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# **3406E, C-10, C-12, C-15, and C-16 ON-HIGHWAY ENGINES**

**Maintenance Intervals**

Excerpted from Operation & Maintenance Manual (SEBU7186-08-01)

## Maintenance Interval Schedule (3406E , C-15 , and C-16 Truck Engines)

**SMCS Code:** 1000; 7500

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

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

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

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

### When Required

Battery - Replace .....	139
Battery or Battery Cable - Disconnect .....	142
Engine Air Cleaner Element - Clean/Replace .....	173
Engine Oil Level Gauge - Calibrate .....	180
Engine Oil Level Gauge - Calibrate .....	183
Fuel System - Prime .....	196
Severe Service Application - Check .....	217

### Daily

Cooling System Coolant Level - Check .....	159
Engine Air Cleaner Service Indicator - Inspect .....	173
Engine Oil Level - Check .....	176
Fuel System Primary Filter/Water Separator - Drain .....	206
Fuel System Water Separator - Drain .....	210
Walk-Around Inspection .....	220

**PM Level 1 - Every 24 000 km (15 000 miles) or 9500 L (2500 US gal) of Fuel or 300 Service Hours**

Air Compressor Filter - Clean/Replace .....	138
Alternator - Inspect .....	138
Battery Electrolyte Level - Check .....	141
Belt - Inspect .....	142
Belt Tensioner - Inspect .....	145
Cooling System Supplemental Coolant Additive (SCA) - Test/Add .....	163
Cylinder Head Grounding Stud - Inspect/Clean/Tighten .....	169
Engine Crankcase Breather - Clean .....	175
Engine Oil Sample - Obtain .....	185
Engine Oil and Filter - Change .....	186
Fuel System Primary Filter - Clean/Replace .....	204
Fuel System Secondary Filter - Replace .....	208
Fuel Tank Water and Sediment - Drain .....	211
Hoses and Clamps - Inspect/Replace .....	213

**Every 250 Service Hours**

Cooling System Coolant Sample (Level 1) - Obtain .....	160
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**Between 24 000 and 96 000 km (15 000 and 60 000 miles) (Between the First and Fourth Oil Change)**

Compression Brake - Inspect/Adjust .....	146
Electronic Unit Injector - Inspect/Adjust .....	171
Engine Valve Lash - Inspect/Adjust .....	194

**PM Level 2 - Every 320 000 km (200 000 miles) or 125 000 L (33 000 US gal) of Fuel or 4000 Service Hours or 2 Years**

Aftercooler Core - Clean/Test .....	135
Cooling System Coolant (DEAC) - Change .....	150
Cooling System Water Temperature Regulator - Replace .....	166
Fan Drive Bearing - Lubricate .....	195
Radiator - Clean .....	215

**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**

Air Compressor - Inspect .....	136
Compression Brake - Inspect/Adjust/Replace .....	148
Crankshaft Vibration Damper - Inspect .....	168
Electronic Unit Injector - Inspect/Adjust .....	171
Engine - Clean .....	172

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Engine Valve Lash - Inspect/Adjust .....	194
Turbocharger - Inspect .....	218

**Every Year**

Cooling System Coolant Sample (Level 2) - Obtain .....	163
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**Every 483 000 km (300 000 miles) or 3 Years**

Cooling System Coolant Extender (ELC) - Add .....	157
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**Every 966 000 km (600 000 miles) or 6 Years**

Cooling System Coolant (ELC) - Change .....	154
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**PM Level 4 - Every 966 000 km (600 000 miles) or 380 000 L (100 000 US gal) of Fuel or 12 000 Service Hours or 6 Years**

Compression Brake - Inspect/Adjust/Replace .....	148
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## Aftercooler Core - Clean/Test (Air-To-Air Aftercooler)

**SMCS Code:** 1064-070; 1064-081

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

Inspect the cooling air side of the aftercooler for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the cooling air side of the aftercooler, if necessary.

For air-to-air aftercoolers, use the same methods that are used for cleaning the outside of radiators.



### **WARNING**

**Personal injury can result from air pressure.**

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

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

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.

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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”.

**Note:** If parts of the aftercooler system are repaired or replaced, a leak test is highly recommended. The FT1984 Aftercooler Testing Group is used to perform leak tests on the aftercooler. Refer to the Systems Operation/Testing and Adjusting, “Aftercooler - Test” and the Special Instruction, SEHS8622 for the proper testing procedure.

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, see Special Publication, SEBD0518, “Know Your Cooling System”.

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## 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.**

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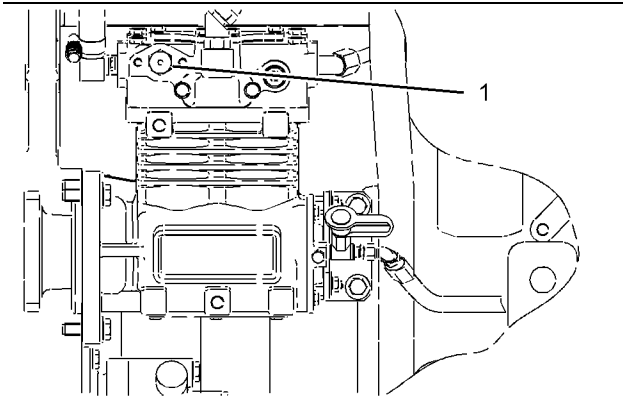


Illustration 45

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(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 air compressor system.

The pressure relief valve releases air at 1723 kPa (250 psi). Do not stand near the pressure relief valve. Compressed air may be released without warning. 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.

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## Air Compressor Filter - Clean/Replace

**SMCS Code:** 1803-070-FQ; 1803-510-FQ

One of the single most important aspects of preventive maintenance for the air compressor is the induction of clean air. The type of maintenance that is required for the air compressor and the maintenance interval depends on the type of air induction system that is used. Operating conditions (dust, dirt and debris) may require more frequent service.

Refer to the Service Manual for the type of air compressor that is installed on the engine. Follow the maintenance recommendations that are provided by the OEM of the air compressor. Some engines use boost air pressure so the engine air cleaner will require servicing.

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## 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.

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## 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.

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**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.

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## 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.

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## Battery or Battery Cable - Disconnect

SMCS Code: 1402-029

### **WARNING**

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

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

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

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## Belt - Inspect

SMCS Code: 1357-040; 1357; 1397-040; 1397

### Inspection

**Belt tension should be checked initially between the first 20 to 40 hours of engine operation.**

After the initial check, the belt tension should be checked at Every PM Level 1 or Three Months.

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To maximize the engine performance, inspect the belts for wear and for cracking. Replace belts that are worn or damaged.

