

## Product Information Section

### Model Views

i01228039

### Model View Illustrations

**SMCS Code:** 1000

The illustrations show various typical features of 3500 Series Engines. The illustrations do not show all of the options that are available.

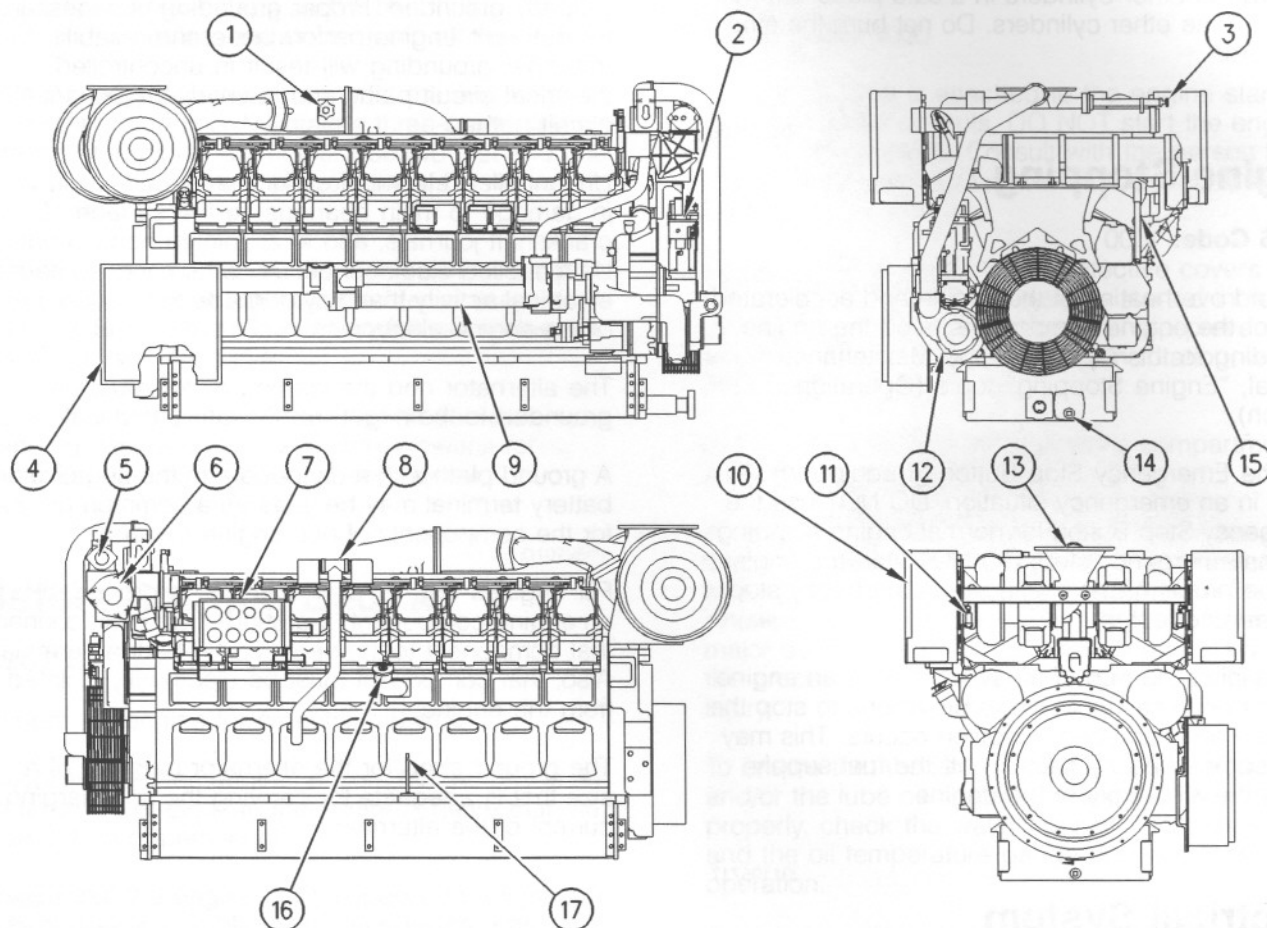


Illustration 14

g00657011

- (1) Air shutoff
- (2) Governor
- (3) Fuel priming pump
- (4) Junction box
- (5) Fuel filter
- (6) Oil filter

- (7) Instrument panel
- (8) Crankcase breather
- (9) Oil cooler
- (10) Air cleaner
- (11) Air cleaner service indicator
- (12) Jacket water pump

- (13) Exhaust
- (14) Oil drain
- (15) Manual shutoff lever
- (16) Oil filler
- (17) Oil level gauge (dipstick)

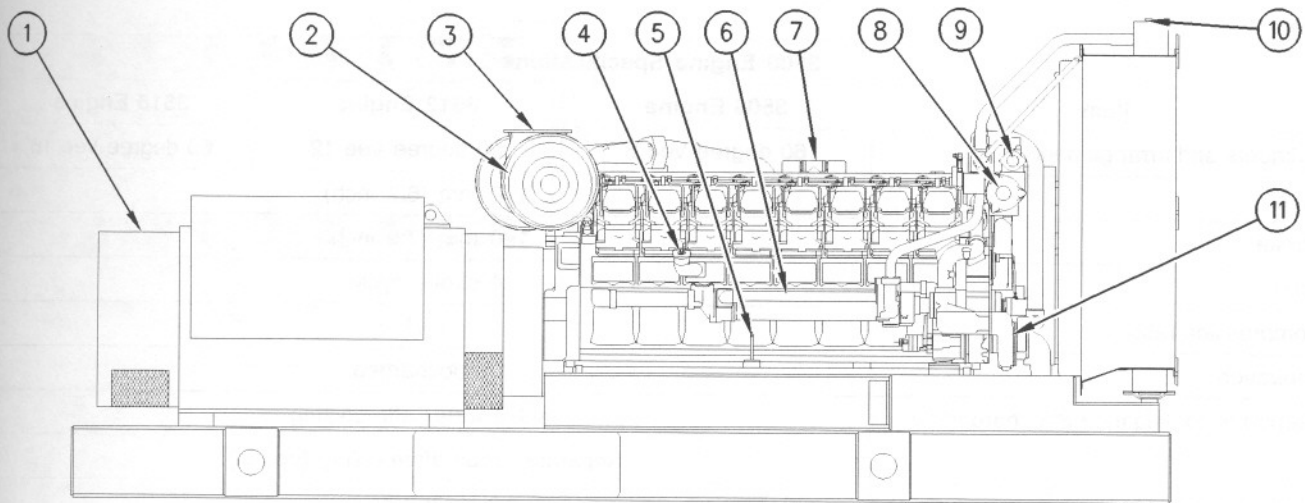


Illustration 15

g00657276

- (1) Generator
- (2) Air cleaner
- (3) Exhaust
- (4) Oil filler

- (5) Oil level gauge (dipstick)
- (6) Oil cooler
- (7) Crankcase breather
- (8) Oil filter

- (9) Fuel filter
- (10) Cooling system filler
- (11) Jacket water pump

i01228233

## Engine Description

**SMCS Code:** 1000

The 3500 Series Engines were developed in order to provide power for industrial applications and generator set applications. The diesel engines are rated from 900 rpm to 1800 rpm. The engines can be equipped with either separate circuit aftercooling or jacket water aftercooling.

## 3500 Engine Specifications

Table 1

3500 Engine Specifications			
Item	3508 Engine	3512 Engine	3516 Engine
Cylinders and arrangement	60 degree Vee 8	60 degree Vee 12	60 degree Vee 16
Bore	170 mm (6.7 inch)		
Stroke	190 mm (7.5 inch)		
Type	4 stroke cycle		
Compression ratio	13:1		
Aspiration	Turbocharged		
Method of cooling the turbocharged air	Jacket water aftercooling		
	Separate circuit aftercooling (option)		
Displacement per cylinder	4.3 L (263 cu in)		
Total displacement	34.5 L (2105 cu in)	51.8 L (3158 cu in)	69.1 L (4210 cu in)
Rotation (flywheel end)	Counterclockwise rotation is standard.		
	Clockwise rotation is optional.		
Fuel	See this Operation and Maintenance Manual, "Fuel Recommendations" (Maintenance Section).		
Method of fuel injection	Electronic unit injectors		
Method of starting	Air starting motor		
	Electric starting motor		
Maximum allowable back pressure	6.7 kPa (27 inch of H <sub>2</sub> O)		
Maximum inlet air Restriction	6.2 kPa (25 inches of H <sub>2</sub> O)		
Inlet valve lash	0.50 mm (0.020 inch)		
Exhaust valve lash	01.00 mm (0.039 inch)		

## 3500 Engine Design

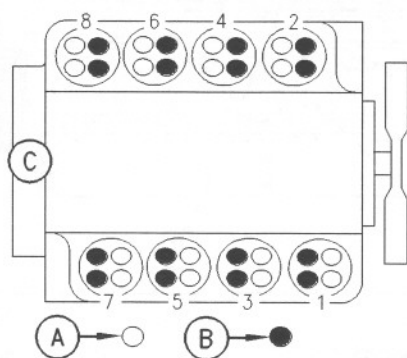


Illustration 16  
3508 Engine design  
(A) Inlet valve  
(B) Exhaust valve  
(C) Flywheel

g00308097

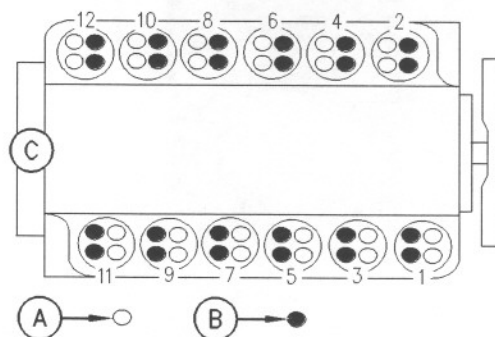


Illustration 17  
3512 Engine design  
(A) Inlet valve  
(B) Exhaust valve  
(C) Flywheel

g00308167

# Gauges and Indicators

i01228302

## Gauges and Indicators

**SMCS Code:** 7450

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Compare the gauge readings to the data that were recorded during the engine commissioning. Determine the normal operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings can indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings. Consult your Caterpillar dealer for assistance.

