CATERPILLAR®

RENR2235-03
April 2001

Systems Operation Testing and Adjusting

C-10 and C-12 Truck Engines

CPD1-Up (Engine)
2KS1-Up (Engine)
3CS1-Up (Engine)

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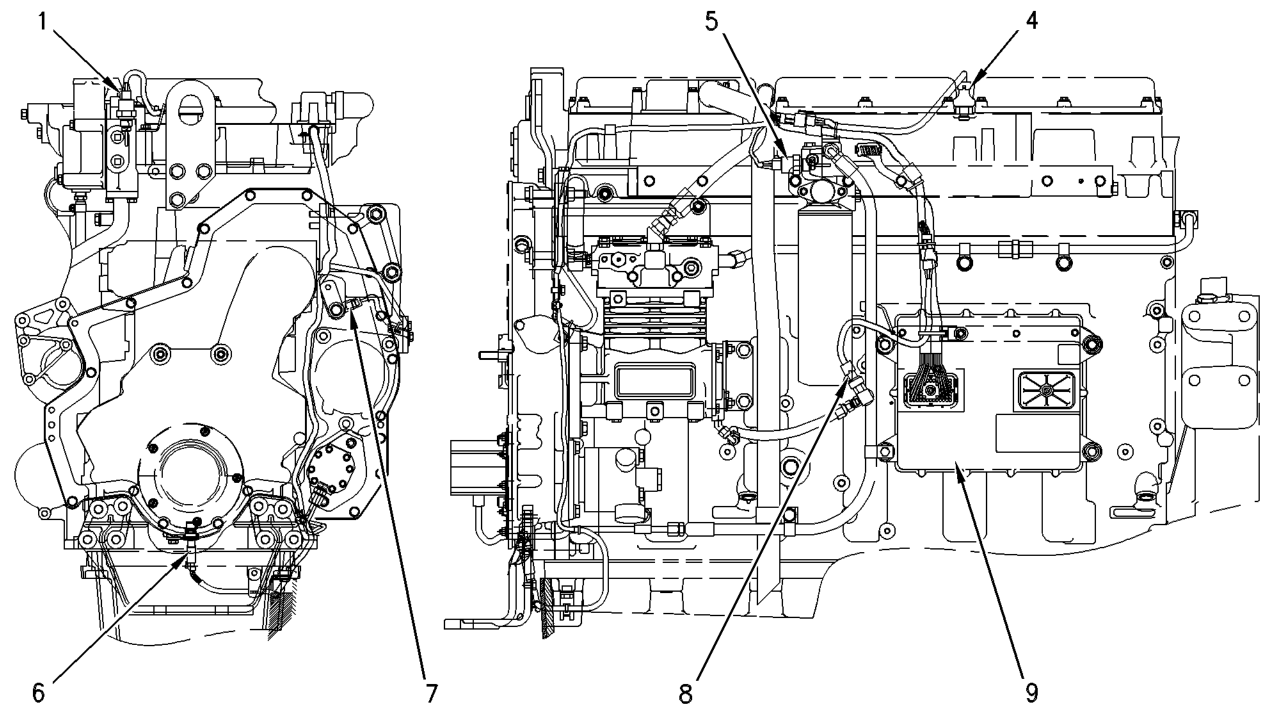

Illustration 4 g00499283

Front view and left side view

(1) Coolant temperature sensor
(2) Inlet air temperature sensor
(3) Boost pressure sensor
(4) Atmospheric pressure sensor
(5) Fuel temperature sensor
(6) Crankshaft position sensor
(7) Camshaft position sensor
(8) Oil pressure sensor
(9) Electronic control module (ECM)

The electronic control system is integrally designed into the engine's fuel system and the engine's air inlet and exhaust system in order to electronically control the fuel delivery and the injection timing. The electronic control system provides increased timing control and fuel air ratio control in comparison to conventional mechanical engines. Injection timing is achieved by precise control of injector firing time, and engine rpm is controlled by adjusting the firing duration. The ECM energizes the solenoid in the unit injector in order to start the injection of fuel. Also, the ECM de-energizes the unit injector solenoids in order to stop injection of fuel. Refer to the Systems Operation, "Fuel System" topic for a complete explanation of the fuel injection process.

