Engine Port Diagrams

Use the following diagrams to identify engine ports:

- For a Caterpillar CFE engine, see Fig. 1.
- For a Caterpillar C-7/C-9 and C-11/C-13 engine, see Fig. 2.
- For a Caterpillar C-10/C-12 engine, see Fig. 3.

1. Oil Pressure Connection, 1/4-Inch NPT
2. Oil Return, 9/16–18
3. Oil Pan, 1-1/16–12
4. Oil Drain, 3/4–16
5. Magnetic Pick-Up
6. Fuel Inlet, 9/16–18
7. Fuel Return, 9/16–18
8. Ether Start Ports
9. Vent-to-Radiator, 3/8-Inch NPT
10. Water Outlet
11. Water Temperature Gauge Connection, 1/2-Inch NPT
12. Water Temperature Alarm Connection, 1/2-Inch NPT
13. Water Temperature, 1/2-Inch NPT
15. Water Drain, M12
17. Water Temperature, 3/4-Inch NPT
18. Radiator Shunt Line Connection
19. Water Return Line, 3/4-Inch NPT
20. Water Inlet, 51 mm
21. Oil Drain

Fig. 1, Caterpillar CFE Engine Ports
1. Lube Heater Inlet, 1-5/16 x 12 (No. 16 Port)
2. Oil Drain, 1-1/8 x 12
3. Bypass Oil Supply, 9/16-18 (No. 16 Port)
4. Bypass Oil Filter Mounting
5. Oil Pressure Connection, 9/16-18 (No. 16 Port)
6. Block Heater Mounting, 1-5/16 x 12 (No. 16 Port)
7. Live Oil Sample Location, 9/16-18 (No. 6 Port)
8. Turbocharger Exhaust Outlet
9. Cab Heater Supply, 1-1/16 x 12 (No. 10 Port)
10. Turbocharge Air Inlet
11. Water Outlet, 2.5" (63.5 mm) OD
12. Air Outlet (to Aftercooler)
13. Cab Heater Return, 7/8-14 (No. 10 Port)
14. Water Drain, 7/8-14 (No. 10 Port)
15. Water Inlet, 2.5" (63.5 mm) OD
16. Air Inlet (from Aftercooler)
17. Air Compressor Water Return
18. Air Outlet-Air Compressor 1/2 STD Pipe
19. Live Oil Sample Location, 9/16 x 18 (No. 6 Port)
20. Fuel Inlet, 7/8-14 x 45° Flare
21. Starting Mounting Pad
22. Oil Drain, 1-1/18 x 12
23. Air Compressor Water Supply
24. Oil Level Gauge
25. Air Inlet (from Aftercooler)
26. Fuel Return, 5/8-18 x 45° Flare
27. Electrical Ground Connection, M10 x 1.5 x 30.4 LG
28. Electrical Control Module
29. Magnetic Pick-Up
30. Fuel Bleed
31. Fumes Disposal Tube, 1.25" (31.8 mm) OD
32. Hydraulic Drive Location
33. Bypass Oil Return, 1-5/16 (No. 16 Port)

Fig. 2, Caterpillar C-7/C-9 Engine Ports (C-11/C-13 similar)
Fig. 3, Caterpillar C-10/C-12 Engine Ports

1. Water Supply, 1/2 NPT
2. Water Inlet
3. Water Return, 1/2 NPT
4. Oil, 1/8 NPT
5. Water Drain, 3/8 NPT
6. Oil Pan Connection, 1/2 NPT
7. Water Outlet
8. Water Return, 3/4 NPT
10. Oil Connection, 1 NPT
11. Magnetic Pick-Up
12. Fuel Inlet, 7/8-14
13. Oil Pressure Connection, 9/16-18
14. Air Manifold Port, 1/4 NPT
15. Air Manifold Port, 9/16-18
16. Water, 1/2 NPT
17. Engine Block Heater
18. Oil Drain, 1-1/8 –12
19. Vent to Radiator, 3/8 NPT
Inspection

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

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

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

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

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

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

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

   IMPORTANT: Replacing only one belt of a matched set will cause the new belt to carry more load, due to previous stretching in the older belt. This additional load can cause the new belt to break.

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

   Inspect for cracks, see (Fig. 2). Small, irregular cracks are usually signs of an old belt.

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

3. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a nonflammable cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.

4. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls see (Fig. 3), or use your little finger or fingernail to find grooves in the inner walls. If there are any grooves, replace the pulley.

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

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

   If there is misalignment of the pulleys, adjust the pulleys or brackets if their positions are adjustable. See Fig. 4. Replace bent or broken pulleys, pulley brackets, or shafts.

6. Check all drive component mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners. Repair or replace cracked or damaged brackets.
**Pulley and Drive Belt Inspection, Caterpillar Engines**

**Fig. 1, Drive Belt Problems**
- A. Glazing
- B. Separating Layers
- C. Streaked Sidewalls
- D. Tensile Break
- E. Uneven Ribs
- F. Cracks

**Fig. 2, Check for Cracks**
- A. Cracks Normal, Belt Okay
- B. Cracks not Normal, Replace Belt

**Fig. 3, Check for Pulley Wear**
- 1. Groove in Pulley Wall
- 2. Small Straightedge
A. Side View of Misaligned Pulleys.

Fig. 4, Check for Misaligned Pulleys
Belt Replacement (See Fig. 1)

1. Remove the belt.
   1.1 Remove the belt from the refrigerant compressor pulley and let the belt rest on the fan hub. Refer to the refrigerant compressor belt removal procedure in this subject.
   1.2 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner down and off the belt.
   1.3 Holding the belt tensioner down, remove the belt from the alternator pulley.
   1.4 Slowly release the belt tensioner, and remove the breaker bar.
   1.5 Lower the belt, and take it off the vibration damper. Raise the belt, and take it off over the fan. Remove the belt from the engine compartment.

2. Install the belt.
2.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in Subject 100.

2.2 If the fan or fan hub was removed to remove the compressor belt, install the fan or fan hub with the compressor belt in the fan pulley groove. Do not attach the compressor belt to the compressor at this time.

2.3 Loop the fan/alternator belt around the fan and align it in the rear channel of the fan pulley.

2.4 Loop the belt down and around the vibration damper pulley.

2.5 Install the refrigerant compressor belt on the compressor. Refer to the refrigerant compressor belt installation instructions in this subject.

2.6 Insert a 1/2-inch breaker bar in the belt tensioner, and rotate the tensioner counterclockwise while installing the belt on the alternator pulley.

2.7 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.

2.8 Remove the breaker bar from the tensioner.

3. Adjust the belt tension.

3.1 The Caterpillar belt tensioner automatically adjusts the fan and alternator belt to the correct tension.

3.2 If the belt slips, repair or replace the tensioner. For instructions, refer to the Caterpillar C-10/C-12 Truck Engine Service Manual.

Refrigerant Compressor Belt

1. Remove the belt.

   NOTE: The pulley bolt has left-handed threads.

   1.1 Use a 15-mm socket on the bolt and rotate the tensioner counterclockwise.

   1.2 Holding the belt tensioner up, remove the belt from the compressor pulley.

   1.3 Slowly release the belt tensioner, and remove the socket.

   1.4 Remove the compressor belt from the fan pulley. If necessary, remove the fan from the fan pulley according to the instructions in Section 20.01, Subject 110.

2. Install the belt.

   2.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in Subject 100.

   2.2 Install the belt around the fan pulley.

   2.3 If the fan was removed, install it according to the instructions in Section 20.01, Subject 110.

   2.4 Use a 15-mm socket on the bolt and rotate the tensioner counterclockwise while installing the belt on the compressor pulley.

   2.5 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.

   2.6 Remove the socket from the tensioner.

3. Adjust the belt tension.

   3.1 The Caterpillar belt tensioner automatically adjusts the fan and alternator belt to the correct tension.

   3.2 If the belt slips, repair or replace the tensioner. For instructions, refer to the Caterpillar C-10/C-12 Truck Engine Service Manual.
Replacement

1. Insert a 1/2-inch ratchet drive into the square hole in the belt tensioner, and turn the tensioner down and off the belt. See Fig. 1.
2. Remove the engine accessory drive belt.
3. Inspect the pulleys and the drive belt, even if installing a new belt, as instructed in Subject 100.
4. Position the drive belt over all the pulleys except the drive belt tensioner. For the correct belt routing, see Fig. 1.
5. Insert a 1/2-inch ratchet drive into the square hole in the belt tensioner, and turn the tensioner clockwise. See Fig. 1.
6. Position the tensioner against the belt, and remove the ratchet drive from the tensioner.

CAUTION

When installing a serpentine accessory drive belt, route the belt correctly. If the belt is not routed correctly, the water pump pulley may rotate in the wrong direction, allowing the engine to overheat.
Removal

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

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

3. Disconnect the batteries.

4. Remove the section of exhaust ducting that runs between the turbocharger and the muffler. See Fig. 1.

**WARNING**

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

5. Drain the radiator. See Section 20.01, Subject 100.

6. Drain the power steering fluid to a level below the pump. See Group 46.

7. Remove the vertical air intake snorkel upper bracket assembly and related components. See Section 09.00, Subject 130.

8. Remove the air duct between the turbocharger and the air cleaner. See Fig. 2.

9. Remove the charge air cooler ducting from between the charge air cooler and the turbocharger outlet.

10. Remove the charge air cooler ducting from between the intake manifold and charge air cooler.

11. Cover the intake manifold and turbocharger openings with a cloth, and clamp securely.

12. Recover the A/C refrigerant from the system.

13. Remove the radiator, CAC and A/C condenser as an assembly. See Section 20.01.

14. Disconnect the cab heater hoses.

15. Disconnect the A/C suction and discharge hoses from the compressor, then cap the openings.

16. Remove the fan and fan clutch. See Section 20.02.

17. Label and disconnect the wiring.

   17.1 Disconnect the wiring from the starter.

   17.2 Disconnect the wiring from the alternator.

   17.3 Disconnect the wiring from the coolant temperature sensors.

   17.4 Unplug the lower wiring harness connector from the electronic control module.

   17.5 Label and disconnect any remaining wiring harness connectors.

---

Fig. 1, Engine Compartment Component Identification (rear)
18. If equipped, disconnect the ether start tube and sensor wire.

