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MAINTENANCE INTERVALS

Operation and Maintenance
Manual Excerpt

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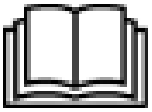

Operation and Maintenance Manual

C7 and C9 On-highway Engines

MFF1-Up (Engine)
C7S1-Up (Engine)
C9S1-Up (Engine)
C7W1-Up (Engine)
C9W1-Up (Engine)

Includes C9 Mass Transit Bus Engines

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i02871972

Maintenance Interval Schedule (C7 Engines with Shallow Sumps)

SMCS Code: 1000; 7500

S/N: C7S1-Up

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 installation of new components due to normal wear and aging. The performance of this product may be diminished if proper maintenance intervals and procedures are not followed. Components may experience accelerated wear if proper maintenance intervals and procedures are not followed.

Use whichever of the following that occurs first in order to determine the maintenance intervals: fuel consumption, mileage, service hours, and calendar time . Products that operate in severe operating conditions may require more frequent maintenance.

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

When Required

Daily

Initial 17 700 km (11 000 miles) or 4150 L (1100 US gal) of Fuel or 250 Service Hours or 6 Months

PM Level 1 - Every 17 700 km (11 000 miles) or 4150 L (1100 US gal) of Fuel or 250 Service Hours or 6 Months

Every 80 500 km (50 000 miles) or 1500 Service Hours

Every 144 800 km (90 000 mi) or 1500 Service Hours

PM Level 2 - Every 161 000 km (100 000 miles) or 56 850 L (15 000 US gal) of Fuel or 2000 Service Hours or 2 Years

PM Level 3 - Every 483 000 km (300 000 miles) or 190 000 L (50 000 US gal) of Fuel or 6000 Service Hours or 3 Years

Every Year

Every 3 Years or 322 000 km (200 000 miles)

Every 6 Years or 966 000 km (600 000 miles)

Every 483 000 km (300 000 miles) or 3 Years

i02871969

Maintenance Interval Schedule (C7 Engines with Deep Sumps)

SMCS Code: 1000; 7500

S/N: C7S1-Up

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 installation of new components due to normal wear and aging. The performance of this product may be diminished if proper maintenance intervals and procedures are not followed. Components may experience accelerated wear if proper maintenance intervals and procedures are not followed.

Use whichever of the following that occurs first in order to determine the maintenance intervals: fuel consumption, mileage, service hours, and calendar time . Products that operate in severe operating conditions may require more frequent maintenance.

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

When Required

Daily

Initial 24 000 km (15 000 miles) or 5700 L (1500 US gal) of Fuel or 400 Service Hours or 6 Months

PM Level 1 - Every 24 000 km (15 000 miles) or 5700 L (1500 US gal) of Fuel or 400 Service Hours or 6 Months

Every 80 500 km (50 000 miles) or 1500 Service Hours

Every 144 800 km (90 000 mi) or 1500 Service Hours

PM Level 2 - Every 161 000 km (100 000 miles) or 56 850 L (15 000 US gal) of Fuel or 2000 Service Hours or 2 Years

PM Level 3 - Every 483 000 km (300 000 miles) or 190 000 L (50 000 US gal) of Fuel or 6000 Service Hours or 3 Years

Every Year

Every 3 Years or 322 000 km (200 000 miles)

Every 6 Years or 966 000 km (600 000 miles)

Every 483 000 km (300 000 miles) or 3 Years

i02871975

Maintenance Interval Schedule (C9 Engines)

SMCS Code: 1000; 7500

S/N: MFF1-Up

S/N: C9S1-Up

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 installation of new components due to normal wear and aging. The performance of this product may be diminished if proper maintenance intervals and procedures are not followed. Components may experience accelerated wear if proper maintenance intervals and procedures are not followed.

Use whichever of the following that occurs first in order to determine the maintenance intervals: fuel consumption, mileage, service hours, and calendar time . Products that operate in severe operating conditions may require more frequent maintenance.

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

When Required

Daily

Initial 24 000 km (15 000 miles) or 7500 L (2000 US gal) of Fuel or 400 Service Hours or 6 Months

Initial 24 000 km (15 000 miles) or 5700 L (1500 US gal) of Fuel or 400 Service Hours or 6 Months

Every 24 000 km (15 000 miles) or 7500 L (2000 US gal) of Fuel or 400 Service Hours or 6 Months

Every 80 500 km (50 000 miles) or 1500 Service Hours

Every 144 800 km (90 000 mi) or 1500 Service Hours

PM Level 2 - Every 161 000 km (100 000 miles) or 56 850 L (15 000 US gal) of Fuel or 2000 Service Hours or 2 Years

PM Level 3 - Every 483 000 km (300 000 miles) or 190 000 L (50 000 US gal) of Fuel or 6000 Service Hours or 3 Years

Every Year

Every 3 Years or 322 000 km (200 000 miles)

Every 6 Years or 966 000 km (600 000 miles)

Every 483 000 km (300 000 miles) or 3 Years

i03528370

ARD Nozzle - Clean

SMCS Code: 1050-070

The Effect of Fuel Selection on the Interval for Cleaning the Nozzle for the Aftertreatment Regeneration Device (ARD Nozzle)

Using a blend of biodiesel and ultralow sulfur diesel (ULSD) shortens the intervals between cleanings of the ARD nozzle.

Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for information about the types of fuels that may be used in this Caterpillar On-highway Engine.

Use the following table to determine the correct interval for cleaning the ARD nozzle.

Table 12

Intervals for Cleaning the ARD Nozzle (1)		
Engine	Biodiesel Blend (2)	ULSD
C7 Engine with a Shallow Sump	PM1: Every 17700 km (11000 miles) or 4150 L (1100 US gal) of fuel or 250 service hours or 6 months	Every 80500 km (50000 miles) or 1500 service hours
C7 Engine with a Deep Sump	PM1: Every 24000 km (15000 miles) or 5700 L (1500 US gal) of fuel or 400 service hours or 6 months	Every 80500 km (50000 miles) or 1500 service hours
C9 Engine	Every 24000 km (15000 miles) or 7500 L (2000 US gal) of fuel or 400 service hours or 6 months	Every 80500 km (50000 miles) or 1500 service hours

(1) Use the interval that occurs first.

(2) An acceptable biodiesel blend must consist of at least 95 percent ULSD and five percent or less of an acceptable biodiesel.

Procedure for Cleaning the ARD Nozzle

The liquid cleaner that is used to clean the nozzle for the Aftertreatment Regeneration Device (ARD) is available at your Caterpillar dealer. The cleaner is already measured into a dispenser. Contact your authorized Caterpillar dealer for the current part number for the filled bottle.

Turn off the engine.

Use an allen wrench in order to remove the access plug from the cleaning port. Inspect the access plug for damage. An undamaged plug may be reused.

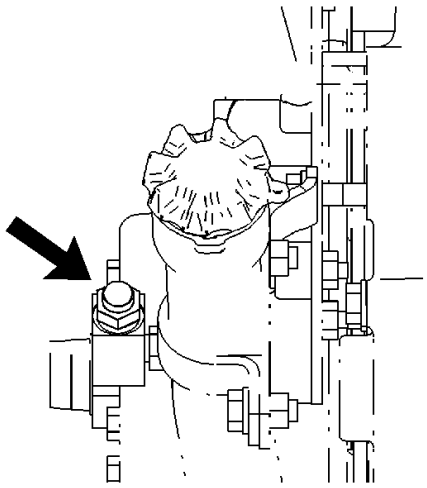


Illustration 35 g01351823

The cleaning port is located on the left side of the engine next to the oil filler tube on the C7 Engine.

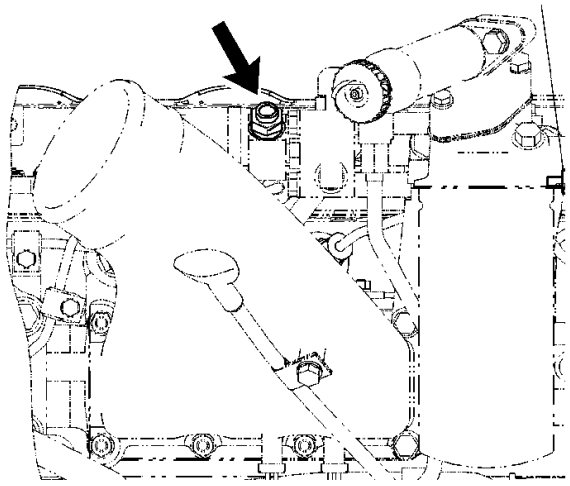


Illustration 36 g01351825

The cleaning port is located on the left side of the engine to the left of the fuel filter on the C9 Engine. The priming pump that is shown is optional.

