

Operation and Maintenance Manual

3208 Marine Engine

75V1-Up (Engine)
01Z1-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 "WARNING" as 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. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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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

Warning Signs and Labels

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SMCS Code: 1000; 7405

There may be several specific warning signs on an engine. The exact location of the hazards and the description of the hazards are reviewed in this section. Please become familiar with all warning signs.

Ensure that all of the warning signs are legible. Clean the warning signs or replace the warning signs if the words cannot be read or if the pictures are not visible. When the warning signs are cleaned, use a cloth, water, and soap. Do not use solvent, gasoline, or other harsh chemicals to clean the warning signs. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the warning signs. The warning signs that are loosened could drop off of the engine.

Replace any damaged warning signs or missing warning signs. If a warning sign is attached to a part of the engine that is replaced, install a new warning sign on the replacement part. Any Caterpillar dealer can provide new warning signs.

WARNING

Do not operate or work on this engine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could result in injury or death. Contact any Caterpillar dealer for replacement manuals. Proper care is your responsibility.

The warning labels that may be found on the engine are illustrated and described below.

Battery

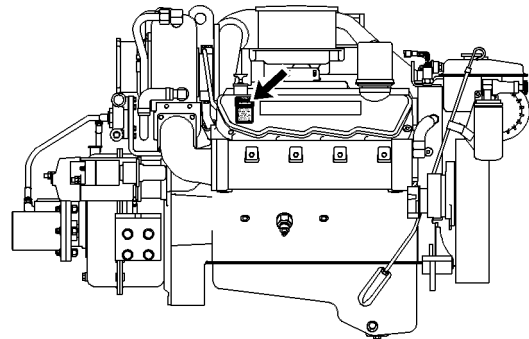
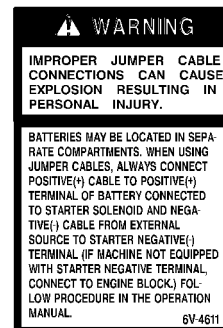


Illustration 1

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The warning label for the battery should be installed on the side of the engine or in a visible location near the batteries. If the batteries are located on both sides of the package, the warning label should be located on both sides of the engine.



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WARNING

Improper jumper cable connections can cause an explosion resulting in personal injury.

Batteries may be located in separate compartments. When you are using jump start cables, always connect the positive “+” cable to the positive “+” terminal of the battery that is connected to the starter solenoid. Connect the negative “-” cable from the external source to the negative “-” terminal of the starter. If the engine is not equipped with a negative “-” terminal on the starter, connect the negative “-” cable from the external source to the engine block. Follow the procedure in this Operation and Maintenance Manual.

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General Hazard Information

SMCS Code: 1000; 7405

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.

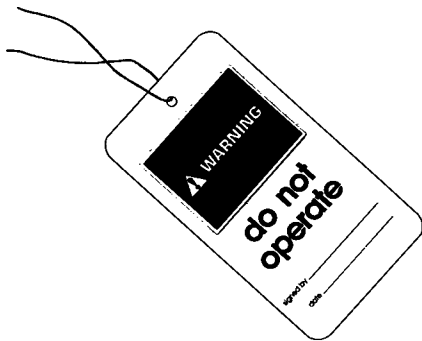


Illustration 2

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Do not allow unauthorized personnel on the engine or around the engine when the engine is 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:

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

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

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.

- 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.
- The protective locks or the controls are in the applied position.
- 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 or any adjustments to the engine while the engine is operating.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- For initial start-up of a new engine or for starting an engine that has been serviced, make provisions to stop the engine if an overspeed occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Start the engine from the operator’s position or from the control panel that is in the local engine room.

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 is used for cleaning, wear a protective face shield, protective clothing, and protective shoes.

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

Always wear eye protection for cleaning the cooling system.

Fluid Penetration

Always use a board or cardboard when the engine components are checked for leaks. Leaking fluid that is under pressure can cause serious injury or possible death. This includes leaks that are the size of a pin hole.

If fluid is injected into the skin, seek treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

Fluid Spillage

Care must be used in order to ensure that the fluids are contained during the inspection, the maintenance, the testing, the adjusting, and the repair of the engine. Make provision to collect the fluid with a suitable container before any compartment is opened or before any component is disassembled. Refer to the Special Publication, NENG2500. This publication explains the items that are needed for collecting and for containing fluids that are used in Caterpillar engines. Dispose of fluids according to local regulations.

Asbestos Information

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 any replacement parts that contain asbestos or debris that contains asbestos are handled.

The asbestos in these components is usually sealed or bonded in a resin. Handling these materials normally is not hazardous unless airborne dust that contains asbestos is generated.

Do not inhale dust that might be generated when components that contain asbestos fibers are handled. Inhaling this dust can be hazardous to your health.

If dust which may contain asbestos is present, follow these guidelines:

- Never use compressed air for cleaning.
- Avoid abrasion of materials that contain asbestos.

- Use a wet method to clean up asbestos debris. A vacuum cleaner that is equipped with a high efficiency particulate air filter can also be used.
- Use exhaust ventilation when parts that contain asbestos are machined.
- 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 USA, use the Occupational Safety and Health Administration requirements. These OSHA requirements can be found in "29 CFR 1910.1001".
- Obey environmental regulations for disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

Lines, Tubes, and Hoses

Do not bend or strike high pressure lines. Do not install lines, tubes, or hoses that are damaged.

Repair any fuel lines, oil lines, tubes, or hoses that are loose or damaged. Leaks can cause fires.

Inspect all lines, tubes and hoses carefully. Do not use bare hands to check for leaks. Always use a board or cardboard for checking engine components for leaks. 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
- Wire that is exposed in reinforced hose
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

Ensure that all of the clamps, the guards, and the heat shields are installed correctly. This will help to prevent the following items: vibration, rubbing against other parts, and excessive heat during operation.

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Burn Prevention

SMCS Code: 1000; 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 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. When pressure is relieved rapidly, the hot coolant can turn into steam.

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 only after the engine has been stopped.

Do not step on the engine in order to remove the filler cap. Use a ladder, if necessary. Ensure that the filler cap is cool before removing the filler cap. 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 components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Keep all of the exhaust manifold and turbocharger shields in place in order to protect components from oil spray if there is a failure of a line, a tube, or a seal.

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.

Batteries give off combustible gases which can explode. Ensure proper ventilation for batteries that are in an enclosure. 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 to ignite. Do not smoke when batteries are serviced.

Always thaw a frozen battery before jump starting the battery. Frozen batteries can explode.

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Fire Prevention and Explosion Prevention

SMCS Code: 1000; 7405

Fire may result from lubricating oil or from fuel that is sprayed on hot surfaces. Fire may cause personal injury and property damage. Inspect all lines and tubes for wear or for deterioration. The lines must be routed, supported, or clamped securely. Tighten all connections to the recommended torque. Leaks can cause fires.

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

If the application involves the presence of combustible gases, consult your Caterpillar dealer in order to obtain additional information concerning suitable protection devices.

Leaking fuel or fuel that is spilled onto hot surfaces or onto electrical components can cause a fire.

All fuels, most lubricants, and some coolant mixtures are flammable. Diesel fuel is flammable. Gasoline is flammable. The mixture of diesel fumes and gasoline fumes is extremely explosive.

Do not smoke while the engine is refueled. Do not smoke in the refueling area.

Store all fuels and all lubricants in properly marked containers. Store the protective containers in a safe place.

Do not smoke in battery charging areas. Batteries give off flammable fumes which can explode.

Do not smoke in areas that contain flammable material.

Store oily rags and other flammable material in protective containers.

Do not weld on pipes or tubes that contain flammable fluids. Do not flame cut pipes or tubes that contain flammable fluids. Before pipes or tubes are welded or flame cut, clean the inside and clean the outside of the pipes or tubes thoroughly with nonflammable solvent.

Do not allow flammable materials to accumulate on the engine.

Do not expose the engine to flames.

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.

Dispose of oil according to local regulations. Oil filters and fuel filters must be properly installed. The housing covers must be tightened to the proper torque when the housing covers are reinstalled.

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.

When the engine is started from an external source, always connect the positive "+" jump start cable to the positive "+" terminal of the battery of the engine that is being started. Make this connection before the negative "-" jump start cable is connected.

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 operated. See the Operation and Maintenance Manual for specific starting instructions.

Wiring must be kept in good condition, properly routed, and securely attached. Routinely inspect the wiring for wear or for deterioration. Loose wiring, unattached wiring, or unnecessary wiring must be eliminated. All wires and all cables must be of the recommended gauge. The wires and cables must be connected to a fuse or to a circuit breaker, if necessary. Do not bypass fuses and/or circuit breakers. Do not use a wire of a smaller gauge. Arcing or sparking could cause a fire. Secure connections, recommended wiring, and properly maintained battery cables will help to prevent arcing or sparking.

Fire Extinguisher

Ensure 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. Service the fire extinguisher according to the recommendations on the instruction plate.

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Crushing Prevention and Cutting Prevention

SMCS Code: 1000; 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 (if equipped). The fan blades will throw objects and the fan blades can 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; 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 are climbing. Use a hand line or other means for carrying equipment up to the work area.

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Before Starting Engine

SMCS Code: 1000

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.

Ensure that the engine is equipped with a lighting system that is suitable for the conditions. Ensure that all lights work properly.

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.

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

See the Service Manual for repairs and for adjustments.

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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 39 °C (102 °F).

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

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Engine Stopping

SMCS Code: 1000

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.

Uncontrolled electrical circuit paths can result in damage to main bearings, to crankshaft 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 and 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 common ground connections.

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Electrical System

SMCS Code: 1000; 1400

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 the Operation and Maintenance Manual 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.

Product Information Section

Model Views

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Model View Illustrations

SMCS Code: 1000

The following model views show typical 3208 Marine Engine features. Due to individual applications, your engine may appear different from the illustrations.

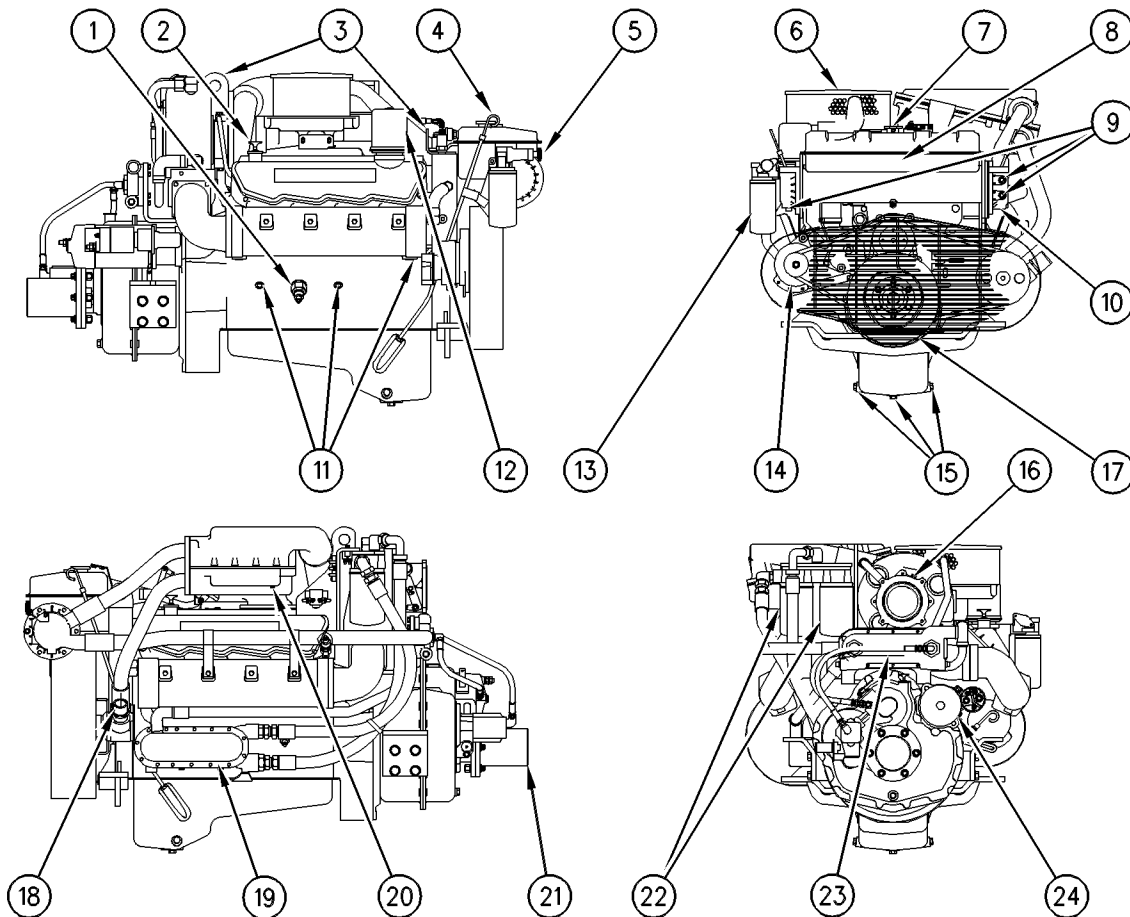


Illustration 3

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- | | | |
|---------------------------------|--------------------------------|-------------------------------------|
| (1) Jacket water heater element | (9) Zinc rods | (17) Crankshaft vibration damper |
| (2) Oil filler | (10) Heat exchanger drain | (18) Auxiliary water pump |
| (3) Lifting eye | (11) Jacket water drain plug | (19) Engine oil cooler |
| (4) Oil level gauge | (12) Engine crankcase breather | (20) Aftercooler drain |
| (5) Fuel priming pump | (13) Secondary fuel filter | (21) Companion flange |
| (6) Engine air cleaner element | (14) Alternator | (22) Oil filters |
| (7) Cooling system filler cap | (15) Oil drain plug | (23) Marine transmission oil cooler |
| (8) Heat exchanger | (16) Exhaust | (24) Starting motor |

i00885764

Engine Description

SMCS Code: 1000

The Caterpillar 3208 Marine Engine is available for applications in pleasure craft with planing hulls, patrol boats, pilot boats, harbor master vessels, customs, police boats, fire boats, yachts with displacement hulls, ferries, and fishing boats. The engines can be mounted with various marine gears (transmissions) for vessel propulsion.

The 3208 Marine Engine provides the following features:

- Mechanical fuel system
- Eight cylinders
- Two valves per cylinder
- Four stroke cycle
- Direct Injection

The 3208 Marine Engine is available in the following configurations:

- Direct Injection Naturally Aspirated (DINA)
- Direct Injection Turbocharged (DIT)
- Direct Injection Turbocharged Aftercooled (DITA) with Separate Circuit Aftercooler (SCAC)

Engine Specifications

Note: The front end of the engine is opposite the flywheel end of the engine. The left and the right sides of the engine are determined from the flywheel end. The number 1 cylinder is the left front cylinder.

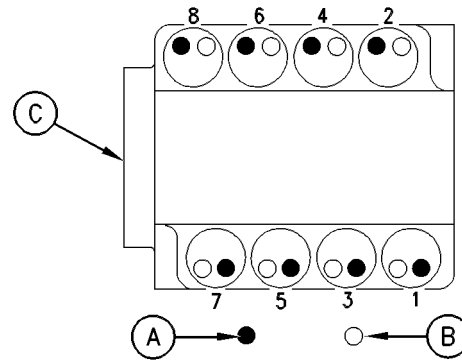


Illustration 4

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Cylinder and valve locations

- (A) Inlet valve
- (B) Exhaust valve
- (C) Flywheel

Table 1

| 3208 Marine Engine Specifications | |
|-----------------------------------|---------------------------------|
| Cylinders and Arrangement | 8 cylinder vee block |
| Bore | 114.3 mm (4.5 inch) |
| Stroke | 127 mm (5.0 inch) |
| Compression Ratio | 16.5:1 or 15.5:1 ⁽¹⁾ |
| Displacement | 10.4 L (636 in ³) |
| Firing Order | 1-2-7-3-4-5-6-8 |
| Rotation (flywheel end) | Counterclockwise |
| Valve Lash Setting (Inlet) | 0.38 mm (.015 inch) |
| Valve Lash Setting (Exhaust) | 0.64 mm (.025 inch) |

⁽¹⁾ 435 hp engine arrangement

Engine Features

Inlet Air and Fuel System

The fuel ratio control, which is located on the governor, restricts the movement of the fuel rack. The fuel ratio control minimizes exhaust smoke by allowing only the proper amount of fuel to be injected into the cylinders during acceleration.

Inlet air is filtered by an air cleaner and compressed by a turbocharger (if equipped) before entering the cylinders. The turbocharger is driven by the engine exhaust. There is one inlet valve and one exhaust valve per cylinder. The camshaft actuates the rocker arms and valves through mechanical lifters and pushrods.

Cooling System

The jacket water cooling system uses an expansion tank and a belt driven water pump. The engine coolant is circulated through the engine in two parallel paths. One path begins at the engine oil cooler and passes through the water cooled turbocharger (if equipped) and the exhaust manifold before returning to the water pump. The other path circulates the coolant through the cylinder block and the cylinder head before returning the coolant to the water pump.

Two water temperature regulators restrict the coolant flow for quick engine warm-up. The water temperature regulators open in order to allow free circulation of the coolant after the operating temperature has been reached. The water cooled exhaust manifolds and the water cooled turbocharger (if equipped) are designed to minimize radiated heat in the engine room.

Lubrication System

The engine lubricating oil, that is supplied by a gear type pump, is cooled. The engine lubricating oil is also filtered. Bypass valves provide unrestricted flow of lubrication oil to the engine components during the following conditions:

- High oil viscosity
- Plugged oil cooler
- Plugged oil filter elements (paper cartridge)

Several manufacturers offer marine transmissions through local distributors. Lubrication oil for the marine transmission is cooled by an engine mounted transmission oil cooler.

Engine Service Life

Engine efficiency and maximum utilization of engine performance depend on the adherence to proper operation and maintenance recommendations. In addition, use recommended fuels, coolants and lubricants. Use this Operation and Maintenance Manual as a guide for required engine maintenance.

Expected engine life is generally predicted by the average power demand, which is based on fuel consumption of the engine over a period of time. Reduced hours of operation at full throttle and/or operating at reduced throttle settings result in a lower average power demand. This will increase the length of operating time before an engine overhaul is required. See the Operation and Maintenance Manual, "Overhaul Considerations" topic for more information.

Product Identification Information

i00061495

Information Plate

SMCS Code: 1000

Engine Identification

i00671956

SMCS Code: 1000

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 that is 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.

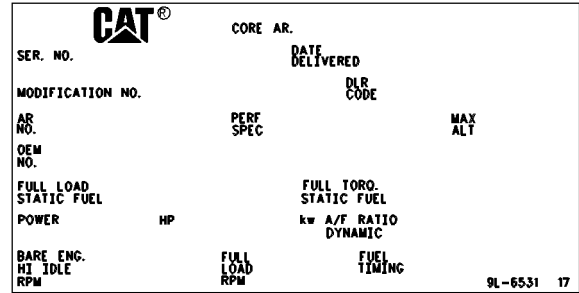


Illustration 6

g00102789

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

Serial Number Plate

i00995225

SMCS Code: 1000

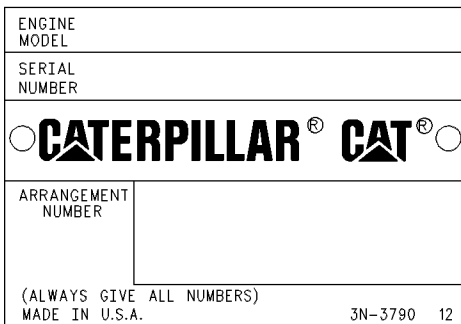


Illustration 5

g00123229

Typical serial number plate

The Serial Number Plate is located on the top center of the cylinder block at the front of the engine.

The following information is stamped on the Serial Number Plate:

- Serial number
- Engine model
- Arrangement number

Reference Numbers

SMCS Code: 1000

Information for the following items may be needed to order parts for your marine engine. Locate the information for your engine. Record the information on the appropriate space. Make a copy of this list for a record. Keep this information for future reference.

Record for Reference

Engine Model _____

Engine Serial Number _____

Engine Arrangement Number _____

Modification Number _____

Engine Low Idle rpm _____

Engine Full Load rpm _____

Performance Specification Number _____

Primary Fuel Filter Number _____

Water Separator Element Number _____

Secondary Fuel Filter Element Number _____

Lubrication Oil Filter Element Number _____

i00845105

Auxiliary Oil Filter Element Number _____

Supplemental Coolant Additive Maintenance Element
Number (Optional) _____

Total Lubrication System Capacity _____

Total Cooling System Capacity _____

Air Cleaner Element Number _____

Alternator Belt Number _____

Operation Section

Towing Information

i00872651

Marine Towing

SMCS Code: 1000

The vessel should be towed under the following conditions:

- The vessel is disabled.
- The vessel can not continue to maneuver.

During towing, the propeller of a vessel will rotate through the water. This rotation is called back driving.

NOTICE

Rotation of the propeller shaft without proper lubrication for long periods of time will damage the propeller shaft bearings. If pressurized oil cannot be supplied to the propeller shaft bearings while the vessel is being towed, the propeller shaft must be secured in order to help prevent shaft rotation.

NOTICE

Reverse rotation of the propeller shaft can cause engine damage. To help prevent reverse rotation of the propeller, secure the propeller. Lock the propeller shaft, when possible.

Towing Procedure

Under the following conditions, back driving is permitted for most marine transmissions:

- The towing speed does not exceed the normal maximum propulsion speed of the vessel that is being towed.
- The marine transmission must be properly lubricated.

Intermittent Back Driving

Perform the following procedure for short sailboat auxiliary trips, and for towing purse boats in seining operations.

1. Ensure that the marine transmission is in NEUTRAL while the vessel is being towed.

2. Place the marine transmission in NEUTRAL and start the engine for at least three minutes. Perform this procedure during every 24 hours.
3. Maintain the marine transmission oil at one of the following levels:
 - a. Maintain the marine transmission oil at the normal propulsion level.
 - b. Maintain the oil level at the "FULL" mark.

Continuous Back Driving

For these continuous back driving circumstances, perform the following procedure for song sailboat auxiliary trips, for delivering a vessel by towing, and for towing a vessel home on a trip that will last more than one day.

1. Ensure that the marine transmission is in NEUTRAL while the vessel is being towed.
2. Place the marine transmission in NEUTRAL and start the engine for at least three minutes. Perform this procedure during every 12 to 14 hours.
3. Maintain the marine transmission oil level to the input shaft on the centerline of the engine.

Securing the Propeller

There are several ways to help prevent the propeller shaft from rotating. The correct method depends on the turning force of the propeller and the construction of the propeller shaft tunnel. Use the method that is best suited for the vessel.

To minimize the force on the propeller, tow the vessel at a slow speed.

Wrapping the Propeller Shaft

1. On small vessels, wrap a heavy rope around the propeller shaft.

Note: The number of wraps that are needed will depend upon the mass of the propeller and the mass of the propeller shaft.

2. Secure the rope in the opposite direction of the shaft rotation.

Securing the Companion Flange

1. Remove one or more bolts from the coupling on the companion flange.
2. Bolt a chain to the companion flange.

3. Wrap the chain several times around the propeller shaft.
4. Secure the loose end of the chain at a right angle to the propeller shaft. Secure the chain in the opposite direction of the shaft rotation.

Engine Lifting and Storage

i00117672

Engine Lifting

SMCS Code: 1000; 1122

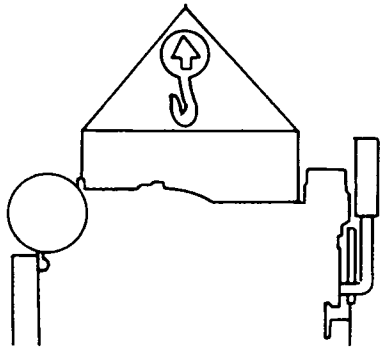


Illustration 7

g00103219

NOTICE

When it is necessary to remove a component, remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees. Eyebolts and brackets should never be bent and should only be loaded in tension.

