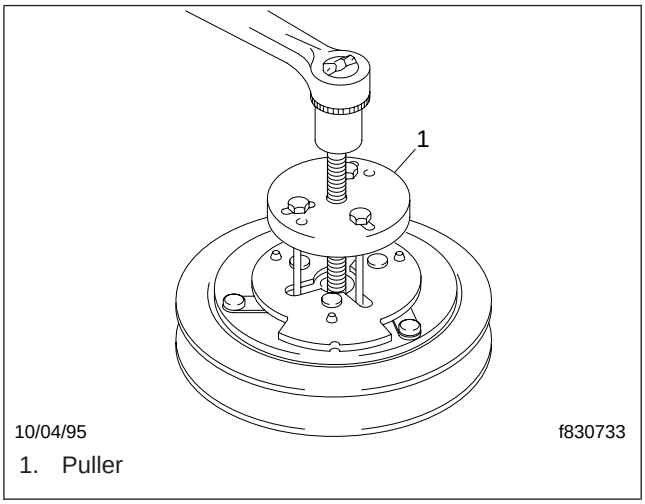


Fig. 4, Removing the Drive Plate

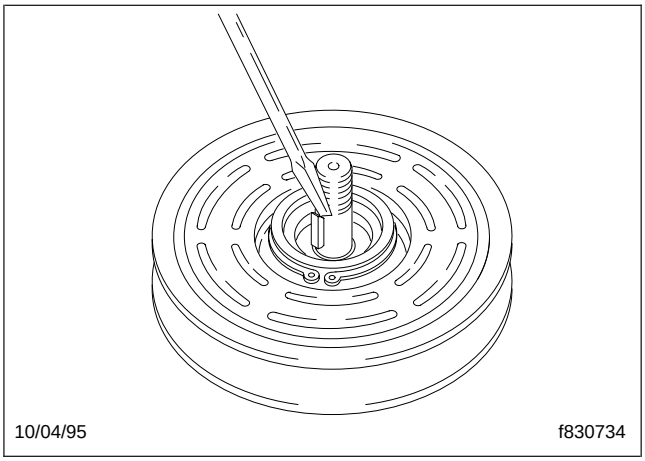


Fig. 5, Removing the Shaft Key

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, as follows.

8.1 Remove the coil's lead wire from the wire holder on the compressor.

8.2 Disconnect the wiring harness.

8.3 Remove the snap ring (**Fig. 7**); then, remove the coil assembly.

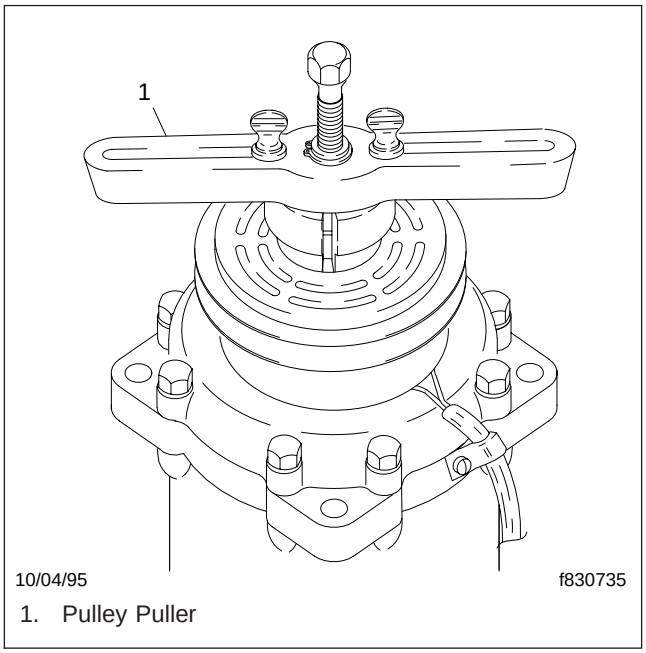


Fig. 6, Positioning the Pulley Puller Jaws

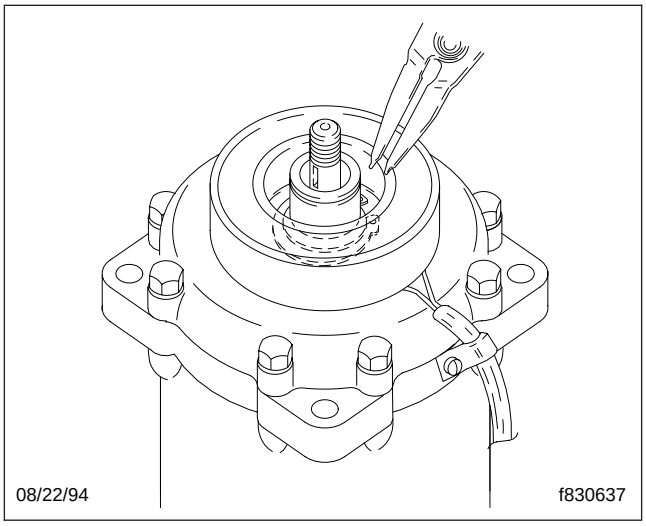


Fig. 7, Removing the Snap Ring

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.

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, as follows.
   - 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, as follows.
   - 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. 8**.
   - 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, as follows.
   - 3.1 Using pliers, install the shaft key. See **Fig. 9**.
   - 3.2 Install the shims.

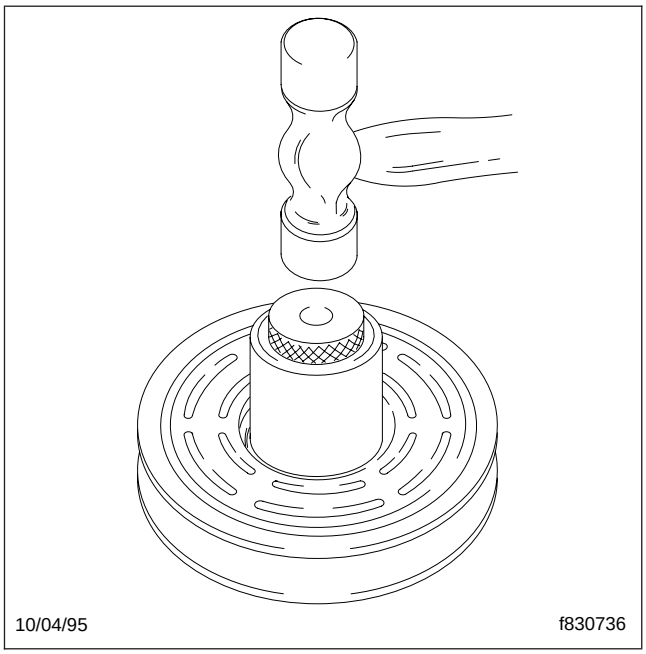


Fig. 8, Driving the Pulley Down Against the Front Housing Step

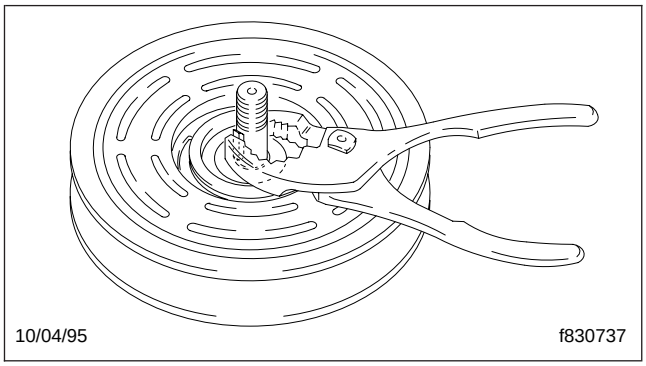


Fig. 9, Installing the Shaft Key

   - 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. 10**.
   - 3.4 Install the retaining nut. Tighten the nut to the torque value 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. 11**. Adjust the clearance by gently tapping down on the front plate at the high spots, or gently prying up at the low spots.

Clutch Assembly Removal, Inspection, and Installation

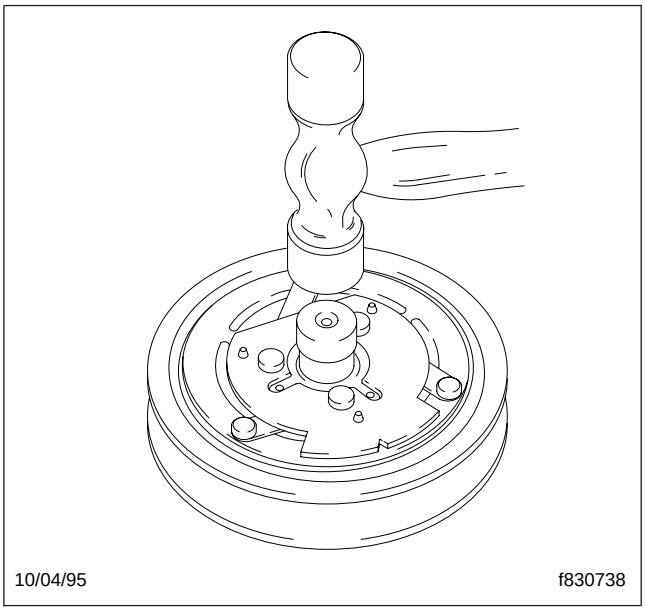
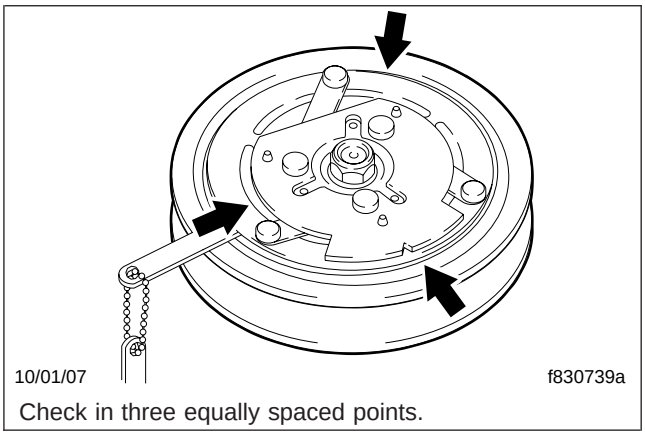


Fig. 10, Installing the Drive Plate Assembly



Check in three equally spaced points.

Fig. 11, Checking the Clutch Clearance

5. Install the drive plate dust cover. Tighten the bolts to the torque value in **Specifications 400**.
6. Install the compressor on the vehicle. For instructions, see **Subject 110**.

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)**
Compressor Mounting Fasteners	—	20–25 (27–34)
Clutch Retaining Nut (1/2")	—	22 (30)
Clutch Retaining Nut (M8)	—	13 (18)
Oil Drain Plug	—	15 (20)
Dust Cover Screws, M5	78 (880)	—
Clutch Lead Wire Clamp Screw	132 (1500)	—

Table 1, Torque Values

SlimLine Seal Assembly Bolt Torque Values	
HVAC Component	**Torque: lbf·ft (N·m)**
A/C Compressor	11–15 (15–20)
Condenser	
Receiver-Drier	
Thermal Expansion Valve	
Evaporator	
Junction Block	

Table 2, SlimLine Seal Assembly Bolt Torque Values

General Information

Standard Configuration

In the standard configuration, the ParkSmart sleeper heater and air conditioner system consists of an electrically-powered A/C system, a fuel-operated coolant heater mounted under the cab, and four isolated deep-cycle batteries. The system can provide heating or cooling whether the engine is on or off. While the engine is running, power is drawn from the alternator to run the refrigerant compressor, and the batteries are charged by the vehicle charging system. While the engine is running, it provides heat to the vehicle coolant circulating through the heater. During parked operation, A/C power comes from the dedicated batteries, and the fuel-operated coolant heater provides heat to the system. The starting batteries are separated from the parked HVAC system, and are not affected by the parked HVAC operation. The system can keep the sleeper compartment cool for up to ten hours running on the batteries. The heater will keep the sleeper warm for over 34 hours. The unit is mounted on the floor in the cabinet tower, behind the driver's seat, and contains the following major components:

- sealed A/C system (pre-July 2011)
- blower motor
- heater core
- recirculation filter
- blend door stepper motor
- blend door
- bunk temperature sensor
- evaporator temperature sensor
- ambient (outside) temperature sensor
- condenser fan
- unit control module

Major components outside the HVAC compartment include the following:

- control panel
- fuel-operated coolant heater
- four batteries
- battery isolator

On vehicles manufactured from July 1, 2011, the A/C system is no longer sealed; the system is serviceable. The condenser, condenser fan, and ambient air temperature sensor are externally mounted in a module on the backwall of the sleeper, and are connected to the unit in the sleeper by refrigerant lines.

The heating, air conditioning, and ventilating functions of the parked sleeper heater and air conditioner system are controlled by the auxiliary control panel mounted in the bunk on the driver's side of the vehicle. See the *Cascadia™ Driver's Manual* for operating instructions.

ParkSmart with Optimized Idle

On vehicles with DDC Optimized Idle (O/I), the O/I runs the engine as required to maintain battery voltage and engine temperature, but not for cab heating and cooling. The main HVAC is disabled when the vehicle is in O/I mode, but the system is configured to allow the ParkSmart to provide bunk comfort during O/I operation. When O/I is not operating, the ParkSmart system functions in the regular operating mode by pressing the "Park" button to start the system.

The electrical system is set up with the main and auxiliary batteries connected in parallel. There is no battery separator in the system.

ParkSmart Operation in O/I Mode

NOTE: The engine may need to be warmed up before O/I will initiate. The key must be in the "ON" position during O/I operation.

O/I is initiated following the O/I instruction label on the dash.

During the O/I start up sequence the power relays to the main HVAC will cycle a few times causing the fans to turn on and off. This is normal.

When in O/I mode, the ParkSmart automatically runs if the blower switch is turned to any position other than zero. It is not necessary to press the "Park" button to activate the ParkSmart system. The "Park" button and LED indicator light are inoperative during O/I operation.

If a fault causes the O/I to turn off during a run (such as a air leak causing a low pressure fault) the ParkSmart will continue to operate until it is shut off by the driver, or by the ParkSmart system low voltage disconnect protection.

General Information

Handling and Storage

NOTICE

The ParkSmart auxiliary HVAC unit should never be turned upside down. Doing so will allow the lubricant to leave the compressor. The lubricant can not return to the compressor, and this may lead to premature compressor failure.

Whether handling or storing the ParkSmart auxiliary HVAC unit, always keep it in an upright position. If the unit is turned on its side for any length of time, allow it to sit for one hour prior to operating the system to allow the compressor oil to settle.

Troubleshooting

Refer to **Subject C02.03** in the "Cab Systems" group in the *Cascadia™ Troubleshooting Manual* for all diagnostics. The troubleshooting manual groups are listed above the workshop manual title page in ServicePro.

Description of Components

Refrigerant Loop

On vehicles manufactured before July 1, 2011, the refrigerant loop of the parked HVAC system is a sealed unit. If any of the components of this refrigerant loop fail, the refrigerant loop must be replaced as a unit.

On vehicles manufactured from July 1, 2011, the refrigerant loop is divided into three separate assemblies. The in-cab assembly contains the compressor, evaporator, high-pressure switch, and thermal expansion valve. The external assembly, mounted on the sleeper backwall, contains the condenser and the receiver dryer. These are connected by refrigerant lines. The high pressure line is equipped with the service port. If any of the components of one of the subassemblies fail, the subassembly must be replaced as a unit.

Blower Motor

The blower motor pulls air through the HVAC assembly, and blows it through the duct work to the air outlets.

Blend Door

The blend door controls the flow of air directed through the heater core after the evaporator, to regulate the bunk temperature. The door is actuated by a stepper motor.

Stepper Motor

The stepper motor is an electric actuator; it is a combined motor and gearbox, and is used to rotate the door within the HVAC assembly. Movement of the door is controlled by the settings on the climate control panel. There is only one actuator on the parked HVAC assembly; it operates the blend door.

Evaporator Temperature Sensor

The temperature of the air coming through the evaporator is monitored by the low temperature sensor.

The low temperature sensor is on the outlet side of the evaporator; it measures the temperature of the air leaving the evaporator. The temperature sensor disengages the compressor to prevent the evaporator from freezing up due to, for example, moderate or low cooling requirements.

Heater Core

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. During parked operation, the engine coolant is heated by the fuel-operated coolant heater mounted under the cab. When the engine is on, the coolant is heated by the engine.

Recirculation Filter

The recirculation filter cleans air that is drawn into the HVAC assembly from the sleeper area, preventing the evaporator and heater core fins from becoming clogged with dust and debris.

Condenser

On vehicles manufactured from July 1, 2011, the condenser is externally mounted on the backwall of the sleeper in a module that also contains the condenser fan and the ambient air temperature sensor.

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 and humidity of air in the cab.

Ambient Air Temperature The temperature of air around an object, or the outside temperature.

Blower Motor A brushless blower motor that forces air through the HVAC assembly and through the duct work to the air outlets.

Dehumidify To remove water from the air at the evaporator.

Duct A passageway for the transfer of air from one area to another.

Electric Actuator A combined motor and gearbox used to drive the temperature control doors and the air selection mode door within the HVAC assembly.

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.

Fuel-Operated Coolant Heater A part of the heating system that heats engine coolant to provide heat to the cab or to adjust the temperature produced by the air conditioner.

A/C System Safety Precautions

IMPORTANT: The refrigerant system on units manufactured before July 2011 are **not** serviceable. 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.

On systems manufactured from July 2011, the system is serviceable, and all normal refrigerant handling precautions should be followed.

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 unmedicated 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 service equipment 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).

The ParkSmart system uses a non-conductive compressor oil. Use only polyvinylether (PVE) refrigerant oil in this system. The refrigerant system has enough oil capacity to be recovered four times over the life of the unit. Oil should never need to be added, but if it does, the correct type must be used to prevent a dangerous electrical short from occurring in the compressor. When handling this oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the oil container to air for more than five minutes. The 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 PVE oil with other types of refrigerant oil.

Fuel-Operated Heater Safety Precautions

The heater must be turned off while refueling. 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 or explosion, possibly resulting in serious personal injury or property damage.

When draining the fuel system, drain the fuel into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel onto the ground. Clean up any spills immediately.

The use of Espar coolant heaters requires that the coolant in the system to be heated contain a proper mixture of water and antifreeze to prevent the coolant from freezing or slushing. If the coolant becomes slushy or frozen, the heater's coolant pump cannot move the coolant, causing a blockage of the circulating system. Once this occurs, pressure will build up rapidly in the heater, and the coolant hose will either burst or blow off at the connection point to the heater. This situation could cause engine damage and/or personal injury. Extreme care should be taken to ensure a proper mixture of water and antifreeze is used in the coolant system. Refer to the engine manufacturer's or coolant manufacturer's recommendations for your specific requirements.

During electrical welding work on the vehicle, disconnect the power to the heater in order to protect the control unit.

Replacement

1. Remove the fasteners. See **Fig. 1**.

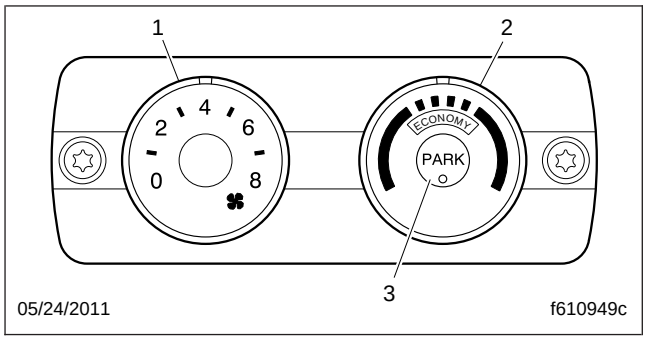


Fig. 1, Parked HVAC Control Module

2. Carefully pull the module out, and disconnect the wiring harnesses.
3. Connect the wiring harnesses to the new module.
4. Position the module in the panel and install the fasteners.

⚠ 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.

NOTICE

The ParkSmart auxiliary HVAC unit should never be turned upside down; not even if only for a few minutes. Doing so will allow the lubricant to leave the compressor. The lubricant can not return to the compressor, and this may lead to premature compressor failure.

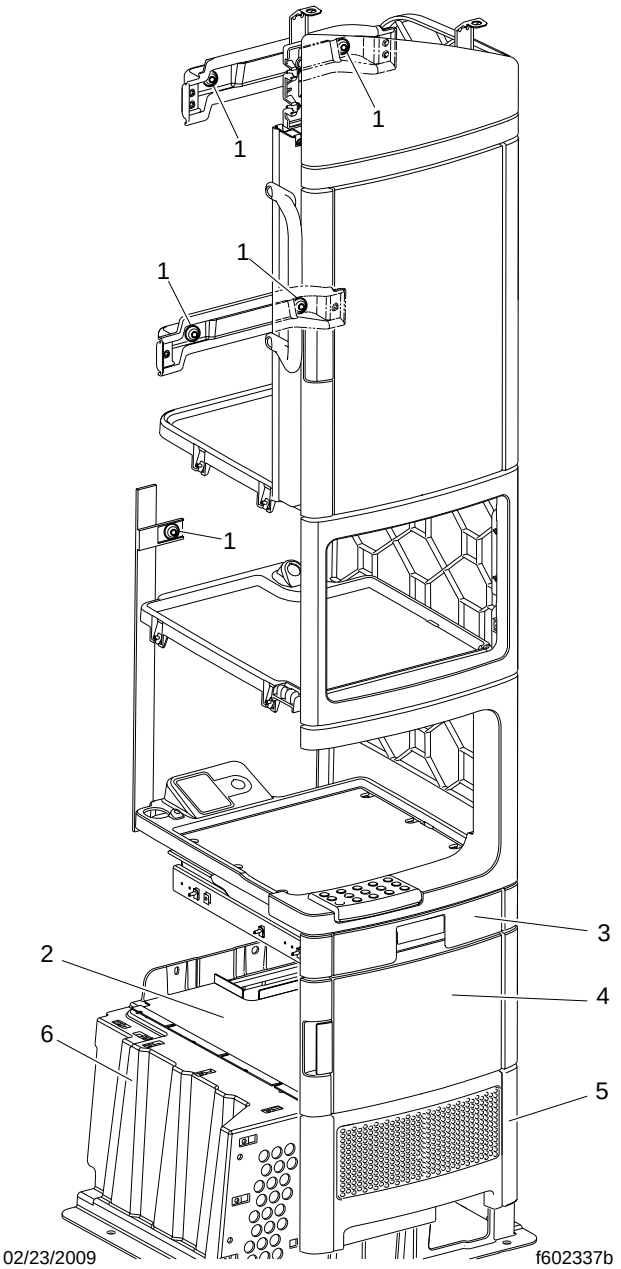
Whether handling or storing the ParkSmart auxiliary HVAC unit, always keep it in an upright position. If the unit is turned on its side for any length of time, allow it to sit for one hour prior to operating the system to allow the compressor oil to settle.

Determine the version of the ParkSmart system installed on the vehicle, then use the procedure for that system. The easiest way to determine which version is installed is to check the manufacture date. Also, the condenser module is easy to see on the backwall of the sleeper on units built from July 2011.

Units Built Prior to July 2011

Removal

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Raise and secure the upper bunk.



1. Cabinet Fasteners
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel
6. HVAC Cover

Fig. 1, Sleeper Cabinet Stack

Parked HVAC Unit Removal and Installation

7. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
8. Remove the lower bunk front panel and any dividers under the bunk.
9. Remove the cabinet stack. See **Group 60** for instructions.

NOTE: A small number of trucks built prior to July 2011 have the battery interconnect controller installed under the bunk, rather than on the frame rail.

10. If the unit has the interconnect controller installed under the bunk, disconnect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
11. Remove the HVAC cover.
12. Remove the vanity skirt and frame fairing as needed to improve access.
13. Disconnect the main power cables under the cab floor at the outlet cover.
14. Disconnect the condenser intake duct from the under the cab. See **Fig. 2**.
15. Disconnect the coolant lines from the heater core. See **Fig. 2**.
    - 15.1 Place a drain pan under the cab, below the coolant line connections to the heater core.
    - 15.2 Use radiator-hose pinch pliers to shut off the flow of coolant from the rest of the system, then carefully disconnect the hoses.
16. Remove the mounting nuts from the bottom of the HVAC unit.
17. Lift the unit out.

Installation

1. Position the unit and install the mounting nuts. Tighten 9 to 12 lbf·ft (13 to 16 N·m).
2. Install the main power connector receptacles on the outlet cover.
3. Connect the main power cables.
4. Connect the coolant lines.
5. Install the condenser inlet duct.
6. Install the HVAC cover.
7. If the unit has the interconnect controller installed under the bunk, connect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
8. Install the cabinet stack. See **Group 60** for instructions.
9. Install the lower bunk front panel and any dividers under the bunk.
10. Connect the lower bunk gas cartridge, and lower the bunks.
11. Connect both sets of batteries.
12. Add coolant to the cooling system as needed. For instructions, see **Group 20**.

Units Built From July 2011

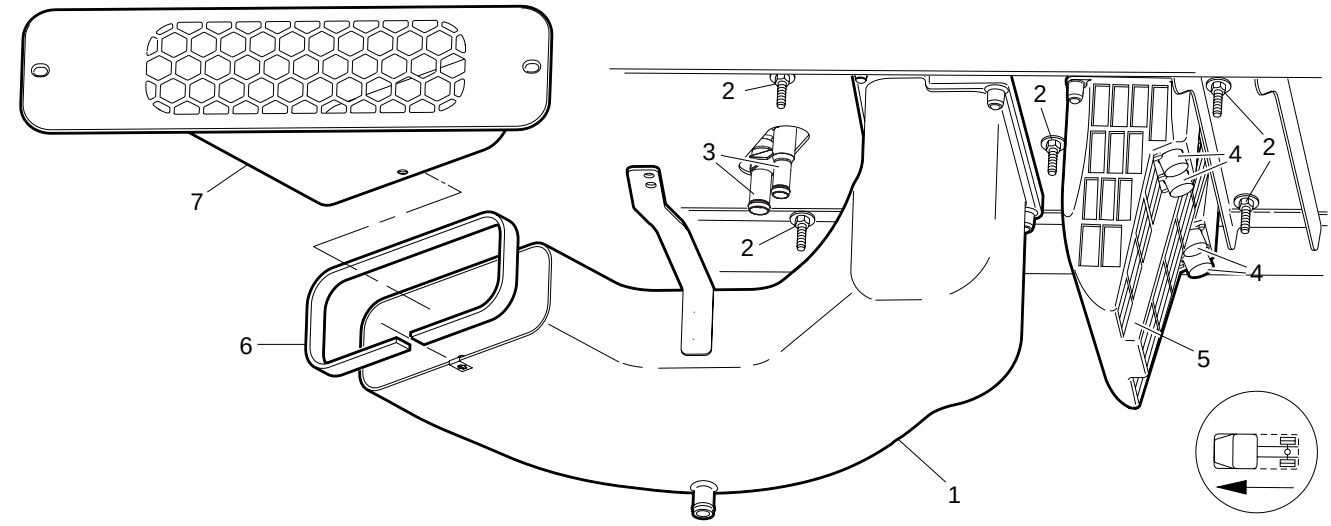
IMPORTANT: These models have a servicable refrigerant loop, and must be evacuated prior to removal of any refrigerant loop components.

NOTE: Vehicles equipped with Detroit Diesel Optimized Idle (O/I) do not have an interconnect controller.

Removal

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Recover the refrigerant from the system. See **Subject 250**.
3. Disconnect the starting batteries at the negative cables.
4. Disconnect the parked HVAC batteries at the negative cables.
5. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.
6. Remove the perforated panel on the front of the HVAC compartment.
7. Raise and secure the upper bunk.

Parked HVAC Unit Removal and Installation



1. Condenser Inlet Duct
2. Mounting Bolts
3. Coolant Hose Connections
4. Main Power Connectors
5. Condenser Outlet Cover
6. Gasket
7. Condenser Inlet Grille

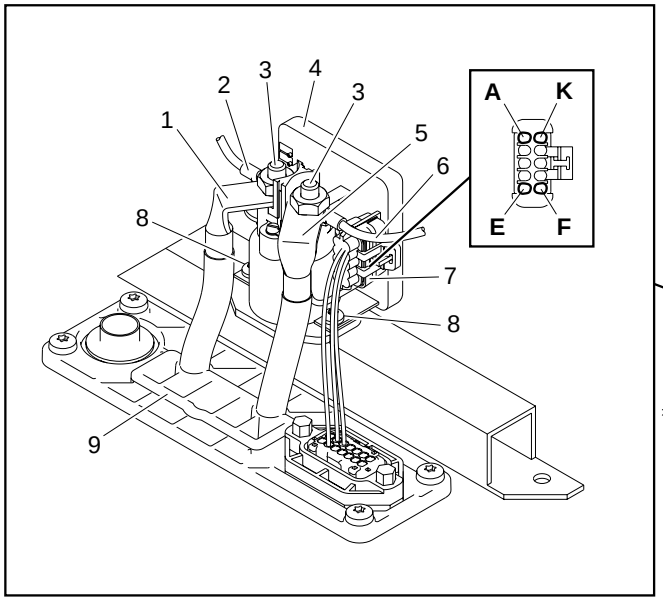
Fig. 2, Under Cab Components (pre-July 2011)

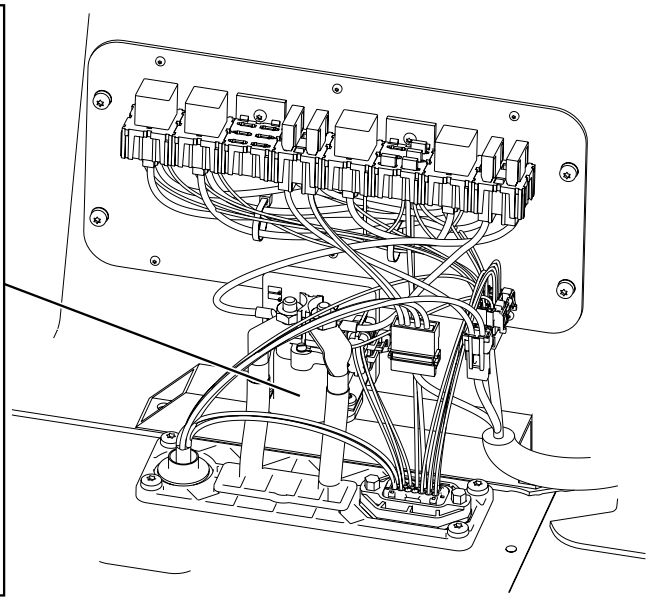
8. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
9. Remove the lower bunk front panel and any dividers under the bunk.
10. Remove the cabinet stack. See **Group 60** for instructions.
11. Remove a section of the vanity skirt fasteners, or the frame-mounted fairing as needed for undercab access.
12. On standard configuration vehicles, disconnect the wiring at the electrical center as follows.
    - 12.1 Access the interconnect controller through the baggage door on the left side of the sleeper.
    - 12.2 Remove the electrical center cover.
    - 12.3 Remove the terminal nuts from the interconnect controller, and disconnect the two wires going to the electrical center. See **Fig. 3**.

    NOTE: The fastener for the passthrough wedge is an Allen screw with a captured nut on the underside of the sleeper.

    - 12.4 Remove the fastener from the passthrough wedge, and remove the wedge.
    - 12.5 Slide the battery cables off of the terminals.
    - 12.6 Disconnect the two harness connections coming from the electrical center.
13. On vehicles with DDC O/I, disconnect the three connectors on the harness coming from the unit at the ParkSmart electrical center. See **Fig. 4**.
14. Remove the HVAC cover.
15. Remove the side fairing and vanity skirt as needed.
16. Disconnect the coolant hoses from the heater core. See **Fig. 5**.
    - 16.1 Place a drain pan under the cab, below the coolant line connections to the heater core.
    - 16.2 Use radiator-hose pinch pliers to shut off the flow of coolant from the rest of the system, then carefully disconnect the hoses.

Parked HVAC Unit Removal and Installation





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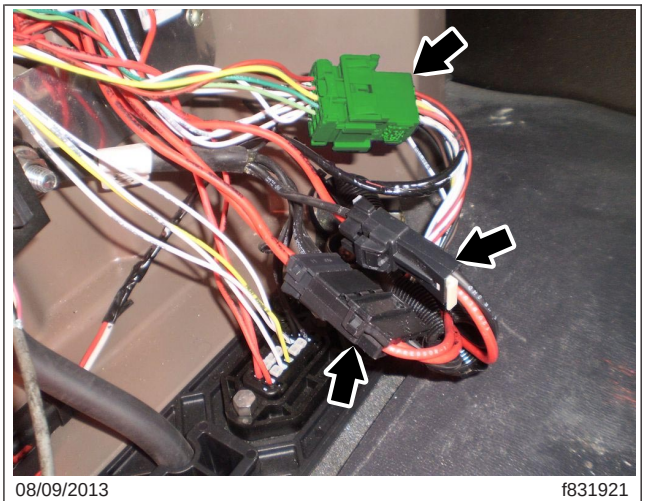
1. Cable, Interconnect Controller-to-Start Batteries
2. Cable, Interconnect Controller-to-PHVAC Unit
3. Switched Terminals
4. Interconnect Controller
5. Cable, Park Batteries-to-Interconnect Controller
6. Cable, Interconnect Controller-to-PHVAC Unit
7. Harness, Interconnect Controller-to-Batteries

Fig. 3, Interconnect Controller Installation (from July 2011)



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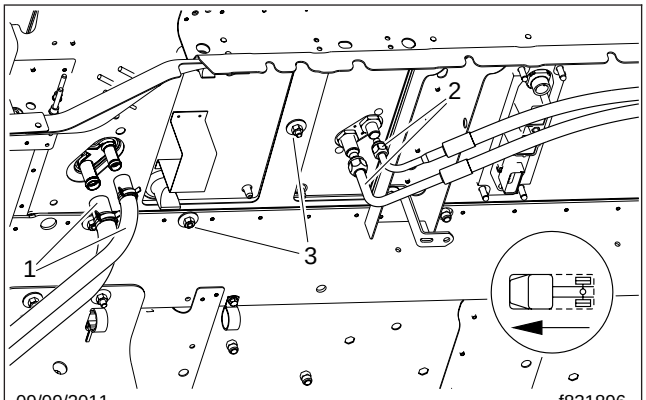
Disconnect these three connectors.

Fig. 4, Electrical Center, Vehicles with DDC O/I



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1. Refrigerant Lines
2. Coolant Hoses
3. Mounting Nuts

Fig. 5, Under-Cab Components (from July 2011)

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).

17. Under the sleeper, disconnect the condenser refrigerant lines from the unit. Cap or plug the fittings immediately.
18. Remove the mounting nuts from the bottom of the HVAC unit.
19. Lift the unit out.

Installation

IMPORTANT: A new unit comes sealed and filled with nitrogen gas. When installing a new unit in the vehicle, gently release the nitrogen gas from the unit by loosening the condenser line fittings and slowly removing the "jumper" tube.

1. Loosen the line fittings, and slowly remove the "jumper" tube from the refrigerant line connections on the underside of the unit to allow the nitrogen gas to release. Save the jumper tube for installation on the old unit.
2. Position the unit and install the mounting nuts. Tighten 9 to 12 lbf·ft (13 to 16 N·m).
3. Lubricate the new O-rings with polyvinylether (PVE) refrigerant oil and install them on the refrigerant lines.
4. Connect the refrigerant lines to the unit. Tighten the fittings. See **Table 1** for torque values.

Refrigerant Line Fitting Torque Values	
Fitting	**Torque**
#6 A/C O-Ring Joint	20 to 25 lbf·ft (27 to 34 N·m)
#8 A/C O-Ring Joint	30 to 35 lbf·ft (14 to 47 N·m)

Table 1, Refrigerant Line Fitting Torque Values

5. Evacuate and charge the refrigerant system. See **Subject 250**.
6. Connect the main power connector at the ParkSmart electrical center.
7. Connect the coolant lines.
8. Install the HVAC cover, and feed the harness connectors through the hole to the electrical center.
9. On standard configuration vehicles, connect the wiring at the electrical center as follows.
   - 9.1 Connect the battery cables to the interconnect controller.
   - 9.2 Install the wedge.
   - 9.3 Connect the two wires from the electrical center.
   - 9.4 Connect the wire harness.

NOTICE

Do not allow the wire terminals to rotate while tightening the nuts on the interconnect controller. This can damage the interconnect controller control board.

   - 9.5 Install the terminal nuts. Tighten 112 lbf·in (1270 N·cm).
10. On vehicles with DDC O/I, connect the three connectors on the harness coming from the unit at the ParkSmart electrical center. See **Fig. 4**.
11. Install the electrical center cover.
12. Install the cabinet stack. See **Group 60** for instructions.
13. Install the lower bunk front panel and any dividers under the bunk.
14. Connect the lower bunk gas cartridges, and lower the bunks.
15. Connect both sets of batteries.
16. Install the vanity skirt and side fairing if removed.
17. Add coolant to the cooling system as needed. For instructions, see **Group 20**.

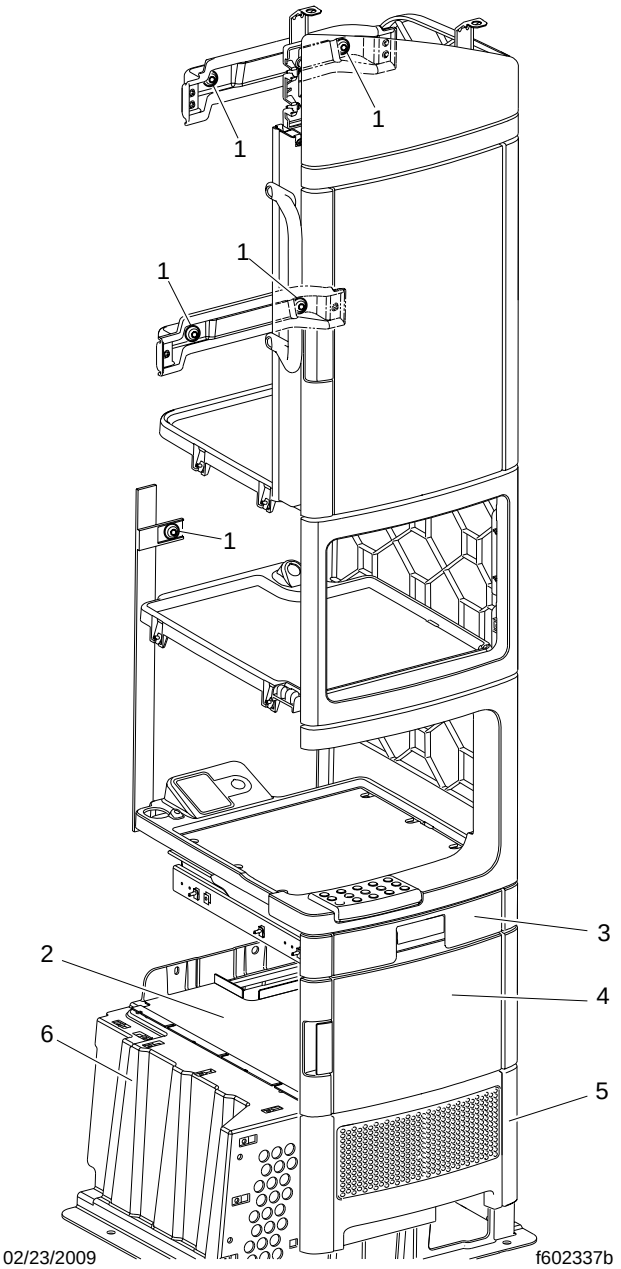
Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Remove the vanity skirt or frame fairing as needed to access the under cab area.
7. Disconnect the coolant lines from the heater core. See **Fig. 2**.
   - 7.1 Place a drain pan under the cab, below the coolant line connections to the heater core.
   - 7.2 Use radiator-hose pinch pliers to shut off the flow of coolant from the rest of the system, then carefully disconnection the hoses.
8. Remove the heater core cover, then remove the heater core. See **Fig. 3**.

NOTICE

Make sure the "guide ear" on the heater core is properly aligned. Do not force the heater core into the housing. Forcing an improperly aligned heater core into the housing will break the "guide ear," and may cause the heater core to leak. It may be necessary to manipulate the core from both inside and outside the vehicle to get it into place without damaging it.

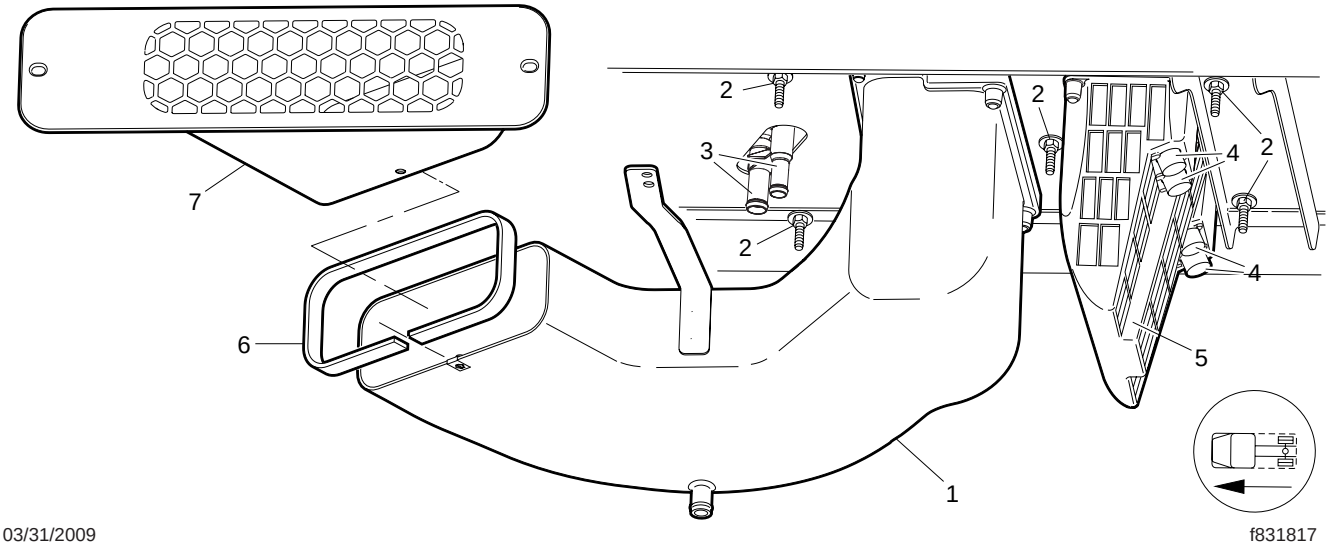
9. Orient the "guide ear" on the new heater core to the right, and slide the heater core in the housing. Install the cover.
10. Connect the coolant lines.
11. Connect both sets of batteries.
12. Add coolant to the cooling system as needed. See **Group 20** for instructions.



1. Cabinet Fasteners
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel
6. HVAC Cover

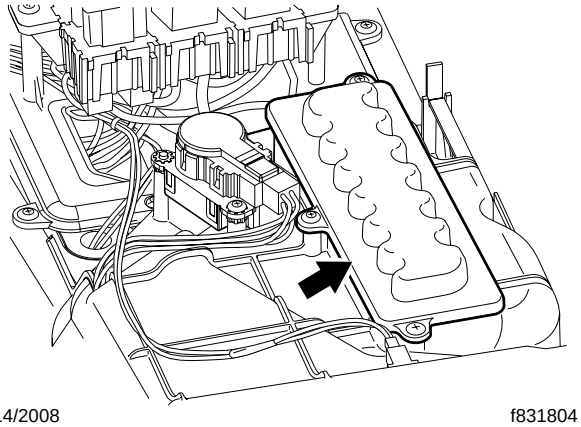
Fig. 1, Sleeper Cabinet Stack

Heater Core Replacement



1. Condenser Inlet Duct
2. Mounting Bolts
3. Coolant Hose Connections
4. Main Power Connectors
5. Condenser Outlet Cover
6. Gasket
7. Condenser Inlet Grille

Fig. 2, Under Cab Components (pre-July 2011 shown)



Remove this cover.

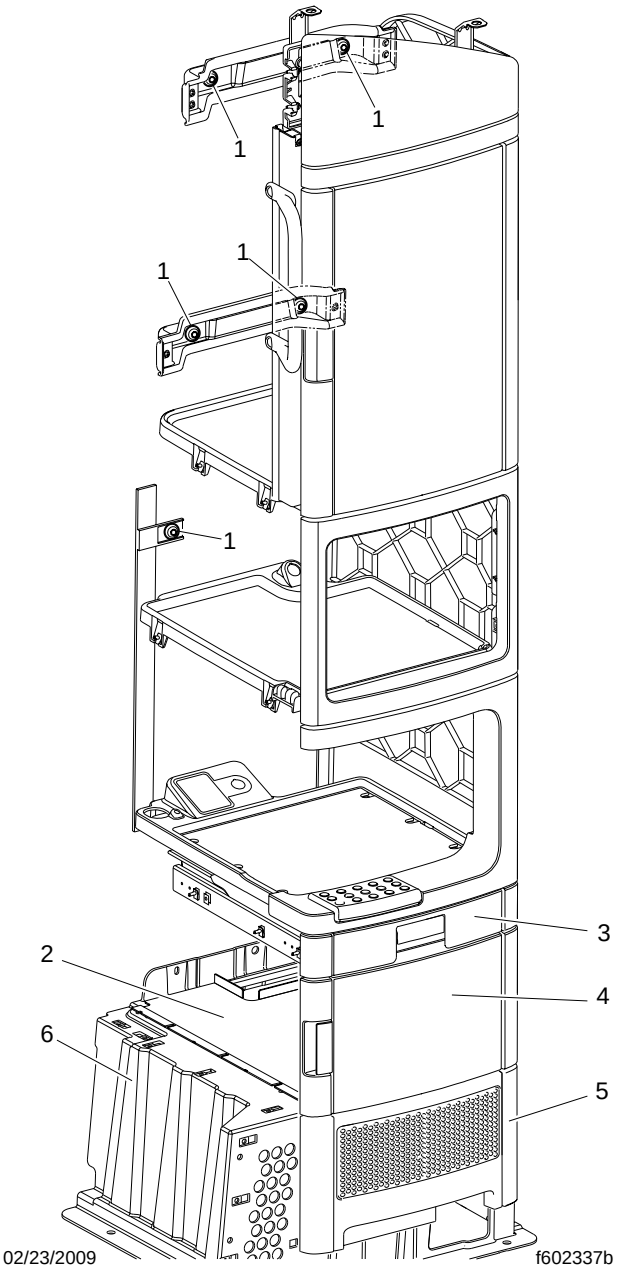
Fig. 3, Heater Core Cover (pre-July 2011 shown)

Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Raise and secure the upper bunk.
7. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
8. Remove the lower bunk front panel and any dividers under the bunk.
9. Remove the cabinet stack. See **Group 60** for instructions.
10. Remove a section of the vanity skirt fasteners, or the frame-mounted fairing as needed for undercab access.

NOTE: A small number of trucks manufactured prior to July 2011 have the battery interconnect controller installed under the bunk, rather than on the frame rail.

11. If the vehicle was manufactured before July 2011, and has the interconnect controller installed under the bunk, disconnect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
12. On vehicles manufactured from July 2011, disconnect the wiring at the electrical center as follows.
    - 12.1 Access the interconnect controller through the baggage door on the left side of the sleeper.
    - 12.2 Remove the electrical center cover.



1. Cabinet Fasteners
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel
6. HVAC Cover

Fig. 1, Sleeper Cabinet Stack

Blower Replacement

12.3 Remove the terminal nuts from the interconnect controller, and disconnect the two wires going to the electrical center. See **Fig. 2**.

NOTE: The fastener for the passthrough wedge is an Allen screw with a captured nut on the underside of the sleeper.

12.4 Remove the fastener from the passthrough wedge, and remove the wedge.

12.5 Slide the battery cables off of the terminals.

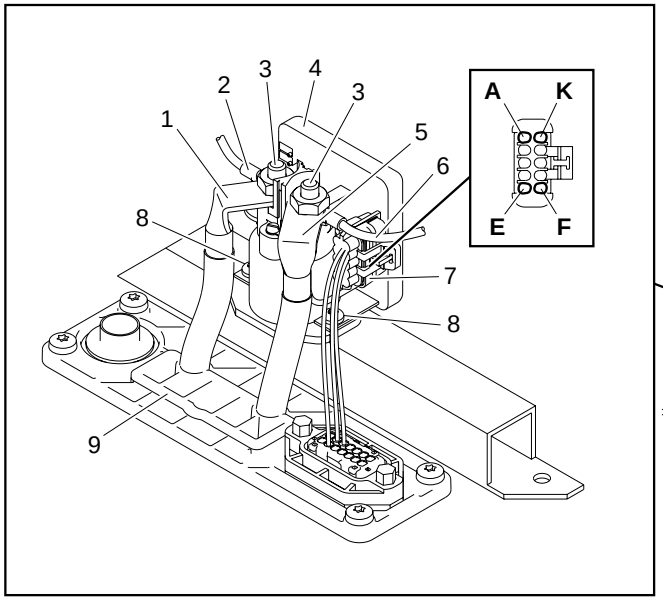
15. On vehicles manufactured before July 2011, remove the fuse/relay panel from the blower access cover.

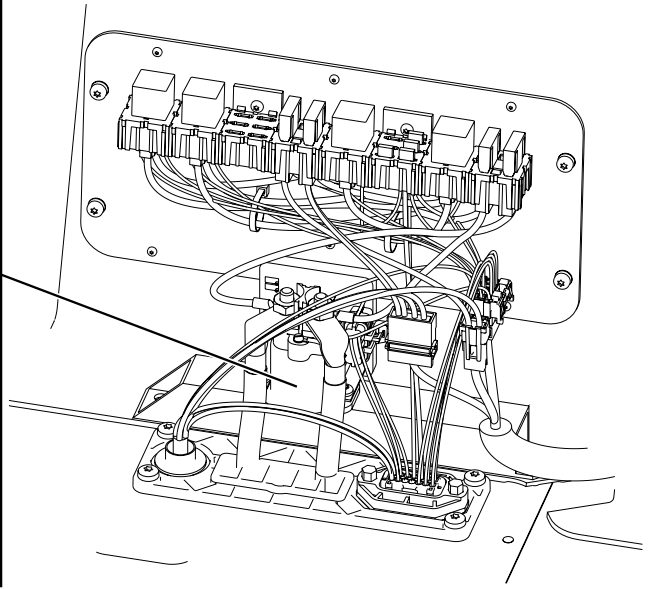
    On vehicles manufactured from July 2011, remove the unit control module from the blower access cover.