Note: Remove the red cap from the dispenser immediately before use. Ensure that no debris is present on the dispenser. Make sure that the cleaning port is free of debris.

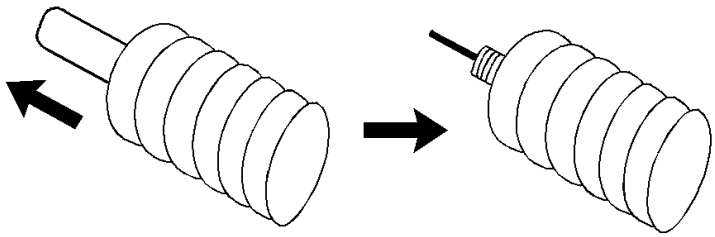


Illustration 37 g01348096

Insert the tip of the dispenser completely into the cleaning port.

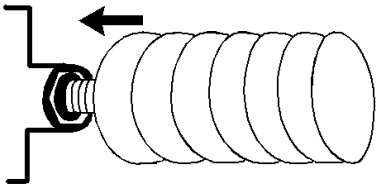


Illustration 38 g01346064

Squeeze the container in order to dispense the fluid. All of the fluid should be dispensed before the dispenser is removed from the cleaning port. Remove the dispenser and ensure that all of the liquid was dispensed. Inspect the cleaning port in order to ensure that no part of the dispenser remains in the cleaning port.

Insert an undamaged access plug into the cleaning port. Torque the plug to 10 ± 1 N·m (7.4 ± 0.7 lb ft). Start the engine and run the engine for at least five minutes at low idle.

i03340980

ARD Spark Plug - Inspect/Replace

SMCS Code: 1555-040; 1555-510

Removing the Spark Plug

NOTICE
If the engine is running or the key is in the ON position the ARD plug will continue to fire. Turn the key to the OFF position before servicing the ARD plug.

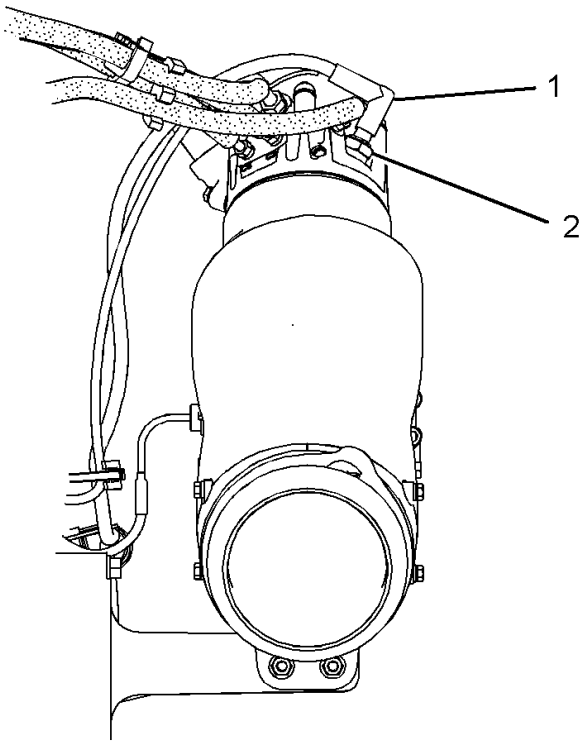


Illustration 39 g01308813

(1) Wiring harness
(2) Spark plug

1. Remove wire harness (1) from spark plug (2).

⚠ 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.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded.

2. Debris may have collected in the spark plug well. Thoroughly remove any debris. Use compressed air. The maximum air pressure for cleaning purposes must be below 205 kPa (30 psi). Ensure that the area around the spark plug is clean and free of dirt and debris.

3. Use a deep well socket and a breaker bar to loosen the spark plug. If necessary, see your Caterpillar dealer for the part number of the socket. After the spark plug has been loosened, use the socket to remove the spark plug by hand in order to detect problems with the threads. After the spark plug has been removed, inspect the used spark plug and the gasket.

If the spark plug could not be removed by hand, clean the threads with a 305-2389 brush. This tool scrapes debris from the seat and from the threads.

NOTICE
Do not use a thread tap. A thread tap will remove metal unnecessarily. The threads could be stripped and the combustion group could be damaged.

Inspecting the Spark Plug

Inspect the spark plug closely for damage. The condition of the spark plug can indicate the operating condition of the engine.

The terminal post must not move. If the terminal post can be moved by hand, discard the spark plug.

Inspect the insulator for cracks. If a crack is found, discard the spark plug.

Inspect the shell for damage. Cracks can be caused by overtightening the spark plug. Overtightening can also loosen the shell. Discard any spark plug that has a shell that is cracked or loose.

Inspect the electrode for excessive wear.

Installing the Spark Plug

Note: Do not use anti-seize compound on the spark plug. Most of the heat is transferred through the threads and the seat area of the spark plug. Contact of the metal surfaces must be maintained in order to provide the heat transfer that is required.

1. Ensure that the spark plug is clean and free of dirt and oil.

NOTICE

Do not overtighten the spark plug. The shell can be cracked and the gasket can be deformed. The metal can deform and the gasket can be damaged. The shell can be stretched. This will loosen the seal that is between the shell and the insulator, allowing combustion pressure to blow past the seal. Serious damage to the engine can occur.

Use the proper torque.

2. Install the spark plug by hand until the spark plug contacts the ARD. Torque the spark plug to the proper specification. Refer to Specifications, “Spark Plug” for the proper torque specification.

3. Connect the wiring harness.

i01807350

Aftercooler Core - Clean/Test (Air-To-Air Aftercooler)

SMCS Code: 1064-070; 1064-081

The air-to-air aftercooler is OEM installed in many applications. Please refer to the OEM specifications for information that is related to the aftercooler.

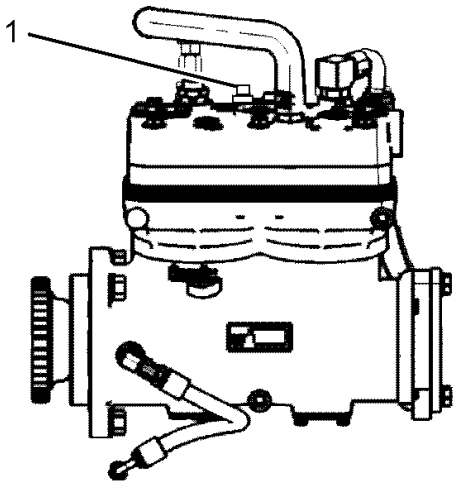
i02426101

Air Compressor - Inspect

SMCS Code: 1803-040

⚠ WARNING

Do not disconnect the air line from the air compressor governor without purging the air brake and the auxiliary air systems. Failure to purge the air brake and the auxiliary air systems before removing the air compressor and/or the air lines could cause personal injury.



g01212654

Illustration 40

Typical example

(1) Pressure relief valve

⚠ WARNING

If the air compressor pressure relief valve that is mounted in the air compressor cylinder head is bypassing compressed air, there is a malfunction in the air system, possibly ice blockage. Under these conditions, your engine may have insufficient air for normal brake operation.

Do not operate the engine until the reason for the air bypass is identified and corrected. Failure to heed this warning could lead to property damage, personal injury, or death to the operator or bystanders.

The function of the pressure relief valve is to bypass air when there is a malfunction in the system for the air compressor.

The pressure relief valve for the air compressor releases air at 1723 kPa (250 psi). If the pressure relief valve for the air compressor exhausts, all personnel should be at a safe distance away from the air compressor. All personnel should also stay clear of the air compressor when the engine is operating and the air compressor is exposed.