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 and in order to provide safe handling.

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.

Engine and Marine Transmission Lifting

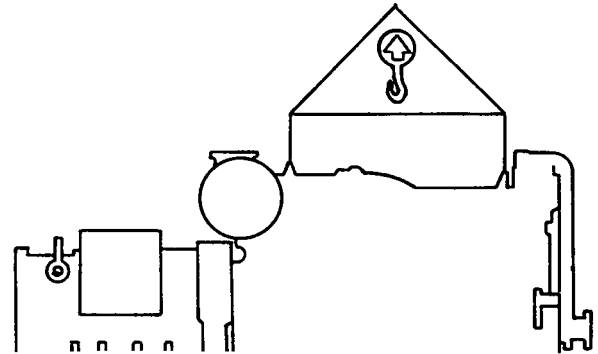


Illustration 8

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.

i00994205

Engine Storage

SMCS Code: 1000

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder 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, “General Coolant Information” 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

i00995942

Gauges and Indicators

SMCS Code: 1900; 7450

Your engine may not have the same gauges or all of the gauges that are described. For more information about the gauge package, see the vessel's literature from the OEM.

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over a period of time.

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

NOTICE

Be ready to activate the engine shutoff manually, if there is no oil pressure. Damage to the engine will result if the engine continues to run without the correct oil pressure.



Engine Oil Pressure – Typical oil pressure for this engine at rated speed with SAE 10W30 or with SAE 15W40 is 345 to 600 kPa (50 to 87 psi).

A lower oil pressure is normal at low idle. If the load is stable and the gauge reading changes, perform the following procedure:

1. Remove the load.
2. Reduce engine speed to low idle.
3. Check the oil level. Maintain the oil level at the proper amount.



Engine Oil Temperature – This gauge indicates the engine oil temperature. Maximum oil temperature at rated speed with a full load is 116 °C (240 °F).



Jacket Water Coolant Temperature – Typical temperature range is 77 to 91 °C (170 to 195 °F). The maximum allowable temperature with the pressurized cooling system is 99 °C (210 °F). Higher temperatures may occur under certain conditions. The water temperature reading may vary according to load. The reading should never exceed the boiling point for the pressurized system that is being used.

If the engine is operating above the normal range and steam becomes apparent, perform the following procedure:

1. Reduce the load and 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.



Tachometer – This gauge indicates engine rpm. When the throttle control lever is moved to the full throttle position without load, the engine is running at high idle. The engine is running at the full load rpm when the throttle control lever is at the full throttle position with maximum rated load.

NOTICE

Engine overspeed may cause serious damage.

Keep the tachometer indicator in the green operating range.

Note: The high idle rpm and the full load rpm are stamped on the Information Plate.



Ammeter – This gauge indicates the amount of charge or of discharge in the battery charging circuit. Operation of the indicator should be to the right side of “0” (zero).



Service Hour Meter – This gauge indicates the total number of clock hours that the engine has operated.



Fuel Pressure – This gauge indicates fuel pressure to the fuel injection pump. The indicator should indicate the “NORMAL” range. Minimum fuel pressure is 140 kPa (20 psi) when the engine is under load. A decrease in fuel pressure may indicate a plugged fuel filter.

Engine Features and Controls

Engine Shutoffs and Engine Alarms

i01007515

SMCS Code: 1900; 7400; 7418

Shutoffs

Shutoffs and alarms are electrically operated or mechanically operated. The operation of all electric shutoffs and alarms utilize components which actuate switches in a sensing unit.

Shutoffs are set at critical levels for the following items: operating temperature, operating pressure, operating level, and operating rpm. The particular shutoff may need to be reset before the engine will start.

NOTICE

Always determine the cause of the engine shutdown. Make necessary repairs before attempting to restart the engine.

Be familiar with the following items:

- Types and locations of shutoff
- Conditions which cause each shutoff to function
- The resetting procedure that is required to restart the engine

Alarms

Alarms consist of a switch and a contactor. The switches are wired to the contactors. The contactors activate alarm circuits in an annunciator panel. Your engine may be equipped with the following switches:

Engine oil pressure – The engine oil pressure switch indicates when oil pressure drops below rated system pressure.

Coolant level – The low coolant level switch indicates when the coolant level is low.

Coolant temperature – The coolant temperature switch indicates high jacket water coolant temperature.

Note: The sensing element of the coolant temperature switch must be submerged in coolant in order to operate.

Engines may be equipped with alarms in order to alert the operator when undesirable operating conditions occur.

NOTICE

When an alarm is activated, corrective measures must be taken before the situation becomes an emergency in order to avoid possible engine damage.

If corrective measures are not taken within a reasonable time, engine damage could result. The alarm will continue until the condition is corrected. The alarm may need to be reset.

A switch may be installed in the alarm while the engine is stopped for repairs. Before the engine is started, ensure that the switch is moved to the ON position and that the warning lights are flashing. The engine will not be protected if the switch is left in the OFF position.

Testing the Shutoff and Alarm System

Most control panels are equipped with a lamp test switch. Turn the switch to the ON position in order to check the indicator lights for proper operation. Replace defective bulbs immediately.

NOTICE

During testing, abnormal operating conditions must be simulated. Perform the tests correctly in order to help prevent possible engine damage.

Refer to the Service Manual for more information on testing procedures or consult your Caterpillar dealer.

Engine Starting

i00074447

Before Starting Engine

SMCS Code: 1000; 1400; 1450

Perform the required daily maintenance and other periodic maintenance before the engine is started. Inspect the engine compartment. This inspection can help prevent major repairs at a later date. Refer to the Operation and Maintenance Manual for more information.

- For the maximum service life of the engine, make a thorough inspection before starting the engine. Look for the following items: oil leaks, coolant leaks, loose bolts, and trash buildup. Remove trash buildup and arrange for repairs, as needed.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the alternator and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn wires or frayed wires.
- Check the fuel supply. Drain water from the water separator (if equipped). Open the fuel supply valve.

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.

If the engine has not been run for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air space will be left in the housing. In these instances, prime the fuel system. Refer to the Operation and Maintenance Manual for more information on priming the fuel system.

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.

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

- Ensure that the areas around the rotating parts are clear.
- All of the guards must be put in place. Check for damaged guards or for missing guards. Repair any damaged guards. Replace damaged guards and/or missing guards.
- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor (if equipped) is engaged. Check electrical cables and check the battery for poor connections and for corrosion.
- Reset any of the shutoff components or alarm components.
- Check the engine lubrication oil level. Maintain the oil level between the “ADD” mark and the “FULL” mark on the oil level gauge.
- Check the coolant level. Observe the coolant level in the coolant recovery bottle (if equipped). Maintain the coolant level to the “FULL” mark on the coolant recovery bottle.
- If the engine is not equipped with a coolant recovery bottle, maintain the coolant level within 13 mm (.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level in the sight glass.
- Observe the air cleaner service indicator (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.
- Open the valve for the sea water on the engine jacket water heat exchanger (if equipped).
- Place the marine transmission in NEUTRAL.

i00881449

Starting the Engine

SMCS Code: 1000; 1450

This start procedure may be used for all engines that are not equipped with an air inlet heater regardless of ambient temperature.

Refer to the Owner’s Manual of the OEM for your type of controls. Use the following procedure to start the engine.

1. Place the transmission in NEUTRAL. Disengage the flywheel clutch in order to allow the engine to start faster. This also reduces the draining of the battery.

2. Move the throttle to the low idle position in order to move the fuel rack to the Fuel-On position.
3. Turn the ignition switch to the ON position.

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.

4. Push the start button or turn the ignition switch to the START position in order to crank the engine. If the engine fails to start within 30 seconds, release the start button, or the ignition switch. Wait for two minutes in order to allow the starting motor to cool before attempting to start the engine again.

Note: If the engine does not start after a few attempts, move the throttle in order to shut off the fuel. Continue cranking the engine for ten seconds. This will clear the cylinders of fuel.

5. As soon as the engine starts, release the start button, or the ignition switch.

NOTICE

Oil pressure should rise within 15 seconds after the engine starts. Do not increase engine rpm until the oil pressure gauge indicates normal. If oil pressure is not indicated on the gauge within 15 seconds, DO NOT operate the engine. STOP the engine, investigate and correct the cause.

6. Allow the engine to idle for approximately five minutes. Idle the engine until the water temperature gauge has begun to rise. Check all gauges during the warm-up period.

Note: Oil pressures and fuel pressures should be in the normal range on the instrument panel, if equipped. Do not apply a load to the engine or increase engine rpm until the oil pressure gauge indicates at least normal pressure. Inspect the engine for leaks and/or unusual noises.

i00881569

Cold Weather Starting

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

Refer to the Owner's Manual of the OEM for your type of controls. Use the following procedure to start the engine.

WARNING

DO NOT USE ETHER (starting fluids) unless specifically instructed to do so. If the engine is equipped with an Air Inlet Heater (electrically or fuel ignited manifold heater), DO NOT use ether (starting fluids) at any time. The use could result in engine damage and/or personal injury.

Startability will be improved at temperatures below 0 °C (32 °F) from the use of a jacket water heater or from other means that are used to heat the crankcase oil. This will help reduce white smoke and misfire during start-up in cold weather. Additional batteries or extra battery capacity may be required in order to start the engine at colder temperatures.

Note: Consult your Caterpillar dealer before installing an oil heater. Immersion oil heaters are NOT recommended for heating of the engine oil.

NOTICE

When using ether (starting fluid), follow the manufacturer's instructions carefully, use it sparingly and spray it only while cranking the engine. Excessive ether can cause piston and ring damage. Use ether (starting fluid) for cold weather starting purposes only.

For engines that are not equipped with an Air Inlet Heater, use ether when temperatures are below 0 °C (32 °F). If the engine is equipped with an injection system for starting fluid, crank the engine. Depress the ether switch for three seconds. Additional injections may be necessary in order to start the engine.

Note: If the engine has not been run for several weeks, fuel may have drained. Air may have moved into the filter housing. Also, when fuel filters have been changed, some air will be left in the filter housing. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" topic for more information.

1. Place the transmission in NEUTRAL. Disengage the flywheel clutch in order to allow the engine to start faster. This also reduces draining of the battery.
2. Move the throttle to the low idle position in order to move the fuel rack to the Fuel-On position.
3. Turn the ignition switch to the ON position.

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.

4. Push the start button or turn the ignition switch to the START position in order to crank the engine. If the engine fails to start within 30 seconds, release the start button, or the ignition switch. Wait for two minutes in order to allow the starting motor to cool before attempting to start the engine again.

Note: If the engine does not start after a few attempts, move the throttle in order to shut off the fuel. Continue cranking the engine for ten seconds. This will clear the cylinders of fuel.

5. As soon as the engine starts, release the start button, or the ignition switch.
-

NOTICE

Oil pressure should rise within 15 seconds after the engine starts. Do not increase engine speed until the oil pressure gauge indicates normal. If oil pressure is not indicated on the gauge within 15 seconds, DO NOT operate the engine. STOP the engine, investigate and correct the cause.

6. Allow the engine to idle for approximately five minutes. Idle the engine until the water temperature gauge has begun to rise. Check all gauges during the warm-up period.

Note: Oil pressures and fuel pressures should be in the normal range on the instrument panel, if equipped. Do not apply a load to the engine or increase engine rpm until the oil pressure gauge indicates at least normal pressure. Inspect the engine for leaks and/or unusual noises.

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.

If the installation is not equipped with a backup battery system, it may be necessary to start the engine from an external electrical source.

First, determine the reason that it is necessary to start with power from an external source. Refer to Special Instruction, SEHS7768, "Use of the 6V-2150 Starting/Charging Analyzer".

Many batteries which are considered unusable are still rechargeable. After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be charged to the proper voltage with a battery charger. For information on testing and charging, refer to the Special Instruction, SEHS7633, "Battery Test Procedure".

NOTICE

Using a battery source with the same voltage as the electric starting motor. Use ONLY equal voltage for jump starting. The use of higher voltage will damage the electrical system.

Do not reverse the battery cables. The alternator can be damaged. Attach ground cable last and remove first.

When using an external electrical source to start the engine, turn the engine control switch to the "OFF" position. Turn all all electrical accessories OFF before attaching the jump start cables.

Ensure that the main power switch is in the OFF position before attaching the jump start cables to the engine being started.

1. Turn the start switch on the stalled engine to the OFF position. Turn off all accessories.

2. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.
3. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting combustible gases that are produced by some batteries.
4. Charge the batteries. The engine will not continue to run after starting if the batteries have not been charged.
5. Start the engine.
6. Immediately after the stalled engine is started, disconnect the jump start cables in reverse order.

Refer to the Electrical Schematic for your engine.
Consult your Caterpillar dealer for more information.

After Starting Engine

SMCS Code: 1000

Note: In temperatures from 0 to 60 °C (32 to 140 °F), the warm-up time is approximately five minutes. In temperatures below 0 °C (32 °F), additional warm-up time may be required.

1. Operate the engine at low idle rpm for five minutes. Perform these checks during the warm-up:
 - Check for any fluid leaks and any air leaks.
 - Check all the gauges.

Observe the gauges and record the data frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. This will also help detect abnormal operating developments. Investigate any significant changes in the readings.

2. After the engine has idled for five minutes and the inspections have been made, increase the engine speed to 1/2 rated rpm.

NOTICE

To avoid engine overheating and possible engine damage, ensure that water discharge is visible at the sea water outlet and/or the water flow is not restricted.

If the water flow is restricted and/or water discharge is not visible at the sea water outlet, follow the recommended procedure.

-
3. Observe the water discharge at the sea water outlet. If water discharge is not visible or the water flow is restricted, perform the following procedure:
 - a. Stop the engine immediately.
 - b. Inspect the inlet screen and the sea water strainer for debris. Remove any debris that is found.
 - c. Inspect the cooling system and the auxiliary water pumps for evidence of leaks.
 4. Check for any fluid leaks and any air leaks.
 5. Perform any necessary repairs before operating the engine.
 6. After the inspections have been made, move the throttle control to the idle position and proceed with operation.

Engine Operation

i00879167

i00718869

Engine Operation

SMCS Code: 1000

Proper operation and maintenance are key factors in obtaining the maximum life and economy of the engine. If the directions in the Operation and Maintenance Manual are followed, costs can be minimized and engine service life can be maximized.

The time that is needed for the engine to reach normal operating temperature can be less than the time needed for a walk-around inspection of the engine.

After the engine is started and after the engine reaches normal operating temperature, the engine can be operated at the rated rpm. The engine will reach normal operating temperature faster when the engine is at rated speed. The engine will reach normal operating temperature faster when the engine is at low power demand. This procedure is more effective than idling the engine at no load. The engine should reach operating temperature in a few minutes.

Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

Engine and Marine Transmission Operation

SMCS Code: 1022

Transmission Selector Lever

Power is transferred from the engine through the marine transmission to the propeller shaft. The marine transmissions can be operated by using one of the following methods:

- Mechanical
- Hydraulic
- Pneumatic
- Electrical

A control valve directs the flow of oil to the forward clutch or to the reverse clutch. The control valve is operated by a transmission selector lever. The transmission selector lever can be manually operated or remotely operated.

Normally, the marine transmission is operated from the pilot house. The controls of the pilot house must be adjusted in order to permit full travel of the transmission selector lever. This will also permit full engagement of the clutch plates.

When the remote controls are properly adjusted, periodic clutch adjustment is not required.

Moving and Getting Underway

For the best performance and the maximum service life, shift the transmission in the following manner:

1. Fully engage the marine transmission selector lever in the desired direction of travel.
2. Wait for at least three seconds in order to allow the clutch to engage completely before increasing the rpm of the engine.
3. Gradually increase engine rpm.

NOTICE

Operate the marine transmission controls **ONLY** with the engine running. A rotating propeller shaft with an engaged clutch is not lubricated sufficiently when the engine is not running, and may be damaged.

i00076753

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. As necessary, repair the fuel lines.

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

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

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

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

- Ensure that the belts are properly adjusted. The belt should be in good condition.
- 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 energy of 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.

Cruising Speed

The recommended cruising speed is 300 rpm to 400 rpm below the rated rpm of the engine.

Operating at the recommended cruising speed will help to provide the maximum engine service life and the most economical operation.

i00076738

Full Load Operation

SMCS Code: 1000

Move the throttle control to full rpm. An engine can operate at full rpm for long periods of time if the engine is rated for continuous operation. The risk of engine damage can be minimized if the installation meets the guidelines for the vessel.

Trolling

SMCS Code: 1022

Note: Refer to the Operation and Maintenance Manual for additional information.

The trolling valve is an attachment to the marine transmission. The trolling valve operates only in the forward direction. Refer to the OEM recommendations for the marine transmission for the limits of the engine rpm during trolling.

Note: Engine rpm and the marine transmission oil temperature must be within the limits that are specified by the OEM manufacturer of the marine transmission.

It may be acceptable to mark the tachometer and the oil temperature gauges at the trolling limits. Proper monitoring of the tachometer and oil temperature gauges is required in order to help prevent overheating of the clutch plates.

Trolling at reduced load for several hours may cause excessive oil consumption and carbon buildup in the combustion chamber. This buildup results in poor engine performance and power loss. Load the engine at full rpm in order to burn the carbon from the combustion chamber. Perform this procedure at four hour intervals during service.

Follow the OEM recommendations for operating attachments to marine transmissions for trolling.

Docking or Reversing Travel Direction

SMCS Code: 1022

NOTICE

Do not shift across the NEUTRAL position without a few seconds delay. The engine torque must be able to overcome the propeller and drive inertia, the marine transmission inertia, and the propeller slip stream torque.

A direct through-shift will cause severe shock loads to the engine, marine transmission and hull. Also, it can cause the engine to reverse its rotation (run backwards). If the engine reverses rotation, the engine and marine transmission oil pumps will be running opposite normal rotation. Oil will not reach the bearings, and severe engine damage will occur.

When reversing direction of travel (propeller rotation), reduce engine rpm to low idle. Place the transmission selector lever in the NEUTRAL position for approximately three seconds to allow the clutch plates to completely disengage and the propeller to stop turning. Move the transmission selector lever to the other direction and allow three seconds for the clutch to become fully engaged before increasing engine rpm.

1. Reduce engine rpm to a low idle.
2. Move the transmission selector lever to the NEUTRAL position. Wait for three seconds so that the clutch plates will disengage and the propeller will stop turning.
3. Move the transmission selector lever to the engaged position. Wait for at least three seconds so that the clutch will completely engage before the engine rpm is increased. The rotation of the marine transmission should not be changed at full engine rpm. To help prevent the propeller from stalling or reversing the engine's rotation, gradually increase engine rpm.

Stopping the Vessel Temporarily

Use the following procedure for a temporary stop while the engine is running:

1. Reduce engine rpm to low idle.
2. Shift the marine transmission to the NEUTRAL position.

- 3.** To resume travel, shift into the FORWARD position or the REVERSE position at low idle. Wait for at least three seconds so that the clutch will completely engage before the engine rpm is increased. Gradually increase the engine rpm.

Engine Stopping

i00176657

Emergency Stopping

SMCS Code: 1000; 7418

NOTICE

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

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

Emergency Stop Button

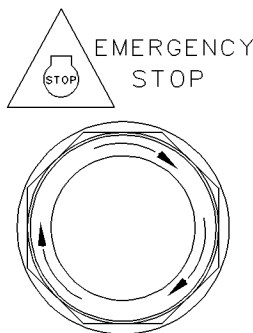


Illustration 9

g00104303

Typical emergency stop button

The emergency stop button is in the OUT position for normal engine operation. Push the emergency stop button. The engine will not start when the button is locked. Turn the button clockwise in order to reset.

NOTICE

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

If the engine has been operating at high rpm and/or high loads, run at low idle for at least three minutes to reduce and stabilize internal engine temperature before stopping the engine.

Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

Manual Stop Procedure

SMCS Code: 1000

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.

Allow the engine to gradually cool before stopping the engine

There may be several ways to shut off your engine. Make sure that the shutoff procedures are understood. Use the following general guidelines for stopping the engine:

1. Reduce engine rpm to low idle.
2. Shift into the NEUTRAL position.
3. Follow one of the following steps, as recommended.
 - a. If the engine has been operated at low loads, run the engine at low idle for 30 seconds before you stop the engine.
 - b. If the engine has been operated at high load, increase engine rpm to no more than 1/2 rated rpm for three to five minutes.

This reduces coolant temperatures and oil temperatures. A reduction in these temperatures stabilizes internal engine coolant and oil temperatures. Then reduce the engine rpm to low idle before stopping.

4. Check the marine transmission oil level while the engine is idling. Maintain the oil level between the "ADD" and "FULL" marks on the "CHECK WITH ENGINE RUNNING" side of the dipstick.
5. The engine may be stopped by using one of the following engine mounted controls.

Toggle Switch

Move the toggle switch to the "OFF" position in order to shut off the fuel shutoff solenoid.

Manual Fuel Shutoff (If Equipped)

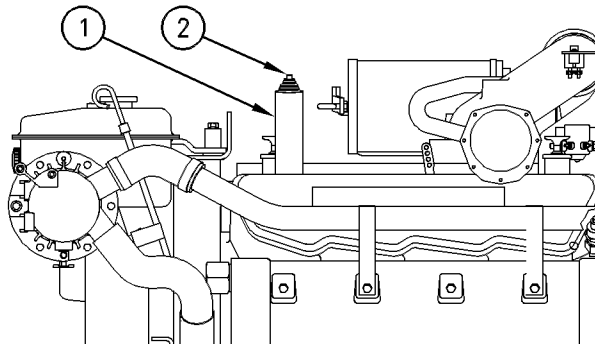


Illustration 10

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Fuel Shutoff Solenoid

- (1) Fuel shutoff solenoid
- (2) Button for manual fuel shutoff

All engines are equipped with a fuel shutoff solenoid. Fuel shutoff solenoid (1) is located on the top front of the engine. The button for manual fuel shutoff (2) (if equipped) is located on the fuel shutoff solenoid. Press the button for the manual fuel shutoff. This will stop the fuel delivery to the engine. The engine will coast to a stop.

Note: Take great care to secure any external components that are used to support the engine operation.

After Stopping Engine

SMCS Code: 1000

- Check the crankcase oil level. Maintain the oil level between the “ADD” mark and the “FULL” mark on the oil level gauge.
- If necessary, repair any leaks, perform minor adjustments or tighten loose bolts.
- Note the service hour meter reading. Perform the maintenance that is in the Operation and Maintenance Manual.
- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

NOTICE

Only use antifreeze/coolant mixtures recommended in the Coolant Specifications of this manual. Failure to do so can cause engine damage.

- Allow the engine to cool. Check the coolant level. Maintain the cooling system at 13 mm (.5 inch) from the bottom of the pipe for filling. The cooling system can also be maintained between the “COLD FULL” mark and the “LOW ADD” mark on the coolant recovery bottle (if equipped).
- If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture, if necessary.
- If freezing temperatures are expected, drain the keel cooling system (if equipped).
- Perform all required periodic maintenance on all driven equipment. This maintenance is outlined in the instructions from the OEM.

Cold Weather Operation

i00891918

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250

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 that the engine will be operated. 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 Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations".

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Fuel Related Components in Cold Weather

SMCS Code: 1000; 1250

Fuel Tanks

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

Fuel tanks should contain some 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.

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.

Drain the water and sediment from any fuel storage tank at the following intervals: weekly, oil changes, and refueling of the fuel tank. This will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

Fuel Filters

It is possible that a primary fuel filter is installed between the fuel tank and the engine fuel inlet. After changing the fuel filter, always prime the fuel system in order to remove air bubbles from the fuel system. Refer to the Operation and Maintenance Manual in the Maintenance Section for more information on priming the fuel system.

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 fine enough or low enough in order to protect the fuel transfer pump. A primary filter that is fine or a primary filter that has a low micron rating can be plugged by wax crystals more easily in cold weather.

Note: Refer to the Parts Manual for this engine in order to determine the part numbers that are required for the fuel filters.

Fuel Heaters

Fuel heaters help to prevent fuel filters from plugging in cold weather due to waxing. A fuel heater should be installed so that the fuel is heated before the fuel enters the primary fuel filter.