16. Remover the blower access cover. See **Fig. 4**.

17. Remove the blower housing fasteners, then lift the blower assembly up, and unplug the wiring harness connector. See **Fig. 5**.

18. Remove the blower from the housing. See **Fig. 6**.





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1. Cable, Interconnect Controller-to-Start Batteries
2. Cable, Interconnect Controller-to-PHVAC Unit
3. Switched Terminals
4. Interconnect Controller
5. Cable, Park Batteries-to-Interconnect Controller
6. Cable, Interconnect Controller-to-PHVAC Unit
7. Harness, Interconnect Controller-to-Batteries

Fig. 2, Interconnect Controller Installation (from July 2011)

12.6 Disconnect the two harness connections between the electrical center and the harness.

13. On vehicles with DDC O/I, disconnect the three connectors on the harness coming from the unit at the ParkSmart electrical center. See **Fig. 3**.

14. Remove the HVAC cover.

19. Install the new blower in the housing.

20. Partially insert the blower assembly into the main housing, connect the wiring harness, then complete the blower installation.

21. Install the blower access cover.

22. Install the fuse/relay panel, or unit control module, on the blower access cover.

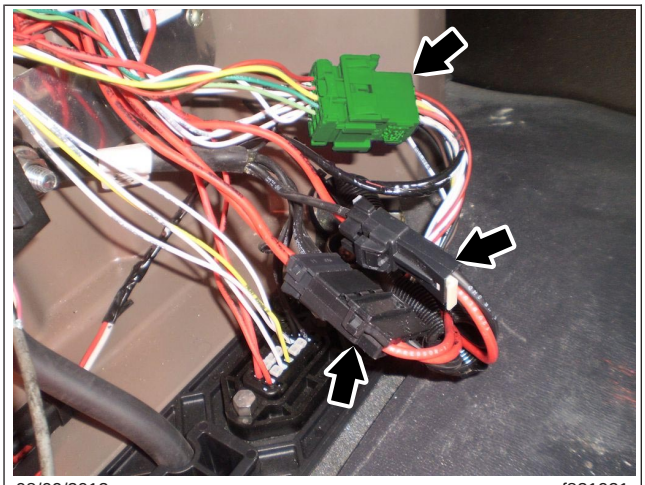


Fig. 3, Electrical Center, Vehicles with DDC O/I

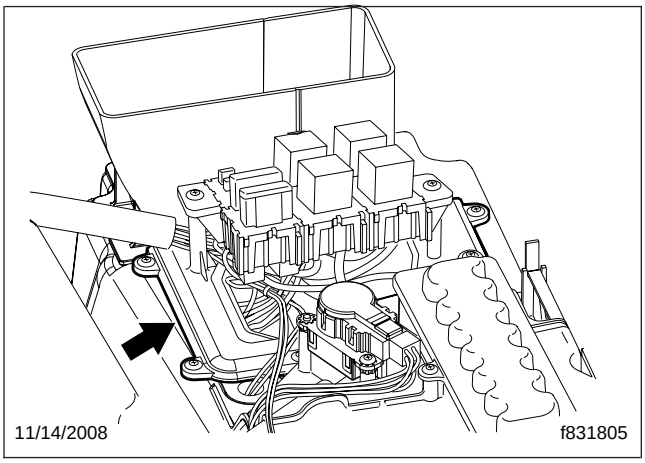


Fig. 4, Blower Access Cover

23. Connect both sets of batteries.
24. Install the HVAC cabinet.
25. Install the HVAC cover.
26. On vehicles manufactured before July 2011, with under bunk interconnect controller, connect the cables from the interconnect controller and the passthroughs on the floor to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
27. On vehicles manufactured from July 2011, connect the wiring at the electrical center as follows.

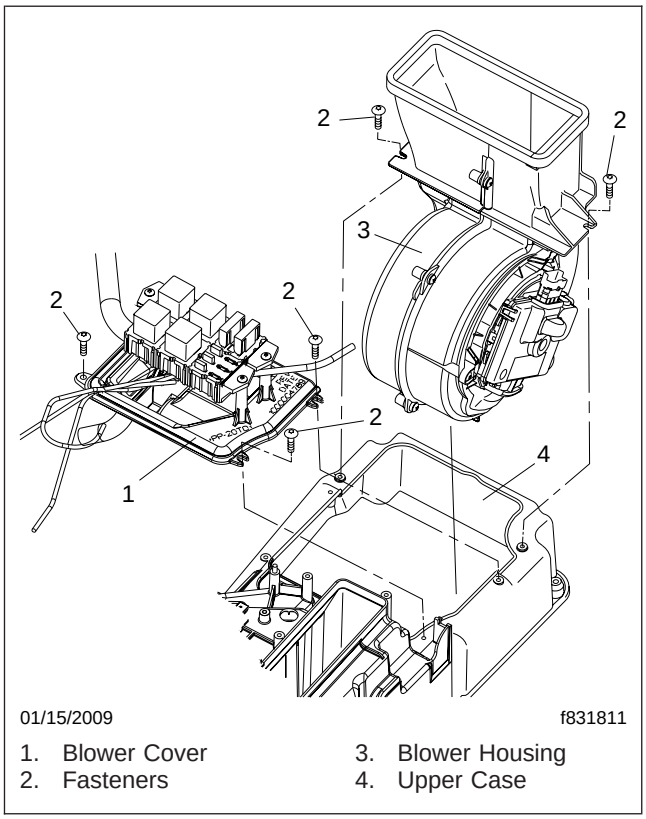


Fig. 5, Blower Housing Removal

27.1 Connect the battery cables to the interconnect controller.

27.2 Install the wedge.

27.3 Connect the two wires from the electrical center.

27.4 Connect the wire harness.

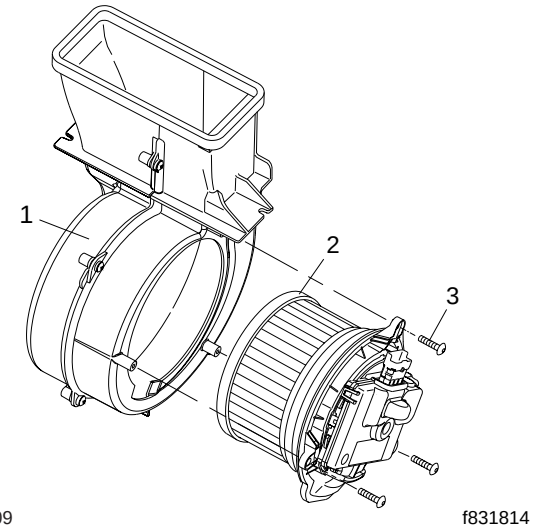
NOTICE

Do not allow the wire terminals to rotate while tightening the nuts on the interconnect controller. This can damage the interconnect controller control board.

27.5 Install the terminal nuts. Tighten 112 lbf·in (1270 N·cm).

28. On vehicles with DDC O/I, connect the three connectors on the harness coming from the unit at the ParkSmart electrical center. See **Fig. 3** .
29. Install the electrical center cover.

Blower Replacement



1. Blower Housing
2. Blower
3. Fastener

Fig. 6, Blower Installation

30. Install the lower bunk front panel and any dividers under the bunk.
31. Install the cabinet stack. See **Group 60** for instructions.
32. Connect the lower bunk gas cartridge, and lower the bunks.

Condenser Fan Replacement

⚠ 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.

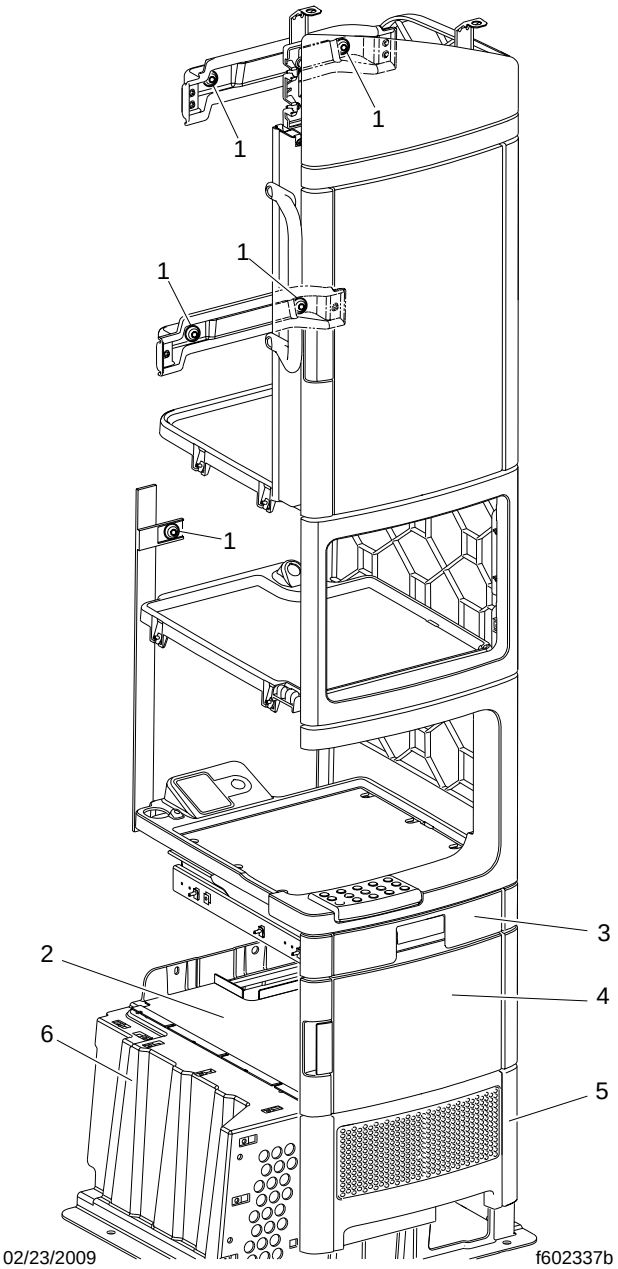
Internal Condenser Fan Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Raise and secure the upper bunk.
7. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
8. Remove the lower bunk front panel and any dividers under the bunk.
9. Remove the cabinet stack. See **Group 60** for instructions.

NOTE: A small number of trucks manufactured prior to July 2011 have the battery interconnect controller installed under the bunk, rather than on the frame rail.

Vehicles with DDC optimized idle (O/I) do not have an interconnect controller.

10. If the unit has the interconnect controller installed under the bunk, disconnect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.



1. Cabinet Fasteners
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel
6. HVAC Cabinet

Fig. 1, Sleeper Cabinet Stack

Condenser Fan Replacement

11. On vehicles with DDC O/I, disconnect the three connectors on the harness coming from the unit at the ParkSmart electrical center. See **Fig. 2**.

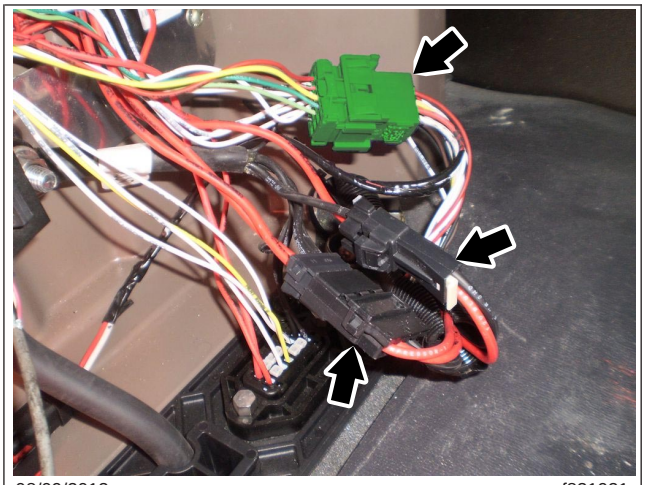
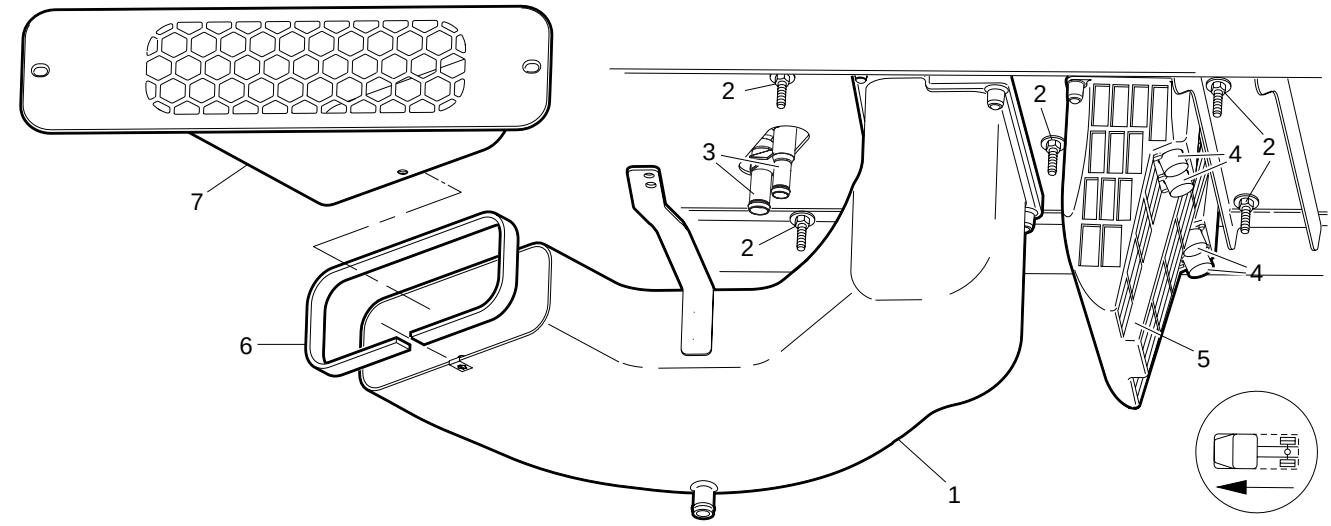


Fig. 2, Electrical Center, Vehicles with DDC O/I

12. Remove the HVAC cover.
13. Remove the vanity skirt or frame fairing as needed to access the under cab area.
14. Remove the condenser inlet duct.
15. Disconnect the coolant lines from the heater core. See **Fig. 3**.
    - 15.1 Place a drain pan under the cab, below the coolant line connections to the heater core.
    - 15.2 Use radiator-hose pinch pliers to shut off the flow of coolant from the rest of the system, then carefully disconnect the hoses.
16. Remove the blend door motor. See **Subject 170**.
17. Remove the heater core. See **Subject 130**.
18. Remove the blower assembly. See **Subject 140**.
19. Remove the wire harness clamps that hold the harness as it routes around the top case.
20. Disconnect the wire harness connections for the controller, ambient air temperature sensor, and compressor.
21. Remove the top half of the case.
22. Remove the fasteners, and lift the condenser fan assembly up. See **Fig. 4**.
23. Disconnect the wiring harness from the condenser fan motor, and remove the fan assembly.
24. Partially install the new fan assembly and connect the wiring harness.
25. Position the condenser fan assembly, and install the fasteners. Do not overtighten.

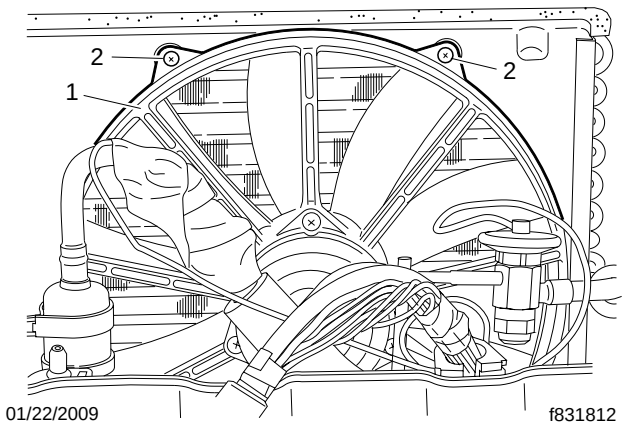
NOTE: Be sure to align the blend door when installing the top half of the case.

26. Install the top half of the case.
27. Connect the wire harnesses for the internal controller, and ambient air temperature sensor.
28. Position the wire harness, and install the clamps that hold the harness as it routes around the top case.
29. Install the blower assembly. See **Subject 140**.
30. Install the heater core. See **Subject 130**.
31. Install the blend door motor. See **Subject 170**.
32. Connect the coolant lines.
33. Connect both sets of batteries.
34. Add coolant to the cooling system as needed. For instructions, see **Group 20**.
35. Install the HVAC cover.
36. If the unit has the interconnect controller installed under the bunk, connect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
37. On vehicles with DDC O/I, connect the three connectors on the harness coming from the unit at the ParkSmart electrical center. See **Fig. 2**.
38. Install the cabinet stack. See **Group 60** for instructions.
39. Install the lower bunk front panel and any dividers under the bunk.
40. Connect the lower bunk gas cartridges, and lower the bunks.



1. Condenser Inlet Duct
2. Mounting Bolts
3. Coolant Hose Connections
4. Main Power Connectors
5. Condenser Outlet Cover
6. Gasket
7. Condenser Inlet Grille

Fig. 3, Under Cab Components



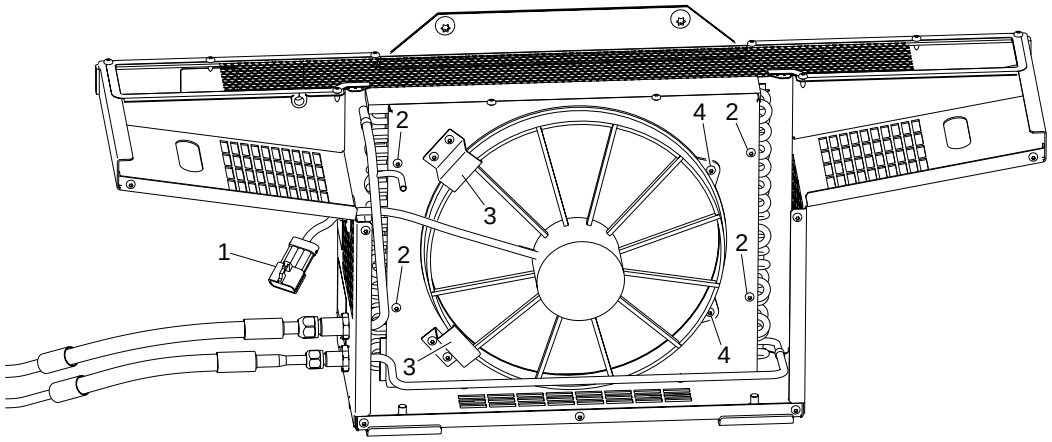
1. Condenser Fan Assembly
2. Fasteners

Fig. 4, Condenser Fan Assembly Installation

External Condenser Fan Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Remove the cover from the condenser housing. See **Fig. 5**.
5. Extract the grommet from the condenser housing.
6. Disconnect the wire harness, and feed the pigtail through the hole.
7. Remove the condenser fan and shroud assembly.
8. Loosen the fasteners on the two clamps.
9. Remove the fasteners on the opposite side from the clamps, and remove the fan from the shroud.
10. Position the new fan on the shroud, install the fasteners, and tighten the clamps.
11. Position the fan and shroud assembly in the condenser housing, and install the fasteners.
12. Feed the pigtail through the hole, and connect it to the wire harness.
13. Install the grommet.

Condenser Fan Replacement



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1. Condenser Fan Pigtail
2. Fastener, Fan Shroud
3. Clamp, Fan
4. Fastener, Fan

Fig. 5, External Condenser Fan Installation

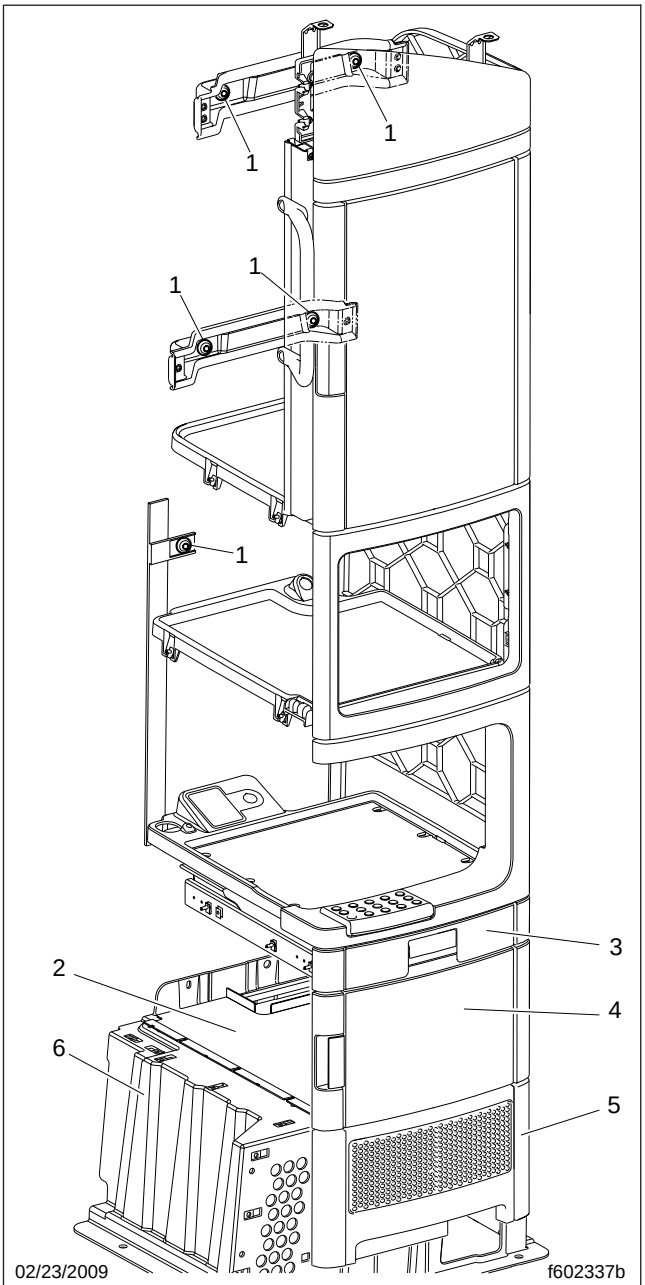
14. Install the cover on the condenser housing.
15. Connect the batteries.

Replacement (pre-July 2011)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Raise and secure the upper bunk.
7. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
8. Remove the lower bunk front panel and any dividers under the bunk.
9. Remove the cabinet stack. See **Group 60** for instructions.

NOTE: A small number of trucks manufactured prior to July 2011 have the battery interconnect controller installed under the bunk, rather than on the frame rail.

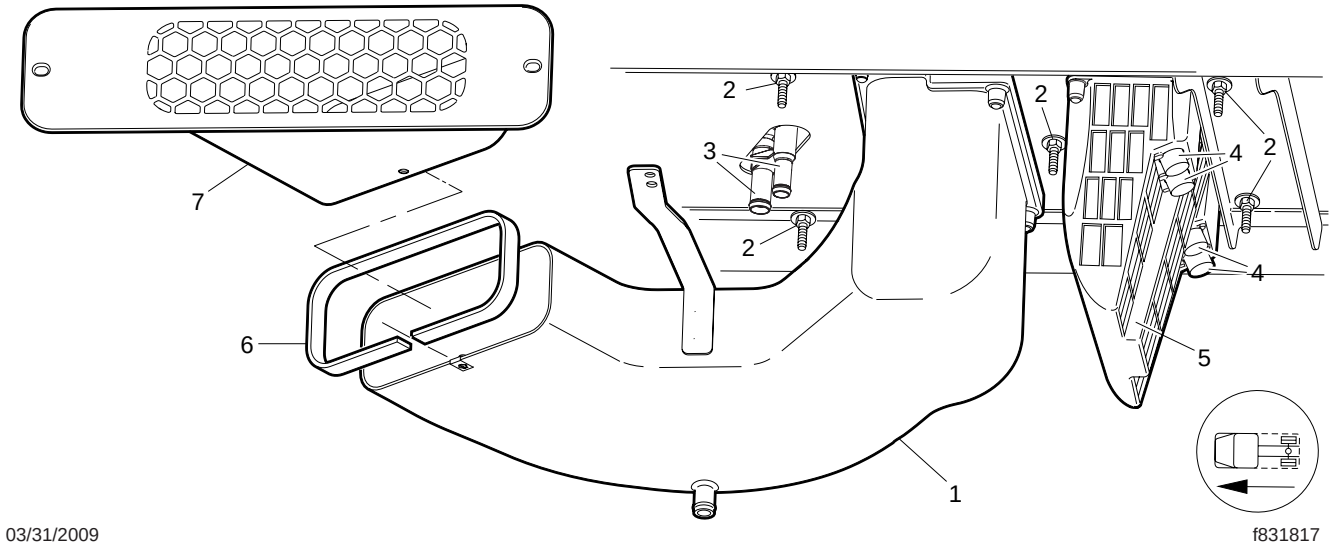
10. If the unit has the interconnect controller installed under the bunk, disconnect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
11. Remove the vanity skirt or frame fairing as needed to access the under cab area.
12. Remove the condenser air inlet duct.
13. Remove the HVAC cover.
14. Disconnect the coolant lines from the heater core. See **Fig. 2**.
    - 14.1 Place a drain pan under the cab, below the coolant line connections to the heater core.
    - 14.2 Use radiator-hose pinch pliers to shut off the flow of coolant from the rest of the system, then carefully disconnection the hoses.



1. Cabinet Fasteners
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel
6. HVAC Cover

Fig. 1, Sleeper Cabinet Stack

Unit Control Module Replacement



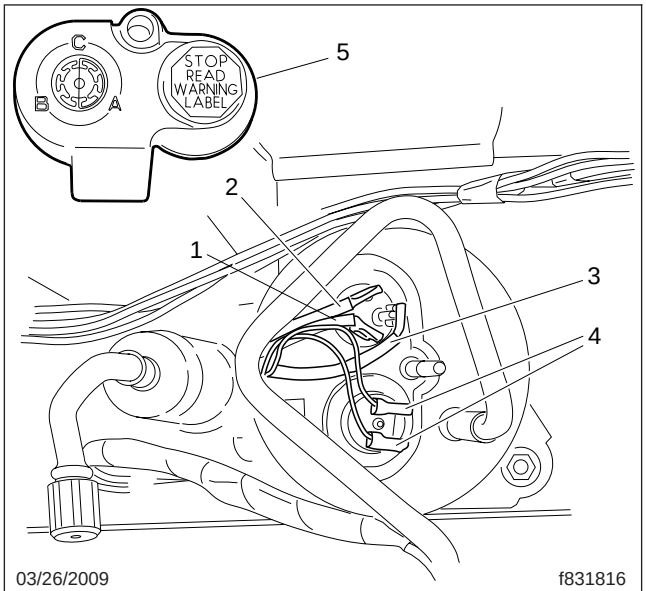
1. Condenser Inlet Duct
2. Mounting Bolts
3. Coolant Hose Connections
4. Main Power Connectors
5. Condenser Outlet Cover
6. Gasket
7. Condenser Inlet Grille

Fig. 2, Under Cab Components

15. Remove the blend door motor. See **Subject 170**.
16. Remove the heater core. See **Subject 130**.
17. Remove the blower assembly. See **Subject 140**.
18. Remove the wire harness clamps that hold the harness as it routes around the top case.
19. Disconnect the wire harness connections for the controller and the ambient air temperature sensor.
20. Remove the top half or the case.

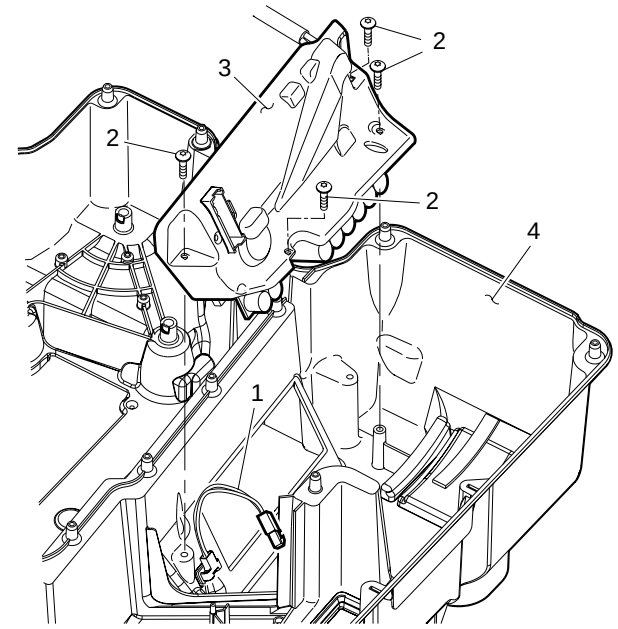
IMPORTANT: Make sure to note the positions of the wires to the compressor motor. Connecting them incorrectly will cause the compressor to malfunction. The wires to the temperature sensor can go either way. See **Fig. 3** for wire positions.

21. Remove the connector cap from the compressor, and disconnect the wires to the motor and temperature sensor.
22. Remove the fasteners, and lift out the control module and cover assembly. See **Fig. 4**.
23. Transfer the cover to the new control module.



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



1. Ambient Air Temperature Sensor Wiring Harness
2. Fasteners
3. Control Module Cover
4. Lower Case

Fig. 4, Control Module Installation (pre-July 2011)

24. Position the new control module and cover assembly, and install the fasteners.
25. Connect the wires from the new controller to the compressor motor and temperature sensor. See **Fig. 3**. Install the cap.

NOTE: Be sure to align the blend door when installing the top half of the case.

26. Install the top half of the case.
27. Connect the wire harness connections for the controller, ambient air temperature sensor, and compressor.
28. Position the wire harness, and install the clamps that hold the harness as it routes around the top case.
29. Install the blower assembly. See **Subject 140**.
30. Install the heater core. See **Subject 130**.
31. Install the blend door motor. See **Subject 170**.
32. Connect the coolant lines.
33. Install the condenser inlet duct.
34. Install the vanity skirt and side fairing, if removed.
35. Install the HVAC cabinet.
36. If the unit has the interconnect controller installed under the bunk, connect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
37. Install the cabinet stack. See **Group 60** for instructions.
38. Install the lower bunk front panel and any dividers under the bunk.
39. Connect the lower bunk gas cartridges, and lower the bunks.
40. Connect both sets of batteries.
41. Add coolant to the cooling system as needed. For instructions, see **Group 20**.

Replacement (from July 2011 to June 2012)

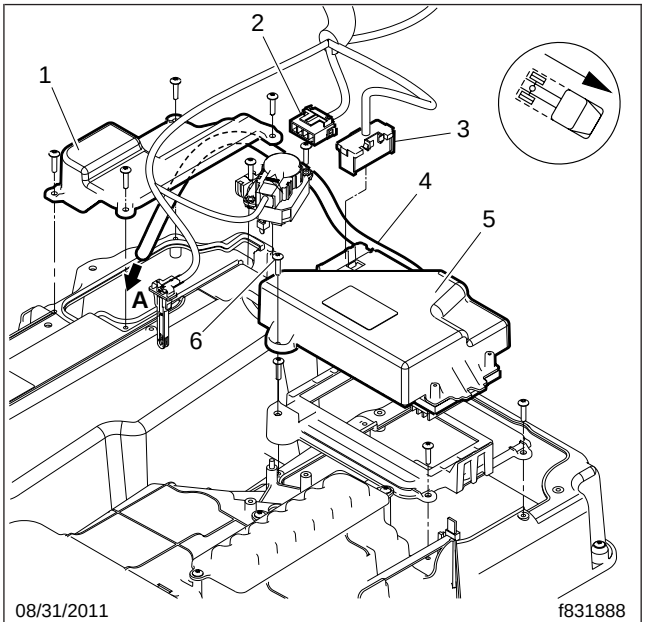
The control module on units built from July 2011 is mounted on the top of the unit case. Refer to **Fig. 5** for this procedure.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Remove a section of the vanity skirt fasteners, or the frame-mounted fairing as needed for undercab access.

NOTE: Vehicles equipped with Detroit Diesel Optimized Idle (O/I) do not have an interconnect controller.

5. On standard configuration vehicles, disconnect the wiring at the electrical center as follows.
   - 5.1 Access the interconnect controller through the baggage door on the left side of the sleeper.

Unit Control Module Replacement



1. Compressor Access Cover
2. Connector
3. Connector
4. Cable to Compressor
5. Control Module
6. Fastener

Fig. 5, Control Module Installation (from July 2011 to June 2012)

5.2 Remove the electrical center cover.

5.3 Remove the terminal nuts from the interconnect controller, and disconnect the two wires going to the electrical center. See **Fig. 6**.

NOTE: The fastener for the passthrough wedge is an Allen screw with a captured nut on the underside of the sleeper.

5.4 Remove the fastener from the passthrough wedge, and remove the wedge.

5.5 Slide the battery cables off of the terminals.

5.6 Disconnect the two harness connections between the electrical center and the harness.

6. On vehicles with DDC O/I, disconnect the three connectors on the harness coming from the unit at the ParkSmart electrical center. See **Fig. 7**.
7. Remove the HVAC cover.
8. Remove the cabinet stack. See **Group 60** for instructions.
9. Remove the hold-down fastener on the controller.
10. Pull the controller away from the PHVAC housing.
11. Disconnect the wire harnesses that are accessible.
12. Remove the compressor access panel on the top of the housing.

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.

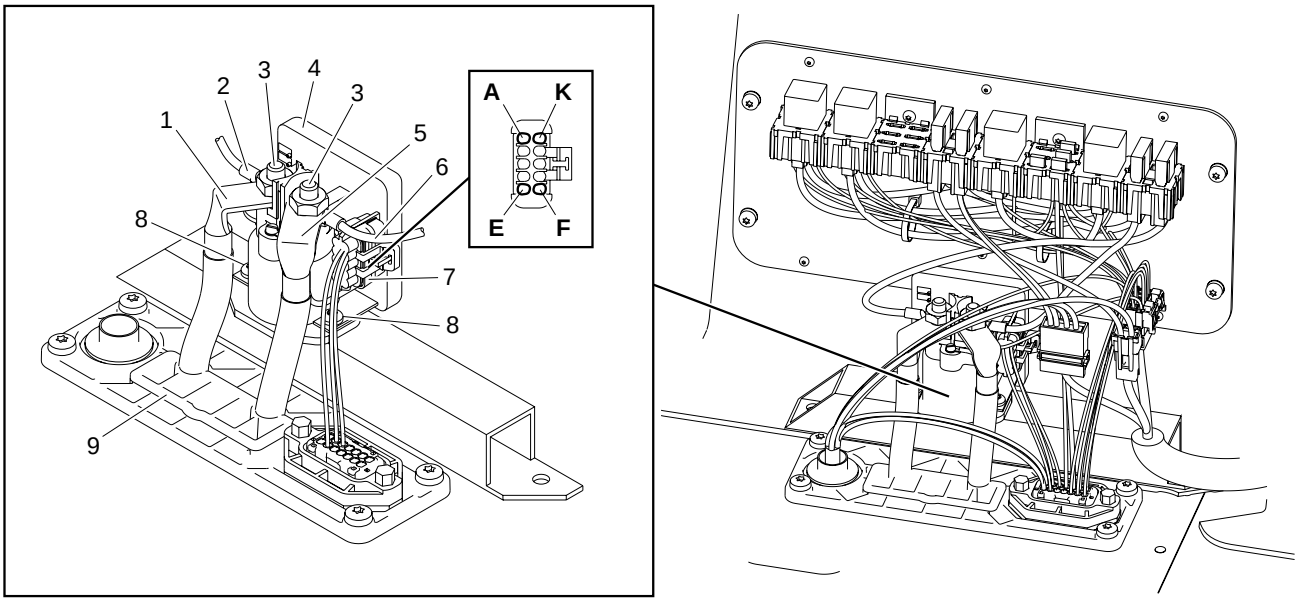
13. Remove the connector cap from the compressor, and disconnect the wires to the motor and temperature sensor.
14. Remove the controller.
15. Feed the new controller harness into the housing and connect it to the compressor.
16. Install the compressor electrical cover.
17. Install the top of the housing. Make sure to get the blend door positioned correctly.
18. Install the HVAC cover.
19. Feed the harness connectors through the hole to the electrical center.
20. On standard configuration vehicles, connect the wiring at the electrical center as follows.

    20.1 Connect the battery cables to the interconnect controller.

    20.2 Install the wedge.

    20.3 Connect the two wires from the electrical center.

    20.4 Connect the wire harness.



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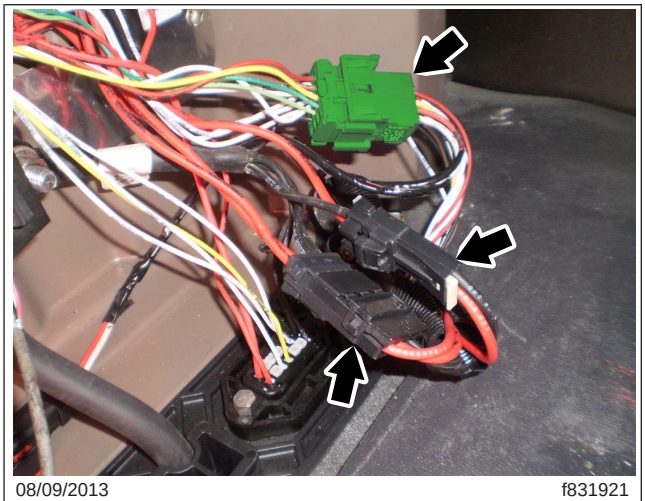
1. Cable, Interconnect Controller-to-Start Batteries
2. Cable, Interconnect Controller-to-PHVAC Unit
3. Switched Terminals
4. Interconnect Controller
5. Cable, Park Batteries-to-Interconnect Controller
6. Cable, Interconnect Controller-to-PHVAC Unit
7. Harness, Interconnect Controller-to-Batteries

Fig. 6, Interconnect Controller Installation (from July 2011)



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Disconnect these three connectors.

Fig. 7, Electrical Center, Vehicles with DDC O/I

NOTICE

Do not allow the wire terminals to rotate while tightening the nuts on the interconnect controller. This can damage the interconnect controller control board.

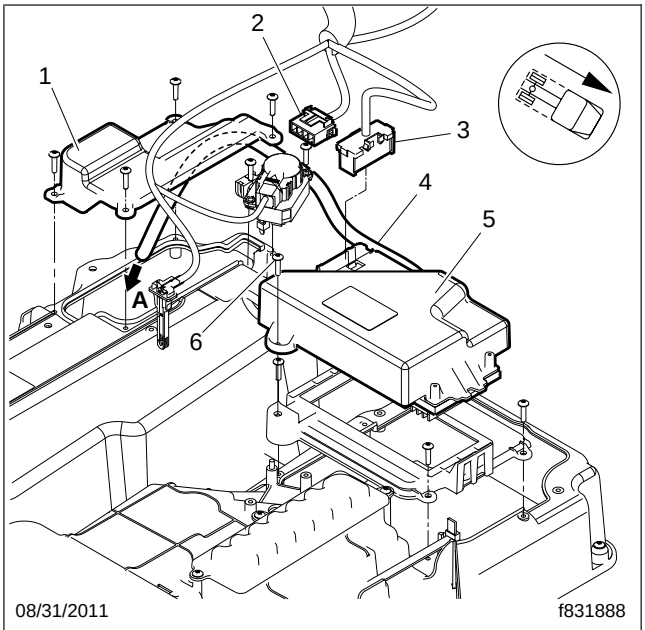
20.5 Install the terminal nuts. Tighten 112 lbf·in (1270 N·cm).

21. On vehicles with DDC O/I, connect the three connectors on the harness coming from the unit at the ParkSmart electrical center. See **Fig. 7** .
22. Install the electrical center cover.
23. Install the cabinet stack. See **Group 60** for instructions.
24. Connect the ground cables on the main and auxiliary batteries.
25. Add coolant to the cooling system as needed. For instructions, see **Group 20**.

Unit Control Module Replacement

Replacement (from June 21, 2012)

The control module on units built from June 2012 is designed with a removable harness. Refer to **Fig. 8** for this procedure.



1. Compressor Access Cover
2. Connector
3. Connector
4. Cable to Compressor
5. Control Module
6. Fastener

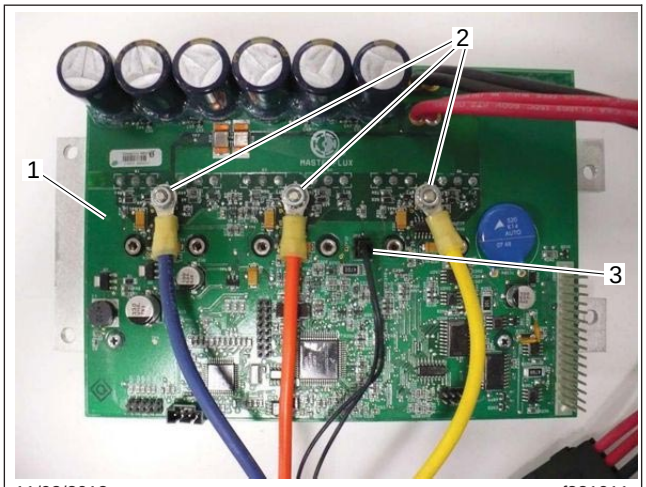
Fig. 8, Control Module Installation (from July 2011 to June 2012)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door.
5. Remove the drawer.
6. Remove the lower storage compartment bottom panel.
7. Remove the hold-down fastener on the controller.
8. Pull the controller away from the PHVAC housing.
9. Disconnect the controller power-wire harness at the main harness.

NOTICE

Do not allow the wires or terminals to turn while loosening or tightening the nuts. Doing so will damage the circuit board.

10. Remove the terminal nuts, and disconnect the three phase-wires from the circuit board terminals as shown in **Fig. 9**.



1. Circuit Board
2. Terminal Nuts
3. Temperature Sensor Connection
4. Power Wire Harness

Fig. 9, Circuit Board Wiring

11. Disconnect the temperature sensor wire from the curcuit board.
12. Remove the controller.

NOTICE

Do not allow the wires or terminals to turn while tightening the nuts. Doing so will damage the circuit board.

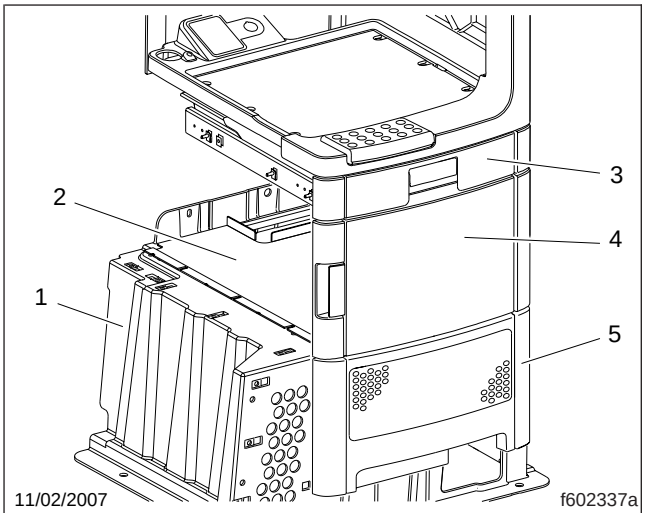
13. Connect the three phase-wires to the new circuit board terminals as shown in **Fig. 9**. Install the

blue wire on the left terminal, the orange wire on the middle terminal, and the yellow wire on the right terminal. Carefully tighten the nuts 10 lbf·in (113 N·cm). Do not over tighten or under tighten.

14. Connect the temperature sensor wire connector to the circuit board.
15. Install the lower storage compartment bottom panel.
16. Install the drawer.
17. Connect the ground cables on the main and auxiliary batteries.

Replacement

1. Turn the key off, and put the auxiliary fan knob in the off position.
2. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.



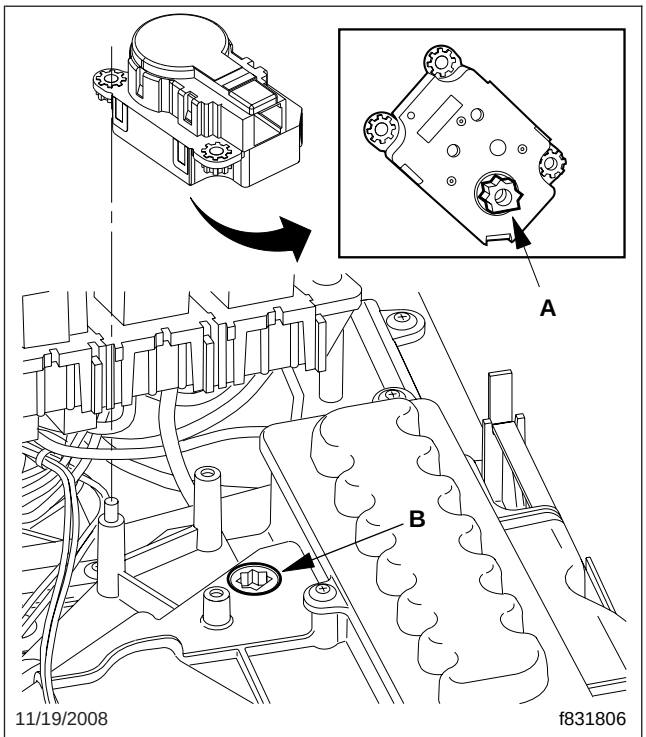
1. HVAC Cabinet
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel
6. HVAC Cover

Fig. 1, Sleeper Cabinet Stack

3. Remove the fasteners, and lift off the blend door motor. See **Fig. 2**.
4. Disconnect the wiring harness.
5. Connect the wiring harness to the new blend door motor.

NOTE: If it is necessary to improve door/motor alignment, the motor shaft can be slowly turned manually without damaging the motor internally.

6. Position the blend door motor shaft in the drive socket on the blend door, then align the mounting holes and install the fasteners.
7. Install the bottom panel in the lower storage compartment and close the door.



Align A with B to install the blend door motor.

A. Blend Door Motor Drive Gear
B. Blend Door Drive Socket

Fig. 2, Blend Door Motor Installation

Ambient Temperature Sensor Replacement

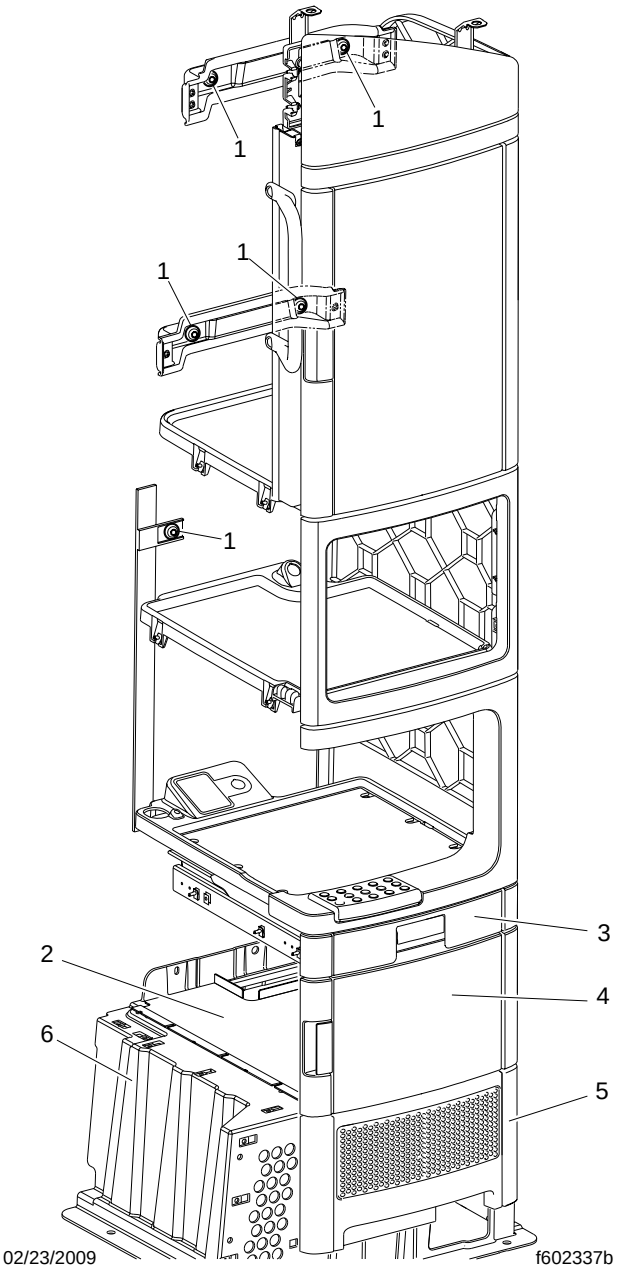
Replacement (pre-July 2011)

On vehicles manufactured before July 2011, the ambient air temperature sensor is located in the bottom of the parked HVAC unit housing.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Raise and secure the upper bunk.
7. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
8. Remove the lower bunk front panel and any dividers under the bunk.
9. Remove the cabinet stack. See **Group 60** for instructions.

NOTE: A small number of trucks manufactured prior to July 2011 have the battery interconnect controller installed under the bunk, rather than on the frame rail.

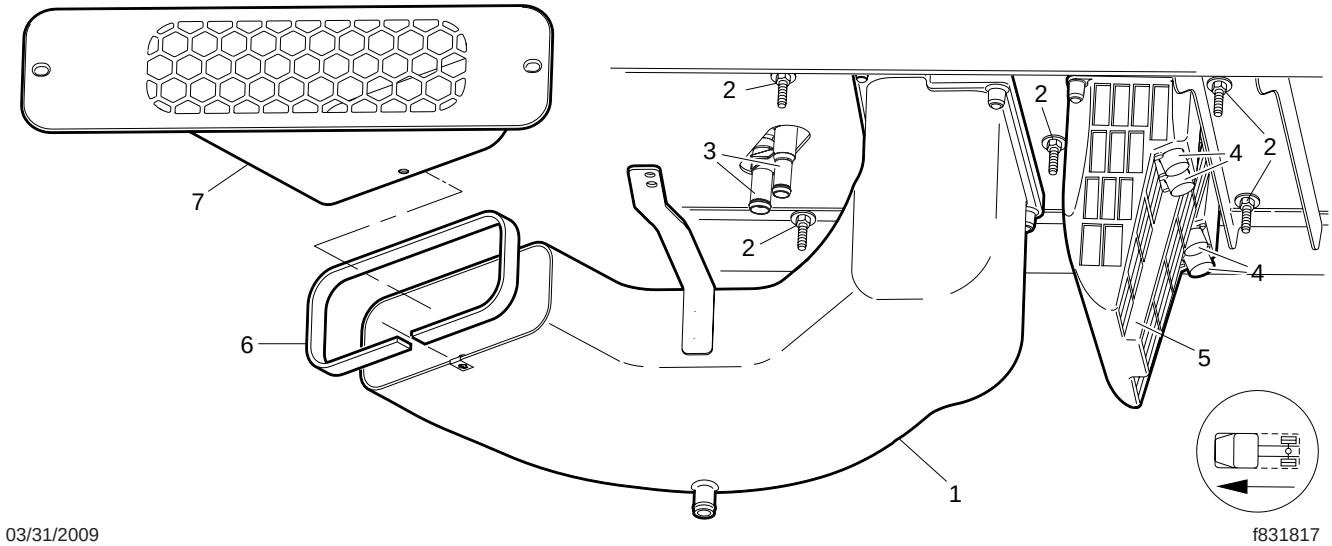
10. If the unit has the interconnect controller installed under the bunk, disconnect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
11. Remove the HVAC cover.
12. Remove the vanity skirt and frame fairing as needed to gain access.
13. Remove the condenser inlet duct.
14. Disconnect the coolant lines from the heater core. See **Fig. 2**.
    - 14.1 Place a drain pan under the cab, below the coolant line connections to the heater core.



