SEBU7005-14 (en-us)
September 2018

Operation and Maintenance Manual

3406E and C15 Marine Engines

9WR 1-UP (Engine)
RLA 1-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.

⚠ WARNING

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.

⚠ WARNING

When replacement parts are required for this product Caterpillar recommends using Cat replacement parts.

Failure to follow this warning may 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.

Table of Contents

Foreword

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.

WARNING – This product can expose you to chemicals including ethylene glycol, which is known to the State of California to cause birth defects or other reproductive harm. For more information go to:

www.P65Warnings.ca.gov

Do not ingest this chemical. Wash hands after handling to avoid incidental ingestion.

WARNING – This product can expose you to chemicals including lead and lead compounds, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to:

www.P65Warnings.ca.gov

Wash hands after handling components that may contain lead.

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 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 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 various 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.

Safety Section

i04359470

Safety Messages

SMCS Code: 1000; 7405

Type 1

The engine may be equipped with the following safety messages.

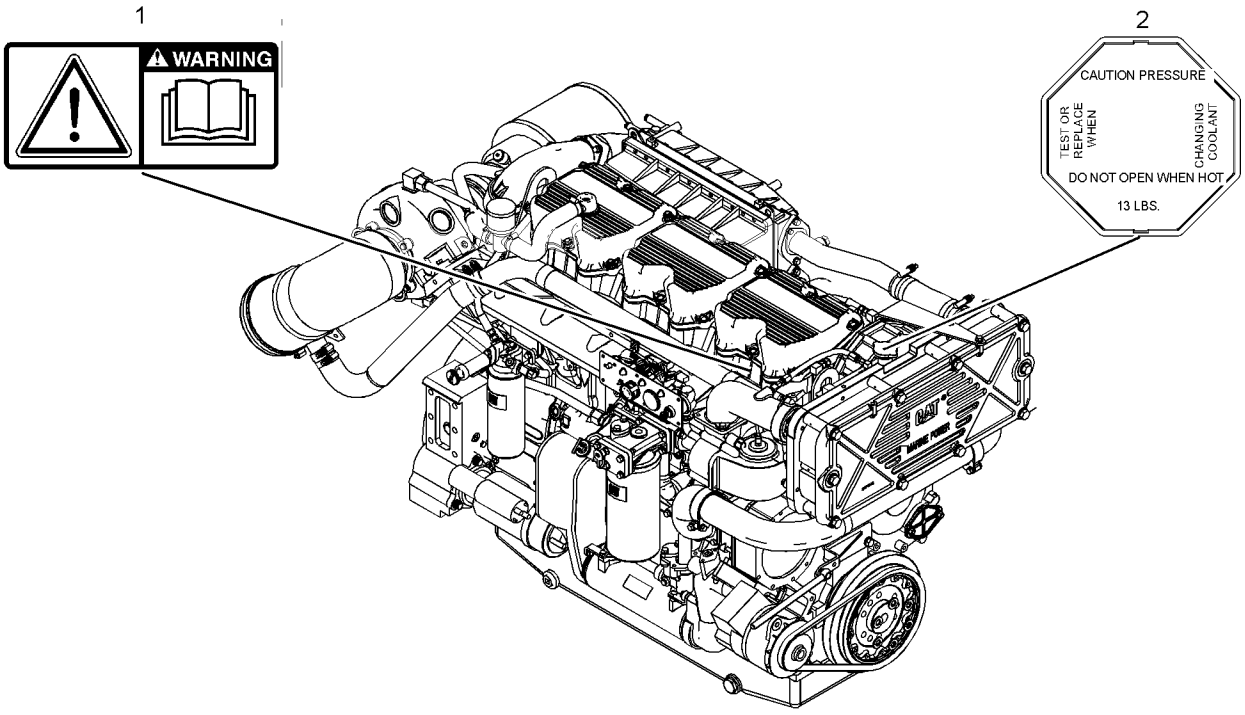

Illustration 1 g01159707

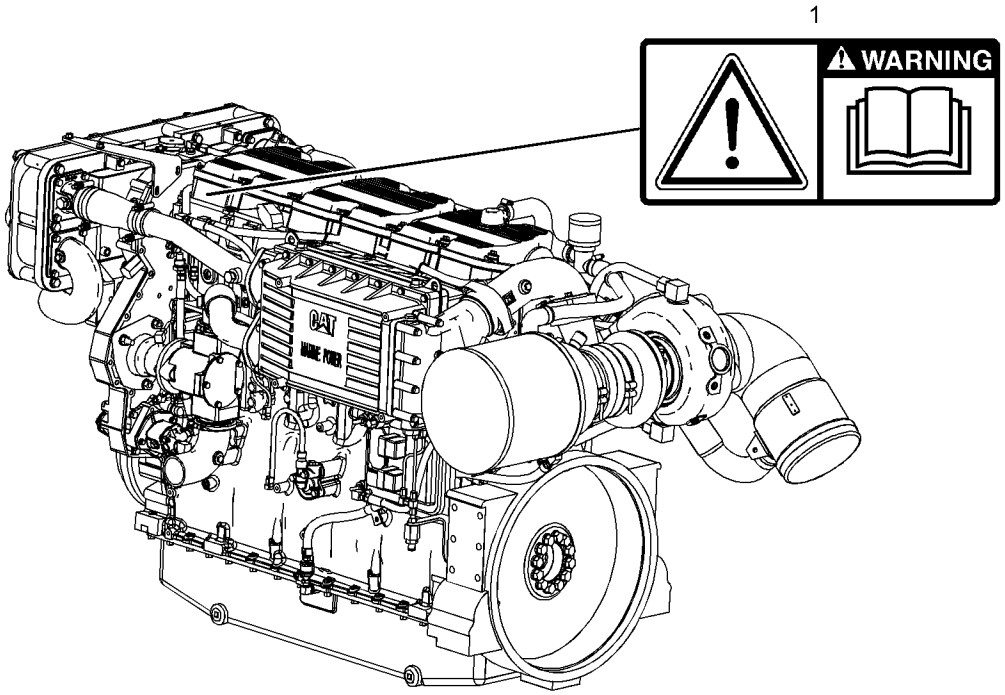

Illustration 2 g01159708

Universal Warning (1)

Illustration 3 g00934493

One safety message is located on the valve cover base in front of the connector for the electronic control module (ECM) on the left side of the engine. One safety message is located on the front valve cover base on the right side of the engine.

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.

Hot Coolant Under Pressure (2)

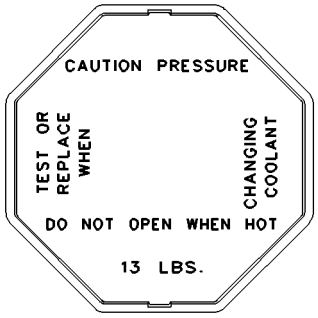

Illustration 4 g00900877

One safety message is located on the cap for the expansion tank.

WARNING

Pressurized system! Hot coolant can cause serious burns, injury or death. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure. Read and understand the Operation and Maintenance Manual before performing any cooling system maintenance.

Type 2

The engine may be equipped with the following safety messages.