Refer to the Service Manual or refer to the OEM specifications in order to find information concerning the air compressor. Consult your Caterpillar dealer for assistance.

i00863920

Air Dryer - Check

SMCS Code: 4285-535

Follow the maintenance recommendations that are provided by the OEM or consult your Caterpillar dealer for assistance.

i02676048

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.

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.

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.

i02601752

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.

⚠ 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.

i02719973

Belts - Inspect/Adjust/Replace

SMCS Code: 1357-025; 1357-040; 1357-510

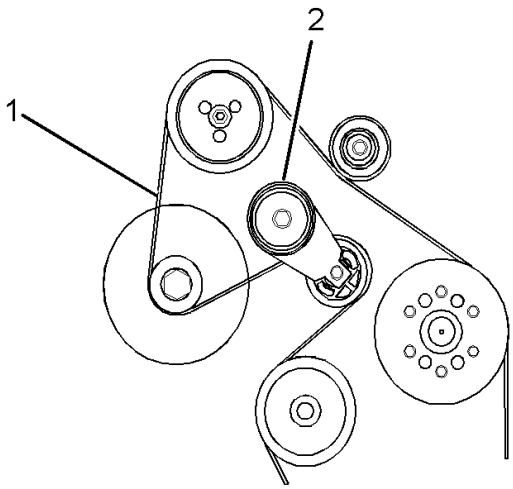


Illustration 41 g01272337

Your engine is equipped with a serpentine belt (1). For maximum engine performance and maximum utilization of your engine, inspect the belt for the following conditions: wear, cracks, and damage. If necessary, replace the belt.

To replace the serpentine belt, perform the following steps:

1. Insert a ratchet with a square drive into the square hole that is located in belt tensioner (2). Rotate the belt tensioner clockwise in order to relieve tension on the fan drive belt. Remove the belt.

2. Install the new belt correctly, as shown. Be sure that the belt is fully seated on the pulleys. The correct tension will automatically be applied when the ratchet is removed.

i02768003

Compression Brake - Inspect/Adjust (Caterpillar Compression Brake)

SMCS Code: 1119-025; 1119-040

S/N: MFF1-Up

S/N: C9S1-Up

S/N: C9W1-Up

The maintenance of the Caterpillar compression brake should be performed in conjunction with scheduled maintenance of the valve lash.

Note: The adjustment of the actuator piston lash must be performed after the engine valve lash adjustment is performed. Make the adjustment of the actuator piston lash while the engine is stopped. Refer to the Systems Operation, Testing and Adjusting module for additional information.

Table 13

Component	Required Maintenance
Wiring and Terminal Connections	Inspect
Clutch/Throttle/Buffer Screw	Inspect/Adjust
Actuator Piston Lash Adjusting Screws	Inspect/Adjust
Crosshead Bridges/Valve Stem Caps	Inspect
Housing	Inspect
Hold Down Bolts	Inspect
Control Valve	Inspect
Oil Seal Ring(1)	Inspect/Replace

(1) Inspect the oil seal rings for signs of wear and for signs of damage. If necessary, replace the oil seal rings. Refer to the Parts Manual for further information.

i02139869

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.

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.

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

Note: If equipped, be sure to drain the heater and any related supply and return lines.

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 Dealer Service Tool Group:

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

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 Manual, 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 a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add 0.5 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. The coolant temperature should be 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. If equipped, be sure to flush the heater and any related supply and return lines. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual, 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.

Note: If equipped, be sure to flush the heater and any related supply and return lines.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual, 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 a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add 0.5 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).

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 the Specifications Manual, 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.

1. Fill the cooling system with coolant/antifreeze. Refer to the Operation and Maintenance Manual, “Refill Capacitites and Recommendations” topic (Maintenance Section) 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 high idle 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 (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 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 that is on 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 that is on the cooling system filler cap is not damaged, perform a pressure test. A 9S-8140 Pressurizing Pump is used to perform the pressure test. 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.

i03292691

Cooling System Coolant (ELC) - 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.

Note: When the cooling system is cleaned, only clean water is needed when the ELC is drained and replaced.

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.

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.

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.

   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 Dealer Service Tool Group:

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

Flush

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

Note: If equipped, be sure to flush the heater and any related supply and return lines.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. For the proper torque, refer to the Specifications Manual, SENR3130, “Torque Specifications”.

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.

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. For the proper torque, refer to the Specifications Manual, SENR3130, “Torque Specifications”.

Fill

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

1. Fill the cooling system with Extended Life Coolant (ELC). See Special Publication, SEBU6385, “Caterpillar On-highway Diesel Truck Engine Fluids 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 for 5 minutes. Then, increase the engine rpm to high idle. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block.

3. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 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 that is on 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 that is on 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.

i03085827

Cooling System Coolant Extender (ELC) - Add

SMCS Code: 1352-045; 1395-081

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

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

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

4. Refer to the schedule that is found in Operation and Maintenance Manual , “Maintenance Interval Schedule”. This schedule lists the interval for adding Cat ELC Extender to this engine.

5. Use the formula in Table 14 to determine the proper amount of Cat ELC Extender for your cooling system. The total cooling capacity will vary depending on the radiator that is provided by the vehicle manufacturer.

Table 14

Formula For Adding Cat ELC Extender To Cat ELC
V × 0.02 = X
V is the total capacity of the cooling system.
X is the amount of Cat ELC Extender that is required.

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

For more information about Cat ELC Extender, refer to Special Publication, SEBU6385, “Caterpillar On-highway Diesel Engine Fluid Recommendations”.

i01197583

Cooling System Coolant Level - Check

SMCS Code: 1395-082

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

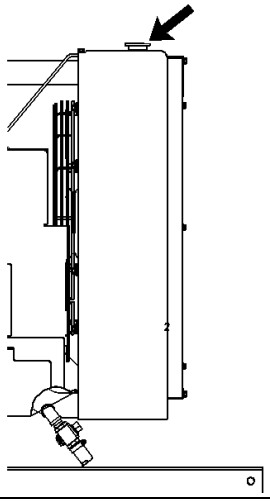


Illustration 42 g00285520
Cooling system filler cap

⚠ 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.

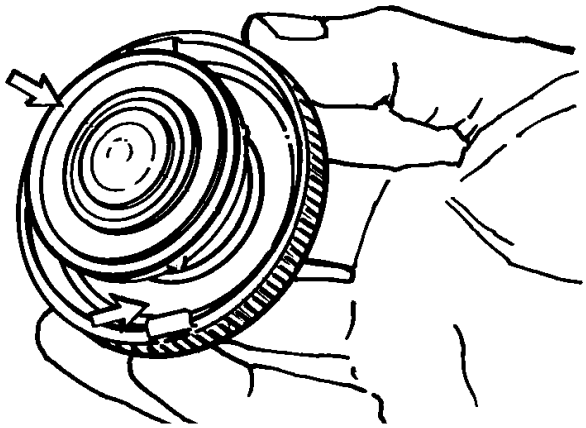


Illustration 43 g00103639

Typical filler cap gaskets

3. Clean the cooling system filler cap and check 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.

i02762476

Cooling System Coolant Sample (Level 1) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

Note: Level 1 results may indicate a need for Level 2 Analysis.

Obtain the sample of the coolant as close as possible to the recommended sampling interval. In order to receive the full effect of S·O·S analysis, you must establish a consistent trend of data. In order to establish a pertinent history of data, perform consistent samplings that are evenly spaced. Supplies for collecting samples can be obtained from your Caterpillar dealer.

Use the following guidelines for proper sampling of the coolant:

- Complete the information on the label for the sampling bottle before you begin to take the samples.

- Keep the unused sampling bottles stored in plastic bags.
- Obtain coolant samples directly from the coolant sample port. You should not obtain the samples from any other location.
- Keep the lids on empty sampling bottles until you are ready to collect the sample.
- Place the sample in the mailing tube immediately after obtaining the sample in order to avoid contamination.
- Never collect samples from expansion bottles.
- Never collect samples from the drain for a system.

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.

Submit the sample for Level 1 analysis.

For additional information about coolant analysis, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” article or consult with your Caterpillar dealer.

i03085829

Cooling System Coolant Sample (Level 2) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

Note: Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for the proper maintenance interval for your application.

