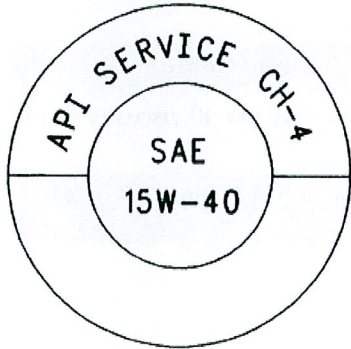


5-3 Engine Maintenance

5-3 Engine Maintenance

5-3.1 Refill Capacities and Recommendations

5-3.1.1 Engine Oil



Typical API Symbol

API Oils

The Engine Oil Licensing and Certification System by the American Petroleum Institute (API) is recognized by Caterpillar. For detailed information about this system, see the latest edition of the "API publication No. 1509". Engine oils that bear the API symbol are authorized by API.

Diesel engine oils, CC, CD, CD-2, and CE have not been API authorized classifications since January 1, 1996. The API Classification Table that follows summarizes the status of the classifications.

API Classifications	
Current	Obsolete
C1-4 ⁽¹⁾ , CH-4 ⁽¹⁾ , CG-4 ⁽²⁾ , CF-4 ⁽³⁾	CE
CF ⁽⁴⁾	CC, CD
CF-2 ⁽⁵⁾	CD-2 ⁽⁵⁾

- (1) API-CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specifications-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.
- (2) API CG-4 oils are acceptable for all Caterpillar diesel engines. When the API CG-4 oils are used, the oil drain interval should not exceed 75 Percent of the standard oil drain interval for your engine.
- (3) API CF-4 oils are no longer recommended for Caterpillar on-highway diesel engines.
- (4) API CF oils are not recommended for Caterpillar on-highway diesel engines.
- (5) API CF-2 and CD-2 oils are classifications for two-cycle diesel engines. Caterpillar does not sell engines that utilize the CD-2 and the API CF-2 oils.

5-3.1.2 Caterpillar Diesel Engine Oil (DEO)

Caterpillar Oils have been developed and tested in order to provide the full performance and service life that has been designed and built into Caterpillar Engines. Caterpillar Oils are currently used to fill diesel engines at the factory. These oils are offered by Caterpillar dealers for continued use when the engine oil is changed. Consult your Caterpillar dealer for more information on these oils.

Due to significant variations in the quality and in the performance of commercially available oils, Caterpillar makes the following recommendations:

- Caterpillar Diesel Engine Oil (DEO) (10W-30)
- Caterpillar Diesel Engine Oil (DEO) (15W-40)

5-3.1.3 Lubricant Viscosity Recommendations

The proper SAE viscosity grade of oil is determined by the minimum ambient temperature during cold engine start-up, and the maximum ambient temperature during engine operation.

Refer the following table (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to this table in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

NOTE: Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

If ambient temperature conditions at engine start-up require the use of multigrade SAE 0W oil, SAE 0W-40 viscosity grade is preferred over SAE 0W-20 or SAE 0W-30.

NOTE: SAE 10W-30 is the preferred viscosity grade for the following diesel engines when the ambient temperature is above -18°C (0°F) and below 40°C (104°F).

Engine Oil Viscosities for Ambient Temperatures ⁽¹⁾		
Viscosity Grade	Ambient Temperature	
	Minimum	Maximum
SAE 0W-20	-40°C (-40°F)	10°C (50°F)
SAE 0W-30	-40°C (-40°F)	30°C (86°F)
SAE 0W-40	-40°C (-40°F)	40°C (104°F)
SAE 5W-30	-30°C (-22°F)	30°C (86°F)
SAE 5W-40	-30°C (-22°F)	50°C (122°F)
SAE 10W-30	-18°C (0°F)	40°C (104°F)
SAE 10W-40	-18°C (0°F)	50°C (122°F)
SAE 15W-40	-9.5°C (15°F)	50°C (122°F)

NOTE: Supplemental heat is recommended below the minimum recommended ambient temperature.

5-3.1.4 S•O•S Oil Analysis

Caterpillar has developed a tool for maintenance management that evaluates oil degradation and the tool also detects the early signs of wear in internal components. The Caterpillar tool for oil analysis is called S•O•S Analysis and the tool is part of the S•O•S Services program. S•O•S Oil Analysis divides oil analysis into three categories:

- Wear Analysis
- Oil Condition
- Additional Tests

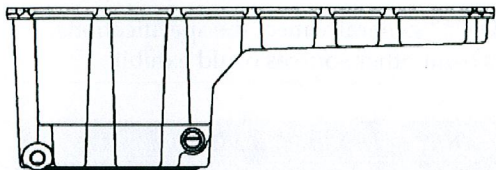
The wear analysis monitors metal particles, some oil additives, and some contaminants.

Oil condition uses infrared (IR) analysis to evaluate the chemistry of the oil. Infrared analysis is also used to detect certain types of contamination.

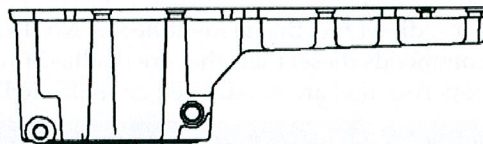
Additional tests are used to measure contamination levels from water, fuel, or coolant. Oil viscosity and corrosion protection can be evaluated, as needed.

5-3.1.5 Refill Capacities (Engine Oil)

The refill capacities for the engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil.



C11 and C13 - 210-1745 Pan (Deep-Standard) This pan has an overall height of 335 mm (13.2 inch).



C11 and C13 - 240-3277 Pan (Shallow-Optional) This pan has an overall height of 278 mm (10.9 inch).

Approximate Refill Capacities of the Engine Lubrication System	
Compartment or System	C13
Standard-Deep Oil Sump ⁽¹⁾	40L (42 qt)
Shallow Oil Sump ⁽¹⁾	34L (36 qt)
Capacity of the Auxiliary Oil Filter System ⁽²⁾	
Total Capacity of the Lubrication System ⁽³⁾	

(1) Approximate sump capacity of the crankcase includes standard oil filters that are factory installed. Engines with auxiliary oil filters will require additional oil. Optional bypass oil filters that are supplied by Caterpillar require an additional 2.5 L (2.6 qt) of oil. If the engine is equipped with another type of auxiliary oil filter, refer to the OEM specifications for that capacity of the auxiliary oil filter.

