



# Operation and Maintenance Manual

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## **3500B Series II and 3500C Marine Propulsion Engines**

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TTA1-Up (Engine)	S2N1-Up (Engine)
TTB1-Up (Engine)	S2S1-Up (Engine)
TTC1-Up (Engine)	S2T1-Up (Engine)
S2D1-Up (Engine)	E3W1-Up (Engine)
TTD1-Up (Engine)	S2W1-Up (Engine)
S2E1-Up (Engine)	E3X1-Up (Engine)
TTE1-Up (Engine)	S2X1-Up (Engine)
S2F1-Up (Engine)	S2Y1-Up (Engine)
TTF1-Up (Engine)	
B5G1-Up (Engine)	
MRG1-Up (Engine)	
PAG1-Up (Engine)	
TTG1-Up (Engine)	
MKH1-Up (Engine)	
TTH1-Up (Engine)	
S2J1-Up (Engine)	
TTJ1-Up (Engine)	
S2K1-Up (Engine)	
S2L1-Up (Engine)	
S2M1-Up (Engine)	

## Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

**Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.**

**Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.**

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "DANGER", "WARNING" or "CAUTION". The Safety Alert "WARNING" label is shown below.



The meaning of this safety alert symbol is as follows:

**Attention! Become Alert! Your Safety is Involved.**

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by "NOTICE" labels on the product and in this publication.

**Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. If a tool, procedure, work method or operating technique that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.**

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Caterpillar dealers have the most current information available.



**When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.**

**Failure to heed this warning can lead to premature failures, product damage, personal injury or death.**

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## Foreword

### Literature Information

This manual contains safety, operation instructions, lubrication and maintenance information. This manual should be stored in or near the engine area in a literature holder or literature storage area. Read, study and keep it with the literature and engine information.

English is the primary language for all Caterpillar publications. The English used facilitates translation and consistency in electronic media delivery.

Some photographs or illustrations in this manual show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this manual. Whenever a question arises regarding your engine, or this manual, please consult with your Caterpillar dealer for the latest available information.

### Safety

This safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance and repair on this product.

### Operation

Operating techniques outlined in this manual are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

The operation section is a reference for operators. Photographs and illustrations guide the operator through procedures of inspecting, starting, operating and stopping the engine. This section also includes a discussion of electronic diagnostic information.

### Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by fuel consumption, service hours and/or calendar time maintenance intervals. Items in the maintenance schedule are referenced to detailed instructions that follow.

Use fuel consumption or service hours to determine intervals. Calendar intervals shown (daily, annually, etc.) may be used instead of service meter intervals if they provide more convenient schedules and approximate the indicated service meter reading.

Recommended service should be performed at the appropriate intervals as indicated in the Maintenance Interval Schedule. The actual operating environment of the engine also governs the Maintenance Interval Schedule. Therefore, under extremely severe, dusty, wet or freezing cold operating conditions, more frequent lubrication and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

The maintenance schedule items are organized for a preventive maintenance management program. If the preventive maintenance program is followed, a periodic tune-up is not required. The implementation of a preventive maintenance management program should minimize operating costs through cost avoidances resulting from reductions in unscheduled downtime and failures.

### Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. Each level and/or individual items in each level should be shifted ahead or back depending upon your specific maintenance practices, operation and application. We recommend that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

See the section in the Operation and Maintenance Manual, "Maintenance Records" for information regarding documents that are generally accepted as proof of maintenance or repair. Your authorized Caterpillar dealer can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

### Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance Manual except for the interval and the maintenance items in that interval. Major repairs are best left to trained personnel or an authorized Caterpillar dealer. Your Caterpillar dealer offers a variety of options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available from your Caterpillar dealer. Consult with your dealer for information regarding these options.

## California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Battery posts, terminals and related accessories contain lead and lead compounds. **Wash hands after handling.**

# Safety Section

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## Safety Messages

**SMCS Code:** 1000; 7405

There may be several specific safety messages on your engine. The exact location and a description of the safety messages are reviewed in this section. Please become familiar with all of the safety messages.

Ensure that all of the safety messages are legible. Clean the safety messages or replace the safety messages if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap for cleaning the safety messages. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the safety messages. The safety messages that are loosened could drop off of the engine.

Replace any safety message that is damaged or missing. If a safety message is attached to a part of the engine that is replaced, install a new safety message on the replacement part. Your Caterpillar dealer can provide new safety messages.

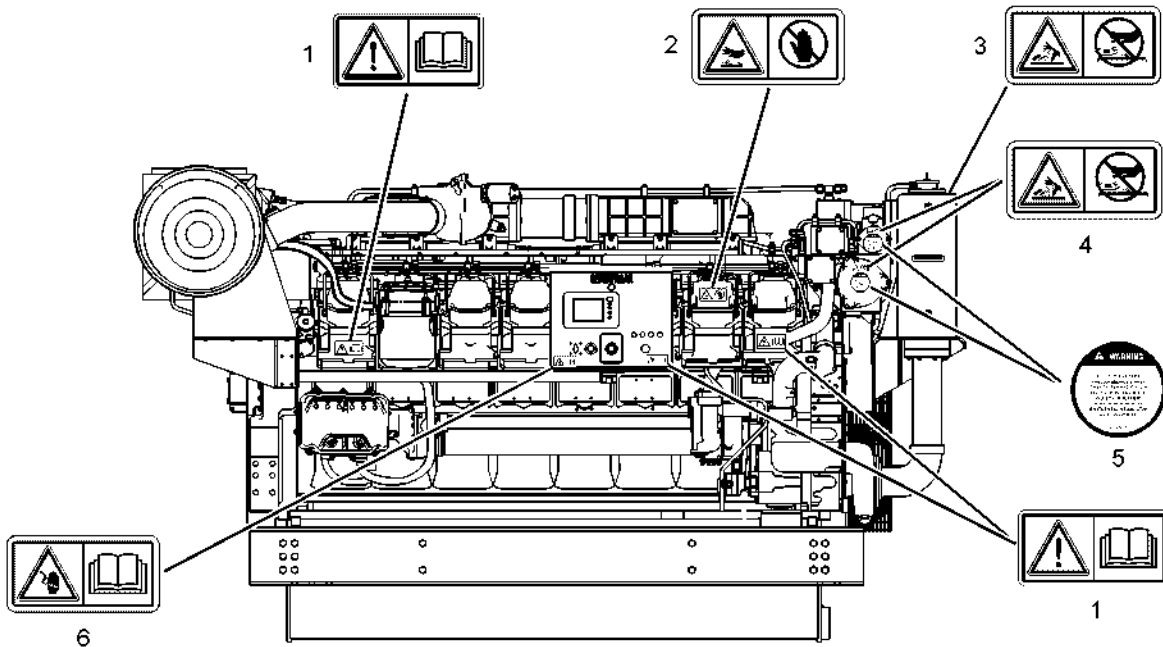


Illustration 1

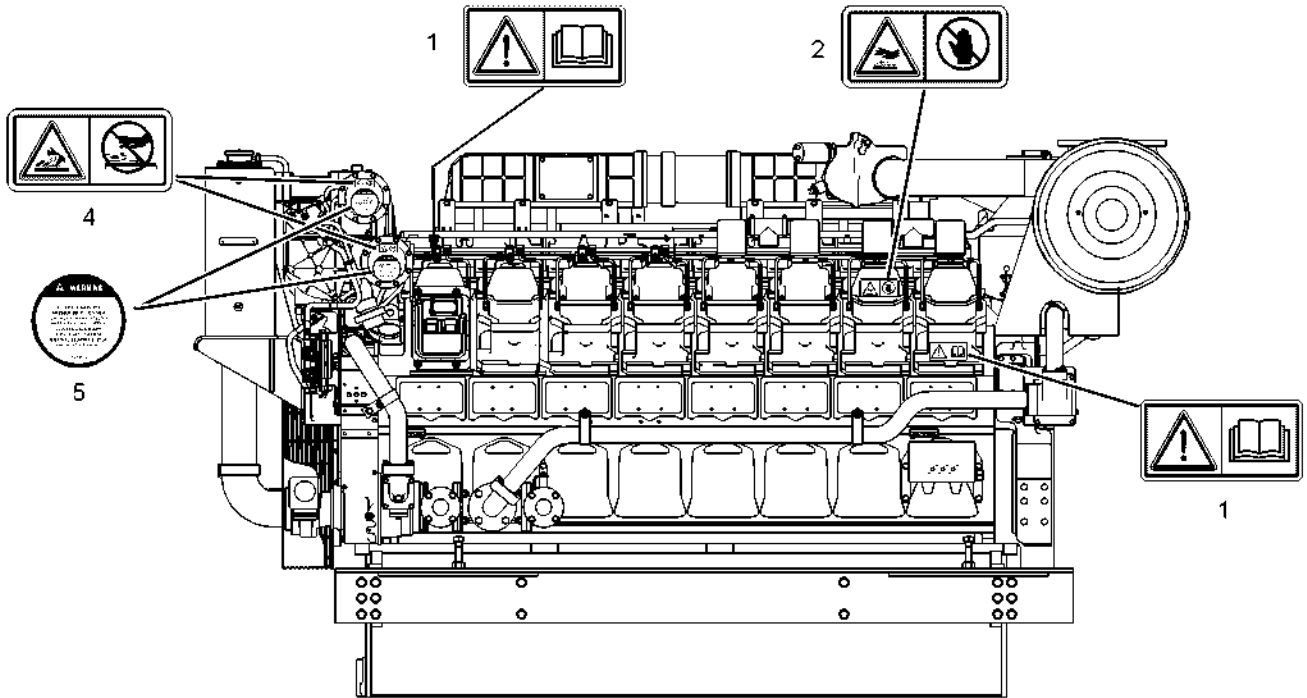


Illustration 2

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### (1) Universal Warning

This warning label is located on the first cylinder on each side of 8, 12, and 16 cylinder engines.

This warning label is located on the last cylinder on each side of 12 and 16 cylinder engines.

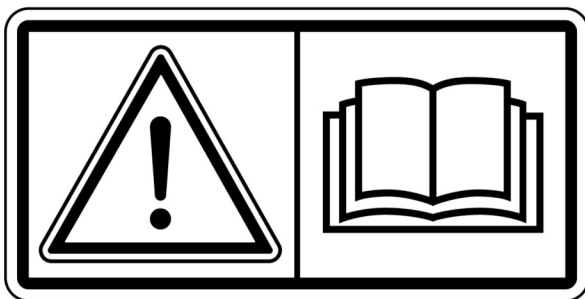


Illustration 3

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Do not operate or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals. Failure to follow the instructions or heed the warnings could result in serious injury or death.

This warning label is located on the lower right hand face of the ECM panel.

### (2) Hot Surface



Illustration 4

g01372256



Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

This warning label is located on the valve cover for cylinder 5 and on the valve cover for cylinder 6 on 8 cylinder engines.

This warning label is located on the valve cover for cylinder 9 and on the valve cover for cylinder 10 on 12 cylinder engines.

This warning label is located on the valve cover for cylinder 13 and on the valve cover for cylinder 14 on 16 cylinder engines.

### (3) Pressurized System



Illustration 5

g01371640

#### **WARNING**

**Pressurized system! Hot coolant can cause serious burns, injury or death. 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. Read and understand the Operation and Maintenance Manual before performing any cooling system maintenance.**

This warning is located on the top of the pressurized coolant tank.

### (4) Pressurized System



Illustration 6

g01371640

#### **WARNING**

**Hot Fluid Under Pressure**

**Do Not Remove Pressure Cap When Hot**

**Failure to Follow Instructions Could Result in Injury or Death**

This warning label is located on both sides of the duplex fuel filter housing.

This warning label is located on both sides of the duplex oil filter housing.

### (5) Hot Fluid Under Pressure



Illustration 7

g01061488



**WARNING**

Filter contains hot pressurized fluid when engine is running. Follow instructions on control valve to avoid injury if rapid air movement exists to blow fluid. Stop engine to avoid fire.

This warning label is located on both sides of the duplex fuel filter housing.

This warning label is located on both sides of the duplex oil filter housing.

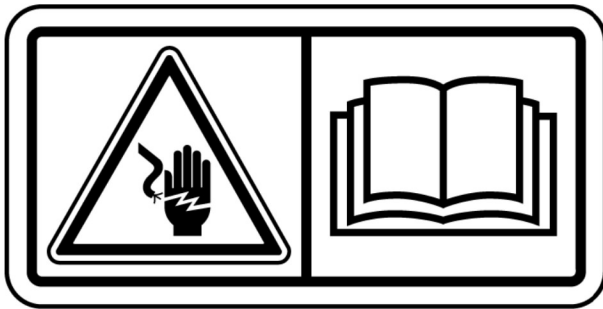
**(6) Shock Hazard**

Illustration 8

g01372247

**WARNING**

**WARNING! Shock/Electrocution Hazard! Read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could cause serious injury or death.**

This warning label is located on the lower left hand face of the ECM panel.

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**General Hazard Information**

**SMCS Code:** 1000; 4450; 7405

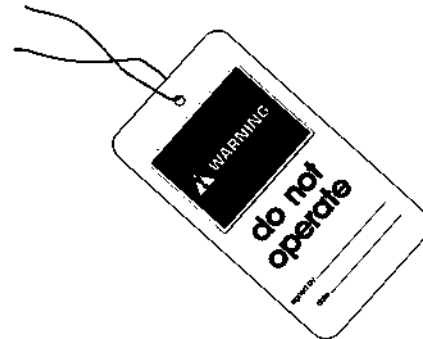


Illustration 9

g00104545

Attach a "Do Not Operate" warning tag or a similar warning tag to the start switch or to the controls before the engine is serviced or before the engine is repaired. These warning tags (Special Instruction, SEHS7332) are available from your Caterpillar dealer. Attach the warning tags to the engine and to each operator control station. When it is appropriate, disconnect the starting controls.

Do not allow unauthorized personnel on the engine, or around the engine when the engine is being serviced.

Engine exhaust contains products of combustion which may be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is in an enclosed area, vent the engine exhaust to the outside.

Cautiously remove the following parts. To help prevent spraying or splashing of pressurized fluids, hold a rag over the part that is being removed.

- Filler caps
- Grease fittings
- Pressure taps
- Breathers
- Drain plugs

Use caution when cover plates are removed. Gradually loosen, but do not remove the last two bolts or nuts that are located at opposite ends of the cover plate or the device. Before removing the last two bolts or nuts, pry the cover loose in order to relieve any spring pressure or other pressure.

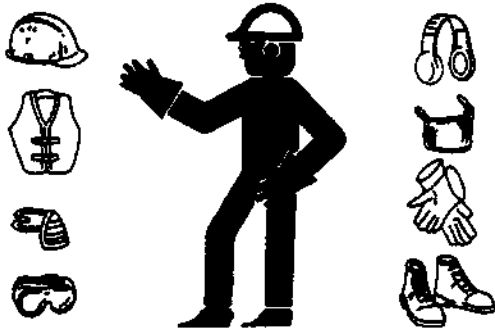


Illustration 10

g00702020

- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

**Unless other instructions are provided, perform the maintenance under the following conditions:**

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

## Pressurized Air and Water

Pressurized air and/or water can cause debris and/or hot water to be blown out. This could result in personal injury.

When pressurized air and/or pressurized water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield.

The maximum air pressure for cleaning purposes must be below 205 kPa (30 psi) when the air nozzle is deadheaded. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

## Fluid Penetration

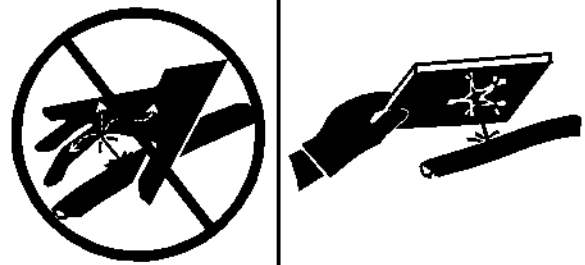


Illustration 11

g00687600

Always use a board or cardboard when you check for a leak. Leaking fluid that is under pressure can penetrate body tissue. Fluid penetration can cause serious injury and possible death. A pin hole leak can cause severe injury. If fluid is injected into your skin, you must get treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

## Containing Fluid Spillage

Care must be taken in order to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the engine. Prepare to collect the fluid with suitable containers before opening any compartment or disassembling any component that contains fluids.

Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tools Catalog" for the following items:

- Tools that are suitable for collecting fluids and equipment that is suitable for collecting fluids
- Tools that are suitable for containing fluids and equipment that is suitable for containing fluids

Obey all local regulations for the disposal of liquids.

## Asbestos Information

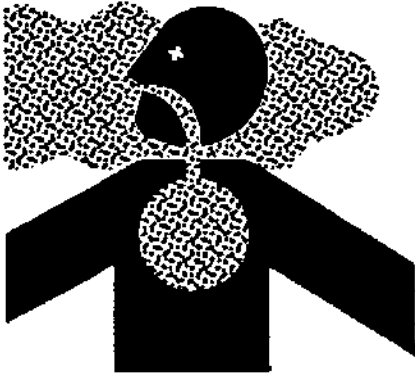


Illustration 12

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Caterpillar equipment and replacement parts that are shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts. Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

Use caution. Avoid inhaling dust that might be generated when you handle components that contain asbestos fibers. Inhaling this dust can be hazardous to your health. The components that may contain asbestos fibers are brake pads, brake bands, lining material, clutch plates, and some gaskets. The asbestos that is used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous unless airborne dust that contains asbestos is generated.

If dust that may contain asbestos is present, there are several guidelines that should be followed:

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.

- Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in "29 CFR 1910.1001".
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

## Dispose of Waste Properly

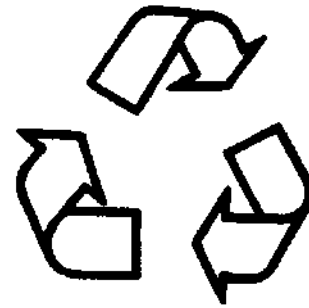


Illustration 13

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Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations.

Always use leakproof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

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## Burn Prevention

**SMCS Code:** 1000; 4450; 7405

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine. Relieve all pressure in the air system, in the hydraulic system, in the lubrication system, in the fuel system, or in the cooling system before any lines, fittings or related items are disconnected.

### Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant.

Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check the coolant level after the engine has stopped and the engine has been allowed to cool.

Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly in order to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

## Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Also, do not allow hot components to contact the skin.

## Batteries

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or the eyes. Always wear protective glasses for servicing batteries. Wash hands after touching the batteries and connectors. Use of gloves is recommended.

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# Fire Prevention and Explosion Prevention

**SMCS Code:** 1000; 4450; 7405



Illustration 14

g00704000

All fuels, most lubricants, and some coolant mixtures are flammable.

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

A flash fire may result if the covers for the engine crankcase are removed within fifteen minutes after an emergency shutdown.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Caterpillar dealer for additional information about suitable protection devices.

Remove all flammable materials such as fuel, oil, and debris from the engine. Do not allow any flammable materials to accumulate on the engine.

Store fuels and lubricants in properly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in case of a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

Do not weld on lines or tanks that contain flammable fluids. Do not flame cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. All electrical wires must be properly routed and securely attached. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and properly maintained battery cables will help to prevent arcing or sparking.

Inspect all lines and hoses for wear or for deterioration. The hoses must be properly routed. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Oil filters and fuel filters must be properly installed. The filter housings must be tightened to the proper torque.



Illustration 15

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Use caution when you are refueling an engine. Do not smoke while you are refueling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refueling.

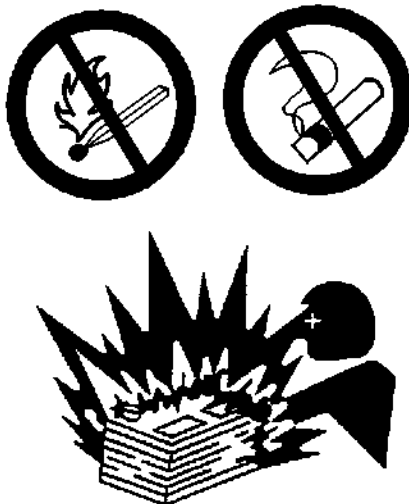


Illustration 16

g00704135

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.

Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Improper jumper cable connections can cause an explosion that can result in injury. Refer to the Operation Section of this manual for specific instructions.

Do not charge a frozen battery. This may cause an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

## Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

## Ether

Ether is flammable and poisonous.

Use ether in well ventilated areas. Do not smoke while you are replacing an ether cylinder or while you are using an ether spray.

Do not store ether cylinders in living areas or in the engine compartment. Do not store ether cylinders in direct sunlight or in temperatures above 49 °C (120 °F). Keep ether cylinders away from open flames or sparks.

Dispose of used ether cylinders properly. Do not puncture an ether cylinder. Keep ether cylinders away from unauthorized personnel.

Do not spray ether into an engine if the engine is equipped with a thermal starting aid for cold weather starting.

## Lines, Tubes and Hoses

Do not bend high pressure lines. Do not strike high pressure lines. Do not install any lines that are bent or damaged.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Caterpillar dealer for repair or for replacement parts.

Check lines, tubes and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. Tighten all connections to the recommended torque.

Replace the parts if any of the following conditions are present:

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible part of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly. During engine operation, this will help to prevent vibration, rubbing against other parts, and excessive heat.

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## Crushing Prevention and Cutting Prevention

**SMCS Code:** 1000; 4450; 7405

Support the component properly when work beneath the component is performed.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating parts and of all moving parts. Leave the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw objects or cut objects.

When objects are struck, wear protective glasses in order to avoid injury to the eyes.

Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensure that no one will be injured by flying debris.

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## Mounting and Dismounting

**SMCS Code:** 1000; 4450; 7405

Inspect the steps, the handholds, and the work area before mounting the engine. Keep these items clean and keep these items in good repair.

Mount the engine and dismount the engine only at locations that have steps and/or handholds. Do not climb on the engine, and do not jump off the engine.

Face the engine in order to mount the engine or dismount the engine. Maintain a three-point contact with the steps and handholds. Use two feet and one hand or use one foot and two hands. Do not use any controls as handholds.

Do not stand on components which cannot support your weight. Use an adequate ladder or use a work platform. Secure the climbing equipment so that the equipment will not move.

Do not carry tools or supplies when you mount the engine or when you dismount the engine. Use a hand line to raise and lower tools or supplies.

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## Before Starting Engine

**SMCS Code:** 1000

### NOTICE

For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

Overspeed shutdown should occur automatically. If automatic shutdown does not occur, press the emergency stop button in order to cut the fuel and/or air to the engine.

Inspect the engine for potential hazards.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work properly, if equipped.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided in order to help prevent personal injury. The circuits are also provided in order to help prevent engine damage.

See the Service Manual for repairs and for adjustments.

i01103904

## Engine Starting

**SMCS Code:** 1000

If a warning tag is attached to the engine start switch or to the controls, DO NOT start the engine or move the controls. Consult with the person that attached the warning tag before the engine is started.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Start the engine from the operator's compartment or from the engine start switch.

Always start the engine according to the procedure that is described in this Operation and Maintenance Manual, "Engine Starting" topic (Operation Section). Knowing the correct procedure will help to prevent major damage to the engine components. Knowing the procedure will also help to prevent personal injury.

To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working properly, check the water temperature gauge and the oil temperature gauge during the heater operation.

Engine exhaust contains products of combustion that can be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

## Ether

Ether is poisonous and flammable.

Do not inhale ether, and do not allow ether to contact the skin. Personal injury could result.

Do not smoke while ether cylinders are changed.

Use ether in well ventilated areas.

Use ether with care in order to avoid fires.

Keep ether cylinders out of the reach of unauthorized persons.

Store ether cylinders in authorized storage areas only.

Do not store ether cylinders in direct sunlight or at temperatures above 49 °C (120 °F).

Discard the ether cylinders in a safe place. Do not puncture the ether cylinders. Do not burn the ether cylinders.

i01964154

## Engine Stopping

**SMCS Code:** 1000

### WARNING

**Flash fire may result in personal injury, if crankcase covers are removed within fifteen minutes after emergency shut down. Do not restart engine until cause for shutdown has been corrected.**

To avoid overheating of the engine and accelerated wear of the engine components, stop the engine according to this Operation and Maintenance Manual, "Engine Stopping" topic (Operation Section).

Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. DO NOT use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.

On the initial start-up of a new engine or an engine that has been serviced, make provisions to stop the engine if an overspeed condition occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

i02623688

## Electrical System

**SMCS Code:** 1000; 1400

### WARNING

**Electrical shock hazard. The electronic unit injector system uses 90-120 volts.**

The ECM sends a high voltage signal to the unit injectors. To help prevent personal injury, do not disconnect the unit injector connector while the engine is operating. Do not come in contact with the harness connector for the unit injector while the engine is operating.

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative “-” jump start cable should be connected last from the external power source to the negative “-” terminal of the starting motor. If the starting motor is not equipped with a negative “-” terminal, connect the jump start cable to the engine block.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is operated. Repair all frayed electrical wires before the engine is started. See this Operation and Maintenance Manual, “Starting the Engine and Cold Weather Starting” for specific starting instructions.

## Grounding Practices

The electrical system for the vessel and the engine must be properly grounded. Proper grounding is necessary for optimum engine performance and reliability. Improper grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths.

Uncontrolled electrical circuit paths can result in damage to main bearings, to crankshaft bearing journal surfaces, and to aluminum components. Uncontrolled electrical circuit paths can also cause electrical noise. Electrical noise may degrade the performance of the vessel and of the radio.

The alternator, the starting motor, and all of the electrical systems **MUST** be grounded to the negative battery terminal. The alternator must meet marine isolation requirements. The starting motor must also meet marine isolation requirements.

For engines which have an alternator that is grounded to an engine component, a ground strap **MUST** connect that component to the negative battery terminal and the component **MUST** be electrically isolated from the engine.

A bus bar with a direct path to the negative “-” battery terminal is permissible and recommended for use for all components that require a negative “-” battery connection. The bus bar should be directly connected to the negative “-” battery terminal. A bonding cable should also be connected from the cylinder block to the bus bar on the negative “-” battery connection.

Use of a bus bar ensures that the Electronic Control Module (ECM) and all of the components that are connected to the ECM have a common reference point.

101964086

## Engine Electronics

**SMCS Code:** 1000; 1900

### **WARNING**

**Electrical shock hazard. The electronic unit injector system uses 90-120 volts.**

The ECM sends a high voltage signal to the unit injectors. To help prevent personal injury, do not disconnect the unit injector connector while the engine is operating. Do not come in contact with the harness connector for the unit injector while the engine is operating.

### **WARNING**

**Tampering with the electronic system installation of the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.**

**Note:** The monitoring system can only be programmed with electronic service tools and passwords. For information on programming, see the Service Manual, “Troubleshooting” module.

The engine has a monitoring system that can respond to abnormal engine operation with these modes: **WARNING, DERATE, and SHUTDOWN**. These modes are available in order to help prevent damage to the engine. The customer can program these modes “ON” or “OFF”.

A warning indicates a serious condition that requires immediate attention. If a derating occurs, the engine power and/or the engine rpm is limited.

The following conditions will cause an engine shutdown:

- Engine overspeed



- 
- High aftercooler coolant temperature
  - High coolant temperature (jacket water)
  - High crankcase pressure
  - Low engine oil pressure

Except for an overspeed shutdown, the monitoring system can be overridden. An override switch is located in the Electronic Instrument Panel. Use of the switch will allow the engine to provide full power during an abnormal engine operating condition. The override switch is provided only for use in emergency situations.

For more information on the conditions that can initiate warnings, deratings, and shutdowns, see this Operation and Maintenance Manual, "Monitoring System" topic (Operation Section).

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# Product Information Section

## Model Views and Specifications

i02299070

### Product Description

**SMCS Code:** 1000; 4450

The Marine Engines are electronically controlled diesel engines. The engines have electronic unit injectors. The engines can be equipped with either separate circuit aftercooling or jacket water aftercooling. The engines are offered in a 8 cylinder engine, 12 cylinder engine, and 16 cylinder engines.

Engine efficiency and engine performance depend on adherence to proper operation and maintenance recommendations. Use the recommended fuels, lubrication oils, and coolant. Pay special attention to the air cleaner, to the fuel system, to the lubrication system, and to the cooling system maintenance. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information on maintenance items.

i02630265

## Specifications

**SMCS Code:** 1000

Table 1

Engine Specifications					
Item	3508B Engine	3512B Engine 3512C Engine		3516B Engine 3516C Engine	
	Standard	Standard	High Displacement	Standard	High Displacement
Rated Speed (rpm)	1200 to 1925				
Idle Speed (rpm)	450 to 900				
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)	190 mm (7.5 inch)	215 mm (8.5 inch)	190 mm (7.5 inch)	215 mm (8.5 inch)
Type	4 stroke cycle				
Compression ratio	14:1				
Aspiration	Turbocharged				
Method of cooling the turbocharged air	Jacket water aftercooling				
	Separate circuit aftercooling				
Displacement per cylinder	4.3 L (263 in <sup>3</sup> )	4.3 L (263 in <sup>3</sup> )	4.9 L (299 in <sup>3</sup> )	4.3 L (263 in <sup>3</sup> )	4.9 L (299 in <sup>3</sup> )
Total displacement	34.5 L (2105 in <sup>3</sup> )	51.8 L (3158 in <sup>3</sup> )	58.5 L (3570 in <sup>3</sup> )	69.1 L (4210 in <sup>3</sup> )	78 L (4760 in <sup>3</sup> )
Rotation (flywheel)	Counterclockwise rotation (standard)				
	Clockwise rotation (option)				
Fuel	See this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section).				
Method of fuel injection	Electronic fuel injectors				
Method of starting	Electric starting motor				
	Air starting motor				
Designed back pressure in the exhaust system	2.5 kPa (10 inches of H <sub>2</sub> O)				
Maximum allowable back pressure	5.0 kPa (20 inches of H <sub>2</sub> O)				
Maximum inlet air Restriction	6.2 kPa (25 inches of H <sub>2</sub> O)				
Air cleaners	Single element				
	Dual element				

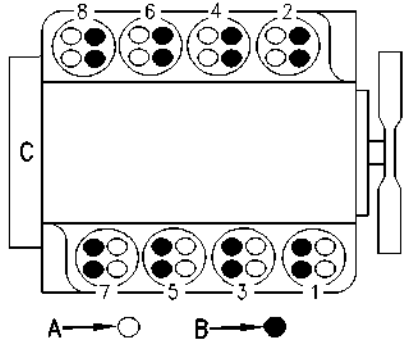


Illustration 17 g00739600  
3508B Engine  
(A) Inlet valve  
(B) Exhaust valve  
(C) Flywheel

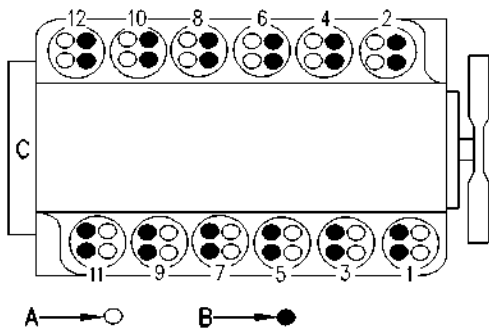


Illustration 18 g00749769  
3512B Engine  
3512C Engine  
(A) Inlet valve  
(B) Exhaust valve  
(C) Flywheel

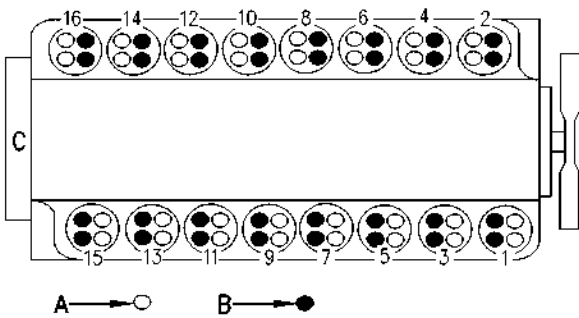


Illustration 19 g00749770  
3516B Engine  
3516C Engine  
(A) Inlet valve  
(B) Exhaust valve  
(C) Flywheel

# Product Identification Information

i01536676

## Plate Locations and Film Locations

SMCS Code: 1000; 4450

### Engine Identification

Caterpillar engines are identified with serial numbers, with performance specification numbers, and with arrangement numbers. In some of the cases, modification numbers are used. These numbers are shown on the Serial Number Plate and the Information Plate that are mounted on the engine.