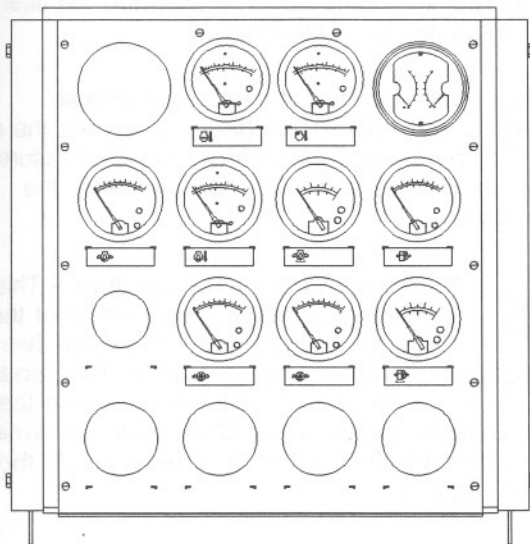


Illustration 24

g00665930

Typical instrument panel

Your engine may not have the same gauges or all of the gauges that are described. For more information about the gauge package, refer to the literature that is provided by the OEM of the package.

### NOTICE

If no oil pressure is indicated, **STOP** the engine. The engine will be damaged from operating without oil pressure.



**Engine Oil Pressure** – This gauge indicates the pressure of the engine oil. This pressure will be highest after a cold engine is started. The pressure will decrease as the engine warms up. The pressure will increase when the engine rpm is increased. The pressure will stabilize when the engine rpm and temperature are stable.

If the load is stabilized but the engine oil pressure fluctuates, perform the following procedure:

1. Remove the load.
2. Reduce the engine speed to low idle rpm.
3. Check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the "LOW IDLE" side of the oil level gauge (dipstick).
4. Inspect the lubrication system for leaks.



**Jacket Water Temperature** – This gauge indicates the temperature of the engine coolant at the outlet for the jacket water. The temperature may vary according to the load. Do not allow the temperature to exceed the boiling temperature of the pressurized cooling system.

The sensor for jacket water temperature must be fully submerged in order to detect the temperature correctly. If the engine is operating above the normal temperature range, perform the following procedure:

1. Reduce the load and/or the engine rpm.
2. Inspect the cooling system for leaks.
3. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load and/or rpm.



**System Voltage** – This gauge indicates the amount of charge or discharge in the battery charging circuit.



**Fuel Pressure** – This gauge indicates fuel pressure to the fuel injection pump from the fuel filter. A decrease in fuel pressure usually indicates a dirty fuel filter or a plugged fuel filter. As the fuel filter becomes plugged, there will be a noticeable reduction in the engine's performance.





**Exhaust Temperature** – This gauge indicates the exhaust temperature at the exhaust inlet to the turbochargers. The two exhaust temperatures may vary slightly. This may be due to variation of the sensitivity of the two thermocouples.

The exhaust temperatures at the exhaust inlets to the turbochargers provide a good indication of engine performance. For engines with dry exhaust manifolds, the temperatures are representative of the actual temperatures of the valves. Monitor this parameter frequently.

**Pyrometer** – The pyrometer displays the temperature of the exhaust for the exhaust port of each individual cylinder and for the exhaust stacks.

The exhaust port temperatures are a good indication of the condition of the cylinders. The displayed temperature is slightly lower than the actual temperature in the cylinder. This is because of the constant flow of exhaust gas past the thermocouple. For engines with dry exhaust manifolds, the exhaust port temperatures are usually lower than the temperatures at the inlets to the turbochargers.

Guttering of valves can be diagnosed with the exhaust port temperature. The ability to diagnose this problem may help to prevent additional damage that could cause further downtime with a higher repair cost.

During normal operation at rated load, the temperature of the hottest cylinder and the coldest cylinder may differ by 38 to 52 °C (100 to 125 °F).

The exhaust stack temperature is not a suitable substitute for the exhaust temperature at the inlet to the turbocharger. However, a comparison of the two temperatures can help to assess the performance of the turbocharger.

#### NOTICE

To help prevent engine damage, never exceed the high idle rpm. An overspeed can result in serious damage to the engine. The engine can be operated at high idle without damage, but the engine should never be allowed to exceed the high idle rpm.

**Tachometer** – The tachometer displays the engine rpm. The high idle rpm and the rated rpm are printed on the engine Information Plate.



**Hourmeter** – This meter indicates the hours of engine operation.



**Inlet Air Restriction (Air Cleaner Differential Pressure)** – This gauge indicates the difference in air pressure between the inlet side and the engine side of the air filter element. The air cleaner differential pressure is measured from the turbocharger air inlet. As the air filter element becomes plugged, the difference in pressure between the two sides of the air cleaner element will increase.



**Fuel Filter Differential Pressure (Restriction)** – This gauge indicates the difference in fuel pressure between the inlet side and the outlet side of the fuel filter. As the fuel filter element becomes plugged, the difference in pressure between the two sides of the fuel filter increases.



**Oil Filter Differential Pressure (Restriction)** – This gauge indicates the difference in pressure between the inlet side and the outlet side of the engine oil filters. As the oil filter elements become plugged, oil filter differential pressure will increase.



**Inlet Manifold Air Pressure (Boost Pressure)** – This gauge indicates the air pressure (turbocharger boost pressure) in the air plenum (air inlet manifold) after the aftercooler.



**Aftercooler Coolant Temperature** – This gauge indicates the temperature of the coolant in the aftercooler system. Two methods of aftercooling are available. The separate circuit aftercooler operates at a temperature that is lower than the jacket water aftercooler. Determine the method of aftercooling in order to verify the gauge reading.



**Inlet Manifold Air Temperature** – This gauge indicates the inlet manifold air temperature to the cylinders. The sensor for inlet manifold air temperature is located after the aftercooler.



**Engine Oil Temperature** – This gauge indicates the engine oil temperature after the oil has passed through the oil cooler.

# Engine Operation

i00817012

## Engine Operation

**SMCS Code:** 1000

Proper operation and maintenance are key factors in attaining the maximum service life and economy for the engine. Follow the instructions in this Operation and Maintenance Manual in order to minimize operating costs and maximize the service life of the engine.

Observe the gauges frequently while the engine is operating. Record the data from the gauges in a log regularly. Compare the data to the specifications for normal engine operation. Comparing the data over time will help to detect changes in engine performance.

Investigate any significant change in the gauge readings. Monitor the engine operation and take action when discrepancies are found.

## Operating the Engine and the Driven Equipment

Check the gauges and the driven equipment frequently while the engine is operating under a load. The engine can be operated for extended periods of time at full load.

## Partial Load Operation

Extended operation at low idle or at reduced load may cause increased oil consumption and carbon buildup in the cylinders. Carbon buildup results in a loss of power and/or poor performance.

When possible, apply a full load at least on an hourly basis. This will burn excess carbon from the cylinders.

## Partial Load Operation In Cold Weather

Operation of the jacket water heater is recommended if the engine is operating at a low load in extreme cold.

## Fuel Conservation Practices

**SMCS Code:** 1000; 1250

The efficiency of the engine can affect the fuel economy. Caterpillar's design and technology in manufacturing provides maximum fuel efficiency in all applications. Follow the recommended procedures in order to attain optimum performance for the life of the engine.

- Avoid spilling fuel.

Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.

- Be aware of the properties of the different fuels. Use only the recommended fuels.

- Avoid unnecessary idling.

Shut off the engine rather than idle for long periods of time.

- Observe the service indicator frequently. Keep the air cleaner elements clean.
- Ensure that the turbochargers are operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.
- Maintain a good electrical system.

One defective battery cell will overwork the alternator. This will consume excess power and excess fuel.