1. Cabinet Fasteners
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel
6. HVAC Cover

Fig. 1, Sleeper Cabinet Stack

Ambient Temperature Sensor Replacement



1. Condenser Inlet Duct
2. Mounting Bolts
3. Coolant Hose Connections
4. Main Power Connectors
5. Condenser Outlet Cover
6. Gasket
7. Condenser Inlet Grille

Fig. 2, Under-Cab Components

14.2 Use radiator-hose pinch pliers to shut off the flow of coolant from the rest of the system, then carefully disconnect the hoses.

15. Remove the blend door motor. See **Subject 170**.
16. Remove the heater core. See **Subject 130**.
17. Remove the blower assembly. See **Subject 140**.
18. Disconnect the wire harness connections for the controller, ambient air temperature sensor, and compressor.
19. Remove the top half of the case.
20. Remove the control module.
21. Remove the ambient temperature sensor. See **Fig. 3**.
22. Transfer the wiring harness jumper to the new ambient temperature sensor.
23. Install the new ambient temperature sensor.
24. Position the control module, and install the fasteners.

NOTE: Be sure to align the blend door when installing the top half of the case.

25. Install the top half of the case.

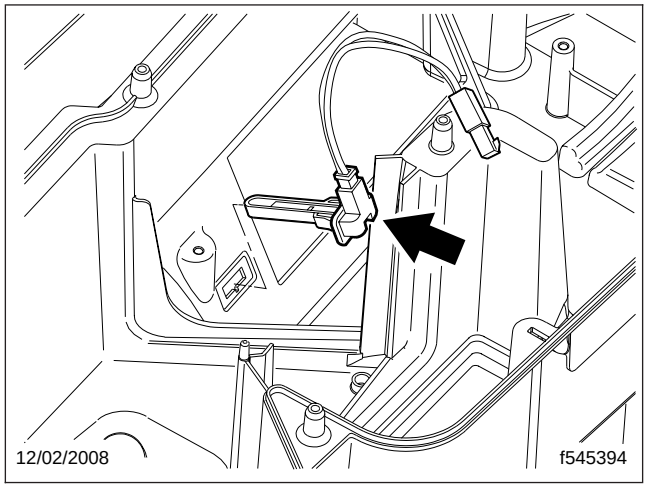


Fig. 3, Ambient Air Temperature Sensor Installation

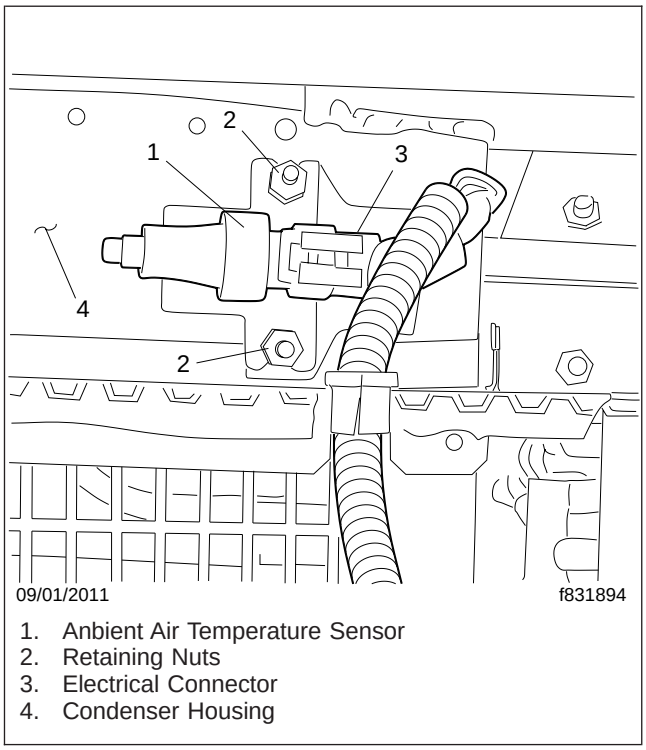
26. Connect the wire harness connections for the controller, ambient air temperature sensor, and compressor.
27. Position the wire harness, and install the clamps that hold the harness as it routes around the top case.
28. Install the blower assembly. See **Subject 140**.

29. Install the blend door motor. See **Subject 170**.
30. Install the heater core. See **Subject 130**.
31. Connect the coolant lines.
32. Install the HVAC cabinet.
33. If the unit has the interconnect controller installed under the bunk, connect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
34. Install the cabinet stack. See **Group 60** for instructions.
35. Install the lower bunk front panel and any dividers under the bunk.
36. Connect the lower bunk gas cartridges, and lower the bunks.
37. Install the condenser inlet duct.
38. Install the vanity skirts and fairings.
39. Connect both sets of batteries.
40. Add coolant to the cooling system as needed. For instructions, see **Group 20**.

Replacement (from July 2011)

On vehicles manufactured from July 2011, the ambient air temperature sensor is located in the condenser housing on the backwall of the sleeper. See **Fig. 4**.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Remove the cover from the condenser housing.
3. Disconnect the wire from the sensor.
4. Remove the retaining nuts.
5. Remove the sensor.
6. Position the new sensor and install the retaining nuts.
7. Connect the wire.
8. Install the cover.



1. Anbient Air Temperature Sensor
2. Retaining Nuts
3. Electrical Connector
4. Condenser Housing

Fig. 4, Ambient Air Temperature Sensor Installation

Bunk Temperature Sensor Replacement

Replacement

1. Remove the auxiliary control panel access cover from the inside of the cabinet stack. See **Fig. 1**.

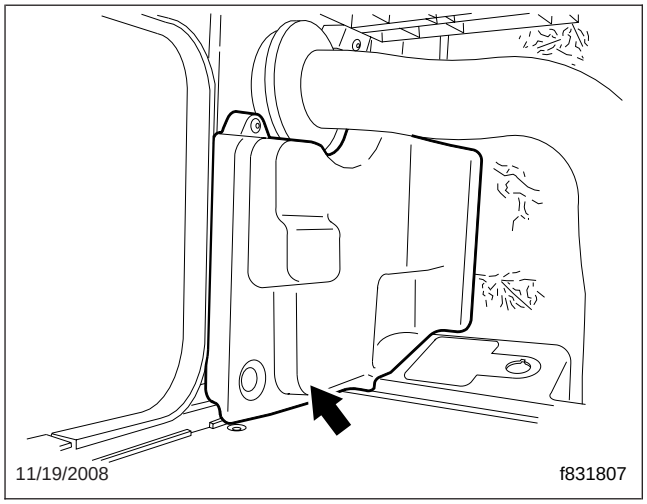
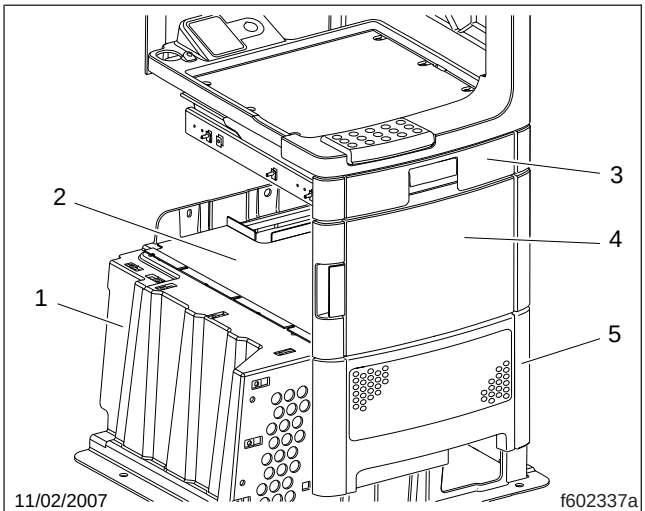


Fig. 1, Auxiliary Control Panel Access Cover

2. Disconnect the wiring harness from the bunk temperature sensor.
3. Remove the bunk temperature sensor.
4. Install the new bunk temperature sensor.
5. Connect the wiring harness to the new bunk temperature sensor.
6. Install the auxiliary control panel access panel.

Replacement

1. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 1**.

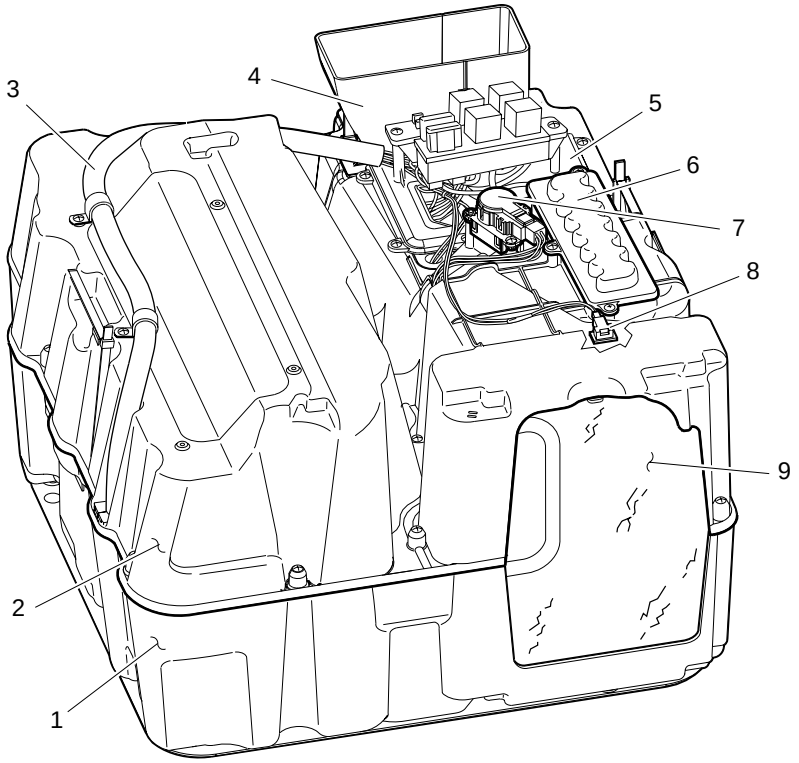


1. HVAC Cabinet
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel

Fig. 1, Sleeper Cabinet Stack

2. Remove the evaporator temperature sensor. See **Fig. 2**, Item 8.
3. Disconnect the wiring harness from the evaporator temperature sensor.
4. Connect the wiring harness to the new evaporator temperature sensor.
5. Install the new evaporator temperature sensor.
6. Install the bottom panel in the lower storage compartment and close the door.

Evaporator Temperature Sensor Replacement



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1. Lower Case
2. Upper Case
3. Main Harness
4. Blower Outlet Duct
5. Blower Cover
6. Heater Core Cover
7. Blend Door Motor
8. Evaporator Temperature Sensor
9. Intake Filter

Fig. 2, Evaporator Temperature Sensor Installation

Interconnect Controller Replacement

General Information

The battery interconnect controller, also known as the separator, is located on the left-hand side of one of the crossmembers under the back of the cab, or under the bunk on the left side of the sleeper. Prior to July 2011, a small number of units were installed, of retrofitted, to under the bunk. Starting in July 2011, all interconnect controllers were installed under the bunk. It is a sealed unit, and is not serviceable. If the controller fails, replace it. Refer to **Subject C02.03** of the *Cascadia Troubleshooting Manual* for interconnect controller diagnostics.

NOTE: Vehicles equipped with Detroit Diesel Optimized Idle (O/I) do not have an interconnect controller.

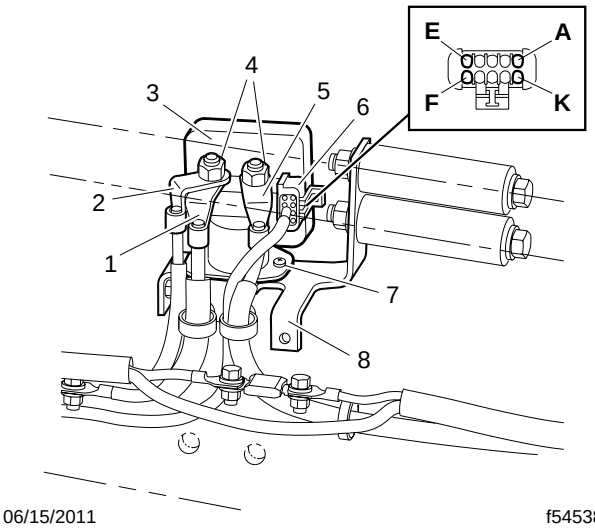
Replacement, Frame-Mounted Installation

Refer to **Fig. 1** for this procedure.

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC (PHVAC) batteries at the negative cables.
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.
8. Position the new controller and install the mounting fasteners. Tighten 4 to 5 lbf·in (45 to 56 N·cm).

NOTICE

Do not allow the battery cable terminals to rotate while tightening the nuts on the interconnect controller posts. This can damage the control board.



1. Cable, Interconnect Controller-to-PHVAC Unit
2. Harness, Interconnect Controller-to-Battery
3. Interconnect Controller
4. Controller Posts and Nuts
5. Cable, Battery-to-Interconnect Controller
6. Harness, Interconnect Controller-to-PHVAC Unit
7. Fasteners
8. Bracket

Fig. 1, Frame Mounted Interconnect Controller Installation

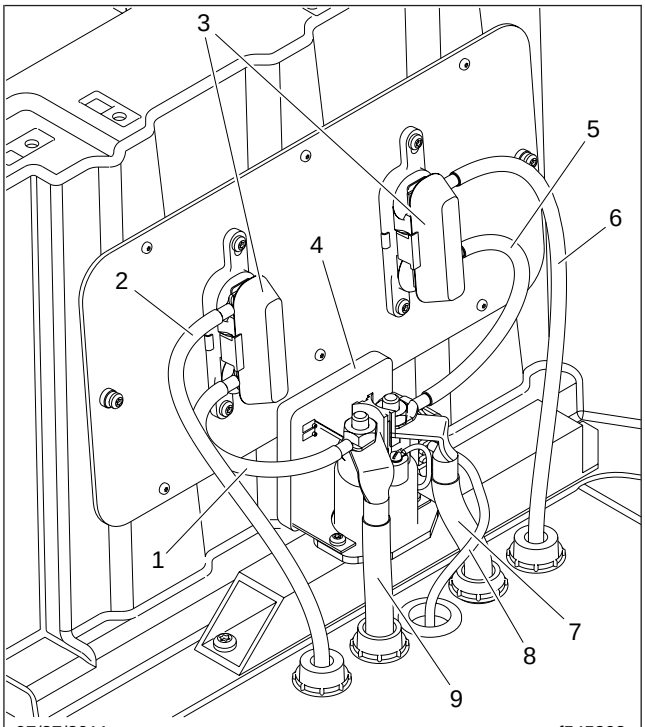
9. Connect the controller-to-PHVAC unit harness.
10. Connect the battery cables and controller-to-battery harness to the controller posts, and install the nuts and washers. Tighten 112 lbf·in (1265 N·cm).
11. Apply anti-corrosion enamel or petroleum jelly to the battery post connections on the interconnect controller.
12. Install the controller cover.
13. Connect both sets of batteries.

Replacement, Under-Bunk Installation (pre-July 2011)

For under-bunk units installed prior to July 2011, refer to **Fig. 2** for this procedure.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.

Interconnect Controller Replacement



1. Harness, Interconnect Controller-to-Fuse Block
2. Harness, Fuse Block-to-Internal Controller
3. Fuse Block, 80-Amp Mega Fuse
4. Interconnect Controller
5. Harness, Interconnect Controller-to-Fuse Block
6. Harness, Fuse Block-to-PHVAC Unit
7. Cable, Park Batteries-to-Interconnect Controller
8. Harness, Interconnect Controller-to-Start Batteries
9. Cable, Interconnect Controller-to-Start Batteries

Fig. 2, Interconnect Controller, Under-Bunk Installation (pre-July 2011)

2. Disconnect the starting batteries at the negative cables.
3. Disconnect the PHVAC batteries at the negative cables.
4. Remove any side fairings and vanity skirts from the left side of the vehicle as needed.
5. Access the interconnect controller through the baggage door on the left side of the sleeper.
6. Remove the electrical center cover.
7. Unplug the controller-to-PHVAC unit harness.
8. Remove the terminal nuts from the interconnect controller, and disconnect the two wires going to the the power distribution module (PDM).
9. Remove the mounting fasteners from the interconnect controller.
10. Slide the battery cables off of the terminals.
11. Position the new interconnect controller, and connect the battery cables.
12. Connect the two wires from the PDM.
13. Connect the controller-to-PHVAC unit harness.
14. Install the terminal nuts. Tighten 112 lbf·in (1265 N·cm).
15. Install the electrical center cover.
16. Connect the ground cables on the main and auxiliary batteries.
17. Install the side fairings and vanity skirts if removed.

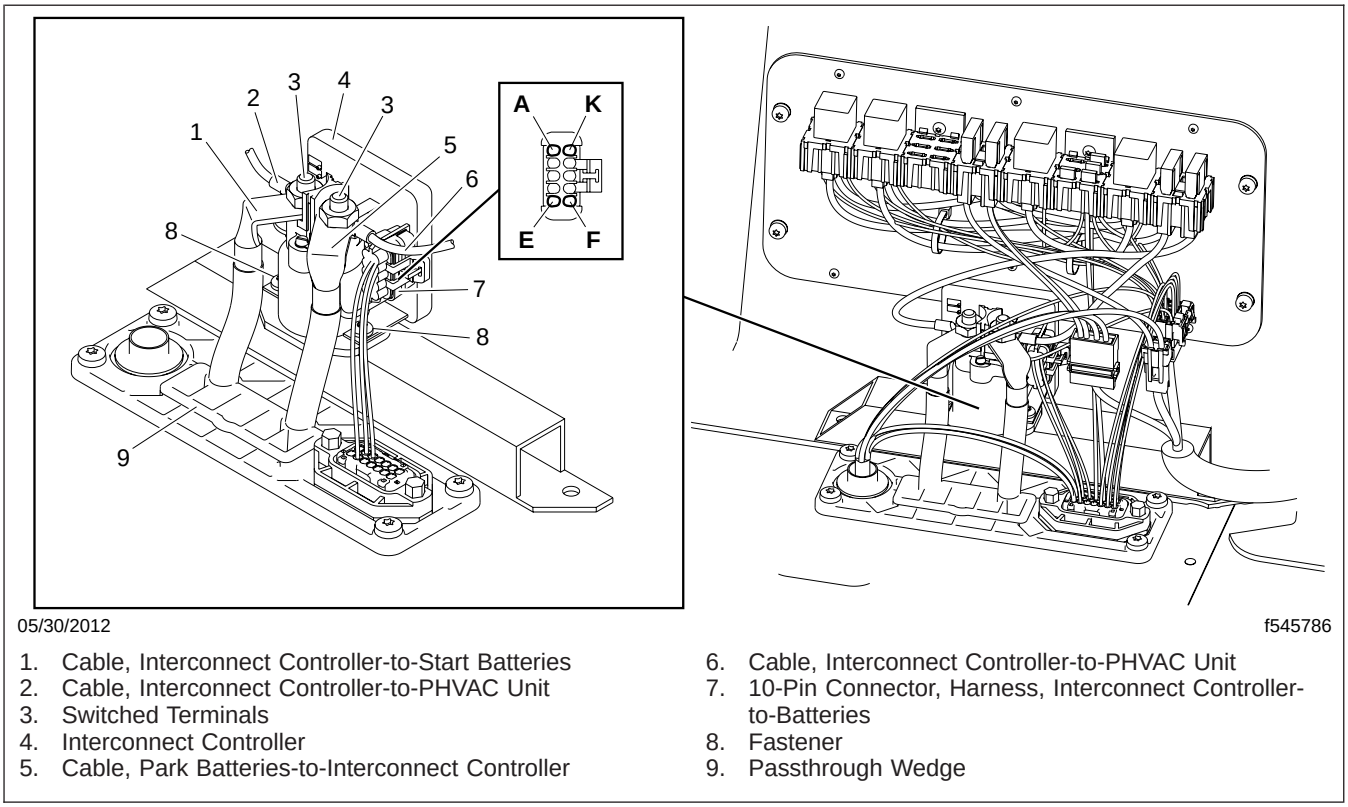
Replacement, Under-Bunk Installation (from July 2011)

For under-bunk units installed from to July 2011 to date, refer to **Fig. 3** for this procedure.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the ground cables on the main and auxiliary batteries.
3. Remove any side fairings and vanity skirts from the left side of the vehicle, as needed.
4. Access the interconnect controller through the baggage door on the left side of the sleeper.
5. Remove the electrical center cover.
6. Remove the terminal nuts from the interconnect controller, and disconnect the two wires going to the PDM.

NOTE: The fastener for the passthrough wedge is an Allen screw with a captured nut on the underside of the sleeper.

7. Remove the fastener from the passthrough wedge, and remove the wedge.
8. Remove the mounting fasteners from the interconnect controller.



05/30/2012 f545786

1. Cable, Interconnect Controller-to-Start Batteries
2. Cable, Interconnect Controller-to-PHVAC Unit
3. Switched Terminals
4. Interconnect Controller
5. Cable, Park Batteries-to-Interconnect Controller
6. Cable, Interconnect Controller-to-PHVAC Unit
7. 10-Pin Connector, Harness, Interconnect Controller-to-Batteries
8. Fastener
9. Passthrough Wedge

Fig. 3, Interconnect Controller Installation (from July 2011)

9. Slide the battery cables off of the terminals.
10. Position the new interconnect controller, and install the mounting fasteners.

IMPORTANT: The following steps for connecting the wiring must be done in the exact order stated for the interconnect controller logic to work correctly.

11. Connect the 10-pin connector wire harness to the interconnect controller.
12. Position the two wires from the PDM on the switched terminals.
13. Position the battery cables on the switched terminals.
14. Install the terminal nuts. Tighten 112 lbf·in (1265 N·cm).
15. Install the passthrough wedge.
16. Install the electrical center cover.
17. Connect the ground cables on the main and auxiliary batteries.
18. Install the side fairings and vanity skirts, if removed.

Fuel-Operated Heater Replacement

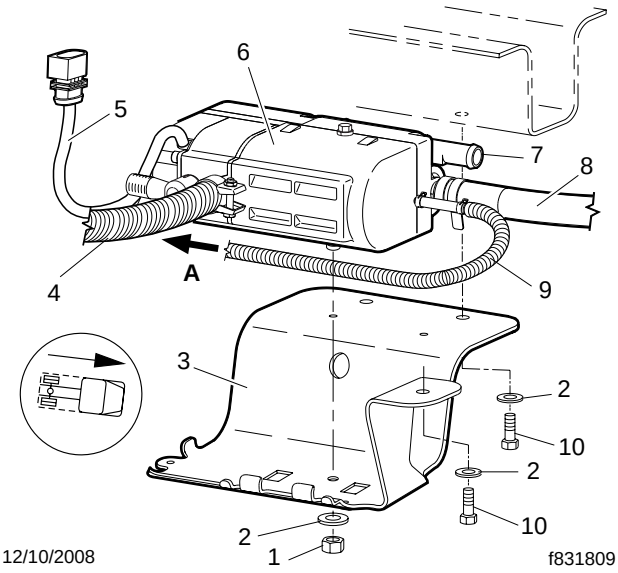
The fuel-operated heater mounts under the cab. It heats the engine coolant to provide heat for the parked HVAC system.

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.

⚠ 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.

4. Place a drain pan under the heater, then disconnect and cap/plug the fuel supply line.
5. Disconnect the control harness.
6. Disconnect the exhaust flex pipe from the heater.
7. Disconnect the coolant lines from the heater. See **Fig. 1**.
   - 7.1 Place a drain pan under the cab, below the coolant line connections to the heater.
   - 7.2 Use radiator-hose pinch pliers to shut off the flow of coolant from the rest of the system, then carefully disconnection the hoses.
8. Remove the heater with the hanger bracket attached.
9. Transfer the hanger bracket to the new heater, and tighten the fastener 9 to 12 lbf·ft (13 to 16 N·m).
10. Install the heater/bracket assembly. Tighten the fasteners 9 to 12 lbf·ft (13 to 16 N·m).
11. Connect the exhaust flex pipe.
12. Connect the coolant lines.
13. Connect the electrical harness.



A. To Fuel Tank

1. Nut, Heater-to-Mounting Bracket
2. Washer
3. Mounting Bracket
4. Exhaust Flex Pipe
5. Electrical Harness
6. Fuel-Operated Heater
7. Coolant Line to Heater Core
8. Coolant Line to Engine
9. Fuel Line
10. Capscrew, Mounting Bracket

Fig. 1, Fuel-Operated Heater Connections

IMPORTANT: Connections in the fuel supply circuit can trap air bubbles if the plastic lines are not completely inserted until they are touching inside the rubber hose sections.

14. Connect the fuel line.
15. Connect both sets of batteries.
16. Add coolant to the cooling system as needed. See **Group 20** for instructions.

Main Harness (pre-July 2011)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Remove the left side fairing behind the steps, if equipped.
5. Remove the condenser air inlet duct.
6. Under the vehicle, disconnect the main power connectors at the outlet cover.
7. Remove the outlet cover.
8. Remove the four electrical connector receptacles from the outlet cover. See **Fig. 1**.

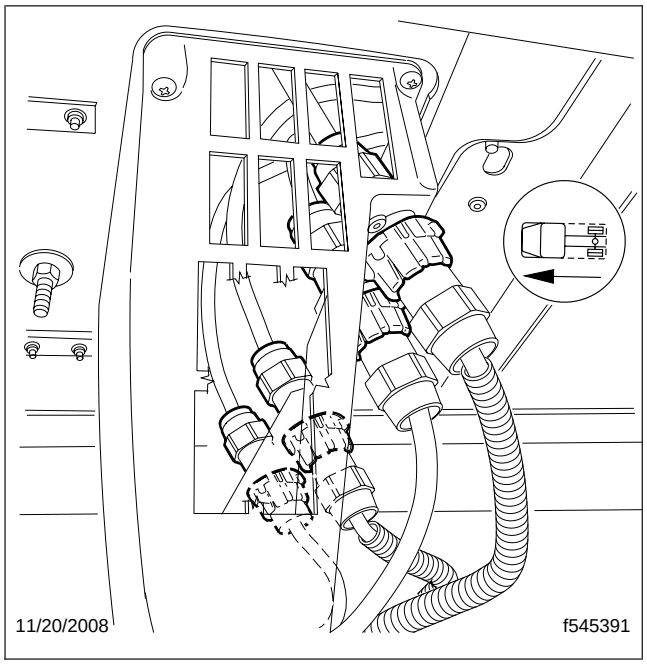


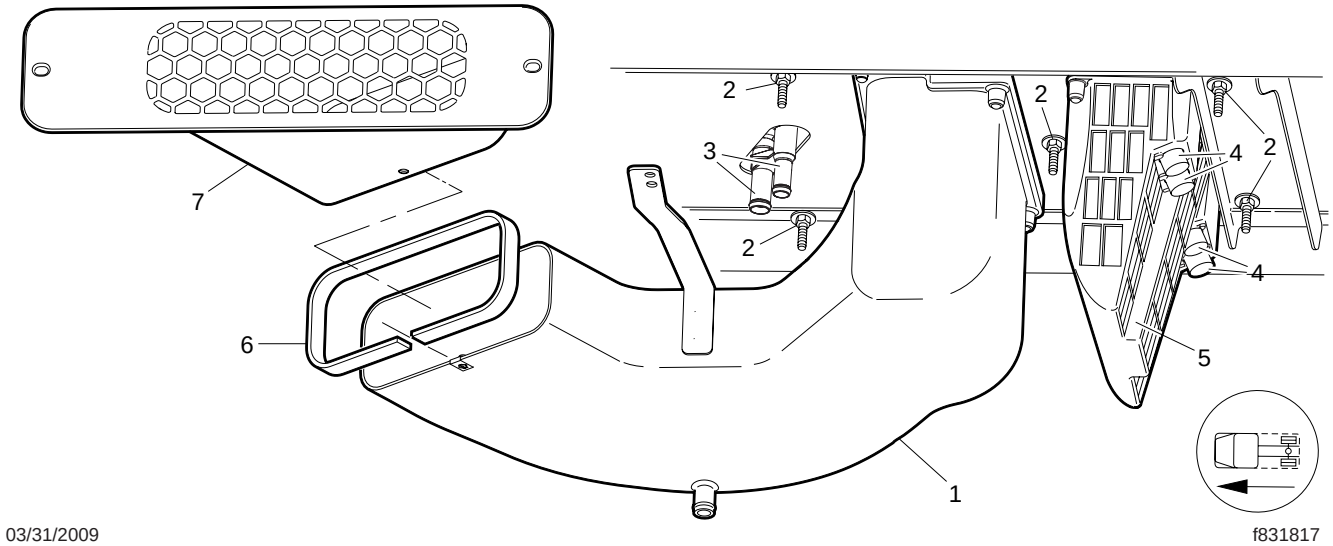
Fig. 1, Outlet Cover Connections

9. Disconnect the coolant lines from the heater core. See **Fig. 2**.
   - 9.1 Place a drain pan under the cab, below the coolant line connections to the heater core.
   - 9.2 Use radiator-hose pinch pliers to shut off the flow of coolant from the rest of the system, then carefully disconnection the hoses.
10. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 3**.
11. Remove the perforated panel on the front of the HVAC compartment.
12. Raise and secure the upper bunk.
13. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
14. Remove the lower bunk front panel and any dividers under the bunk.
15. Remove the cabinet stack. See **Group 60** for instructions.

NOTE: A small number of trucks manufactured prior to July 2011 have the battery interconnect controller installed under the bunk, rather than on the frame rail.

16. If the unit has the interconnect controller installed under the bunk, disconnect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
17. Remove the HVAC cover. See **Fig. 3**.
18. Remove the blend door motor. See **Subject 170**.
19. Remove the heater core. See **Subject 130**.
20. Remove the blower assembly. See **Subject 140**.
21. Unplug the harness connection to the internal controller, and ambient air temperature sensor.
22. Remove the wire harness clamps that hold the harness as it routes around the top case, and disconnect the three harness plugs.
23. Remove the top half of the case.
24. Lift the condenser fan assembly up. Disconnect the wiring harness from the condenser fan motor. See **Fig. 4**.
25. Disconnect the wiring harness from the refrigerant pressure switch.
26. Position the four connectors of the new wiring harness on the outlet cover, and install the mounting fasteners. Do not overtighten.

Wiring Harness Replacement



1. Condenser Inlet Duct
2. Mounting Bolts
3. Coolant Hose Connections
4. Main Power Connectors
5. Condenser Outlet Cover
6. Gasket
7. Condenser Inlet Grille

Fig. 2, Under-Cab Components

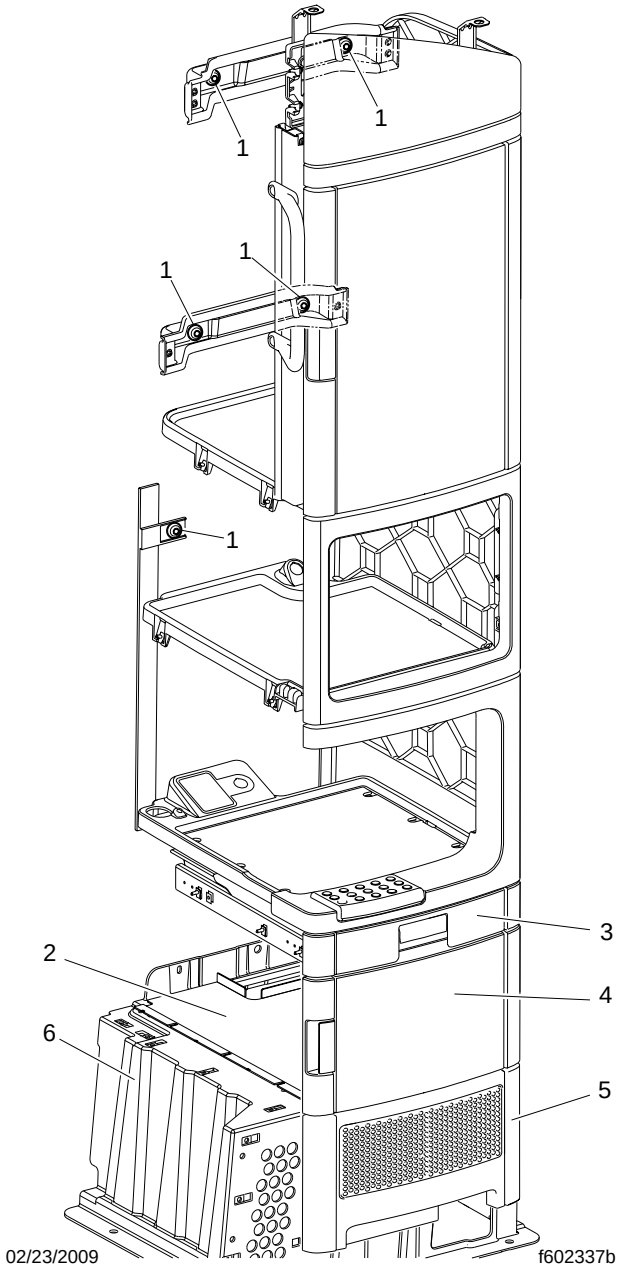
27. Install the condenser outlet cover.
28. Connect the refrigerant pressure sensor.
29. Connect the condenser fan electrical connections and install the condenser fan.

NOTE: Be sure to align the blend door when installing the top half of the case.

30. Install the top half of the case.
31. Connect the new wiring harness to the internal controller and the ambient air temperature sensor.
32. Install the heater core. See **Subject 130**.
33. Install the blower assembly. See **Subject 140**.
34. Install the blend door motor. See **Subject 170**.
35. Connect the coolant lines.
36. Connect the four cables to the parked HVAC outlet cover.
37. Install the condenser air inlet duct.
38. Install the HVAC cover.
39. If the unit has the interconnect controller installed under the bunk, connect the cables from the interconnect controller and the passthroughs on the floor that connect to the fuses on the plate mounted on the HVAC cover. For detailed instructions, refer to **Subject 210**.
40. Install the cabinet stack. See **Group 60** for instructions.
41. Install the lower bunk front panel and any dividers under the bunk.
42. Connect the lower bunk gas cartridges, and lower the bunks.
43. Connect both sets of batteries.
44. Add coolant to the cooling system as needed. For instructions, see **Group 20**.

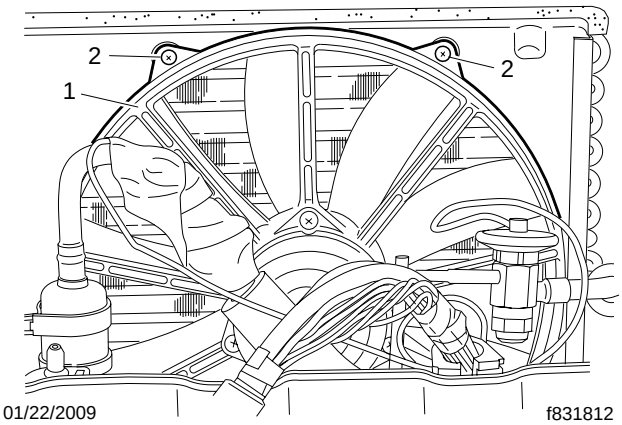
Main Harness (from July 2011)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.



1. Cabinet Fasteners
2. Lower Storage Compartment Bottom Panel
3. Drawer
4. Door
5. Perforated Panel
6. HVAC Cover

Fig. 3, Sleeper Cabinet Stack



1. Condenser Fan Assembly
2. Fasteners

Fig. 4, Condenser Fan Assembly Installation

4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 3**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Raise and secure the upper bunk.
7. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
8. Remove the lower bunk front panel and any dividers under the bunk.
9. Remove the cabinet stack. See **Group 60** for instructions.
10. Remove a section of the vanity skirt fasteners, or the frame-mounted fairing as needed for undercab access.
11. Access the interconnect controller through the baggage door on the left side of the sleeper.
12. Remove the electrical center cover.
13. Remove the terminal nuts from the interconnect controller, and disconnect the two wires going to the electrical center. See **Fig. 5**.

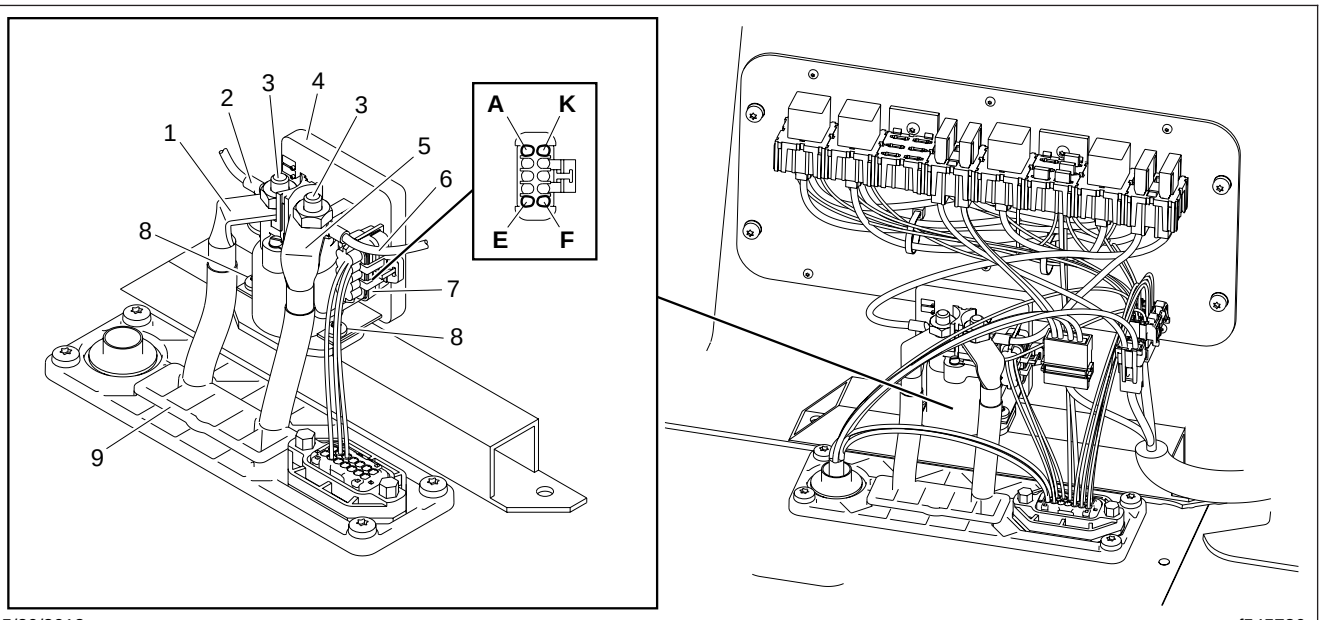
NOTE: The fastener for the passthrough wedge is an Allen screw with a captured nut on the underside of the sleeper.

14. Remove the fastener from the passthrough wedge, and remove the wedge.

Wiring Harness Replacement

15. Slide the battery cables off of the terminals.

27. Connect the battery cables to the interconnect



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1. Cable, Interconnect Controller-to-Start Batteries
2. Cable, Interconnect Controller-to-PHVAC Unit
3. Switched Terminals
4. Interconnect Controller
5. Cable, Park Batteries-to-Interconnect Controller
6. Cable, Interconnect Controller-to-PHVAC Unit
7. Harness, Controller-to-Batteries

Fig. 5, Interconnect Ccontroller Installation (from July 2011)

16. Disconnect the two harness connections between the electrical center and the harness.
17. Remove the HVAC cover. See **Fig. 3**.
18. Disconnect the harnesses at the internal controller.
19. Remove the blower and unplug the harness.
20. Disconnect the harness at the blend door motor.
21. Disconnect the harness at the evaporator temperature sensor.
22. Remove any wire ties.
23. Remove the harness.
24. Position the new harness, make all the electrical connections to the external components.
25. Secure the harness with wire ties.
26. Install the HVAC cover, and feed the harness connectors through the hole to the electrical center.

controller.

28. Install the wedge.
29. Connect the two wires from the electrical center.
30. Connect the wire harness.

NOTICE

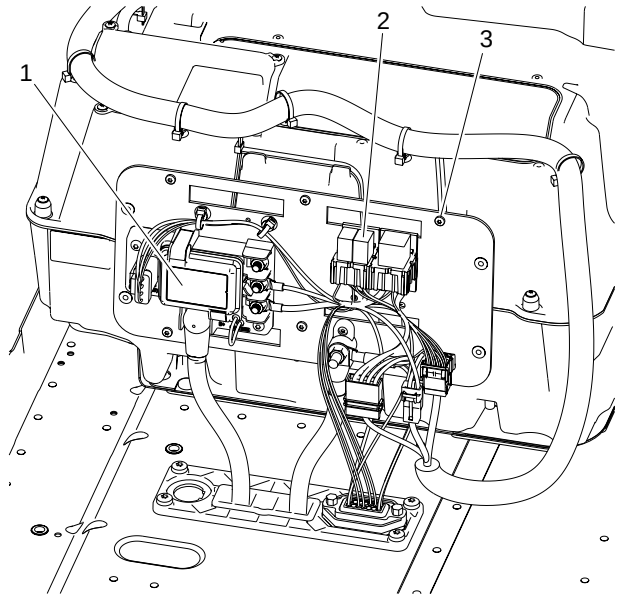
Do not allow the wire terminals to rotate while tightening the nuts on the interconnect controller. This can damage the interconnect controller control board.

31. Install the terminal nuts. Tighten 112 lbf·in (1270 N·cm).
32. Install the electrical center cover.
33. Install the cabinet stack. See **Group 60** for instructions.
34. Install the lower bunk front panel and any dividers under the bunk.

35. Connect the lower bunk gas cartridges, and lower the bunks.
36. Install the side-fairing or vanity skirt if removed.
37. Connect both sets of batteries.

Main Harness (vehicles with DDC O/I)

NOTE: Vehicles equipped with Detroit Diesel Optimized Idle (O/I) do not have an interconnect controller. See **Fig. 6**.



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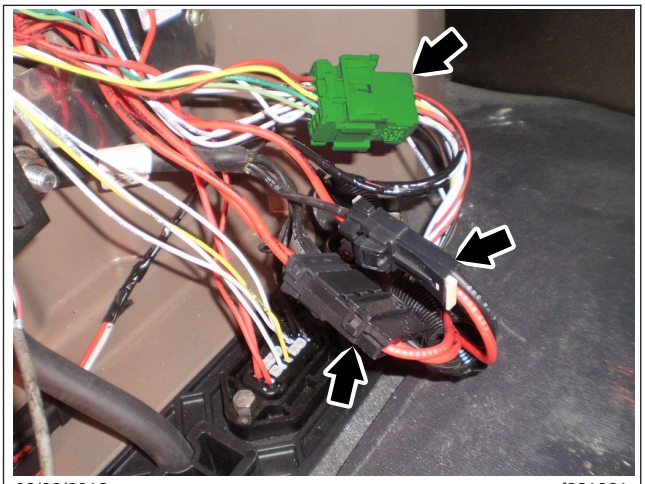
1. Power Distribution Module
2. Fuse Block
3. Fastener, Electrical Center

Fig. 6, Electrical Center Installation

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 3**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Raise and secure the upper bunk.
7. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
8. Remove the lower bunk front panel and any dividers under the bunk.
9. Remove the cabinet stack. See **Group 60** for instructions.
10. Remove a section of the vanity skirt fasteners, or the frame-mounted fairing as needed for undercab access.
11. Access the electrical center through the baggage door on the left side of the sleeper.
12. Remove the electrical center cover.
13. Disconnect the three harness connections between the electrical center and the harness. See **Fig. 8**.



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Disconnect these three connectors.

Fig. 7, Electrical Center

14. Remove the HVAC cover. See **Fig. 3**.
15. Disconnect the harnesses at the internal controller.
16. Remove the blower and unplug the harness.
17. Disconnect the harness at the blend door motor.
18. Disconnect the harness at the evaporator temperature sensor.

19. Remove any wire ties.
20. Remove the harness.
21. Position the new harness, make all the electrical connections to the external components.
22. Secure the harness with wire ties.
23. Install the HVAC cover, and feed the harness connectors through the hole to the electrical center.
24. Install the electrical center cover.
25. Install the cabinet stack. See **Group 60** for instructions.
26. Install the lower bunk front panel and any dividers under the bunk.
27. Connect the lower bunk gas cartridges, and lower the bunks.
28. Install the side-fairing or vanity skirt if removed.
29. Connect both sets of batteries.

Condenser Fan Harness, External

On units manufactured from July 2011 to date, the condenser is mounted on the backwall of the cab, and the harness for the condenser fan and the ambient air temperature sensor runs from the condenser housing to a connector under the cab.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Remove any side fairings and vanity skirts from the left side of the vehicle as needed.
5. Disconnect the wire harness at the condenser.
6. Disconnect the wire harness at the following locations under the sleeper.
    - heater fuel pump
    - sense wire harness connection
    - bottom of unit
7. Cut the wire ties holding the harness in place and remove the harness.
8. Position the new harness and connect it to all locations.
9. Secure the harness with wire ties leaving adequate slack for cab flexing.
10. Connect both sets of batteries.

Compressor Harness

On vehicles manufactured from June 21, 2012, the compressor harness is connects to threaded terminals on the conrtoler circuit board and can be replaced as a separate component.

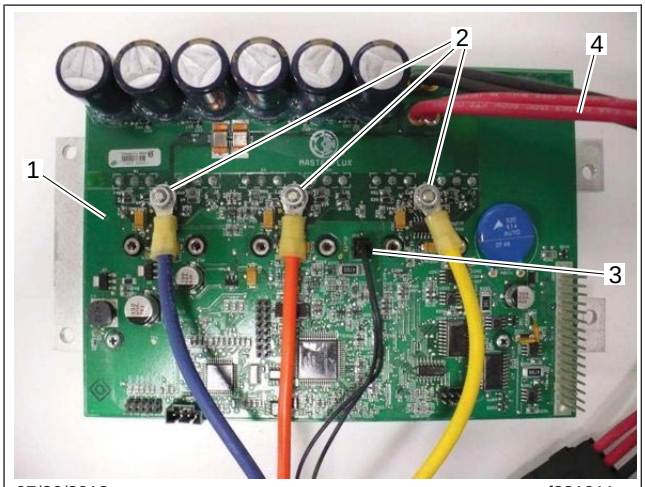
1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Open the lower storage compartment door, and remove the panel on the bottom. See **Fig. 3**.
5. Remove the perforated panel on the front of the HVAC compartment.
6. Raise and secure the upper bunk.
7. Disconnect one end of each lower bunk gas cartridge, and raise the bunk frame. Secure the frame to the back wall with a cinch strap.
8. Remove the lower bunk front panel and any dividers under the bunk.
9. Remove the cabinet stack. See **Group 60** for instructions.
10. Access the electrical center through the baggage door on the left side of the sleeper.
11. Remove the electrical center cover.
12. Disconnect the three harness connections between the electrical center and the main harness. See **Fig. 8**.
13. Remove the HVAC cover. See **Fig. 3**.
14. Disconnect the main harnesses at the internal controller.
15. Remove the interconnect conroller from the PHVAC case.

16. Remove the blower and unplug the harness.
17. Disconnect the main harness at the blend door motor.
18. Disconnect the main harness at the evaporator temperature sensor.
19. Remove any wire ties.
20. Move the main harness out of the way.
21. Remove the top half of the PHVAC housing.
22. Remove the cover from the internal controller.

NOTICE

Do not allow the wires or terminals to turn while loosening or tightening the nuts. Doing so will damage the circuit board.

23. Remove the terminal nuts, and disconnect the three phase-wires from the circuit board terminals as shown in **Fig. 9**.



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1. Circuit Board
2. Terminal Nuts
3. Temperature Sensor Connection
4. Power Wire Harness

Fig. 9, Circuit Board Wiring

24. Disconnect the temperature sensor wire from the curcuit board.
25. Remove the connector cap from the compressor, and disconnect the phase-wires from the compressor, and the temperature sensor wires from the temperature sensor.
26. Remove the harness.

NOTICE

Press the phase-wire connector onto the compressor terminals firmly until they bottom out. A loose connection can cause an overheat condition.

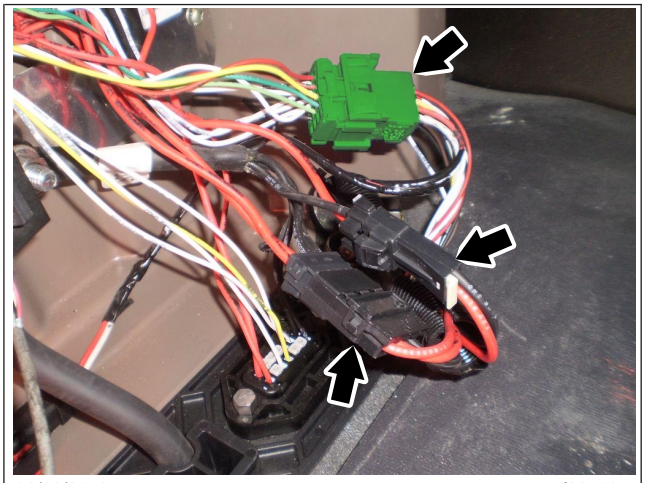
27. Position the new harness, and connect the phase-wires to the compressor, and temperature sensor wires to the temperature sensor.
28. Install the top half of the PHVAC housing.
29. Connect the temperature sensor wire connector to the circuit board.
30. Connect the main harness, make all the electrical connections to the external components.
31. Secure the main harness with wire ties.
32. Install the blower.
33. Connect the wire harness to blend door actuator.