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

If the belts are too loose, vibration causes unnecessary wear on the belts and pulleys. Loose belts may slip enough to cause overheating.

If the belts are too tight, unnecessary stresses are placed on the pulley bearings and on the belts. This may shorten the service life of the components.

Remove the belt guard. Inspect the condition and adjustment of the alternator belts and accessory drive belts (if equipped).

To check the belt tension, apply 110 N (25 lb ft) of force midway between the pulleys. A correctly adjusted belt will deflect 9 mm (0.35 inch) to 15 mm (0.59 inch).

If the belt does not require replacement or adjustment, install the belt guard. If the belt requires adjustment or replacement, perform the following procedure to adjust the belt tension.

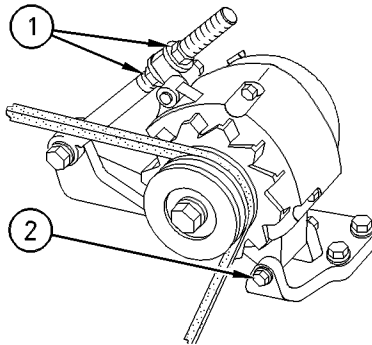
- If the engine is equipped with a refrigerant compressor (air conditioner), the belt for the fan drive, the alternator, and the accessories will have an automatic belt tensioner.
- If the engine is not equipped with a refrigerant compressor, the alternator is used to adjust the belt tension.

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## Adjustment

### Alternator Belt

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Illustration 46

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Typical alternator mounting

- (1) Adjusting nuts
- (2) Mounting bolts

1. Slightly loosen mounting bolt (2) and adjusting nut (1).
2. Move the pulley in order to adjust the belt tension.
3. Tighten adjusting nuts (1) and mounting bolts (2). Refer to the Specifications, SENR3130 in order to locate the proper torques.
4. Install the belt guard.

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

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## Belt Tensioner - Inspect

**SMCS Code:** 1358-040

It is essential to check the position of the belt tightener in order to maintain the proper belt tension. A film (decal) is located on the side of the belt tightener. The decal indicates when the belts have stretched beyond the belt tightener's ability.

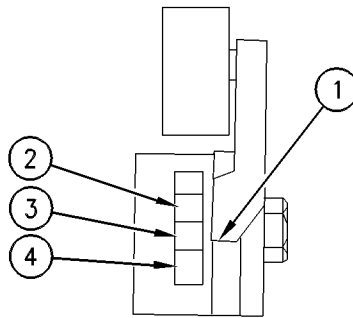


Illustration 47

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Side view of the belt tensioner

- (1) Indicator
- (2) Upper red zone
- (3) Green zone
- (4) Lower red zone

If the pointer (1) is in green zone (3), the belt tension is correct. If the pointer (1) is in the upper red zone (2), the belt has stretched. The tension must be adjusted or the belt must be replaced. If the pointer (1) is in the lower red zone (4), the belt is too short. The belt must be replaced.

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## Compression Brake - Inspect/Adjust

**SMCS Code:** 1119-025; 1119-040

The maintenance of the compression brake should be performed in conjunction with scheduled engine maintenance. The correct tune-up kit is required when parts are replaced on the compression brake. Refer to the Parts Manual for additional information.

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

Table 17

<b>Component</b>	<b>Required Maintenance</b>
Wiring and Terminal Connections	Inspect
Clutch/Throttle/Buffer Screw	Adjust
Slave Piston Lash Adjusting Screw	Adjust/Inspect
Solenoid Valves	Inspect
Crosshead Bridges/Valve Stem Caps	Inspect
Injector/Exhaust Rocker Arm Screws	Inspect
Master Piston/Fork Assembly	Inspect
Slave pistons	Inspect
External Hose Assembly	Inspect
Housings	Inspect
Fuel Pipes	Inspect
Hold Down Bolts	Inspect
Accumulator Springs <sup>(1)</sup>	Inspect
Solenoid Harness <sup>(1)</sup>	Inspect
Solenoid Seal Rings <sup>(1)</sup>	Inspect
Control Valve Springs <sup>(1)</sup>	Inspect
Control Valves <sup>(1)</sup>	Inspect
Oil Seal Rings <sup>(1)</sup>	Inspect
Master Piston Return Springs <sup>(1)</sup>	Inspect
Terminal Lead Out <sup>(1)</sup>	Inspect
Crosshead Pin Assembly <sup>(1)</sup>	Inspect

<sup>(1)</sup> Contained in tune-up kits

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## Compression Brake - Inspect/Adjust/Replace

**SMCS Code:** 1119-025; 1119-040; 1119-510

The maintenance of the compression brake should be performed in conjunction with scheduled engine maintenance. The correct tune-up kit is required when parts are replaced on the compression brake. Refer to the Parts Manual for additional information.

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

Refer to the Disassembly and Assembly Module for instructions on replacing the components.

Table 18

<b>Component</b>	<b>Required Maintenance (300,000 miles)</b>	<b>Required Maintenance (600,000 miles)</b>
Wiring and Terminal Connections	Inspect	Inspect
Clutch/Throttle/Buffer Screw	Adjust/Replace	Adjust/Replace
Slave Piston Lash Adjusting Screw	Adjust/Inspect	Adjust/Replace
Solenoid Valves	Inspect	Replace
Crosshead Bridges/ Valve Stem Caps	Inspect	Inspect
Injector/Exhaust Rocker Arm Screws	Inspect	Inspect
Master Piston/Fork Assembly	Inspect	Inspect
Slave pistons	Inspect	Inspect
External Hose Assembly	Inspect	Inspect
Housings	Inspect	Inspect
Fuel Pipes	Inspect	Inspect
Hold Down Bolts	Inspect	Replace
Accumulator Springs <sup>(1)</sup>	Replace	Inspect
Solenoid Harness <sup>(1)</sup>	Replace	Inspect
Solenoid Seal Rings <sup>(1)</sup>	Replace	Inspect
Control Valve Springs <sup>(1)</sup>	Replace	Inspect
Control Valves <sup>(1)</sup>	Replace	Inspect
Oil Seal Rings <sup>(1)</sup>	Replace	Inspect
Master Piston Return Springs <sup>(1)</sup>	Replace	Inspect
Terminal Lead Out <sup>(1)</sup>	Replace	Inspect
Crosshead Pin Assembly <sup>(1)</sup>	Replace	Inspect

<sup>(1)</sup> Contained in tune-up kits

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## 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.

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### 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.

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**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.**

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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.

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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.

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#### 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.

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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.

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#### NOTICE

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

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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).

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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.

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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.

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NOTICE

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

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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).

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#### 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.

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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

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#### NOTICE

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

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1. Fill the cooling system with coolant/antifreeze. Refer to the Operation and Maintenance Manual, "Refill Capacities 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.