(2) Fill in the capacity of the auxiliary oil filter system (if equipped) in the space that is provided.

(3) Fill in the total capacity of the lubrication system. Add the auxiliary oil filter system to the correct capacity of the oil sump in order to find the total capacity of the lubrication system.

5-3.1.6 Lubricating Grease

Caterpillar provides a range of moderate greases to extremely high performance greases in order to service the entire line of Caterpillar products that operate throughout the wide variety of climates. From this variety of Caterpillar grease products, you will find at least one of the Caterpillar greases that will meet or exceed the performance requirements for any machine or equipment application.

Before selecting a grease product for any application, the performance requirements must be determined. Consult the grease recommendations that are made by the OEM for the equipment when the equipment is operated in the expected conditions. Then, consult with your Caterpillar dealer for a list of greases and the following related characteristics.

- Performance specifications
- Available sizes of containers
- Part numbers

Always choose a grease that meets or exceeds the recommendations that are specified by the equipment manufacturer for the application.

If it is necessary to choose a single grease to use for all of the equipment at one site, always choose a grease that meets or exceeds the requirements of the most demanding application. Remember, products that barely meet the minimum performance requirements can be expected to barely product minimum parts life. It is false economy to use grease that was purchased based on the lowest cost per pound. Instead, use the grease that yields the lowest total operating cost based on an analysis that includes the costs of parts, labor, and downtime, as well as the cost of the amount of grease that is actually used.

NOTE: Because some greases are not chemically compatible, it is generally recommended to purge all of the old grease from the joint when switching from one type of grease to another, and/or from one supplier to another. Consult your supplier in order to determine if the greases are compatible.

If in doubt, Purge!

NOTE: All Caterpillar brand name greases are compatible with each other.

5-3.1.7 Fuel

Distillate Diesel Fuel

Caterpillar recommends that all distillate diesel fuel, including ULSD fuel (ie fuel ≤ 15 ppm sulfur using ASTM D 2622 or DIN 51400) meet the requirements of the Caterpillar Specifications for Distillate Diesel Fuel.

In North America, diesel fuel that is identified as No. 1-D or No. 2-D in "ASTM D975" generally meet the specifications. Caterpillar recommends diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

NOTE: Caterpillar recommends that fuel be filtered through a fuel filter with a rating of less than five (5) microns absolute at the point where the fuel is dispensed into the vehicle.

NOTICE: Operating with fuels that do not meet Caterpillar's recommendations can cause the following effects: starting difficulty, poor combustion, deposits in the fuel injectors, reduced service life of the fuel system, deposits in the combustion chamber, and reduced service life of the engine.

5-3.2 Coolant

NOTICE: Do not use a commercial coolant/antifreeze that only meets the ASTM D3306 specification. This type of coolant/antifreeze is made for light duty automotive applications.

The following two coolants are used in Caterpillar diesel engines:

Preferred - Caterpillar Extended Life Coolant (ELC) or a commercial extended life coolant that meets the Caterpillar EC-1 specification.

Acceptable - A Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) or a commercial heavy-duty coolant/antifreeze that meets "ASTM D4985", or "ASTM D6210" specifications.

NOTE: Caterpillar DEAC does not require a treatment with a SCA at the initial fill. A commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D6210" specifications MAY require a treatment with an SCA at the initial fill. These coolants WILL require a treatment with an SCA on a maintenance basis.

Service Life Before Flushing and Before Refilling	
Coolant	Service Life ^{(1) (2) (3)}
Cat® ELC	965,606 kilometers (600,000 miles) or 12000 hours or 6 years
Commercial coolant that meets the Caterpillar EC-1 specification	482,803 kilometers (300,000 miles) or 6000 hours or 6 years
Cat® DEAC	321,869 kilometers (200,000 miles) or 3000 hours or 3 years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985" or "ASTM D6210"	241,402 kilometers (150,000 miles) or 3000 hours or 1 year

(1) Whichever comes first

(2) Refer to the specific engine OMM, "Maintenance Interval Schedule" for the interval for the Cooling System Water Temperature Regulator.

(3) Cat truck engines with excessive idle time must reduce coolant drain intervals to one-half of the stated kilometers/miles recommendations, or base the coolant service life on the stated hours. Engine hours of operation are reported in the ECM (Electronic Control Module). Two examples where engines may experience excessive idle time are engines that are normally operated in city pickup and delivery applications, and over the road truck applications where the engines are kept running in order to provide heat and/or air conditioning while the driver sleeps. Refer to the OMM for the specific engine for additional information.

NOTE: Add Cat ELC Extender at the half-life of the coolant drain interval.

NOTE: These drain intervals are only achievable with annual Level 2 coolant analysis.

5-3.2.1 Glycol

Glycol in the coolant helps to provide protection against the following conditions:

- Boiling
- Freezing
- Cavitation of the water pump and cylinder liners

For optimum performance, Caterpillar recommends a 1:1 mixture of a water/glycol solution.

NOTE: Use a mixture that will provide protection against the lowest ambient temperature.

NOTE: 100 percent pure glycol will freeze at a temperature of -23°C (-9°F).

Refer to the following two tables for additional information.

Most conventional heavy-duty coolant/antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. Refer to the following two tables for additional information.

Ethylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	-37°C (-34°F)	106°C (223°F)
60 Percent	-51°C (-60°F)	111°C (232°F)

NOTICE: Do not use propylene glycol in concentrations that exceed 50 percent glycol because of propylene glycol's reduced heat transfer capability. Use ethylene glycol in conditions that require additional protection against boiling or freezing.

Propylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	-32°C (-26°F)	106°C (223°F)

To check the concentration of glycol, use the 1U-7298 Coolant/Battery Tester (Degree Celsius) or use the 1U-7297 Coolant/Battery Tester (Degree Fahrenheit). The testers give readings that are immediate and accurate. The testers can be used with ethylene or propylene glycol.