The engine uses the following types of electronic components:

- Inputs
- Controls
- Outputs

An input component is one that sends an electrical signal to the ECM. The signal that is sent varies in one of the following ways:

- Voltage
- Frequency
- Pulse width

The variation of the signal is in response to a change in some specific system of the vehicle. The electronic control module sees the input sensor signal as information about the condition, environment, or operation of the vehicle.

A control component (ECM) receives the input signals. Electronic circuits inside the control component evaluate the signals from the input components. These electronic circuits also supply electrical energy to the output components of the system. The electrical energy that is supplied to the output components is based on predetermined combinations of input signal values.

An output component is one that is operated by a control module. The output component receives electrical energy from the control component. The output component uses that electrical energy in one of two ways. The output component can use that electrical energy in order to perform work. The output component can use that electrical energy in order to provide information.

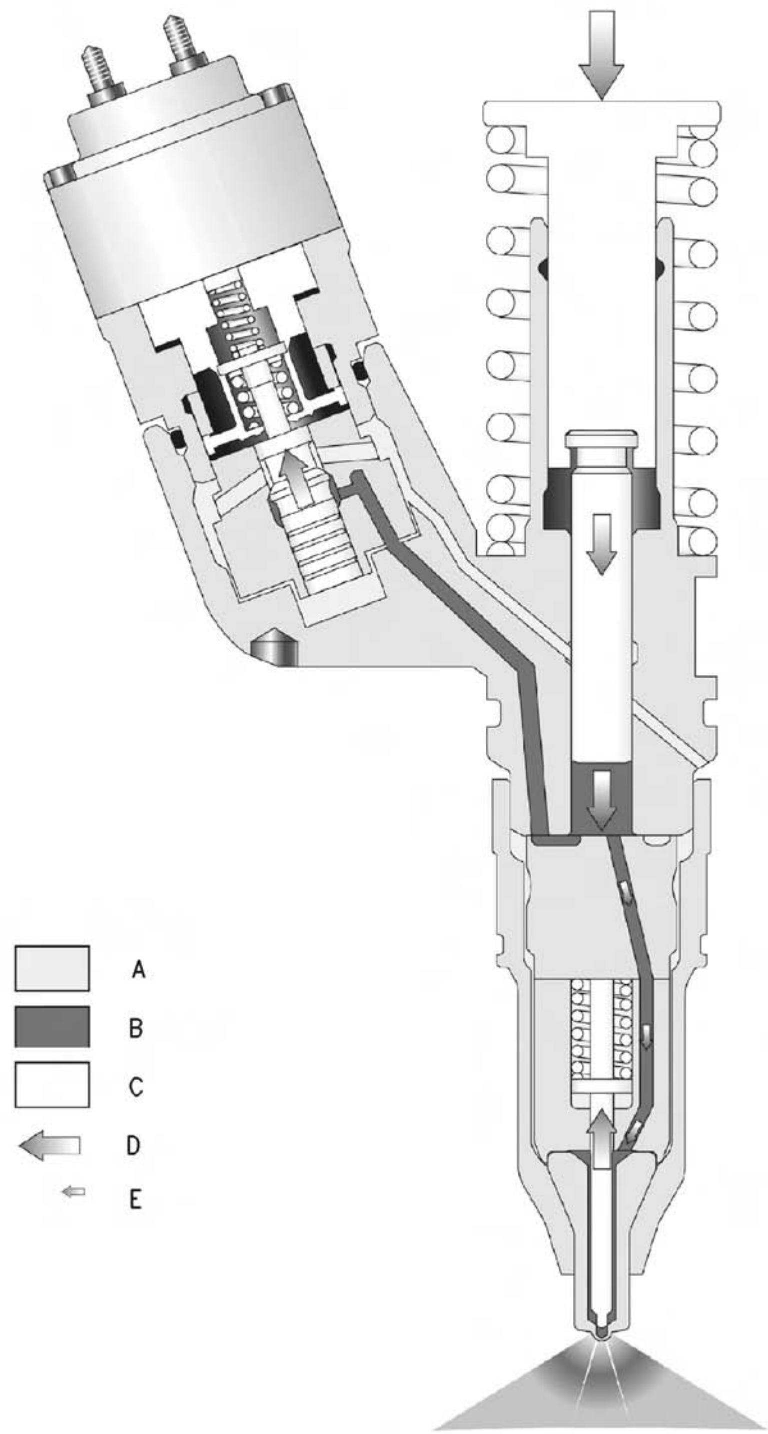

Illustration 10 g00660658

Injection

(A) Fuel supply pressure.
(B) Injection pressure
(C) Moving parts
(D) Mechanical movement
(E) Fuel movement.