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## 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.

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## 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.**

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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.

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### 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.

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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.

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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".

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**NOTICE**

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

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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

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**NOTICE**

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

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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. 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. 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, 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.

i02482066

## Cooling System Coolant Extender (ELC) - Add

**SMCS Code:** 1352-045; 1395-081

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

---

### NOTICE

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

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

---

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

---

 **WARNING**

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

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

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

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

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

---

**NOTICE**

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

Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

---

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. It may be necessary to drain enough coolant from the cooling system in order to add the Cat ELC Extender.

3. Add Cat ELC Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" article for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i01197583

## Cooling System Coolant Level - Check

**SMCS Code:** 1395-082

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

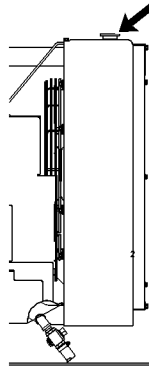


Illustration 48

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.

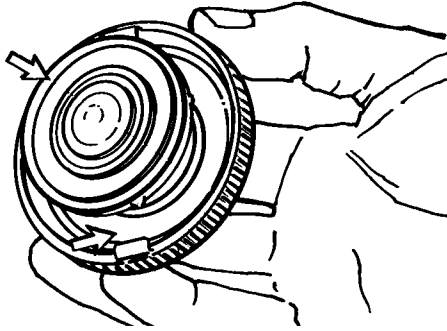


Illustration 49  
Typical filler cap gaskets

g00103639

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.

i02603581

## Cooling System Coolant Sample (Level 1) - Obtain

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

**Note: Obtaining a Coolant Sample (Level 1) is optional if the cooling system is filled with Cat ELC (Extended Life Coolant).** Cooling systems that are filled with Cat ELC should have a Coolant Sample (Level 2) that is obtained at the recommended interval that is stated in the Maintenance Interval Schedule.

**Note: Obtain a Coolant Sample (Level 1) if the cooling system is filled with any other coolant instead of Cat ELC.** This includes the following types of coolants:

- Commercial long life coolants that meet the Caterpillar Engine Coolant Specification -1 (Caterpillar EC-1)
- Cat DEAC (Diesel Engine Antifreeze/Coolant)
- Commercial heavy-duty coolant/antifreeze

Table 19

Recommended Interval		
Type of Coolant	Level 1	Level 2
Cat DEAC	Every 250 Hours <sup>(1)</sup>	Yearly <sup>(1)(2)</sup>
Cat ELC	Optional <sup>(2)</sup>	Yearly <sup>(2)</sup>

(1) This is the recommended interval for coolant samples for all conventional heavy-duty coolant/antifreeze. This is also the recommended interval for coolant samples of commercial coolants that meet the Cat EC-1 specification for engine coolant.

(2) The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

---

#### 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.

---

#### 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.

Submit the sample for Level 1 analysis.

For additional information about coolant analysis, see Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" or consult your Caterpillar dealer.

i01987714

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## Cooling System Coolant Sample (Level 2) - Obtain

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

---

### 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 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, SEBU6251, "Caterpillar Commercial Diesel Engines Fluids Recommendations" or consult your Caterpillar dealer.

i02440893

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

**SMCS Code:** 1352-045; 1395-081

---

### 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 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 8T-5296 Coolant Conditioner Test Kit or use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA. See Special Publication, SEBU6385, "Caterpillar On-highway Diesel Truck Engine Fluids Recommendations" for more information.

## S·O·S Coolant Analysis

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

### Level I

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

- Glycol Concentration
- Concentration of SCA
- pH
- Conductivity

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

---

## Add the SCA, If Necessary

---

### NOTICE

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

---



### WARNING

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

---

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

**Note:** Always discard drained fluids according to local regulations.

2. If necessary, drain some coolant from the cooling system into a suitable container in order to allow space for the extra SCA.
3. Add the proper amount of SCA. Refer to Operation and Maintenance Manual, SEBU6385, "Caterpillar On-highway Diesel Truck Engines Fluids Recommendations" for more information on SCA requirements.
4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.

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.

---

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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.

---

## 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 difficult to remove from surfaces.

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 Service Manual or consult your Caterpillar dealer for information about damper replacement.

i01167013

# Cylinder Head Grounding Stud - Inspect/Clean/Tighten

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

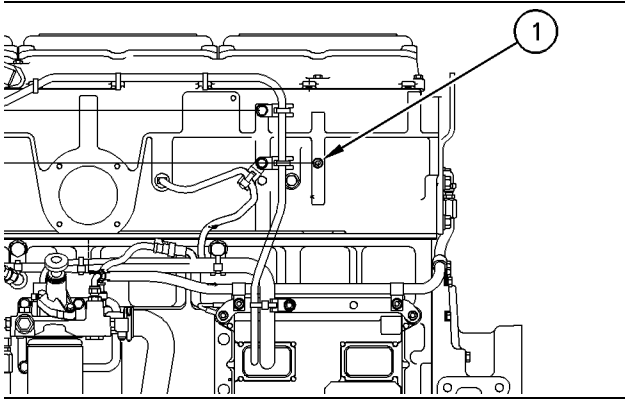


Illustration 50

g00471796

(1) 3406E cylinder head ground stud

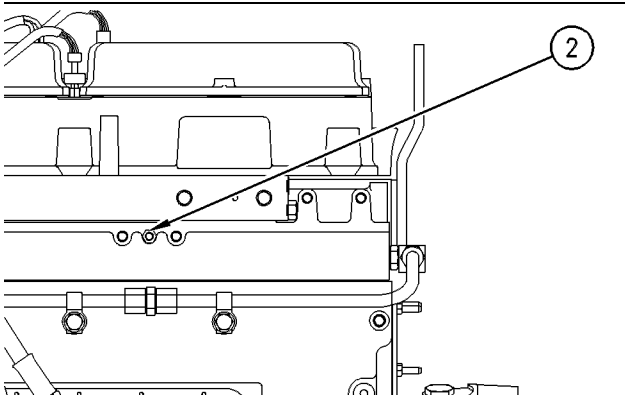


Illustration 51

g00471797

(2) C-10 and C-12 cylinder head ground stud

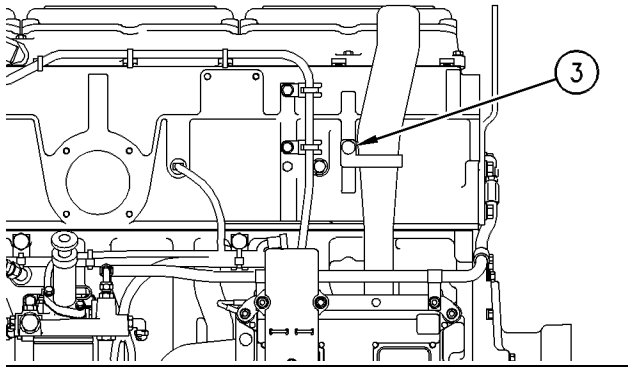


Illustration 52

g00621928

(3) C-15 and C-16 cylinder head ground stud

Inspect the OEM vehicle wiring harness for the following conditions:

- Connections that are loose or disconnected
- Mounting hardware that is missing
- Insulation that is chafed or cut
- Wires that are bare

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.

