3176C and 3196 MARINE ENGINES

Maintenance Intervals

Excerpted from Operation & Maintenance Manual (SEBU7040-04-01)

CATERPILLAR

i02507419

Maintenance Interval Schedule

SMCS Code: 1000; 7500

Ensure that all safety information, warnings, and instructions are read and understood before any operation or any maintenance procedures are performed.

The user is responsible for the performance of maintenance, including all adjustments, the use of proper lubricants, fluids, filters, and the replacement of components due to normal wear and aging. Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the product and/or accelerated wear of components.

Use mileage, fuel consumption, service hours, or calendar time, WHICH EVER OCCURS FIRST, in order to determine the maintenance intervals. Products that operate in severe operating conditions may require more frequent maintenance.

Note: Before each consecutive interval is performed, all maintenance from the previous interval must be performed.

When Required

Daily

Between 250 Service Hours and 1000 Service Hours (or between first and fourth oil change)

Every 1900 L (500 US gal) of Fuel or 50 Service Hours

PM Level 1 - Every 9500 L (2500 US gal) of Fuel or 250 Service Hours or 1 Year

Every 28 500 L (7500 US gal) of Fuel or 750 Service Hours or 1 Year

Every 38 000 L (10 000 US gal) of Fuel or 1000 Service Hours

PM Level 2 - Every 114 000 L (30 000 US gal) of Fuel or 3000 Service Hours or 2 Years

Every 190 000 L (50 000 US gal) of Fuel or 5000 Service Hours

Every 228 000 L (60 000 US gal) of Fuel or 6000 Service Hours or 4 Years

Every 380 000 L (100 000 US gal) of Fuel or 10 000 Service Hours

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Aftercooler Condensate Drain Valve - Inspect/Clean

SMCS Code: 1063-042-DN, VL

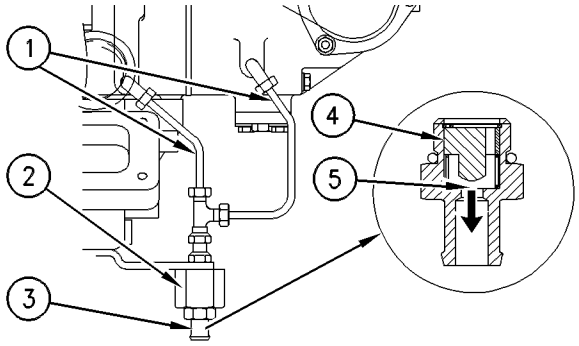

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Illustration 20

(1) Drain lines. (2) Adapter. (3) Valve. (4) Plunger. (5) Valve seat.

The turbocharger boost pressure forces plunger (4) to move down to valve seat (5). The plunger must close against the seat at a pressure of 27.5 kPa (4 psi). When the engine is stopped, the absence of boost pressure allows the plunger to rise to the open position, which allows condensation from the aftercooler to drain out.

The plunger must be able to move freely in order to close the system when the engine is running. The plunger must be able to move freely in order to allow condensation to drain from the aftercooler when the engine is stopped. Residue from normal engine operation could cause the plunger to stick.

1. Remove valve (3) from adapter (2). Check the valve in order to determine if plunger (4) moves freely. If the plunger does not move easily, clean the valve with solvent.

2. Remove drain lines (1). Check the lines for plugging. Clean the lines, if necessary. Pressure air or a flexible rod with a small diameter can be used to clean the lines.

3. Reassemble the aftercooler condensate drain valve. Refer to the Specifications, SENR3130, “Torque Specifications” for the correct torque values .

i01546702

Aftercooler Core - Clean/Test

SMCS Code: 1064-070; 1064-081

1. Remove the core. Refer to the Service Manual for the procedure.

2. Turn the aftercooler core upside-down in order to remove debris.

NOTICE

Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

3. Back flush the core with cleaner.

   Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 17 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 17

Hydrosolv Liquid Cleaners[1]		
Part Number	**Description**	**Size**
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

(1) Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F). Refer to Application Guide, NEHS0526 or consult your Caterpillar dealer for more information.

4. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris.

5. Wash the core with hot, soapy water. Rinse the core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

6. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.

7. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.

8. Install the core. Refer to the Service Manual for the procedure.

For more information on cleaning the core, consult your Caterpillar dealer.

i00072207

Alternator - Inspect

SMCS Code: 1405-040

Caterpillar recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and proper battery charging. Inspect the ammeter (if equipped) during engine operation in order to ensure proper battery performance and/or proper performance of the electrical system. Make repairs, as required. Refer to the Service Manual.

Check the alternator and the battery charger for proper operation. If the batteries are properly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine. The battery will not crank the engine, even if the engine is warm. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

i02456322

Alternator Belt - Inspect/Adjust/Replace

SMCS Code: 1357-036; 1357-510

Inspection

To maximize the engine performance, inspect the belt for wear and for cracking. Check the belt tension. Adjust the belt tension in order to minimize belt slippage. Belt slippage will decrease the life of the belt.

To check the belt tension, apply 110 N (25 lb) of force midway between the pulleys. A correctly adjusted belt will deflect 13 to 19 mm (0.50 to 0.75 inch).

Adjustment

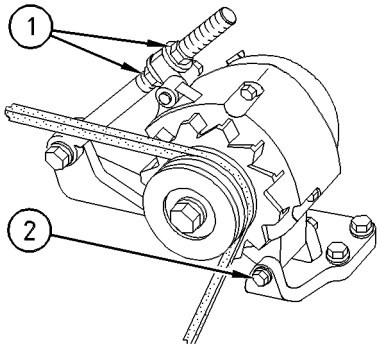

Illustration 21 g00122875

(1) Adjusting nuts
(2) Mounting bolt

1. Remove the belt guard.

2. Loosen mounting bolt (2) and adjusting nuts (1).

3. Turn adjusting nuts (1) in order to increase or decrease the belt tension.

4. Tighten adjusting nuts (1). Tighten mounting bolt (2). Refer to the Specifications, SENR3130, “Torque Specifications” for the proper torques.

5. Reinstall the belt guard.

If new belts are installed, check the belt adjustment again after 30 minutes of engine operation at the rated rpm.

Replacement

For applications that require multiple drive belts, replace the belts in matched sets. Replacing only one belt of a matched set will cause the new belt to carry more load because the older belts are stretched. The additional load on the new belt could cause the new belt to break.

Refer to the Service Manual for more information on the procedures for the following topics: belt removal and installation of the belt.

i01059376

Auxiliary Water Pump - Inspect

SMCS Code: 1371-040

Impellers require periodic inspection and seals require periodic inspection. Impellers have a service life that is limited. The service life depends on the engine operating conditions.

Inspect the components of the pump more frequently when the pump is exposed to debris, sand, or other abrasive materials. Inspect the components if the pump is operating at a differential pressure of more than 103 kPa (15 psi).

Check the following components for wear and check the following components for damage:

- Cam
- Impeller
- Seals
- Wear plate

If wear is found or if damage is found, replace the components which are worn or replace the components which are damaged. Use the proper repair kit for the pump. Refer to the Disassembly and Assembly for more information on servicing the auxiliary water pump.

i02153996

Battery - Replace

SMCS Code: 1401-510

⚠ WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the key start switch to the OFF position. Remove the key and all electrical loads.
2. Turn OFF the battery charger. Disconnect the charger.
3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the ground plane. Disconnect the cable from the NEGATIVE “-” battery terminal.
4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

Note: Always recycle a battery. Never discard a battery. Return used batteries to an appropriate recycling facility.

5. Remove the used battery.
6. Install the new battery.

Note: Before the cables are connected, ensure that the key start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.
8. Connect the cable from the ground plane to the NEGATIVE “-” battery terminal.

i02340858

Battery Electrolyte Level - Check

SMCS Code: 1401-535

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are properly charged, ammeter reading should be very near zero, when the engine is in operation.

⚠ WARNING

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the “FULL” mark on the battery.

   If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

2. Check the condition of the electrolyte with the 245-5829 Coolant Battery Tester Refractometer.
3. Keep the batteries clean.

Clean the battery case with one of the following cleaning solutions:

- A mixture of 0.1 kg (0.2 lb) of baking soda and 1 L (1 qt) of clean water
- A mixture of 0.1 L (0.11 qt) of ammonia and 1 L (1 qt) of clean water

Thoroughly rinse the battery case with clean water.

Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit properly. Coat the clamps and the terminals with 5N-5561 Silicone Lubricant, petroleum jelly or MPGM.

i01492654

Battery or Battery Cable - Disconnect

SMCS Code: 1402-029

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
2. Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, the negative side of two batteries must be disconnected.
3. Tape the leads in order to help prevent accidental starting.
4. Proceed with necessary system repairs. Reverse the steps in order to reconnect all of the cables.

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Closed Crankcase Ventilation (CCV) Filter Service Indicator - Inspect

SMCS Code: 1317-040-FI

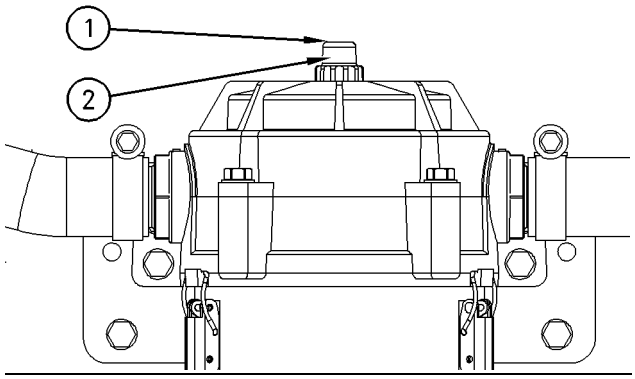

Illustration 22 g00744250

(1) Plastic cover
(2) Service indicator

The Closed Crankcase Ventilation system (CCV) is equipped with a service indicator. If the fumes disposal filter becomes plugged prior to the normal service interval, increased restriction of the filter will cause the crankcase pressure to become positive. When the pressure continues to rise, the service indicator will show through the plastic cover. The service indicator indicates the need for the fumes disposal filter to be changed. Refer to the Operation and Maintenance Manual, “Closed Crankcase Ventilation (CCV) Fumes Disposal Filter - Replace” topic for more information.