19. Disconnect the power steering hoses from the reservoir and pump. See Group 46.

20. Disconnect the air lines from the air governor.

21. At the fuel/water separator, disconnect the fuel delivery line that runs to the engine.

22. Disconnect the fuel return line from the back of the cylinder head.

23. Disconnect the wire-braid air compressor outlet line from the chassis air supply line.

24. Disconnect the engine flexplate from the transmission flexplate adaptor (torque converter).

24.1 Remove the access cover from the front of the engine flywheel housing (bottom side). See Fig. 3.

24.2 Using a pry bar or a breaker bar, turn the engine until a flexplate self-locking bolt can be seen through the access hole. Using a ratchet-and-socket wrench, loosen and remove the flexplate self-locking bolt. See Fig. 4.

24.3 Repeat the previous substep until all 12 flexplate self-locking bolts are removed.

25. Slide a transmission jack into place under the transmission. Raise the jack support plate until it contacts the bottom of the transmission. Secure the transmission to the jack. See Fig. 5.
26. Remove the 12 transmission flange bolts from the engine flywheel housing. See Fig. 6.

**WARNING**

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

27. Remove the engine from the vehicle.

27.1 Attach the chain to the existing lifting eyes at the front and the rear of the engine. See Fig. 2 and Fig. 7.

27.2 With the engine lifting eyes connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.

27.3 Remove the nuts from the bolts from the front engine mount.
27.4 With the engine securely supported by the crane and lifting chains, separate the rear engine mounts by removing the nut from the bolt that runs down through mount.

27.5 Slightly raise the engine, then separate the engine from the transmission.

NOTE: Be sure that the engine has cleared the torque converter before continuing to remove the engine from the vehicle.

27.6 Using the crane, lift the engine and pull it forward.

27.7 Once the engine is clear of the vehicle, place the engine on an engine stand.

Installation

1. Check all of the front and rear engine support parts for damage or extreme wear. Replace the parts as needed.

   Install the isolators in the engine front crossmember. Coat the rubber mounts with soapy water, and install them in the rear engine mounts.

   **CAUTION**

   Do not lubricate the components with oil, grease, or silicone lubricants, which can soften the rubber and damage the mounts.

2. Install the engine in the vehicle.

   2.1 Attach the chain to the existing lifting eyes at the front and the rear of the engine.

   2.2 With the two engine lifting eyes connected by chain to the crane, lift the engine, and position it in the engine compartment.

   **CAUTION**

   The engine flywheel housing must be free to seat against the transmission. If the engine flywheel housing will not seat freely (without force) against the transmission, then move the engine away from the transmission and correct the problem. Do not force the engine flywheel housing to seat against the transmission housing by installing and tightening the flange bolts. To do so could cause damage to the transmission.

   2.3 With the bolt holes in the transmission flange aligned with the mounting holes in the engine flywheel housing, seat the transmission squarely against the flywheel housing. To help push the bell housing square against the flywheel housing, insert a pry bar between the rear engine support bracket and the frame bracket, and push forward. If the transmission will not seat freely (without excessive force) against the engine flywheel housing, then move the transmission away from the engine and correct the problem.

   2.4 Install the transmission flange bolts finger-tight.
2.5 Connect the engine to the rear engine mounts, and tighten each bolt that runs down through the engine leg, rubber isolators, and engine mount 241 lbf-ft (327 N·m).

2.6 Remove the nuts from the bolts from the front engine mount. Tighten the nuts 136 lbf-ft (184 N·m).

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

3. Remove the transmission jack from the transmission.

NOTE: Do not tighten any flexplate-to-flexplate adaptor bolts until all of the bolts have been installed and tightened finger-tight.

4. Attach the engine flexplate to the transmission flexplate adaptor (torque converter).

4.1 Using a pry bar or a breaker bar, turn the engine until the next flexplate bolt hole can be seen through the access hole. Install a M8 x 1.25 flexplate self-locking bolt into the flexplate bolt hole and tighten it finger-tight.

4.2 Repeat the previous substep until all 12 flexplate self-locking bolts are installed finger-tight.

4.3 After all the self-locking bolts have been installed finger-tight, tighten them 13 to 18 lbf-ft (18 to 24 N·m).

4.4 Install the access cover (plug) on the front of the engine flywheel housing. See Fig. 3.

5. Connect the wire-braid air compressor outlet line to the chassis air supply line.

6. Connect the fuel delivery and return lines.

7. Connect the air lines to the air governor on top of the air compressor.

8. Connect the power steering components. For instructions, see Group 46.

9. If equipped, connect the ether start tube and sensor wire.

10. Connect the engine wiring.

10.1 Connect the wiring to the starter.

10.2 Connect the wiring to the alternator.

10.3 Connect the wiring to the coolant temperature sensors.

10.4 Plug the lower wiring harness connector into the electronic control module.

10.5 Connect any remaining electrical harness connectors.

11. If removed, install the fan and fan clutch. See Section 20.02.

12. Replace the refrigerant compressor O-rings, then connect the hoses to the compressor.

13. Connect the cab heater hoses.

14. Install the radiator, CAC and A/C condenser. See Section 20.01.

15. Remove the intake manifold and turbocharger covers, then install the ducting.

16. Install the vertical air intake snorkel upper bracket assembly and related components. See Section 09.00, Subject 130.

17. Fill the cooling system with coolant.

18. Fill the engine with the proper type and quantity of engine oil.

19. Fill and bleed the power steering system. For instructions, see Group 46.

20. Prime the fuel system to ease starting.

21. Install the exhaust ducting that runs between the turbocharger and the muffler. See Group 49.

22. Connect the batteries.

23. Start the engine, and check for leaks. Repair any leaks found.

DANGER

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

24. Return the cab to the normal operating position.

25. Test drive the vehicle.
Drive Belt Replacement

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

**DANGER**

Before tilting the cab or returning the cab to operating position, read the instructions and hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

3. Insert a 1/2-inch drive ratchet into the square hole in the drive belt tensioner pulley, and turn the tensioner down and off the belt. See Fig. 1, Ref. 4.

4. Remove the drive belt, without prying or rolling it off of the pulleys.

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

**CAUTION**

When installing a serpentine drive belt, route the belt correctly. If the belt is not routed correctly, the water pump pulley may rotate in the wrong direction, allowing the engine to overheat.

6. Position the replacement drive belt over all the pulleys except the drive belt tensioner pulley. For the correct drive belt routing, see Fig. 2 for vehicles with a refrigerant compressor, and Fig. 3 for vehicles without a refrigerant compressor.

---

**Fig. 1, Relieving/Adjusting Belt Tension**

1. Alternator Pulley
2. Tensioner Pulley
3. Drive Belt
4. Drive Ratchet

**Fig. 2, Drive Belt Routing With a Refrigerant Compressor (C-11 shown, C-13 similar)**

4. AC Compressor
5. Fan Clutch
6. Drive Belt

**NOTE:** Turn the belt tensioner counterclockwise, off the belt.

---

7. Insert a 1/2-inch drive ratchet into the square hole in the belt tensioner, and turn the tensioner clockwise. See Fig. 1.

8. Position the tensioner against the belt, and remove the drive ratchet from the tensioner.

9. Check that the drive belt has been correctly routed; see Fig. 2 for vehicles with a refrigerant...
10. Start the engine and check the drive belt for proper operation.

11. Shut down the engine. If there is a problem, correct it, and check the drive belt again.

**DANGER**

Before tilting the cab or returning the cab to operating position, read the instructions and hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

12. Lower the cab.

13. Remove the chocks from the tires.
Drive Belt Replacement

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

**DANGER**

Before tilting the cab or returning the cab to operating position, read the instructions and hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

3. Insert a 1/2-inch drive ratchet into the square hole in the drive belt tensioner pulley, and turn the tensioner down and off the belt. See Fig. 1, Ref. 4.

4. Remove the drive belt, without prying or rolling it off of the pulleys.

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

**CAUTION**

When installing a serpentine drive belt, route the belt correctly. If the belt is not routed correctly, the water pump pulley may rotate in the wrong direction, allowing the engine to overheat.

6. Position the replacement drive belt over all the pulleys except the drive belt tensioner pulley. For the correct drive belt routing, see Fig. 2 for vehicles with a refrigerant compressor, and Fig. 3 for vehicles without a refrigerant compressor.

7. Insert a 1/2-inch drive ratchet into the square hole in the belt tensioner, and turn the tensioner clockwise. See Fig. 1.

8. Position the tensioner against the belt, and remove the drive ratchet from the tensioner.

9. Check that the drive belt has been correctly routed; see Fig. 2 for vehicles with a refrigerant.
10. Start the engine and check the drive belt for proper operation.

11. Shut down the engine. If there is a problem, correct it, and check the drive belt again.

**DANGER**

Before tilting the cab or returning the cab to operating position, read the instructions and hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

12. Lower the cab.

13. Remove the chocks from the tires.
### Engine Mount Fastener Torque

<table>
<thead>
<tr>
<th>Fastener Description</th>
<th>Bolt Size</th>
<th>Grade</th>
<th>Torque: lbf·ft (N·m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame Rail Leg-to-Frame Rail</td>
<td>5/8–11 x 2.25 Inch</td>
<td>8</td>
<td>190 (258)</td>
</tr>
<tr>
<td>Frame Rail Leg-to-Engine Mount</td>
<td>1–8</td>
<td>5</td>
<td>280–380 (380–515)</td>
</tr>
<tr>
<td>Frame Rail Leg-to-Engine Mount</td>
<td>5/8–11 x 3.5 Inch</td>
<td>8</td>
<td>120–152 (163–206)</td>
</tr>
<tr>
<td>Engine Mount-to-Flywheel Housing</td>
<td>3/4–10 x 2 Inch</td>
<td>8</td>
<td>Aluminum flywheel housings: 180–220 (244–298)</td>
</tr>
<tr>
<td>Frame Rail Leg-to-Engine Mount</td>
<td>5/8–11 x 3.5 Inch</td>
<td>8</td>
<td>Iron flywheel housings: 213–269 (289–365)</td>
</tr>
<tr>
<td>Engine Mount-to-Transmission</td>
<td>M16 x 50</td>
<td>Class 10.9</td>
<td>168–196 (228–266)</td>
</tr>
<tr>
<td>Front Engine Support Bracket-to-Front Engine Mount</td>
<td>5/8–11 x 5 Inch</td>
<td>8</td>
<td>140–160 (190–217)</td>
</tr>
<tr>
<td>Rear Engine-to-Mount</td>
<td>—</td>
<td>—</td>
<td>213–269 (289–365)</td>
</tr>
<tr>
<td>Front Engine-to-Mount</td>
<td>—</td>
<td>—</td>
<td>213–269 (289–365)</td>
</tr>
</tbody>
</table>