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

i01117091

## Electronic Unit Injector - Inspect/Adjust

**SMCS Code:** 1251-025; 1251-040; 1290-025; 1290-040



### **WARNING**

**Be sure the engine cannot be started while this maintenance is being performed. To 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 the unit injectors.**

**The electronic unit injectors use high voltage. Disconnect the unit injector enable circuit connector in order to prevent personal injury. Do not come in contact with the injector terminals while the engine is running.**

---

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

---

## 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.

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)

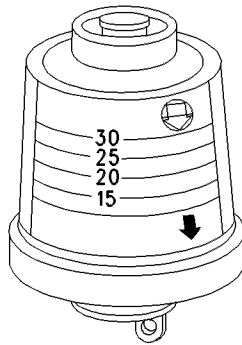
**SMCS Code:** 7452-040

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.

---



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Illustration 53

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).

i01848984

## Engine Crankcase Breather - Clean

**SMCS Code:** 1317-070

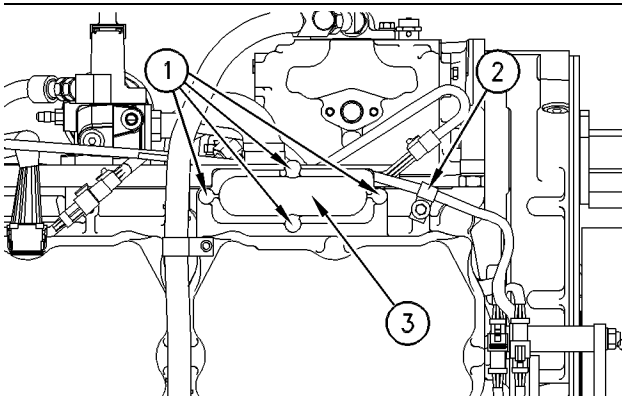


Illustration 54

g00485291

(1) Bolts. (2) Hose clamp. (3) Breather cover.

### NOTICE

Perform this maintenance with the engine stopped.

---

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

1. Loosen hose clamp (2) and remove the hose from breather cover (3).
2. Loosen four bolts (1) for the breather cover and remove breather cover (3).
3. Remove the breather element and wash the breather element in solvent that is clean and nonflammable. Allow the breather element to dry.
4. Install a breather element that is clean and dry. Install breather cover (3) and install bolts (1). Refer to the Specifications, SENR3130 in order to locate the proper torques.
5. Install the hose. Install hose clamp (2). Refer to the Specifications, SENR3130 in order to locate the proper torques.

i01167360

## 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.**

---

**Note:** The location of the oil level gauge and the oil filler cap will vary with the truck model.

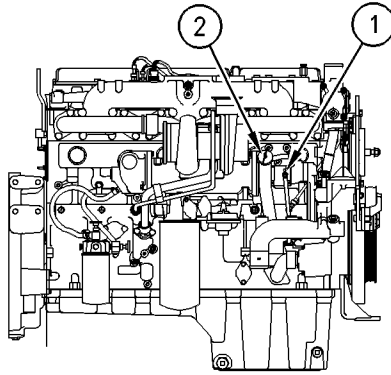


Illustration 55  
C-10 and C-12 truck engines  
(1) Oil level gauge  
(2) Oil filler cap

g00471626

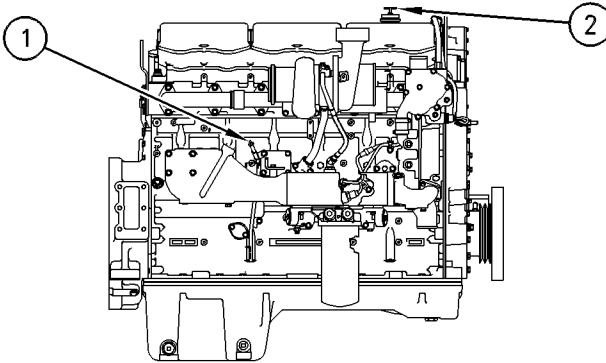


Illustration 56  
3406E truck engine  
(1) Oil level gauge  
(2) Oil filler cap

g00471622

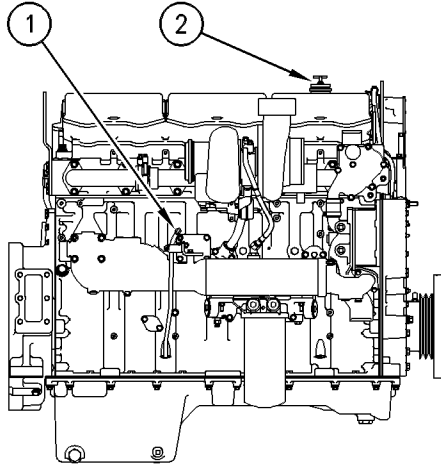


Illustration 57  
C-15 and C-16 truck engines  
(1) Oil level gauge  
(2) Oil filler cap

g00622328

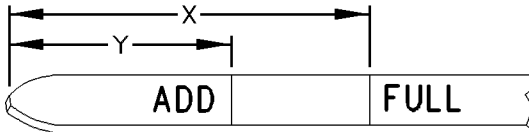


Illustration 58  
(Y) "ADD" mark  
(X) "FULL" mark

g00110310

**NOTICE**

Perform this maintenance with the engine stopped.

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 enable 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 of the pistons, oil blowing out of the crankcase breathers, and excessive oil consumption.

Excessive oil consumption will enable 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, see this Operation and Maintenance Manual, “Engine Oil” topic (Maintenance Section). 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.

i01534821

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## Engine Oil Level Gauge - Calibrate (3406E, C-15 and C-16 Truck Engines Only)

**SMCS Code:** 1326-524

**S/N:** EGH1-Up

**S/N:** 1MM1-Up

**S/N:** 2WS1-Up

**S/N:** 6NZ1-Up

**S/N:** 7CZ1-Up

**S/N:** 9NZ1-Up

### 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.

---

#### NOTICE

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

---

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:



#### **WARNING**

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

---

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. The oil drain plug from the shallow portion of the oil pan should be removed. This will allow all of the oil to drain. The control valve must also be drained on engines equipped with a BrakeSaver. 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 the oil drain plugs to a torque of  $70 \pm 15$  N·m ( $50 \pm 11$  lb ft).