- Ensure that the belts are properly adjusted. The belts should be in good condition.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the driven equipment is in good working order.
- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

# Engine Stopping

i01232206

## Emergency Stopping

SMCS Code: 1000; 7418

### NOTICE

Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use emergency shutoff devices or controls for normal stopping procedure.

Ensure that any components for the external system that support the engine operation are secured after the engine is stopped.

## Emergency Stop Button



Illustration 35

g00104303

Typical emergency stop button

The emergency stop button is in the OUT position for normal engine operation. For an emergency stop, push the emergency stop button. This shuts off the fuel to the engine. This also activates the air shutoff (if equipped).

### NOTICE

Do not start the engine until the problem necessitating the emergency stop has been located and corrected.

The engine control switch, the emergency stop button, and the air shutoff must be reset before the engine can be restarted. Reset the engine control switch before resetting the emergency stop button.

To reset the engine control switch, turn the switch to the "OFF/RESET" position.

To reset the emergency stop button, turn the button clockwise. The spring-loaded button will return to the OUT position. The button may also be pulled to the OUT position.

To reset the air shutoff, turn the reset knob to the "OPEN" position. **Ensure that both of the air shutoffs are reset.**

## Air Shutoffs

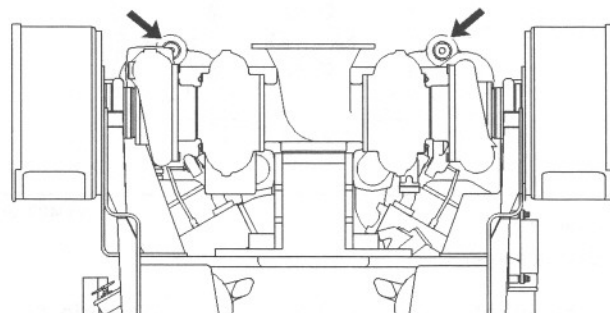


Illustration 36

g00429164

Air shutoffs

The air shutoffs are activated by oil pressure when energy to a solenoid is interrupted. Each air shutoff uses a plate that rotates on a shaft in order to shut off inlet air to the aftercooler. The engine stops because of the restricted air supply to the combustion chamber. The air shutoffs will actuate for the following conditions:

**Note:** A switch may be supplied by the customer in order to activate the air shutoffs.

- The emergency stop button is pressed.
- The air shutoff is activated.
- An overspeed shutdown occurs.

The air shutoffs must be manually reset before the engine is restarted. To reset the air shutoffs, turn the reset knobs to the "OPEN" position. **Ensure that the air shutoff is reset. If the engine has two air shutoffs, ensure that both of the air shutoffs are reset.**

## Fuel Shutoff

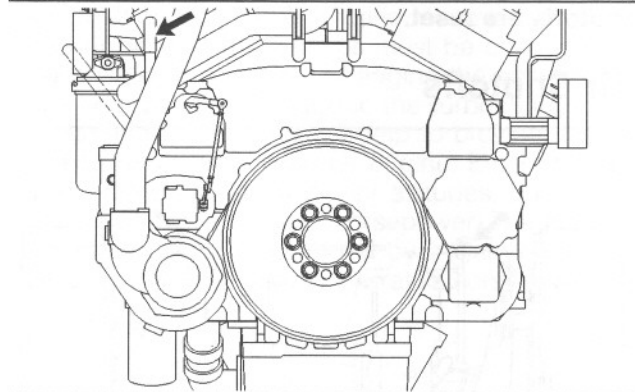


Illustration 37  
Fuel shutoff lever

g00429138

A fuel shutoff lever is located on the right side of the engine near the front of the engine. To shut off the fuel, move the lever.

i01232212

## Manual Stop Procedure

**SMCS Code:** 1000; 7418

### NOTICE

Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of engine components.

Excessive temperatures in the turbocharger center-housing will cause oil coking problems.

Allow the engine to gradually cool before stopping the engine

There may be several methods for shutting off the engine. Make sure that the shutoff procedures are understood. Use the following general guidelines for stopping the engine.

## Automatic Stopping

Automatic stopping will occur when the engine is operating in the automatic mode and the remote start/stop initiate contact opens. If the cooldown feature is utilized, the engine will operate for a programmed period of time before the engine stops. Otherwise, the engine will immediately shut off.

## Industrial Engines

1. Disengage the driven equipment. Unload the compressor or pump.

- a. Disengage the clutch (if equipped).
  - b. Place the transmission and/or other attachments for the power take-off in NEUTRAL.
2. Reduce the engine rpm to low idle. Operate the engine at low idle rpm for a cooldown period before stopping the engine.
    - a. If the cooldown feature is utilized, turn the engine control switch to the "COOLDOWN/STOP" position.

The engine will operate for a programmed period of time. After the cooldown, the timer will activate the fuel shutoff. The control panel will remain powered until the engine control switch is turned to the "OFF/RESET" position.
    - b. If the engine has been operated at a low load, operate the engine at low idle for approximately 30 seconds before stopping the engine.
    - c. If the engine has been operated at a high load, operate the engine at low idle for three to five minutes before stopping the engine.
  3. Turn the engine control switch to the stop position.

The engine will coast to a stop. Ensure that any system that provides external support to the engine operation is secured after the engine is stopped.

## Generator Set Engines

1. Open the main circuit breaker in order to disengage the driven equipment.
2. Operate the engine for a cooldown period before stopping the engine.
  - a. If the cooldown feature is utilized, turn the engine control switch to the "COOLDOWN/STOP" position.

The engine will operate for a programmed period of time. After the cooldown, the timer will activate the fuel shutoff. The engine control module will remain powered until the engine control switch is turned to the "OFF/RESET" position.

- b. If the cooldown feature is not utilized, operate the engine at high idle for approximately five minutes. Then stop the engine.



## Refill Capacities

i01228526

### Refill Capacities

**SMCS Code:** 1000; 1348; 1395; 7560

### Lubrication System

The capacity of the lubrication system includes the capacity of the oil filters that are installed at the factory.

Auxiliary oil filter systems (if equipped) will require additional oil. Refer to the specifications that are provided by the OEM of the auxiliary oil filter system.

For the recommended oil, see this Operation and Maintenance Manual, "Engine Oil" topic (Maintenance Section).

### 3508 Engine

Table 30

Approximate Refill Capacities for 3508 Engine Lubrication Systems		
Compartment or System	Liters	US Gallons
Shallow sump	104 L	27 US gal
Standard sump	227 L	60 US gal
Deep sump	443 L	117 US gal

### 3512 Engine

Table 31

Approximate Refill Capacities for 3512 Engine Lubrication Systems		
Compartment or System	Liters	US Gallons
Shallow sump	152 L	40 US gal
Standard sump	318 L	84 US gal
Deep sump	625 L	165 US gal

### 3516 Engine

Table 32

Approximate Refill Capacities for 3516 Engine Lubrication Systems		
Compartment or System	Liters	US Gallons
Shallow sump	204 L	53 US gal
Standard sump	405 L	107 US gal
Deep sump	807 L	213 US gal

## Cooling System

To properly maintain the cooling system, the total capacity of the cooling system must be determined. The capacity of the total cooling system will vary between individual installations. The external system can include the following components: expansion tank, radiator, and piping. Refer to the specifications that are provided by the locomotive OEM. Record the total cooling system capacity in the appropriate Table.

For the recommended coolant, see this Operation and Maintenance Manual, "Coolant Recommendations" (Maintenance Section).

### Engines with Separate Circuit Aftercooling

#### 3508 Engine

Table 33

Approximate Refill Capacities for the 3508 Engine Cooling System with Separate Circuit Aftercooling		
Compartment or System	Liters	US Gallons
Jacket water system	86.6 L	21.8 US gal
Separate circuit aftercooler	20.1 L	5.3 US gal
External system		
Total cooling system		

#### 3512 Engine

Table 34

Approximate Refill Capacities for the 3512 Engine Cooling System with Separate Circuit Aftercooling		
Compartment or System	Liters	US Gallons
Jacket water system	134.2 L	35.4 US gal
Separate circuit aftercooler	22.8 L	6 US gal
External system		
Total cooling system		



## 3516 Engine

Table 35

Approximate Refill Capacities for the 3516 Engine Cooling System with Separate Circuit Aftercooling		
Compartment or System	Liters	US Gallons
Jacket water system	205.4 L	54.2 US gal
Separate circuit aftercooler	28 L	7.4 US gal
External system		
Total cooling system		

## Engines with Jacket Water Aftercooling

### 3508 Engine

Table 36

Approximate Refill Capacities for the 3508 Engine Cooling System with Jacket Water Aftercooling		
Compartment or System	Liters	US Gallons
Engine only	103 L	27.1 US gal
External system		
Total cooling system		

### 3512 Engine

Table 37

Approximate Refill Capacities for the 3512 Engine Cooling System with Jacket Water Aftercooling		
Compartment or System	Liters	US Gallons
Engine only	160 L	42.3 US gal
External system		
Total cooling system		

### 3516B Engine

Table 38

Approximate Refill Capacities for the 3516 Engine Cooling System with Jacket Water Aftercooling		
Compartment or System	Liters	US Gallons
Engine only	235 L	62 US gal
External system		
Total cooling system		

i01228549

## Maintenance Interval Schedule

**SMCS Code:** 1000; 7500

**Before performing any operation or maintenance procedures, ensure that the Safety Information, warnings, and instructions are read and understood.**

To determine the maintenance intervals, use fuel consumption, service hours or calendar time, whichever occurs first. Experience has shown that maintenance intervals are most accurately scheduled on the basis of fuel consumption. For information on service hours and fuel consumption, see this Operation and Maintenance Manual, "Maintenance Recommendations" topic (Maintenance Section).