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.

Refer to this Operation and Maintenance Manual, “Cooling System Coolant Sample (Level 1) - Obtain” for the guidelines for proper sampling of the coolant.

Submit the sample for Level 2 analysis.

For additional information about coolant analysis, see Special Publication, SEBU6385, “Caterpillar On-highway Diesel Engines Fluids Recommendations” or consult your Caterpillar dealer.

i03085828

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

SMCS Code: 1352-045; 1395-081

Note: This procedure is NOT required for applications that use Cat Extended Life Coolant (ELC).

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

Test the SCA Concentration

Coolant, Antifreeze and SCA

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

⚠ 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.

Use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA. Refer to the Special Publication, SEBU6385, “Caterpillar On-highway Diesel Engine Fluid Recommendations” for more 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.

Follow the instructions that are provided by the OEM or follow the instructions that are provided by the manufacturer of the coolant conditioner element on engines that are equipped with a coolant conditioner element.

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 Special Publication, SEBU6385, “Caterpillar On-highway Diesel Truck Engine Fluid 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.

i02623972

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.

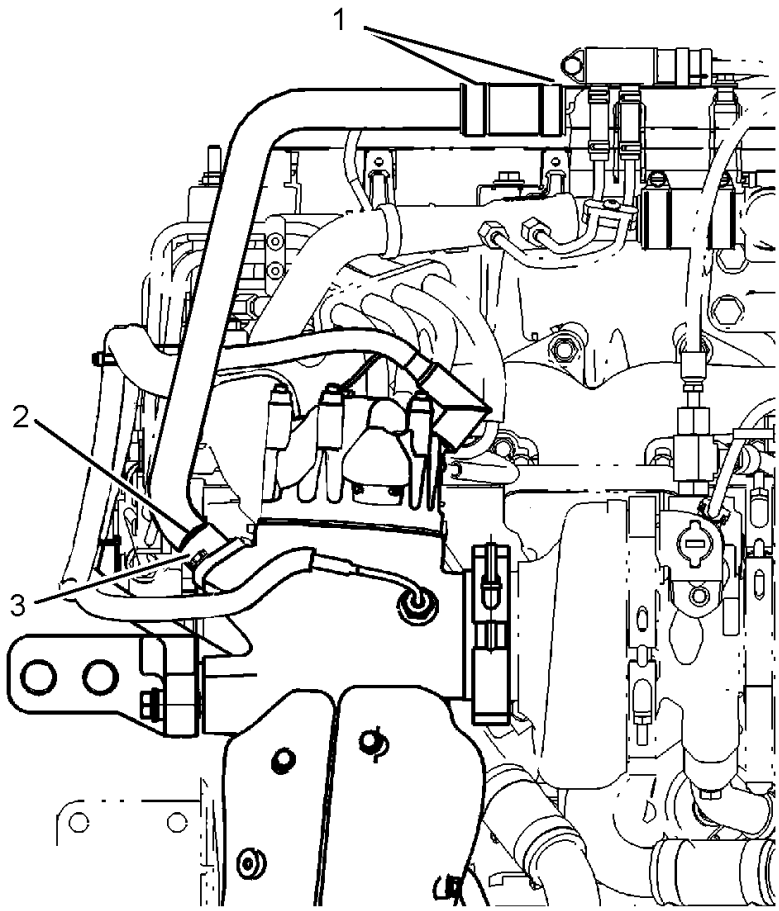
Refer to two articles in the Disassembly and Assembly Manual, “Water Temperature Regulators - Remove and Water Temperature Regulators - Install” for the replacement procedure of the water temperature regulator, or consult your Caterpillar dealer.

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.

i02678214

Crankcase Fumes Fitting - Inspect/Clean

SMCS Code: 1317-040; 1317-070



g01345683

Illustration 44

(1) Clamps
(2) Nut
(3) Fitting

1. Loosen the clamps that attach the tube that carries fumes from the engine crankcase breather to the aftertreatment regeneration device (ARD). Remove the end of the tube from the breather.

2. Remove the nut at the end of the tube from the fitting and move the tube to one side. The fitting will remain in the ARD.

3. If fitting (3) is accessible, this procedure may be performed with the fitting on the combustion head. If the fitting is not accessible, remove the fitting and use a vise to hold the fitting.

4. Install a 6V-7092 Brush into a drill and clean the fitting.

5. Reinstall the nut onto the tube and tighten the nut. Refer to the engine's Specifications manual for the proper torque.

6. Reinstall the end of the tube through the hose into the breather. Reinstall the hose clamps. Refer to Specifications, SENR3130 for the proper torque for the hose clamp.

i02933380

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 damper that is damaged 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.

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 fluid leaks. If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous, smooth, and adhering.

If the fluid leak is oil, inspect the crankshaft seals for leaks. If a leak is observed, replace the crankshaft seals.

Inspect the damper and repair or replace the damper for any of the following reasons:

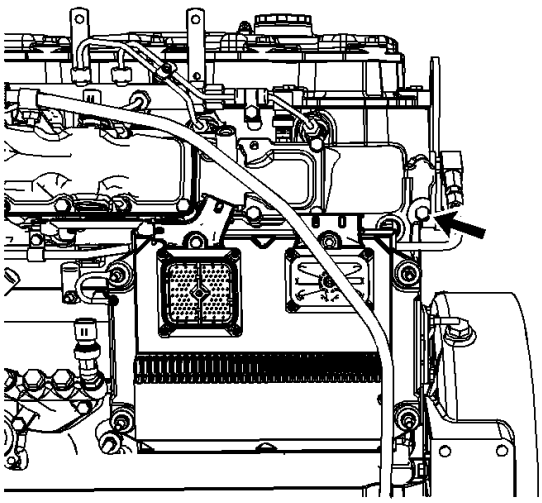
- The damper is dented, cracked, or leaking.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of a broken crankshaft.
- Analysis of the oil has revealed that the front main bearing is badly worn.
- There is a large amount of gear train wear that is not caused by a lack of oil.

Refer to the Disassembly and Assembly Manual, “Vibration Damper and Pulley - Remove and Install” or consult your Caterpillar dealer for information about damper replacement.

i02370278

Cylinder Head Grounding Stud - Inspect/Clean/Tighten

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



g01182654

Illustration 45

Cylinder head grounding stud

Inspect the OEM harness for good connections and condition.

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 for the cylinder head ground strap 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.

i03536467

Diesel Particulate Filter - Clean

SMCS Code: 1091-070

Note: Caterpillar recommends the use of the Caterpillar ash service tool. Caterpillar does not endorse the use of non-Caterpillar ash service tools. Improper cleaning or repair of the diesel particulate filter (DPF) can damage the DPF and the engine aftertreatment system. Contact your Caterpillar dealer for more information.

Minimum Maintenance Intervals

Refer to table 15 in order to determine the minimum maintenance interval for cleaning ash from the DPF. The intervals may vary because of the following operational factors: idle time for the engine, route, and ambient conditions.

Optimum intervals for cleaning the DPF require the use of the following products:

- Oil that meets the performance requirements of the Caterpillar ECF-3 specification
- Ultralow sulfur diesel fuel (ULSD)

Refer to this Operation and Maintenance Manual , “Refill Capacities and Recommendations” for more information.

Table 15

Minimum Maintenance Intervals for Cleaning Ash from the DPF					
Engine	**Rating**		**Comments**	**Minimum Interval (Distance)**	**Minimum Interval (Hours)**
C7	190	350		241400 kilometers (150000 miles)	4500
C9	285	425	Including RV	241400 kilometers (150000 miles)	4500

Exceptions to Minimum Maintenance Intervals

A number of vehicle applications impose certain restraints on the locations of exhaust system components. These applications are primarily classified as medium service and heavy-duty service. The Environmental Protection Agency has determined that a DPF that has a reduced size may be installed in a vehicle if the DPF is cleaned more frequently.

The EPA has issued a list of vehicle applications which may be suitable for a DPF with a reduced volume. The vehicle applications are listed below.