Table 1, Engine Mount Fastener Torque

### Engine Leg-to-Flywheel Housing Fastener Torque

<table>
<thead>
<tr>
<th>Engine</th>
<th>Fastener Size</th>
<th>Torque: lbf·ft (N·m)</th>
<th>Plus/Minus lbf·ft (N·m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-7</td>
<td>M14–2</td>
<td>94–100 (128–136)</td>
<td>6 (8)</td>
</tr>
<tr>
<td>C-9, C-10, C-12</td>
<td>3/4–10</td>
<td>170–190 (231–258)</td>
<td>20 (27)</td>
</tr>
</tbody>
</table>

Table 2, Engine Leg-to-Flywheel Housing Fastener Torque

### Drive Belt Tension

<table>
<thead>
<tr>
<th>Engine</th>
<th>Component</th>
<th>Belt Tension, New Belt lb (kg)</th>
<th>Belt Tension, Used Belt lb (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFE</td>
<td>Refrigerant Compressor</td>
<td>80–100 (36–45)</td>
<td>80–100 (36–45)</td>
</tr>
<tr>
<td>3176</td>
<td>Refrigerant Compressor</td>
<td>80–100 (36–45)</td>
<td>80–100 (36–45)</td>
</tr>
<tr>
<td>3406</td>
<td>Alternator and Refrigerant Compressor</td>
<td>115–125 (52–57)</td>
<td>80–100 (36–45)</td>
</tr>
<tr>
<td></td>
<td>Fan</td>
<td>115–125 (52–57)</td>
<td>80–100 (36–45)</td>
</tr>
</tbody>
</table>

Table 3, Drive Belt Tension
General Information

Three mounts support the engine and transmission, holding a total of almost 1,800 lb (816 kg). Two of the engine mounts support the rear of the engine and transmission assembly. The third supports the front of the assembly.

The rear mounts are positioned on the engine flywheel housing.

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.

To isolate the engine and transmission from road shock, and to isolate the vehicle frame from engine vibration, the engine mounts are sandwiched between rubber isolator cushions (sometimes called restriction pads). Steel spacers protect the cushions from wearing on the engine support brackets, and bolts run through the mount, cushions, and spacers to hold the assembly together and hold the engine on the mount.
Replacement (See Fig. 1)

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

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

**WARNING**

The jack used to lift the transmission must be capable of safely lifting and supporting 4400 lbs (1996 kg). Once the mount is disconnected, do not get under the transmission until it is securely supported on stands. An unsecured transmission may fall, causing personal injury or death, and component damage.

3. Disconnect the left rear engine mount.

---

**Rear Engine Mount Replacement**

3.1 Place a jack under the transmission, and raise the jack until it’s braced against the transmission.

3.2 Remove the bolt from the left rear mount. Save the fasteners and the rubber isolator cushions, and spacer(s).

3.3 Lift the transmission slightly to take its weight off the left rear mount. Place stands under the transmission to keep it off the mount.

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

5. Place a new mount against the inside of the frame rail, and secure it with capscrews, washers, and nuts. Tighten the nuts 190 lbf-ft (258 N-m).

6. If removed, install the engine support bracket on the left side of the engine. Apply Loctite® 271 to the capscrews, and tighten as follows:

   *For aluminum flywheel housings:* tighten the nuts 180 to 220 lbf-ft (244 to 298 N-m).

   *For iron flywheel housings:* tighten the nuts 213 to 269 lbf-ft (289 to 365 N-m).

**NOTE:** Inspect the rubber isolators for wear or damage, and replace them if necessary.

7. Install the rubber isolators in the engine mount.

---

**CAUTION**

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

**WARNING**

The jack used to lower the transmission must be capable of safely lifting and supporting 4400 lbs (1996 kg). Once the transmission is removed from the stands, do not get under the transmission until it is securely installed on the mount. An unsecured transmission may fall, causing personal injury or death, and component damage.

8. Secure the engine to the mounts.
Rear Engine Mount Replacement

8.1 If not in place, set a jack under the transmission and raise the jack until it is braced against the transmission.

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

8.3 Holding the lower isolator and spacer in place, install the bolt in the left rear mount, and secure it with the nut and hardened washer. Tighten the nut 120 to 152 lbf·ft (163 to 206 N·m).

9. Repeat this procedure for the other rear mount.

10. Remove the jack from under the transmission.

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

11. Return the cab to the normal operating position.

12. Remove the chocks from the tires.
Replacement (See Fig. 1)

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

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

**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.

3. Disconnect the engine from the front engine mount.

   3.1 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.

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

3.3 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.

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

5. 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.

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

**WARNING**

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

7. Secure the engine to the front engine mount.
   
   7.1 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.
   
   7.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   
   7.3 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 140 to 160 lbf·ft (190 to 217 N·m).

   NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 280 to 380 lbf·ft (380 to 515 N·m).
   
   7.4 Remove the lifting chain from the engine lifting hooks.

DANGER

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

8. Return the cab to the normal operating position.

9. Remove the chocks from the tires.
Replacement (See Fig. 1)

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

DANGER

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

CAUTION

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

3. Disconnect the left rear engine mount.

3.1 Place a jack under the transmission, and raise the jack until it’s braced against the transmission.

3.2 Remove the bolt from the left rear mount. Save the fasteners and the rubber isolator cushions, and spacer(s).

3.3 Lift the transmission slightly to take its weight off the left rear mount. Place stands under the transmission to keep it off the mount.

3.4 Remove the mount from the frame rail. For instructions, see Subject 100. Remove and discard the isolator.

WARNING

The jack used to lower the transmission must be capable of safely lifting and supporting 4400 lbs (1996 kg). Once the transmission is removed from the stands, do not get under the transmission until it is securely installed on the mount. An unsecured transmission may fall, causing personal injury or death, and component damage.

4. Install the new isolator in the mount, and install the mount on the frame rail. For instructions, see Subject 100.

5. Secure the transmission to the mount.

5.1 If not in place, set a jack under the transmission and raise the jack until it is braced against the transmission.

5.2 Lift the transmission slightly to remove the stands. Remove the stands, and carefully lower the transmission onto the mount.

5.3 Holding the lower isolator and spacer in place, install the bolt in the left rear mount, and secure it with the nut and hardened washer. Tighten the nut 120 to 152 lbf·ft (163 to 206 N·m).

6. Repeat this procedure for the other rear mount.

Fig. 1, Rear Engine Mount Assembly

1. Frame
2. Capscrew, 1/2–13 x 1.5 Inch, Grade 8
3. Upper Isolator
4. Capscrew, 3/4–10 x 5.00 Inch, Grade 8
5. Washer
6. Engine Support Bracket
7. Lower Isolator
8. Capscrew, M14 x 35, Grade 10.9
7. Remove the jack from under the transmission.

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

8. Return the cab to the normal operating position.

9. Remove the chocks from the tires.
Replacement (See Fig. 1)

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

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

**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.

3. Disconnect the engine from the front engine mount.

3.1 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.

3.2 Remove the bolt(s) from the front engine mount. Save the fasteners, and the spacer(s). Discard the rubber isolator cushions.

3.3 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.

**CAUTION**

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

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

**WARNING**

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

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

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

5.3 Holding the lower isolator in place, install the bolts in the front engine mount and secure them with the nuts and washers. Tighten the nuts 140 to 160 lbf-ft (190 to 217 N·m).

NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 280 to 380 lbf-ft (380 to 515 N·m).

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

---

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

6. Return the cab to the normal operating position.

7. Remove the chocks from the tires.
## Engine Mount Bolt Torques

<table>
<thead>
<tr>
<th>Description</th>
<th>Bolt Size</th>
<th>Grade</th>
<th>Torque: lbf·ft (N·m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame Rail Leg-to-Frame Rail Capscrew</td>
<td>5/8–11 x 2.25 Inch</td>
<td>Grade 8</td>
<td>190 (258)</td>
</tr>
<tr>
<td>Frame Rail Leg-to-Engine Mount Bolt</td>
<td>1–8 Inch</td>
<td>Grade 5</td>
<td>280–380 (380–515)</td>
</tr>
<tr>
<td>Frame Rail Leg-to-Engine Mount Bolt</td>
<td>5/8–11 x 3.5 Inch</td>
<td>Grade 8</td>
<td>120–152 (163–206)</td>
</tr>
<tr>
<td>Engine Mount-to-Flywheel Housing Capscrew</td>
<td>3/4–10 x 2 Inch</td>
<td>Grade 8</td>
<td>Aluminum flywheel housings: 180–220 (244–298)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Iron flywheel housings: 213–269 (289–365)</td>
</tr>
<tr>
<td>Front Engine Support Bracket-to-Front Engine Mount Bolt</td>
<td>5/8–11 x 5 Inch</td>
<td>Grade 8</td>
<td>140–160 (190–217)</td>
</tr>
</tbody>
</table>

Table 1, Engine Mount Torques
An engine block heater keeps the engine coolant about 80°F (27°C) warmer than the ambient air temperature. In cold weather, the heater helps engine starting and reduces wear on the piston walls.

When starting the engine, the diesel normally ignites on the compression stroke of each piston, when the compressed air within the cylinder reaches about 725°F (385°C). However, during cold weather starts, the heat of the compressed air dissipates into the surrounding engine block so the diesel may never reach the temperature it needs to ignite. Using the engine block heater, the engine block is already warm so heat is held in the cylinder to ignite the diesel. To reduce engine wear, the block heater warms the oil film on the piston walls and reduces piston drag caused by cold oil film.

The heater consists of an element that bolts into the side of the engine water jacket. A heater power cord plugs into the outside end of the element.

To turn on the heater, connect the heater cord to a power source. The element has no thermostat. Heat dissipating from the engine block prevents coolant overheating.
Replacement

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

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

**WARNING**

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

3. Drain the radiator. For instructions, refer to Section 20.01, Subject 100.

4. If applicable, unscrew the threaded cover that secures the cord to the element.

5. Pull the cord off the element.

6. Using a 1-1/8 inch socket, loosen and remove the jam nut (if applicable) and unscrew the element from the engine block.

7. Position the heater element in the engine block.
   Coat the threads of the element with a small amount of sealant. For the approved sealants, refer to Specifications, 400.

8. Screw the element into the engine block hand tight, then use a wrench to turn the element 1-1/2 turns more.

9. Plug the cord into the element and (if applicable) secure it by screwing the threaded cord cover in place.

10. Fill the cooling system. For instructions, refer to Section 20.01, Subject 100.

11. Return the cab to the normal operating position.

12. 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.

13. 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.

14. Remove the chocks from the tires.
Troubleshooting

Use the following procedures to check for the most common engine block heater problems.