Caterpillar dealers need these numbers in order to determine the components that were included with the engine. This permits accurate identification of replacement part numbers.

### Serial Number Plate

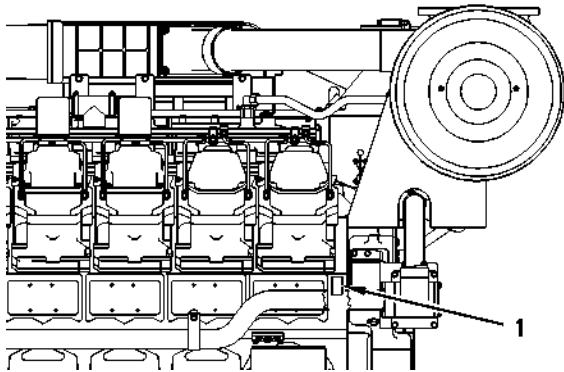


Illustration 20 g00798278  
(1) Location of the Serial Number Plate

The Serial Number Plate is on the left side of the cylinder block near the rear of the engine.

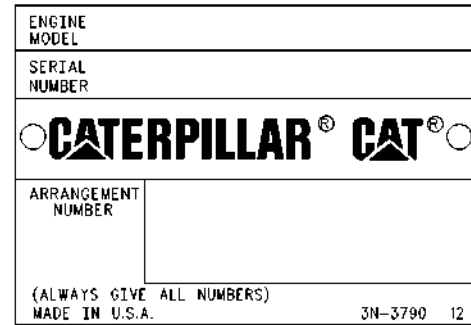


Illustration 21 g00123229  
Typical Serial Number Plate

The following information is stamped on the Serial Number Plate: engine serial number, model, and arrangement number.

### Information Plate

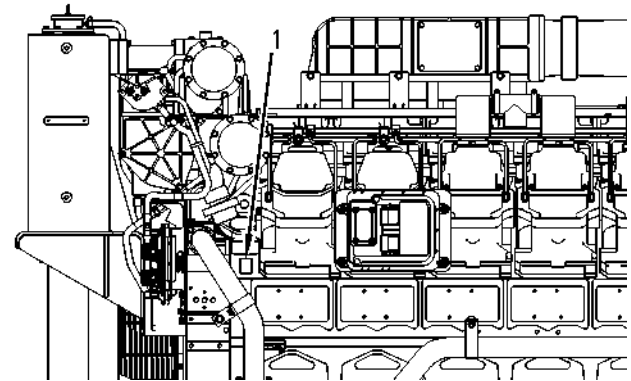


Illustration 22 g00798277  
(1) Location of the Information Plate

The Information Plate is on the left side top surface of the cylinder block in front of the front cylinder head.

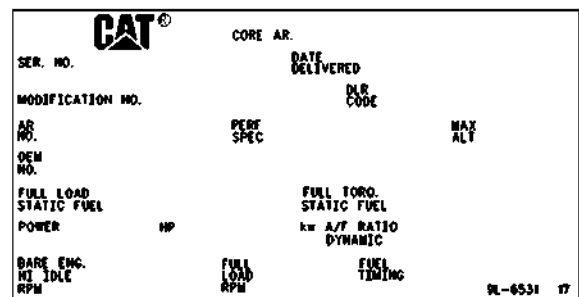


Illustration 23 g00102789  
Typical Information Plate

The following information is stamped on the Information Plate: engine's maximum altitude, horsepower, high idle rpm, full load rpm, fuel settings, and other information.

i01966044

## Emissions Certification Film

**SMCS Code:** 1000; 7405

**Note:** This information is pertinent in the United States, in Canada, and in Europe.

A typical example is shown.

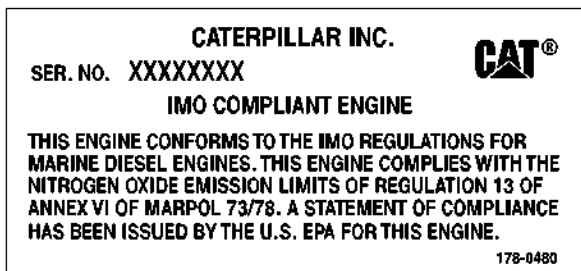


Illustration 24

g01021016

The IMO Certification label is mounted on the engine.

i01382270

## Reference Information

**SMCS Code:** 1000; 4450

Identification of the items in Table 2 may be needed in order to obtain parts and service. Some of the information is on the engine Serial Number Plate and/or Information Plate. Locate the information for your engine. Record the information on the appropriate space in Table 2. Make a copy of this list for a record. Retain the information for future reference.

The top level part numbers in the Parts Manual for the engine are listed with the engine arrangement number. Occasionally, an arrangement may be slightly modified before the product is shipped from the factory. In these cases, a modification number indicates that the arrangement has been modified.

The packaging arrangement may also be called a pricing arrangement or a customer arrangement. This is the total package with attachments and options that are not included in the engine arrangement.

The performance specification can be used by your Caterpillar dealer with the Technical Marketing Information system. Before the engine leaves the factory, the engine performance is tested. Detailed performance data is recorded. The performance specification number can be used for obtaining the data.

Table 2

Reference Information	
Engine Model	
Serial Number	
Arrangement Number	
Modification Number	
Packaging Arrangement	
Turbocharger	
Fuel Filter Element	
Lubrication Oil Filter Element	
Auxiliary Oil Filter Element	
Air Cleaner Element	
Fan Drive Belt	
Alternator Belt	
Capacity of the Lubrication System	
Capacity of the Cooling System	
Performance Specification Number	
Personality Module	
Low Idle rpm	
High Idle rpm	
Full Load rpm	
Power Rating	

# Operation Section

## Lifting and Storage

### Product Lifting

SMCS Code: 7000; 7002

### Engine Lifting

The warning message for lifting the engine is located on the valve covers.

i02299521

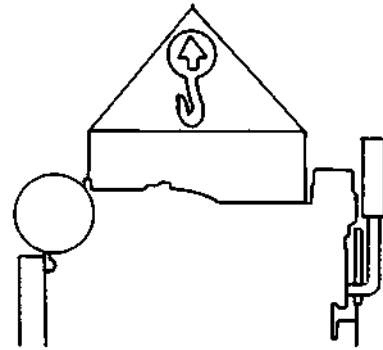


Illustration 26

g00103219

#### NOTICE

Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

When it is necessary to remove a component at an angle, only use a link bracket that is properly rated for the weight.

Use a hoist to remove heavy components. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other. The chains and cables should be perpendicular to the top of the object that is being lifted.

Some removals require lifting fixtures in order to obtain proper balance. Lifting fixtures also help to provide safety.

To remove the engine ONLY, use the lifting eyes that are on the engine.

Lifting eyes are designed and installed for the specific engine arrangement. Alterations to the lifting eyes and/or the engine make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that proper lifting devices are provided. Consult your Caterpillar dealer for information regarding fixtures for proper engine lifting.

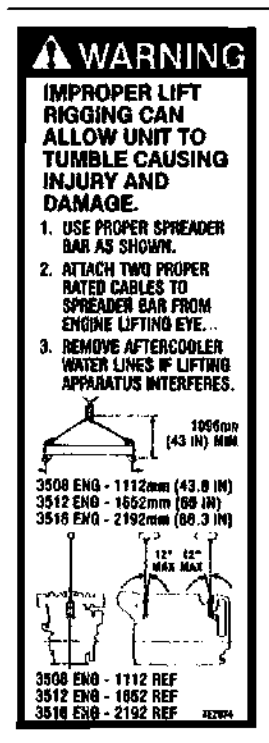


Illustration 25

g01020684

**WARNING**  
 Improper lift rigging can allow unit to tumble causing injury and damage.

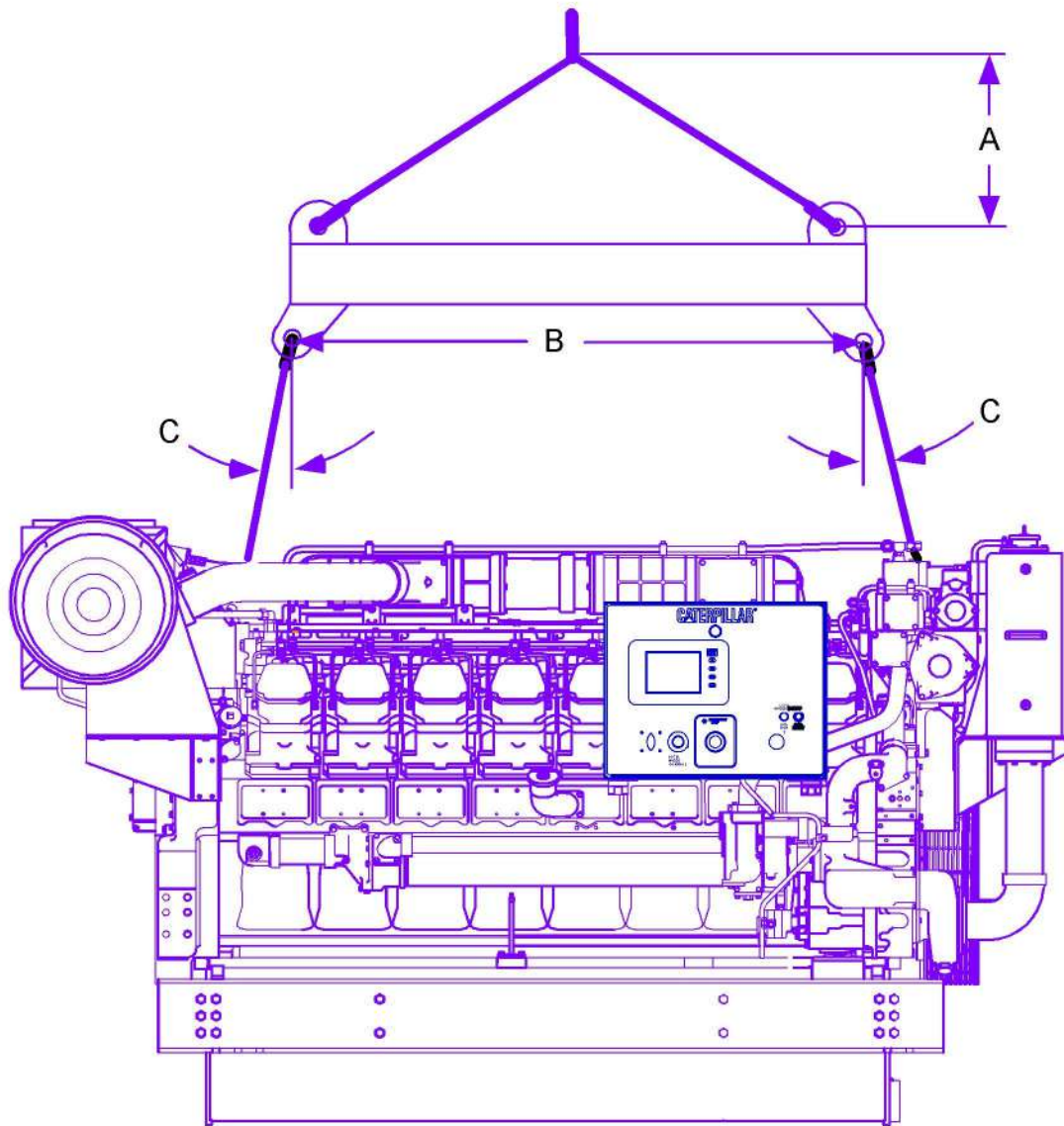


Illustration 27

g01020524

Table 3

Dimensions for the Lifting Beam			
Engine	A	B	C
3508	1096 mm (43.0 inch)	1112 mm (43.8 inch)	12° Max
3512	1096 mm (43.0 inch)	1652 mm (65.0 inch)	12° Max
3516	1096 mm (43.0 inch)	2192 mm (86.3 inch)	12° Max



Table 4

i02703000

Engine Weight	
Engine	Approximate Net Dry Engine Weight Without Transmission kg (lb)
3508B	4882 kg (10763 lb)
3512B 3512C	5554 kg (12244 lb)
3516B 3516C	7795 kg (17185 lb)

## Engine and Marine Transmission Lifting

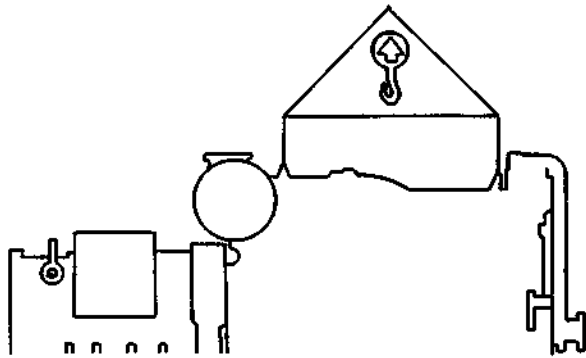


Illustration 28

g00103228

### NOTICE

Do not use the eyebolts that are on the marine transmission housing to lift the engine.

To remove both the engine and the marine transmission, use the lifting eyes that are on the engine. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other. The chains and cables should be perpendicular to the top of the object that is being lifted. Consult your Caterpillar dealer or consult the OEM for information regarding fixtures for proper lifting of your complete package.

## Marine Transmission Lifting

To remove the marine transmission ONLY, use the eyebolts that are on the marine transmission housing. Refer to the OEM for proper lifting instructions (if equipped).

If a component resists removal, ensure that all of the nuts and bolts have been removed. Ensure that no adjacent parts are interfering.

## Product Storage

SMCS Code: 7002

## Engine Storage

If the engine will not be started for one month, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder walls, resulting in increased engine wear and reduced engine service life.

To help prevent excessive engine wear, use the following guidelines:

- Complete all of the lubrication recommendations that are listed in the Operation and Maintenance Manual, "Maintenance Interval Schedule" in the Maintenance Section.
- If freezing temperatures are expected, check the cooling system for adequate protection against freezing. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" in the Maintenance Section for additional information.

Special precautions should be made under the following conditions:

- The engine is out of operation.
- Use of the engine is not planned.

If the engine will be stored for more than one month, a complete protection procedure is recommended. Consult your Caterpillar dealer. Your Caterpillar dealer will have instructions for preparing the engine for extended storage periods.

Refer to the Special Instruction, SEHS9031 for more detailed information on engine storage.

## Marine Transmission Storage

### Storage Procedure

1. Thoroughly clean the transmission.
2. Paint the transmission with a good quality paint.
3. If the transmission will be stored for more than six months, VCI oil will provide additional protection against moisture. Add VCI oil at a rate of two percent of the lubricating oil capacity.
4. Operate the transmission for a short period in order to circulate the oil.

5. Seal all of the openings with covers and/or tape.
6. Use a multipurpose grease to coat all of the external moving parts such as the linkage, etc.
7. Store the transmission under a waterproof cover.

**Procedure After Storage**

1. Remove the waterproof cover. Clean the transmission.
2. Install a new transmission oil filter.
3. Ensure that there is no water in the oil and that the oil level is correct.

# Gauges and Indicators

i02861551

## 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.

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.



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

Engine oil performs several functions: keeping the engine clean, preventing rust and corrosion, acting as a coolant, and reducing friction and wear. The oil cooler transfers heat from the oil to the engine jacket water. Oil temperature that is higher than normal indicates a problem with the lubrication system and/or the cooling system. Excessive oil temperature can adversely affect the cylinder heads, cylinder liners, pistons, and crankshaft bearings.



**Jacket water coolant 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 coolant 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 voltage of the electrical system. Normally, the system has 24 volts.



**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 inlets to the turbochargers. The two exhaust temperatures may vary slightly. This may be due to variation of the sensitivity of the two thermocouples. The “LH/RH” switch on the instrument panel is used for toggling between the left side and the right side exhaust temperature.

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.

If the recommendations for the engine installation, the rating, and engine maintenance are followed, most engines will operate at the normal limit or below the normal limit.

**NOTICE**

Severe damage to the engine can result if the exhaust temperature at the inlet to the turbocharger exceeds the extreme limit.

Table 5

Temperature Limits for the Exhaust Inlet to the Turbocharger		
Rating <sup>(1)</sup>	Normal Limit	Extreme Limit
"A"	650 °C (1202 °F)	702 °C (1295 °F)
"B"	700 °C (1292 °F)	728 °C (1342 °F)
"C"		
"D"	725 °C (1337 °F)	756 °C (1392 °F)
"E"		

<sup>(1)</sup> For the rating definitions, see this Operation and Maintenance Manual, "Engine Rating Definitions".

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

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 inlet 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).

Be alert if an exhaust port temperature varies by more than 50 °C (122 °F) from the average temperature of all of the cylinders.

Perform corrective measures immediately if an exhaust port temperature varies by more than 100 °C (212 °F) from the average temperature of all of the cylinders.

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.



**Hour meter** – This meter indicates the total number of hours of operation of the engine.



**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 differential pressure for the air cleaner is measured from the air inlet for the turbocharger. The "LH/RH" switch on the instrument panel is used for toggling either the left or right side. 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.



**Marine transmission oil temperature** – This gauge indicates the temperature of the marine transmission oil.



**Marine transmission oil pressure** – This gauge indicates the pressure of the marine transmission oil.

# Features and Controls

i02580036

## Monitoring System

**SMCS Code:** 1900; 7400; 7450; 7451

### Caterpillar Monitoring System

The engine is equipped with a programmable Caterpillar Monitoring System. The Electronic Control Module (ECM) monitors the operating parameters of the engine. The ECM can initiate responses if a specific engine parameter exceeds an acceptable range. Three possible responses may be available for each parameter: "WARNING", "DERATE", and "SHUTDOWN". Some of the responses are not available for some of the parameters. An ET service tool is used to perform the following activities:

- Select the available responses.
- Program the level for monitoring.
- Program delay times for each response.

The default settings for the parameters are programmed at the factory. To accommodate unique applications and sites, the parameters may be reprogrammed with an ET service tool.

The screens of the ET service tool provide guidance for the programming. The following options can be programmed "ON" or "OFF": "WARNING", "DERATE", and "SHUTDOWN".

The screens of the ET service tool also provide guidance for changing setpoints. For information on programming the Caterpillar Monitoring System, use the appropriate ET service tool and see the Service Manual, "Troubleshooting" module.

The Caterpillar Monitoring System is enabled after the engine is started. When the engine rpm exceeds 50 rpm below low idle, the ECM begins checking parameters. The ECM monitors the parameters in order to determine if the parameters exceed the setpoints.

If the monitoring system initiates a warning, a deration, or a shutdown, the event is logged into the ECM. This occurs even if the parameter is programmed "OFF". If a setpoint for a parameter is exceeded, the event will be logged.

Any failure of a sensor will result in disabling the corresponding portion of the monitoring system. The failure of a sensor will cause an "ACTIVE" diagnostic code for the sensor.

The derating is cumulative. For example, a derating of five percent followed by a derating of two percent results in a total derating of seven percent. If the conditions that cause the derating are not corrected, the derating will continue.

### Default Settings for the Caterpillar Monitoring System

**Derate** – This is a reduction of engine horsepower in response to an abnormal operating condition.

**Setpoint** – This is a specific value which can activate the following responses: warning, deration, and shutdown. The setpoint can be a pressure, a speed, a temperature, or a voltage.

**Hysteresis** – This is the change in the signal from a sensor that is tolerated by the ECM. This is the difference between the setpoint that activates a response and the value that deactivates the response. For example, a warning for low voltage can activate if a value below 20 volts is detected by the ECM. The voltage must rise to 22 volts in order to clear the warning. The hysteresis is the 2 volts that are above the 20 volts.

### Voltage

The ECM automatically warns the operator of low system voltage. The default settings that are programmed at the factory are listed in Table 6.

Table 6

Voltage Monitoring	
Parameter	Default Setting
Warning setpoint	20 volts
Warning delay	10 seconds
Hysteresis	2 volts
Security level	No required password

If the voltage is below 20 volts for 10 seconds, a warning will occur. To deactivate the warning, the voltage must rise above 22 volts.

The setpoint can be programmed to a value between 20 and 22 volts.

### Engine Oil Pressure

The ECM automatically performs the following functions for low engine oil pressure:

- Warning
- Shutdown

The strategy is based on a map of the engine oil pressure versus the engine rpm. For engines that are rated up to 1300 rpm, see Illustration 29. For engines that are rated at 1300 rpm and above, see Illustration 30. The default settings that are programmed at the factory are listed in Table 7.

Table 7

Engine Oil Pressure	
Parameter	Default Settings
Hysteresis	Map
Activation delay	10 seconds
Security level	Required password
Warning setpoint	Map
Warning delay	4 seconds
Shutdown setpoint	Map
Shutdown delay	9 seconds

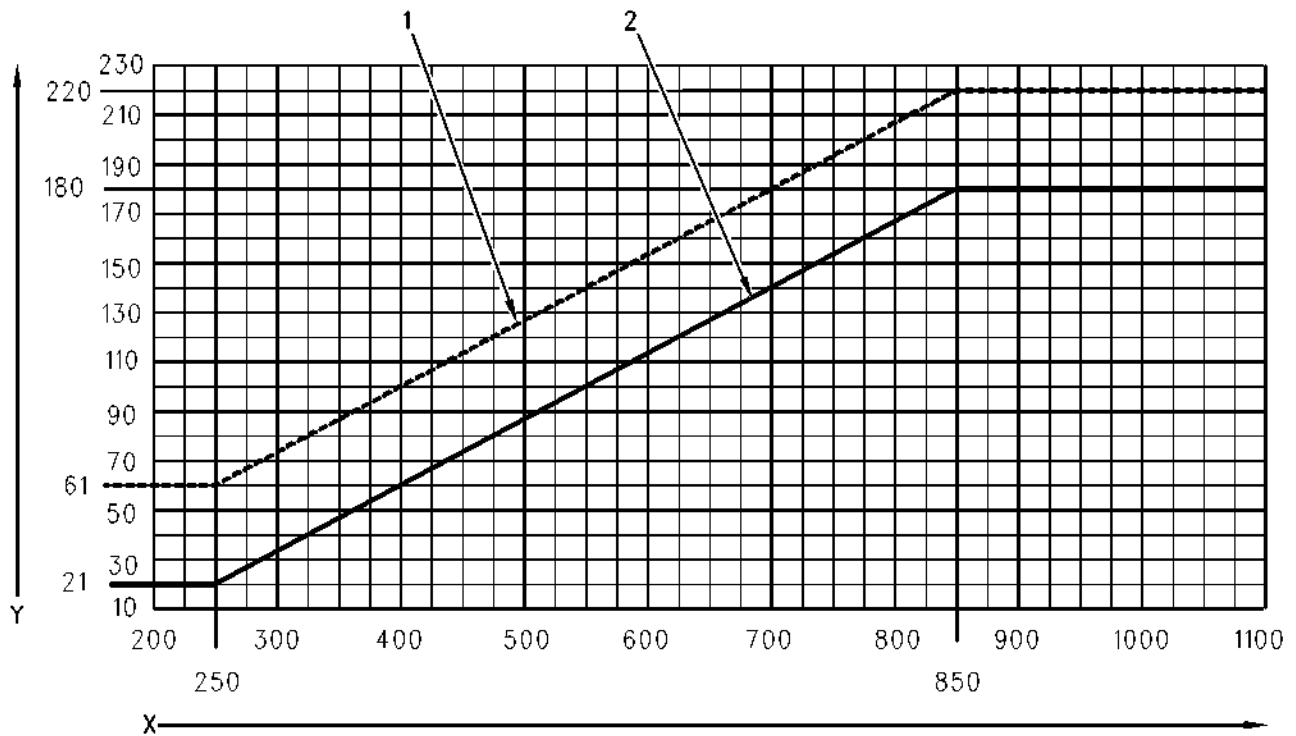


Illustration 29

g00799501

Map of the engine oil pressure versus the engine rpm for engines that are rated up to 1300 rpm

(Y) Engine oil pressure in kPa  
(X) Engine rpm

(1) Hysteresis  
(2) Minimum engine oil pressure

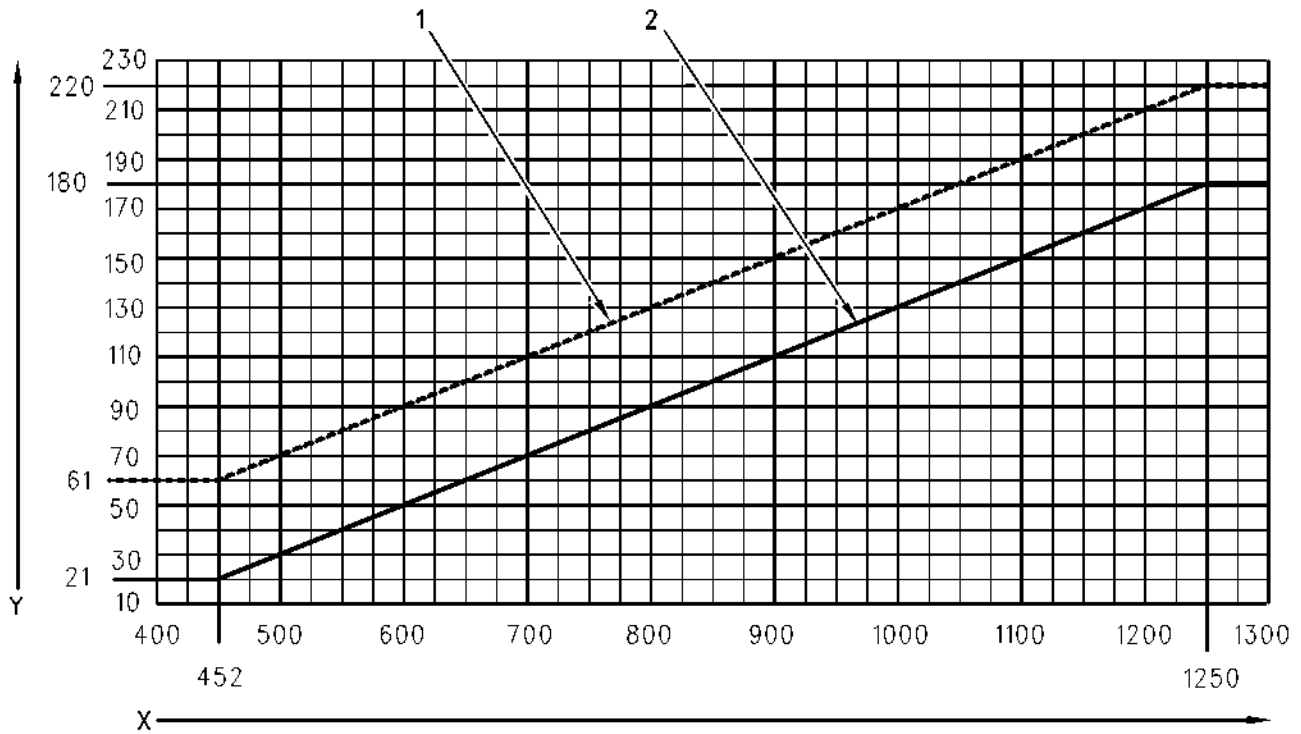


Illustration 30

g00799502

Map of the engine oil pressure versus the engine rpm for engines that are rated at 1301 rpm and above

(Y) Engine oil pressure in kPa  
 (X) Engine rpm

(1) Hysteresis  
 (2) Minimum engine oil pressure

If the engine oil pressure is below the minimum pressure for four seconds, a warning will occur. To deactivate the warning, the engine oil pressure must rise above the hysteresis that is set in the map.

If the engine oil pressure is below the minimum pressure for nine seconds, a shutdown will occur.

The map cannot be reprogrammed.

### High Coolant Temperature

The ECM will automatically perform the following functions for high coolant temperature:

- Warning
- Derating
- Shutdown

The default settings that are programmed at the factory are listed in Table 8.

Table 8

High Coolant Temperature	
Parameter	Default Setting
Warning setpoint	102 °C (216 °F)
Warning delay	5 seconds
Derate setpoint	107 °C (225 °F)
Derate delay	30 seconds
Maximum time of derating	480 seconds
Hysteresis	5 °C (9 °F)
Security level	No required password
Maximum derating	25%
Shutdown setpoint	107 °C (225 °F)
Shutdown delay	5 seconds

If the coolant temperature is above 102 °C (216 °F) for five seconds, a warning will occur. The coolant temperature must be below 97 °C (207 °F) in order to deactivate the warning.



If the coolant temperature is above 107 °C (225 °F) for 30 seconds, a derating will occur. A continuous 25 percent derating is reached in 480 seconds. When the coolant temperature is less than 102 °C (216 °F), the percent of the derating decreases. The percent of the derating decreases until the capability of providing full power is restored. However, if the coolant temperature rises above the setpoint again, the derating will resume.

If the coolant temperature is above 107 °C (225 °F) for five seconds, a shutdown will occur.

**Note:** The default setting for the delay of the derating is programmed to the maximum value of 30 seconds. The delay for the shutdown is five seconds. These settings result in a shutdown that occurs before a derating. These settings are programmed because most customers prefer a shutdown for high coolant temperature. The settings can be programmed to different values.

The setpoint can be programmed in the range of 90 to 102 °C (194 to 215 °F).

## Low Coolant Temperature

The ECM will automatically warn the operator of low coolant temperature. The default settings that are programmed at the factory are listed in Table 9.

Table 9

Low Coolant Temperature	
Parameter	Default Setting
Warning setpoint	80 °C (176 °F)
Warning delay	5 seconds
Activation delay	10 minutes
Hysteresis	5 °C (9 °F)
Security level	No required password

To activate this strategy, the engine must operate for a minimum of ten minutes. If the coolant temperature is below 80 °C (176 °F) for five seconds, a warning will occur. To deactivate the warning, the coolant temperature must rise above 85 °C (185 °F).

The setpoint can be programmed in the range of 63 to 85 °C (145 to 185 °F).

**Note:** The low coolant temperature is monitored in order to detect a failure of the water temperature regulators. **This feature is not intended to monitor the operation of jacket water heaters.**

## Overspeed

The ECM will automatically perform the following functions if an engine overspeed occurs:

- Warning
- Shutdown

Different setpoints are based on the engine application and the engine rating. The default settings that are programmed at the factory are listed in Table 10.

Table 10

Overspeed	
Parameter	Default Setting
Warning setpoint	1.15 times the rated rpm
Warning delay	0 seconds
Shutdown setpoint	1.15 times the rated rpm
Shutdown delay	0 seconds
Hysteresis	100 rpm
Security level	Required password

If the engine speed exceeds the setpoint rpm, a warning and a shutdown will occur. The fuel will be shut off and the air shutoff (if equipped) will be activated.

**The air shutoff must be reset before the engine can be restarted. Ensure that the air shutoff on the right side and the air shutoff on the left side are reset.**

**Note:** The default settings for the warning and for the shutdown are equal. Therefore, the warning and the shutdown occur simultaneously. These settings were selected in order to log both a warning and a shutdown; furthermore, an overspeed condition can occur rapidly.

The setpoints can be programmed to a value between 1200 and 2400 rpm.

## Inlet Air Restriction

The ECM will automatically perform the following functions if a high inlet air restriction occurs:

- Warning
- Derating

The strategy is applied to the right side air filter and/or the left side air filter. The default settings that are programmed at the factory are listed in Table 11.

Table 11

Inlet Air Restriction	
Parameter	Default Setting
Warning setpoint	7 kPa (1 psi)
Warning delay	5 seconds
Derate setpoint	7 kPa (1 psi)
Derate delay	5 seconds
Security level	No required password
Derating per 1 kPa (.15 psi)	2%
Maximum restriction	25 kPa (3.6 psi)

If the inlet air restriction is above 7 kPa (1 psi) for five seconds, both a warning and a derating will occur. The continuous schedule of the derating is two percent per 1 kPa (0.15 psi). The maximum derating is 50 percent at 25 kPa (3.6 psi).

The derating remains at the maximum level until the situation is corrected. To reset the derating to zero percent, remove power from the ECM. The ECM will reset when power is returned.