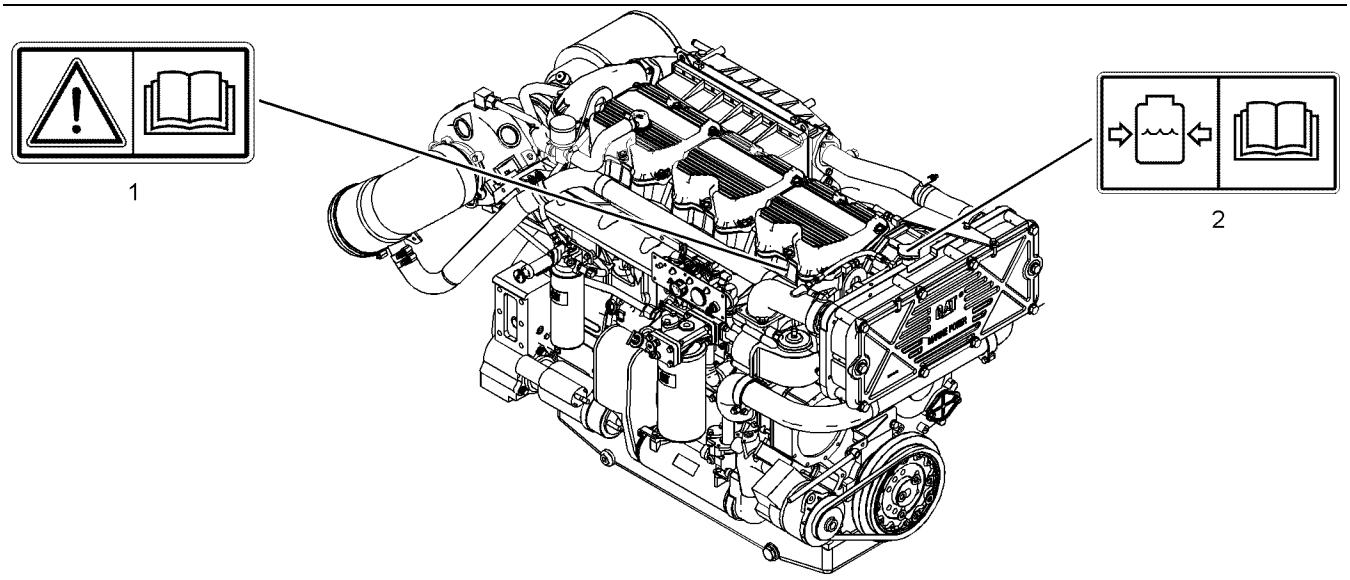

Illustration 5 g02512860

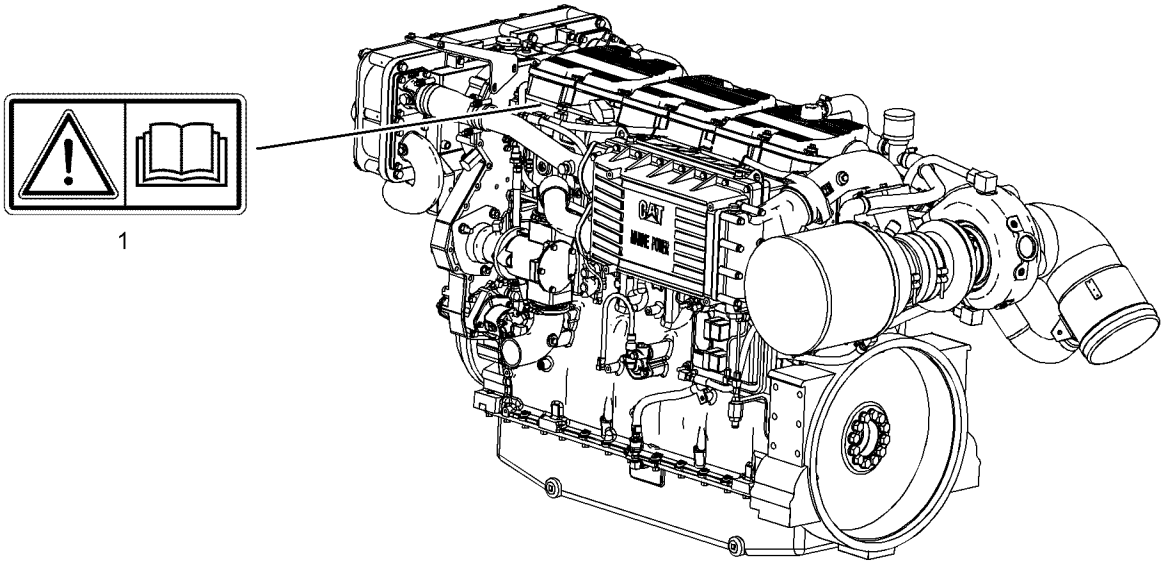

Illustration 6 g02512866

Universal Warning (1)

Illustration 7 g01370904

One safety message is located on the valve cover base in front of the connector for the electronic control module (ECM) on the left side of the engine. One safety message is located on the front valve cover base on the right side of the engine.

⚠ WARNING

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

Hot Coolant Under Pressure (2)

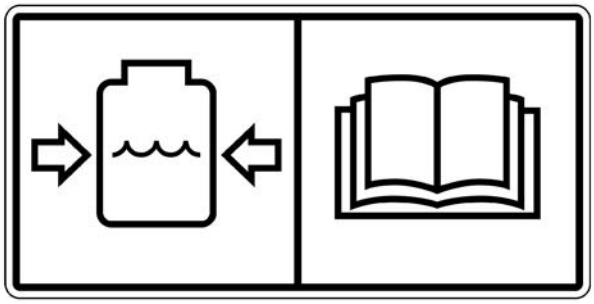

Illustration 8 g01379094

One safety message is located on the heat exchanger.

⚠ WARNING

Pressurized system! Hot coolant can cause serious burns, injury or death. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure. Read and understand the Operation and Maintenance Manual before performing any cooling system maintenance.

i06300340

General Hazard Information

SMCS Code: 1000; 4450; 7405

Illustration 9 g03838041

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.

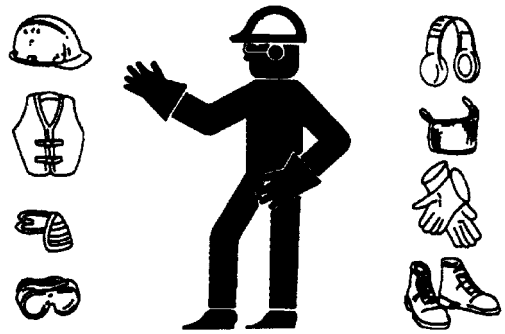

Illustration 10 g00702020

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

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

- The engine is stopped. Ensure that the engine cannot be started.
- 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, make provisions to stop the engine if an overspeed occurs. If an engine 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.

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).

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. Always wear eye protection for cleaning the cooling system.

Avoid direct spraying of water on electrical connectors, connections, and components. When using air for cleaning, allow the machine to cool to reduce the possibility of fine debris igniting when redeposited on hot surfaces.

Fluid Penetration

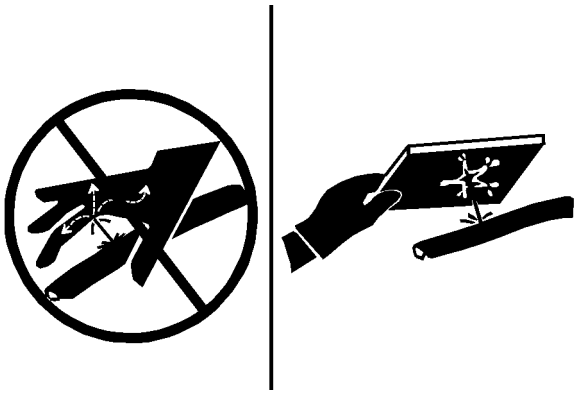

Illustration 11 g00687600

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

Containing Fluid Spillage

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.

Static Electricity Hazard when Fueling with Ultra-low Sulfur Diesel Fuel

The removal of sulfur and other compounds in ultra-low sulfur diesel fuel (ULSD fuel) decreases the conductivity of ULSD and increases the ability of ULSD to store static charge. Refineries may have treated the fuel with a static dissipating additive. Many factors can reduce the effectiveness of the additive over time. Static charges can build up in ULSD fuel while the fuel is flowing through fuel delivery systems. Static electricity discharge when combustible vapors are present could result in a fire or explosion. Ensure that the entire system used to refuel your machine (fuel supply tank, transfer pump, transfer hose, nozzle, and others) is properly grounded and bonded. Consult with your fuel or fuel system supplier to ensure that the delivery system complies with fueling standards for proper grounding and bonding.

⚠ WARNING

Avoid static electricity risk when fueling. Ultra-low sulfur diesel fuel (ULSD fuel) poses a greater static ignition hazard than earlier diesel formulations with a higher sulfur contents. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

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

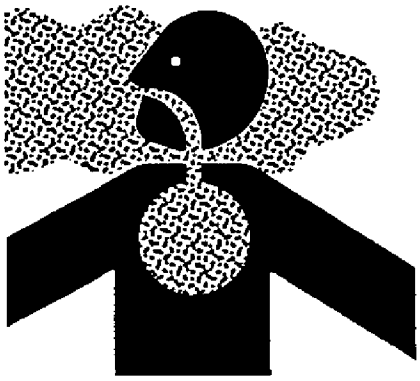

Illustration 12 g02159053

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

Cat 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 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 using part number or the name:

https://catmsds.cat.com/MSDSSearch/servlet/cat.cis.ecs.msdsSearch.controller.UserIdentificationDisplayServlet

Dispose of Waste Properly

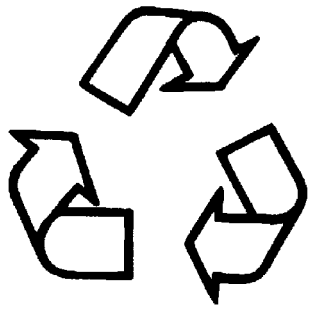

Illustration 13 g00706404

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.

i01480768

Burn Prevention

SMCS Code: 1000; 4450; 7405

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

Coolant

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

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

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

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

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

Oils

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

Batteries

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

i05326156

Fire Prevention and Explosion Prevention

SMCS Code: 1000; 4450; 7405

Illustration 14 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 15 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.

Note: Avoid static electricity risk when fueling. Ultra-low sulfur diesel fuel (ULSD fuel) poses a greater static ignition hazard than earlier diesel formulations with a higher sulfur content. Avoid death or serious injury from fire or explosion. Consult your fuel or fuel system supplier to ensure that the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

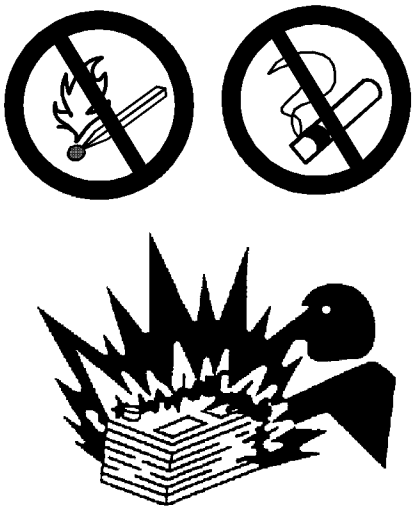

Illustration 16 g02298225

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.

i06948165

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 gases 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 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.