Note: Check the service indicator when the engine is running at low idle.

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Closed Crankcase Ventilation (CCV) Fumes Disposal Filter - Replace

SMCS Code: 1317-510-FI

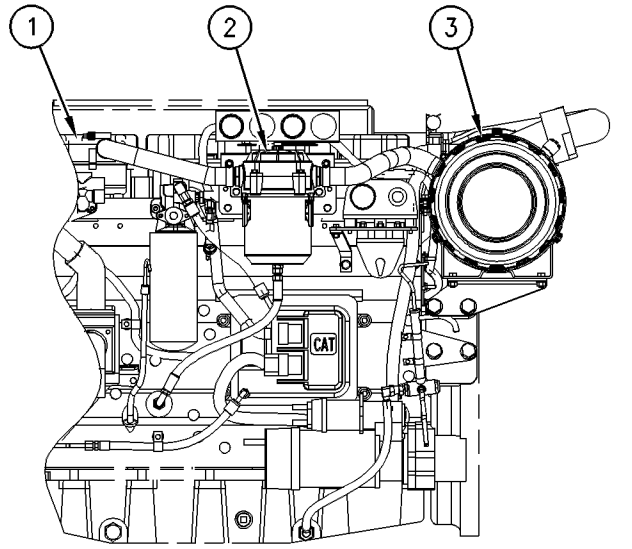


Illustration 23 g00585620

Typical example of the Closed Crankcase Ventilation system (CCV)

(1) Crankcase breather
(2) Fumes disposal filter base and fumes disposal filter
(3) Air cleaner

The Closed Crankcase Ventilation system (CCV) requires the replacement of the fumes disposal filter. The service interval of the CCV will be affected by the following items:

- Engine load
- Soot concentration
- Condition of the engine

The CCV is equipped with a service indicator. If the fumes disposal filter becomes plugged prior to the normal service interval, increased restriction of the filter will cause the vacuum to become positive. When the pressure continues to rise, the service indicator will show through the cap. The service indicator indicates the need for the fumes disposal filter to be changed. Reset the service indicator by using the following procedure:

Resetting the Service Indicator

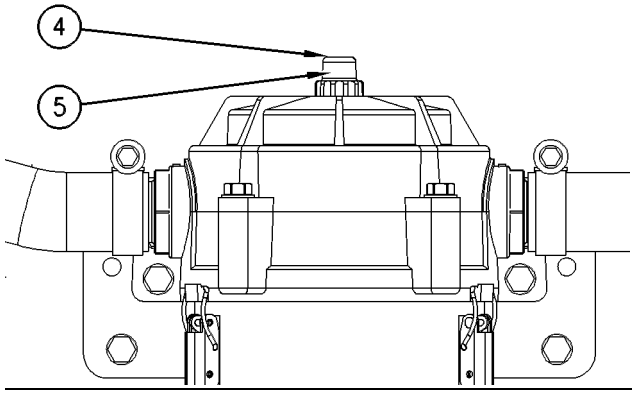


Illustration 24 g00585674

1. Remove the plastic cover (4).
2. Push down on the service indicator (5).
3. Replace the cover (4).
4. Replace the fumes disposal filter by using the following procedure:

Replacing the Fumes Disposal Filter

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Note: When possible, perform the maintenance while the engine is off.

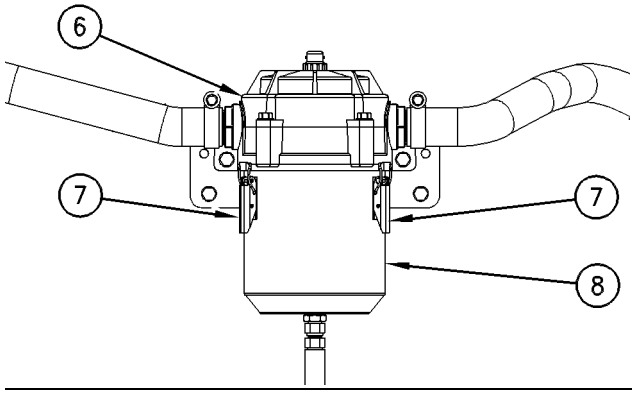


Illustration 25 g00585616

1. Release the latches (7) that hold the canister to the filter base assembly (6).

Note: The canister (8) may be difficult to remove while the engine is operating. The canister has negative air pressure while the engine is operating. This creates a vacuum.

2. Lower the canister (8) in order to expose the element. There may be oil in the bottom of the canister. Avoid spilling the oil.

3. Remove the filter element by pulling down. Dispose of the used element properly.

4. Remove the O-ring assembly on the top end cap of the used element.

5. Replace the O-ring seal on the bottom of the filter base assembly.

6. Install the new O-ring on the top end cap of the element. Install the element into the correct place.

7. Replace the canister (8) and align the canister with the boss on the filter base assembly (6).

8. Clamp the latches (7) in the closed position.

i02456328

Cooling System Coolant (DEAC) - Change

SMCS Code: 1350-070; 1395-044

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

NOTICE
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

Note: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

Drain

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

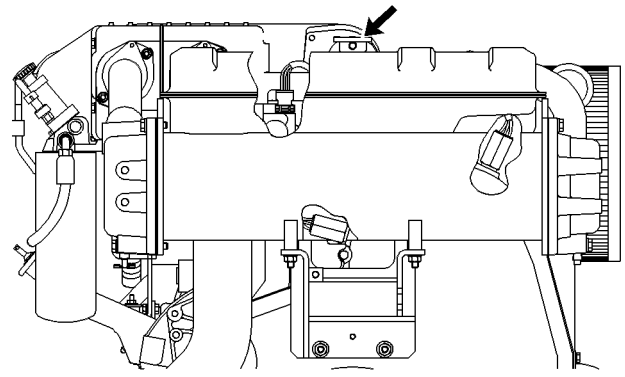


Illustration 26 g00104910

Cooling System Filler Cap

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

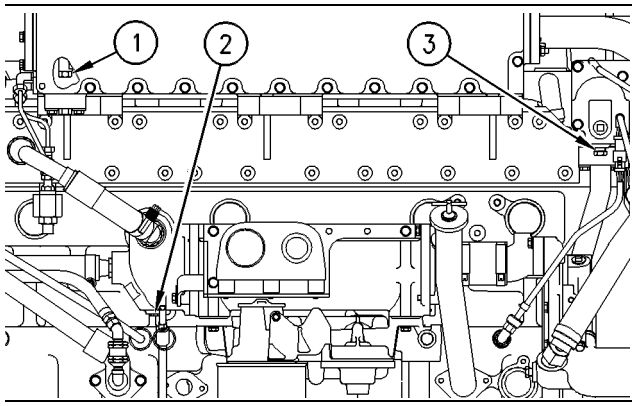


Illustration 27 g00104911

(1) Aftercooler drain plug. (2) Oil cooler drain plug. (3) Drain Plug for the water temperature regulator.

2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove the cooling system drain plugs.

   Remove the drain plug from the bottom of the water cooled exhaust manifold. Remove the drain plug for the water temperature regulator (3), aftercooler drain plug (1) and oil cooler drain plug (2). Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Service Technology Group:

Outside Illinois: 1-800-542-8665
Inside Illinois: 1-800-541-8665
Canada: 1-800-523-8665

Flush

1. Flush the cooling system with clean water in order to remove any debris.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications, SENR3130, “Torque Specifications” for more information on the proper torques.

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.

4. Start and run the engine at low idle for a minimum of 30 minutes with a coolant temperature of at least 82°C (180°F).

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to Specifications, SENR3130, “Torque Specifications” for more information on the proper torques.

Cooling Systems with Heavy Deposits or Plugging

Note: For the following procedure to be effective, there must be some active flow through the cooling system components.

1. Flush the cooling system with clean water in order to remove any debris.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to Specifications, SENR3130, “Torque Specifications” for more information on the proper torques.

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the cooling system filler cap.

4. Start and run the engine at low idle for a minimum of 90 minutes. The coolant temperature should be at least 82°C (180°F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to Specifications, SENR3130, “Torque Specifications” for more information on the proper torques.

Fill

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

Engines That Are Equipped with a Coolant Recovery Tank

1. Fill the system to the top with the mixture of coolant that is recommended. Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at 1500 rpm for one minute in order to purge the air from the cavities of the engine block. Stop the engine.

3. Check the coolant level. Maintain the coolant level within 13 mm (.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (.5 inch) to the proper level on the sight glass (if equipped).

4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket for the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket for the cooling system filler cap is not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

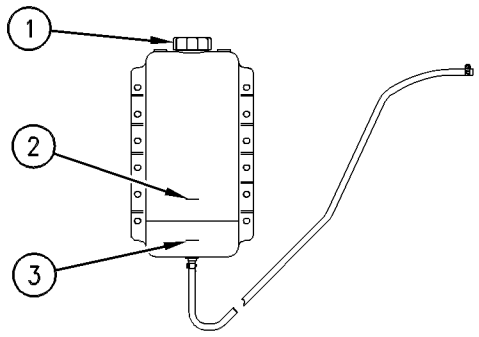


Illustration 28 g00103638

(1)Filler cap for the recovery tank. (2) “COLD FULL” mark. (3) “LOW ADD” mark.

5. Pour coolant into the recovery tank until the coolant reaches “COLD FULL” mark (2). Do not fill the recovery tank above “COLD FULL” mark (2).

6. Clean the filler cap for the recovery tank. Install the filler cap for the recovery tank. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

Engines That Are Not Equipped with a Coolant Recovery Tank

1. Fill the cooling system with coolant. Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at 1500 rpm for one minute in order to purge the air from the cavities of the engine block. Stop the engine.

3. Check the coolant level. Maintain the coolant level within 13 mm (.5 inch) below the bottom of the pipe for filling. Maintain the coolant level at the proper level on the sight glass (if equipped).

4. Clean the cooling system filler cap. Inspect the gasket for the cooling system filler cap. If the gasket for the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket for the cooling system filler cap is not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02456377

Cooling System Coolant (ELC) - Change

SMCS Code: 1350-070; 1395-044

WARNING

Personal injury can result from hot coolant, steam and alkali.