### Altitude

The ECM automatically compensates for engine operation at higher elevations. The ECM derates the fuel delivery according to the barometric pressure. The barometric pressure is sensed by the atmospheric pressure sensor. The atmospheric pressure has an effect on the performance of the engine. Derating the fuel delivery maintains the temperatures of the exhaust gas within acceptable limits.

The derating of the engine starts at a specific barometric pressure. The barometric pressure is equal to the atmospheric pressure of an elevation. The atmospheric pressure is specific for the engine and for the engine rating. The default settings that are programmed at the factory are listed in Table 12.

Table 12

Altitude	
Parameter	Default Setting
Derate setpoint	2T specification
Security level	Required password
Derating per 305 m (1000 ft)	3%
Maximum derating	35% of the rated power

If the barometric pressure is below the setpoint, a warning and a derating will occur. The continuous schedule of the derating is three percent per 1 kPa (.15 psi) of pressure below the setpoint. The maximum derating is 35 percent.

### Exhaust Temperature

The ECM will automatically perform the following functions if a high exhaust temperature occurs:

- Warning
- Derating

The strategy is applied to the right side exhaust manifold and/or the left side exhaust manifold. The default settings that are programmed at the factory are listed in Table 13.

Table 13

Exhaust Temperature			
Parameter	Default Setting and Ratings		
	A	B and C	D and E
Warning setpoint	702 °C (1296 °F)	728 °C (1342 °F)	756 °C (1393 °F)
Warning delay	0 seconds		
Derate setpoint	702 °C (1296 °F)	728 °C (1342 °F)	756 °C (1393 °F)
Derate delay	0 seconds		
Delay per step	15 seconds		
Hysteresis	10 °C (18 °F)		
Security level	A password is not required.		
Derating per step	2% per step		

If the exhaust temperature is above the warning setpoint for the period of the warning delay setpoint, a warning will occur.

If the exhaust temperature is above the derate setpoint for the period of the derate delay setpoint, the derate sequence will occur.

The factory default setting for the warning setpoint and the derate setpoint are the same value so that the warning alarm and the derate sequence are activated at the same time.

When the derate first activates, the derating reduces the available rated power by two percent, which is followed by a 15 second delay. If the exhaust temperature is not reduced below the setpoint value minus the hysteresis value after the 15 second delay, the engine's available power is derated another two percent.

When the exhaust temperature is reduced to less than the setpoint minus the hysteresis value, two percent of the engine's available power is restored for every 15 seconds. This continues until full power availability is restored. However, if the exhaust temperature rises above the setpoint again, the derating resumes.

## Oil Filter Differential Pressure

The ECM automatically warns the operator of high oil filter differential pressure. The default settings that are programmed at the factory are listed in Table 13.

Table 14

Oil Filter Differential Pressure	
Parameter	Default Setting
Warning setpoint	105 kPa (15 psi)
Warning delay	5 seconds
Hysteresis	10 kPa (1.5 psi)
Security level	No required password

If the oil filter differential pressure is above 105 kPa (15 psi) for five seconds, a warning will occur. To deactivate the warning, the oil filter differential pressure must be below 95 kPa (13.5 psi).

## Fuel Filter Differential Pressure

The ECM automatically warns the operator of high fuel filter differential pressure. The default settings that are programmed at the factory are listed in Table 15.

Table 15

Fuel Filter Differential Pressure	
Parameter	Default Setting
Warning setpoint	105 kPa (15 psi)
Warning delay	5 seconds
Hysteresis	10 kPa (1.5 psi)
Security level	No required password

If the fuel filter differential pressure is above 105 kPa (15 psi) for five seconds, a warning will occur. To deactivate the warning, the fuel filter differential pressure must be below 95 kPa (13.8 psi).

## Crankcase Pressure

The ECM will automatically perform the following functions if high crankcase pressure occurs:

- Warning
- Derating
- Shut down

The default settings that are programmed at the factory are listed in Table 16.

Table 16

Crankcase Pressure	
Parameter	Default Setting
Warning setpoint	2 kPa (.3 psi)
Warning delay	3 seconds
Derate setpoint	6 kPa (.9 psi)
Derate delay	10 seconds
Maximum time of derating	480 seconds
Hysteresis	0.25 kPa (.036 psi)
Security level	Required password
Maximum derating	15%
Shutdown setpoint	3.5 kPa (.51 psi)
Shutdown delay	3 seconds

If the crankcase pressure is above 2 kPa (.3 psi) for three seconds, a warning will occur. To deactivate the warning, the crankcase pressure must be below 1.75 kPa (.254 psi).

If the crankcase pressure is above 6 kPa (.9 psi) for 10 seconds, a derating will occur. The continuous schedule of the derating will reach 15 percent in 480 seconds.

When the crankcase pressure is less than 5.75 kPa (.39 psi), the percent of the derating is decreased until full power is restored. However, if the crankcase pressure rises above the setpoint again, the derating resumes.

If the crankcase pressure is above 3.5 kPa (.51 psi) for three seconds, a shutdown will occur.

**Note:** The default settings result in a shutdown that occurs before a derating. These settings were selected for the reason that high crankcase pressure can occur rapidly. The settings can be reprogrammed.

## Aftercooler Coolant Temperature

**Note:** The following information concerns engines with separate circuit aftercooling. For engines with jacket water aftercooling, monitoring of the aftercooler coolant temperature is disabled. However, the jacket water coolant temperature is monitored for all engines.

The ECM will automatically perform the following functions when high aftercooler coolant temperature occurs:

- Warning
- Derating
- Shut down

The default settings that are programmed at the factory are listed in Table 17.

Table 17

Aftercooler Coolant Temperature	
Parameter	Default Setting
Warning setpoint	50 °C (122 °F)
Warning delay	5 seconds
Derate setpoint	107 °C (225 °F)
Derate delay	5 seconds
Maximum time of derating	480 seconds
Hysteresis	3 °C (5.4 °F)
Security level	No required password
Maximum derating	25%
Shutdown setpoint	107 °C (225 °F)
Shutdown delay	5 seconds

If the aftercooler coolant temperature is above 50 °C (122 °F) for five seconds, a warning will occur. To deactivate the warning, the aftercooler coolant temperature must be below 47 °C (117 °F).

If the aftercooler coolant temperature is above 107 °C (225 °F) for five seconds, a derating will occur. The continuous schedule of the derating will reach 25 percent in 480 seconds.

When the aftercooler coolant temperature is less than 104 °C (220 °F), the percent of the derating is decreased until full power is restored. However, if the aftercooler coolant temperature rises above the setpoint again, the derating resumes.

If the aftercooler coolant temperature is above 107 °C (225 °F) for five seconds, a shutdown will occur.

## Transmission Oil Pressure

The ECM automatically warns the operator of low transmission oil pressure. This strategy detects actual low transmission oil pressure. The strategy does not activate when the transmission is shifted or when the transmission is in neutral.

The default settings that are programmed at the factory are listed in Table 18.

Table 18

Low Transmission Oil Pressure	
Parameter	Default Setting
Warning setpoint	1500 kPa (218 psi)
Warning delay	5 seconds
Hysteresis	10 kPa (1.5 psi)
Security level	No required password
Arming pressure	862 kPa (125 psi)
Arming delay	10 seconds

The strategy must be armed. The strategy is armed when the transmission oil pressure rises above 862 kPa (125 psi) for ten seconds.

If the transmission oil pressure is less than 862 kPa (125 psi), the monitoring system assumes that the transmission is in neutral. In this case, the strategy is disarmed. The warning will only activate when the transmission oil pressure is between 862 kPa (125 psi) and 1500 kPa (218 psi).

If the transmission oil pressure is between 862 kPa (125 psi) and 1500 kPa (218 psi) for five seconds, a warning will occur. To deactivate the warning, the pressure must be more than 1510 kPa (219 psi).

The setpoint can be programmed to a value between 1000 kPa (145 psi) and 3000 kPa (435 psi).

## Transmission Oil Temperature

The ECM automatically warns the operator of high transmission oil temperature. The default settings that are programmed at the factory are listed in Table 19.

Table 19

High Transmission Oil Temperature	
Parameter	Default Setting
Warning setpoint	99 °C (210 °F)
Warning delay	5 seconds
Hysteresis	5 °C (9 °F)
Security level	No required password

If the transmission oil temperature is more than 99 °C (210 °F) for five seconds, a warning will occur. To deactivate the warning, the temperature must be less than 94 °C (201 °F).

The setpoint can be programmed to a value between 80 °C (176 °F) and 120 °C (248 °F).

## Override Switch

The override switch enables the operator to override the monitoring system. The switch is provided for use in emergency situations when an engine must be operated at full capability immediately. Use of the switch will override conditions of derating and/or shutdown. However, an overspeed shutdown cannot be overridden. The switch can also be used to prevent an engine shutdown during critical maneuvers.

The switch is a two-position “ON/OFF” switch that is located in the Electronic Instrument Panel. When the switch is in the “OFF” position, the monitoring system will operate normally.

When the switch is in the “ON” position, the monitoring system is disabled. All of the warnings will continue to function normally. No derating will occur. **The overspeed shutdown will continue to function normally.** Except for the overspeed shutdown, no shutdowns will occur. If the engine has already had a shutdown, the engine can be restarted when the switch is in the “ON” position. The alarm conditions and events will continue to function normally.

An event will be logged in the ECM when the switch is placed in the “ON” position. Also, an event will be logged in the ECM when the switch is returned to the “OFF” position. No delay is required for use of the switch.

## General System Alarm Output

The general system alarm output is a relay that has a normally open contact and a normally closed contact. The two contacts are provided in order to accommodate the type of indicator that is provided by the customer. The customer can provide an annunciator for activation by the monitoring system in response to an event. The customer must also provide a switch for disabling of the annunciator, if necessary.

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## Alarms and Shutoffs

**SMCS Code:** 7400

This section contains some general information about the function of typical engine protective devices.

Alarms and shutoffs are electronically controlled. The operation of all alarms and shutoffs utilize components which are actuated by a sensing unit. The alarms and shutoffs are set at critical operating temperatures, pressures, or speeds in order to protect the engine from damage.

The alarms function in order to warn the operator when an abnormal operating condition occurs. The shutoffs function in order to shut down the engine when a more critical abnormal operating condition occurs. The shutoffs help to prevent damage to the equipment.

If an engine protective device shuts off the engine, always determine the cause of the shutoff. Make the necessary repairs before attempting to start the engine.

Become familiar with the following information:

- Types of the alarm and shutoff controls
- Locations of the alarm and shutoff controls
- Conditions which cause each control to function
- Resetting procedure that is required before starting the engine

For information about the specific alarms and shutoffs for the engine, see this Operation and Maintenance Manual, “Monitoring System” topic (Operation Section).

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## Instrument Panel

SMCS Code: 7451

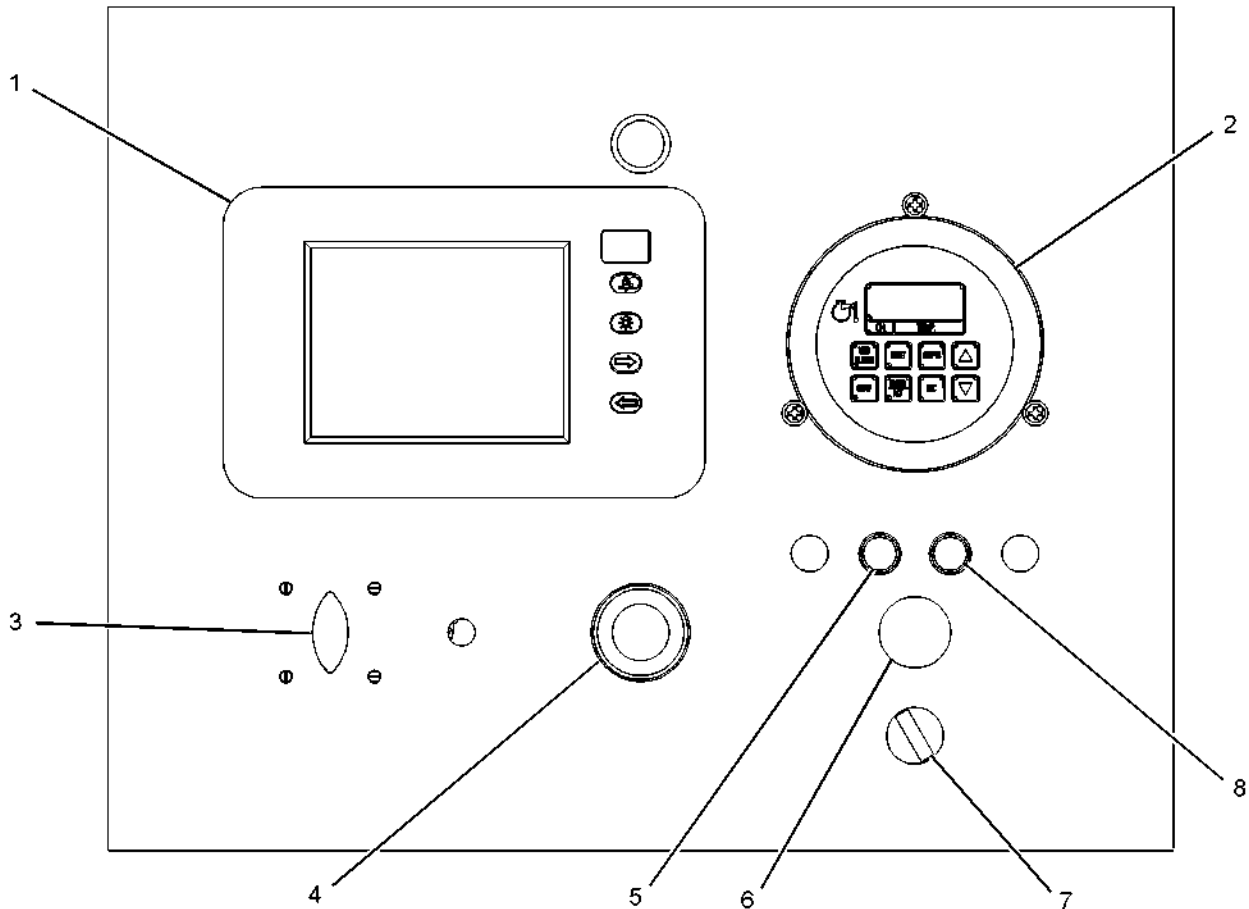


Illustration 31

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(1) Marine Power Display (MPD)  
(2) Pyrometer (if equipped)  
(3) Engine control switch (ECS)

(4) Emergency stop switch  
(5) Overspeed Indicator  
(6) Alarm (horn)

(7) Starter select switch (if equipped)  
(8) Emergency stop lamp

### Marine Power Display (MPD) (1)

The Caterpillar Marine Power Display is an attachment that is available from your Caterpillar dealer. The Caterpillar Marine Power Display will supply the current engine data. The Caterpillar Marine Power Display will supply the current data for the transmission. The screens can be customized. The screens can display a variety of engine parameters. The parameters are described in the following text.

### Operating Information

There are three modes of display for the engine data: Analog, digital, and bar graph. The following parameters are displayed: Engine Speed, Percent Load, Boost Pressure, Coolant Temperature, Oil Pressure, Oil Temperature, Fuel Rate, Fuel Pressure, Fuel Temperature, Inlet Manifold Temperature, Transmission Temperature, Transmission Pressure, Engine Hours, and Battery Voltage.

**Note:** The Oil Temperature and the Inlet Manifold Temperature will be displayed if the engine is equipped with the appropriate sensors.

## Display Modes

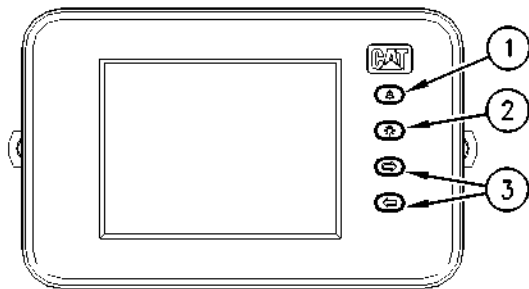


Illustration 32

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- (1) Alarm acknowledgment
- (2) Screen display
- (3) Arrow keys

**Day Mode** – The normal display is a white background with black letters and gauges. Press and hold down screen display (2) in order to display the slide bar that adjusts the contrast. Use arrow keys (3) to adjust the contrast.

**Night Mode** – Press screen display (2) in order to change the display. The display will have a black background with red letters and gauges. Press and hold down screen display (2) again in order to display the slide bar that adjusts the brightness. Use arrow keys (3) to adjust the brightness. Press screen display (2) again in order to display the slide bar that adjusts the contrast while the Backlight is on. Use arrow keys (3) to adjust the contrast. Press screen display (2) in order to exit the slide bar that adjusts the contrast.

## Diagnostic Data

All diagnostic messages from the engine's Electronic Control Module (ECM) are indicated by both a visual alarm and an audible alarm. Diagnostic indicators will not be shown when there are no active diagnostic codes. The diagnostic indicator will appear in the upper left corner of the screen. A window that describes the diagnostic code will appear in the center of the screen, and the audible alarm will sound. Press "alarm acknowledgment" key (1) in order to silence the alarm. Press "alarm acknowledgment" key (1) again in order to scroll through the diagnostic codes or remove the diagnostic codes. The diagnostic code indicator will remain on the screen until the fault is corrected.

**Note:** The loss of signal to the display will result in a Diagnostic Code with the description "NO DATA LINK SIGNAL".

## Configuration and Operation of the Marine Power display

The Caterpillar Marine Power Display can be programmed for three users with five screens for each user. Three users can set up the Caterpillar Marine Power Display for the preferences of each user.

The buttons have multiple functions that are dependent on the screen that is displayed.

**Reference:** See Operator Manual, LEBM0189, "Marine Power Display" for the functions of the buttons.

### "System Information" Screen

When power is first applied, scroll through the screens until the "System Information" screen is shown. This screen allows the following parameters to be configured: "User Name", "Unit Location", "Display Units", and "Vessel Speed". A menu driven screen is located in the upper right corner of the Marine Power Display screen. Press "alarm acknowledgment" key (1) in order to display the functions of the buttons.

**Reference:** See Operator Manual, LEBM0189, "Marine Power Display" in order to configure the parameters.

### Gauge Screens

The gauge screens can be configured with three different sizes of three types of gauges. Each user can configure the screens to display the engine data according to individual preferences. Each user can configure the screens to display the engine data in the following formats: analog, digital, and bar graph.

**Note:** Consult your Caterpillar Dealer in order to customize the screens of the Caterpillar Marine Power Display.

## Pyrometer (if equipped) (2)

The pyrometer is an electronic scanner for exhaust temperatures. This scanner can monitor 24 points via standard type K thermocouples. An LCD displays the number of the channel and the temperature in °C or °F. The scanner has two switches that can be wired to alarms or relays. The scanner can provide readings, monitoring, and alarms for the temperatures of 20 cylinder exhaust ports and four turbocharger inlets and/or outlets. The scanner can be programmed with the on board keypad. Service information and programming instructions are available in the Service Manual, RENR4911, "Exhaust Temperature Scanner".

## Engine Control Switch (ECS) (3)

Refer to Operation and Maintenance Manual, “Starting the Engine” for detailed information about starting the engine with the engine control switch. Refer to Operation and Maintenance Manual, “Engine Stopping” for detailed information about stopping the engine with the engine control switch.

### **WARNING**

**When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the the engine when the engine is in the AUTOMATIC mode.**

For automatic starting, the engine control switch must be in the “AUTO” position. The engine will automatically start when the remote start/stop initiate contact closes.

To start the engine, turn the engine control switch to the “MAN. START” position. Do not start the engine or move any of the controls if there is a “DO NOT OPERATE” warning tag or a similar warning tag attached to the start switch or to the controls. Ensure that no one will be endangered before the engine is started and when the engine is started.

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.

When the engine control switch is turned to the “OFF/RESET” position, power is removed from the ECM and the instrument panel.

## Emergency Stop Switch (4)

Use the emergency stop switch ONLY in an emergency situation. DO NOT use the emergency stop switch for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.

## Overspeed Indicator (5)

The overspeed indicator will illuminate if an engine overspeed occurs.

## Alarm (horn) (6)

The alarm will sound in order to alert the operator to an abnormal condition.

## Starter Select Switch (if equipped) (7)

This switch does not start the engine. Use the starter select switch to choose the method for starting the engine. When the switch is in the PRIMARY position, the primary starter will be used to start the engine. When the switch is in the SECONDARY position, the secondary starter will be used to start the engine.

## Emergency Stop Lamp (8)

The emergency stop lamp will illuminate when the emergency stop switch is activated.



# Engine Starting

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## Before Starting Engine

**SMCS Code:** 1000; 1400; 1450 **WARNING**

**Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.**

Perform the required daily maintenance and other periodic maintenance before starting the engine. Inspect the engine room. This inspection can help prevent major repairs at a later date. See this Operation and Maintenance Manual (Maintenance Section), "Maintenance Interval Schedule".

## Walk-Around Inspection

### 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.

To obtain maximum service life for your engine, make a thorough inspection before starting the engine. Make a walk-around inspection of the installation. Look for items such as oil or coolant leaks, loose bolts and trash buildup. Remove any trash. Arrange for repairs, as needed.

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Ensure that the areas around the rotating parts are clear.

## Air Inlet System

- Ensure that the air inlet piping and the air filters are in place.
- Ensure that all clamps and connections are secure.
- Check the air cleaner service indicator. Clean the air cleaner element or replace the air cleaner element when the yellow diaphragm enters the red zone or the red piston locks in the visible position.

**Note:** If the engine is equipped with air shutoff mechanisms, ensure that all air shutoff mechanisms are in the open position prior to starting.

## Cooling System

- Inspect the cooling system for leaks or loose connections.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the water pumps for evidence of leaks.
- Inspect the fan drive belts for cracks and for deterioration.
- Check the coolant level. Add coolant, if necessary. For information on the proper coolant to use, see this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section).

## Driven Equipment

**Note:** If the engine is equipped with a system for external support, prepare the system before starting the engine. Perform all prestart checks for the control system.

- Check the oil level of the marine transmission. Perform any maintenance that is required. See the literature that is provided by the OEM of the vessel or the marine transmission.

## Electrical System

Inspect the wiring for the following conditions:

- Loose connections
- Wiring that is worn or frayed

Inspect the alternator belt for cracks and for deterioration.

Ensure that the grounds are secure.

## Fuel System

### NOTICE

All valves in the fuel return line must be open before and during engine operation to help prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage.

- Inspect the fuel lines for loose fittings and leaks. Ensure that the fuel lines are properly clamped.

- Ensure that fuel is supplied to the engine.

If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been replaced, some air space will be left in the filter housing. In these instances, prime the fuel system. For information on priming the fuel system, see this Operation and Maintenance Manual, "Fuel System-Prime" topic (Maintenance Section).

## Lubrication System

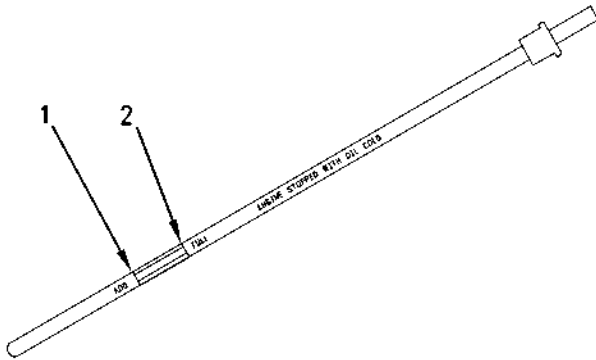


Illustration 33

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Oil level gauge

- (1) "ADD" mark
- (2) "FULL" mark

### NOTICE

Excessive engine oil will increase oil consumption and result in excessive deposits in the combustion chamber. Do not overfill the engine with oil.

- Check the engine crankcase oil level. Maintain the oil level between the "ADD" and "FULL" marks on the "ENGINE STOPPED" side of the oil level gauge. For information on the proper oil to use, see this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section).
- Check for leaks at the following components: crankshaft seals, crankcase, oil filters, oil gallery plugs, sensors, and valve covers.
- Inspect the tubes, tee pieces, and clamps on the crankcase breathers.

## Starting System

- Inspect the instrument panel and the control panel for good condition.
- Reset the shutoff and alarm components.

## Air Starting Motor

- Drain moisture and sediment from the air tank and from any other air piping.
- Check the oil level in the lubricator. Keep the lubricator at least half full. Add oil, if necessary. For temperatures above 0 °C (32 °F), use a nondetergent 10W oil. For temperatures below 0 °C (32 °F), use air tool oil.
- Check the air pressure for starting. The air starting motor requires a minimum of 690 kPa (100 psi). The maximum allowable air pressure is 1030 kPa (150 psi). Open the air supply valve.

## Electric Starting Motor

- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor engages.

Inspect the wiring, the electrical cables, and the battery for the following conditions:

- Loose connections
- Wires that are worn or frayed
- Corrosion

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## Cold Weather Starting

**SMCS Code:** 1000; 1250; 1450; 1453; 1456; 1900

**Note:** Oil pan immersion heaters are not recommended for heating the lube oil. To ensure the compatibility of the components, only use equipment that is recommended by Caterpillar.

Startability will be improved at temperatures below 12 °C (55 °F) with a starting aid. When the temperature is below 13 °C (55 °F), Caterpillar recommends the use of the following starting aids before you start the engine:

- Jacket Water Heater
- Crankcase Oil Heater

**Note:** The fluid that is heated must be continuously circulated. This will help to prevent localized overheating of the fluid.

Jacket water heaters are available for cold weather starting. The heated water will help to keep the oil in the engine block warm enough to flow when the engine is started.

When No. 2 diesel fuel is used, a fuel heater will maintain the temperature of the fuel above the cloud point. Fuel line insulation will help to maintain the fuel temperature.

Consult your Caterpillar dealer for more information on the starting aids that are available for cold weather starting.

**Note:** Engines that are started at temperatures below 13 °C (55 °F) without starting aids may damage internal components.

## Electric Starting Motor

Maintain the proper level of electrolyte in the batteries. Keep the batteries fully charged.

To maximize the battery power, heat the battery compartment or store the batteries in a warm location. Typically, batteries only have 50 percent of the capability at -10 °C (14 °F) versus 27 °C (80 °F).

Extra battery capacity may be necessary for very cold temperatures.

## Air Starting Motor

**Note:** The maximum air pressure for starting must not exceed 1030 kPa (150 psi).

To start the engine at colder temperatures, the following conditions may be necessary:

- Maximum air pressure for the starting motor
- An additional volume of air

## Starting With Ether

### WARNING

**Personal injury or property damage can result from alcohol or starting fluids.**

**Alcohol or starting fluids are highly flammable and toxic and if improperly stored could result in injury or property damage.**

### NOTICE

Excessive starting fluid can cause piston and ring damage.

Use starting fluid for cold starting purposes only.

Do not use excessive starting fluid during starting or after the engine is running.

**The optional ether starting aid is controlled through the electronic control module (ECM). This is the only method that is recommended for the injection of starting fluid.**

An ether starting aid is available as an option. Under the following conditions, the ECM will automatically inject ether during cranking:

- The crankshaft is rotating.
- The jacket water coolant temperature is less than 10 °C (50 °F).

Additional injections of ether may be necessary in order to achieve normal operation at low idle rpm. The instrument panel will have a "STARTING AID" switch. The switch is normally in the "AUTO" position. After the engine has started, the operator can inject additional ether by holding the switch in the "MANual" position. The ECM will control the amount of ether that is injected. Ether can be injected by this method under the following conditions:

- The engine speed is less than 1900 rpm.
- The jacket water coolant temperature is less than 10 °C (50 °F).

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## Starting the Engine

**SMCS Code:** 1000; 1450

### WARNING

**Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.**

## Prelubrication

The engine prelube system is optional. If the engine has the option, the electronic control module (ECM) will operate the prelube pump under these conditions:

- The "ENGINE PRELUBE DURATION" parameter is programmed to a value that is greater than zero.
- The engine control switch is turned to the "MAN.START" position. Alternatively, the engine control switch is in the "AUTO" position when the remote start/stop initiate contact closes.

The prelube pump will supply oil under pressure to the engine until one of the following conditions occurs:

- The oil pressure closes a pressure contactor.
- The programmed “ENGINE PRELUBE DURATION” expires.

Engine cranking will begin after the prelube pump stops.

## Automatic Starting

### WARNING

**When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the the engine when the engine is in the AUTOMATIC mode.**

For automatic starting, the engine control switch must be in the “AUTO” position. The engine will automatically start when the remote start/stop initiate contact closes.

## Manual Starting

### NOTICE

For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

Do not start the engine or move any of the controls if there is a “DO NOT OPERATE” warning tag or a similar warning tag attached to the start switch or to the controls.

Ensure that no one will be endangered before the engine is started and when the engine is started.

1. Perform all of the procedures that are described in this Operation and Maintenance Manual, “Before Starting Engine” topic (Operation Section).
2. Ensure that the marine transmission is disengaged.

### NOTICE

Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the starter switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

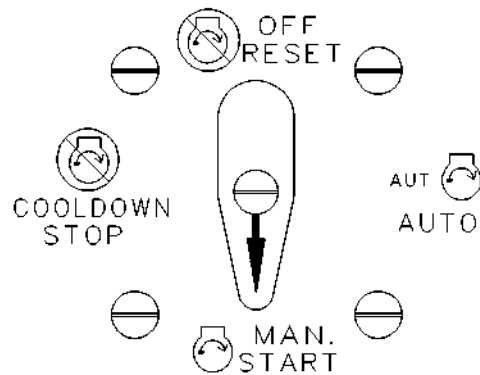


Illustration 34

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Engine control switch in the “MAN. START” position

**Note:** If the optional prelube is used, the prelube pump will operate before cranking begins.

3. To start the engine, turn the engine control switch to the “MAN. START” position.

The ECM will allow the engine to be operated at rated rpm when the oil pressure sensors indicate that the oil pressure is sufficient.

## Overcrank

The crank cycle is the amount of time for engagement of the starting motor. This also includes the amount of time for cooling of the starting motor between crank cycles. The crank cycle and the number of crank cycles are programmable.

If the engine does not start within the number of crank cycles that are programmed, the fuel system is disabled. The “OVERCRANK” indicator will illuminate in order to warn the operator of an overcrank.

If an overcrank occurs, the ECM must be reset before starting can be attempted. To reset the ECM, turn the engine control switch to the “OFF/RESET” position.

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## Starting with Jump Start Cables

**SMCS Code:** 1000; 1401; 1402; 1900

### WARNING

**Improper jump start cable connections can cause an explosion resulting in personal injury.**

**Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jump start cable ends to contact each other or the engine.**

**Note:** The engine is electronically controlled. The engine requires an isolated 24 volt DC power supply in order to operate. The power supply must be continuous. If the power supply is removed or disconnected, the engine will not operate.

### NOTICE

When starting with power from an external source, only use a source that has the same voltage as the starting motor.

The use of a greater voltage or the use of a welder will damage the electrical system. A power surge could damage the engine's electronic control module.

When starting with power from an external source, only use batteries as a source of power.

**Starting from an external power source is not recommended. A backup battery system is recommended.**

## After Starting Engine

**SMCS Code:** 1000

**Note:** After the engine has been installed or rebuilt, carefully monitor the engine in order to detect any unusual engine performance.

1. Operate the engine at low idle for two to three minutes. Allow the jacket water temperature to begin to rise before increasing the engine rpm.

**Note:** More warm-up time may be necessary when the ambient temperature is below  $-18^{\circ}\text{C}$  ( $0^{\circ}\text{F}$ ).

2. Turn the air supply to the air starting motor OFF (if equipped).
3. Make another walk-around inspection. Inspect the engine for fluid leaks and air leaks.

**Note:** For instructions on engaging the driven equipment, see the literature that is provided by the OEM of the vessel.

4. Ensure that the gauges are in the normal ranges for the engine rpm. After verifying that the engine systems are normal, engage the driven equipment.

Begin operating the engine at low load. Continue to check the gauges and the driven equipment. Operate the engine at a low load until the engine reaches normal operating temperature. The engine should reach operating temperature before the vessel enters open water.