Table 20

<b>3406E, C-15 and C-16 Oil Volumes for Engine Oil Level Gauge Calibration</b>				
<b>Engine</b>	<b>“ADD” Mark<sup>(1)</sup></b>	<b>“FULL” Mark<sup>(1)</sup></b>	<b>ADDITIONAL<sup>(2)</sup></b>	<b>TOTAL Fill</b>
3406E, C-15 and C-16	26.5 L (28 qt)	5.7 L (6 qt)	5.7 L (6 qt)	37.8 L (40 qt)
3406E, C-15 and C-16 (Rear Sump With BrakeSaver)	20.8 L (22 qt)	5.7 L (6 qt)	11.3 L (12 qt)	37.8 L (40 qt)
3406E, C-15 and C-16 Front Sump With BrakeSaver	34 L (36 qt)	5.7 L (6 qt)	9.5 L (10 qt)	49.2 L (52 qt)

<sup>(1)</sup> Calibration is only for standard sumps. Does not include engine oil filters or other system requirements.

<sup>(2)</sup> Calibration is only for standard equipment. Does not include optional bypass filters or auxiliary 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 information on the auxiliary oil filters.

3. Locate your engine in Table 20. Pour the correct volume of oil into the crankcase. The correct volume will be found under the “ADD” Mark in the Table. 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.

4. 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.
5. Locate your engine in Table 20. Pour the correct volume of oil into the crankcase. The correct volume will be found under the “FULL” Mark in the Table. Allow enough time for the oil to drain into the crankcase.
6. 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.
7. Locate your engine in Table 20. Pour the ADDITIONAL volume of oil into the crankcase. Start the engine and run the engine enough to ensure that the lubrication system is filled. Inspect the engine for oil leaks.
8. Stop the engine and allow enough time for the oil to drain into the crankcase.
9. 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. The added oil plus the oil from the TOTAL column of Table 20 is the total oil capacity of the lubrication system. Record the total oil capacity of the lubrication system for future oil changes.

---

## Engine Oil Level Gauge - Calibrate (C-10 and C-12 Engines Only)

**SMCS Code:** 1326-524

**S/N:** CPD1-Up

**S/N:** 8YF1-Up

**S/N:** 2KS1-Up

**S/N:** 9NZ1-Up

**Note:** If it is necessary to calibrate the oil level gauge for the following engines: C-15, C-16, and 3406E, contact your Caterpillar dealer for assistance.

### 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. The oil drain plug from the shallow portion of the oil pan should be removed. This will allow all of the oil to drain. 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  $70 \pm 15$  N·m ( $50 \pm 11$  lb ft).

---

**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. Pour 26.5 L (28 qt) of oil into the crankcase. 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.
4. 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.
5. Pour 3.8 L (4 qt) of oil into the crankcase. Allow enough time for the oil to drain into the crankcase.
6. 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.

---

**NOTICE**

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

---

7. Pour an additional 3.8 L (4 qt) of oil into the crankcase. Start the engine and run the engine enough to ensure that the lubrication system is filled. Inspect the engine for oil leaks.
8. Stop the engine and allow enough time for the oil to drain into the crankcase.
9. 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. The additional oil and the 34.1 L (36 qt) of oil that was in the crankcase is the oil capacity of the lubrication system. Record the oil capacity of the lubrication system for future oil changes.

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.

i01390835

## Engine Oil and Filter - Change

**SMCS Code:** 1318-510; 1348-044



### **WARNING**

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

---

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

---

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

## Drain the Engine Oil

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



### 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.

---

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

After the engine oil has drained, the oil drain plugs should be cleaned and installed. Tighten the oil drain plugs to the proper torque. Refer to the Specifications Module, “Engine Oil Pan” topic for additional information.

---

## 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 2P - 8250 Strap Wrench.
2. Cut the oil filter open with a 4C - 5084 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 59

g00103713

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 new 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, "Lubricant Specifications" topic (Maintenance Section) for more information. Fill the crankcase with the proper amount of engine oil. Refer to the Operation and Maintenance Manual, "Refill Capacities" topic (Maintenance Section) for more information.

---

**NOTICE**

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

---

**NOTICE**

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

---

2. Start the engine and run the engine at "LOW IDLE" for two minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filter for oil leaks.
3. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.
4. Remove the oil level gauge in order to check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the oil level gauge.

## **Oil Change Intervals**

Many conditions affect the selection of an oil change interval. Some of the conditions that affect the selection of oil are listed: premium API CH-4 multigrade oil, oil analysis at 16,100 km (10,000 miles), and premium oil filters.

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.

Fuel consumption and oil consumption are the most important factors that are used in order to calculate an oil change interval.

The rate of fuel consumption is a direct result of the load factor of the engine. An engine with a high fuel consumption rate is working harder than an identical engine with a lower fuel consumption rate.

---

## Tables for Extended Oil Change Intervals

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

1. Determine the average fuel consumption of the vehicle.
2. Determine the gross vehicle weight (GVW) of the vehicle.
3. Determine the percent of idle time for the vehicle. A download of the histogram data from the ECM can provide a more accurate “percent idle time” measurement. Contact your nearest Caterpillar dealer for information on obtaining data from the ECM.
4. The intersection of the column and the row lists the maximum number of kilometers or miles between oil change intervals.

For example, a C-12 Engine with an average fuel consumption of 3 km/L (7 mpg) in a light-duty application will have a maximum permissible oil change interval of 40,250 kilometers (25,000 miles).

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

**Note:** Metric units are listed before English units.

### **The following requirements must be met in order to use Tables 21 and 22:**

- Use premium API CH-4 multigrade oil only.
- DEO Caterpillar multigrade oil is recommended.
- S-O-S Oil analysis is taken at 16,100 km (10,000 mile) intervals and all oil change intervals. The oil analysis must evaluate oil condition, wear metals and soot. Caterpillar’s Oil Analysis is preferred. Caterpillar’s Oil Analysis is the only oil analysis program with wear tables and limits for soot and oxidation, that are approved by Caterpillar.
- Use premium oil filter(s). Caterpillar 1R-0716 Oil Filter or an oil filter with equivalent performance and durability is recommended.
- Use North American low sulfur diesel fuel (0.05% sulfur).