At operating temperature, engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Remove cooling system pressure cap slowly to relieve pressure only when engine is stopped and cooling system pressure cap is cool enough to touch with your bare hand.

Do not attempt to tighten hose connections when the coolant is hot, the hose can come off causing burns.

Cooling System Coolant Additive contains alkali. Avoid contact with skin and eyes.

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 Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

Use only clean water to flush the cooling system when Extended Life Coolant (ELC) is drained and replaced.

Drain

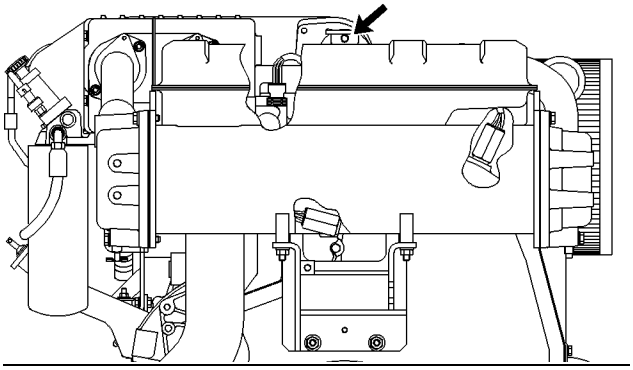


Illustration 29 g00105134

Filler Cap for the Cooling System

1. Stop the engine and allow the engine to cool. Loosen the filler cap for the cooling system slowly in order to relieve any pressure. Remove the filler cap for the cooling system.

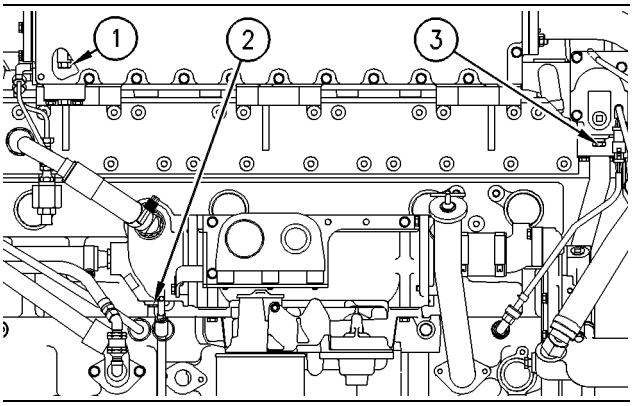


Illustration 30 g00105135

(1) Aftercooler drain plug. (2) Oil cooler drain plug. (3) Drain plug for the water temperature regulator.

2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove the cooling system drain plugs.

Remove the drain plug from the bottom of the water cooled exhaust manifold. Remove the drain plug for the water temperature regulator (3), aftercooler drain plug (1) and oil cooler drain plug (2). Allow the coolant to drain.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Service Technology Group:

Outside U.S.A.: (309) 675-6277
Inside U.S.A.: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL
CSTG COSA Geneva, Switzerland:
41-22-849 40 56

Clean the Cooling System

1. Flush the cooling system with clean water in order to remove any debris.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer toSpecifications, SENR3130, “Torque Specifications” for more information on the proper torques.

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with clean water. Install the cooling system filler cap. Operate the engine until the temperature reaches 49 °C (120 °F) to 66 °C (150 °F).

4. Start and run the engine at low idle until the temperature reaches 49 to 66°C (120 to 150°F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to Specifications, SENR3130, “Torque Specifications” for more information on the proper torques.

Fill the Cooling System

Engines That Are Equipped with a Coolant Recovery Tank

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

1. Fill the cooling system to the top with Cat ELC. Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for more information on coolant specifications. Do not install the filler cap for the recovery tank.

2. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at 1500 rpm for one minute in order to purge the air from the cavities of the engine block. Stop the engine.

3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.

4. Clean the cooling system filler cap. Inspect the filler cap gasket. If the filler cap gasket is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the filler cap gasket is not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

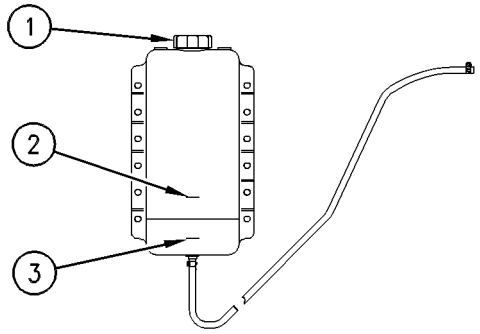


Illustration 31 g00103638

(1) Filler cap for the recovery tank. (2) “COLD FULL” mark. (3) “LOW ADD” mark.

5. Pour Cat ELC into the recovery tank until the coolant reaches “COLD FULL” mark (2). Do not fill the tank above “COLD FULL” mark (2).

6. Clean the filler cap. Install the filler cap. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

Engines That Are Not Equipped with a Coolant Recovery Tank

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

1. Fill the cooling system to the top with Cat ELC. Refer to this Operation and Maintenance Manual, “Refill Capacitties and Recommendations” for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at 1500 rpm for one minute in order to purge the air from the cavities of the engine block. Stop the engine.

3. Check the coolant level. Maintain the coolant level within 13 mm (.5 inch) below the bottom of the pipe for filling. Maintain the coolant level at the proper level on the sight glass (if equipped).

4. Clean the filler cap. Inspect the gasket for the filler cap for the cooling system. If the gasket is damaged, discard the old filler cap for the cooling system and install a new filler cap. If the gasket for the cooling system filler cap is not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

5. Start the engine. Inspect the cooling system for leaks. Inspect the cooling system for proper operating temperature.

i02482066

Cooling System Coolant Extender (ELC) - Add

SMCS Code: 1352-045; 1395-081

Cat ELC (Extended Life Coolant) does not require the frequent additions of any supplemental cooling additives which are associated with the present conventional coolants. The Cat ELC Extender only needs to be added once.

NOTICE
Use only Cat Extended Life Coolant (ELC) Extender with Cat ELC.

Do NOT use conventional supplemental coolant additive (SCA) with Cat ELC. Mixing Cat ELC with conventional coolants and/or conventional SCA reduces the Cat ELC service life.

Check the cooling system only when the engine is stopped and cool.

WARNING

Personal injury can result from hot coolant, steam and alkali.

At operating temperature, engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Remove cooling system pressure cap slowly to relieve pressure only when engine is stopped and cooling system pressure cap is cool enough to touch with your bare hand.

Do not attempt to tighten hose connections when the coolant is hot, the hose can come off causing burns.

Cooling System Coolant Additive contains alkali. Avoid contact with skin and eyes.

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 Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.

2. It may be necessary to drain enough coolant from the cooling system in order to add the Cat ELC Extender.

3. Add Cat ELC Extender according to the requirements for your engine’s cooling system capacity. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” article for more information.

4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

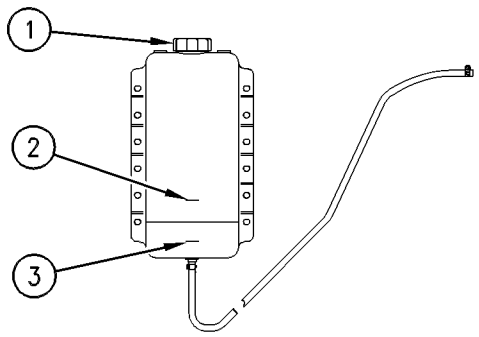
i02456586

Cooling System Coolant Level - Check

SMCS Code: 1395-082

Check the coolant level when the engine is stopped and cool.

Engines That Are Equipped with a Coolant Recovery Tank



g00103638

Illustration 32

(1) Filler cap
(2) “COLD FULL” mark
(3) “LOW ADD” mark

1. Observe the coolant level in the coolant recovery tank. Maintain the coolant level to “COLD FULL” mark (2) on the coolant recovery tank.

2. Loosen filler cap (1) slowly in order to relieve any pressure. Remove the filler cap.

3. Pour the proper coolant mixture into the tank. Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for information about coolants. Do not fill the coolant recovery tank above “COLD FULL” mark (2).

4. Clean filler cap (1) and the receptacle. Reinstall the filler cap and inspect the cooling system for leaks.

Note: The coolant will expand as the coolant heats up during normal engine operation. The additional volume will be forced into the coolant recovery tank during engine operation. When the engine is stopped and cool, the coolant will return to the engine.

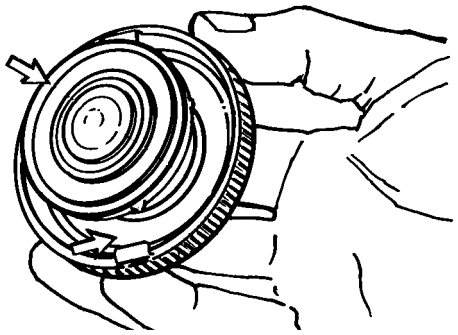
Engines That Are Not Equipped with a Coolant Recovery Tank

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly in order to relieve pressure.

2. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.



g00103639

Illustration 33

Typical filler cap gaskets

3. Clean the cooling system filler cap and inspect the condition of the filler cap gaskets. Replace the cooling system filler cap if the filler cap gaskets are damaged. Reinstall the cooling system filler cap.

4. Inspect the cooling system for leaks.

i02456600

Cooling System Supplemental Coolant Additive (SCA) - Test/Add

SMCS Code: 1352-045; 1395-081

⚠ WARNING

Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and the eyes. Do not drink cooling system coolant additive.

Note: Test the concentration of the Supplemental Coolant Additive (SCA) or test the SCA concentration as part of an S·O·S Coolant Analysis.

Test for SCA Concentration

Coolant and SCA

NOTICE
Do not exceed the recommended six percent supplemental coolant additive concentration.

Use the 8T-5296 Coolant Conditioner Test Kit or use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA. Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for more information.

Water and SCA

NOTICE
Do not exceed the recommended eight percent supplemental coolant additive concentration.

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit. Refer to the Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” for more information.