Wiring Problems

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

**DANGER**
Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

3. Unscrew the threaded cover that secures the cord to the element. Pull the cord off the element.

4. Using an ohmmeter, check the continuity between the two poles of the element. The resistance should be very low, typically between 9 and 10 ohms. If there is no reading, the element has burned out, and if the reading is very high, the element is about to burn out.

5. If the element is good, check the cord. Plug the cord into the element and secure it by screwing the threaded cover in place.

6. Using an ohmmeter at the receptacle, check the continuity between the two power terminals. The resistance should be low, typically between 9 and 10 ohms. If there is no reading or a very high reading, the cord is damaged. Replace the cord.

7. Check the continuity between each power terminal and the ground terminal. There should be no ohmmeter reading. If there is a reading, replace the cord.

8. Check the ohmmeter reading between the ground terminal and a good vehicle ground. The reading should be zero. If not, replace the cord.

**WARNING**
Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

3. Drain the radiator. For instructions, refer to Section 20.01.

4. Unscrew the threaded cover that secures the cord to the element. Pull the cord off the element.

5. Remove the element from the engine block. For instructions, refer to the Subject 100.

6. Inspect the element for residue deposits, discoloration, or damage.

Greenish residue indicates the coolant solution contains too much antifreeze. Replace the element, and refer to Group 20 for the recommended antifreeze/water ratio.
Gray or black residue indicates anti-leak coolant additives have been added to the system. Replace the element, and refer to Group 20 of the Condor Maintenance Manual for the recommended coolant additives.

Blue or black discoloration on the element indicates the coolant system needs more coolant. Replace the element, and fill the coolant system until coolant is visible in the surge tank sight glass.

Holes in the element indicate the coolant solution contains too little antifreeze. The weak solution is boiling inside the engine block and causing pitting of the element and block. Replace the element, and refer to Group 20 of this manual for the recommended antifreeze to water concentrations.

For element installation instructions, refer to Subject 100.

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**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

7. Return the cab to the normal operating position.

8. Remove the chocks from the tires.
Specifications

Approved Sealants

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

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

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

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

The starting fluid cylinder (Fig. 1) is mounted under the front steps. It fits into the Dieselmatic® valve and Blockor® fitting which measure, hold, and release a controlled amount of fluid for each start attempt.

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

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

Fig. 1, KBi Ether Start System
Replacement (See Fig. 1)

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

WARNING

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

2. Remove the old cylinder.
   2.1 Clean all dirt from the neck of the cylinder and the top of the Dieselmatic® valve before removing the cylinder.
   2.2 Loosen the cylinder clamp.
   2.3 Pry the dirt eliminator collar off the neck of the cylinder.

2.4 Unscrew the cylinder from the Dieselmatic valve.

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

3. Remove the old dirt eliminator collar from the valve assembly.

4. Replace the Dieselmatic valve gasket. Spread the new gasket with a light film of clean oil.

5. Place a new dirt eliminator collar, adhesive-side up, on the valve assembly. Peel off the collar’s paper backing to expose the adhesive.

6. Install the new cylinder.
   6.1 Place the new cylinder into the Dieselmatic valve and hand tighten it firmly.
   6.2 Slide the dirt eliminator collar up so it sticks to the cylinder.
   6.3 Tighten the clamp around the cylinder 60 lbf-in (680 N·cm).

7. If the ambient temperature is below 40°F (4°C), test the starting fuel system.

8. Remove the chocks from the tires.
Troubleshooting

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

**WARNING**

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

Empty Fluid Cylinder *(See Fig. 1)*

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

2. Weigh the cylinder to see if it is empty. See Table 1 for the weight of each cylinder size.

3. Replace the Dieselmatic valve gasket. Spread the new gasket with a light film of clean oil.

4. Check that the fluid cylinder has at least 120 psi pressure at 68°F (20°C).

5. If the cylinder is good, install it; if not, replace it.
   5.1 Place a new dirt eliminator collar, adhesive-side up, on the valve assembly. Peel off the collar’s paper backing to expose the adhesive.
   5.2 Place the new cylinder into the Dieselmatic valve and hand-tighten it firmly.
   5.3 Slide the dirt eliminator collar up so it sticks to the cylinder.
   5.4 Tighten the clamp around the cylinder 60 lbf-in (680 N·cm).

**Electrical Problems**

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

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

**WARNING**

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

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

**CAUTION**

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

5. If the plunger does not move, disconnect both valve assembly wires and momentarily touch the leads across battery terminals. If the valve plunger still does not move up, replace the valve.

6. If the valve operates correctly, check the engine temperature sensor.
   6.1 Connect the appropriate wire to the "M" terminal of the starter.
   6.2 Remove the sensor from the engine water jacket, and chill it to below freezing for at least ten minutes.
   6.3 Install the sensor, grounding it at a good ground.
   6.4 Connect the black ground wire from the valve assembly to the sensor.
   6.5 Crank the engine, and look for the valve plunger to move up and stay up while the starter is cranked.

**CAUTION**

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

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

---

**Clogged Ether Nozzle**

1. Disconnect the ether tubing from the nozzle, and cover the nozzle fitting.

2. Disconnect the black ground wire from the engine temperature sensor, and ground it.

**WARNING**

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

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

**CAUTION**

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

4. If no ether sprays from the tubing, disconnect the tubing at the Blockor® fitting in the base of the cylinder assembly. See Fig. 1.
5. Start the engine, and look for ether to spray from the Blockor fitting in the base of the cylinder assembly.

![CAUTION]

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

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

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

<table>
<thead>
<tr>
<th>Description</th>
<th>lbf·in (N·cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Clamp</td>
<td>60 (680)</td>
</tr>
</tbody>
</table>

Table 1, Ether System Torques
The Jacobs engine brake model 312A is installed on Caterpillar (C-12) engines and model 310A is installed on Caterpillar (C-10) engines, and slows the vehicle by converting a power-producing diesel engine into a power-consuming air compressor. See Fig. 1. The brake does this by opening the cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust.

The release or "blowdown" of compressed air to atmosphere prevents the return of energy to the engine piston on the expansion stroke. The effect is a net energy loss, because the work done in compressing the cylinder charge is not returned during the expansion process.

Exhaust blowdown of the braking cylinder is accomplished by using the injector arm motion of that cylinder. See Fig. 2.

Energizing the solenoid valve permits engine lube oil to flow under pressure through the control valve to the master piston, slave piston, and accumulator.

Oil pressure makes the master piston move down, coming to rest on the corresponding injector rocker arm.

The injector rocker arm moves (as in a normal injector cycle), forcing the master piston upward and creating a high pressure oil flow to the slave piston of the braking cylinder. The ball check valve in the control valve traps high pressure oil in the master/slave piston system.

Under the influence of the high pressure oil flow, the slave piston moves down, momentarily opening the exhaust valves at a pre-determined amount of slave stroke. The Power-Lash™ uncovers a passageway in the slave piston, thus allowing oil to flow back to the undersides of the control valve and accumulator piston, where it is stored for the next cycle. Prior to top dead center position, the exhaust valve is forced open, releasing the compressed cylinder air to the exhaust manifold.

Compressed air escapes into the atmosphere, completing the braking cycle.
1. Master Piston Assembly
2. Power-Lash™ Slave Piston Adjusting Screw
3. Slave Piston
4. Control Valve
5. Accumulator
6. Solenoid Valve

Fig. 1, Engine Brake (sectional view)
1. Control Valve
2. Solenoid Valve
3. Power-Lash Slave Piston Adjusting Screw
4. Slave Piston
5. Master Piston Assembly

Fig. 2, Engine Brake Components
Removal (See Fig. 1)

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to Subject 140.

**WARNING**

The accumulator spring is under strong compression. Use caution when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally discharged, personal injury may result.

2. Push down on the accumulator cover using the appropriate diameter rod and remove the retaining ring.
3. Relieve pressure on the accumulator cover; remove the cover and the spring.
4. Use a magnet to remove the piston from the accumulator bore.

**Inspection**

Inspect the parts for wear or damage; replace them if needed.

---

Installation

1. Install the piston, then the spring, the cover, and the retaining ring.
2. Install the rocker cover. For instructions, refer to Subject 140.
Removal *(See Fig. 1)*

![Image of Control Valve Assembly]

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to Subject 140.

   **WARNING**

   The control valve covers are under load from the control valve springs. Wear safety glasses. Remove the control valve covers carefully and slowly to avoid personal injury. The valve covers could jump out and cause personal injury.

   2. Apply pressure on the control valve cover, and remove the retaining ring using retaining ring pliers.

   3. Slowly remove the cover until the spring pressure ceases, then remove the two control valve springs.

   4. Using needle-nose pliers, reach into the bore and grasp the stem of the control valve. Remove the control valve.

   **Cleaning**

   1. Wash the control valves with an approved solvent. Push a wire into the hole in the base of the valve to the distance required to insure that the ball check is free. The ball should lift with light pressure on the wire. If the ball is stuck, replace the control valve. Dry the valve with compressed air and wipe clean with a paper towel.

   2. Thoroughly clean the control valve bore in the housing using clean paper towels.

   **Installation**

   1. Install the control valve in the bore, then the springs, the cover, and the retaining ring.

   2. Install the rocker cover. For instructions, refer to Subject 140.
Bleeding (See Fig. 1)

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to Subject 140.

**WARNING**

Wear eye protection, and do not expose your face to the engine area. Take precautions to prevent oil leakage onto the engine. Whenever the engine is running with the valve covers removed, oil splashing in the engine area could cause personal injury.

**NOTE:** Place a rag over the control valve and the accumulator covers to reduce oil spray.

2. Start the engine, and allow it to run for a few minutes.

3. Press and release the engine brake solenoid disc several times to allow the housing to be filled with oil.

4. Watch the master piston to be sure it is moving down onto the injector rocker arm pad.

5. Watch the slave piston assembly. It should move down to contact the pin in the exhaust valve screw.

6. Check all the housings to be sure they are functioning.

7. Shut down the engine, and clean the gasket surface for the rocker cover.

8. Install the rocker cover. For instructions, refer to Subject 140.
Removal and Cleaning (See Fig. 1)

Fig. 1, Removing the Master Piston

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to Subject 140.

2. Press down on the master piston retaining washer to relieve the spring force. While holding the washer, use a pair of snap ring pliers to remove the retaining ring from the groove. Carefully release the retainer and remove it along with the old spring.

3. Remove the master piston from the bore. Clean the piston in a solvent, and inspect it for wear. Also inspect the piston bore for wear.

Installation

1. Install a new master piston return spring by inserting the small end into the bore. The large coil, marked with white paint, should always be facing out.

2. Place the retaining washer and snap ring over the foot of the master piston and compress them into the bore. Using snap ring pliers, replace the snap ring in the groove to retain the master piston.