NOTE: Propylene glycol coolant used in Caterpillar Diesel Engine cooling systems must meet "ASTM D6211-98a Fully-Formulated Propylene Glycol-Based Engine Coolant for Heavy-Duty Engines". When Propylene glycol is used in heavy-duty diesel engines, regular addition of Supplemental Coolant Additive (SCA) is required for liner cavitation protection. Consult your Caterpillar dealer for more information.

5-3.2.2 S•O•S Coolant Analysis

Recommended Interval		
Type of Coolant	Level 1	Level 2
DEAC	Every 250 Hours	Yearly ⁽¹⁾
ELC	Not Required	Yearly

(1) The Level 2 Coolant Analysis should be performed sooner if a problem is identified by a Level 1 Coolant Analysis.

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and from corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and from freezing. The S•O•S Coolant Analysis can be done at your Caterpillar dealer. Caterpillar S•O•S Coolant Analysis is the best way to monitor the condition of your coolant and your cooling system. S•O•S Coolant Analysis is a program that is based on periodic samples.

5-3.2.3 Refill Capacity (Coolant System)

The total cooling system capacity will vary depending on the radiator that is installed in the coach. The table for the capacity of the cooling system is blank. The customer should fill in the table and keep for their records.

Approximate Capacity of the Cooling System		
Compartment or System	Liters	Quarts
Total Cooling System ⁽¹⁾		

(1) The total cooling system capacity includes the following components: the engine block, the radiator, and all coolant hoses and lines.

5-3.3 Maintenance Interval Schedule for C13 Engines with Standard/Deep Oil Sumps

!!IMPORTANT: Ensure that the Safety Information, Warnings, and Instructions are read and understood before operation or maintenance procedures are performed.

NOTE: Use fuel consumption, service hours, or calendar time, whichever occurs first, in order to determine the maintenance intervals. Engines that operate in severe operating conditions may require more frequent maintenance.

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

NOTE: Some maintenance items are for optional equipment.

Instructions for performing the following procedures may be found later in the manual after these schedules.

When Required	
Battery	Replace
Battery or Battery Cable	Disconnect
Engine Air Cleaner Element	Clean/Replace
Engine Oil Level Gauge	Calibrate
Fuel System	Prime
Severe Service Application	Check
Daily	
Cooling System Coolant Level	Check
Engine Air Cleaner Service Indicator	Inspect
Engine Oil Level	Check
Fuel System Primary Filter/Water Separator	Drain
Fuel System Water Separator	Drain
Walk-Around Inspection	Inspect

PM Level 1 - Every 48 000 km (30 000 miles) or 17 400 L (4600 US gal) of Fuel or 600 Service Hours

Air Compressor Filter	Clean/Replace
Alternator	Inspect
Battery Electrolyte Level	Check
Belt	Inspect
Belt Tensioner	Inspect
Cooling System Supplemental Coolant Additive (SCA)	Test/Add
Cylinder Head Grounding Stud	Inspect/Clean/Tighten
Engine Crankcase Breather	Clean
Engine Oil Sample	Obtain
Engine Oil and Filter	Change
Fuel System Primary Filter	Clean/Replace
Fuel System Secondary Filter	Replace
Fuel Tank Water and Sediment	Drain
Hoses and Clamps	Inspect/Replace

Between 24 000 and 96 000 km (15 000 and 60 000 miles)

Compression Brake	Inspect/Adjust
Electronic Unit Injector	Inspect/Adjust
Engine Valve Lash	Inspect/Adjust
Valve Actuators	Inspect/Adjust

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
Cooling System Coolant (DEAC)	Change
Cooling System Water Temperature Regulator	Replace
Fan Drive Bearing	Lubricate
Radiator	Clean

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
Compression Brake	Inspect/Adjust/Replace
Crankshaft Vibration Damper	Inspect
Electronic Unit Injector	Inspect/Adjust
Engine	Clean
Engine Valve Lash	Inspect/Adjust
Turbocharger	Inspect
Valve Actuators	Inspect/Adjust

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

Cooling System Coolant Extender (ELC)	Add
---------------------------------------	-----

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

Cooling System Coolant (ELC)	Change
------------------------------	--------

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
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5-3.4 Maintenance Interval Schedule for C13 Engines with Shallow/Optional Oil Sumps and 525 HP RV Ratings

!!!IMPORTANT: Ensure that the Safety Information, Warnings, and Instructions are read and understood before operation or maintenance procedures are performed.

NOTE: Use fuel consumption, service hours, or calendar time, whichever occurs first, in order to determine the maintenance intervals. Engines that operate in severe operating conditions may require more frequent maintenance.

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

NOTE: Some maintenance items are for optional equipment.

Instructions for performing the following procedures may be found later in the manual after these schedules.

When Required

Battery	Replace
Battery or Battery Cable	Disconnect
Engine Air Cleaner Element	Clean/Replace
Engine Oil Level Gauge	Calibrate
Fuel System	Prime
Severe Service Application	Check

Daily

Cooling System Coolant Level	Check
Engine Air Cleaner Service Indicator	Inspect
Engine Oil Level	Check
Fuel System Primary Filter/Water Separator	Drain
Fuel System Water Separator	Drain
Walk-Around Inspection	Inspect

PM Level 1 - Every 32 000 km (20 000 miles) or 11 700 L (3100 US gal) of Fuel or 400 Service Hours

Air Compressor Filter	Clean/Replace
Alternator	Inspect
Battery Electrolyte Level	Check
Belt	Inspect
Belt Tensioner	Inspect
Cooling System Supplemental Coolant Additive (SCA)	Test/Add
Cylinder Head Grounding Stud	Inspect/Clean/Tighten
Engine Crankcase Breather	Clean
Engine Oil Sample	Obtain
Engine Oil and Filter	Change
Fuel System Primary Filter	Clean/Replace
Fuel System Secondary Filter	Replace
Fuel Tank Water and Sediment	Drain
Hoses and Clamps	Inspect/Replace

Between 24 000 and 96 000 km (15 000 and 60 000 miles)

Electronic Unit Injector	Inspect/Adjust
Engine Valve Lash	Inspect/Adjust
Valve Actuators	Inspect/Adjust