S·O·S Coolant Analysis

S·O·S coolant samples can be analyzed at your Caterpillar dealer. S·O·S Coolant Analysis is a program that is based on periodic samples.

Level 1

Level 1 is a basic analysis of the coolant. The following items are tested:

- Glycol Concentration
- Concentration of SCA
- pH
- Conductivity

The results are reported, and recommendations are made according to the results. Consult your Caterpillar dealer for information on the benefits of managing your equipment with an S·O·S Coolant Analysis.

Level 2

This level coolant analysis is recommended when the engine is overhauled. Refer to this Operations and Maintenance Manual, “Overhaul Considerations” for further information.

Add the SCA, If Necessary

NOTICE
Do not exceed the recommended amount of supplemental coolant additive concentration. Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine’s heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive supplemental coolant additive concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear. Never use both liquid supplemental coolant additive and the spin-on element (if equipped) at the same time. The use of those additives together could result in supplemental coolant additive concentration exceeding the recommended maximum.

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Slowly loosen the cooling system filler cap in order to relieve the pressure. Remove the cooling system filler cap.

Note: Always discard drained fluids according to local regulations.

2. If necessary, drain some coolant from the cooling system into a suitable container in order to allow space for the extra SCA.

3. Add the proper amount of SCA. Refer to the Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engines Fluids Recommendations” for more information on SCA requirements.

4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.

i00912898

Cooling System Water Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulator before the water temperature regulator fails. This is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or piston seizure problems.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner.

NOTICE

Failure to replace your water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

Do not use liquid gasket material on the gasket or cylinder head surface.

Refer to the Service Manual for the replacement procedure of the water temperature regulator, or consult your Caterpillar dealer.

Note: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

i00072369

Crankshaft Vibration Damper - Inspect

SMCS Code: 1205-040

Damage to the crankshaft vibration damper or failure of the crankshaft vibration damper can increase torsional vibrations. This can result in damage to the crankshaft and to other engine components. A deteriorating damper can cause excessive gear train noise at variable points in the speed range.

The damper is mounted to the crankshaft which is located behind the belt guard on the front of the engine.

Removal and Installation

Refer to the Service Manual for the damper removal procedure and for the damper installation procedure.

Visconic Damper

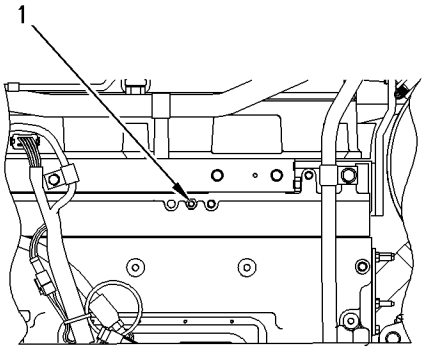
The visconic damper has a weight that is located inside a fluid filled case. The weight moves in the case in order to limit torsional vibration. Inspect the damper for evidence of dents, cracks or leaks of the fluid.

Replace the damper if the damper is dented, cracked or leaking. Refer to the Service Manual or consult your Caterpillar dealer for damper replacement.

i01684727

Cylinder Head Grounding Stud - Inspect/Clean/Tighten

SMCS Code: 7423-040; 7423-070; 7423-079



g00738038

Illustration 34

Typical example for location of cylinder head grounding stud

(1) Cylinder head grounding stud

Inspect the wiring harness for good connections.

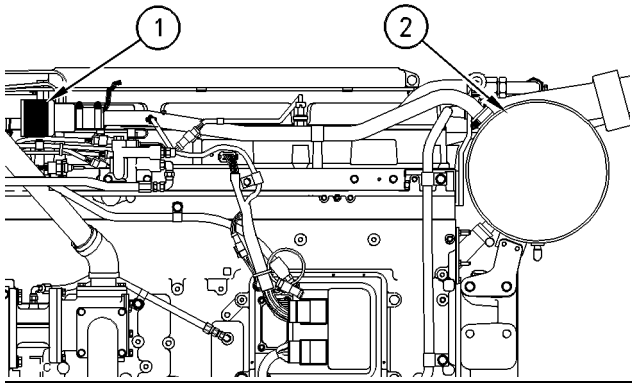
The cylinder head grounding stud must have a wire ground to the battery. Tighten the cylinder head grounding stud at every oil change. Ground wires and straps should be combined at engine grounds. All grounds should be tight and free of corrosion.

- Clean the cylinder head grounding stud and the terminals with a clean cloth.
- If the connections are corroded, clean the connections with a solution of baking soda and water.
- Keep the cylinder head grounding stud and the strap clean and coated with MPGM grease or petroleum jelly.

i01708992

Engine Air Cleaner Element - Clean/Replace

SMCS Code: 1054-070; 1054-510



g00105025

Illustration 35

(1) Vacuum regulator filter element
(2) Air cleaner element

Note: The air cleaner element should be replaced after three cleanings.

Note: Use the 102-9720 Cleaning Kit. This product contains the detergent and oil that is made specifically for the maintenance of the air cleaner elements.

1. Remove the vacuum regulator filter element (1) and the air cleaner element (2).

Note: The same procedure is used for cleaning both the air filter element and the vacuum regulator filter element.

2. Tap the element in order to dislodge dirt particles. Gently brush the element with a soft bristle brush.

Note: The element may be oiled and the element may be reinstalled , if complete cleaning is not practical at this time. Refer to step 6.

NOTICE

Do not use gasoline, steam, caustic or unapproved detergents, or parts cleaning solvents. Do not use high pressure water or air to clean the air cleaner element. Any of those liquids or methods can cause air cleaner element damage.

3. Spray the element with the cleaning solution. Allow the element to stand for 10 minutes.

4. Rinse the element with low water pressure. The maximum water pressure for this procedure is 275 kPa (40 psi). Tap water is acceptable. Start to rinse the element from the clean side (inside). Next, clean the dirty side (outside) in order to flush out dirt. Inspect the element for tears and/or holes after the element is cleaned. Do not reuse damaged elements.

NOTICE
Do not use compressed air, open flame, or hot air to dry the air cleaner element. Excess heat shrinks cotton fiber, and compressed air may blow holes in the material. Allow the air cleaner element to air dry.

5. Shake excess water off the element and allow the element to air dry. Drying the element in the sun speeds the process.

NOTICE
Do not use transmission fluid, engine oil, diesel fuel, or other lubricant to oil the air cleaner element. The air cleaner element can not function correctly if improper oil is used. Never operate an engine with a dry air cleaner element. The air cleaner element can not function correctly without oil. Always saturate the clean air cleaner element with the recommended oil.

6. The dry element should be oiled before installation. Apply small amounts of oil across the top of each pleat. Allow the oil to wick into the element for 20 minutes. Oil any remaining “white” spots.

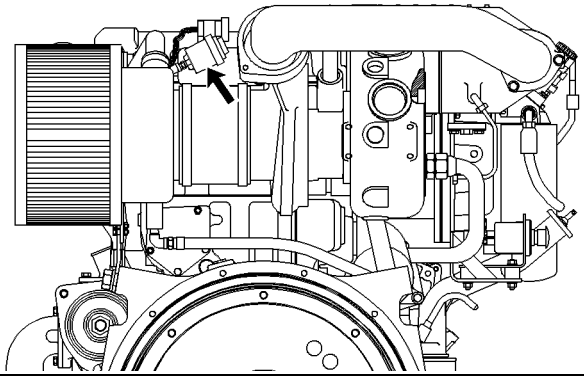
7. Inspect the housing and the clamp for air cleaner element (2). Replace the housing and the clamp, if necessary. Install the clean, oiled air cleaner element. Refer to the Torque Specifications, SENR3130 for more information on the proper torques.

8. Install the vacuum regulator filter element (1) on the vacuum regulator filter.

i00072989

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040



g00105037

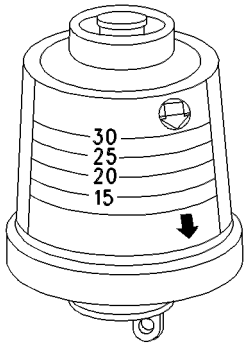
Illustration 36

Service Indicator

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The gauge reads the difference between inlet air pressure before the air cleaner element and after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the recommendations for the vessel or follow the recommendations in the air cleaner OEM in order to service the air cleaner element.

A service indicator may be mounted on the air cleaner element or in a remote location.



g00103777

Illustration 37

Typical Service Indicator

Observe the service indicator. The air cleaner element should be cleaned or replaced when the yellow diaphragm enters the red zone or the red piston locks in the visible position. If the service indicator appears red at any time, clean the air cleaner element or install a new air cleaner element.

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated rpm. The yellow core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be plugged.

The service indicator may need to be replaced frequently in environments that are severely dusty (if applicable). Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

Note: When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N·m (18 lb in).

Service the Air Cleaner Element

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent air-borne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

If the air cleaner element becomes plugged, the air can split the filter material. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has air filter elements in order to service this unit. Consult your Caterpillar dealer for the correct air cleaner element.

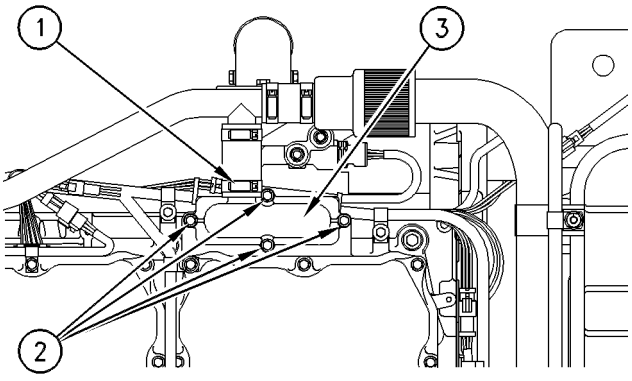
If the service indicator appears red at any time, clean the air cleaner element or install a new air cleaner element. Clean the air cleaner element or replace the air cleaner element at 250 hour intervals.

Refer to the Operation and Maintenance Manual for more information on servicing the air cleaner element.

i01102895

Engine Crankcase Breather - Clean

SMCS Code: 1317-070



g00580871

Illustration 38

Typical example

(1) Hose clamp
(2) Four bolts
(3) Breather cover

NOTICE
Perform this maintenance with the engine stopped.