NOTICE

Do not allow the wires or terminals to turn while tightening the nuts. Doing so will damage the circuit board.

34. Connect the three phase-wires to the new circuit board terminals as shown in **Fig. 9**. Install the blue wire on the left terminal, the orange wire on the middle terminal, and the yellow wire on the right terminal. Carefully tighten the nuts 10 lbf·in (113 N·cm). Do not over tighten or under tighten.
35. Install the controller cover.
36. Install the controller.
37. Connect the controller power harness to the main harness.
38. Connect the main harness at the electrical center.
39. Install the HVAC cover.
40. Install the cabinet stack. See **Group 60** for instructions.
41. Install the lower bunk front panel and any dividers under the bunk.
42. Connect the lower bunk gas cartridges, and lower the bunks.

Wiring Harness Replacement



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Disconnect these three connectors.

Fig. 10, Electrical Center

43. Connect both sets of batteries.

Condenser Refrigerant Line Replacement

⚠ WARNING

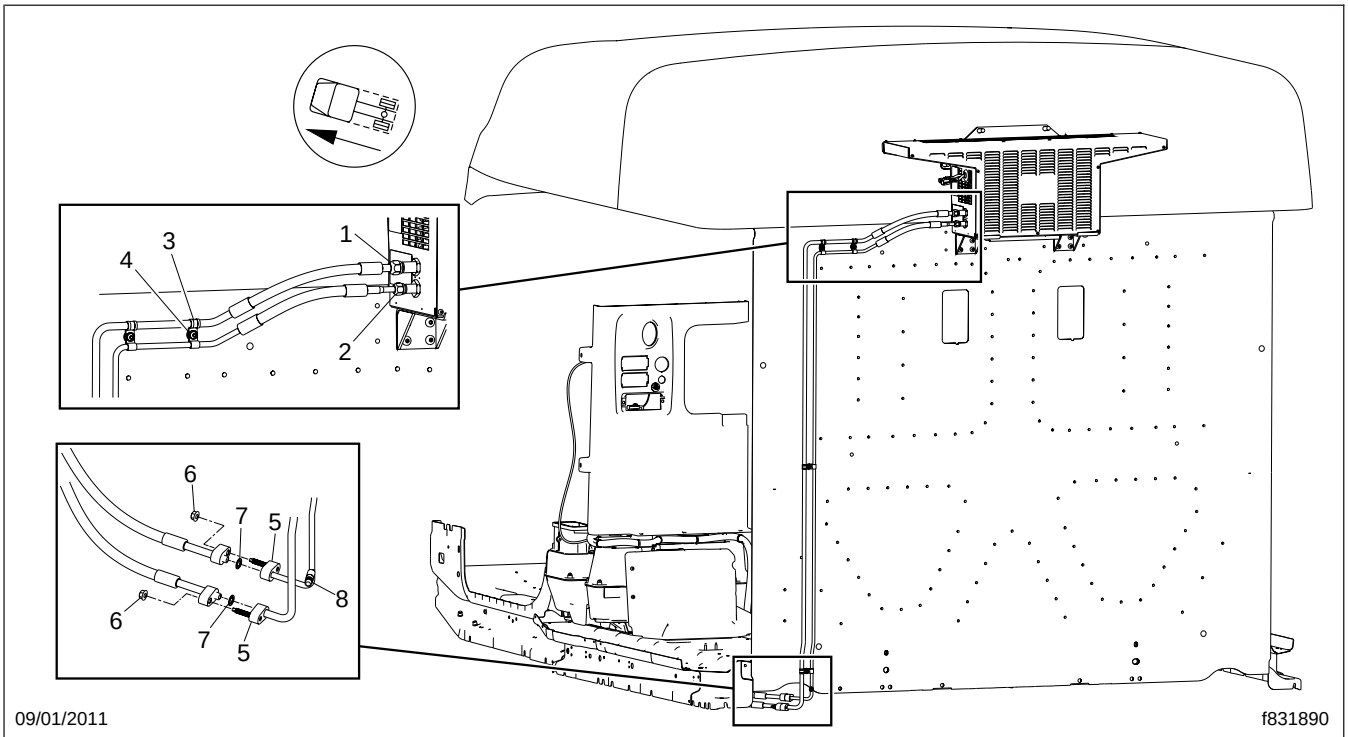
Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant, could lead to serious personal injury.

Backwall Refrigerant Line Replacement

Refer to **Fig. 1** for this procedure.

3. Remove any side skirts and fairings as needed.
4. Cut the tie straps and free the wiring harness from the refrigerant lines to the condenser as needed.
5. Remove the mounting bolts and the P-clamps holding the refrigerant lines to the back of the sleeper.
6. Place a protective cover over the fuel tank to protect it from oil dripping from the refrigerant line after it is disconnected.

NOTE: The fitting on the condenser is "captured," so no back-up wrench is needed.



1. #8 A/C O-Ring Joint
2. #6 A/C O-Ring Joint
3. P-Clamp
4. Fastener
5. Connector Block
6. Retaining Nut
7. Seal
8. Service Port

Fig. 1, Backwall Refrigerant Line Installation

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Recover the refrigerant system. See **Subject 250** for instructions.
7. Loosen the fitting at the top of the line where it connects to the condenser.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage

Condenser Refrigerant Line Replacement

the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

8. Using a back-up wrench on the connector block, remove the retaining nut, and disconnect the line from the connector block at the base of the backwall. Discard the seal. Cap or plug the fittings immediately.
9. Disconnect the line from the condenser, and remove the line. Cap or plug the fittings immediately.
10. Lubricate a new O-ring with with polyvinylether (PVE) refrigerant oil and install it on the refrigerant line.
11. Connect the new line to the condenser. Do not tighten the line at this time.

NOTE: Do not lubricate the seal.

12. Using a new seal, connect the new line to the connector block at the base of the backwall. Using a back-up wrench on the connector block, tighten the retaining nut 14 to 16 lbf·ft. (19 to 22 N·m).
13. Tighten the fitting at the condenser. See **Table 1** for torque values.
14. Position the line, and install the P-clamps.
15. Secure the wiring harness with new tie straps.
16. Evacuate and charge the refrigerant system. See **Subject 250** for instructions.

Under-Cab Refrigerant Line Replacement

Refer to **Fig. 2** for this procedure.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Evacuate the refrigerant system. See **Subject 250** for instructions.
3. Remove the mounting bolt and the P-clamp holding the refrigerant line to the standoff bracket.
4. Place a protective cover over the fuel tank to protect it from oil dripping from the refrigerant line after it is disconnected.

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. Disconnect the fitting at the passthrough fitting on the sleeper floor. Cap or plug the fittings immediately.
6. Using a back-up wrench on the J-block, remove the retaining nut, and disconnect the line from the connector block at the base of the backwall. Discard the seal. Cap or plug the fittings immediately.

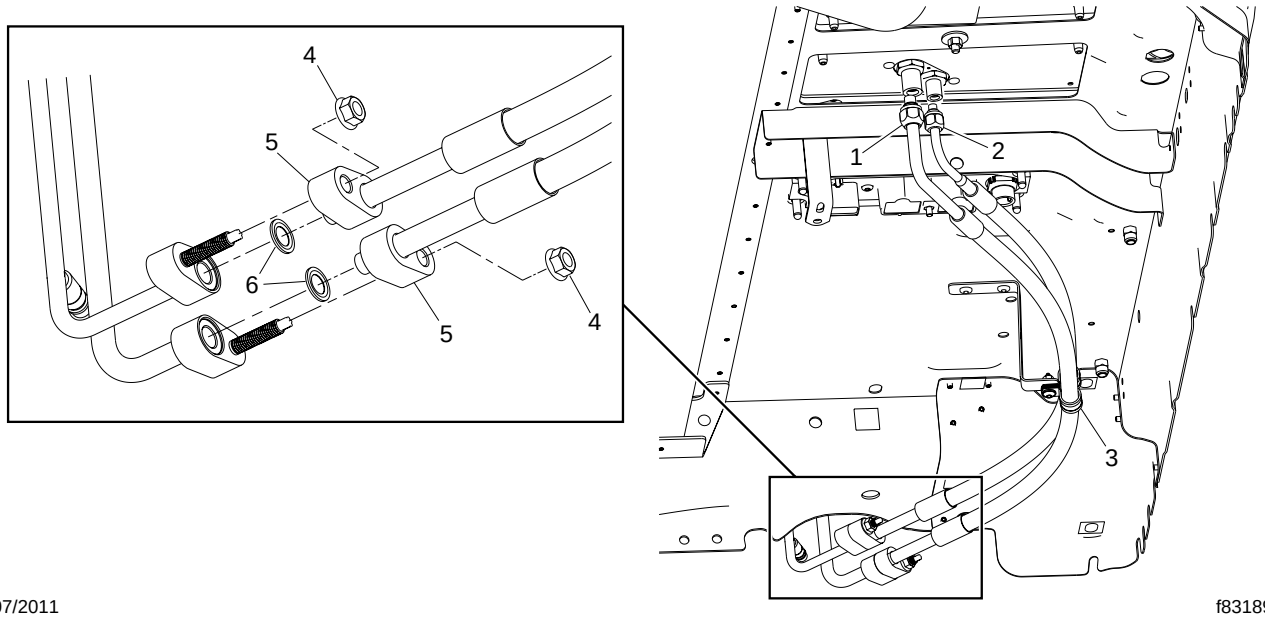
NOTE: Do not lubricate the seal.

7. Using a new seal, connect the new line to the connector block at the base of the backwall. Using a back-up wrench on the connector block, tighten the retaining nut 14 to 16 lbf·ft. (19 to 22 N·m).
8. Lubricate a new O-ring with with polyvinylether (PVE) refrigerant oil and install it on the refrigerant line.
9. Connect the new line to the passthrough fitting on the sleeper floor. Tighten the fitting. See **Table 1** for torque values.
10. Position the P-clamp on the line, and attach it to the standoff bracket.
11. Evacuate and charge the system. See **Subject 250** for instructions.

Refrigerant Line Fitting Torque Values	
Fitting	**Torque**
#6 A/C O-Ring Joint	20 to 25 lbf·ft (27 to 34 N·m)
#8 A/C O-Ring Joint	30 to 35 lbf·ft (14 to 47 N·m)
M8 Fastener, Block Joint	14 to 16 lbf·ft. (19 to 22 N·m)

Table 1, Refrigerant Line Fitting Torque Values

Condenser Refrigerant Line Replacement



1. #8 A/C O-Ring Joint
2. #6 A/C O-Ring Joint
3. P-Clamp
4. Retaining Nut
5. Connector Block
6. Seal

Fig. 2, Under-Cab Refrigerant Line Installation

Required Equipment

To perform work on A/C systems, the repair facility needs to be able to confidently identify refrigerant, and to recover, evacuate, and charge the refrigerant systems. Servicing equipment must meet current SAE standard (2788) and be able to perform 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 refrigerant on every refrigerant service.
- Recovery—The machine must be able to fully recover the refrigerant from a refrigerant system that meets the current SAE standard (2788).
- Evacuation—A vacuum pump must be rated at 6 cfm or better. A vacuum pump that requires maintenance is acceptable, as long as it is properly maintained.
- Charging—The charging process must meet the current SAE standard (2788) for charge accuracy and on-site scale calibration.

Refrigerant Identification

IMPORTANT: Always use a refrigerant identifier before hooking up any equipment to the refrigerant system. This practice will protect your tools and ensure that you are not held responsible for an improper repair.

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 non-condensable gas, recover the refrigerant system, then purge the recovery tank of the non-condensable 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

The recovery process removes most of the refrigerant charge in the system.

NOTE: To recover the refrigerant system, the ambient temperature must be above 50°F (10°C) and preferably 70°F (20°C).

1. Park the vehicle on a level surface, turn off the engine, and apply the parking brakes. Chock the tires.

NOTE: The service valve is located on the backwall of the sleeper on the left side of the vehicle.

2. Remove the cap from the service valve.
3. Identify the refrigerant using the "Refrigerant Identification" procedures.
4. Wearing protective goggles and non-leather gloves, attach the refrigerant recovery and charging machine hose (red) to the valve.

IMPORTANT: Push down firmly on the hose connectors until a click 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.

Evacuating

The main purpose of evacuating the refrigerant system is to remove non-condensable gases, such as nitrogen and air. The secondary purpose is to boil off free water molecules. You can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum, causing 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, non-condensable

gases and water vapor are pulled out of the system. This process is called evacuation or dehydration.

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.

The ability to hold a vacuum is only an indication that there are not any leaks that are present *under a vacuum*. The system may still leak when it is under positive pressure, so a pressure leak test must also be performed.

Maintaining an Oil-Lubricated Vacuum Pump

Maintenance is important for a high-vacuum pump. The oil must be changed at regular intervals to prevent moisture buildup, which will cause decreased pump performance and eventual pump failure.

Pumping down extremely wet air conditioning systems can completely saturate the pump oil, in which case, the oil must be replaced.

NOTICE

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.

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. Make sure the vacuum pump has been properly maintained.
2. Attach the refrigerant recovery and charging machine hose (red), or a vacuum pump, to the valve.

IMPORTANT: Push down firmly on the hose connector until a click is heard. This will ensure that the coupler is locked.

3. Follow the refrigerant recovery and charging machine manufacturer's instructions, and evacuate the refrigerant system.
4. Using a 6-cfm pump, the system should be evacuated for 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.

Charging

NOTE: Before charging, the system must be recovered and evacuated with the recovery and charging machine connected to the service port connection.

1. Charge the system on the high side following the refrigerant recovery and charging machine manufacturer's instructions.
2. Start the ParkSmart system and use the information in **C02.01** of the *Cascadia Troubleshooting Manual* to evaluate the system performance.
3. Disconnect the hose.
4. Recover the refrigerant that is in the hose.

Leak Testing Methods

NOTICE

The ParkSmart system uses a non-conductive compressor oil. Use only polyvinylether (PVE) refrigerant oil in this system. The system should never be recovered to check AC charge. The ParkSmart system does not need any oil added unless refrigerant loop components have been replaced, or the system has been recovered in excess of four times. Adding improper oil types, or too much oil, will cause damage to the compressor.

In units built from start of production through June of 2011, the ParkSmart refrigerant loop is not serviceable. When a performance complaint is coupled with evidence of a refrigerant leak, standard leak detecting methods may be employed to confirm the unit is losing refrigerant. The refrigerant type is R-134a. Follow the manufacture's operating instructions and use the leak detectors from the approved tool list to confirm suspected leaks. If a leak is confirmed on an under-performing unit, replace the refrigerant loop.

Beginning in July of 2011, an R-134a A/C service port has been added to the high-pressure side of the ParkSmart system for charging and recovery of refrigerant. Charging and recovery of this system should never be done until after other troubleshooting methods have pointed to low or no refrigerant in the system.

General Information

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 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.

NOTE: Recovering the refrigerant from the A/C system is not an approved leak detection method.

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.

See the recommended tool list for the most up to date list of approved tools.

Do not use a corona discharge type leak detector.

Use the following procedure to locate refrigerant system 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, 1/2-lb (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 below 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 port (with cap installed), brazed or welded areas, and areas around attachment points and hold-downs.

Refrigerant Service Operations

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 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.
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.
10. Leak test repaired areas of the system after repairs have been performed. Leak test the service port (with cap installed) after any service that disturbs the refrigerant system.

Condenser Replacement

⚠ 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.

Replacement

On vehicles manufactured from July 2011, the ParkSmart A/C condenser is externally mounted on the backwall of the sleeper. Refer to **Fig. 1** for the unit removal procedure.

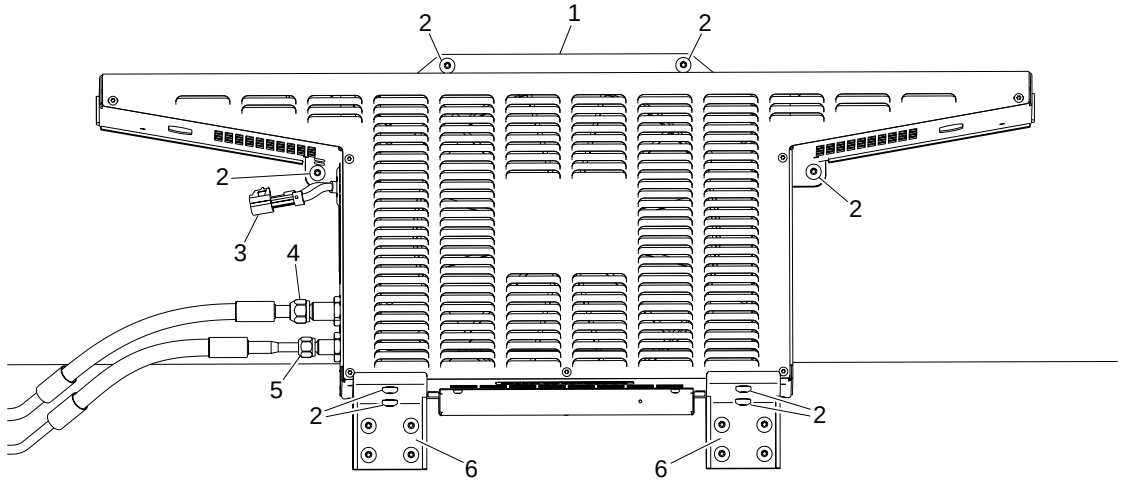
NOTICE

Replacement condensers come installed in the condenser housing. They are not meant to be removed from the housing. Attempting to remove the condenser from the housing will damage the condenser or lines.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Recover the refrigerant from the system. See **Subject 250** for instructions.
3. Disconnect the starting batteries at the negative cables.
4. Disconnect the parked HVAC batteries at the negative cables.
5. Disconnect the wire harnesses at the condenser housing.

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).

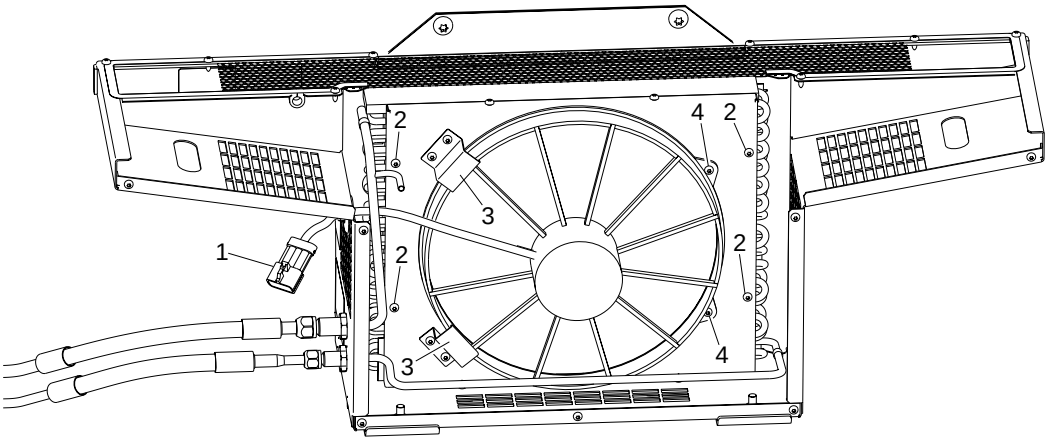
6. Disconnect the refrigerant lines from the condenser. Immediately cap the lines and fittings.
7. Remove the fasteners from the backwall and the support brackets.
8. Remove the condenser housing assembly, and place it on the work bench.
9. Remove the cover from the condenser housing.
10. Extract the grommet.
11. Feed the pigtail through the hole.
12. Remove the condenser fan and shroud assembly. See **Fig. 2**.



1. Condenser Housing
2. Fastener
3. Electrical Harness
4. #8 A/C O-Ring Joint
5. #6 A/C O-Ring Joint
6. Mounting Bracket

Fig. 1, Condenser Installation

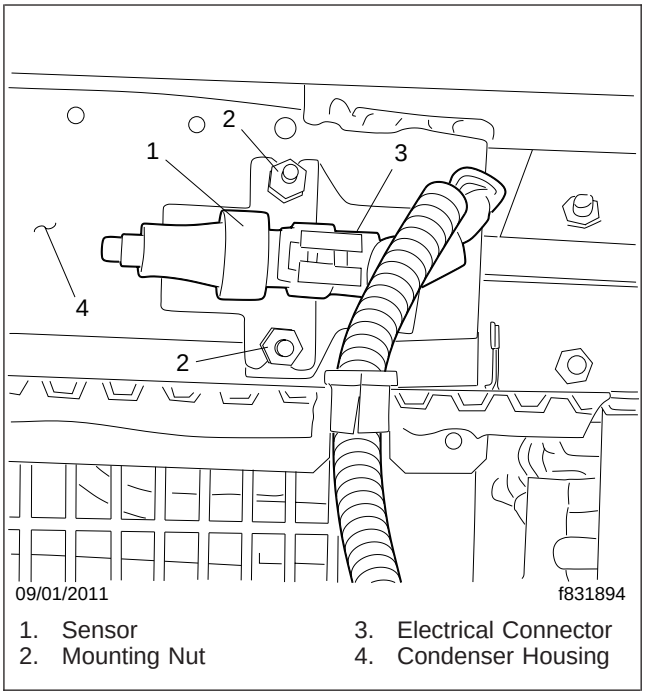
Condenser Replacement



1. Pigtail
2. Fastener, Shroud
3. Clamp, Fan
4. Fastener, Fan

Fig. 2, Condenser Fan and Shroud Removal

13. Remove the ambient air temperature sensor. See **Fig. 3**.



1. Sensor
2. Mounting Nut
3. Electrical Connector
4. Condenser Housing

Fig. 3, Ambient Air Temperature Sensor

14. Install the ambient air temperature sensor in the new condenser housing.
15. Install the condenser fan and shroud assembly in the new condenser housing.
16. Install the cover on the condenser housing.
17. Position the condenser assembly on the support brackets, and install the fasteners. Tighten 15 lbf-ft (20 N-m).
18. Insert the pigtails in the hole and install the grommet.
19. Lubricate the new O-rings with polyvinylether (PVE) refrigerant oil and install them on the refrigerant lines.
20. Connect the refrigerant lines to the condenser. Tighten the fittings. See **Table 1** for torque values.

Refrigerant Line Fitting Torque Values	
Fitting	**Torque**
#6 A/C O-Ring Joint	20 to 25 lbf·ft (27 to 34 N·m)
#8 A/C O-Ring Joint	30 to 35 lbf·ft (14 to 47 N·m)

Table 1, Refrigerant Line Fitting Torque Values

21. Connect the wiring harnesses.
22. Connect both sets of batteries.

23. Evacuate and charge the refrigerant system. See **Subject 250** for instructions.

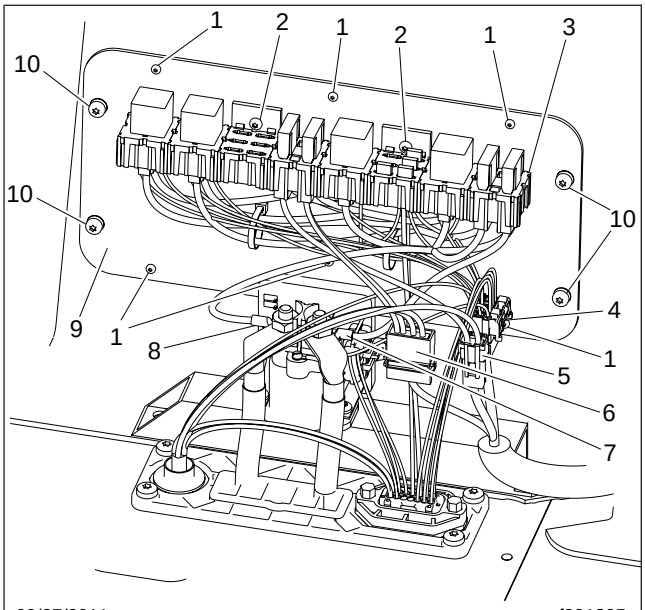
Replacement (pre-July 2011)

On ParkSmart systems manufactured from start of production through June 2011, the electrical center is part of the main harness. Refer to **Subject 230** for replacement instructions.

Replacement (from July 2011)

NOTE: Vehicles equipped with Detroit Diesel Optimized Idle (O/I) do not have an interconnect controller. See "Replacement (vehicles with DDC O/I)" for the replacement procedure for these vehicles.

On vehicles manufactured from July 2011 to date the electrical center is located under the lower bunk on the driver's side. Refer to **Fig. 1** for this procedure.



1. Fastener, Mounting Plate
2. Fastener, PDM
3. PDM
4. Connector
5. Connector
6. Connector
7. Wire, Interconnect Controller-to-PDM
8. Wire, Interconnect Controller-to-PDM
9. PDM Mounting Plate
10. Fastener, PDM Cover

Fig. 1, Electrical Center Installation (from July 2011)

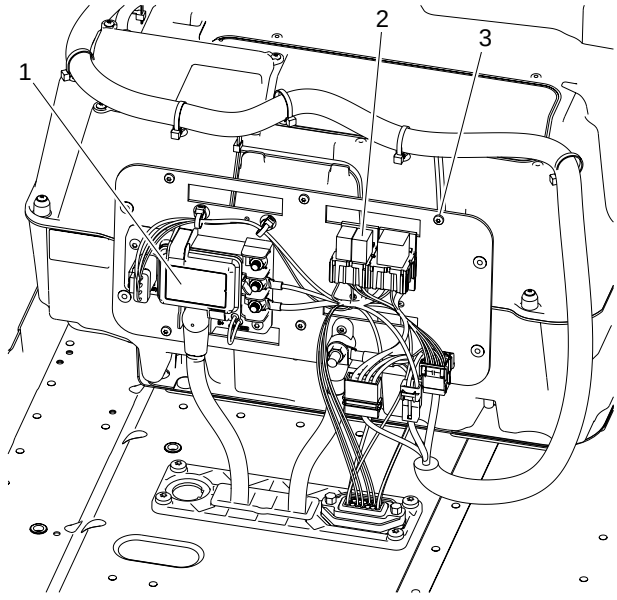
1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Access the electrical center through the baggage door on the left side of the sleeper.
5. Remove the side fairing or vanity skirt as needed to improve access.
6. Remove the electrical center cover.
7. Remove the terminal nuts from the interconnect controller, and disconnect the two wires going to the electrical center.
8. Disconnect the three connectors from the electrical center.
9. Remove the fasteners and remove the electrical center and mounting plate.
10. Remove the electrical center from the mounting plate.
11. Install the new electrical center on the mounting plate.
12. Install the electrical center and mounting plate.
13. Connect the three connectors to the electrical center.
14. Connect the two wires going from the electrical center to the terminals on the interconnect controller, and install the terminal nuts. Tighten 112 lbf·in (1270 N·cm).
15. Install the electrical center cover.
16. Install any side fairing or vanity skirt removed for access.
17. Connect the ground cables on the main and auxiliary batteries.

Electrical Center Replacement

Replacement (vehicles with DDC O/I)

Vehicles equipped with Detroit Diesel Optimized Idle (O/I), the electrical center is located under the lower bunk on the driver's side. Refer to **Fig. 2** for this procedure.

NOTE: Vehicle with O/I do not have an interconnect controller.



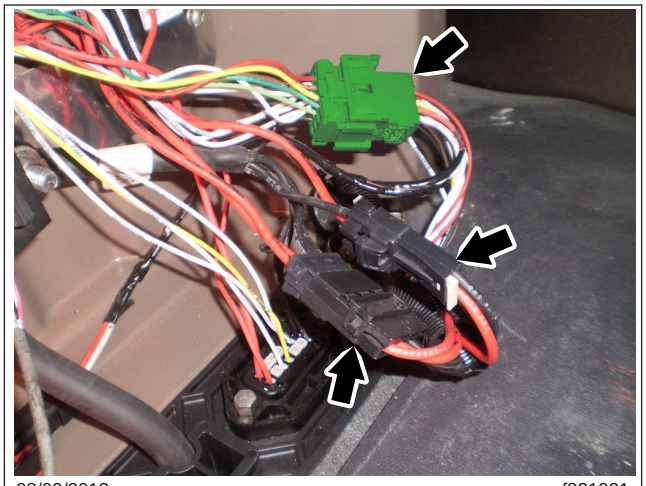
1. Power Distribution Module
2. Fuse Block
3. Fastener, Electrical Center

Fig. 2, Electrical Center Installation (vehicles with DDC O/I)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the auxiliary batteries at the negative cables.
4. Access the electrical center through the baggage door on the left side of the sleeper.
5. Remove the electrical center cover.

NOTE: Mark all wires as needed before disconnecting them for ease of installation.

6. Disconnect the battery cables at the electrical center.
7. Disconnect the three harness connections between the electrical center and the harness. See **Fig. 3**.



Disconnect these three connectors.

Fig. 3, Electrical Center, Vehicles with DDC O/I

8. Remove the fasteners and remove the electrical center and mounting plate.
9. Remove the electrical center components from the mounting plate.
10. Install the new electrical center components on the mounting plate.
11. Install the electrical center and mounting plate.
12. Connect the three connectors on the ParkSmart harness to the electrical center.
13. Connect the battery cables to the electrical center. Tighten 177 lbf·in (240 N·cm).
14. Install the electrical center cover.
15. Connect the ground cables on the main and auxiliary batteries.

Refrigerant Service Loop Replacement

General Information

NOTICE

The ParkSmart auxiliary HVAC unit should never be turned upside down. Doing so will allow the lubricant to leave the compressor. The lubricant can not return to the compressor, and this may lead to premature compressor failure.

Whether handling or storing the ParkSmart auxiliary HVAC unit, always keep it in an upright position. If the unit is turned on its side for any length of time, allow it to sit for one hour prior to operating the system to allow the compressor oil to settle. Briefly tipping the unit less than 40 degrees while moving it will not damage the unit.

NOTICE

Do not remove the new refrigerant loop from its case. Transfer the removable parts from the original case to the new one. Attempting to remove the refrigerant loop from the case will damage the loop.

For ParkSmart units manufactured before July 1, 2011 refer to "Sealed Unit Replacement" below. For ParkSmart units built from July 1, 2011, refer to "Split Unit Replacement" below.

Refrigerant Service Loop Training Video

The DTNA Aftermarket Resource Center (ARC) has a training video available that demonstrates the following procedures.

www.DTNAARC.com

Sealed Unit Replacement

Transfer the following components from the original unit to the new unit.

- main harness
- heater core
- blower motor assembly
- blend door
- blend door actuator
- controller and harness (if not being replaced)
- temperature sensors

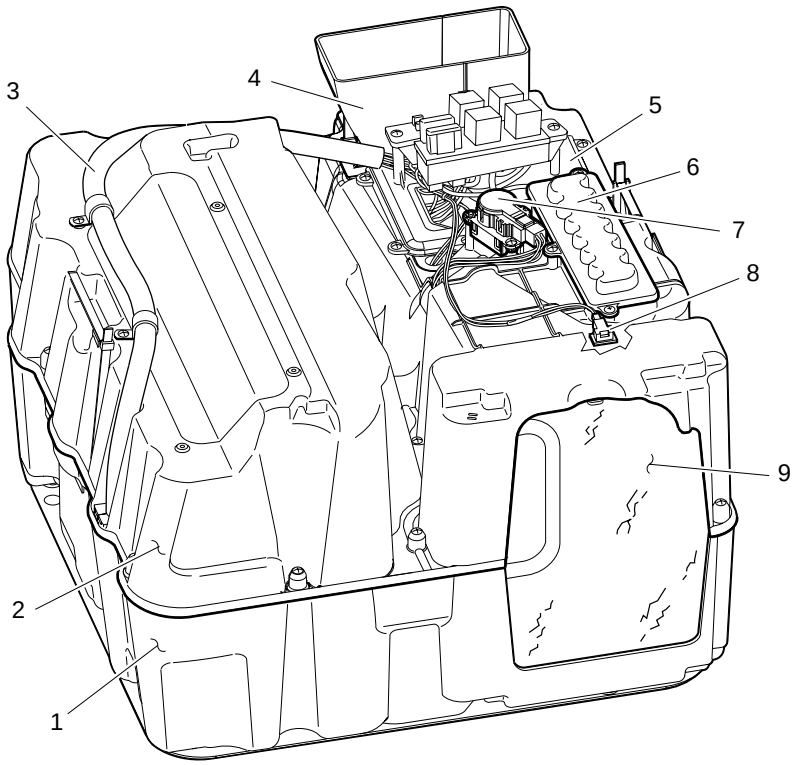
1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Disconnect the starting batteries at the negative cables.
3. Disconnect the parked HVAC batteries at the negative cables.
4. Remove the ParkSmart unit from the vehicle following the directions in **Subject 120**.

NOTE: A work surface with cutouts to accommodate the two units makes this procedure much faster and helps prevent tipping the unit.

5. Place the two units side-by-side on a suitable workbench.
6. Cut the zip ties and remove the top of the replacement unit.
7. Remove the evaporator temperature sensor. See **Fig. 1**, Item 8. Leave the sensor attached to the harness.
8. Remove the fasteners, and lift off the blend door motor. See **Fig. 2**.
9. Disconnect the wiring harness.
10. Remove the outlet cover.
11. Remove the four electrical connector receptacles from the outlet cover. See **Fig. 3**.
12. Unplug the harness connection to the internal controller.
13. Remove the wire harness clamps that hold the harness as it routes around the top case, and disconnect the three harness plugs.
14. On vehicles manufactured before July 1, 2011, remove the fuse/relay panel from the blower access cover.

    On vehicles manufactured from July 1, 2011, remove the unit control module from the blower access cover.
15. Remover the blower access cover with the fuse/relay panel, or unit control module. See **Fig. 4** for fuse/relay panel installations, or **Fig. 5** for unit control module installations.

Refrigerant Service Loop Replacement



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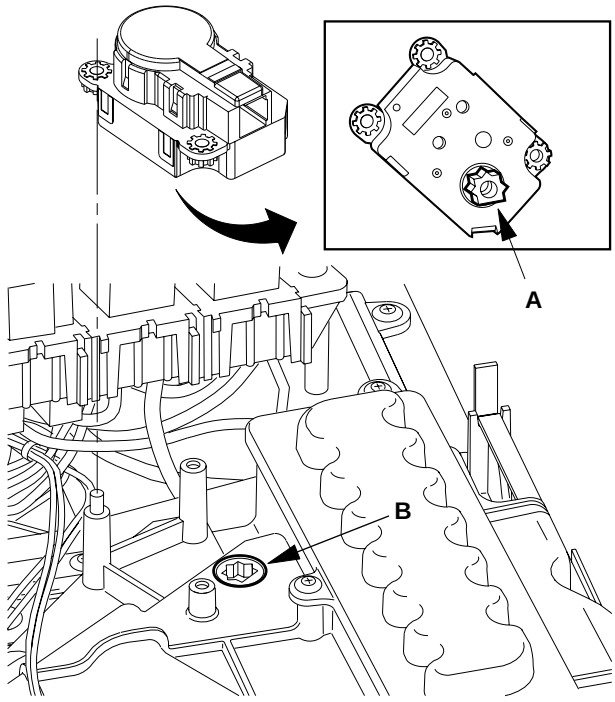
1. Lower Case
2. Upper Case
3. Main Harness
4. Blower Outlet Duct
5. Blower Cover
6. Heater Core Cover
7. Blend Door Motor
8. Evaporator Temperature Sensor
9. Intake Filter

Fig. 1, Evaporator Temperature Sensor Installation

16. Remove the blower housing fasteners, then lift the blower assembly up, and unplug the wiring harness connector. See **Fig. 6**.
17. Remove the upper case.
18. Remove the heater core from the old unit.

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. 7** for wire positions.

19. Remove the connector cap from the compressor, and disconnect the wires to the motor and temperature sensor.
20. Remove the ambient temperature sensor. See **Fig. 8**.
21. Install the ambient temperature sensor.
22. Position the control module and cover assembly in the new unit, and install the fasteners.
23. Connect the wires from the controller to the compressor motor and temperature sensor. See **Fig. 8**. Install the cap.
24. Remove the fasteners, and lift the condenser fan assembly up. See **Fig. 9**.
25. Disconnect the wiring harness from the condenser fan motor, and remove the fan assembly.
26. Partially install the fan assembly in the new unit and connect the wiring harness.
27. Position the condenser fan assembly, and install the fasteners. Do not overtighten.
28. Install the four electrical connector receptacles in the outlet cover.



Align A with B to install the blend door motor.

A. Blend Door Motor Drive Gear
B. Blend Door Drive Socket

Fig. 2, Blend Door Motor Installation

29. Install the outlet cover.
30. Remove the foam strip from the top of the condenser in the old unit and attach it to the top of the condenser in the new unit.
31. Remove the blend door from the old unit and install it in the new unit.

NOTE: Be sure to align the blend door when installing the top half of the case.

32. Install the upper case of the new unit.

NOTICE

Make sure the "guide ear" on the heater core is properly aligned. Do not force the heater core into the housing. Forcing an improperly aligned heater core into the housing will break the "guide ear," and may cause the heater core to leak. It may be necessary to manipulate the core from both inside and outside the vehicle to get it into place without damaging it.

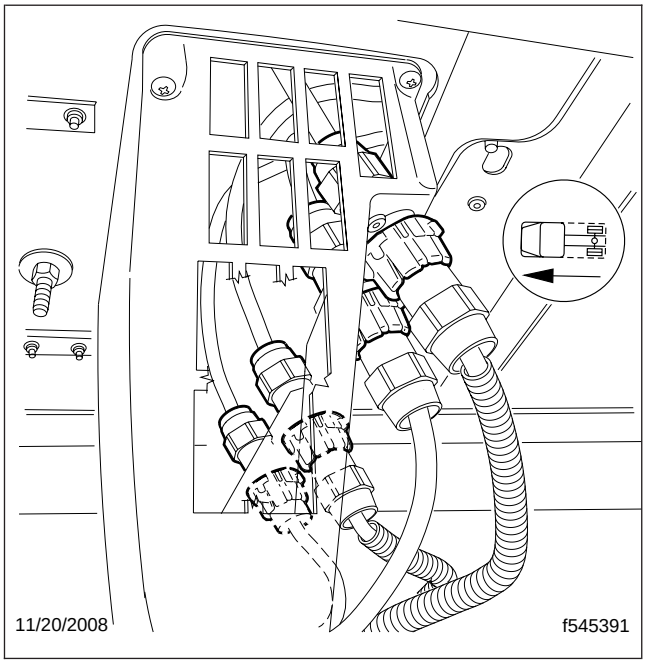


Fig. 3, Outlet Cover Connections

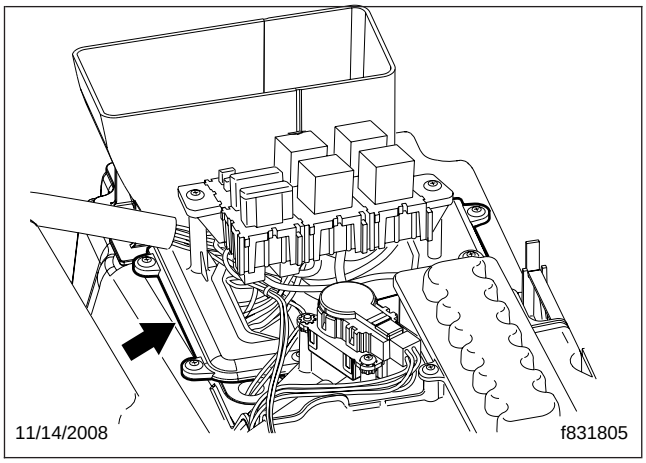
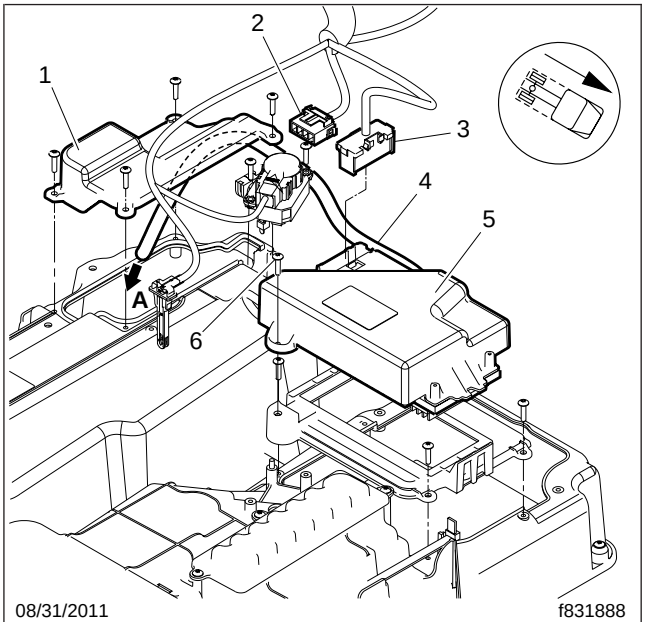


Fig. 4, Blower Access Cover

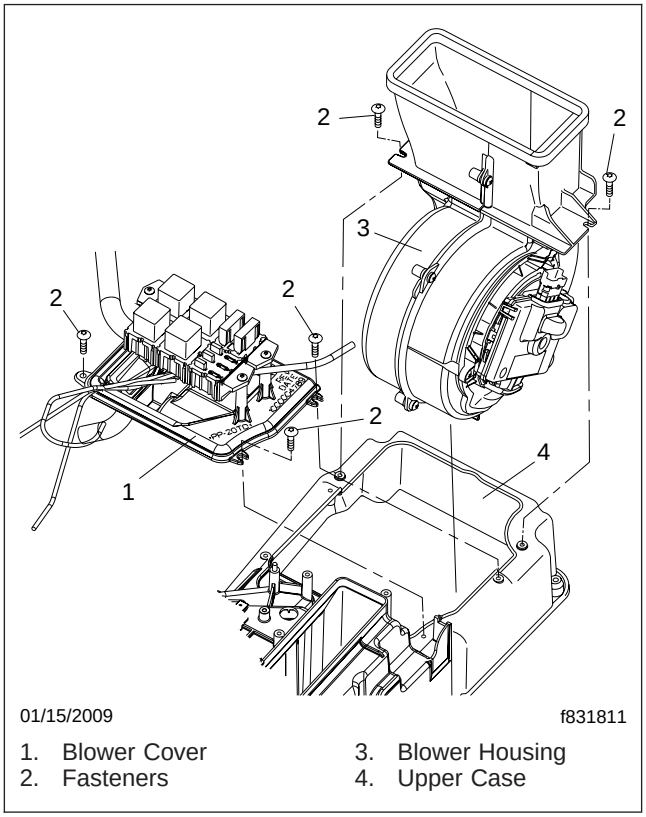
33. Orient the "guide ear" on the heater core, and slide the heater core in the new housing. Install the heater core cover.
34. Partially insert the blower assembly into the main housing, connect the wiring harness, then complete the blower installation.

Refrigerant Service Loop Replacement



1. Compressor Access Cover
2. Connector
3. Connector
4. Cable to Compressor
5. Control Module
6. Fastener

Fig. 5, Control Module Installation (from July 2011)



1. Blower Cover
2. Fasteners
3. Blower Housing
4. Upper Case

Fig. 6, Blower Housing Removal

35. Install the fuse/relay panel, or unit control module, on the blower access cover.
36. Connect the wiring harness to the blend door motor.

NOTE: If it is necessary to improve door/motor alignment, the motor shaft can be slowly turned manually without damaging the motor internally.

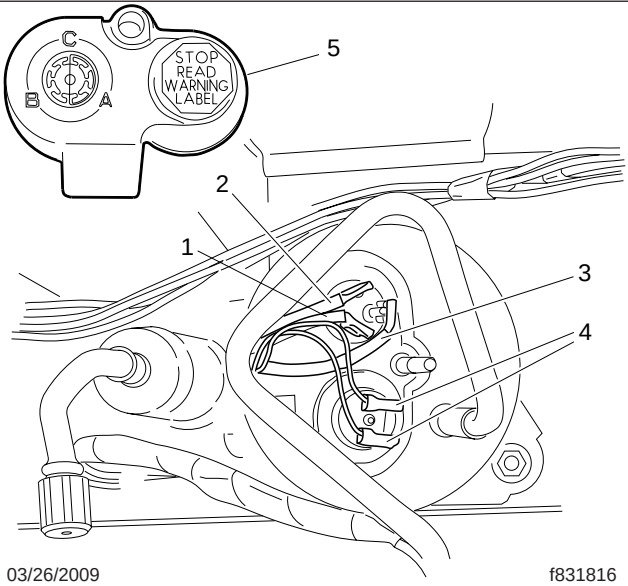
37. Position the blend door motor shaft in the drive socket on the blend door, then align the mounting holes and install the fasteners.
38. Install the evaporator temperature sensor.
39. Install the assembled unit in the vehicle following the instructions in **Subject 120**.

Split Unit Replacement

⚠ WARNING

The ParkSmart system uses a non-conductive compressor oil. Use only polyvinylether (PVE) refrigerant oil in this system. The refrigerant system has enough oil capacity to be recovered four times over the life of the unit. Oil should never need to be added, but if it does, the correct type must be used to prevent a dangerous electrical short from occurring in the compressor. When handling this oil, observe the following guidelines.

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the oil container to air for more than five minutes. The oil has a high moisture absorption capacity and the oil container should be sealed immediately after each use.



1. Blue Wire (position A)
2. Orange Wire (position B)
3. Yellow Wire (position C)
4. Black Wires, Temperature Sensor
5. Connector Cap

Fig. 7, Compressor Wire Connections

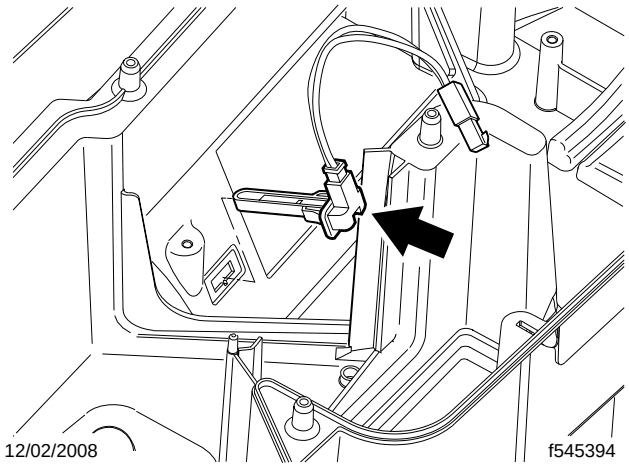
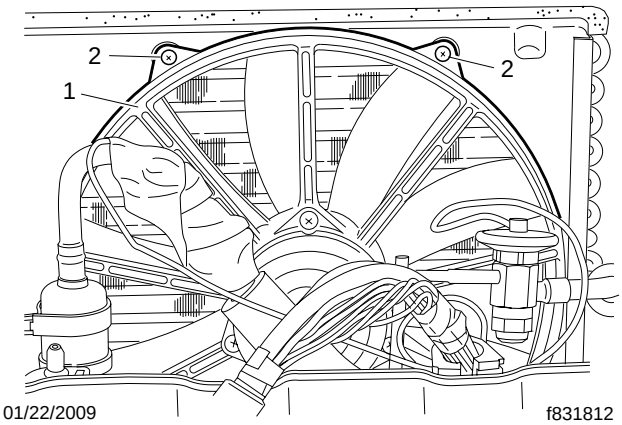


Fig. 8, Ambient Air Temperature Sensor Installation

- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix PVE oil with other types of refrigerant oil.



1. Condenser Fan Assembly
2. Fasteners

Fig. 9, Condenser Fan Assembly Installation

Failure to follow these guidelines could lead to component damage or severe electrical shock to anyone touching the system components.

Transfer the following components from the original unit to the new unit.

- main harness
- heater core
- blower motor assembly
- blend door
- blend door actuator
- controller and harness (if not being replaced)
- evaporator temperature sensor

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Recover the refrigerant from the system following the instructions in **Subject 250**.
3. Disconnect the starting batteries at the negative cables.
4. Disconnect the parked HVAC batteries at the negative cables.
5. Remove the ParkSmart unit from the vehicle following the directions in **Subject 120**.

Refrigerant Service Loop Replacement

NOTE: A work surface with cutouts to accommodate the two units makes this procedure much faster and helps prevent tipping the unit.

6. Place the two units side-by-side on a suitable workbench.
7. Cut the zip ties and remove the top of the replacement unit.
8. Remove the evaporator temperature sensor. See **Fig. 1**, Item 8. Leave the sensor attached to the harness.
9. Remove the fasteners, and lift off the blend door motor. See **Fig. 2**.
10. Disconnect the wiring harness.
11. Remove the unit control module and blower cover as a unit. See **Fig. 6**.
12. Unplug the harness connection to the unit control module.
13. Remove the wire harness clamps that hold the harness as it routes around the top case, and disconnect the three harness plugs.
14. Remove the unit control module and blower access cover. See **Fig. 4**.
15. Remove the blower housing fasteners, then lift the blower assembly up, and unplug the wiring harness connector. See **Fig. 6**.
16. Remove the upper case.
17. Remove the heater core from the old unit.

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. 7** for wire positions.

18. Remove the connector cap from the compressor, and disconnect the wires to the motor and temperature sensor.
19. Connect the wires from the controller to the compressor motor and temperature sensor. See **Fig. 7**. Install the cap.
20. Remove the blend door from the old unit and position it in the new unit.

NOTE: Be sure to align the blend door when installing the top half of the case.

21. Install the upper case of the new unit.

NOTICE

Make sure the "guide ear" on the heater core is properly aligned. Do not force the heater core into the housing. Forcing an improperly aligned heater core into the housing will break the "guide ear," and may cause the heater core to leak. It may be necessary to manipulate the core from both inside and outside the vehicle to get it into place without damaging it.

22. Orient the "guide ear" on the heater core, and slide the heater core in the new housing. Install the heater core cover.
23. Partially insert the blower assembly into the main housing, connect the wiring harness, then complete the blower installation.
24. Install the unit control module, with the blower access cover. See **Fig. 5**.
25. Connect the wiring harness to the blend door motor.

NOTE: If it is necessary to improve door/motor alignment, the motor shaft can be slowly turned manually without damaging the motor internally.

26. Position the blend door motor shaft in the drive socket on the blend door, then align the mounting holes and install the fasteners.
27. Install the evaporator temperature sensor.
28. Install the assembled unit in the vehicle following the instructions in **Subject 120**.
29. Evacuate and charge the system following the instructions in **Subject 250**.