Select a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also help to prevent overheating of the fuel. High fuel temperatures reduce engine performance and the availability of engine power. Choose a fuel heater with a large heating surface. The fuel heater should be practical in size. Small heaters can be too hot due to the limited surface area.

Disconnect the fuel heater in warm weather.

Note: Fuel heaters that are controlled by the water temperature regulator or self-regulating fuel heaters should be used with this engine. Fuel heaters that are not controlled by the water temperature regulator can heat the fuel in excess of 65°C (149°F). A loss of engine power can occur if the fuel supply temperature exceeds 37°C (100°F).

Note: Heat exchanger type fuel heaters should have a bypass provision in order to prevent overheating of the fuel in warm weather operation.

The following fuel heaters are recommended for use with Caterpillar engines:

- 7C-3557 Fuel Heater Group
- 7C-3558 Heater Kit

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

Maintenance Section

Torque Specifications

Standard Torque for Inch Fasteners

SMCS Code: 7553

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Table 2

General Torque Information

SMCS Code: 7553



WARNING

Mismatched or incorrect fasteners can result in damage or malfunction, or possible injury.

Take care to avoid mixing metric dimensioned fasteners and inch dimensioned fasteners.

Exceptions to these torques are given in the Service Manual, if necessary.

Prior to installation of any hardware, ensure that components are in near new condition. Bolts and threads must not be worn or damaged. Threads must not have burrs or nicks. Hardware must be free of rust and corrosion. Clean the hardware with a noncorrosive cleaner. Do not lubricate the fastener threads except for the rust preventive. The rust preventive should be applied by the supplier of that component for purposes of shipping and storage. Other applications for lubricating components may also be specified in the Service Manual.

| Inch Nuts and Bolts | |
|---------------------|-----------------------------------|
| Thread Size Inch | Standard Torque |
| 1/4 | 12 ± 3 N·m (9 ± 2 lb ft) |
| 5/16 | 25 ± 6 N·m (18 ± 4 lb ft) |
| 3/8 | 47 ± 9 N·m (35 ± 7 lb ft) |
| 7/16 | 70 ± 15 N·m (50 ± 11 lb ft) |
| 1/2 | 105 ± 20 N·m (75 ± 15 lb ft) |
| 9/16 | 160 ± 30 N·m (120 ± 22 lb ft) |
| 5/8 | 215 ± 40 N·m (160 ± 30 lb ft) |
| 3/4 | 370 ± 50 N·m (275 ± 37 lb ft) |
| 7/8 | 620 ± 80 N·m (460 ± 60 lb ft) |
| 1 | 900 ± 100 N·m (660 ± 75 lb ft) |
| 1 1/8 | 1300 ± 150 N·m (960 ± 110 lb ft) |
| 1 1/4 | 1800 ± 200 N·m (1320 ± 150 lb ft) |
| 1 3/8 | 2400 ± 300 N·m (1780 ± 220 lb ft) |
| 1 1/2 | 3100 ± 350 N·m (2280 ± 260 lb ft) |

Table 3

| Inch Taperlock Studs | |
|----------------------|----------------------------------|
| Thread Size Inch | Standard Torque |
| 1/4 | 8 ± 3 N·m (6 ± 2 lb ft) |
| 5/16 | 17 ± 5 N·m (13 ± 4 lb ft) |
| 3/8 | 35 ± 5 N·m (26 ± 4 lb ft) |
| 7/16 | 45 ± 10 N·m (33 ± 7 lb ft) |
| 1/2 | 65 ± 10 N·m (48 ± 7 lb ft) |
| 5/8 | 110 ± 20 N·m (80 ± 15 lb ft) |
| 3/4 | 170 ± 30 N·m (125 ± 22 lb ft) |
| 7/8 | 260 ± 40 N·m (190 ± 30 lb ft) |
| 1 | 400 ± 60 N·m (300 ± 44 lb ft) |
| 1 1/8 | 525 ± 60 N·m (390 ± 44 lb ft) |
| 1 1/4 | 750 ± 80 N·m (550 ± 60 lb ft) |
| 1 3/8 | 950 ± 125 N·m (700 ± 90 lb ft) |
| 1 1/2 | 1200 ± 150 N·m (880 ± 110 lb ft) |

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i00623412

Standard Torque for Metric Fasteners

SMCS Code: 7553

Table 4

| Metric Nuts and Bolts | |
|-----------------------|-----------------------------------|
| Thread Size Metric | Standard Torque |
| M6 | 12 ± 3 N·m (9 ± 2 lb ft) |
| M8 | 28 ± 7 N·m (21 ± 5 lb ft) |
| M10 | 55 ± 10 N·m (41 ± 7 lb ft) |
| M12 | 100 ± 20 N·m (75 ± 15 lb ft) |
| M14 | 160 ± 30 N·m (120 ± 22 lb ft) |
| M16 | 240 ± 40 N·m (175 ± 30 lb ft) |
| M20 | 460 ± 60 N·m (340 ± 44 lb ft) |
| M24 | 800 ± 100 N·m (590 ± 75 lb ft) |
| M30 | 1600 ± 200 N·m (1180 ± 150 lb ft) |
| M36 | 2700 ± 300 N·m (2000 ± 220 lb ft) |

Table 5

| Metric Taperlock Studs | |
|------------------------|----------------------------------|
| Thread Size Metric | Standard Torque |
| M6 | 8 ± 3 N·m (6 ± 2 lb ft) |
| M8 | 17 ± 5 N·m (13 ± 4 lb ft) |
| M10 | 35 ± 5 N·m (26 ± 4 lb ft) |
| M12 | 65 ± 10 N·m (48 ± 7 lb ft) |
| M16 | 110 ± 20 N·m (80 ± 15 lb ft) |
| M20 | 170 ± 30 N·m (125 ± 22 lb ft) |
| M24 | 400 ± 60 N·m (300 ± 44 lb ft) |
| M30 | 750 ± 80 N·m (550 ± 60 lb ft) |
| M36 | 1200 ± 150 N·m (880 ± 110 lb ft) |

Standard Torque for Worm Drive Band Hose Clamps

SMCS Code: 7553; 7554

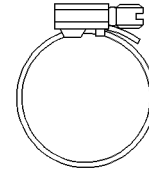


Illustration 11

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Table 6

| Width of Clamp | Initial Installation Torque On New Hose |
|--------------------|---|
| 7.9 mm (.31 inch) | 0.9 ± 0.2 N·m (8 ± 2 lb in) |
| 13.5 mm (.53 inch) | 4.5 ± 0.5 N·m (40 ± 4 lb in) |
| 15.9 mm (.63 inch) | 7.5 ± 0.5 N·m (65 ± 4 lb in) |
| Width of Clamp | Reassembly or Retightening Torque |
| 7.9 mm (.31 inch) | 0.7 ± 0.2 N·m (6 ± 2 lb in) |
| 13.5 mm (.53 inch) | 3.0 ± 0.5 N·m (27 ± 4 lb in) |
| 15.9 mm (.63 inch) | 4.5 ± 0.5 N·m (40 ± 4 lb in) |

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Standard Torque for Constant Torque Hose Clamps

SMCS Code: 7553; 7554

Use a constant torque hose clamp in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard hose clamp. Due to extreme temperature changes, the hose will heat set. Heat setting can cause hose clamps to loosen. Loose hose clamps can result in leaks. There have been reports of component failures that have been caused by hose clamps that have loosened. The constant torque hose clamp will help prevent these failures.

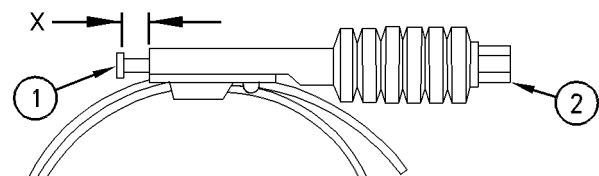


Illustration 12

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Use a torque wrench for proper installation of the constant torque hose clamps. The constant torque hose clamp is installed correctly under the following conditions:

- Screw tip (1) extends 6.35 mm (.250 inch) (X) beyond the housing.
- The belleville washers are collapsed nearly flat after screw (2) is tightened to a torque of 11 ± 1 N·m (98 ± 9 lb in).

Lubricant Specifications

i00998503

Lubricant Information

SMCS Code: 1000; 1300; 7581

API Authorized Oils

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

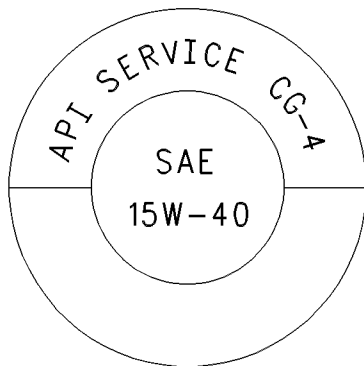


Illustration 13

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Typical API symbol

Diesel engine oils CD, CD-2, and CE have not been API authorized categories since 1 January 1996. Table 7 summarizes the status of the categories.

Table 7

| Current | Obsolete |
|---------------------------------|---------------------|
| CF-4, CG-4, CH-4 ⁽¹⁾ | CE |
| CF | CC, CD |
| CF-2 ⁽²⁾ | CD-2 ⁽²⁾ |

⁽¹⁾ CH-4 oil does not have a license for the API oil classification. Oils that were developed for the CH-4 classification are currently available in North America. However, oil companies cannot display CH-4 within the API symbol. A license from the API is anticipated in 1999. At that time, the oil companies will be allowed to list API CH-4 inside of the API symbol.

⁽²⁾ CD-2 and CF-2 are categories for two-cycle diesel engines. Caterpillar does not sell engines that utilize CD-2 and CF-2 oils.

Note: CF is not the same classification as CF-4. API CF oils are only recommended for Caterpillar engines with Precombustion Chamber fuel systems (PC).

Grease

The classifications of grease are based on the "ASTM D2718 68" worked penetration characteristics. These characteristics for grease are given a defined consistency number.

Terminology

Certain abbreviations follow the nomenclature of "SAE J754". Some classifications follow "SAE J183" abbreviations. Definitions that differ from Caterpillar definitions will assist the customer when lubricants are purchased. Recommended oil viscosities can be found in the Operation and Maintenance Manual, "Engine Oil" (Maintenance Section).

i00998525

Engine Oil

SMCS Code: 1300; 1348; 7581

Caterpillar Diesel Engine Oil

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

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

- **Caterpillar Diesel Engine Oil (10W30)**
- **Caterpillar Diesel Engine Oil (15W40)**

Caterpillar multigrade Diesel Engine Oil is formulated with the correct amounts of detergents, dispersants, and alkalinity in order to provide superior performance in Caterpillar Diesel Engines.

Caterpillar multigrade Diesel Engine Oil is available in two grades of viscosity (10W30 and 15W40). To choose the correct grade for the ambient temperature, see Table 8. Multigrade oils provide the correct viscosity for a broad range of operating temperatures.

Multigrade oils are effective in maintaining low oil consumption and low levels of piston deposits.

Caterpillar multigrade Diesel Engine Oil can be used in other diesel engines and in gasoline engines. See the engine manufacturer's guide for the recommended specifications. Compare the specifications to the specifications of Caterpillar multigrade Diesel Engine Oil. The current industry standards for Caterpillar Diesel Engine Oil are listed on the product label and on the data sheets for the product.

Consult your Caterpillar dealer for part numbers and for available sizes of containers.

Commercial Oils

The performance of commercial diesel engine oils are based on classifications that were created by the American Petroleum Institute (API). These API classifications are developed in order to provide commercial lubricants for a broad range of diesel engines that operate in various conditions.

If Caterpillar multigrade Diesel Engine Oil is not used, only use commercial oils that meet the following classifications:

- CH-4 multigrade oil
- API CG-4 multigrade oil
- API CF-4 multigrade oil

The following explanations of these API classifications can be used to make the proper choice when a commercial oil is chosen:

CG-4 and CH-4 – CG-4 and CH-4 oils can be used in Caterpillar diesel engines that are recommended to use CF-4 oils.

In comparison to CF-4 oils, CG-4 and CH-4 oils provide improvements in the following performance:

- Cleanliness of the crankcase
- Cleanliness of the pistons
- Soot dispersancy
- Viscosity control

CH-4 – CH-4 oils were developed in order to meet the requirements of the new high performance diesel engines. Also, the oil was designed to meet the requirements of the low emissions diesel engines. CH-4 oils are also acceptable for use in older diesel engines and in diesel engines that use high sulfur diesel fuel. CH-4 oils may be used in Caterpillar engines that use CG-4 and CF-4 oils. CH-4 oils will generally exceed the performance of CG-4 oils in the following critical areas: deposits on pistons, control of oil consumption, wear of piston rings, valve train wear, viscosity control, and corrosion.

Three new engine tests were developed for the CH-4 oil. The first test specifically evaluates deposits on pistons for engines with the two-piece steel piston. This test (piston deposit) also measures the control of oil consumption. A second test is conducted with moderate oil soot. The second test measures the following criteria: wear of piston rings, wear of cylinder liners, and resistance to corrosion. A third new test measures the following characteristics with high levels of soot in the oil: wear of the valve train, resistance of the oil in plugging the oil filter, and control of sludge.

In addition to the new tests, CH-4 oils have tougher limits for viscosity control in applications that generate high soot. The oils also have improved oxidation resistance. CH-4 oils must pass an additional test (piston deposit) for engines that use aluminum pistons (single piece). Oil performance is also established for engines that operate in areas with high sulfur diesel fuel.

All of these improvements allow the CH-4 oil to achieve optimum oil change intervals. CH-4 oils are recommended for use in extended oil change intervals. CH-4 oils are recommended for conditions that demand a premium oil. Your Caterpillar dealer has specific guidelines for optimizing oil change intervals.

Note: CH-4 oil does not have a license for the API oil classification. Oils that were developed for the CH-4 classification are currently available in North America. However, oil companies cannot display CH-4 within the API symbol. A license from the API is anticipated in 1999. At that time, the oil companies will be allowed to list API CH-4 inside of the API symbol.

CG-4 oils were developed primarily for diesel engines that use a .05 percent level of fuel sulfur. However, CG-4 oils can be used with higher sulfur fuels. The TBN of the new oil determines the maximum fuel sulfur level for CG-4 and CF-4 oils. See Illustration 14.

CG-4 oils were the first oils that passed the industry standard tests for foam control and viscosity shear loss. CG-4 oils must also pass tests that were developed for corrosion and wear.

CF-4 – These oils service a wide variety of modern diesel engines. CF-4 oils provide more stable oil control and reduced piston deposits in comparison to the obsolete API CE oils. CF-4 oils provide improved soot dispersancy in comparison to API CF and obsolete CD oils. The API CF-4 classification was developed with a 0.40 percent sulfur diesel fuel. This represents the type of diesel fuels that are commonly available worldwide.

Some commercial oils that meet the API CG-4 and CF-4 classifications may require reduced oil change intervals. To determine the oil change interval, closely monitor the condition of the oil and perform a wear metal analysis. Caterpillar’s S·O·S oil analysis program is the preferred method.

NOTICE

Failure to follow these oil recommendations can cause shortened engine service life due to deposits and/or excessive wear.

Total Base Number (TBN) and Fuel Sulfur Levels for Direct Injection Engines

The Total Base Number (TBN) for an oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the minimum TBN must be 10 times the fuel sulfur level. The TBN is determined by the “ASTM D2896” procedure. The minimum TBN of the oil is 5 regardless of a low fuel sulfur level. Illustration 14 demonstrates the TBN.

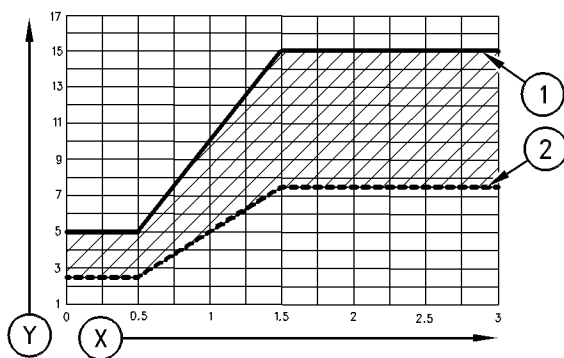


Illustration 14

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- (Y) TBN by “ASTM D2896”
- (X) Percentage of fuel sulfur by weight
- (1) TBN of new oil
- (2) Change the used oil when the TBN reaches this level.

Use the following guidelines for fuel sulfur levels that exceed 1.5 percent:

- Choose an oil with the highest TBN within the API CG-4 or API CF-4 and CH-4 classification.

- Reduce the oil change interval. Base the oil change interval on the oil analysis. Ensure that the oil analysis includes the condition of the oil and a wear metal analysis.

Oils with a high TBN that are not within the API CG-4 or API CF-4 and CH-4 classifications can produce excessive deposits on the pistons and valves. These deposits can lead to the following results:

- A loss of stable oil control
- Polishing of the cylinder bore
- Guttering of the valves

NOTICE

Operating Direct Injected (DI) diesel engines with fuel sulfur levels over 1.0 percent may require shortened oil change intervals in order to help maintain adequate wear protection.

Lubricant Viscosity Recommendations

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

Refer to Table 8 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 8 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

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

Table 8

| Engine Oil Viscosity | | |
|---|---------------------|----------------|
| Caterpillar DEO Multigrade CH-4 API CG-4 and API CF-4 Viscosity Grade | Ambient Temperature | |
| | Minimum | Maximum |
| SAE 0W20 | -40 °C (-40 °F) | 10 °C (50 °F) |
| SAE 5W30 | -30 °C (-22 °F) | 30 °C (86 °F) |
| SAE 5W40 | -30 °C (-22 °F) | 40 °C (104 °F) |
| SAE 10W30 | -20 °C (-4 °F) | 40 °C (104 °F) |
| SAE 15W40 | -15 °C (5 °F) | 50 °C (122 °F) |

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Synthetic Base Stock Oils

SMCS Code: 1300; 1348; 7581

Synthetic base oils are acceptable for use in Caterpillar engines if these oils meet the performance requirements that are specified for a particular compartment.

Synthetic base oils generally perform better than conventional oils in the following two areas:

- Synthetic base oils have improved characteristics of viscosity in low temperatures especially in arctic conditions.
- Synthetic base oils have improved oxidation stability especially at high operating temperatures.

Some synthetic base oils have performance characteristics that enhance the service life of the oil. However, Caterpillar does not recommend the automatic extension of oil change intervals for any type of oil. Oil change intervals for Caterpillar engines can only be adjusted after an oil analysis program that contains the following tests: Oil condition and wear metal analysis (Caterpillar S-O-S oil analysis), trend analysis, fuel consumption, and oil consumption.

i00062735

Re-refined Base Stock Oils

SMCS Code: 1300; 7581

Re-refined base stock oils are acceptable for use in Caterpillar engines if these oils meet the performance requirements that are specified by Caterpillar. Re-refined base stock oils can be used exclusively in finished oil or in a combination with new base stock oils. The US military specifications and the specifications of other heavy equipment manufacturers also allow the use of re-refined base stock oils that meet the same criteria.

The process that is used to make re-refined base stock oil should adequately remove all engine wear metals that were in the used oil and all additives that were in the used oil. The process that is used to make re-refined base stock oil generally involves the processes of vacuum distillation and hydrotreating the used oil. Filtering is inadequate for the production of high quality, re-refined base stock oils from used oil.

Cold Weather Lubricants

SMCS Code: 1300; 1348; 7581

When an engine is started and operated in ambient temperatures below -20°C (-4°F), use multigrade oils that are capable of flowing in low temperatures.

These oils have viscosity grades of SAE 0W or of SAE 5W.

When an engine is started and operated in ambient temperatures below -30°C (-22°F), use a synthetic base stock multigrade oil with a 0W viscosity grade or with a 5W viscosity grade. Use an oil with a pour point that is lower than -50°C (-58°F).

The number of acceptable lubricants is limited in cold weather conditions. Caterpillar recommends the following lubricants for use in cold weather conditions:

- **First choice:** API CG-4 or API CF-4 oils with a SAE 0W20, 0W30, 5W30, or 5W40 viscosity grade.
- **Second Choice:** Oils with a CG-4 additive package or oils with a CF-4 additive package and an SAE 0W20, SAE 0W30, SAE 5W30, or SAE 5W40 viscosity grade.

NOTICE

Shortened engine service life could result if second choice oils are used.

i00062739

Aftermarket Oil Additives

SMCS Code: 1300; 1348; 7581

Caterpillar does not recommend the use of aftermarket additives in oil. It is not necessary to use aftermarket additives in order to achieve the engine's maximum service life or rated performance. Fully formulated, finished oils consist of base oils and of commercial additive packages. These additive packages are blended into the base oils at precise percentages in order to help provide finished oils with performance characteristics that meet industry standards.

There are no industry standard tests that evaluate the performance or the compatibility of aftermarket additives in finished oil. Aftermarket additives may not be compatible with the finished oil's additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil. This could produce sludge in the crankcase. Caterpillar discourages the use of aftermarket additives in finished oils.

i00948365

Lubricating Grease

SMCS Code: 7581

Caterpillar provides grease in order to cover a variety of applications and extreme temperature conditions. Consult your Caterpillar dealer for part numbers and for available sizes of containers.

Note: Some greases may not be used with other greases. When a commercial grease is used, ensure that the grease is compatible with the grease that is currently used in the system. If the commercial grease is not compatible, the system must be purged. If any questions arise concerning the compatibility of a grease, consult the supplier.

Multipurpose Greases

Multipurpose Lithium Complex Grease (MPG)

Multipurpose Lithium Complex Grease (MPG) is a general purpose lithium complex grease for medium duty applications. This product has good characteristics at high temperatures such as a dropping point over 260°C (500°F). MPG contains unleaded extreme pressure additives, antiwear inhibitors and corrosion inhibitors that provide extra protection in the following applications:

- Construction
- Agricultural
- Automotive

MPG meets the requirements for extended service intervals of automotive chassis points and for extended service intervals of wheel bearings with disc brakes in automobiles, in vans, and in light trucks. This product meets the NLGI certification of "GC-LB". MPG is also available in NLGI grade No. 2. Normal operating temperatures for this product are -28 to 149°C (-18 to 300°F). This product is also available as a white lithium complex grease.

Multipurpose Lithium Complex Grease with Molybdenum (MPGM)

Multipurpose Lithium Complex Grease with Molybdenum (MPGM) is a general purpose lithium complex grease that is used for light-duty applications and for medium-duty applications. The MPGM is available in NLGI grade No. 2 or NLGI grade No. 0. The MPGM is fortified with a molybdenum disulfide and polymer for extra lubrication and protection. MPGM contains unleaded additives. MPGM also contains antiwear inhibitors, oxidation inhibitors, and corrosion inhibitors that are for protection and lubrication in many environments. The MPGM is formulated with a base fluid that has high viscosity.

The MPGM has the following features:

- Increased protection against water washout
- Increased retention
- Resistance to heavy loads

This product is recommended for heavily loaded pin joints and for journal bearings. This product meets the certification of "GC-LB". Normal operating temperatures for this product are -28 to 149°C (-18 to 300°F) for the NLGI No. 2. Normal operating temperatures for this product are -18 to 149°C (0 to 300°F) for the NLGI No. 0.

Note: If MPGM is not available, use a multipurpose type grease which contains three to five percent molybdenum.

Special Purpose Grease (SPG)

Bearing Lubrication (SPG)

Bearing Lubricant (SPG) is a NLGI No. 2 lubricating grease with a polyurea thickener. This grease is recommended for high temperature antifriction bearings in the following applications: electric starter motors, alternators, fan drives, and generators. The Bearing Lubricant (SPG) has an effective operating range of -29 to 177°C (-20 to 350°F).

Water and Temperature Resistant Grease

The Water and Temperature Resistant Grease is designed for use whenever the following conditions are a concern: water washout, severe corrosion, and high operating temperatures. The Water and Temperature Resistant Grease provides extreme pressure, antiwear, oxidation, and corrosion protection. The Water and Temperature Resistant Grease is an environmentally friendly grease which does not contain antimony, sulfur, barium, zinc, lead or phosphorous. The Water and Temperature Resistant Grease has excellent shear stability and can also resist a breakdown in the presence of water. The Water and Temperature Resistant Grease works well in the following applications:

- Construction
- Agricultural
- Automotive
- Industrial
- Marine

This product meets the NLGI certification of "GC-LB". Normal operating temperatures for this product are -40 to 204°C (-40 to 400°F).