The engine will reach normal operating temperature faster when the engine is operated at low rpm and low power demand. This procedure is more effective than idling the engine with no load.

5. After normal oil pressure is reached and the jacket water temperature rises, the engine may be operated at full load. Increase the load, as required.

# Engine Operation

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## 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. At certain ratings, the engine can be operated for extended periods of time at full load.

### Partial Load Operation

Extended operation at reduced load (less than 30%) may cause increased oil consumption and carbon buildup in the cylinders. Extended operation at reduced load may also cause fuel to slobber through the exhaust system. This may result in a loss of power and/or poor performance.

To maintain engine efficiency and performance, apply a full load to the engine on an hourly basis, or operate the engine at a load level that is greater than 30%. This will burn excess carbon from the cylinders.

When possible, before shutting down the engine after running the engine for extended periods at low load, apply a full load for approximately 30 minutes. Running the engine at full load allows excess carbon to burn from the following components: cylinders, pistons, and valves. Then follow the recommended cooldown procedures.

## RPM for Cruising

Table 20 lists the ratings for 3500 Marine Engines and the corresponding rated rpm. Table 20 also lists the engine rpm that is suggested for optimum fuel efficiency. For data regarding a specific engine, consult your Caterpillar dealer.

Table 20 assumes the use of a fixed pitch propeller. If the vessel has a variable pitch propeller, consult your Caterpillar dealer for information on marine engine performance and reduced engine rpm.

### NOTICE

Operating an engine above the engine's rating will reduce the service life of the engine before overhaul.

**Note:** For the definitions of the engine ratings, see this Operation and Maintenance Manual, "Engine Rating Definitions" topic (Reference Information Section).

Table 20

Marine Engine Ratings and Suggested RPM for Cruising			
Rating	Time That Is Allowed At Rated Power	Rated RPM	Suggested RPM for Cruising
"A"	100%	n/a	n/a
"B"	80%	1200	1150
		1600	1520
		1785	1695
		1800	1700
"C"	50%	1200	1110
		1600	1450
		1800	1620
		1835	1650
"D"	16%	1880	1600
"E"	8%	1925	1650

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## 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, if necessary.

- 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.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- When possible, utilize the heat of the jacket water system and the heat from the exhaust system.
- Keep keel coolers, heat exchangers, and water pumps clean. Keep the components in good repair.
- Ensure that all of the accessory pumps are repaired. The pumps should operate efficiently.
- Do not exceed the maximum oil level.
- Never operate without water temperature regulators.

Water temperature regulators regulate heat. Water temperature regulators help to provide efficient operating temperatures. Cold engines consume excessive fuel. Water temperature regulators also help prevent engine overheating.

## Engine Stopping

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### Emergency Stopping

SMCS Code: 1000; 7418

#### WARNING

Flash fire may result in personal injury, if crankcase covers are removed within fifteen minutes after emergency shut down. Do not restart engine until cause for shutdown has been corrected.

#### NOTICE

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

Ensure that any system that provides external support to the engine is secured after the engine is stopped.

### Emergency Stop Button

**Note:** An emergency stop button is located on the junction box and on the control panel that is shipped with the engine. The OEM of the vessel is responsible for any additional controls for emergency stopping.

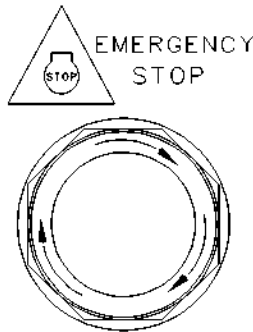


Illustration 35

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Typical emergency stop button

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

**Note:** Some marine engines are equipped with an emergency stop button that must be pulled in order to stop the engine.

#### 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.**

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## 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 centerhousing will cause oil coking problems. Excessive temperatures in the turbocharger centerhousing may damage the turbocharger bearing/shaft system and significantly shorten the life of the turbocharger.

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.

1. Disengage the marine transmission in order to remove the load.
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.



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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, allow the engine to operate at low idle rpm for three to five minutes. Then stop the engine.

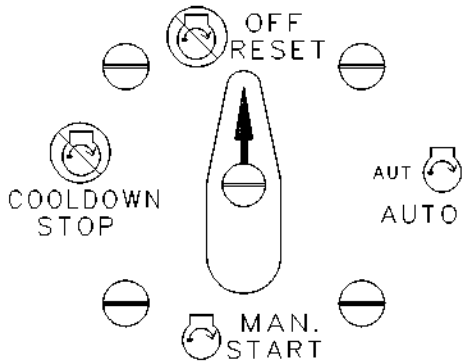


Illustration 36

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Engine control switch in the "OFF/RESET" position

3. Turn the engine control switch to the "OFF/RESET" position.

When the engine control switch is turned to the "OFF/RESET" position, power is removed from the ECM and the instrument panel.

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

## 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.

## After Stopping Engine

**SMCS Code:** 1000

- Check the engine crankcase oil level. Maintain the oil level between the "ADD" and "FULL" marks on the "ENGINE STOPPED" side of the oil level gauge.
- If necessary, perform minor adjustments. Repair any leaks and tighten loose bolts.
- Note the service hour meter reading. Perform the maintenance that is scheduled in this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

### NOTICE

Follow the guidelines for antifreeze/coolant mixtures that are recommended in this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic. Failure to do so can cause engine damage.

- Allow the engine to cool. Check the coolant level.
- Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
- If freezing temperatures are expected, check the coolant for protection against freezing. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. Refer to the instructions that are provided by the OEM of the driven equipment.

# Cold Weather Operation

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## Fuel and the Effect from Cold Weather

**SMCS Code:** 1000; 1250; 1280

The following fuels are the grades that are available for Caterpillar engines:

- No. 1
- No. 2
- Blend of No. 1 and No. 2

No. 2 diesel fuel is the most commonly used fuel. Either No. 1 diesel fuel or a blend of No. 1 and No. 2 is best suited for cold weather operation.

Quantities of No. 1 diesel fuel are limited. No. 1 diesel fuels are usually available during the months of the winter in the colder climates. During cold weather operation, if No. 1 diesel fuel is not available, use No. 2 diesel fuel, if necessary.

There are three major differences between No. 1 and No. 2 diesel fuel. No. 1 diesel fuel has the following properties:

- Lower cloud point
- Lower pour point
- Lower rating of kJ (BTU) per unit volume of fuel

When No. 1 diesel fuel is used, a decrease in power and in fuel efficiency may be noticed. Other operating effects should not be experienced.

The cloud point is the temperature when a cloud of wax crystals begins to form in the fuel. These crystals can cause the fuel filters to plug. The pour point is the temperature when diesel fuel will thicken. The diesel fuel becomes more resistant to flow through fuel pumps and through fuel lines.

Be aware of these values when diesel fuel is purchased. Anticipate the average ambient temperature of the area. Engines that are fueled in one climate may not operate well if the engines are moved to another climate. Problems can result due to changes in temperature.

Before troubleshooting for low power or for poor performance in the winter, check the type of fuel that is being used.

When No. 2 diesel fuel is used the following components provide a means of minimizing problems in cold weather:

- Starting aids
- Engine oil pan heaters
- Engine coolant heaters
- Fuel heaters
- Fuel line insulation

For more information on cold weather operation, see Special Publication, SEBU5898, "Cold Weather Recommendations".

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## Fuel Related Components in Cold Weather

**SMCS Code:** 1000; 1250; 1280

### Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off the fuel tanks after operating the engine.

Fuel tanks should have a provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Drain the water and sediment in order to help prevent freezing.

### Fuel Filters

A primary fuel filter and/or a water separator is recommended between the fuel tank and the secondary fuel filter.

The micron rating and the location of a primary fuel filter is important in cold weather operation. The primary fuel filter and the fuel supply line are the most common components that are affected by cold fuel.

The micron rating of the primary fuel filter should only be low enough to protect the fuel transfer pump. A primary filter with a low micron rating can be plugged by wax crystals in cold weather.

**Note:** Refer to the Parts Manual for the engine in order to determine the part numbers of the fuel filters.

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## Fuel Heaters

Fuel heaters help prevent plugging of the fuel filters due to waxing in cold weather. Install fuel heaters so that the fuel is heated before the fuel enters the primary fuel filters.

Use a fuel heater that is mechanically simple but adequate for the application. The fuel heater should also prevent the fuel from overheating. High fuel temperatures reduce the performance of the engine. Choose a fuel heater with a surface for heating that is as large as possible but also practical. Small heaters can be too hot because of a limited surface area.

For warm weather, disconnect the fuel heater or deactivate the fuel heater. Heat exchanger type fuel heaters should have a bypass provision in order to prevent the fuel from overheating in warm weather.

Only use thermostatically controlled fuel heaters or self-regulated fuel heaters with this engine. A fuel heater that is not thermostatically controlled can heat the fuel above 65 °C (149 °F). A loss of engine power can occur if the fuel supply temperature exceeds 29 °C (85 °F).

For further information on fuel heaters, consult your Caterpillar dealer.

# Maintenance Section

## Refill Capacities

### Refill Capacities and Recommendations

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

These recommendations may be changed without notice. Contact your local Caterpillar dealer for the most recent recommendations about fluids.

### Lubrication System

#### Lubricant Recommendations

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

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

**Note:** If Caterpillar DEO Multigrade is not used, use only commercial oils that meet the following classifications.

- API CH-4 multigrade oils and API CI-4 multigrade oils are acceptable if the requirements of Caterpillar's Engine Crankcase Fluid -1 (ECF-1) specification are met. CH-4 oils and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 specification may cause reduced engine life.
- API CG-4 multigrade oils are acceptable for all Caterpillar diesel engines. When the API CG-4 oils are used, the oil drain interval should not exceed the standard oil drain interval for your engine.

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. To determine the oil viscosity that is required for starting a cold soaked engine, refer to the minimum temperature in Table 21. To select the oil viscosity for operation at the highest anticipated ambient temperature, refer to the maximum temperature in the Table. Use the highest oil viscosity that is available in order to meet the required temperature during start-up.

Table 21

Engine Oil Viscosities for Ambient Temperatures		
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)

Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that relates to lubricants.

### 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 on internal components. The Caterpillar tool for oil analysis is called S·O·S Oil 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.

Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" or contact your local Caterpillar dealer for additional information concerning the S·O·S Oil Analysis program.

## Lubricant Capacities

The capacity of the engine 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.

Table 22

Approximate Refill Capacities for 3508B 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

Table 23

Approximate Refill Capacities for 3512B Engine and 3512C 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

Table 24

Approximate Refill Capacities for 3516B Engine and 3516C 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

## Fuel

### Fuel Recommendations

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

Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that relates to diesel fuel.

## Cooling System

### Coolant Recommendations

#### 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.

Use only the coolant/antifreeze that is recommended.

The following coolants are the primary types of coolants that are used in Caterpillar Engines:

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

**Acceptable** – Cat DEAC (Diesel Engine Antifreeze/Coolant) or a commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D6210" specifications

Caterpillar recommends a 1:1 mixture of water and glycol. This mixture will provide optimum heavy-duty performance as a coolant/antifreeze.

**Note:** Cat DEAC DOES NOT require a treatment with an SCA at the initial fill. Commercial heavy-duty coolant that meets "ASTM D4985" or "ASTM D6210" specifications MAY require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

In stationary engine applications and marine engine applications that do not require protection from boiling or freezing, a mixture of SCA and water is acceptable. **Caterpillar recommends a minimum of six percent to a maximum of eight percent SCA concentration in those cooling systems.** Distilled water or deionized water is preferred. Water which has the required properties may be used. Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that pertains to coolants.

**Note:** Table 25 is a list of the coolants that are recommended and the service life (calendar) of the coolants. The service life of coolant is also limited by use (service hours). Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule". **To achieve this service life, the coolants must be properly maintained. The maintenance program includes S·O·S coolant analysis.**

Table 25

Coolant Service Life	
Coolant Type	Service Life <sup>(1)</sup>
Cat ELC	Six Years
Cat DEAC	Three Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D6210"	Two Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985"	One Year
Cat SCA and Water	Two Years
Commercial SCA and Water	One Year

<sup>(1)</sup> The service life of coolant is also limited by use (service hours). Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

## S·O·S Coolant Analysis

### S·O·S Coolant Analysis (Level 1)

A coolant analysis (Level 1) is a test of the properties of the coolant.

The following properties of the coolant are tested:

- Glycol concentration for freeze protection and boil protection
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Visual analysis
- Odor analysis

The results are reported, and appropriate recommendations are made.

Refer to the Maintenance Interval Schedule in this Operation and Maintenance Manual, "Cooling System Coolant Sample (Level 1) - Obtain" for a sampling location and the maintenance interval for collecting the coolant samples.

### S·O·S Coolant Analysis (Level 2)

A coolant analysis (Level 2) is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the inside of the cooling system.

The S·O·S Coolant Analysis has the following features:

- Full coolant analysis (Level 1)
- Identification of the source of metal corrosion and of contaminants
- Water hardness
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling

The results are reported, and appropriate recommendations are made.

Refer to the Maintenance Interval Schedule in this Operation and Maintenance Manual, "Cooling System Coolant Sample (Level 2) - Obtain" for a sampling location and the maintenance interval for collecting the coolant samples.

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.

## Coolant Capacities

### Engines with Separate Circuit Aftercooling

Table 26

Approximate Refill Capacities for the 3508B 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		

Table 27

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

Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information.

Table 28

<b>Approximate Refill Capacities for the 3516B and 3516C Engine Cooling System with Separate Circuit Aftercooling</b>		
<b>Compartment or System</b>	<b>Liters</b>	<b>US Gallons</b>
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

Table 29

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

Table 30

<b>Approximate Refill Capacities for the 3512B and 3512C Engine Cooling System with Jacket Water Aftercooling</b>		
<b>Compartment or System</b>	<b>Liters</b>	<b>US Gallons</b>
Engine only	160 L	42.3 US gal
External system		
Total cooling system		

Table 31

<b>Approximate Refill Capacities for the 3516B and 3516C Engine Cooling System with Jacket Water Aftercooling</b>		
<b>Compartment or System</b>	<b>Liters</b>	<b>US Gallons</b>
Engine only	235 L	62 US gal
External system		
Total cooling system		

## Maintenance Recommendations

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### System Pressure Release

SMCS Code: 1250; 1300; 1350; 5050

#### Coolant System

##### WARNING

**Pressurized system: Hot coolant can cause serious burn. To open cap, stop engine, wait until radiator is cool. Then loosen cap slowly to relieve the pressure.**

To relieve the pressure from the coolant system, turn off the engine. Allow the cooling system pressure cap to cool. Remove the cooling system pressure cap slowly in order to relieve pressure.

#### Fuel System

To relieve the pressure from the fuel system, turn off the engine.

#### High Pressure Fuel Lines (If Equipped)

##### WARNING

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

The high pressure fuel lines are the fuel lines that are between the high pressure fuel pump and the high pressure fuel manifold and the fuel lines that are between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

This is because of the following differences:

- The high pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high pressure fuel lines are higher than other types of fuel system.

Before any service or repair is performed on the engine fuel lines, perform the following tasks:

1. Stop the engine.
2. Wait for ten minutes.

Do not loosen the high pressure fuel lines in order to remove air pressure from the fuel system.

#### Engine Oil

To relieve pressure from the lubricating system, turn off the engine.

i02869643

### Welding on Engines with Electronic Controls

SMCS Code: 1000

##### NOTICE

Because the strength of the frame may decrease, some manufacturers do not recommend welding onto a chassis frame or rail. Consult the OEM of the equipment or your Caterpillar dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary in order to avoid damage to the engine's ECM, sensors, and associated components. When possible, remove the component from the unit and then weld the component. If removal of the component is not possible, the following procedure must be followed when you weld on a unit that is equipped with a Caterpillar Electronic Engine. The following procedure is considered to be the safest procedure to weld on a component. This procedure should provide a minimum risk of damage to electronic components.

##### NOTICE

Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train bearings, hydraulic components, electrical components, and other components.

Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld. This will help reduce the possibility of damage.

1. Stop the engine. Turn the switched power to the OFF position.
2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.



3. Disconnect the J1/P1 and J2/P2 connectors from the ECM. Move the harness to a position that will not allow the harness to accidentally move back and make contact with any of the ECM pins.

5. Protect the wiring harness from welding debris and spatter.
6. Use standard welding practices to weld the materials.

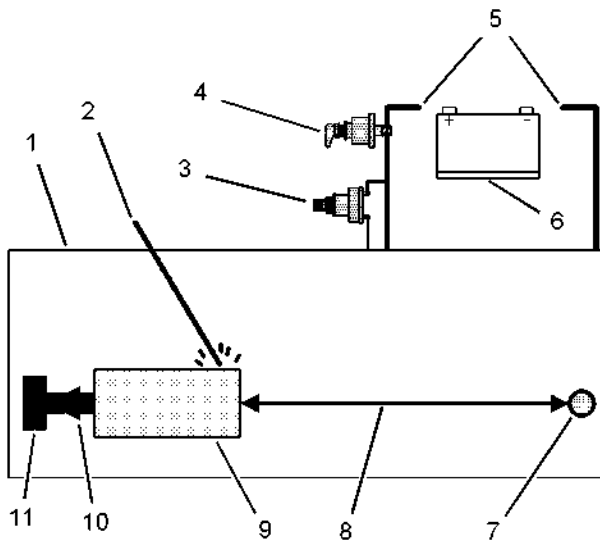


Illustration 37

g01075639

Use the example above. The current flow from the welder to the ground clamp of the welder will not cause damage to any associated components.

- (1) Engine
- (2) Welding electrode
- (3) Keyswitch in the OFF position
- (4) Battery disconnect switch in the open position
- (5) Disconnected battery cables
- (6) Battery
- (7) Electrical/Electronic component
- (8) Minimum distance between the component that is being welded and any electrical/electronic component
- (9) The component that is being welded
- (10) Current path of the welder
- (11) Ground clamp for the welder

4. Connect the welding ground cable directly to the part that will be welded. Place the ground cable as close as possible to the weld in order to reduce the possibility of welding current damage to bearings, hydraulic components, electrical components, and ground straps.

**Note:** If electrical/electronic components are used as a ground for the welder, or electrical/electronic components are located between the welder ground and the weld, current flow from the welder could severely damage the component.

i02975516

## Maintenance Interval Schedule

**SMCS Code:** 1000; 4450; 7500

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

The user is responsible for the performance of all maintenance which includes the following items: performing all adjustments, using proper lubricants, fluids, and filters, and replacing old components with new components due to normal wear and aging .

Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the product and/or accelerated wear of components.

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

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

**All of the following will affect the oil change interval: operating conditions, fuel type, oil type, and size of the oil sump . Scheduled oil sampling analyzes used oil in order to determine if the oil change interval is suitable for your specific engine.**

In the absence of scheduled oil sampling, replace the engine oil and filters according to the following intervals:

If the engine has a standard oil sump, change the oil after every 500 service hours.

If the engine has a deep oil sump, change the oil after every 1000 service hours.

Refer to this Operation and Maintenance Manual, "Engine Oil and Filter - Change" in order to determine the oil change interval that is suitable for your specific engine.

To determine the maintenance intervals for the overhauls, refer to this Operation and Maintenance Manual, "Maintenance Recommendations" .

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Engine Oil Level - Check .....	89
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### Every 250 Service Hours

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i02828620

## Aftercooler Core - Inspect/Clean

**SMCS Code:** 1063-040; 1064-571

1. Remove the core. Refer to the Disassembly and Assembly Manual, "Aftercooler - Remove and Install" for the procedure.
2. Turn the aftercooler core on one side in order to remove debris. Remove the debris that is accessible.

### NOTICE

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

3. Back flush the core with cleaner.

Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 32 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 32

Hydrosolv Liquid Cleaners <sup>(1)</sup>		
Part Number	Description	Size
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

<sup>(1)</sup> Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F). Consult your Caterpillar dealer for more information.

4. Remove the drain plug.
5. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris from the inside and from the outside of the core.

**Note:** Do not use high pressure when the fins are cleaned. High pressure can damage the fins.

6. Wash the core with hot, soapy water.
7. Flush the core thoroughly in order to remove residue and remaining debris. Flush the core with clean, fresh water until the water that is exiting the core is clear and free of debris.

### 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.

8. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.
9. Prior to installation, inspect any O-rings or seals for damage. If necessary, replace the O-rings or seals.
10. Inspect the core for trapped debris and cleanliness. If it is necessary, remove the debris and repeat the cleaning procedure.
11. Inspect the core for damage and perform a pressure test in order to detect leaks. Many shops that service radiators are equipped to perform pressure tests.
12. Install the core. Refer to Disassembly and Assembly Manual, "Aftercooler - Remove and Install" for the procedure.

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

i02566367

## Air Shutoff - Test (Engines That Are Equipped with ADEM II or ADEM III Engine Control Modules)

SMCS Code: 1078-081

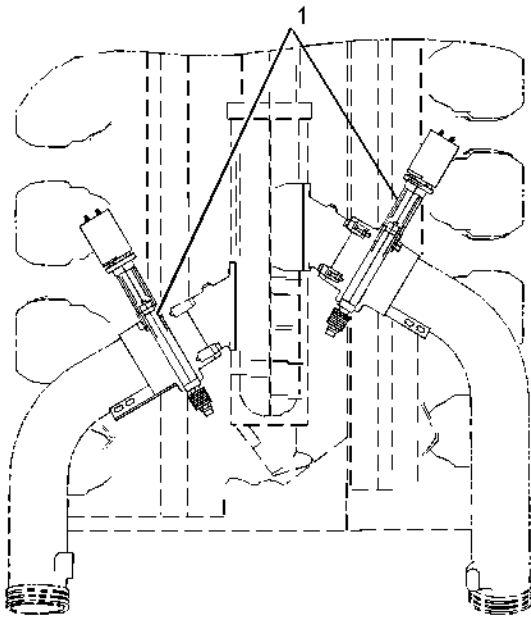


Illustration 38

g01285348

Typical air shutoffs on a 3500B engine

(1) Air shutoffs

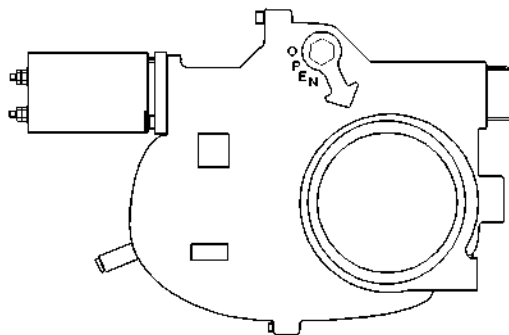


Illustration 39

g01285609

Left hand side air shutoff in the OPEN position

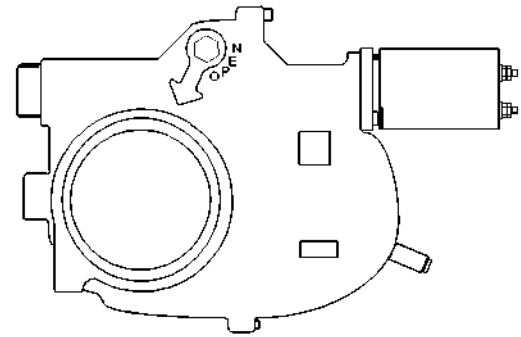


Illustration 40

g01285610

Right hand side air shutoff in the OPEN position

Refer to the Troubleshooting Guide, "Air Shutoff System" information in your Service Manual for further information about the electrical system for the air shutoff system.

### Engines That Are Equipped with ADEM II Engine Control Modules

**Note:** Do not start the engine. Ensure that the engine control is in the "OFF" position.

1. Ensure that both air shutoff gates are latched in the OPEN position and ensure that both air shutoff switches are connected. Turn on the power to the engine control panel. Both air shutoff gates should remain open. If both air shutoff gates do not remain open, check the wiring for the air shutoff switches.
2. With the power for the engine control panel in the ON position, activate the "EMERGENCY STOP" switch. Both of the air shutoff gates should close. If both air shutoff gates close, proceed to step 3. If both air shutoff gates do not close, check the wiring for the air shutoff switches and check the wiring for the solenoids. Activate the "EMERGENCY STOP" switch again. When both air shutoff gates close, proceed to step 3.
3. Turn the power to the engine control panel to the OFF position. Ensure that the "EMERGENCY STOP" switch is in the RUN position. Latch only the right side air shutoff gate to the OPEN position. Turn the power for the engine control panel to the ON position. The right side air shutoff gate should close. If the right side air shutoff closes, proceed to step 4. If the right side air shutoff gate does not close, check the air shutoff switch for the right side air shutoff and check the wiring for the right side air shutoff. When the right side air shutoff closes, proceed to step 4.

4. Turn the power for the engine control panel to the OFF position. Latch only the left side air shutoff gate to the OPEN position. Turn the power for the engine control panel to the ON position. The left side air shutoff gate should close. If the left side air shutoff gate does not close, check the switch and the wiring for the left side air shutoff .

**Note:** Testing is only complete when the engine successfully passes step 1 through step 4.

5. Operate the engine normally. Ensure that the air shutoff gates continue to be latched.

## Engines That Are Equipped with ADEM III Engine Control Modules

**Note:** Do not start the engine. Ensure that the engine control is in the "OFF" position.

1. Ensure that both air shutoff gates are latched in the OPEN position. Ensure that both air shutoff switches are connected. Turn the power for the engine control panel to the ON position. The air shutoff gates should remain in the OPEN positions. If the air shutoff gates do not remain in the OPEN positions, check the wiring for the air shutoffs. When step 1 has been successfully completed, proceed to step 2.
2. While the power for the engine control panel is in the ON position, activate the "EMERGENCY STOP" switch . Both air shutoff gates should close. If the air shutoff gates do not close, check the wiring for the air shutoffs and the wiring for the solenoids. Both air shutoff gates must close before proceeding to step 3.
3. Turn the power for the engine control panel to the OFF position. Reset the "EMERGENCY STOP" switch to the RUN position. Reset the right side air shutoff to the OPEN position. Turn the power for the engine control panel to the ON position. Select "Run/Start" on the engine control panel. **The engine should fail to start.** If the engine does not start, proceed to 4. If the engine starts, turn off the engine. Check the right side air shutoff. Check the wiring for the right side air shutoff. Retest the air shutoff. When the procedure in 3 is followed and the engine fails to start, proceed to 4.

4. Reset the "EMERGENCY STOP" switch to the RUN position. Set the power for the engine control panel to the ON position. Activate the "EMERGENCY STOP" switch . Both air shutoff gates should close. Set power for the engine control panel to the OFF position. Reset the "EMERGENCY STOP" switch to the RUN position. Reset the left side air shutoff to the OPEN position. Turn the power for the engine control panel to the ON position. Select "START/RUN" on the engine control panel. **The engine should fail to start.** If the engine does not start, proceed to 5. If the engine starts, turn off the engine. Check the left side air shutoff. Check the wiring for the left side air shutoff. Retest the left side air shutoff. When the procedure in step 4 is followed and the engine fails to start, proceed to 5.

5. Turn the power for the engine control panel to the ON position. Reset both air shutoffs. Start the engine. Disconnect only the right side air shutoff. Both air shutoff gates should close. The engine should shut down. If the engine does not shut down, use the "EMERGENCY STOP" switch to stop the engine. Check the wiring for both air shutoffs. Use the above procedure in order to retest the right side air shutoff. When the procedure in step 5 is followed and results of the test are successful, reconnect the right side air shutoff. Reset both air shutoffs.
6. Turn the power for the engine control panel to the ON position. Reset both air shutoffs. Start the engine. Disconnect only the left side air shutoff. Both air shutoff gates should close. The engine should shut down. If the engine does not shut down, use the "EMERGENCY STOP" switch to stop the engine. Check the wiring for both air shutoffs. Use the above procedure in order to retest the left side air shutoff. When the procedure in 6 is followed and the results of the test are successful, reconnect the right side air shutoff. Reset both air shutoffs.
7. Testing is complete only when the engine successfully passes steps 1 through 6.
8. Reset both air shutoffs. Ensure that the "EMERGENCY STOP" switch has been reset. Operate the engine normally.

i02567801

## Air Shutoff Damper - Remove/Check

**SMCS Code:** 1078-011; 1078-535

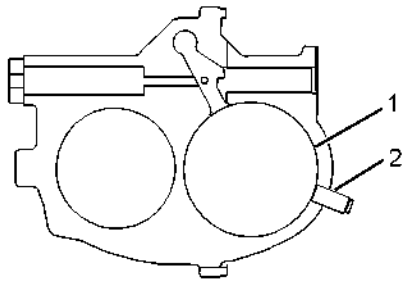


Illustration 41

g01286554

Typical air shutoff (back view)

- (1) Air shutoff gate
- (2) Damper assembly

The vibration damper on the air shutoff minimizes the vibration of the air shutoff gate when the engine is operating and the air shutoff gate is in the latched position. The components of the damper assembly must be removed in order to ensure correct performance of the damper.

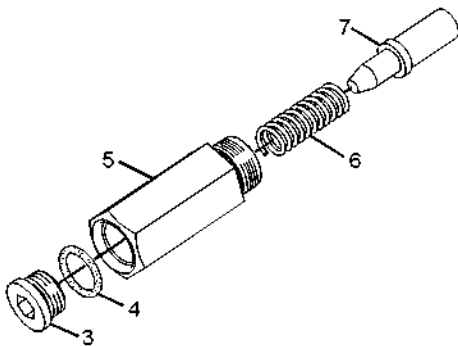


Illustration 42

g01286567

Damper assembly

- (3) Plug
- (4) Seal ring
- (5) Housing
- (6) Spring
- (7) Plunger

1. The body of the damper should not be loosened or removed from the air shutoff when the plunger is removed. In order to remove the plunger without loosening or removing the damper, unscrew the plug with the following tools: a 6.35 mm (0.25 inch) Allen wrench and an open end wrench .

2. Check the seal ring for damage or wear. If necessary, replace the seal ring.
3. Inspect the internal parts of the vibration damper for wear or damage. Clean the components with 138 - 8440 component cleaner.

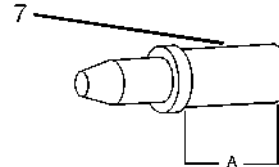


Illustration 43

g01286606

Damper plunger

4. Remove the plunger from the spring. Visually inspect the exposed end of the plunger for dirt, fouling, damage, and wear. If distance "A" is less than 18.3 mm (0.72 inch) or if a visual inspection reveals dirt, fouling, damage, or wear on the active end of the plunger, replace the plunger. Insert the tapered end of a clean, undamaged plunger into the spring. Install the open end of the spring into the plug. Apply 9S - 3263 thread lock or apply 9S - 4030 thread lock onto the threads of the plug. Screw the assembly into the damper body. The thread lock should cure for a minimum of 1 hour before the air shutoff is used.

i01076477

## Air Starting Motor - Inspect

**SMCS Code:** 1451-040

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

**WARNING**

Personal injury or death can result from improperly checking for a leak.

Always use a board or cardboard when checking for a leak. Escaping air or fluid under pressure, even a pin-hole size leak, can penetrate body tissue causing serious injury, and possible death.

If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

Inspect all of the components in the air circuit for the starting motor. Inspect all of the air lines and connections for leaks.

If damaged teeth are found, the air circuit for the starting motor must be examined in order to determine the cause of the problem.

## Removal and Installation of the Starting Motor

Refer to the Service Manual, "Disassembly and Assembly" module for information on removing the starting motor and installing the starting motor.