Oil Flow Through The Lubrication System

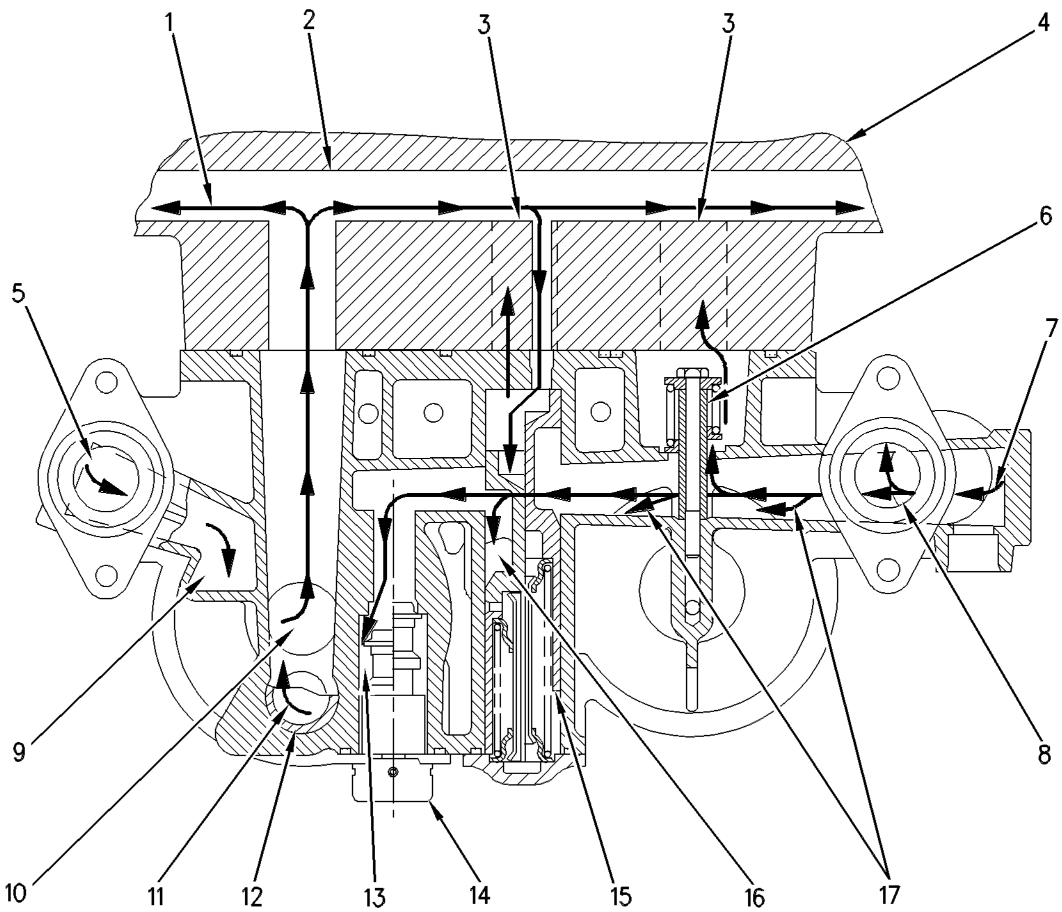

Illustration 19 g00421838

Oil flow through engine

(1) Oil flow to the piston, piston cooling jets, valve mechanism, camshaft journals, crankshaft main bearings, and the turbocharger
(2) Main oil gallery in cylinder block
(3) Oil drains to sump
(4) Cylinder block
(5) Oil from engine oil cooler
(6) High pressure relief valve
(7) Oil from engine oil pump
(8) Oil to engine oil cooler
(9) Passage to primary engine oil filter
(10) Filtered oil
(11) Bypassed oil
(12) Oil filter bypass valve
(13) Passage to primary engine oil filter
(14) Oil cooler bypass valve
(15) Oil pump bypass valve
(16) Oil pump bypass drain
(17) Passages to secondary oil filter

The engine oil pump is mounted to the back of the front gear train on the lower right hand side of the engine. The engine oil pump is driven by an idler gear from the crankshaft gear. Oil is pulled from the sump through oil pump bypass valve (15) on the way to the engine oil cooler. The bypass valve controls the oil pressure from the engine oil pump. The engine oil pump can supply excess oil for the lubricating system. When this situation is present, the oil pressure increases and the bypass valve opens. The open bypass valve allows the excess oil to return to the sump.

