



Operation and Maintenance Manual

3176C and 3196 Marine Engines

2XR1-Up (Engine)
6BW1-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, including human factors that can affect safety. 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 verify that you are authorized to perform this work, and have read and understood the operation, lubrication, maintenance and repair information.

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

A non-exhaustive list of 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. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. 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 you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

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. Cat dealers have the most current information available.



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

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

In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner's choosing.

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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 Cat 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 Cat 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 Cat 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 Cat dealer. Your Cat 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 Cat 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

Safety Messages

i05162739

SMCS Code: 1000; 7405

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

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

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

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.

Type 1

The safety messages that are on the engine may look like the safety messages that are illustrated and described below.

Electrical Shock Hazard (1)

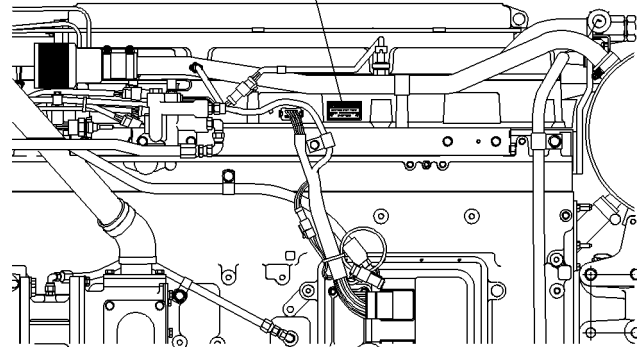
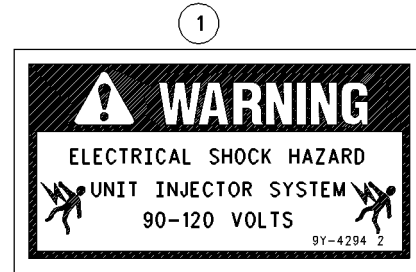


Illustration 1

g00887196

A safety message for the electronic unit injector is located on each side of the valve cover base near the front of the engine.

WARNING

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

The ECM sends a high voltage signal to the injector solenoid. To help prevent personal injury, disconnect the electronic unit injector enable circuit connector. Do not come in contact with the electronic unit injector terminals while the engine is running.

Type 2

The safety messages that are on the engine may look like the safety messages that are illustrated and described below.

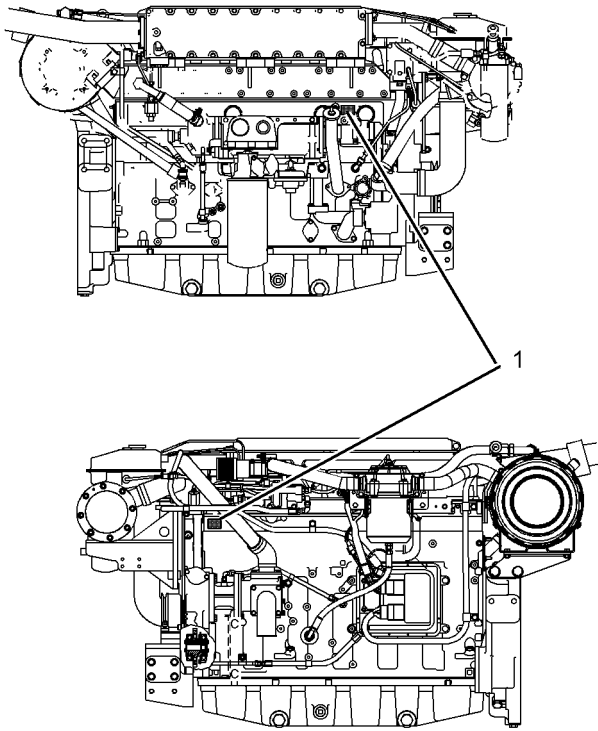


Illustration 2

g03316940

Universal Warning



Illustration 3

g01370904

The safety message is located on the valve cover base toward the front of both sides of the engine.



Do not operate or work on this equipment 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 Cat dealer for replacement manuals. Proper care is your responsibility.

Additional Messages

The following safety messages may be located on the heat exchanger.

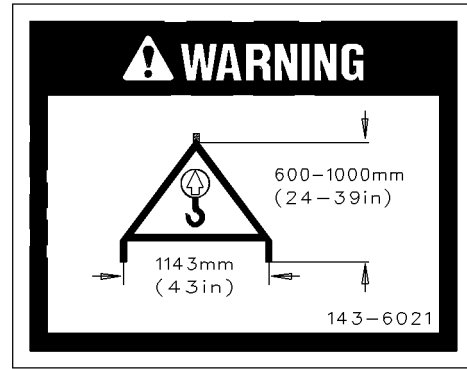


Illustration 4

g00887228

i04074884

General Hazard Information

SMCS Code: 1000; 4450; 7405

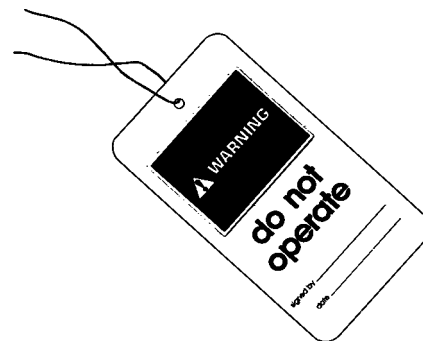


Illustration 5

g00104545

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

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

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

- Filler caps

- Grease fittings
- Pressure taps
- Breathers
- Drain plugs

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

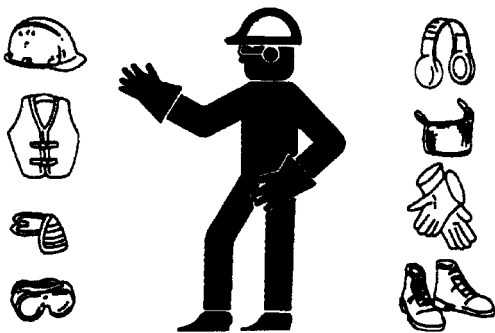


Illustration 6

g00702020

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

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

- The engine is stopped. Ensure that the engine cannot be started.
- 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.
- When starting a new engine or an engine which has not been started since service has been performed, make provisions to stop the engine if an overspeed occurs. Shutting down the engine may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- Start the engine with the operator controls. Never short across the starting motor terminals or the batteries. This method of starting the engine could bypass the engine neutral start system and/or the electrical system could be damaged.

Pressurized Air and Water

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

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

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded and used with effective chip guarding (if applicable) and personal protective equipment. 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

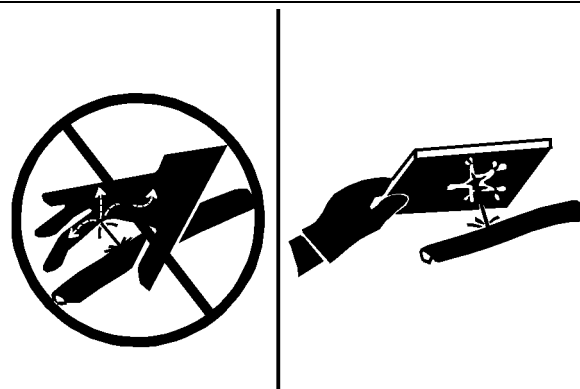


Illustration 7

g00687600

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

Containing Fluid Spillage

NOTICE

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

Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog" or refer to Special Publication, PECJ0003, "Caterpillar Shop Supplies and Tools Catalog" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

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. Correct installation of these components will help to prevent these effects: vibration, rubbing against other parts, and excessive heat during operation.

Inhalation

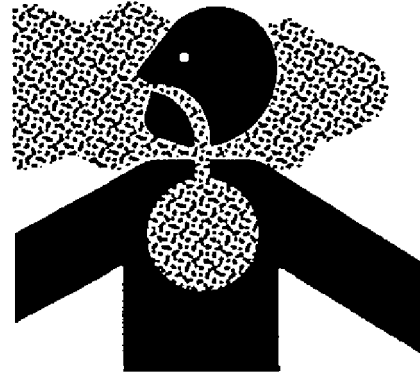


Illustration 8

g02159053

Exhaust

Use caution. Exhaust fumes can be hazardous to your health. If you operate the equipment in an enclosed area, adequate ventilation is necessary.

Asbestos Information

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

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

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

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.

- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in "29 CFR 1910.1001".
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

Softwrap

Keep the engine room ventilation operating at full capacity. Wear a particulate respirator that has been approved by the National Institute of Occupational Safety and Health (NIOSH). Wear appropriate protective clothing in order to minimize direct contact. Use good hygiene practices and wash hands thoroughly after handling Softwrap material. Do not smoke until washing hands thoroughly after handling Softwrap material. Clean up debris with a vacuum or by wet sweeping. Do not use pressurized air to clean up debris.

Reference: The applicable material safety data sheets can be found at the following web site by searching by the part number or the name of the product:

<http://dsf2ws.cat.com/msds/servlet/cat.cis.ecs.msdsSearch.controller.UserIdentificationDisplayServlet>

Dispose of Waste Properly

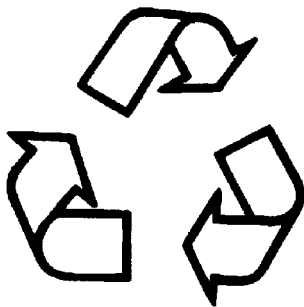


Illustration 9

g00706404

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

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

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Burn Prevention

SMCS Code: 1000; 4450; 7405

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

Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant. Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check the coolant level after the engine has stopped and the engine has been allowed to cool. Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly in order to relieve pressure.

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

Oils

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

If the application has a makeup tank, remove the cap for the makeup tank after the engine has stopped. The filler cap must be cool to the touch.

Batteries

The liquid in a battery is an electrolyte. Electrolyte is an acid that can cause personal injury. Do not allow electrolyte to contact the skin or the eyes.

Do not smoke while checking the battery electrolyte levels. Batteries give off flammable fumes which can explode.

Always wear protective glasses when you work with batteries. Wash hands after touching batteries. The use of gloves is recommended.

i04363128

Fire Prevention and Explosion Prevention

SMCS Code: 1000; 4450; 7405



Illustration 10

g00704000

Use of personal protection equipment (PPE) may be needed.

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

Always perform a Walk-Around Inspection, which may help you identify a fire hazard. Do not operate a product when a fire hazard exists. Contact your Caterpillar dealer for service.

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

A flash fire may result if the covers for the engine crankcase are removed within 15 minutes after an emergency shutdown.

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

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

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

All fluids that are captured in the fluid spill containment basin should be cleaned up immediately. Failure to clean up spilled fluids can cause a fire. Fire may cause personal injury and property damage.

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

Do not expose the engine to any flame.

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

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

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

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

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

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

Properly install all oil filters and all fuel filters. The filter housings must be tightened to the proper torque.



Illustration 11

g00704059

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

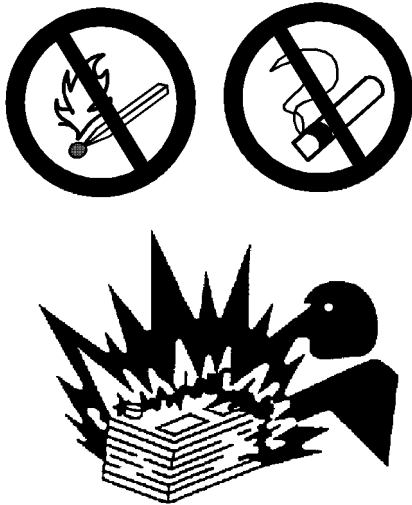


Illustration 12

g02298225

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

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

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

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

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

Fire Extinguisher

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

Ether

Do not use ether as a starting aid. Refer to this Operation and Maintenance Manual, "Starting the Engine" for information about starting the engine.

Lines, Tubes, and Hoses

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

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

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

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

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

Make sure that all clamps, guards, and heat shields are installed correctly in order to prevent vibration, rubbing against other parts, and excessive heat.

i01359666

Crushing Prevention and Cutting Prevention

SMCS Code: 1000; 4450; 7405

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

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

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

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

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

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

i01372247

Mounting and Dismounting

SMCS Code: 1000; 4450; 7405

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

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

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

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

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

i03560601

Before Starting Engine

SMCS Code: 1000

NOTICE

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

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.

Inspect the engine for potential hazards.

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.

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

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

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

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

See the Service Manual for repairs and for adjustments.

i03941639

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 with the engine start switch.

Always start the engine according to the procedure that is described in this Operation and Maintenance Manual, "Starting the Engine" for information about starting the engine. Know the correct procedure to prevent major damage to the engine components. Know the correct procedure 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 ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

i01462046

Engine Stopping

SMCS Code: 1000

Stop the engine according to the procedure in the Operation and Maintenance Manual, "Engine Stopping (Operation Section)" in order to avoid overheating of the engine and accelerated wear of the engine components.

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.

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

To stop an electronically controlled engine, cut the power to the engine.

i05082933

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 may cause the combustible gasses that are produced by some batteries to ignite.

Connect the negative jump-start cable last from the external power source to the negative terminal of the starting motor. This connection sequence helps to prevent sparks from igniting any combustible gasses which batteries may produce. If the starting motor is not equipped with a negative terminal, connect the jump-start cable to the engine block.

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

Grounding Practices

Properly ground the electrical system for the vessel and the engine. Proper grounding is necessary for optimum engine performance and reliability. Improper grounding will result in uncontrolled or unreliable electrical circuit paths.

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

Connect the starting motor directly to the negative battery terminal. Connect the alternator to the negative battery or negative terminal for the starting motor. The alternator and the starting motor must meet marine isolation requirements.

Note: All electrical connections must meet or exceed the American Boat and Yacht Council Standard E-11.

Use a bus bar with a direct path to the negative battery terminal for low current components that require a negative battery connection. Connect the bus bar directly to the negative battery terminal.

Note: All return paths to the negative battery must be able to carry any likely fault currents.

The use of a bus bar ensures that the electronic control module (ECM) and the components connected to the ECM have a common reference point.

Refer to Special Instruction, REHS1187, "Marine Engine Electronic Installation Guide" for additional information on grounding procedures.

Negative Battery Connection for Multiple Engines

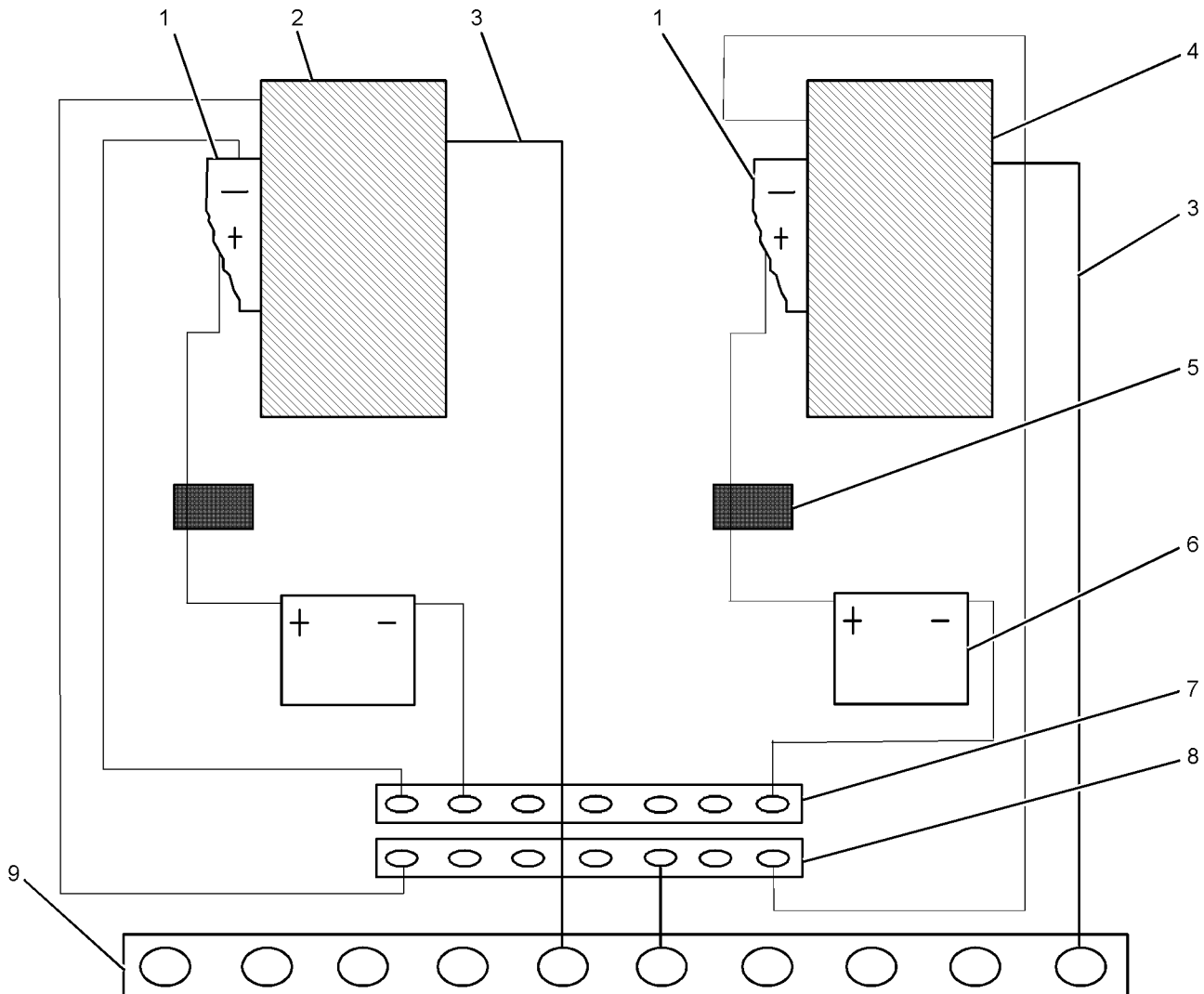


Illustration 13

g03171056

- (1) Starting motor
- (2) Electronic control module (ECM) battery negative battery connection or customer connector for one engine
- (3) Grounding strap for the cylinder block

- (4) ECM battery positive connection or customer connector for one engine
- (5) Battery disconnect switch
- (6) Battery (12V or 24V)

- (7) Direct current (DC) main negative battery bus
- (8) DC grounding bus
- (9) Vessel bonding circuit

Install the battery disconnect switch (5) as close as possible to the battery positive (+) but outside of the battery enclosure.

Note: If multiple bus bars are used to connect components to the negative battery, a common reference should be provided. All bus bars must be wired together for proper engine synchronization for multiple engine operations.

i02784356

Engine Electronics

SMCS Code: 1000; 1900

WARNING

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

This engine has a comprehensive, programmable Engine Monitoring System. The Engine Control Module (ECM) has the ability to monitor the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control: WARNING, DERATE, and SHUTDOWN. These engine monitoring modes have the ability to limit engine speed and/or the engine power.

Many of the parameters that are monitored by the ECM can be programmed for the engine monitoring functions. The following parameters can be monitored as a part of the Engine Monitoring System:

- Operating Altitude
- Engine Coolant Level
- Engine Coolant Temperature
- Engine Oil Pressure
- Engine Speed
- Fuel Temperature
- Intake Manifold Air Temperature
- System Voltage

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

Note: Many of the engine control systems and display modules that are available for Caterpillar Engines will work in unison with the Engine Monitoring System. Together, the two controls will provide the engine monitoring function for the specific engine application. Refer to the Troubleshooting Manual for more information.

Product Information Section

General Information

i01110258

Model View Illustrations

SMCS Code: 1000

The following model views show typical 3176C and 3196 Marine Engine features. Due to individual applications, your engine may appear different from the illustrations.