- Beverage truck
- Maintenance truck (with integral toolbox)
- Trash collection truck (with hydraulic packing or picking apparatus)
- Fire truck
- Airport refueling truck (with exhaust directed toward the front of the truck)
- Utility truck (with integral toolboxes and outrigger apparatus)
- Snowplow (with the plow located under the chassis)
- Dump truck
- Concrete mixer
- Car hauler (with integral open racks)
- Street sweeper
- Armored car
- Day cab truck with no rear seat (only a day cab truck for which the entire DPF is located in front of the vertical plane established by the back side of the cab)

Use the interval which occurs first in order to determine the minimum maintenance interval for a DPF with a reduced volume:

- 128750 kilometers (80000 miles)
- 2400 hours

Note: This minimum maintenance interval is only valid for engines that are built in 2007, 2008, or 2009.

Note: The following vehicles are not qualified for reduced maintenance intervals, even when the vehicles are included in the above list.

- Any vehicle with an exhaust system that is mounted vertically
- Any vehicle that has a DPF that is mounted behind the cab and outside of the frame rails

Please consult your Caterpillar dealer in order to determine if a DPF with a reduced volume is installed in your vehicle. A DPF with a reduced volume requires a more frequent maintenance interval.

Recommended Maintenance Interval

Caterpillar strongly recommends the cleaning of ash from the DPF at no later than 2882000 kilometers (175000 miles) from the initial start-up or from the last cleaning. The removal of ash from the DPF is a key factor in the following: the performance of the engine aftertreatment system, the life of the DPF, and fuel economy.282000 kilometers (175000 miles)

i01646701

Engine - Clean

SMCS Code: 1000-070

⚠ WARNING

Personal injury or death can result from high voltage.

Moisture can create paths of electrical conductivity.

Make sure that the electrical system is OFF. Lock out the starting controls and tag the controls "DO NOT OPERATE".

NOTICE

Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Periodic cleaning of the engine is recommended. Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

Note: Caution must be used in order to prevent electrical components from being damaged by excessive water when you clean the engine. Avoid electrical components such as the alternator, the starter, and the ECM.

i02353651

Engine Air Cleaner Element (Dual Element) - Clean/Replace (If Equipped)

SMCS Code: 1054-037; 1054-510

See this Operation and Maintenance Manual, “Engine Air Cleaner Element - Clean/Replace” for information on servicing the primary air filter.

Inspecting and Replacing the Secondary Air Cleaner Element (If Equipped)

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.

Operating conditions (dust, dirt, and debris) may require more frequent service of the air cleaner element. If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element.

The secondary air cleaner element is not serviceable or washable. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.

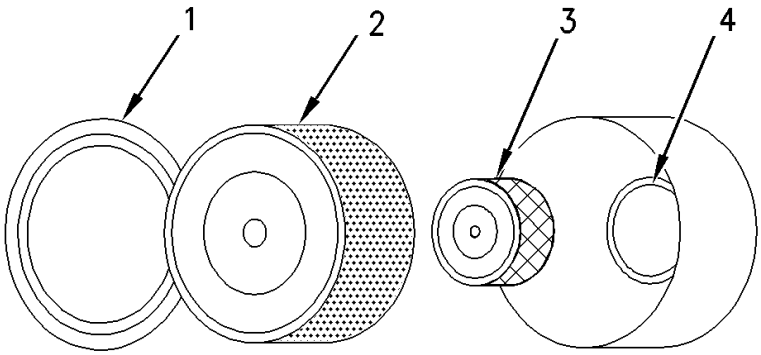


Illustration 46 g00736431

(1) Cover
(2) Primary air cleaner element
(3) Secondary air cleaner element
(4) Air inlet for the turbocharger

1. Remove the cover. Remove the primary air cleaner element.

2. Cover the air inlet for the turbocharger with adhesive material in order to keep dirt out of the turbocharger.

3. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

4. Remove the adhesive covering that covers the air inlet for the turbocharger. Install the secondary air cleaner element. Install a primary air cleaner element that is new or clean.

5. Install the air cleaner cover.

6. Reset the air cleaner service indicator.

i00857000

Engine Air Cleaner Element - Clean/Replace

SMCS Code: 1054-070; 1054-510

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 material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear.

- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, the air cleaner elements should be thoroughly checked for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element or follow the instructions that are provided by the OEM.

i01900118

Engine Air Cleaner Service Indicator - Inspect (If Equipped)

SMCS Code: 7452-040

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before the air cleaner element and the pressure that is measured 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 OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the air cleaner housing or in a remote location.

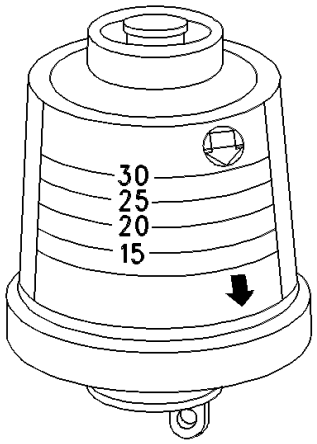


Illustration 47 g00103777

Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

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 speed. 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 necessary. 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).

i02333200

Engine Crankcase Breather - Clean

SMCS Code: 1317-070

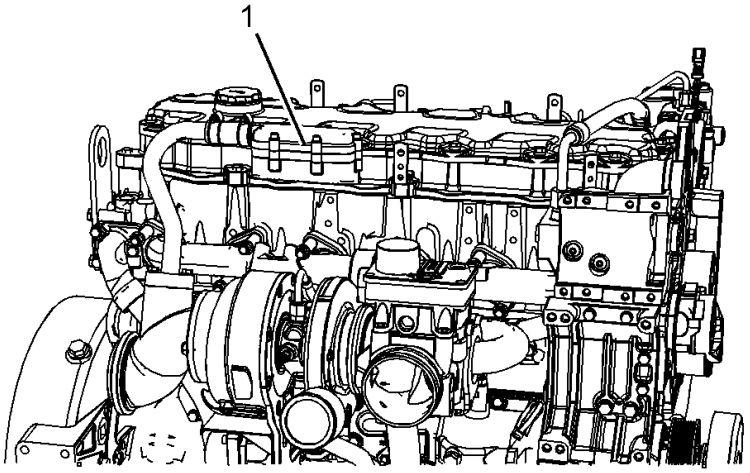


Illustration 48 g01164541

1. Remove the cover on breather (1). Remove the breather assembly and the seal.
2. Wash the breather element in solvent that is clean and nonflammable. Allow the breather element to dry before installation.
3. Install a breather element that is clean and dry. Install the breather assembly and the seal.
4. Install the cover on breather (1).

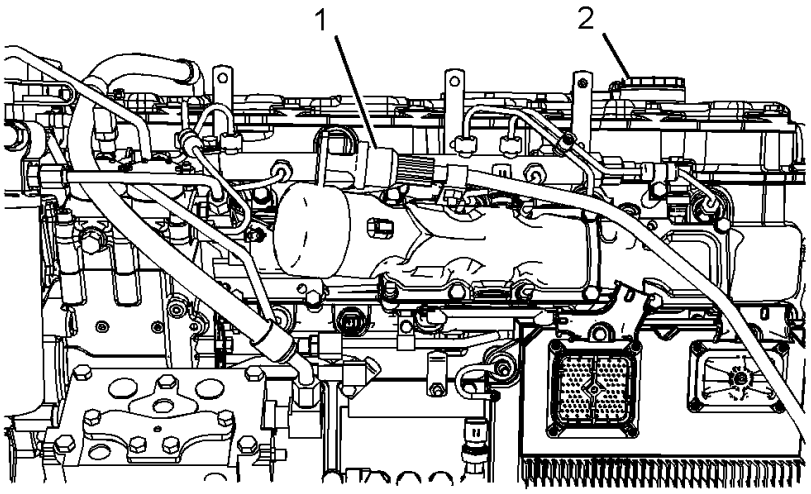
i02526978

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

⚠ WARNING

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

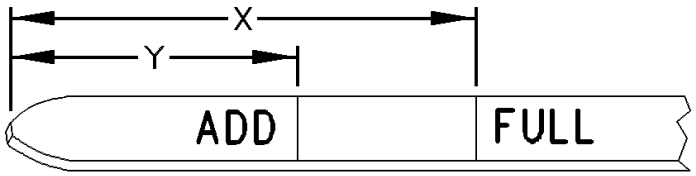


g01182634

Illustration 49

Typical configuration

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



g00110310

Illustration 50

(Y) “ADD” mark
(X) “FULL” mark

NOTICE
Perform this maintenance with the engine stopped.