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

**Note:** For information on generator maintenance, see the Operation and Maintenance Manual for the generator.

**Note:** For engines with a shallow oil sump, change the engine oil and oil filters after 500 hours of operation. For engines with a standard oil sump, change the engine oil and oil filters after 500 hours of operation. For engines with a deep oil sump, change the engine oil and oil filters after 1000 hours of operation.

### When Required

Maintenance Recommendations .....	79
Batteries - Replace .....	84
Engine Air Cleaner Element (Dual Element) - Clean/Replace .....	94
Engine Air Cleaner Element (Single Element) - Inspect/Replace .....	97
Fuel System - Prime .....	108
Zinc Rods - Inspect/Replace .....	126

### Daily

Air Starting Motor Lubricator Oil Level - Check ....	82
Air Tank Moisture and Sediment - Drain .....	83
Cooling System Coolant Level - Check .....	90
Engine Air Cleaner Service Indicator - Inspect ....	98
Engine Air Precleaner - Clean .....	99
Engine Oil Filter Differential Pressure - Check ...	100
Engine Oil Level - Check .....	101
Fuel System Fuel Filter Differential Pressure - Check .....	108
Fuel Tank Water and Sediment - Drain .....	112
Instrument Panel - Inspect .....	113
Walk-Around Inspection .....	124

### Initial 250 Service Hours (or at first oil change)

Engine Valve Lash - Inspect/Adjust .....	107
Fuel Injector - Inspect/Adjust .....	108
Magnetic Pickups - Clean/Inspect .....	114

### Every 250 Service Hours

Alternator and Fan Belts - Inspect/Adjust/ Replace .....	83
Battery Electrolyte Level - Check .....	85
Cooling System Supplemental Coolant Additive (SCA) - Test/Add .....	91
Engine Oil Sample - Obtain .....	101
Engine Oil and Filter - Change .....	102
Fan Drive Bearing - Lubricate .....	107
Hoses and Clamps - Inspect/Replace .....	112
Radiator - Clean .....	121

### Every 500 Service Hours

Engine Oil and Filter - Change .....	102
--------------------------------------	-----

### Every 1000 Service Hours

Cooling System Coolant Analysis (Level II) - Obtain .....	90
Engine - Clean .....	93
Engine Crankcase Breather - Clean .....	99
Engine Oil and Filter - Change .....	102
Engine Protective Devices - Check .....	107
Fuel System Primary Filter - Clean/Inspect/ Replace .....	109
Fuel System Secondary Filter - Replace .....	109

### Every 2000 Service Hours

Actuator Control Linkage - Lubricate .....	81
Air Starting Motor Lubricator Bowl - Clean .....	82
Crankshaft Vibration Damper - Inspect .....	93
Engine Mounts - Check .....	100
Engine Valve Lash - Inspect/Adjust .....	107
Fuel Injector - Inspect/Adjust .....	108
Magnetic Pickups - Clean/Inspect .....	114

### Every 3000 Service Hours or 3 Years

Cooling System Coolant (DEAC) - Change .....	86
Cooling System Coolant Extender (ELC) - Add ....	90

### Every 6000 Service Hours or 6 Years

Alternator - Inspect .....	83
Cooling System Coolant (ELC) - Change .....	88
Cooling System Water Temperature Regulator - Replace .....	92
Starting Motor - Inspect .....	123
Turbocharger - Inspect .....	123
Water Pump - Inspect .....	126

**Between 7500 and 11 000 Service Hours**

Overhaul (Top End) .....	116
Overhaul Considerations .....	118

**Between 15 000 and 22 000 Service Hours**

Overhaul (Top End) .....	116
Overhaul Considerations .....	118

**Between 22 500 and 33 000 Service Hours**

Overhaul (Major) .....	114
Overhaul Considerations .....	118

i01228599

## Maintenance Recommendations

SMCS Code: 1000

### Service Hours and Fuel Consumption

Experience has shown that maintenance intervals are most accurately based on fuel consumption. Fuel consumption corresponds more accurately to the engine load. Tables 39, 40, and 41 list average ranges of fuel consumption and service hours for a load factor of approximately 60 percent. Use the range of fuel consumption only as a guideline.

Table 39

**Maintenance Interval Schedule**  
**Service Hours and Fuel Consumption for 3508 Engines <sup>(1)</sup>**

Interval	Rated Up To 1300 RPM	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
250 Service Hours	22 700 L (6000 US gal)	27 700 L (7200 US gal)	32 000 L (8500 US gal)
500 Service Hours	45 400 L (12,000 US gal)	54 400 L (14,400 US gal)	64 000 L (17,000 US gal)
1000 Service Hours	89 000L (23,500 US gal)	109 000 L (28,800 US gal)	128 000 L (34,000 US gal)
2000 Service Hours	178 000 L (47,000 US gal)	218 000 L (57,600 US gal)	257 000 L (68,000 US gal)
3000 Service Hours	267 500 L (70,500 US gal)	327 500 L (84,000 US gal)	386 500 L (102,000 US gal)
6000 Service Hours	535 000 L (141,000 US gal)	636 000 L (168,000 US gal)	774 000 L (204,000 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours
	976 000 L (257,500 US gal)		
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours
	1 952 000 L (515,000 US gal)		
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours
	2 928 000 L (772,500 US gal)		

<sup>(1)</sup> Fuel consumption is based on a load factor of approximately 60 percent.

Table 40

Maintenance Interval Schedule Service Hours and Fuel Consumption for 3512 Engines <sup>(1)</sup>			
Interval	Rated Up To 1300 RPM	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
250 Service Hours	33 400 L (8800 US gal)	41 000 L (10,800 US gal)	48 500 L (12,800 US gal)
500 Service Hours	66 800 L (17,600 US gal)	82 000 L (21,600 US gal)	97 000 L (25,600 US gal)
1000 Service Hours	133 500 L (35,000 US gal)	164 000 L (43,200 US gal)	194 000 L (51,200 US gal)
2000 Service Hours	267 000 L (70,000 US gal)	328 000 L (86,400 US gal)	388 000 L (102,400 US gal)
3000 Service Hours	398 000 L (105,000 US gal)	491 000 L (129,600 US gal)	582 000 L (153,600 US gal)
6000 Service Hours	796 000 L (210,000 US gal)	982 000 L (259,200 US gal)	1 164 000 L (307,200 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours
	1 460 000 L (385,000 US gal)		
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours
	2 920 000 L (770,000 US gal)		
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours
	4 380 000 L (1,155,000 US gal)		

(1) Fuel consumption is based on a load factor of approximately 60 percent.

Table 41

Maintenance Interval Schedule Service Hours and Fuel Consumption for 3516 Engines <sup>(1)</sup>			
Interval	Rated Up To 1300 RPM	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
250 Service Hours	44 000 L (11,600 US gal)	53 000 L (14,000 US gal)	64 500 L (17,000 US gal)
500 Service Hours	88 000 L (23,200 US gal)	106 000 L (28,000 US gal)	129 000 L (34,000 US gal)
1000 Service Hours	176 000 L (46,500 US gal)	212 000 L (56,000 US gal)	258 000 L (68,000 US gal)
2000 Service Hours	352 000 L (93,000 US gal)	424 000 L (112,000 US gal)	516 000 L (136,000 US gal)
3000 Service Hours	528 700 L (139,500 US gal)	636 700 L (168,100 US gal)	773 000 L (204,000 US gal)
6000 Service Hours	1 056 000 L (279,000 US gal)	1 272 000 L (336,000 US gal)	1 548 000 L (408,000 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours
	1 942 000 L (512,500 US gal)		
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours
	3 884 000 L (1,025,000 US gal)		
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours
	5 826 000 L (1,537,500 US gal)		

(1) Fuel consumption is based on a load factor of approximately 60 percent.

## Severe Operation

Severe operation is the use of an engine that exceeds current published standards for that engine. Caterpillar maintains standards for the following engine parameters:

- Horsepower
- Range of rpm
- Fuel consumption
- Fuel quality
- Altitude
- Maintenance intervals
- Selection of oil



- Selection of coolant
- Environmental qualities
- Installation

Refer to the standards for your engine or consult your Caterpillar dealer in order to determine if your engine is operating within the defined parameters.

Severe operation can accelerate component wear. Engines that are operating under severe conditions may need more frequent maintenance intervals for the following reasons:

- Maximum reliability
- Retention of full service life

Because of individual applications, it is not possible to identify all of the factors which can contribute to severe operation. Consult your Caterpillar dealer about the maintenance that is needed for your specific engine.