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
Cooling System Coolant (DEAC)	Change
Cooling System Water Temperature Regulator	Replace
Fan Drive Bearing	Lubricate
Radiator	Clean

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
Crankshaft Vibration Damper	Inspect
Electronic Unit Injector	Inspect/Adjust
Engine	Clean
Engine Valve Lash	Inspect/Adjust
Turbocharger	Inspect
Valve Actuators	Inspect/Adjust

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

Cooling System Coolant Extender (ELC)	Add
---------------------------------------	-----

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

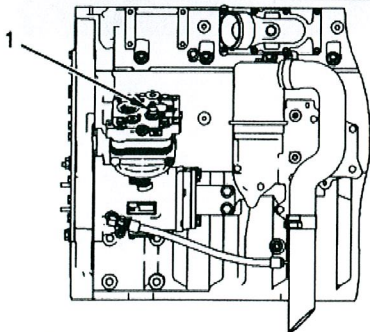
Cooling System Coolant (ELC)	Change
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5-3.5 Aftercooler Core - Clean/Test (Air-To-Air Aftercooler)

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

5-3.6 Air Compressor - Inspect

▲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.



▲WARNING: If the air compressor pressure relief valve that is mounted in the air compressor cylinder head is bypassing compressed air, there is a malfunction in the air system, possibly ice blockage. Under these conditions, your engine may have insufficient air for normal brake operation. Do not operate the engine until the reason for the air bypass is identified and corrected. Failure to heed this warning could lead to property damage, personal injury, or death to the operator or bystanders.

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

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

Consult your Caterpillar dealer for assistance.

5-3.7 Air Compressor Filter - Clean/Replace (If Equipped)

One of the single most important aspects of preventative 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.

5-3.8 Alternator - Inspect

Caterpillar recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and proper battery charging.

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.

5-3.9 Battery - Replace

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

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

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

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

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

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

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

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

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

5-3.10 Battery Electrolyte Level - Check

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

▲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.
2. 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.
3. Check the condition of the electrolyte with the 1U-7298 Coolant/Battery Tester (°C) or the 1U-7297 Coolant/Battery Tester (°F).
4. 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 and 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 grease.

5-3.11 Battery or Battery Cable - Disconnect

▲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.

5-3.12 Belt - Inspect

5-3.12.1 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.

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•m (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.

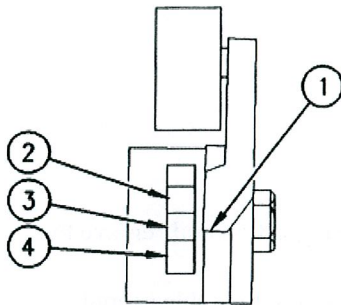
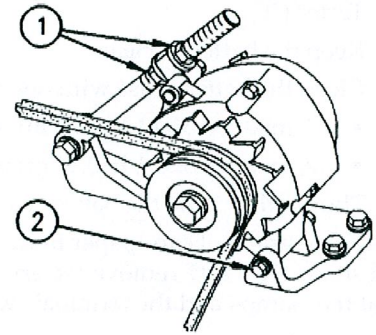
- If the engine is equipped with a refrigerant compressor (air conditioner), the belt for the fan drive, the alternator, and the accessories will have an automatic belt tensioner.
- If the engine is not equipped with a refrigerant compressor, the alternator is used to adjust the belt tension.

5-3.12.2 Adjustment

Alternator Belt

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 "Torque Specifications" section of this manual.
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.



Side view of the belt tensioner

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

5-3.13 Belt Tensioner - Inspect

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.

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.

5-3.14 Compression Brake - Inspect/Adjust

S/N: BXS1-Up

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.

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.

Component	Required Maintenance
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 ⁽¹⁾	Inspect
Solenoid Harness ⁽¹⁾	Inspect
Solenoid Seal Rings ⁽¹⁾	Inspect
Control Valve Springs ⁽¹⁾	Inspect
Control Valves ⁽¹⁾	Inspect
Oil Seal Rings ⁽¹⁾	Inspect
Master Piston Return Springs ⁽¹⁾	Inspect
Terminal Lead Out ⁽¹⁾	Inspect
Crosshead Pin Assembly ⁽¹⁾	Inspect

5-3.15 Compression Brake - Inspect/Adjust/Replace

S/N: BXS1-Up

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.

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.

Component	Required Maintenance	Required Maintenance
	(300,000 miles)	(600,000 miles)
Wiring and Terminal Connections	Inspect	Inspect
Clutch/Throttle/Buffer Screw	Adjust/Replace	Adjust/Replace
Slave Piston Lash Adjusting Screw	Adjust/Inspect	Adjust/Inspect
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 ⁽¹⁾	Replace	Inspect
Solenoid Harness ⁽¹⁾	Replace	Inspect
Solenoid Seal Rings ⁽¹⁾	Replace	Inspect
Control Valve Springs ⁽¹⁾	Replace	Inspect
Control Valves ⁽¹⁾	Replace	Inspect
Oil Seal Rings ⁽¹⁾	Replace	Inspect
Master Piston Return Springs ⁽¹⁾	Replace	Inspect
Terminal Lead Out ⁽¹⁾	Replace	Inspect
Crosshead Pin Assembly ⁽¹⁾	Replace	Inspect

5-3.16 Cooling System Coolant (DEAC) - Change

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

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

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

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

5-3.16.1 Drain

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

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove one of the drain plugs.

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

Allow the coolant to drain.

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

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

Caterpillar Service Technology Group:

Outside Illinois: 1-800-542-TOOL

Inside Illinois: 1-800-541-TOOL

Canada: 1-800-523-TOOL

5-3.16.2 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.

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

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add 0.5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.
4. Start and run the engine at low idle for a minimum of 30 minutes. The coolant temperature should be at least 82°C (180°F).

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

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

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. If equipped, be sure to flush the heater and any related supply and return lines. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

5-3.16.3 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 to the specified torque.

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

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add 0.5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the cooling system filler cap.
4. Start and run the engine at low idle for a minimum of 90 minutes. The coolant temperature should be at least 82°C (180°F).