When the solenoid is activated by a signal from the logic for the compression brake, solenoid valve (2) moves downward. This causes oil drain passage (15) to engine oil pan (11) to be closed. At the same time, low pressure oil passage (16) to control valve (5) is opened. As low pressure oil passage (16) is filled with engine oil, the control valve is pushed upward in the chamber against the force of spring (4). At this position, a groove in control valve (5) is in alignment with high pressure oil passage (6). Slave piston (14) and master piston (8) are supplied by the high pressure oil passage. Engine oil pressure will now lift ball check valve (17). High pressure oil passage (6) and the chambers behind the slave pistons and behind the master pistons will be filled with engine oil pressure. This pressure moves the master piston downward until contact is made with fuel injector rocker arm (12). When upward motion is initiated on the master piston, the pressure increases above the current level of the engine supply pressure. This causes ball check valve (17) to seat. The system is now operating in conjunction with the exhaust valve and with the injector rocker mechanism. When the solenoid is activated, the compression brake could be operable within 1/5 of a second.

Fuel injector pushrod (13) will begin to move upward on the pumping stroke of the electronically controlled unit injector. When this occurs, fuel injector rocker arm (12) makes contact with extending master piston (8). As the master piston begins to move upward, the oil pressure increases in high pressure oil passage (6). This happens because ball check valve (17) will not allow oil to exit. The upward movement of the fuel injector rocker arm creates a constant increase in pressure. This forces the slave piston downward against the screw assembly in exhaust bridge assembly (20). The slave piston moves downward with enough force to open exhaust valve (19).

Note: Only one of the two exhaust valves for each cylinder on this engine is used in the operation of the compression brake.

This master-slave circuit is designed so that master piston (8) is moved only when the engine cylinder is on the compression stroke. The master-slave circuit is designed so that slave piston (14) opens one exhaust valve of the same cylinder only on the compression stroke. This occurs slightly before the piston reaches the top center position. The braking force is constant. The operation of the compression brake of a cylinder is caused by the motion of the valve mechanism of that cylinder. This causes the firing sequence of the valves to be identical to the firing order of the engine.

When solenoid valve (2) is in the Off position, the engine oil supply passage is closed and oil drain passage (15) is opened. This allows oil to drain from underneath control valve (5). This also allows spring (4) to push the control valve to the bottom of the chamber. This position allows oil from high pressure oil passage (6) to drain into the chamber above the control valve's piston. This chamber vents to the outside of the compression brake housing. Spring (10) now moves master piston (8) to the retracted position away from fuel injector rocker arm (12). The time that is necessary for the system to stop operation is approximately 1/10 of a second. The compression brake will not be able to operate until solenoid (2) is activated again.

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Electrical System

SMCS Code: 1400; 1550; 1900

Grounding Practices

Proper grounding for the machine electrical system and engine electrical systems is necessary for proper machine performance and reliability. Improper grounding will result in uncontrolled electrical circuit paths and unreliable electrical circuit paths.

Uncontrolled engine electrical circuit paths can result in damage to main bearings, crankshaft bearing journal surfaces, and aluminum components.

To ensure proper functioning of the vehicle and engine electrical systems, an engine-to-frame ground strap with a direct path to the negative battery post must be used. This may be provided by way of a starting motor ground, a frame to starting motor ground, or a direct frame to engine ground.

An engine-to-frame ground strap must be used in order to connect the grounding stud of the engine to the frame of the vehicle and to the negative battery post.