Specifications

Coolant Heater Operation									
Component	Operating Mode								
	Starting Phase					Running Phase	Shutdown Phase		
	Initial Attempt			2nd Attempt (if Required)		Controlled Heating	After Glow	Cool Down	OFF or Stand-By
	System Check	Pre-Heat	Ignition	Pre-Heat	Ignition				
Water Pump	Off	On	On	On	On	On	On	On	Off On if in Stand-By
Blower	On Momentarily	On	On	Off	On	On	On	On	Off
Glow Pin	Off	On	On	On	On	Off	On	Off	Off
Fuel Pump	Off	Off	On	Off	On	On	Off	Off	Off
Time	1–3 sec	40 sec	Up to 80 sec	40 sec	Up to 80 sec	Continuous	20 sec	2.5 min	—
	High/Low Operation (until switched off manually or automatically)								

Table 1, Coolant Heater Operation

Refrigerant Line Fitting Torque Values	
Fitting	**Torque**
#6 A/C O-Ring Joint	20 to 25 lbf·ft (27 to 34 N·m)
#8 A/C O-Ring Joint	30 to 35 lbf·ft (14 to 47 N·m)
M8 Fastener, Block Joint	14 to 16 Lb·ft. (19 to 22 N·m)

Table 2, Refrigerant Line Fitting Torque Values

Return Water Manifold or HT2 Line Removal and Installation

Removal

Refer to **Fig. 1** for this procedure.

NOTICE

Proper alignment, and tightening sequence, of the water heater manifold and the HT2 line is required. Incorrect installation of these parts will put stress on the HT2 line that may cause it to fail.

1. Shut down the engine, set the parking brakes, and chock the wheels.
2. Open the hood.

⚠ 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.

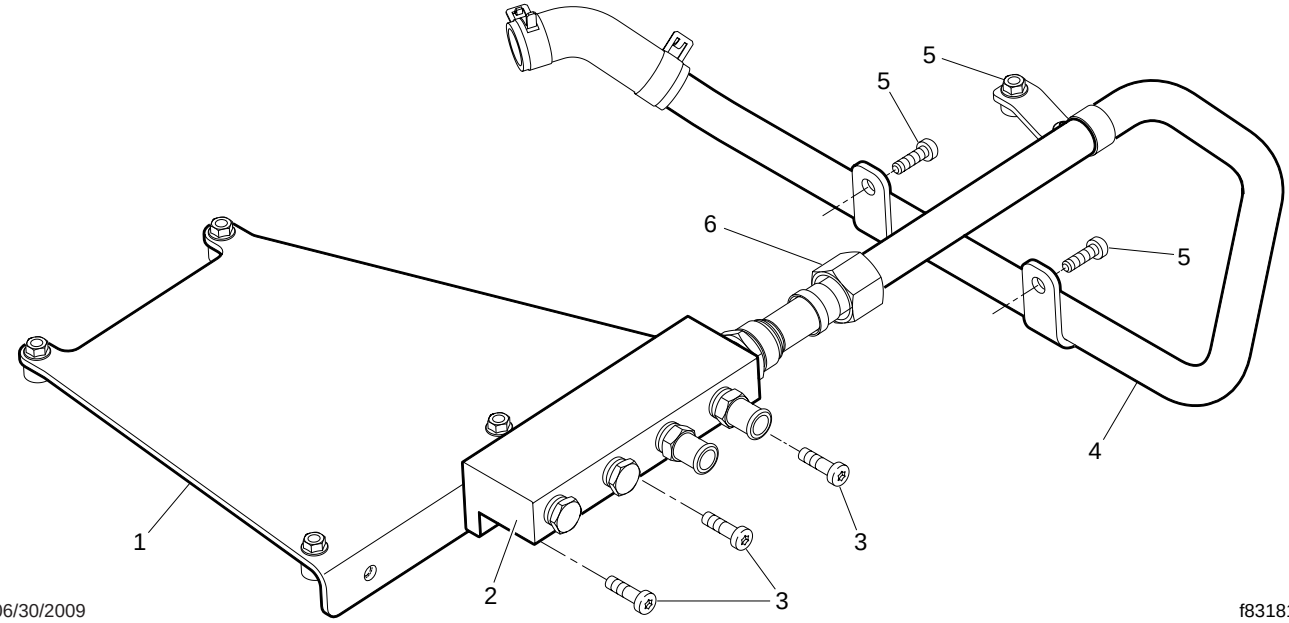
Be very careful when venting or opening the cooling system, and use appropriate protective gear.

3. Drain the coolant from the cooling system enough to bring the coolant level below the parts to be removed. For instructions, see **Group 20** of the *Cascadia Workshop Manual*.
4. Using a backup wrench to hold the manifold fitting, disconnect the HT2 line from the manifold.
5. If the manifold is being removed, mark and disconnect any hoses as needed.
6. Loosen the manifold mounting bolts.
7. Remove the part(s) to be replaced.

Installation

1. If removed, install the manifold on the mounting bracket. Do not tighten at this time; leave the fasteners just loose enough to allow forward and backward movement. Slide the manifold backward.
2. If removed, install the HT2 line. Tighten the fasteners 11 to 15 lbf·ft (15 to 20 N·m).
3. Slide the manifold into position to match with the HT2 line. When properly assembled, the HT2 line will seat squarely against the manifold fitting in all directions. If the two halves cannot align properly before the installation of the HT2 line nut, adjust the line and/or manifold mounting bracket to ensure a proper "dry" fit, before installing the line nut.
4. Hand-start the HT2 line nut to the manifold, then, using proper tools, tighten it securely.
5. Tighten the manifold fasteners 11 to 15 lbf·ft (15 to 20 N·m).
6. Connect any hoses that were disconnected.
7. Add coolant as needed.
8. Start the engine and check for leaks. Repair as needed.
9. Close the hood.

Return Water Manifold or HT2 Line Removal and Installation



1. Manifold Mounting Bracket
2. Heater Return Manifold
3. Manifold Mounting Fasteners
4. HT2 Line
5. HT2 Line Fasteners
6. HT2 Line Nut

Fig. 1, Heater Return Manifold and HT2 Line Installation

General Information

The compressor compresses low-temperature, low-pressure gas refrigerant gasified in the evaporator, into high-temperature, high-pressure gas refrigerant. The compressor then sends the refrigerant to the condenser.

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, and charged. 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 more than 30 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 (drive belts)
- **never** mix PAG oil with other types of refrigerant oil

⚠ 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.

Pre-Service Checks

NOTE: Compressor problems usually show in one of four ways: abnormal noise, seizure, leakage, or low discharge pressure. 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.

1. Check the drive belt and mounting:
   - 1.1 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.
   - 1.2 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.
   - 1.3 Check the tension of the compressor drive belt. See the drive belt section in **Group 01** for instructions.
2. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
3. 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.

NOTE: For other possible causes of air conditioner problems, see **C02.01** in the *Cascadia™ Troubleshooting Manual*, *Heater and Air Conditioner Troubleshooting* and the applicable fan clutch section in **Group 20**.

Refrigerant Compressor Removal and Installation

⚠ 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.

Removal

1. Apply the parking brakes, and chock the tires.
2. Raise the hood.
3. Begin recovery of the refrigerant from the air conditioning system; for instructions, see **Section 83.00, Subject 220**.
4. Turn off the engine.
5. Remove the drive belt. Do not pry or roll the belt off the pulleys. See the drive belt section in **Group 01** for instructions.
6. Disconnect the wiring harness from the compressor.

NOTICE

Under no circumstances should the ports on the compressor or 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).

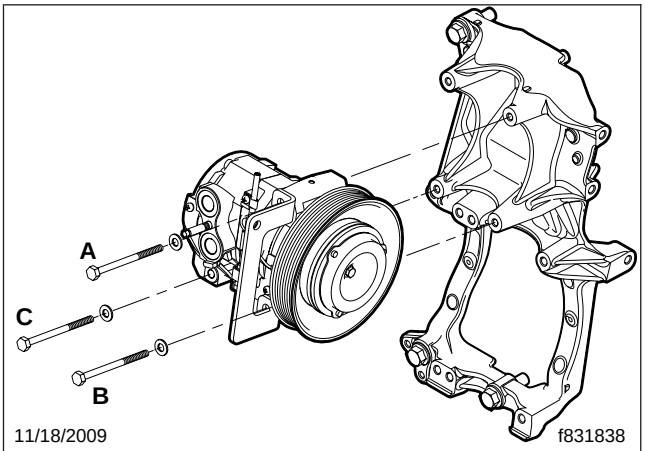
7. After the refrigerant has been fully recovered, remove the capscrews that attach the refrigerant lines and retaining plate(s) to the compressor. Remove the refrigerant lines and the retaining plates. Remove and discard the Mini Stat-O-Seals. Cap the discharge and suction ports and the refrigerant lines.
8. Being careful not to spill any refrigerant oil, remove the capscrews and washers that attach the refrigerant compressor to the engine, and remove the compressor.

Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. The oil quantity is printed on a label attached to the compressor.

When installing a new compressor on the vehicle, gently release the nitrogen gas from the discharge side of the compressor.

1. Adjust the refrigerant oil level in the compressor; for instructions, see **Subject 130**.
2. Position the compressor on the mounting bracket and install the capscrews and washers. Tighten 15 to 19 lbf·ft (21 to 26 N·m) in the sequence shown in **Fig. 1**.



Tighten A, then B, then C.

A. Front Top
B. Front Bottom
C. Rear

Fig. 1, Tightening Sequence (typical installation shown)

3. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
4. Install new Mini Stat-O-Seals on the refrigerant lines.
5. Attach the refrigerant lines to the compressor. Tighten the capscrew 14 to 16 lbf·ft (19 to 22 N·m).
6. Connect the wiring harness to the compressor.
7. Install the drive belt.
8. If installing a new compressor, or if the system was without any refrigerant pressure before repairs were started, replace the receiver-drier; for instructions, see **Section 83.00, Subject 120**.

Refrigerant Compressor Removal and Installation

9. Evacuate, charge, and leak test the refrigerant system; for instructions, see **Section 83.00, Subject 220**.
10. Return the hood to the operating position.

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

Denso compressors require ND-8 PAG refrigerant oil. When the air conditioning system is operating, refrigerant oil can leave the compressor and circulate 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 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. 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.

Order Denso PAG oil (ND-8OIL, P/N DII LA446963 0040) from your local Freightliner parts distribution center, it is the only acceptable oil to use in a system with a Denso compressor.

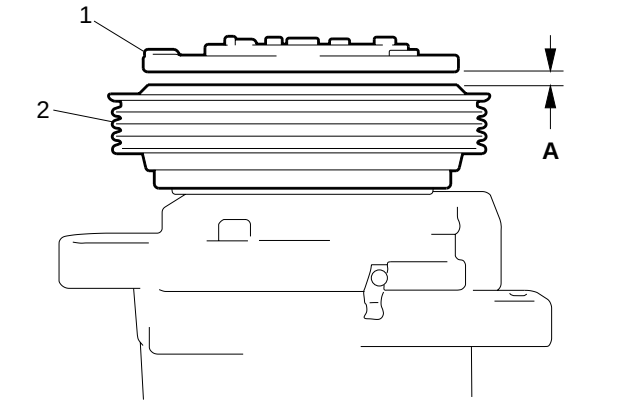
Denso Total System Oil Volume

Denso refrigerant compressors are supplied with approximately 4.5 oz. of ND-8 oil, but the vehicle configuration affects the total charge volume. If a complete new oil charge is required, the amount will be determined by the volume stated in the new compressor literature, and the volume listed in PartsPro. The two amounts will be combined to give the total oil charge required. If a complete new oil charge is not required, use the oil balancing info in **Section 83.00, Subject 220**.

Clutch Assembly Removal, Inspection, and Installation

IMPORTANT: The clutch should be replaced if it is worn.

Before replacing the clutch, check the air gap at three equally spaced points around the perimeter. The air gap should be at least 0.014 in (0.35 mm), and no greater than 0.024 inch (0.60 mm). The gap must be greater than 0.024 inch (0.60 mm) at all three points for the clutch to need replacing. See **Fig. 1**.



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Check at three equally spaced points.
A. 0.014 to 0.024 in (0.35 to 0.60 mm)
1. Hub Sub-Assembly
2. Magnetic Clutch

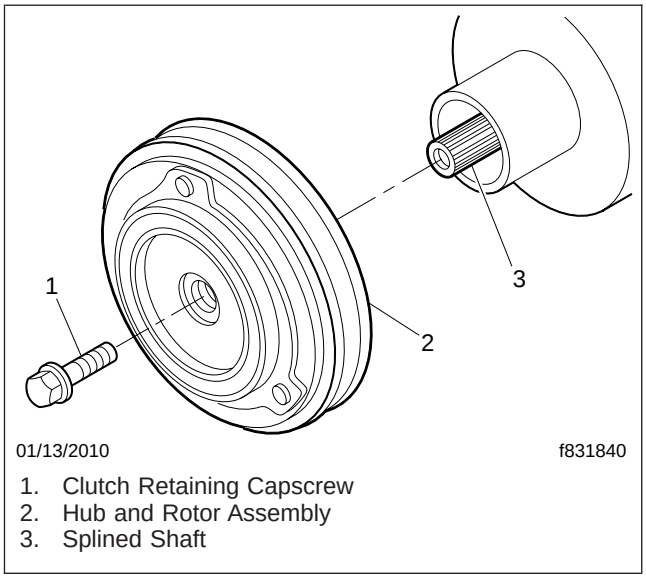
Fig. 1, Checking the Clutch Clearance

Removal

NOTE: The hub is secured with a bolt (splined shaft is used for connection with compressor).

1. Remove the compressor from the vehicle. For instructions, see **Subject 110**.
2. Remove the clutch retaining capscrew from the compressor shaft. See **Fig. 2**.
3. Remove the shims from the pressure plate.
   NOTE: Save the air gap shims for reassembly.

NOTE: If the rotor cannot be removed easily, tap the rotor lightly with a plastic hammer, then remove it from the compressor shaft being careful not to damage the pulley when tapping on the rotor.



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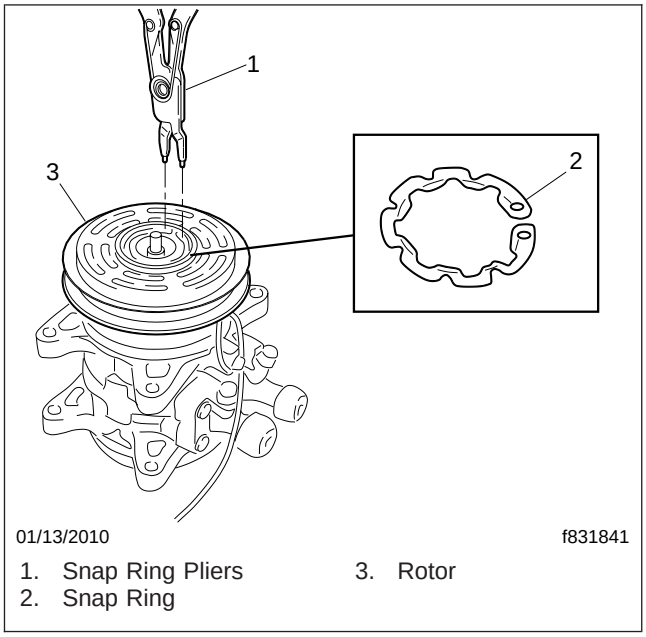
1. Clutch Retaining Capscrew
2. Hub and Rotor Assembly
3. Splined Shaft

Fig. 2, Removing the Retaining Capscrew

4. Using snap ring pliers, remove the snap ring, then remove the rotor. Discard the snap ring. See **Fig. 3**.



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1. Snap Ring Pliers
2. Snap Ring
3. Rotor

Fig. 3, Rotor Removal

5. Using snap ring pliers, remove the snap ring, then remove the stator. Discard the snap ring. See **Fig. 4**.

Clutch Assembly Removal, Inspection, and Installation

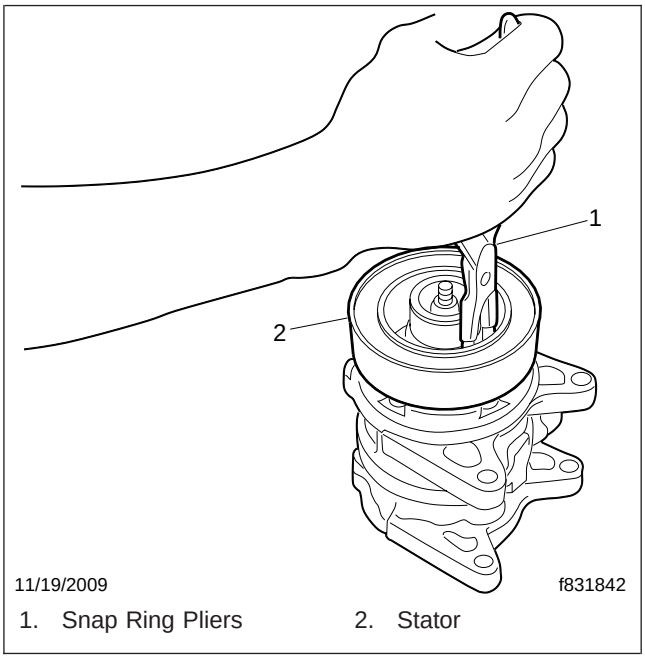


Fig. 4, Stator Removal

Inspection

After the magnetic clutch is disassembled, inspect each component and decide whether they can be reused. Refer to **Table 1** for clutch inspection and recommended action.

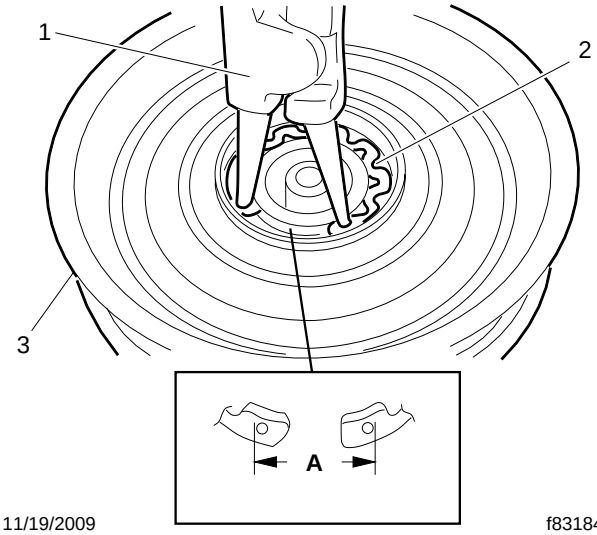
Magnetic Clutch Inspection		
Part Name	**Check Point and Expected Damage**	**Action**
Hub	Dislocation or peeling of rubber.	Replace or Repair
	Roughness, burn, rust, slip or extreme wear on mating surface.	Replace
Rotor	Play, unusual sound, rust, insufficient grease or seizure of bearing.	
	Roughness, burn, rust, slip or extreme wear on mating surface.	
Stator	Burn, wire breakage or layer short circuit of stator coil. Resistance of stator coil at 68°F (20°C) should be 2.8 to 3.2 ohms.	
	Damage of deformation of rotor (pulley) groove(s).	

Table 1, Magnetic Clutch Inspection

Installation

NOTICE

Excessive opening of the snap rings may weaken the fixing force of the snap ring. Maximum allowed opening must not exceed 1.2 in (30.9 mm). See Fig. 5.



A. Do not exceed 1.2 in (30.9 mm).

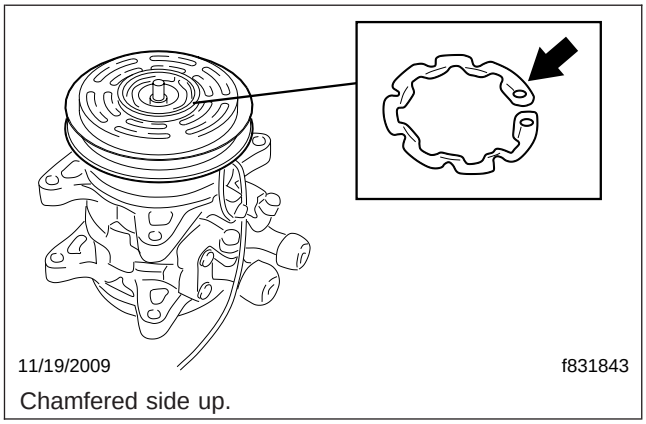
1. Snap Ring Pliers
2. Snap Ring
3. Rotor

Fig. 5, Snap Ring Installation

1. Align the stator to the compressor housing by positioning the index pin into its indexing hole/slot.

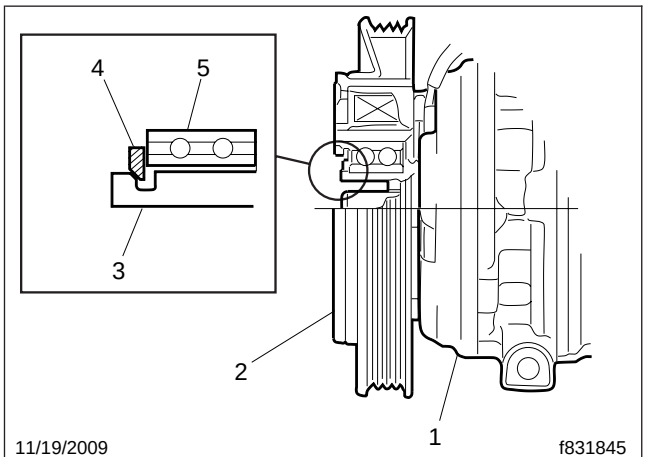
IMPORTANT: The snap ring must be installed with the chamfered side facing up. See **Fig. 6**.

2. Secure the stator with a new snap ring. Make sure the snap ring is fully seated. See **Fig. 7**.
3. Install the rotor on the compressor and secure it with a new snap ring.
4. Temporarily install the hub to verify the gap clearance. See **Fig. 1**.
5. Check the air gap. The air gap between the hub and rotor should be 0.014 to 0.024 in (0.35 to 0.60 mm). Check the clearance at 3 locations.



Chamfered side up.

Fig. 6, Snap Ring Installation



1. Compressor
2. Clutch Assembly
3. Compressor Shaft
4. Snap Ring
5. Bearing

Fig. 7, Seating the Snap Ring

6. Set the air gap clearance between the pressure plate and rotor by adding or removing compressor shaft shims so that the air gap clearance is within the specified range and distance.
7. Install the clutch retaining capscrew in the compressor shaft. Tighten 15 to 19 lbf·ft (21 to 26 N·m).
8. After the clutch is assembled, turn the rotor by hand to verify it does not contact either the pressure plate or stator.

Specifications

Special tools can be purchased from the following independent suppliers:

Classic Tool Design
31 Walnut St.
New Windsor, NY 12553
845-562-8700

Mastercool USA Inc.
One Aspen Drive
Randolph, NJ 07869
(973) 252-9119

Torque Values		
Description	**Torque**	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Compressor Mounting Fasteners	—	15–19 (21–26)
Clutch Retaining Capscrew	—	22 (30)
Clutch Lead Wire Clamp Screw	132 (1500)	—

Table 1, Torque Values

General Information

The Cascadia hood is made of fiberglass using the SMC process. The hood is composed of three hood panels, several reinforcing members (also made of SMC) bonded to the engine side of the hood, a steel front crossmember, and aluminum front brackets. The front grille is made of injection-molded plastic.

A handle for hood tilting is mounted in a recess in the hood, above the grille.

SMC Process

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.

Hood Mounting and Components

The front of the hood assembly is mounted on a pivot bracket. The hood pivot and tilt-assist mechanisms allow the hood to be tilted forward for vehicle service.

In the closed position, the rear of the hood is supported by brackets attached to the cab front wall. The hood rear support brackets hold the hood in the correct position for operation. The rear of the hood is held in place with latches, one on each side.

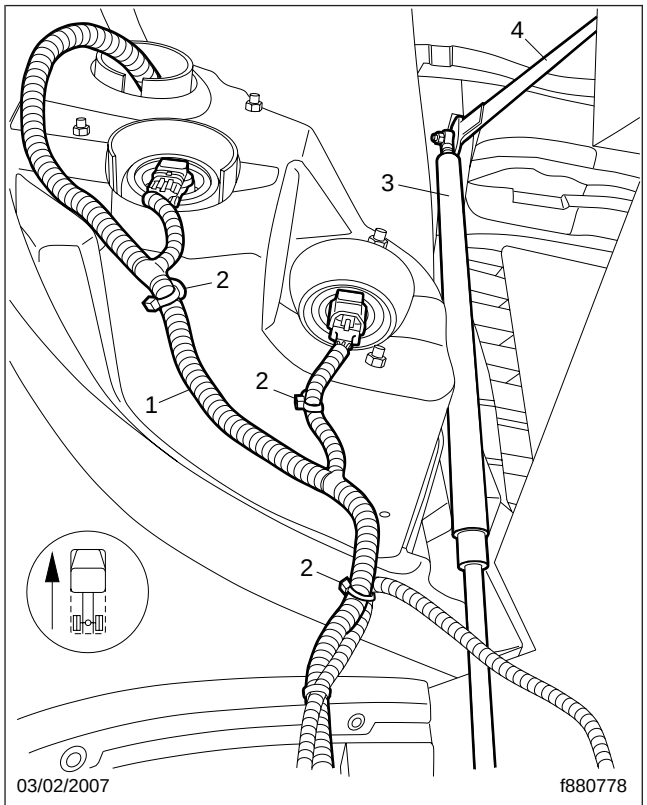
The chrome-plated plastic grille is attached to the hood with four spring clips on the top and four fasteners at the lower front.

The hood is equipped with a headlight assembly on each fender, and hood-mounted auxiliary mirrors.

Hood Removal, Installation, and Adjustment

Removal

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Remove the grille; see **Subject 110**.
3. Remove the bumper; see **Section 31.02, Subject 100**.
4. Open the hood.
5. Disconnect the headlight wiring from both sides of the hood. Pull loose the tie clips that hold the wiring harness against the inside of the hood; see **Fig. 1**.

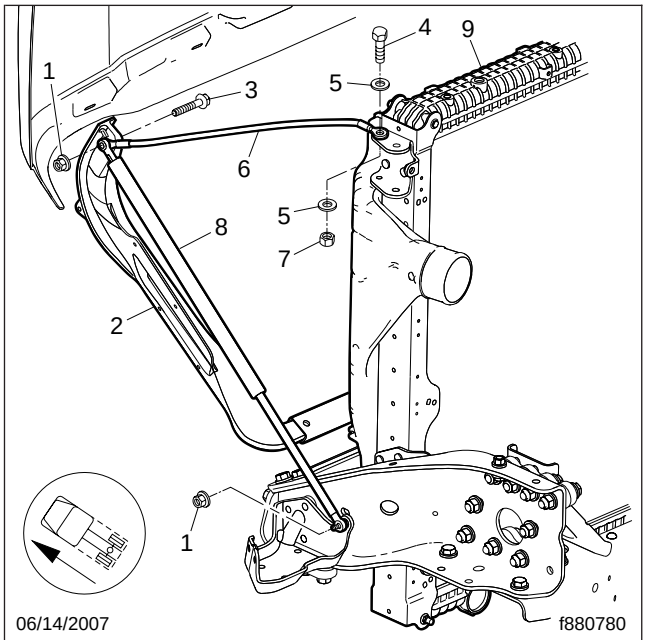


NOTE: Left-hand wiring shown.

1. Headlight Wiring Harness
2. Tie Clip
3. Tilt-Assist Strut
4. Hood Check Strap

Fig. 1, Headlight Wiring Harness

6. On each side of the hood, remove the hood tilt-assist strut by removing the nuts that attach it to the hood pivot bracket and the bumper bracket; see **Fig. 2**.



NOTE: Left-hand side shown. Some hood structure omitted for clarity.

1. Flange Nut, M8 x 1.25
2. Hood Pivot Bracket
3. Flange Bolt, M8 x 1.25
4. Bolt, 3/8–16
5. Washer
6. Check Strap
7. Nut, 3/8–16
8. Tilt-Assist Strut
9. Radiator

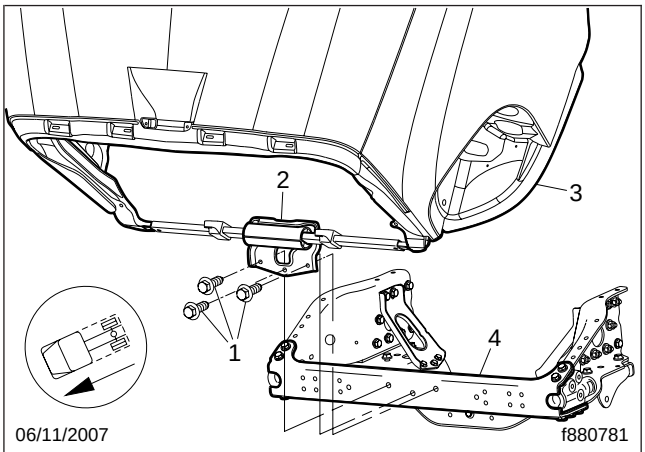
Fig. 2, Hood Tilt-Assist Strut and Check Strap Installation

NOTICE

Do not allow the hood to tilt past the normal full-open position with the hood check straps and tilt-assist struts disconnected. Doing so could break the hood pivot brackets.

7. With an assistant supporting the hood in a less than full-tilt position, disconnect the hood check straps by removing the fasteners that attach them to the radiator; see **Fig. 2**.
8. Close, but do not latch, the hood.
9. Remove the three capscrews that attach the hood hinge assembly to the front crossmember; see **Fig. 3**.

Hood Removal, Installation, and Adjustment



1. Capscrew, 1/2–13 x 1.25
2. Hood Hinge Assembly
3. Hood
4. Front Closing Crossmember

Fig. 3, Hood Pivot Installation

10. With the help of assistants, lift the hood off the vehicle, then set it on blocks supporting the front pivot and rear supports. Make sure the exterior surface of the hood does not touch the floor, and take care not to damage the splash shields.

Installation

1. With the tires chocked, and with the help of assistants, lift the hood into place on the vehicle, making sure that the hood rear supports rest in the hood support sockets.
2. Attach the hood hinge assembly to the front crossmember with the three capscrews; see **Fig. 3**.

NOTICE

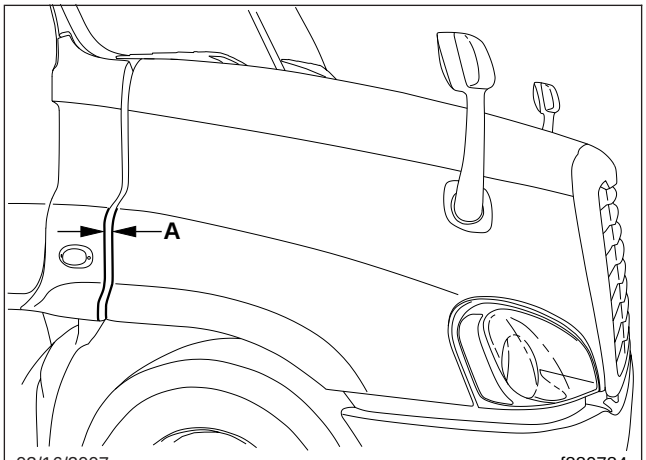
Do not allow the hood to tilt past the normal full-open position with the hood check straps and tilt-assist struts disconnected. Doing so could break the hood pivot brackets.

3. Open the hood to a less than full-tilt position, and support it in place while connecting the two hood check straps to the brackets on the radiator; see **Fig. 2**.
4. Attach the two hood tilt-assist struts to the hood pivot brackets and the bumper brackets. Secure both ends of each strut with the fasteners; see **Fig. 2**.
5. Connect the headlight wiring on both sides of the hood. Use new tie clips to secure the harnesses to the inside of the hood; see **Fig. 1**.
6. Close and latch the hood.
7. Install the bumper; see **Section 31.02, Subject 100**.
8. Install the grille; see **Subject 110**.

Adjustment

NOTE: If the vehicle has had damage to the chassis, the frame must be straightened before adjusting the hood.

Determine whether hood adjustment is necessary. With the hood in the operating position and the hood latches latched, the seam between the hood top and side panels should match the upper bend line on the cowl side panel. The clearance between the hood and the cowl side panel should be within the range specified in **Fig. 4**. If necessary, adjust the hood, as follows.



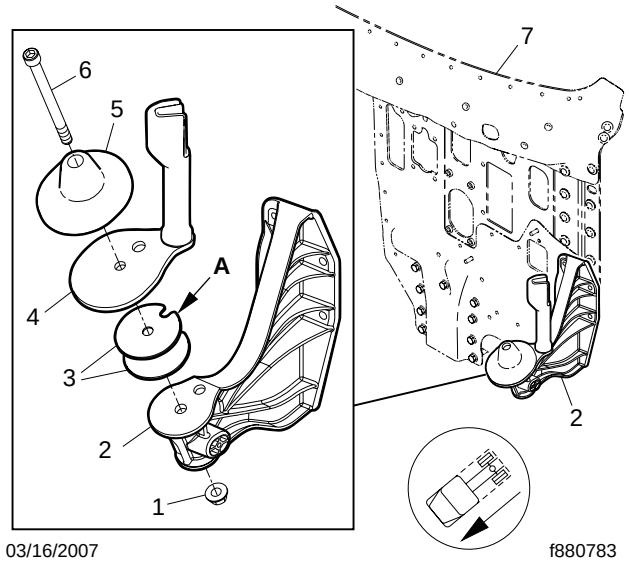
A. Measurement = 7/8 in (22 mm); Range = 13/16 to 1-1/16 in (20 to 27 mm)

Fig. 4, Hood-to-Cowl Panel Clearance

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. Open the hood.
3. If the hood needs to be vertically adjusted, add or subtract shims at the hood rear support; see **Fig. 5**.



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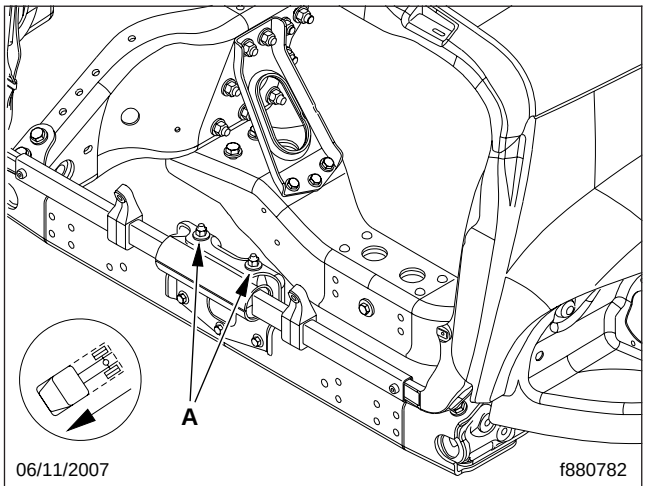
A. Add or subtract shims to adjust hood height.

1. Flanged Nut
2. Hood Rear Support Bracket
3. Shims
4. Hood Latch Hold-Down
5. Isolator/Locator
6. Bolt
7. Cab Front Wall

Fig. 5, Hood Rear Support

4. If the hood needs to be moved forward or backward, loosen the fasteners that attach the hood pivot bracket to the hood hinge; see **Fig. 6**. Move the hood forward or back as needed, and tighten the fasteners.



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A. Loosen the hood pivot attachment fasteners, and slide the hood forward or backward as needed.

Fig. 6, Hood Adjustment at Hood Pivot

Removal

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Remove the four fasteners that attach the grille to the hood; see **Fig. 1**.

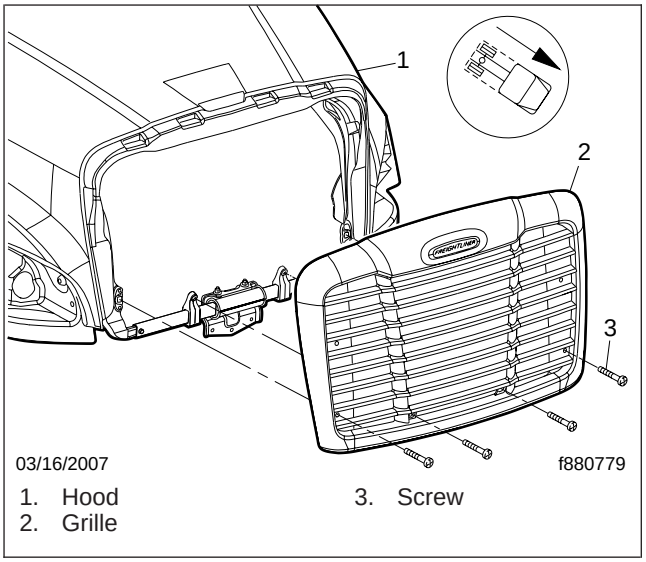


Fig. 1, Grille Installation

3. Lift the grille up to disengage the four spring clips, and to loosen the double-sided tape under the top lip of the grille.
4. If the grille is to be reinstalled, remove the double-sided tape under the top lip.

Installation

1. With the tires chocked, clean and dry the hood surface area to be 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.

   If the original grille is being reinstalled, clean the surface under the top lip of the grille, using rubbing alcohol. After drying the surface, affix a piece of double-sided tape to it.
3. Position the grille in place, fitting the spring clips into the holes along the top edge of the hood.
4. Attach the grille to the hood with the four fasteners; see **Fig. 1**.
5. Apply firm pressure to the top of the grille over the adhesive strip to ensure good adhesion.
6. Remove the chocks.

Hood Repair Safety Precautions

Safety Precautions

⚠ WARNING

Before performing any fiberglass repairs, read and comply with the following warnings and precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

- 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 repair material contacting your eyes. If repair material contacts eyes, rinse with plenty of water (15 minutes), and call a doctor.
- Fiberglass repair materials can be skin irritants. Do not allow the materials to contact skin. Wear protective gloves made from the following recommended materials: butyl rubber, nitrile rubber, polyvinyl alcohol. If the repair material contacts skin, wash with soap and water.
- Some fiberglass repair materials are toxic. Perform repairs in a well ventilated area. If ventilation is not adequate, wear appropriate respiratory protection.
- Most of the materials involved in fiberglass repair and cleanup are flammable. Do not perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material.
- When grinding or sanding fiberglass surfaces, wear goggles or other protective eye shields, and appropriate respiratory protection. Do not breathe grinding dust or particles, otherwise irritation may occur.

Hood Repair

General Information

The Cascadia hood is an assembly of panels and reinforcing members bonded together with a structural adhesive; see **Fig. 1**.

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 120**. Observe any additional precautions given by the manufacturers of the repair materials used.

Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred for frequent use.

NOTE: Store fiberglass repair adhesives in a cool, dry, well ventilated area that is out of direct sunlight. 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.

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.

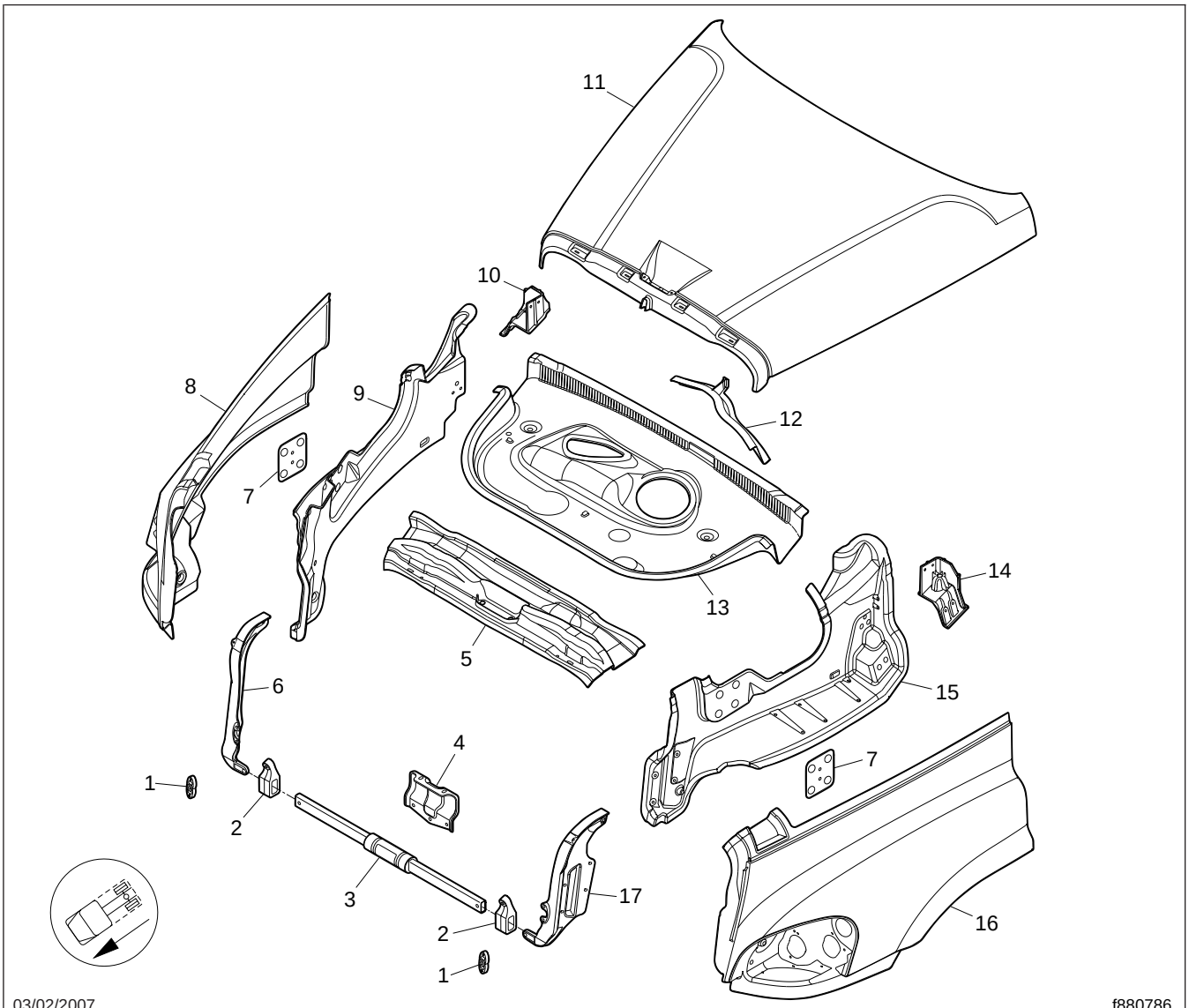
6. After the adhesive dries (about 35 minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with dry compressed shop air. Mask the area, then spot prime and paint it. Primer can be applied immediately 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

Hood Repair



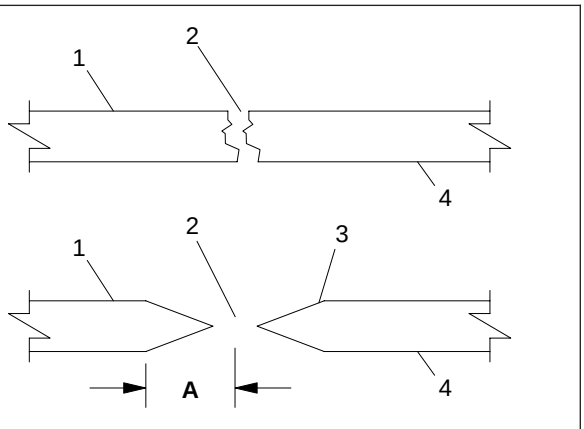
1. Grille Mounting Bracket
2. Crossbar Bracket
3. Pivot and Crossbar Assembly
4. Pivot Support Bracket
5. Top Panel Reinforcement
6. Hood Pivot Bracket, RH
7. Backing Plate, Hood-Mounted Mirror
8. Side Panel, RH
9. Side Reinforcement, RH
10. Hood Rear Support Socket, RH
11. Top Panel
12. Baffle, Hood Plenum
13. Reinforcement, Hood Plenum
14. Hood Rear Support Socket, LH
15. Side Reinforcement, LH
16. Side Panel, LH
17. Hood Pivot Bracket, LH

Fig. 1, Hood Assembly Components

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. 2**.



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. 2, Tapered Hole

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.
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 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.
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 Repair

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 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.

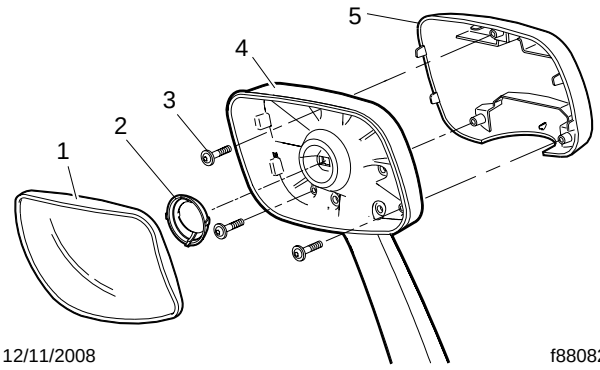
3M Adhesives Open Time			
3M Part Number	**Syringe Size**	**Open Time**	**Use**
08270	400 ml	1.5 min.	Minor crack repair and small part replacement
08271	400 ml	3.5 min.	Inner hood structure replacement
08267	600 ml	3.5 min.	Inner hood structure replacement
08277	400 ml	10.0 min.	Inside crack repair (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

Hood-Mounted Mirror Glass Replacement

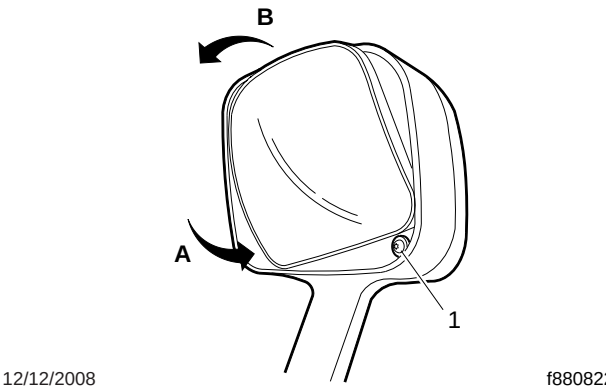
Replacement

1. Apply the parking brakes and chock the tires.
2. Open the hood so that the mirror reflective surface faces up.
3. Push in the bottom of the mirror glass and rotate it to one side to access one of the lower cover mounting screws; see **Fig. 1** and **Fig. 2**.



1. Mirror Glass Assembly
2. Middle Sphere
3. Screw, T20
4. Bezel and Arm
5. Back Cover

Fig. 1, Hood-Mounted Mirror Glass Installation



A. Push the bottom of mirror glass in.
B. Rotate the mirror glass to one side.

1. Cover Mounting Screw

Fig. 2, Accessing Back Cover Mounting Screws

4. Loosen the screw completely, but do not remove it from the hole.
5. Rotate the mirror glass in the opposite direction to expose the screw in the other corner. Loosen the screw, but do not remove it.
6. Push in the top of the mirror glass to expose the mounting screw at the top center of the mirror. Loosen the screw but do not remove it.
7. Remove the back cover, using care not to break the tabs on the rim.
8. While holding the mirror glass in place, use a pair of pliers to pull out on the locking tab at the back of the mirror, then rotate the tab 90 degrees in either direction to unlock the glass assembly; see **Fig. 3**. Remove the glass assembly, using care not to lose the middle sphere.

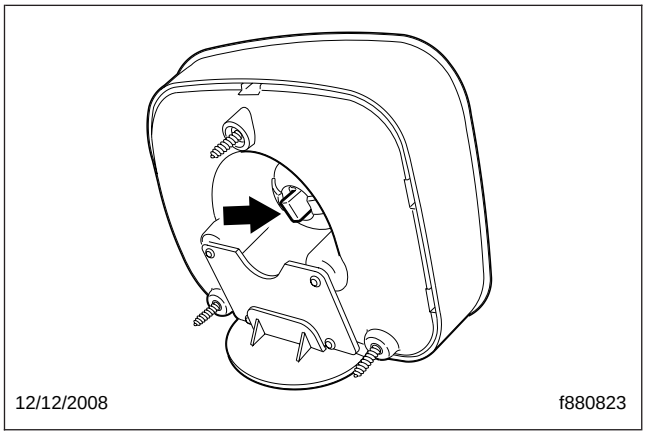


Fig. 3, Mirror Locking Tab

9. Place the middle sphere in the bezel, so that the middle sphere ribs engage in the bezel channels.
10. Position the new mirror glass assembly in place. From the back of the mirror, while holding the glass assembly in place, use a pair of pliers to pull outward on the locking tab, then rotate it 90 degrees in either direction to lock the glass assembly in place.
11. Install the back cover in place, then secure it with the three screws.

Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the grille; see **Subject 110**.
3. Lay the grille on a flat surface, with the front facing down.
4. Using wire cutters, cut the heads off the nylon retainers that attach the bug screen to the grille. See **Fig. 1**.

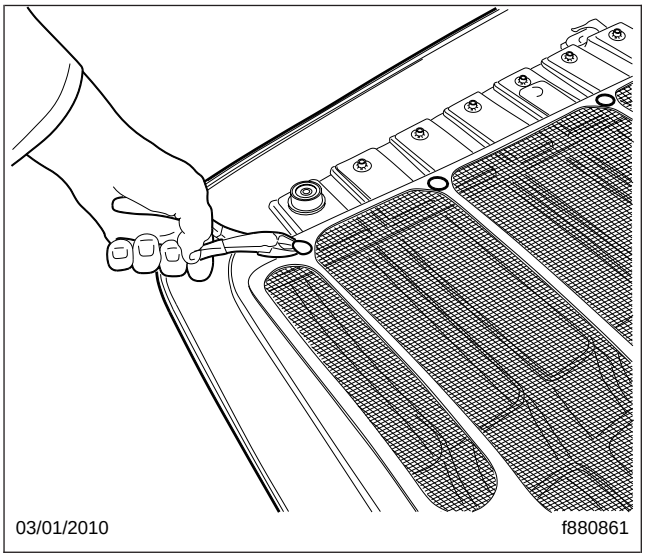


Fig. 1, Removing Nylon Retainers

5. Using a screwdriver, push the shanks of the retainers through the holes. Remove the bug screen.
6. Attach the new bugscreen to the grille with new nylon retainers.
7. Install the grille on the hood; see **Subject 110**.

Hood Pivot Bracket Replacement

General Information

Before performing any fiberglass repairs, read the precautions listed in **Subject 120**. Observe any additional precautions given by the manufacturers of the repair materials used.

Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred for frequent use.

NOTE: Store fiberglass repair adhesives in a cool, dry, well-ventilated area that is out of direct sunlight. 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.