3. Ensure the snap ring is properly engaged in the groove by gently grasping the master piston foot and pulling out until the master piston bottoms on the retaining washer. Release the master piston. If the assembly is correct, all parts should return to their original position.

NOTE: After the new spring is installed within the retaining washer and snap ring, it is normal to be able to see the spring in the bore around the retaining washer.

4. Repeat this procedure on the five other master pistons.

5. Install the rocker cover. For instructions, refer to Subject 140.
Removal (See Fig. 1)

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

DANGER

Before tilting the cab or returning the cab to the normal operating position, read the instructions and the hazard notices in Section 60.00. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the cab.

3. Wipe the engine brake housing area clean.

4. Remove the six bolts that hold each rocker cover, and remove the rocker covers.

5. Inspect the cover seals, and replace them if they are damaged.

Installation

CAUTION

Be sure to tighten all the rocker cover bolts evenly. Excessive or uneven tightening may cause the rocker cover to crack.
Removal

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to Subject 140.

2. Loosen the slave piston adjusting screw locknut, and remove the adjusting screw from the housing. See Fig. 1.

![Fig. 1, Remove the Adjusting Screw](image1)

Inspection and Installation

1. Clean the adjusting screw in an approved solvent.

--- CAUTION ---

**Do not adjust or tamper with the adjusting screw, engine damage could result.**

NOTE: The part number for the screw is located at the top of the screw, next to the screwdriver slot. Refer to the manufacturer’s parts manual for part number identification.

2. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw, should have light spring pressure apparent when depressed, and should move freely. See Fig. 2. Replace the entire screw assembly if any problem is found.

3. Install the rocker cover. For instructions, refer to Subject 140.

![Fig. 2, Check the Adjusting Screw Plunger](image2)
Removal (See Fig. 1 and Fig. 2)

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to Subject 140.

**WARNING**
The slave piston is retained by springs that are under heavy compression. Use the following tools and instructions or the springs will be discharged with enough force to cause personal injury.

2. Remove the locknut on the slave piston adjusting screw. Back out the adjusting screw until the slave piston is fully retracted (the screw is loose).

3. Place the hole in the clamp fixture over the slave piston adjusting screw. See Fig. 1.

4. While holding the fixture in position, screw the holder down over the slave piston until the spring retainer is contacted.

5. Turn the handle slowly until the retainer is depressed to about 1/32 inch (1 mm), relieving pressure against the retaining ring.

6. Remove the retaining ring using retaining ring pliers. Back out the holder until the springs are loose. Remove the fixture.

7. Remove all the components, ensuring there is no binding or burrs. Clean in an approved cleaning solvent. Inspect parts and replace as needed.

Installation

1. Use the clamp fixture to install the piston and springs. Be sure the retaining ring is placed on the retainer before screwing the clamp-holder down over the slave piston.

2. Compress the slave piston springs down until the retainer is about 1/32 inch (1 mm) below the retaining ring groove. Install the retaining ring. Be sure the retaining ring is fully seated in the groove.

3. Remove the clamp fixture slowly to ensure correct seating of the retaining ring.

4. Install the rocker cover. For instructions, refer to Subject 140.
Removal (See Fig. 1)

1. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, refer to Subject 140.

CAUTION
Do not disassemble or tamper with the solenoid valve. Engine damage could result. The solenoid valve is not field serviceable.

2. Disconnect the solenoid harness. Using a 7/8-inch socket and an extension, unscrew the solenoid valve.

3. Remove and discard the three rubber seal rings. If the lower ring stays in the bottom of the housing bore, remove it with a pick.

Cleaning and Installation

1. Wash out the solenoid valve with an approved solvent. Use a brush to clean the oil screen. When clean, dry the valve with compressed air.

2. Clean out the solenoid valve bore in the housing. Use clean paper towels. Never use rags as they may leave lint and residue which can plug the oil passageways.

3. Using new solenoid seal rings, coat them with clean lube oil. Install the upper and center seal rings on the solenoid body, and install the lower seal ring into the bottom of the solenoid bore in the housing.

4. Be sure the seals are seated properly and carefully screw the solenoid into the housing without unseating the seals. Tighten the valve 5 lbf-ft (7 N·m). Be careful not to twist the seals while installing the solenoid.

5. Install the rocker cover. For instructions, refer to Subject 140.

Fig. 1, Solenoid Seals

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

09/20/93

Jacobs Engine Brake

Condor Workshop Manual, Supplement 0, January 2000

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## Troubleshooting Tables

### NOTE: For engine brake service procedures, refer to the applicable section for your model of engine brake in this workshop manual group.

#### Problem—Engine Will Not Start

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The solenoid valve is stuck in the &quot;on&quot; position.</td>
<td>Make sure the electrical current to the engine brake is off. If the solenoid valve stays &quot;on&quot; (cap down) with the current off, replace the solenoid valve.</td>
</tr>
</tbody>
</table>

#### Problem—Engine Brake Will Not Function

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>An electrical lead is open.</td>
<td>Replace any broken wires.</td>
</tr>
<tr>
<td>The engine oil pressure is too low.</td>
<td>Determine the oil pressure at the engine brake. Refer to the applicable section in this group for your engine brake. If the oil pressure is below specifications, repair the engine following the manufacturer's procedures.</td>
</tr>
<tr>
<td>The throttle switch is malfunctioning.</td>
<td>Check for correct operation of the throttle.</td>
</tr>
</tbody>
</table>

#### Problem—Engine Brake Engages With the Switches Off

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The solenoid valve center seal ring is damaged.</td>
<td>Remove the solenoid. Replace all the seal rings.</td>
</tr>
<tr>
<td>The engine brake is incorrectly wired.</td>
<td>Check the wiring against the Jacobs wiring diagram.</td>
</tr>
</tbody>
</table>

#### Problem—Engine Brake Weak or Slow to Engage

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lubricating oil is too cold and thick.</td>
<td>Allow the engine to warm up before operating the Jake Brake.</td>
</tr>
</tbody>
</table>
| The slave piston is adjusted incorrectly or is binding in its bore. | **WARNING**

Slave piston springs are under heavy compression. Remove the slave piston carefully when disassembly is necessary. Use either an arbor press or C-clamp. Failure to follow this procedure could result in personal injury.

Adjust the slave piston. Make sure it responds smoothly to the adjusting screw—loosen the jam nut and screw the adjusting screw through its full range for full slave piston travel. Make sure the piston travels the full range without binding or sticking. |
## Troubleshooting

<table>
<thead>
<tr>
<th>Problem—Engine Brake Weak or Slow to Engage</th>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The solenoid lower seal is damaged, allowing oil to escape the housing.</td>
<td>The solenoid screen is clogged, stopping the supply of oil to the engine brake.</td>
<td>Remove the solenoid valve and replace all the seal rings. Remove the solenoid valve; clean or replace the screen.</td>
</tr>
<tr>
<td>The master piston is not moving in its bore.</td>
<td>The master piston is not moving in its bore.</td>
<td>Inspect the master piston and bore for scoring or burrs. If any are present, clean the surface with a crocus cloth. If the burrs cannot be removed, replace the piston or housing. Inspect the lubricating oil for signs of contaminants. If any are present, replace the oil and filters, and correct the cause of the contamination.</td>
</tr>
<tr>
<td>The control valves are binding in the housing bores.</td>
<td>The control valves are binding in the housing bores.</td>
<td>Remove each control valve. If the body is scored, replace the valve. Check for contaminants in the lubricating oil. Clean the housing and control valve. If the control valve still binds, replace the housing.</td>
</tr>
<tr>
<td>The control valves are malfunctioning.</td>
<td>The control valves are malfunctioning.</td>
<td>Remove each control valve. Make sure the check ball is seating in the bore and that it can be moved off the seat. Make sure there is spring pressure against the ball. Flush the valve in diesel fuel. Replace the control valve if needed.</td>
</tr>
<tr>
<td>Dash switches or throttle switch has sluggish operation.</td>
<td>Dash switches or throttle switch has sluggish operation.</td>
<td>Adjust or replace the switch. Check the throttle for proper operation.</td>
</tr>
<tr>
<td>The electrical insulation of the solenoid valve is breaking down.</td>
<td>The electrical insulation of the solenoid valve is breaking down.</td>
<td></td>
</tr>
</tbody>
</table>

**WARNING**

Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.

Make sure the solenoid valve meets electrical specifications. If not, replace the solenoid valve.

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The engine brake housing plugs are leaking.</td>
<td>Check the plugs for signs of leaks. If leaks are found, remove the plugs, clean the threads, and install the plugs. Thread locking compound may help. Tighten the plugs 115 lbf·in (1300 N·cm).</td>
</tr>
<tr>
<td>The outer control valve spring is broken, or the engine oil pressure is extremely high.</td>
<td>Replace the outer control valve spring. Refer to the engine manufacturer’s service manual for causes of high oil pressure.</td>
</tr>
<tr>
<td>The upper solenoid seal ring is damaged, causing oil pressure to drop below the minimum required for engine brake operation.</td>
<td>Remove the solenoid. Inspect the seal rings and replace them if needed.</td>
</tr>
<tr>
<td>The oil supply seals under or between the housings are damaged, causing oil pressure to drop below the minimum required for engine brake operation.</td>
<td>Remove the housings and replace the seals. Check for cracked or broken oil connectors. Replace the seals.</td>
</tr>
<tr>
<td>There is air in the lubricating oil, causing oil pressure to drop below the minimum required for engine brake operation.</td>
<td>Check for aeration of the oil. Turn the engine brake on, then off. Watch the escape oil coming from under the control valve cover. If the oil has bubbles or is foamy, air is present in the system. Aeration can be caused by an over-or underfilled crankcase, by cracks in the oil pickup tube, or by leaks in the oil suction tube or hose. Refer to the engine manufacturer’s service manual for corrective measures.</td>
</tr>
</tbody>
</table>
### Problem—Engine Brake Weak or Slow to Engage