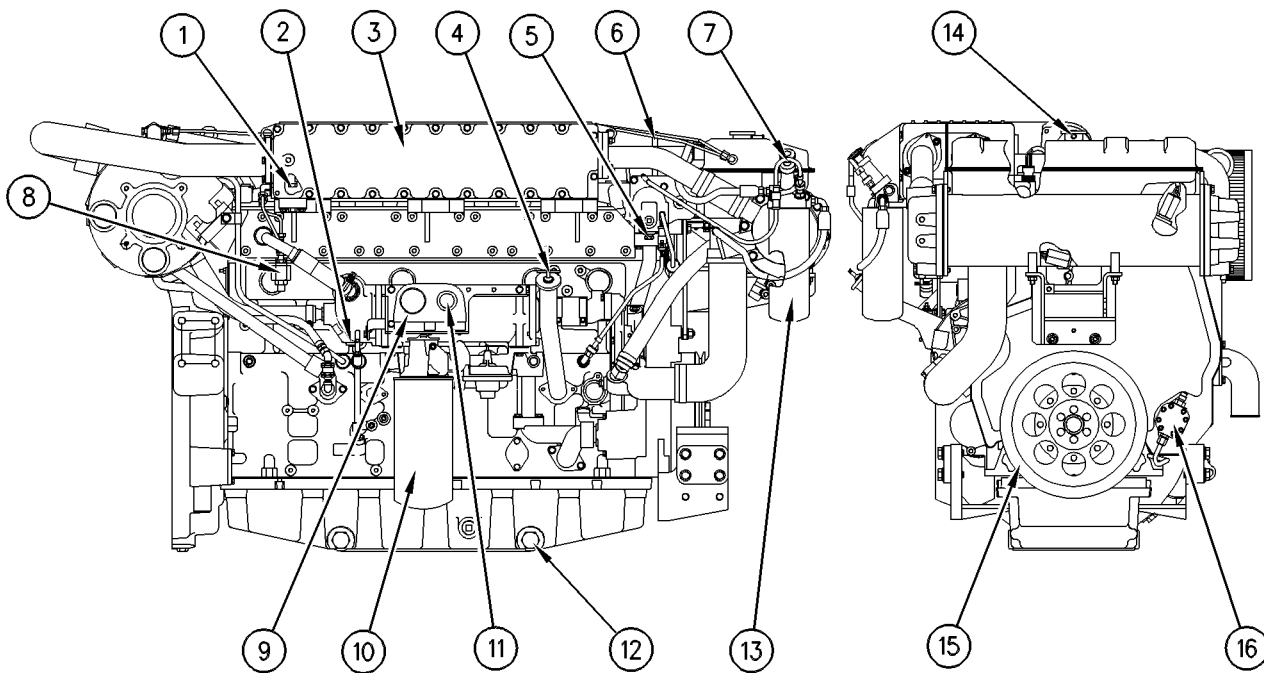


Illustration 14

g00103095

- (1) Aftercooler drain
- (2) Oil cooler drain plug
- (3) Aftercooler
- (4) Oil filler
- (5) Drain plug for the water temperature regulator

- (6) Lifting eye
- (7) Fuel priming pump
- (8) Aftercooler condensate drain valve
- (9) Service hour meter
- (10) Oil filter
- (11) Emergency stop button

- (12) Oil drain plug
- (13) Fuel filter
- (14) Cooling system filler cap
- (15) Crankshaft vibration damper
- (16) Fuel transfer pump

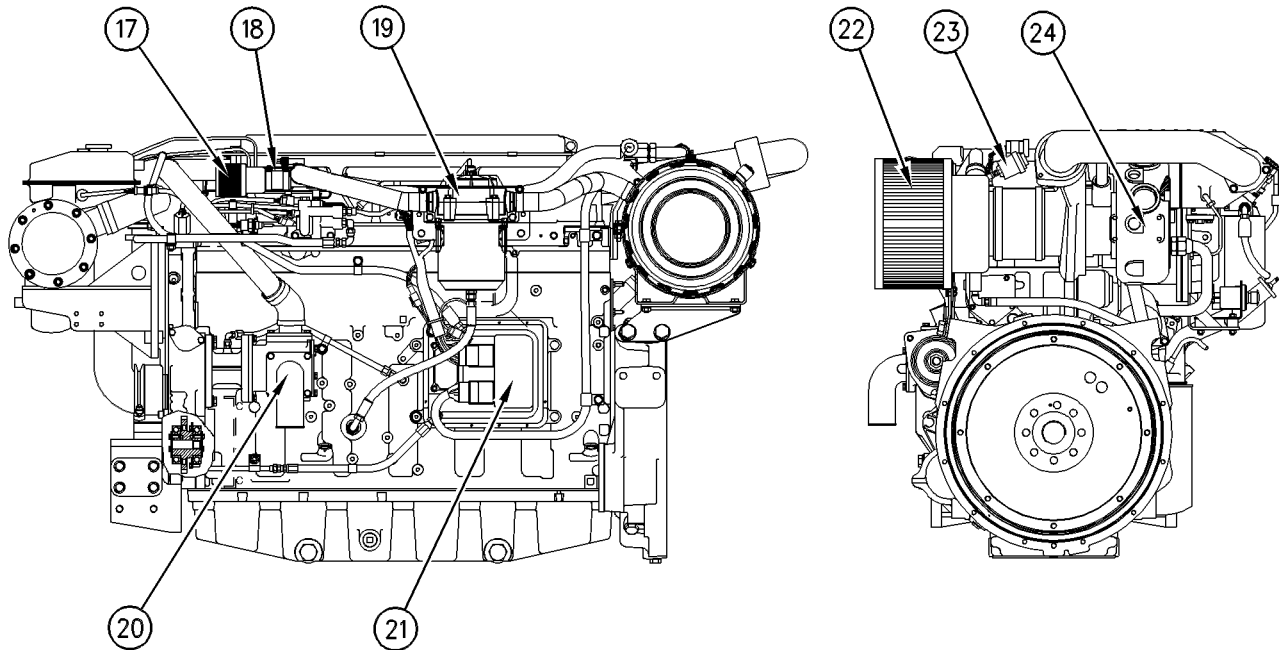


Illustration 15

g00585871

(17) Vacuum regulator element
 (18) Engine crankcase breather
 (19) Closed crankcase ventilation system (CCV)

(20) Auxiliary water pump
 (21) Electronic control module
 (22) Engine air cleaner element
 (23) Air cleaner service indicator

(24) Water cooled turbocharger

i05162828

Product Description

SMCS Code: 1000; 4450; 4491

The Cat 3176C and 3196 Marine Engines provide the following features:

- Four cycle
- Direct fuel injection
- Electronic unit injection
- Turbocharged
- Raw/Sea water aftercooled or separate circuit aftercooled (SCAC)

The electronic engine control system provides the following features:

- Engine monitoring
- Electronic governing
- Automatic air/fuel ratio control

- Torque rise shaping
- Injection timing control
- System diagnostics

Electronic unit injectors combine the metering of fuel (duration and timing) and the injection of fuel. Electronic unit injectors produce very high injection pressures.

The Electronic Control Module (ECM) controls the amount of fuel that is injected by varying the signals to the electronic unit injectors. High injection pressures help to reduce fuel consumption and emissions. The use of this type of electronic unit injector helps to provide precise control of injection timing. The injection timing varies with engine operating conditions thus optimizing engine performance for starting, emissions, noise, and fuel consumption.

The timing advance is achieved through the precise control of electronic unit injector firing. Engine rpm is controlled by adjusting the firing duration. A speed/timing sensor provides information to the ECM for detection of cylinder position and engine rpm.

The engine has built-in diagnostics that are used in order to ensure that all of the components function properly.

The cooling system consists of the following components:

- Gear driven centrifugal pump
- One water temperature regulator which regulates the engine coolant temperature
- Oil cooler
- Auxiliary water pump or a separate circuit aftercooled (SCAC)
- Raw/Sea water aftercooler

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 or plugged oil filter elements (paper cartridge)

Note: Most illustrations represent typical right-hand service. The 3176C and 3196 Marine Engines are also available with left-hand service. The following items will be located on the left side for left-hand service:

- Fuel filter
- Oil filter
- Oil filler
- Oil level gauge

Marine Transmissions

Several manufacturers offer marine transmissions through local distributors. Lubrication oil for the marine transmission can be cooled by an optional engine mounted transmission oil cooler (certain engine ratings).

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.

Expected engine life is generally predicted by the average power demanded, based on fuel consumption of the engine over a time. Reduced hours of operation at full throttle and/or operating at reduced throttle settings result in a lower average power demand. Reduced hours of operation will increase the length of operating time before an engine overhaul is required

Engine Specifications

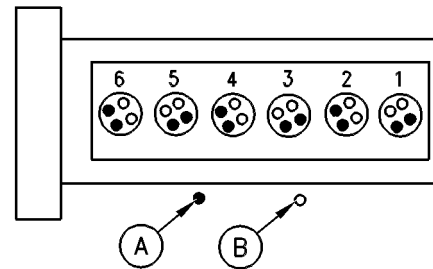


Illustration 16

g00275578

Cylinder and valve locations

(A) Exhaust valve. (B) Inlet valve.

Table 1

3176C Marine Engine Specifications	
Cylinders and Arrangement	6 In-Line
Bore	125 mm (4.9 inch)
Stroke	140 mm (5.5 inch)
Compression Ratio	16:1
Aspiration	TA ⁽¹⁾
Displacement	10.3 L (629 cu in)
Firing Order	1-5-3-6-2-4
Rotation (viewed from flywheel)	Counterclockwise
Valve Lash Setting (Inlet)	0.38 mm (.015 inch)
Valve Lash Setting (Exhaust)	0.76 mm (.030 inch)

⁽¹⁾ Turbocharged Aftercooled

Table 2

3196 Marine Engine Specifications	
Cylinders and Arrangement	6 In-Line
Bore	130 mm (5.1 inch)
Stroke	150 mm (5.9 inch)
Compression Ratio	16:1
Aspiration	TA ⁽¹⁾
Displacement	12 L (732 cu in)
Firing Order	1-5-3-6-2-4
Rotation (viewed from flywheel)	Counterclockwise
Valve Lash Setting (Inlet)	0.38 mm (.015 inch)
Valve Lash Setting (Exhaust)	0.76 mm (.030 inch)

⁽¹⁾ Turbocharged Aftercooled

Product Identification Information

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

i05163183

Plate Locations and Film Locations

SMCS Code: 1000; 4450

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

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

Serial Number Plate


CATERPILLAR			CAT
SERIAL NUMBER		ARRANGEMENT NUMBER	
ENGINE MODEL			
(ALWAYS GIVE ALL NUMBERS)			

Illustration 17

g00104547

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

Information Plate


	SER. NO.	ENGINE MODEL
FULL LOAD RPM		MAX ALT ROTATION
AR NO.		FUEL PUMP/GOV
BARE ENG HI IDLE RPM		INJECTOR
		TURBO
POWER	HP	KW

Illustration 18

g00755014

i02507433

Declaration of Conformity

SMCS Code: 1000

**Declaration of Conformity for Recreational Craft Propulsion Engines with the requirements of
Directive 94/25/EC as amended by 2003/44/EC**
(To be completed by manufacturer of inboard engines without integral exhaust)

Revision No :00

Name of engine manufacturer: Caterpillar Inc.

Address: 3701 State Road 26 East

Town: Lafayette IN **Post Code:** 47905 **Country:** USA

Name of Authorised Representative: _____

Address: _____

Town: _____ **Post Code:** _____ **Country:** _____

Name of Notified Body for exhaust emission assessment: Germanischer Lloyd

Address: Vorsetzen 32-35

Town: Hamburg **Post Code:** 20459 **Country:** Germany **ID Number:** 0098

Module used for exhaust emission assessment: B+C B+D B+E B+F G H
or engine type-approved according to: stage II of Directive 97/68/EC Directive 88/77/EC
Other Community Directives applied: _____

DESCRIPTION OF ENGINE(S) AND ESSENTIAL REQUIREMENTS

Engine Type:
 z or sterndrive without integral exhaust
 Inboard engine

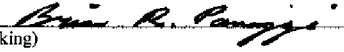
Fuel Type: **Combustion cycle:**
 Diesel 2 stroke
 Petrol 4 stroke

Essential requirements	Standards Used	Other normative document used	See technical file
Annex I.B – Exhaust Emissions			
engine identification			<input checked="" type="checkbox"/>
exhaust emission requirements	EN ISO 8178-1:1996		
durability	2003/44/EC		<input type="checkbox"/>
owner's manual			<input checked="" type="checkbox"/>
Annex I.C – Noise Emissions	see craft manufacturer's Declaration of Conformity		

ENGINE(S) COVERED BY THIS DECLARATION

Engine model(s) or engine family name(s):	EC Type certificate number
3196C12P1800&2100&2300	32172-05 HFH

This declaration of conformity is issued under the sole responsibility of the manufacturer. I declare on behalf of the engine manufacturer that the engine(s) will meet the requirements of above mentioned directives when installed in a recreational craft, in accordance with the engine manufacturer's supplied instructions and that this (these) engine(s) must not be put into service until the recreational craft into which it is (they are) to be installed has been declared in conformity with the relevant provisions of the above mentioned Directives.

Name / function: Brian R. Panizzi / Sr. Marine Engineer **Signature and title:** 
 (Identification of the person empowered to sign on behalf of the engine manufacturer or his authorised representative) (or an equivalent marking)

Date and place of issue: (yr/month/day) 2006 / February / 23

i04602210

Reference Information

SMCS Code: 1000; 4450

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 _____

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

i01052770

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.

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.

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.

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 is properly lubricated.

Intermittent Back Driving

Perform the following items for short trips and for towing purse boats in seining operations.

- Ensure that the marine transmission is in NEUTRAL while the vessel is being towed.
- Start the engine. Run the engine for at least three minutes. Perform this procedure during every 24 hours.

- Maintain the marine transmission oil level at the normal propulsion level or maintain the marine transmission oil level at the "FULL" mark.

Continuous Back Driving

Perform the following items for these continuous back driving circumstances: long trips, delivering a vessel by towing, and towing a vessel home on a trip that will last more than one day.

- Ensure that the marine transmission is in NEUTRAL while the vessel is being towed.
- Start the engine. Run the engine for at least three minutes. Perform this procedure during every 12 to 14 hours.
- 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 is needed will depend on 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.

Lifting and Storage

i05163194

Product Lifting

SMCS Code: 7000; 7002

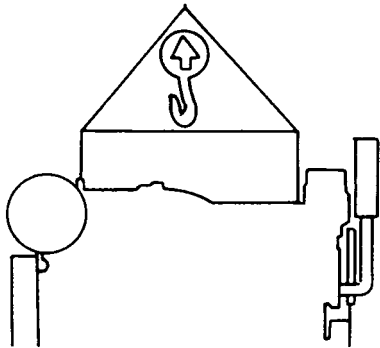


Illustration 20

g00103219

NOTICE

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

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

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

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

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

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

Engine and Marine Transmission Lifting

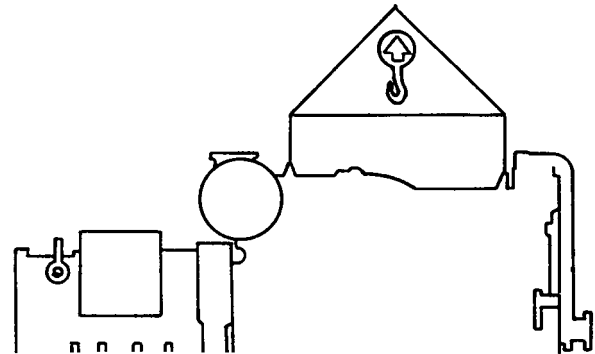


Illustration 21

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 Cat 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.

i04986396

Product Storage

SMCS Code: 7002

Note: If the engine will be stored for more than 1 year, contact your local Cat dealer for the preferred procedure.

Engine

Storage (Less Than One Year)

If an engine is not used, oil can run off the following parts that normally receive lubrication: cylinder walls, piston rings, main bearings, connecting rod bearings, crankshaft, and gears.

This lack of lubricant allows corrosion to begin to appear on the metal. This condition is worse in areas of high humidity.

When the engine is started again, metal to metal contact will cause wear before the surfaces receive oil. To minimize this wear, use the starter to turn the engine with the throttle in the FUEL OFF position. When oil pressure is shown on the pressure gauge, start the engine.

1. Clean the engine of any dirt, rust, grease, and oil. Inspect the exterior. Paint areas that contain paint damage with a good quality paint.
 2. Remove any dirt from all air cleaners. Check all seals, gaskets, and the filter element for damage.
 3. Apply lubricant to all points in this Operation and Maintenance Manual, "Maintenance Interval Schedule".
 4. Drain the crankcase oil. Replace the crankcase oil and change the oil filters. For the proper procedure, refer to this Operation and Maintenance Manual, "Engine Oil and Filter - Change".
 5. If the engine is equipped with an air starting motor, fill the reservoir with a mixture of 50 percent volatile corrosion inhibitor (<nomen>VCI </nomen>) and 50 percent engine oil.
 6. Add VCI to the crankcase oil. The volume of VCI in the crankcase oil should be 3 to 4 percent.
- Note:** If the engine crankcase is full, drain enough engine oil so the mixture can be added.
7. Remove the air filter elements. Turn the engine at cranking speed with the throttle control in FUEL OFF position. Use a sprayer to add a mixture of 50 percent VCI and 50 percent engine oil into the air inlet or turbocharger inlet.

Note: The mixture of VCI can be added to the inlet by removing the plug for checking turbocharger boost pressure. The minimum rate of application is 5.5 mL per 1 L (3 oz per 1000 cu in) of engine displacement.

8. Use a sprayer to apply a mixture of 50 percent VCI and 50 percent crankcase oil into the exhaust openings. The minimum application rate for the oil mixture is 5.5 mL per L (3 oz per 1000 cu in) of engine displacement. Seal the exhaust pipe and seal any drain holes in the muffler.
9. Remove the fuel from the secondary fuel filter housing. Alternately, empty and reinstall the spin-on fuel filter element in order to remove any dirt and water. Drain any sleeve metering fuel pump.

Clean the primary fuel filter. Fill with calibration fluid or kerosene. Install the primary fuel filter and operate the priming pump in order to send clean oil to the secondary filter and the engine.

Open the fuel tank drain valve in order to drain any water and dirt from the fuel tank. Apply a spray of calibration fluid or kerosene at the rate of 30 mL per 30 L (1 oz per 7.50 gal US) of fuel tank capacity in order to prevent rust in the fuel tank. Add 0.15 mL per L (.02 oz per 1 gal US) of commercial biocide such as Biobor JF to the fuel.

Apply a small amount of oil to the threads on the fuel tank filler neck and install the cap. Seal all openings to the tank in order to prevent evaporation of the fuel and as a preservative.

10. Remove the fuel nozzles or spark plugs. Apply 30 mL (1 oz) of the mixture of oils (50 percent VCI oil and 50 percent engine oil) into each cylinder.

Use a bar or a turning tool in order to turn over the engine slowly. This action puts the oil on the cylinder walls. Install all fuel nozzles or spark plugs and tighten to the correct torque.

11. Spray a thin amount of the mixture of oil (50 percent VCI oil and 50 percent engine oil) onto the flywheel, the ring gear teeth, and the starter pinion. Install the covers in order to prevent evaporation of the vapors from the VCI oil.

12. Apply a heavy amount of Cat Multipurpose Grease (MPGM) to all outside parts that move, such as rod threads, ball joints, linkage, etc.

Note: Install all covers. Ensure that tape has been installed over all openings, air inlets, exhaust openings, the flywheel housing, the crankcase breathers, the dipstick tubes, etc.

Ensure that all covers are airtight and weatherproof. Use a waterproof weather resistant tape such as Kendall No. 231 or an equivalent. Do not use duct tape. Duct tape will only seal for a short time.

13. Under most conditions, it is best to remove the batteries. As an alternative, place the batteries in storage. As needed, periodically charge the batteries while the batteries are in storage.

If the batteries are not removed, wash the tops of the batteries until the tops are clean. Apply an electrical charge to the batteries in order to obtain a specific gravity of 1.225.

Disconnect the battery terminals. Place a plastic cover over the batteries.

Note: For additional information, refer to Special Instruction, SEHS7633, "Battery Test Procedure".

14. Loosen all belts.

15. Place a waterproof cover over the engine. Ensure that the engine cover is secure. The cover should be loose enough to allow air to circulate around the engine in order to prevent damage from condensation.

16. Attach a tag with the date of storage to the engine.

17. Remove the waterproof cover at 2 month or 3 month intervals in order to check the engine for corrosion. If the engine has signs of corrosion, repeat the protection procedure.

Conventional Coolant System

Completely fill the cooling system before storage.

Water or water which is mixed with supplemental coolant additive (SCA) is not an approved coolant for use with Cat C7-C32 Marine Engines which are cooled with heat exchangers. Cat C7-C32 Marine Engines which are cooled with heat exchangers require a minimum of 30 percent glycol in order to prevent cavitation of cooling system components. A minimum of 50 percent glycol is very strongly recommended.

Refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" or refer to this Operation and Maintenance Manual, "Fluids Recommendations" for more information about coolants.

Raw Water System

Completely drain the raw water system by removing all the drain plugs from the raw water pump, the water shielded manifolds, the heat exchanger bonnets, and the aftercooler.

After the system has been drained, inspect all zinc plugs (normally painted red) for damage from corrosion.

Note: To ensure complete drainage and evaporation during storage, DO NOT install the drain plugs and zinc plugs. Place all removed plugs in a cloth bag and fasten the bag to the engine for storage.

Removal from Storage

1. Remove all outside protective covers.
2. Change the oil and filters.
3. Check the condition of the fan and alternator belts. Replace the belts, if necessary. Refer to this Operation and Maintenance Manual, "Belts - Inspect/Adjust/Replace" or refer to this Operation and Maintenance Manual, "Belts - Inspect/Replace" for the correct procedure.
4. Replace the fuel filter elements.
5. Remove the plastic covers from the air cleaner elements.
6. Use a bar or a turning tool in order to turn the engine in the normal direction of rotation. The procedure ensures that no hydraulic locks or resistance exist.
7. Before starting the engine, remove the valve cover or covers. Put a large amount of engine oil on the camshaft, cam followers, and valve mechanism in order to prevent damage to the mechanism.
8. Pressure lubricate the engine before starting the engine. Pressure lubrication of the engine ensures immediate lubrication. Pressure lubrication of the engine prevents damage to the engine which might otherwise occur at start-up. If the engine is not equipped with a prelube pump, contact your Cat dealer for information about lubrication of the engine before the engine is started.
9. Check the condition of all rubber hoses. Replace any worn hoses. Replace any damaged hoses.
10. Before start-up, test the cooling system for a 3 to 6 percent concentration of coolant conditioner. Add liquid coolant conditioner or a coolant conditioner filter, if equipped.

Test the coolant mixture for proper nitrite level. If necessary, adjust the coolant mixture.

Prime the engine with clean diesel fuel before starting.
11. If the engine is equipped with a fresh water system, ensure that the system is clean. Ensure that the system is full. Ensure that the system has the correct amount of supplemental cooling system conditioner.

If the engine is equipped with a raw water system, install all of the drain plugs and zinc plugs. Fill the system. It may be necessary to prime the raw water system pumps before operation.

12. On the first day of operation, check the entire engine several times for leaks and correct operation.
13. Refer to Special Publication, SEBU5898, "Cold Weather Recommendations Operation and Maintenance" when the temperature is less than -12°C (10°F) at the time of removal from 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 6 months, VCI oil will provide additional protection against moisture. Add VCI oil at a rate of 2 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.

Features and Controls

i01491446

Cold Start Strategy

SMCS Code: 1450; 1456; 1900

The ECM will set the cold start strategy when the coolant temperature is below 18 °C (64 °F).

When the cold start strategy is activated, low idle rpm will be increased to 1000 rpm and the engine's power will be limited.

Cold mode operation will be deactivated when any of the following conditions have been met:

- Coolant temperature reaches 18 °C (64 °F).
- The engine has been running for fourteen minutes.

Cold mode operation varies the fuel injection amount for white smoke cleanup. Cold mode operation also varies the timing for white smoke cleanup. The engine operating temperature is usually reached before the walk-around inspection is completed. The engine will idle at the programmed low idle rpm in order to be put in gear.

NOTICE

A machine equipped with this electronically controlled engine should not be moved until it is out of Cold Mode operation.