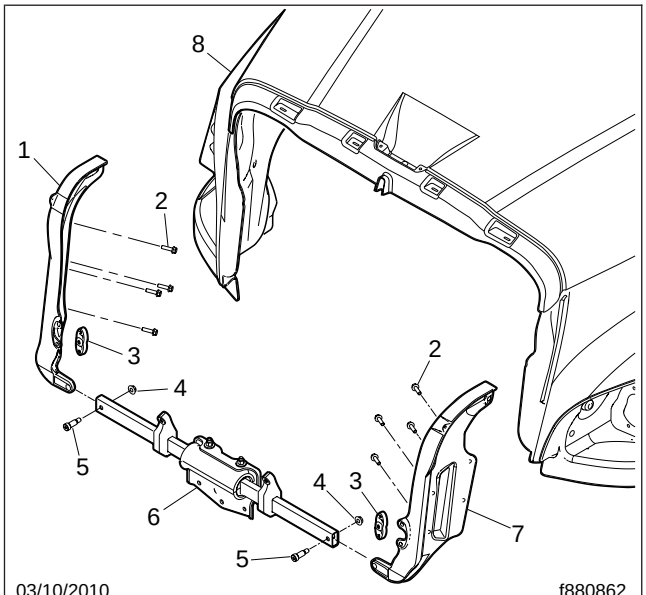
Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the hood; see **Subject 100**.
3. Place the hood upside down on a flat surface protected with cloth.
4. If still attached, remove the hood crossbar assembly from the pivot brackets. See **Fig. 1**.
5. Remove the grille mounting bracket (isolator) from the pivot bracket.
6. Remove the check strap from the pivot bracket.
7. Remove the four capscrews (if equipped) that attach the pivot bracket to the hood.
8. Using a torch, heat the part of the bracket that is attached to the hood. At 350°F (175°C) the adhesive will become soft. Pry the bracket loose from the hood. See **Fig. 2**.

NOTICE

Apply heat to the bracket only. Applying heat directly to the fiberglass hood panel may damage it.

9. While the adhesive is still soft, scrape it off the hood. See **Fig. 3**.
10. Clean the bonding surfaces with 3M™ General Purpose Adhesive Cleaner. Inspect the area closely to be sure all adhesive, dirt, water, grease, and oils are removed. See **Fig. 4**.



1. Hood Pivot Bracket, RH
2. Capscrew
3. Grille Mounting Bracket (Isolator)
4. Nut
5. Bolt
6. Hood Crossbar Assembly and Pivot
7. Hood Pivot Bracket, LH
8. Hood

Fig. 1, Hood Pivot Bracket Installation

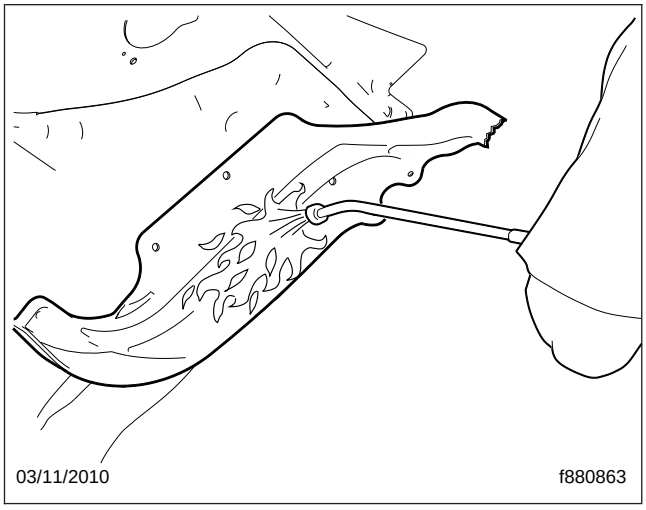


Fig. 2, Heating Pivot Bracket

Hood Pivot Bracket Replacement

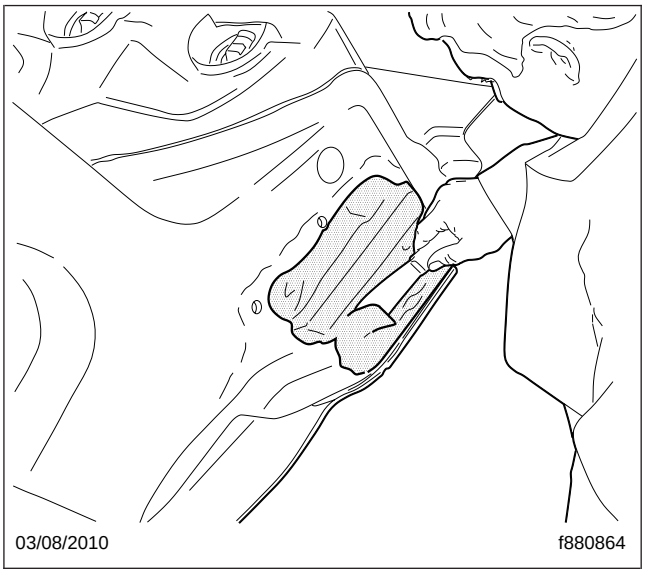
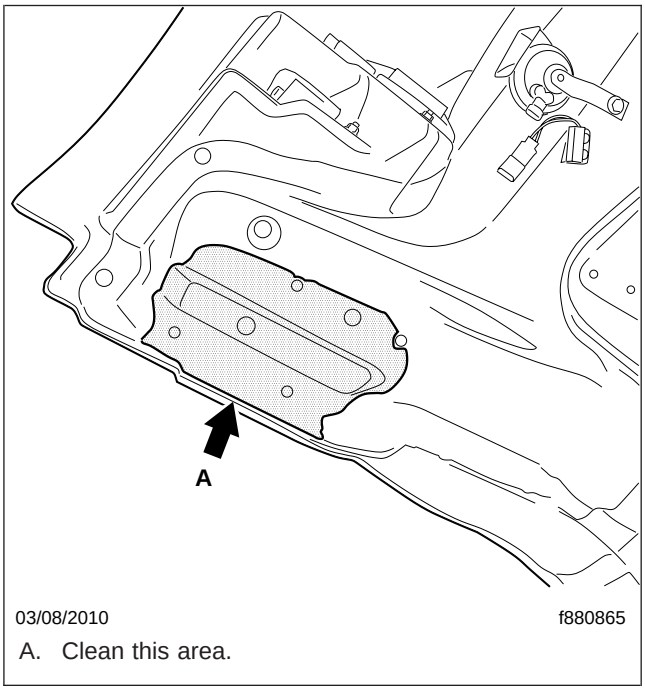


Fig. 3, Removing Old Adhesive



A. Clean this area.

Fig. 4, Bracket Contact Surface on Hood

11. Scuff the bonding surfaces of the hood and the pivot bracket with 80-grit sandpaper.
12. Blow off the sanding residue with clean compressed air. Do not wipe with solvent.
13. Before applying the adhesive, test fit the parts.
14. Apply 3M Automix™ 8273 Adhesive to the bonding area on the hood. See **Fig. 5**.

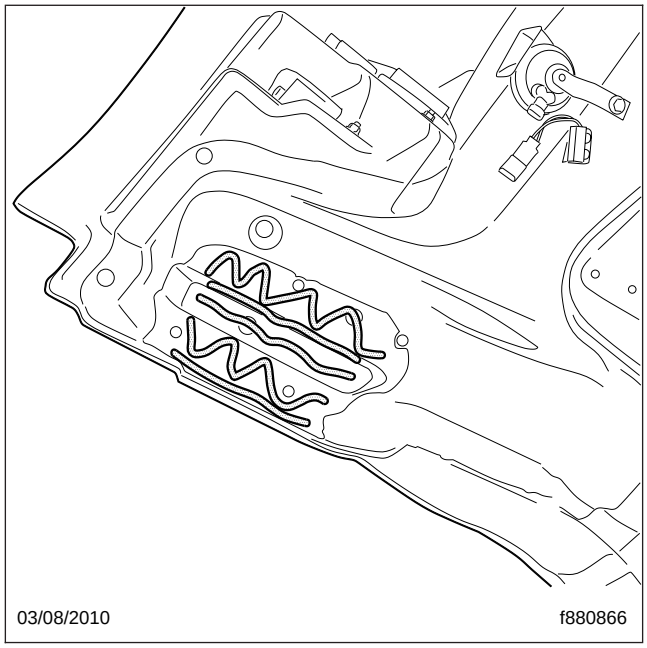


Fig. 5, Adhesive Application Pattern

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 are produced.

15. Position the pivot bracket in place, using the capscrews (if equipped) or dowels through the holes to locate the bracket accurately.
16. Tighten the capscrews (if equipped) or use clamps to secure the bracket against the hood until the adhesive has hardened.

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, use paper clips as spacers at several places to act as spacers.

17. If clamps were used, let the adhesive dry, as specified in the adhesive instructions, before removing the clamps.

18. Install the the grille mounting brackets (isolators) on the pivot brackets.
19. Install the check strap on the pivot bracket.
20. Install the pivot crossbar assembly on the pivot brackets.
21. Install the hood on the vehicle; see **Subject 100**.

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

Cab-Mounted Splash Shield Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the Torx screw and the washer that attach the cowl side panel to the cab-mounted splash shield; see **Fig. 1**.

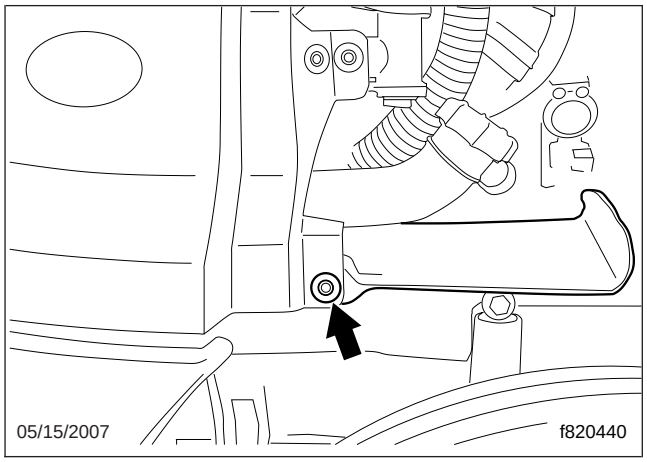


Fig. 1, Cowl Side Panel Torx Screw and Washer

4. From underneath the splash shield, remove the nut (**Fig. 2**, item 3) located on the inboard side of the splash shield; see **Fig. 3**.
5. Remove the two aft nuts (**Fig. 2**, item 2).
6. Remove the front wall stud nut (**Fig. 2**, item 1).

NOTICE

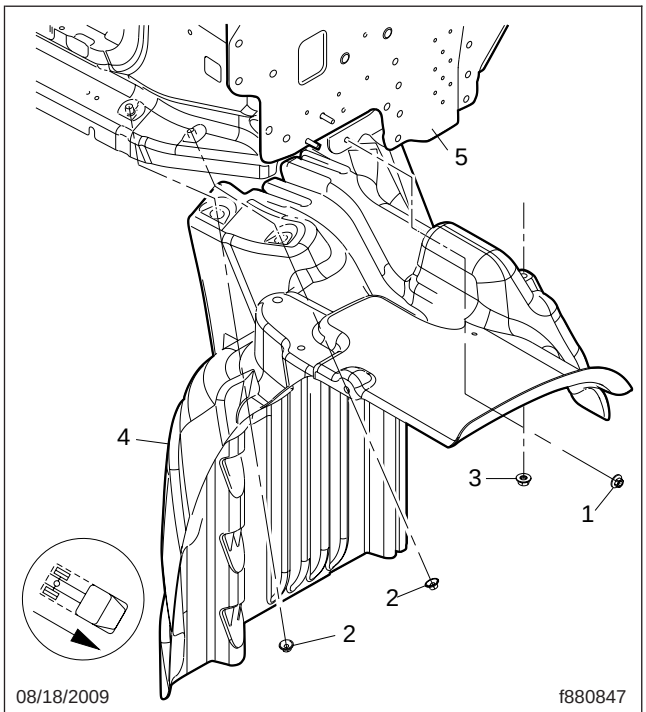
NOTICE: Use care to avoid damaging the rocker panel on the lower edge of the cab side when removing the splash shield.

7. Remove the splash shield by pulling it forward until it clears the rocker panel, then pull it to the side.

Installation

1. Hang the splash shield from the front wall stud. From underneath the splash shield install, but do not tighten, the front wall stud nut (**Fig. 2**, item 1).

NOTE: If the front wall stud nut is tightened first, installation of the other nuts creates stress on the splash shield when it is not allowed shift into the correct position.



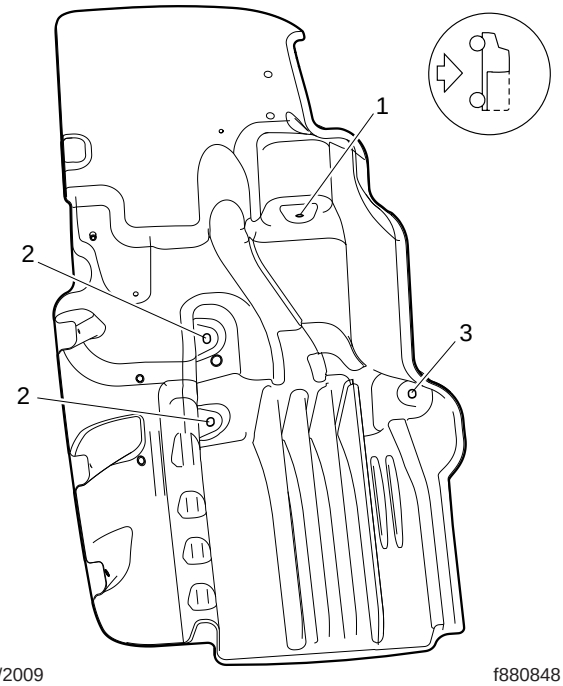
NOTE: RH shown, LH opposite.

1. Front Wall Stud Nut
2. Aft Nut
3. Inboard Nut
4. Splash Shield
5. Cab Front Wall

Fig. 2, Splash Shield Fasteners

2. Shift the splash shield to align the cab studs to the splash shield holes. Install the two aft nuts (**Fig. 2**, item 2) on the studs. Tighten the nuts 11 lbf·ft (15 N·m).
3. Install the inboard nut (**Fig. 2**, item 3) on the stud. Tighten the nuts 11 lbf·ft (15 N·m).
4. Tighten the front wall stud nut 11 lbf·ft (15 N·m)

Cab-Mounted Splash Shield Removal and Installation



NOTE: RH shown, LH opposite.

1. Front Wall Stud Nut
2. Aft Nut
3. Inboard Nut

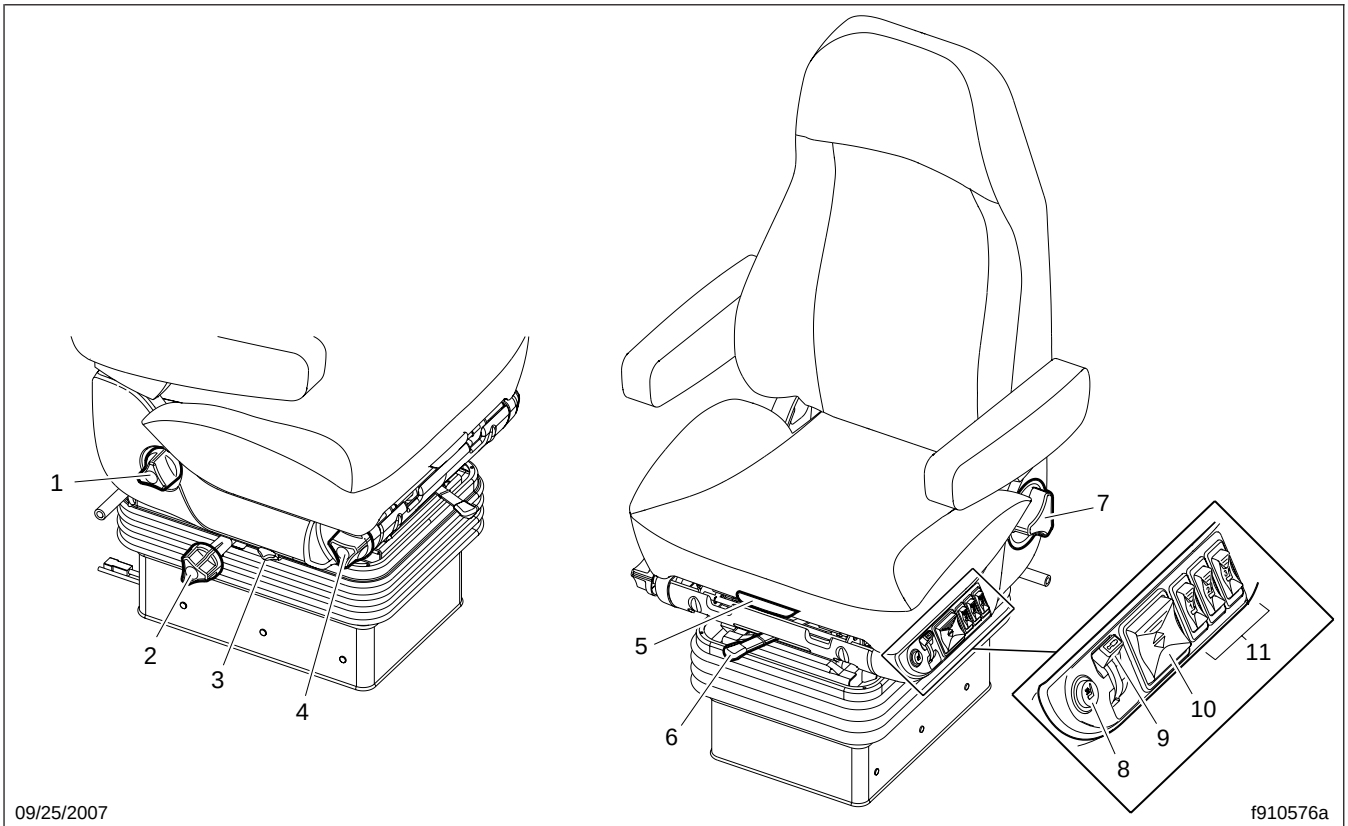
Fig. 3, Splash Shield Fastener Locations (view from underneath)

General Information

The Cascadia High-Back air suspension seat features height adjustment, fore and aft seat adjustment, back cushion tilt, lumbar support, bottom cushion front and rear height adjustments, cushion extension, swivel, heat, shock absorber adjustment, and an isolator; see **Fig. 1**. The air suspension adjustment features receive air from the vehicle air system. Pressure in the air suspension is controlled by the switches attached to the seat frame.

For seat adjustment operating instructions, see the *Cascadia Driver's Manual*.

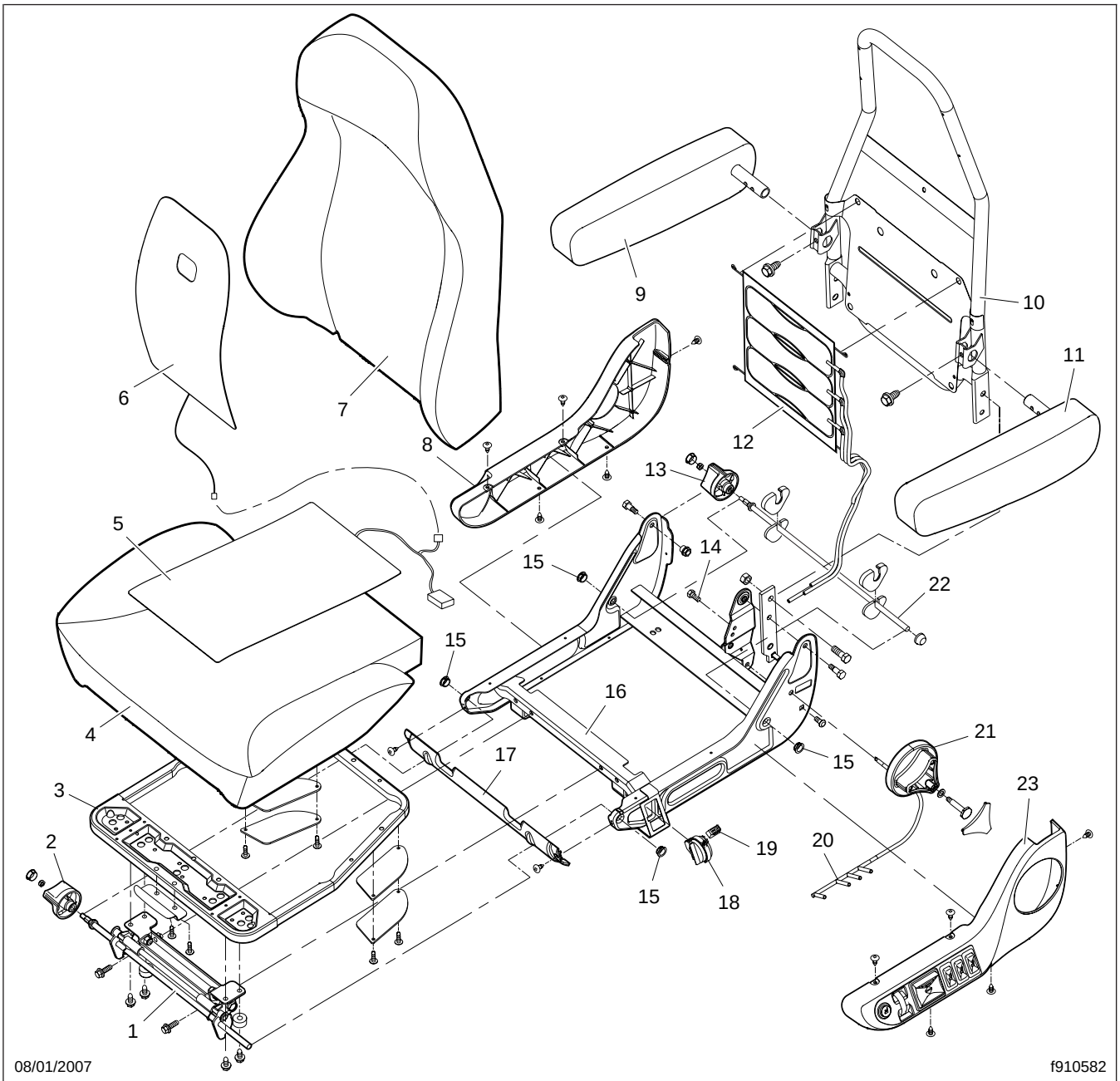
For exploded assembly drawings of the seat and the seat base, see **Fig. 2** and **Fig. 3**.



1. Rear Cushion Adjuster Knob
2. Isolator Control Knob
3. Swivel Lever
4. Front Cushion Adjuster Knob
5. Cushion Extension Handle
6. Seat Fore-and-Aft Adjustment Lever
7. Back Cushion Tilt Knob
8. Seat Heater Switch
9. Adjustable Shock Control
10. Height Adjuster Switch
11. Lumbar Adjustment Switches

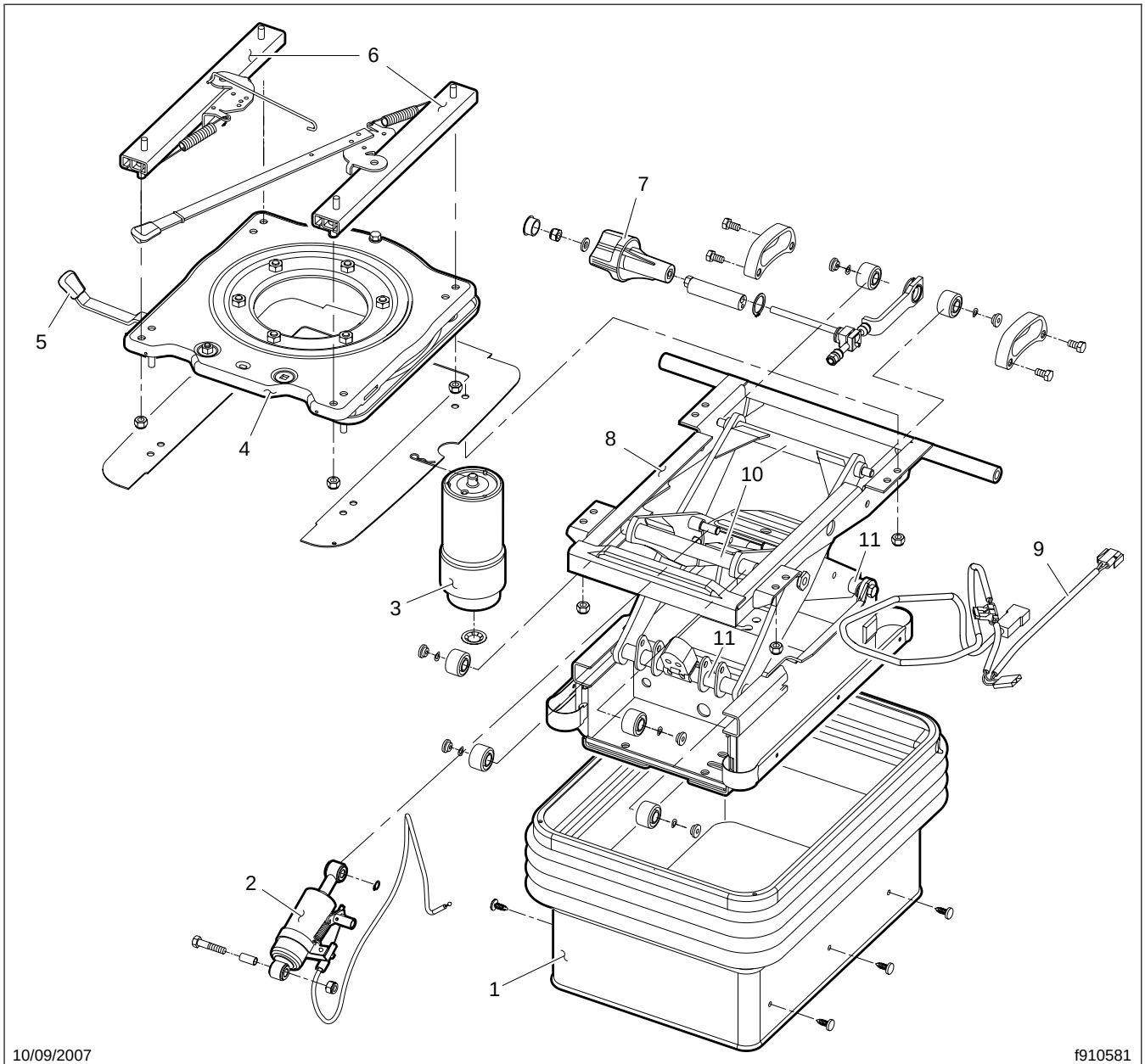
Fig. 1, Cascadia High-Back Seat Controls

General Information



1. Front Cushion Adjuster
2. Front Cushion Adjuster Knob
3. Seat Cushion Frame Assembly
4. Seat Cushion
5. Seat Cushion Heater Element
6. Seat Back Heater Element
7. Seat Back
8. Side Shield, Inboard
9. Armrest, RH
10. Seat Back Frame Assembly
11. Armrest, LH
12. Lumbar Bag
13. Rear Cushion Adjuster Knob
14. Recline Stop Bolt
15. Nylon Bearing
16. Lower Frame
17. Front Shield
18. Shock Housing Kit
19. Shock Knob
20. Manifold Assembly
21. Recline Knob
22. Rear Cushion Adjuster
23. Side Shield, Outboard

Fig. 2, Cascadia High-Back Seat (exploded assembly)

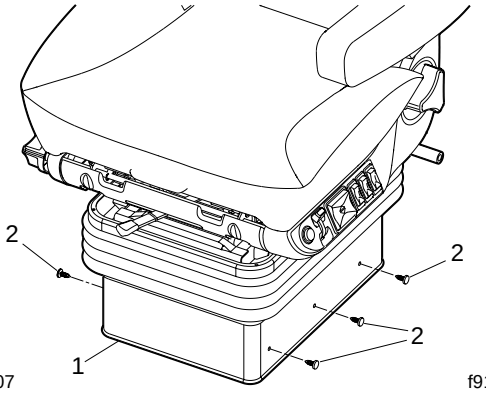


1. Suspension Skirt
2. Shock
3. Air Spring
4. Swivel Assembly
5. Swivel Knob
6. Track Kit
7. Chugger (Isolator) Knob
8. Seat Base
9. Heater Harness
10. Upper Cross Rods
11. Lower Cross Rod

Fig. 3, Cascadia High-Back Seat Base (exploded assembly)

Removal

1. Apply the parking brakes and chock the tires.
2. Adjust the seat to the maximum height.
3. Remove the seat suspension skirt, if so equipped, by removing the six Christmas-tree fasteners that attach the skirt to the seat base; see **Fig. 1**.



1. Suspension Skirt
2. Christmas-Tree Fastener

Fig. 1, Seat Suspension Skirt Installation

4. To secure the seat suspension in the extended position, bind the two cross-rods together with a large tie strap, at either the top or bottom of the fully extended scissor arms.

⚠ WARNING

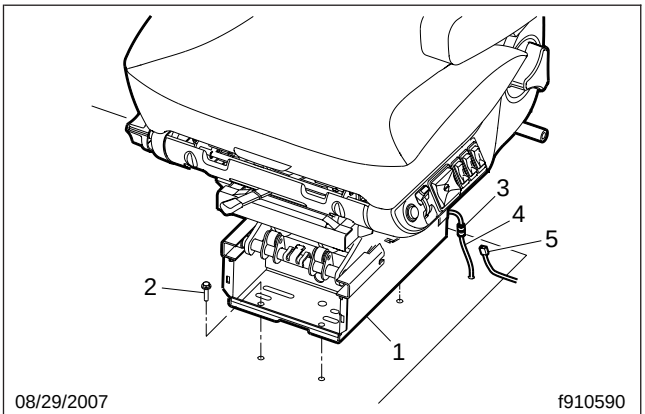
Do not remove the seat without first draining the seat air spring, and holding the seat suspension extended by securing the cross-rods together at either the top or bottom of the fully extended scissor arms. If the seat suspension is not properly secured, the seat could lower unexpectedly, pinching a hand or finger between the suspension parts, resulting in personal injury.

5. Drain the vehicle air reservoirs.

⚠ 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. If equipped with a seat heater, disconnect the power supply from the seat; see **Fig. 2**.



1. Seat Base
2. Capscrew
3. Air Line Quick-Connect Union
4. Air Supply Tubing
5. Power Supply Harness

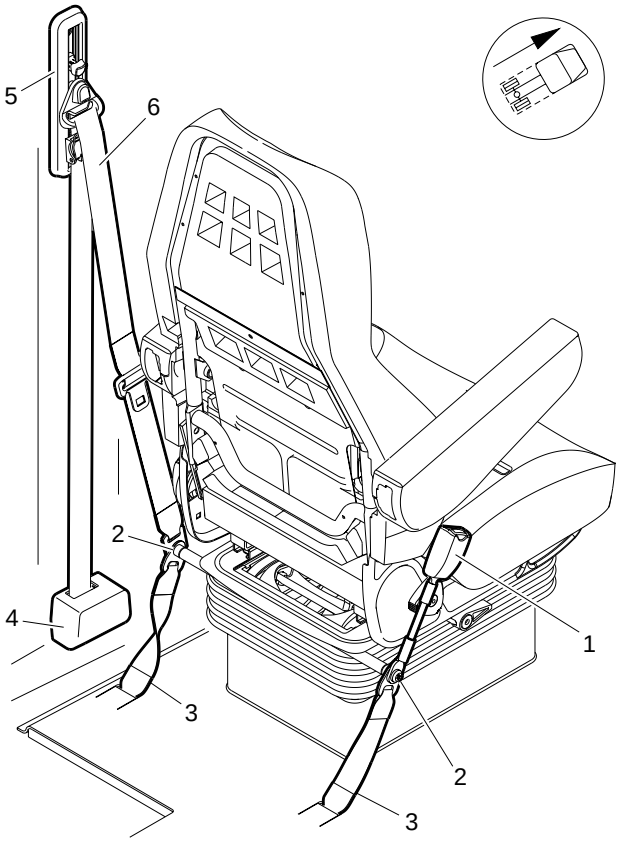
Fig. 2, Seat Installation

7. Disconnect the air supply tubing from the quick-connect union behind the seat.
8. Remove the Torx® screws that attach the seat belt and tether belts to the intermediate-connection-point (ICP) bar; see **Fig. 3**.
9. Remove the four capscrews that attach the seat to the cab floor; see **Fig. 2**. Remove the seat from the cab.

Installation

1. With the vehicle tires chocked, position the seat on the cab floor. Attach the seat to the cab floor with four capscrews; see **Fig. 2**. Tighten the capscrews 16 to 18 lbf·ft (22 to 25 N·m).
2. Attach the seat belt and tether belts to the intermediate-connection-point (ICP) bar; see **Fig. 3**. Tighten the Torx screws 35 to 50 lbf·ft (48 to 68 N·m).
3. Connect the air supply by pressing the pneumatic tubing into the quick-connect union behind the seat.

Seat Removal and Installation



1. Buckle
2. Intermediate Connection Point (ICP)
3. Tether Belt
4. Retractor
5. Height Adjuster
6. Seat Belt

Fig. 3, Seat Belt Installation, Air Suspension Seats

4. If equipped with a seat heater, plug in the power supply to the seat.
5. Start the engine and allow the air reservoirs to fill. Adjust the seat to its maximum height, then remove the tie strap that binds either the top or bottom cross-rods together.
6. If equipped with a seat suspension skirt, install the skirt using six Christmas-tree fasteners; see **Fig. 1**.
7. Remove the chocks.

Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.01**.

Torque Specifications		
Fastener Description	**lbf·ft**	**N·m**
Seat Mounting Screws	16–18	22–25
Seat Belt and Tether Belt Attachment Screws	35–50	48–68

Table 1, Torque Specifications

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 140**.

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 System 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.

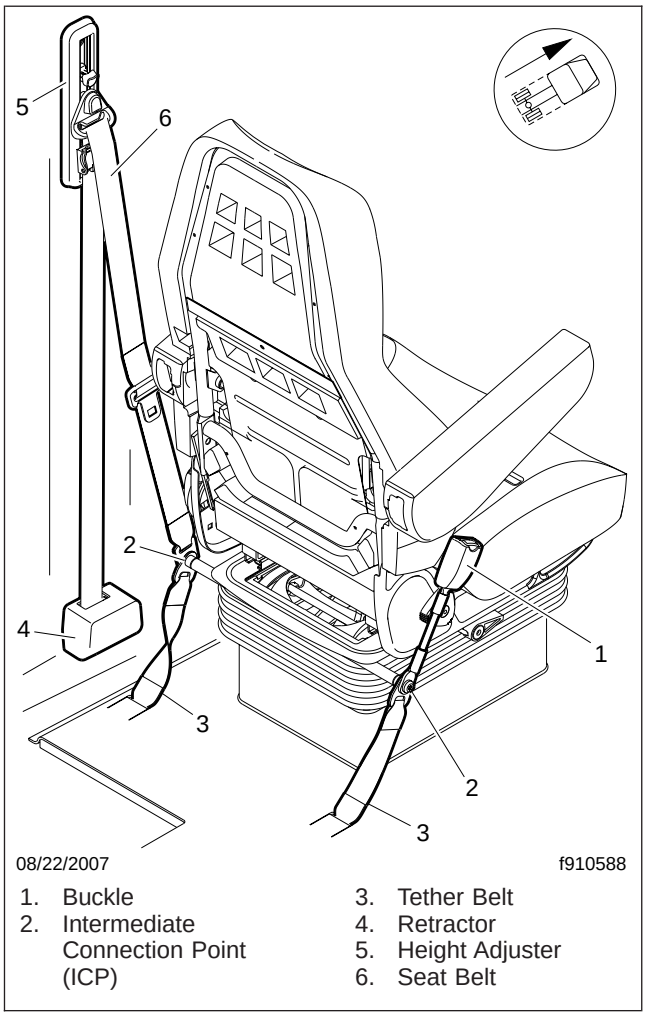
Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire seat-belt system must be replaced before operating the vehicle.

Air Suspension Seat

1. Apply the parking brakes and chock the tires.
2. Disconnect the seat and tether belts from the seat by removing the Torx® capscrew from each end of the intermediate-connection-point (ICP) bar; see **Fig. 1**. Remove and discard the buckle side of the seat belt.
3. Remove the Torx capscrews that attach the tether belts to the cab deck. Remove and discard the tether belts.
4. Remove the Torx screw that attaches the seat-belt retractor to the lower B-pillar.
5. Remove the capscrews that attach the height adjuster to the upper B-pillar. Remove and discard the retractor side of the seat belt.
6. Install the height adjuster of the new seat belt on the upper B-pillar. Tighten the capscrews 35 to 50 lbf·ft (48 to 68 N·m).
7. Install the seat-belt retractor on the lower B-pillar. Tighten the Torx screw 35 to 50 lbf·ft (48 to 68 N·m).
8. Attach the angle brackets of the new tether belts to the cab floor. Tighten the capscrews 35 to 50 lbf·ft (48 to 68 N·m).
9. On both sides of the seat, first place the tether bracket against the ICP bar, then place the seat-belt bracket on top of the tether bracket. Insert the capscrew through the brackets into the ICP bar. Tighten both capscrews 35 to 50 lbf·ft (48 to 68 N·m).
10. Remove the chocks.

Static Seat

1. Apply the parking brakes and chock the tires.

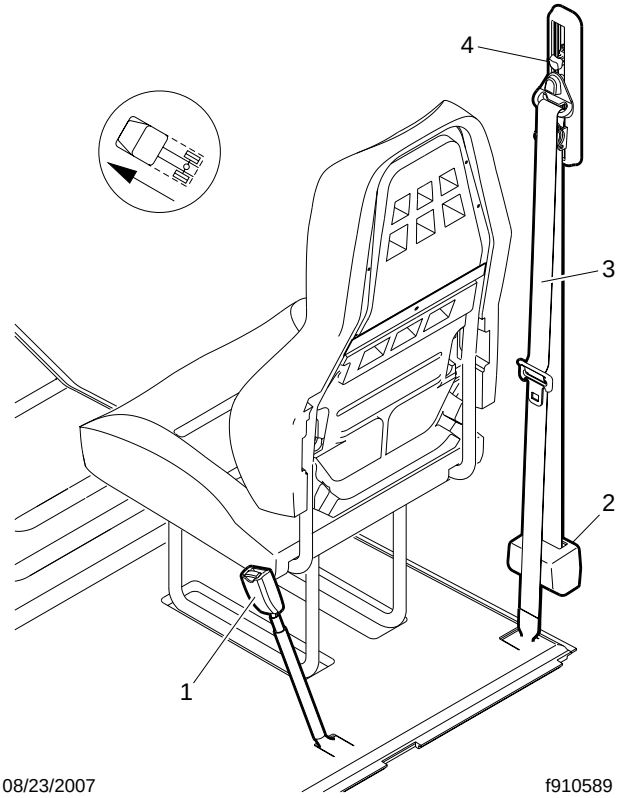


1. Buckle
2. Intermediate Connection Point (ICP)
3. Tether Belt
4. Retractor
5. Height Adjuster
6. Seat Belt

Fig. 1, Seat Belt Installation, Air Suspension Seats

2. Remove the Torx capscrews that attach the seat-belt brackets to the cab deck; see **Fig. 2**. Remove and discard the buckle-side of the seat belt.
3. Remove the Torx screw that attaches the seat-belt retractor to the lower B-pillar.
4. Remove the capscrews that attach the height adjuster to the upper B-pillar. Remove and discard the retractor side of the seat belt.
5. Install the height adjuster of the new seat belt on the upper B-pillar. Tighten the capscrews 35 to 50 lbf·ft (48 to 68 N·m).

Seat Belt System Replacement



1. Buckle
2. Retractor
3. Seat Belt
4. Height Adjuster

Fig. 2, Seat Belt Installation, Static Seats

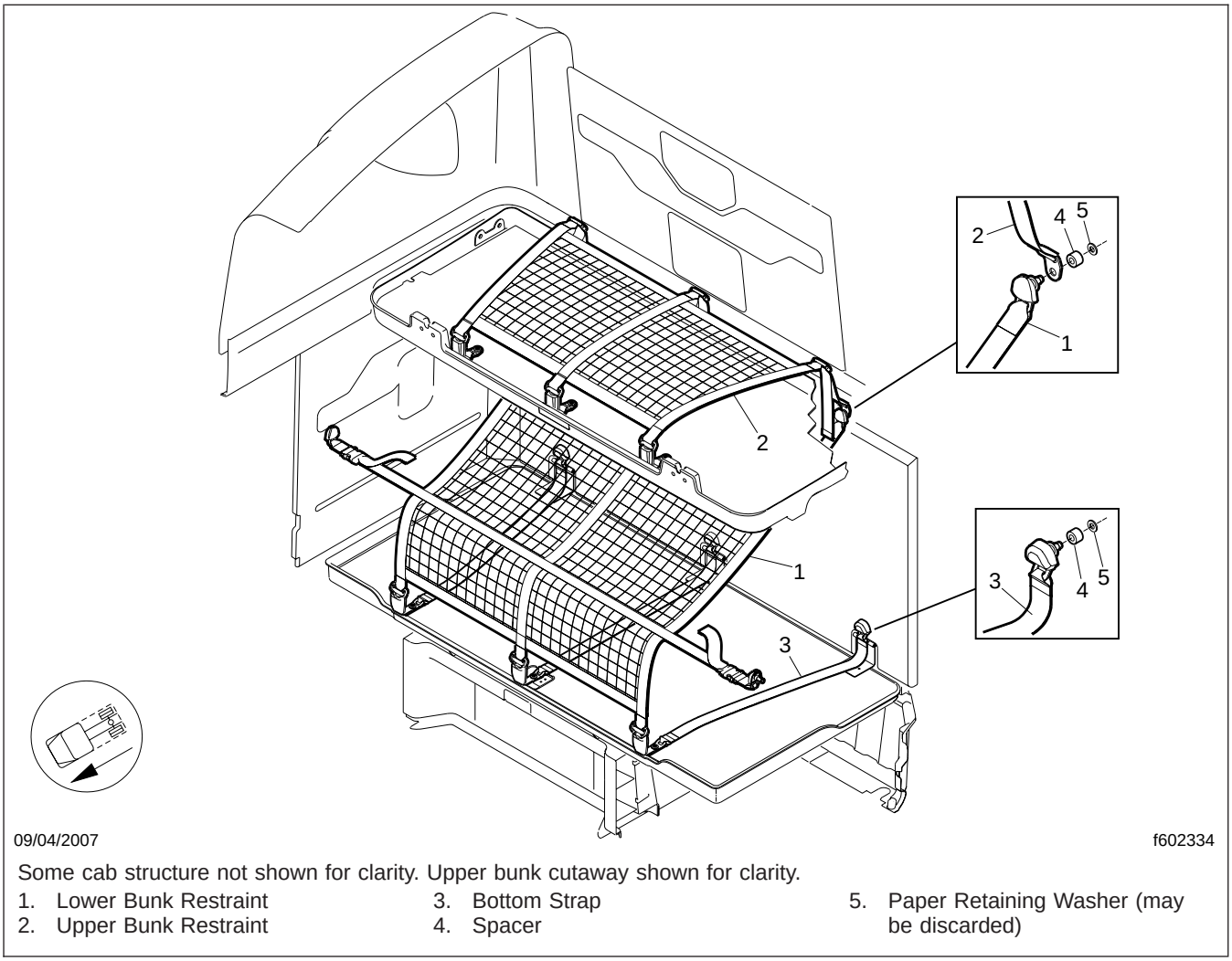
6. Install the seat-belt retractor on the lower B-pillar. Tighten the Torx screw 35 to 50 lbf·ft (48 to 68 N·m).
7. Attach both seat-belt brackets to the cab deck. Tighten the capscrews 35 to 50 lbf·ft (48 to 68 N·m).
8. Remove the chocks.

Replacement

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, and the restraint system was in use, the entire restraint system must be replaced before again operating the vehicle.

1. Apply the parking brakes and chock the tires.
2. Unbuckle the restraint.
3. Remove the mattress from the lower bunk.
4. Flip the bolt cover caps open, and remove the capscrews that attach the bunk restraint to the rear and side walls of the cab; see **Fig. 1**. Remove and discard the bunk restraint.
5. Tilt the lower bunk up, and remove the bolts and nuts that attach the restraint buckles to the bunk.
6. Lower the bunk, and remove the capscrews and spacers that attach the three bottom straps to the back wall. A paper retaining washer may be present; it is not needed, and does not need to be replaced. Remove and discard the straps.



Some cab structure not shown for clarity. Upper bunk cutaway shown for clarity.

1. Lower Bunk Restraint
2. Upper Bunk Restraint
3. Bottom Strap
4. Spacer
5. Paper Retaining Washer (may be discarded)

Fig. 1, Bunk Restraint Installation (raised roof with upper bunk shown)

Lower Bunk Restraint Replacement

NOTE: In a raised roof sleeper equipped with an upper bunk restraint, the fasteners that attach the lower restraint to the back wall also secure the upper bunk restraint.

7. Attach new bottom straps to the back wall with the capscrews and spacers. Tighten the capscrews 35 to 45 lbf·ft (48 to 61 N·m).

⚠ CAUTION

Do not overtighten the fasteners that attach the bunk restraint buckles to the bunk. Overtightening the fasteners can crush the molded plastic shell of the bunk.

8. Tilt the bunk up, and attach the straps to the bunk with the bolts and nuts. Tighten the nuts 10 to 20 lbf·ft (14 to 27 N·m).
9. Lower the bunk, and place a new bunk restraint on the bunk.
10. Using the capscrews and spacers provided with the restraints, attach the bunk restraint to the back wall, in three places. Insert each capscrew through the lower restraint anchor plate, then slide the upper restraint anchor plate (if so equipped) and the spacer onto the capscrew. Tighten the nuts 35 to 45 lbf·ft (48 to 61 N·m). Snap the anchor plate covers closed.
11. Using the capscrews provided with the restraint, attach the restraint to the side walls.
12. Place the mattress on the lower bunk.
13. Remove the chocks.

Replacement

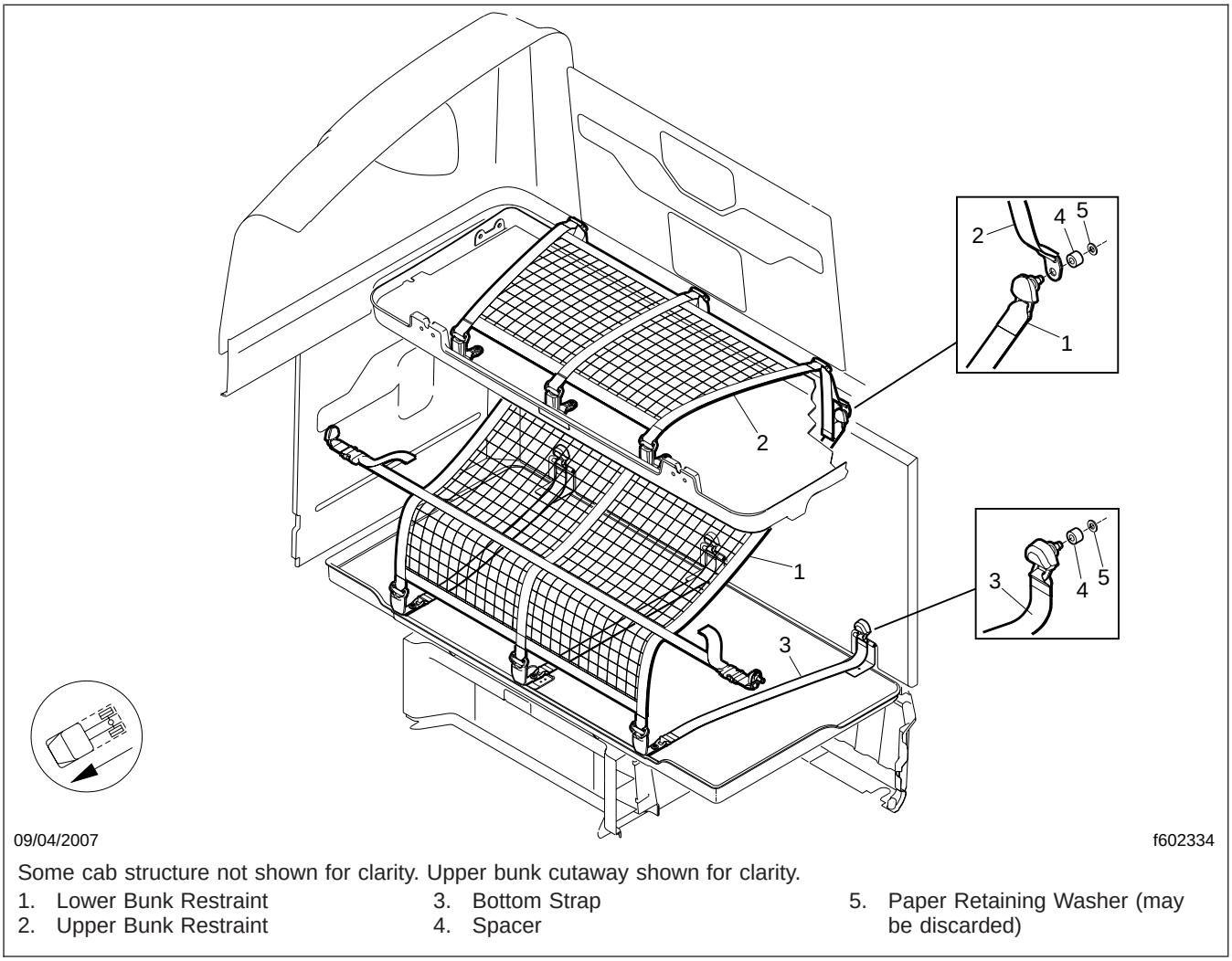
IMPORTANT: When any part of a restraint system needs replacement, the entire restraint system must be replaced.

Any time a vehicle is involved in an accident, and the restraint system was in use, the entire restraint system must be replaced before again operating the vehicle.

1. Apply the parking brakes and chock the tires.
2. Tilt the upper bunk up, and latch it securely.
3. Flip the anchor plate covers open, and remove the capscrews that attach the bunk restraint to the back wall of the cab; see **Fig. 1**. A paper retaining washer may be present; it is not needed, and does not need to be replaced. Remove and discard the restraint.

NOTE: In a raised roof sleeper, the fasteners that attach the upper restraint to the back wall also secure the lower bunk restraint.