Note: Before you perform this maintenance, do not operate the engine for at least 10 minutes in order to allow the engine oil to return to the oil pan.

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

Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil's ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers, and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings, and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

2. Remove oil filler cap (2) and add oil, if necessary. For the correct oil to use, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations”. Do not fill the crankcase above “FULL” mark (X) on the oil level gauge. Clean the oil filler cap. Install the oil filler cap.

3. Record the amount of oil that is added. For the next oil sample and analysis, include the total amount of oil that has been added since the previous sample. This will help to provide the most accurate oil analysis.

i02944876

Engine Oil Level Gauge - Calibrate

SMCS Code: 1326-524

Check Calibration at the First Oil Change

The engine oil level will vary depending on the angle and the slant of the engine installation. The angle is the front to back tilt. The slant is the sideways tilt.

The oil level gauge markings must be verified in order to ensure that it is correct. Verify the oil level gauge markings at the first oil change.

Verify the “ADD” mark and verify the “FULL” mark that is on the oil level gauge. Use the following procedure.

NOTICE
The vehicle must be parked on a level surface in order to perform this maintenance procedure.

1. Operate the engine until normal operating temperature is achieved. Stop the engine. Remove the crankcase oil drain plugs. The oil drain plug from the deep portion of the oil pan should be removed. Drain the oil from the crankcase for 20 minutes.

2. Remove the used oil filter(s). Install the new oil filter(s). Install the oil drain plugs and tighten to 70 ± 15 N·m (50 ± 11 lb ft). Caterpillar recommends the use of Cat Advanced Efficiency oil filters.

Note: Your engine may be equipped with auxiliary oil filters. The auxiliary oil filters require a different volume of oil. Refer to the OEM specifications for the auxiliary oil filter.

3. Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for information about choosing the correct oil for your engine.

4. Refer to the table that is correct for your engine and oil pan below. Pour quantity “A” of engine oil into the crankcase.

5. Allow enough time for the oil to drain into the crankcase. Approximately 20 minutes should be allowed. Check the oil level. Wait for several minutes and check the oil level again. Proceed after the oil level stops changing.

6. Check the oil level on the oil level gauge. The oil level should be at the “ADD” mark. If the oil level is not at the existing “ADD” mark, grind off the “ADD” mark and engrave the new “ADD” level. Use an engraving pen in order to engrave the new “ADD” mark.

7. Pour quantity “B” of oil into the crankcase. Allow enough time for the oil to drain into the crankcase.

8. Check the oil level on the oil level gauge. The oil level should be at the “FULL” mark. If the oil level is not at the existing “FULL” mark, grind off the “FULL” mark. Use an engraving pen in order to engrave the new “FULL” mark.

9. Pour quantity “C” of oil into the crankcase in order to allow oil to fill the oil filter.

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

10. Start the engine and run the engine enough to ensure that the lubrication system is filled. Inspect the engine for oil leaks.

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

12. Check the oil level on the oil level gauge. If the oil level is not at the calibrated “FULL” mark, fill the crankcase to the calibrated “FULL” mark. Record the amount of oil that was added as quantity D. Record the oil capacity of the lubrication system for future oil changes.

Table 16

C7		
Quantity of Oil	Shallow Sump	Standard (Deep) Sump
A	13 L (13.7 qt)	20 L (21.1 qt)
B	3 L (3.2 qt)	3 L (3.2 qt)
C	2 L (2.1 qt)	2 L (2.1 qt)
D		
Total Capacity of the Lubrication System for Engine Oil		

Table 17

C9	
Quantity of Oil	Center, Rear, and Front Sump
A	24 L (25.4 qt)
B	4 L (4.2 qt)
C	2 L (2.1 qt)
D	
Total Capacity of the Lubrication System for Engine Oil	

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.

i03017821

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.

NOTICE
The vehicle must be parked on a level surface for this maintenance procedure.

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 while the oil is warm. This draining method will allow the waste particles that are suspended in the oil to be properly drained.

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

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” or refer to Special Publication, PECJ0003, “Caterpillar Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

Drain the Engine Oil

After the engine has been run at the normal operating temperature, stop the engine. Attach a “DO NOT OPERATE” or a similar warning tag to the ignition keyswitch before the engine is serviced. Catch the oil in a suitable container. Recycle the used oil, or dispose of the used oil properly.

1. Remove the oil drain plug in order to allow the oil to drain.

2. After the oil has drained, the oil drain plug should be cleaned and installed.

   Tighten the oil drain plug to the following torque: ..... 70 ± 15 N·m (50 ± 11 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 185-3630 Chain Wrench.

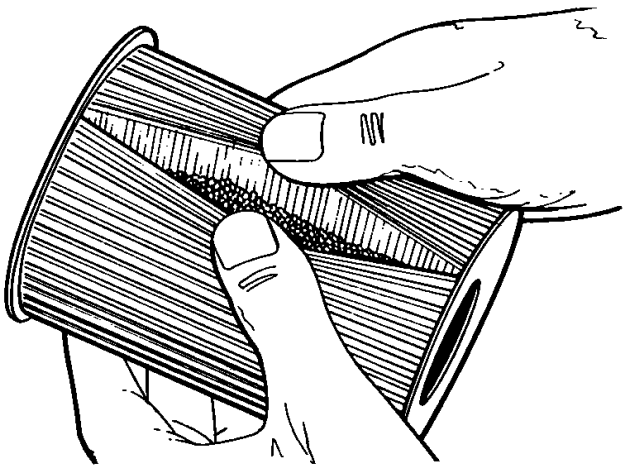


Illustration 51 g00588944
Element with debris

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 52 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, “Refill Capacities and Recommendations” topic for more information about selecting the correct engine oil and finding the correct refill capacity for your engine. Fill the crankcase with the proper amount of oil.

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 “ENGINE STOPPED” side of the oil level gauge.

5. Remove the “DO NOT OPERATE” tag from the ignition keyswitch.

Adjustments to the Oil Change Intervals

Many conditions affect the selection of an oil change interval. Proper oil change intervals are important for maintaining engine service life and engine performance and fully utilizing the lubricant. The engine oil must be able to control the following items: corrosion, oxidation, soot, and wear metals. The engine oil must be able to control the conditions during the time between oil changes.

In some severe service applications, reducing the oil change interval may be necessary in order to maintain the integrity of the engine lubricant. Refer to this Operation and Maintenance Manual, “Severe Service Operation - Check” or consult with your Cat dealer in order to determine whether your engine is operating under severe service conditions.

Fuel consumption and oil consumption are the most important factors that are used in order to calculate an oil change interval. All engines do not consume fuel and oil at the same rate due to several factors: manufacturing tolerances, maintenance variations, and engine application.

Extended Oil Change Intervals

Note: The following requirements must be met in order to use table 18. :

- Cat DEO-ULS is used or an oil that meets the requirements of the Caterpillar ECF-3 (Engine Crankcase Fluid specification-3) specification is used.
- S·O·S Services oil analysis is performed at 16,100 km (10,000 mile) intervals and all oil change intervals. The S·O·S Services lab must be notified of the extended oil change interval. The use of an extended oil change interval makes a difference in the interpretation of the data.
- A Cat Advanced Efficiency oil filter is used.
- A Cat Advanced Efficiency 4 micron(c) absolute or less fuel filter is used.
- Fuel with 0.015% (15 ppm) or less sulfur is used.

NOTICE
Contact your Caterpillar dealer for more information about extended oil change intervals.

Note: Caterpillar cannot guarantee the performance of lubricants or filters that are not sold by Caterpillar. The performance guarantee of any commercially available lubricant is the responsibility of that oil company. The performance guarantee of any commercially available filter is the responsibility of the filter manufacturer.

Table for Extended Oil Change Intervals

In order to understand the tables for maximum permissible oil change intervals, use the following procedures.