Consult your Caterpillar dealer for assistance and/or for options on replacement of the starting motor.

i02654935

## Air Starting Motor Lubricator Bowl - Clean

**SMCS Code:** 1451-070

If the engine is equipped with an air starting motor, use the following procedure:

**WARNING**

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

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

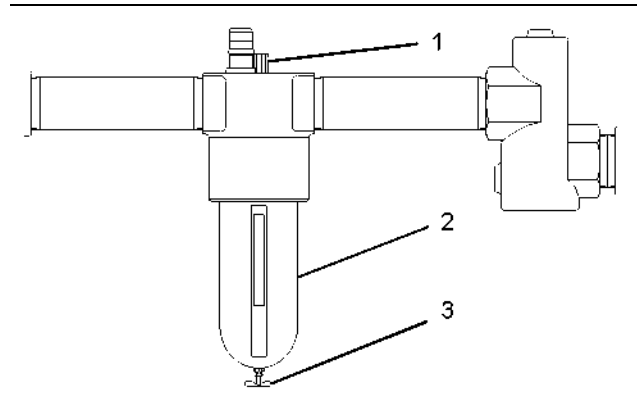


Illustration 44

g01333332

- (1) Filler plug
- (2) Bowl
- (3) Drain valve

2. Slowly loosen filler plug (1) in order to release the pressure from the lubricator.

### NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

- 3. Place a suitable container under bowl (2) and open drain valve (3) in order to drain the oil from the bowl.
- 4. Remove bowl (2). Clean the bowl with warm water.
- 5. Dry the bowl. Inspect the bowl for cracks. If the bowl is cracked, replace the damaged bowl with a new bowl. Inspect the gasket. If the gasket is damaged, replace the gasket.
- 6. Install the bowl.
- 7. Make sure that drain valve (3) is closed.
- 8. For instructions on filling the lubricator, see this Operation and Maintenance Manual, "Air Starting Motor Lubricator Oil Level - Check" topic.



i02654969

## 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.

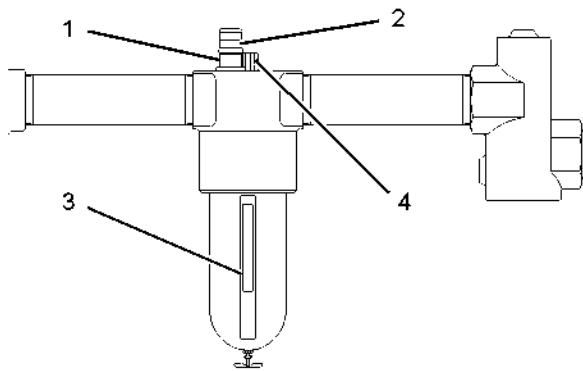


Illustration 45

g01333366

1. Observe the oil level in sight gauge (3). If the oil level is less than 1/2, add oil to the lubricator bowl.

### **WARNING**

**Personal injury can result from removing hoses or fittings in a pressure system.**

**Failure to relieve pressure can cause personal injury.**

**Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.**

2. Ensure that the air supply to the lubricator is OFF. Slowly loosen filler plug (4) in order to release pressure from the lubricator bowl.
3. Remove filler plug (4). Pour oil into the lubricator bowl. Use nondetergent SAE 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 filler 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).

**Note:** Some lubricators have an adjustment screw rather than a knob.

3. If necessary, adjust the lubricator in order to release from one to three drops of oil per second. To increase the rate, turn knob (2) counterclockwise. To decrease the rate, turn the knob clockwise.

i00351324

## Air Tank Moisture and Sediment - Drain

**SMCS Code:** 1466-543-M&S

Moisture and sediment in the air starting system can cause the following conditions:

- Freezing
- Corrosion of internal parts
- Malfunction of the air starting system

### **WARNING**

**When opening the drain valve, wear protective gloves, a protective face shield, protective clothing, and protective shoes. Pressurized air could cause debris to be blown and result in personal injury.**

1. Open the drain valve that is on the bottom of the air tank. Allow the moisture and sediment to drain.
2. Close the drain valve.

i02256018

## Auxiliary Water Pump - Inspect

**SMCS Code:** 1371-040; 1371

Refer to the Disassembly and Assembly Manual for the engine in order to perform the disassembly of the auxiliary water pump.

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

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

There are different types of pumps. Some pumps will have a cover that is bolted to the main pump body. Some pumps will have a clamp that holds the front part of the pump body to the main part of the pump body. The cover or the front part of the pump body must be removed in order to inspect the pump.

## Pumps with a Cover

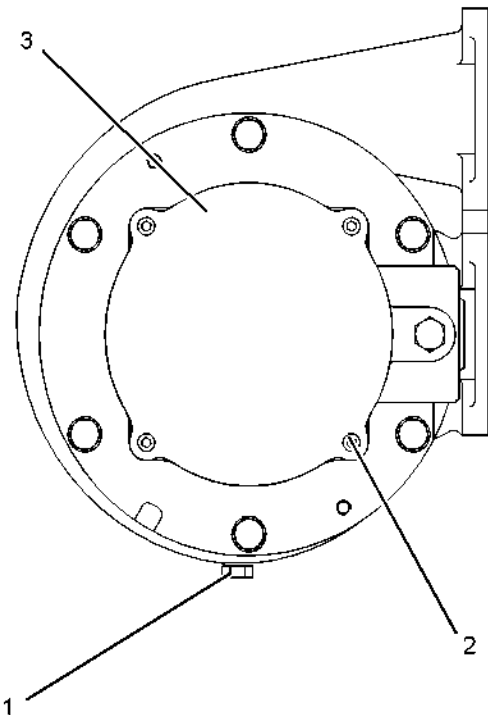


Illustration 46

g01136356

- (1) Plug
- (2) Bolt
- (3) Cover

1. Remove plug (1) and drain the water out of the pump.
2. Remove bolts (2) and cover (3).
3. Inspect the priming impeller, the priming impeller wear plates and the impeller for wear or damage. Inspect the pump housing for wear, damage or buildup.

4. Inspect the pump shaft and the impeller for excessive axial movement.
5. If wear or damage is found, replace the components which are worn or damaged. Use the proper repair kit for the pump.

## Pumps with a Clamp

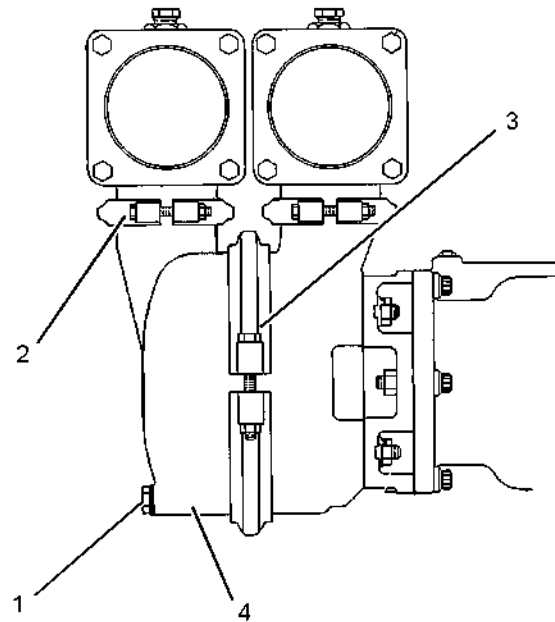


Illustration 47

g01136382

- (1) Plug
- (2) Clamp
- (3) Clamp
- (4) Front part of the pump body

1. Remove plug (1) and drain the water out of the pump.
2. Remove the water line and clamp (2), if necessary.
3. Loosen clamp (3) and remove the front part of the pump body (4).
4. Inspect the impeller, the wear plates and the wear ring for wear or damage. Inspect the pump housing for wear, damage or buildup.
5. Inspect the pump shaft and the impeller for excessive axial movement.
6. If wear or damage is found, replace the components which are worn or damaged. Use the proper repair kit for the pump.

i01041029

i02601752

## Batteries - Replace

SMCS Code: 1401-510

### WARNING

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

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

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 connecting the cables, 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.

## Battery Electrolyte Level - Check

SMCS Code: 1401-535-FLV

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing.

### WARNING

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

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

If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.
2. Check the condition of the electrolyte with the 245-5829 Coolant Battery Tester Refractometer.
3. Keep the batteries clean.

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

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

Thoroughly rinse the battery case with clean water.

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

i01492654

## Battery or Battery Cable - Disconnect

SMCS Code: 1401; 1402-029

### WARNING

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

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

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

i02229322

## Belts - Inspect/Adjust/Replace

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

### Inspection

Inspect the alternator belt and any accessory belts for wear and for cracking. Replace the belts if the belts are not in good condition.

Check the belt tension according to the information in the Service Manual, "Specifications".

Slippage of loose belts can reduce the efficiency of the driven components. Vibration of loose belts can cause unnecessary wear on the following components:

- Belts
- Pulleys
- Bearings

If the belts are too tight, unnecessary stress is placed on the components. This reduces the service life of the components.

### Replacement

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

### Alternator Belt Adjustment

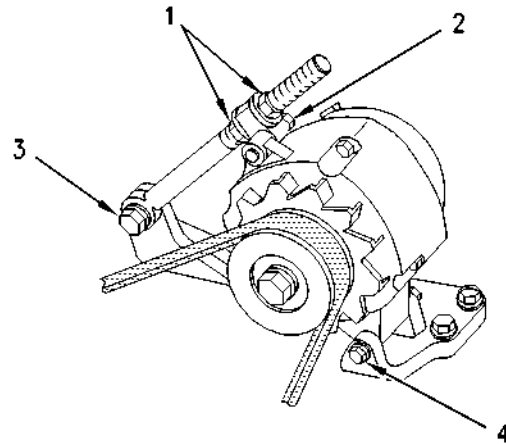


Illustration 48

g00960176

- (1) Adjusting nuts
- (2) Mounting bolt
- (3) Mounting bolt
- (4) Mounting bolt

1. Remove the drive belt guard.
2. Loosen mounting bolts (2), (3), and (4). Loosen adjusting nuts (1).
3. Turn adjusting nuts (1) in order to increase or decrease the drive belt tension.
4. Tighten adjusting nuts (1). Tighten mounting bolts (2), (3), and (4).
5. Reinstall the drive belt guard.

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

i02756549

## Camshaft Roller Followers - Inspect

**SMCS Code:** 1209-040

For instructions on disassembly and assembly of the valve lifter group, see the Service Manual, "Disassembly and Assembly" module.

See Reuse and Salvage Guidelines, SEBF8146, "Visual Inspection of Camshafts", and inspect the following components for wear at each metal to metal contact point:

- Rollers for the valve lifters
- Camshaft

Inspect each roller for wear, excessive movement, and end play.

If excessive wear or other signs of deterioration are found, replace the damaged components.

i02576503

## Centrifugal Oil Filter - Inspect

**SMCS Code:** 1328-040

### WARNING

Hot oil and components can cause personal injury.

Do not allow hot oil or components to contact skin.

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

### NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

Table 33

Required Tools			
Tool	Part Number	Part Description	Qty
A	185-3630	Strap Wrench Assembly	1
B	8T-0890	Puller Group	1
C	8T-5096	Dial Indicator Group	1

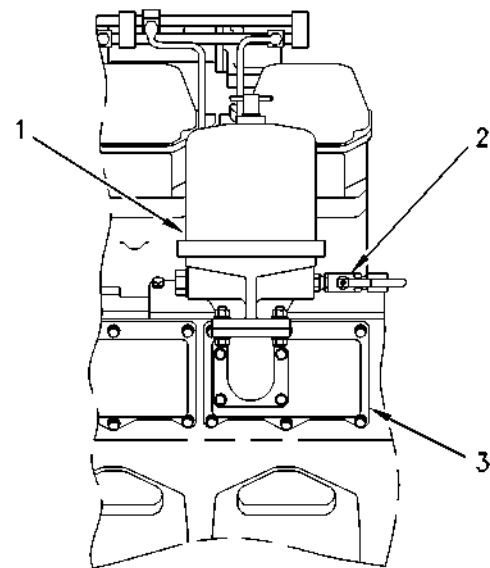


Illustration 49

g00810377

- (1) Centrifugal oil filter
- (2) Valve
- (3) Camshaft cover

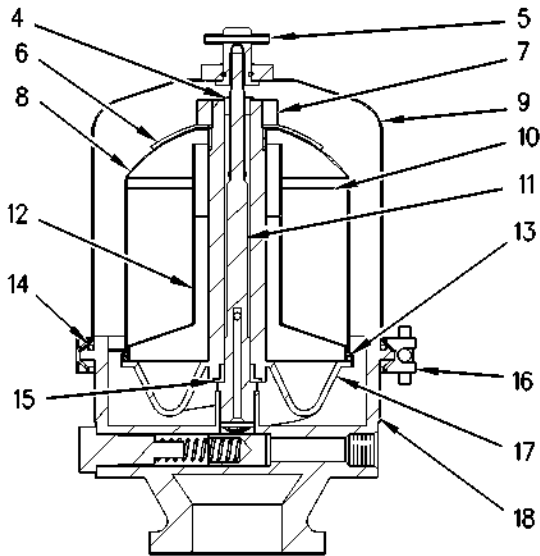


Illustration 50

g00810333

- (4) Bearing
- (5) Nut
- (6) Stiffener plate
- (7) Nut
- (8) Rotor cover
- (9) Cover
- (10) Paper liner
- (11) Spindle
- (12) Stand tube
- (13) O-ring
- (14) O-ring
- (15) Bearing
- (16) Clamp
- (17) Rotor base
- (18) Filter body

1. Close valve (2) to centrifugal oil filter (1).
2. Loosen clamp (16) and nut (5). Remove cover (9) from filter body (18).
3. Remove O-ring seal (14) from the body.
4. Remove the rotor assembly from spindle (11). Lift the rotor assembly carefully so the bearings are not damaged.
5. Use tool (A) to hold the rotor assembly and remove nut (7).
6. Remove stiffener plate (6).
7. Use tool (B) to remove rotor cover (8) from rotor base (17). Remove O-ring seal (13) from the base. Remove paper liner (10) from the rotor cover. Properly dispose of the paper liner. Use a plastic scraper to clean out the inside of rotor cover (8).
8. Remove stand tube (12) from rotor base (17) and clean the stand tube.

9. Clean the nozzles in rotor base (17). Do not enlarge the nozzles.
10. Inspect bearings (4) and (15) for excessive wear.
11. Inspect spindle (11) for excessive wear.
12. If there is minimal wear to bearing (4), bearing (15), and spindle (11) go to step 14. If there is considerable wear to bearing (4), bearing (15), and spindle (11) go to step 13.
13. Use tool (C) to measure the clearances between the bearing (4) and bearing (15) and spindle (6).

The maximum clearance between bearing (4) and spindle (11) is 0.25 mm (0.010 inch).

The maximum clearance between bearing (15) and spindle (11) is 0.20 mm (0.008 inch).

If the rotor bearings and the spindle are not within specifications, replace the parts.

**Note:** The spindle and the filter body are replaced as a complete assembly. The rotor assembly is replaced as a complete assembly.

Before you assemble the centrifugal oil filter, thoroughly clean all of the parts and inspect all of the parts. Replace parts that are damaged or worn.

#### NOTICE

Ensure that all of the rotor components are thoroughly clean before assembling the rotor. Failure to do so can cause an out of balance condition that can cause rapid wear to the bearings and the spindle.

14. Install stand tube (12) on rotor base (17).
15. Install a new paper liner (10) in rotor cover (8). Place O-ring seal (13) on rotor base (17). Position rotor cover (8) on rotor base (17).
16. Install stiffener plate (6).
17. Use tool (A) to hold the rotor assembly and install nut (7).
18. Install the rotor assembly on spindle (11). Install the rotor assembly carefully so the bearings are not damaged.
19. Install O-ring seal (14) on filter body (18).
20. Install cover (9) and clamp (16) on filter body (18). Tighten clamp (16) and nut (5).
21. Open valve (2) to centrifugal oil filter (1).

22. Check the centrifugal oil filter for leaks. Feel the centrifugal oil filter for excessive vibration.

i02576516

## Cooling System Coolant (DEAC) - Change

SMCS Code: 1350-044

### NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

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

- The engine overheats frequently.
- The coolant is foaming.
- Oil or fuel has entered the cooling system and the coolant is contaminated.

## Drain the Cooling System

### 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. Ensure that the engine will not start when the cooling system is drained.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

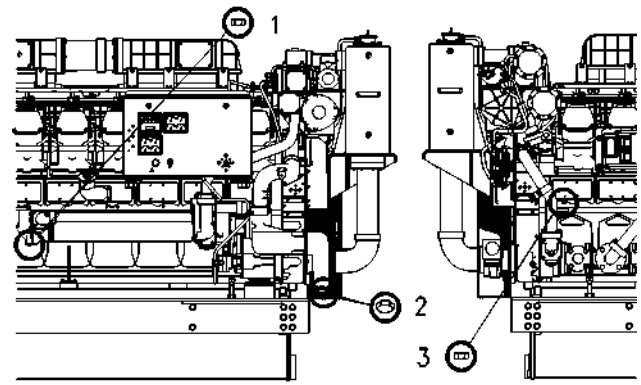


Illustration 51

g00799692

Location of the cooling system drain plugs

- (1) Oil cooler
- (2) Jacket water pump
- (3) Engine block

**Note:** If the engine has a jacket water heater, drain the coolant from the heater.

3. Open the cooling system drain valves (if equipped). Remove the cooling system drain plugs. Allow the coolant to drain.

### NOTICE

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

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

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

## Clean the Cooling System

### 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.

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.

2. Close the cooling system drain valves (if equipped). Clean the cooling system drain plugs and install the cooling system 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 .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 the engine. Operate the engine for a minimum of 30 minutes with a coolant temperature of at least 82 °C (180 °F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped). Remove the cooling system drain plugs. Allow the water to drain.

---

**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.

---

6. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain valves (if equipped). Clean the cooling system drain plugs and install the cooling system drain plugs.

## Cleaning a Cooling System that has Heavy Deposits or Plugging

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

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.
2. Close the cooling system drain valves (if equipped). Clean the cooling system drain plugs and install the cooling system drain plugs.

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

4. Start the engine. Operate the engine for a minimum of 90 minutes with a coolant temperature of at least 82 °C (180 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped). Remove the cooling system drain plugs. Allow the water to drain.

---

**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.

---

6. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain valves (if equipped). Clean the cooling system drain plugs and install the cooling system drain plugs.

## Fill the Cooling System

**Note:** For information about the proper coolant to use, see this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section). For the capacity of the cooling system, see this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section).

---

**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. After filling the cooling system, do not install the cooling system filler cap.
2. Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Allow the coolant to warm and allow the coolant level to stabilize. Stop the engine.



3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.
4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets of the cooling system filler cap are damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gaskets of the cooling system filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not maintain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

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## Cooling System Coolant (ELC) - Change

SMCS Code: 1350-044-NL

### NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

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

## Drain the Cooling System

### 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. Ensure that the engine will not start when the cooling system is drained.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

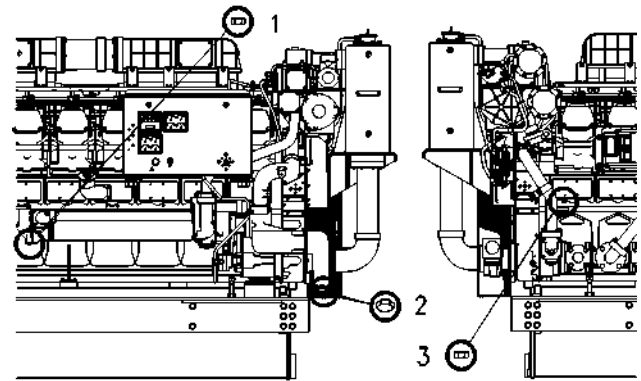


Illustration 52

g00799692

Location of the cooling system drain plugs

- (1) Oil cooler
- (2) Jacket water pump
- (3) Cylinder block

3. Open the cooling system drain valves (if equipped). Remove the cooling system drain plugs. Allow the coolant to drain.

### NOTICE

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

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

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

## Clean the Cooling System

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.
2. Close the cooling system drain valves (if equipped). Clean the drain plugs and 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 clean water. Install the cooling system filler cap. Operate the engine until the temperature reaches 49 °C (120 °F) to 66 °C (150 °F).
4. Stop the engine and allow the engine to cool. Ensure that the engine will not start when the cooling system is drained. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
5. Open the cooling system drain valves (if equipped). Remove the drain plugs. Allow the coolant to drain. Flush the cooling system with clean water. Close the cooling system drain valves (if equipped). Install the drain plugs.
6. Repeat Steps 3, 4, and 5.

## Fill the Cooling System

---

### 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 Cat ELC (Extended Life Coolant). After filling the cooling system, do not install the cooling system filler cap.
2. Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Allow the ELC to warm and allow the coolant level to stabilize. Stop the engine.

3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.
4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets of the cooling system filler cap are damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gaskets of the cooling system filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not maintain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02482066

## Cooling System Coolant Extender (ELC) - Add

**SMCS Code:** 1352-544-NL

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

---

### NOTICE

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

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

---

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

**WARNING**

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

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

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

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

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

**NOTICE**

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

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

Dispose of all fluids according to local regulations and mandates.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. It may be necessary to drain enough coolant from the cooling system in order to add the Cat ELC Extender.
3. Add Cat ELC Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" article for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i02158408

**Cooling System Coolant Level - Check**

SMCS Code: 1350-535-FLV

**WARNING**

Climbing equipment may be required to access this service point. Refer to the Operation and Maintenance Manual, "Mounting and Dismounting" topic for safety information.

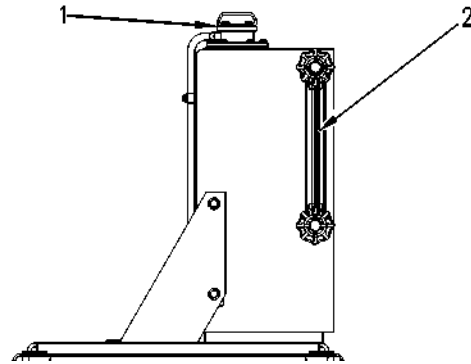
**Engines That Are Equipped With a Sight Gauge**

Illustration 53

g00750429

- (1) Filler cap  
(2) Sight gauge

If the engine is equipped with a sight gauge, observe the position of the coolant in the sight gauge. At normal operating temperature, the proper coolant level is in the upper half of the sight gauge. If the coolant level is low, add the proper coolant mixture.

**Engines That Are Not Equipped With a Sight Gauge****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.

Check the coolant level when the engine is stopped and cool. Check the coolant level only after the engine has been stopped and the cooling system filler cap is cool enough to touch with your bare hand.

Remove the cooling system filler cap slowly in order to relieve any pressure. Maintain the coolant within 13 mm (0.5 inch) below the bottom of the filler pipe.

## Add Coolant

**Note:** For the proper coolant mixture to use, see this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section).

1. Stop the engine. Allow the engine to cool.
2. Remove the cooling system filler cap slowly in order to relieve any pressure. Pour the proper coolant mixture into the filler pipe.

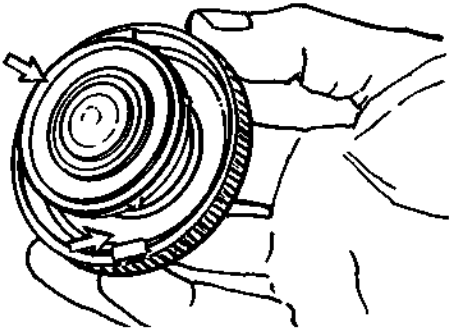


Illustration 54  
 Gaskets

g00103639

3. 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.
4. Start the engine. Inspect the cooling system for leaks.

i02837191

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

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

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

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

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

Table 34

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

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

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

### NOTICE

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

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

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

Use the following guidelines for proper sampling of the coolant:

- Complete the information on the label for the sampling bottle before you begin to take the samples.
- Keep the unused sampling bottles stored in plastic bags.

i02839449

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

Submit the sample for Level 1 analysis.

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

i01987714

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

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

### NOTICE

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

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

Submit the sample for Level 2 analysis.

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

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

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

### WARNING

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

### NOTICE

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 blockage of the heat exchanger, overheating, and/or accelerated wear of the water pump seal.

Do not exceed the recommended amount of supplemental coolant additive concentration.

### NOTICE

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

Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog" and to Special Publication, GECJ0003, "Cat Shop Supplies and Tools" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to applicable regulations and mandates.

**Note:** Caterpillar recommends an S-O-S coolant analysis (Level 1).

## Cooling Systems that Use Conventional Coolant

This maintenance procedure is required for conventional coolants such as DEAC. **This maintenance is NOT required for cooling systems that are filled with Extended Life Coolant.**

### Test the Concentration of the SCA

#### NOTICE

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

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit.

### Add the SCA, If Necessary

#### 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.
2. If necessary, drain some coolant in order to allow space for the addition of the SCA.
3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic. The proper concentration of SCA depends on the type of coolant that is used. For the proper concentration of SCA, refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations".
4. Clean the cooling system filler cap. Install the cooling system filler cap.

## Cooling Systems that Use Water and SCA

### Test the Concentration of the SCA

Test the concentration of the SCA with a 298-5311 Coolant Nitrite Test Kit for SCA or perform an S·O·S Coolant Analysis. The test kit includes the following items: a tool for the testing, 30 ampoules for testing nitrite, instructions, and a case. 294-7420 Test Kit contains the refill ampoules for the 298-5311 Coolant Nitrite Test Kit. Use the instructions that are included with the test kit in order to properly conduct the testing.

Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule" for the times at which the procedures should be conducted. Test the concentration of the SCA more frequently if more frequent testing is indicated by the results of the S·O·S Coolant Analysis.

#### NOTICE

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

### Add the SCA, If Necessary

#### 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.
2. If necessary, drain some coolant in order to allow space for the addition of the SCA.
3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic. For the proper concentration of SCA, refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations".
4. Clean the cooling system filler cap. Install the cooling system filler cap.

i02623972

## Cooling System Water Temperature Regulator - Replace

**SMCS Code:** 1355-510

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

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

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

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

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### NOTICE

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

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

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

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

---

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

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

i02871204

## 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 torsional vibrations.

A damper that is hot may be the result of excessive torsional vibration, worn bearings, or damage to the damper. Use an infrared thermometer to monitor the temperature of the damper during operation. Follow the instructions that are included with the infrared thermometer. If the temperature reaches 100°C (212 °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, and smooth.

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.
- The crankshaft bearings are showing excessive wear.
- There is a large amount of gear train wear that is not caused by a lack of oil.

## Dampers With Sampling Ports

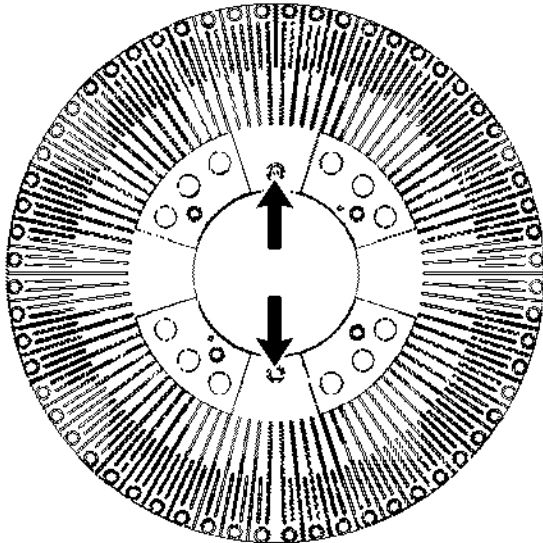


Illustration 55

g00819045

Some dampers have ports for fluid samples. If the damper has no external damage, collect a sample of the damper fluid. The fluid should be analyzed in order to check for a loss of viscosity. Use the results of the analysis to determine if the damper should be rebuilt or replaced. Kits for fluid samples are available from the address that follows. Return the kits to the same address for analysis.

Hasse & Wrede GmbH  
Georg-Knorr-Straße 4  
12681 Berlin  
Germany  
Phone: +49 30 9392-3135  
Fax: +49 30 9392-7-3135  
Alternate phone: +49 30 9392-3156  
Alternate fax: +49 30 9392-7-3156

The typical limit for the degradation of the damper fluid viscosity that is used by Hasse & Wrede GmbH is 20 percent for the majority of applications. The reports from Hasse & Wrede should indicate that the fluid samples meet this viscosity limit.

## Dampers Without Sampling Ports

Some dampers do not have a port for a fluid sample. These dampers must be rebuilt or the dampers must be replaced when one of the following criteria has been met:

- The damper has been operated for 20000 hours.
- The engine is undergoing a major overhaul.

## Removal and Installation

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

i00449093

## Driven Equipment - Check

**SMCS Code:** 3279-535

To minimize bearing problems and vibration of the engine crankshaft and the driven equipment, the alignment between the engine and driven equipment must be maintained properly.

Check the alignment according to the instructions that are provided by the following manufacturers:

- Caterpillar
- OEM of the coupling
- OEM of the driven equipment

i00935098

## Driven Equipment - Inspect/Replace/Lubricate

**SMCS Code:** 3279-040

Observe the driven equipment during operation. Look for the following items:

- Unusual noise and vibration
- Loose connections
- Damaged parts

Perform any maintenance that is recommended by the OEM of the driven equipment. Refer to the literature of the OEM of the driven equipment for the following service instructions.

- Inspection
- Lubricating grease and lubricating oil requirements
- Specifications for adjustment
- Replacement of components
- Requirements for ventilation



i01076519

i01646701

## Electric Starting Motor - Inspect

**SMCS Code:** 1453-040

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

Problems with the electric starting motor can be caused by the following conditions: malfunction of the solenoid and malfunction of the electric starting system.

Inspect the electrical system for the following conditions:

- Loose connections
- Corrosion
- Wires that are worn or frayed
- Cleanliness

Make repairs, if necessary.

## Removal and Installation of the Starting Motor

Refer to the Service Manual, "Disassembly and Assembly" module for information on removing the starting motor and installing the starting motor.

Consult your Caterpillar dealer for assistance and/or for options on replacement of the starting motor.

## Engine - Clean

**SMCS Code:** 1000-070



**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.

i01553486

## Engine Air Cleaner Element (Dual Element) - Clean/Replace

**SMCS Code:** 1051; 1054-037

### NOTICE

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

**NOTICE**

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

## Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- 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.

### Dual Element Air Cleaners

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element. The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable or washable. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element. When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

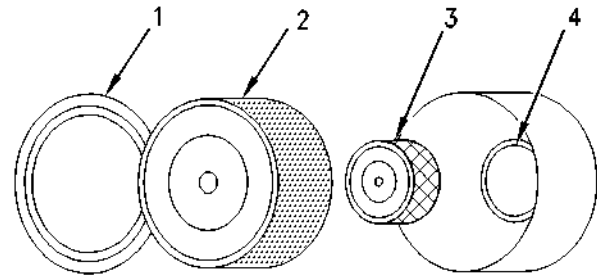


Illustration 56

g00736431

- (1) Cover
- (2) Primary air cleaner element
- (3) Secondary air cleaner element
- (4) Turbocharger air inlet

1. Remove the cover. Remove the primary air cleaner element.
2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.

**Note:** Refer to "Cleaning the Primary Air Cleaner Elements".

3. Cover the turbocharger air inlet with tape in order to keep dirt out.
4. Clean the inside of the air cleaner cover and body with a clean, dry cloth.
5. Remove the tape for the turbocharger air inlet. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.
6. Install the air cleaner cover.
7. Reset the air cleaner service indicator.

## Cleaning the Primary Air Cleaner Elements

### NOTICE

Caterpillar recommends certified air filter cleaning services that are available at Caterpillar dealers. The Caterpillar cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. When the primary air cleaner element is cleaned, check for rips or tears in the filter material. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean primary air cleaner elements while dirty elements are being cleaned.

### NOTICE

Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the primary air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean primary air cleaner elements:

- Pressurized air
- Vacuum cleaning

## Pressurized Air

Pressurized air can be used to clean primary air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

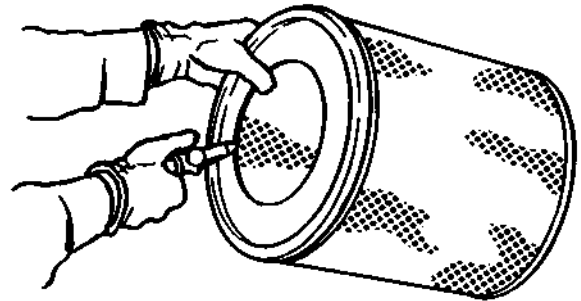


Illustration 57

g00281692

**Note:** When the primary air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of air directly at the primary air cleaner element. Dirt could be forced further into the pleats.