If the machine is operated while in Cold Mode operation power will be noticeably reduced.

After the cold mode is completed, the engine should be operated at mid-speed to low speed until normal operating temperature is reached. The engine will reach normal operating temperature faster when the engine is operated at low speed and low power demand.

i01738754

Engine Monitoring System (EMS)

SMCS Code: 7490

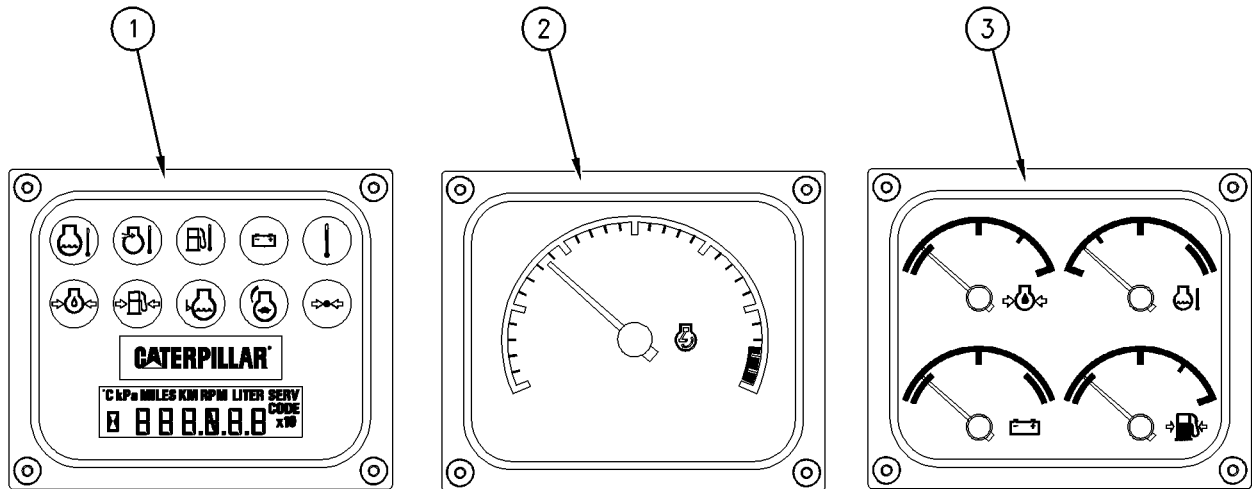


Illustration 22

g00788015

(1) Main unit

(2) Tachometer (unit)

(3) Quad gauge

The Caterpillar Engine Monitoring System (EMS) is an option. The engine parameters are displayed in both digital display and analog. The EMS display is for electronically controlled engines.

The EMS includes three individual gauge units. The units can be installed in various combinations. The main unit must be used if any of the units are used.

For information on installation and troubleshooting, refer to Installation Guide, SENR5002.

EMS Main Unit

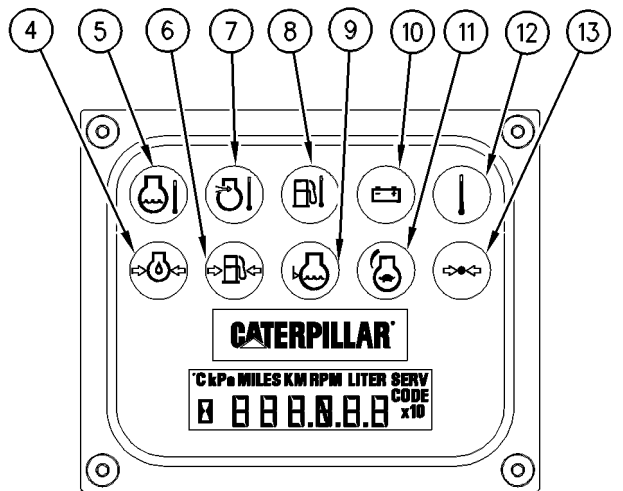


Illustration 23

g00595165

- (4) Engine oil pressure
- (5) Engine coolant temperature
- (6) Fuel pressure
- (7) Inlet manifold temperature
- (8) Fuel temperature
- (9) Engine coolant level
- (10) Battery voltage
- (11) Active engine derate
- (12) Auxiliary temperature
- (13) Auxiliary pressure

The Engine Monitoring System provides warning lamps. Refer to Illustration 23. The Engine Monitoring System provides a LCD display for engine parameters. When the scroll switch is depressed, the parameters will scroll on the screen. The EMS displays the real time value for the parameter that is selected. The default is engine speed.

The parameters are abbreviated on the LCD display. Table 3 lists the parameters.

Table 3

Abbreviation	Parameter
Spd	Engine Speed
GA-1	Engine Oil Pressure
GA-2	Coolant Temperature
GA-3	Battery Voltage
GA-4	Fuel Pressure
Boost	Boost Pressure
IAirT	Inlet Air Temperature
FuelT	Fuel Temperature
AccrP	Auxiliary Pressure
AccrT	Auxiliary Temperature
Fuel	Fuel Rate
Hrs	Engine Hours
Load	Percent of Engine Load (speed and derate)

Note: For detailed information on the exact parameters for your engine, refer to the Operation and Maintenance Manual, "Gauges and Indicators".

Quad Gauge Unit

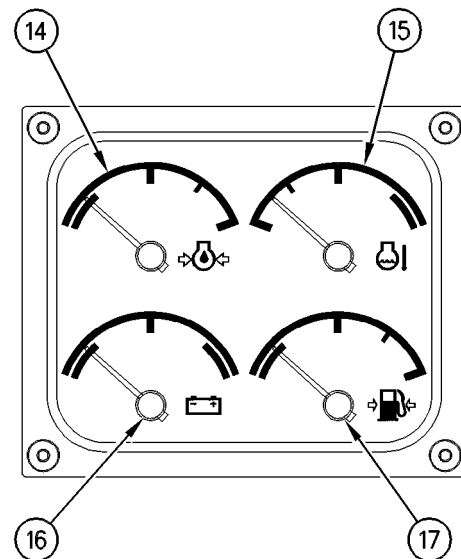


Illustration 24

g00595166

- (14) Engine oil pressure
- (15) Engine coolant temperature
- (16) Battery voltage
- (17) Fuel pressure

The quad gauge unit displays the following information: engine oil pressure, engine coolant temperature, battery voltage, and fuel pressure

Note: The gauge needles may not always return to zero position when the engine is not running.

Note: For detailed information on the exact parameters for your engine, refer to the Operation and Maintenance Manual, “Gauges and Indicators”.

Tachometer Unit

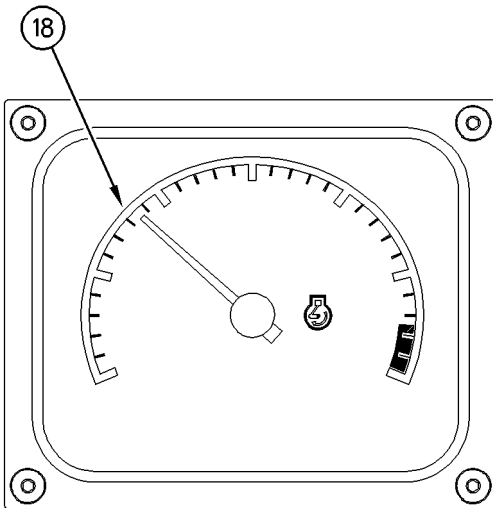


Illustration 25

g00788023

(18) Tachometer

The tachometer displays the engine speed (rpm) on an analog gauge.

Note: For detailed information on the exact parameters for your engine, refer to the Operation and Maintenance Manual, “Gauges and Indicators”.

Communication Data Link

The EMS provides two pins that are connected to the data link. The data link is available to share data with other modules. The ECM processes engine parameters. The parameters will then be transmitted to the EMS through the data link. The EMS receives the information. The information is then displayed on various gauges.

For additional information, refer to the Troubleshooting Manual, “Cat Data Link Circuit-Test”.

Gauges and Indicators

SMCS Code: 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 literature that is from the OEM of the vessel.

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 a potential problem with a gauge or with the engine. 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 and/or correct the cause of any significant change in the readings. Consult your Caterpillar dealer for assistance. Caterpillar requires two lamps in addition to the gauge package that is normally provided.

The “Diagnostic” lamp is yellow or amber. The “Diagnostic” lamp will communicate the status of the electronic system of the engine.

The “Warning” lamp is red. This red “Warning” lamp warns the operator of engine problems.

The following conditions are some examples of the problems:

- low oil pressure
- high coolant temperature
- low coolant level
- high inlet air temperature

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 – This gauge indicates the engine oil pressure.

A lower oil pressure reading 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. Shut down the engine, and allow time for the oil to settle back into the engine oil pan.
4. Check the oil level. Maintain the oil level at the proper amount.

The diagnostic lamp will turn on if the oil pressure drops below a safe range. A safe range for the oil pressure is determined by the engine protection package. The diagnostic code will be logged in the Engine Control Module (ECM).



Engine Oil Temperature – This gauge indicates the engine oil temperature. Maximum oil temperature at rated speed with a full load is 104°C (220°F).



Jacket Water Coolant Temperature – Typical temperature range is 87 to 98°C (189 to 208°F). The maximum allowable temperature with the pressurized cooling system is 102°C (216°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 speed.
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 speed. 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 of engine operation. Hours of operation are logged in the ECM. A service tool is needed to retrieve the hours from the ECM. A Service Hour Meter may be installed on the engine.



Fuel Pressure – This gauge indicates fuel pressure to the electronic unit injectors from the fuel filter. The indicator should indicate the “NORMAL” range. Typical fuel pressure at low idle is 410 kPa (60 psi). Typical operating fuel pressure is 500 kPa (73 psi). Minimum fuel pressure at rated speed is 400 kPa (58 psi). Minimum fuel pressure is 160 kPa (23 psi) when the engine is under load. A decrease in fuel pressure usually indicates a plugged fuel filter.



Inlet Air Temperature – This gauge indicates inlet manifold air temperature. As the inlet air increases in temperature the following conditions occur: expansion of the air, less oxygen in the cylinders, and less available power. If the temperature of the inlet air is too high during full speed and load operation, the engine may be overfueled. Maximum inlet manifold air temperature is 85°C (185°F).



Exhaust Stack Temperature – This gauge indicates exhaust gas temperature. Maximum exhaust temperature is approximately 575°C (1065°F).

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Marine Power Display

SMCS Code: 1900; 7400; 7402; 7450; 7451

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

Refer to Special Publication, LEBM0189, “Marine Power Display Operator's Guide” for additional information regarding the marine power display.

Operating Information

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

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

Display Modes

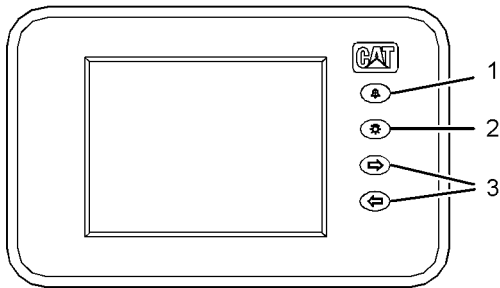


Illustration 26

g01768017

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

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

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

Diagnostic Data

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

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

Marine Power Display Configuration And Operation

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

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

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

“System Information”

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

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

Gauge Screens

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

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

i01060008

Overspeed

SMCS Code: 1900; 1907; 1912; 7427

An overspeed condition is detected by the Electronic Control Module (ECM). If the engine speed exceeds 2500 rpm, the ECM will shut off the electronic unit injectors. The electronic unit injectors will be shut off until the engine speed drops below 2500 rpm. A diagnostic fault code will be logged into the ECM memory and the "DIAGNOSTIC" lamp will indicate a diagnostic fault code.

i01110843

Sensors and Electrical Components

SMCS Code: 1900; 7400

Sensor Locations

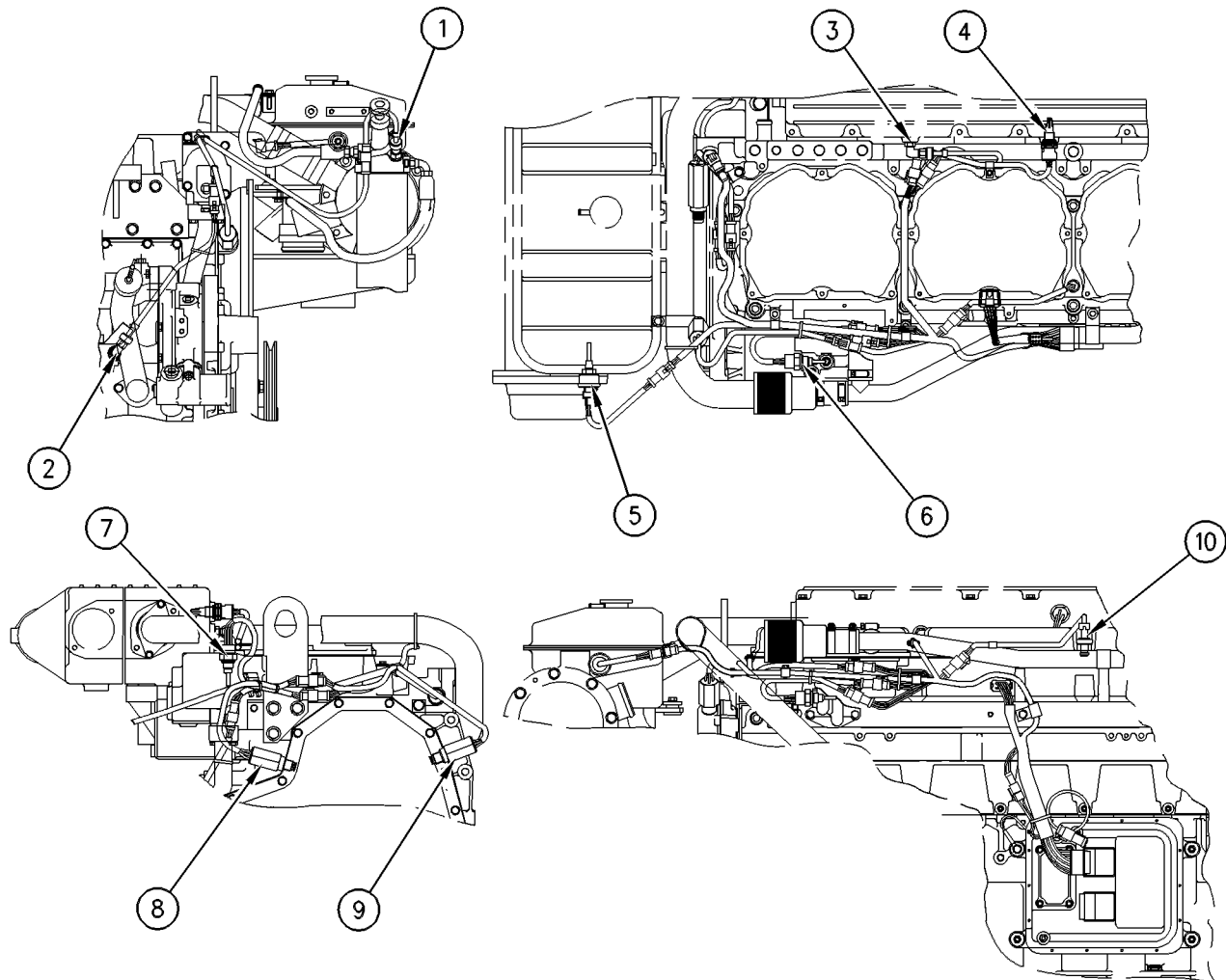


Illustration 27

g00104780

- (1) Fuel pressure sensor
- (2) Oil pressure sensor
- (3) Air pressure sensor for the inlet manifold

- (4) Air temperature sensor for the inlet manifold
- (5) Coolant level sensor
- (6) Fuel temperature sensor

- (7) Coolant temperature sensor
- (8) Primary speed/timing sensor
- (9) Backup speed/timing sensor
- (10) Atmospheric pressure sensor

Failure of Sensors

All Sensors

A failure of any of the sensors may be caused by one of the following malfunctions:

- Sensor output is open.
- Sensor output is shorted to “- battery” or “+ battery”.
- Measured reading of the sensor is out of specification.

Atmospheric Pressure Sensor

Atmospheric pressure sensor (10) measures the atmospheric pressure in the crankcase. A signal is sent to the Electronic Control Module (ECM).

Table 4

Atmospheric Pressure Sensor	
Operating pressure range for the atmospheric pressure sensor	0 to 116 kPa (0 to 16.8 psi)

Coolant Temperature Sensor

The coolant temperature sensor (7) monitors engine coolant temperature. This feature is used for engine system diagnostics with an output from the Electronic Control Module (ECM). The output of the ECM can indicate a high coolant temperature through a relay or a lamp. In addition, the sensor activates the cold start strategy which improves the startability of the engine.

The minimum coolant temperature that will activate the alarm is 106°C (223°F). The switch opens as the coolant cools. A resetting procedure is not required.

Failure of the Coolant Temperature Sensor

If one of the following conditions exist, a failure of the coolant temperature sensor may have occurred:

- Sensor output is open.
- Sensor output is shorted to ground or supply.
- Measured reading of the coolant temperature is out of specification.

The ECM will detect the failure of the coolant temperature sensor. The diagnostic lamp will warn the operator about the status of the coolant temperature sensor. The coolant temperature related strategies will be disabled. The failure of the coolant temperature sensor will not cause a shutdown of the engine or any horsepower change.

Coolant Level Sensor

The coolant level sensor (5) monitors the engine coolant level. The sensor will detect coolant level. The coolant level sensor provides information to the ECM. The output from the ECM can indicate a low coolant level through a relay or a lamp. Coolant must be added to the cooling system in order to correct the condition. See the Operation and Maintenance Manual for more information.

The system can be programmed with one of the following options:

Enabled – The system will monitor the input from the coolant level sensor. The system is programmed with this value when the engine is shipped by Caterpillar.

Disabled – The system will monitor the input from the coolant level sensor. All of the diagnostics that are associated with the coolant level sensor will be disabled.

Failure of the Coolant Level Sensor

A failure of the coolant level sensor may occur under the following conditions:

- The coolant level sensor is open.
- The coolant level sensor is shorted to ground.
- The coolant level sensor is shorted to supply.

The failure of the coolant level sensor will not cause a shutdown of the engine or any horsepower change.

Engine Oil Pressure Sensor

The engine oil pressure sensor (2) can detect engine oil pressure for diagnostic purposes. The engine oil pressure sensor sends a signal to the Electronic Control Module (ECM).

Low Oil Pressure Warning

The setpoint is dependent upon the engine rpm. The fault will be active and logged only if the engine has been running for more than 15 seconds.

Very Low Oil Pressure Warning

The very low oil pressure setpoint is dependent upon the engine rpm. If Derate mode is selected, the ECM will derate the engine power. The engine horsepower will be limited.

Failure of the Engine Oil Pressure Sensor

If one of the following conditions exist, a failure of the engine oil pressure sensor may have occurred:

- The engine oil pressure sensor is open.
- The engine oil pressure sensor is shorted to ground or supply.
- Measured reading of the oil pressure is out of specification.

The ECM will detect the failure of the engine oil pressure sensor. The diagnostic lamp warns the user about the status of the engine oil pressure sensor. The oil pressure related strategies will be disabled. The failure of the engine oil pressure sensor will not cause a shutdown of the engine or any horsepower change.

Fuel Pressure Sensor

Fuel pressure sensor (1) monitors the fuel filter outlet pressure. Low fuel pressure or high fuel pressure will not cause a shutdown of the engine or any horsepower change. Fuel pressure that is outside of the normal range will affect the engine performance. If the fuel filter outlet pressure is low, the fuel filter may need to be replaced.

Table 5

Fuel Pressure Sensor	
Minimum allowable pressure of the fuel transfer pump at full load speed	415 kPa (60 psi)
Minimum allowable pressure in the fuel manifold at full load speed	276 kPa (40 psi)

Fuel Temperature Sensor

Fuel temperature sensor (6) monitors the fuel temperature. Fuel temperature is monitored in order to adjust the fuel rate so that the engine will deliver consistent power. The fuel temperature sensor can also be used to warn the operator of excessive fuel temperature. A high fuel temperature can adversely affect the engine performance.

Table 6

Fuel Temperature Sensor	
Operating range of the fuel temperature sensor for activation of the power correction by the ECM	30 to 70°C (86 to 158°F)

Air Temperature Sensor for the Inlet Manifold

The air temperature sensor for the inlet manifold (4) measures the inlet manifold air temperature. The Electronic Control Module (ECM) monitors the signal from the air temperature sensor for the inlet manifold. The output of the ECM can indicate high inlet manifold air temperature through a relay or a lamp. The air temperature sensor for the inlet manifold will not cause a shutdown of the engine or any horsepower change.

Note: The air temperature sensor for the inlet manifold will be affected by the heat that is conducted from the inlet manifold. This is true when the engine is idling and after the engine is shut off. This warm-up is due to the lack of coolant circulation through the engine. The reading from the air temperature sensor for the inlet manifold may be significantly higher than the actual temperature of the air inside the inlet manifold until the inlet manifold cools.

Air Pressure Sensor for the Inlet Manifold

The air/fuel ratio control utilizes actual engine speed and actual boost pressure (inlet manifold air pressure) in order to control the transient smoke level. When the throttle is increased and when the engine demands more fuel, the fuel limit is controlled in order to reduce overall smoke levels of the engine exhaust.

The Electronic Control Module (ECM) controls injection timing and the amount of fuel that is injected.

Note: The air pressure sensor for the inlet manifold (3) is located on the top right side of the engine. The sensor is located in front of the air pressure sensor for the inlet manifold.

The boost pressure is determined from the difference in pressure between the air pressure sensor for the inlet manifold and the atmospheric pressure sensor (crankcase pressure).

Failure of the Air Pressure Sensor for the Inlet Manifold

A failure of the air pressure sensor for the inlet manifold may have occurred if any of the following conditions are present:

- The output of the air pressure sensor for the inlet manifold is open.
- The output of the air pressure sensor for the inlet manifold is shorted to ground or to supply.
- The reading of the air pressure sensor for the inlet manifold is out of specification.