Caterpillar Premium Grease

Desert Gold

Desert Gold is a heavy duty, premium synthetic, extreme pressure lubricating grease developed for the most extreme operating environments. Desert Gold is formulated with a high viscosity, synthetic base fluid, high molecular weight polymers and molybdenum disulfide, as well as a high viscosity index and high dropping point. Desert Gold will protect equipment against heavy shock loads. Desert Gold protects against corrosion in extreme heat, in moist conditions, or in dusty conditions. This product has excellent characteristics of adhesion and of stability. Desert Gold provides longer protection than other greases. Desert Gold is an environmentally friendly grease which does not contain antimony, sulfur, barium, zinc, lead, or phosphorous. Normal operating temperatures are -6 to 230°C (21 to 450°F). Desert Gold can operate at higher temperatures for shorter time periods. Desert Gold has additional extreme pressure protection for highly loaded pin joints.

Arctic Platinum

Arctic Platinum is a super-premium extreme pressure lubricating grease developed for lubrication in below zero temperatures to moderate operating temperatures. Arctic Platinum is available in grades 000, 00, 0, 1, and 2 to ensure pumpability in central lube systems in a variety of ambient temperatures from -60 to 18°C (-76 to 65°F). Arctic Platinum has a high drop point and contains five percent molybdenum disulfide for protection against extra heavy loads. Arctic Platinum provides excellent protection against corrosion and against oxidation. Arctic Platinum is an environmentally friendly grease which does not contain antimony, sulfur, barium, zinc, or phosphorous.

Arctic Platinum is designed for long life lubrication of horizontal pivot and lower link bearings, of steering cylinders, of kingbolt bearings, of upper hitch link bearings and of ejector carrier roller bearings. This grease is extra tacky for retention on excavator carbody bearings. Arctic Platinum has additional extreme pressure protection for highly loaded pin joints.

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Transmission/Drive Train Oil

SMCS Code: 3080

Refer to the lubrication recommendations of the OEM for the marine transmission.

100703641

S-O-S Oil Analysis

SMCS Code: 1348; 7542; 7581

Caterpillar recommends the use of the S-O-S oil analysis program in order to monitor the condition and the maintenance requirements of the equipment. The S-O-S oil analysis program will complement the preventive maintenance program.

The S-O-S oil analysis is a diagnostic tool that is used to determine oil performance and component wear rates. Contamination can be identified and measured through the use of the S-O-S oil analysis. The S-O-S oil analysis is composed of four basic tests:

- The Wear Rate Analysis monitors wear by detecting, identifying and assessing the amount of engine wear metal and type of engine wear metal that is in the oil. The increase in the rate of engine wear metal in the oil is as important as the quantity of engine wear metal in the oil. For this reason, regular sampling at specified intervals is necessary in order to establish wear rates. Intermittent sampling does not allow wear rate trend lines to be established. Engine wear metals in the oil sample are compared to established Caterpillar norms in order to determine acceptability.
- The Oil Cleanliness Analysis uses a Particle Count test for nonengine oil. This analysis detects both metallic debris and nonmetallic debris (friction disc material) that is generated by wear as well as dirt from outside sources. This information and the Wear Rate Analysis permits a comprehensive evaluation of the hydraulic systems and the power train systems. This combination can detect potential failures that are not identified by the Wear Rate Analysis alone.
- Tests are conducted in order to detect contamination of the oil by water, glycol or fuel.
- The Oil Condition Analysis determines the loss of the oil's lubricating properties. An infrared analysis is used to compare the properties of new oil to the properties of the used oil sample. This analysis allows technicians to determine the amount of deterioration of the oil during use. This analysis also allows technicians to verify the performance of the oil according to the specification during the entire oil change interval.

The test results of the oil samples will then be used as a basis for determining the oil change interval for the engine. The results of the S-O-S oil analysis may allow the engine to operate longer between oil changes without the risk of engine damage.

Refer to Special Publication, PEDP7036 for more information.

Table 9

| S-O-S Oil Analysis Interval Table | |
|--|-------------------------|
| Compartment | Interval |
| Engine crankcase | Every 250 Service Hours |

Obtain the oil sample when the oil is warm and well mixed in order to ensure that the sample is representative of the oil in the engine crankcase.

Consult your Caterpillar dealer for complete information and assistance about the program.

Fuel Specifications

i00907494

Fuel Recommendations

SMCS Code: 1250; 1280

Diesel fuels that meet the specifications in Table 10 will help to provide rated engine performance and full component life. In North America, diesel fuel that is identified as No. 1-D or No. 2-D in “ASTM D975” meet the specifications. Table 10 is for diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

Table 10

| Caterpillar Distillate Diesel Fuel Specifications | |
|--|--|
| Specifications (ASTM Test) | Requirements |
| Aromatics (D1319) | 35% maximum |
| Ash (D482) | 0.02% maximum (weight) |
| Carbon Residue on 10% Bottoms (D524) | 1.05% maximum (weight) |
| Cetane Number (D613) | 35 minimum (PC engines) 40 minimum (DI engines) |
| Cloud Point (D97) | The maximum cloud point must not exceed the lowest expected ambient temperature. |
| Copper Strip Corrosion (D130) | No. 3 maximum |
| Distillation (D86) | 10% at 282 °C (540 °F) 90% at 360 °C (680 °F) |
| Flash Point (D293) | legal minimum |
| API Gravity (D287) | 30 minimum 45 maximum |
| Pour Point (D97) | 6 °C (10 °F) minimum below ambient temperature |
| Sulfur ⁽¹⁾ (D3605 or D1552) | 3% maximum |
| Viscosity ⁽²⁾ (D445) Kinematic at 40°C (104°F) | 1.4 cSt minimum 20.0 cSt maximum |
| Water and Sediment (D1796) | 0.1% maximum |
| Water (D1744) | 0.1% maximum |
| Sediment (D473) | 0.05% maximum (weight) |

(continued)

(Table 10, contd)

| Caterpillar Distillate Diesel Fuel Specifications | |
|---|---|
| Specifications (ASTM Test) | Requirements |
| Gums and Resins (D381) | 10 mg per 100 ml (5.8 grains per US gal) |
| Lubricity by Scuffing Load Wear Test (SBOCLE) or High Frequency Reciprocating Rig (HFRR) ⁽³⁾ | 3100 g minimum .45 mm (.018 inch) maximum at 80 °C (140 °F) or .38 mm (.015 inch) maximum at 25 °C (77 °F) |

- (1) Caterpillar fuel systems and engine components can operate on high sulfur fuels. Fuel sulfur levels affect exhaust emissions. High sulfur fuels also increase the potential for corrosion in internal components. Fuel sulfur levels above 1.0 percent may significantly shorten the oil change interval. For additional information, see this Operation and Maintenance Manual, “Engine Oil” topic (Maintenance Section).
- (2) The values of the fuel viscosity are the values that are delivered to the fuel injection pumps. If a fuel with a low viscosity is used, the fuel should maintain a 1.4 cSt viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters in order to bring down the viscosity to a 20 cSt viscosity. For additional information, see Special Publication, SEBD0717.
- (3) Lubricity of a fuel is a concern with low sulfur fuel. If the lubricity of a fuel does not meet the minimum requirements, consult your fuel supplier. Do not treat the fuel without consulting the fuel supplier. Some additives are not compatible and can cause problems in the fuel system.

There are many other diesel fuel specifications that are published by governments and by technological societies. These other diesel fuel specifications do not contain all of the parameters that are addressed by Caterpillar. To achieve optimum engine performance, a complete analysis of the fuel should cover all of the properties that are listed in Table 10. If the fuel that is used does not meet the minimum Caterpillar requirements, the engine could have excessive wear of the fuel system, failure of the fuel system, or excessive engine wear that is caused by deposits or by corrosion.

In the USA, 0.05 percent diesel fuels have been used in all on-highway truck engines since 1 January 1994. This low sulfur diesel fuel was mandated as a means of directly reducing particulate emissions from diesel truck engines. This low sulfur fuel will also be used in Caterpillar commercial diesel engines when low emissions are needed or when supply sources provide this type of fuel. Caterpillar has not seen any detrimental effects with 0.05 percent sulfur fuel in Caterpillar diesel engines.

NOTICE

Heavy Fuel Oil (HFO), Residual fuel, or Blended fuel must NOT be used in Caterpillar diesel engines (except in 3600 Series HFO engines). Severe component wear and component failures will result if HFO type fuels are used in engines that are configured to use distillate fuel.

Cooling System Specifications

i00911048

General Coolant Information

SMCS Code: 1350; 1395

Many engine failures are related to the cooling system. The following problems are related to cooling system failures: overheating, leakage of the water pump, plugged radiators or heat exchangers, and pitting of the cylinder liners.

These failures can be avoided with proper cooling system maintenance. Cooling system maintenance is as important as maintenance of the fuel system and the lubrication system. Quality of the coolant is as important as the quality of the fuel and the lubricating oil.

Coolant is normally composed of three elements: water, additives, and glycol.

Water

NOTICE

Never use water alone without Supplemental Coolant Additives (SCA) or without inhibited coolant. Water alone is corrosive at engine operating temperatures. Water alone does not provide adequate protection against boiling or freezing.

Water is used in the cooling system in order to transfer heat.

Distilled water or deionized water is recommended for use in engine cooling systems.

DO NOT use the following types of water in cooling systems: hard water, softened water that has been conditioned with salt, and sea water.

If distilled water or deionized water is not available, use water with the characteristics that are listed in Table 11.

Table 11

| Acceptable Characteristics Of Water For Use In Engine Cooling Systems | | |
|---|---------------------------------|---------------------------------|
| Characteristic | Maximum Limit | ASTM Test |
| Chloride (Cl) | 40 mg/L (2.4 grains/US gal) | "D512b", "D512d", "D4327" |
| Sulfate (SO ₄) | 100 mg/L (5.9 grains/US gal) | "D516B", "D516d" |
| Total Hardness | 170 mg/L (10 grains/US gal) | "D1126b" |
| Total Solids | 340 mg/L (20 grain/US gal) | "D1888a" |
| pH | 5.5 to 9.0 | "D1293" |

For a water analysis, consult one of the following sources:

- Caterpillar dealer
- Local water utility company
- Agricultural agent
- Independent laboratory

Additives

Additives help to protect the metal surfaces of the cooling system. A lack of coolant additives or insufficient amounts of additives enable the following conditions to occur:

- Corrosion
- Formation of mineral deposits
- Rust
- Scale
- Corrosion and erosion from cavitation of the cylinder liner
- Foaming of the coolant

Many additives are depleted during engine operation. These additives must be replaced periodically. This can be done by adding Supplemental Coolant Additives (SCA) to Diesel Engine Antifreeze/Coolant (DEAC) or by adding ELC Extender to Extended Life Coolant (ELC).

Additives must be added at the proper concentration. Overconcentration of additives can cause the inhibitors to drop out-of-solution. The deposits can enable the following problems to occur:

- Formation of gel compounds
- Reduction of heat transfer
- Leakage of the water pump seal
- Plugging of radiators, coolers, and small passages

Glycol

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

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

For optimum performance, Caterpillar recommends a 50/50 mixture of a water/glycol solution.

Note: Caterpillar engines with air-to-air aftercooling require a minimum of 30 percent glycol in order to help prevent water pump cavitation.

Most conventional heavy-duty coolant/antifreezes use ethylene glycol. Propylene glycol may also be used. In a 50/50 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. See Tables 12 and 13.

Table 12

| Ethylene Glycol | | |
|-----------------------------------|--------------------|-----------------|
| Concentration % Glycol/% Water | Protection Against | |
| | Freezing | Boiling |
| 50/50 | -36 °C (-33 °F) | 106 °C (223 °F) |
| 60/40 | -51 °C (-60 °F) | 108 °C (226 °F) |

NOTICE

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

Table 13

| Propylene Glycol | | |
|-----------------------------------|--------------------|-----------------|
| Concentration % Glycol/% Water | Protection Against | |
| | Freezing | Boiling |
| 50/50 | -29 °C (-35 °F) | 106 °C (223 °F) |

To check the concentration of glycol, use the 1U-7298 Coolant Test Kit for °C or use the 1U-7297 Coolant Test Kit for °F. The testers give readings that are immediate and accurate. The testers can be used with ethylene or propylene glycol.

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Coolant Recommendations

SMCS Code: 1350; 1395

NOTICE

Do not use a commercial coolant/antifreeze that only meets the ASTM D3306 or D4656 specification. This type of coolant/antifreeze is made for light duty automotive applications.

The following two coolants are used in Caterpillar engines:

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

Acceptable – A Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) or a commercial heavy-duty coolant/antifreeze that meets “ASTM D4985” or “ASTM D5345” specifications

Caterpillar recommends a 50/50 water/glycol mixture for optimum coolant/antifreeze performance.

Note: Caterpillar DEAC does not require a treatment with an SCA at the initial fill. A commercial heavy-duty coolant/antifreeze that meets “ASTM D4985” or “ASTM D5345” specifications requires a treatment with an SCA at the initial fill.

In stationary engine and marine engine applications that do not require anti-boil or anti-freeze protection, a mixture of SCA and water is acceptable. Caterpillar recommends a six percent to eight percent concentration of SCA in those cooling systems. Distilled water or deionized water is preferred. Water which has the recommended properties may be used.

Table 14

| Coolant Service Life | |
|--|-----------------------------------|
| Coolant Type | Service Life |
| Caterpillar ELC | 6000 Service Hours or Six Years |
| Caterpillar DEAC | 3000 Service Hours or Three Years |
| Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D5345" | 3000 Service Hours or Two Years |
| Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985" | 3000 Service Hours or One Year |
| Caterpillar SCA and Water | 3000 Service Hours or Two Years |
| Commercial SCA and Water | 3000 Service Hours or One Year |

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S-O-S Coolant Analysis

SMCS Code: 1352; 1395; 7542

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.

NOTICE

Do not use the same vacuum sampling pump for extracting oil samples that is used for extracting coolant samples.

A small residue of either type sample may remain in the pump and may cause a false positive analysis for the sample being taken.

Always use a designated pump for oil sampling and a designated pump for coolant sampling.

Failure to do so may cause a false analysis which could lead to customer and dealer concerns.

Recommended Interval for S-O-S Coolant Sample

Table 15

| Recommended Interval | | |
|----------------------|-----------------|---------|
| Type of Coolant | Level 1 | Level 2 |
| DEAC | Every 250 Hours | Yearly |
| ELC | N/A | Yearly |

Converted Systems

Perform a coolant analysis (Level 2) at 500 service hours for new systems or for converted systems that use ELC or use DEAC. This 500 hour check will also check for any residual cleaner that may have contaminated the system.

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
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Water hardness
- Visual analysis
- Odor analysis

The results are reported, and appropriate recommendations are made.

S-O-S Coolant Analysis (Level 2)

Level 2 coolant analysis 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 five features:

- Full analysis of Level 1
- 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 machines' cooling system

The results are reported, and appropriate recommendations are made.

For more information on S-O-S Coolant Analysis, consult your Caterpillar dealer.

i00823417

Extended Life Coolant (ELC)

SMCS Code: 1350; 1395

Caterpillar provides Extended Life Coolant (ELC) for use in the following applications:

- Heavy-duty spark ignited gas engines
- Heavy-duty diesel engines
- Automotive applications

The ELC anti-corrosion package is totally different from conventional coolants. ELC has been formulated with the correct amounts of additives in order to provide superior corrosion protection for all metals in engine cooling systems.

ELC extends the service life of the coolant to 6000 service hours or six years. ELC does not require a frequent addition of a Supplemental Coolant Additive (SCA). An Extender is the only additional maintenance that is needed at 3000 service hours or three years.

Premixed ELC is available with distilled water in a 50/50 concentration. The Premixed ELC provides freeze protection to -36°C (-33°F). The Premixed ELC is recommended for the initial fill of the cooling system. The Premixed ELC is also recommended for topping off the cooling system.

ELC Concentrate is also available. ELC Concentrate will lower the freezing point to -52°C (-62°F) for arctic conditions. Use ELC Concentrate to adjust the freezing point of the coolant, if necessary.

Containers of several sizes are available. Consult your Caterpillar dealer for the part numbers.

Note: Caterpillar developed the EC-1 specification. The EC-1 specification is an industry standard. The EC-1 specification defines all of the performance requirements that are needed for an engine coolant to be sold as an extended life coolant for Caterpillar engines. ELC can be used in most of the following types of engines: diesel, gasoline, and natural gas. ELC meets the industry performance requirements of "ASTM D4985" and "ASTM D5345" for heavy duty low silicate coolant/antifreezes. ELC also meets the industry performance requirements of "ASTM D3306" and "ASTM D4656" for automotive applications.

i00995306

Extended Life Coolant (ELC) Cooling System Maintenance

SMCS Code: 1350; 1352; 1395

Caterpillar ELC Extender

Caterpillar ELC Extender is added to the cooling system halfway through the ELC service life. Treat the cooling system with ELC Extender at 3000 hours or one half of the coolant service life. Use Table 16 in order to determine the proper amount of ELC Extender that is required.

Containers of several sizes are available. Consult your Caterpillar dealer for the part numbers.

Table 16

| Caterpillar ELC Extender Additions by Cooling System Capacity | |
|---|--------------------------|
| Cooling System Capacity | Addition of ELC Extender |
| 22 to 30 L (6 to 8 US gal) | 0.57 L (20 fl oz) |
| 31 to 38 L (9 to 10 US gal) | 0.71 L (24 fl oz) |
| 39 to 49 L (11 to 13 US gal) | 0.95 L (32 fl oz) |
| 50 to 64 L (14 to 17 US gal) | 1.18 L (40 fl oz) |
| 65 to 83 L (18 to 22 US gal) | 1.60 L (54 fl oz) |
| 84 to 114 L (23 to 30 US gal) | 2.15 L (72 fl oz) |
| 115 to 163 L (31 to 43 US gal) | 3.00 L (100 fl oz) |
| 164 to 242 L (44 to 64 US gal) | 4.40 L (148 fl oz) |

ELC Cooling System Cleaning

Note: Clean water is the only agent that is required when the ELC is flushed from the cooling system.

The ELC can be recycled. The drained coolant mixture can be distilled. The distillation process can remove the ethylene glycol and the water. Consult your Caterpillar dealer for more information.

After the cooling system is drained and after the cooling system is refilled, operate the engine while the cooling system filler cap is removed. Operate the engine until the coolant level reaches the normal operating temperature and until the coolant level stabilizes. As needed, add the coolant mixture in order to fill the system to the proper level.

Changing to Caterpillar ELC

1. Drain the cooling system.
2. Flush the system with clean water in order to remove any debris.
3. Clean the cooling system with Caterpillar Cooling System Cleaner. Follow the instructions on the label.

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.

4. Flush the cooling system with clean water. Removing all of the cleaning agent is very important.
5. Fill the cooling system with clean water. Operate the engine until the cooling system temperature is 49 to 66° C (120 to 150° F).
6. Drain the cooling system. Flush the cooling system with clean water.
7. Repeat Steps 5 and 6. Continue flushing the cooling system with clean water until the draining water is clean.
8. Fill the cooling system with Premixed ELC.
9. Attach a label to the cooling system in order to indicate that the system has been changed to Caterpillar ELC.

ELC Cooling System Contamination

NOTICE

Mixing ELC with other products reduces the effectiveness of the ELC and shortens the ELC service life. Use only Caterpillar products or commercial products that have passed the Caterpillar EC-1 specification for premixed or concentrate coolants. Use only Caterpillar ELC Extender with Caterpillar ELC. Failure to follow these recommendations can result in shortened cooling system component life.

ELC cooling systems can withstand contamination to a maximum of ten percent of conventional heavy-duty coolant/antifreeze. If the contamination exceeds ten percent of the total system capacity, perform one of the following procedures:

- Drain the cooling system. Flush the system with clean water. Refill the system with Premixed ELC.
- Check and add Supplemental Coolant Additive (SCA) in order to maintain the cooling system as if the system is filled with conventional heavy-duty coolant/antifreeze. Refer to the Operation and Maintenance Manual, "Conventional Coolant/Antifreeze Cooling System Maintenance" topic (Maintenance Section).

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Diesel Engine Antifreeze/Coolant (DEAC)

SMCS Code: 1350; 1395

Caterpillar recommends the use of Diesel Engine Antifreeze/Coolant (DEAC) in cooling systems that use conventional heavy-duty antifreeze/coolant. DEAC is a coolant/antifreeze with these characteristics:

- Alkaline type
- Single-phase
- Ethylene glycol

DEAC contains inorganic corrosion inhibitor and antifoam agents. Premixed DEAC is mixed with distilled water in a 50/50 concentration. Containers of DEAC are available in several sizes. Consult your Caterpillar dealer for the part numbers.

DEAC is also available as a concentrate. Caterpillar recommends mixing the concentrate with distilled water or with deionized water. If distilled water is not available or deionized water is not available, use water with the properties that are listed in the table that can be found in the Operation and Maintenance Manual, "General Coolant Information" (Maintenance Section).

i00995307

Supplemental Coolant Additive (SCA)

SMCS Code: 1350; 1352; 1395

The use of SCA helps to prevent the following conditions from occurring:

- Corrosion
- Formation of mineral deposits
- Cavitation erosion
- Foaming of the coolant

Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) is formulated with the correct level of Caterpillar SCA. When the cooling system is originally filled with DEAC, adding more SCA is not necessary until the scheduled cooling system maintenance. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for the specific maintenance interval.

Containers of SCA are available in several sizes. Consult your Caterpillar dealer for the part numbers.

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Commercial Heavy-Duty Coolant/Antifreeze and SCA

SMCS Code: 1350; 1395

If Caterpillar DEAC is not used, select a coolant/antifreeze with low silicate content for heavy-duty applications that meets "ASTM D5345" or "ASTM D4985" specifications.

When a heavy-duty coolant/antifreeze is used, the cooling system should be treated with three to six percent Caterpillar SCA by volume. Refer to the Operation and Maintenance Manual, "Conventional Coolant/Antifreeze Cooling System Maintenance" in the Maintenance Section for more information.

If Caterpillar SCA is not used, select a commercial SCA. The commercial SCA must provide a minimum of 1200 mg/L or 1200 ppm (70 grains/US gal) of nitrates in the final coolant mixture.

Coolant/antifreezes for heavy-duty applications that meet "ASTM D5345" or "ASTM D4985" specifications require treatment at the initial fill and on a maintenance basis.

When concentrated coolants are mixed, Caterpillar recommends mixing the concentrate with distilled water or with deionized water. If distilled water or deionized water is not available, refer to the table in the Operation and Maintenance Manual, "General Coolant Information" in the Maintenance Section.

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Water/Supplemental Coolant Additive (SCA)

SMCS Code: 1350; 1352; 1395

In engine cooling systems that use Supplemental Coolant Additive (SCA) and water alone, Caterpillar recommends the use of SCA. SCA helps to prevent the following conditions from occurring:

- Corrosion
- Formation of mineral deposits
- Cavitation erosion
- Foaming of the coolant

If Caterpillar SCA is not used, select a commercial SCA. The commercial SCA must provide a minimum of 2400 mg/L or 2400 ppm (140 grains/US gal) of nitrates in the final coolant mixture.

The quality of the water is a very important factor in this type of cooling system. Distilled water or deionized water is recommended for use in cooling systems. If distilled water or deionized water is not available, use water that meets the minimum requirements that are listed in the table for recommended water properties.

A cooling system that uses a mixture of SCA and water only needs more SCA than a cooling system that uses a mixture of glycol and water. The SCA concentration in a cooling system that uses SCA and water should be six to eight percent by volume. Refer to Table 17 for the amount of SCA that is required for various capacities of the cooling system.