2. Determine if contaminants are present in the fuel. Remove a sample of fuel from the bottom of the fuel tank. Visually inspect the fuel sample for contaminants. The color of the fuel is not necessarily an indication of fuel quality. However, fuel that is black, brown, and/or similar to sludge can be an indication of the growth of bacteria or oil contamination. In cold temperatures, cloudy fuel indicates that the fuel may not be suitable for operating conditions. The following methods can be used to prevent wax from clogging the fuel filter:

   - Fuel heaters
   - Blending fuel with additives
   - Utilizing fuel with a low cloud point such as kerosene

   Refer to Operation and Maintenance Manual, “Fuel Recommendations” for more information.

3. Check fuel API with a 9U-7840 Fluid and Fuel Calibration Gp for low power complaints. The acceptable range of the fuel API is 30 to 45 when the API is measured at 15 °C (60 °F), but there is a significant difference in energy within this range. Refer to Tool Operating Manual, NEHS0607 for API correction factors when a low power problem is present and API is high.

Note: A correction factor that is greater than 1.000 may be the cause of low power and/or poor fuel consumption.

4. If fuel quality is still suspected as a possible cause to problems regarding engine performance, disconnect the fuel inlet line, and temporarily operate the engine from a separate source of fuel that is known to be good. This will determine if the problem is caused by fuel quality. If fuel quality is determined to be the problem, drain the fuel system and replace the fuel filters. Engine performance can be affected by the following characteristics :

   - Cetane number of the fuel
   - Air in the fuel
   - Other fuel characteristics

i01180507

Fuel System - Prime

SMCS Code: 1258-548

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE

Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

NOTICE

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

If the fuel system runs out of fuel or if air is introduced into the fuel system the following procedure may be followed.

1. Turn the ignition switch to the “OFF” position.

2. Fill the fuel tank(s) with clean diesel fuel.

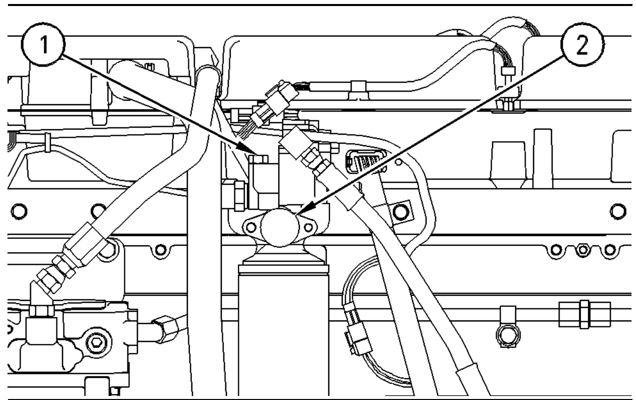

Illustration 45 g00474457

Typical example

(1) Air bleed screw
(2) Fuel priming pump (IF EQUIPPED)

3. Open air bleed screw (1) for the fuel filter three full turns. Do not remove the air bleed screw.

NOTICE

Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

c. Inspect the engine crankcase breather. Clean the engine crankcase breather or replace the engine crankcase breather if the engine crankcase breather is plugged.

d. Remove the turbocharger oil drain line. Inspect the drain opening. Inspect the oil drain line. Inspect the area between the bearings of the rotating assembly shaft. Look for oil sludge. Inspect the oil drain hole for oil sludge. Inspect the oil drain line for oil sludge in the drain line. If necessary, clean the rotating assembly shaft. If necessary, clean the oil drain hole. If necessary, clean the oil drain line.

e. If Steps 4.a through 4.d did not reveal the source of the oil leakage, the turbocharger has internal damage. Replace the turbocharger.

Inspection of the Turbine Wheel and the Turbine Housing

Remove the air piping from the turbine housing.

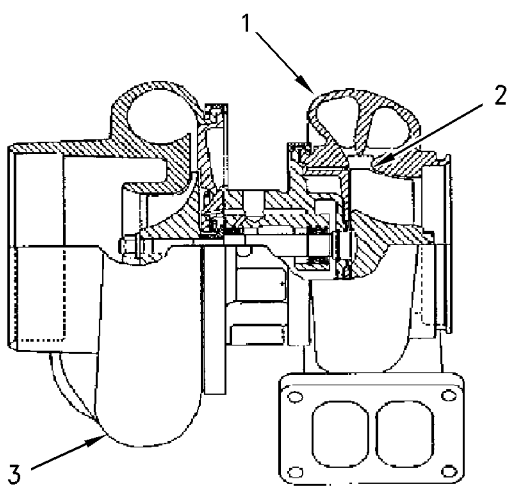

Illustration 60 g00763164

(1) Turbine Housing
(2) Turbine Wheel
(3) Turbocharger

1. Inspect the turbine for damage by a foreign object. If there is damage, determine the source of the foreign object. Replace turbocharger (3). If there is no damage, go to Step 2.