The ECM will detect the failure of the air pressure sensor for the inlet manifold. The operator will be warned of the problem through the diagnostic lamp. The strategies that are related to the boost will be disabled. The failure of the air pressure sensor for the inlet manifold will not cause a shutdown of the engine or any horsepower change.

Speed/Timing Sensor

If the ECM can not receive a signal from the primary speed/timing sensor (8), the “DIAGNOSTIC” lamp will indicate a diagnostic fault code which will be logged in the ECM memory.

The backup speed/timing sensor (9) is used when the ECM does not receive a signal from the primary speed/timing sensor (8). The backup speed/timing sensor will be used until the primary speed/timing sensor is replaced.

Failure of the Speed/Timing Sensor

A failure of the speed/timing sensor may have occurred if one of the following conditions occur:

- The output of the speed/timing sensor has opened.
- The speed/timing sensor is shorted to ground.
- The speed/timing sensor is shorted to supply.
- The speed/timing sensor is missing pulses.
- The speed/timing sensor has extra pulses.

Intermittent failure causes erratic engine control. The ECM will detect a failure of the primary speed/timing sensor. The operator will be warned through the diagnostic lamp.

Marine Transmission Oil Pressure

Monitoring the transmission oil pressure is a programmable option. The Electronic Control Module (ECM) monitors transmission oil pressure with a sensor. The sensor is located on the high pressure side of the transmission. High transmission oil pressure is detected for diagnostics, similar to the monitoring of the engine oil pressure.

The output from the ECM monitors the transmission oil pressure. The maximum allowable transmission oil pressure is 700 to 2963 kPa (102 to 430 psi). The output of the ECM can indicate high oil pressure through a relay or a lamp.

Marine Transmission Oil Temperature

The transmission oil temperature sensor measures the temperature of the transmission oil. The Electronic Control Module (ECM) uses this information to diagnose a problem. The information is also used to warn the operator of excessive transmission temperature.

The output from the ECM monitors the transmission oil pressure. The maximum allowable transmission oil temperature is 50 to 120°C (122 to 248°F). The output of the ECM can indicate high transmission oil temperature through a relay or a lamp.

Engine Diagnostics

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Self-Diagnostics

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SMCS Code: 1000; 1900; 1901; 1902

Caterpillar Electronic Engines have the capability to perform a self-diagnostics test. When the system detects an active problem, the “DIAGNOSTIC” lamp is activated. Diagnostic codes will be stored in permanent memory in the Electronic Control Module (ECM). The diagnostic codes can be retrieved by using the following components:

- Caterpillar electronic service tools
- “DIAGNOSTIC” lamp

Note: The “DIAGNOSTIC” lamp must be installed by the OEM or by the customer.

Some installations have electronic displays that provide direct readouts of the engine diagnostic codes. Refer to the manual that is provided by the OEM for more information on retrieving engine diagnostic codes.

Active codes represent problems that currently exist. These problems should be investigated first. If a code is active, the “DIAGNOSTIC” lamp will flash the flash code at five second intervals.

Logged codes represent the following items:

- Intermittent problems
- Recorded events
- Performance history

The problems may have been repaired since the logging of the code. These codes do not indicate that a repair is needed. The codes are guides or signals when a situation exists. Codes may be helpful to troubleshoot problems.

When the problems have been corrected, the corresponding logged fault codes should be cleared.

Diagnostic Lamp

SMCS Code: 1000; 1900; 1901; 1902; 7451

The “DIAGNOSTIC” lamp is used to indicate the existence of an active fault by flashing codes.

When the ignition switch is first turned on, the “DIAGNOSTIC” lamp will go through the following procedure:

- The “DIAGNOSTIC” lamp will come on and the “DIAGNOSTIC” lamp will remain on for five seconds. This checks the operation of the lamp.
- The “DIAGNOSTIC” lamp will turn off.
- The “DIAGNOSTIC” lamp will come on again and the “DIAGNOSTIC” lamp will flash codes for any active diagnostic codes. Not all diagnostic codes have a unique flash code.
- The “DIAGNOSTIC” lamp will turn off for five seconds.
- The “DIAGNOSTIC” lamp repeats all active diagnostic codes.

A fault diagnostic code will remain active until the problem is repaired. The electronic control module will continue flashing the flash code at five second intervals until the problem is repaired.

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Diagnostic Flash Code Retrieval

SMCS Code: 1000; 1900; 1901; 1902

“Diagnostic” Lamp

Use the “DIAGNOSTIC” Lamp or a Caterpillar electronic service tool to determine the diagnostic flash code.

Use the following procedure to retrieve the diagnostic codes if the engine is equipped with a “DIAGNOSTIC” lamp:

1. Turn the ignition key to the ON position. The engine does not need to be started in order to view codes. The engine does not need to be running while the ignition switch is in the ON position.

The “DIAGNOSTIC” lamp flashes on and off at five second intervals.

- When the ignition key is in the ON position, the lamp is checked for proper operation. Active codes are displayed at this time. Code 34 will not be displayed.

Note: The “DIAGNOSTIC” lamp will flash for five seconds. The lamp will stay on if there is an active diagnostic code.

2. The diagnostic codes will always be flashed. There is no toggle switch that will shut off the lamp.
3. The “DIAGNOSTIC” lamp will flash in order to indicate a two-digit code. The sequence of flashes represents the system diagnostic message. Each digit of the two-digit code is determined by counting the number of flashes. The lamp flashes at a rate of two times per second. The lamp will pause for one second between digits. The lamp will pause for two seconds between codes.

Table 7 indicates the potential effect on the engine performance with active flash codes. Table 7 also forms a list of Electronic diagnostic codes and descriptions.

For further information or assistance for repairs, consult an authorized Caterpillar dealer.

Table 7

Diagnostic Flash Codes for 3176C and 3196 Marine Engines						
Diagnostic Flash Code		Effect On Engine Performance			Suggested Action by the Operator	
		Engine Misfire	Low Power	Reduced Engine Speed	Shut down the Engine ⁽¹⁾	Service ⁽²⁾
13	Fault of the Fuel Temperature Sensor ⁽⁴⁾					X
17	Battery Voltage Below Normal ⁽⁴⁾					X
21	Sensor Supply Voltage Above Normal or Below Normal ⁽⁴⁾		X			X
24	Oil Pressure Sensor Fault ⁽⁴⁾					X
25	Fault of the Sensor for the Inlet Manifold Air Pressure ⁽⁵⁾		X			X
26	Atmospheric Pressure Sensor Fault ⁽⁴⁾					X
27	Coolant Temperature Sensor Fault ⁽⁴⁾					X
28	Check The Adjustment of the Throttle Position Sensor.					X
32	Throttle Position Sensor Fault			X	X	
34	Engine RPM Signal Fault	X		X	X	
35	Engine Overspeed Warning					X
38	Fault of the Sensor for the Inlet Manifold Air Temperature ⁽⁴⁾					X
42	Check The Calibration of the Timing Sensor.		X			X

(continued)

(Table 7, contd)

Diagnostic Flash Codes for 3176C and 3196 Marine Engines							
Diagnostic Flash Code		Effect On Engine Performance			Suggested Action by the Operator		
		Engine Misfire	Low Power	Reduced Engine Speed	Shut down the Engine ⁽¹⁾	Service ⁽²⁾	Schedule Service for the Engine. ⁽³⁾
46	Low Oil Pressure Warning		X	X	X	X	
51	Intermittent Battery Power to the ECM	X	X			X	
52	Personality Module Fault	X	X	X		X	
53	ECM Fault	X	X	X		X	
56	The Following Parameters Must Be Checked: Customer and System		X	X			X
59	Incorrect Engine Software	X	X	X			X
61	High Coolant Temperature Warning		X			X	
62	Low Coolant Level Warning					X	
63	Low Fuel Pressure					X	X
64	Warning for High Inlet Manifold Air Temperature						X
65	Warning for High Fuel Temperature						X
67	Fault of the Marine Transmission Oil Temperature						X
72	Fault of Cylinder 1 or Cylinder 2	X	X			X	
73	Fault of Cylinder 3 or Cylinder 4	X	X			X	
74	Fault of Cylinder 5 or Cylinder 6	X	X			X	
81	Warning for High Marine Transmission Oil Temperature					X	
86	Warning for High Marine Transmission Oil Pressure					X	

⁽¹⁾ Operate the engine cautiously. Get immediate service. Severe engine damage may result.

⁽²⁾ The operator should go to the nearest location for service.

⁽³⁾ The operator should investigate the problem at a convenient time.

⁽⁴⁾ The Diagnostic Flash Codes reduce the effectiveness of the Engine Monitoring feature.

⁽⁵⁾ These Diagnostic Flash Codes may affect the system only under specific environmental conditions such as engine start-up at cold temperatures, etc.

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i00074446

Fault Logging

SMCS Code: 1000; 1900; 1901; 1902

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates an active diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged in the memory of the ECM can be retrieved with Caterpillar electronic service tools. The codes that have been logged can be cleared with Caterpillar electronic service tools. The codes that have been logged in the memory of the ECM will be automatically cleared from the memory after 100 hours. The following faults cannot be cleared from the memory of the ECM without using a factory password: overspeed, low engine oil pressure, and high engine coolant temperature.

Engine Operation with Active Diagnostic Codes

SMCS Code: 1000; 1900; 1901; 1902

If the diagnostic lamp starts to flash codes during normal engine operation, the system has identified a situation that is not within the specification. Check the following conditions:

- Engine oil pressure
- Coolant temperature
- Coolant level
- Transmission oil pressure
- Transmission oil temperature

Use an electronic service tool to retrieve the active diagnostic code. Refer to the Operation and Maintenance Manual for one of the following necessary actions of the operator:

- Shut down the engine.
- Service the engine.
- Schedule service for the engine.

Note: If low engine oil pressure occurs, the mode for engine monitoring is programmed to "DERATE". The Electronic Control Module (ECM) will limit the maximum engine rpm until the oil pressure problem is corrected. If oil pressure is registering in the normal range, the engine may be operated at the rated rpm and load. However, maintenance should be performed as soon as possible. Refer to Operation and Maintenance Manual for more information.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the active diagnostic code will turn off.

Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. Acceleration rates may be significantly slower. Refer to the Operation and Maintenance Manual for more information on the relationship between these active diagnostic codes and engine performance.

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Engine Operation with Intermittent Diagnostic Codes

SMCS Code: 1000; 1900; 1901; 1902

If the diagnostic lamp starts to flash codes during normal engine operation and the diagnostic lamp shuts off, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged into the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the logged fault codes and the operator should reference the appropriate information in order to identify the nature of the event. The operator should log any observation that could have caused the lamp to light.

- Low power
- Limits of the engine speed
- Excessive smoke, etc

This information can be useful to help troubleshoot the situation. The information can also be used for future reference. For more information on diagnostic codes, refer to the Troubleshooting Guide for this engine.

Configuration Parameters (Customer Specified Parameters)

SMCS Code: 1000; 1900; 1901; 1902

Customer specified parameters that will enhance the fuel efficiency can be programmed into the Electronic Control Module (ECM). Some parameters may affect engine operation. The customer may program the following engine-related parameters may be programmed with Cat electronic service tools to customize engine operation to the specific application:

- Low Idle
- Engine Rating
- Vessel ID
- Engine Monitoring Mode
- Maintenance Indicator Mode
- Customer Specified Password
- Engine Location
- Transmission Oil Set Points
- Air/Fuel Ratio
- Maximum Trolling Speed
- Coolant Level Sensor – Enable/Disable

The customer specified parameters can be changed as often as needed. Password protection is provided so that the customer can change the parameters. Ensure that a record of the parameters is kept in the Operation and Maintenance Manual. For detailed instructions on programming the engine for optimum performance and for optimum fuel economy, consult your Cat dealer.

Engine Starting

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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.

- 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, "Fuel System - Prime" 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 (0.5 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.

i03954049

Cold Weather Starting

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

Refer to the Owners Manual of the OEM for your type of controls. Use the following procedure in order 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 10°C (50°F) from the use of a cylinder block coolant heater or from other means that are used to heat the crankcase oil. Some engine applications use a jacket water heater to improve startability. The jacket water heater will help reduce white smoke and misfire during start-up in cold weather.

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 3 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" (Maintenance Section) for more information on priming the fuel system.

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.

1. Place the transmission in NEUTRAL. Disengage the flywheel clutch in order to allow the engine to start faster and reduce the drain on the batter.
2. Turn the ignition switch to the ON position.

The "CHECK ENGINE/DIAGNOSTIC" lamp will flash while the engine is cranking. The lamp should turn off after proper engine oil pressure is achieved. If the lamp fails to flash, notify your authorized Caterpillar dealer. If the lamp continues to flash, the Electronic Control Module (ECM) has detected a problem in the system. Refer to the Operation and Maintenance Manual, "Diagnostic Flash Code Retrieval" for more information.

3. Push the start button or turn the ignition switch to the START position in order to crank the engine.

Do not push down or hold the throttle down while the engine is cranked. The system will automatically provide the correct amount of fuel that is needed to start the engine.

4. If the engine fails to start within 30 seconds, release the start button, or the ignition switch. Wait for 2 minutes in order to allow the starting motor to cool before attempting to start the engine again.

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.

Note: The "CHECK ENGINE/DIAGNOSTIC" lamp may come on after the engine is started. If the lamp comes on, the Electronic Control Module (ECM) has detected a problem with the system. Refer to the Operation and Maintenance Manual, "Diagnostic Flash Code Retrieval" for more information.

5. Allow the engine to idle for approximately 3 minutes. Idle the engine until the water temperature gauge has begun to rise. Check all gauges during the warm-up period.

Note: The oil pressures and fuel pressures should be in the normal range on the instrument panel. 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.

i05164655

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. Turn the keyswitch to the ON position.

The "CHECK ENGINE/DIAGNOSTIC" lamp will flash while the engine is cranking. The lamp should turn off after proper engine oil pressure is achieved. If the lamp fails to flash, notify your authorized Caterpillar dealer. If the lamp continues to flash, the Electronic Control Module (ECM) has detected a problem in the system. Refer to the Operation and Maintenance Manual, "Diagnostic Flash Code Retrieval" (Operation Section) for more information.

3. Push the start button or turn the keyswitch to the START position in order to crank the engine.

Do not push down or hold the throttle down while the engine is cranked. The system will automatically provide the correct amount of fuel that is needed to start the engine.

4. If the engine fails to start within 30 seconds, release the start button, or the keyswitch. Wait for 2 minutes in order to allow the starting motor to cool before attempting to start the engine again.

Note: The "CHECK ENGINE/DIAGNOSTIC" lamp may come on after the engine is started. If this occurs, the ECM has detected a problem with the system. Refer to the Operation and Maintenance Manual, "Diagnostic Flash Code Retrieval" (Operation Section) for more information.

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.

5. Allow the engine to idle for approximately 3 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. 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.

Engine Starting with the Air Starting Motor

1. Open the drain valve and close the drain valve in order to drain condensation and oil carryover. This drain valve is located on the bottom of the air tank.
2. Check the air supply pressure. The air starting motor requires a minimum of 620 kPa (90 psi) air pressure to operate properly. The maximum air pressure must not exceed 1034 kPa (150 psi).

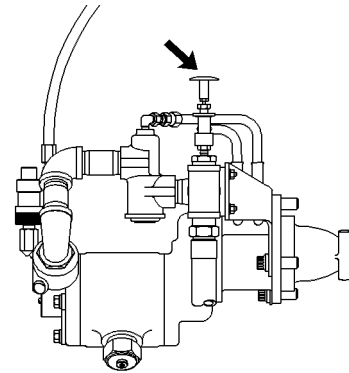


Illustration 28

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Air Valve

3. Press the air valve or press the start button for the engine in order to crank the engine. After the engine starts, release the air valve or release the start button.

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Starting with Jump Start Cables

SMCS Code: 1000; 1401; 1402; 1900

WARNING

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

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

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

For information on troubleshooting the charging system, refer to Special Instruction, REHS0354, "Charging System Troubleshooting".

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

Use a battery that is sourced 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 the negative battery cable last and remove the negative battery cable first.

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

Ensure that the main power switch is in the OFF position before jump start cables are attached to the engine that is 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 charging or starting source.
3. Connect one negative end of the jump start cable to the negative cable terminal of the charging or starting source. Connect the other negative end of the jump start cable to the stalled 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 three minutes. In temperatures below 0°C (32°F), additional warm-up time may be required.

Note: Ensure that the self test for the monitoring system (if equipped) is completed before operating the engine under load.

When the engine idles during warm-up, observe the following conditions:

- Check for any fluid or for any air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under load. This is not possible in some applications.
- Operate the engine at low idle until all systems achieve operating temperatures. Check all gauges during the warm-up period.

Note: 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 Operation

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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 engine can reach normal operating temperature in less than the time for a walk-around inspection of the engine.

The engine can be operated at the rated rpm after the engine is started and after the engine reaches operating temperature. The engine will reach normal operating temperature sooner during a low engine speed (rpm) and during a 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 Speed Governing

The engine speed governor monitors the throttle position and the actual engine speed in order to help control the following items: engine speed, response, torque output, and smoke limiting. The engine speed governor also helps to maintain constant engine speed.

The engine speed is controlled by the governing of the fuel injection duration of the electronic unit injectors. Throttle input is used to calculate the desired engine speed.

Engine Synchronization

Engine synchronization connects the Electronic Control Module (ECM) of the port engine and the ECM of the starboard engine to a common throttle. Engine synchronization increases the convenience of the operator and the control of the vessel. This feature is standard in marine applications.

The engine synchronization enables either throttle to be used in a backup situation. The operator can use a switch to transfer the control of both engines to either the port throttle lever or starboard throttle lever. Refer to the Installation Guide for more information on engine synchronization.

Engine and Marine Transmission Operation

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 3 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.

Docking and Reverse Travel

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 one second 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 one second 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 one second 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 one second 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.

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 one second so that the clutch will completely engage before the engine rpm is increased. Gradually increase the engine rpm.

Slow Vessel Mode

Activating the slow vessel mode switch reduces the low idle to 550 rpm. The slow vessel mode should only be used for the following operations:

- Docking
- Tight maneuvering
- Slow vessel operation in no-wake zones or similar circumstances

NOTICE

Excessive use of the slow vessel mode may cause battery discharge from some alternators.

Trolling Mode Strategy

This strategy limits the engine speed in order to help avoid high loads on the transmission during trolling.

During trolling, moving the engine throttle to full throttle will cause the speed of the engine to change from a programmable low idle speed to a maximum programmable trolling speed. The maximum programmable trolling speed is a customer specified parameter.

Table 8

Programmable Range		
Minimum	Default	Maximum
900 rpm	900 rpm	1200 rpm

The trolling mode will only be activated or deactivated by the Electronic Control Module (ECM) when engine speed is within 50 rpm of the programmed low idle engine speed. The trolling mode can also be activated when the engine is not running.

i01060957

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. The fuel lines should be repaired if there is evidence of failure.

- 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 energy from the heat 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 the temperature of the coolant. 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 of the engine is 300 to 400 rpm below the rated speed of the engine.

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

Transmission Operation

i05163215

Transmission Operation

SMCS Code: 3030; 3101

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 3 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.

Cold Weather Operation

i02237624

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250; 1280

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

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

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

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

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

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

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

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

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

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

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

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

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

i00078412

Fuel Related Components in Cold Weather

SMCS Code: 1000; 1250; 1280

Fuel Tanks

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

Fuel tanks should 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.

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

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

Engine Stopping

i01057256

Emergency Stopping

i03353845

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 (If Equipped)

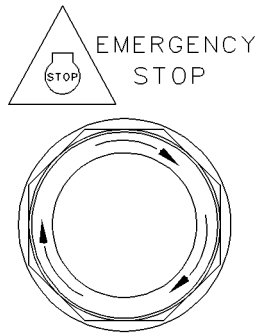


Illustration 29

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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.

Refer to Operation and Maintenance Manual, "Features and Controls" for the location and the operation of the emergency stop button.

Manual Stop Procedure

SMCS Code: 1000; 7418

NOTICE

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

Note: Individual applications will have different control systems. Follow the OEM recommendations or the instructions for stopping the vessel.

1. Reduce the engine rpm to low idle. Shift the marine transmission to the NEUTRAL position and secure the vessel.
2. Increase the engine rpm to no more than 50 percent of the rated rpm for three to five minutes in order to cool the engine. Reduce the engine rpm to low idle.
3. Check the marine transmission oil level. Follow the instructions for the marine transmission or the OEM of the vessel for the procedure to maintain the marine transmission oil level.
4. Turn the start switch to the OFF position.

i02702528

After Stopping Engine

SMCS Code: 1000

- Stop the engine and allow the oil to drain back into the sump for a minimum of ten minutes.
- 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.
- If necessary, 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.

WARNING

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

NOTICE

Only use antifreeze/coolant mixtures recommended in the Refill Capacities and Recommendations topic that is in this Operation and Maintenance 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 (0.5 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.

Maintenance Section

Refill Capacities

i00072100

Refill Capacities

SMCS Code: 1000; 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 filter. Refer to the Operation and Maintenance Manual for more information.

Table 9

Refill Capacities (Approximate)		
Compartment or System	Liters	Quarts
Engine Crankcase Standard Sump	28	30

Cooling System

Table 10

Refill Capacities (Approximate)		
Compartment or System	Liters	Quarts
Engine and Expansion Tank ⁽¹⁾	45	48

⁽¹⁾ 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.

i05163682

Fluid Recommendations

SMCS Code: 1280; 1348; 1395; 7560

Diesel Engine Oil

Cat Diesel Engine Oil (Cat DEO)

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

Table 11

Cat Lubricants		Viscosity Grade
Diesel Engine Oil-Ultra Low Sulfur	Cat DEO-ULS	SAE 15W-40
	Cat Cold Weather DEO-ULS	SAE 10W-30
Diesel Engine Oil	Cat DEO	SAE 0W-40
		SAE 15W-40
		SAE 10W-30

Commercial Oil

Note: Non-Cat commercial oils are second choice oils for your engine.