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

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

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

5-3.16.4 Fill

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

1. Fill the cooling system with coolant/antifreeze. Refer to "Refill Capacities and Recommendations" section of this manual 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 fitting. 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.

5-3.17 Cooling System Coolant (ELC) - Change

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.

5-3.17.1 Drain

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

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove the cooling system drain plugs.
Allow the coolant to drain.

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

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

Caterpillar Service Technology Group:

Outside Illinois: 1-800-542-TOOL

Inside Illinois: 1-800-541-TOOL

Canada: 1-800-523-TOOL

5-3.17.2 Flush

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

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

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

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

3. Fill the cooling system with clean water. Install the cooling system filler cap.
4. Start and run the engine at low idle until the temperature reaches 49 to 66°C (120 to 150°F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

5-3.17.3 Fill

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

1. Fill the cooling system with Extended Life Coolant (ELC). Refer to "Refill Capacities and Recommendations" section of this manual 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.

5-3.18 Cooling System Coolant Extender (ELC) - Add

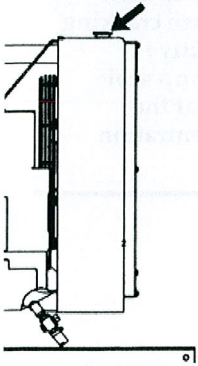
Caterpillar Extended Life Coolant (ELC) does not require the frequent Supplemental Coolant Additive (SCA) additions that are associated with the present conventional coolants. The Extender only needs to be added once.

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

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 Extender.
3. Add Extender according to the requirements for your engine's cooling system capacity. Refer to the "[Refill Capacities and Recommendations](#)" section of this manual for the capacity of the cooling system for your engine.
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 for the cooling system filler cap are damaged. Install the cooling system filler cap.

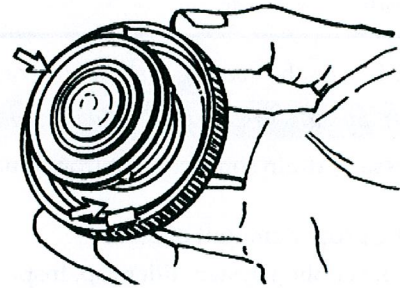
5-3.18 Cooling System Coolant Level - Check

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



▲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.
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.



5-3.19 Cooling System Supplemental Coolant Additives (SCA) - Test/Add

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

NOTE: Test the Supplemental Coolant Additive (SCA) or test the SCA concentration as part of the S•O•S Coolant Analysis.

5-3.19.1 Test the SCA Concentration Coolant/Antifreeze and SCA

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

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

Use the 8T-5296 Coolant Conditioner Test Kit or use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA.

5-3.19.2 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.
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.

5-3.20 Cooling System Water Temperature Regulator - Replace

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 seizer 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 shut 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.

Consult your Caterpillar dealer for the replacement procedure of the water temperature regulator.

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.

5-3.21 Crankshaft Vibration Damper - Inspect

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.

5-3.21.1 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.

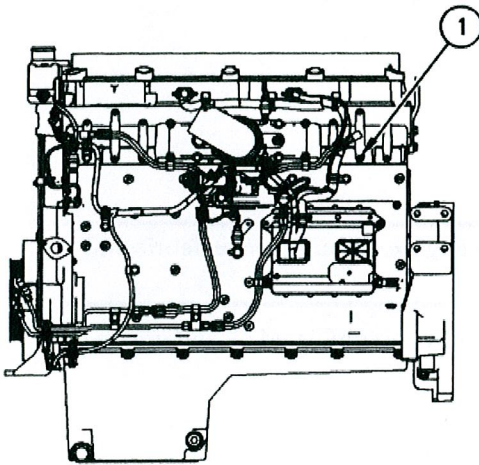
If the fluid leak is oil, inspect the crankshaft seals for leaks. If a leak is observed, replace the crankshaft seals.

Inspect the damper and repair or replacement 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 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.

Consult your Caterpillar dealer for information about damper replacement.

5-3.22 Cylinder Head Grounding Stud - Inspect/Clean/Tighten



(1) Cylinder head grounding 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.

5-3.23 Electronic Unit Injector - Inspect/Adjust

▲ 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.

▲ WARNING: Electrical shock hazard. The electronic unit injector system uses 90-120 volts.

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.

NOTICE: The camshafts must be correctly timed with the crankshaft before an adjustment of the lash for the fuel injector is made. The timing pins must be removed from the camshafts before the crankshaft is turned or damage to the cylinder block will be the result.

Inspect the adjustment of the lash for the electronic unit injector according to the Systems Operation/Testing and Adjusting "Fuel System" section. Adjust the lash for the electronic unit injector, if necessary.

5-3.24 Engine - Clean

▲ 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.

5-3.25 Engine Air Cleaner Element - Clean/Replace

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

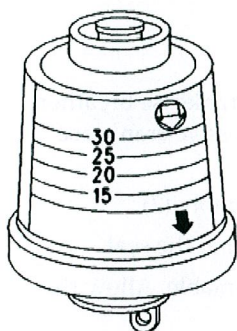
If the air cleaner element becomes plugged, the air can split the material out of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear.

- 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.

5-3.26 Engine Air Cleaner Service Indicator - Inspect (If Equipped)



Typical service indicator

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The 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.

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.

5-3.26.1 Test the Service Indicator

Service indicators are important instruments.

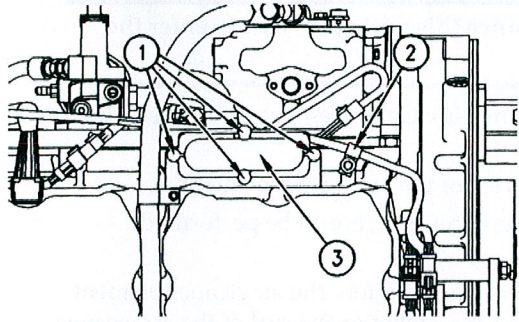
- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated speed. The yellow core should latch approximately at the greatest vacuum that is attained.

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).