1. Determine your type of vehicle application. Locate the column which lists your type of vehicle application.

2. Determine your available oil in liters or quarts. The oil quantity equals the sum of the capacities of the oil sump and the oil filter. Locate the row which lists your available oil.

3. The intersection of the column and the row lists the maximum permissible number of kilometers or miles between oil change intervals.

Table 18

Maximum Permissible Oil Change Intervals				
Engine Model	**Vehicle Applications**			
	Light Duty(1)	**Medium Duty(2)**	**Heavy Duty(3)**	**Severe Service(4)**
	KM (Miles) to Next Oil Change			
C7 Engine with a Shallow Sump 18 L (19 qt)	17380 (10800)	13905 (8640)	10430 (6480)	6950 (4320)
C7 Engine with a Standard (Deep) Sump 25 L (26.4 qt)	24140 (15000)	19300 (12000)	14500 (9000)	9660 (6000)
C9 Engine with a Standard (Deep) Sump 30 L (31.7 qt)	30900 (19200)	24720 (15360)	18540 (11520)	12360 (7680)

(1) Typical applications are recreational vehicles and intercity delivery (average that is greater than 10 mpg).

(2) Typical applications are intracity driving (average 8 to 10 mpg).

(3) Typical applications are bus services and pickup and/or delivery services (5 to 7 mpg).

(4) Refer to the Operation and Maintenance Manual, “Severe Service Application - Check” for the requirements (4 mpg or less).

For more information on optimizing oil change intervals, see your Caterpillar dealer.

i01458399

Engine Storage Procedure - Check

SMCS Code: 1000-535

The oil change interval may be extended to 12 months for a vehicle that is operated seasonally and placed in storage for the remainder of the year by using the required storage procedures and the required start-up procedures. This extension is permitted if the following categories for oil change intervals in the Operation and Maintenance Manual, “Maintenance Interval Schedule” have not been reached:

- Mileage
- Operating hours
- Fuel consumption

If an engine is out of operation and if use of the engine is not planned, special precautions should be made. If the engine will be stored for more than three months, a complete protection procedure is recommended. For more detailed information on engine storage, see Special Instruction, SEHS9031, “Storage Procedure For Caterpillar Products”.

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder liner surface. Rust on the cylinder liner surface will cause increased engine wear and a reduction in engine service life. Caterpillar recommends the use of volatile corrosion inhibitor (VCI) oil in order to prevent internal engine damage due to moisture during storage. These inhibitors in the VCI oil act by evaporating inside the engine. The inhibitors then condense over the inside surfaces of the engine. The evaporation process and the condensing process offers full protection to surfaces that cannot be reached with preservatives. 0.9 L (1.0 qt) of 4C-6792 VCI oil will treat 28.4 L (30.0 qt) of engine oil. This will give a 3 percent concentration of VCI oil. The engine must be completely sealed when the engine is stored in order for the VCI oil to function properly. The VCI oil is easily cleaned from the engine when you remove the engine from storage. The volatile vapors are removed by simply running the engine to operating temperature. A mineral oil base is left behind after the volatile vapors are removed.

i00869628

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 adjustment is necessary due to the initial wear of the valve train components and to the 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.

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.

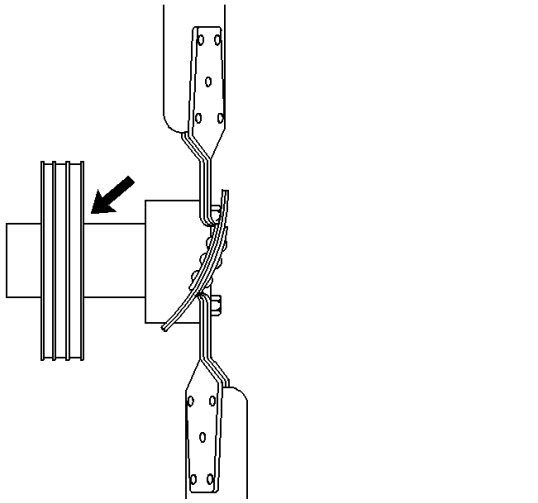
Ensure that the engine is stopped before measuring the valve lash. To obtain an accurate measurement, allow the valves to cool before this maintenance is performed.

Refer to the Service Manual for more information.

i01771215

Fan Drive Bearing - Lubricate

SMCS Code: 1359-086-BD



g00746166

Illustration 53

Typical location of the grease fitting that is for the fan drive bearing

The belt guards have been removed in this illustration.

Note: In some applications, the fan drives are supplied by the OEM. Refer to the OEM specifications if the fan drive is not supplied by Caterpillar.

Lubricate the grease fitting that is on the fan drive bearing with Bearing Lubricant or the equivalent.

Inspect the fan drive pulley assembly for wear or for damage. If the shaft is loose, an inspection of the internal components should be performed. Refer to the Service Manual for additional information.

i02686443

Fuel System - Prime

SMCS Code: 1258-548

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

⚠ 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 any disconnected fuel system components.

Refer to this Operation and Maintenance Manual , “General Hazard Information” before any adjustments or repairs are performed. Refer to this Operation and Maintenance Manual, “High Pressure Fuel Lines” before any adjustments or repairs are performed.

Ensure that all adjustments and repairs are performed by authorized personnel that have had the correct training.

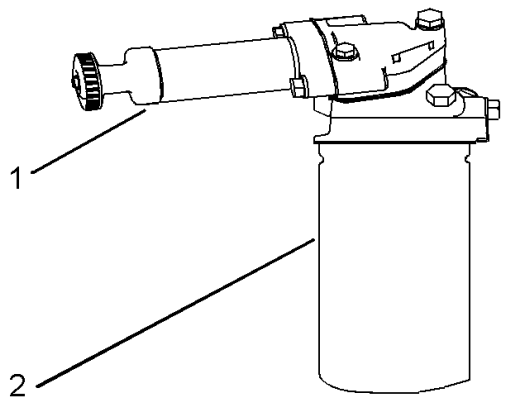
After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, “Fuel Injection Lines - Install”.

The fuel system should be primed under the following conditions:

- The fuel tank is empty or the fuel tank has been partially drained.
- The engine has been in storage.
- The fuel filter has been replaced.
- The low pressure fuel lines have been disconnected.

Engines that are Equipped with a Fuel Priming Pump

NOTICE
Do not loosen the fuel lines at the fuel manifold. The fittings may be damaged and/or a loss of priming pressure may occur when the fuel lines are loosened.



g01327092

Illustration 54

Secondary fuel filter and optional fuel priming pump

(1) Fuel priming pump
(2) Secondary fuel filter

1. Check that the fuel supply valve (if equipped) is in the “ON” position.

2. Open the fuel priming pump and operate the fuel priming pump until a strong pressure is felt. This procedure will require considerable strokes. Lock the fuel priming pump.

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. Promptly start the engine. If the engine runs rough, continue to operate the engine at low idle. Do not raise the engine rpm above an idle, until the engine operates smoothly.

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

Engines that are Not Equipped with a Fuel Priming Pump

If the engine is not equipped with a fuel priming pump, you can use the following procedures to prime the fuel system. These procedures will allow only filtered fuel to enter the fuel 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.

1. Operate the starting motor. This will fill the fuel filter and the fuel lines with fuel.

2. Once the engine starts, operate the engine at low idle. Do not raise the engine speed above an idle, until the engine operates smoothly.

i03342138

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 an electronic unit injector to fail. If the fuel has been contaminated with water, the element should be changed before the regularly scheduled interval.

Note: Caterpillar requires the use of a 10 micron(c) absolute primary fuel filter with a water separator.

⚠ 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

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 any disconnected fuel system components.

NOTICE

Do not fill the primary 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.

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” or refer to Special Publication, PECJ0003, “Caterpillar Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

Caterpillar Primary Fuel Filter and Water Separator

1. Close the main fuel supply valve.

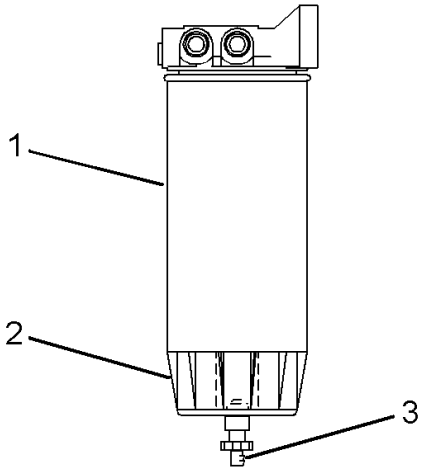


Illustration 55 g01453091

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

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. If necessary, replace the old O-ring with a new O-ring.