NOTICE

Caterpillar does not warrant the quality or performance of non-Cat fluids.

The three current Caterpillar ECF specifications are: Cat ECF-1-a, Cat ECF-2, and Cat ECF-3. Each higher Cat ECF specification provides increased performance over lower Cat ECF specifications.

A commercial oil must meet the following standards to be considered an equivalent of a Cat Diesel Engine Oil:

Table 12

Cat Engine Crankcase Fluids (ECF) Definitions	
Cat Performance Requirement	Cat ECF Specifications Requirements
Cat ECF-3	API CJ-4 Oil Category performance requirements
Cat ECF-2	API CI-4 / CI-4 PLUS Oil Category performance requirements
	Passing standard Cat C13 engine test per API requirements
Cat ECF-1-a	Oils of sulfated ash > 1.50 percent are not allowed
	API CH-4 Oil Category performance requirements
	For oils that are between 1.30 percent and 1.50 percent sulfated ash, passing one additional Cat 1P SCOTE test ("ASTM D6681") is required
	Oils of sulfated ash > 1.50 percent are not allowed

In selecting oil for any engine application, both of the following must be satisfied: the oil viscosity and the category of oil performance or the specification for oil performance. Using only one of these parameters will not sufficiently define oil for an engine application.

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

Refer to Table 13 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 13 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Note: Use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

Table 13

Lubricant Viscosities for Ambient Temperatures for Cat Diesel Engines					
Oil Type and Performance Requirements	Viscosity Grade	°C		°F	
		Min	Max	Min	Max
Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 0W-30	-40	30	-40	86
Cat Cold Weather DEO-ULS Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 0W-40	-40	40	-40	104
Cat DEO-ULS Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 5W-30	-30	30	-22	86
Cat DEO-ULS SYN Cat DEO Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 5W-40	-30	50	-22	122
Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 10W-30	-18	40	0	104
Cat DEO-ULS Cat DEO	SAE 10W-40	-18	50	0	122
	SAE 15W-40	-9.5	50	15	122

Note: A cold soaked start occurs when the engine has not been operated recently, allowing the oil to become more viscous due to cooler ambient temperatures. Supplemental heat is recommended for cold soaked starts below the minimum ambient temperature. Supplemental heat may be necessary for cold soaked starts that are above the minimum temperature depending on factors such as parasitic load.

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. The TBN for new oil is typically determined by the "ASTM D2896" procedure. For direct injection engines that use distillate fuel, the following guidelines apply:

Total Base Number (TBN) and Fuel Sulfur Levels

The use of Cat S·O·S Services oil analysis is recommended strongly for determining oil life.

Table 14

TBN recommendations for applications in Cat Engines		
Fuel Sulfur Level percent (ppm)	Cat Engine Oils ⁽¹⁾	TBN of Commercial Engine Oils
0.05 percent (500ppm)	Cat DEO-ULS Cat DEO	Min 7
>0.05-0.2 percent (>500-2000 ppm) ⁽²⁾	Cat DEO-ULS Cat DEO	Min 7
Above 0.1 percent (above 1000ppm) ⁽³⁾⁽⁴⁾	Cat DEO ⁽⁵⁾	Min 10

- (1) Cat DEO-ULS applies to Cat DEO-ULS SAE 15W-40, SAE10W-30 and Cat DEO Cold Weather SAE 0W-40. Cat DEO applies to Cat DEO SAE 15W-40 and SAE 10W-30.
- (2) Use of an oil analysis program to determine oil drain intervals is strongly recommended if fuel sulfur is between 0.05% (500 ppm) and 0.5% (5000 ppm).
- (3) Use of an oil analysis program to determine oil drain intervals is required if fuel sulfur is above 0.5% (5000 ppm).
- (4) For fuels of sulfur levels that exceed 1.0 percent (10,000 ppm), refer to TBN and engine oil guidelines given in Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations", "Engine Oil".
- (5) Cat DEO-ULS may be used if an oil analysis program is followed. High fuel sulfur levels may reduce the oil drain intervals.

Note: For PC (Precombustion Chamber) diesel engines, the minimum new oil TBN must be 20 times the fuel sulfur level.

For regions in the world where fuels of high sulfur that exceed 1.0 percent (10,000 ppm (mg/kg)) are available and allowed for use by law, use the following guidelines:

- Choose multigrade oil with the highest TBN that meets one of these specifications: Cat ECF-1-a, Cat ECF-2, or Cat ECF-3.
- 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. Cat S·O·S Services oil analysis is required.

For more information, refer to Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations".

S·O·S Services Oil Analysis

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

- Component wear rate
- Oil condition
- Oil contamination
- Identification of oil

These four types of analysis are used to monitor the condition of your equipment. The four types of analysis will also help you identify potential problems. A properly administered S·O·S oil analysis program will reduce repair costs and the program will lessen the impact of downtime.

The S·O·S Oil Analysis program uses a wide range of tests to determine the condition of the oil and the crankcase. Guidelines that are based on experience and a correlation to failures have been established for these tests. Exceeding one or more of these guidelines could indicate serious fluid degradation or a pending component failure. A trained person at your Cat dealership should make the final analysis.

NOTICE

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

Refer to Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations" in order to obtain additional information about S·O·S Services oil analysis. You can also contact your local Cat dealer.

Fuel

Note: Caterpillar strongly recommends the filtration of fuel through a fuel filter with a rating of four microns(c) absolute or less. This filtration should be located on the device that dispenses the fuel to the fuel tank for the engine. This filtration should also be located on the device that dispenses fuel from the bulk storage tank. Series filtration is recommended.

NOTICE

In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat Diesel Engines that are equipped with unit injected fuel systems. All current Cat Diesel Engines are factory equipped with Cat Advanced Efficiency 4 micron(c) absolute fuel filters.

Caterpillar does not warrant the quality or performance of non-Cat fluids and filters.

For more information, refer to Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations" or consult your Cat dealer for further information.

Specifications for Distillate Diesel Fuel

Note: Diesel fuel used to operate a Cat Marine Diesel Engine must also meet the "Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines". The acceptability of these fuels for use is determined on a case by case basis. A complete fuel analysis is required. Consult your Cat dealer for further information.

NOTICE

The footnotes are a key part of the "Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines" Table. Read ALL of the footnotes.

Table 15

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	Requirements	ASTM Test	ISO Test
Aromatics	35% maximum	"D1319"	"ISO 3837"
Ash	0.01% maximum (weight)	"D482"	"ISO 6245"
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	"D524"	"ISO 4262"
Cetane Number ⁽¹⁾	40 minimum (DI engines)	"D613" or "D6890"	"ISO 5165"
	35 minimum (PC engines)		
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	"D2500"	"ISO 3015"

(continued)

(Table 15, contd)

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	Requirements	ASTM Test	ISO Test
Copper Strip Corrosion	No. 3 maximum	"D130"	"ISO 2160"
Distillation	10% at 282 °C (540 °F) maximum	"D86"	"ISO 3405"
	90% at 360 °C (680 °F) maximum		
Flash Point	legal limit	"D93"	"ISO 2719"
Thermal Stability	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	"D6468"	No equivalent test
API Gravity ⁽²⁾	30 minimum	"D287"	No equivalent test
	45 maximum		
Pour Point	6 °C (10 °F) minimum below ambient temperature	"D97"	"ISO 3016"
Sulfur	⁽³⁾	"D5453" or "D2622"	ISO 20846 or ISO 20884
Kinematic Viscosity	1.4 cSt minimum and 20.0 cSt maximum as delivered to the fuel injection pumps	-	-
	1.4 cSt minimum and 4.5 cSt maximum as delivered to the rotary fuel injection pumps		
Water and Sediment	0.05% maximum	"D1796" or "D2709"	"ISO 3734"
Water	0.05% maximum	"D6304"	No equivalent test

(continued)

(Table 15, contd)

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	Requirements	ASTM Test	ISO Test
Sediment	0.05% maximum (weight)	"D473"	"ISO 3735"
Gums and Resins ⁽⁴⁾	10 mg per 100 mL maximum	"D381"	"ISO 6246"

- (1) Alternatively, to ensure a minimum cetane number of 35 (PC engines), and 40 (DI engines), distillate diesel fuel should have a minimum cetane index of 37.5 (PC engines), and 44.2 (DI engines) when the "ASTM D4737-96a" test method is used. A fuel with a higher cetane number may be required for operation at a higher altitude or in cold weather.
- (2) Via standards tables, the equivalent kg/m³ (kilograms per cubic meter) using the "ASTM D287" test method temperature of 15.56° C (60° F) for the minimum API gravity of 30 is 875.7 kg/m³, and for the maximum API gravity of 45 is 801.3 kg/m³.
- (3) Certain Cat fuel systems and engine components can operate on fuel with a maximum sulfur content of 3%. Contact your Cat dealer for guidance about appropriate maintenance intervals and fluids for engines operating on fuel with sulfur levels between 0.1% and 3%.
- (4) Follow the test conditions and procedures for gasoline (motor).

Biodiesel

A biodiesel blend of up to 20 percent may be used in the engine when the fuel blend meets the recommendations in table 16 and meets the recommendations in Special Publication, SEBU6251, "Biodiesel". A blend of greater than 20 percent biodiesel may be acceptable in some cases. See your Cat dealer for more information.

Note: A complete Cat S·O·S Services oil analysis program is **recommended strongly** when using biodiesel blends above 5 percent.

Table 16

Biodiesel Blends for Cat Commercial Diesel Engines		
Biodiesel blend stock	Final blend	Distillate diesel fuel used for blend
Caterpillar biodiesel specification, "ASTM D6751" or "EN14214"	B20: "ASTM D7467" and "API" gravity 30-45	Caterpillar distillate diesel fuel specification, "ASTM D975" or "EN590"

Fuel Additives

Cat Diesel Fuel Conditioner

Cat Diesel Fuel Conditioner is a proprietary formulation that has been extensively tested for use with distillate diesel fuels for use in Cat Diesel Engines. Cat Diesel Fuel Conditioner is a high performance diesel fuel conditioner for use with lower quality fuels that do not meet the minimum requirements of any of the following:

- "Caterpillar Specification for Distillate Diesel Fuel"
- National Conference on Weights and Measures (NCWM) Premium Diesel definition (refer to the 2004 or newer National Institute of Standards & Technology (NIST) Handbook).
- EN590 (non-arctic)
- ASTM D975

Cat Diesel Fuel Conditioner is the only fuel conditioner/additive available to the end user that is tested and approved by Caterpillar for use in Cat Diesel Engines.

Refer to Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations" for information about the use of Cat Diesel Fuel Conditioner.

Cat Diesel Fuel System Cleaner

Note: Cat Diesel Fuel System Cleaner is the only fuel system cleaner available to the end user that is tested and approved by Caterpillar for use in Cat Diesel Engines.

Cat Diesel Fuel System Cleaner is a proven high performance detergent product designed specifically for cleaning deposits that form in the fuel system. Deposits in the fuel system reduce system performance and can increase fuel consumption. Cat Diesel Fuel System Cleaner addresses the deposits formed due to the use of degraded diesel fuel, poor quality diesel fuel, and diesel fuel containing high quantities of high molecular weight compounds. Cat Diesel Fuel System Cleaner addresses deposits formed due to the use of biodiesel, biodiesel blends, and biodiesel that does not meet the appropriate quality specifications. Continued use of Cat Diesel Fuel System Cleaner is proven to inhibit the growth of new deposits.

Caterpillar strongly recommends that Cat Diesel Fuel System Cleaner be used with biodiesel and biodiesel blends. Cat Diesel Fuel System Cleaner is suitable for use with biodiesel/biodiesel blends that meet Caterpillar biodiesel recommendations and requirements. Not all fuel cleaners are suitable for use with biodiesel/biodiesel blends. Read and follow all applicable label usage instructions. Also, refer to Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations", "Distillate Diesel Fuel", article and also refer to the "Biodiesel" article, which includes Caterpillar biodiesel recommendations and requirements.

Aftermarket Fuel Additives

There are many different types of fuel additives that are available to use. Caterpillar does not generally recommend the use of fuel additives.

In special circumstances, Caterpillar recognizes the need for fuel additives. Use fuel additives with caution. The additive may not be compatible with the fuel. Some additives may precipitate. This action causes deposits in the fuel system. The deposits may cause seizure. Some additives may plug fuel filters. Some additives may be corrosive, and some additives may be harmful to the elastomers in the fuel system. Some additives may damage emission control systems. Some additives may raise fuel sulfur levels above the maximum levels that are allowed by the following agencies: EPA and other regulatory agencies. Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use and for the proper level of treatment.

Note: For best results, your fuel supplier should treat the fuel when additives are needed.

Cooling System

Note: Refer to Special Publication , SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations" for complete information about the proper fluids for use in the cooling system.

WARNING

The cooling system operates under pressure which is controlled by the radiator pressure cap. Removing the cap while the system is hot may allow the escape of hot coolant and steam, causing serious burns.

Before you remove the radiator cap, allow the system to cool. Use a thick cloth and turn the radiator cap slowly to the first stop to allow pressure to escape before fully removing the cap.

Avoid contact with coolant.

NOTICE

Never add coolant to an overheated engine. Engine damage could result. Allow the engine to cool first.

NOTICE

If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or drained completely in order to prevent damage caused by freezing coolant.

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. Removing the regulators allows some coolant to bypass the radiator, potentially causing overheating.

Coolant Recommendations

Table 17

Coolant Recommendations for use in Cat Diesel Engines			
Recommendations	Product	Service Hours ⁽¹⁾⁽²⁾⁽³⁾	Required Maintenance
Preferred	Cat ELC (Cat Extended Life Coolant)	12000 hours or 6 years	Add Cat ELC Extender at 6000 service hours or one half of service life
	Cat ELI (Cat Extended Life Inhibitor)	12000 hours or 6 years	Add Cat ELC Extender at 6000 service hours or one half of service life
Min requirements	Cat EC-1 specification and "ASTM D6210" and Organic Additive Technology (OAT) based on a combination of a monocarboxylic acid and a dicarboxylic acid Phosphate, borate, and silicate free Tolyltriazole: minimum typical concentration of 900 ppm Nitrite: minimum typical concentration of 500 ppm in new coolants	6000 hours or 6 years	Add Extender at 3000 service hours or one half of service life
Acceptable	Cat DEAC (Cat Diesel Engine Antifreeze/Coolant)	3000 hours or 3 years	SCA (Supplemental coolant additive) at maintenance intervals
Min requirements for fully formulated Heavy Duty Commercial coolants	"ASTM D6210" and Nitrite (as NO ₂) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 2 years	SCA at maintenance intervals
Min requirements for Commercial coolants requiring SCA precharge	"ASTM D4985" and(1) Nitrite (as NO ₂) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 1 year	SCA at initial fill and SCA at maintenance intervals

(1) New Coolants at 50 volume percent diluted. Coolants that are prediluted at the coolant manufacturer must be diluted with water that meets Reagent 4 "ASTM D1193" requirements.

(2) Maintain the in-service coolant at the given limits.

(3) When referring to the service hours, use the interval that occurs first. These coolant change intervals are only achievable with annual S-O-S Services Level 2 coolant sampling analysis.

Table 18

Special Requirements	
Cat C7-C32 Marine Engines with heat exchangers	Minimum of 30% glycol is required. 50% Glycol is recommended. Water alone or water with SCA or with ELI is NOT allowed.
Cat diesel engines equipped with air-to-air aftercooling (ATAAC)	

NOTICE**Use Only Approved SCAs and Extenders**

Conventional coolants require the maintenance addition of SCA throughout the expected life of the coolants. Do NOT use an SCA with a coolant unless approved specifically by the coolant supplier. The coolant manufacturer is responsible for ensuring compatibility and acceptable performance.

To help ensure expected performance, EC-1 coolants require the one time maintenance addition of an extender at coolant service mid-life. Do not use an extender with a coolant unless the extender has been approved specifically for use by the coolant manufacturer. The coolant manufacturer is responsible for ensuring compatibility and acceptable performance.

Failure to follow these recommendations can result in shortened cooling system component life.

Cat ELC can be recycled into conventional coolants.

For more information, refer to Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations".

Cat S·O·S Services Coolant Analysis

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and freezing. S·O·S coolant analysis can be done at your Cat dealer. Cat 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.

Note: Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engines Fluids Recommendations" or contact your Cat dealer for additional information concerning the S·O·S program for coolant analysis.

Maintenance Recommendations

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System Pressure Release

SMCS Code: 1250; 1300; 1350; 5050

Coolant System

WARNING

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

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

Fuel System

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

High Pressure Fuel Lines (If Equipped)

WARNING

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

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

This is because of the following differences:

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

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

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

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

Engine Oil

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

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Maintenance Interval Schedule

SMCS Code: 1000; 4450; 7500

Ensure that all safety information, warnings, and instructions are read and understood before any operation or any maintenance procedures are performed. The user is responsible for the performance of all maintenance including the following procedures: all adjustments, the use of proper lubricants, fluids, filters, and the installation of new components due to normal wear and aging . The performance of this product may be diminished if proper maintenance intervals and procedures are not followed. Components may experience accelerated wear if proper maintenance intervals and procedures are not followed.

Note: Use whichever of the following that occurs first in order to determine the maintenance intervals: fuel consumption, service hours, and calendar time . Before each consecutive interval is performed, all maintenance from the previous intervals must be performed.

Products that operate in severe operating conditions may require more frequent maintenance.

When Required

Aftercooler Core - Clean/Test	68
Battery - Replace	70
Battery or Battery Cable - Disconnect	71
Coolant - Change	71
Coolant Extender (ELC) - Add	74
Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace	78
Engine Oil Level Gauge - Calibrate	83
Engine Storage Procedure - Check	87
Fuel System - Prime	88

Daily

Coolant Level - Check	74
Engine Air Cleaner Service Indicator - Inspect	80
Engine Oil Level - Check	82
Fuel System Primary Filter/Water Separator - Drain	89
Fumes Disposal Filter Service Indicator - Check ..	93
Transmission Oil Level - Check	100
Walk-Around Inspection	101

Between 250 Service Hours and 1000 Service Hours (or between first and fourth oil change)

Engine Valve Lash - Check	87
Engine Valve Rotators - Inspect	87

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

Zinc Rods - Inspect/Replace	102
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PM Level 1 - Every 9500 L (2500 US gal) of Fuel or 250 Service Hours or 1 Year

Aftercooler Condensate Drain Valve - Inspect/Clean	68
Alternator - Inspect	69
Auxiliary Water Pump - Inspect	69
Battery Electrolyte Level - Check	70
Belts - Inspect/Adjust/Replace	71
Cooling System Supplemental Coolant Additive (SCA) - Test/Add	76
Engine Crankcase Breather - Clean	81
Engine Oil Sample - Obtain	84
Engine Oil and Filter - Change	85
Fuel System Primary Filter (Water Separator) Element - Replace	88
Fuel System Secondary Filter - Replace	90
Fuel Tank Water and Sediment - Drain	91
Hoses and Clamps - Inspect/Replace	94

Every 28 500 L (7500 US gal) of Fuel or 750 Service Hours or 1 Year

Fumes Disposal Filter Element - Replace	92
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Every 38 000 L (10 000 US gal) of Fuel or 1000 Service Hours or 2 Years

Aftercooler Core - Clean/Test	68
Heat Exchanger - Inspect	94
Turbocharger - Inspect	100

PM Level 2 - Every 114 000 L (30 000 US gal) of Fuel or 3000 Service Hours or 2 Years

Coolant Temperature Regulator - Replace	75
Crankshaft Vibration Damper - Inspect	77
Engine Mounts - Inspect	82
Engine Speed/Timing Sensor - Clean/Inspect	87
Engine Valve Lash - Check	87
Engine Valve Rotators - Inspect	87

Every 190 000 L (50 000 US gal) of Fuel or 5000 Service Hours

Starting Motor - Inspect	100
Water Pump - Inspect	102

Every 380 000 L (100 000 US gal) of Fuel or 10 000 Service Hours

Overhaul Considerations	97
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Aftercooler Condensate Drain Valve - Inspect/Clean

SMCS Code: 1063-042-DN

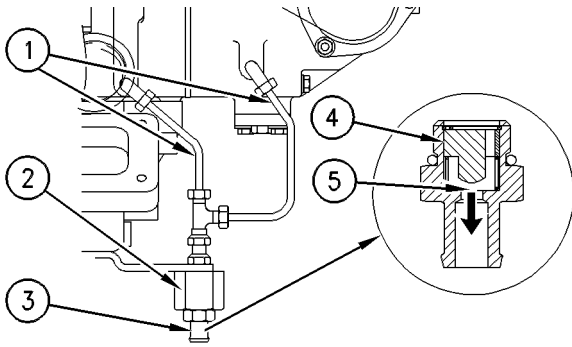


Illustration 30

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(1) Drain lines. (2) Adapter. (3) Valve. (4) Plunger. (5) Valve seat.

The turbocharger boost pressure forces plunger (4) to move down to valve seat (5). The plunger must close against the seat at a pressure of 27.5 kPa (4 psi). When the engine is stopped, the absence of boost pressure allows the plunger to rise to the open position, which allows condensation from the aftercooler to drain out.

The plunger must be able to move freely in order to close the system when the engine is running. The plunger must be able to move freely in order to allow condensation to drain from the aftercooler when the engine is stopped. Residue from normal engine operation could cause the plunger to stick.

1. Remove valve (3) from adapter (2). Check the valve in order to determine if plunger (4) moves freely. If the plunger does not move easily, clean the valve with solvent.
2. Remove drain lines (1). Check the lines for plugging. Clean the lines, if necessary. Pressure air or a flexible rod with a small diameter can be used to clean the lines.
3. Reassemble the aftercooler condensate drain valve. Refer to the Specifications, SENR3130, "Torque Specifications" for the correct torque values .

Aftercooler Core - Clean/Test

SMCS Code: 1064-070; 1064-081

Note: An aftercooler that circulates fresh water or treated water may require cleaning less often than an aftercooler which circulates salt water. The maintenance interval for an aftercooler which circulates fresh water or treated water should be evaluated when the aftercooler is cleaned and tested after the first 1000 hours of engine operation. The interval will vary depending on operating conditions.