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lubricating oil is being diluted by diesel fuel, causing oil pressure to</td>
<td>Have the lubricating oil analyzed to determine if fuel is present. Refer to the engine</td>
</tr>
<tr>
<td>drop below the minimum required for engine brake operation.</td>
<td>manufacturer’s service manual for corrective measures.</td>
</tr>
<tr>
<td>The engine oil level is low, causing oil pressure to drop below the</td>
<td>Refer to the engine manufacturer’s service manual for specifications. Add oil or recalibrate</td>
</tr>
<tr>
<td>minimum required for engine brake operation.</td>
<td>the dipstick as required.</td>
</tr>
<tr>
<td>The engine rocker arm bushings are worn, causing oil pressure to drop below</td>
<td>Replace the bushings. Refer to the engine manufacturer’s service manual for instructions.</td>
</tr>
<tr>
<td>the minimum required for engine brake operation.</td>
<td></td>
</tr>
<tr>
<td>Oil is leaking around the cylinder heads, causing oil pressure to drop below</td>
<td>Repair the cause of the leaks. Refer to the engine manufacturer’s service manual for instructions.</td>
</tr>
<tr>
<td>the minimum required for engine brake operation.</td>
<td></td>
</tr>
<tr>
<td>Restrictions in the oil passage leading to the engine brake are causing oil</td>
<td>Inspect all the passageways; remove anything restricting the oil flow.</td>
</tr>
<tr>
<td>pressure to drop below the minimum required for engine brake operation.</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The control valve inner spring is broken.</td>
<td>Replace the inner spring.</td>
</tr>
<tr>
<td>One or more control valves are stuck in the &quot;on&quot; (up) position.</td>
<td>Check the control valves for binding. Remove and clean or replace them if necessary. Inspect the</td>
</tr>
<tr>
<td></td>
<td>lubrication oil for contaminants.</td>
</tr>
<tr>
<td>The solenoid valve is sticking in the &quot;on&quot; position.</td>
<td>If the solenoid valve cap remains down with no electric current being supplied, replace the</td>
</tr>
<tr>
<td></td>
<td>solenoid valve.</td>
</tr>
<tr>
<td>The center solenoid seal ring is damaged, allowing oil to enter the engine</td>
<td>Remove the solenoid and replace all the seal rings.</td>
</tr>
<tr>
<td>brake with the solenoid valve closed.</td>
<td></td>
</tr>
<tr>
<td>The solenoid valve exhaust is plugged.</td>
<td>Remove any restrictions at the exhaust (bottom) of the solenoid valve.</td>
</tr>
<tr>
<td>The dash switch is stuck in the &quot;on&quot; position.</td>
<td>Check for correct switch operation. Replace the switch as needed.</td>
</tr>
</tbody>
</table>

### Problem—Engine Misses or Loses Power

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The slave piston is adjusted too tight.</td>
<td>Adjust the slave piston. Refer to the applicable section in this group for the correct engine</td>
</tr>
<tr>
<td></td>
<td>brake model.</td>
</tr>
</tbody>
</table>
Problem—Sudden Drop in Engine Lubrication Oil Pressure

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The oil inlet supply seal is missing or damaged.</td>
<td>Replace the seal.</td>
</tr>
<tr>
<td>The upper solenoid valve seal is missing or damaged.</td>
<td>Remove the solenoid and replace all the seal rings.</td>
</tr>
<tr>
<td>The external oil supply hoses or fittings are cracked and leaking.</td>
<td>Inspect all hoses and fittings for tightness, chafing, or cuts.</td>
</tr>
</tbody>
</table>
General Information

WARNING

Do not use the exhaust retarder brake if road surfaces are slippery. Using the exhaust retarder on wet, icy, or snow-covered roads could result in loss of vehicle control, possibly causing personal injury and property damage.

The Pacbrake exhaust brake is an auxiliary braking device that greatly increases the stopping power of your vehicle. By using the exhaust brake at every opportunity your brakes stay cooler reducing the risk of brake fade and “run-away”. The principal of the exhaust brake is to capture the exhaust pressure and hold it in the cylinders, which creates resistance against the pistons of the engine. This resistance translates through the engine into the driveline and out to the drive wheels causing the vehicle to decelerate. The exhaust brake uses a butterfly valve that is attached directly to the outlet of the turbocharger. When activated the butterfly closes, restricting the exhaust gas. In essence the engine is converted from energy production to energy absorbing. The exhaust brake assembly is attached directly to the engine turbocharger.

Since the exhaust retarder is most effective at 300 RPM above the rated governed engine speed, gear selection is very important. Gearing down the vehicle within the limits of the rated engine speed makes the exhaust retarder more effective. Maximum braking occurs with the use of the lowest gear that does not exceed the rated engine speed. A rule of thumb for gear choice is to select the gear that normally would be used to climb an approaching downhill grade. Generally, this same gear can be used with the exhaust retarder for a controlled descent of the hill.

If the vehicle is equipped with an Allison World MD series transmission, the exhaust retarder is interfaced with the transmission ECU. When exhaust retarder operation is requested, a signal is sent to the transmission ECU. This signal tells the transmission ECU that the exhaust retarder is requested and to provide converter lock-up in second through sixth gears. In addition the ECU will operate in the pre-select downshift mode, allowing for increased braking by preselecting a lower transmission range, depending on vehicle road speed.

"Control speed" is the speed at which the exhaust retarder performs 100 percent of the required downhill braking, resulting in a constant speed of descent. The control speed varies, depending on vehicle weight and the downhill grade.

For faster descent, select a higher gear than that used for control speed. Service brakes must then be used intermittently to prevent engine overspeed and to maintain desired vehicle speed.

A driver may descend slower than control speed by selecting a lower gear, but one that will not over-speed the engine. The exhaust retarder retarding force will then be sufficient to cause vehicle deceleration. Occasional deactivation of the exhaust retarder may be necessary to maintain the designated road speed under these conditions.

WARNING

Using the exhaust retarder as a primary braking system when the service brakes are operable is dangerous. This can cause long, unpredictable stopping distances, possibly resulting in personal injury or property damage.

Whenever vehicle braking is required, the exhaust retarder may be used with the service brakes. There is no time limit for operation of the exhaust retarder.

The exhaust retarder activates when the dash switch is in ON position and the driver’s feet are removed from the throttle pedal. Refer to the service information available from the manufacturer for instructions.

To obtain maximum retarding, maintain the top governed speed of the engine through appropriate selection of gears when the exhaust retarder is in use.
Removal  (See Fig. 1)

1. Air Line
2. Pacbrake Exhaust Brake
3. Clamp
4. Turbocharger
5. Exhaust Pipe

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.00 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result severe injury or death.

2. Install the section of exhaust ducting that runs between the exhaust brake and the muffler.
3. Connect the air line to the exhaust brake.
4. Tighten all exhaust clamps.
5. Return the cab to the normal operating position.
6. Remove the chocks from the tires.

**Installation**

1. Install the exhaust brake to the turbocharger.
# Troubleshooting Tables

## Problem—The Exhaust Brake Engages But Will Not Hold Back

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>An exhaust leak upstream from the exhaust brake.</td>
<td>Check welds, clamps and exhaust manifold gaskets.</td>
</tr>
<tr>
<td>Insufficient air supply.</td>
<td>Check air supply and lines for sufficient pressure.</td>
</tr>
<tr>
<td></td>
<td>Check quick release valve for restriction or air loss.</td>
</tr>
<tr>
<td>Possible internal damage.</td>
<td>Check for a bent butterfly valve.</td>
</tr>
<tr>
<td></td>
<td>Verify that the butterfly valve is attached to the shaft.</td>
</tr>
<tr>
<td></td>
<td>Close the valve to check for even clearance between valve and the housing bore.</td>
</tr>
<tr>
<td>Operating the exhaust brake at too low of RPM's.</td>
<td>Exhaust brake must be operated at high engine RPM.</td>
</tr>
<tr>
<td></td>
<td>Down shifting will be necessary to increase engine RPM.</td>
</tr>
<tr>
<td></td>
<td>Do not exceed engine manufacturers rated RPM. Most engine manufacturer’s allow 300 RPM higher than governor setting on exhaust brake.</td>
</tr>
</tbody>
</table>

## Problem—The Exhaust Brake Will Not Engage

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission does not down shift.</td>
<td>Check the transmission interface connectors.</td>
</tr>
<tr>
<td></td>
<td>Check throttle position sensor signal.</td>
</tr>
<tr>
<td>Blown Fuse.</td>
<td>Check the fused power source.</td>
</tr>
<tr>
<td>No voltage to the air control solenoid.</td>
<td>NOTE: Exhaust brakes interfaced with an Allison MD3060 transmission require road speed to operate. To test in shop, separate the connector at the Pacbrake solenoid and apply 12 volts to the solenoid to check activation. Check the solenoid for a good ground. Repair or replace as necessary.</td>
</tr>
<tr>
<td>Poor air supply.</td>
<td>Air supply must come from the dry air tank.</td>
</tr>
<tr>
<td></td>
<td>Inspect all air lines for leaks or internal obstructions.</td>
</tr>
<tr>
<td></td>
<td>Be sure air flows through the quick release valve to the cylinder.</td>
</tr>
<tr>
<td></td>
<td>Check for air leaking out of quick release port when the brake is applied.</td>
</tr>
<tr>
<td></td>
<td>Repair or replace as necessary.</td>
</tr>
<tr>
<td>Faulty mechanical actuation.</td>
<td>Remove clevis pin from cylinder clevis. Actuate the cylinder and check for binding, leaking, or slow actuation.</td>
</tr>
<tr>
<td></td>
<td>Rotate the butterfly to check the shaft for binding in the housing.</td>
</tr>
<tr>
<td></td>
<td>Replace housing assembly as necessary.</td>
</tr>
</tbody>
</table>
Problem—the Exhaust Brake Will Not Disengage

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faulty air release valve.</td>
<td>Air release from quick release valve. Replace if necessary.</td>
</tr>
<tr>
<td></td>
<td>Air release from exhaust port of solenoid. Replace if necessary.</td>
</tr>
<tr>
<td></td>
<td>Check all air lines for restrictions. Repair or replace as necessary.</td>
</tr>
<tr>
<td></td>
<td>Check cylinder breather for blockage. Replace if necessary.</td>
</tr>
<tr>
<td>Blown Fuse.</td>
<td>Check the fused power source.</td>
</tr>
<tr>
<td>No voltage to the air control solenoid</td>
<td>NOTE: Exhaust brakes interfaced with an Allison MD3060 transmission require road speed to operate.</td>
</tr>
<tr>
<td></td>
<td>To test in shop, separate the connector at the Pacbrake solenoid and apply 12 volts to the solenoid to check activation.</td>
</tr>
<tr>
<td></td>
<td>Check the solenoid for a good ground. Repair or replace as necessary.</td>
</tr>
<tr>
<td>Poor air supply.</td>
<td>Air supply must come from the dry air tank.</td>
</tr>
<tr>
<td></td>
<td>Inspect all air lines for leaks or internal obstructions.</td>
</tr>
<tr>
<td></td>
<td>Be sure air flows through the quick release valve to the cylinder.</td>
</tr>
<tr>
<td></td>
<td>Check for air leaking out of quick release port when the brake is applied.</td>
</tr>
<tr>
<td></td>
<td>Repair or replace as necessary.</td>
</tr>
<tr>
<td>Faulty mechanical actuation.</td>
<td>Remove clevis pin from cylinder clevis. Actuate the cylinder and check for binding, leaking, or slow actuation.</td>
</tr>
<tr>
<td></td>
<td>Rotate the butterfly to check the shaft for binding in the housing.</td>
</tr>
<tr>
<td></td>
<td>Replace housing assembly as necessary.</td>
</tr>
</tbody>
</table>
General Information

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

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

American LaFrance uses the following models of bypass oil filters:

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

Fleetguard Model LF 750 (See Fig. 1)

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

An engine equipped with the Model LF 750 needs 3 gallons (11.3 liters) more oil than an engine without a bypass oil filter.