If the crankcase breather is not maintained on a regular basis, the crankcase breather will become plugged. A plugged crankcase breather will cause excessive crankcase pressure that may cause crankshaft seal leakage.

1. Loosen hose clamp (1) and remove the hose from breather cover (3).
2. Loosen four bolts (2) for the breather cover and remove breather cover (3).
3. Remove the breather element and wash the breather element in solvent that is clean and nonflammable. Allow the breather element to dry.
4. Install a breather element that is clean and dry. Install breather cover (3) and install bolts (2). Refer to the Operation and Maintenance Manual for the proper torques.

5. Install the hose. Install hose clamp (1). Refer to the Operation and Maintenance Manual for the proper torques.

i02456872

Engine Mounts - Inspect

SMCS Code: 1152-040

Inspect the engine mounts for deterioration and for proper bolt torque. Engine vibration can be caused by the following conditions:

- Improper mounting of the engine
- Deterioration of the engine mounts

Any engine mount that shows deterioration should be replaced. Refer to Special Publication, SENR3130, “Torque Specifications” for the recommended torques. Refer to the OEM recommendations for more information.

i00573217

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

Check the oil level after the engine has stopped.

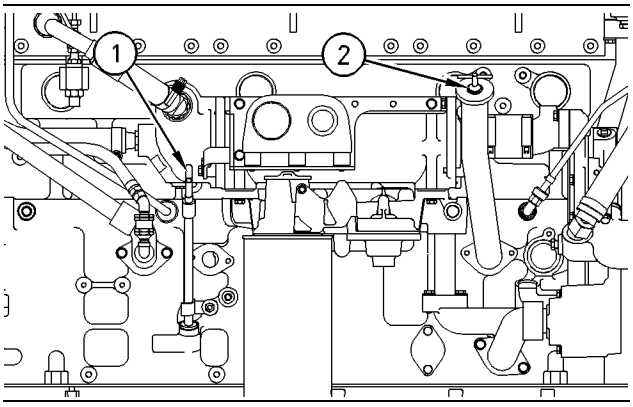


Illustration 39 g00105043

(1) Oil level gauge. (2) Oil filler cap.

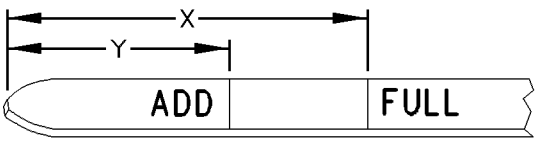


Illustration 40 g00110310

(Y) “ADD” mark. (X) “FULL” mark.

1. Maintain the oil level between “ADD” mark (Y) and “FULL” mark (X) on oil level gauge (1). Do not fill the crankcase above “FULL” mark (X).

NOTICE
Operating your engine when the oil level is above the “FULL” mark could cause your crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduces the oil’s lubricating characteristics and could result in the loss of power.

2. Remove oil filler cap (2) and add oil, if necessary. Clean the oil filler cap. Reinstall the oil filler cap.

i01708884

Engine Oil Level Gauge - Calibrate

SMCS Code: 1326-524

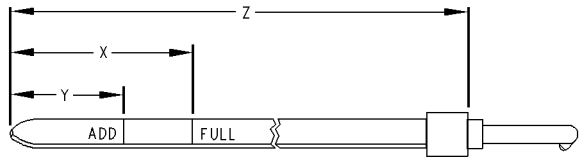


Illustration 41 g00882677

(Y) “ADD” mark. (X) “FULL” mark. (Z) “Effective Length”.

(Z-LH Service Engines) 642 mm (25.3 inch)
(Z-RH Service Engines) 479 mm (18.9 inch)

The engine is shipped with an engine oil level gauge that is not marked. The engine oil level gauge is not marked because the angle of the installation and the side for servicing the engine oil can be different for each engine. The angle of the installation and the side for servicing the engine oil will affect “ADD” mark (Y) and “FULL” mark (X) that is engraved on the engine oil level gauge.

The engine oil level gauge should be calibrated after the engine is installed in the vessel. Use the following procedure in order to verify that “ADD” mark (Y) is correct. Use the following procedure in order to establish actual “FULL” mark (X) on the engine oil level gauge. Refer to table 18 and table 19 in order to determine the location for the “ADD” and “FULL” marks for a particular installation.

NOTICE
Refer to the Operation and Maintenance Manual for more information on lubricant specifications.

1. Operate the engine until normal operating temperature is achieved. Stop the engine. Remove one of the drain plugs for the engine crankcase. Allow the engine oil to drain.

2. Remove the used engine oil filter. Install the new engine oil filter. Install the drain plug for the engine crankcase. Tighten the drain plug for the engine crankcase to 70 ± 14 N·m (50 ± 10 lb ft).

Note: The engine may be equipped with auxiliary engine oil filters. Volumes that are different from the standard amounts may be required. Refer to the OEM specifications.

3. Pour 20.8 L (22 qt) of engine oil into the engine crankcase. Allow enough time for the engine oil to drain into the engine crankcase. Approximately 20 minutes should be allowed. Check the engine oil level. Wait for a few minutes. Check the engine oil level again. Proceed after the engine oil level stops changing.

4. Mark the engine oil level on the engine oil level gauge. Use a marking pen in order to engrave “ADD” mark (Y).

5. Pour 3.8 L (4 qt) of engine oil into the engine crankcase. Allow enough time for the engine oil to drain into the engine crankcase.

6. Mark the engine oil level on the engine oil level gauge. Use a marking pen in order to engrave “FULL” mark (X).

7. Start the engine. Ensure that the lubrication system is filled. Inspect the lubrication system for leaks.

8. Stop the engine and allow enough time for the engine oil to drain into the engine crankcase.

9. Check the engine oil level on the engine oil level gauge. If the engine oil level is not at calibrated “FULL” mark (X), fill the sump to the calibrated “FULL” mark. Record the amount of oil that is added. This additional engine oil is the system capacity plus the engine oil in the sump. This additional engine oil is the amount of engine oil that is required when the engine oil is changed. Record the engine oil capacity for the system for future changes of the engine oil.

3176C and 3196 Marine Engine Dipstick Markings

Note: Use the following tables if these conditions exist:

- The engine is installed with a 0 degree slant angle.
- No auxiliary engine oil filters are used on the engine.

Table 18

3176C and 3196 Marine Engine Oil Gauge Markings (mm) LH Service [1]		
Tilt Angle[2]	**LH Service “ADD” Mark Y**	**LH Service “FULL” Mark X**
-15°	120 mm (4.7 inch)	133 mm (5.2 inch)
-13°	113 mm (4.4 inch)	125 mm (4.9 inch)
-11°	110 mm (4.3 inch)	124 mm (4.9 inch)
-9°	106 mm (4.2 inch)	118 mm (4.6 inch)
-7°	100 mm (3.9 inch)	110 mm (4.3 inch)
-5°	93 mm (3.7 inch)	106 mm (4.2 inch)
-3°	87 mm (3.4 inch)	99 mm (3.9 inch)
-1°	82 mm (3.2 inch)	93 mm (3.7 inch)
0°	79 mm (3.1 inch)	89 mm (3.5 inch)
1°	73 mm (2.9 inch)	85 mm (3.3 inch)
3°	68 mm (2.7 inch)	81 mm (3.2 inch)
5°	63 mm (2.5 inch)	74 mm (2.9 inch)
7°	54 mm (2.1 inch)	67 mm (2.6 inch)
9°	47 mm (1.9 inch)	61 mm (2.4 inch)
11°	38 mm (1.5 inch)	52 mm (2.0 inch)
13°	30 mm (1.2 inch)	43 mm (1.7 inch)
15°	19 mm (0.7 inch)	36 mm (1.4 inch)

[1] (Z-LH Service Engines) 642 mm (25.3 inch).

[2] The tilt angles in this chart are the engine installation angles for the vessel. A positive angle indicates that the front of the engine is raised.

Table 19

3176C and 3196 Marine Engine Oil Gauge Markings (mm) RH Service (1)		
Tilt Angle(2)	**RH Service "ADD" Mark Y**	**RH Service "FULL" Mark X**
-15°	25 mm (1.0 inch)	44 mm (1.7 inch)
-13°	37 mm (1.5 inch)	55 mm (2.2 inch)
-11°	48 mm (1.9 inch)	65 mm (2.6 inch)
-9°	57 mm (2.2 inch)	73 mm (2.9 inch)
-7°	65 mm (2.6 inch)	81 mm (3.2 inch)
-5°	72 mm (2.8 inch)	88 mm (3.5 inch)
-3°	79 mm (3.1 inch)	96 mm (3.8 inch)
-1°	86 mm (3.4 inch)	102 mm (4.0 inch)
0°	89 mm (3.5 inch)	106 mm (4.2 inch)
1°	94 mm (3.7 inch)	110 mm (4.3 inch)
3°	101 mm (4.0 inch)	116 mm (4.6 inch)
5°	107 mm (4.2 inch)	122 mm (4.8 inch)
7°	115 mm (4.5 inch)	125 mm (4.9 inch)
9°	121 mm (4.8 inch)	136 mm (5.4 inch)
11°	127 mm (5.0 inch)	140 mm (5.5 inch)
13°	134 mm (5.3 inch)	145 mm (5.7 inch)
15°	135 mm (5.3 inch)	150 mm (5.9 inch)

(1) (Z-RH Service Engines) 479 mm (18.9 inch).
(2) The tilt angles in this chart are the engine installation angles for the vessel. A positive angle indicates that the front of the engine is raised.

i01935337

Engine Oil Sample - Obtain

SMCS Code: 1000-008; 1348-554-SM; 7542-554-OC, SM

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals in order to monitor the condition of the engine and the maintenance requirements of the engine. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

Obtain the Sample and the Analysis

WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Before you take the oil sample, complete the Label, PEEP5031 for identification of the sample. In order to help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEHP6001, “How To Take A Good Oil Sample”. Consult your Caterpillar dealer for complete information and assistance in establishing an S·O·S program for your engine.

i01536470

Engine Oil and Filter - Change

SMCS Code: 1318-510; 1348-044

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped. Drain the crankcase with the oil warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Oil

After the engine has been run at the normal operating temperature, stop the engine. Use one of the following methods to drain the engine crankcase oil:

- If the engine is equipped with a drain valve, turn the drain valve knob counterclockwise in order to drain the oil. After the oil has drained, turn the drain valve knob clockwise in order to close the drain valve.
- If the engine is not equipped with a drain valve, remove the oil drain plug in order to allow the oil to drain. If the engine is equipped with a shallow sump, remove the bottom oil drain plugs from both ends of the oil pan.