**Note:** Refer to “Inspecting the Primary Air Cleaner Elements”.

## Vacuum Cleaning

Vacuum cleaning is a good method for cleaning primary air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

**Note:** Refer to “Inspecting the Primary Air Cleaner Elements”.

## Inspecting the Primary Air Cleaner Elements

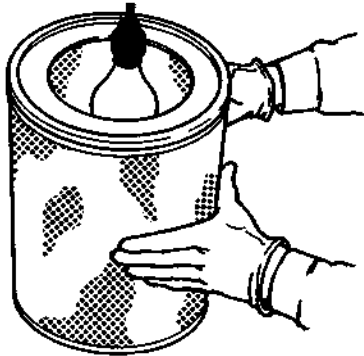


Illustration 58

g00281693

Inspect the clean, dry primary air cleaner element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the primary air cleaner element. Rotate the primary air cleaner element. Inspect the primary air cleaner element for tears and/or holes. Inspect the primary air cleaner element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the primary air cleaner element to a new primary air cleaner element that has the same part number.

Do not use a primary air cleaner element that has any tears and/or holes in the filter material. Do not use a primary air cleaner element with damaged pleats, gaskets or seals. Discard damaged primary air cleaner elements.

## Storing Primary Air Cleaner Elements

If a primary air cleaner element that passes inspection will not be used, the primary air cleaner element can be stored for future use.

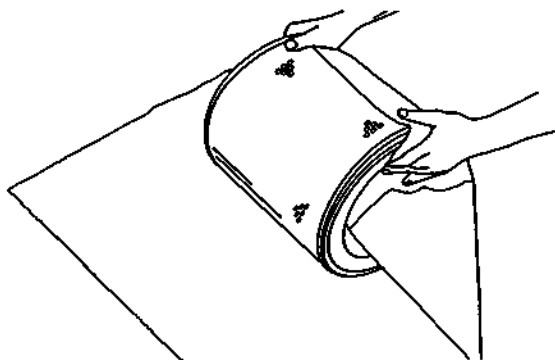


Illustration 59

g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the primary air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the primary air cleaner element into a box for storage. For identification, mark the outside of the box and mark the primary air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i01553508

## Engine Air Cleaner Element (Single Element) - Clean/Replace

**SMCS Code:** 1051; 1054-037

### NOTICE

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

### NOTICE

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

## Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.

- 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.

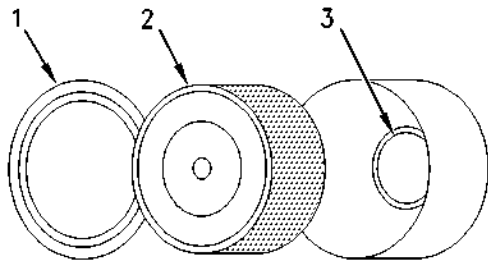


Illustration 60

g00735127

- (1) Cover  
(2) Air cleaner element  
(3) Turbocharger air inlet

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

**Note:** Refer to “Cleaning the Air Cleaner Elements”.

2. Cover the air inlet with tape in order to keep dirt out.
3. Clean the inside of the air cleaner cover and body with a clean, dry cloth.
4. Remove the tape for the air inlet. Install an air cleaner element that is new or cleaned.
5. Install the air cleaner cover.
6. Reset the air cleaner service indicator.

## Cleaning the Air Cleaner Elements

### NOTICE

Caterpillar recommends certified air filter cleaning services that are available at Caterpillar dealers. The Caterpillar cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

The air cleaner element can be used up to six times if the element is properly cleaned and inspected. When the air cleaner element is cleaned, check for rips or tears in the filter material. The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean air cleaner elements while dirty elements are being cleaned.

### NOTICE

Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean air cleaner elements:

- Pressurized air
- Vacuum cleaning

## Pressurized Air

Pressurized air can be used to clean air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

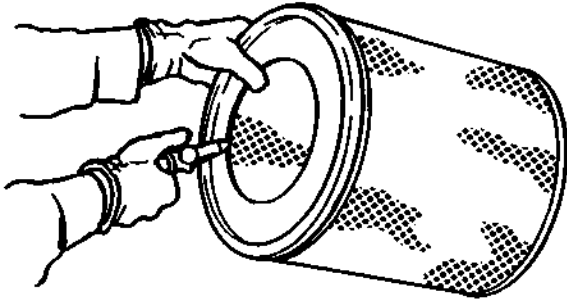


Illustration 61

g00281692

**Note:** When the air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of air directly at the air cleaner element. Dirt could be forced further into the pleats.

**Note:** Refer to "Inspecting the Air Cleaner Elements".

## Vacuum Cleaning

Vacuum cleaning is a good method for cleaning air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

**Note:** Refer to "Inspecting the Air Cleaner Elements".

## Inspecting the Air Cleaner Elements

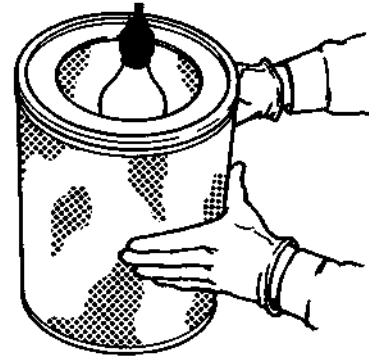


Illustration 62

g00281693

Inspect the clean, dry air cleaner element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the air cleaner element. Rotate the air cleaner element. Inspect the air cleaner element for tears and/or holes. Inspect the air cleaner element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the air cleaner element to a new air cleaner element that has the same part number.

Do not use an air cleaner element that has any tears and/or holes in the filter material. Do not use an air cleaner element with damaged pleats, gaskets or seals. Discard damaged air cleaner elements.

## Storing Air Cleaner Elements

If an air cleaner element that passes inspection will not be used, the air cleaner element can be stored for future use.

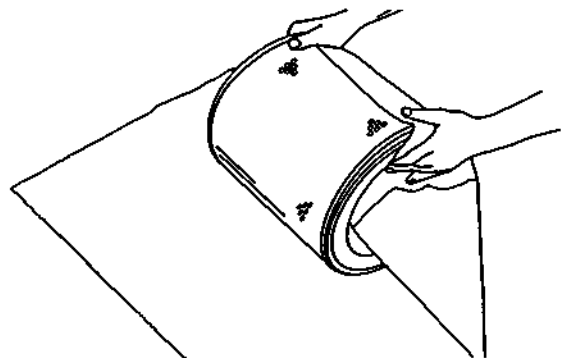


Illustration 63

g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the air cleaner element into a box for storage. For identification, mark the outside of the box and mark the air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i01397712

## Engine Air Cleaner Service Indicator - Inspect

**SMCS Code:** 7452-040

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

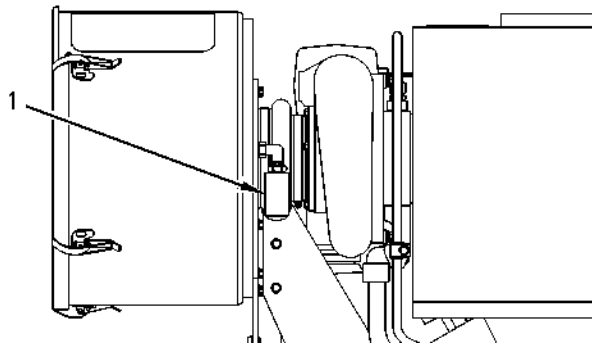


Illustration 64

g00736586

(1) Service indicator

Some engines may be equipped with a different service indicator.

Observe the service indicator. Clean the air cleaner element or replace the air cleaner element when the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.
- The air restriction reaches 6 kPa (25 inches of H<sub>2</sub>O).

### Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.

- Check the movement of the yellow core when the engine is accelerated to the engine rated rpm. The yellow core should latch approximately at the greatest vacuum that is attained.

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

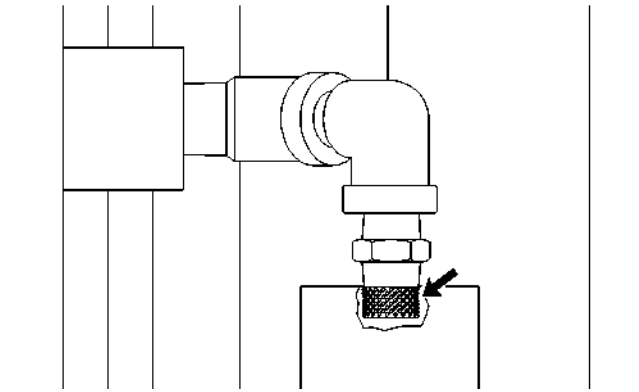


Illustration 65

g00351792

Porous filter

A porous filter is part of a fitting that is used for mounting of the service indicator. Inspect the filter for cleanliness. Clean the filter, if necessary. Use compressed air or a clean, nonflammable solvent.

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).

i01225429

## Engine Crankcase Breather - Clean

**SMCS Code:** 1317-070

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.

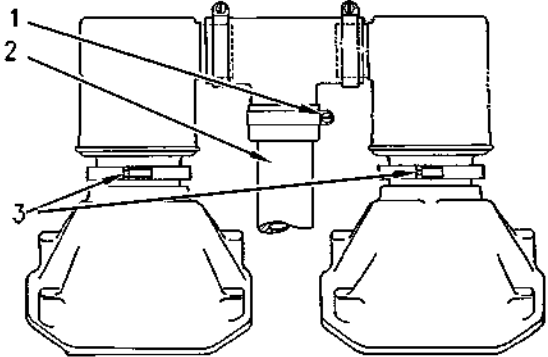


Illustration 66

g00597463

1. Loosen clamp (1). Slide the clamp down on tube (2).
2. Loosen clamps (3). Remove both breathers as a unit.

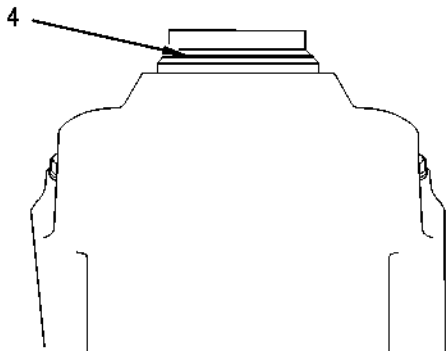


Illustration 67

g00597465

3. Remove O-ring seals (4) from the valve covers. Inspect the O-ring seals for good condition. Obtain new O-ring seals, if necessary.

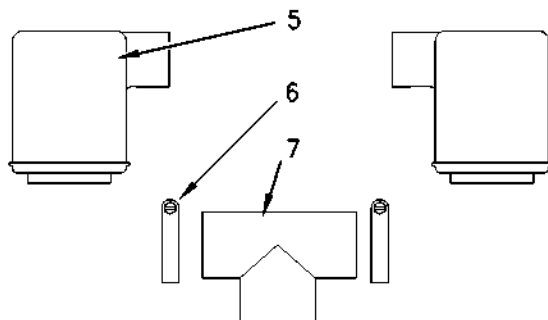


Illustration 68

g00597466

4. Remove two clamps (6). Remove both breathers (5) from hose tee (7).

Inspect the hose tee for cracks. If the tee is cracked, discard the old tee and obtain a new tee for installation.

5. Turn the breathers upside-down in order to inspect the condition of the breather elements.

Clean the breather elements with clean, nonflammable solvent. If the breather elements remain contaminated after the cleaning, discard the breathers and obtain new breathers. Do not attempt to disassemble the breathers.

Allow the breather elements to dry before installation.

**Note:** Coat the rubber parts with clean engine oil or petroleum jelly in order to make installation easier.

6. Place clamps (6) over the parts of hose tee (7) that will receive breathers (5). Install the breathers into the tee. Tighten the clamps to the torque that is listed in the Service Manual, "Specifications".
7. Coat O-ring seals (4) with clean engine oil. Place the O-ring seals on the valve covers.
8. Place clamps (3) around the parts of the breathers that will be attached to the valve covers. Install both breathers as a unit. Tighten the clamps.
9. Place clamp (1) on the part of the hose tee that will receive tube (2). Install the tube into the hose tee. Tighten the clamp to the torque that is listed in the Service Manual, "Specifications".

i01786814

## Engine Mounts - Check

**SMCS Code:** 1152-535

Misalignment of the engine and the driven equipment will cause extensive damage. Excessive vibration can lead to misalignment. Excessive vibration of the engine and the driven equipment can be caused by the following conditions:

- Improper mounting
- Loose bolts
- Deterioration of the isolators

Ensure that the mounting bolts are tightened to the proper torque. For standard torques, see Specifications, SENR3130, "Torque Specifications".



Ensure that the isolators are free of oil and contamination. Inspect the isolators for deterioration. Ensure that the bolts for the isolators are tightened to the proper torque.

Replace any isolator that shows deterioration. For more information, see the literature that is provided by the OEM of the isolators. Also see the Application and Installation Guide for the engine. Consult your Caterpillar dealer for assistance.

i02110431

## Engine Oil Filter Differential Pressure - Check

**SMCS Code:** 1308-535

Observe the oil filter differential pressure frequently during engine operation.



**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.

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

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

For instructions on replacement of the oil filter elements, see this Operation and Maintenance Manual, “Engine Oil and Filter - Change” topic.

i02418058

## Engine Oil Level - Check

**SMCS Code:** 1348-535-FLV

The most accurate check of the engine oil level is obtained when the engine is stopped.

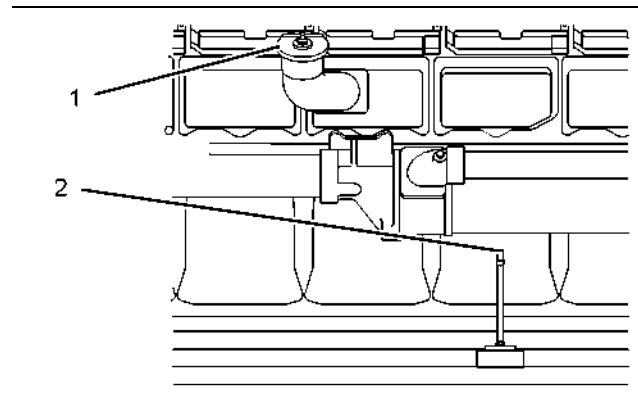


Illustration 69

g01208341

- (1) Filler cap  
(2) Engine oil level gauge (dipstick)

1. Remove filler cap (1) in order to ensure that the crankcase pressure is equal to the atmospheric pressure.

Excess pressure or a slight vacuum will affect engine oil level that is measured.

2. Ensure that engine oil level gauge (2) is seated.

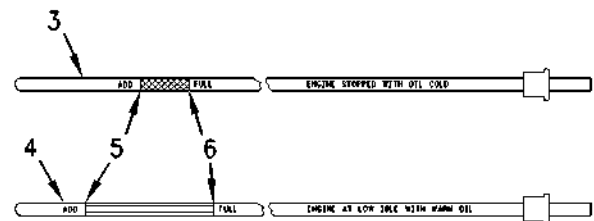


Illustration 70

g00735162

- (3) “ENGINE STOPPED WITH OIL COLD” side  
(4) “ENGINE AT LOW IDLE WITH WARM OIL” side  
(5) “ADD” mark  
(6) “FULL” mark

- a. If the engine is stopped, remove the engine oil level gauge. Observe the engine oil level on “ENGINE STOPPED WITH OIL COLD” side (3).
- b. If the engine is operating, reduce the engine speed to low idle. Remove the engine oil level gauge and observe the engine oil level on “ENGINE AT LOW IDLE WITH WARM OIL” side (4).

The engine oil level should be between “ADD” mark (5) and “FULL” mark (6).

---

**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.

3. If necessary, add engine oil. For the correct engine oil to use, refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic (Maintenance Section). Do not fill the crankcase above the "FULL" mark on the engine oil level gauge. Clean the filler cap (1). Install the filler cap.
4. Record the amount of engine oil that is added. For the next engine oil sample and analysis, include the total amount of engine oil that has been added since the previous oil change. This will help to provide the most accurate analysis.

i01935337

## Engine Oil Sample - Obtain

**SMCS Code:** 1348-554-SM

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

### Obtain the Sample and the Analysis



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

---

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

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

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

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

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

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

---

**NOTICE**

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

---

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

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

i02419365

## Engine Oil and Filter - Change

**SMCS Code:** 1318-510

If the engine is equipped with duplex oil filters, the engine oil filter elements can be changed while the engine is in operation. This is useful if the oil filter elements require more frequent replacement than the engine oil. Refer to “Replacing the Engine Oil Filters During Engine Operation”.

The oil change interval can be affected by several factors:

- Air/fuel ratio
- Ambient air conditions
- Engine application
- Fuel type
- Oil type
- Size of the oil sump

The S-O-S oil analysis program analyzes used oil in order to determine if the oil change interval is suitable for your specific engine. In the absence of S-O-S oil analysis, change the engine oil and filters according to the interval that is listed in Table 35.

Table 35

Engine Oil Change Intervals		
Engine	Sump Capacity	Oil Change Interval
<b>Engines With a Shallow Sump</b>		
3508B	104 L (27 US gal)	Every 250 Service Hours
3512B 3512C	152 L (40 US gal)	
3516B 3516C	204 L (53 US gal)	
<b>Engines With a Standard Sump</b>		
3508B	227 L (60 US gal)	Every 500 Service Hours
3512B 3512C	318 L (84 US gal)	
3516B 3516C	405 L (107 US gal)	
<b>Engines With a Deep Sump</b>		
3508B	443 L (117 US gal)	Every 1000 Service Hours
3512B 3512C	625 L (165 US gal)	
3516B 3516C	807 L (213 US gal)	

## Drain the Oil



**Hot oil and components can cause personal injury.**

**Do not allow hot oil or components to contact skin.**

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

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

1. After the engine has been operated at normal operating temperature, STOP the engine.
2. Drain the oil according to the equipment on the engine.

**Note:** Drain the oil into a suitable container. DO NOT drain the oil into the bilge sump. Dispose of the oil according to local regulations.

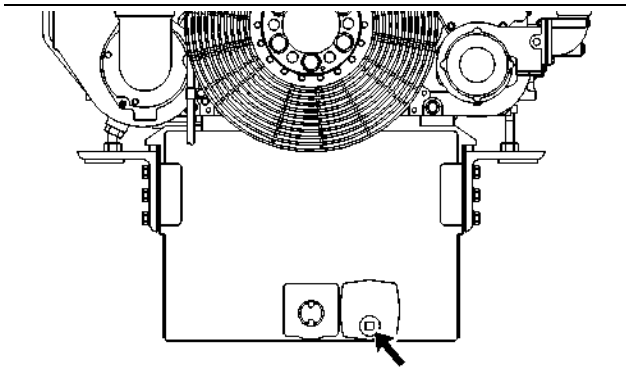


Illustration 71  
Oil drain plug

g00574534

**Note:** If a suction device is used in order to remove the oil from the oil pan, ensure that the suction device is clean. This will prevent dirt from entering into the oil pan. Be careful not to strike the engine oil suction tubes or the piston cooling jets.

- a. If the engine does not have a drain valve or a pump, remove an oil drain plug. Allow the oil to drain. After the oil has drained, clean the drain plug and clean the fitting for the drain plug. Install the drain plug. Tighten the drain plug to  $145 \pm 15 \text{ N}\cdot\text{m}$  ( $105 \pm 10 \text{ lb ft}$ ).
  - b. If the engine has an oil drain valve, open the valve. After the oil has drained, close the valve.
  - c. If the engine has a pump for removing dirty oil, connect a hose to the outlet of the pump. Place the hose in a suitable container. Open the valve for the drain line. The two marks on the valve must be turned so that one mark points to the pump and the second mark points to the drain line. Operate the pump until the crankcase is empty. Close the valve to the drain line. Disconnect the hose.
  - d. If the oil drain valve has a “quick connect” coupling, attach the coupling. Open the drain valve in order to drain the crankcase. After the oil has drained, close the drain valve. Disconnect the coupling.
3. Replace the engine oil filter elements before filling the crankcase with new oil.

## Replace the Oil Filter Elements

Replace the engine oil filters when any of the following conditions occur:

- Every oil change

- The engine oil filter differential pressure reaches 103 kPa (15 psi).
- The oil filter elements have been used for 1000 service hours.

**Note:** Do not attempt to clean the used oil filters. Used oil filters will retain waste particles. The used oil filters would not filter the oil properly.

Service tools are available to aid in the service of oil filters. Consult your Caterpillar dealer for the part names and the part numbers. Follow the instructions that are supplied with the service tools. If the service tools are not used, perform the following appropriate procedure.

## Replacing the Engine Oil Filters With the Engine Stopped

### WARNING

Hot oil and components can cause personal injury.

Do not allow hot oil or components to contact skin.

Perform the following procedure after the oil has been drained.

**Note:** Use this procedure if the engine oil filters do not have a control valve.

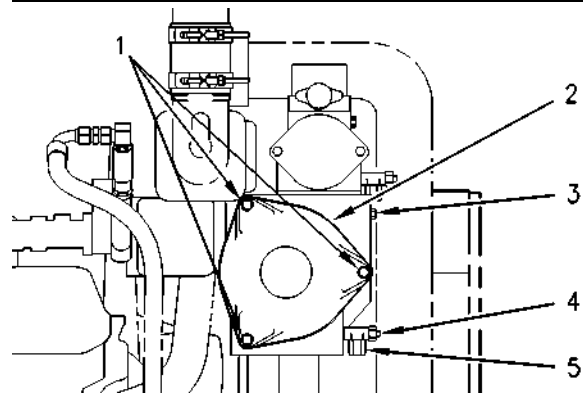


Illustration 72

g00799719

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

**Note:** Drain the oil into a suitable container. Dispose of the oil according to local regulations.

1. Connect a hose to drain (5). Place the other end of the hose into a suitable container in order to collect the oil.

- Open drain valve (4). Remove plug (3). Allow the oil to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

**Note:** Some oil will remain in the housing after the oil has been drained. This oil will pour out of the housing when cover (2) is removed. Prepare to catch the oil in a suitable container. Clean up any spilled oil with absorbent pillows or towels. DO NOT use absorbent particles to clean up the oil.

### 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.**

- Be alert to the spring force. Gradually loosen but do not remove bolts (1). Before removing the bolts, pry cover (2) loose or tap the cover with a rubber mallet in order to relieve any spring pressure.

Section view of the engine oil filter

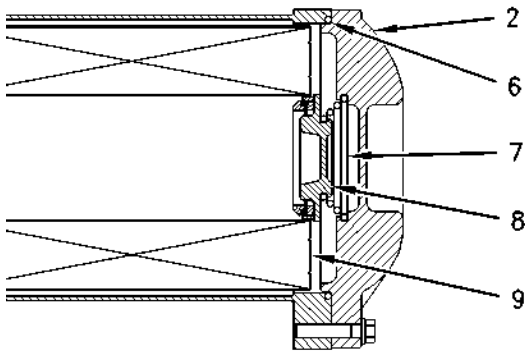


Illustration 73

g00799721

- (2) Cover
- (6) O-ring seal
- (7) Spring
- (8) Retainer
- (9) Oil filter element

- Remove cover (2) and spring (7). Remove O-ring seal (6), retainer (8), and oil filter elements (9).
- Clean cover (2), spring (7), O-ring seal (6), and retainer (8). Clean the inside of the oil filter housing.

### 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.

- Ensure that the new oil filter elements are in good condition. Install the new oil filter elements.
- 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.
- Install retainer (8), spring (7) and cover (2). Ensure that the retainer and the spring are properly seated between the oil filter elements and the cover.
- Start the engine according to this Operation and Maintenance Manual, "Starting The Engine" procedure (Operation Section). Check for oil leaks.

## Replacing the Engine Oil Filters During Engine Operation

If the engine is equipped with duplex oil filters, the engine oil filter elements can be changed while the engine is in operation. This is useful if the oil filter elements require more frequent replacement than the engine oil.

### WARNING

**This filter contains hot, pressurized oil that can cause burns and fire hazards, which may result in bodily injury or death. Follow the instructions given in this Operation and Maintenance Manual and stop the engine if rapid air movement exists to blow the oil.**

- Open the "FILL" valve for a minimum of five minutes in order to fill the oil filter elements that will not be serviced. The oil filters that will not be serviced must be full of engine oil. Close the FILL valve.
- Move the control valve to the "AUX RUN" position in order to change the main oil filter elements. Move the selector valve to the "MAIN RUN" position in order to change the auxiliary oil filter elements.
- Allow the oil pressure gauge for the oil filter that is being changed to reach a "ZERO" pressure reading.

4. Perform Step 1 through Step 8 of “Replacing the Engine Oil Filters With the Engine Stopped”.
5. Open the “FILL” valve for a minimum of five minutes in order to fill the new oil filter elements.
6. Close the “FILL” valve. Rotate the control valve to the “RUN” position for the oil filter that was serviced.

## Fill the Crankcase

### NOTICE

Only use oils that are recommended by Caterpillar. For the proper oil to use, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section).

### NOTICE

If the engine is equipped with an auxiliary oil filter system, extra oil must be added when filling the crankcase. If equipped with an auxiliary oil filter system that is not supplied by Caterpillar, follow the recommendations of the OEM.

### 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.

Use the following procedure in order to fill the crankcase if the engine oil filters were replaced during engine operation.

1. If the engine oil filters were replaced during engine operation operate the engine at low idle. Ensure that the oil level is at the “FULL” mark on the “LOW IDLE” side of the oil level gauge.
2. Add oil, if necessary. Remove the oil filler cap. Fill the crankcase through the oil filler tube only.

Use the following procedure in order to fill the crankcase if the engine oil filters were replaced with the engine stopped.

1. Remove the oil filler cap. Fill the crankcase through the oil filler tube only. For the amount of oil to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section). Clean the oil filler cap. Install the oil filler cap.

### NOTICE

To prevent crankshaft or bearing damage, crank engine with fuel off to fill all filters before starting.

Do Not crank engine for more than 30 seconds.

2. Close the fuel supply line and crank the engine until the oil pressure gauge indicates 70 kPa (10 psi). Open the fuel supply line. Allow the starting motor to cool for two minutes before cranking again.
3. Start the engine according to this Operation and Maintenance Manual, “Starting The Engine” procedure (Operation Section). Operate the engine at low idle for two minutes. This will ensure that the lubrication system has oil and that the oil filters are filled with oil. Inspect the engine for oil leaks. Ensure that the oil level is at the “FULL” mark on the “LOW IDLE” side of the oil level gauge.
4. Stop the engine and allow the oil to drain back into the sump for a minimum of ten minutes.
5. Remove the oil level gauge and check the oil level. Maintain the oil level to the “FULL” mark on the “ENGINE STOPPED” side of the oil level gauge.

## Inspect the Used Oil Filter Elements

Cut the used oil filter element open with a utility knife. Remove the metal wrap. Cut the filter element free from the end caps. Spread apart the pleats and inspect the element for metal debris. An excessive amount of debris in the element 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 element. Ferrous metals may indicate wear on the steel and the cast iron parts of the engine. Nonferrous metals may indicate wear on the aluminum parts, the brass parts, or the bronze parts of the engine. Parts that may be affected include the following components: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Aluminum debris may indicate problems with the bearings of the front gears. If you find aluminum debris, inspect the crankshaft vibration damper and the idler gear bearings.

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

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.

i02209352

## Engine Speed/Timing Sensor - Clean/Inspect

**SMCS Code:** 1905-040; 1905-070; 1907-040; 1907-070

An engine speed/timing sensor is mounted in the flywheel housing. The speed/timing sensor provides information about engine speed and the position of the crankshaft to the ECM.

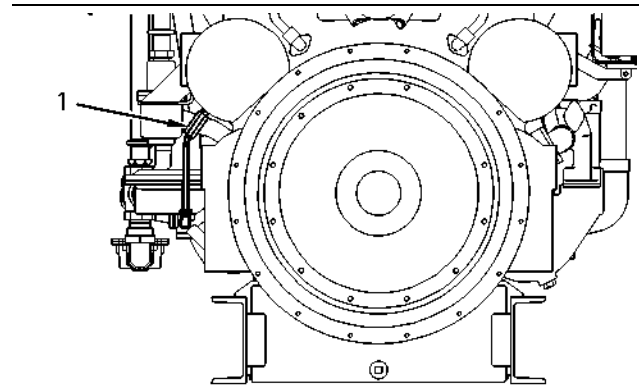


Illustration 74

g00760464

1. Remove engine speed/timing sensor (1). Inspect the condition of the end of the magnet. Look for signs of wear and contaminants.
2. Clean any debris from the face of the magnet.

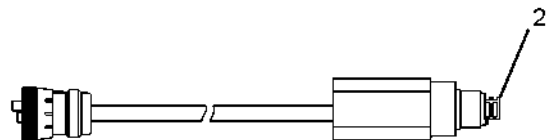


Illustration 75

g01115363

3. Check the tension of the sliphead. Gently extend sliphead (2) for a minimum of 4 mm (0.16 inch). Then push back the sliphead.

When the sliphead has the correct tension, at least 22 N (5 lb) of force is required to push in the sliphead from the extended position.

---

### NOTICE

The sliphead must be fully extended when the speed/timing sensor is installed so that the sensor maintains the correct clearance with the speed-timing wheel. If the correct clearance is not maintained, the signal from the sensor will not be generated.

Do not install the sensor between the teeth of the speed-timing wheel. Damage to the sensor would result. Before installing the sensor, ensure that a tooth of the wheel is visible in the mounting hole for the sensor.

---

4. Install the engine speed/timing sensor.
  - a. Ensure that a tooth on the speed-timing wheel is visible in the mounting hole for the sensor.
  - b. Extend sliphead (2) by a minimum of 4 mm (0.16 inch).
  - c. Coat the threads of the sensor with 4C-5597 Anti-Seize Compound.

**Note:** The sliphead is designed to contact a tooth during the first revolution of the speed-timing wheel. For the maximum allowable clearance between the sliphead and the tooth, refer to the engine's Specifications manual.

- d. Install the sensor. Tighten the locknut to  $40 \pm 5$  N·m ( $30 \pm 4$  lb ft).

i01878914

## Engine Valve Lash - Adjust

**SMCS Code:** 1102; 1209-025

**Note:** For procedures on adjusting the valve lash and adjusting the valve bridge, see Testing and Adjusting, "Valve Lash and Valve Bridge Adjustment". Consult your Caterpillar dealer for assistance.

### Valve Bridge

Adjust the valve bridge. Perform the procedure for both valve bridges for each cylinder. After the valve bridge is adjusted for each cylinder, proceed with the valve lash adjustment.

---

## 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 shutdown 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, "Specifications" topic (Product Information Section).

i01225237

## Fuel Injector - Inspect/Adjust

**SMCS Code:** 1290-025

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

 **WARNING**

**The Electronic Control module produces high voltage. To prevent personal injury make sure the Electronic Control Module is not powered and the unit injector solenoids are disconnected.**

---

---

### 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.



i01398238

## 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.

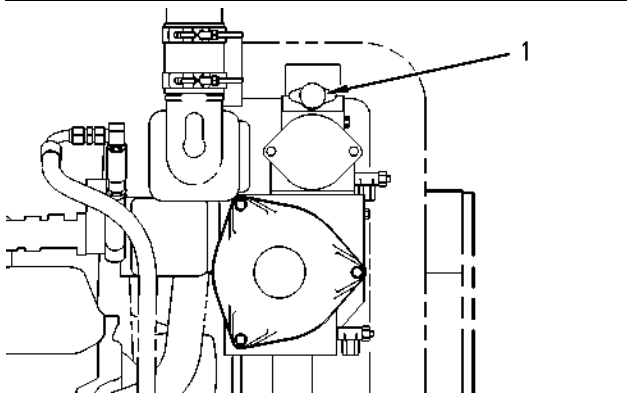


Illustration 76

g00736817

(1) Fuel priming pump plunger

2. Turn the fuel priming pump plunger 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.

### Priming Procedure for Dry Starting

If the air cannot be completely purged from the fuel system and the engine will not start, see Special Instruction, SEHS9586, "3500 EUI Fuel Priming Procedure".

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.

i01539891

## Fuel System Primary Filter/Water Separator - Clean/Replace

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



**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 disconnected fuel system component.

**Note:** After cleaning or replacing the element, it may be necessary to prime the fuel system before the engine will start. See this Operation and Maintenance Manual, "Fuel System - Prime" topic (Maintenance Section).