4. Unlatch and lower the bunk.



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Some cab structure not shown for clarity. Upper bunk cutaway shown for clarity.

1. Lower Bunk Restraint
2. Upper Bunk Restraint
3. Bottom Strap
4. Spacer
5. Paper Retaining Washer (may be discarded)

Fig. 1, Bunk Restraint Installation

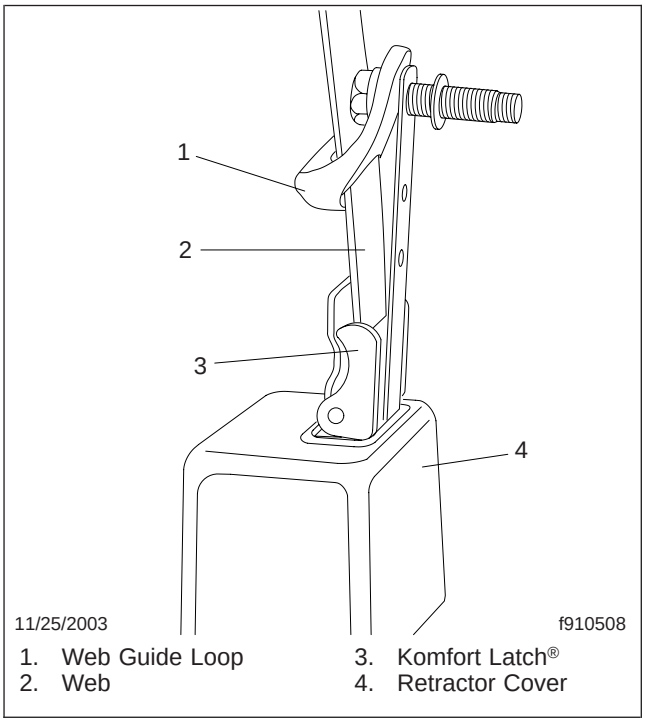
Upper Bunk Restraint Replacement

5. Unbuckle the upper bunk restraint. Remove and discard the bunk restraint.
6. Remove the mattress from the upper bunk.
7. Remove the three capscrews that attach the restraint buckles to the bunk pan. Remove and discard the restraint buckles.
8. Using capscrews provided with the new restraint, install new restraint buckles on the bunk pan. Tighten the capscrews 35 to 45 lbf·ft (48 to 61 N·m).
9. Place the mattress on the lower bunk.
10. Place the new restraint on the bunk. Fasten the three buckles, and hang the loose ends of the straps between the bunk and the back wall.
11. Tilt the upper bunk up, and latch it securely.
12. Using the capscrews and spacers provided with the restraints, attach the bunk restraint to the back wall, in three places. If the lower restraint is attached to the back wall using common fasteners, insert each capscrew through the lower restraint anchor plate, then slide the upper restraint anchor plate and the spacer onto the capscrew. Tighten the capscrews 35 to 45 lbf·ft (48 to 61 N·m). Snap the anchor plate covers closed.
13. Remove the chocks.

Unlocking an Installed Retractor

Seat belt retractors can lock up, preventing the webbing from being extracted. This condition, known as reverse lock-up, is caused by excessive webbing spooling into the retractor before installation in the vehicle.

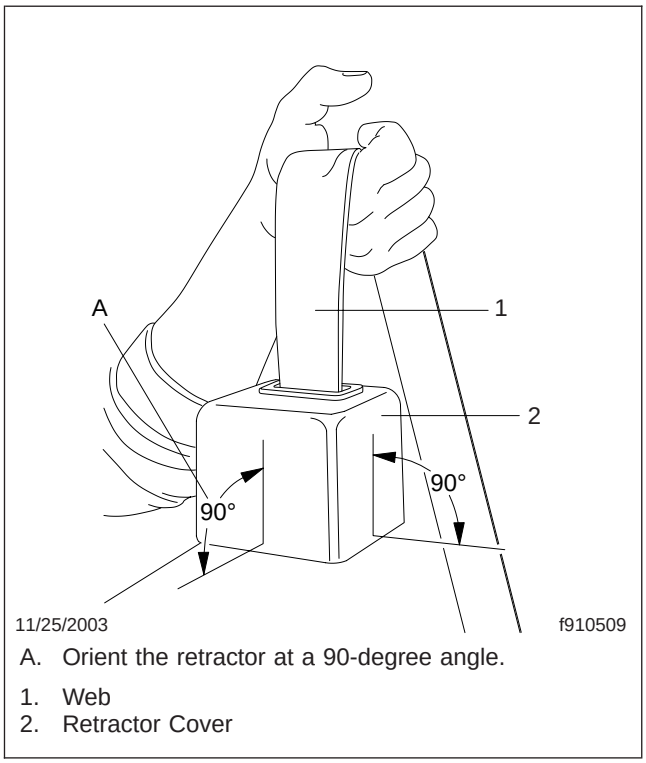
1. Apply the parking brakes and chock the tires.
2. Verify that the retractor is mounted in the 90-degree position, as shown in **Fig. 1**.
3. Firmly grasp the web close to the retractor; see **Fig. 2**.



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. The retractor should unlock when tension is released and least 1/2 inch (12.7 mm) of the web is allowed to retract back into the retractor.



A. Orient the retractor at a 90-degree angle.

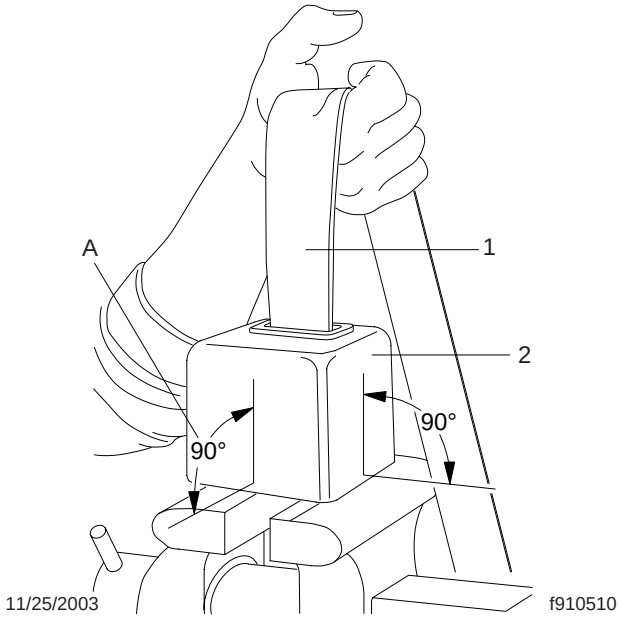
1. Web
2. Retractor Cover

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**.

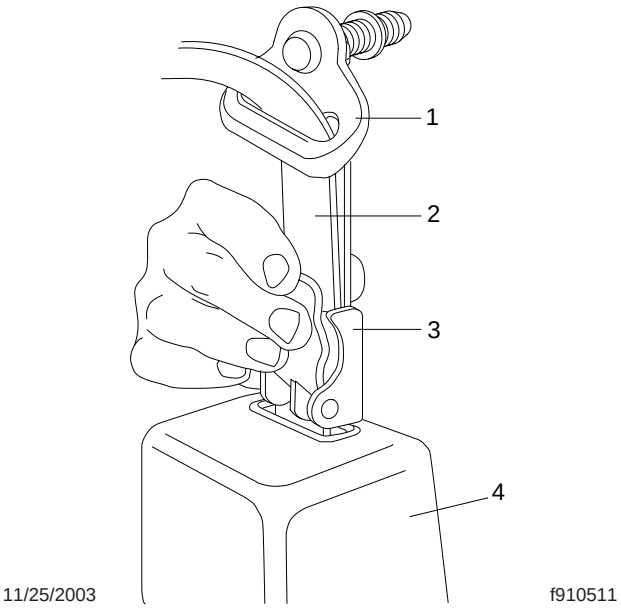
Seat Belt Retractor Unlocking



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.

Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.01**.

Torque Specifications		
Fastener Description	**lbf·ft**	**N·m**
Height Adjuster Mounting Screws	35–50	48–68
Seat Belt Retractor Mounting Screw	35–50	48–68
Tether Belt Angle Bracket Screws	35–50	48–68
Intermediate-Connecting-Point (ICP) Bar Screws	35–50	48–68
Bottom Straps-to-Back Wall Capscrews	35–45	48–61
Bottom Strap Nuts, Lower Bunk Restraint	10–20	14–27
Bunk Restraint-to-Back Wall Capscrews	35–45	48–61
Upper Bunk Buckle Capscrews	35–50	48–68

Table 1, Torque Specifications

General Information

The air bag (crash) sensor detects a sudden change in momentum resulting from a frontal or near-frontal collision. In the event of a moderate or severe collision, the sensor sends a signal to the air bag module inflator unit. Within a fraction of a second after the collision, the air bag inflates, cushioning the vehicle occupant.

The air bag sensor module is installed under the seat. The sensor mounting fasteners also attach the seat to the cab floor. Depending on the seat, the sensor is mounted with two or four capscrews. The sensor wiring harness is connected to the cab harness near the seat base, and is clipped to the seat frame to keep it above the floor surface.

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 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.

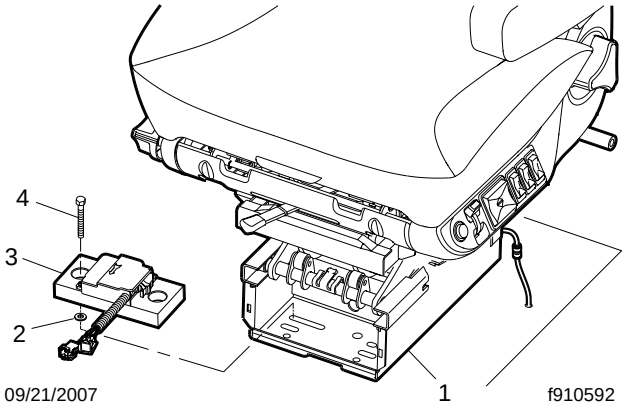
3. Raise the seat to its maximum position. If the seat is equipped with a seat shroud, remove or lift the shroud to access the air bag sensor module.
4. Disconnect the sensor harness from the cab harness.
5. Remove the M8 capscrews that attach the air bag sensor to the seat and to the cab floor; see **Fig. 1** (Cascadia seat) or **Fig. 2** (Atlas seat). Remove the air bag sensor.

⚠ WARNING

Do not substitute the air bag sensor mounting fasteners. Use the fasteners provided with the sensor to ensure adequate engagement.

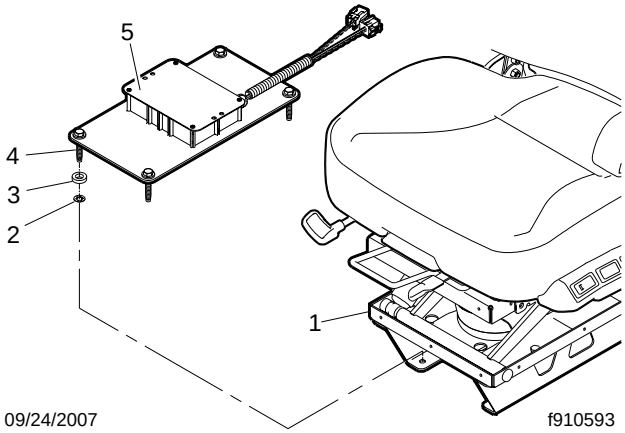
6. Install the new sensor using the M8 capscrews provided with the sensor. Make sure that the sensor is oriented correctly, with the arrow on the sensor label pointed to the front of the vehicle, and that the mounting surface is flat, with no foreign objects between the sensor housing and the mounting surface. Tighten the capscrews 16 to 18 lbf·ft (22 to 24 N·m).

Air Bag Sensor Replacement



1. Seat Base
2. Retaining Washer
3. Air Bag Sensor
4. Capscrew, M8

Fig. 1, Air Bag Sensor Installation, Cascadia Seat



1. Seat Base
2. Retaining Washer
3. Spacer
4. Capscrew, M8
5. Air Bag Sensor

Fig. 2, Air Bag Sensor Installation, Atlas Seat

⚠ 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.

7. Connect the cab wiring harness to the sensor harness.
8. Lower the seat. If the seat is equipped with a seat shroud, install or lower the shroud.
9. Connect the batteries.

Specifications

For fastener torque values, see **Table 1**.

Torque Specifications		
Fastener Description	**lbf·ft**	**N·m**
Air Bag Sensor Mounting Screws	16–18	22–24

Table 1, Torque Specifications

General Information

DANGER

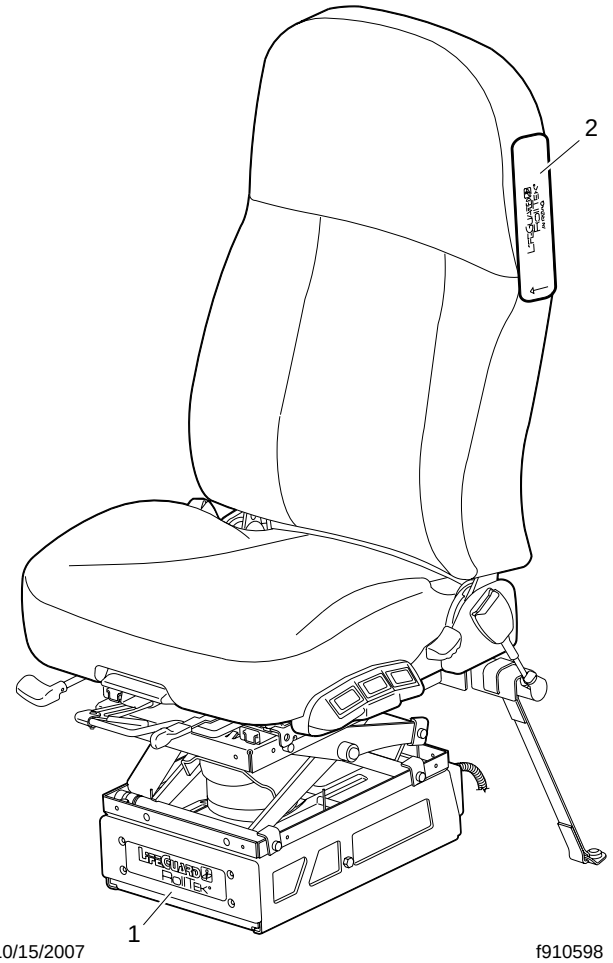
Do not place objects on the seat back or block the side-roll air bag. Objects that block the side-roll air bag may prevent proper inflation and may increase the potential for serious injury or death.

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.

Diagnostics

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.

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 the *Cascadia Troubleshooting Manual*, **C07.08—J1587/ J1708 Air Bag and Rollover Protection System** or **C07.11—J1939 Air Bag and Rollover Protection System**.

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 Service-Link to clear all historic (inactive) codes. The SRS lamp should now be off, unless an uncorrected fault exists.

1. Determine the appropriate service procedure based on the information provided by the active fault codes.
2. After the service procedure has been performed, clear the fault codes as instructed in the diagnostic procedure, then repeat the diagnostic procedure to determine if the active faults have been resolved.

Replacement

IMPORTANT: Prior to performing any service work on the RollTek Rollover Protection System, perform the diagnostic check using the procedure under "Diagnostics" in **Subject 100**.

⚠ 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

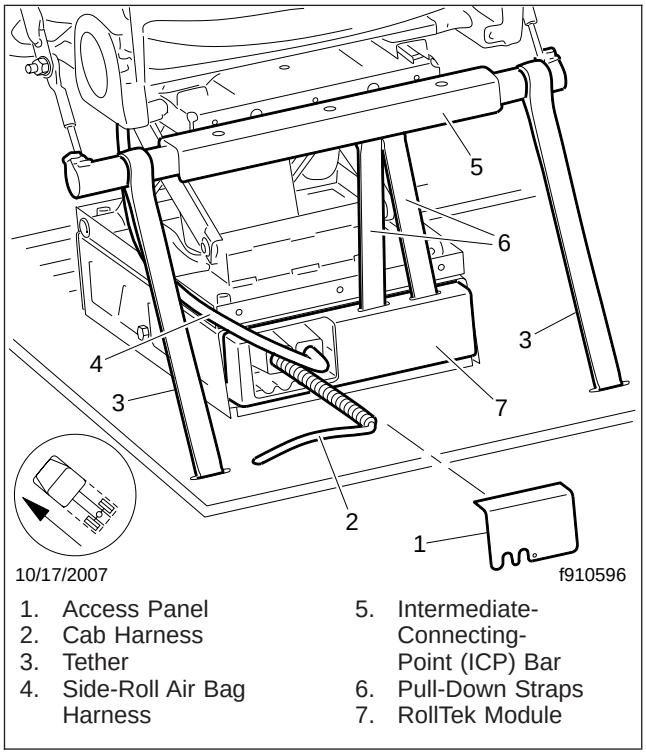
Before removing the mounting capscrews from the RollTek module, be sure to disconnect the batteries and disconnect the wiring from the module. Failure to follow these precautions may result in the air bag(s) being unintentionally deployed, which could cause severe bodily injury or death.

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**.



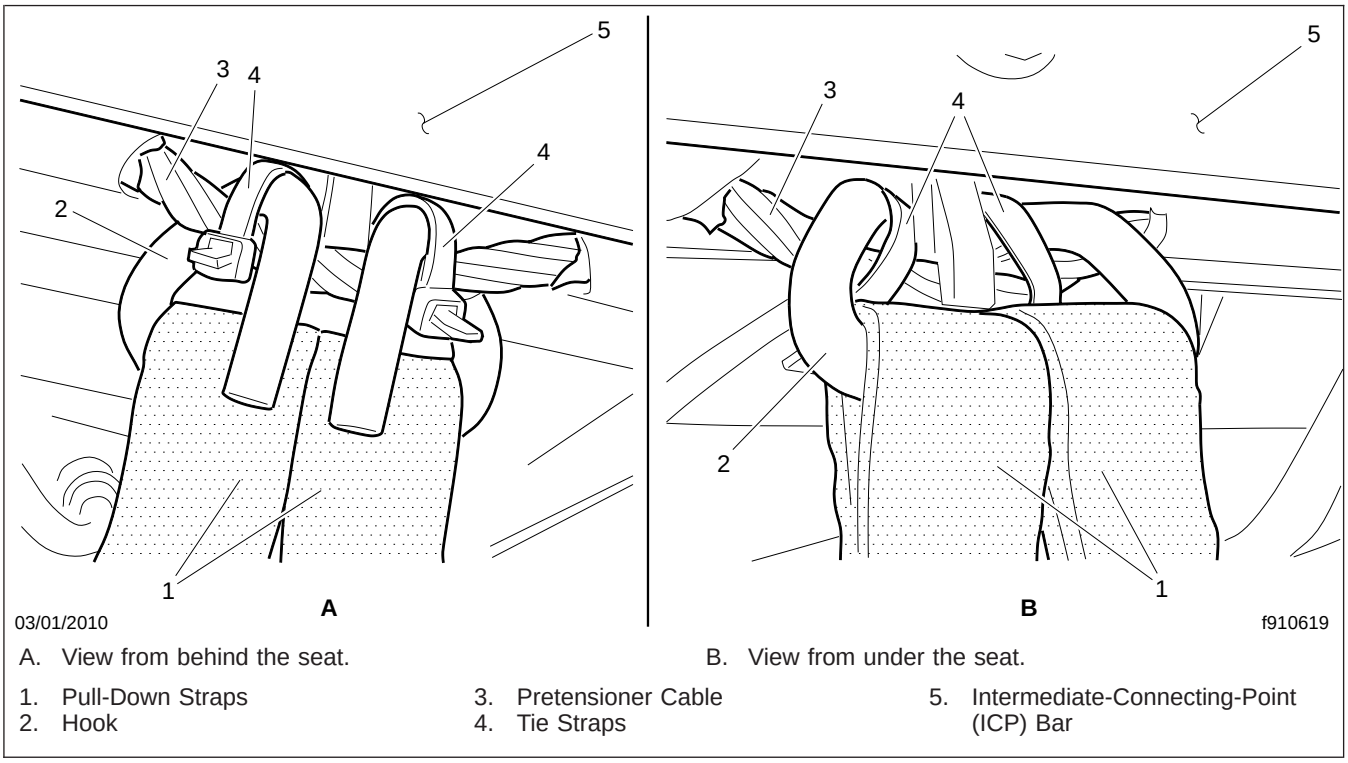
1. Access Panel
2. Cab Harness
3. Tether
4. Side-Roll Air Bag Harness
5. Intermediate-Connecting-Point (ICP) Bar
6. Pull-Down Straps
7. RollTek Module

Fig. 1, RollTek Module Wiring Access

7. Disconnect the wiring from the back of the RollTek module.
8. *For J1587/J1708 RollTek systems,* cut the tie straps that secure the pulldown-strap hook to the seat belt pretensioner cable; see **Fig. 2**.

   For J1939 RollTek systems, rotate the rubber keeper down to release the pulldown-strap hook from the seat belt pretensioner cable; see **Fig. 3**.
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. 4**. Slide the RollTek module forward, out of the seat riser.

RollTek Module Replacement



A. View from behind the seat.
B. View from under the seat.

1. Pull-Down Straps
2. Hook
3. Pretensioner Cable
4. Tie Straps
5. Intermediate-Connecting-Point (ICP) Bar

Fig. 2, Pulldown-Strap Hook, J1587/J1708 RollTek System

WARNING

Do not substitute the RollTek module mounting fasteners. Use the fasteners provided with the module to ensure adequate engagement.

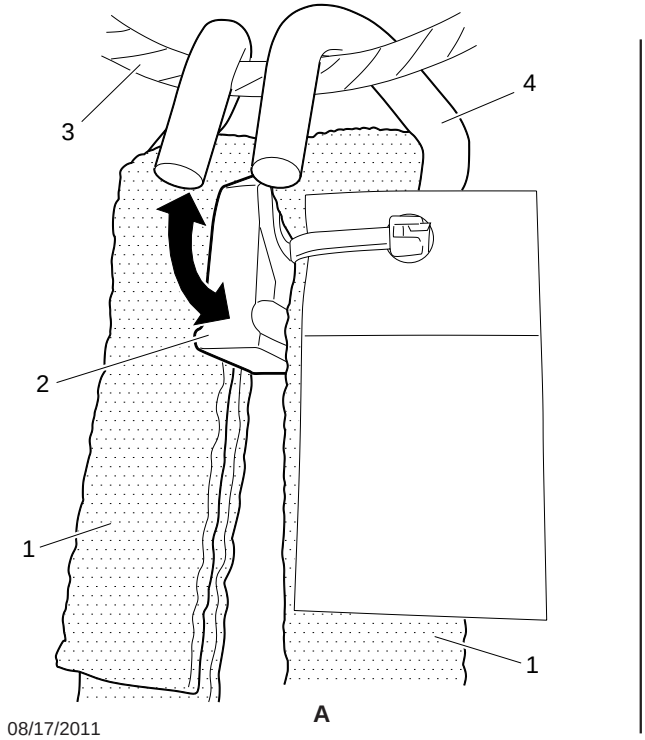
13. Install the new RollTek module using the capscrews and spacers provided with the module. Make sure that the module is oriented correctly, with the arrow on the top pointed to the front of the vehicle, and that the mounting surface is flat, with no foreign objects inside the riser. Tighten the capscrews 16 to 18 lbf·ft (22 to 24 N·m).

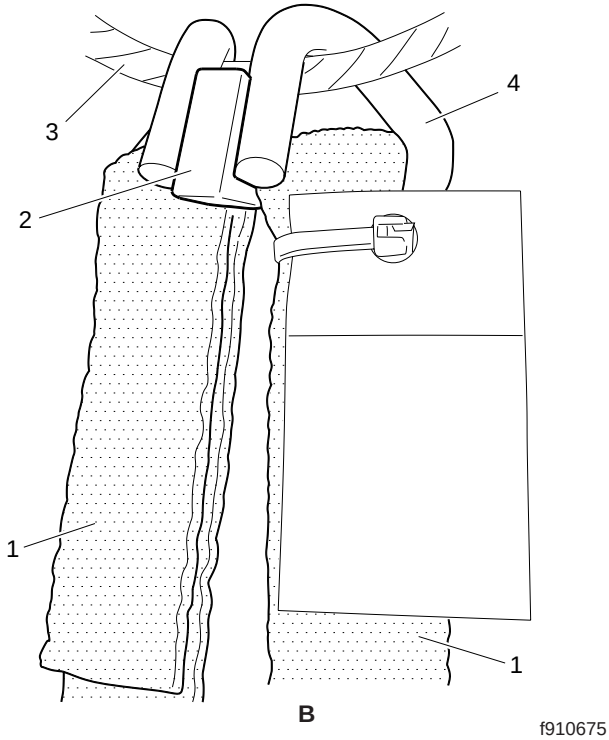
WARNING

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. *For J1587/J1708 RollTek systems,* secure the hook to the pretensioner cable with two tie straps, as shown in **Fig. 2**.

    For J1939 RollTek systems, rotate the rubber keeper up to secure the pulldown-strap hook to the seat belt pretensioner cable; see **Fig. 3**.
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,



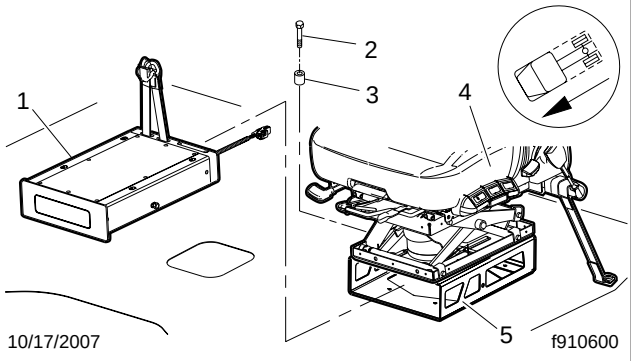


A. Rotate rubber keeper to release/secure the pulldown-strap hook.

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. 3, Pulldown-Strap Hook, J1939 RollTek System



1. RollTek Module
2. Capscrew
3. Spacer
4. Seat
5. Seat Riser

Fig. 4, RollTek Module Installation

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 applicable diagnostic procedure to test for proper installation; see the *Cascadia Troubleshooting Manual*, **C07.08—J1587/J1708 Air Bag and Rollover Protection System** or **C07.11—J1939 Air Bag and Rollover Protection System**.

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

Removal

1. Apply the parking brakes and chock the tires.
2. On each side of the seat, remove the two capscrews that attach the seat to the bracket on the battery box. See **Fig. 1**.
3. Remove the seat, letting the seat belt buckle slip out between the seat and back cushions.

Installation

1. With the battery box cover installed, position the seat on the battery box.
2. From the back of the seat, push the seat belt buckle in between the seat and back cushions.
3. On each side of the seat, install the two capscrews that attach the seat to the bracket on the battery box. Tighten the capscrews 10 to 12 lbf·ft (14 to 16 N·m).

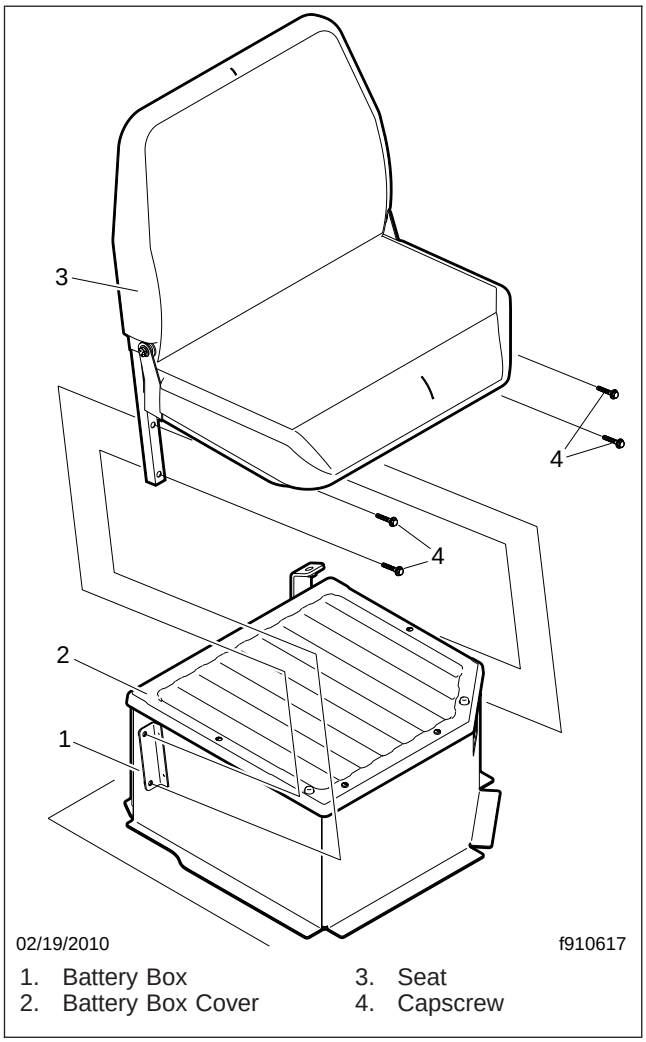


Fig. 1, Battery Box Seat Installation

Specifications

Torque Specifications		
Fastener Description	**lbf·ft**	**N·m**
Seat Mounting Capscrews	10–12	14–16

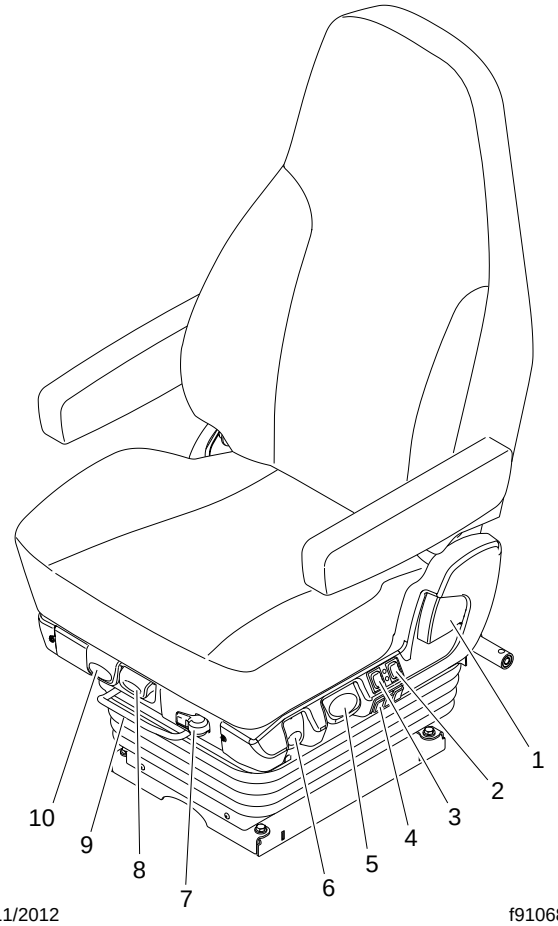
Table 1, Torque Specifications

General Information

The Cascadia 2.0 High-Back air suspension seat features height adjustment, fore and aft seat adjustment, back cushion tilt, lumbar support, seat cushion tilt and extension, heat, shock absorber adjustment, and an isolator; see **Fig. 1**. Optional features include shock absorber adjustment, heating, and ventilation. The air suspension adjustment features receive air from the vehicle air system. Pressure in the air suspension is controlled by the switches attached to the seat frame.

For seat adjustments and operating instructions, see the *Cascadia Driver's Manual*.

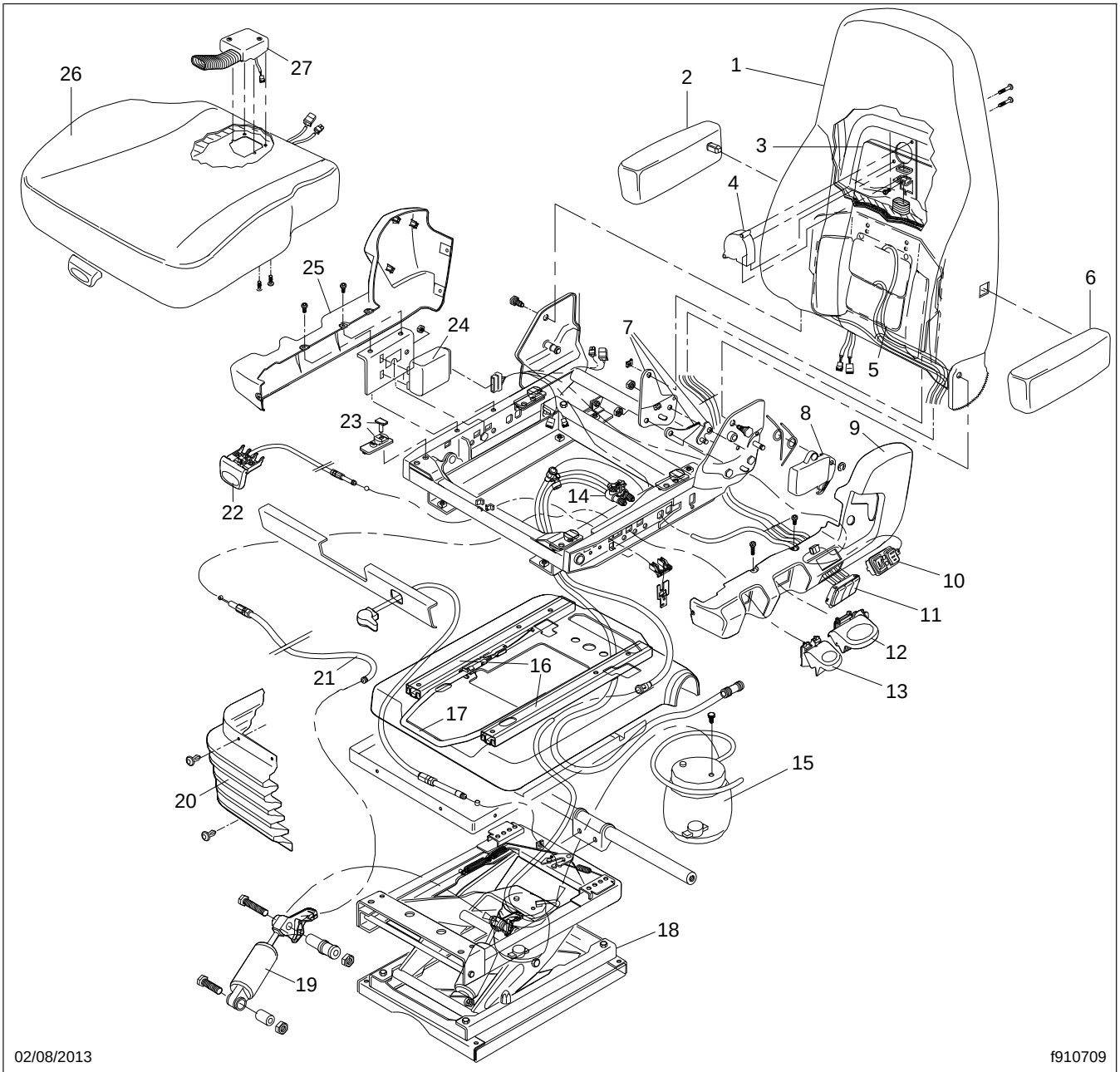
For an exploded assembly drawing of the seat, see **Fig. 2**.



1. Recline Handle
2. Heat/Ventilation Adjustment Switch
3. Heat/Ventilation ON/OFF Switch
4. Lumbar and Side Support Switches
5. Height Adjustment Lever
6. Shock Absorber Adjustment Lever
7. Fore/Aft Isolator Lever
8. Bottom Cushion Extension Lever
9. Seat Fore/Aft Slide Lever
10. Seat Tilt Lever

Fig. 1, Cascadia 2.0 Hi-Back Seat

General Information



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1. Backrest
2. Armrest, RH
3. Backrest Heater
4. Backrest Fan
5. Air Chamber, Lumbar Support
6. Armrest, LH
7. Recline Mechanism
8. Recline Handle
9. Side Cover, LH
10. Heat/Ventilation Controls
11. Lumbar and Side Support Switches
12. Height Adjustment Lever
13. Shock Absorber Adjustment Lever
14. Height Adjustment Valve
15. Air Spring
16. Seat Fore/Aft Slide Rails
17. Seat Fore/Aft Slide Lever
18. Seat Base
19. Adjustable Shock Absorber
20. Seat Suspension Skirt
21. Shock Absorber Cable
22. Seat Tilt Lever
23. Seat Cushion Slider Tab and Pin
24. Electronic Control Unit (ECU)
25. Side Cover, RH
26. Seat Cushion
27. Seat Cushion Fan

Fig. 2, Cascadia 2.0 Hi-Back Seat (exploded assembly)

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Adjust the seat to the maximum height.
3. To secure the seat suspension in the extended position, bind the two cross-rods together with a large tie strap, at either the top or bottom of the fully extended scissor arms.

CAUTION

Do not remove the seat air spring without first 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.

4. Drain the vehicle air reservoirs.

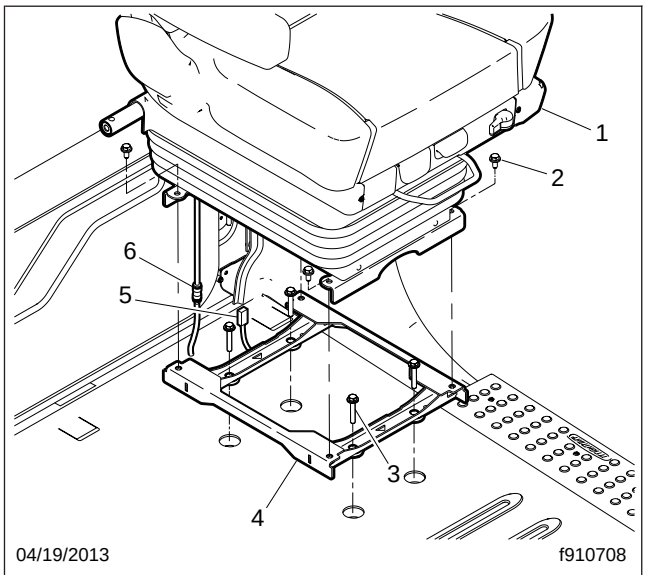
WARNING

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.

5. Disconnect the power supply from the seat, if applicable. See **Fig. 1**.
6. Disconnect the air supply tubing from the quick-connect union behind the seat.
7. Remove the Torx® screws that attach the seat belt and tether belts to the intermediate-connection-point (ICP) bar. See **Fig. 2**.
8. Remove the four capscrews that attach the seat to the mounting bracket. Remove the seat from the cab.

Installation

1. With the vehicle tires chocked, position the seat on the mounting bracket. Attach the seat to the mounting bracket with four capscrews. See **Fig. 1**. Tighten the capscrews 11 to 13 lbf·ft (15 to 18 N·m).

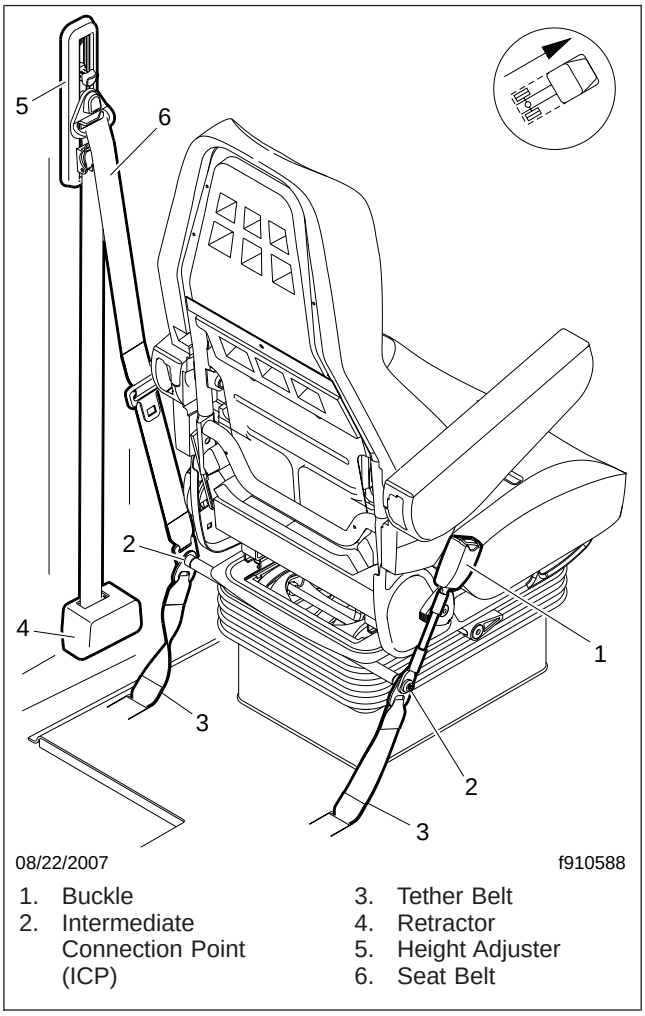


1. Seat
2. Seat Mounting Capscrew
3. Mounting Bracket Capscrew
4. Mounting Bracket
5. Power Supply Connector
6. Air Line Quick-Connect Union

Fig. 1, Seat Installation

2. Attach the seat belt and tether belts to the intermediate-connection-point (ICP) bar. See **Fig. 2**. Tighten the Torx screws 35 to 50 lbf·ft (48 to 68 N·m).
3. Connect the air supply by pressing the tubing into the quick-connect union behind the seat.
4. Plug in the power supply to the seat, if applicable.
5. Start the engine and allow the air reservoirs to fill. Adjust the seat to its maximum height, then remove the tie strap that binds either the top or bottom cross-rods together.

Seat Removal and Installation



1. Buckle
2. Intermediate Connection Point (ICP)
3. Tether Belt
4. Retractor
5. Height Adjuster
6. Seat Belt

Fig. 2, Seat Belt Installation, Air Suspension Seats

Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Move the seat cushion forward while pulling up on the cushion extension lever. See **Fig. 1**.

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Pull up, then forward on the cushion extension lever.

Fig. 1, Moving the Cushion Forward

3. Remove the two screws that attach the seat tilt lever to the seat cushion base. See **Fig. 2**.

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Fig. 2, Removing the Tilt Lever Screws

4. Pull the tilt lever out, then move the cable over to the right side of the seat extension lever. See **Fig. 3**.
5. Pull up on the cushion extension lever, then move it to the left. See **Fig. 4**.
6. Using both hands, pull the cushion forward, then lift it off the seat frame.

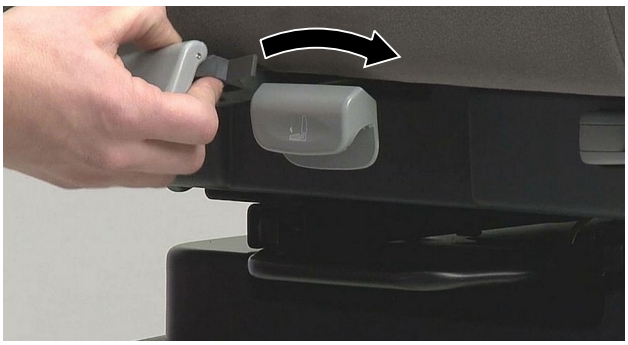
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Fig. 3, Moving the Tilt Lever

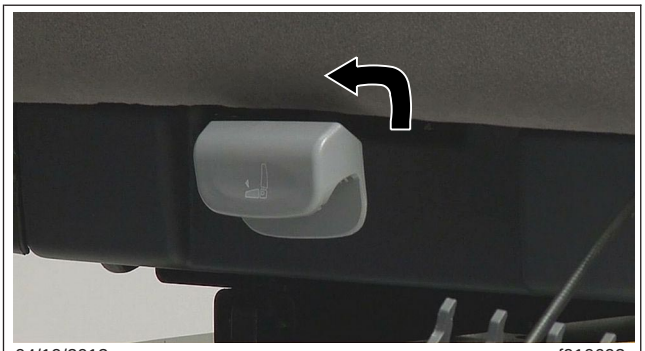
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Fig. 4, Moving the Cushion Extension Lever

7. If applicable, disconnect the two electrical connectors (see **Fig. 5**), then remove the seat cushion.

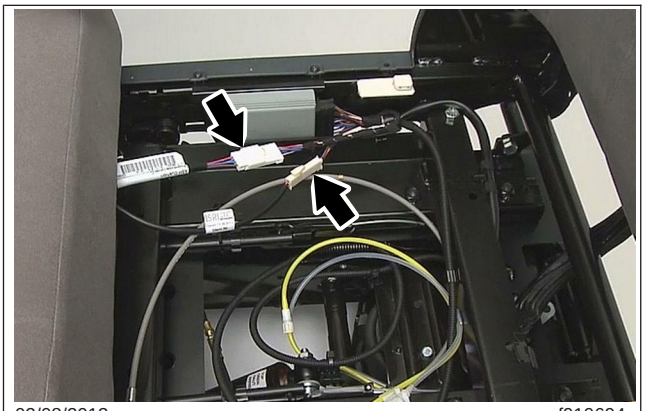
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Fig. 5, Seat Cushion Electrical Connectors

Seat Cushion Removal and Installation

Installation

1. Using a small brush, apply grease to both sides of each of the four slider tabs. See **Fig. 6** and **Fig. 7**.

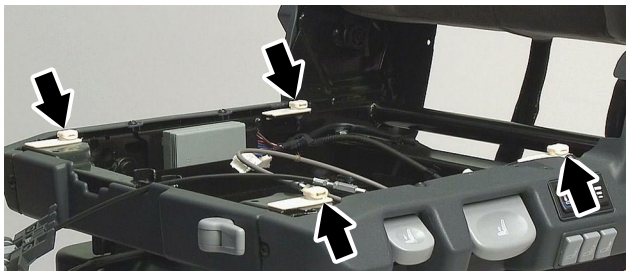

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Fig. 6, Slider Tabs

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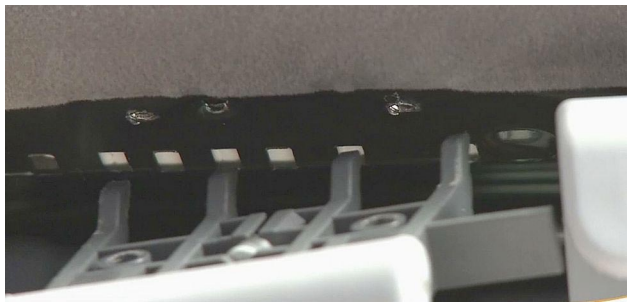
Fig. 7, Applying Grease to Slider Tab

2. Connect the seat cushion wiring. See **Fig. 5**.
3. Position the ends of the seat cushion rails on the two rear slider tabs. Lower the cushion.
4. Push the seat cushion all the way back.
5. Move the cushion extension lever to the right. Pull up on the cushion to make sure it is securely attached.
6. Move the cable of the seat tilt lever over the cushion extension lever to the left. Insert the four prongs of the lever into the holes in the seat cushion base. See **Fig. 8**. Secure the lever with two screws. Tighten the screws 22 to 31 lbf·in (250 to 350 N·cm).
7. Pull up the cushion extension lever and push the cushion back. Release the lever, then push the cushion back until the lever clicks down.



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Insert the lever prongs into the holes in the cushion base.

Fig. 8, Installing the Cushion Extension Lever

Seat Cushion Sliders, Removal and Installation

Removal

1. Remove the seat cushion. See **Subject 110**.
2. Using a flat-blade screwdriver, pry up the slider tab pin. See **Fig. 1** and **Fig. 2**. Pull the pin out.

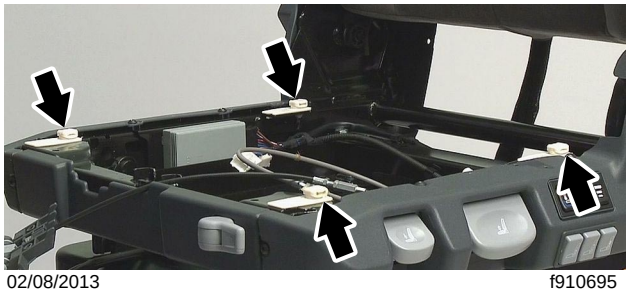

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Fig. 1, Slider Tabs

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Fig. 2, Removing the Slider Tab Pin

3. Using the screwdriver, pry the slider loose from the seat frame.
4. Repeat for other sliders as needed.

Installation

1. Install the sliders on the seat frame.
2. Push the pins in place.
3. Using a small brush, apply grease to the right and left sides of each slider tab. See **Fig. 3**.
4. Install the seat cushion. See **Subject 110**.

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Fig. 3, Applying Grease to Slider Tab

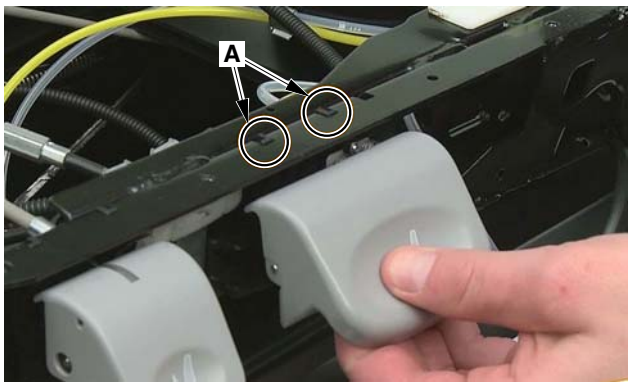
Height Adjustment Lever

Removal

1. Remove the seat cushion. See **Subject 110**.
2. While pulling up on the seat tilt lever, tilt the front of the seat frame up. Release the lever.
3. From inside the frame, remove the two screws that attach the height adjustment lever to the frame. Remove the lever.

Installation

1. Install the height adjustment lever on the seat frame. Make sure the two prongs fit into the slots in the seat frame. See **Fig. 1**.



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A. Fit the prongs into the slots in the seat frame.

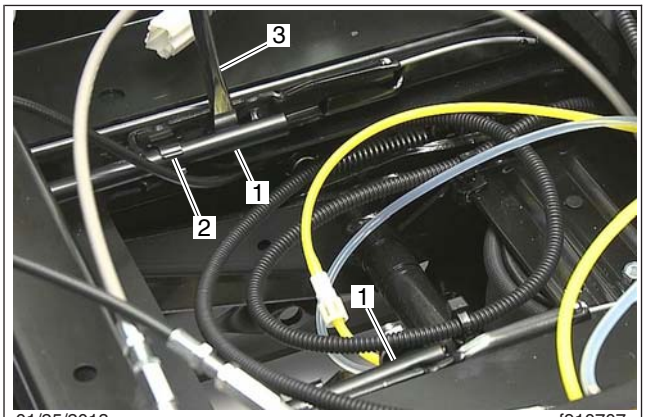
Fig. 1, Installing the Height Adjustment Lever

2. From inside the frame, attach the lever to the seat frame with the two screws. Tighten the screws 13 lbf·in (150 N·cm).
3. Push the front of the seat frame down, while pulling up on the seat tilt lever.
4. Install the seat cushion. See **Subject 110**.