Table 17

| Caterpillar SCA Requirements for SCA and Water Cooling Systems | | |
|--|---------------------------------|------------------------------|
| Cooling System Capacity | Caterpillar SCA at Initial Fill | Caterpillar SCA at 250 Hours |
| 22 to 30 L (6 to 8 US gal) | 1.75 L (64 fl oz) | 0.44 L (15 fl oz) |
| 31 to 38 L (9 to 10 US gal) | 2.30 L (80 fl oz) | 0.57 L (20 fl oz) |
| 39 to 49 L (11 to 13 US gal) | 3.00 L (100 fl oz) | 0.75 L (25 fl oz) |
| 50 to 64 L (14 to 17 US gal) | 3.90 L (128 fl oz) | 0.95 L (32 fl oz) |
| 65 to 83 L (18 to 22 US gal) | 5.00 L (168 fl oz) | 1.25 L (42 fl oz) |
| 84 to 110 L (23 to 29 US gal) | 6.60 L (224 fl oz) | 1.65 L (56 fl oz) |
| 111 to 145 L (30 to 38 US gal) | 8.75 L (296 fl oz) | 2.19 L (74 fl oz) |
| 146 to 190 L (39 to 50 US gal) | 11.50 L (392 fl oz) | 2.88 L (98 fl oz) |
| 191 to 250 L (51 to 66 US gal) | 15.00 L (512 fl oz) | 3.75 L (128 fl oz) |

Refer to Table 18 for part numbers and for quantities of SCA.

Table 18

| Caterpillar Liquid SCA | |
|------------------------|-------------------|
| Part Number | Quantity |
| 6V-3542 | .24 L (8 oz) |
| 111-2372 | .36 L (12 oz) |
| 8T-1589 | .47 L (16 oz) |
| 3P-2044 | .94 L (32 oz) |
| 5P-2907 | 208 L (55 US gal) |

Maintain the SCA in the same way as you would maintain a cooling system that uses heavy-duty coolant/antifreeze. Adjust the maintenance for the amount of SCA additions. See Table 17 for the amount of SCA that is required.

Note: The 8T-5296 Coolant Conditioner Test Kit can be used to evaluate the concentration of SCA. The following modifications must be made to STEP 3 and STEP 5 of the instructions that are included in the 8T-5296 Coolant Conditioner Test Kit.

STEP 3 – Add tap water to the vial up to the “20 ml” mark.

STEP 5 – A concentration of six to eight percent will yield between 20 drops and 27 drops. If the number of drops is below 20 drops, the concentration of SCA is low. If the number of drops is above 27 drops, the concentration of SCA is high. Make the appropriate adjustments to the concentration of SCA.

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Conventional Coolant/ Antifreeze Cooling System Maintenance

SMCS Code: 1350; 1352; 1395

NOTICE

Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

Check the coolant/antifreeze (glycol concentration) in order to ensure adequate protection against boiling or freezing. Caterpillar recommends the use of a refractometer for checking the glycol concentration. Use the 1U-7298 Coolant Test Kit for °C or use the 1U-7297 Coolant Test Kit for °F. The testers give readings that are immediate and accurate. The testers can be used with ethylene or with propylene glycol.

Caterpillar engine cooling systems should be tested at 250 hour intervals for the concentration of Supplemental Coolant Additive (SCA). SCA test kits are available from your Caterpillar dealer. Test the concentration of SCA or submit a coolant sample to your Caterpillar dealer at 250 hour intervals. Refer to the Operation and Maintenance Manual, “S·O·S Coolant Analysis” topic (Maintenance Section).

Additions of SCA are based on the results of the test or based on the results of the coolant analysis. An SCA that is liquid or a maintenance element for an SCA (if equipped) may be needed at 250 hour intervals.

Table 19 lists the amount of Caterpillar SCA that is needed in order to treat coolant/antifreeze. These amounts of SCA are for systems that use heavy-duty coolant/antifreeze.

Table 19 also lists additions of SCA for liquid and for maintenance elements at 250 hours. The additions are required for Caterpillar DEAC and for commercial coolant/antifreezes.

Table 19

| Caterpillar SCA Requirements for Heavy-Duty Coolant/Antifreeze | | | |
|--|---|---|---|
| Cooling System Capacity | SCA at Initial Fill ⁽¹⁾ "ASTM D5345" and "ASTM D4985" Heavy-Duty Coolant | SCA at 250 Hours for All Heavy-Duty Coolants ⁽²⁾ | SCA Element at 250 Hours for All Heavy-Duty Coolants ⁽³⁾ Pt. No. (Qty) |
| 22 to 30 L (6 to 8 US gal) | 0.95 L (32 fl oz) | 0.24 L (8 fl oz) | 111-2370 (1) |
| 31 to 38 L (9 to 10 US gal) | 1.18 L (40 fl oz) | 0.36 L (12 fl oz) | 111-2369 (1) |
| 39 to 49 L (11 to 13 US gal) | 1.42 L (48 fl oz) | 0.36 L (12 fl oz) | 111-2369 (1) |
| 50 to 64 L (14 to 17 US gal) | 1.90 L (64 fl oz) | 0.47 L (16 fl oz) | 9N-3368 (1) |
| 65 to 83 L (18 to 22 US gal) | 2.37 L (80 fl oz) | 0.60 L (20 fl oz) | 111-2371 (1) |
| 84 to 114 L (23 to 30 US gal) | 3.32 L (112 fl oz) | 0.95 L (32 fl oz) | 9N-3718 (1) |
| 115 to 163 L (31 to 43 US gal) | 4.75 L (160 fl oz) | 1.18 L (40 fl oz) | 111-2371 (2) |
| 164 to 242 L (44 to 64 US gal) | 7.60 L (256 fl oz) | 1.90 L (64 fl oz) | 9N-3718 (2) |

- (1) When the coolant system is first filled, the SCA is not required to be used with Caterpillar DEAC.
 (2) Do not exceed the six percent maximum concentration. Check the concentration of SCA with a SCA test kit.
 (3) Do not use the maintenance element for the SCA and the liquid for the SCA at the same time.

Note: Specific engine applications may require maintenance practices to be periodically evaluated in order to properly maintain the engine's cooling system.

Refer to Table 20 for part numbers and for quantities of SCA.

Table 20

| Caterpillar Liquid SCA | |
|------------------------|-------------------|
| Part Number | Quantity |
| 6V-3542 | .24 L (8 oz) |
| 111-2372 | .36 L (12 oz) |
| 8T-1589 | .47 L (16 oz) |
| 3P-2044 | .94 L (32 oz) |
| 5P-2907 | 208 L (55 US gal) |

Cleaning the System of Heavy-Duty Coolant/Antifreeze

Caterpillar cooling system cleaners are designed to clean the cooling system of harmful scale and corrosion. Caterpillar cooling system cleaners dissolve mineral scale, corrosion products, light oil contamination and sludge.

- Clean the cooling system after used coolant is drained or before the cooling system is filled with new coolant.
- Clean the cooling system whenever the coolant is contaminated or whenever the coolant is foaming.

Refill Capacities

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Refill Capacities

SMCS Code: 1348; 1395; 7560

Lubrication System

The refill capacities for the engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filters, if equipped. Refer to the Operation and Maintenance Manual, "Lubricant Specifications" for more information.

Table 21

| Approximate Lubrication System Refill Capacities | | |
|--|--------|--------|
| Compartment or System | Liters | Quarts |
| 75V1-Up (Standard Sump) | 12 | 13 |
| 01Z1-Up (Standard Sump) | 15 | 16 |

Cooling System

The following capacities are for engines that have expansion tanks that are installed in the factory. Cooling systems which are installed by the OEM for the vessel may differ. Refer to the OEM specifications. Refer to the Operation and Maintenance Manual, "Coolant Specifications" for more information.

Table 22

| Approximate Cooling System Refill Capacities | | |
|--|--------|--------|
| Engine and Expansion Tank | Liters | Quarts |
| 75V1-Up | 47.3 | 50.1 |
| 01Z1-Up ⁽¹⁾ | 52.8 | 56.0 |
| 01Z1-Up ⁽²⁾ | 56.0 | 59.4 |

⁽¹⁾ 320 hp engine arrangement

⁽²⁾ Engine arrangements that are not 320 hp

Note: The engine horsepower is stamped on the Information Plate on the valve cover. Refer to the Operation and Maintenance Manual, "Information Plate" topic (Product Information Section).

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Maintenance Interval Schedule

SMCS Code: 1000; 7500

Note: Ensure that the Safety Information, warnings, and instructions are read and understood before operation or maintenance procedures are performed.

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

Note: For engines that are equipped with AIRSEP® engine air cleaners, the turbocharger should be inspected every 1000 service hours.

When Required

| | |
|---|----|
| Belt - Inspect/Adjust/Replace | 59 |
| Battery - Recycle | 61 |
| Battery or Battery Cable - Disconnect | 62 |
| Engine Oil Level Gauge - Calibrate | 78 |
| Fuel System - Prime | 87 |

Daily

| | |
|--|-----|
| Cooling System Coolant Level - Check | 66 |
| Engine Air Cleaner Service Indicator - Inspect | 75 |
| Engine Oil Level - Check | 77 |
| Fuel System Water Separator - Drain | 90 |
| Marine Transmission Oil Level - Check | 95 |
| Walk-Around Inspection | 102 |

Every 1900 L (500 US gal) of Fuel or 50 Service Hours

| | |
|---|-----|
| Aftercooler Drain Plug - Inspect | 57 |
| Engine Air Cleaner Element (Foam) - Clean/Replace | 71 |
| Zinc Rods - Inspect/Replace | 104 |

Initial 9000 L (2400 US gal) of Fuel or 250 Service Hours or 1 Year

| | |
|--|----|
| Engine Valve Lash - Inspect/Adjust | 84 |
|--|----|

Every 9000 L (2400 US gal) of Fuel or 250 Service Hours or Yearly

| | |
|---|----|
| Auxiliary Water Pump - Inspect | 59 |
| Belt - Inspect/Adjust/Replace | 59 |
| Battery Electrolyte Level - Check | 61 |
| Cooling System Supplemental Coolant Additive (SCA) - Test/Add | 67 |
| Engine Air Cleaner Element - Clean/Replace | 72 |
| Engine Crankcase Breather - Clean | 76 |
| Engine Oil Sample - Obtain | 81 |
| Engine Oil and Filter - Change | 82 |
| Engine Protective Devices - Check | 83 |
| Exhaust Restrictor - Inspect/Adjust | 84 |

| | |
|--|-----|
| Fuel System Primary Filter/Water Separator Element - Replace | 88 |
| Fuel System Secondary Filter - Replace | 89 |
| Fuel Tank Water and Sediment - Drain | 91 |
| Hoses and Clamps - Inspect/Replace | 93 |
| Magnetic Pickups - Clean/Inspect | 94 |
| Oil Fumes Filter - Replace | 95 |
| Sea Water Strainer - Clean/Inspect | 100 |

Every 36 000 L (9000 US gal) of Fuel or 1000 Service Hours or 2 Years

| | |
|--|----|
| Aftercooler Core - Clean/Test | 57 |
| Cooling System Coolant (DEAC) - Change | 62 |
| Cooling System Water Temperature Regulator - Replace | 69 |
| Engine - Clean | 71 |
| Governor Housing - Drain | 92 |
| Marine Transmission Oil Cooler - Clean/Inspect .. | 94 |
| PCV Valve - Inspect | 99 |

Every 72 000 L (19 000 US gal) of Fuel or 2000 Service Hours

| | |
|--|-----|
| Alternator - Inspect | 58 |
| Crankshaft Vibration Damper - Inspect | 70 |
| Engine Mounts - Inspect | 77 |
| Engine Valve Lash - Inspect/Adjust | 84 |
| Fuel Injection Nozzles - Test/Exchange | 86 |
| Fuel Ratio Control - Inspect/Adjust | 87 |
| Heat Exchanger - Inspect | 92 |
| Starting Motor - Inspect | 101 |
| Turbocharger - Inspect | 101 |

Every 108 000 L (28 500 US gal) of Fuel or 3000 Service Hours or 2 Years

| | |
|--|-----|
| Cooling System Coolant Extender (ELC) - Add | 66 |
| Water Pump - Inspect | 103 |

Every 114 000 L (30 000 US gal) of Fuel

| | |
|-------------------------------|----|
| Overhaul Considerations | 96 |
|-------------------------------|----|

Every 216 000 L (57 000 US gal) of Fuel or 6000 Service Hours or 4 Years

| | |
|---|----|
| Cooling System Coolant (ELC) - Change | 64 |
|---|----|

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Aftercooler Drain Plug - Inspect

SMCS Code: 1063-040

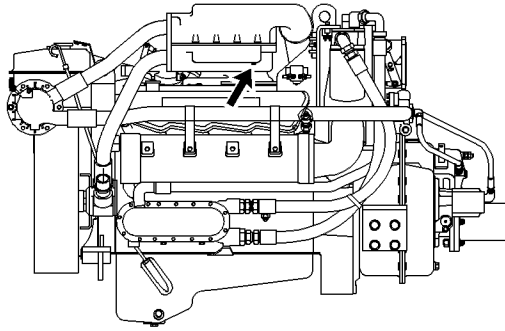


Illustration 15

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Typical location of aftercooler drain

Inspect the plug for the aftercooler drain (if equipped). Ensure that the plug is one of the following plugs:

- 101 - 3713 Tethered Plug
- 9x - 8406 Plug (stainless steel)

NOTICE

A failed aftercooler drain plug can cause the engine compartment to fill with sea water. Any plugs used in the aftercooler drain port, other than those recommended above, may corrode. Use only those recommended plugs.

Aftercooler Core - Clean/Test

SMCS Code: 1064-070; 1064-081

1. Remove the core. Refer to the Service Manual for the procedure.
2. Turn the aftercooler 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.

3. Back flush the core with cleaner.

Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 23 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 23

| Hydrosolv Liquid Cleaners ⁽¹⁾ | |
|--|-------------------|
| Description | Container |
| 1U-8812 Hydrosolv 4165 | 4 L (1 US gal) |
| 1U-5490 Hydrosolv 4165 | 19 L (5 US gal) |
| 8T-7570 Hydrosolv 4165 | 208 L (55 US gal) |
| 1U-8804 Hydrosolv 100 | 4 L (1 US gal) |
| 1U-5492 Hydrosolv 100 | 19 L (5 US gal) |
| 8T-7571 Hydrosolv 100 | 208 L (55 US gal) |

⁽¹⁾ 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.

4. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris.
5. Wash the core with hot, soapy water. Rinse the core thoroughly with clean water.

 **WARNING**

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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.

6. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.
7. 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.
8. Install the core. Refer to the Service Manual for the procedure.

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

Alternator - Inspect

SMCS Code: 1405-040

Note: This engine is equipped with an alternator circuit breaker. Note the location of the alternator circuit breaker for your particular application. If the alternator circuit breaker trips, you will need to reset the breaker in order for the charging system to operate. Refer to the information that is provided by the OEM for more information.

Caterpillar recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and proper battery charging. Inspect the ammeter (if equipped) during engine operation in order to ensure proper battery performance and/or proper performance of the electrical system. Make repairs, as required. Refer to the Service Manual.

Check the alternator and the battery charger for proper operation. If the batteries are properly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine. The battery will not crank the engine, even if the engine is warm. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

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Auxiliary Water Pump - Inspect

SMCS Code: 1371-040

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).

Check the following components for wear or damage:

- Bearings
- Cam
- Impeller
- Seals
- Wear plate

If wear or damage is found, replace the components which are worn or damaged. Use the proper repair kit for the pump. Refer to the Disassembly and Assembly for more information on servicing the auxiliary water pump.

Belt - Inspect/Adjust/Replace

SMCS Code: 1357-039

Inspection

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

After the initial check, the belt tension should be checked at Every 250 Service Hours or Three Months.

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

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

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

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

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

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

Adjustment

Alternator Belt

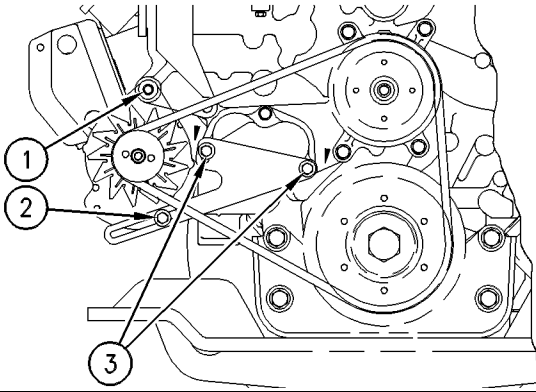


Illustration 16

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Typical illustration

- (1) Mounting bolt
- (2) Adjustment bolt
- (3) Bracket bolts

1. Slightly loosen mounting bolt (1) and adjusting bolt (2).
2. Move the alternator in order to adjust the belt tension. If the alternator will not adjust, it may be necessary to slightly loosen bracket bolts (3). Refer to the Specifications, "Belt Tension Chart" topic.
3. Tighten adjusting bolt (2) and mounting bolt (1). Tighten bracket bolts (3) if the bracket bolts were loosened. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section).
4. Install the belt guard.

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

Auxiliary Water Pump Belt

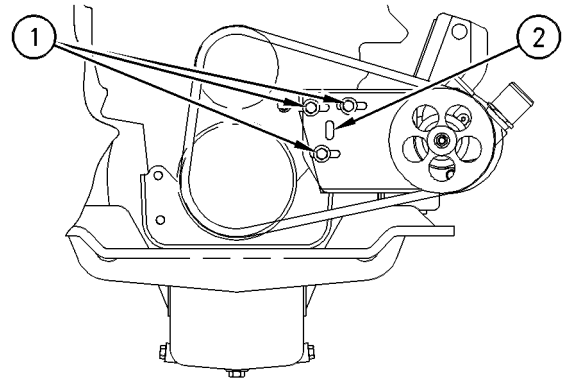


Illustration 17

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Typical illustration

- (1) Mounting bolts
- (2) Slotted hole

1. Slightly loosen mounting bolts (1).
2. Adjust the belt tension with a pry bar in slotted hole (2). Refer to the Specifications, "Belt Tension Chart" topic.
3. Tighten mounting bolts (2). Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section).
4. Install the belt guard.

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

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Battery - Recycle

SMCS Code: 1401-561

1. Always recycle a battery. Never discard a battery.
2. Always return used batteries to one of the following locations.
 - A battery supplier
 - An authorized battery collection facility
 - Recycling facility

Battery Electrolyte Level - Check

SMCS Code: 1401-081

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

WARNING

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

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

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 1U-7298 Coolant/Battery Tester (°C) or the 1U-7297 Coolant/Battery Tester (°F).

3. Keep the batteries clean.

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

- A mixture of 0.1 L (.12 qt) of baking soda and 1 L (1 qt) of clean water
- A mixture of 0.1 L (.12 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 Lubrication Compound, petroleum jelly or MPGM grease.

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Battery or Battery Cable - Disconnect

SMCS Code: 1402-029

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.

Cooling System Coolant (DEAC) - Change

SMCS Code: 1350-070; 1395-044

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

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

NOTICE

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

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

Drain

WARNING

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

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

Allow the coolant to drain.

NOTICE

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

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

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

Flush

1. Flush the cooling system with clean water in order to remove any debris.
 2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for more information on the proper torques.
-

NOTICE

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

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.
 4. Start and run the engine at low idle for a minimum of 30 minutes. The coolant temperature should be at least 82 °C (180 °F).
-

NOTICE

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

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

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for more information on the proper torques.

Cooling Systems with Heavy Deposits or Plugging

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

1. Flush the cooling system with clean water in order to remove any debris.
 2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for more information on the proper torques.
-

NOTICE

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

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the cooling system filler cap.
 4. Start and run the engine at low idle for a minimum of 90 minutes. The coolant temperature should be at least 82 °C (180 °F).
-

NOTICE

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

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

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for more information on the proper torques.

Fill

NOTICE

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

1. Fill the cooling system with coolant/antifreeze. Refer to the Operation and Maintenance Manual, "Cooling System Specifications" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.
2. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block. Stop the engine.
3. Check the coolant level. Maintain the coolant level within 13 mm (.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (.5 inch) to the proper level on the sight glass (if equipped).
4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, perform a pressure test. A 9S-8140 Pressurizing Pump is used to perform the pressure test. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

Cooling System Coolant (ELC) - Change

SMCS Code: 1350-070; 1395-044

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

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

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

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

Drain

WARNING

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

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

Allow the coolant to drain.

NOTICE

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

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

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

Flush

1. Flush the cooling system with clean water in order to remove any debris.
 2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for more information on the proper torques.
-
- NOTICE
- Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.
-
3. Fill the cooling system with clean water. Install the cooling system filler cap.
 4. Start and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).
 5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for more information on the proper torques.

Fill

NOTICE

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

1. Fill the cooling system with Extended Life Coolant (ELC). Refer to the Operation and Maintenance Manual, "Cooling System Specifications" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start and run the engine at low idle. Increase the engine rpm to high idle. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block. Stop the engine.
3. Check the coolant level. Maintain the coolant level within 13 mm (.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (.5 inch) to the proper level on the sight glass (if equipped).
4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

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Cooling System Coolant Extender (ELC) - Add

SMCS Code: 1352-045; 1395-081

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

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

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

Cooling System Coolant Level - Check

SMCS Code: 1395-082

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

Engines That Are Equipped with a Coolant Recovery Tank

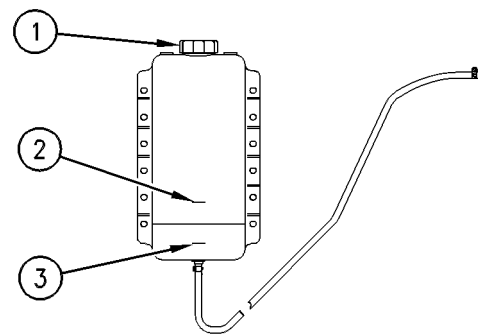


Illustration 18

g00103638

(1) Filler cap. (2) "COLD FULL" mark. (3) "LOW ADD" mark.

1. Observe the coolant level in the coolant recovery tank. Maintain the coolant level to "COLD FULL" mark (2) on the coolant recovery tank.
2. Loosen filler cap (1) slowly in order to relieve any pressure. Remove the filler cap.
3. Pour the proper coolant mixture into the tank. Refer to the coolant specifications in the maintenance information for your product. Do not fill the coolant recovery tank above "COLD FULL" mark (2).
4. Clean filler cap (1) and the receptacle. Reinstall the filler cap and inspect the cooling system for leaks.

Note: The coolant will expand as the coolant heats up during normal engine operation. The additional volume will be forced into the coolant recovery tank during engine operation. When the engine is stopped and cool, the coolant will return to the engine.

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Engines That Are Not Equipped with a Coolant Recovery Tank

WARNING

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

1. Remove the cooling system filler cap slowly in order to relieve pressure.
2. Maintain the coolant level within 13 mm (.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.

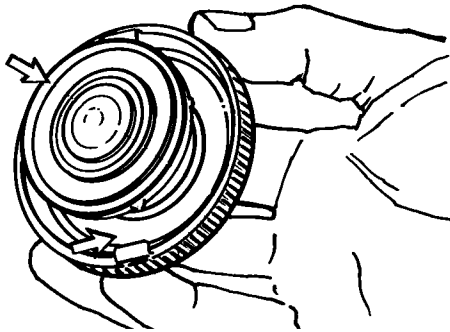


Illustration 19

g00103639

Typical filler cap gaskets

3. Clean the cooling system filler cap and inspect the condition of the filler cap gaskets. Replace the cooling system filler cap if the filler cap gaskets are damaged. Reinstall the cooling system filler cap.
4. Inspect the cooling system for leaks.

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 the eyes. Do not drink cooling system coolant additive.

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

Test for SCA Concentration

Coolant/Antifreeze and SCA

NOTICE

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

Use the 8T-5296 Coolant Conditioner Test Kit or use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA. Refer to the Operation and Maintenance Manual for more information on conventional coolant/antifreeze cooling system maintenance.