**Note:** Caterpillar cannot guarantee the performance of lubricants or filters that are not made by Caterpillar. 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 21

<b>Maximum Permissible Oil Change Intervals for On-Highway C-10 and C-12 Engines</b>			
	<b>Severe Duty</b>	<b>Normal Duty</b>	<b>Light Duty</b>
<b>Fuel Consumption Kilometers Per Liter (Miles Per Gallon)</b>	Less than 2.6 km/L (6 MPG)	2.6 km/L (6 MPG) to 3 km/L (7 MPG)	Greater than 3 km/L (7 MPG)
<b>Gross Vehicle Weight</b>	More than 80,000 lb	80,000 lb or less	80,000 lb or less
<b>Minimum Oil Sump Capacity<sup>(1)</sup></b>	34 L (36 qt)	34 L (36 qt)	34 L (36 qt)
<b>Idle Time</b>	More than 40%	20% to 40%	Less than 20%
<b>Oil Classification</b>	API CH-4		
<b>Kilometers (Miles)</b>	24,150 kilometers (15,000 miles)	32,200 kilometers (20,000 miles)	40,250 kilometers (25,000 miles)

<sup>(1)</sup> If the oil sump capacity is greater than the oil sump capacity that is listed in Table 21, the oil change interval can be extended 1600 kilometers (1000 miles) for every 2 L (2 qt) increase in oil sump capacity.

Table 22

<b>Maximum Permissible Oil Change Intervals for On-Highway 3406E, C-15 and C-16 Engines</b>			
	<b>Severe Duty</b>	<b>Normal Duty</b>	<b>Light Duty</b>
<b>Fuel Consumption Kilometers Per Liter (Miles Per Gallon)</b>	Less than 2.3 km/L (5.5 MPG)	2.3 km/L (5.5 MPG) to 2.8 km/L (6.5 MPG)	Greater than 2.8 km/L (6.5 MPG)
<b>Gross Vehicle Weight</b>	More than 80,000 lb	80,000 lb or less	80,000 lb or less
<b>Minimum Oil Sump Capacity<sup>(1)</sup></b>	38 L (40 qt)	38 L (40 qt)	38 L (40 qt)
<b>Idle Time</b>	More than 40%	20% to 40%	Less than 20%
<b>Oil Classification</b>	API CH-4		
<b>Kilometers (Miles)</b>	32,200 kilometers (20,000 miles)	48,300 kilometers (30,000 miles)	64,350 kilometers (40,000 miles)

<sup>(1)</sup> If the oil sump capacity is greater than the oil sump capacity that is listed in Table 22, the oil change interval can be extended 1600 kilometers (1000 miles) for every 2 L (2 qt) increase in oil sump capacity.

---

## 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.

i02239650

## Fan Drive Bearing - Lubricate

**SMCS Code:** 1359-086-BD

Some of the fan drives have grease fittings and some of the fan drives do not have grease fittings. If there is no grease fitting, periodic lubrication is not required. The fan drive requires grease only if the fan drive is equipped with a zerk.

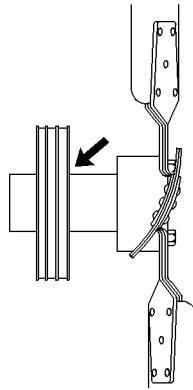


Illustration 60

g00746166

Typical location of the grease fitting (if equipped) that is for the fan drive bearing

The pulley is shown with the belt guards that have been removed.

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.

---

## Fuel System - Prime

SMCS Code: 1258-548

### C-10 and C-12 Truck Engines

#### The Secondary Fuel Filter Has Been Replaced

 **WARNING**

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

---

**NOTICE**

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

---

**NOTICE**

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

---

**Note:** Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for information on replacing the filter.

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

**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.

---

2. Start the engine. Operate the engine at 1000 to 1200 rpm until the engine runs smoothly in order to remove the residual air from the fuel system.

3. Once the engine runs smoothly, stop the engine. Turn the ignition switch to the OFF position.

**Note:** You may use the hand priming pump for the fuel filter (IF EQUIPPED) instead of starting engine and running the engine. Perform the following procedure when the hand priming pump is used:

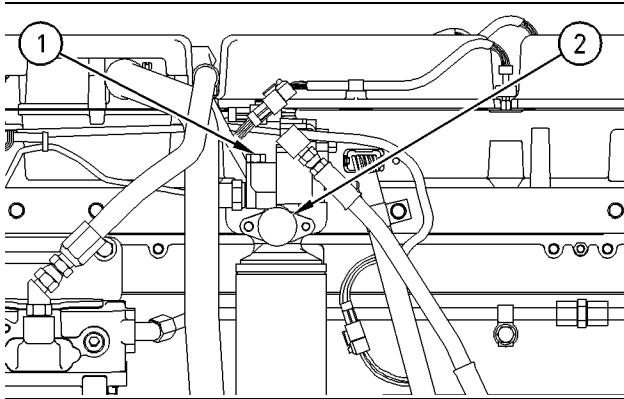


Illustration 61

g00474457

C-10 and C-12 Truck Engine

- (1) Air purge screw
- (2) Fuel priming pump (IF EQUIPPED)

- a. Open the air purge screw (1) for the fuel filter by three full turns. Do not remove the air purge screw.
- b. While you operate the hand priming pump (2), observe air purge screw (1). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (1).

**Note:** Failure to tighten all fittings could result in serious fuel leaks.

- c. Clean any residual fuel from the engine components.
- d. Continue to operate the fuel priming pump (2) until a strong resistance is felt. Listen for an audible click from the fuel manifold. The click will indicate that the valve has opened and the fuel system is pressurized. Lock the fuel priming pump (2).

---

NOTICE

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

---

- e. Crank the engine. If the engine starts but the engine runs rough, continue to operate the engine at low idle until the engine runs smoothly.

**Note:** If the engine will not start, further priming is necessary. If the engine starts but the engine continues to misfire or smoke, further priming is necessary.

## The Engine Has Been Run Out of Fuel

---

NOTICE

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

---

---

NOTICE

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

---

1. Turn the ignition switch to the "OFF" position.
2. Fill the fuel tank(s) with clean diesel fuel.

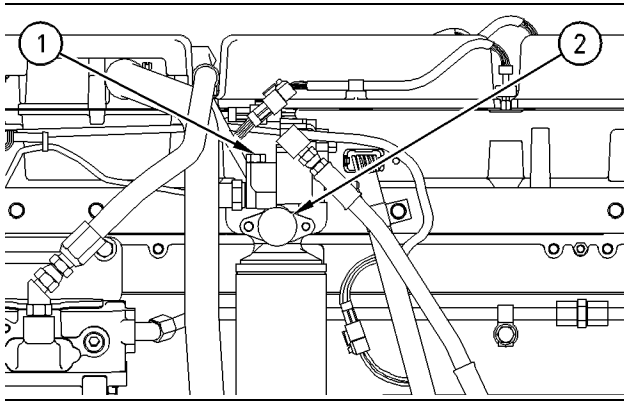


Illustration 62

g00474457

C-10 and C-12 Truck Engine

- (1) Air purge screw
- (2) Fuel priming pump (IF EQUIPPED)

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

---

#### NOTICE

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

---

4. Crank the engine for 30 seconds. Use a suitable container to catch the fuel while you crank the engine. Allow the starter motor to cool for 2 minutes.