Clean the Aftercooler Core

Remove the core. Refer to the Disassembly and Assembly Manual, "Aftercooler - Remove" for the procedure.

1. Turn the aftercooler core on one side in order to remove debris. Remove the debris that is accessible.

NOTICE

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

2. Back flush the core with cleaner.

Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 19 lists Hydrosolv liquid cleaners that are available from your Cat dealer.

Table 19

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

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

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

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

4. Wash the core with hot, soapy water.

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

WARNING

Personal injury can result from air pressure.

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

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded.

6. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.

Test the Aftercooler Core

1. Inspect the core for trapped debris and cleanliness. If necessary, remove the debris and repeat the cleaning procedure.
2. Inspect the core for damage and perform a pressure test in order to detect leaks. Many shops that service radiators are equipped to perform pressure tests.
3. Plug both ends of the aftercooler core and pressurize the core to 205 kPa (30 psi). Submerge the core in water. Look for bubbles which are being emitted from the core. The bubbles are evidence of leaks.
4. If any leaks are found, do not attempt to repair the core.

Install a core that is clean and a core that passes the pressure test in step 3. Refer to the Disassembly and Assembly Manual, "Aftercooler - Install" for the procedure.

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

Alternator - Inspect

SMCS Code: 1405-040

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

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

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Auxiliary Water Pump - Inspect

SMCS Code: 1371-040; 1371

Impellers require periodic inspection 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 of the pump 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 and check the following components for damage:

- Cam
- Impeller
- Seals
- Wear plate

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

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Battery - Replace

SMCS Code: 1401-510

WARNING

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

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

WARNING

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

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

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

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

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

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

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.

8. Connect the cable from the ground plane to the NEGATIVE “-” battery terminal.

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Battery Electrolyte Level - Check

SMCS Code: 1401-535-FLV

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

WARNING

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

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

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

3. Keep the batteries clean.

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

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

Thoroughly rinse the battery case with clean water.

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

i01492654

Battery or Battery Cable - Disconnect

SMCS Code: 1401; 1402-029

⚠ WARNING

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

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

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

i05163782

Belts - Inspect/Adjust/Replace

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

Inspection

To maximize the engine performance, inspect the belt for wear and for cracking. Check the belt tension. Adjust the belt tension in order to minimize belt slippage. Belt slippage will decrease the life of the belt.

To check the belt tension, apply 110 N (25 lb) of force midway between the pulleys. A correctly adjusted belt will deflect 13 to 19 mm (0.50 to 0.75 inch).

Adjustment

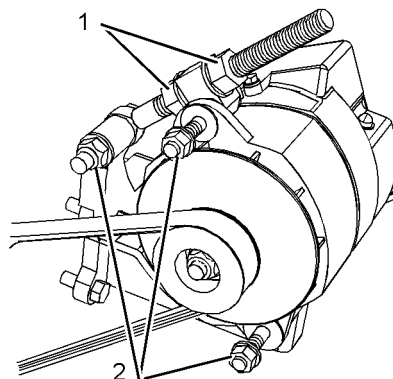


Illustration 31

g02533519

- (1) Adjusting nuts
(2) Mounting bolt

1. Remove the belt guard.
2. Loosen the mounting bolt and the adjusting nuts.
3. Turn the adjusting nuts to increase or decrease the belt tension.
4. Tighten adjusting nuts . Tighten the mounting bolt . Refer to the Specifications, SENR3130, "Torque Specifications" for the proper torques.
5. Reinstall the belt guard.

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

Replacement

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 belts are stretched. The additional load on the new belt could cause the new belt to break.

Refer to the Service Manual for more information on the procedures for the following topics: belt removal and installation of the belt.

i04538352

Coolant - Change

SMCS Code: 1350-044; 1352; 1395-044; 1395

Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the correct intervals for changing the coolant.

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.

Drain the Cooling System

WARNING

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

NOTICE

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

Refer to Special Publication, NENG2500, "Cat Dealer Service Tool Catalog" or refer to Special Publication, PECJ0003, "Cat Shop Supplies and Tools Catalog" for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

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

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

Allow the coolant to drain.

NOTICE

Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant 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 Cat dealer or consult Cat Dealer Service Tool Group:

Inside USA: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL
International: 1-309-578-7372

Flush

Systems Filled with Cat ELC, Cat ELI, or a Conventional Coolant that Meets the Cat EC-1 Requirements and the Standards of ASTM D6210

1. Flush the cooling system with clean water in order to remove any debris.
2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual, SENR3130, "Torque Specifications" for more information on the proper torques.

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 Specifications Manual, SENR3130, "Torque Specifications" for more information on the proper torques.

Systems Filled with Cat DEAC, Conventional Coolant which does not Meet the Cat EC-1 Requirements, or Supplemental Coolant Additive (SCA) and Water

3. Flush the cooling system with clean water in order to remove any debris.
4. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual, SENR3130, "Torque Specifications" for more information on the proper torques.

NOTICE

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

5. Fill the cooling system with a mixture of clean water and Cat Fast Acting Cooling System Cleaner.
6. Choose 1 of the following options.
 - Add 0.5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity.
 - For cooling systems with heavy deposits or plugging, add 0.5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity.
7. Install the cooling system filler cap.
8. Start and run the engine at low idle for a minimum of 30 minutes. For cooling systems with heavy deposits or plugging, run the engine for 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.

9. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. If equipped, be sure to flush the heater and any related supply and return lines. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual, SENR3130, "Torque Specifications" for more information on the proper torques.

Fill the Cooling System

NOTICE

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

1. Fill the cooling system. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for more information on cooling system specifications. Refer to this Operation and Maintenance Manual, "Refill Capacities" for information about the capacity of the cooling system. 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 1 minute in order to purge the air from the cavities of the engine block. Stop the engine.
3. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 inch) to the proper level on the sight glass (if equipped).
4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. Only install the used filler cap if the gasket is not damaged. Use a 9S-8140 Pressurizing Pump to pressure test a reinstalled 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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Coolant Extender (ELC) - Add

SMCS Code: 1352-544-NL

Note: Refer to this Operation and Maintenance Manual, "Fluid Recommendations" (Cooling System) for the maintenance interval for the addition of the coolant extender.

Cat ELC (Extended Life Coolant) and Cat ELI (Extended Life Inhibitor) do not require the frequent additions of any supplemental cooling additives. The Cat ELC Extender will only be added one time.

Note: Do not use conventional supplemental coolant additive (SCA) with Cat ELC or with Cat ELI.

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

WARNING

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

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

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

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

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

NOTICE

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

Refer to Special Publication, NENG2500, "Cat Dealer Service Tool Catalog" or refer to Special Publication, PECJ0003, "Cat Shop Supplies and Tools Catalog" for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. If necessary, drain enough coolant from the cooling system in order to add the Cat ELC Extender.
3. Add Cat ELC Extender according to the requirements for the cooling system capacity. Refer to this Operation and Maintenance Manual, "Refill Capacities" for the coolant capacity.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

For further information, refer to this Operation and Maintenance Manual, "Fluid Recommendations".

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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

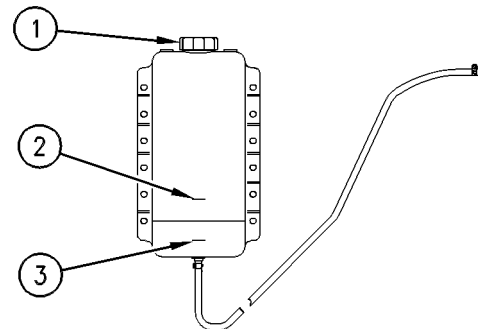


Illustration 32

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.

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3. Pour the proper coolant mixture into the tank. Refer to this Operation and Maintenance Manual, "Refill Capacities" for information about coolants. 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.

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 (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.

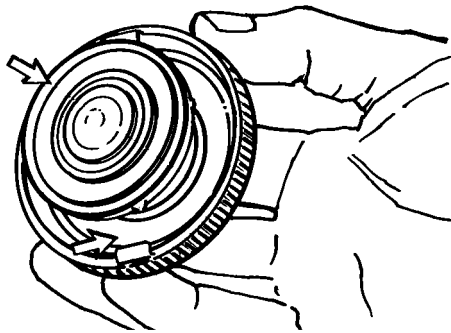


Illustration 33

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.

Coolant Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulator before the water temperature regulator fails. 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 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.

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.

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.

NOTICE

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

Refer to Special Publication, NENG2500, "Cat Dealer Service Tool Catalog" or refer to Special Publication, PECJ0003, "Cat Shop Supplies and Tools Catalog" for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Note: If replacing only the water temperature regulator, only drain the coolant to a level that is below the water temperature regulator housing.

Refer to two articles in the Disassembly and Assembly Manual, "Water Temperature Regulator - Remove and Water Temperature Regulator - Install" for the replacement procedure or consult your Cat dealer.

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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 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 this Operation and Maintenance Manual, "Refill Capacities and Recommendations" for more information.

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 Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for more information.

S·O·S Coolant Analysis

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

Level 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.

Level 2

This level coolant analysis is recommended when the engine is overhauled. Refer to this Operations and Maintenance Manual, "Overhaul Considerations" for further information.

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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 Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engines Fluids Recommendations" for more information on SCA requirements.
4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.

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.

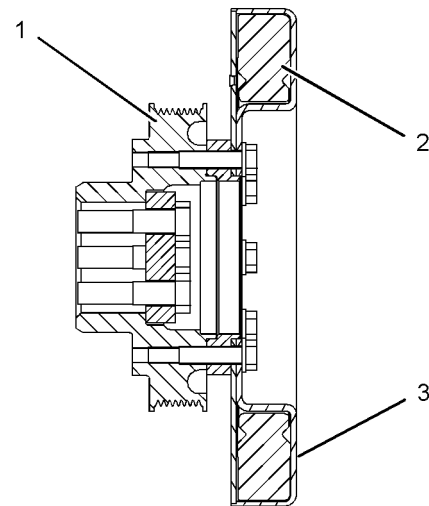


Illustration 34

g01134779

Viscous vibration damper

Typical example

- (1) Crankshaft pulley
- (2) Weight
- (3) Case

Inspection

Inspect the damper for the following conditions:

- The damper is dented, cracked, or fluid is leaking from the damper.
- The paint on the damper is discolored from excessive heat.
- The damper is bent.
- The bolt holes are worn or there is a loose fit for the bolts.

- The engine has had a crankshaft failure due to torsional forces.

Replace the damper if any of these conditions exist.

Removal and Installation

Refer to this Operation and Maintenance Manual, "Belts - Inspect/Adjust/Replace" for information on removing and on installing the belt. Refer to the Disassembly and Assembly Manual, "Vibration Damper and Pulley - Remove and Install" for information on removing and installing the damper.

i05163931

Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace (Air Cleaner Element and Vacuum Regulator Filters)

SMCS Code: 1051; 1054-040; 1054-070; 1054-510

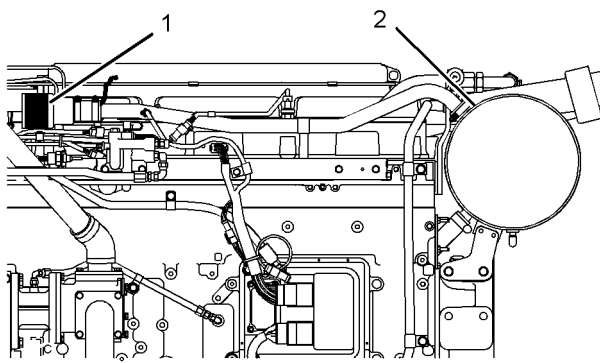


Illustration 35

g03317242

- (1) Vacuum regulator filter element
- (2) Engine 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.

Note: Use the information about cleaning the air cleaner element for maintenance of the vacuum regulator filter.

Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Cat dealer has the proper air cleaner elements for your application. Consult your Cat dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt, and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the air cleaner element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, thoroughly check the air cleaner elements for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

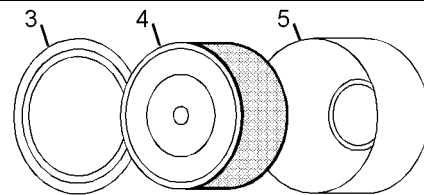


Illustration 36

g03317283

- (3) Cover
- (4) Air cleaner element
- (5) Turbocharger inlet

1. Remove the air cleaner cover. Remove the air cleaner element.

Note: Refer to "Cleaning the Air Cleaner Elements".

2. Cover the air inlet with tape in order to keep out dirt.
3. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

4. Remove the tape for the air inlet. Install an air cleaner element that is new or cleaned.
5. Install the air cleaner cover.
6. Reset the air cleaner service indicator.

Cleaning the Air Cleaner Elements

NOTICE

Caterpillar recommends certified air filter cleaning services that are available at Caterpillar dealers. The Caterpillar cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

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

Use clean air cleaner elements while dirty elements are being cleaned.

NOTICE

Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean air cleaner elements:

- Pressurized air
- Vacuum cleaning

Pressurized Air

Pressurized air can be used to clean air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

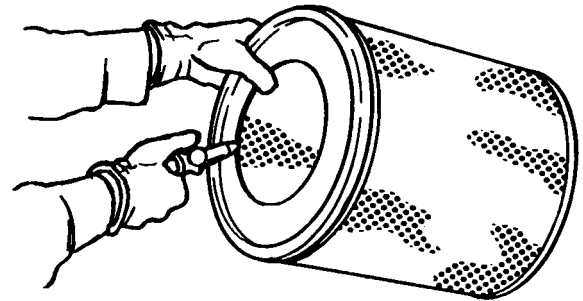


Illustration 37

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Note: When the air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter to prevent damage to the paper pleats. Do not aim the stream of air directly at the air cleaner element. Dirt could be forced further into the pleats.

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

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

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

Inspecting the Air Cleaner Elements

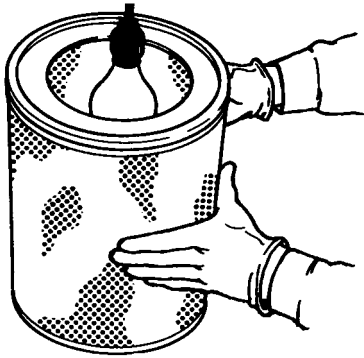


Illustration 38

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

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

Storing Air Cleaner Elements

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

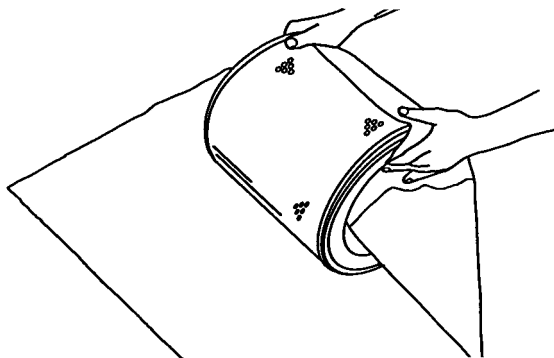


Illustration 39

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

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

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

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Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

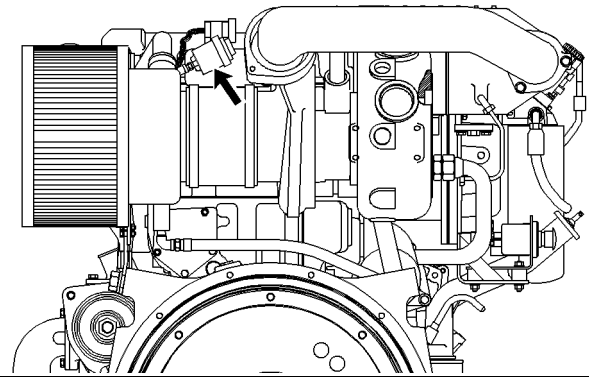


Illustration 40

g00105037

Service Indicator

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The 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 recommendations for the vessel or follow the recommendations in the air cleaner OEM in order to service the air cleaner element.

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

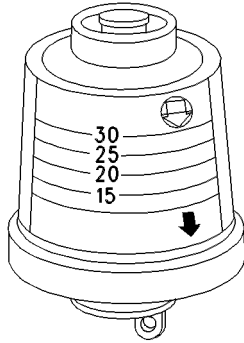


Illustration 41

g00103777

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 applicable). 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).

Service the 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.

If the air cleaner element becomes plugged, the air can split the filter material. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has air filter elements in order to service this unit. Consult your Caterpillar dealer for the correct air cleaner element.

If the service indicator appears red at any time, clean the air cleaner element or install a new air cleaner element. Clean the air cleaner element or replace the air cleaner element at 250 hour intervals.

Refer to the Operation and Maintenance Manual for more information on servicing the air cleaner element.

i01102895

Engine Crankcase Breather - Clean

SMCS Code: 1317-070

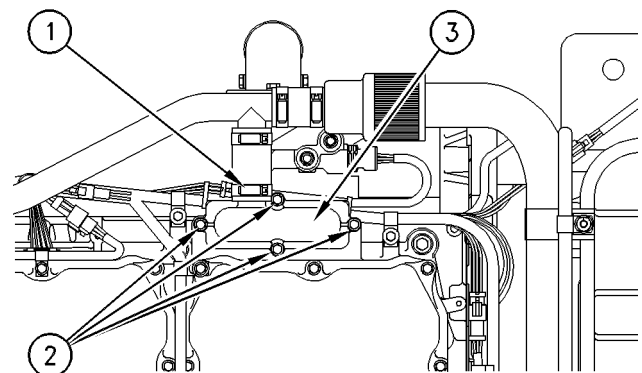


Illustration 42

g00580871

Typical example

- (1) Hose clamp
- (2) Four bolts
- (3) Breather cover

NOTICE

Perform this maintenance with the engine stopped.

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

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

i02456872

Engine Mounts - Inspect

SMCS Code: 1152-040; 1152

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 Special Publication, SENR3130, "Torque Specifications" for the recommended torques. Refer to the OEM recommendations for more information.

i00573217

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

Check the oil level after the engine has stopped.

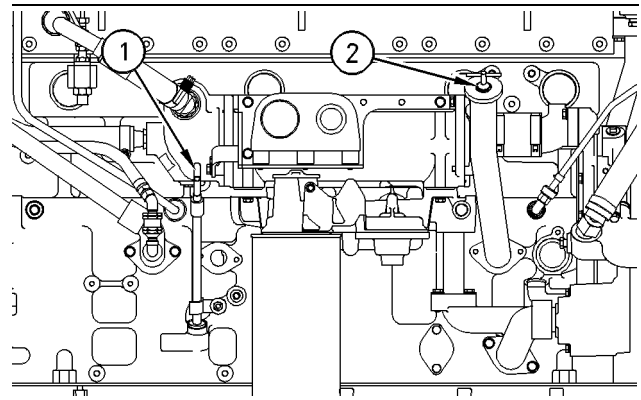


Illustration 43

g001105043

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

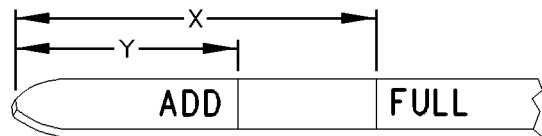


Illustration 44

g00110310

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

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

Operating your engine when the oil level is above the "FULL" mark could cause your crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduces the oil's lubricating characteristics and could result in the loss of power.

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

i01708884

Engine Oil Level Gauge - Calibrate

SMCS Code: 1326-524; 1326

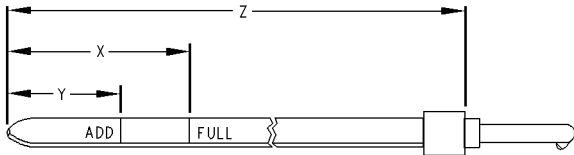


Illustration 45

g00882677

(Y) "ADD" mark. (X) "FULL" mark. (Z) "Effective Length".

(Z-LH Service Engines) 642 mm (25.3 inch)
(Z-RH Service Engines) 479 mm (18.9 inch)

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 side for servicing the engine oil can be different for each engine. The angle of the installation and the side for servicing the engine oil will affect "ADD" mark (Y) and "FULL" mark (X) that is engraved on the engine oil level gauge.

The engine oil level gauge should be calibrated after the engine is installed in the vessel. Use the following procedure in order to verify that "ADD" mark (Y) is correct. Use the following procedure in order to establish actual "FULL" mark (X) on the engine oil level gauge. Refer to table 20 and table 21 in order to determine the location for the "ADD" and "FULL" marks for a particular installation.

NOTICE

Refer to the Operation and Maintenance Manual for more information on lubricant specifications.

1. Operate the engine until normal operating temperature is achieved. Stop the engine. Remove one of the drain plugs for the engine crankcase. Allow the engine oil to drain.
2. Remove the used engine oil filter. Install the new engine oil filter. Install the drain plug for the engine crankcase. Tighten the drain plug for the engine crankcase to 70 ± 14 N·m (50 ± 10 lb ft).

Note: The engine may be equipped with auxiliary engine oil filters. Volumes that are different from the standard amounts may be required. Refer to the OEM specifications.

3. Pour 20.8 L (22 qt) of engine oil into the engine crankcase. Allow enough time for the engine oil to drain into the engine crankcase. Approximately 20 minutes should be allowed. Check the engine oil level. Wait for a few minutes. Check the engine oil level again. Proceed after the engine oil level stops changing.
4. Mark the engine oil level on the engine oil level gauge. Use a marking pen in order to engrave "ADD" mark (Y).
5. Pour 3.8 L (4 qt) of engine oil into the engine crankcase. Allow enough time for the engine oil to drain into the engine crankcase.
6. Mark the engine oil level on the engine oil level gauge. Use a marking pen in order to engrave "FULL" mark (X).
7. Start the engine. Ensure that the lubrication system is filled. Inspect the lubrication system for leaks.
8. Stop the engine and allow enough time for the engine oil to drain into the engine crankcase.
9. Check the engine oil level on the engine oil level gauge. If the engine oil level is not at calibrated "FULL" mark (X), fill the sump to the calibrated "FULL" mark. Record the amount of oil that is added. This additional engine oil is the system capacity plus the engine oil in the sump. This additional engine oil is the amount of engine oil that is required when the engine oil is changed. Record the engine oil capacity for the system for future changes of the engine oil.