After the oil has drained, the oil drain plugs should be cleaned and installed. Tighten the oil drain plugs to 70 ± 14 N·m (50 ± 10 lb ft).

Replace the Oil Filter

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.

1. Remove the oil filter with a 1U-8760 Chain Wrench.
2. Cut the oil filter open with a 175-7546 Oil Filter Cutter. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

   Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of the engine.

   Nonferrous metals may indicate wear on the aluminum parts, brass parts or bronze parts of the engine. Parts that may be affected include the following items: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

   Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter. Consult your Caterpillar dealer in order to arrange for a further analysis if an excessive amount of debris is found in the oil filter.

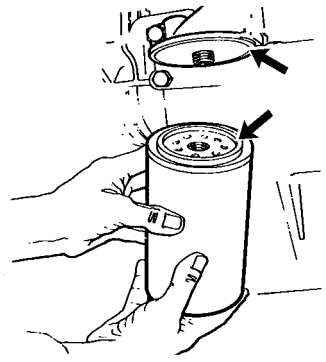


Illustration 42 g00103713
Typical filter mounting base and filter gasket

3. Clean the sealing surface of the filter mounting base. Ensure that all of the old oil filter gasket is removed.
4. Apply clean engine oil to the new oil filter gasket.

NOTICE
Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

5. Install the oil filter. Tighten the oil filter until the oil filter gasket contacts the base. Tighten the oil filter by hand according to the instructions that are shown on the oil filter. Do not overtighten the oil filter.

Fill the Engine Crankcase

1. Remove the oil filler cap. Refer to the Operation and Maintenance Manual for more information on lubricant specifications. Fill the crankcase with the proper amount of oil. Refer to the Operation and Maintenance Manual for more information on refill capacities.

NOTICE
If equipped with an auxiliary oil filter or system, extra oil must be added when filling the crankcase. Follow the OEM or filter manufacturer's recommendations. If the extra oil is not added, the engine may starve for oil.

NOTICE
To help prevent crankshaft or bearing damage, crank engine to fill all filters before starting. Do not crank engine for more than 30 seconds.

2. Start the engine and run the engine at "LOW IDLE" for two minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filter for oil leaks.

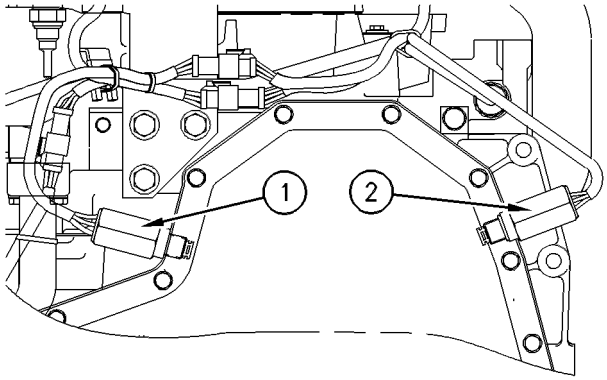
3. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.

4. Remove the oil level gauge in order to check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the oil level gauge.

i00096280

Engine Speed/Timing Sensors - Check/Clean/Calibrate

SMCS Code: 1912-040; 1912-070; 1912-524



g00105127

Illustration 43

Primary Speed/Timing Sensor (1) and Backup Speed/Timing Sensor (2)

1. Remove the speed/timing sensors from the front housing. Check the condition of the plastic end of the speed/timing sensors for wear and/or contaminants.

2. Clean the metal shavings and other debris from the face of the speed/timing sensors. Use the procedure in the Service Manual in order to calibrate the speed/timing sensors.

Refer to the Service Manual for more information on the speed/timing sensors.

i01430860

Engine Storage Procedure - Check

SMCS Code: 1000-535

Caterpillar requires all engines that are stored for more than 3 months to follow storage procedures and start-up procedures. These procedures provide maximum protection to internal engine components. Refer to Special Instruction, SEHS9031, "Storage Procedure For Caterpillar Products" for information on these procedures.

An extension of the oil change interval to 12 months is permitted if you follow the required procedures for storage and start-up. This extension is permitted if the following intervals in the Operation and Maintenance Manual, "Maintenance Interval Schedule" have not been reached:

- Operating hours
- Fuel consumption

i00869413

Engine Valve Lash - Inspect/Adjust

SMCS Code: 1102-025

The initial valve lash adjustment on new engines, rebuilt engines, or remanufactured engines is recommended at the first scheduled oil change. The initial adjustment is necessary due to initial wear of the valve train components and seating of the valve train components.

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule in order to help provide maximum engine life.

Adjustment of the Electronic Unit Injector

Adjust the electronic unit injector (preload) at the same interval as the valve lash adjustment. The operation of Caterpillar engines with improper valve adjustments and with improper adjustments of the electronic unit injector can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

NOTICE
Only qualified service personnel should perform this maintenance. Refer to the Service Manual or your Caterpillar dealer for the complete valve lash adjustment procedure.

Operation of Caterpillar engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

⚠ WARNING

Ensure that the engine can not be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

i01597115

Engine Valve Rotators - Inspect

SMCS Code: 1109-040

⚠ WARNING

When inspecting the valve rotators, protective glasses or face shield and protective clothing must be worn, to help prevent being burned by hot oil or spray.

Engine valve rotators rotate the valves when the engine runs. This helps to prevent deposits from building up on the valves and the valve seats.

Perform the following steps after the engine valve lash is set, but before the valve covers are installed:

1. Start the engine according to Operation and Maintenance Manual, “Engine Starting” (Operation Section) for the procedure.
2. Operate the engine at low idle.
3. Observe the top surface of each valve rotator. The valve rotators should turn slightly when the valves close.

NOTICE
A valve rotator which does not operate properly will accelerate valve face wear and valve seat wear and shorten valve life. If a damaged rotator is not replaced, valve face guttering could result and cause pieces of the valve to fall into the cylinder. This can cause piston and cylinder head damage.

If a valve fails to rotate, consult your Caterpillar dealer.

i00103413

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.

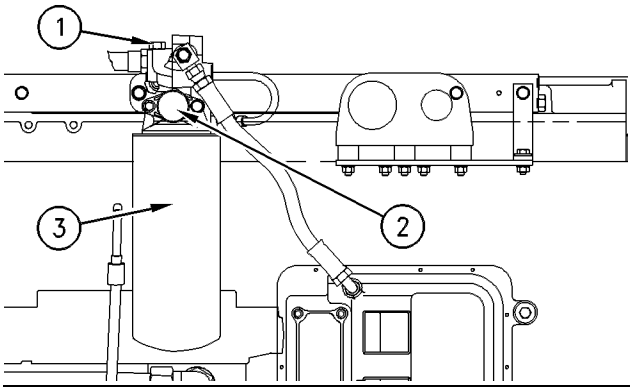


Illustration 44 g00105140

Plug (1), Fuel Priming Pump (2), and Fuel Filter (3)

Priming the fuel system fills the fuel filters. Priming the fuel system also removes air from the fuel system. This procedure is used primarily when the engine runs out of fuel.

Note: DO NOT remove plug (1) in the fuel filter base in order to release air from the fuel system during periodic service of the fuel filter. Periodic removal of the plug will result in increased wear of the threads in the fuel filter base. This can lead to fuel leakage. However, the plug in the fuel filter base can be used to bleed air from the fuel system if the engine runs out of fuel.

1. Open fuel priming pump (2) and operate the fuel priming pump until a strong pressure is felt on the fuel priming pump and until the check valve “clicks”. This procedure will require considerable strokes. Lock the fuel priming pump.

2. Crank the engine after pressurizing the system.

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.

3. If the engine does not start, open fuel priming pump (2) and repeat Steps 1 and 2 in order to start the engine.

i01341997

Fuel System Primary Filter/Water Separator - Drain

SMCS Code: 1260-543; 1263-543

⚠ 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.

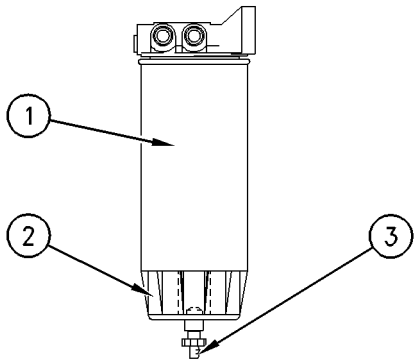


Illustration 45 g00709596

(1) Element
(2) Bowl
(3) Drain

Bowl (2) should be monitored daily for signs of water. If water is present, drain the water from the bowl.

1. Open drain (3). The drain is a self-ventilated drain. Catch the draining water in a suitable container. Dispose of the water properly.

2. Close drain (3).

NOTICE
The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

i02053433

Fuel System Primary Filter (Water Separator) Element - Replace

SMCS Code: 1260-510-FQ; 1263-510-FQ

Water in the fuel can cause the engine to run rough. Water in the fuel may cause a electronic unit injector to fail. If the fuel has been contaminated with water, the element should be changed before the regularly scheduled interval.

The primary filter/water separator also provides filtration in order to help extend the life of the secondary fuel filter. The element should be changed regularly. If a vacuum gauge is installed, the primary filter/water separator should be changed at 50 to 70 kPa (15 to 20 inches Hg).