Refer to Application and Installation Guide, LEBM0001-01, “Marine Engine Electronics C7 - C32” for additional information on grounding procedures.

Negative Battery Connection for Multiple Engines

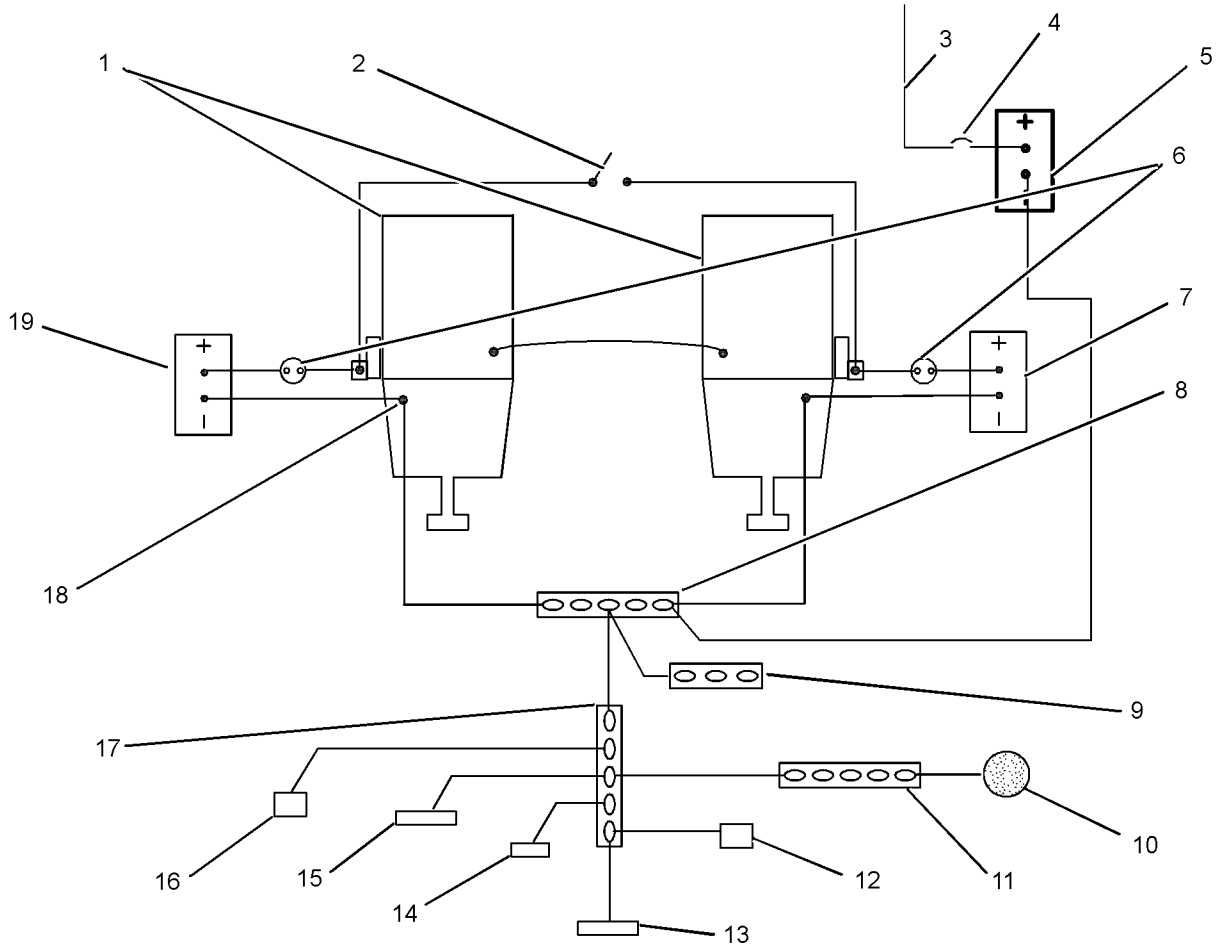

Illustration 17 g03324810

(1) Engines
(2) Parallel switch
(3) Customer miscellaneous vessel loads
(4) Overcurrent protection
(5) Battery
(6) Battery disconnect switches
(7) Battery
(8) Direct current (DC) main negative bus bar
(9) Alternating current (AC) grounding bus bar
(10) Strainer
(11) Cathodic protection bus bar
(12) Lightening protection ground point
(13) Immersed ground plate
(14) Zinc bar
(15) Electronics ground plate
(16) Chain plates
(17) Grounding bus bar
(18) Engine negative terminal
(19) Battery

Install the battery disconnect switches 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

i01406118

Model View Illustrations

SMCS Code: 1000

The following model views show typical 3406E Marine Engine features. Due to individual applications, your engine may appear different from the illustrations.

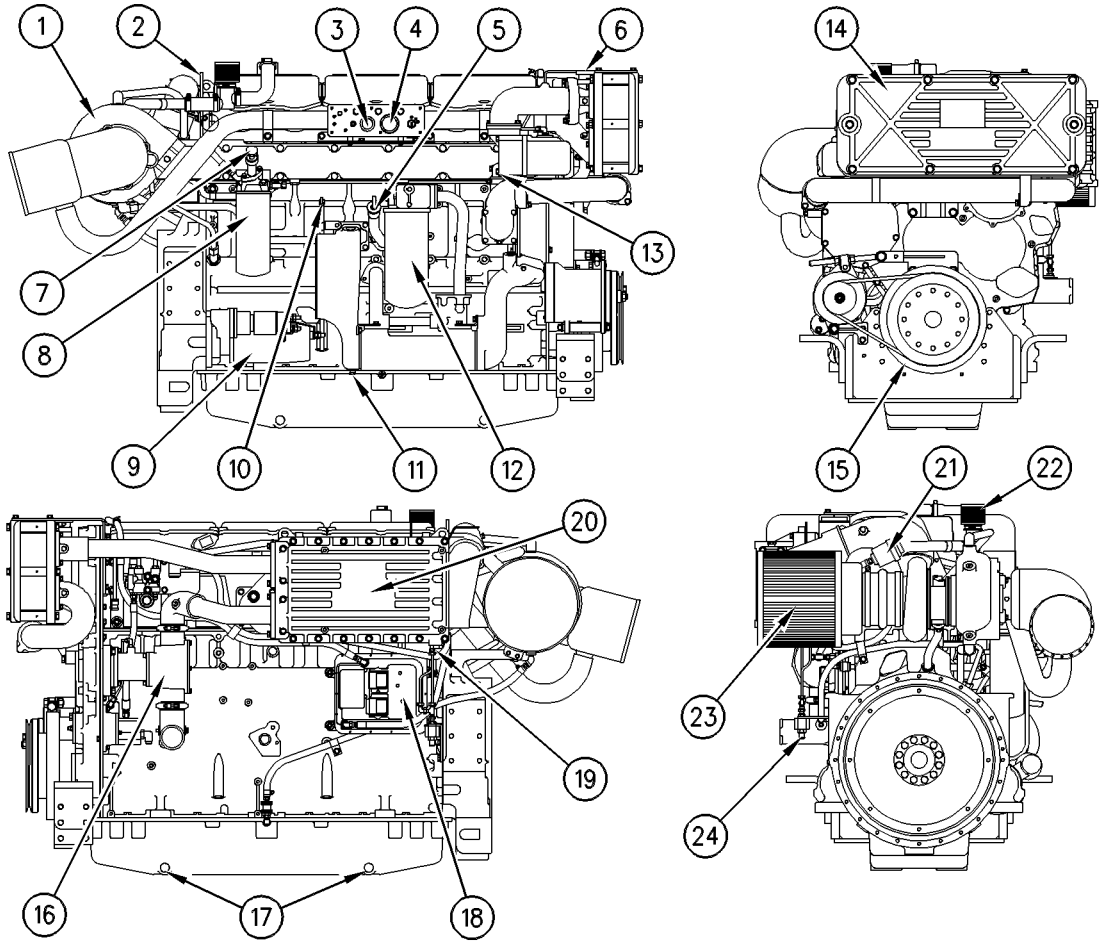

Illustration 18 g00107400

(1) Turbocharger
(2) Lifting eye
(3) Emergency stop button
(4) Service hour meter
(5) Engine oil filler
(6) Expansion tank filler cap
(7) Fuel priming pump
(8) Fuel filter
(9) Starting motor
(10) Engine oil level gauge
(11) Oil cooler drain plug
(12) Engine oil filter
(13) Drain plug for the water temperature regulator
(14) Heat exchanger
(15) Crankshaft vibration damper
(16) Auxiliary water pump
(17) Crankcase oil drain plugs
(18) Electronic control module
(19) Aftercooler drain plug
(20) Aftercooler
(21) Air filter service indicator
(22) Vacuum limiter element
(23) Engine air cleaner element
(24) Aftercooler condensate drain valve

i04359670

Product Description

SMCS Code: 1000; 4450; 4491

The Cat 3406E Marine Engine and the Cat C15 Marine Engine provides 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. This optimizes the engine's performance for starting, emissions, noise, and fuel consumption.