**Note:** After four or five cranking intervals, most of the air should be purged from the system.

5. Crank the engine for 30 seconds. Allow the starter motor to cool for 2 minutes.
6. Repeat Step 5 until the engine starts and runs. If the engine runs rough, continue to operate the engine at low idle until the engine runs smoothly.
7. Observe air purge screw (1). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (1).

**Note:** Failure to tighten all fittings could result in serious fuel leaks.

8. Clean any residual fuel from the engine components.
9. Once the engine runs smoothly, stop the engine. Turn the ignition switch to the OFF position.

**Note:** You may use the hand priming pump for the fuel filter (IF EQUIPPED) instead of starting engine and running the engine. Perform the following procedure when the hand priming pump is used:

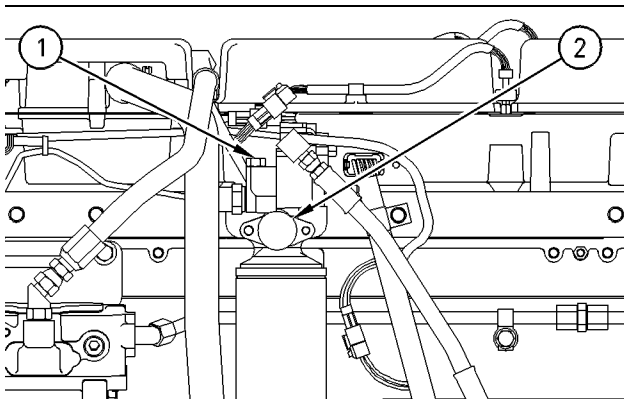


Illustration 63

g00474457

C-10 and C-12 Truck Engine

- (1) Air purge screw
- (2) Fuel priming pump (IF EQUIPPED)

- a. Open air purge screw (1) for the fuel filter by three full turns. Do not remove the air purge screw.
- b. While you operate the hand priming pump (2), observe air purge screw (1). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (1).

**Note:** Failure to tighten all fittings could result in serious fuel leaks.

- c. Clean any residual fuel from the engine components.
- d. Continue to operate the fuel priming pump (2) until a strong resistance is felt. Listen for an audible click from the fuel manifold. The click will indicate that the valve has opened and the fuel system is pressurized. Lock the fuel priming pump (2).

---

**NOTICE**

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

---

- e. Crank the engine. If the engine starts but the engine runs rough, continue to operate the engine at low idle until the engine runs smoothly.

**Note:** If the engine will not start, further priming is necessary. If the engine starts but the engine continues to misfire or smoke, further priming is necessary.

## 3406E, C-15, and C-16 Truck Engines

### The Secondary Fuel Filter Has Been Replaced

**WARNING**

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

---

**NOTICE**

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

---

**NOTICE**

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

---

**Note:** Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for information on replacing the filter.

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

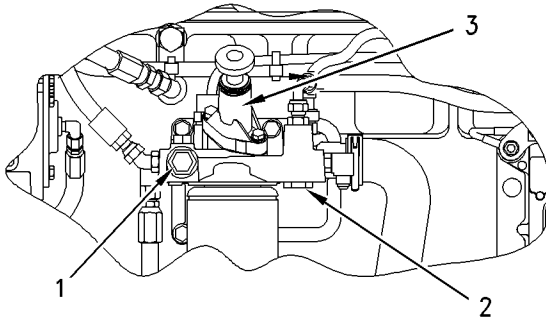


Illustration 64

g00634216

Typical example

- (1) Air purge screw
- (2) Fuel pressure regulating valve
- (3) Hand priming pump (IF EQUIPPED)

2. Open air purge screw (1) for the fuel filter by three full turns. Do not remove the air purge screw.

---

#### NOTICE

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

---

3. Start the engine. The engine should start and the engine should run smoothly.

**Note:** You may use the hand priming pump for the fuel filter (IF EQUIPPED) instead of starting engine and running the engine.

4. While the engine is running, observe air purge screw (1). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (1).

**Note:** There may be a noticeable change in the sound of the running engine when the air purge screw is tightened. The change in the sound of the engine is normal.

**Note:** Failure to tighten all fittings could result in serious fuel leaks.

- 
5. Clean any residual fuel from the engine components.

## The Engine Has Been Run Out of Fuel

---

### NOTICE

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

---

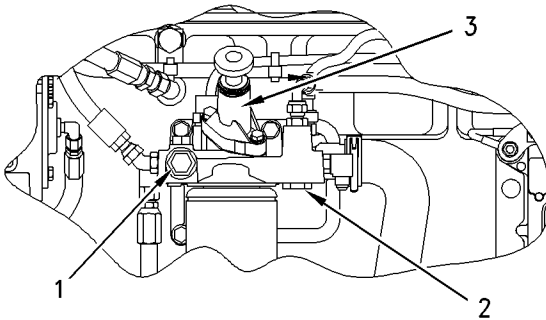
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### NOTICE

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

---

1. Turn the ignition switch to the "OFF" position.
  2. Fill the fuel tank(s) with clean diesel fuel.
- 



---

Illustration 65

g00634216

Typical example

- (1) Air purge screw
- (2) Fuel pressure regulating valve
- (3) Hand priming pump (IF EQUIPPED)

3. Open fuel pressure regulating valve (2) by two and a half turns. The regulating valve is located in the integral fuel filter base.

**Note:** Do not remove the regulating valve completely. Open the valve enough to allow the air that is trapped in the cylinder head to be purged from 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.

---

4. Crank the engine for 30 seconds. Use a suitable container to catch the fuel while you crank the engine. Allow the starter motor to cool for 2 minutes.

**Note:** You may use the hand priming pump (3) (IF EQUIPPED) for the fuel filter instead of cranking the engine.

5. Crank the engine for 30 seconds. Allow the starter motor to cool for 2 minutes.
6. Close and tighten fuel pressure regulating valve (2).
7. Crank the engine for 30 seconds. Allow the starter motor to cool for 2 minutes.
8. Repeat Step 7 until the engine starts and the engine runs.