3176C and 3196 Marine Engine Dipstick Markings

Note: Use the following tables if these conditions exist:

- The engine is installed with a 0 degree slant angle.
- No auxiliary engine oil filters are used on the engine.

Table 20

3176C and 3196 Marine Engine Oil Gauge Markings (mm) LH Service ⁽¹⁾		
Tilt Angle ⁽²⁾	LH Service “ADD” Mark Y	LH Service “FULL” Mark X
-15°	120 mm (4.7 inch)	133 mm (5.2 inch)
-13°	113 mm (4.4 inch)	125 mm (4.9 inch)
-11°	110 mm (4.3 inch)	124 mm (4.9 inch)
-9°	106 mm (4.2 inch)	118 mm (4.6 inch)
-7°	100 mm (3.9 inch)	110 mm (4.3 inch)
-5°	93 mm (3.7 inch)	106 mm (4.2 inch)
-3°	87 mm (3.4 inch)	99 mm (3.9 inch)
-1°	82 mm (3.2 inch)	93 mm (3.7 inch)
0°	79 mm (3.1 inch)	89 mm (3.5 inch)
1°	73 mm (2.9 inch)	85 mm (3.3 inch)
3°	68 mm (2.7 inch)	81 mm (3.2 inch)
5°	63 mm (2.5 inch)	74 mm (2.9 inch)
7°	54 mm (2.1 inch)	67 mm (2.6 inch)
9°	47 mm (1.9 inch)	61 mm (2.4 inch)
11°	38 mm (1.5 inch)	52 mm (2.0 inch)
13°	30 mm (1.2 inch)	43 mm (1.7 inch)
15°	19 mm (0.7 inch)	36 mm (1.4 inch)

- (1) (Z-LH Service Engines) 642 mm (25.3 inch).
 (2) The tilt angles in this chart are the engine installation angles for the vessel. A positive angle indicates that the front of the engine is raised.

Table 21

3176C and 3196 Marine Engine Oil Gauge Markings (mm) RH Service ⁽¹⁾		
Tilt Angle ⁽²⁾	RH Service “ADD” Mark Y	RH Service “FULL” Mark X
-15°	25 mm (1.0 inch)	44 mm (1.7 inch)
-13°	37 mm (1.5 inch)	55 mm (2.2 inch)
-11°	48 mm (1.9 inch)	65 mm (2.6 inch)
-9°	57 mm (2.2 inch)	73 mm (2.9 inch)
-7°	65 mm (2.6 inch)	81 mm (3.2 inch)
-5°	72 mm (2.8 inch)	88 mm (3.5 inch)
-3°	79 mm (3.1 inch)	96 mm (3.8 inch)
-1°	86 mm (3.4 inch)	102 mm (4.0 inch)
0°	89 mm (3.5 inch)	106 mm (4.2 inch)
1°	94 mm (3.7 inch)	110 mm (4.3 inch)
3°	101 mm (4.0 inch)	116 mm (4.6 inch)
5°	107 mm (4.2 inch)	122 mm (4.8 inch)
7°	115 mm (4.5 inch)	125 mm (4.9 inch)
9°	121 mm (4.8 inch)	136 mm (5.4 inch)
11°	127 mm (5.0 inch)	140 mm (5.5 inch)
13°	134 mm (5.3 inch)	145 mm (5.7 inch)
15°	135 mm (5.3 inch)	150 mm (5.9 inch)

- (1) (Z-RH Service Engines) 479 mm (18.9 inch).
 (2) The tilt angles in this chart are the engine installation angles for the vessel. A positive angle indicates that the front of the engine is raised.

i04237495

Engine Oil Sample - Obtain

SMCS Code: 1348-554-SM

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

Obtain the Sample and the Analysis



WARNING

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

i04363400

Before you take the oil sample, complete the Label, PEEP5031 for identification of the sample. In order to help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE

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

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEGJ0047, "How To Take A Good S·O·S Oil Sample". Consult your Cat dealer for complete information and assistance in establishing an S·O·S program for your engine.

Engine Oil and Filter - Change

SMCS Code: 1318-510

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

NOTICE

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

Refer to Special Publication, NENG2500, "Cat Dealer Service Tool Catalog" or refer to Special Publication, PECJ0003, "Cat Shop Supplies and Tools Catalog" for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

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. Tighten the oil drain plugs to $70 \pm 14 \text{ N}\cdot\text{m}$ ($50 \pm 10 \text{ lb ft}$).

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 175-7546 Oil Filter Cutter. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

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

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

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

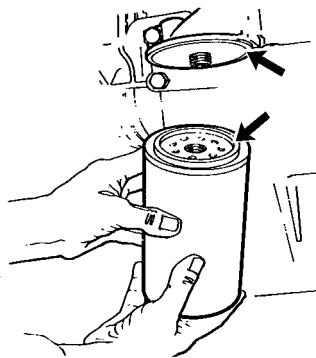


Illustration 46

g00103713

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 this Operation and Maintenance Manual, "Refill Capacities and Recommendations" or to this Operation and Maintenance Manual, "Fluid Recommendations" for more information on lubricant specifications. Fill the crankcase with the proper amount of oil. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" or to this Operation and Maintenance Manual, "Fluid Recommendations" for more information on refill capacities.

NOTICE

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

NOTICE

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

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

i05164102

i04242309

Engine Speed/Timing Sensor - Clean/Inspect

SMCS Code: 1905-040; 1905-070; 1907-040; 1907-070

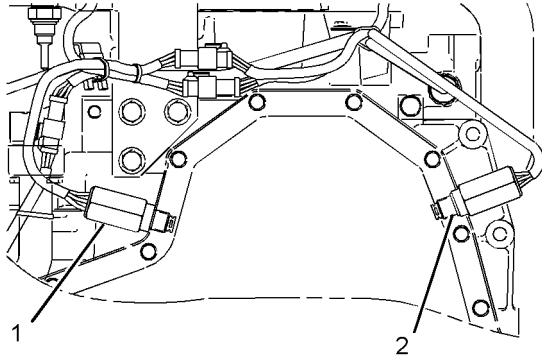


Illustration 47

g03317333

Primary speed/timing sensor (1) and Secondary speed/timing sensor (2)

1. Remove the speed/timing sensors from the front housing. Check the condition of the plastic end of the speed/timing sensors for wear and/or contaminants.
2. Clean the metal shavings and other debris from the face of the speed/timing sensors.
3. Install the sensors.

i02703023

Engine Storage Procedure - Check

SMCS Code: 1000-535

Caterpillar recommends storage procedures and start-up procedures for all engines that are stored for more than 1 month. These procedures provide maximum protection to internal engine components. Refer to Special Instruction, SEHS9031, "Storage Procedure For Caterpillar Products" for information on these procedures.

An extension of the oil change interval to 12 months is permitted if you follow the required procedures for storage and start-up. This extension is permitted if the following intervals in the Operation and Maintenance Manual, "Maintenance Interval Schedule" have not been reached:

- Operating hours
- Fuel consumption

Engine Valve Lash - Check

SMCS Code: 1105-535

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.

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

Note: Only qualified service personnel should perform this maintenance. For procedures on adjusting the valve lash and adjusting the valve bridge, see System Systems Operation/Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust". Consult your Cat dealer for assistance.

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.

i01597115

Engine Valve Rotators - Inspect

SMCS Code: 1109-040

WARNING

When inspecting the valve rotators, protective glasses or face shield and protective clothing must be worn, to help prevent being burned by hot oil or spray.

Engine valve rotators rotate the valves when the engine runs. This helps to prevent deposits from building up on the valves and the valve seats.

Perform the following steps after the engine valve lash is set, but before the valve covers are installed:

1. Start the engine according to Operation and Maintenance Manual, "Engine Starting" (Operation Section) for the procedure.

2. Operate the engine at low idle.
3. Observe the top surface of each valve rotator. The valve rotators should turn slightly when the valves close.

NOTICE

A valve rotator which does not operate properly will accelerate valve face wear and valve seat wear and shorten valve life. If a damaged rotator is not replaced, valve face guttering could result and cause pieces of the valve to fall into the cylinder. This can cause piston and cylinder head damage.

If a valve fails to rotate, consult your Caterpillar dealer.

i00103413

Fuel System - Prime

SMCS Code: 1250-548; 1258-548

⚠ 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.

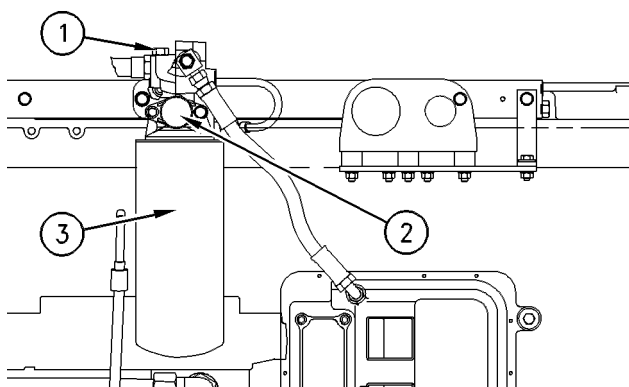


Illustration 48

g00105140

Plug (1), Fuel Priming Pump (2), and Fuel Filter (3)

Priming the fuel system fills the fuel filters. Priming the fuel system also removes air from the fuel system. This procedure is used primarily when the engine runs out of fuel.

Note: DO NOT remove plug (1) in the fuel filter base in order to release air from the fuel system during periodic service of the fuel filter. Periodic removal of the plug will result in increased wear of the threads in the fuel filter base. This can lead to fuel leakage. However, the plug in the fuel filter base can be used to bleed air from the fuel system if the engine runs out of fuel.

1. Open fuel priming pump (2) and operate the fuel priming pump until a strong pressure is felt on the fuel priming pump and until the check valve "clicks". This procedure will require considerable strokes. Lock the fuel priming pump.
2. Crank the engine after pressurizing the system.

NOTICE

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

3. If the engine does not start, open fuel priming pump (2) and repeat Steps 1 and 2 in order to start the engine.

i04938892

Fuel System Primary Filter (Water Separator) Element - Replace

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

Water in the fuel can cause the engine to run rough. Water in the fuel may cause an electronic unit injector 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. If a vacuum gauge is installed, the primary filter/water separator should be changed at 50 to 70 kPa (15 to 20 inches 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.

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

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. Close the main fuel supply valve.

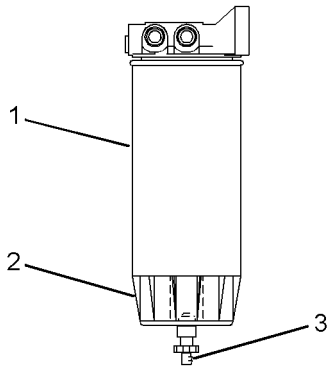


Illustration 49

g01453091

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

2. Remove element (1) from the element mounting base while bowl (2) is attached.
3. Dispose of the contents of the filter. Remove bowl (2) from element (1). The bowl is reusable. Do not discard the bowl. Dispose of the used element.
4. Remove the O-ring from the gland of the bowl. Clean the following components:
 - Bowl
 - O-ring
 - Mounting base

Inspect the O-ring for damage and for deterioration. Replace the O-ring, if necessary.

5. Lubricate the O-ring with clean diesel fuel.
6. Install bowl (2) on a new element. Tighten the bowl by hand. Do not use tools in order to tighten the bowl.

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.

7. Lubricate the top seal of element (1) with clean diesel fuel. Install the new element on the mounting base. Tighten the element by hand.

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.

8. Open the main fuel supply valve.
9. Start the engine and check for leaks. Run the engine for 1 minute. Stop the engine and check for leaks again.

Detecting leaks is difficult 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. Ensure that the components are correctly installed to prevent air from entering the fuel system.

i02927285

Fuel System Primary Filter/Water Separator - Drain

SMCS Code: 1260-543; 1263-543

WARNING

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

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

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

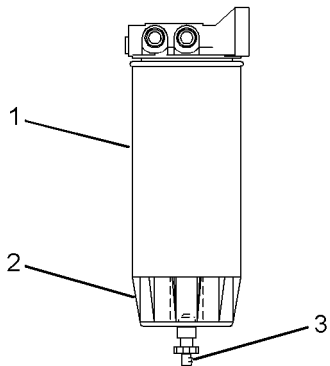


Illustration 50

g01453091

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

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

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

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.

100581566

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.

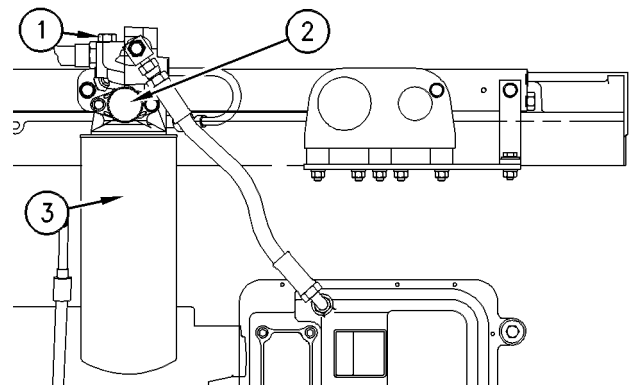


Illustration 51

g00103835

- (1) Plug. (2) Fuel priming pump. (3) Fuel Filter.

1. Stop the engine.
2. Turn off the start switch or disconnect the battery (starting motor) when maintenance is performed on fuel filters.
3. Shut off the fuel tank supply valve to the engine.

NOTICE

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

4. Unlock fuel priming pump (2) in order to relieve residual pressure in the fuel system.
5. Remove used fuel filter (3). Use a cloth or use a container in order to catch excess fuel.
6. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.
7. Apply clean diesel fuel to the new fuel filter gasket.

i05111531

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.

8. Install new fuel filter (3). Tighten the fuel filter until the gasket contacts the base. Tighten the fuel filter by hand according to the instructions that are shown on the fuel filter. Do not overtighten the fuel filter.

Note: DO NOT remove plug (1) in the fuel filter base in order to release air from the fuel system during periodic service of the fuel filter. Periodic removal of the plug will result in increased wear of the threads in the fuel filter base.

9. Operate fuel priming pump (2) until a strong pressure is felt on the fuel priming pump and until the check valve “clicks”. This procedure will require considerable strokes. Lock the fuel priming pump.

10. Open the fuel tank supply valve.

11. Start the engine according to the normal operating procedures. Immediately increase the engine rpm between 1000 to 1200 rpm with no load. The engine will begin to misfire briefly until air from the fuel filter is purged. No damage to the engine will occur.

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.

12. If the engine stalls during the purging of the air, refer to the Operation and Maintenance Manual, “Fuel System - Prime” in the Maintenance Section for more information.

Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

NOTICE

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

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Note: Failure to close the drain can allow air into the system, which could have detrimental results to performance.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine. Drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow 5 to 10 minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This procedure 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 procedure will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A four micron(c) absolute filter for the breather vent on the fuel tank is also recommended.

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.

i05165128

Fumes Disposal Filter Element - Replace

SMCS Code: 1074

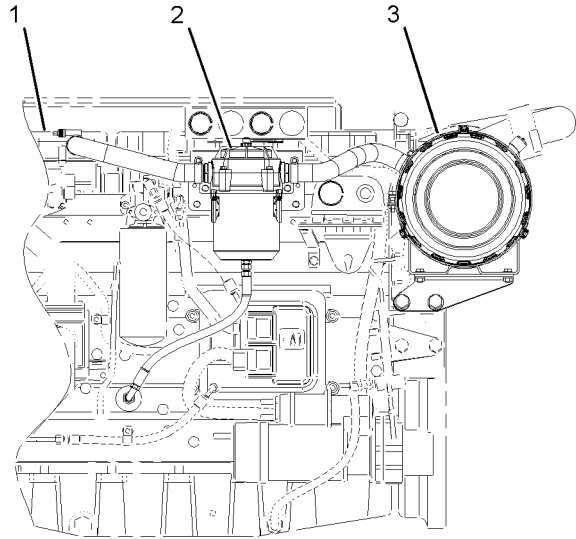


Illustration 52

g03317973

Typical example of the fumes disposal filter

- (1) Crankcase breather
- (2) Fumes disposal filter base and fumes disposal filter
- (3) Air cleaner

The fumes disposal filter requires the replacement of the fumes disposal filter. The service interval of the fumes disposal filter will be affected by the following items:

- Engine load
- Soot concentration
- Condition of the engine

The fumes disposal filter is equipped with a service indicator. If the fumes disposal filter becomes plugged prior to the normal service interval, increased restriction of the filter will cause the vacuum to become positive. When the pressure continues to rise, the service indicator will show through the cap. The service indicator indicates the need for the fumes disposal filter to be changed. Reset the service indicator by using the following procedure:

Resetting the Service Indicator

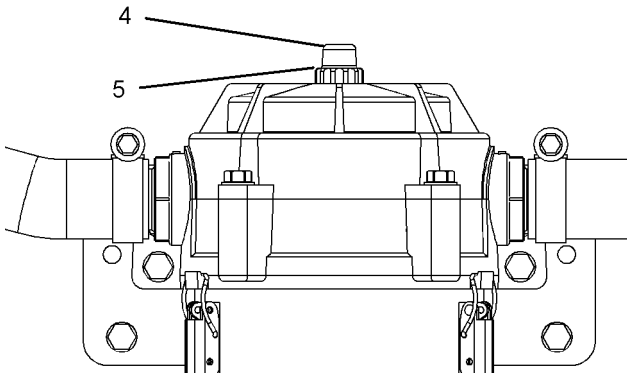


Illustration 53

g03317975

1. Remove the plastic cover (4).
2. Push down on the service indicator (5).
3. Replace the cover (4).
4. Replace the fumes disposal filter by using the following procedure:

Replacing the Fumes Disposal Filter

WARNING

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

Note: When possible, perform the maintenance while the engine is off.

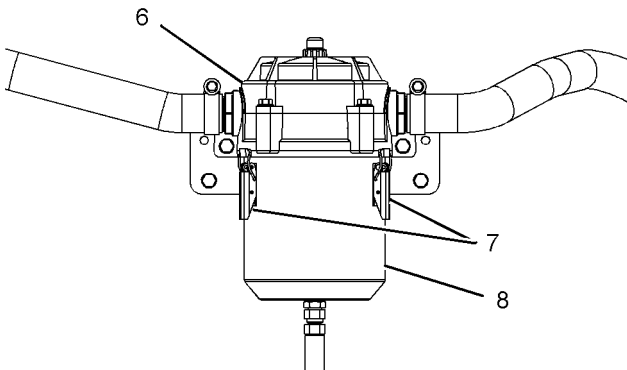


Illustration 54

g03317977

1. Release the latches (7) that hold the canister to the filter base assembly (6).

Note: The canister (8) may be difficult to remove while the engine is operating. The canister has negative air pressure while the engine is operating which creates a vacuum.

2. Lower the canister (8) in order to expose the element. There may be oil in the bottom of the canister. Avoid spilling the oil.
3. Remove the filter element by pulling down. Dispose of the used element properly.
4. Remove the O-ring assembly on the top end cap of the used element.
5. Replace the O-ring seal on the bottom of the filter base assembly.
6. Install the new O-ring on the top end cap of the element. Install the element into the correct place.
7. Replace the canister (8) and align the canister with the boss on the filter base assembly (6).
8. Clamp the latches (7) in the closed position.

i04434870

Fumes Disposal Filter Service Indicator - Check

SMCS Code: 1074-535-IND; 1317-535-IND

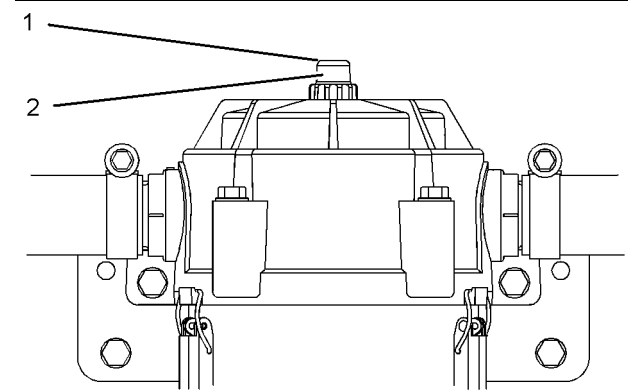


Illustration 55

g01768374

Typical example

- (1) Plastic cover
- (2) Service indicator

The fumes disposal filter is equipped with a service indicator. If the fumes disposal filter becomes plugged, increased restriction of the filter will cause the crankcase pressure to become positive. When the pressure continues to rise, the service indicator will show through the plastic cover. The service indicator indicates the need for the fumes disposal filter to be changed. Refer to the Operation and Maintenance Manual, "Fumes Disposal Filter - Replace" topic for more information.

Note: Check the service indicator when the engine is running at low idle.

i05162232

Heat Exchanger - Inspect

SMCS Code: 1379-040

Note: The maintenance interval for the heat exchanger will vary depending on operating conditions and environment. The maintenance interval should be evaluated at the following intervals:

- At the interval stated in this Operation and Maintenance Manual, "Maintenance Interval Schedule"
- After the first 1000 hours of engine operation.
- At least once every 2 years

The raw/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 the engine in water that contains silt, sediment, salt, algae, or other significant contaminants will have an adverse effect on 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 is required if the engine is overheating.

For information on maintenance of the heat exchanger and cleaning of the heat exchanger, refer to Disassembly and Assembly, "Heat Exchanger - Disassemble".

Your Cat dealer has the equipment and the personnel in order to measure the pressure drop across the heat exchanger.

Consult your Cat dealer for more information.

i04301694

Hoses and Clamps - Inspect/Replace

SMCS Code: 7554-040; 7554-510

Hoses and clamps must be inspected periodically in order to ensure safe operation and continuous operation of the engine. Take proper safety precautions before inspecting or replacing hoses and clamps.

Note: 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. Leaks that are the size of a pin hole are included. Refer to Operation and Maintenance Manual, "General Hazard Information" for more information.