The following factors can contribute to severe operation: environment, improper operating procedures, and improper maintenance practices.

## Environmental Factors

### Extreme Ambient Temperatures

Extended operation in environments that are extremely cold or hot can damage components. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in very cold temperatures. Extremely hot inlet air reduces the performance capabilities of the engine.

**Note:** See this Operation and Maintenance Manual, "Cold Weather Operation" topic (Operation Section), or see Supplement, SEBU5898, "Cold Weather Recommendations".

### Cleanliness

Unless the equipment is cleaned regularly, extended operation in a dirty environment and in a dusty environment can damage components. Built up mud, dirt, and dust can encase components. This can make maintenance difficult. The buildup can contain corrosive chemicals. Corrosive chemicals and salt can damage some components.

### Improper Operating Procedures

- Extended operation at low idle

- Minimum cool down periods after high load factor operation
- Operating the engine beyond the guidelines for the engine rating
- Operating the engine at loads that are greater than the rated load
- Operating the engine at speeds that are greater than the rated speed
- Use of the engine for an application that is not approved

## Improper Maintenance Practices

- Extension of maintenance intervals
- Not using recommended fuel, lubricants, and coolant/antifreeze

i00855723

## Actuator Control Linkage - Lubricate

**SMCS Code:** 1265-086

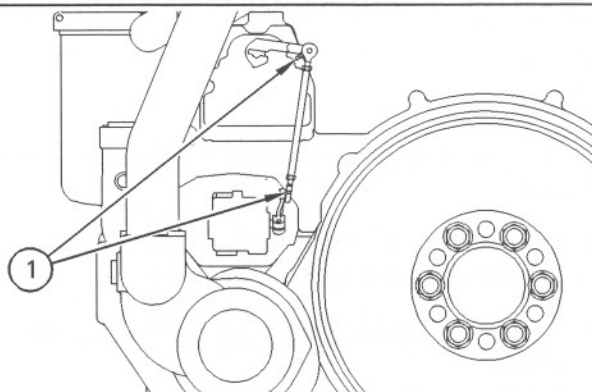


Illustration 43

g00426785

(1) Grease Fitting

Apply grease to the grease fittings (1).

Use a hand grease gun and lubricate the grease fittings with MPGM.

## Check the Linkage

Use the following procedure to check the linkage for binding.

1. Stop the engine.
2. Move the linkage by hand.

If the linkage binds, repair the linkage.

For information on adjustment, removal, and replacement, see the Service Manual. Consult your Caterpillar dealer for assistance.

## Air Starting Motor Lubricator Bowl - Clean

SMCS Code: 1451-070

1. Ensure that the air supply to the lubricator is OFF.

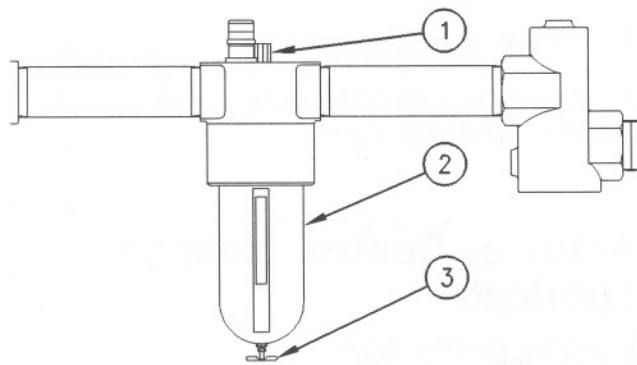


Illustration 44

g00270335

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

**Note:** Always dispose of fluids according to local regulations.

2. Open drain (3). Drain the oil into a suitable container. Dispose of the used oil.
3. Remove bowl (2). Clean the bowl with warm water.
4. Dry the bowl. Inspect the bowl for cracks. If the bowl is cracked, replace the damaged bowl with a new bowl.
5. Install the bowl. Close drain (3).
6. Remove plug (1). Fill bowl (2) with oil. Use nondetergent "10W" oil for temperatures that are greater than 0°C (32°F). Use air tool oil for temperatures that are below 0°C (32°F). Install oil filler plug (1).
7. If necessary, adjust the lubricator in order to release two drops of oil per 30 seconds. For instructions, see this Operation and Maintenance Manual, "Air Starting Motor Lubricator Oil Level - Check" topic (Maintenance Section).

i00691569

## Air Starting Motor Lubricator Oil Level - Check

SMCS Code: 1451-535

### NOTICE

Never allow the lubricator bowl to become empty. The air starting motor will be damaged by a lack of lubrication. Ensure that sufficient oil is in the lubricator bowl.

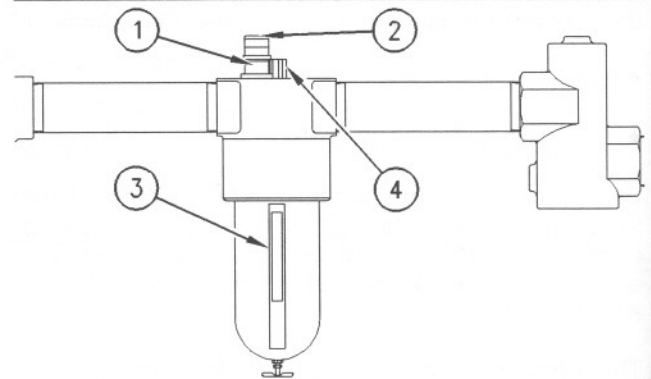


Illustration 45

g00349048

- (1) Dome
- (2) Knob
- (3) Sight gauge
- (4) Plug

1. Observe the oil level in sight gauge (3). If the oil level is less than 1/2, add oil to the lubricator bowl.
2. Ensure that the air supply to the lubricator is OFF.
3. Remove plug (4). Pour oil into the lubricator bowl. Use "10W" oil for temperatures that are greater than 0°C (32°F). Use air tool oil for temperatures that are below 0°C (32°F).
4. Install plug (4).

## Adjust the Lubricator

**Note:** Adjust the lubricator with a constant rate of air flow. After the adjustment, the lubricator will release oil in proportion to variations of the air flow.

1. Ensure that the fuel supply to the engine is OFF.

### NOTICE

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

2. Operate the air starting motor. Observe the drops of oil that are released in dome (1).

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

#### NOTICE

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

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

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

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

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

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

i01064210

## Crankshaft Vibration Damper - Inspect

**SMCS Code:** 1205-040

The crankshaft vibration damper limits the torsional vibration of the crankshaft. The visconic damper has a weight that is located inside a fluid filled case.

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

A damper that is hot may be the result of excessive friction. This could be due to misalignment. Use an infrared thermometer to monitor the temperature of the damper during operation. If the temperature reaches 93 °C (200 °F), consult your Caterpillar dealer.

Inspect the damper for evidence of dents, cracks, and leaks of the fluid.

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 all of the seals.

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

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

## Removal and Installation

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

i01108937

## Engine - Clean

**SMCS Code:** 1000-070

### **WARNING**

**Personal injury or death can result from high voltage.**

**Moisture could create paths of electrical conductivity.**

**Make sure the unit is off line (disconnected from utility and/or other generators), locked out and tagged "Do Not Operate".**

#### NOTICE

Water or condensation can cause damage to generator components. Protect all electrical components from exposure to water.

i00626013

## Engine Protective Devices - Check

**SMCS Code:** 7400-535

Alarms and shutoffs must function properly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. It is impossible to determine if the engine protective devices are in good working order during normal operation. Malfunctions must be simulated in order to test the engine protective devices.

A calibration check of the engine protective devices will ensure that the alarms and shutoffs activate at the setpoints. Ensure that the engine protective devices are functioning properly.

### NOTICE

During testing, abnormal operating conditions must be simulated.

The tests must be performed correctly in order to prevent possible damage to the engine.

To prevent damage to the engine, only authorized service personnel or your Caterpillar dealer should perform the tests.

## Visual Inspection

Visually check the condition of all gauges, sensors and wiring. Look for wiring and components that are loose, broken, or damaged. Damaged wiring or components should be repaired or replaced immediately.

i01071128

## Engine Valve Lash - Inspect/Adjust

**SMCS Code:** 1102-025

**Note:** For procedures on adjusting the valve bridge and adjusting the engine valve lash, see the Service Manual, "Systems Operation/Testing and Adjusting" module. Consult your Caterpillar dealer for assistance.

## Valve Bridge

Check the valve bridge and adjust the valve bridge, if necessary. Perform the procedure for both valve bridges for each cylinder. After the valve bridge is checked for each cylinder, proceed with the valve lash adjustment, if necessary.

## Engine Valve Lash

### NOTICE

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

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

The valve bridge adjustment must be performed before making a valve lash adjustment. If the valve lash is within the tolerance, an adjustment of the valve lash is NOT necessary.

Perform the valve lash setting when the engine is cold. After the engine has been shut down and the valve covers are removed, the engine is considered cold. Before performing maintenance, prevent the entry of foreign matter into the top of the cylinder head and the valve mechanism. Thoroughly clean the area around the valve mechanism covers.