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

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 SCAC water pump
- 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)

Engine Service Life

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

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

Engine Specifications

Table 1

Cat 3406E Marine Engine and the Cat C15 Marine Engine Specifications	
Number of cylinders	6 In-line
Bore	137 mm (5.4 inch)
Stroke	165 mm (6.5 inch)
Compression ratio	14.7:1
Aspiration	Turbocharged/Aftercooled
Displacement	14.6 L (893 cu in)
Firing order	1-5-3-6-2-4
Rotation (viewed from flywheel)	Counterclockwise

Product Identification Information

i04359797

Plate Locations and Film Locations

SMCS Code: 1000; 4450

Serial Number Plate

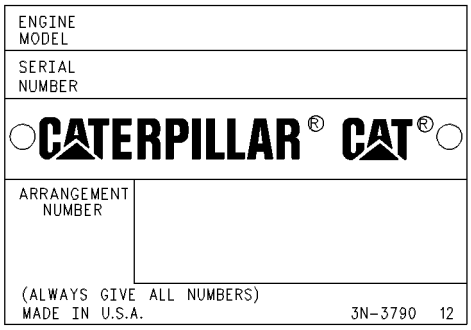

Illustration 19 g00123229

Typical serial number plate

The serial number plate is located on the left side of the cylinder block near the rear of the engine.

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

Engine Information Plate

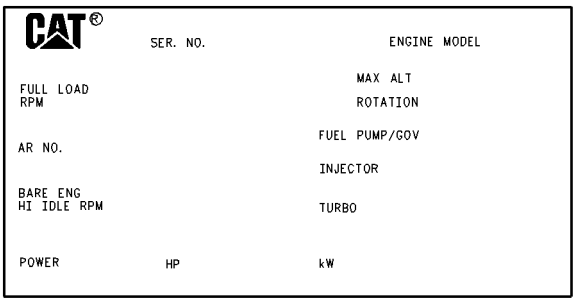

Illustration 20 g00755014

The information plate is on the valve cover.

The following information is stamped on the information plate: maximum altitude of the engine, horsepower, high idle, full load rpm, fuel settings and other information.

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 REQUIERMENTS

Engine Type:		Fuel Type:		Combusion cycle:	
☐	z or sterndrive without integral exhaust	☒	Diesel	☐	2 stroke
☒	Inboard engine	☐	Petrol	☒	4 stroke

Essential requirements	Standards Used	Other normative document used	See technical file
Annex I.B – Exhaust Emissions			
engine identification			☒
exhaust emission requirements	EN ISO 8178-1:1996		
durability	2003/44/EC		☐
owner's manual			☒
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
3406EP2100&2200&2300	32191-05 HH
3406EP1800	31613-05 HH

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 (identification of the person empowered to sign on behalf of the engine manufacturer or his authorised representative)

Signature and title: [redacted] (or an equivalent marking)

Date and place of issue: (yr/month/day) 2005 / December / 05

i04128675

Reference Information

SMCS Code: 1000; 4450

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

Record for Reference

Table 2

System or Component	Information
Chassis serial number	
Engine model	
Engine serial number	
Engine arrangement number	
Modification number	
Engine low idle rpm	
Engine full load rpm	
Performance specification number	
Engine horsepower	
Primary fuel filter part number	
Water separator element part number	
Secondary fuel filter element part number	
Lubrication oil filter element part number	
Auxiliary oil filter element part number	
Supplemental coolant additive maintenance element part number (if equipped)	
Total lubrication system capacity	
Total cooling system capacity	
Engine air cleaner element part number	
Fan drive belt part number	
Alternator belt part 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

i01999213

Product Lifting

SMCS Code: 7000; 7002

Engine Lifting

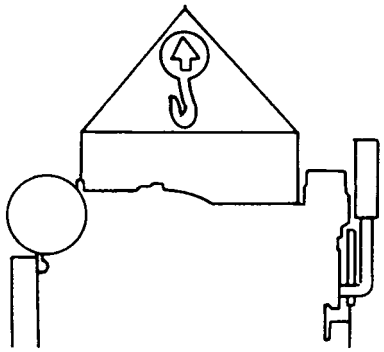

Illustration 22 g00103219

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.

Illustration 23 g01034418

The lifting labels are located on the inside of each lifting eye. These labels designate the proper lifting locations for the engine.

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

Engine and Marine Transmission Lifting

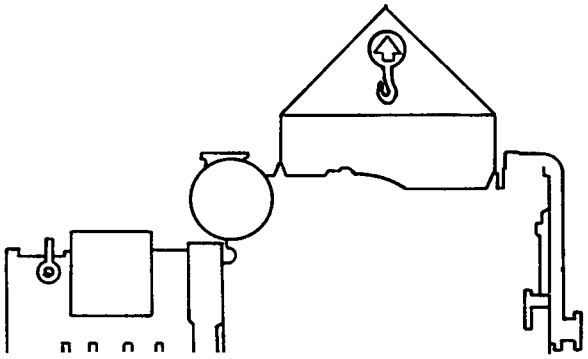

Illustration 24 g00103228

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

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

Marine Transmission Lifting

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

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

i07032177

Product Storage

SMCS Code: 7002

Engine

Storage - Greater than 7 Days and less than 30 Days

Caterpillar recommends maintaining the temperature of the engine to a temperature of at least 5° C (9° F) above ambient temperature to prevent corrosion. The usage of jacket water heaters is an appropriate method.

Storage - Greater than 30 Days and less than 1 Year

Note: If long-term storage for time exceeding 1 year is necessary, contact your local Caterpillar Dealer for the preferred procedure to use in your specific case.

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 (VCI) 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: VCI oil mixture is also to be added to the inlet by removing a plug for checking boost pressure/ temperature at the cylinder head air inlet area. The sprayer should produce a fog to ensure it is drawn into each cylinder. The minimum application rate is 5.5 mL per 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 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 to send clean oil to the secondary filter and the engine.

Open the fuel tank drain valve 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 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 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 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 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 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 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 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 to prevent cavitation of cooling system components. A minimum of 50 percent glycol is verystronglyrecommended.

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 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 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 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 to circulate the oil.

5. Seal all the openings with covers and/or tape.

6. Use a multipurpose grease to coat all 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

i03646563

Battery Disconnect Switch (If Equipped)

SMCS Code: 1411

The battery disconnect switch and the engine start switch perform different functions. Turn off the battery disconnect switch in order to disable the entire electrical system. The battery remains connected to the electrical system when you turn off the engine start switch.

Turn the battery disconnect switch to the OFF position and remove the key when you service the electrical system or any other components.

Also turn the battery disconnect switch to the OFF position and remove the key when the engine will not be used for an extended period of a month or more. This will prevent drainage of the battery.

NOTICE
Never move the battery disconnect switch to the OFF position while the engine is operating. Serious damage to the electrical system could result.

To ensure that no damage to the engine occurs, verify that the engine is fully operational before cranking the engine. Do not crank an engine that is not fully operational.

Perform the following procedure in order to check the battery disconnect switch for proper operation:

1. With the battery disconnect switch in the ON position, verify that electrical components are functioning. Verify that the hour meter is displaying information. Verify that the engine will crank.
2. Turn the battery disconnect switch to the OFF position.
3. Verify that the following items are not functioning: electrical components, hour meter and engine cranking. If any of the items continue to function with the battery disconnect switch in the OFF position, consult your Caterpillar dealer.

i00117669

Cold Start Strategy

SMCS Code: 1450; 1456; 1900

The cold start strategy utilizes the input of the coolant temperature sensor. The cold start strategy helps to provide the following features: quicker cold starts, white smoke cleanup, decreased deep cycling of the battery and extended engine life. When the coolant temperature is below 18°C (64°F), the cold start strategy is activated.

Three Cylinder Cutout

After the engine is started and after the engine reaches 200 rpm, electronic unit injectors 4, 5, and 6 are turned off. The engine continues to run on cylinders 1, 2 and 3 until one of the following conditions is met:

- Coolant temperature reaches 19°C (66°F).
- Desired engine speed exceeds 1200 rpm.
- Cold mode shuts off at five minutes.

i01405936

Control Panel

SMCS Code: 7451

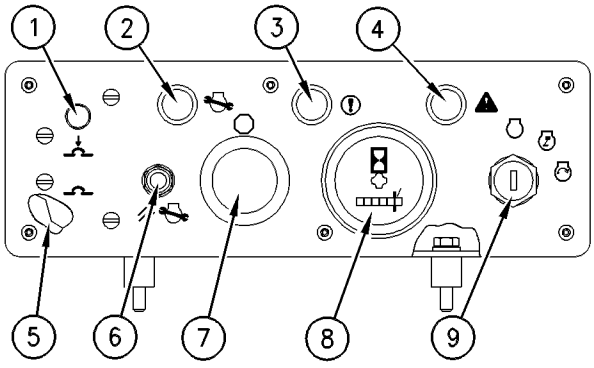

Illustration 25 g00110215

(1) Manual reset button for the circuit breaker
(2) Maintenance indicator lamp
(3) Diagnostic lamp
(4) Warning lamp
(5) Auto circuit breaker reset
(6) Maintenance clear switch
(7) Emergency stop button
(8) Service hour meter
(9) Start switch

The control panel that is listed as standard equipment for the 3406E Marine Engine has the following features:

- Manual reset button for the circuit breaker

- Maintenance indicator lamp
- Diagnostic lamp
- Warning lamp
- Auto circuit breaker reset
- Maintenance clear switch
- Emergency stop button
- Service hour meter
- Start switch

The enclosure is mounted on the service side of the engine in a remote location.