Inspect the Hoses and the Clamps

Inspect all hoses for leaks that are caused by the following conditions. Replace any hose which exhibits any of the following conditions. Failure to replace a hose which exhibits any of the following conditions may result in a hazardous situation.

- Hoses which are cracked
- Hoses which are soft
- 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

- Hoses which exhibit signs of leakage which are not the result of loose couplings or clamps

Inspect all clamps for the following conditions. Replace any clamp which exhibits signs of any of the following conditions.

- Cracking
- Looseness
- Damage

Inspect all couplings for leaks. Replace any coupling which exhibits signs of leaks.

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

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

Replace hoses that are cracked or soft. Replace hoses that show signs of leakage. Replace hoses that show signs of damage. Replace hose clamps that are cracked or damaged. Tighten or replace hose clamps which are loose.

Replace the Hoses and the Clamps

NOTICE

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

Refer to Special Publication, NENG2500, "Cat Dealer Service Tool Catalog" or refer to Special Publication, PECJ0003, "Cat Shop Supplies and Tools Catalog" for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Cooling System

WARNING

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

WARNING

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

Failure to relieve pressure can cause personal injury.

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

1. Stop the engine.
2. Allow the engine to cool.
3. Before servicing a coolant hose, slowly loosen the filler cap for the cooling system in order to relieve any pressure.
4. Remove the filler cap for the cooling system.
5. Drain the coolant from the cooling system to a level that is below the hose that is being replaced. Drain the coolant into a suitable clean container. The coolant can be reused.
6. Remove the hose clamps.
7. Disconnect the old hose.
8. Replace the old hose with a new hose.
9. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, "Torque Specifications", "Hose Clamps" for information about selecting and installing the proper hose clamps.
10. Refill the cooling system.
11. Clean the filler cap for the cooling system. Inspect the gaskets on the filler cap. Replace the filler cap if the gaskets are damaged. Install the filler cap.
12. Start the engine. Inspect the cooling system for leaks.

Fuel System

WARNING

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

Failure to relieve pressure can cause personal injury.

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

WARNING

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

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.

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.

Note: High-pressure fuel lines may be installed between the high-pressure fuel pump and the fuel injectors. High-pressure fuel lines are constantly charged with high pressure. Do not check the high-pressure fuel lines with the engine or the starting motor in operation. Wait for 10 minutes after the engine stops before you perform any service or repair on high-pressure fuel lines. Waiting for 10 minutes will allow the pressure to be purged.

1. Drain the fuel from the fuel system to a level that is below the hose that is being replaced.
2. Remove the hose clamps.
3. Disconnect the old hose.
4. Replace the old hose with a new hose.

5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, "Torque Specifications", "Hose Clamps" for information about selecting and installing the proper hose clamps.

6. Carefully inspect the engine for any spilled fuel. Make sure that no fuel remains on or close to the engine.

Note: Fuel must be added to the fuel system ahead of the fuel filter.

7. Refill the fuel system. Refer to this Operation and Maintenance Manual, "Fuel System - Prime" for information about priming the engine with fuel.

8. Start the engine. Inspect the fuel system for leaks.

Lubrication System

WARNING

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

1. Drain the oil from the lubrication system to a level that is below the hose that is being replaced.
2. Remove the hose clamps.
3. Disconnect the old hose.
4. Replace the old hose with a new hose.
5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, "Torque Specifications", "Hose Clamps" for information about selecting and installing the proper hose clamps.
6. Refill the lubrication system. Refer to this Operation and Maintenance Manual, "Engine Oil Level - Check" in order to ensure that the lubrication system is filled with the proper amount of engine oil.
7. Start the engine. Inspect the lubrication system for leaks.

Air System

1. Remove the hose clamps.
2. Disconnect the old hose.
3. Replace the old hose with a new hose.

4. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, "Torque Specifications", "Hose Clamps" for information about selecting and installing the proper hose clamps.

Note: The bellows and the V-clamps that are used on the bellows should never be reused.

5. Start the engine. Inspect the air lines for leaks.

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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:

- The need for preventive maintenance
- The quality of the fuel that is being used
- The operating conditions
- The 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:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the standards for reusable parts.
- The engine's service life can be extended without the risk of a major catastrophe due to engine failure.
- The best cost/value relationship per hour of extended life can be attained.

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

Cylinder Head Assembly, Cylinder Packs, Oil Pump, and Fuel Transfer Pump

These components should be inspected 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.

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 dealt with in one of the following manners:

- Salvaging
- Repairing
- Replacing

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.

Inspection and/or Replacement

Crankshaft Bearings, Valve Rotators, and Crankshaft Seals

The following components may not last until the second overhaul.

- Thrust bearings
- Main bearings
- Rod bearings

- Valve rotators
- Crankshaft seals

Caterpillar Inc. recommends the installation of new parts at each overhaul period.

Inspect these parts while the engine is disassembled for an overhaul.

Inspect the crankshaft for any of the following conditions:

- Deflection
- Damage to the journals
- Bearing material that has seized to the journals

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the following components:

- Rod bearing
- Main bearings

Note: If the crankshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the crankshaft.

Inspect the camshaft for damage to the journals and to the lobes.

Note: If the camshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the camshaft.

Inspect the following components for signs of wear or for signs of scuffing:

- Camshaft bearings
- Camshaft followers

Caterpillar Inc. recommends replacing the crankshaft vibration damper.

Oil Cooler Core and Aftercooler Core

During an overhaul, Caterpillar Inc. recommends the removal of both the oil cooler core and the aftercooler core. Clean the oil cooler core and the aftercooler core. Then, pressure test both of these cores.

NOTICE

Do not use caustic cleaners to clean the core.

Caustic cleaners can attack the internal metals of the core and cause leakage.

Note: Use this cleaning procedure to clean the oil cooler core and the aftercooler core.

1. Remove the oil cooler core and the aftercooler core.
2. Remove any debris from the oil cooler core and the aftercooler core. To remove debris from the oil cooler core, turn the oil cooler core onto one end. To remove debris from the aftercooler core, turn the aftercooler core upside-down.
3. Flush the oil cooler core and the aftercooler core internally with cleaner in order to loosen foreign substances. This will also help to remove oil from the oil cooler core and the aftercooler core.

Note: Caterpillar Inc. recommends the use of Hydrosolv Liquid Cleaners. Table 22 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 22

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

⁽¹⁾ Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F).

4. Use steam to clean the oil cooler core and the aftercooler core. This removes any remaining residue from the cleaner. Flush the fins of the oil cooler core and the aftercooler core. Remove any other trapped debris.
5. Wash the oil cooler core and the aftercooler core with hot, soapy water. Rinse the oil cooler core and the aftercooler core thoroughly with clean water.

WARNING

Personal injury can result from air pressure.

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

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

6. Dry the oil cooler core and the aftercooler core with compressed air. Direct the air in the reverse direction of the normal flow.
7. Inspect the components in order to ensure cleanliness. The oil cooler core and the aftercooler core should be pressure tested. Repair the oil cooler core and the aftercooler core, if necessary. Install the oil cooler core and the aftercooler core.

For more information about cleaning the cores, consult your Caterpillar dealer.

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 1). 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 2).

S-O-S Coolant Analysis (Level 2)

An S-O-S Coolant Analysis (Level 2) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S-O-S Coolant Analysis (Level 2) provides the following information:

- Complete S-O-S Coolant Analysis (Level 1)
- 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.

For more information about coolant analysis, see your Caterpillar dealer.

i01539769

Starting Motor - Inspect

i00651416

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.

i04237689

Transmission Oil Level - Check

SMCS Code: 3030-535-FLV

Check the marine transmission oil level according to the instructions that are provided by the OEM of the transmission or the OEM of the vessel.

For the lubrication requirements of the transmission, refer to the recommendations on the nameplate or the service information for the transmission.

Marine Transmission Operation, Maintenance, Warranty, and Parts Support

For information on maintenance and operation of the marine transmission, consult your Cat dealer and/or the OEM dealer of the transmission.

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

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

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

4. Use a dial indicator to check the end clearance on the shaft. If the measured end play is greater than the Service Manual specifications, the turbocharger should be repaired or replaced. An end play measurement that is less than the minimum Service Manual specifications could indicate carbon buildup on the turbine wheel. The turbocharger should be disassembled for cleaning and for inspection if the measured end play is less than the minimum Service Manual specifications.
5. Inspect the bore of the turbine housing for corrosion.
6. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.
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 require 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 the cooling lines are tight and ensure that the cooling lines are properly clamped. Check for leaks. Check the condition of all pipes.
- Inspect the water pumps for coolant leaks.

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

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

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.

- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- 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.
- Inspect the ECM to the cylinder head ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges which are cracked and replace any gauges that can not be calibrated.

i03543200

Water Pump - Inspect

SMCS Code: 1361-040

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

A failed water pump might cause severe engine overheating problems that could result in cracks in the cylinder head, a piston seizure or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking of the water pump seals is observed, replace all of the water pump seals. Refer to two articles in the Disassembly and Assembly Manual, "Water Pump - Disassemble and Water Pump - Assemble" for the disassembly and assembly procedure. If it is necessary to remove the water pump, refer to two articles in the Disassembly and Assembly Manual, "Water Pump - Remove and Water Pump - Install".

Inspect the water pump for wear, cracks, pin holes and proper operation. Refer to the Parts Manual for the correct part numbers for your engine or consult your Caterpillar dealer if repair is needed or replacement is needed.

i02456923

Zinc Rods - Inspect/Replace

SMCS Code: 1388-040; 1388-510

Corrosion in sea water circuits can result in premature deterioration of system components, leaks, and possible cooling system contamination. The cause for the premature corrosion may be 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 action of salt water. The reaction of the zinc to the sea water causes the zinc rods to deteriorate. The zinc rods deteriorate instead of engine parts for the cooling system that are more critical. Rapid deterioration of zinc rods may indicate the presence of uncontrolled electrical currents from improperly installed electrical attachments or 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 23 shows the locations of the zinc rods and the quantities of the zinc rod:

Table 23

Locations of the Zinc Rods	
Location	Quantity
Right Heat Exchanger Bonnet	2
Left Heat Exchanger Bonnet	1
Transmission Oil Cooler	2
Fuel Cooler	2

1. Remove the zinc rod.

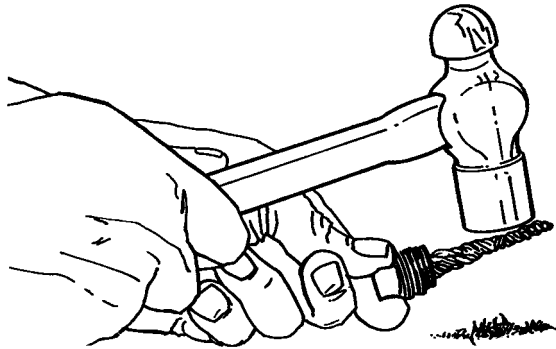


Illustration 56

g00104048

2. Tap the zinc rod lightly with a hammer. If the zinc rod has deteriorated, or if the zinc rod flakes, install a new zinc rod.

Replace the Zinc Rods

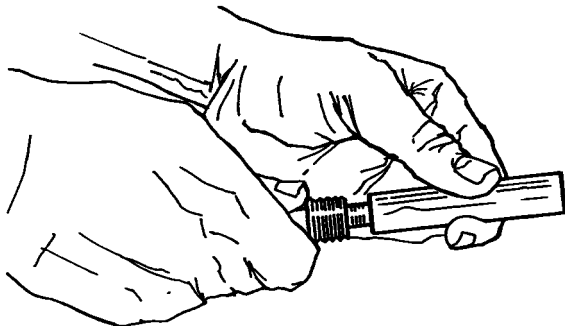


Illustration 57

g00104049

1. Unscrew the old zinc rod or drill the old zinc rod from the plug. Clean the plug.
2. Apply 9S-3263 Compound to the shoulder of a new zinc rod. Apply the compound only to the shoulder of the zinc rod. Install the zinc rod into the plug.
3. Coat the external threads of the plug with 5P-3413 Pipe Sealant. Install the zinc rod. Refer to Special Publication, SENR3130, "Torque Specifications" for more information on torque specifications.

Reference Information Section

i05037211

Engine Ratings

Engine Rating Conditions

i00727327

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

The use of the vessel must be known for the rating to match the operating profile.

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 (Unrestricted Continuous) – Vessels operating at rated load and rated speed up to 100% of the time without interruption or load cycling (80% to 100% load factor). Typical operation is 5000 service hours to 8000 service hours per year. Typical applications may include the following vessels: freighters, tugboats, and bottom drag trawlers.

B (Heavy Duty) – Vessels operating at rated load and speed up to 80% of the time with some load cycling (40% to 80% load factor). Typical operation is from 1000 service hours to 3000 service hours per year. Typical applications may include the following vessels: cold-water trawlers, purse seiners, crew boats, supply boats, ferries, and towboats.

C (Maximum Continuous) – Vessels operating at rated load and rated speed up to 50% of the time with cyclical load and speed (20% to 80% load factor). Typical operation is from 2000 service hours to 4000 service hours per year. Typical applications may include the following vessels: ferries, harbor tugs, fishing boats, offshore service boats, displacement hull yachts, and short trip coastal freighters.

D (Intermittent Duty) – Vessels operating at rated load and rated speed up to 16% of the time (up to 50% load factor). Typical operation is from 1000 service hours to 3000 service hours per year. Typical applications may include the following vessels: offshore patrol boats, customs boats, police boats, fishing boats, fire boats, and harbor tugs.

E (High Performance) – Vessels operating at rated load and speed up to 8% of the time (up to 30% load factor). Typical operation is from 250 service hours to 1000 service hours per year. Typical applications may include the following vessels: pleasure craft, harbor patrol boats, harbor master boats, fishing boats, and patrol boats.

NOTICE

Operating engines above the rating definitions can result in shorter service life before overhaul.

For more information about the engine rating, refer to your Application and Installation Guide or contact your Cat dealer.

i00899220

Marine Classification Society Certification Requirements

SMCS Code: 1000

The major seafaring nations have established technical groups called marine classification societies. Caterpillar Inc. has maintained standards and quality under the guidelines that are set forth by the 14 major marine classification societies that are listed. For more information, refer to Engine Data Sheet, 103.1 and Engine Data Sheet, 103.1.1 in the Caterpillar Technical Manual.

ABS – American Bureau of Shipping (USA)

BV – Bureau Veritas (France)

CCG – Canadian Coast Guard (Canada)

CCRS – China Corporation Register of Shipping (Taiwan)

CCS – China Classification Society (China)

CR – Croatian Register of Shipping (Croatia)

DnV – Det norske Veritas (Norway)

GL – Germanischer Lloyd (Germany)

KR – Korean Register of Shipping (Korea)

LR – Lloyd's Register of Shipping (Great Britain)

NK – Nippon Kaiji Kyokai (Japan)

PR – Polish Register (Poland)

RINa – Registro Italiano Navale (Italy)

RS – Maritime Register of Shipping (Russia)

Engine Performance and Performance Analysis Report (PAR)

i04537530

Engine Performance

SMCS Code: 1000

Today's marine operator is concerned with performance, cost of operation and satisfactory engine life. Traditionally, poor performance of the vessel is believed to result from a lack of engine performance or from a loss of engine performance. In fact, the engine is only one of numerous factors that influence the overall performance of a vessel.

Several factors determine the power demand on an engine. The engine does not have control over the demand that is caused by the vessel design. The vessel design includes the following features:

- Hull
- Propeller
- Drive train

Those features also affect the amount of power that is available to perform additional work. For example, those features affect the power that is used to drive an auxiliary pump.

If a problem with the performance of the vessel occurs, consider the following effects on power demand:

- Loads
- Condition of the vessel
- Vessel design
- Condition of the drive train
- Condition of the propeller

Deterioration of the engine systems decreases the ability of the engine to produce power and vessel speed. Engine systems include the cooling system, the lubrication system, the fuel system, etc. The engine is not likely to be the cause of poor fuel economy without excessive exhaust smoke and/or the loss of power.

If you have a valid problem with the engine's performance, consult an authorized Cat dealer for assistance.

If the engine is covered by a warranty, the Cat 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.

Cat engines are manufactured with state-of-the-art technology. Cat engines are designed to help provide two characteristics in all applications:

- Maximum performance
- Fuel efficiency

To ensure optimum performance for the service life of the engine, follow the recommended operation procedures that are described in this manual. Also, follow the preventive maintenance procedures that are described in this manual.

Performance Analysis Report (PAR)

To verify the condition of the propulsion system, Caterpillar has developed the Performance Analysis Report (PAR) for marine engines.

A PAR is an in-vessel test procedure that is performed by a Caterpillar analyst under operating conditions. The test compares the performance of all marine engine systems to the original testing specifications.

When a PAR is conducted at Sea Trial, an installation of high quality can be ensured. The PAR will confirm the matching of the following components for optimum performance and for fuel efficiency: hull, rudders, propeller, marine transmission, ventilation, and cooling systems.

Caterpillar recommends scheduling a PAR in order to maintain optimum performance.

A periodic PAR can define deterioration of the propulsion system. A PAR can assist in repairs, in overhauls, and in maintenance schedules. This will help to provide the most economical, efficient cost of operation.

Customer Service

i03910803

Customer Assistance

SMCS Code: 1000; 4450

USA and Canada

When a problem arises concerning the operation or 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, use the phone number that is listed below to talk with a Field Service Coordinator:

1-800-447-4986

The normal hours are from 8:00 to 4:30 Monday through Friday Central Standard Time.

3. If your needs have not been met still, submit the matter in writing to the following address:

Caterpillar Inc.
Marine Center of Excellence
Manager, Customer Service
111 Southchase Blvd
Fountain Inn, SC 29644

Please keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

Outside of the USA and of Canada

If a problem arises outside the USA and outside Canada, and if the problem cannot be resolved at the dealer level, consult the appropriate Caterpillar office.

Latin America, Mexico, Caribbean
Caterpillar Americas Co.
701 Waterford Way, Suite 200
Miami, FL 33126-4670
USA
Phone: 305-476-6800
Fax: 305-476-6801

Europe, Africa, and Middle East
Caterpillar Overseas S.A.
76 Route de Frontenex
P.O. Box 6000
CH-1211 Geneva 6
Switzerland
Phone: 22-849-4444
Fax: 22-849-4544

Far East
Caterpillar Asia Pte. Ltd.
7 Tractor Road
Jurong, Singapore 627968
Republic of Singapore
Phone: 65-662-8333
Fax: 65-662-8302

China
Caterpillar China Ltd.
37/F., The Lee Gardens
33 Hysan Avenue
Causeway Bay
G.P.O. Box 3069
Hong Kong
Phone: 852-2848-0333
Fax: 852-2848-0440

Japan
Shin Caterpillar Mitsubishi Ltd.
SBS Tower
10-1, Yoga 4-Chome
Setagaya-Ku, Tokyo 158-8530
Japan
Phone: 81-3-5717-1150
Fax: 81-3-5717-1177

Japan
Caterpillar Power Systems, Inc.
SBS Tower (14th floor)
4-10-1, Yoga
Setagaya-Ku, Tokyo 158-0097
Phone: 81-3-5797-4300
Fax: 81-3-5797-4359

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Phone: 03-9953-9333
Fax: 03-9335-3366

i01028392

Ordering Replacement Parts

SMCS Code: 4450; 7567

WARNING

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

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

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout the world. Caterpillar dealers' parts inventories are up-to-date. The parts stocks include all of the parts that are normally needed to protect your Caterpillar engine investment.

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

If there is a question concerning the part number, please provide your dealer with a complete description of the needed item.

When a Caterpillar engine requires maintenance and/or repair, provide the dealer with all the information that is stamped on the Information Plate. This information is described in this Operation and Maintenance Manual (Product Information Section).

Discuss the problem with the dealer. Inform the dealer about the conditions of the problem and the nature of the problem. Inform the dealer about when the problem occurs. This will help the dealer in troubleshooting the problem and solving the problem faster.

Reference Materials

- Maintenance log

i00912149

Maintenance Records

SMCS Code: 1000; 4450

Caterpillar Inc. recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for a variety of other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is well managed. Accurate maintenance records can help your Caterpillar dealer to fine tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

Fuel Consumption – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

Service Hours – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs
- Owner's receipts

i00576062

Reference Material

SMCS Code: 1000; 4450

The following literature can be obtained through any Caterpillar dealer.

Lubricants

- Special Publication, PEHP6046, "Data Sheet - Caterpillar Diesel Engine Oils (DEO) (CG-4 and CF-4) (North America and selected International)"
- Special Publication, PEHP1026, "Data Sheet - Caterpillar Diesel Engine Oil (DEO) (CF-4) (International only)"
- 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, PECP4025, "One Safe Source"
- Special Publication, SEBD0640, "Oil and Your Engine"
- Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations"
- Special Publication, PEDP1129, "Listen To Your Oil"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"

Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

Coolants

- Special Publication, PEHP4036, "Data Sheet-Caterpillar Coolant"
- Special Publication, PEHP5033, "S·O·S Coolant Analysis"
- Special Publication, PECP4025, "One Safe Source"

- Special Publication, SEBD0518, "Knowing Your Cooling System"
- Special Publication, SEBD0970, "Coolant and Your Engine"

Miscellaneous

- Service Manual, REG1139F, "Service Manual Contents Microfiche"
- Service Manual, RENR1215, "3176C and 3196 Marine Engines"
- Specifications, SENR3130, "Torque Specifications"
- Special Publication, LEDM5615, "Caterpillar Marine Parts and Service Locations Directory"
- Special Publication, LEXM0683, "Pleasure Craft Storage Guide"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"
- Special Publication, SEBF8062, "Guideline for Reusable Parts - Cleaning and Inspection of Air Filters"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Instruction, SEHS8622, "Using the FT-1984 Air-To-Air Aftercooler Leak Test Group"
- Special Instruction, SEHS8742, "Using the 8T-8697 Electronic Control Analyzer Programmer (ECAP)"
- Special Instruction, SEHS7633, "Battery Test Procedure"
- Special Instruction, SEHS7332, "Do Not Operate Tag"

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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: _____