5-3.27 Engine Crankcase Breather - Clean



(1) Bolts (2) Hose Clamp (3) Breather Cover

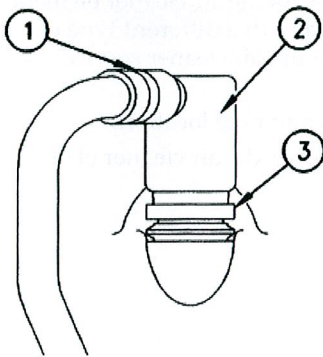
NOTICE: Perform this maintenance with the engine stopped.

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 element to dry.
4. Install a breather element that is clean and dry. Install breather cover (3) and install bolts (1).
5. Install the hose. Install hose clamp (2).

5-3.28 Engine Crankcase Breather - Clean

NOTICE: Perform this maintenance with the engine stopped.



Typical Example

- (1) Hose Clamp
 (2) Breather Assembly
 (3) Retaining Clamp

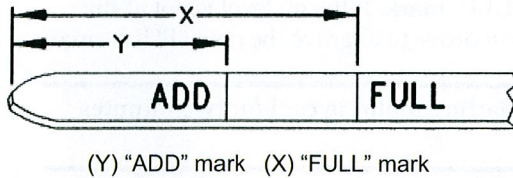
If the crankcase breather is not maintained on a regular basis, the crankcase breather will become plugged. A plugged crankcase breather will cause excessive crankcase pressure that may cause crankshaft seal leakage.

1. Loosen hose clamp (1) and remove the hose from breather assembly (2).
2. Loosen the retaining clamp (3). Remove breather assembly (2) and the seal.
3. Wash the breather element in solvent that is clean and nonflammable. Allow the breather element to dry before installation.
4. Install a breather element that is clean and dry. Install breather assembly and seal (2) and install (3) to the specified torque.
5. Install the hose. Install hose clamp (1) to the specified torque.

5-3.29 Engine Oil Level - Check

▲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 model.



NOTICE: Perform this maintenance with the engine stopped.

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

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

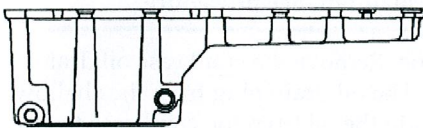
An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil's ability to lubricate, reduction of oil pressure, inadequate cooling,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

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

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

2. Remove the oil filler cap and add oil, if necessary. For the correct oil to use, see "Engine Oil" section in this manual. 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.

5-3.30 Engine Oil Level Gauge - Calibrate (Optional-Shallow)



240-3277 Pan (Optional-Shallow) - This pan has an overall height of 278 mm (10.9 inch).

5-3.31.1 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 $70 \pm 15 \text{ N} \cdot \text{m}$ ($50 \pm 11 \text{ lb ft}$).

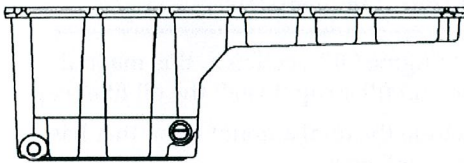
NOTE: Your engine may be equipped with auxiliary oil filters. The auxiliary oil filters require a different volume of oil. Refer to the OEM specifications for the auxiliary oil filter.

3. Pour 26 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 4 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 4 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 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.

5-3.32 Engine Oil Level Gauge - Calibrate (Standard-Deep)



210-1745 Pan (Standard-Deep) - This pan has an overall height of 335 mm (13.2 inch).

5-3.32.1 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 they are 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 $70 \pm 15 \text{ N}\cdot\text{m}$ ($50 \pm 11 \text{ lb ft}$).

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 32 L (34 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 4 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 4 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 40 L (42 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.

5-3.33 Engine Oil Sample - Obtain

In addition to a good preventative 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.

5-3.33.1 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 part that is 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.

5-3.34 Engine Oil and Filter - Change

▲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.

5-3.34.1 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.

5-3.34.2 Replace the Oil Filter

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

1. Remove the oil filter with a 185-3630 Chain Wrench.
2. Cut the oil filter open with a 175-7546 Oil Filter Cutter. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.



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

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

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

3. Clean the sealing surface of the filter mounting base. Ensure that all of the 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 over tighten the oil filter.

5-3.34.3 Fill the Engine Crankcase

1. Remove the oil filler cap. Refer to "*Lubricant Specifications*" section of this manual for more information. Fill the crankcase with the proper amount of engine oil. Refer to "*Refill Capacities*" section of this manual 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.

1. 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.
2. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.
3. 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.

5-3.34.4 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.

5-3.34.5 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 C13 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) with a shallow oil sump. The maximum permissible oil change interval for the same situation with a Deep oil sump would be 64,350 km (40,000 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 1 and 2:

- Use premium API CH-4 or API CI-4 multigrade oil only. API CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid Specification-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.
- 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 1

Maximum Permissible Oil Change Intervals for On-Highway C11 and C13 Engines with Optional Shallow Sumps			
	Severe Duty	Normal Duty	Light Duty
Fuel Consumption Kilometers Per Liter (Miles Per Gallon)	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)
Gross Vehicle Weight	More than 80,000 lb	80,000 lb or less	80,000 lb or less
Minimum Oil Sump Capacity⁽¹⁾	34 L (36 qt)	34 L (36 qt)	34 L (36 qt)
Idle Time	More than 40%	20% to 40%	Less than 20%
Oil Classification	API CH-4 or API CI-4 ⁽²⁾		
Kilometers (Miles)	24,150 kilometers (15,000 miles)	32,200 kilometers (20,000 miles)	40,250 kilometers (25,000 miles)

- (1) If the oil sump capacity is greater than the oil sump capacity that is listed in Table 1, the oil change interval can be extended 1600 kilometers (1000 miles) for every 2 L (2 qt) increase in sump capacity.
- (2) API CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.