5. Lubricate the O-ring with clean diesel fuel. Place the lubricated O-ring into the gland of the bowl.

6. Install bowl (2) on a new element. Tighten the bowl by hand. Do not use tools in order to tighten the bowl.

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. 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.

Primary Fuel Filter and Water Separator which are Provided by an OEM

1. Close the main fuel supply valve.
2. In order to replace the primary fuel filter, use the instructions which are provided by the OEM.
3. Open the main fuel supply valve.
4. 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.

i03365140

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.

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” or refer to Special Publication, PECJ0003, “Caterpillar Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

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 any disconnected fuel system components.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

1. Stop the engine. Turn the ignition switch to the OFF position or disconnect the battery. Refer to the Operation and Maintenance Manual, “Battery or Battery Cable - Disconnect” topic (Maintenance Section) for more information. Shut off the fuel supply valve (if equipped).

2. Clean the outside of the fuel filter. Remove the used fuel filter and discard the used fuel filter.

3. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is completely removed.

NOTICE

In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Caterpillar Diesel Engines that are equipped with unit injected fuel systems. Note that all current Caterpillar Diesel Engines are factory equipped with Caterpillar Advanced Efficiency 4 micron(c) absolute fuel filters.

Caterpillar does not warrant the quality or performance of non-Caterpillar fluids and filters.

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.

4. Apply clean diesel fuel to the gasket that is located on the new fuel filter.

5. Install the new fuel filter. Spin the fuel filter onto the fuel filter base until the gasket contacts the base. Instructions for the installation of the filter are printed on the side of each Caterpillar spin-on filter. For non-Caterpillar filters, refer to the installation instructions that are provided by the supplier of the filter.

6. Open the fuel supply valve. Prime the fuel system. Refer to the Operation and Maintenance Manual, “Fuel System - Prime” topic (Maintenance Section) for more information.

7. Turn on the ignition or reconnect the battery cable. Start the engine and inspect the fuel system for leaks.

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.

i03009440

Fuel System Water Separator - Check/Drain

SMCS Code: 1263-535; 1263-543

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” or refer to Special Publication, PECJ0003, “Caterpillar Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

Drain any water from the water separator daily.

For more information on the checking and draining procedures for the water separator, refer to the literature that is provided by the OEM of the vehicle, or refer to the literature that is provided by the OEM of the water separator.

i03071053

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” or refer to Special Publication, PECJ0003, “Caterpillar Shop Supplies and Tools 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 four micron(c) absolute 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.

i02357283

Hoses and Clamps - Inspect/Replace

SMCS Code: 7554-040; 7554-510

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

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.

i02559063

Radiator - Clean

SMCS Code: 1353-070

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the radiator, if necessary.

⚠ 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.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a “comb”. Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

For more detailed information on cleaning and inspection, refer to Special Publication, SEBD0518, “Know Your Cooling System”.

i03196558

Severe Service Application - Check

SMCS Code: 1000-535

Operation and maintenance practices affect the service life of the components when the engine is operated in severe service applications.

The following factors are crucial to the service life of the engine:

- The level of maintenance
- Operating speeds
- Operating loads
- Gross vehicle weights

Reduce the maintenance intervals for engines that operate in severe service applications.

An application is a severe service application if any of the following conditions apply:

- The weight is higher than the weight that is listed in the table.
- The average mpg is less than the mpg listed in the table.
- The average kilometer per liter is less than the kilometer per liter listed in the table.

Table 19

Severe Service Applications (1)(2)				
Engine Model	Gross Vehicle Weight	Average Miles per Gallon	Average Kilometer per Liter	Average liters per 100 km
C7 On-highway Engine	22680 kg (50000 lb)	10	4.3	23.5
C9 On-highway Engine	27215 kg (60000 lb)	8	3.4	29.4
C9 On-highway Engine (Urban transit bus application)(3)	27215 kg (60000 lb)	4	1.7	58.8
C13 On-highway Engine	36287 kg (80000 lb)	6	2.6	39.2
C15 On-highway Engine	36287 kg (80000 lb)	5	2.1	47

(1) An engine is operating in a severe service application when the gross operating weight is higher than the gross operating weight in this table.

(2) An engine is operating in a severe service application when the fuel consumption is greater than the fuel consumption in this table.

(3) An engine for an urban transit bus generally operates in severe service conditions..

- Frequent low speed operation (less than 20 Miles per Hour)
- Use of fuel with more than 15 ppm sulfur
- No water separator

- Frequent operation in dusty conditions or off-highway operation
- Off-highway operation
- Frequent high altitude operation above 1525 m (5000 ft)
- Extreme ambient temperature conditions that may cause the lubricating properties of the fuel to diminish
- Frequent plugging of the fuel filter
- Extended maintenance intervals of the fuel system
- Inadequate maintenance of fuel storage tanks (excessive water, sediment, microorganism growth, etc.)
- Extending maintenance beyond the recommended maintenance intervals
- Use of fuels, coolants or lubricants that are not specified by Caterpillar in Special Publication, SEBU6385, “Caterpillar On-highway Diesel Truck Engine Fluids Recommendations”
- Frequent operation at low idle (more than 20%)
- Frequent cold starts at temperatures below −18 °C (0 °F)
- Frequent dry starting (starting after more than 3 days of shutdown)
- Frequent hot shutdowns (minimum five minute cool down periods after high load factor operation)
- If the engine is stored over 3 months, see Special Instruction, SEHS9031, “Storage Procedure for Caterpillar Products”.

For additional information about severe service applications, consult 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.

i03008672

Turbocharger - Inspect

SMCS Code: 1052-040; 1052

⚠ WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

⚠ WARNING

Personal injury can result from rotating and moving parts.

Stay clear of all rotating and moving parts.

Never attempt adjustments while the machine is moving or the engine is running unless otherwise specified.

The machine must be parked on a level surface and the engine stopped.

A risk of corrosion exists for the compressor side of the turbocharger if ultralow sulfur diesel fuel is not used. A risk of corrosion exists for the compressor side of the turbocharger if unfiltered air intake occurs.

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. A failed turbocharger can cause damage to the diesel particulate filter.

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Refer to Special Publication, NENG2500, “Caterpillar 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.

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. Inspect the bore of the turbine housing for corrosion.

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

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

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Walk-Around Inspection

SMCS Code: 1000-040

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.

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.

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.

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. If it is necessary, make repairs or correct fluid levels.

- 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.
- Check the cooling system coolant level. Ensure that the cooling lines are properly clamped and that the cooling lines are tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pumps for coolant leaks. 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.
- Check the engine oil level. 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 or for loose tie-wraps around fuel lines.

- Check the water separator (if equipped) for water on a daily basis. Drain any water from the water separator. If necessary, drain the water and the sediment from fuel tanks in order to ensure that only clean fuel enters the fuel system.

- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps. Ensure that hoses and tubes are not contacting other hoses, tubes, wiring harnesses, etc. Check the air cleaner service indicator (if equipped).

- 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.

- 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 that are cracked. Replace any gauge that can not be calibrated.

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Water Pump - Inspect

SMCS Code: 1361-040; 1361

Overconcentration of coolant additive (conditioner), mineral deposits from hard water, or cooling system contamination can accelerate the wear on the water pump seal.

Replace the Water Pump Seal, If Necessary

Inspect the water pump for leaks. 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.

Removal and Installation

Refer to the Service Manual for more information on the removal and installation of the water pump, or consult your Caterpillar dealer for assistance.

Inspect the Bearing for the Water Pump Pulley

Inspect the water pump pulley for unusual noise, excessive looseness and/or vibration of the bearings.

Refer to the Service Manual for more information on the removal and installation of the water pump pulley, or consult your Caterpillar dealer for assistance.