Manual Reset Button for the Circuit Breaker (1) (15 amp breaker) – There are two circuit breaker reset buttons that are located within the control panel: auto circuit breaker reset (3 amp) (5) and manual reset button for the circuit breaker (15 amp). Check the circuit breaker reset button if there is a total loss of electrical power to the engine.

Maintenance Indicator Lamp (2) – This lamp will flash when scheduled maintenance needs to be performed. Refer to the Operation and Maintenance Manual for more information on the proper maintenance intervals.

Diagnostic Lamp (3) – This lamp will flash when a diagnostic code has been generated by the Electronic Control Module (ECM). The active diagnostic code will flash.

Warning Lamp (4) – This lamp will flash when a critical condition has occurred such as low oil pressure or high coolant temperature.

Maintenance Clear Switch (6) – The maintenance clear switch is pushed after the appropriate maintenance is performed. Push the maintenance clear switch in order to clear the maintenance indicator lamp.

Emergency Stop Button (7) – The OUT position is for normal engine operation. Once the emergency stop button is pushed to the IN position, the emergency stop button will be locked. The engine will shut down via a shutdown signal to the ECM. The ECM will remain on. When the emergency stop button is pushed to the IN position, the start switch is locked out. The start switch will not energize the starting motor magnetic switch. Turn the emergency stop button clockwise in order to release and allow start-up.

Service Hour Meter (8) – The service hour meter monitors the service hours of engine. The service hour meter will operate only when the engine is running.

Start Switch (9) – The start switch has three positions: OFF, RUN and START. When the start switch is turned clockwise to the RUN position, the lamps will flash for five seconds during the system test. The lamps will then shut off. In the RUN position, the ECM and electronic systems are powered up.

When the switch is turned to the START position, the starting motor magnetic switch is energized. The electric starting motor is engaged. The starting motor will continue to crank while the start switch is held in the START position. The start switch is spring loaded in order to return to the RUN position when the start switch is released. The engine may be shut down by turning the start switch to the OFF position. This mode of shutdown removes power to the ECM.

i01741580

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).

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.

i04363569

Sensors and Electrical Components

SMCS Code: 1900; 7400

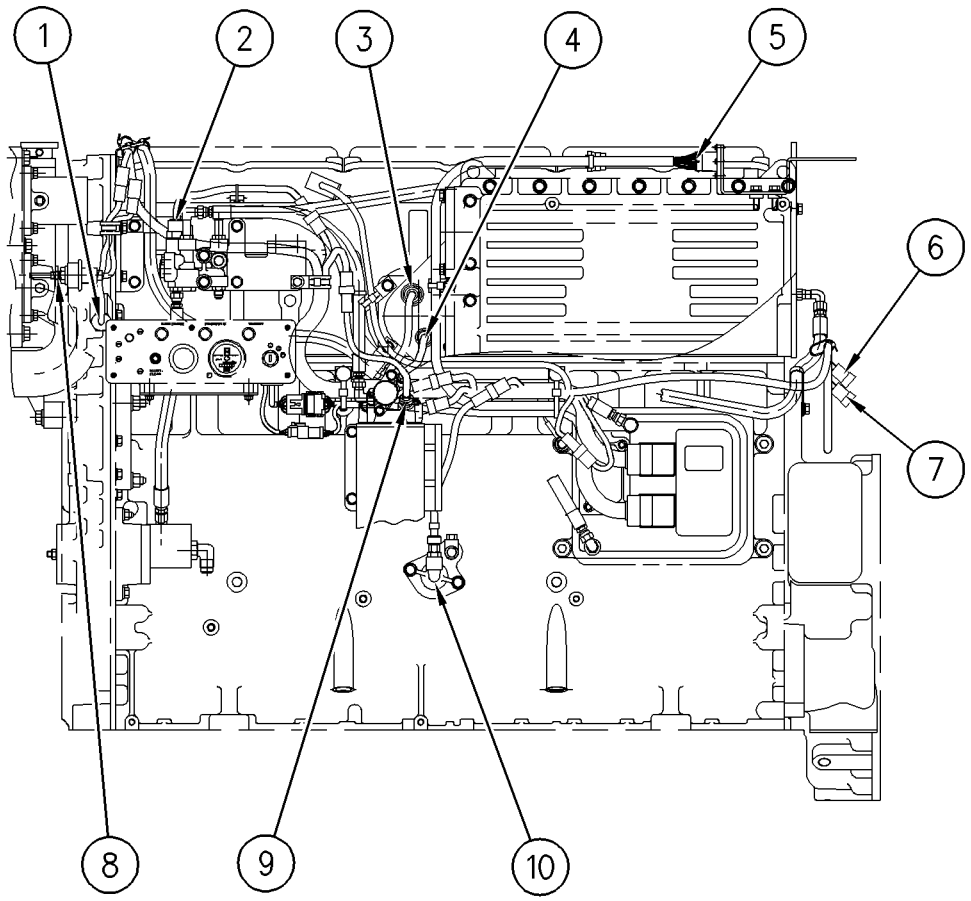

Illustration 26 g00739609

Left side view

(1) Primary speed/timing sensor
(2) Fuel temperature sensor
(3) Inlet air temperature sensor (If Equipped)
(4) Inlet manifold pressure sensor
(5) Customer connector
(6) Marine transmission temperature sensor

(7) Marine transmission oil pressure sensor
(8) Coolant level sensor
(9) Fuel pressure sensor
(10) Atmospheric pressure sensor (If Equipped)

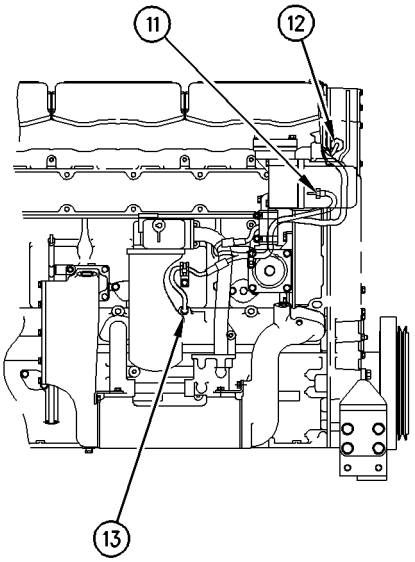

Illustration 27 g00739611

Right side view

(11) Coolant temperature sensor
(12) Secondary speed/timing sensor
(13) Engine oil pressure sensor

Your engine may be equipped with various optional engine features and controls that are not pictured here. This section discusses the general information about various features and the engine control systems.

Coolant Temperature Sensor

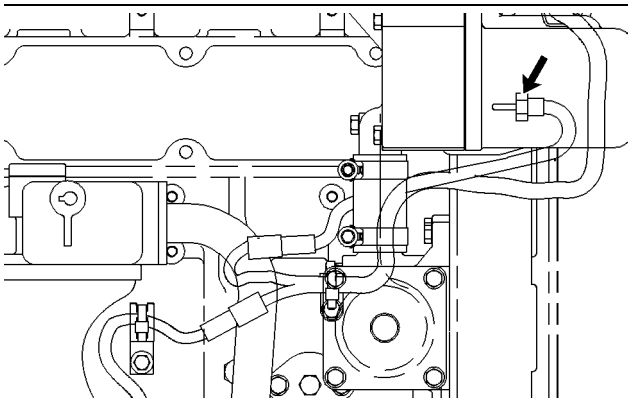

Illustration 28 g00107952

Coolant temperature sensor

This sensor monitors engine coolant temperature. The coolant temperature signal is sent to the Electronic Control Module (ECM) for engine monitoring and for improved engine control. 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 the 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. Strategies that are related to the coolant temperature will be disabled. A failure of the coolant temperature sensor will not cause a shutdown of the engine or any horsepower change.

Coolant Level Sensor

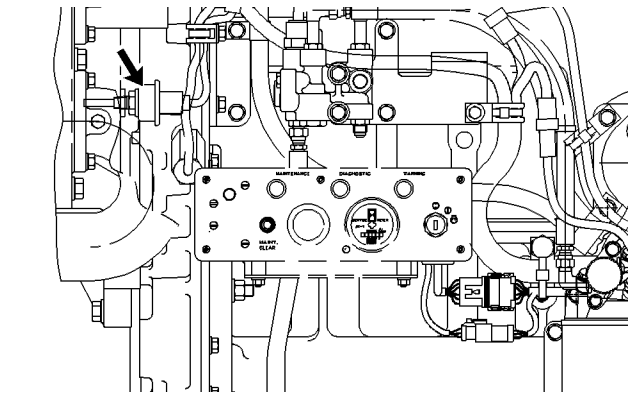

Illustration 29 g00110143

Coolant level sensor

The coolant level sensor monitors the engine coolant level. The coolant level sensor is used to detect a condition when the coolant level is low. The coolant level sensor provides information to the Electronic Control Module (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 this Operation and Maintenance Manual, “Refill Capacities” and this Operation and Maintenance Manual, “Fluid Recommendations” for more information.