Table 2

Maximum Permissible Oil Change Intervals for On-Highway C11 and C13 Engines with Deep Sumps (Standard)			
	Severe Duty	Normal Duty	Light Duty
Fuel Consumption Kilometers Per Liter (Miles Per Gallon)	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)
Gross Vehicle Weight	More than 80,000 lb	80,000 lb or less	80,000 lb or less
Minimum Oil Sump Capacity⁽¹⁾	40 L (42 qt)	40 L (42 qt)	40 L (42 qt)
Idle Time	More than 40%	20% to 40%	Less than 20%
Oil Classification	API CH-4 or API CI-4 ⁽²⁾		
Kilometers (Miles)	32,200 kilometers (20,000 miles)	48,300 kilometers (30,000 miles)	64,350 kilometers (40,000 miles)

- (1) If the oil sump capacity is greater than the oil sump capacity that is listed in Table 2, the oil change interval can be extended 1600 kilometers (1000 miles) for every 2 L (2 qt) increase in sump capacity.
- (2) API CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.

5-3.35 Engine Valve Lash - Inspect/Adjust

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. Consult 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 cannot 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.

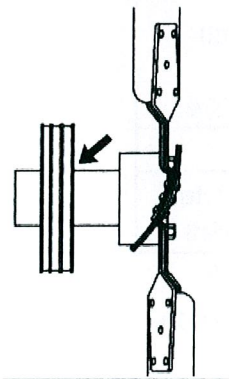
Ensure that the engine is stopped before measuring the valve lash. To obtain an accurate measurement, allow the valves to cool before this maintenance is performed.

The following components should be inspected and adjusted when the valves are inspected and adjusted.

- Valve Actuators
- Injectors
- Compression Brakes

5-3.36 Fan Drive Bearing - Lubricate

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



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

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

5-3.37 Fuel System - Prime

5-3.37.1 C11 and C13 On-highway 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.

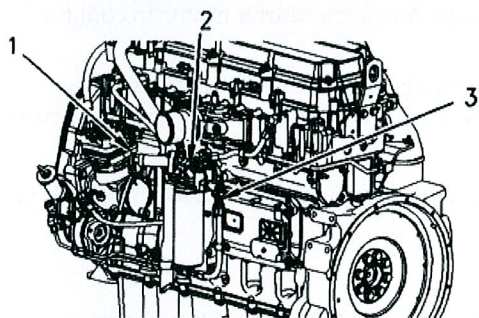
NOTICE: Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

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 "Fuel System Secondary Filter - Replace" section for more 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.



(1) Fuel Priming Pump,
(2) Air Purge Screw, (3) Priming Valve (if equipped)

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 the engine and running the engine. Perform the following procedure when the hand priming pump is used:

- Turn the priming valve (3) (if equipped) to the "Closed (Prime)" position in order to prime the fuel system.
 - Open the air purge screw (2) for the fuel filter by three full turns. Do not remove the air purge screw.
- c. While you operate the hand priming pump (1), observe air purge screw (2). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (2).

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

- d. Clean any residual fuel from the engine components.
- e. Continue to operate the fuel priming pump (1) 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 (1).

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.

- f. 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.

- g. After the engine has operated smoothly for 30 seconds, turn the priming valve (3) to the "Open (Run)" position.

NOTE: Shortened injector life may occur if the priming valve (3) is left in the "Closed (Prime)" position.

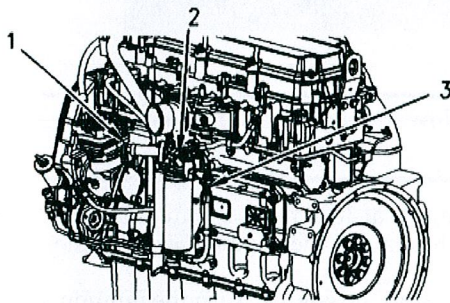
5-3.37.2 The Engine Has Been Run Out of Fuel

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.
3. Turn the priming valve (3) (if equipped) to the "Closed (Prime)" position in order to prime the fuel system.
4. Open air purge screw (2) 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.



(1) Fuel Priming Pump,
(2) Air Purge Screw, (3) Priming Valve (if equipped)

5. 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: Most of the air should be purged from the system after four or five cranking cycles.

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

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

9. After the engine has operated smoothly for 30 seconds, turn the priming valve (3) to the "Open (Run)" position.

NOTE: Shortened injector life may occur if the priming valve (3) is left in the "Closed (Prime)" position.

10. Clean any residual fuel from the engine components.
11. 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 the engine and running the engine. Perform the following procedure when the hand priming pump is used:

- a. Turn the priming valve (3) (if equipped) to the "Closed (Prime)" position in order to prime the fuel system.
- b. Open air purge screw (2) for the fuel filter by three full turns. Do not remove the air purge screw.
- c. While you operate the hand priming pump (1), observe air purge screw (2). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (2).

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

- d. Clean any residual fuel from the engine components.
- e. Continue to operate the fuel priming pump (1) 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 (1).

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.

- f. 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.

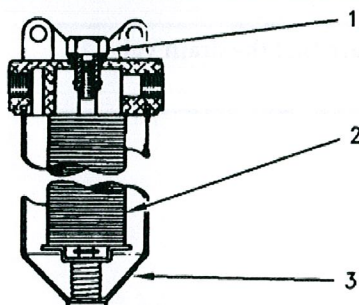
NOTE: If the engine will not start, further priming is necessary. If the engine starts but the engine continues to misfire or smoke, further priming is necessary.

- g. After the engine has operated smoothly for 30 seconds, turn the priming valve (3) to the "Open (Run)" position.

NOTE: Shortened injector life may occur if the priming valve (3) is left in the "Closed (Prime)" position.

5-3.38 Fuel System Primary Filter - Clean/Replace

▲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) Bolt, (2) Element, (3) Case

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.

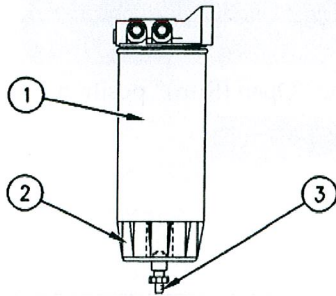
5. Loosen the bolt (1) that is on the filter housing. Remove the filter case (3).
6. Remove the element (2) and wash the element in clean, nonflammable solvent.

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.

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

5-3.39 Fuel System Primary Filter/Water Separator - Drain

▲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) Element, (2) Bowl, (3) Drain

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

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.