### Primary Filter

1. Stop the engine. Turn the start switch to the "OFF" position. Disconnect the battery.
2. Shut off the fuel tank supply valve to the engine.

3. 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.

**Note:** Illustration 77 shows a Caterpillar Primary Fuel Filter. If the engine has a different primary filter, service the filter according to the instructions that are provided by the OEM of the filter.

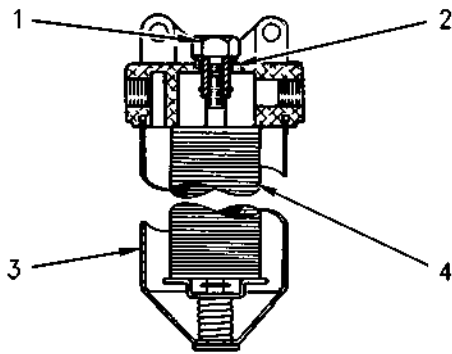


Illustration 77

g00799801

- (1) Bolt
- (2) O-ring seal
- (3) Case
- (4) Element

4. Remove bolt (1), O-ring seal (2), case (3) and element (4).
5. Wash the element and the case in clean, nonflammable solvent.

Inspect the element for good condition. Inspect the O-ring seal for damage and deterioration. Obtain new parts, if necessary.

**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.

6. Install the element, the case, the O-ring seal, and the bolt. Tighten the bolt to  $25 \pm 5$  N·m ( $18 \pm 4$  lb ft).

## Water Separator

Service the water separator according to the instructions that are provided by the OEM of the water separator.

i00744357

## Fuel System Primary Filter/Water Separator - Drain

**SMCS Code:** 1260-543; 1263-543

**WARNING**

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

**NOTICE**

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

Drain the primary filter/water separator on a daily basis before starting the engine.

For specific instructions for draining the primary filter/water separator, see the service information that is provided by the OEM of the primary filter/water separator.

**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.

i02828884

## Fuel System Secondary Filter - Replace

**SMCS Code:** 1261-510-SE

**Note:** If the engine is equipped with duplex fuel filters, the fuel filter elements can be changed while the engine is in operation. Refer to "Replacing the Fuel Filter Elements During Engine Operation".

**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.

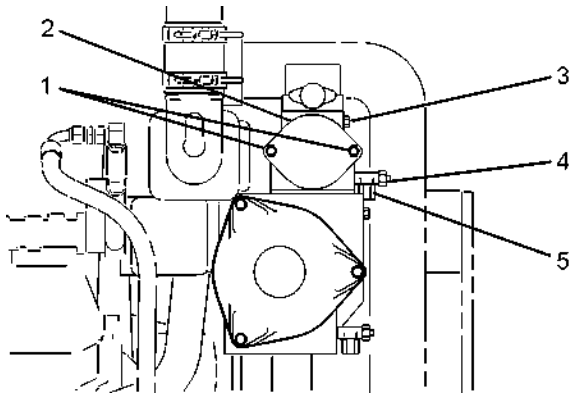


Illustration 78

g01411122

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

3. Connect a hose to drain (5). Place the other end of the hose into a suitable container in order to collect the fuel.
4. Open drain valve (4). 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 (2) 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 (1). Before removing bolts (1), pry cover (2) loose in order to relieve any spring pressure. Remove cover (2). Remove the O-ring seal on the inside of the cover. Remove the fuel filter elements.
6. Clean cover (2) 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 (2). 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.

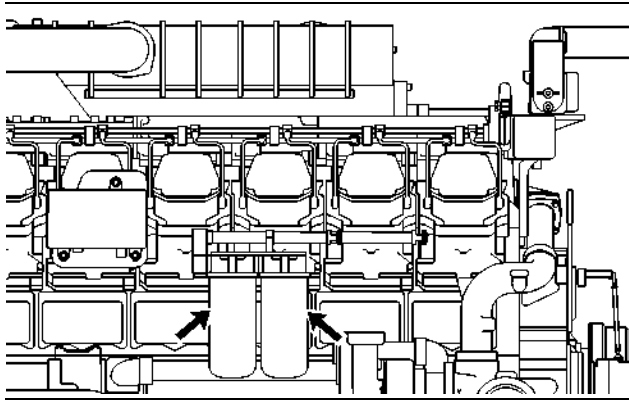


Illustration 79  
Secondary fuel filters  
g00425598

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

If the engine is equipped with duplex fuel filters, the fuel filters can be changed while the engine is in operation.

### **WARNING**

If the filter is changed during rapid air movement, an explosive vapor may be created. The explosive vapor may result in personal injury or in death.

If rapid air movement exists, stop the engine in order to change the filter.

### **WARNING**

Filter contains hot pressurized fluid when engine is running.

Follow instructions on control valve to avoid personal injury.

## Duplex Fuel Filters

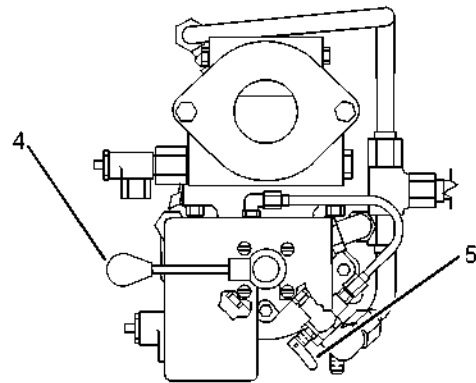


Illustration 80  
g01411130

- (4) Control valve  
(5) Fill valve

1. Open FILL valve (5) for a minimum of five minutes in order to fill the fuel filters that will not be serviced. The fuel filters that will not be serviced must be full of fuel. Close the FILL valve.
2. If the main filter will be serviced, rotate control valve (4) to the "AUX RUN" position.  
  
If the auxiliary filters will be serviced, rotate control valve (4) 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 3 through Step 9 from the “Canister” instructions.
4. Open fill valve (5) 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.

i03071053

## Fuel Tank Water and Sediment - Drain

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

### NOTICE

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

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Caterpillar Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

## Fuel Tank

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

## Drain the Water and the Sediment

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

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

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

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

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

## Fuel Storage Tanks

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

- Weekly
- Oil change
- Refill of the tank

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

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

i02259870

## Heat Exchanger - Inspect

SMCS Code: 1379-040

### WARNING

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

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

**Remove the filler cap slowly to relieve pressure only when the engine is stopped and the filler cap for the heat exchanger is cool enough to touch with your bare hand.**

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

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

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

## Shell and Tube Heat Exchanger

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

- Cleanliness of the tubes for the heat exchanger
- Effectiveness of the heat exchanger system

Operating in water that contains the following will adversely affect the heat exchanger system: silt, sediment, salt, and algae. In addition, intermittent use of the vessel will adversely affect the heat exchanger system.

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

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

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

## Cleaning the Shell and Tube Heat Exchanger

Refer to the Disassembly and Assembly Manual for the engine.

1. Drain the heat exchanger.
2. Remove the heat exchanger.
3. Turn the heat exchanger core upside-down in order to remove debris.

#### NOTICE

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

4. Back flush the core with cleaner.

Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 36 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 36

Hydrosolv Liquid Cleaners <sup>(1)</sup>		
Part Number	Description	Size
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

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

5. Steam clean the core in order to remove any residue. Flush the tubes of the heat exchanger core. Remove any other trapped debris.
6. Wash the core with hot, soapy water. Rinse the core thoroughly with clean water.

 **WARNING**

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

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

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

7. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.
8. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.
9. Install the heat exchanger. Refer to the Service Manual for the procedure.

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

## Plate Type Heat Exchanger

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

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

Operating in water that contains the following will adversely affect the heat exchanger system: silt, sediment, salt, and algae. In addition, intermittent use of the vessel will adversely affect the heat exchanger system.

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

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

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

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

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

## Cleaning the Plate Type Heat Exchanger

Refer to the Disassembly and Assembly Manual for the engine. The heat exchanger must be disassembled in order to be cleaned. The Disassembly and Assembly Manual will contain instructions for cleaning the heat exchanger prior to reassembly. The following general guidelines are for cleaning a plate type heat exchanger. Refer to Table 37 for types of cleaners.

### NOTICE

Do not use hydrochloric acid to clean stainless steel plates.

Do not use hydrofluoric acid to clean titanium plates.

Water that contains more than 300 ppm of chlorine should not be used to prepare cleaning solutions.

Do not use Ketones such as Acetone and Methyl-tyketone.

Do not use esters such as Ethylacetate and Butylacetate.

Do not use Halogenated hydrocarbons such as Chlorothene and Carbon Tetrachloride

Do not use Aromatics such as Benzene and Toluene.

Table 37

Problem	Source	Cleaners <sup>(1)</sup>
Scaling	Calcium carbonate Calcium sulphate Silicates	Nitric acid Sulfamic acid Citric acid Phosphoric acid Complexing agents Sodium polyphosphates
Sediment <sup>(2)</sup>	Corrosion products Metal oxides Silt Diatomic organisms	
Gross fouling	Seaweed Chips of wood and fibers Mussels Barnacles	
Biological growth	Bacteria Nematodes Protozoa	
Residue	Oily films Asphalt Fats	

(1) Cleaners should be mixed at a maximum concentration of 4 percent by weight. The temperature of the cleaning solution should be less than 60 °C (140 °F).  
 (2) The addition of surfactants to the cleaning solution may ease cleaning.  
 (3) Do not mix the solvent with water for cleaning. Dry the plates with a cloth or rinse the plates with water.  
 (4) Gaskets that are made from natural rubber, butyl rubber and EPDM rubber will swell in these solvents. Do not allow the solvent to contact the gasket more than half an hour.

1. Drain the heat exchanger.
2. Disassemble the heat exchanger and remove the plates. Keep the plates in order.
3. Clean the plates with a cleaning solution and a soft brush. Pressurized water may also be used. Do not use steel wool or a wire brush, which may scratch the plate. Any iron scratches on the plates can lead to corrosion of the plates. Rinse the plates with water.
4. Assemble the heat exchanger.

i02121526

## Hoses and Clamps - Inspect/Replace

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

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

- Cracking

- Softness
- Loose clamps

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

### NOTICE

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

Check for the following conditions:

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

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

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

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

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



## Replace the Hoses and the Clamps

### WARNING

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

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

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

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

**Note:** Refer to the Specifications, SENR3130, "Torque Specifications" in order to locate the proper torques.

8. Refill the cooling system.
9. Clean the cooling system filler cap. Inspect the cooling system filler cap's gaskets. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.
10. Start the engine. Inspect the cooling system for leaks.

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## Instrument Panel - Inspect

**SMCS Code:** 7451-040

Inspect the instrument panel for good condition. Perform the self-test. All of the warning lamps should illuminate. If a warning lamp does not illuminate, replace the bulb immediately. If the alarm does not sound, investigate the problem and correct the problem.

Check the condition of all of the gauges. If a gauge is broken, repair the gauge or replace the gauge immediately.

Frequently monitor the gauges during normal operation.

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.

i02995306

## Maintenance Recommendations

**SMCS Code:** 1000

### 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**

Experience has shown that maintenance intervals are most accurately based on fuel consumption. Fuel consumption corresponds more accurately to the engine load. Tables 38, 39, and 40 list average ranges of fuel consumption and service hours for standard displacement engines. These tables are based on a load factor of approximately 60 percent.

## Standard Displacement Engines

Table 38

<b>Maintenance Interval Schedule</b> <b>Service Hours and Fuel Consumption for 3508B Engines and 3508 Engines with EUI Option</b>					
<b>Interval</b>	<b>Rated Up To 1300 RPM<sup>(1)</sup></b>	<b>Rated 1301 To 1600 RPM<sup>(1)</sup></b>	<b>Rated 1601 To 1800 RPM<sup>(1)</sup></b>	<b>High Performance B<sup>hp</sup> and C<sup>hp</sup> Ratings <sup>(1)</sup></b>	<b>High Performance D<sup>hp</sup> and E<sup>hp</sup> Ratings<sup>(2)</sup></b>
250 Service Hours	22 700 L (6000 US gal)	27 700 L (7200 US gal)	32 000 L (8500 US gal)	40 500 L (10,700 US gal)	29 150 L (7600 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)	81 000 L (21,400 US gal)	58 300 L (15,200 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)	162 000 L (42,800 US gal)	116 700 L (30,800 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)	324 000 L (85,600 US gal)	233 400 L (61,600 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)	485 500 L (128,400 US gal)	350 000 L (92,500 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)	971 000 L (256,250 US gal)	700 000 L (185,000 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours	6000 Service Hours	4500 Service Hours
	976 000 L (257,500 US gal)			971 000 L (256,250 US gal)	525 000 L (135,500 US gal)
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours	n/a	n/a
	1 952 000 L (515,000 US gal)			n/a	n/a
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours	12 000 Service Hours	9000 Service Hours
	2 928 000 L (772,500 US gal)			1 942 000 L (512,500 US gal)	1 050 000 L (275,000 US gal)

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

(2) Fuel consumption is based on a load factor of approximately 40 percent.

Table 39

<b>Maintenance Interval Schedule</b>					
<b>Service Hours and Fuel Consumption for 3512B Engines and 3512 Engines with EUI Option</b>					
<b>Interval</b>	<b>Rated Up To 1300 RPM<sup>(1)</sup></b>	<b>Rated 1301 To 1600 RPM<sup>(1)</sup></b>	<b>Rated 1601 To 1800 RPM<sup>(1)</sup></b>	<b>High Performance B<sup>hp</sup> and C<sup>hp</sup> Ratings<sup>(1)</sup></b>	<b>High Performance D<sup>hp</sup> and E<sup>hp</sup> Ratings<sup>(2)</sup></b>
250 Service Hours	33 400 L (8800 US gal)	41 000 L (10,800 US gal)	48 500 L (12,800 US gal)	60 800 L (21,400 US gal)	43 750 L (11,500 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)	121 600 L (32,200 US gal)	87 500 L (23,000 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)	243 300 L (64,200 US gal)	175 000 L (46,000 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)	486 600 L (128,400 US gal)	350 000 L (92,000 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)	729 900 L (192,500 US gal)	525 000 L (138,000 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)	1 460 000 L (385,000 US gal)	1 050 000 L (276,000 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours	6000 Service Hours	4500 Service Hours
	1 460 000 L (385,000 US gal)				787 500 L (206,250 US gal)
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours	n/a	n/a
	2 920 000 L (770,000 US gal)			n/a	n/a
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours	12 000 Service Hours	9000 Service Hours
	4 380 000 L (1,155,000 US gal)			2 920 000 L (770,000 US gal)	1 575 000 L (412,500 US gal)

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

(2) Fuel consumption is based on a load factor of approximately 40 percent.

Table 40

<b>Maintenance Interval Schedule</b>						
<b>Service Hours and Fuel Consumption for 3516B Engines and 3516 Engines with EUI Option</b>						
<b>Interval</b>	<b>Rated Up To 1300 RPM<sup>(1)</sup></b>	<b>Rated 1301 To 1600 RPM<sup>(1)</sup></b>	<b>Rated 1601 To 1800 RPM<sup>(1)</sup></b>	<b>High Performance A<sup>hp</sup> Rating<sup>(2)</sup></b>	<b>High Performance B<sup>hp</sup> and C<sup>hp</sup> Ratings<sup>(1)</sup></b>	<b>High Performance D<sup>hp</sup> and E<sup>hp</sup> Ratings<sup>(3)</sup></b>
250 Service Hours	44 000 L (11,600 US gal)	53 000 L (14,000 US gal)	64 500 L (17,000 US gal)	97 000 L (25,600 US gal)	81 000 L (21,400 US gal)	58 300 L (15,200 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)	194 000 L (51,300 US gal)	162 000 L (42,800 Us gal)	116 600 L (30,400 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)	388 000 L (102,500 US gal)	324 000 L (85,600 US gal)	233 300 L (61,600 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)	777 000 L (205,300 US gal)	648 000 L (171,200 US gal)	466 600 L (123,200 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)	1 165 000 L (308,000 US gal)	972 000 L (257,000 US gal)	700 000 L (185,000 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)	2 330 000 L (615,500 US gal)	1 942 000 L (512,500 US gal)	1 400 000 L (370,000 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours	5000 Service Hours	6000 Service Hours	4500 Service Hours
	1 942 000 L (512,500 US gal)					1 050 000 L (275,000 US gal)
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours	n/a	n/a	n/a
	3 884 000 L (1,025,000 US gal)			n/a	n/a	n/a
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours	10 000 Service Hours	12 000 Service Hours	9000 Service Hours
	5 826 000 L (1,537,500 US gal)			3 884 000 L (1,025,000 US gal)		2 100 000 L (550,000 US gal)

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

(2) Fuel consumption is based on a load factor of approximately 80 percent.

(3) Fuel consumption is based on a load factor of approximately 40 percent.

- For engines that operate at less than 50 percent load, use the 50 percent load fuel consumption rate in order to determine the first top end, the second top end, and the overhaul hour intervals.
- Maintenance intervals must be reduced for engines that operate in a severe service application and for engines that operate in excess of the engine rating definition.

### 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.

## 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

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## Marine Transmission Oil Level - Check

**SMCS Code:** 3300-535-OC

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

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

## Marine Transmission Operation, Maintenance, Warranty, and Parts Support

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

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

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## Overhaul (Major)

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

Refer to this Operation and Maintenance Manual, "Maintenance Recommendations" in order to determine the maintenance interval for a major overhaul.

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.

## Replacement of Components

Replace the following components during the major overhaul:

- Camshaft bearings
- Connecting rod bearings
- Crankshaft seals
- Crankshaft thrust washers
- Electronic unit injectors
- Gear train bushings
- Gear train bearings
- Main bearings
- Piston rings

## Inspection, Reconditioning or Exchanging of Components

Inspect the following 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".

Recondition the worn components or exchange the components, if necessary. Your Caterpillar dealer can provide these services and components.

- Camshaft followers
- Camshaft thrust washers
- Connecting rods
- Crankshaft vibration damper
- Cylinder head assembly
- Cylinder liners
- Engine mounts
- Scavenge oil pump
- Engine wiring harness
- Exhaust manifold seals
- Exhaust manifold bellows
- Fuel pressure regulating valve
- Fuel priming pump
- Fuel transfer pump
- Inlet manifold gaskets
- Inlet manifold seals
- Oil cooler core
- Oil pump
- Pistons
- Piston pins
- Prelube pump
- Pushrods
- Rocker arms
- Spacer plate

- Software update
- Turbocharger

## Inspection of Components

Inspect the following 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".

- Aftercooler core
- Camshaft
- Crankshaft
- Driven equipment (alignment)
- Engine cylinder block
- Engine control module
- Exhaust bellow shields
- Flywheel
- Front gear train (gears)
- Oil suction screen
- Rear gear train

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

Inspect the crankshaft for any of the following conditions:

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

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

- Rod bearing
- Main bearings

**Note:** If the crankshaft or the camshaft are removed for any reason, use the magnetic particle inspection process to check for cracks.



Replace the crankshaft vibration damper if any of the following conditions occur:

- Engine failure due to a broken crankshaft
- Excessive wear of the front bearing for the crankshaft
- Excessive wear of the gear train that is not caused by a lack of lubrication

Inspect the gears of the gear train and inspect the gear train bushings for the following conditions:

- Worn gear teeth
- Unusual fit
- Unusual wear

In addition to the inspection of components, inspect the alignment of the driven equipment. See the Application and Installation Guide for the engine or see the literature that is provided by the OEM of the driven equipment.

## Cleaning of Components

Clean the oil cooler core and the aftercooler core. Then, pressure test both of these cores. For instructions on cleaning the cores, see this Operation and Maintenance Manual, "Aftercooler Core - Inspect/Clean" topic.

Clean the oil suction screen. Also, remove side covers in order to clean the oil sump. For instructions on removal and installation of components, see the Service Manual, "Disassembly and Assembly" module.

## Obtain a Coolant Analysis

For conventional heavy-duty coolant/antifreeze, check the concentration of supplemental coolant additive (SCA) regularly. The concentration of SCA can be checked with an S-O-S coolant analysis (Level I). A more detailed coolant analysis is recommended periodically.

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

A coolant analysis can be conducted in order to verify the condition of the water that is being used in the cooling system. A full water analysis may be obtained from the following sources:

- Caterpillar dealer
- Local water utility company
- Agricultural agent
- Independent laboratory

Caterpillar recommends an S-O-S coolant analysis (Level II). This is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the inside of the cooling system. The following services are provided:

- Full Level I analysis
- Identification of the source of metal corrosion and of contaminants
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of possible electrolysis within the engines' cooling system

A report of the results of the analysis is provided. Maintenance recommendations are based on the results.

For more information about S-O-S coolant analysis, consult your Caterpillar dealer.

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## Overhaul (Top End)

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

Refer to this Operation and Maintenance Manual, "Maintenance Recommendations" in order to determine the maintenance interval for a top end overhaul.

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

## First Top End Overhaul

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

### Cylinder Head Assembly

Inspect the cylinder head assembly 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".

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

The use of out-of-spec parts will cause unscheduled downtime and/or costly repairs.

### Unit Injectors

Replace the unit injectors. Consult your Caterpillar dealer about exchanging the unit injectors. Your Caterpillar dealer can provide these services and components.

The wear of unit injectors is affected by the following considerations:

- Quality of the fuel
- Quality of the filtration of the fuel

The wear of the unit injectors can result in elevated levels of exhaust emissions and/or poor engine performance. The misfire of a single cylinder is not typically attributed to normal wear. This condition can be repaired by replacing the faulty unit injector.

The following list of circumstances indicate that the unit injectors should be inspected more frequently:

- Use of fuels that are not recommended in this Operation and Maintenance Manual, "Refill Capacities and Recommendations"
- Extreme ambient temperatures that reduce the ability of the fuel to provide lubrication
- Frequent plugging of the fuel filters
- Insufficient maintenance of the fuel tank or the fuel storage tank that can allow excessive water, sediment, etc.
- Insufficient maintenance of the fuel filters

### Oil Suction Screen

Clean the oil suction screen after the oil has been drained.

**Note:** Approximately 1 L (1 qt) of oil will remain in the housing after the sump has been completely drained. This oil will pour out of the housing when cover (1) is removed. Prepare to catch the oil in a pan. Clean up any spilled oil with absorbent towels or pillows. DO NOT use absorbent particles to clean up the oil.

1. Remove the screen assembly according to the instructions in the Service Manual, "Disassembly and Assembly" module. Discard the used O-ring seals.
2. Wash the screen assembly in clean nonflammable solvent. Allow the screen assembly to dry before installation.
3. Remove side covers in order to gain access to the sump. Clean the bottom of the sump with absorbent towels or pillows. When the bottom of the sump is clean, install the side covers.
4. Inspect the screen assembly for good condition. Obtain a new screen assembly, if necessary. Install the screen assembly. Install new O-ring seals.

### Replacement of Components

Replace the following components during the top end overhaul:

- Electronic unit injectors

### Inspection, Reconditioning or Exchanging of Components

Inspect the following 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".

Recondition the worn components or exchange the components, if necessary. Your Caterpillar dealer can provide these services and components.

- Camshaft followers
- Cylinder head assembly
- Scavenge oil pump
- Engine wiring harness
- Exhaust manifold seals

- Exhaust manifold bellows
- Fuel pressure regulating valve
- Fuel priming pump
- Fuel transfer pump
- Inlet manifold gaskets
- Inlet manifold seals
- Oil pump
- Prelube pump
- Pushrods
- Rocker arms
- Spacer plate
- Software update
- Turbocharger

### Inspection of Components

Inspect the following 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".

- Aftercooler core
- Camshaft
- Driven equipment (alignment)
- Engine control module
- Exhaust bellow shields
- Oil suction screen

### Top End Overhaul (Second)

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

### Cylinder Head Assembly

Inspect the cylinder head assembly 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".

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

The use of out-of-spec parts will cause unscheduled downtime and/or costly repairs.

### Unit Injectors

Replace the unit injectors. Consult your Caterpillar dealer about exchanging the unit injectors. Your Caterpillar dealer can provide these services and components.

The wear of unit injectors is affected by the following considerations:

- Quality of the fuel
- Quality of the filtration of the fuel

The wear of the unit injectors can result in elevated levels of exhaust emissions and/or poor engine performance. The misfire of a single cylinder is not typically attributed to normal wear. This condition can be repaired by replacing the faulty unit injector.

The following list of circumstances indicate that the unit injectors should be inspected more frequently:

- Use of fuels that are not recommended in this Operation and Maintenance Manual, "Refill Capacities and Recommendations"
- Extreme ambient temperatures that reduce the ability of the fuel to provide lubrication
- Frequent plugging of the fuel filters
- Insufficient maintenance of the fuel tank or the fuel storage tank that can allow excessive water, sediment, etc.
- Insufficient maintenance of the fuel filters

### Oil Suction Screen

Clean the oil suction screen after the oil has been drained.

**Note:** Approximately 1 L (1 qt) of oil will remain in the housing after the sump has been completely drained. This oil will pour out of the housing when cover (1) is removed. Prepare to catch the oil in a pan. Clean up any spilled oil with absorbent towels or pillows. DO NOT use absorbent particles to clean up the oil.

1. Remove the screen assembly according to the instructions in the Service Manual, "Disassembly and Assembly" module. Discard the used O-ring seals.
2. Wash the screen assembly in clean nonflammable solvent. Allow the screen assembly to dry before installation.
3. Remove side covers in order to gain access to the sump. Clean the bottom of the sump with absorbent towels or pillows. When the bottom of the sump is clean, install the side covers.
4. Inspect the screen assembly for good condition. Obtain a new screen assembly, if necessary. Install the screen assembly. Install new O-ring seals.

### Replacement of Components

Replace the following components during the top end overhaul:

- Electronic unit injectors

### Inspection, Reconditioning or Exchanging of Components

Inspect the following 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".

Recondition the worn components or exchange the components, if necessary. Your Caterpillar dealer can provide these services and components.

- Camshaft followers
- Connecting rods
- Connecting rod bearings
- Cylinder head assembly
- Cylinder liners
- Scavenge oil pump
- Engine wiring harness

- Exhaust manifold seals
- Exhaust manifold bellows
- Fuel pressure regulating valve
- Fuel priming pump
- Fuel transfer pump
- Inlet manifold gaskets
- Inlet manifold seals
- Oil pump
- Pistons
- Piston pins
- Prelube pump
- Pushrods
- Rocker arms
- Spacer plate
- Software update
- Turbocharger

### Inspection of Components

Inspect the following 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".

- Aftercooler core
- Camshaft
- Crankshaft
- Driven equipment (alignment)
- Engine control module
- Exhaust bellow shields
- Oil suction screen

**Note:** Inspect only two of the components from each cylinder bank. Inspecting only two components will provide an adequate example of the condition of the other components.

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## Overhaul Considerations

**SMCS Code:** 7595-043

### 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

## 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 81.

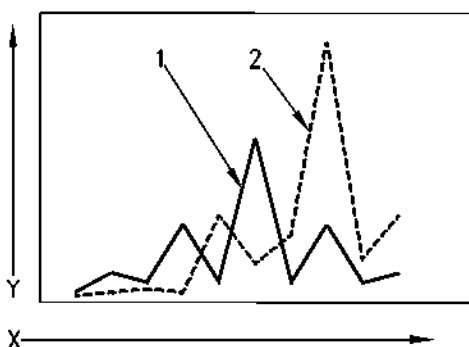


Illustration 81

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- (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 81, 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 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.

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## Prelube Pump - Inspect

**SMCS Code:** 1319-040

Inspect the prelube pump for the following conditions:

- Cracks
- Pin holes
- Proper operation
- Wear

Perform a pressure check on the prelube pump.

Inspect the hoses and the fittings for leaks.

Inspect the prelube pump for leaks. Replace all of the seals if a leak is observed.

Inspect the wiring for the following conditions:

- Damage
- Fraying

Ensure that the wiring is in good condition.

Inspect the electrical connections. Ensure that the electrical connections are secure.

Inspect the brushes. Replace the brushes, if necessary.

If repair or replacement is necessary, see the Service Manual or see literature that is provided by the OEM of the pump. Consult your Caterpillar dealer for assistance.

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## Sea Water Strainer - Clean/Inspect

**SMCS Code:** 1371-040; 1371-070

The sea water strainer must be clean in order to allow proper engine cooling. Check the sea water strainer for plugging. Inspect the sea water strainer more frequently if the vessel is being operated in water which is shallow or dirty. Refer to the OEM recommendations for more information about inspecting and cleaning the sea water strainer.

i02618737

## Starting Motor - Inspect (If equipped)

**SMCS Code:** 1451-040; 1453-040

**S/N:** TTA1-Up

**S/N:** TTB1-Up

**S/N:** TTC1-Up

**S/N:** S2D1-Up

**S/N:** TTD1-Up

**S/N:** S2E1-Up

**S/N:** TTE1-Up

**S/N:** S2F1-Up

**S/N:** TTF1-Up

**S/N:** B5G1-Up

**S/N:** MRG5-Up

**S/N:** PAG1-Up

**S/N:** TTG1-Up

**S/N:** MKH1-Up

**S/N:** TTH1-Up

**S/N:** S2J1-Up

**S/N:** TTJ1-Up

**S/N:** S2K1-Up

**S/N:** S2L1-Up

**S/N:** S2M1-Up

**S/N:** S2N1-Up

**S/N:** S2S1-Up

**S/N:** S2T1-Up

**S/N:** E3W1-Up

**S/N:** S2W1-Up

**S/N:** E3X1-Up

**S/N:** S2X1-Up

**S/N:** S2Y1-Up

## Air Starting Motor

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

### **WARNING**

**Personal injury or death can result from improperly checking for a leak.**

**Always use a board or cardboard when checking for a leak. Escaping air or fluid under pressure, even a pin-hole size leak, can penetrate body tissue causing serious injury, and possible death.**

**If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.**

Inspect all of the components in the air circuit for the starting motor. Inspect all of the air lines and connections for leaks.

If damaged teeth are found, the air circuit for the starting motor must be examined in order to determine the cause of the problem.

## Electric Starting Motor

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

Problems with the electric starting motor can be caused by the following conditions: malfunction of the solenoid and malfunction of the electric starting system.

Inspect the electrical system for the following conditions:

- Loose connections
- Corrosion
- Wires that are worn or frayed
- Cleanliness

## Removal and Installation of the Starting Motor

Refer to the Service Manual, "Disassembly and Assembly" module for information on removing the starting motor and installing the starting motor.

Consult your Caterpillar dealer for assistance and/or for options on replacement of the starting motor.



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## Turbocharger - Inspect

SMCS Code: 1052-040

### WARNING

**Avoid contact with hot surfaces. Exhaust piping and engine components become hot during engine operation and cool slowly after engine shut-down. Any contact with hot surfaces can cause severe burns.**

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

Fouling of the compressor can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel could allow parts from the compressor wheel to enter an engine cylinder. This can cause additional damage to the pistons, the valves, and the cylinder head.

### NOTICE

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

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

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

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

**Note:** Turbocharger components require clearances that are precise. The turbocharger cartridge must be balanced due to high rpm. Severe service applications can accelerate the wear of the components. Severe service applications may require more frequent inspections of the turbocharger.

## Removal and Installation

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

## Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil.
2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the turbocharger wheel and the turbocharger housing, the turbocharger should be reconditioned or replaced.
3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.  
  
The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.
4. Inspect the bore of the turbine housing for corrosion.
5. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.
6. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

## Inspect the Exhaust Bypass

The exhaust bypass is a wear component that is sensitive to the load cycles of the engine. Replacement of the exhaust bypass is predicted at the top end overhaul for a general "C" or "D" load profile. Applications that have frequent cycling of the engine will increase the wear rate of the valve in the exhaust bypass. Applications that have extended periods of operation at the opening position of the valve will increase the wear rate of the valve. The valve stem should be inspected periodically for wear of the valve stem. A reduced service interval may be required if the inspection reveals heavy wear of the valve. This will ensure proper operation of the exhaust bypass. Use the following steps in order to inspect the exhaust bypass.