**Note:** Failure to tighten all fittings could result in serious fuel leaks.

9. Clean any residual fuel from the engine components.

i00951418

## Fuel System Primary Filter - Clean/Replace

**SMCS Code:** 1260-070; 1260-510



### 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.**

---

1. Stop the engine.

2. Turn the start switch to the "OFF" position. Disconnect the battery.
3. Shut off the fuel tank supply valve to the engine.
4. If the primary fuel filter is equipped with a drain valve, open the drain valve in order to drain any fuel from the filter case. Close the drain valve.

---

**NOTICE**

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

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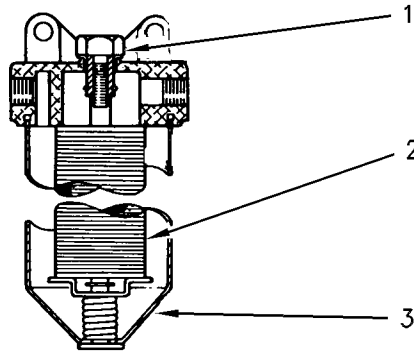


Illustration 66

g00485293

- (1) Bolt  
(2) Element  
(3) Case

5. Loosen the bolt (1) that is on the filter housing. Remove the filter case (3).
6. Remove the element (2) and wash the element in clean, nonflammable solvent.

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**NOTICE**

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

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- 
7. Install the element (2) and the filter case (3). Tighten the bolt (1) to a torque of  $24 \pm 4$  N·m ( $18 \pm 3$  lb ft).

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## Fuel System Primary Filter/Water Separator - Drain

SMCS Code: 1260-543; 1263-543

### WARNING

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

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### NOTICE

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

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### NOTICE

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

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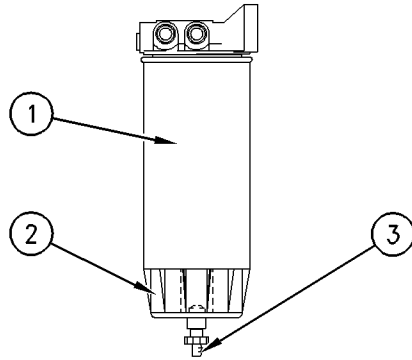


Illustration 67

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

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

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

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#### NOTICE

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

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## 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.**

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### 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.

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### NOTICE

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

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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. It may be necessary to relieve residual fuel pressure from the fuel system before the fuel filter is removed. Wait for one to five minutes until the fuel pressure has lowered. Use a suitable container in order to catch any fuel that may spill.
3. Remove the used fuel filter and discard the used fuel filter.
4. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.
5. Apply clean diesel fuel to the new fuel filter gasket.

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**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.

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**NOTICE**

In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, a two micron high efficiency fuel filter is required for all Caterpillar Electronic Unit Injectors. Caterpillar High Efficiency Fuel Filters meet these requirements. Consult your Caterpillar dealer for the proper part numbers.

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6. Install the new fuel filter. Spin the fuel filter onto the fuel filter base until the gasket contacts the base. Use the rotation index marks on the filters as a guide for proper tightening. Tighten the filter according to the instructions that are on the fuel filter. Do not overtighten the filter.
7. Open the fuel supply valve. The 3406E, C-15 and C-16 engines will need to be purged of air. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" topic (Maintenance Section) for more information. The C-10 and C-12 engines do not need to be purged of air when the filter is replaced. The C-10 and C-12 engines need to be purged of air only when the engines run dry of fuel. Start the engine. Operate the engine at 1000 rpm to 1200 rpm until the engine runs smoothly. Inspect the fuel system for leaks.

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**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.

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**Note:** There should be enough residual fuel in the cylinder head in order to start the engine. If the engine stops after starting, do not crank the engine for more than 30 seconds. Then allow the starting motor to cool for two minutes. Repeat this procedure until the engine starts and the engine operates.

## Fuel System Water Separator - Drain

SMCS Code: 1263-543

### **WARNING**

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

### **NOTICE**

The water separator is not a filter. It separates water from the fuel.

The engine should never be allowed to run with the water level in the separator more than 1/2 full or engine damage may result.

A water separator is recommended. The water separator should be installed between the fuel tank and the engine fuel inlet. Drain the water and sediment from the water separator on a daily basis.

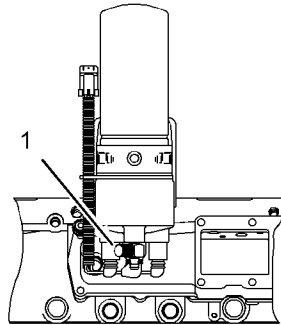


Illustration 68

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(1) Drain

- 
1. Open drain (1). Catch the draining water in a suitable container. Dispose of the water properly.

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**NOTICE**

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

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2. Close drain (1).

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## Fuel Tank Water and Sediment - Drain

**SMCS Code:** 1273-543-M&S

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**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.

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## 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.

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## 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 4 micron [c] filter for the breather vent on the fuel tank is also recommended. Refer to Special Publication, SENR9620, "Improving Fuel System Durability".

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.

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## Hoses and Clamps - Inspect/Replace

**SMCS Code:** 7554-040; 7554-510

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

- Cracking
- Softness
- Loose clamps

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

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### 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.

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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.

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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.**

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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.

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## 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.

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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".

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## 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 level of maintenance is crucial to the service life of the engine. Other major factors that affect service life are operating speed and loads.

The conditions that follow can indicate severe service operation:

- Operation above 36,320 kg (80,000 lb) gross vehicle weight (GVW) and other high load factor operations (such as off-highway)
- Frequent high altitude operation above 1525 m (5000 ft)
- Extended operation at low idle
- Arctic operation (regular cold starts at temperatures below  $-18^{\circ}\text{C}$  ( $0^{\circ}\text{F}$ ))
- Extending maintenance beyond the recommended maintenance intervals
- Frequent hot shutdowns (minimum five minute cool down periods after high load factor operation)
- Use of fuels that are NOT recommended by Caterpillar in the Fuel Specifications
- 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.)

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## Turbocharger - Inspect

**SMCS Code:** 1052-040; 1052

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

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

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### 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.

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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.

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## Removal and Installation

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

## Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.
2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the compressor wheel and the turbocharger housing, the turbocharger must be reconditioned.
3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

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

4. Use a dial indicator to check the end clearance on the shaft. If the measured end play is greater than the Service Manual specifications, the turbocharger should be repaired or replaced. An end play measurement that is less than the minimum Service Manual specifications could indicate carbon buildup on the turbine wheel. The turbocharger should be disassembled for cleaning and for inspection if the measured end play is less than the minimum Service Manual specifications.
5. Inspect the bore of the turbine housing for corrosion.
6. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.

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7. 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

### Inspect the Engine for Leaks and for Loose Connections

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

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

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

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#### 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.

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#### 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.

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- 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.

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

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

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

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

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

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- Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauge that can not be calibrated.