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

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

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

5-3.40 Fuel System Secondary Filter - Replace

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

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

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

1. Stop the engine. Turn the ignition switch to the OFF position or disconnect the battery. Refer to "Battery or Battery Cable - Disconnect" section of this manual for more information. Shut off the fuel supply valve (if equipped).
2. Remove the used fuel filter and discard the used fuel filter.
3. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.
4. Apply clean diesel fuel to the new fuel filter gasket.

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

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

5. 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 for an additional one turn (360 degrees) by hand. Do not overtighten the filter.
6. Open the fuel supply valve. Prime the fuel system. Refer to "*Fuel System - Prime*" section in this manual for more information. Start the engine and inspect the fuel system for leaks.

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

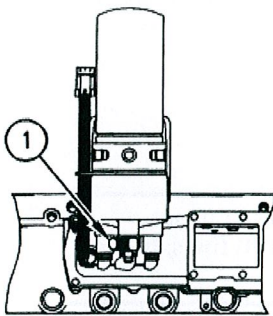
NOTE: There should be enough residual fuel in the cylinder head in order to start the engine. If the engine stops after starting, do not crank the engine for more than 30 seconds. Then allow the starting motor to cool for two minutes. Repeat this procedure until the engine starts and the engine operates.

5-3.41 Fuel System Water Separator - Drain

▲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 ½ full or engine damage may result.



(1) Drain

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.

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

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.

2. Close drain (1).

5-3.42 Fuel Tank Water and Sediment - Drain

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.

Dispose of all fluids according to local regulations and mandates.

5-3.42.1 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.

5-3.42.2 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.

5-3.42.3 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.

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 pump from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

5-3.43 Hoses and Clamps - Inspect/Replace

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

- Cracking
- Softness
- Loose Clamps

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

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

Check the following conditions:

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

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

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

Each installation application can be different. The difference depends 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

5-3.41.1 Replace the Hoses and the Clamps

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

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

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

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

NOTE: Refer to the Specifications, SENR3130 in order to locate the proper torques.

7. Install the hose clamps with a torque wrench.

NOTE: For the proper coolant to use, see "Coolant Recommendations" section of this manual.

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.

5-3.44 Radiator - Clean

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.

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.

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.

5-3.45 Severe Service Application - Check

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°C (0°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.)

5-3.46 Turbocharger - Inspect

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side)

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

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

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

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

A periodic inspection of the turbocharger can minimize unscheduled downtime and the chance for potential damage to other engine parts.

NOTE: Turbocharger components require precision clearances with proper balancing in order to support high operating speeds. Severe Service Applications can accelerate component wear. Therefore, more frequent inspections of the cartridge are required.

5-3.46.1 Removal and Installation

For options regarding the inspection, removal, installation, repair and replacement, consult your authorized Caterpillar service center.

5-3.47 Valve Actuators - Inspect/Adjust

The valve actuators should be inspected and adjusted when adjustments to the following components occur.

- Valves
- Injectors
- Compression Brakes

Refer to the System Operation, Test and Adjust Manual for the proper adjustment procedure.

5-3.48 Walk-Around Inspection

5-3.48.1 Inspect the Engine for Leaks and for Loose Connections

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

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

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

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

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

- 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 contact.*

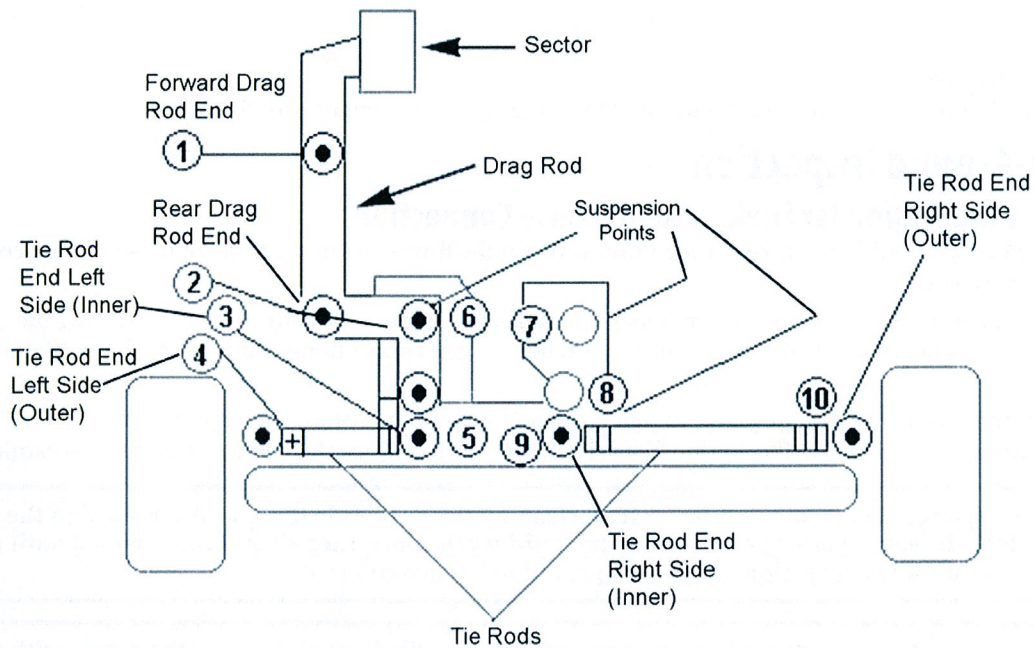
Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pumps and the installation of water pumps and/or seals, refer to your servicing dealer.

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

5-3.49 Lubrication Points



NOTE: There are also two universal joints on drive shaft to include in Lubrication Points.

5-3.50 Customer Service

5-3.50.1 Customer Assistance

USA and Canada

When a problem arises concerning the operation of an engine or concerning the service of an engine, the problem will normally be managed by the dealer in your area.

Your satisfaction is a primary concern to Caterpillar and to Wanderlodge. To get in touch with the Caterpillar Field Service Coordinator: 1-800-447-4986 or submit problem in writing to:

Caterpillar Inc.
 Manager, Customer Service, Engine Division
 Mossville Bldg AC
 P.O. Box 610
 Mossville, Illinois 61552-0610