Failure of the Coolant Level Sensor

When the output of the coolant level sensor is open, shorted to ground or shorted to supply, a failure of the coolant level sensor may have occurred.

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

Engine Oil Pressure Sensor

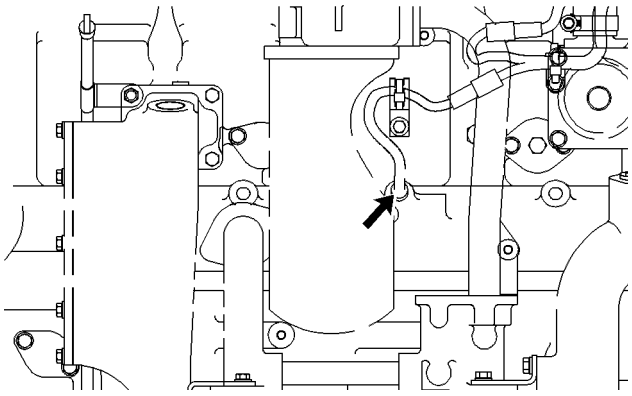

Illustration 30 g00107956

Engine oil pressure sensor

The engine oil pressure sensor 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 the DERATE mode of the engine monitoring system 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:

- Sensor output is open.
- Sensor output is shorted to ground or supply.
- Measured reading of the engine oil pressure is out of the 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. Strategies that are related to engine oil pressure will be disabled.

A failure of the engine oil pressure sensor will not cause a shutdown of the engine or any horsepower change.

Marine Transmission Oil Pressure Sensor

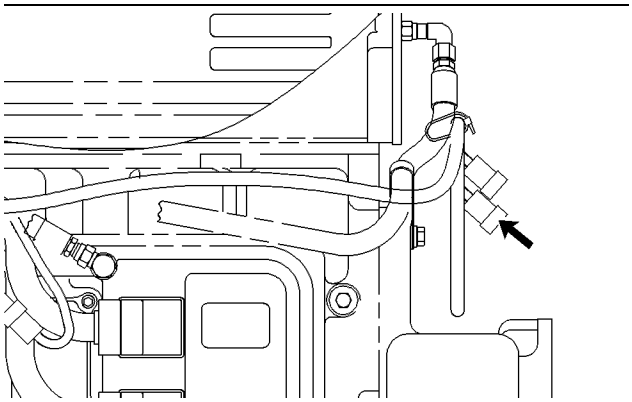

Illustration 31 g00110144

Marine transmission oil pressure sensor

Monitoring the marine transmission oil pressure is a programmable option. The ECM monitors marine transmission oil pressure with a sensor that is located on the high-pressure side of the transmission. High marine transmission oil pressure is detected for diagnostics.

The output from the ECM monitors the marine transmission oil pressure. The maximum allowable marine 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 Sensor

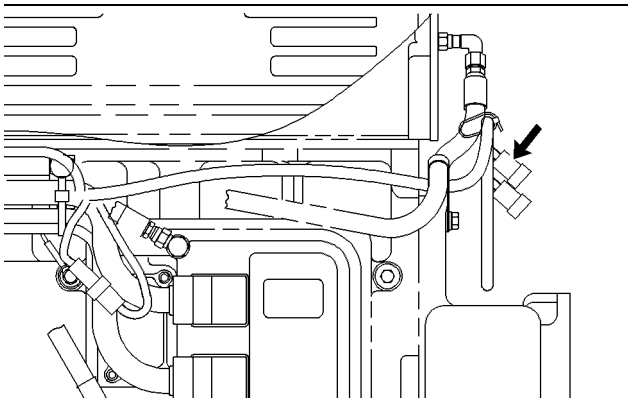

Illustration 32 g00110148

Marine transmission oil temperature sensor

The marine transmission oil temperature sensor measures the temperature of the oil in the marine transmission. The ECM uses the information from the sensor in order to diagnose a fault. The information is also used to warn the operator of excessive marine transmission oil temperature.

The maximum allowable marine transmission oil temperature is 50 to 120°C (122 to 248°F). The ECM will indicate high marine transmission oil temperature through the diagnostic lamp, and the ECM will log a fault.

Throttle Position Sensor

The Throttle Position Sensor (TPS) sends a signal to the ECM. The signal from the TPS is required in order to govern engine speed. The signal from the TPS is used by the ECM in order to calculate the desired engine speed. The TPS is calibrated during the initial installation of the engine.

Failure of the Throttle Position Sensor

An intermittent failure in the TPS causes the engine speed to vary erratically. The ECM will perform the following process:

- The ECM will detect the failure of the TPS.
- The ECM will warn the operator of the failure through the diagnostic lamp.
- The ECM will set the desired engine speed to low idle.

If a TPS fails in a twin engine application, the operator can use a synchronization switch to transfer the throttle control to the second TPS. Both engines can then be controlled with the second throttle. If both throttle position sensors fail, the engine speed will be reduced to low idle.

Fuel Temperature Sensor

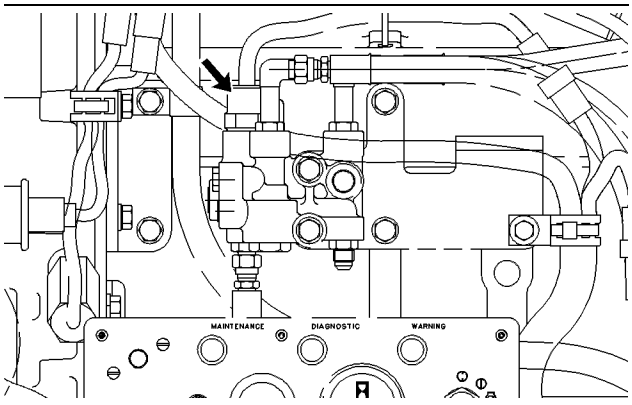

Illustration 33 g00107961

Fuel temperature sensor

The fuel temperature sensor 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.

Fuel Pressure Sensor

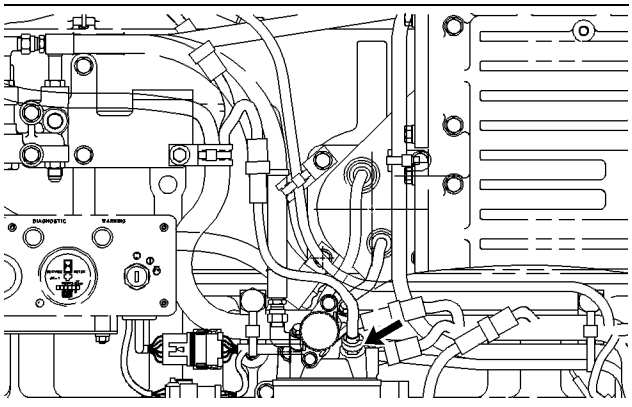

Illustration 34 g00107983

Fuel pressure sensor

The fuel pressure sensor 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.

Inlet Air Temperature Sensor (If Equipped)

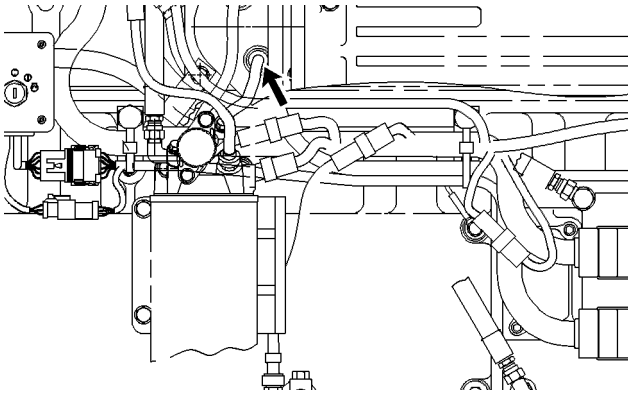

Illustration 35 g00107984

Inlet air temperature sensor

The inlet air temperature sensor detects the temperature of the air that is passing through the inlet manifold. A signal is sent to the Electronic Control Module (ECM) for interpretation. The output of the ECM can indicate high inlet manifold temperature through a relay or a lamp. The inlet air temperature sensor will not cause a shutdown of the engine or any horsepower change.

The ECM uses the information from the inlet air temperature sensor in order to accurately control the emissions levels of the engine. As the inlet manifold air temperature changes, the fuel injection timing is advanced. This is done in order to maintain the exhaust emission standards.

Note: The reading from the inlet air temperature sensor may be significantly higher than the actual temperature of the air inside the inlet manifold until the inlet manifold cools.

Inlet Manifold Pressure Sensor

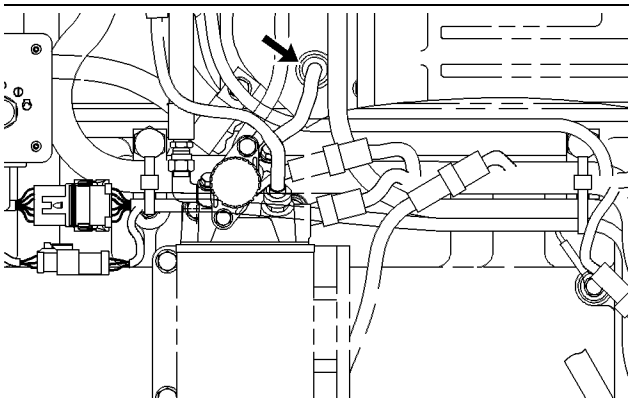

Illustration 36 g00108003

Inlet manifold pressure sensor

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.