Water and SCA

NOTICE

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

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit. Refer to the Operation and Maintenance Manual, "Water/Supplemental Coolant Additive (SCA)" topic (Maintenance Section). Refer to the Operation and Maintenance Manual, "Conventional Coolant/Antifreeze Cooling System Maintenance" topic (Maintenance Section).

S·O·S Coolant Analysis

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

Level 1

Level 1 is a basic analysis of the coolant. The following items are tested:

- Glycol Concentration
- Concentration of SCA
- pH
- Conductivity

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

Add the SCA, If Necessary

NOTICE

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

WARNING

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

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

Note: Always discard drained fluids according to local regulations.

2. If necessary, drain some coolant from the cooling system into a suitable container in order to allow space for the extra SCA.

3. Add the proper amount of SCA. Refer to the Operation and Maintenance Manual for more information on SCA requirements.
4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.

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Cooling System Water Temperature Regulator - Replace

SMCS Code: 1355-510

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

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

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

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

NOTICE

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

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

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

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

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

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

i00894991

Crankshaft Vibration Damper - Inspect

SMCS Code: 1205-040

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

The damper is mounted to the crankshaft which is located behind the belt guard on the front of the engine.

Rubber Damper

Your engine may be equipped with a rubber damper. The rubber damper uses a ring which is mounted in rubber in order to reduce vibrations in the crankshaft.

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

- There is deterioration and cracking of the rubber.
- There is slippage of the outer ring from the original position.
- The engine has had a failure because of a broken crankshaft.
- Analysis of the oil has revealed that the front main bearing is badly worn.
- There is a large amount of gear train wear that is not caused by lack of oil.

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

Visconic Damper

Your engine may be equipped with a visconic damper. The visconic damper has a weight that is located inside a fluid filled case. The weight moves in the case in order to limit torsional vibration.

Inspect the damper for evidence of fluid leaks. If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous, smooth, and difficult to remove from surfaces.

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

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

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

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

i00737417

i00911444

Engine - Clean

SMCS Code: 1000-070

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.

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

Engine Air Cleaner Element (Foam) - Clean/Replace

SMCS Code: 1054-070; 1054-510

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.

1. Remove the air cleaner cover and the element.
2. Cover the air inlet opening with a clean cloth, or seal with tape in order to prevent dirt and debris from entering the engine.
3. Clean the inside of the air cleaner cover and the body with a clean, dry cloth.
4. Wash the element in warm water and mild nonsudsing household detergent. Rinse the element after washing.
5. Inspect the element for deterioration. Replace the element if the element is deteriorated or torn.
6. Remove the seal from the air inlet opening. Install the element and the air cleaner cover.

i00912642

Engine Air Cleaner Element - Clean/Replace

SMCS Code: 1054-070; 1054-510

AIRSEP®

NOTICE

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

NOTICE

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

Note: Use the 102-9720 Cleaning Kit. This product contains the detergent and oil that is made specifically for the maintenance of the AIRSEP® elements.

1. Remove the vacuum limiter element and the AIRSEP® element.
 2. Cover the air inlet opening with a clean cloth, or seal with tape in order to prevent dirt and debris from entering the engine.
 3. Tap the element in order to dislodge dirt particles. Gently brush the element with a soft bristle brush.
-

NOTICE

Do not use gasoline, steam, caustic or unapproved detergents, or parts cleaning solvents. Do not use high pressure water or air to clean the air cleaner element. Any of those liquids or methods can cause air cleaner element damage.

4. Spray the element with the cleaning solution. Allow the element to stand for 20 minutes.
5. Rinse the element with low water pressure. The maximum water pressure for this procedure is 275 kPa (40 psi). Tap water is acceptable. Start to rinse the element from the clean side (inside). Next, clean the dirty side (outside) in order to flush out dirt. Inspect the element for tears and/or holes after the element is cleaned. Do not reuse damaged elements.

NOTICE

Do not use compressed air, open flame, or hot air to dry the air cleaner element. Excess heat shrinks cotton fiber, and compressed air may blow holes in the material. Allow the air cleaner element to air dry.

6. Shake excess water off the element, and allow the element to air dry. Drying the element in the sun speeds the process.
-

NOTICE

Do not use transmission fluid, engine oil, diesel fuel, or other lubricant to oil the air cleaner element. The air cleaner element can not function correctly if improper oil is used. Never operate an engine with a dry air cleaner element. The air cleaner element can not function correctly without oil. Always saturate the clean air cleaner element with the recommended oil.

7. The dry element should be oiled before installation. Apply small amounts of oil across the top of each pleat. Allow the oil to soak into the element for 20 minutes. Oil any remaining "white" spots.
8. Inspect the housing and the clamp for the element. Replace the housing and the clamp, if necessary.
9. Remove the seal from the air inlet opening. Install the clean, oiled element. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section).

Paper Air Cleaner Element

NOTICE

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

NOTICE

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

1. Remove the cover. Remove the element.
2. Cover the air inlet opening with a clean cloth, or seal with tape in order to prevent dirt from entering the engine.
3. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

4. Clean the element and inspect the element. Replace the element, if necessary. Refer to "Cleaning Paper Air Cleaner Elements".
5. Remove the seal from the air inlet opening. Install an element that is new or cleaned.

Cleaning Paper Air Cleaner Elements

The element can be used up to six times if the element is properly cleaned and inspected. When the element is cleaned, check for rips or tears in the filter material. The element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean 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 element before cleaning. Inspect the element for damage to the seal, the gaskets, and the outer cover. Discard any damaged elements.

There are four common methods that are used to clean elements:

- Pressurized water
- Pressurized air
- Vacuum cleaning
- Washing with nonsudsing detergent

Pressurized Water

Pressurized water will clean the element unless carbon and oil have accumulated on the surface of the element. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi). Do not use a spray nozzle.

Note: When the element is 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 water 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 water directly at the element. Dirt could be forced further into the pleats.

Note: Refer to "Drying the Paper Air Cleaner Elements". Refer to "Inspecting the Paper Air Cleaner Elements".

Pressurized Air

Pressurized air can be used to clean 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).

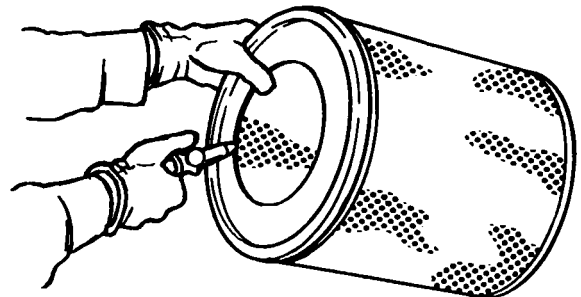


Illustration 20

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Note: When the paper 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 element. Dirt could be forced further into the pleats.

Note: Refer to "Inspecting the Paper Air Cleaner Elements".

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning paper 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 Paper Air Cleaner Elements".

Washing the Paper Air Cleaner Elements with Nonsudsing Detergent

WARNING

Do not wash air cleaner elements in any flammable solution such as diesel fuel or gasoline. Doing so can cause fire or an engine runaway and can result in personal injury.

Washing with nonsudsing detergent is effective for cleaning elements that have deposits of carbon or oil. Use a cleaning agent that is specifically manufactured for cleaning paper air cleaner elements. Cleaning with pressurized water, pressurized air, or vacuum cleaning is recommended prior to washing with nonsudsing detergent.

1. Place the element into a wash tank so that the gasket is up. The wash tank should be equipped with a rack so that the element does not sit on the bottom of the wash tank.

Note: Caterpillar does not recommend a process for washing the element which includes vigorously shaking. By vigorously shaking the element, carbon particles may be distributed.

2. Fill the wash tank with the cleaning agent and warm water to a maximum temperature of 60 °C (140 °F). Follow the manufacturers recommendations for the cleaning agent. Allow the element to soak for six hours.
3. Drain the wash tank. Do not use the cleaning agent more than one time. Remove the element from the wash tank. Rinse the element by performing the method for cleaning with pressurized water.

Note: Refer to “Drying the Paper Air Cleaner Elements”. Refer to “Inspecting the Paper Air Cleaner Elements”.

Drying the Paper Air Cleaner Elements

The oven method may be used in order to dry the elements. If an oven is used, do not expose the elements to temperatures that exceed 82 °C (160 °F).

Note: Do not use compressed air in order to dry the elements.

The elements may be allowed to air dry. Allow two days for the elements to air dry before the elements are inspected and installed.

Inspecting the Paper Air Cleaner Elements

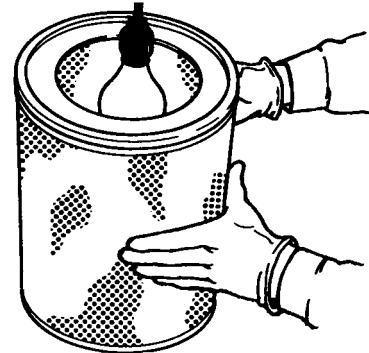


Illustration 21

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Inspect the clean, dry element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the element. Rotate the element. Inspect the element for tears and/or holes. Inspect the filter material for light that may show through the filter material. If it is necessary in order to confirm the result, compare the element to a new element that has the same part number.

Do not use an element that has any tears and/or holes in the filter material. Do not use an element with damaged pleats, gaskets or seals. Discard damaged elements.

Storing Paper Air Cleaner Elements

If an element that passes inspection will not be used, the element can be stored for future use.

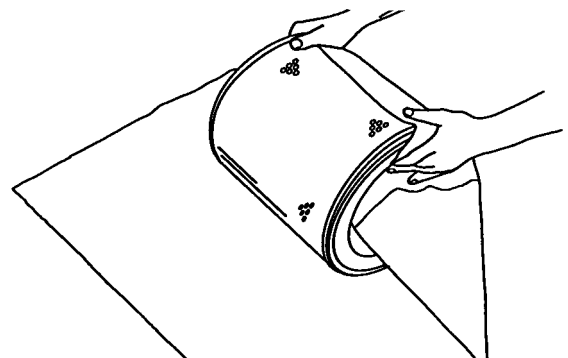


Illustration 22

g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. Restricted air flow may result. To protect against dirt and damage, wrap the elements in Volalite Corrosion Inhibited (VCI) paper.

Place the element into a box for storage. For identification, mark the outside of the box and mark the element. Include the following information:

- Date of the cleaning
- Number of cleanings

Store the box in a dry location.

For more detailed information on cleaning the paper air cleaner element, refer to Special Publication, SEBF8062, "Procedure to Inspect and Clean Air Filters".

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The gauge reads the difference between inlet air pressure before the air cleaner element and after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner element.

A service indicator may be mounted on the air cleaner element or in a remote location.

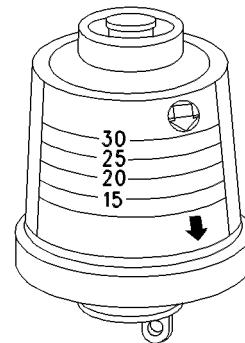


Illustration 23

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Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or replaced when the yellow diaphragm enters the red zone or the red piston locks in the visible position. If the service indicator appears red at any time, clean the air cleaner element or install a new air cleaner element.

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 hole for the service indicator may be plugged.

The service indicator may need to be replaced frequently in environments that are severely dusty, if necessary. Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

Note: When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N·m (18 lb in).

Engine Crankcase Breather - Clean

SMCS Code: 1317-070

NOTICE

Perform this maintenance with the engine stopped.

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

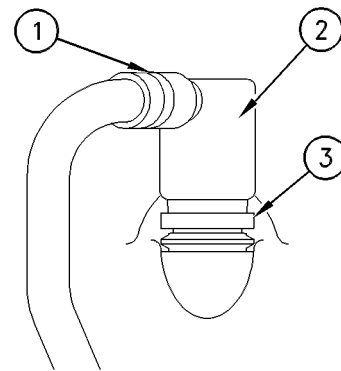


Illustration 24

g00463048

Typical example

- (1) Hose clamp
- (2) Breather assembly
- (3) Retaining clamp

1. Loosen hose clamp (1) and remove the hose from breather assembly (2).
2. Loosen the retaining clamp (3). Remove breather assembly (2) and the seal.
3. Wash the breather element in solvent that is clean and nonflammable. Allow the breather element to dry before installation.
4. Install a breather element that is clean and dry. Install breather assembly and seal (2) and install clamp (3). Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for the proper torques.
5. Install the hose. Install hose clamp (1). Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for the proper torques.

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i00908787

Engine Mounts - Inspect

SMCS Code: 1152-040

Inspect the engine mounts for deterioration and for proper bolt torque. Engine vibration can be caused by the following conditions:

- Improper mounting of the engine
- Deterioration of the engine mounts

Any engine mount that shows deterioration should be replaced. Refer to the Service Manual for the recommended torques. Refer to the OEM recommendations for more information.

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

WARNING

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

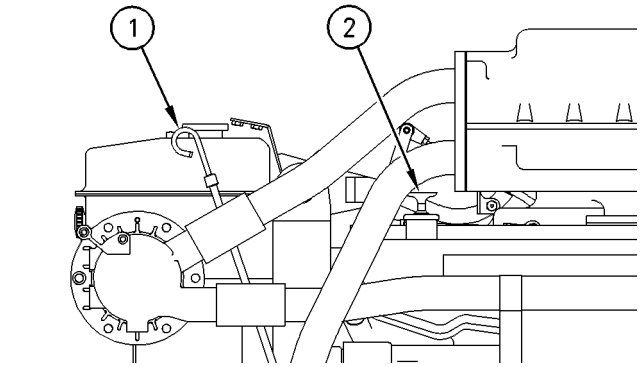


Illustration 25

g00463731

Typical example

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

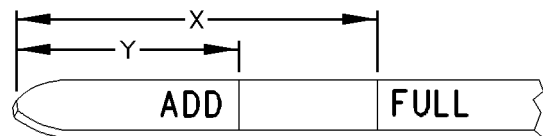


Illustration 26

g00110310

- (Y) "ADD" mark
- (X) "FULL" mark

NOTICE

Perform this maintenance with the engine stopped.

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

NOTICE

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

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

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

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

-
2. Remove oil filler cap (2) and add oil, if necessary. Clean the oil filler cap. Reinstall the oil filler cap.

Engine Oil Level Gauge - Calibrate

SMCS Code: 1326-524

The engine is shipped with an engine oil level gauge that is not marked. The engine oil level gauge is not marked because the angle of the installation and the location of the engine oil level gauge can be different for each engine. The angle of the installation and the location of the engine oil level gauge will affect "ADD" mark (Y) and "FULL" mark (X). These marks are engraved on the engine oil level gauge.

The engine oil level gauge must be calibrated after the engine is installed in the vessel.

Tables 24 through 27 list the installation angles (front to rear) and the corresponding oil level marks. Use a marking pen in order to engrave "ADD" mark (Y) and "FULL" mark (X) on the engine oil level gauge according to the information in Tables 24 through 27.

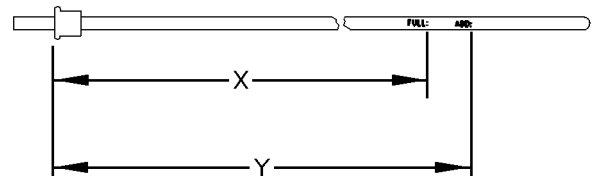


Illustration 27

g00468470

Oil level gauge
(X) "FULL" mark
(Y) "ADD" mark

Table 24

| 3208 Marine Engine (75V1-Up) Oil Level Gauge Calibration Left Hand Service | | |
|---|--------------------|--------------------|
| Angle ⁽¹⁾ | (X) "FULL" Mark | (Y) "ADD" Mark |
| 15 degrees | 759 mm (29.9 inch) | 773 mm (30.4 inch) |
| 14 degrees | 755 mm (29.7 inch) | 769 mm (30.3 inch) |
| 13 degrees | 751 mm (29.6 inch) | 766 mm (30.2 inch) |
| 12 degrees | 748 mm (29.4 inch) | 762 mm (30.0 inch) |
| 11 degrees | 743 mm (29.6 inch) | 758 mm (29.8 inch) |
| 10 degrees | 739 mm (29.1 inch) | 755 mm (29.7 inch) |
| 9 degrees | 735 mm (28.9 inch) | 752 mm (29.6 inch) |
| 8 degrees | 732 mm (28.8 inch) | 748 mm (29.4 inch) |
| 7 degrees | 728 mm (28.7 inch) | 748 mm (29.4 inch) |
| 6 degrees | 723 mm (28.5 inch) | 740 mm (29.1 inch) |
| 5 degrees | 719 mm (28.3 inch) | 736 mm (29.0 inch) |
| 4 degrees | 714 mm (28.1 inch) | 732 mm (28.8 inch) |
| 3 degrees | 711 mm (28.0 inch) | 728 mm (28.7 inch) |
| 2 degrees | 707 mm (27.8 inch) | 725 mm (28.5 inch) |
| 1 degree | 702 mm (27.6 inch) | 720 mm (28.3 inch) |
| 0 degrees | 698 mm (27.5 inch) | 716 mm (28.2 inch) |
| -1 degree | 693 mm (27.3 inch) | 713 mm (28.1 inch) |
| -2 degrees | 689 mm (27.1 inch) | 710 mm (28.0 inch) |
| -3 degrees | 683 mm (26.9 inch) | 707 mm (27.8 inch) |
| -4 degrees | 679 mm (26.7 inch) | 704 mm (27.7 inch) |
| -5 degrees | 676 mm (26.6 inch) | 702 mm (27.6 inch) |
| -6 degrees | 671 mm (26.4 inch) | 700 mm (27.6 inch) |
| -7 degrees | 669 mm (26.3 inch) | 698 mm (27.5 inch) |
| -8 degrees | 665 mm (26.2 inch) | 695 mm (27.4 inch) |
| -9 degrees | 661 mm (26.0 inch) | 693 mm (27.3 inch) |
| -10 degrees | 659 mm (25.9 inch) | 692 mm (27.3 inch) |

(1) A positive angle indicates the number of degrees that the front of the engine is raised. A negative angle indicates the number of degrees that the front of the engine is lowered.

Table 25

| 3208 Marine Engine (75V1-Up) Oil Level Gauge Calibration Right Hand Service | | |
|--|--------------------|--------------------|
| Angle ⁽¹⁾ | (X) "FULL" Mark | (Y) "ADD" Mark |
| 15 degrees | 756 mm (29.8 inch) | 771 mm (30.4 inch) |
| 14 degrees | 752 mm (29.6 inch) | 768 mm (30.2 inch) |
| 13 degrees | 749 mm (29.5 inch) | 763 mm (30.0 inch) |
| 12 degrees | 745 mm (29.3 inch) | 760 mm (29.9 inch) |
| 11 degrees | 741 mm (29.2 inch) | 757 mm (29.8 inch) |
| 10 degrees | 737 mm (29.0 inch) | 752 mm (29.6 inch) |
| 9 degrees | 733 mm (28.9 inch) | 749 mm (29.5 inch) |
| 8 degrees | 730 mm (28.7 inch) | 746 mm (29.4 inch) |
| 7 degrees | 726 mm (28.6 inch) | 742 mm (29.2 inch) |
| 6 degrees | 722 mm (28.4 inch) | 738 mm (29.1 inch) |
| 5 degrees | 718 mm (28.3 inch) | 735 mm (28.9 inch) |
| 4 degrees | 714 mm (28.1 inch) | 730 mm (28.7 inch) |
| 3 degrees | 710 mm (28.0 inch) | 726 mm (28.6 inch) |
| 2 degrees | 706 mm (27.8 inch) | 723 mm (28.5 inch) |
| 1 degree | 702 mm (27.6 inch) | 719 mm (28.3 inch) |
| 0 degrees | 697 mm (27.4 inch) | 715 mm (28.1 inch) |
| -1 degree | 692 mm (27.2 inch) | 712 mm (28.0 inch) |
| -2 degrees | 689 mm (27.1 inch) | 710 mm (28.0 inch) |
| -3 degrees | 685 mm (27.0 inch) | 707 mm (27.8 inch) |
| -4 degrees | 680 mm (26.8 inch) | 704 mm (27.7 inch) |
| -5 degrees | 677 mm (26.7 inch) | 702 mm (27.6 inch) |
| -6 degrees | 673 mm (26.5 inch) | 700 mm (27.6 inch) |
| -7 degrees | 670 mm (26.4 inch) | 698 mm (27.5 inch) |
| -8 degrees | 670 mm (26.4 inch) | 696 mm (27.4 inch) |
| -9 degrees | 663 mm (26.1 inch) | 694 mm (27.3 inch) |
| -10 degrees | 662 mm (26.1 inch) | 693 mm (27.3 inch) |

(1) A positive angle indicates the number of degrees that the front of the engine is raised. A negative angle indicates the number of degrees that the front of the engine is lowered.

Table 26

| 3208 Marine Engines (01Z1-Up) Oil Level Gauge Calibration Left Hand Service | | |
|--|------------------------|-----------------------|
| Angle⁽¹⁾ | (X) "FULL" Mark | (Y) "ADD" Mark |
| 15 degrees | 743 mm (29.3 inch) | 759 mm (29.9 inch) |
| 14 degrees | 738 mm (29.1 inch) | 755 mm (29.7 inch) |
| 13 degrees | 734 mm (28.9 inch) | 752 mm (29.6 inch) |
| 12 degrees | 733 mm (28.8 inch) | 748 mm (29.4 inch) |
| 11 degrees | 737 mm (28.6 inch) | 743 mm (29.2 inch) |
| 10 degrees | 723 mm (28.4 inch) | 739 mm (29.1 inch) |
| 9 degrees | 719 mm (28.3 inch) | 735 mm (29.0 inch) |
| 8 degrees | 715 mm (28.2 inch) | 732 mm (28.8 inch) |
| 7 degrees | 713 mm (28.1 inch) | 728 mm (28.7 inch) |
| 6 degrees | 707 mm (27.8 inch) | 723 mm (28.5 inch) |
| 5 degrees | 703 mm (27.6 inch) | 719 mm (28.3 inch) |
| 4 degrees | 697 mm (27.5 inch) | 715 mm (28.1 inch) |
| 3 degrees | 694 mm (27.3 inch) | 711 mm (28.0 inch) |
| 2 degrees | 690 mm (27.2 inch) | 707 mm (27.8 inch) |
| 1 degree | 684 mm (26.9 inch) | 702 mm (27.6 inch) |
| 0 degrees | 679 mm (26.7 inch) | 698 mm (27.5 inch) |
| -1 degree | 673 mm (26.5 inch) | 693 mm (27.3 inch) |
| -2 degrees | 667 mm (26.3 inch) | 689 mm (27.1 inch) |
| -3 degrees | 660 mm (25.7 inch) | 683 mm (26.9 inch) |
| -4 degrees | 655 mm (25.8 inch) | 679 mm (26.7 inch) |
| -5 degrees | 650 mm (25.6 inch) | 676 mm (26.6 inch) |
| -6 degrees | 643 mm (25.3 inch) | 671 mm (26.4 inch) |
| -7 degrees | 640 mm (25.2 inch) | 669 mm (26.3 inch) |
| -8 degrees | 635 mm (25.0 inch) | 665 mm (26.2 inch) |
| -9 degrees | 629 mm (24.8 inch) | 661 mm (26.0 inch) |
| -10 degrees | 627 mm (24.7 inch) | 659 mm (26.0 inch) |

(1) A positive angle indicates the number of degrees that the front of the engine is raised. A negative angle indicates the number of degrees that the front of the engine is lowered.