Replace the Element

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

1. Close the main fuel supply valve.

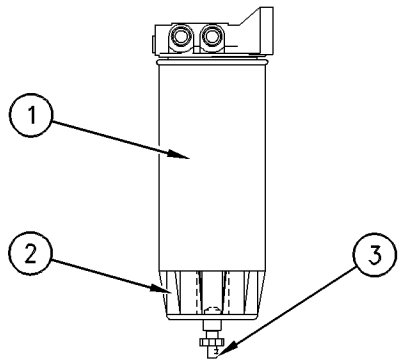


Illustration 46 g00104012

Element (1), Bowl (2), and Drain (3)

2. Remove element (1) from the element mounting base while bowl (2) is attached.
3. Dispose of the contents of the filter. Remove bowl (2) from element (1). The bowl is reusable. Do not discard the bowl. Dispose of the used element.
4. Remove the O-ring from the gland of the bowl. Clean the following components:
   - Bowl
   - O-ring
   - Mounting base

   Inspect the O-ring for damage and for deterioration. Replace the O-ring, if necessary.
5. Lubricate the O-ring with clean diesel fuel.
6. Install bowl (2) on a new element. Tighten the bowl by hand. Do not use tools in order to tighten the bowl.

NOTICE

The primary filter/water separator may be prefilled with fuel to avoid rough running/stalling of the engine due to air. Do not fill the secondary filter with fuel before installation. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

7. Lubricate the top seal of element (1) with clean diesel fuel. The element may be filled with fuel at this time. Install the new element on the mounting base. Tighten the element by hand.

NOTICE

The water separator is under suction during normal engine operation. Ensure that the vent plug is tightened securely to help prevent air from entering the fuel system.

8. Open the main fuel supply valve.
9. Start the engine and check for leaks. Run the engine for one minute. Stop the engine and check for leaks again.

   Detecting leaks is difficult while the engine is running. The primary filter/water separator is under suction. A leak will allow air to enter the fuel. The air in the fuel can cause low power due to aeration of the fuel. If air enters the fuel, check the components for overtightening or undertightening.

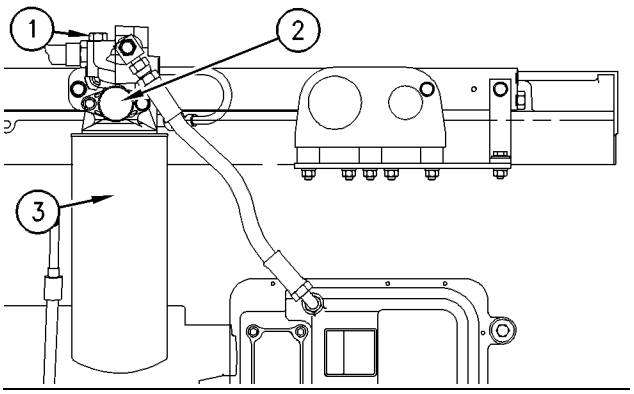
i00581566

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

⚠ 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.



g00103835

Illustration 47

(1) Plug. (2) Fuel priming pump. (3) Fuel Filter.

1. Stop the engine.
2. Turn off the start switch or disconnect the battery (starting motor) when maintenance is performed on fuel filters.
3. Shut off the fuel tank supply valve to the engine.

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

4. Unlock fuel priming pump (2) in order to relieve residual pressure in the fuel system.
5. Remove used fuel filter (3). Use a cloth or use a container in order to catch excess fuel.
6. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.
7. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE
Do not fill the secondary fuel filter with fuel before installing. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

8. Install new fuel filter (3). Tighten the fuel filter until the gasket contacts the base. Tighten the fuel filter by hand according to the instructions that are shown on the fuel filter. Do not overtighten the fuel filter.

Note: DO NOT remove plug (1) in the fuel filter base in order to release air from the fuel system during periodic service of the fuel filter. Periodic removal of the plug will result in increased wear of the threads in the fuel filter base.

9. Operate fuel priming pump (2) until a strong pressure is felt on the fuel priming pump and until the check valve “clicks”. This procedure will require considerable strokes. Lock the fuel priming pump.
10. Open the fuel tank supply valve.
11. Start the engine according to the normal operating procedures. Immediately increase the engine rpm between 1000 to 1200 rpm with no load. The engine will begin to misfire briefly until air from the fuel filter is purged. No damage to the engine will occur.

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.

12. If the engine stalls during the purging of the air, refer to the Operation and Maintenance Manual, “Fuel System - Prime” in the Maintenance Section for more information.

i02436696

Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

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 Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine or drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow five to ten minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank during the following conditions:

- Weekly
- Oil change
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A 2 micron filter for the breather vent on the fuel tank is also recommended. Refer to Special Publication, SENR9620, “Improving Fuel System Durablity”.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i01065537

Heat Exchanger - Inspect

SMCS Code: 1379-040

The interval for the maintenance of the plate type heat exchanger depends on the operating environment of the vessel and on the operating time. The raw/sea water that is circulated through the heat exchanger and the amount of operating time of the vessel affects the following items:

- Cleanliness of the heat exchanger plates
- Effectiveness of the heat exchanger system

Operating the engine in water that contains silt, sediment, salt, algae, or other significant contaminants will have an adverse effect on the heat exchanger system. In addition, intermittent use of the vessel will adversely affect the heat exchanger system.

The following items indicate that the heat exchanger may require cleaning:

- Increased coolant temperature

- Engine overheating
- Excessive pressure drop between the water inlet and the water outlet

An operator that is familiar with the normal operating temperature of the coolant can determine when the coolant temperature is out of the normal range. Inspection and maintenance of the heat exchanger is required if the engine is overheating.

For information on maintenance of the heat exchanger and cleaning of the heat exchanger, refer to Disassembly and Assembly, “Heat Exchanger - Disassemble”.

Your Caterpillar dealer has the equipment and the personnel in order to measure the pressure drop across the heat exchanger.

Consult your Caterpillar dealer or refer to the Service Manual for service information for the heat exchanger.

i02121526

Hoses and Clamps - Inspect/Replace

SMCS Code: 7554-040; 7554-510

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking
- Softness
- Loose clamps

Replace hoses that are cracked or soft. Tighten any loose clamps.

NOTICE
Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will heat set. Heat setting causes hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Replace the Hoses and the Clamps

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine. Allow the engine to cool.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

Note: Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.
4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.
7. Install the hose clamps with a torque wrench.

Note: Refer to the Specifications, SENR3130, “Torque Specifications” in order to locate the proper torques.

8. Refill the cooling system.

9. Clean the cooling system filler cap. Inspect the cooling system filler cap's gaskets. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

10. Start the engine. Inspect the cooling system for leaks.

i01089872

Marine Transmission Oil Level - Check

SMCS Code: 3081-535

Check the marine transmission oil level according to the instructions that are provided by the OEM of the transmission or the OEM of the vessel.

For the lubrication requirements of the transmission, refer to the recommendations on the nameplate or the "Owner's Manual" for the transmission.

Marine Transmission Operation, Maintenance, Warranty, and Parts Support

For information on maintenance and operation of the marine transmission, consult your Caterpillar dealer and/or the OEM dealer of the transmission.

All support for the warranty of the transmission will be the responsibility of the OEM. All parts support for the transmission will be the responsibility of the OEM. This parts support includes both the installation of parts and the resolution of any service problems.

i02378613

Overhaul Considerations

SMCS Code: 7595-043

Reduced hours of operation at full load will result in a lower average power demand. A decreased average power demand should increase both the engine service life and the overhaul interval.

The need for an overhaul is generally indicated by increased fuel consumption and by reduced power.

The following factors are important when a decision is being made on the proper time for an engine overhaul:

- The need for preventive maintenance
- The quality of the fuel that is being used
- The operating conditions
- The results of the S·O·S analysis

Oil Consumption as an Overhaul Indicator

Oil consumption, fuel consumption, and maintenance information can be used to estimate the total operating cost for your Caterpillar engine. Oil consumption can also be used to estimate the required capacity of a makeup oil tank that is suitable for the maintenance intervals.

Oil consumption is in proportion to the percentage of the rated engine load. As the percentage of the engine load is increased, the amount of oil that is consumed per hour also increases.

The oil consumption rate (brake specific oil consumption) is measured in grams per kW/h (lb per bhp). The brake specific oil consumption (BSOC) depends on the engine load. Consult your Caterpillar dealer for assistance in determining the typical oil consumption rate for your engine.

When an engine's oil consumption has risen to three times the original oil consumption rate due to normal wear, an engine overhaul should be scheduled. There may be a corresponding increase in blowby and a slight increase in fuel consumption.

Overhaul Options

Before Failure Overhaul

A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the standards for reusable parts.
- The engine's service life can be extended without the risk of a major catastrophe due to engine failure.
- The best cost/value relationship per hour of extended life can be attained.

After Failure Overhaul

If a major engine failure occurs and the engine must be removed from the hull, many options are available. An overhaul should be performed if the engine block or the crankshaft needs to be repaired.

If the engine block is repairable and/or the crankshaft is repairable, the overhaul cost should be between 40 percent and 50 percent of the cost of a new engine with a similar exchange core.

This lower cost can be attributed to three aspects:

- Specially designed Caterpillar engine features
- Caterpillar dealer exchange components
- Caterpillar Inc. remanufactured exchange components

Overhaul Recommendation

To minimize downtime, Caterpillar Inc. recommends a scheduled engine overhaul by your Caterpillar dealer before the engine fails. This will provide you with the best cost/value relationship.

Note: Overhaul programs vary according to the engine application and according to the dealer that performs the overhaul. Consult your Caterpillar dealer for specific information about the available overhaul programs and about overhaul services for extending the engine life.

If an overhaul is performed without overhaul service from your Caterpillar dealer, be aware of the following maintenance recommendations.

Rebuild or Exchange

Cylinder Head Assembly, Cylinder Packs, Oil Pump, and Fuel Transfer Pump

These components should be inspected according to the instructions that are found in various Caterpillar reusability publications. The Special Publication, SEBF8029 lists the reusability publications that are needed for inspecting the engine parts.

If the parts comply with the established inspection specifications that are expressed in the reusable parts guideline, the parts should be reused.