If the timing and the duration of the 90 volt signal is controlled, the Electronic Control Module (ECM) can control injection timing and the amount of fuel that is injected.

Note: The inlet manifold pressure sensor is located on the top right side of the engine that is located in front of the inlet manifold temperature sensor.

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

Failure of the Inlet Manifold Pressure Sensor

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

- Sensor output is open.
- Sensor output is shorted to ground or supply.
- Measured reading of the inlet manifold pressure is out of the specification.

The ECM will detect the failure of the inlet manifold pressure sensor. The diagnostic lamp warns the user about the status of the inlet manifold pressure sensor. Strategies that are related to inlet manifold pressure will be disabled.

A failure of the inlet manifold pressure sensor will not cause a shutdown of the engine or any horsepower change.

Atmospheric Pressure Sensor (If Equipped)

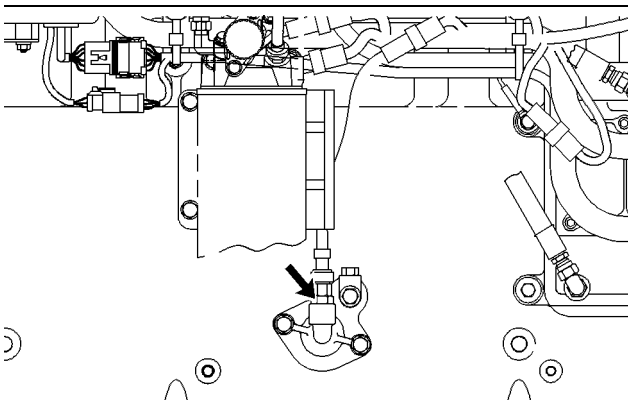

Illustration 37 g00108006

Atmospheric pressure sensor

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

The ECM utilizes the value that is read by the atmospheric pressure sensor for the following functions:

- Reference source for pressure sensor calibrations
- Calculating the operating altitude
- Calculating boost pressure
- Checking for air inlet restriction

When the ECM is powered, all of the pressure sensors that are used for engine monitoring receive an automatic calibration. The ECM uses the value that is received from the atmospheric pressure sensor to calculate the pressure offset value.

The ECM also utilizes atmospheric pressure to determine the active engine derate during high elevation operation. The engine monitoring system compares the current atmospheric pressure value to the programmed derate setpoint. The engine is derated by limiting the fuel delivery at a rate of approximately 3 percent for each 304 m (1000 ft) of elevation.

Actual boost pressure is calculated by the ECM. The difference between the turbocharger outlet pressure and the atmospheric pressure is equal to the actual boost pressure. Boost pressure is used for calculating fuel system adjustments.

Engine Diagnostics

i01563934

Self-Diagnostics

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.

i01463253

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.

i02322154

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 blinks on and off at five second intervals.

   - When the ignition key is in the ON position, the lamp is checked for proper operation. If there are any active codes except for code 34, the codes are displayed at this time.

Note: The “DIAGNOSTIC” lamp will illuminate 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 3 indicates the potential effect on the engine performance with active flash codes. Table 3 also forms a list of electronic diagnostic codes and descriptions.

Table 3

Diagnostic Flash Code or Engine Performance Relationship for 3406E and C15 Marine Engine							
Diagnostic Flash Code		Effect On Engine Performance			Suggested Operator Action		
		Engine Misfire	Low Power	Reduced Engine Speed	Shut down the Engine(1)	Service(2)	Schedule Service(3)
13	Fuel Temperature Sensor Open/Short Circuit(4)						X
17	Battery Voltage Below Normal(4)						X
21	Sensor Supply Voltage Above/Below Normal(4)		X				X
24	Oil Pressure Sensor Open/Short Normal(4)						X
25	Inlet Manifold Air Pressure Sensor Open/Short(5)		X				X
26	Atmospheric Pressure Sensor Open/Short(4)						X
27	Coolant Temperature Sensor Open/Short(4)						X
28	Check Throttle Sensor Adjustments						X
32	Throttle Position Sensor Fault, Inlet Manifold Air Pressure Sensor Calibration			X		X	
34	Loss Of Engine RPM Signal	X		X		X	
35	Engine Overspeed Warning						X
38	Inlet Manifold Air Temperature Sensor Open/Short(4)						X
42	Check Timing Sensor Calibration		X				X
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	Check Customer/System Parameters		X	X			X
59	Incorrect Engine Software	X	X	X			X
61	High Coolant Temperature Warning		X	X		X	
62	Low Coolant Level Warning					X	

(continued)

(Table 3, contd)

Diagnostic Flash Code or Engine Performance Relationship for 3406E and C15 Marine Engine							
Diagnostic Flash Code		Effect On Engine Performance			Suggested Operator Action		
		Engine Misfire	Low Power	Reduced Engine Speed	Shut down the Engine(1)	Service(2)	Schedule Service(3)
64	High Inlet Manifold Air Temperature Warning, Marine Transmission Oil Pressure Open/Short						X
65	High Fuel Temperature Warning						X
67	Marine Transmission Oil Temperature Open/Short						X
72	Cylinder 1 & 2 Fault	X	X			X	
73	Cylinder 3 & 4 Fault	X	X			X	
74	Cylinder 5 & 6 Fault	X	X			X	
81	High Oil Temperature Warning (Marine Transmission)					X	
86	High Oil Pressure Warning (Marine Transmission)					X	

(1) Shut down the Engine: 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.

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

i03840813

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.

i02784364

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. Use Caterpillar electronic service tools to check the active diagnostic codes.

Note: If the customer has selected “DERATE” and if there is a low oil pressure condition, the Electronic Control Module (ECM) will limit the engine power until the problem is corrected. If the oil pressure is within the normal range, the engine may be operated at the rated speed and load. However, maintenance should be performed as soon as possible. Refer to Operation and Maintenance Manual, “Diagnostic Flash Code Retrieval” for more information on flash codes.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the diagnostic lamp will turn off.

i01456915

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.

i03343060

Configuration Parameters

SMCS Code: 1000; 1900; 1901; 1902

Customer specified parameters that will enhance the fuel efficiency and the operator's convenience can be programmed into the Electronic Control Module (ECM). Some parameters may affect engine operation. This may lead to complaints from the operator about power or about performance. The following engine related parameters may be programmed by the customer with Caterpillar electronic service tools in order to customize the operation of the engine 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

Customer Passwords

- First Password _____
- Second Password _____

Identification Number (VIN) _____

Power Rating (hp at rpm) _____

Rating Selection (A-E) _____

Location of Engine (Port or Starboard)

Trolling Speed (Maximum rpm) _____

Air/Fuel Ratio

- Level 1: Minimal Smoke _____
- Level 2: Optimum Performance _____
- Level 3: Maximum Acceleration _____

Warning Set Point

- Transmission Oil Pressure _____
- Transmission Oil Temperature _____

Engine Parameters

- Top Engine Limit (TEL) at 100% load (If Applicable) _____
- High Idle (If Applicable) _____
- Low Idle _____

Engine Monitoring Package

- Warning _____
- Warning/Derate _____
- OFF _____
- 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 Caterpillar dealer.

Engine Starting

i04363611

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.

i01646219

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 Retrival” (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 two 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 Retrival” (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 three 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.

i03640789

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.

i01646248

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

i07509664

Engine Operation
(Hydrocarbon Mitigation)

SMCS Code: 1000

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

The time that is needed for the engine to reach normal operating temperature can be less than the time taken 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.

Hydrocarbon Mitigation

The hydrocarbon mitigation is a feature to protect the DOC against temperatures below 325° C (617° F). Temperatures below this range can damage the aftertreatment of the machine. The initial occurrence displays as a warning and then if temperatures do not increase by the operator or strategy, the machine will go into shutdown. Messages appear sequentially as follows:

- First : Key cycle to warning
- Secondary : Warning to shut down

If the warning messages are not acknowledged, then the shutdown counter begins. Once the engine has shutdown for low exhaust temperatures, the 173-18 Engine Exhaust Manifold #1 Temperature #1: Low - Moderate Severity (2) will return until the engine has successfully reached target temperatures.

Once exhaust temperatures below 325° C (617° F) are observed for an hour, the Hydrocarbon Mitigation feature begins and the following conditions below become active.

Cylinder Cutout Strategy

The cylinder cutout starts at 1000 rpm. The hydrocarbon mitigation monitors the exhaust and intake target temperatures and increases speed if temperatures are not achieved in intervals. The intervals are 20 minutes and with 200 rpm increments. The speed range for the strategy is 1000 rpm to 1800 rpm with a minimum run time of 100 minutes.

Note: This strategy only runs in non-work mode.

The strategy success criteria is based on the following:

- Intake air manifold temperature over 10° C (50° F)
- Exhaust manifold temperature over 325° C (617° F)

If successful, the machine will continue to run indefinitely at the current rpm until taken out of non-work mode.

Exhaust Temperature Low Code Actions

Once the 173-18 Engine Exhaust Manifold #1 Temperature #1: Low - Moderate Severity (2) warning message is shown, there are two actions the can be taken to remove them:

Non-Work Mode

Put the machine in Non-Work mode.