### 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. Drain the cooling system to a sufficient level below the exhaust bypass in order to remove the cooling lines that attach to the exhaust bypass. Refer to the maintenance section of this Operation and Maintenance Manual, "Cooling System Coolant - Change" for instructions on draining the cooling system.

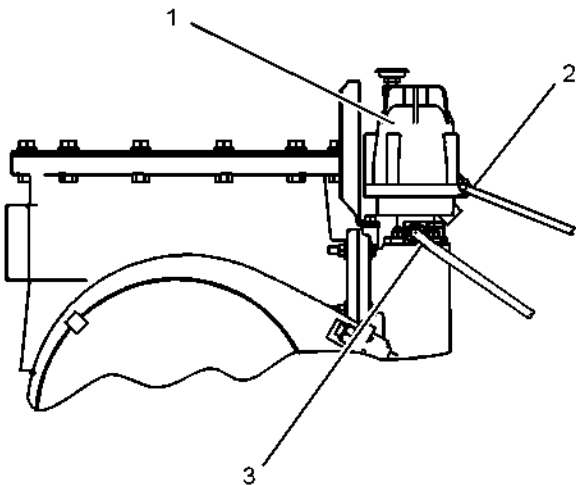


Illustration 82

g01174063

- (1) Exhaust bypass
- (2) Boost line
- (3) Coolant line

2. Disconnect the boost line (2) and the two coolant lines (3) from the exhaust bypass (1). The coolant lines (3) attach to both sides of the exhaust bypass (1).

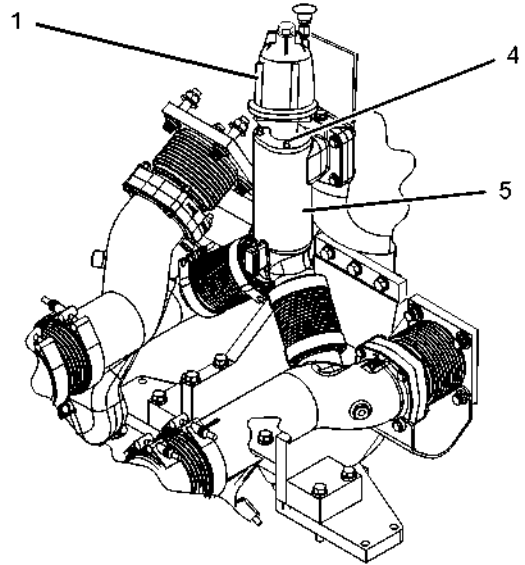


Illustration 83

g01173813

- (1) Exhaust Bypass
- (4) Nut
- (5) Housing

3. Remove the nuts (4) that fasten the exhaust bypass (1) to the housing (5).
4. Remove the exhaust bypass (1) from the housing (5).

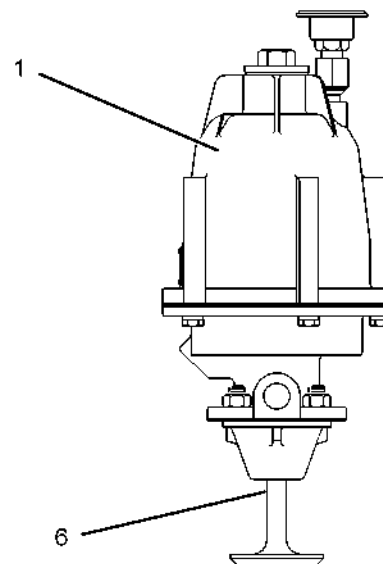


Illustration 84

g01173915

5. Inspect the valve stem (6) for heavy wear.

6. Replace the exhaust bypass (1) if the valve stem is excessively worn.

i02622549

## Walk-Around Inspection

**SMCS Code:** 1000-040

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

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

For maximum engine service life, thoroughly inspect the engine compartment before starting the engine. Look for items such as leaks, loose bolts, 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.

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#### NOTICE

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

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**Note:** Use care when you use steam cleaning. Use care when you use high pressure water. Direct spray to rotating electrics or electronic components can cause nonfixable damage.

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#### NOTICE

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

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- Ensure that the cooling lines are clamped properly and ensure 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 when the engine cools and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pumps and the installation of water pumps and/or seals, refer to two articles in the Disassembly and Assembly Manual, "Water Pump - Remove and Water Pump - Install" or consult your Caterpillar dealer.

- Inspect the lubrication system for leaks at the following locations: front crankshaft seal, rear crankshaft seal, oil pan, oil filters, valve cover, turbocharger, external oil lines, and connections.
- Inspect the fuel system for leaks. Look for loose fuel line clamps or connections.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- 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 closed crankcase ventilation (CCV) filter, if equipped. If the restriction indicator is visible, service the CCV.
- Check the condition of the gauges. Replace any gauge that is damaged. Replace any gauge that can not be calibrated.
- Inspect the exhaust system for leaks. Inspect the gaskets and the exhaust bellows joint. If a leak is found, make repairs.

i02624237

## Water Pump - Inspect

**SMCS Code:** 1361-040

A failed water pump might cause severe engine overheating problems that could result in cracks in the cylinder head, a piston seizure or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking of the water pump seals is observed, replace all of the water pump seals. Refer to two articles in the Disassembly and Assembly Manual, "Water Pump - Disassemble and Water Pump - Assemble" for the disassembly and assembly procedure. If it is necessary to remove the water pump, refer to two articles in the Disassembly and Assembly Manual, "Water Pump - Remove and Water Pump - Install".

Inspect the water pump for wear, cracks, pin holes and proper operation. Refer to the Parts Manual for the correct part numbers for your engine or consult your Caterpillar dealer if repair is needed or replacement is needed.

i03028045

## Zinc Rods - Inspect/Replace

**SMCS Code:** 1388-040; 1388-510

Corrosion in sea water circuits can result in the following issues: premature deterioration of cooling system components, leaks, and possible cooling system contamination. The corrosion may be caused by the lack of zinc rods in the sea water system.

Zinc rods are installed in the sea water cooling system of the engine in order to help prevent the corrosive oxidation that is caused by sea water. Electrical current is conducted through the contact of the zinc rods with the cooling system components. The zinc rods oxidize rather than the cooling system components. Rapid deterioration of zinc rods may indicate the presence of uncontrolled electrical currents from improperly installed electrical attachments or improperly grounded electrical attachments.

The engineer for the operation must determine the interval for inspecting the zinc rods. The interval for inspecting the zinc rods will depend on the size of the zinc rods and the number of zinc rods that are installed.

Table 41

Locations of the Zinc Rods	
Location	Quantity
Elbow of the Auxiliary Water Pump	1
Elbow of the Aftercooler	1

## Inspect the Zinc Rods

1. Remove the zinc rod.
2. Inspect the zinc rod.

Ensure that the zinc rod will remain effective until the next scheduled inspection.

- a. If the zinc rod has deteriorated excessively, install a new zinc rod.

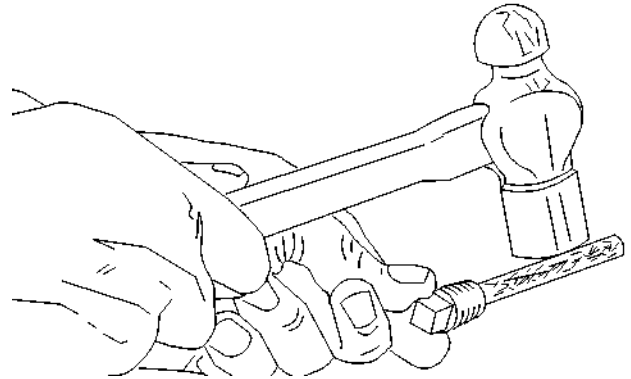


Illustration 85

g00481100

- b. Tap the zinc rod lightly with a hammer. If the zinc rod breaks, install a new zinc rod.
3. If the zinc rod will be reused, scrape the layer of oxidation from the zinc rod before installation. The layer of oxidation reduces the effectiveness of the zinc rod.

## Replace the Zinc Rods

1. Use pliers to unscrew the old zinc rod from the plug.

If not enough material remains or the zinc rod has broken off, drill the zinc from the plug.

2. Clean the plug.

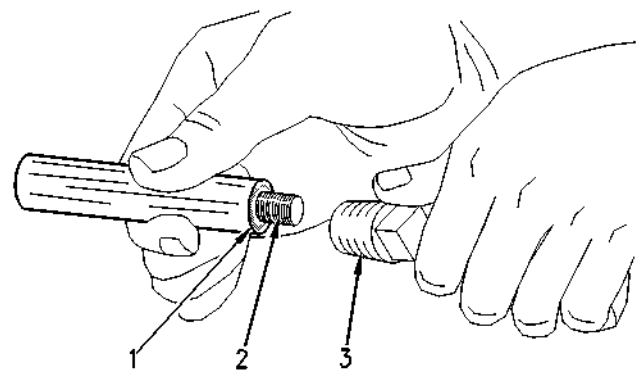


Illustration 86

g00748510

- (1) Shoulder
- (2) Threads
- (3) External threads of the plug

**Note:** Do not apply adhesive or sealant to the threads of the zinc rod (2).

3. Apply 9S-3263 Thread Lock Compound to the shoulder (1) of a new zinc rod. Apply the compound only to the shoulder of the zinc rod. Install the zinc rod onto the plug.
4. Coat the external threads of the plug (3) with 5P-3413 Pipe Sealant. Install the zinc rod. See Specifications, SENR3130, "Torque Specifications" for the torque for the plug.

## Reference Information Section

### Engine Ratings

i01239419

#### Engine Rating Conditions

**SMCS Code:** 1000

All engine ratings are in compliance with the following standard ambient air conditions of “SAE J1349”:

- 100 kPa (29.61 inches of Hg)
- A temperature of 25 °C (77 °F)

The following standard conditions of “ISO3046/1”, “DIN6271”, and “BS5514” are also applicable:

- 100 kPa (29.61 inches of Hg)
- Relative humidity of 60 percent

The ratings are also valid for the following parameters:

- Air temperature (air cleaner) of 50 °C (122 °F) or less
- Sea water temperature (sea level) of 42 °C (108 °F) or less

Fuel consumption is based on the following specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .849 at 15 °C (60 °F)
- Density of 850 kg/m<sup>3</sup> (7.085 lb/US gal)

The engine ratings are gross output ratings.

**Gross Output Ratings** – The total output capability of the engine that is equipped with standard accessories.

Standard accessories include the following components:

- Oil pumps
- Fuel transfer pumps

- Water pumps

Subtract the power that is required to drive auxiliary components from the gross output. This will produce the net power that is available for the external load (flywheel).

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#### Engine Rating Definitions

**SMCS Code:** 1000

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##### NOTICE

Operating an engine above the engine’s rating will reduce the service life of the engine before overhaul.

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The following Table 42 defines the ratings for 3500 Marine Engine.

Table 42

Marine Engine Rating Definitions					
Rating	Typical Application	Typical Hours of Use Per Year	Typical Load Factor	Time That Is Allowed At Rated Power	Interruption or Load Cycling
Unrestricted Continuous "A"	Bottom drag trawlers <sup>(1)</sup> Deep river towboats <sup>(1)</sup> Freighters <sup>(1)</sup> Tugs <sup>(1)</sup>	5000 to 8000	80 to 100%	100%	No
Heavy Duty "B"	Crew boats Ferries <sup>(2)</sup> Mid-water trawlers Purse seiners Supply boats Towboats <sup>(2)</sup>	3000 to 5000	40 to 80%	80%	Some load cycling
Maximum Continuous "C"	Coastal freighters (short trip) Ferries Fishing boats <sup>(3)</sup> Tugs (harbor) Offshore service Yachts (displacement hull vessels)	2000 to 4000	20 to 80%	50%	Cyclical engine load and rpm
Intermittent Duty "D"	Off-shore patrol boats <sup>(4)</sup> Customs <sup>(4)</sup> Police <sup>(4)</sup> Fire boats <sup>(4)</sup> Cruising yachts (planing hull vessels) Fast passenger vessels <sup>(4)</sup> Fishing boats <sup>(3)</sup> Bow/stern thrusters	1000 to 3000	Up to 50%	16%	Some full engine load and rpm
High Performance "E"	Harbor patrol <sup>(4)</sup> Harbor master <sup>(4)</sup> Fishing boats <sup>(3)</sup> Pilot boats <sup>(4)</sup> Fast yachts <sup>(4)</sup> Pleasure craft <sup>(4)</sup>	250 to 1000	Up to 30%	8%	Minimal full engine load and rpm

(1) Heavy-duty service

(2) The vessel must be slowed frequently for locks, sandbars and curves.

(3) Typically, examples of these boats move fast for cruising from the harbor and to the harbor: crayfish boats, lobster boats, and tuna boats

(4) Typically, examples of these boats move fast for cruising from the harbor and to the harbor with low load factors.

i00899220

## Marine Classification Society Certification Requirements

**SMCS Code:** 1000

The major seafaring nations have established technical groups called marine classification societies. Caterpillar Inc. has maintained standards and quality under the guidelines that are set forth by the 14 major marine classification societies that are listed. For more information, refer to Engine Data Sheet, 103.1 and Engine Data Sheet, 103.1.1 in the Caterpillar Technical Manual.

**ABS** – American Bureau of Shipping (USA)

**BV** – Bureau Veritas (France)

**CCG** – Canadian Coast Guard (Canada)

**CCRS** – China Corporation Register of Shipping (Taiwan)

**CCS** – China Classification Society (China)

**CR** – Croatian Register of Shipping (Croatia)

**DnV** – Det norske Veritas (Norway)

**GL** – Germanischer Lloyd (Germany)

**KR** – Korean Register of Shipping (Korea)

**LR** – Lloyd's Register of Shipping (Great Britain)

**NK** – Nippon Kaiji Kyokai (Japan)

**PR** – Polish Register (Poland)

**RINa** – Registro Italiano Navale (Italy)

**RS** – Maritime Register of Shipping (Russia)



# Engine Performance and Performance Analysis Report (PAR)

i01044073

## Engine Performance

**SMCS Code:** 1000

Today's marine operator is concerned with performance, cost of operation and satisfactory engine life. Traditionally, poor performance of the vessel is believed to result from a lack of engine performance or from a loss of engine performance. In fact, the engine is only one of numerous factors that influence the overall performance of a vessel.

Several factors determine the power demand on an engine. The engine does not have control over the demand that is caused by the vessel design. The vessel design includes the following features:

- Hull
- Propeller
- Drive train

Those features also affect the amount of power that is available to perform additional work. For example, those features affect the power that is used to drive an auxiliary pump.

If a problem with the performance of the vessel occurs, consider the following effects on power demand:

- Loads
- Condition of the vessel
- Vessel design
- Condition of the drive train
- Condition of the propeller

Deterioration of the engine systems decreases the ability of the engine to produce power and vessel speed. Engine systems include the cooling system, the lubrication system, the fuel system, etc. The engine is not likely to be the cause of poor fuel economy without excessive exhaust smoke and/or the loss of power.

If you have a valid problem with the engine's performance, consult an authorized Caterpillar dealer for assistance.

If the engine is covered by a warranty, the Caterpillar warranty will cover the cost in order to solve a valid deficiency of the engine's performance. However, if the engine is not at fault, all costs that are incurred will be the responsibility of the owner.

**Note:** Adjustment of the fuel system outside Caterpillar specified limits will not improve fuel efficiency. Adjustment of the fuel system outside Caterpillar specified limits could also result in damage to the engine.

Caterpillar engines are manufactured with state-of-the-art technology. Caterpillar engines are designed to help provide two characteristics in all applications:

- Maximum performance
- Fuel efficiency

To ensure optimum performance for the service life of the engine, follow the recommended operation procedures that are described in this manual. Also, follow the preventive maintenance procedures that are described in this manual.

## Performance Analysis Report (PAR)

To verify the condition of the propulsion system, Caterpillar has developed the Performance Analysis Report (PAR) for marine engines.

A PAR is an in-vessel test procedure that is performed by a Caterpillar analyst under operating conditions. The test compares the performance of all marine engine systems to the original testing specifications.

When a PAR is conducted at Sea Trial, an installation of high quality can be ensured. The PAR will confirm the matching of the following components for optimum performance and for fuel efficiency: hull, rudders, propeller, marine transmission, ventilation, and cooling systems.

Caterpillar recommends scheduling a PAR in order to maintain optimum performance.

A periodic PAR can define deterioration of the propulsion system. A PAR can assist in repairs, in overhauls, and in maintenance schedules. This will help to provide the most economical, efficient cost of operation.

## Customer Service

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## Customer Assistance

**SMCS Code:** 1000; 4450

### 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 Caterpillar dealers. If you have a problem that has not been handled to your complete satisfaction, follow these steps:

1. Discuss your problem with a manager from the dealership.
2. If your problem cannot be resolved at the dealer level without additional assistance, use the phone number that is listed below to talk with a Field Service Coordinator:

1-800-447-4986

The normal hours are from 8:00 to 4:30 Monday through Friday Central Standard Time.

3. If your needs have not been met still, submit the matter in writing to the following address:

Caterpillar Inc.  
Marine Center of Excellence  
Manager, Customer Service  
111 Southchase Blvd  
Fountain Inn, SC 29644

Please keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership's facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

### Outside of the USA and of Canada

If a problem arises outside the USA and outside Canada, and if the problem cannot be resolved at the dealer level, consult the appropriate Caterpillar office.

Latin America, Mexico, Caribbean  
Caterpillar Americas Co.  
701 Waterford Way, Suite 200  
Miami, FL 33126-4670  
USA  
Phone: 305-476-6800  
Fax: 305-476-6801

Europe, Africa, and Middle East  
Caterpillar Overseas S.A.  
76 Route de Frontenex  
P.O. Box 6000  
CH-1211 Geneva 6  
Switzerland  
Phone: 22-849-4444  
Fax: 22-849-4544

Far East  
Caterpillar Asia Pte. Ltd.  
7 Tractor Road  
Jurong, Singapore 627968  
Republic of Singapore  
Phone: 65-662-8333  
Fax: 65-662-8302

China  
Caterpillar China Ltd.  
37/F., The Lee Gardens  
33 Hysan Avenue  
Causeway Bay  
G.P.O. Box 3069  
Hong Kong  
Phone: 852-2848-0333  
Fax: 852-2848-0440

Japan  
Shin Caterpillar Mitsubishi Ltd.  
SBS Tower  
10-1, Yoga 4-Chome  
Setagaya-Ku, Tokyo 158-8530  
Japan  
Phone: 81-3-5717-1150  
Fax: 81-3-5717-1177

Japan  
Caterpillar Power Systems, Inc.  
SBS Tower (14th floor)  
4-10-1, Yoga  
Setagaya-Ku, Tokyo 158-0097  
Phone: 81-3-5797-4300  
Fax: 81-3-5797-4359

Australia and New Zealand  
Caterpillar of Australia Ltd.  
1 Caterpillar Drive  
Private Mail Bag 4  
Tullamarine, Victoria 3043  
Australia  
Phone: 03-9953-9333  
Fax: 03-9335-3366

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## Customer Assistance

**SMCS Code:** 1000; 4450

**S/N:** B5G1-Up

**S/N:** MRG1-Up

**S/N:** PAG1-Up

**S/N:** MKH1-Up

## 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 Caterpillar dealers. If you have a problem that has not been handled to your complete satisfaction, follow these steps:

1. Discuss your problem with a manager from the dealership.
2. If your problem cannot be resolved at the dealer level without additional assistance, use the phone number that is listed below to talk with a Field Service Coordinator:

1-800-447-4986

The normal hours are from 8:00 to 4:30 Monday through Friday Central Standard Time.

3. If your needs have not been met still, submit the matter in writing to the following address:

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

Please keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership's facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

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Latin America, Mexico, Caribbean  
 Caterpillar Americas Co.  
 701 Waterford Way, Suite 200  
 Miami, FL 33126-4670  
 USA  
 Phone: 305-476-6800  
 Fax: 305-476-6801

Europe, Africa, and Middle East  
 Caterpillar Overseas S.A.  
 76 Route de Frontenex  
 P.O. Box 6000  
 CH-1211 Geneva 6  
 Switzerland  
 Phone: 22-849-4444  
 Fax: 22-849-4544

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 Jurong, Singapore 627968  
 Republic of Singapore  
 Phone: 65-662-8333  
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 Japan  
 Phone: 81-3-5717-1150  
 Fax: 81-3-5717-1177

Japan  
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 SBS Tower (14th floor)  
 4-10-1, Yoga  
 Setagaya-Ku, Tokyo 158-0097  
 Phone: 81-3-5797-4300  
 Fax: 81-3-5797-4359

Australia and New Zealand  
 Caterpillar of Australia Ltd.  
 1 Caterpillar Drive  
 Private Mail Bag 4  
 Tullamarine, Victoria 3043  
 Australia  
 Phone: 03-9953-9333  
 Fax: 03-9335-3366

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## Ordering Replacement Parts

SMCS Code: 4450; 7567

### WARNING

When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout the world. Caterpillar dealers' parts inventories are up-to-date. The parts stocks include all of the parts that are normally needed to protect your Caterpillar engine investment.

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

If there is a question concerning the part number, please provide your dealer with a complete description of the needed item.

When a Caterpillar engine requires maintenance and/or repair, provide the dealer with all the information that is stamped on the Information Plate. This information is described in this Operation and Maintenance Manual (Product Information Section).

Discuss the problem with the dealer. Inform the dealer about the conditions of the problem and the nature of the problem. Inform the dealer about when the problem occurs. This will help the dealer in troubleshooting the problem and solving the problem faster.

## On-Board Replacement Parts

SMCS Code: 7567

The various Marine Classification Societies require a supply of replacement parts on vessels that are primarily powered by diesel engines. The replacement parts may be needed for making repairs offshore or at remote ports. The types of replacement parts and the numbers of parts depends on the range of the vessel. The following two categories of vessels are considered:

**Category 1** – This category includes vessels that make short trips between ports.

**Category 2** – This category includes vessels in ocean service that is unrestricted. The vessels may travel far from ports that provide service. The list of replacement parts for this category is more extensive.

Table 43 lists the parts that are recommended by Caterpillar for vessels in both categories.

The requirements of individual Marine Classification Societies may differ. Table 44 lists the requirements of all the Marine Classification Societies. Additionally, some items that are recommended by Caterpillar are listed. All of the parts that are listed in Table 43 and 44 are recommended for vessels in Category 2. To customize this list for your specific engine application, consult your Caterpillar dealer.

Table 43

Replacement Parts for Vessels in Category 1 and Category 2	
Quantity	Item
4	Air cleaner element
1	Alternator belt
1	Electronic control module (ECM)
1	Electronic unit injector
-	Engine oil
-	Extended Life Coolant (ELC) and Extender or Diesel Engine Antifreeze/Coolant (DEAC) and Supplemental Coolant Additive (SCA)
4	Fuel filter elements
1	Fluid sampling bottles
-	Liquid gasket material
4	Engine oil filters
1	Service kit (electronic connector)
4	Water temperature regulators

(continued)

(Table 43, contd)

Replacement Parts for Vessels in Category 1 and Category 2	
Quantity	Item
4	Zinc rods

Table 44

Replacement Parts for Vessels in Category 2		
System	Quantity	Item
Camshaft and crankshaft	1	Bolt (crankshaft to flywheel)
	1	Camshaft gear
	1	Crankshaft gear
	1	Idler gear and balance weight gear assembly (water pump)
	1	Shaft and thrust washer (idler gear and balance weight gear assembly)
Cooling	1	Aftercooler core and gasket
	1	Auxiliary water pump
	1	Jacket water pump
	4	Water temperature regulator
Cylinder head	6	Bolt and washer
	1	Bolt and nut (exhaust manifold)
	1	Cylinder head assembly
	4	Gasket (cylinder)
	-	Water seals for one cylinder
Fuel	3	Electronic unit injector
	1	Fuel transfer pump
	3	Seal (electronic unit injector)
Inlet air	2	Air cleaner element
Lubrication	1	Bypass valve (oil cooler)
	1	Bypass valve (oil filter)
	1	Gasket (oil pan)
	1	Oil cooler core (engine)
	1	Oil cooler core (marine gear)
Miscellaneous	1	Gasket kit (engine)

(continued)

(Table 44, contd)

Replacement Parts for Vessels in Category 2			
System	Quantity	Item	
Piston	1	Connecting rod assembly	
	1	Connecting rod bearing	
	1	Cylinder liner	
	1	Filler band (cylinder liner)	
	1	Main bearing	
	2	Cap bolt and washer (main bearing)	
	1	Piston assembly	
	1	Piston pin	
	2	Piston pin retainer	
Starting	1	Starting motor	
	Turbocharger	1	Complete turbocharger
		4	Gasket
		4	Locknut
		4	Stud (mounting)
	Valves	6	Exhaust valves
		4	Inlet valves
		10	Valve guides
24		Valve locks	
10		Valve rotators	
10	Valve springs		

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## Reference Materials

- Maintenance log

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## Maintenance Records

**SMCS Code:** 1000; 4450

Caterpillar Inc. recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for a variety of other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is well managed. Accurate maintenance records can help your Caterpillar dealer to fine tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

**Fuel Consumption** – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

**Service Hours** – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

**Documents** – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs
- Owner's receipts



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## Reference Material

**SMCS Code:** 1000; 4450

The following publications can be obtained from any Caterpillar dealer.

### Lubricants

- Data Sheet, NEHP6015, "Special Purpose Grease (SPG) Bearing Lubricant"
- Data Sheet, PEHP0002, "Multipurpose Lithium Complex Grease with Molybdenum (MPGM)"
- Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"
- Special Publication, PEDP7036, "S-O-S Fluid Analysis Cornerstone"
- Special Publication, SEBD0640, "Oil and Your Engine"

### Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

### Coolants

- Data Sheet, PEHP7057, "Coolant Analysis"
- Special Publication, PEDP7036, "S-O-S Fluid Analysis"
- Special Publication, SEBD0518, "Know Your Cooling System"
- Special Publication, SEBD0970, "Coolant and Your Engine"

### Miscellaneous

- Disassembly and Assembly, SENR6564, "3500B Series II Marine Engines"
- Electrical Schematic, RENR5010, "3500B Series II Marine Propulsion Engines"
- Engine Data Sheet, LEKM6749, "Marine Classification Society Approved Ratings"
- Module, SENR9620, "Improving Fuel System Component Durability"

- Parts Manual, SEBP3909, "3500B Series II Marine Engines (S2D)"
- Parts Manual, SEBP3910, "3500B Series II Marine Engines (S2E)"
- Parts Manual, SEBP3911, "3500B Series II Marine Engines (S2F)"
- Parts Manual, SEBP3914, "3500B Series II Marine Engines (S2J)"
- Parts Manual, SEBP3915, "3500B Series II Marine Engines (S2K)"
- Parts Manual, SEBP3916, "3500B Series II Marine Engines (S2L)"
- Parts Manual, SEBP3917, "3500B Series II Marine Engines (S2M)"
- Parts Manual, SEBP3918, "3500B Series II Marine Engines (S2N)"
- Parts Manual, SEBP3921, "3500B Series II Marine Engines (S2S)"
- Parts Manual, SEBP3922, "3500B Series II Marine Engines (S2T)"
- Parts Manual, SEBP3923, "3500B Series II Marine Engines (S2W)"
- Parts Manual, SEBP3924, "3500B Series II Marine Engines (S2X)"
- Parts Manual, SEBP3925, "3500B Series II Marine Engines (S2Y)"
- Parts Manual, SEBP4030, "3500B Series II Marine Engines (MKH)"
- Parts Manual, SEBP4031, "3500B Series II Marine Engines (MRG)"
- Parts Manual, SEBP4032, "3500B Series II Marine Engines (PAG)"
- Parts Manual, SEBP4033, "3500B Series II Marine Engines (B5G)"
- Service Manual, RENR5075, "3500B Series II Marine Engines"
- Special Instruction, SEHS7332, "Do Not Operate Tag"
- Special Instruction, SEHS7633, "Battery Test Procedure"



- Special Publication, LEBM0189, "Marine Power Display Operator's Guide"
- Special Publication, LEDM5615, "Caterpillar Marine Parts and Service Locations"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Publication, NENG2500, "Tools and Shop Products Guide"
- Special Publication, PECP9067, "One Safe Source"
- Special Publication, PEDP7035, "Optimizing Oil Change Intervals"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"
- Special Publication, SEBF8062, "Guideline for Reusable Parts - Cleaning and Inspection of Air Filters"
- Special Publication, SEBF8146, "Visual Inspection of Camshaft"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"
- Specifications, RENR5077, "3500B Series II Marine Engines"
- Specifications, SENR3130, "Torque Specifications"
- Supplement, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"
- System Operations, RENR5078, "Testing and Adjusting", "3500B Series II Marine Engines"
- Troubleshooting Guide, RENR5009, "3500B Series II Marine Engines"

## Additional Reference Material

The "Engine Fluids Data Book" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult EMA at the following address:

Engine Manufacturers Association  
Two North LaSalle Street, Suite 2200  
Chicago, Illinois, USA 60602  
E-mail: [ema@enginemanufacturers.org](mailto:ema@enginemanufacturers.org)  
(312) 827-8700  
Facsimile: (312) 827-8737

The "Society of Automotive Engineers (SAE) Specifications" can be found in your SAE handbook. This publication can also be obtained from the following locations: local technological society, local library, and local college. If necessary, consult SAE at the following address:

SAE International  
400 Commonwealth Drive  
Warrendale, PA, USA 15096-0001  
Telephone: (724) 776-4841

The "American Petroleum Institute Publication No. 1509" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult API at the following address:

American Petroleum Institute  
1220 L St. N.W.  
Washington, DC, USA 20005  
Telephone: (202) 682-8000

The International Organization for Standardization (ISO) offers information and customer service regarding international standards and standardizing activities. ISO can also supply information on the following subjects that are not controlled by ISO: national standards, regional standards, regulations, certification, and related activities. Consult the member of ISO in your country.

International Organization for Standardization (ISO)  
1, rue de Varembe  
Case postale 56  
CH-1211 Genève 20  
Switzerland  
Telephone: +41 22 749 01 11  
Facsimile: +41 22 733 34 30  
E-mail: [central@iso.ch](mailto:central@iso.ch)  
Web site: <http://www.iso.ch>

European classifications are established by the Conseil International Des Machines a Combustion (CIMAC) (International Council on Combustion Engines).

CIMAC Central Secretariat  
Lyoner Strasse 18  
60528 Frankfurt  
Germany  
Telephone: +49 69 6603 1567  
Facsimile: +49 69 6603 1566

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## **Emissions Warranty Information**

**SMCS Code:** 1000

This engine may be certified to comply with exhaust emission standards and the engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to emissions certified engines is found in Supplement, SMBU6981, "Federal Emissions Control Warranty Information For U.S., Canada, and California". Consult your authorized Caterpillar dealer in order to determine if your engine is emissions certified and if the engine is subject to an Emissions Warranty.

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## **Warranty Information**

**SMCS Code:** 1000

### **Engine Protection Plans**

#### **Extended Warranties and Service Contracts**

A wide variety of protection plans are available for Caterpillar Engines. Consult your Caterpillar dealer for detailed information on the specific programs and coverages that are available.

Consult your Caterpillar dealer for information on a plan that is tailored in order to fit your requirements.

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# Product and Dealer Information

**Note:** For product identification plate locations, see the section "Product Identification Information" in the Operation and Maintenance Manual.

Delivery Date: \_\_\_\_\_

## Product Information

Model: \_\_\_\_\_

Product Identification Number: \_\_\_\_\_

Engine Serial Number: \_\_\_\_\_

Transmission Serial Number: \_\_\_\_\_

Generator Serial Number: \_\_\_\_\_

Attachment Serial Numbers: \_\_\_\_\_

Attachment Information: \_\_\_\_\_

Customer Equipment Number: \_\_\_\_\_

Dealer Equipment Number: \_\_\_\_\_

## Dealer Information

Name: \_\_\_\_\_ Branch: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Dealer Contact

Phone Number

Hours

Sales: \_\_\_\_\_

Parts: \_\_\_\_\_

Service: \_\_\_\_\_