Horizontal Adjustment Lever

Removal

1. Remove the seat cushion. See **Subject 110**.
2. Using a large flat-blade screwdriver, pry the lever legs out of the clips on each side of the seat frame. See **Fig. 2**.



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1. Horizontal Adjustment Lever
2. Retaining Clip
3. Screwdriver

Fig. 2, Removing the Horizontal Adjustment Lever

3. From the front of the seat, pull the lever out.

Installation

1. From the front of the seat, push the lever into position.
2. Position the lever legs against the clips on the frame, then using a rubber mallet, tap the lever legs into the clips.
3. Install the seat cushion. See **Subject 110**.

Recline Handle and Mechanism

Removal

1. Remove the seat cushion. See **Subject 110**.
2. Remove the LH side cover. See **Subject 160**.
3. Clean the seat cushion slider tabs; see **Fig. 3**.
4. While pulling on the recline handle and holding onto the seat back, let the seat back pivot to its forward-most position.

Seat Controls, Removal and Installation

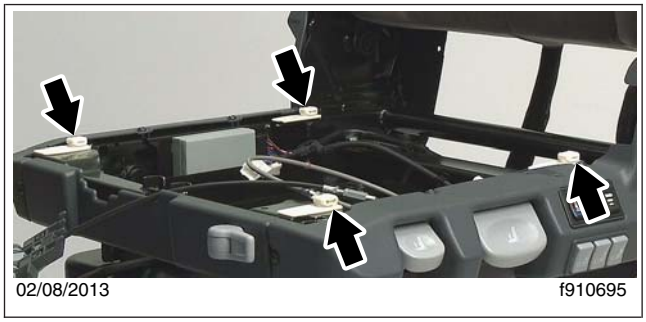
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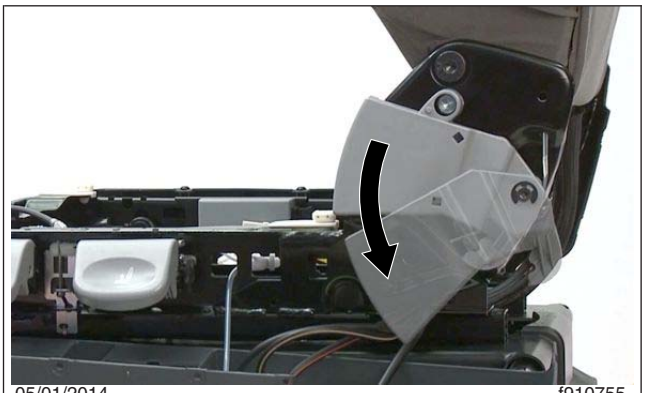
Fig. 3, Slider Tabs

5. Pull the recline handle out slightly to disengage it from the stop, then rotate the handle down; see **Fig. 4**.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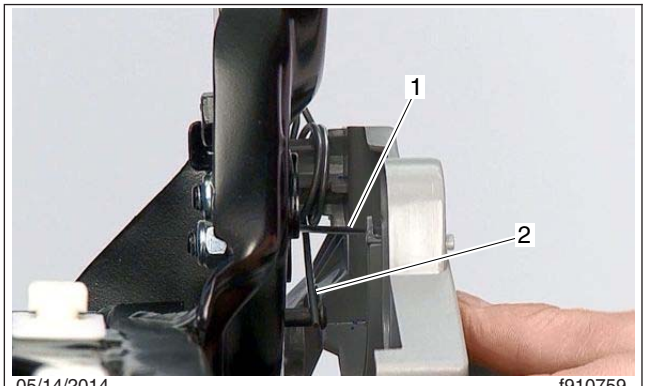
Rotate the recline handle down.

Fig. 4, Recline Handle Rotation

6. Between the recline handle and seat frame, release the recline mechanism spring and the handle spring; see **Fig. 5**.
7. Remove the snap ring from the handle pivot pin, then remove the handle. See **Fig. 6**.
8. Remove the spring clip on the back side of the recline mechanism backing plate.
9. Remove the two nuts that secure the recline mechanism backing plate in place. Remove the backing plate.
10. Remove the two-piece recline mechanism.
11. Remove the recline handle.
12. Remove the recline mechanism and handle springs.



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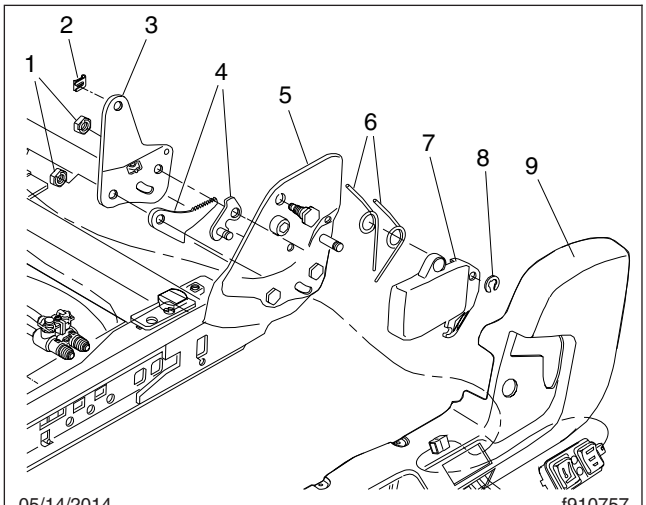
1. Recline Handle Spring
2. Recline Mechanism Spring

Fig. 5, Recline Mechanism and Handle Springs



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1. Nuts
2. Spring Clip
3. Recline Mechanism Backing Plate
4. Recline Mechanism
5. Seat Frame
6. Springs
7. Recline Handle
8. Snap Ring
9. Side Cover

Fig. 6, Recline Handle and Mechanism Installation

Installation

1. Using grease, lubricate the contact edges and pivot holes of the two-piece recline mechanism. See **Fig. 6**.
2. Install the two-piece recline mechanism, as shown in **Fig. 7**.

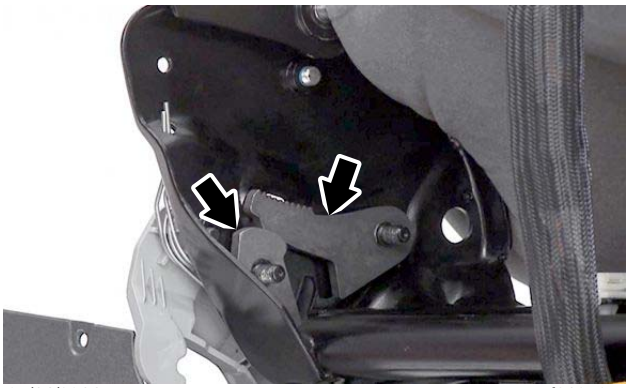
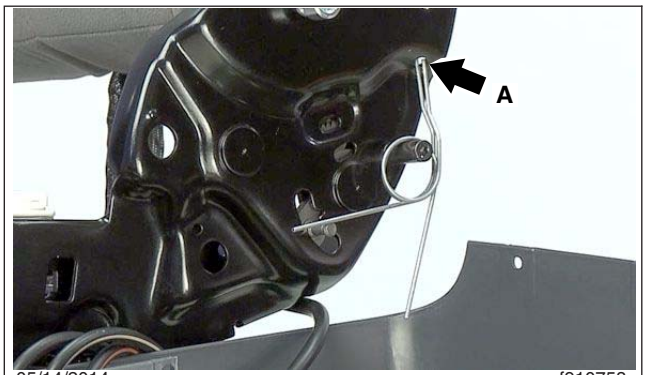


Fig. 7, Recline Mechanism

3. Hang the springs from the stud, with the top ends set into the hole in the seat frame, as shown in **Fig. 8**.



A. Set the top ends of the springs into the hole.

Fig. 8, Recline Handle and Mechanism Springs

4. Install the recline handle.
5. Install the backing plate. Tighten the two nuts 15 to 18 lbf·ft (20 to 24 N·m).
6. Install the snap ring on the handle pivot pin.
7. Set the end of the mechanism spring (the less angled spring, **Fig. 5**, item 2) against the stop on the mechanism stud.
8. Set the end of the handle spring (the more angled spring, **Fig. 5**, item 1) against the stop on the back side of the handle.
9. Rotate the handle into position, engaging the stop on the seat frame.
10. Pull up the handle, and pivot the seat back up.
11. Install the LH side cover. See **Subject 160**.
12. Install the seat cushion. See **Subject 110**.

Shock Absorber Adjustment Lever

Removal

1. Remove the seat cushion; see **Subject 110**.
2. Disconnect the shock absorber control cable; see **Fig. 9**.

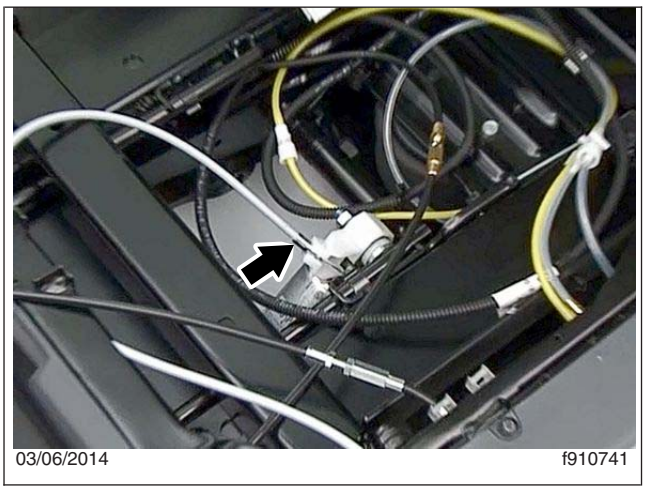
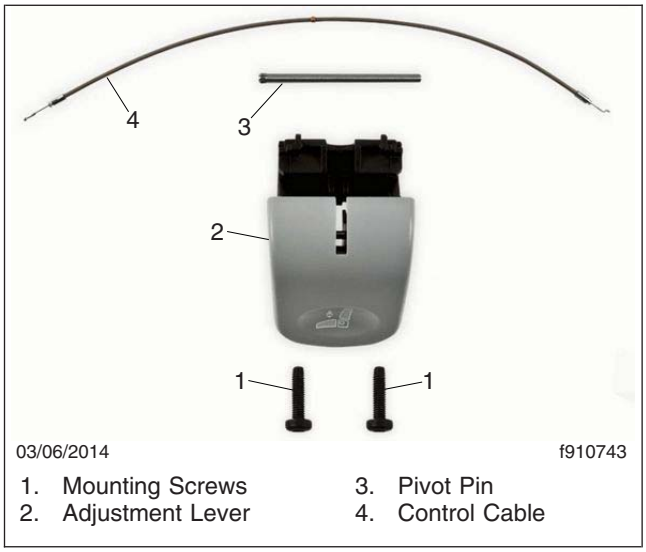


Fig. 9, Shock Absorber Control Cable

3. Pull the shock absorber adjustment lever up and remove the two screws that attach it to the seat frame. See **Fig. 10**.

Fig. 10, Shock Absorber Adjustment Lever Mounting Screws

4. Remove the lever and cable.
5. Push the pivot pin out of the lever, and remove the cable; see **Fig. 11**.



1. Mounting Screws
2. Adjustment Lever
3. Pivot Pin
4. Control Cable

Fig. 11, Shock Absorber Adjustment Lever Components

Installation

1. Install the pivot pin and the cable on the shock absorber adjustment lever; see **Fig. 11**.
2. Push the end of the cable through the hole in the seat frame, then install the lever, with the two tabs on the back of the lever positioned through the locator holes, as shown in **Fig. 12**.

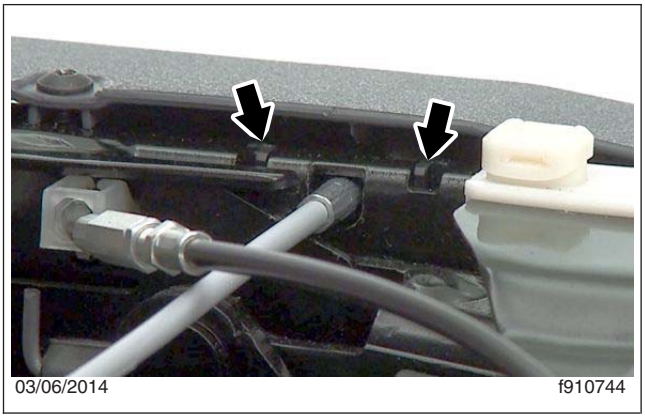


Fig. 12, Locating Tabs, Shock Absorber Adjustment Lever

3. Attach the end of the cable to the shock absorber. See **Fig. 9**.
4. Attach the lever to the seat frame with two screws. Tighten the screws 44 lbf·in (500 N·cm). See **Fig. 10**.
5. Install the seat cushion; see **Subject 110**.

Seat Tilt Lever

Removal

1. Remove the seat cushion; see **Subject 110**.
2. Remove the LH side cover; see **Subject 160**.
3. Remove the seat tilt limiter at the rear of the seat frame; see **Fig. 13**.

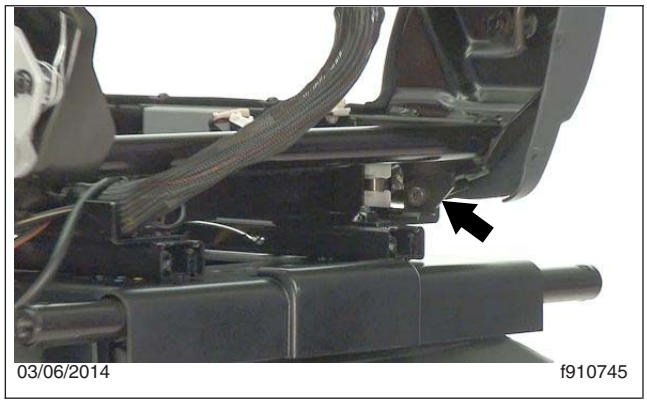


Fig. 13, Seat Tilt Limiter

4. While holding the seat tilt lever in the "up" position, pull up the front of the seat frame. See **Fig. 14**.
5. Remove the two screws that attach the height adjustment lever to the seat frame. Remove the lever. See **Fig. 15**.
6. Remove the tilt mechanism retainer; see **Fig. 16**.
7. Remove the tilt mechanism from the seat frame; see **Fig. 17**.
8. Disconnect the cable from the tilt mechanism. Remove the handle and cable from the seat frame.

Installation

1. Pass the end of the tilt handle cable through the hole in the seat frame; see **Fig. 18**.

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Hold the seat tilt lever in the "up" position and pull up the front of the seat frame.

Fig. 14, Tilting Up the Front of the Seat Frame

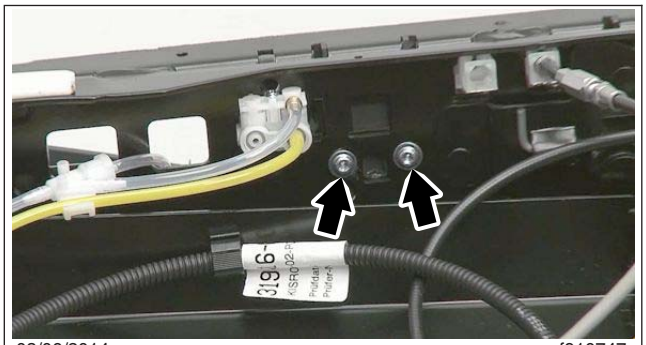

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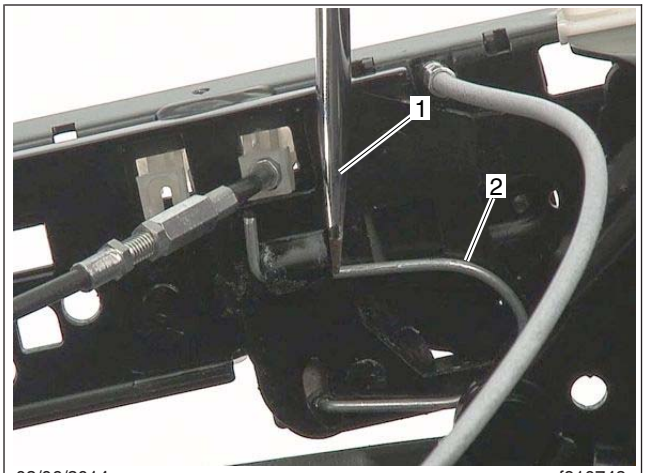
Fig. 15, Height Adjustment Lever Screws

2. Hitch the cable to the tilt mechanism; see **Fig. 19**.
3. Install the tilt mechanism on the seat frame; see **Fig. 17**.
4. Install the tilt mechanism retainer. Make sure the lower prong passes through lower hole in the mechanism; see **Fig. 20**.
5. Pull up on the handle and check for a gap between the lever and the lever mount; see



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1. Flathead Screwdriver 2. Retainer

Fig. 16, Removing Tilt Mechanism Retainer

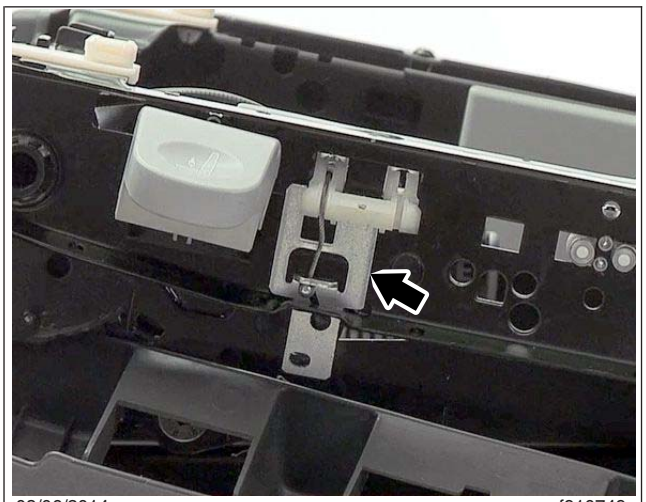

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Fig. 17, Tilt Mechanism

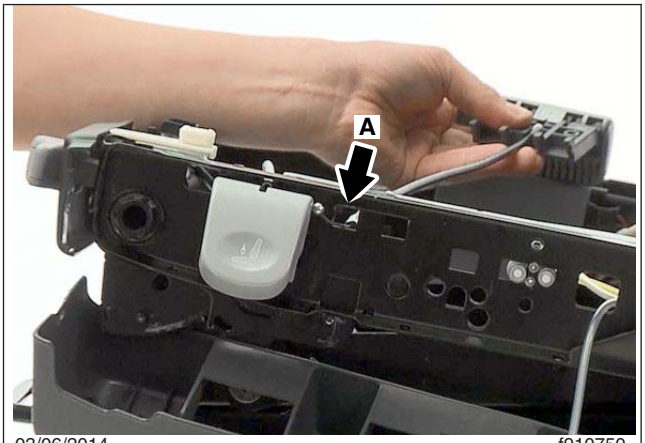
Fig. 21. If there is a gap, correct the adjustment as follows:

5.1 Rotate the adjustment nut until there is no gap between the lever and the lever mount when the lever is pulled up. See **Fig. 22**.

5.2 Make sure that the seat can be tilted.

5.3 Tighten the jam nut against the adjustment nut.

Seat Controls, Removal and Installation



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A. Pass the cable through this hole.

Fig. 18, Passing the Cable Through the Seat Frame

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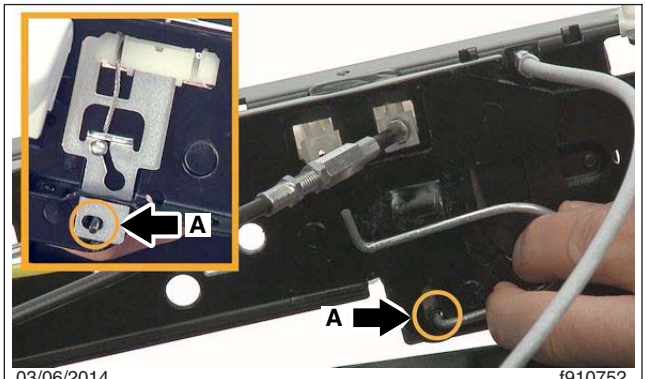
Fig. 19, Hitching the Cable to the Tilt Mechanism

6. Install the height adjustment lever on the seat frame. Make sure the two prongs fit into the slots in the seat frame.
7. From inside the frame, attach the lever to the seat frame with the two screws. Tighten the screws 13 lbf·in (150 N·cm). See **Fig. 15**.
8. While pulling up on the tilt handle, push the front of the seat down.
9. Install the seat tilt limiter at the rear of the seat frame. Add Locktite to the screw and tighten 15 to 18 lbf·ft (20 to 24 N·m). See **Fig. 13**.
10. Install the LH side cover; see **Subject 160**.



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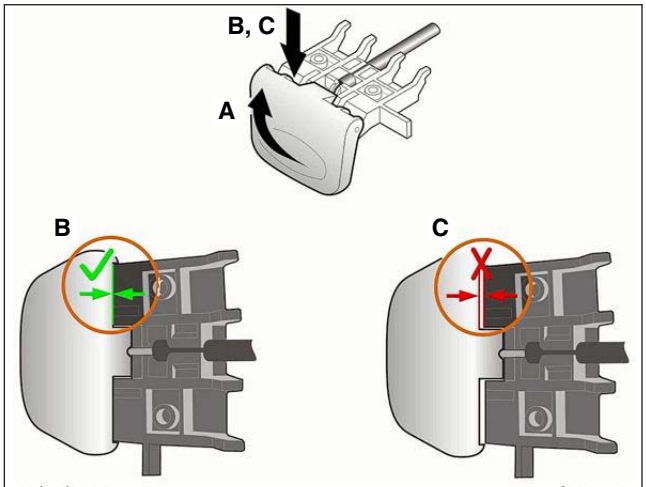
A. Make sure the lower prong of the retainer passes through the lower hole of the mechanism.

Fig. 20, Installing the Tilt Mechanism Retainer



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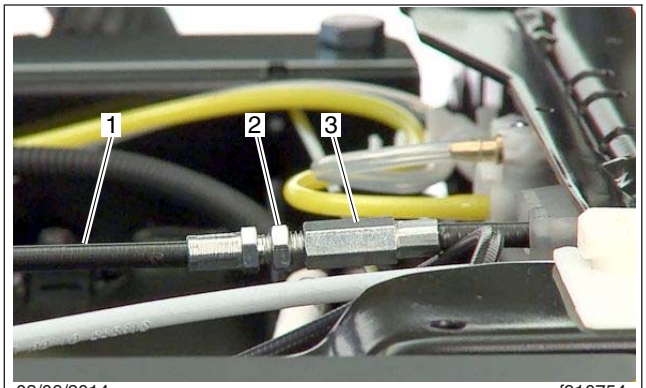
A. Pull the lever up.
B. Correct (no gap between lever and lever mount)
C. Incorrect (gap between lever and lever mount)

Fig. 21, Tilt Lever Adjustment

11. Install the seat cushion; see **Subject 110**.



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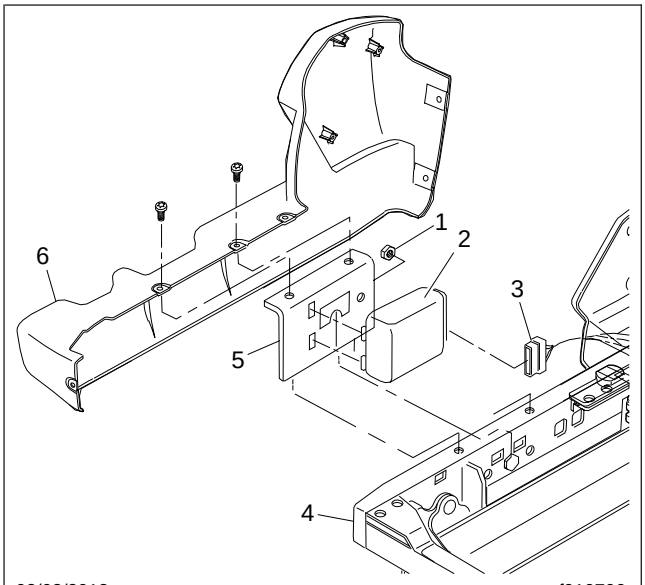
1. Tilt Cable
2. Jam Nut
3. Adjustment Nut

Fig. 22, Tilt Cable Adjustment

Replacement

1. Remove the seat cushion. See **Subject 110**.
2. Remove the screws that attach the RH side cover to the seat frame. Remove the side cover. See **Fig. 1**.



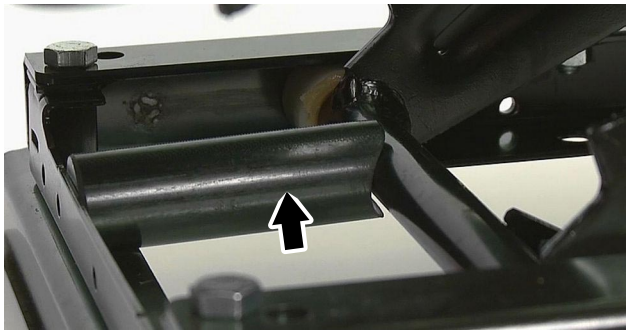
1. Nut
2. Electronic Control Unit (ECU)
3. Wiring Harness
4. Seat Frame
5. ECU Mounting Bracket
6. Side Cover, RH

Fig. 1, Electronic Control Unit Installation

3. Pull the electronic control unit (ECU) and mounting bracket out of the seat frame.
4. Disconnect the wiring connector from the back of the ECU.
5. Remove the nut that attaches the mounting bracket to the ECU. Remove the ECU from the bracket.
6. Attach the new ECU to the mounting bracket with the nut. Tighten the nut 18 lbf·in (200 N·cm).
7. Connect the wiring to the ECU.
8. Push the ECU and mounting bracket into place on the seat frame.
9. Install the RH side cover.
10. Install the seat cushion. See **Subject 110**.

Removal

1. Remove the seat cushion. See **Subject 110**.
2. Adjust the seat to the maximum height.
3. Lift up a front corner of the seat suspension skirt (if equipped), and place a 3-inch long stop between the front crossbar and the front frame of the seat base. See **Fig. 1**.



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A. Install a stop between the front crossbar and the seat base frame.

Fig. 1, Stop Installation

CAUTION

Do not remove the seat air spring without first 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.

4. While holding the stop in place until it is firmly set between the front crossbar and the base frame, exhaust all air from the air spring.
5. Drain the vehicle air reservoirs.

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.

6. Using a small flat-head screwdriver, disconnect the yellow air line to the air spring at the connector. See **Fig. 2**.

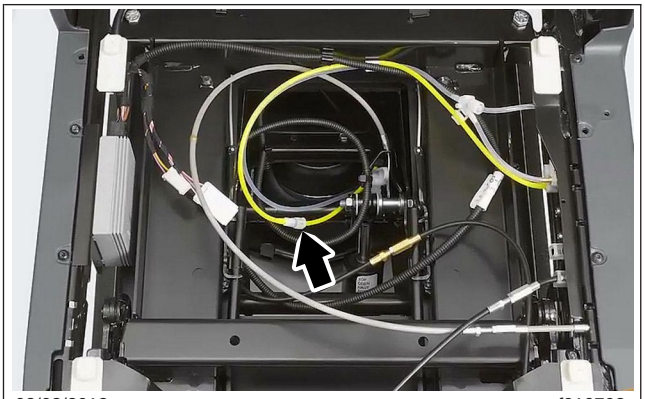

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Fig. 2, Connector, Yellow Air Line

7. Pull the two air lines out of the two hose clips next to the shock absorber. See **Fig. 3**.

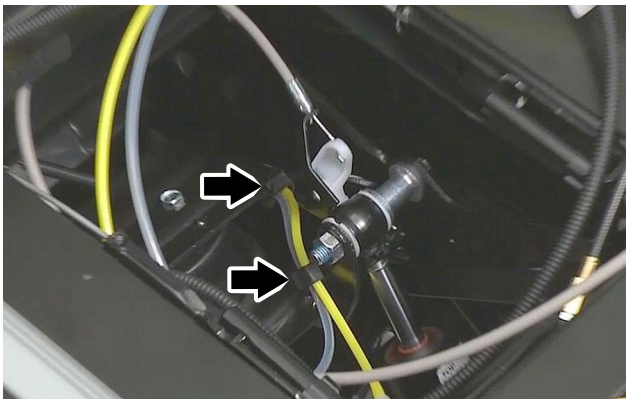

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Fig. 3, Air Hose Clips

8. Hold the suspension skirt (if equipped) up at the left rear corner of the seat and remove the hose clip from the upper air spring bracket. See **Fig. 4**.
9. Lift the suspension skirt (if equipped) up at the rear of the seat, and remove the screw that attaches the top of the air spring to the air spring bracket. See **Fig. 5**.
10. Push the air spring down to disengage the tab on the top of the spring, then rotate it counterclockwise 90 degrees to disengage the key on

Air Spring Replacement

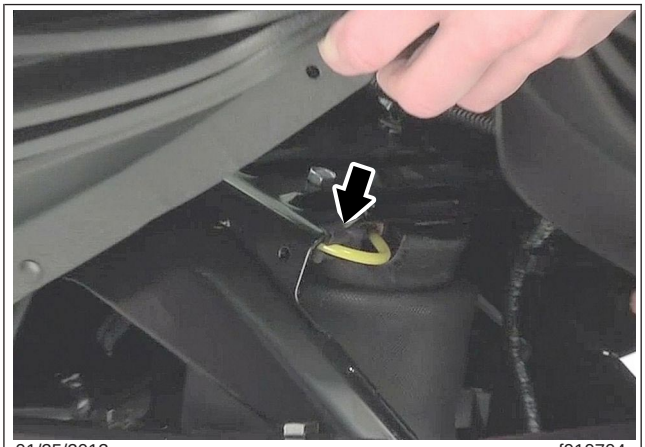

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Fig. 4, Air Hose Clip, Seat Base

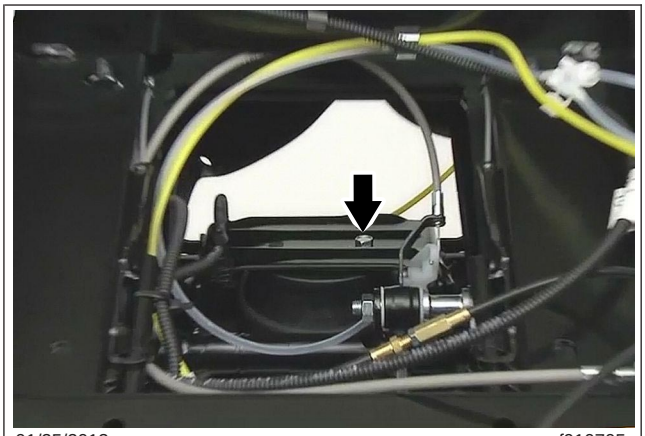

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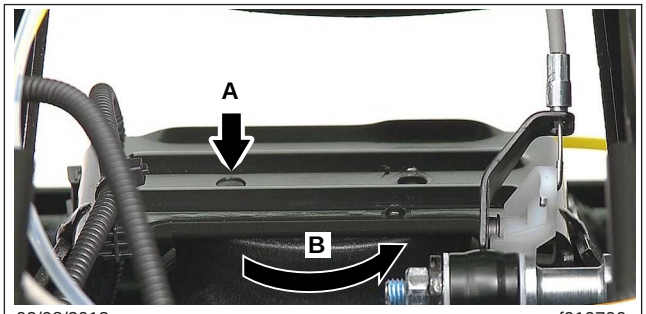
Fig. 5, Air Spring Capscrew

the bottom of the air spring from the slot in the lower bracket. See **Fig. 6**.

11. Lift the front of the suspension skirt (if equipped) up, and remove the air spring.
12. From the front of the seat, insert the new air spring into position. The key at the bottom of the air spring fits into the slot on the lower air spring bracket.
13. Turn the air spring clockwise until the tab on top of the air spring fits into the hole on the upper air spring bracket.
14. Attach the air spring to the top bracket with the screw. See **Fig. 5**. Tighten the screw 44 lbf·in (500 N·cm).



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A. Push the air spring down to disengage the tab.
B. Rotate the air spring counterclockwise 90 degrees.

Fig. 6, Removing the Air Spring

15. Attach the air lines to the two hose clips next to the shock absorber. See **Fig. 3**.
16. Connect the yellow air lines. See **Fig. 2**.
17. At the rear of the seat, attach the yellow air line to the upper air spring bracket with a hose clip. See **Fig. 4**.
18. Start the engine and allow the air reservoirs to fill.
19. Adjust the seat to the maximum height and remove the stop from between the front crossbar and the seat base frame.
20. If applicable, attach the bottom of the suspension skirt to the seat base.
21. Install the seat cushion. See **Subject 110**.

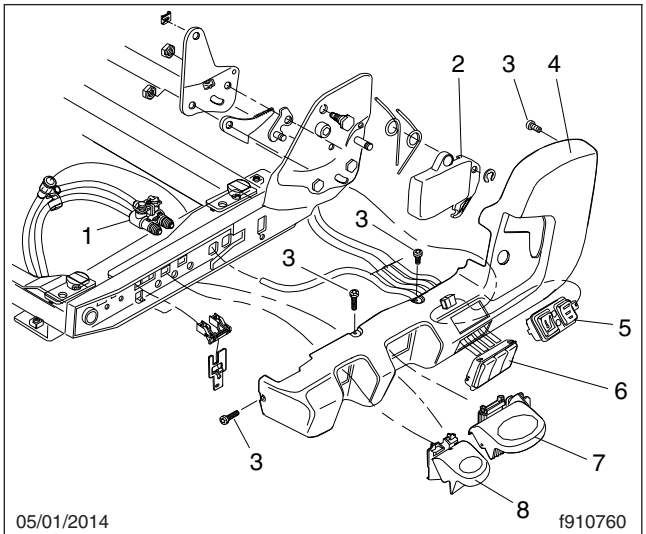
Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Drain the vehicle air reservoirs.

⚠ 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 seat cushion. See **Subject 110**.
4. Remove the screws at the front and top of the side cover; see **Fig. 1**.



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1. Height Adjustment Valve
2. Recline Handle
3. Screw
4. Side Cover
5. Heat/Ventilation Controls
6. Lumbar Controls
7. Height Adjustment Lever
8. Shock Absorber Adjustment Lever

Fig. 1, Side Cover Installation (LH shown)

5. Clean the seat cushion slider tabs; See **Fig. 2**.
6. Pivot the seat back all the way forward.
7. Remove the screw at the rear of the side cover.
8. Pivot the seat back to the upright position.

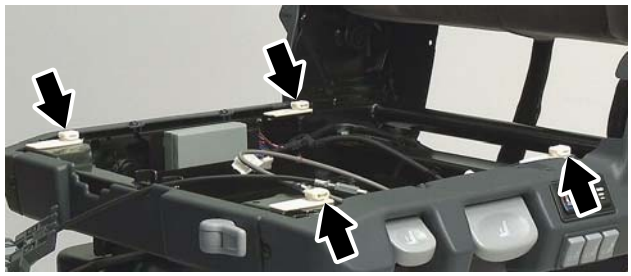

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Fig. 2, Slider Tabs

9. Push a large flathead screwdriver between the recline mechanisms to keep the seat back upright; see **Fig. 3**.

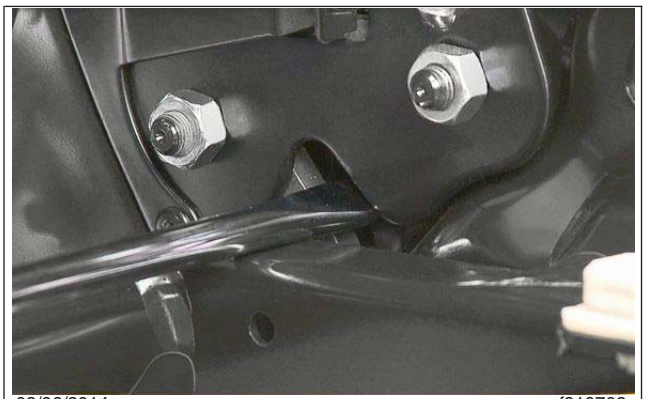

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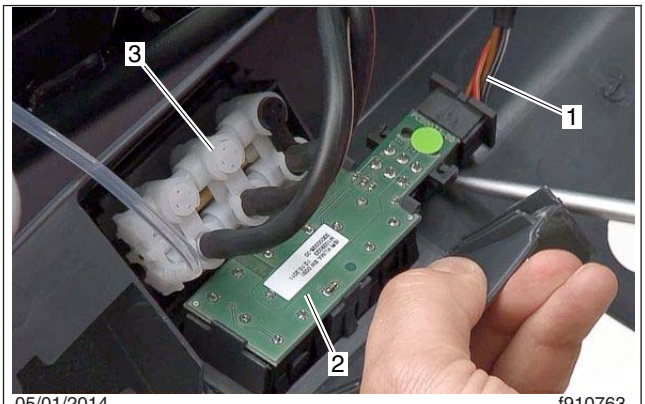
Fig. 3, Jamming the Recline Mechanism

10. Release the side cover from the seat back recline handle, then pull the cover loose.
11. For LH side cover, remove the controls (if equipped):
    - 11.1 Disconnect the wiring from the seat heating and ventilation controls. See **Fig. 4**.
    - 11.2 Snap the seat heating and ventilation controls out of the side cover.
    - 11.3 Disconnect the clear air line under the seat cushion; see **Fig. 5**.
    - 11.4 Disconnect the three black air lines from the lumbar controls; see **Fig. 6**. Note the color stripes on the air lines for installation.
    - 11.5 Snap the lumbar controls out of the side cover.

Side Cover Removal and Installation



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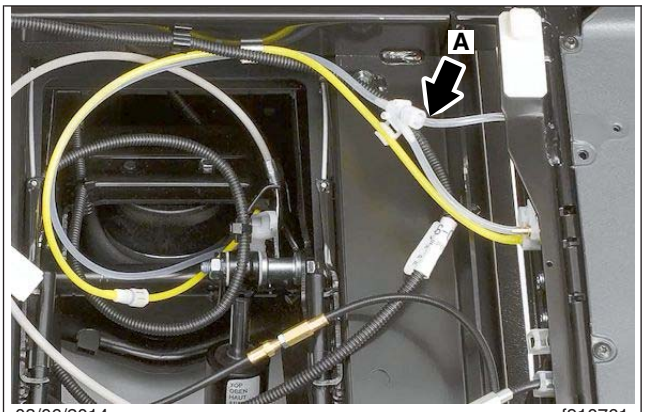
1. Heat/Ventilation Controls Wiring
2. Heat/Ventilation Controls Module
3. Lumbar Controls

Fig. 4, Heat/Ventilation and Lumbar Controls



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A. Disconnect the air line here.

Fig. 5, Air Line Connection

12. Remove the side cover.

Installation

1. For the LH side cover, install controls (if equipped) as follows:
   - 1.1 Snap the lumbar controls into the side cover.
   - 1.2 Connect the three black air lines to the back of the lumbar control; see **Fig. 6**.

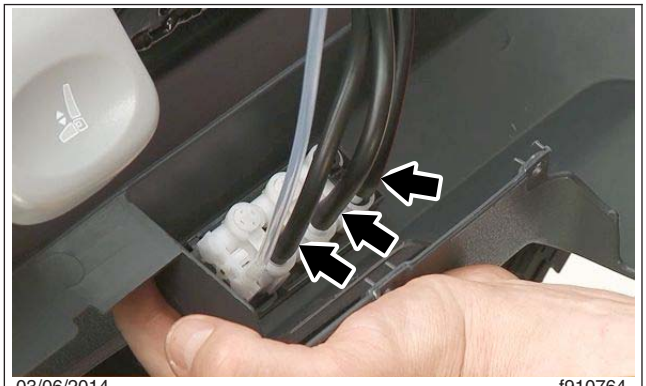

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Fig. 6, Lumbar Control Air Lines

   - 1.3 Route the clear air line through the hole in the seat frame, then connect the line; see **Fig. 5**.
   - 1.4 Snap the heating and ventilation controls module into place on the side cover and connect the wiring; see **Fig. 4**.
2. With a large flathead screwdriver in the seat back recline mechanism to keep the seat upright (**Fig. 3**), position the side cover into place.
3. Remove the screwdriver from the recline mechanism.
4. Make sure the seat cushion sliders are clean, then pivot the seat back to all the way forward.
5. Install the screw at the back of the side cover. Tighten the screw 18 lbf·in (200 N·cm). See **Fig. 1**.
6. Pivot the seat to the upright position.
7. Install the screws at the top and front of the side cover. Tighten the screws 18 lbf·in (200 N·cm).
8. Install the seat cushion; see **Subject 110**.
9. Connect the air lines.
10. Build up system pressure and check for air leaks.

Specifications

Torque Specifications				
Fastener Description	**lbf·ft**	**N·m**	**lbf·in**	**N·cm**
Seat Mounting Capscrews	11–13	15–18	—	—
Intermediate-Connecting-Point (ICP) Bar Screws	35–50	48–68	—	—
Seat Tilt Lever Screws	—	—	22–31	250–350
Height Adjustment Handle Screws	—	—	13	150
ECU Mounting Nut	—	—	18	200
Air Spring Capscrew	—	—	44	500

Table 1, Torque Specifications

General Information

Freightliner LLC currently applies DuPont® single-stage Imron Elite EA (also called Elite SS) or two-stage (base coat and clear coat) Imron Elite EB (also called Elite BC) high-solids polyurethane enamel on the vehicle cab at the factory. Freightliner manufacturing switched from Imron 5000 and Imron 6000, to Imron Elite in 2004.

Black standard urethane or Imron EA is used on the vehicle chassis. The chassis includes the frame, hubs, running gear, and any components attached to the frame. Aluminum fuel tanks are not painted.

To meet the air quality regulations imposed by the EPA and local jurisdictions, these products contain lower levels of volatile organic compounds (VOCs) than earlier types (916Y, Centari®, and Imron), 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 Freightliner Regional Office for use of topcoats produced by other manufacturers.

Color-Matching

The recommended aftermarket paints for color-matching factory-applied paint are as follows:

- Use Imron 4000 or Elite EA for cabs that were factory-painted single-stage Elite EA.
- Use Imron 6000 or Elite EB for cabs that were factory-painted two-stage Elite EB.
- Use Imron 5000 or Elite EA for the chassis.

To ensure proper gloss, durability, and color-matching of the enamel, use only two-stage Imron 6000 or Elite EB on panels that were previously painted with Imron 5000, and use only Imron 6000 on panels painted with Elite EB.

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 the *Cascadia™ 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 the entire vehicle with a mild detergent, and dry.
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 220 sandpaper.

   3.2 Feather the edges by hand, using a sanding block with 400 sandpaper.
4. Sand the entire area to be painted. Using a sanding block and 400 sandpaper, remove the gloss to improve adhesion of the primer.
5. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - On metal surfaces, use DuPont First Klean 3900S, DuPont Final Klean 3901S, or DuPont 3939 S Lacquer and Enamel Cleaner. Do not use these cleaners on plastic or fiberglass substrates.
   - On plastic or fiberglass substrates, use DuPont Low VOC Final Klean 3909S.
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.

Prime Coat Application

- Steel—use DuPont 5718 S metal conversion coating.
- 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. 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 320 grit sandpaper.
4. Wipe the air fairing with a clean cloth soaked in DuPont Low VOC Final Klean 3909S, or a solution of one part water and one part isopropyl alcohol. Allow 10 to 15 minutes for the air fairing to dry.
5. 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 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.
   - On metal surfaces, use DuPont First Klean 3900S, DuPont Final Klean 3901S, or DuPont 3939 S Lacquer and Enamel Cleaner. Do not use these cleaners on plastic or fiberglass substrates.
   - On plastic or fiberglass substrates, use DuPont Low VOC Final Klean 3909S.

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.

Do not apply if the paint temperature is less than 70°F (21°C). Use warm water or paint heaters to heat the paint to an optimum temperature of 85 to 95°F (29 to 35°C). The material, substrate, or ambient temperature should be above 50°F (10°C) and below 110°F (43°C).

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.

Imron Elite EA Topcoating

Imron Elite EA (also called Elite SS) 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) 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.

Mixing

1. Stir the Imron Elite EA enamel thoroughly.
2. Mix three parts Imron Elite EA enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture 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 10 to 19 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 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 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 Allow 5 to 10 minutes drying time between each application. Do not sand.
   - 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).
4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

5. 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 400-grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

Imron Elite EB Topcoating

Imron Elite EB (also called Elite BC) is a two-stage, high-solids polyurethane enamel. It provides good cover with one cross-coat of the base color followed by one coat of Imron Elite EB clear coat. Both the base color and clear coat require the addition of an activator.

⚠ 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.

Mixing

1. Stir the Imron Elite EB base color thoroughly.
2. Mix three parts Imron Elite EB base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture 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 10 to 19 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 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 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 Apply one cross-coat of the Imron Elite EB base color.
   - 2.3 Flash 10 minutes minimum. Do not sand.
   - 2.4 Purge the equipment with DuPont 3602 S lacquer thinner, or 8685 S reducer.
3. Apply clearcoat.
   - 3.1 Mix three parts DuPont 3440 S or 3480 S clear, with one part DuPont 193 S or 194 S activator.
   - 3.2 Apply one coat of the activated DuPont 3440 S or 3480 S clear. Some colors may require additional cross-coats.
4. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the clear coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
5. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
6. Clean the equipment immediately after use, with DuPont 3602 S lacquer thinner or 8685 S reducer.

Recoating or Decorating

Two-toning, striping, and 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.

General Guidelines

This subject provides instructions for making spot repairs or touch-ups with DuPont® enamels. 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. Specific types of surfaces to be painted, require specific types of preparation materials. Do not use preparation materials specified for a given type of surface on another surface, for which it is not specified.

   See **Specifications, 400** for a summary of the materials used in this section.

2. Use only the intermediate coatings, such as primers, of 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.
4. Do not apply if the paint temperature is less than 70°F (21°C). Use warm water or paint heaters to heat the paint to an optimum temperature of 85 to 95°F (29 to 35°C). The material, substrate or ambient temperature should be above 50°F (10°C) and below 110°F (43°C).

⚠ 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, then rinse.
2. Remove imperfections using ultra-fine or micro-fine 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 Fine-Cut Cleaner
   - 3M Finesse-it II 05928

   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 Swirl Remover
   - 3M Perfect-it 05996

   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, 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 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.
4. Sand or grind all dents and scratches.

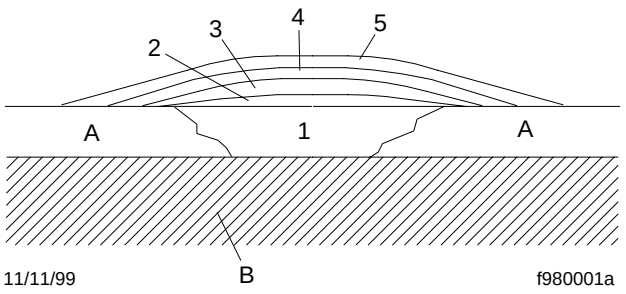
Spot Repair

5. Wet sand the area being repaired with 320-grit or finer sandpaper, or a 3M Scotch-Brite® or similar non-iron abrasive pad. Feather the edge.
6. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
7. Mask all areas that will not be painted.
8. Clean all cracks and surfaces with dry compressed air.
9. 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 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 DuPont primer. See **Fig. 1**.
    - Steel and aluminum—use Corlar 824 S epoxy primer.
    - Fiberglass—use Corlar 825 S epoxy primer.



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

10.1 Stir primer thoroughly.

10.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

10.3 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.

10.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

10.5 Set the air pressure at the spray gun to 45 psi (310 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

10.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

10.7 Spray one wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

10.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

10.9 Air dry 2 to 4 hours or force dry 20 minutes.

11. Wet sand the primer with 400-grit or finer sandpaper. Feather the edge into the surrounding area.
12. If the original paint was Imron Elite EB (also called Elite BC) hand-rub the area around the spot repair with a medium grade compound to ensure a seamless finish.
13. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
14. Wipe the repair area with a tack cloth.
15. If the finish is old, apply one coat of DuPont 222 S adhesion promoter over the entire repair area.

15.1 Set the air pressure to 35 psi (240 kPa) at the spray gun.

15.2 Flash for 5 to 10 minutes at 70°F (21°C) before topcoating.

Topcoating a 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.

Imron Elite EB Topcoating

1. Mix the Elite EB polyurethane enamel.
   - 1.1 Stir the Elite EB base color thoroughly.
   - 1.2 Mix three parts Elite EB 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.

Note: The viscosity of the mixture is about 10 to 19 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
3. Apply the topcoating.
   - 3.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 3.2 Apply one cross-coat of the Elite EB base color over the primed area. No flash time is required before applying a clear coat.
   - 3.3 Purge the equipment with DuPont 3602 S lacquer thinner or 8685 S reducer.
   - 3.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.

   NOTE: For best results, apply the clear coat over the entire panel. If a blend of the repair area is attempted, apply the clear coat only over the repair area, overspraying the edge slightly.
   - 3.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.
4. Purge the equipment with DuPont 3602 S lacquer thinner or 8685 S reducer.
5. Blend the 3440 S or 3480 S clear into the surrounding topcoat.
   - 5.1 Set the air pressure to 25 psi (170 kPa) at the spray gun.
   - 5.2 Apply one coat of 3401 S blending clear over the repair area, only to the overspray edge.
   - 5.3 Flash 2 minutes. Repeat if necessary.
6. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   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. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
8. Clean the equipment immediately after use, with DuPont 3602 S lacquer thinner or 8685 S reducer.

Imron Elite EA Topcoating

1. Mix the Elite EA polyurethane enamel.
   - 1.1 Stir the Elite EA enamel thoroughly.
   - 1.2 Mix three parts Elite EA 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.

   Note: The viscosity of the mixture is about 10 to 19 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.
2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
3. For metallic topcoats only, apply one coat of DuPont 500 S urethane clear.

Spot Repair

3.1 Mix eight parts of 500 S urethane with one part 193 S activator.

3.2 Reduce the activated 500 S urethane mixture 50 percent with 8685 S reducer.

3.3 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.

3.4 Flash 3 minutes before applying the Elite EA 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 (100 to 140 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 air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

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. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

8. 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