Luber-finer Model 750-CT (See Fig. 2 and Fig. 3)

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

Engine oil enters through the inlet check valve assembly on the bottom of the filter housing, and fills the filter housing around the filter pack (element). Inside the housing, oil pressure forces the oil through the sides of the filter pack. Inside the filter pack, fil-
inated oil travels through openings in the T-handle hold-down assembly, then collects in the outlet tube. From the outlet tube, filtered oil goes back to the engine through the outlet check valve assembly.

The inlet and outlet valves normally have #8 orifices.

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

Spinner II (See Fig. 4 and Fig. 5)

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

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

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

Normal continuous operating oil pressure is about 60 psi (413.6 kPa). An engine equipped with the Spinner II doesn’t need any extra oil. Flow rate through the cleaner is about 2 gallons (7.5 liters) per minute at normal operating pressure.
A. Oil Out  
B. Air In  
C. Oil In  
1. Air Valve Cartridge Seal

Fig. 4, Spinner II Bypass Oil Filter

Fig. 5, Spinner II Bypass Oil Filter (sectional view)
Replacement (See Fig. 1)

1. Remove the oil filter element.
   1.1 Remove the drain plug and allow the oil to drain.
   1.2 Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.
   1.3 Unscrew the hold-down assembly T-handle and remove the assembly from the housing. Check the O-ring and spring for damage. Replace if needed.
   1.4 Remove and discard the oil filter element.

2. Clean the inside of the housing, and the hold-down assembly, with solvent.

3. Assemble the filter.
   3.1 Install the drain plug.

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

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

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

1. Remove the oil filter element.
   1.1 Remove the drain plug and allow the oil to drain.
   1.2 Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.
   1.3 Unscrew the hold-down assembly T-handle and remove the assembly from the housing. Check the O-ring and spring for damage. Replace if needed.
   1.4 Remove and discard the oil filter element.

2. Clean the inside of the housing, and the hold-down assembly, with solvent.

3. Assemble the filter.
   3.1 Install the drain plug.

3.2 Install a new filter element.
3.3 Install the hold-down assembly and securely tighten the T-handle.
3.4 Check the cover gasket for damage, and replace it if needed. Position the gasket on the housing.
3.5 Position the cover on the housing. Install the clamp ring and capscrews. Alternately tighten the capscrews to ensure a uniform seal between the cover and gasket.
3.6 Start the engine and let it idle until normal operating oil pressure is reached.

CAUTION

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

3.7 Add oil as needed to bring the oil level up to the high ("H") mark on the dipstick.
Replacement (See Fig. 1)

1. Remove the old filter element.
   1.1 Loosen the vent plug capscrew, then open the drain cock and allow the oil to drain.
   1.2 Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.
   1.3 Unscrew the hold-down assembly T-handle and remove the assembly from the housing.
   1.4 Remove and discard the oil filter element.

2. Clean the inside of the housing, and the hold-down assembly, with solvent.

3. Assemble the filter.
   3.1 Close the drain cock.
   3.2 Install a new filter element.
   3.3 Check the cover gasket for damage, and replace it if needed.
   3.4 Install the hold-down assembly and securely tighten the T-handle.
   3.5 Position the cover on the housing. Install the clamp ring and capscrews. Alternately tighten the clamp capscrews to ensure a uniform seal between the cover and gasket.
   3.6 Add oil to the crankcase, then start the engine and let it idle until normal operating oil pressure is reached.
   3.7 Loosen the vent plug capscrew and bleed any trapped air from the filter housing. Tighten the vent plug capscrew as soon as oil appears at the fitting.

**CAUTION**

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

4. Shut down the engine and add oil as needed to bring the oil level up to the high ("H") mark on the dipstick.
Cleaning (See Fig. 1)

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

1. **Clean the centrifuge bowl.**
   1.1 Shut off the engine, and let the centrifuge turbine assembly come to a complete stop.
   1.2 Loosen the handle on the clamp, disengage the tee bolt and remove the cover, using a coin in the gap to separate the cover from the housing.
   1.3 Partially withdraw the centrifuge turbine assembly from the housing and allow oil to drain from the nozzles before removing the assembly completely.
   1.4 Hold the centrifuge turbine assembly in one hand and loosen the knurled nut several turns until the face of the nut projects beyond the bronze bushing face.
   1.5 Carefully separate the centrifuge bowl from the turbine base by striking the face of the nut with the palm of one hand while holding the bowl in the other. Do not strike the nut or the bushing with or against a hard surface or you will damage them. Finish removing the nut and then remove the bowl and baffle/screen.

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

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

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

2. **Inspect and assemble the centrifuge turbine assembly.**
   2.1 Inspect the top and bottom bushings of the centrifuge turbine base, and replace the turbine assembly if the bushings show severe wear.
2.2 Place the baffle/screen over the stem of the turbine base and seat the baffle/screen evenly over the shoulder on the base.

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

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

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

3. Clean and inspect the oil filter housing.

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

3.2 Clean and inspect the cover.

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

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

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

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

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

Lifting the float should release air into the filter housing.

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

5. Install the centrifuge turbine assembly.

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

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

5.3 Tighten the clamp handle securely by hand pressure only.

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

The AMOT intake air shutoff valve (see Fig. 1) is a butterfly-type valve (see Fig. 2) that is in the intake air duct. The intake air shutoff valve is used as an emergency engine shutoff and provides positive engine shutdown by closing the engine air intake and stopping the flow of air to the engine. This is important in situations where combustible vapors may be present in the intake air that would allow the engine to continue running with the fuel shut off.

The butterfly valve is normally held in the open position in the intake air duct. When the emergency engine shutdown switch on the left portion of the center dash is activated, a solenoid releases the valve control mechanism and closes the flapper valve across the intake air duct, stopping the flow of air. This causes the engine to shutdown.

There are two types of AMOT engine stop systems, manual and automatic. After the intake air shutoff valve has been activated on manual reset systems, the air-restriction filter minder and the AMOT intake air shutoff valve must be reset. On automatic reset systems, only the air-restriction filter minder must be reset after activation.

After the intake air shutoff valve has been activated, the air-restriction filter minder must be reset. On manual type systems, the AMOT intake air shutoff valve must also be reset.

Fig. 1, AMOT Intake Air Shutoff Valve (manual reset type shown)

Fig. 2, AMOT Intake Air Shutoff Valve (inside view)
Replacement (See Fig. 1)

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

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.00 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result severe injury or death.

2. Tilt the cab.

3. Remove the electrical connector from the AMOT intake air shutoff valve solenoid.

4. Loosen the worm clamps and slide them away from the AMOT intake air shutoff valve.

5. Remove the air intake hose from the rear of the AMOT intake air shutoff valve.

6. Remove the AMOT intake air shutoff valve.

7. Position the new AMOT intake air shutoff valve in the air intake ducting with the valve operator on the top.

8. Attach the air intake hose to the rear of the AMOT intake air shutoff valve.

9. Slide the worm clamps to the edge of the air intake hose closest to the AMOT intake air shutoff valve and tighten them.

10. Install the electrical connector into the AMOT intake air shutoff valve solenoid.

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.00 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result severe injury or death.

11. Return the cab to the normal operating position.

12. Start the engine and test the AMOT intake air shutoff valve.

13. Reset the air-restriction filter minder and the AMOT intake air shutoff valve. Refer to Subject 120 for instructions.

14. Remove the chocks.
Replacement (See Fig. 1)

1. Park the vehicle on a level surface, apply the parking brakes, and chock the rear tires.
2. Engage the AMOT intake air shutoff valve.
3. Shut down the engine.

**DANGER**

Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.00 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result severe injury or death.

4. Tilt the cab.

5. Remove the valve operator from the AMOT intake air shutoff valve.
   5.1 Remove the two capscrews and the nut from the top of the top plate.

6. Loosen the worm clamp on the rear air intake duct and slid it away from the AMOT intake air shutoff valve.
7. Remove the air intake hose from the rear of the AMOT intake air shutoff valve.
8. Rotate the butterfly disk 180 degrees from its normal operating position.
9. Remove the old O-ring and replace with a new O-ring
10. Rotate the flapper disk 180 degrees into its normal operating position.
11. Install the valve operator assembly on the AMOT intake air shutoff valve.
   11.1 Hold the bottom plate and solenoid assembly in place and start the phillips screw on the opposite side from the solenoid.
   11.2 Using the control handle to pivot and move the bottom plate assembly, install the other phillips head screw, and tighten both screws.
   11.3 Remove the nut from the square adjustment post and install the top plate using capscrews, nuts; and finger-tighten.
   11.4 Engage the intake air shutoff valve and inspect the flapper disk to ensure that the valve closes completely.
   11.5 Adjust the disk position by turning the square adjustment post.
   11.6 Tighten the capscrews and the nut on the top of the top plate.
   11.7 Reset the AMOT intake air shutoff valve.
12. Install the air intake hose to the rear of the AMOT intake air shutoff valve.
13. Slide the worm clamp to the edge of the air intake hose closest to the AMOT intake air shutoff valve and tighten.
DANGER

Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.00 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result severe injury or death.

14. Return the cab to the normal operating position.

15. Start the engine and test the AMOT intake air shutoff valve.

16. Reset the air-restriction filter minder and the AMOT intake air shutoff valve. Refer to Subject 120 for instructions.

17. Remove the chocks.
Manual Type

1. Place the engine emergency shutdown switch in the "OFF" position.
2. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the rear tires.

**DANGER**
Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.00 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result severe injury or death.

3. Tilt the cab.
4. While standing on the righthand side of the vehicle, pull the valve handle toward you. This allows the engine to be restarted. See Fig. 1 and Fig. 2. The valve will not reset, however, unless the engine emergency shutdown switch is disengaged with the electrical power on.

5. Reset the air-restrictor filter minder mounted on the air intake ducting by pushing on the bottom of the device. See Fig. 3.