2. Inspect turbine wheel (2) for buildup of carbon and other foreign material. Inspect turbine housing (1) for buildup of carbon and foreign material. Clean turbine wheel (2) and clean turbine housing (1) if you find buildup of carbon or foreign material. If there is no buildup of carbon or foreign material, go to Step 3.

3. Turn the rotating assembly by hand. While you turn the assembly, push the assembly sideways. The assembly should turn freely. Turbine wheel (2) should not rub turbine wheel housing (1). Replace turbocharger (3) if turbine wheel (2) rubs turbine housing (1). If there is no rubbing or scraping, go to Step 4.

4. Inspect the turbine and turbine housing (1) for oil leakage. Inspect the turbine and turbine housing (1)for oil coking. Some oil coking may be cleaned. Heavy oil coking may require replacement of the turbocharger. If the oil is coming from the turbocharger center housing go to Step 4.a. Otherwise go to “Inspection of the Wastegate”.

a. Remove the turbocharger oil drain line. Inspect the drain opening. Inspect the area between the bearings of the rotating assembly shaft. Look for oil sludge. Inspect the oil drain hole for oil sludge. Inspect the oil drain line for oil sludge. If necessary, clean the rotating assembly shaft. If necessary, clean the drain opening. If necessary, clean the drain line.

b. If crankcase pressure is high, or if the oil drain is restricted, pressure in the center housing may be greater than the pressure of turbine housing (1). Oil flow may be forced in the wrong direction and the oil may not drain. Check the crankcase pressure and correct any problems.

c. If the oil drain line is damaged, replace the oil drain line.

d. Check the routing of the oil drain line. Eliminate any sharp restrictive bends. Make sure that the oil drain line is not too close to the engine exhaust manifold.

e. If Steps 4.a through 4.d did not reveal the source of the oil leakage, turbocharger (3) has internal damage. Replace turbocharger (3).

Inspection of the Wastegate

Note: All engines are not equipped with waste gates.

The wastegate controls the amount of exhaust gas that is allowed to bypass the turbine side of the turbocharger. This valve then controls the rpm of the turbocharger.

When the engine operates in conditions of low boost (lug), a spring presses against a diaphragm in the canister. The actuating rod will move and the wastegate will close. Then, the turbocharger can operate at maximum performance.

The minimum engine oil pressure at 1800 rpm should be approximately 275 to 414 kPa (40 to 59 psi). Minimum engine oil pressure at low idle rpm (600 to 800 rpm) should be approximately 68 kPa (10 psi).

4. Compare the recorded engine oil pressure with the oil pressure indicators on the instrument panel and the engine oil pressure that is displayed on the electronic service tool.

5. An engine oil pressure indicator that has a defect or an engine oil pressure sensor that has a defect can give a false indication of a low oil pressure or a high oil pressure. If there is a notable difference between the engine oil pressure readings make necessary repairs.

6. If the engine oil pressure is determined to be low, refer to "Reasons for Low Engine Oil Pressure".

7. If the engine oil pressure is determined to be high, refer to "Reason for High Engine Oil Pressure".

Reasons for Low Engine Oil Pressure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

- Engine oil level is low. Refer to Step 1.
- Engine oil is contaminated. Refer to Step 2.
- The engine oil bypass valves are open. Refer to Step 3.
- The engine lubrication system is open. Refer to Step 4.
- The oil pickup tube has a leak or a restricted inlet screen. Refer to Step 5.
- The engine oil pump is faulty. Refer to Step 6.
- Engine Bearings have excessive clearance. Refer to Step 7.

1. Check the engine oil level in the crankcase. The oil level can possibly be too far below the oil pump supply tube. This will cause the oil pump not to have the ability to supply enough lubrication to the engine components. If the engine oil level is low add engine oil in order to obtain the correct engine oil level. Refer to Operation and Maintenance Manual, "Engine Oil" for the recommendations of engine oil.