For the valve lash setting, see this Operation and Maintenance Manual, "Engine Description" topic (Product Information Section).

i01106228

## Fan Drive Bearing - Lubricate

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

**Note:** Lubricate the bearing more frequently if the engine is operated in an environment that is dusty, hot, or humid.



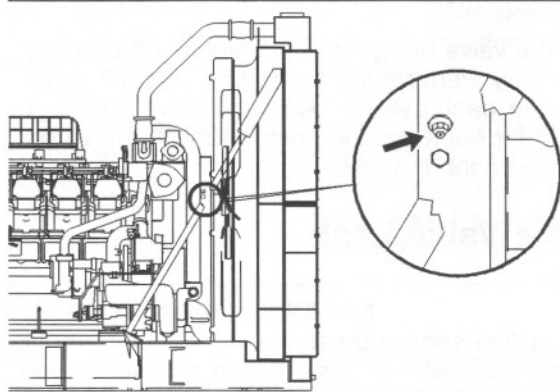


Illustration 72

g00583459

Grease fitting

Fill the grease fitting for the fan drive bearing with Caterpillar Bearing Lubricant. Alternatively, use a multipurpose grease that has three to five percent of molybdenum and a grade of NLGI No. 2.

i01225410

## Fuel Injector - Inspect/Adjust

**SMCS Code:** 1290-025

**Note:** Perform this procedure when the engine valve lash is inspected.

### 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 fuel injector according to the Systems Operation/Testing And Adjusting, "Fuel System" topic. Adjust the lash for the fuel injector, if necessary.

i01239545

## Fuel System - Prime

**SMCS Code:** 1250-548; 1258-548

1. Open the fuel supply valve. Ensure that the engine will not start during the priming procedure. Turn the start switch to the OFF position.

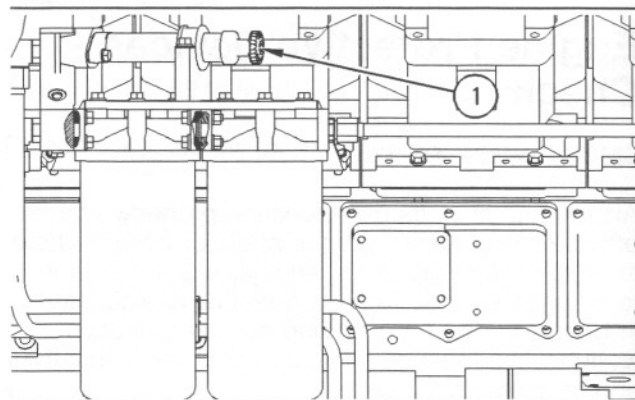


Illustration 73

g00662495

(1) Fuel priming pump plunger

2. Turn fuel priming pump plunger (1) counterclockwise in order to release the lock plate from the retainer.
3. Operate the fuel priming pump until the air in the fuel system has been pumped through the fuel return line back to the fuel tank.
4. Press the fuel priming pump plunger to the locking position. Turn the fuel priming pump plunger clockwise in order to engage the lock plate in the retainer.

**Note:** Enable the starting system only after all maintenance has been completed.

i01076701

## Fuel System Fuel Filter Differential Pressure - Check

**SMCS Code:** 1261-535

Observe the fuel filter differential pressure frequently during engine operation.



### Fuel Filter Differential Pressure

**(Restriction)** – This gauge indicates the difference in fuel pressure between the inlet side and the outlet side of the fuel filter. As the fuel filter element becomes plugged, the difference in pressure between the two sides of the fuel filter increases.

The nominal fuel filter differential pressure during normal engine operation is approximately 60 kPa (9 psi).

Replace the secondary fuel filter elements when the fuel filter differential pressure reaches 103 kPa (15 psi).



For instructions on replacement of the secondary fuel filter elements, see this Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" topic.

i01239630

## Fuel System Primary Filter - Clean/Inspect/Replace

SMCS Code: 1260-510; 1260-571

### WARNING

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

1. Stop the engine. Ensure that the engine will not start during this procedure.
2. Shut off the fuel supply valve to the engine.

### 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.

### NOTICE

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

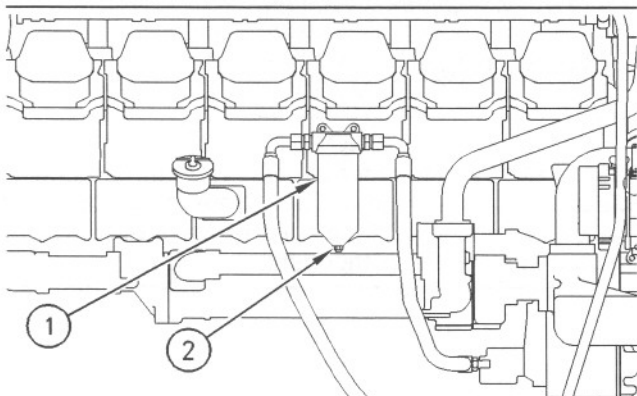


Illustration 74

g00330404

- (1) Filter case  
(2) Nut

3. Loosen nut (2). Hold filter case (1) and remove nut (2). Prepare to catch the fuel that is inside of the filter case with a suitable container. Remove the filter case from the mounting bolt.

4. Remove the element and wash the element in clean, nonflammable solvent. Allow the element to dry. Inspect the element. Install a new element if the old element is damaged or deteriorated.
5. Clean the inside of the filter case. Allow the filter case to dry.
6. Inspect the O-ring seals. Obtain new seal rings if the old seal rings are damaged or deteriorated. Ensure that the sealing surfaces for the seals are clean. Install the seals.

### 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. Place the element in the filter case. Slide the filter case over the mounting bolt.
8. Install the nut.
9. Open the fuel supply valve.
10. Prime the fuel system. See this Operation and Maintenance Manual, "Fuel System - Prime" topic.

i01229595

## Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

### WARNING

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

Replace the secondary fuel filter elements whenever the following conditions occur:

- The fuel filter differential pressure gauge registers 103 kPa (15 psi).
- The fuel filters have been used for 1000 service hours.

## Replacing the Fuel Filter Elements with the Engine Stopped

### Canister

1. Stop the engine. Ensure that the engine will not start during this procedure.
2. Shut off the fuel supply valve to the engine.

#### 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.

#### NOTICE

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

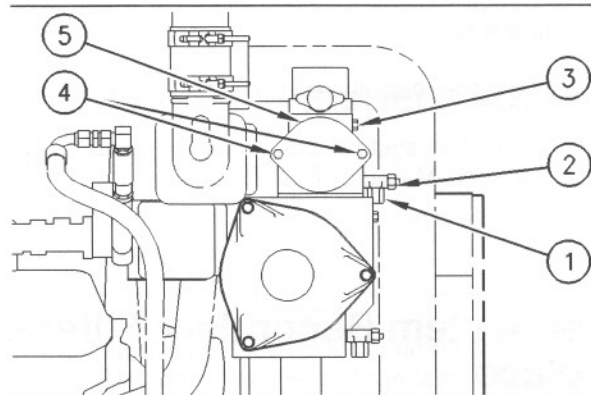


Illustration 75

g00329184

- (1) Drain
- (2) Drain valve
- (3) Plug
- (4) Bolts
- (5) Cover

3. Connect a hose to drain (1). Place the other end of the hose into a suitable container in order to collect the fuel.
4. Open drain valve (2). Remove plug (3). Allow the fuel to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

**Note:** Some fuel will remain in the housing after the fuel has been drained. This fuel will pour out of the housing when cover (5) is removed. Prepare to catch the fuel in a suitable container. Clean up any spilled fuel with absorbent towels or pillows. DO NOT use absorbent particles to clean up the fuel.

### WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

5. Be alert to the spring force. Gradually loosen but do not remove bolts (4). Before removing bolts (4), pry cover (5) loose in order to relieve any spring pressure. Remove cover (5). Remove the O-ring seal on the inside of the cover. Remove the fuel filter elements.
6. Clean cover (5) and clean the O-ring seal. Clean the inside of the fuel filter housing.
7. Install new fuel filter elements.
8. Inspect the O-ring seal. Ensure that the surfaces for the O-ring seal are clean. Install a new O-ring seal if the old O-ring seal is damaged or deteriorated.
9. Install cover (5). Ensure that the springs are seated properly between the cover and the fuel filter elements.
10. Open the fuel supply valve. Reconnect the battery.
11. Prime the fuel system. Refer to this Operation and Maintenance Manual, "Fuel System - Prime" topic (Maintenance Section).