Table 27

| 3208 Marine Engines (01Z1-Up) Oil Level Gauge Calibration Right Hand Service | | |
|---|------------------------|-----------------------|
| Angle⁽¹⁾ | (X) "FULL" Mark | (Y) "ADD" Mark |
| 15 degrees | 743 mm (29.3 inch) | 757 mm (29.8 inch) |
| 14 degrees | 739 mm (29.1 inch) | 754 mm (29.7 inch) |
| 13 degrees | 734 mm (28.9 inch) | 748 mm (29.4 inch) |
| 12 degrees | 730 mm (28.8 inch) | 745 mm (29.3 inch) |
| 11 degrees | 725 mm (28.5 inch) | 741 mm (29.2 inch) |
| 10 degrees | 721 mm (28.4 inch) | 737 mm (29.0 inch) |
| 9 degrees | 717 mm (28.2 inch) | 749 mm (28.8 inch) |
| 8 degrees | 714 mm (28.1 inch) | 730 mm (28.7 inch) |
| 7 degrees | 711 mm (28.0 inch) | 726 mm (28.6 inch) |
| 6 degrees | 706 mm (27.8 inch) | 722 mm (28.4 inch) |
| 5 degrees | 701 mm (27.6 inch) | 718 mm (28.3 inch) |
| 4 degrees | 697 mm (27.4 inch) | 714 mm (28.1 inch) |
| 3 degrees | 693 mm (27.3 inch) | 710 mm (28.0 inch) |
| 2 degrees | 689 mm (27.1 inch) | 706 mm (27.8 inch) |
| 1 degree | 684 mm (26.9 inch) | 702 mm (27.6 inch) |
| 0 degrees | 679 mm (26.7 inch) | 697 mm (27.4 inch) |
| -1 degree | 673 mm (26.5 inch) | 692 mm (27.3 inch) |
| -2 degrees | 668 mm (26.3 inch) | 689 mm (27.1 inch) |
| -3 degrees | 664 mm (26.1 inch) | 685 mm (27.0 inch) |
| -4 degrees | 657 mm (25.8 inch) | 680 mm (26.8 inch) |
| -5 degrees | 652 mm (25.7 inch) | 677 mm (26.6 inch) |
| -6 degrees | 646 mm (25.4 inch) | 673 mm (26.5 inch) |
| -7 degrees | 643 mm (25.3 inch) | 670 mm (26.4 inch) |
| -8 degrees | 638 mm (25.1 inch) | 666 mm (26.2 inch) |
| -9 degrees | 633 mm (24.9 inch) | 663 mm (26.1 inch) |
| -10 degrees | 631 mm (24.9 inch) | 662 mm (26.1 inch) |

(1) A positive angle indicates the number of degrees that the front of the engine is raised. A negative angle indicates the number of degrees that the front of the engine is lowered.

i00978513

Engine Oil Sample - Obtain

SMCS Code: 1000-008; 1348-554-SM;
7542-554-OC, SM

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals in order to monitor the condition of the engine and the maintenance requirements of the engine.

Obtain the Sample and the Analysis

WARNING

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

Before taking the sample, complete the Label, PEEP5031 for identification of the sample. To help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The oil's hours of use
- 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 8T-9190 Fluid Sampling Bottle Group is recommended for use with the sampling valve. The bottle group includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE

Do not use the same vacuum sampling pump for extracting oil samples that is used for extracting coolant samples.

A small residue of either type sample may remain in the pump and may cause a false positive analysis for the sample being taken.

Always use a designated pump for oil sampling and a designated pump for coolant sampling.

Failure to do so may cause a false analysis which could lead to customer and dealer concerns.

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.

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Engine Oil and Filter - Change

SMCS Code: 1318-510; 1348-044

WARNING

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

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

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

Drain the Engine Oil

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

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

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

Replace the Oil Filter

NOTICE

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

1. Remove the oil filter with a 1U-8760 Chain Wrench.

2. Cut the oil filter open with a 4C-5084 Oil Filter Cutter. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

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

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

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

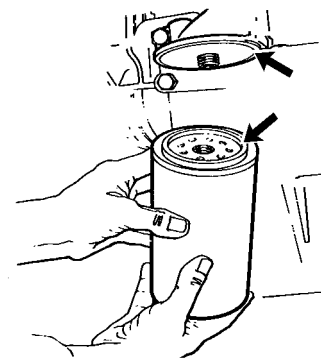


Illustration 28

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Typical filter mounting base and filter gasket

3. Clean the sealing surface of the filter mounting base. Ensure that all of the old oil filter gasket is removed.
4. Apply clean engine oil to the new oil filter gasket.

NOTICE

Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

5. Install the oil filter. Tighten the oil filter until the oil filter gasket contacts the base. Tighten the oil filter by hand according to the instructions that are shown on the oil filter. Do not overtighten the oil filter.

Fill the Engine Crankcase

1. Remove the oil filler cap. Refer to the Operation and Maintenance Manual for more information on lubricant specifications. Fill the crankcase with the proper amount of oil. Refer to the Operation and Maintenance Manual for more information on refill capacities.

NOTICE

If equipped with an auxiliary oil filter system or a remote oil filter system, follow the OEM or filter manufacturer's recommendations. Under filling or overfilling the crankcase with oil can cause engine damage.

NOTICE

To prevent crankshaft bearing damage, crank the engine with the fuel OFF. This will fill the oil filters before starting the engine. Do not crank the engine for more than 30 seconds.

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

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.

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i00915472

Engine Valve Lash - Inspect/Adjust

SMCS Code: 1102-025

The initial valve lash adjustment on new engines, rebuilt engines, or remanufactured engines is recommended at the first scheduled oil change. The adjustment is necessary due to the initial wear of the valve train components and to the seating of the valve train components.

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule in order to help provide maximum engine life.

NOTICE

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

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

WARNING

Ensure that the engine can not be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

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

Refer to the Service Manual for more information.

Exhaust Restrictor - Inspect/Adjust

SMCS Code: 1061-025; 1061-040

Your engine may be equipped with an exhaust restrictor in order to reduce white smoke during engine warm-up.

Inspect Exhaust Back Pressure

NOTICE

If the exhaust restrictor opens too slow, the result is power loss and increased black smoke. If the exhaust restrictor opens too fast, cold starting will produce more white smoke. Avoid these problems by keeping the exhaust restrictor properly adjusted.

Before adjusting the linkage, perform the following steps:

1. Start the engine. Run the engine at low idle rpm.
2. Ensure that the restrictor is in the CLOSED position. Adjust the low idle screw in order to obtain 650 rpm.
3. Measure the exhaust back pressure before the restrictor. No adjustment is needed if the exhaust back pressure is at least 34 kPa (5 psi). Perform the adjustment procedure if the exhaust back pressure is too low.

Note: Set the low idle operating rpm to the desired rpm after adjusting the linkage.

Linkage Adjustment

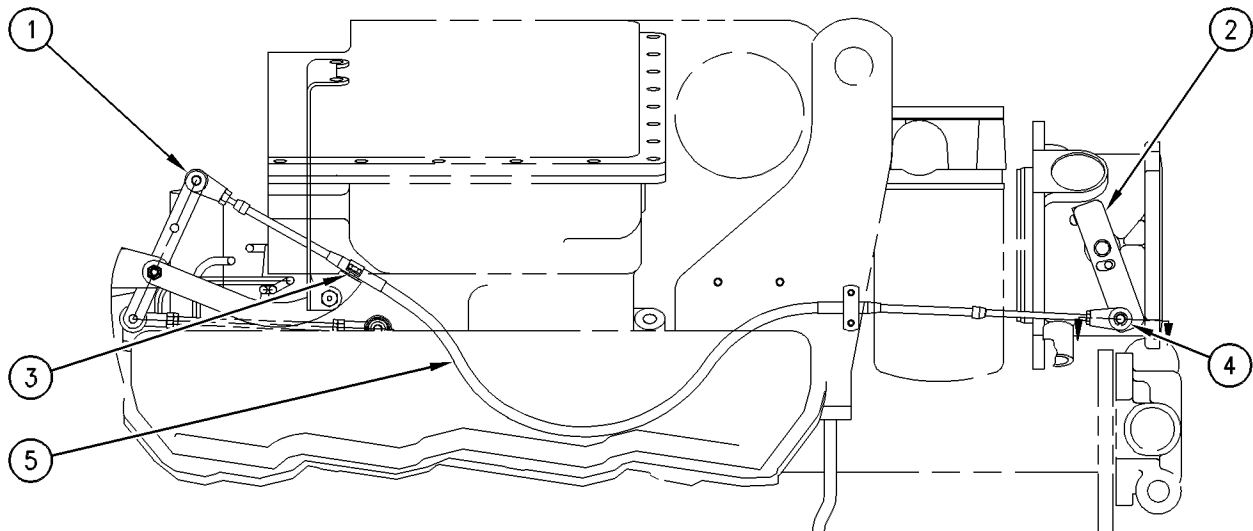


Illustration 29

g00467629

(1) 7E - 8660 Cable End
(2) Lever

(3) Lever assembly
(4) 7E - 8660 Cable End

(5) 7E - 8661 Cable

1. Install the 7E - 8671 Terminal Eye Pin Assembly in lever (2). Install four 4B - 4276 Washers over the threaded end of the pin. Install the threaded end of the pin through the lever. Install the star washer and the nut. Tighten the nut.
2. Install two 7E - 8660 Cable Ends (1) and (4) on the 7E - 8661 Cable (5). Put a 1 mm (0.04 inch) shim between the governor lever and the low idle stop bolt. Place the restrictor in the CLOSED position. Adjust the cable ends. Connect the cable ends to the levers. Remove the shim.

Note: Do not force lever (2) to override the spring during the adjustment of the cable ends (1) and (4).

3. Ensure that the throttle will go into the Low Idle position. The governor lever should be against the low idle stop bolt. Ensure that the throttle will go into the High Idle position. Slight spring tension should be felt when the governor lever goes over center.
4. Use the circlip from the pin assembly in order to attach cable end (4) to the pin on lever (2).
5. Use one 4B - 4276 Washer and one 7H - 9737 Cotter Pin in order to connect cable end (1) to the right side of lever assembly (3), as shown.

Adjust Throttle Cable

Adjust the throttle cable so that there is a slight compressive force in the Low Idle position.

i00626014

Fuel Injection Nozzles - Test/Exchange

SMCS Code: 1254-013; 1254-081

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

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.

Fuel injection nozzles are subject to tip wear. Tip wear is a result of fuel contamination. Tip wear can cause the following problems:

- Increased fuel consumption
- Black smoke
- Misfire
- Rough running

Fuel Injection nozzles should be cleaned, inspected, tested, and replaced, if necessary. Refer to Special Instruction, SEHS7292 for using the 8S-2245 Injection Cleaning Tool Group. Consult your Caterpillar dealer about cleaning the fuel injection nozzle and testing the fuel injection nozzle.

NOTICE

Never wire brush or scrape a fuel injection nozzle. Wire brushing or scraping a fuel injection nozzle will damage the finely machine orifice. Proper tools for cleaning and testing the fuel injection nozzles can be obtained from Caterpillar dealers.

The following items are symptoms of a malfunction of the fuel injection nozzle:

- Abnormal engine operation
- Smoke emission
- Engine knock

Each fuel injection nozzle must be isolated one at a time in order to determine the malfunctioning fuel injection nozzle.

1. Start the engine.

2. Loosen each fuel line nut one at a time at the fuel injection pump. A cloth or similar material must be used in order to prevent fuel from spraying on the hot exhaust components. Tighten each nut before loosening the next nut.

3. A defective fuel injection nozzle may be identified when a fuel line nut is loosened and the following conditions are present:

- The exhaust smoke is partially eliminated or the exhaust smoke is completely eliminated.
- Engine performance is not affected.

A fuel injection nozzle that is suspected of being defective should be removed. A new fuel injection nozzle should be installed in the cylinder in order to determine if the removed fuel injection nozzle is defective.

Removal and Installation of the Fuel Injection Nozzles

For the removal and the installation of fuel injection nozzles, special tooling is required. Refer to the Service Manual for more information. Consult your Caterpillar dealer for assistance.

i00908934

i00909629

Fuel Ratio Control - Inspect/Adjust

SMCS Code: 1278-025; 1278-040

Slow engine response and low power may indicate a need for adjustment or repair of the fuel ratio control. Refer to the Service Manual or your Caterpillar dealer for the complete adjustment procedure on the fuel ratio control.

Fuel System - Prime

SMCS Code: 1258; 1280-045

Priming the fuel system fills the fuel filter. Priming the fuel system removes air bubbles from the fuel system. Prime the fuel system under the following conditions:

- Fuel system that is run dry
- Storage
- Fuel filter maintenance
- Disconnecting fuel lines and installing fuel lines
- Repair of leaks in the fuel lines

WARNING

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

NOTICE

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

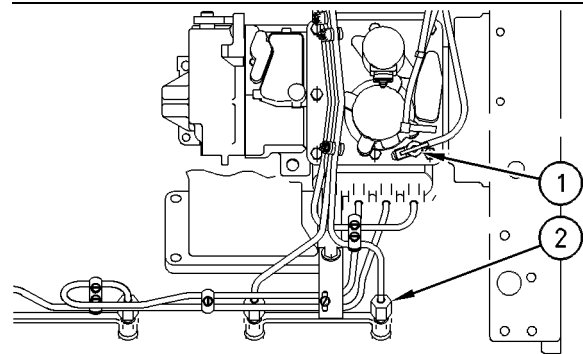


Illustration 30

g00464247

Top view

- (1) Vent valve
- (2) Fuel injection line nuts

NOTICE

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

1. Open vent valve (1) on the fuel injection pump and turn on the fuel tank supply valve.
2. Unlock and operate the priming pump plunger until the flow of fuel from the vent valve is continuous and free of air bubbles.
3. Close vent valve (1) and lock the priming pump plunger. Ensure that any spilled fuel is cleaned up.

NOTICE

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

4. Start the engine. The engine may run rough. Run the engine at low idle until the engine runs smoothly. If the engine will not start, further priming may be necessary. If the engine starts and the engine continues to misfire or smoke, further priming may be necessary.

If further priming is necessary, perform Steps 5 through 9.

NOTICE

Do not let the tops of fuel nozzles turn when the fuel line nuts are loosened or tightened.

The nozzles will be damaged if the top of the nozzle turns in the body.

The engine will be damaged if a defective fuel injection nozzle is used because the shape of fuel (spray pattern) that comes out of the nozzles will not be correct.

5. Loosen fuel injection line nuts (2) at the cylinder head.
6. Unlock and operate the priming pump plunger until the flow of fuel from the fuel injection lines is continuous and free of air bubbles.
7. Lock the priming pump plunger.
8. Tighten the fuel injection line nuts (2). Refer to Specifications for more information on the proper torques. Ensure that any spilled fuel is cleaned up.

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.

9. Start the engine.

Fuel System Primary Filter/Water Separator Element - Replace

SMCS Code: 1260-510; 1260; 1263-510; 1263

Water in the fuel can cause the engine to run rough. Water in the fuel may cause fuel system components to fail. If the fuel has been contaminated with water, the element should be changed before the regularly scheduled interval.

The primary filter/water separator also provides filtration in order to help extend the life of the secondary fuel filter. The element should be changed regularly. The primary filter/water separator should be changed when the vacuum gauge (if equipped) registers 50 to 70 kPa (15 to 20 In Hg).

Replace the Element

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.

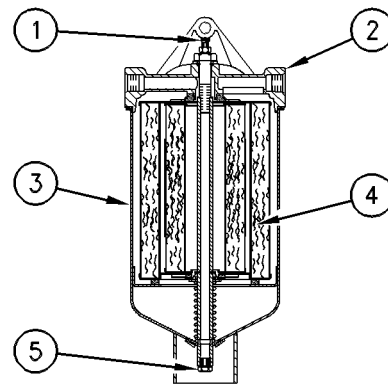


Illustration 31

g00467033

- (1) Vent valve
- (2) Base
- (3) Can
- (4) Element
- (5) Drain plug

1. Close the main fuel supply valve.
2. Remove drain plug (5). Depress vent valve (1) in order to start the flow of fuel. Allow the fuel to drain into a suitable container. Dispose of the fuel properly.
3. Install the drain plug.

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4. Remove can (3) from base (2).
5. Remove element (4) from the can. Dispose of the used element.
6. Remove the gasket. Clean the following components:

- Can
- Gasket
- Base

Inspect the gasket for damage and for deterioration. Replace the gasket, if necessary.

7. Install the gasket. Lubricate the gasket with clean diesel fuel.

NOTICE

The primary filter/water separator may be prefilled with fuel to avoid rough running/stalling of the engine due to air. Do not fill the secondary filter with fuel before installation. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

8. Install a new element in the can. The can may be filled with fuel at this time.
9. Install the can on the base. Tighten the can by hand. Do not use tools in order to tighten the can.

NOTICE

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

10. Open the main fuel supply valve.
11. Start the engine and check for leaks. Run the engine for one minute. Stop the engine and check for leaks again.

Leaks are difficult to detect while the engine is running. The primary filter/water separator is under suction. A leak will allow air to enter the fuel. The air in the fuel can cause low power due to aeration of the fuel. If air enters the fuel, ensure that all components are properly tightened.

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

WARNING

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

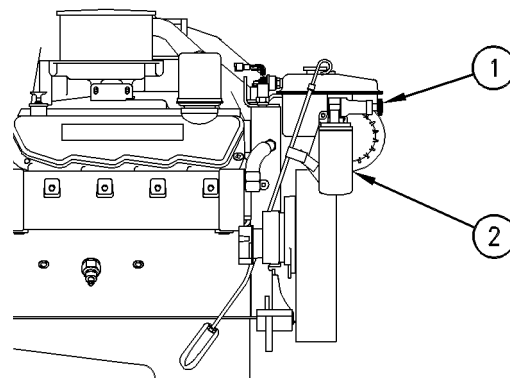


Illustration 32

g00463611

NOTICE

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

1. Stop the engine.
2. Shut off the fuel tank supply valve.

NOTICE

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

3. Remove fuel filter (2).
4. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.
5. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE

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

6. Install the new fuel filter. Spin the fuel filter onto the fuel filter base until the gasket contacts the base. Use the rotation index marks on the filters as a guide for proper tightening. Tighten the filter for an additional 3/4 turn by hand. Do not overtighten the filter.

Fuel System Water Separator - Drain

SMCS Code: 1263-543

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

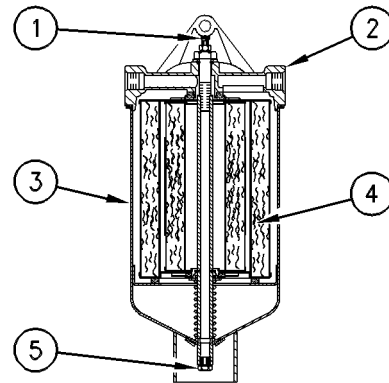


Illustration 33

g00467033

- (1) Vent valve
- (2) Base
- (3) Can
- (4) Element
- (5) Drain plug

Water in the fuel can cause fuel system components to fail. Drain the water separator daily. Drain the water separator more frequently when a large concentration of water is present in the fuel system.

1. Close the fuel supply valve.
-

NOTICE

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

2. Remove drain plug (5). Depress vent valve (1) in order to start the flow. Allow the water to drain into a suitable container. Allow the water to flow until fuel flows from the drain.
 3. Install the drain plug. Dispose of the liquid properly.
 4. Open the fuel supply valve.
-

NOTICE

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

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Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive fuel system wear. 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.

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.

Governor Housing - Drain

SMCS Code: 1287-543

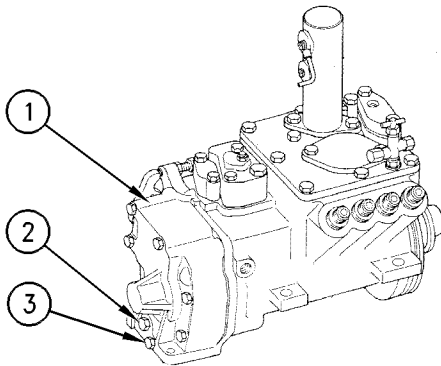


Illustration 34

g00463489

- (1) Governor housing
- (2) Bolt
- (3) Plug

The governor housing (1) is mounted on the rear of the fuel injection pump. Condensation can collect over time in the governor housing. There are two drains which are located at the rear (bottom) of the governor housing. Perform the following procedure in order to drain the water from the governor housing:

1. Remove bolt (2) and plug (3).
2. Allow the water and sediment to drain.
3. Install bolt (2) and plug (3). Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for the proper torques.
4. Prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" topic (Maintenance Section) for more information on priming the fuel system.

Heat Exchanger - Inspect

SMCS Code: 1379-040

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 silt, sediment, salt, algae, etc will adversely affect the heat exchanger system. 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.

Your Caterpillar dealer has the equipment and the trained personnel that are needed in order to measure the pressure drop across the heat exchanger.

The procedure for cleaning the heat exchanger is the same procedure that is used for cleaning the aftercooler core. Refer to the Operation and Maintenance Manual, "Aftercooler Core - Clean/Test" topic (Maintenance Section). For more information on servicing the heat exchanger, consult your Caterpillar dealer.

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Hoses and Clamps - Inspect/Replace

SMCS Code: 7554-040; 7554-510

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

- Cracking
- Softness
- Loose clamps

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

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.

Note: For torques on hose clamps, see this Operation and Maintenance Manual, "Torque Specifications" (Maintenance Section).

7. Install the hose clamps with a torque wrench.

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

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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Magnetic Pickups - Clean/Inspect

SMCS Code: 7400-040; 7400-070

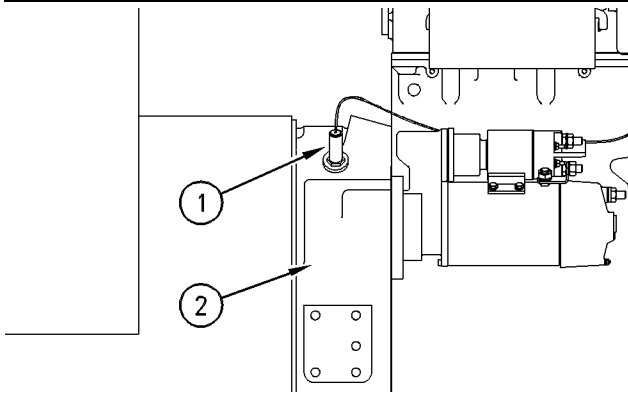


Illustration 35

g00293335

Typical example

- (1) Magnetic pickup
- (2) Flywheel housing

Marine Transmission Oil Cooler - Clean/Inspect

SMCS Code: 3320-040; 3320-070

The procedure for cleaning the marine transmission oil cooler is the same procedure that is used for cleaning the aftercooler core. Refer to the Operation and Maintenance Manual, "Aftercooler Core - Clean/Test" topic (Maintenance Section). For more information on servicing the marine transmission oil cooler, refer to the OEM recommendations or consult your Caterpillar dealer.

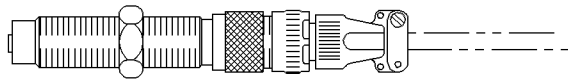


Illustration 36

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Typical magnetic pickup

1. Remove magnetic pickup (1) from flywheel housing (2). Check the condition of the end of the magnetic pickup. Check for signs of wear and contaminants.
2. Clean the metal shavings and other debris from the face of the magnet.
3. Install the magnetic pickup and adjust the magnetic pickup. Refer to the Service Manual for the installation procedure.

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Marine Transmission Oil Level - Check

SMCS Code: 3081-535

Marine Transmission Operation, Maintenance, Warranty, and Parts Support

Caterpillar Inc. encourages customers to refer to a Caterpillar dealer and/or to the OEM dealer for information on the following items:

- Marine transmission operation
- Maintenance of the marine transmission

All support for the warranty will be the responsibility of the OEM. All parts support for the marine transmission will be the responsibility of the OEM. This parts support includes both the installation of parts and the resolution of any service problems.