2. Engine oil that is contaminated with fuel or coolant will cause low engine oil pressure. High engine oil level in the crankcase can be an indication of contamination. Determine the reason for contamination of the engine oil and make the necessary repairs. Replace the engine oil with the approved grade of engine oil. Refer to Operation and Maintenance Manual, "Engine Oil" for the recommendations of engine oil.

NOTICE

Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

3. If the engine oil bypass valves are held in the open position, a reduction in the oil pressure can be the result. This may be due to debris in the engine oil. If the engine oil bypass valves are stuck in the open position, remove each engine oil bypass valve and clean each bypass valve in order to correct this problem. You must also clean each bypass valve bore. Install new engine oil filters. New engine oil filters will prevent more debris from causing this problem. For information on the repair of the engine oil bypass valves, refer to Disassembly and Assembly, "Engine Oil Filter Base - Disassemble".

4. An oil line or an oil passage that is open, broken, or disconnected will cause low engine oil pressure. An open lubrication system could be caused by a piston cooling jet that is missing or damaged. Determine the reason for an open lubrication system of the engine and make the necessary repairs.

2. Heat water in a pan until the temperature is 98 °C (208 °F).

3. Hang the coolant temperature regulator in the pan of water. The coolant temperature regulator must be below the surface of the coolant and away from the sides and the bottom of the pan.

4. Keep the coolant at the correct temperature for ten minutes.

5. After ten minutes, remove the coolant temperature regulator. Check the opening in the housing for the coolant temperature regulator.

   If the distance is less than the specified distance in the Specification manual, replace the coolant temperature regulator. Refer to Specifications, "Water Temperature Regulator".

i01467399

Water Pump - Test

SMCS Code: 1361-040; 1361-081

Table 20

Tools Needed		
Part Number	**Part Name**	**Quantity**
6V-7775	Air Pressure Gauge	1

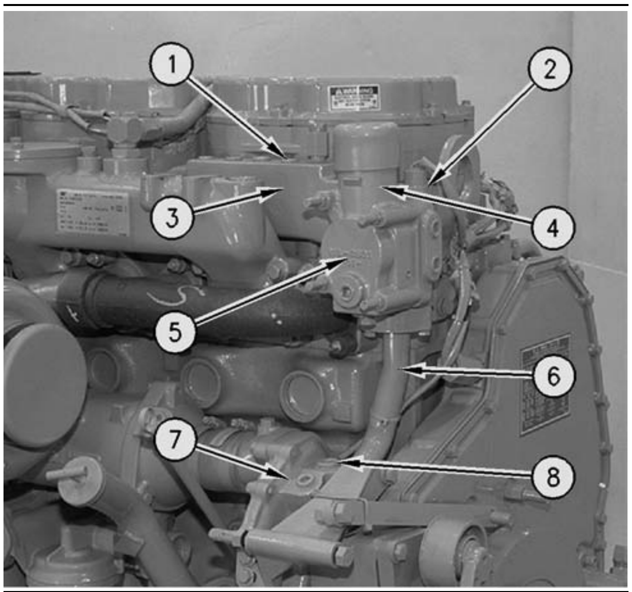

Illustration 79 g00439003

Typical example

(1) Port
(2) Coolant temperature sensor
(3) Water manifold assembly
(4) Water outlet
(5) Coolant temperature regulator
(6) Bypass line
(7) Water pump
(8) Port

WARNING

Making contact with a running engine can cause burns from hot parts and can cause injury from rotating parts.

When working on an engine that is running, avoid contact with hot parts and rotating parts.

Perform the following procedure in order to determine if the water pump is operating correctly:

1. Remove the plug from port (1).

2. Install the 6V-7775 Air Pressure Gauge in port (1).

3. Start the engine. Run the engine until the coolant is at operating temperature.

4. Note the water pump pressure. The water pump pressure should be 100 to 125 kPa (15 to 18 psi).

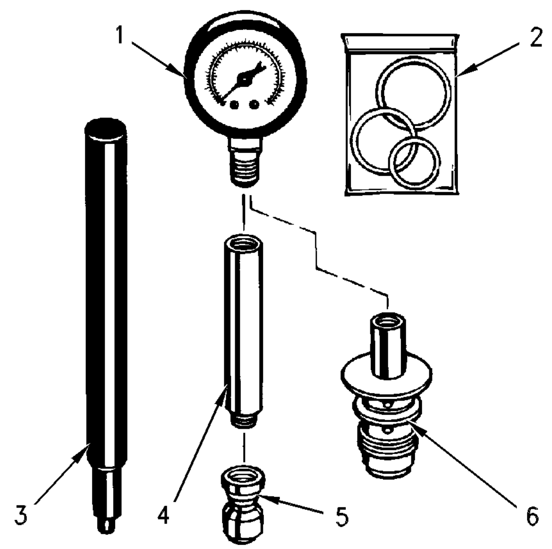

Illustration 98 g00514378

149-6111 Oil Pressure Test Kit

(1) Pressure gauge
(2) Seals
(3) Control valve removal tool
(4) Control valve test body
(5) Control valve adapter
(6) Solenoid valve adapter

1. Attach pressure gauge (1) to solenoid valve adapter (6).

2. Remove the solenoid valve and the three seals from the compression brake housing. Refer to Disassembly and Assembly, "Compression Brake - Disassemble".

3. Install three seals (2), which are included in the **149-6111** Oil Pressure Test Kit. Place the smallest seal in the bottom of the bore for the solenoid. Install the other two seals on solenoid valve adapter (6).

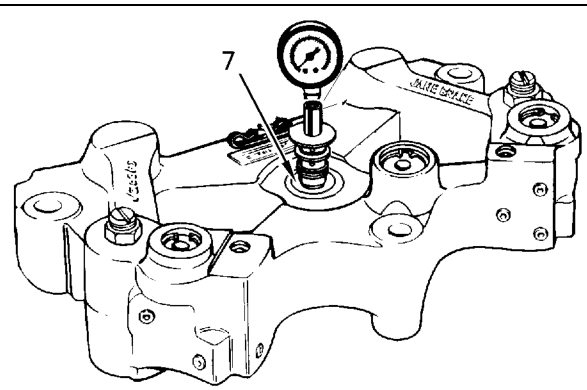

Illustration 99 g00514470

4. Lubricate the seals with clean engine oil and install the adapter assembly in bore (7) for the solenoid valve. Hand tighten the adapter assembly and then tighten the adapter assembly for an additional 1/4 turn.

5. Start the engine. Ensure that the switch for the compression brake is in the OFF position.

6. Record the oil pressure reading.

7. Increase the engine speed by 400 rpm.

8. Repeat Steps 6 and 7 up to the rated engine rpm.

9. Stop the engine. Install the solenoid valve. Refer to Disassembly and Assembly, "Compression Brake - Assemble".

   Compare the oil pressure readings from the solenoid valve to the oil pressure readings from the Testing and Adjusting, "Control Valve (Compression Brake) - Test".

   - If the oil pressure at the solenoid valve is higher than the oil pressure at the control valve, continue with Steps 10 through 15.

   - If the oil pressure at the solenoid valve is the same pressure as the oil pressure at the control valve, the oil pressure to the compression brake is too low. Refer to Testing and Adjusting, "Engine Oil Pressure - Test".

10. Start the engine.

11. Disconnect the wires from each solenoid valve except for the solenoid valve that is being tested in order to check each solenoid valve individually.

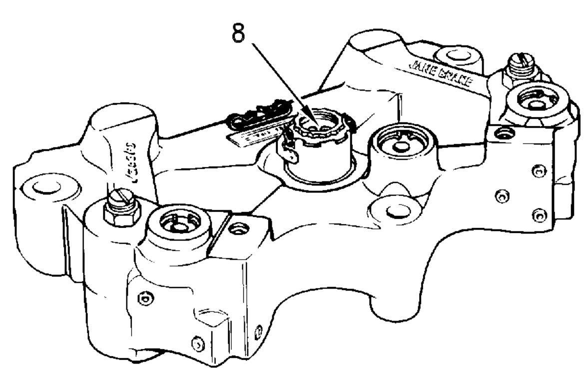

Illustration 100 g00514472

12. Turn the switch for the compression brake to the ON position. Observe the movement of solenoid armature (8). The solenoid armature should snap down fully. Push down on the solenoid armature in order to verify that the solenoid is fully actuated.

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