### Spin-On Filter

#### NOTICE

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

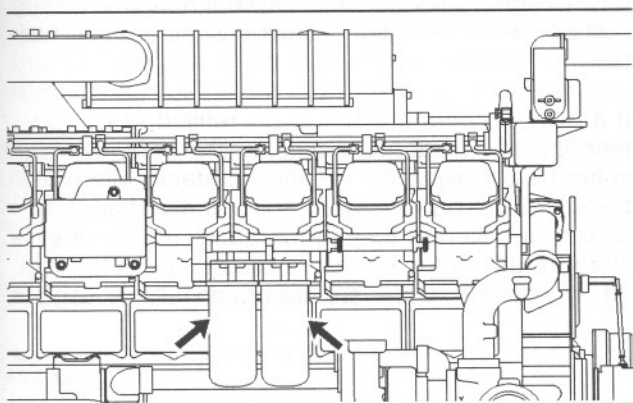


Illustration 76

g00425598

## Secondary fuel filters

1. Remove the used fuel filter with a 1U-8760 Chain Wrench. Discard the used fuel filter.
2. Clean the gasket sealing surface of the fuel filter base.

Ensure that all of the old gasket is removed.

3. Apply clean diesel fuel to the new fuel filter gasket.

**NOTICE**

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

4. Install the new fuel filter.

Spin the new fuel filter onto the fuel filter base until the gasket contacts the base. Tighten the fuel filter by hand by one full turn. Do not overtighten the fuel filter. Use the rotation index marks that are on the fuel filter as a guide for proper tightening.

5. Prime the fuel system.

See this Operation and Maintenance Manual, "Fuel System - Prime" topic (Maintenance Section).

## Replacing the Fuel Filter Elements During Engine Operation

### Duplex Fuel Filters

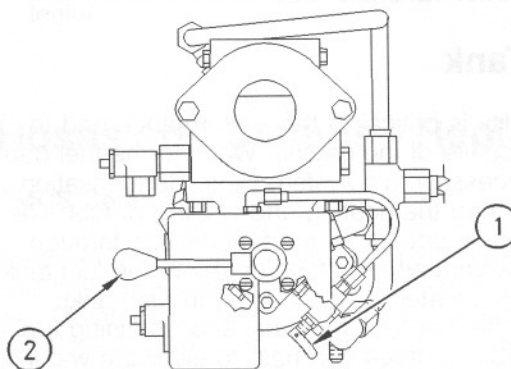


Illustration 77

g00657535

- (1) Fill valve  
(2) Control valve

1. Open fill valve (1) for a minimum of five minutes. Close the valve.
2. If the main filter will be serviced, rotate control valve (2) to the "AUX RUN" position.

If the auxiliary filters will be serviced, rotate control valve (2) to the "MAIN RUN" position.

**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.

**NOTICE**

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

3. See "Replacing the Fuel Filter Elements with the Engine Stopped". Perform Step 75 through Step 9 from the "Canister" instructions.
4. Open fill valve (1) for a minimum of five minutes in order to fill the new elements. Close the fill valve.

After the new filter elements are full of fuel, either the main filter or the auxiliary filter may be used.

Record the data in a log. Compare the new data to the data that was previously recorded. Comparing the new data to the recorded data will help to establish the trends of engine performance. A gauge reading that is abnormal may indicate a problem with operation or a problem with the gauge.

i01042517

## Jacket Water Heater - Check

**SMCS Code:** 1383-535

Jacket water heaters help to improve startability in ambient temperatures that are below 21 °C (70 °F). All installations that require automatic starting should have jacket water heaters.

Check the operation of the jacket water heater. For an ambient temperature of 0 °C (32 °F), the heater should maintain the jacket water temperature at approximately 32 °C (90 °F).

i00738324

## Magnetic Pickups - Clean/Inspect

**SMCS Code:** 1907-040

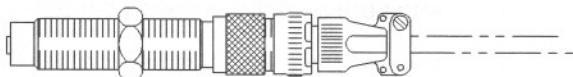


Illustration 78

Typical magnetic pickup

g00293337

1. Remove the magnetic pickup from the flywheel housing. Check the condition of the end of the magnetic pickup. Check for signs of wear and contaminants.
2. Clean the metal shavings and other debris from the face of the magnet.
3. Install the magnetic pickup according to the information in the Service Manual, "Specifications".

i01253023

## Overhaul (Major)

**SMCS Code:** 7595-020-MJ

The maintenance intervals that are listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule" are expressed in service hours. A more accurate figure to use is fuel consumption. Fuel consumption corresponds more accurately to the engine load.

Table 44 lists average ranges of fuel consumption and service hours for a load factor of approximately 60 percent. Use the range of fuel consumption only as a guideline.

Table 44

Major Overhaul Service Hours and Fuel Consumption for 3500 Engines <sup>(1)</sup>			
Engine	Rated Up To 1300 RPM	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours
3508	2 928 000 L (772,500 US gal)		
3512	4 380 000 L (1,555,000 US gal)		
3516	5 826 000 L (1,537,500 US gal)		

<sup>(1)</sup> Fuel consumption is based on a load factor of approximately 60 percent.

The need for a major overhaul is determined by several factors.

- An increase of oil consumption
- An increase of crankcase blowby
- The total amount of fuel consumption
- The service hours of the engine
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

**Note:** It is possible for oil analysis to indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Caterpillar dealer about scheduling a major overhaul.

**Note:** The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

A major overhaul includes all of the work that is done for the top end overhaul. A major overhaul includes additional parts and labor. Additional parts and labor are required in order to completely rebuild the engine.

For the major overhaul, all of the bearings, seals, gaskets, and components that wear are disassembled. The parts are cleaned and inspected. If necessary, the parts are replaced. The crankshaft is measured for wear. The crankshaft may require regrinding. Alternatively, the crankshaft may be replaced with a Caterpillar replacement part.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

The following definitions explain the terminology for the services that are performed during an overhaul:

**Inspect** – Inspect the components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, "Index of Publications on Reusability or Salvage of Used Parts". The guidelines were developed in order to help Caterpillar dealers and customers to avoid unnecessary expenditures. New parts are not required if the existing parts can still be used, reconditioned, or repaired. If the components are not in the reusability guidelines, refer to the Service Manual, "Specifications" module.

**Rebuild** – The component can be reconditioned in order to comply with reusability guidelines.

**Replace** – The service life of the part is exhausted. The part may fail before the next maintenance interval. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a CAT remanufactured part, a rebuilt part, or a used part. Some worn components may be exchanged with your Caterpillar dealer for credit on replacement parts. Consult your Caterpillar dealer about repair options for your engine.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Table 45. Your Caterpillar dealer can provide these services and components.

Table 45

Major Overhaul Instructions <sup>(1)</sup>	
Clean	Oil suction screen
Clean Inspect Test	Aftercooler core <sup>(2)</sup>
Inspect	Camshafts
	Cylinder block
	Crankshaft vibration damper
	Driven equipment (alignment)
	Flywheel
	Front gear train (gears)
	Fuel system linkage
Inspect Rebuild	Rear gear train (gears)
	Rocker arms
Inspect Rebuild Replace	Connecting rods
	Cylinder head assemblies
	Fuel priming pump
	Fuel transfer pump
	Oil cooler core
	Piston pins

(continued)



(Table 45, contd)

Major Overhaul Instructions <sup>(1)</sup>	
Inspect Replace	Camshaft lifters
	Camshaft thrust washers
	Crankshaft
	Cylinder liners
	Engine mounts
	Engine wiring harness
	Fuel pressure regulating valve
	Pistons (Crowns and Skirts)
	Push rods
	Spacer plates
Replace	Camshaft bearings
	Connecting rod bearings
	Crankshaft seals
	Crankshaft thrust plates
	Fuel injectors
	Gear train bushings
	Main bearings
	Piston rings
	Seals and bellows for the exhaust manifold
	Seals and gaskets for the air Inlet manifold

(1) For instructions on removal and installation of components, see the Service Manual, "Disassembly and Assembly" module.

(2) For instructions on cleaning the core, see this Operation and Maintenance Manual, "Aftercooler Core - Clean/Test" topic.

i01252793

## Overhaul (Top End)

**SMCS Code:** 7595-020-TE

The maintenance intervals that are listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule" are expressed in service hours. A more accurate figure to use is fuel consumption. Fuel consumption corresponds more accurately to the engine load.

Table 46 lists average ranges of fuel consumption and service hours for a load factor of approximately 60 percent. Use the range of fuel consumption only as a guideline.

Table 46

Top End Overhaul Service Hours and Fuel Consumption for 3500 Engines <sup>(1)</sup>			
Top End Overhaul (First Interval)			
Engine	Rated Up To 1300 RPM	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
	11 000 Service Hours	9000 Service Hours	7500 Service Hours
3508	976 000 L (257,500 US gal)		
3512	1 460 000 L (385,000 US gal)		
3516	1 942 000 L (512,500 US gal)		
Top End Overhaul (Second Interval)			
Engine	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours
3508	1 952 000 L (515,000 US gal)		
3512	2 920 000 L (770,000 US gal)		
3516	3 884 000 L (1,025,000 US gal)		

(1) Fuel consumption is based on a load factor of approximately 60 percent.

A top end overhaul involves the removal, the inspection, and the rework of the cylinder head components. A few additional components are replaced and serviced.