Refer to the OEM recommendations on the nameplate for the following information about the model of the marine transmission:

- Lubrication specifications
- Requirements for maintenance

Oil Fumes Filter - Replace

SMCS Code: 1317-510

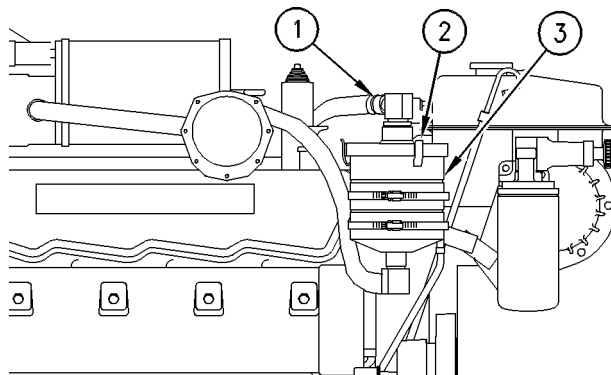


Illustration 37

g00462947

- (1) Hose clamp
- (2) Clip
- (3) Housing

1. Loosen hose clamp (1). Remove the hose.
2. Unfasten clips (2). Remove the cover and the seal from housing (3).

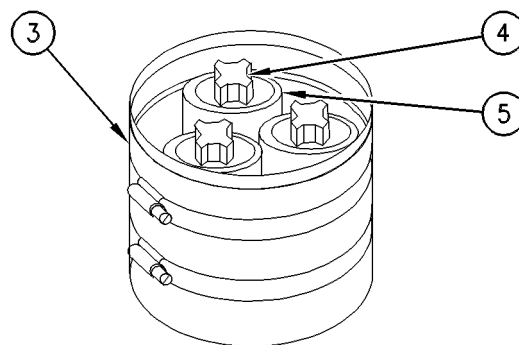


Illustration 38

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- (3) Housing
- (4) Nut
- (5) Filter element

3. Remove nuts (4). Remove filter elements (5) from housing (3). Discard the used elements.
4. Clean the inside of the filter housing with a clean cloth.
5. Install new elements (5) and tighten nuts (4).
6. Clean the cover and the seal with a clean cloth. Inspect the condition of the seal. Replace the seal, if necessary.
7. Install the seal and the cover. Fasten clips (2).

8. Install the hose. Tighten hose clamp (1). Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section) for more information on the proper torques.

Overhaul Considerations

SMCS Code: 7595-043

Reduced hours of operation at full load will result in a lower average power demand. A decreased average power demand should increase both the engine service life and the overhaul interval.

The need for an overhaul is generally indicated by increased fuel consumption and by reduced power.

The following factors are important when a decision is being made on the proper time for an engine overhaul:

- Need for preventive maintenance
- Quality of the fuel that is being used
- Operating conditions
- Results of the S-O-S analysis

Oil Consumption as an Overhaul Indicator

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

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

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

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

Overhaul Options

Before Failure Overhaul

A planned overhaul before failure may be the best value for the following reasons:

- Avoid costly unplanned downtime.
- Reuse many original parts according to the standards for reusable parts.
- Extend the engine's service life without the risk of a major catastrophe due to engine failure.
- Attain the best cost/value relationship per hour of extended life.

After Failure Overhaul

If a major engine failure occurs and the engine must be removed from the hull, many options are available. An overhaul should be performed if the engine block or the crankshaft needs to be repaired.

If the engine block is repairable and/or the crankshaft is repairable, the overhaul cost should be between 40 percent and 50 percent of the cost of a new engine with a similar exchange core.

This lower cost can be attributed to three aspects:

- Specially designed Caterpillar engine features
- Caterpillar dealer exchange components
- Caterpillar Inc. remanufactured exchange components

Overhaul Recommendation

To minimize downtime, Caterpillar Inc. recommends a scheduled engine overhaul by your Caterpillar dealer before the engine fails. This will provide you with the best cost/value relationship.

Note: Overhaul programs vary according to the engine application and according to the dealer that performs the overhaul. Consult your Caterpillar dealer for specific information about the available overhaul programs and about overhaul services for extending the engine life.

If an overhaul is performed without overhaul service from your Caterpillar dealer, be aware of the following maintenance recommendations.

Rebuild or Exchange

Inspect the following components according to the instructions that are found in various Caterpillar reusability publications. The Special Publication, SEBF8029 lists the reusability publications that are needed for inspecting the engine parts.

- Cylinder head assembly
- Connecting rods

- Pistons
- Turbocharger
- Oil pump
- Fuel ratio control
- Cam followers
- Fuel Transfer pump
- Timing advance

If the parts comply with the established inspection specifications that are expressed in the reusable parts guideline, the parts should be reused.

Parts that are not within the established inspection specifications should be salvaged, repaired, or replaced.

Using out-of-spec parts can result in the following problems:

- Unscheduled downtime
- Costly repairs
- Damage to other engine parts
- Reduced engine efficiency
- Increased fuel consumption

Reduced engine efficiency and increased fuel consumption translates into higher operating costs. Therefore, Caterpillar Inc. recommends repairing out-of-spec parts or replacing out-of-spec parts.

Component Replacement

Replace the following components during the overhaul:

- Piston Rings
- Thrust bearings
- Main bearings
- Connecting rod bearings
- Gaskets and seals
- Engine mounts
- Hoses

Inspection

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".

- Camshaft
- Camshaft bearings
- Crankshaft
- Crankshaft vibration damper
- Gear train

Inspect the camshaft for damage to the journals and the lobes. Inspect the camshaft bearings for signs of wear and/or for signs of fatigue.

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 rod bearings and 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 are found:

- Engine failure due to a broken crankshaft
- Excessive wear of the front main bearing
- Excessive wear of the gear train that is not caused by a lack of lubrication
- Visconic damper that is dented, cracked, or leaking
- Visconic damper that is discolored from heat
- Rubber damper that is deteriorated and cracked
- Rubber damper with slippage of the outer ring

Inspect the gear train for the following conditions:

- Worn gear teeth

- Unusual fit
- Unusual wear

Testing

Test the following components during the overhaul:

- Fuel injection nozzles
- Fuel injection pump
- Governor

Testing the fuel system during the overhaul will ensure that your engine operates at peak efficiency. Your Caterpillar dealer can provide these services and components in order to ensure that your fuel system is operating within the appropriate specifications.

Cleaning

The following components should be cleaned and pressure tested during the overhaul:

- Engine oil cooler
- Marine gear oil cooler
- Aftercooler
- Heat exchanger

Refer to the Operation and Maintenance Manual, "Aftercooler Core - Inpect/Clean" topic (Maintenance Section) for the cleaning procedure.

Obtain Coolant Analysis

The concentration of supplemental coolant additive (SCA) should be checked regularly with test kits or with S-O-S Coolant Analysis (Level I). Further coolant analysis is recommended when the engine is overhauled.

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 that 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 can be obtained by consulting your local water utility company or an agricultural agent. Private laboratories are also available for water analysis.

Caterpillar Inc. recommends an S-O-S Coolant Analysis (Level II).

S-O-S Coolant Analysis (Level II)

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An S-O-S Coolant Analysis (Level II) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S-O-S Coolant Analysis (Level II) provides the following information:

- Complete S-O-S Coolant Analysis (Level I)
- Visual inspection of properties
- Identification of metal corrosion
- Identification of contaminants
- Identification of built up impurities (corrosion and scale)

S-O-S Coolant Analysis (Level II) provides a report of the results of both the analysis and the maintenance recommendations that are based on the analysis.

For more information about coolant analysis, consult your Caterpillar dealer.

PCV Valve - Inspect

SMCS Code: 1074-040

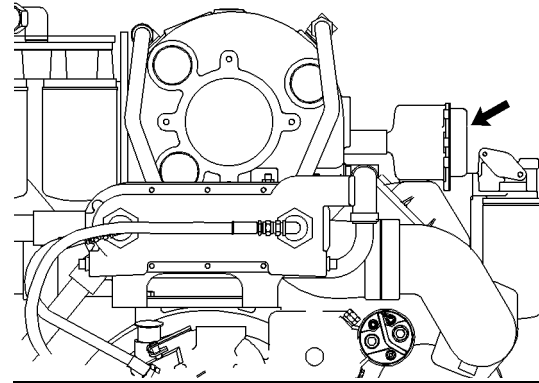


Illustration 39

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Typical PCV valve location

1. Clean the outside of the PCV valve and clean the area around the PCV valve.
2. Inspect the condition of the PCV hose. Replace the PCV hose, if necessary.

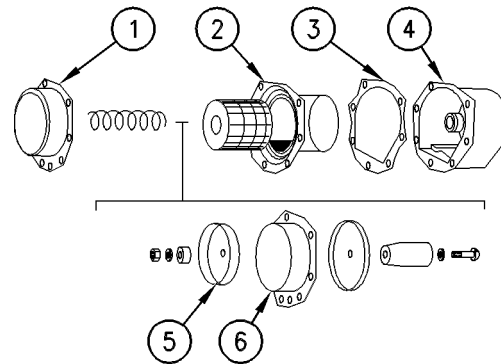


Illustration 40

g00467461

- (1) Cover
- (2) Inner sleeve
- (3) Gasket
- (4) Housing
- (5) Piston
- (6) Diaphragm

3. Remove the screws and washers that hold cover (1) in place.
4. Remove cover (1) and the spring.
5. Remove the diaphragm assembly, inner sleeve (2), and gasket (3) from housing (4).
6. Disassemble the diaphragm assembly.

7. Clean all of the parts. Inspect all of the parts. Replace any part that is worn or damaged. Always install a new gasket and a new diaphragm when the PCV valve is being serviced.
8. Assemble the diaphragm assembly. Use a new diaphragm (6).
9. Coat both flange sides of the diaphragm with gasket cement in order to prevent diaphragm (6) from distorting and cracking. Install the diaphragm so that the face of the diaphragm that is marked "piston face" faces piston (5).
10. Coat the new gasket (3) with gasket cement. Install the gasket against the rear face of inner sleeve (2).
11. Install the diaphragm assembly in housing (4).
12. Install the spring and cover (1). Install the screws and washers that hold the cover in place.

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.

Ensure that the auxiliary water pump is primed and that the suction line is open.

1. Remove the sea water strainer and clean the screen. Remove any dirt and debris.
2. Install the sea water strainer. Fill the sea water strainer and the suction line for the auxiliary water pump with water.

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Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

Caterpillar Inc. recommends a scheduled inspection of the starting motor. If the starting motor fails, the engine may not start in an emergency situation.

Check the starting motor for proper operation. Check the electrical connections and clean the electrical connections. Refer to the Service Manual for more information on the checking procedure and for specifications or consult your Caterpillar dealer for assistance.

Turbocharger - Inspect

SMCS Code: 1052-040

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

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

NOTICE

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

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

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

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Note: Turbocharger components require precision clearances. The turbocharger cartridge must be balanced due to high rpm. Severe Service Applications can accelerate component wear. Severe Service Applications require more frequent inspections of the cartridge.

Removal and Installation

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

Cleaning and Inspecting

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

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

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

Walk-Around Inspection

SMCS Code: 1000-040

Inspect the Engine for Leaks and for Loose Connections

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

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

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

NOTICE

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

NOTICE

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

- Ensure that cooling lines are properly clamped and that cooling lines are tight. Check for leaks. Check the condition of all pipes.
- Check the marine transmission oil level. Refer to the OEM specification for the marine transmission or refer to the OEM specification for the vessel.
- Inspect the water pumps for coolant leaks.

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

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

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

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

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

Water Pump - Inspect

SMCS Code: 1361-040; 1361

A failed water pump might cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head
- A piston seizure
- Other potential damage to the engine

Visually inspect the water pump for leaks. If any leaking is observed, replace each water pump seal. Refer to the Service Manual for the disassembly and assembly procedure.

Inspect the water pump for any of the following conditions:

- Wear
- Cracks
- Pin holes
- Proper operation

Note: Refer to the Service Manual or consult your Caterpillar dealer if any repair is needed or any replacement is needed.

i00917820

Zinc Rods - Inspect/Replace

SMCS Code: 1388-040; 1388-510

Corrosion in sea water circuits can result in 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 inserted in the sea water cooling system of the engine in order to help prevent the corrosive oxidation that is caused by sea water. The reaction of the zinc to the sea water causes the zinc rods to 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 from improperly grounded electrical attachments.

The zinc rods must be inspected at the proper intervals. The zinc rods must be replaced when deterioration occurs.

Inspect the Zinc Rods

The zinc rods are red for easy identification. Table 28 shows the locations of the zinc rods and the quantities of the zinc rod:

Table 28

| Locations of the Zinc Rods | |
|--|----------|
| Location | Quantity |
| Right Heat Exchanger Bonnet | 2 |
| Left Heat Exchanger Bonnet | 1 |
| Transmission Oil Cooler ⁽¹⁾ | 2 |
| Exhaust Elbow ⁽²⁾ | 2 |

(1) Zinc rods will only be located in marine transmission oil coolers that are cooled with sea water.

(2) Exhaust elbows that are aftermarket may or may not be equipped with 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.

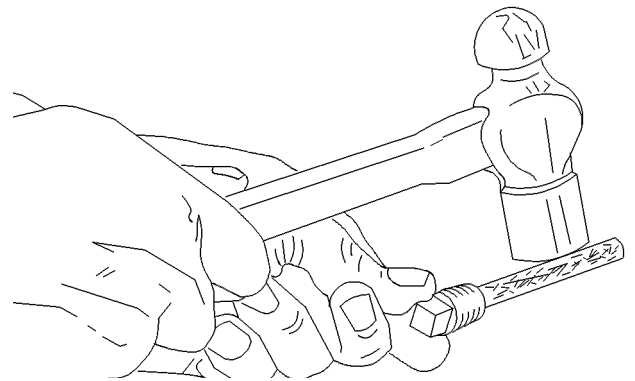


Illustration 41

g00481100

- b. Tap the zinc rod lightly with a hammer. If the zinc rod flakes, 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. Unscrew the old zinc rod from the plug.

If not enough material remains or the zinc rod has broken off, drill the old zinc rod from the plug.

2. Clean the plug.

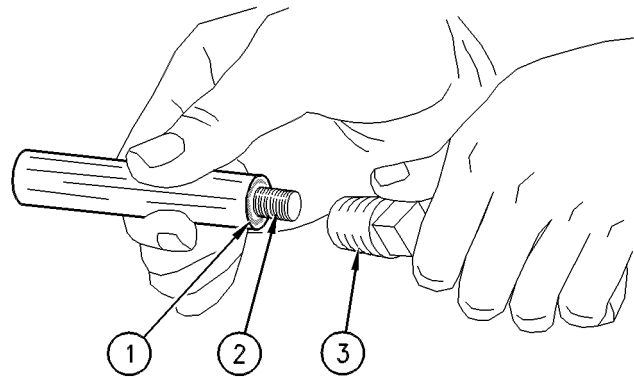


Illustration 42

g00480345

- (1) Shoulder of the zinc rod
- (2) Threads of the zinc rod
- (3) External threads of the plug

Note: DO NOT apply adhesive or sealant to threads (2) of the zinc rod .

3. Apply 9S-3263 Thread Lock Compound to 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 external threads (3) of the plug with 5P - 3413 Pipe Sealant. Install the zinc rod. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section).

Reference Information Section

Engine Ratings

i00727327

Engine Rating Conditions

SMCS Code: 1000

All engine ratings are in compliance with the following standard ambient air conditions of "SAE J1349":

- 99 kPa (29.3 inches of Hg)
- 30 percent relative humidity
- A temperature of 25 °C (77 °F)

Ratings relate to the standard conditions of "ISO8665", of "ISO3046/1", of "DIN6271", and of "BS5514".

The engine ratings are based on the following fuel 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/m³ (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 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).

Engine Rating Definitions

SMCS Code: 1000

It is important to know the use of the vessel so that the rating will match the operating profile. The proper rating selection is also important so that the customer's perception of price and value is realized.

In selecting a rating for a specific application, the most important consideration is the time that is spent at full throttle. These rating definitions identify the percent of time at full throttle. The definitions also identify the corresponding times below rated rpm.

A Continuous – The engine is operated at a rated load and at rated rpm up to 100 percent of the time without interruption or without load cycling. Typical use is 5000 to 8000 hours per year. Continuous operation is used for heavy-duty service in ocean-going displacement hull vessels such as freighters, tugs, bottom drag trawlers, and deep river towboats.

B Medium Duty – The engine may be operated at a load factor up to 80 percent and at rated load and at rated rpm for 80 percent of the duty cycle or for 10 hours out of every 12 hours. Typical use is 3000 to 5000 hours per year in displacement hull vessels such as mid-water trawlers, purse seiners, crew boats, supply boats, ferries, and towboats when locks, sandbars and curves dictate frequent slowing.

C Intermittent – The engine may be operated at a load factor up to 80 percent and at rated load and at rated rpm for 50 percent of the duty cycle or for six hours out of every 12 hours. Typical use is 2000 to 4000 hours per year with a cyclical load and cyclical speed. Intermittent operation is used for planing hull vessels such as ferries, out and back offshore service boats, displacement hull yachts, short trip coastal freighters, and fishing boats that move at higher speeds.

D Patrol Craft – The engine may be operated at a load factor up to 50 percent and at rated load and at rated rpm for 16 percent of the duty cycle or for two hours out of every 12 hours. Typical use is 1000 to 3000 hours per year in vessels such as off-shore patrol boats, customs, police, some fishing boats, some fire boats, and bow and stern thrusters.

E High Performance – The engine may be operated at a load factor up to 30 percent and at rated load and at rated rpm for eight percent of the duty cycle or 1/2 hour out of every six hours. Typical use is 250 to 1000 hours per year in planing hull vessels such as pleasure craft, harbor patrol, harbor master, pilot boats, and some fishing boats.

NOTICE

Operating engines above the rating definitions can result in shorter service life before overhaul.

Typical operating parameters for each rating level are summarized in Table 29. Table 29 assumes the use of a fixed pitch propeller. If a variable pitch propeller is used, consult your Caterpillar dealer for marine engine performance and for information on reduced engine rpm. Optimum fuel consumption can be achieved by operating the engine at the Suggested Reduced rpm.

Table 29

| 3208 Marine Engine Ratings | | | |
|-----------------------------------|----------------------|------------------|---|
| Rating Level | Full Throttle | | Suggested Reduced rpm "Cruising Speed" |
| | Time | Rated rpm | |
| A | Up to 100 percent | - | - |
| B | Up to 80 percent | 2400 | 2300 |
| C | Up to 50 percent | 2600 | 2300 |
| C | Up to 50 percent | 2800 | 2500 |
| D | Up to 16 percent | 2800 | 2400 |
| E | Up to 8 percent | 2800 | 2400 |

For most applications, the customer can provide profile information from similar vessels or from the actual vessel. If the information that is provided by the customer is not sufficient, instruments are available to more precisely define the operating profile. A 7D-1513 Tachograph Assembly can establish an operating profile by recording engine rpm versus time on a paper graph.

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)

i00680564

Engine Performance

SMCS Code: 1000

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, these 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.

Your Caterpillar dealer can determine the condition of the engine. Your Caterpillar dealer can also check the engine's external systems with a diagnostic procedure. For more information on this procedure, refer to the Operation & Maintenance Manual, "Marine Engine Performance Analysis Report (PAR)" in the Reference Information section.

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.

i00079633

Marine Engine Performance Analysis Report (PAR)

SMCS Code: 1000

Today's marine operator is concerned with performance, cost of operation and satisfactory engine life. Although the engine is one of numerous factors that influences the propulsion system, performance has been directly related to the propulsion engine.

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 that the following components are matched 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

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 A
P.O. Box 600
Peoria, Illinois 61552-0600

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.

Central America and Caribbean
Caterpillar Americas Co.
15550 NW 59th Avenue
Miami Lakes, FL 33014
USA
Phone: 305-816-3306
Fax: 305-816-3307

Mexico
Grupo Financiero Caterpillar Mexico, S.A. de C.V.
Primer piso del Arco Oriente de Arco Bosques Corporativa,
Bosques del Alisos 45A
Bosques de Las Lomas
Mexico, D.F. 05120
Phone (from within Mexico): 915-258-1515
Fax (from within Mexico): 915-258-1530
Phone (from within USA): 011-525-258-1515
Fax (from within USA): 011-525-258-1530

Ecuador, Colombia, Venezuela, Guyana, and Suriname
Caterpillar Americas Co.
15550 NW 59th Avenue
Miami Lakes, FL 33014
USA
Phone: 305-816-3316
Fax: 305-816-3317

Peru, Chile, and Bolivia
Caterpillar Americas Co.
Edificio Centro Santa Maria
Av. Los Conquistadores 1700
Piso 14, Oficina A
Santiago, Chile
Phone: 011-562-366-5100
Fax: 011-562-366-5125

Brazil, Argentina, Paraguay, and Uruguay
Caterpillar Americas Co.
Birmann II
Rua Aleandre Dumas, 1.711-9.0
Chac., Sto. Antonio
04717-004-Sao Paulo, SP
Phone: 55-11-5180-2000
Fax: 55-11-5182-9694

Europe, Africa, and Middle East
Caterpillar Overseas S.A.
76 Route de Frontenex
P.O. Box 6000
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, Hong Kong
China
Phone: 852-2848-0333
Fax: 852-2848-0440

Japan
Shin Caterpillar Mitsubishi Ltd.
Setagaya Business Square Tower
10-1, Yoga 4-chome
Setagaya, Tokyo
Japan
Phone: 81-3-5717-1121
Fax: 81-3-5717-1177

Japan
Caterpillar Power Systems, Inc.
Japan Branch Sanno Grand Bldg.
2-14-2 Nagatacho
Chiyoda-ku, Tokyo, 100
Japan
Phone: 81-335-93-3237
Fax: 81-335-93-3238

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Phone: 03-9339-9333
Fax: 03-9335-3366

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 the investment in your Caterpillar engine.

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

Also specify the following information about the engine that needs the parts:

- Serial number
- Arrangement number
- Modification number

If there is a question concerning the part number, please provide your dealer with a complete description of the needed item.

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Ordering Replacement Parts

SMCS Code: 7567

When a Caterpillar engine requires maintenance or a Caterpillar engine requires repair, give the dealer all the information that is provided on the Information Plate. This information is described in the Operation and Maintenance Manual.

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.

Reference Materials

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Reference Material

SMCS Code: 1000

The following literature can be obtained through any Caterpillar dealer.

Lubricants

- Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations"
- Special Publication, PEHP1026, "Data Sheet - Caterpillar Diesel Engine Oil (DEO) (CF-4) (International only)"
- Special Publication, PEHP6046, "Data Sheet - Caterpillar Diesel Engine Oils (DEO) (CG-4 and CF-4) (North America and selected International)"
- Special Publication, PEHP8038, "Data Sheet - Caterpillar Diesel Engine Oils (DEO) (CH-4) (North America and Australia)"
- Special Publication, PEHP0003, "Data Sheet - Multipurpose Lithium Complex Grease (MPG)"
- Special Publication, PEHP0002, "Data Sheet - Multipurpose Lithium Complex Grease with Molybdenum (MPGM)"
- Special Publication, PEHP0017, "Data Sheet - Special Purpose Grease (SPG) Bearing Lubricant"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"
- Special Publication, SEBD0640, "Oil and Your Engine"
- Special Publication, PECP6026, "One Safe Source"
- Special Publication, PEDP7036, "S-O-S Fluid Analysis Cornerstone"

Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

Coolants

- Special Publication, SEBD0970, "Coolant and Your Engine"

- Special Publication, PEHP4036, "Data Sheet-Caterpillar Coolant"
- Special Publication, SEBD0518, "Knowing Your Cooling System"
- Special Publication, PECP6026, "One Safe Source"
- Special Publication, PEHP7057, "S-O-S Coolant Analysis"

Miscellaneous

- Service Manual, SENR4610, "3208 Industrial and Marine Engines"
- Service Manual, SENR6595, "3208 Marine Engine"
- Special Publication, LEBM7535, "3208 Marine Propulsion Engine Performance"
- Special Instruction, SEHS7633, "Battery Test Procedure"
- Special Publication, LEDM5615, "Caterpillar Marine Parts and Service Locations Directory"
- Special Instruction, SEHS7332, "Do Not Operate Tag"
- Special Publication, SEBF8062, "Guideline for Reusable Parts - Cleaning and Inspection of Air Filters"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"
- Special Publication, LEXM8092, "Pleasure Craft Storage Guide"
- Service Manual, REG1139F, "Service Manual Contents Microfiche"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"

i00895871

Additional Reference Material

SMCS Code: 1000

The "EMA Lubricating Oils 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
401 N. Michigan Ave.
Chicago, IL, USA 60611
(312) 644-6610 ext. 3626

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
(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
(202) 682-8000

i00912149

Maintenance Records

SMCS Code: 1000

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
- Maintenance log

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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: _____