**DANGER**
Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.00 of this workshop manual. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result severe injury or death.
6. Return the cab to the normal operating position.
7. Start the engine and check for normal operation.
8. Remove the chocks.

**Automatic Type**

1. Place the engine emergency shutdown switch in the "OFF" position.
2. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the rear tires.
3. Open the rear tunnel access door located in the rear of the cab.
4. Reset the air-restrictor filter minder mounted on the air intake ducting by pushing on the bottom of the device. See Fig. 3.
5. Close and latch the rear tunnel access door.
6. Start the engine and check for normal operation.
7. Remove the chocks.
# Troubleshooting Table

**Problem—The AMOT Engine Stop Does Not Shut Down the Engine**

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage is not present at the AMOT solenoid while the shut down switch is activated.</td>
<td>Check the 251 circuit for an open circuit.</td>
</tr>
<tr>
<td>Ground is not present at the AMOT solenoid.</td>
<td>Check the GND circuit for an open circuit.</td>
</tr>
<tr>
<td>An obstruction in the path of the actuator handle.</td>
<td>Check the actuator and handle for proper clearance when the cab is lowered.</td>
</tr>
<tr>
<td>An obstruction in the air intake at the AMOT valve.</td>
<td>Check the air intake at the AMOT valve for an obstruction.</td>
</tr>
<tr>
<td>The O-ring is worn.</td>
<td>Replace the O-ring.</td>
</tr>
<tr>
<td>The butterfly disk is not sealing completely.</td>
<td>Adjust the butterfly disk so that it closes completely.</td>
</tr>
</tbody>
</table>
NOTE: For engine service and troubleshooting procedures, see the engine manufacturer’s service literature.

For engine brake information for the Cummins engines, see Section 01.05.

For detailed repair procedures and other engine service not covered in this section, refer to the Cummins Operation and Maintenance Manuals, Cummins Troubleshooting and Repair Manuals, and the Cummins Workshop Manuals for your specific engine.
Belt Inspection

NOTE: Refer to Fig. 1 during pulley and drive belt inspections.

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

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

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

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

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

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

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

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

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

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

3. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a nonflammable cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.

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

5. Check alignment (Fig. 3) of pulleys. Use a thin straightedge that is longer than the longest span between the pulleys. Place the straightedge into the V-grooves of two pulleys at a time. The straightedge should be parallel to the outer edges of the pulleys; if not, the pulleys are misaligned.

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

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

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

Fig. 1, Drive Belt Problems

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

Fig. 2, Check for Pulley Wear

1. Groove in Pulley Wall
2. Small Straightedge

Fig. 3, Check for Misaligned Pulleys

A. Side View of Misaligned Pulleys.
Replacement

Alternator

1. Remove the belt.
   1.1 Loosen the alternator mounting bolt and the adjustment link locking capscrew just enough to allow movement of the alternator.
   1.2 Loosen the adjusting screw locknut.
   1.3 Turn the alternator adjusting screw, backing off the alternator toward the drive pulley far enough to allow belt removal without using force.
   1.4 Remove the belt, without prying or rolling it off of the pulleys.

2. Install the new belt.
   2.1 Inspect the pulleys and used alternator belt (even if a new belt is being installed) as instructed in Subject 100.
   2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.
   2.3 Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.
   2.4 While keeping the belt seated in the pulley grooves, turn the adjusting screw clockwise to increase the belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the belt free-span to check the tension while turning the adjusting screw. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, stop.

3. Adjust the belt.
   3.1 If not already done, loosen the adjusting screw locknut, and loosen the alternator mounting bolts, just enough to allow movement of the alternator.
   3.2 Install a belt tension gauge at the center of the belt free-span.
   3.3 Turn the adjusting screw to adjust the tension to a reading of 100 lb (45 kg).

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

3.4 Tighten the adjusting screw locknut 95 lbf·ft (130 N·m).
3.5 Tighten the alternator mounting fastener 70 lbf·ft (95 N·m), the adjusting block nut 35 lbf·ft (50 N·m), and the adjusting link locking capscrew 55 lbf·ft (75 N·m).
3.6 Check the belt tension, and adjust it if needed.
3.7 If a new alternator belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.
3.8 If the alternator belt tension is not 100 lb (45 kg), adjust the tension to 100 lb (45 kg).

Fan Belt

1. Remove the belt.
   1.1 Loosen the locknut that secures the idler pulley to the fan bracket.
   1.2 Turn the fan adjusting screw until there is minimal distance between the pulley centers.
   1.3 Remove the fan belt by slipping it off of the pulleys and working it over one fan blade at a time. Don’t roll or pry the belt off of the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.

2. Install the new belt.
   2.1 Inspect the pulleys and used fan belt (even if a new belt is being installed) as instructed in Subject 100.
   2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.
   2.3 Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.
Drive Belt Replacement

2.4 While keeping the belt seated in the pulley grooves, turn the idler pulley adjustment cap screw to increase the belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the belt free-span to check the tension while turning the cap screw. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, stop.

3. Adjust the belt.

3.1 If not already done, loosen the locknut that secures the idler pulley to the fan bracket.

3.2 Install a belt tension gauge at the center of the belt’s longest free-span.

3.3 Turn the fan adjusting screw to increase or decrease belt tension, but do not adjust the tension to the full value with the idler pulley adjustment cap screw; belt tension can increase when the idler pulley locknut is tightened. Final tension must be 100 lb (45 kg).

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

3.4 Tighten the idler pulley locknut 120 to 140 lbf·ft (165 to 190 N·m).

3.5 Loosen the fan adjusting screw one-half turn, to prevent breakage.

3.6 Check the belt tension, and adjust it if needed.

3.7 If a new fan belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

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

Refrigerant Compressor

1. Remove the belt.

1.1 Back off the adjusting nut. Loosen the pivot bolts just enough to allow movement of the compressor.

1.2 Push the loosened compressor toward the accessory drive pulley until the distance between them is short enough to allow belt removal without using force.

1.3 Remove the belt, without prying or rolling it off of the pulleys.

2. Install the new belt.

2.1 Inspect the pulleys and used refrigerant compressor belt (even if a new belt is being installed) as instructed in Subject 100.

2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.3 Install the belt on the pulleys without prying or rolling it into place.

2.4 Back off the jam nut.

2.5 While keeping the belt seated in the pulley grooves, turn the adjusting nut to increase belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, stop.

3. Adjust the belt.

3.1 If not already done, back off the jam nut, and loosen the mounting bolts just enough to allow movement of the compressor.

3.2 Install a belt tension gauge at the center of the belt free-span.

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

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

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

3.5 Tighten the compressor mounting bolts 30 lbf·ft (40 N·m), and the adjusting link bolt 40 lbf·ft (55 N·m).

3.6 Check the belt tension, and adjust it if needed.

3.7 If a new refrigerant compressor belt was installed, operate the engine for about 20 minutes, then check the belt tension. All
new belts will lose tension after 20 minutes of operation.

3.8 If the refrigerant compressor belt tension is not 100 lb (45 kg), adjust the tension to 100 lb (45 kg).
Engine Port Diagrams

Refer to Fig. 1 to identify engine ports for a Cummins ISL engine.

Fig. 1, Cummins ISL Engine Ports
Specifications

See Fig. 1 for a full view of the grid heater wiring. See Fig. 2 and Fig. 3 for partial views of the grid heater wiring. See Fig. 4 for a full view of the fan clutch wiring. See Fig. 5 and Fig. 6 for partial views of the fan clutch wiring. See Fig. 7 for a full view of the fan clutch wiring for the Cummins ISL engine. See Fig. 8 and Fig. 9 for partial views of the fan clutch wiring for the Cummins ISL engine.

Fig. 1, Grid Heater Wiring (full view)

Refer to the tables below for specific fastener torques.
Fig. 2, Grid Heater Wiring (partial view)
Fig. 5, Fan Clutch Wiring (partial view)
Fig. 6, Fan Clutch Wiring (partial view)
Fig. 7, Fan Clutch Wiring, Cummins ISL engine (full view)
Fig. 8, Fan Clutch Wiring, Cummins ISL engine (partial view)
### Drive Belt Tensions

<table>
<thead>
<tr>
<th>Engine</th>
<th>Component</th>
<th>Belt Tension, New Belt (lb (kg))</th>
<th>Belt Tension, Used Belt (lb (kg))</th>
</tr>
</thead>
<tbody>
<tr>
<td>M11</td>
<td>Alternator</td>
<td>140–160 (64–73)</td>
<td>90–120 (41–55)</td>
</tr>
<tr>
<td></td>
<td>Fan</td>
<td>190–210 (86–95)</td>
<td>155–165 (70–75)</td>
</tr>
<tr>
<td></td>
<td>Refrigerant Compressor</td>
<td>130 (59)</td>
<td></td>
</tr>
<tr>
<td>N14</td>
<td>Alternator</td>
<td>140 (63)</td>
<td>60–110 (27–49)</td>
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<td></td>
<td>Fan</td>
<td>130–50 (58–68)</td>
<td>80–120 (36–54)</td>
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<tr>
<td></td>
<td>Refrigerant Compressor</td>
<td>100 (45)</td>
<td>100 (45)</td>
</tr>
<tr>
<td>ISM, ISC, ISB, ISL,</td>
<td>Refrigerant Compressor</td>
<td>100 (45)</td>
<td>100 (45)</td>
</tr>
<tr>
<td>3126/CFE</td>
<td>Refrigerant Compressor</td>
<td>80–100 (38–45)</td>
<td>80–100 (38–45)</td>
</tr>
</tbody>
</table>

Table 1, Drive Belt Tensions

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Fig. 9, Fan Clutch Wiring, Cummins ISL engine (partial view)
### Fastener Torques

<table>
<thead>
<tr>
<th>Engine</th>
<th>Fastener</th>
<th>Torque lbf·ft (N·m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Models</td>
<td>Rear Engine-to-Mount Bolts</td>
<td>213–269 (289–365)</td>
</tr>
<tr>
<td></td>
<td>Front Engine-to-Mount Bolts</td>
<td></td>
</tr>
<tr>
<td>ISM, M11, ISX</td>
<td>Engine Leg-to-Flywheel Housing Bolts (3/4–10 x 2 inches)</td>
<td></td>
</tr>
<tr>
<td>N14</td>
<td>Engine Leg-to-Flywheel Housing Bolts (3/4–10 x 1-3/4 inches)</td>
<td>190 (258)</td>
</tr>
<tr>
<td>ISC, ISL, ISB</td>
<td>Engine Leg-to-Flywheel Housing Bolts (3/4–10 x 2 inches)</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2, Fastener Torques**