The top end overhaul (second interval) involves the same service that is performed for the first interval. Because of the number of service hours, some additional components are inspected and/or serviced.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

**Note:** The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

The following definitions explain the terminology for the services that are performed during an overhaul:

**Inspect** – Inspect the components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, "Index of Publications on Reusability or Salvage of Used Parts". The guidelines were developed in order to help Caterpillar dealers and customers to avoid unnecessary expenditures. New parts are not required if the existing parts can still be used, reconditioned, or repaired. If the components are not in the reusability guidelines, refer to the Service Manual, "Specifications" module.

**Rebuild** – The component is reconditioned in order to comply with reusability guidelines.

**Replace** – The service life of the part is exhausted. The part may fail before the next maintenance interval. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a CAT remanufactured part, a rebuilt part, or a used part. Some worn components may be exchanged with your Caterpillar dealer for credit on replacement parts. Consult your Caterpillar dealer about repair options for your engine.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Table 47.

Table 47

Recommendations for Top End Overhauls <sup>(1)</sup>		
Service	Top End Overhaul (First Interval)	Top End Overhaul (Second Interval)
Clean	Oil suction screen	
Clean Inspect Pressure test	Aftercooler core <sup>(2)</sup>	
Inspect	Fuel system linkage	
	-	Connecting rod bearings <sup>(3)</sup>
	-	Cylinder liners <sup>(3)</sup>
	-	Piston crowns and skirts <sup>(3)</sup>
	-	Piston pins <sup>(3)</sup>
Inspect Rebuild	Rocker arms	
Inspect Rebuild Replace	Cylinder head assemblies	
	Fuel priming pump	
	-	Engine oil pump
	-	Fuel transfer pump
	-	Prelube pump
	-	Scavenge oil pump
Inspect Replace	-	Camshaft lifters
	Engine wiring harness	
	Fuel pressure regulating valve	
	Push rods	
	Spacer plates	
Rebuild Replace	-	Turbochargers
Replace	Fuel injectors	
	Gaskets and seals for the air inlet manifold	
	Seals and bellows for the exhaust manifold	

<sup>(1)</sup> For instructions on removal and installation of components, see the Service Manual, "Disassembly and Assembly" module.

<sup>(2)</sup> For instructions on cleaning the core, see this Operation and Maintenance Manual, "Aftercooler Core - Clean/Test" topic.

<sup>(3)</sup> For 3508 and 3512 Engines, inspect ONLY ONE of the components from each cylinder bank. For 3516 Engines, inspect ONLY TWO of the components from each cylinder bank. This inspection will provide adequate examples of the condition of the other corresponding components. If the results are questionable, inspect more of the components.

101045650

## Overhaul Considerations

**SMCS Code:** 7595-043

## Overhaul Information

An overhaul is replacing the major worn components of the engine. An overhaul interval is a maintenance interval that is planned. The engine is rebuilt with certain rebuilt parts or new parts that replace the worn parts.

An overhaul also includes the following maintenance:

- Inspection of all the parts that are visible during the disassembly
- Replacement of the seals and gaskets that are removed
- Cleaning of the internal passages of the engine and the engine block

Most owners will save money by overhauling the engine at the intervals that are recommended in this Operation and Maintenance Manual. Consider the graph in Illustration 79.

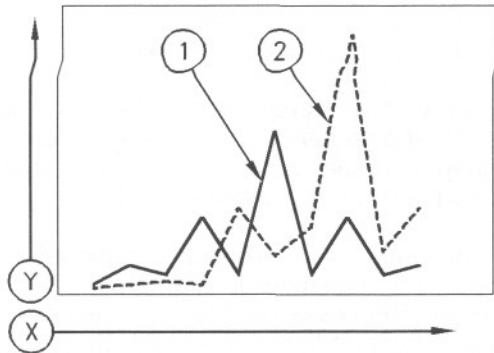


Illustration 79

g00541431

Costs of overhauls over time

(Y) Cost

(X) Time

(1) Cost of maintenance and repair that is planned

(2) Cost of maintenance and repair that is not planned

In Illustration 79, line (1) represents the maintenance and repair costs for an owner that followed the recommendations for inspection, maintenance, and repair. The peaks represent overhauls.

Line (2) represents the maintenance and repair costs for an owner that chose to operate beyond the recommended intervals. The initial cost of the "repair-after-failure" philosophy is lower. Also, the first overhaul was delayed. However, the peaks are significantly higher than the peaks for the customer that used the "repair-before-failure" philosophy.

The higher peaks result from two key factors:

- Delaying an overhaul until a breakdown increases the chance of a catastrophic failure. This type of failure requires more parts, labor, and cleanup.
- Excessive wear means that fewer components will be reusable. More labor may be required for salvage or repair of the components.

When all of the costs are considered, "REPAIR-BEFORE-FAILURE" is the least expensive alternative for most components and engines.

It is not practical to wait until the engine exhibits symptoms of excessive wear or failure. It is not less costly to wait. A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the guidelines for reusable parts.

- The service life of the engine can be extended without the risk of a major catastrophe due to engine failure.
- Achieve the best cost/value relationship per hour of extended service life.

## Overhaul Intervals

Some factors that are important for determining the overhaul intervals include the following considerations:

- Performance of preventive maintenance
- Use of recommended lubricants
- Use of recommended coolants
- Use of recommended fuels
- Proper installation
- Operating conditions
- Operation within acceptable limits
- Engine load
- Engine speed

Generally, engines that are operated at a reduced load and/or speed achieve more service life before an overhaul. However, this is for engines that are properly operated and maintained.

Other factors must also be considered for determining a major overhaul:

- The total amount of fuel consumption
- The service hours of the engine
- An increase of oil consumption
- An increase of crankcase blowby
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

**Note:** It is possible for oil analysis to indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Caterpillar dealer about scheduling a major overhaul.

**Note:** The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

### Using Fuel Consumption For Calculating the Overhaul Intervals

The total fuel consumption is the most important factor for estimating the overhaul interval. Fuel consumption compensates for the application and for the engine load.

If the total fuel consumption has not been recorded, use the equation in Table 48 in order to estimate the hours until the overhaul. The equation may also be used to estimate overhaul intervals for new engines.

Table 48

#### Equation For Calculating Overhaul Intervals

$$H = F/R$$

"H" is the number of estimated hours until the overhaul interval.

"F" is the estimated total amount of fuel consumption of the engine.

"R" is the rate of fuel consumption in liters per hour or gallons per hour.

Use the actual records of fuel consumption, when possible. If the actual records are not available, use the following procedure in order to estimate the fuel consumption.

1. Estimate the average percent of the load for the operation of the engine.
2. Refer to the engine's Caterpillar, "Engine Specifications" ("spec" sheet). This will determine the fuel consumption for the percent of the load that was estimated in Step 1. Use this figure for the equation in Table 48.

### Oil Consumption as an Overhaul Indicator

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

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

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

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

### Overhaul Inspection

Refer to the Service Manual for the disassembly and assembly procedures that are necessary in order to perform the required maintenance on the items that are listed. Consult your Caterpillar dealer for assistance.

To determine the reusability publications that are needed to inspect the engine, refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, "Index of Publications on Reusability or Salvage of Used Parts".

The Guidelines For Reusable Parts and Salvage Operations is part of an established Caterpillar parts reusability program. These guidelines were developed in order to assist Caterpillar dealers and customers reduce costs by avoiding unnecessary expenditures for new parts. If the engine parts comply with the established inspection specifications, the parts can be reused.

The use of out-of-spec parts could result in unscheduled downtime and/or costly repairs. The use of out-of-spec parts can also contribute to increased fuel consumption and reduction of engine efficiency. New parts are not necessary if the old parts can be reused, repaired, or salvaged. Otherwise, the old parts can be replaced or exchanged.



Your Caterpillar dealer can provide the parts that are needed to rebuild the engine at the least possible cost.

## Overhaul Programs

An economical way to obtain most of the parts that are needed for overhauls is to use Caterpillar remanufactured parts. Caterpillar remanufactured parts are available at a fraction of the cost of new parts. These parts have been rebuilt by Caterpillar and certified for use. The following components are examples of the remanufactured parts:

- Cylinder heads
- Oil Pumps
- Turbochargers
- Water pumps

Consult your Caterpillar dealer for details and for a list of the remanufactured parts that are available.

Your Caterpillar dealer may be offering a variety of overhaul options.

A Flat Rate Overhaul guarantees the maximum price that you will pay for an overhaul. Flat rate prices on preventive maintenance programs or major repair options are available from many servicing dealers for all Caterpillar Engines. Consult your Caterpillar dealer in order to schedule a before failure overhaul.

## Overhaul Recommendation

Caterpillar recommends a scheduled overhaul in order to minimize downtime. A scheduled overhaul will provide the lowest cost and the greatest value. Schedule an overhaul with your Caterpillar dealer.

Overhaul programs vary between dealers. To obtain specific information about the types of overhaul programs and services, consult your Caterpillar dealer.

101206548

## Radiator - Clean

**SMCS Code:** 1353-070

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

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



## WARNING

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

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

**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.

For more detailed information on cleaning and inspection, see Special Publication, SEBD0518, "Know Your Cooling System".