Parts that are not within the established inspection specifications should be dealt with in one of the following manners:

- Salvaging
- Repairing
- Replacing

Using out-of-spec parts can result in the following problems:

- Unscheduled downtime
- Costly repairs
- Damage to other engine parts
- Reduced engine efficiency
- Increased fuel consumption

Reduced engine efficiency and increased fuel consumption translates into higher operating costs. Therefore, Caterpillar Inc. recommends repairing out-of-spec parts or replacing out-of-spec parts.

Inspection and/or Replacement

Crankshaft Bearings, Valve Rotators, and Crankshaft Seals

The following components may not last until the second overhaul.

- Thrust bearings
- Main bearings
- Rod bearings
- Valve rotators
- Crankshaft seals

Caterpillar Inc. recommends the installation of new parts at each overhaul period.

Inspect these parts while the engine is disassembled for an overhaul.

Inspect the crankshaft for any of the following conditions:

- Deflection
- Damage to the journals
- Bearing material that has seized to the journals

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the following components:

- Rod bearing
- Main bearings

Note: If the crankshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the crankshaft.

Inspect the camshaft for damage to the journals and to the lobes.

Note: If the camshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the camshaft.

Inspect the following components for signs of wear or for signs of scuffing:

- Camshaft bearings
- Camshaft followers

Caterpillar Inc. recommends replacing the crankshaft vibration damper.

Oil Cooler Core and Aftercooler Core

During an overhaul, Caterpillar Inc. recommends the removal of both the oil cooler core and the aftercooler core. Clean the oil cooler core and the aftercooler core. Then, pressure test both of these cores.

NOTICE
Do not use caustic cleaners to clean the core.

Caustic cleaners can attack the internal metals of the core and cause leakage.

Note: Use this cleaning procedure to clean the oil cooler core and the aftercooler core.

1. Remove the oil cooler core and the aftercooler core.
2. Remove any debris from the oil cooler core and the aftercooler core. To remove debris from the oil cooler core, turn the oil cooler core onto one end. To remove debris from the aftercooler core, turn the aftercooler core upside-down.
3. Flush the oil cooler core and the aftercooler core internally with cleaner in order to loosen foreign substances. This will also help to remove oil from the oil cooler core and the aftercooler core.

Note: Caterpillar Inc. recommends the use of Hydrosolv Liquid Cleaners. Table 20 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 20

Hydrosolv Liquid Cleaners[1]		
Part Number	**Description**	**Size**
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

(1) Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F).

4. Use steam to clean the oil cooler core and the aftercooler core. This removes any remaining residue from the cleaner. Flush the fins of the oil cooler core and the aftercooler core. Remove any other trapped debris.
5. Wash the oil cooler core and the aftercooler core with hot, soapy water. Rinse the oil cooler core and the aftercooler core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

6. Dry the oil cooler core and the aftercooler core with compressed air. Direct the air in the reverse direction of the normal flow.
7. Inspect the components in order to ensure cleanliness. The oil cooler core and the aftercooler core should be pressure tested. Repair the oil cooler core and the aftercooler core, if necessary. Install the oil cooler core and the aftercooler core.

For more information about cleaning the cores, consult your Caterpillar dealer.

Obtain Coolant Analysis

The concentration of supplemental coolant additive (SCA) should be checked regularly with test kits or with S·O·S Coolant Analysis (Level 1). Further coolant analysis is recommended when the engine is overhauled.

For example, considerable deposits are found in the water jacket areas on the external cooling system, but the concentrations of coolant additives were carefully maintained. The coolant water probably contained minerals that were deposited on the engine over time.

A coolant analysis can be conducted in order to verify the condition of the water that is being used in the cooling system. A full water analysis can be obtained by consulting your local water utility company or an agricultural agent. Private laboratories are also available for water analysis.

Caterpillar Inc. recommends an S·O·S Coolant Analysis (Level 2).

S·O·S Coolant Analysis (Level 2)

An S·O·S Coolant Analysis (Level 2) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S·O·S Coolant Analysis (Level 2) provides the following information:

- Complete S·O·S Coolant Analysis (Level 1)
- Visual inspection of properties
- Identification of metal corrosion
- Identification of contaminants
- Identification of built up impurities (corrosion and scale)

S·O·S Coolant Analysis (Level II) provides a report of the results of both the analysis and the maintenance recommendations.

For more information about coolant analysis, see your Caterpillar dealer.

i00651416

Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

Caterpillar Inc. recommends a scheduled inspection of the starting motor. If the starting motor fails, the engine may not start in an emergency situation.

Check the starting motor for proper operation. Check the electrical connections and clean the electrical connections. Refer to the Service Manual for more information on the checking procedure and for specifications or consult your Caterpillar dealer for assistance.

i01539769

Turbocharger - Inspect

SMCS Code: 1052-040; 1052

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side). Any fumes from the crankcase are filtered through the air inlet system. Therefore, by-products from oil and from combustion can collect in the turbocharger compressor housing. Over time, this buildup can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE
Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Note: Turbocharger components require precision clearances. The turbocharger cartridge must be balanced due to high rpm. Severe Service Applications can accelerate component wear. Severe Service Applications require more frequent inspections of the cartridge.

Removal and Installation

For options regarding the removal, installation, repair and replacement, consult your Caterpillar dealer. Refer to the Service Manual for this engine for the procedure and specifications.

Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.

2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the compressor wheel and the turbocharger housing, the turbocharger must be reconditioned.

3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.

4. Use a dial indicator to check the end clearance on the shaft. If the measured end play is greater than the Service Manual specifications, the turbocharger should be repaired or replaced. An end play measurement that is less than the minimum Service Manual specifications could indicate carbon buildup on the turbine wheel. The turbocharger should be disassembled for cleaning and for inspection if the measured end play is less than the minimum Service Manual specifications.

5. Inspect the bore of the turbine housing for corrosion.

6. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.

7. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i00073831

Walk-Around Inspection

SMCS Code: 1000-040

Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections and trash buildup. Make repairs, as needed:

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE
Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove this debris with steam cleaning or high pressure water.

- Ensure that cooling lines are properly clamped and tight. Check for leaks. Check the condition of all pipes.
- Check the marine transmission oil level. Refer to the OEM specification for the marine transmission or refer to the OEM specification for the vessel.
- Inspect the water pumps for coolant leaks.

Note: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pumps and the installation of water pumps and/or seals, refer to the Service Manual for the engine or consult your Caterpillar dealer.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Inspect the alternator belt and the accessory drive belts for cracks, breaks or other damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt is replaced, the belt will carry more load than the belts that are not replaced. The older belts are stretched. The additional load on the new belt could cause the belt to break.

- Drain the water and the sediment from fuel tanks on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Inspect the ECM to the cylinder head ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges which are cracked or can not be calibrated.

i01057943

Water Pump - Inspect

SMCS Code: 1361-040; 1361

A failed water pump might cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head
- A piston seizure
- Other potential damage to the engine

Visually inspect the water pump for leaks. If any leaking is observed, replace the water pump seal or the water pump assembly. Refer to the Service Manual for the disassembly and assembly procedure.

Note: Refer to the Service Manual or consult your Caterpillar dealer if any repair is needed or any replacement is needed.

i02456923

Zinc Rods - Inspect/Replace

SMCS Code: 1388-040; 1388-510

Corrosion in sea water circuits can result in premature deterioration of system components, leaks, and possible cooling system contamination. The cause for the premature corrosion may be the lack of zinc rods in the sea water system.

Zinc rods are inserted in the sea water cooling system of the engine in order to help prevent the corrosive action of salt water. The reaction of the zinc to the sea water causes the zinc rods to deteriorate. The zinc rods deteriorate instead of engine parts for the cooling system that are more critical. Rapid deterioration of zinc rods may indicate the presence of uncontrolled electrical currents from improperly installed electrical attachments or improperly grounded electrical attachments.

The zinc rods must be inspected at the proper intervals. The zinc rods must be replaced when deterioration occurs.

Inspect the Zinc Rods

The zinc rods are red for easy identification. Table 21 shows the locations of the zinc rods and the quantities of the zinc rod:

Table 21

Locations of the Zinc Rods	
Location	**Quantity**
Right Heat Exchanger Bonnet	2
Left Heat Exchanger Bonnet	1
Transmission Oil Cooler	2
Fuel Cooler	2

1. Remove the zinc rod.

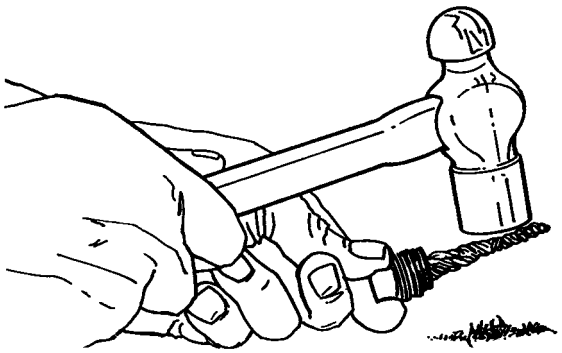


Illustration 48 g00104048

2. Tap the zinc rod lightly with a hammer. If the zinc rod has deteriorated, or if the zinc rod flakes, install a new zinc rod.

Replace the Zinc Rods

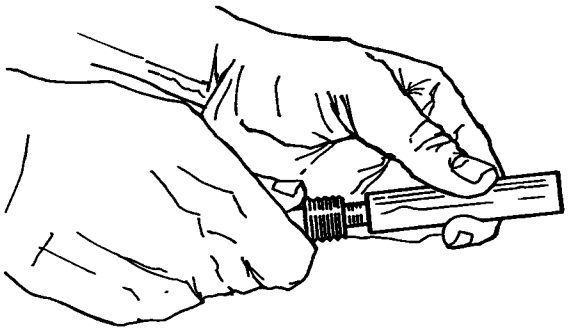


Illustration 49 g00104049

1. Unscrew the old zinc rod or drill the old zinc rod from the plug. Clean the plug.

2. Apply 9S-3263 Compound to the shoulder of a new zinc rod. Apply the compound only to the shoulder of the zinc rod. Install the zinc rod into the plug.

3. Coat the external threads of the plug with 5P-3413 Pipe Sealant. Install the zinc rod. Refer to Special Publication, SENR3130, “Torque Specifications” for more information on torque specifications.