- This will allow Hydrocarbon Mitigation to start automatically and attempt to achieve the target temperatures for the intake and exhaust.
- If the strategy does not achieve target temperatures, the engine will return to low idle for 60 minutes and then Hydrocarbon Mitigation begins.
- If the strategy continues to fail, the next action will need to be taken to clear the codes.

Non-Work Mode Failure

If the machine is being used at the time of the warning message and cannot be put into Non-Work mode, then raise the intake and exhaust temperature for their time thresholds.

- Intake air manifold temperature is greater than 10° C (50° F) for 10 minutes continuously
- Exhaust manifold temperature is greater than 325° C (617° F) for 30 minutes continuously
- Blender - Ideal time to perform this is during the 60 minute low time after a Hydrocarbon Mitigation failure.

Note: Hydrocarbon Mitigation will always start mitigation.

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.

Cold Weather Operation

i05264084

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250; 1280

The following fuels are the grades that are available for Cat 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

i06171418

Emergency Stopping

SMCS Code: 1000; 7418

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

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

Emergency Stop Button (If Equipped)

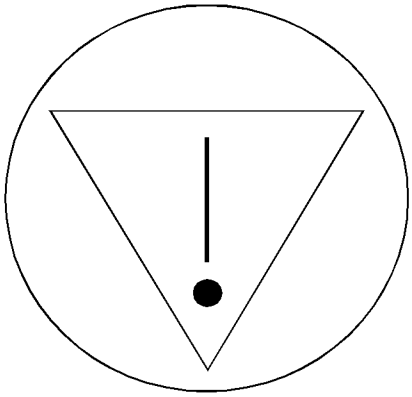

Illustration 38 g03835626

Typical emergency stop symbol located near the 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.

i01057256

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

i04360070

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 one of the following sources for information about the types of fluids for use in the engine:

- Operation and Maintenance Manual, “Lubrication Specifications”
- Operation and Maintenance Manual, “Fluid Recommendations”

Table 4

Refill Capacities (Approximate Amounts)		
Compartment or System	**Liters**	**Quarts**
Engine crankcase (standard sump)	49	(52)
Engine crankcase (deep sump)	68	(72)

Cooling System

Table 5

Refill Capacities (Approximate Amounts)		
Compartment or System	**Liters**	**Quarts**
Engine and expansion tank(1)	45	47

(continued)

(Table 5, contd)

(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.

i04363351

Fluid Recommendations

SMCS Code: 1280; 1348; 1395; 7560

Note: The interval for changing the coolant varies depending on the type of coolant being replaced. Refer to this article, “Coolant Recommendations”, for the intervals for changing the coolant.

Diesel Engine Oil

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

Cat Diesel Engine Oil (Cat DEO)

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

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

Table 6

Cat Lubricants		Viscosity Grade
Diesel Engine Oil-Ultra Low Sulfur	Cat DEO-ULS	SAE 15W-40
		SAE 10W-30
	Cat DEO-ULS SYN	SAE 5W-40
	Cat Cold Weather DEO-ULS	SAE 0W-40
Diesel Engine Oil	Cat DEO	SAE 15W-40
		SAE 10W-30
	Cat DEO SYN	SAE 5W-40

Note: Cat DEO and Cat DEO-ULS multigrade oils are the preferred oils for use in this Cat Diesel Engine.

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 7

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
	Oils of sulfated ash > 1.50 percent are not allowed
Cat ECF-1-a	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 8 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

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

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

Table 8

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	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.

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.

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:

Table 9

TBN recommendations for applications in Cat Engines		
Fuel Sulfur Level percent (ppm)	Cat Engine Oils	TBN of Commercial Engine Oils
≤0.05 percent (≤500 ppm)	Cat DEO-ULS Cat DEO	Min 7
0. 1- 0.05 percent (1000-500 ppm)	Cat DEO-ULS Cat DEO	Min 7
Above 0.1 percent (above 1000 ppm)(1)	Cat DEO(2)	Min 10

(1) For fuels of sulfur levels that exceed 1.0 percent (10,000 ppm), refer to TBN and engine oil guidelines given in this section.
(2) Cat DEO-ULS may be used if an oil analysis program is followed. Base the oil change interval on the analysis.

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.

Diesel engines can burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel fuel. These fuels are not suitable for use in all engine applications. The acceptability of these fuels for use is determined on an individual basis. A complete fuel analysis is required.

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

Diesel Distillate Fuel

Diesel engines may burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace oil, gas oil, or kerosene. These fuels must meet the “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” found in this Special Publication, “Distillate Diesel Fuel” article.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel fuel. **These fuels are not suitable for use in all engine applications.** 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 10

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”
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		

(continued)

(Table 10, contd)

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Pour Point	6 °C (10 °F) minimum below ambient temperature	“D97”	“ISO 3016”
Sulfur	(3)(4)	“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
Sediment	0.05% maximum (weight)	“D473”	“ISO 3735”
Gums and Resins (5)	10 mg per 100 mL maximum	“D381”	“ISO 6246”
Lubricity	0.52 mm (0.0205 inch) maximum at 60 °C (140 °F)	“D6079”	No equivalent test

(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/m^3 (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/m^3, and for the maximum API gravity of 45 is 801.3 kg/m^3.

(3) ULSD 0.0015% (<15 ppm S) is required by law for Tier 4 engines and engines with aftertreatment devices.

(4) 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%.

(5) 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 11 and meets the recommendations in Special Publication, SEBU6251, “Biodiesel”.

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

Table 11

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

Note: A Cat Diesel Engine equipped with air-to-air aftercooling (ATAAC) requires a minimum of 30 percent glycol to help prevent water pump cavitation.

Table 12

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

(continued)

(Table 12, contd)

Coolant Recommendations for use in Cat Diesel Engines			
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 concnetration 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 NO2) 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 NO2) 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 13

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”.

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.

Table 14

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**

(continued)

(Table 14, contd)

Cat DEAC Conventional Heavy-Duty Coolants	Every 250 hours	Yearly(1)
Cat ELC Cat ELI Commercial EC-1 Coolants	Optional	Yearly(1)

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

Note: Check the SCA (Supplemental Coolant Additive) of the conventional coolant at every oil change or at every 250 hours. Perform this check at the interval that occurs first.

S·O·S Services Coolant Analysis (Level 1)

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

The following properties of the coolant are tested:

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

The results are reported, and appropriate recommendations are made.

S·O·S Services Coolant Analysis (Level 2)

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

The S·O·S coolant analysis (Level 2) has the following features:

- Full coolant analysis (Level 1)
- Identification of metal corrosion and of contaminants
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of the possibility of electrolysis within the cooling system of the engine

The results are reported, and appropriate recommendations are made.

For more information on S·O·S coolant analysis, consult your Cat dealer.

Greases

If it is necessary to choose a single grease, always choose a grease that meets or exceeds the requirements of the most demanding application. Remember that the products which barely meet the minimum performance requirements can be expected to barely produce the minimum lives of your parts. False economy is being used if a grease is purchased with the lowest cost as the only consideration. Instead, use the grease that yields the lowest total operating cost. The cost should be based on an analysis that includes the costs of parts, labor, downtime, and the cost of the amount of grease that is required.

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

Maintenance Recommendations

i02909163

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.

i05909227

Welding on Engines with Electronic Controls

SMCS Code: 1000

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

Proper welding procedures are necessary in order to avoid damage to the engine ECM, sensors, and associated components. When possible, remove the component from the unit and then weld the component. If removal of the component is not possible, the correct procedure must be followed. When welding on a unit that is equipped with a Cat Electronic Engine, the following is considered to be the safest procedure:

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

Do not ground the welder across the centerline of the package. Improper grounding could cause damage to the bearings, the crankshaft, the rotor shaft, and other components.

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

Note: Perform the welding in areas that are free from explosive hazards.

1. Stop the engine. Turn the switched power to the OFF position.

2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.

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

4. Disconnect any component with a microprocessor from the engine harness, such as:

- Engine ECM
- Product Link
- Cell/Sat Radio
- DOC Identity Modules

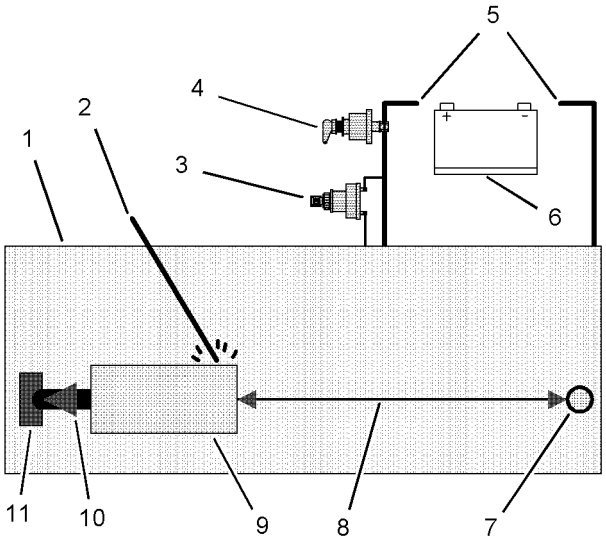

Illustration 39 g01075639

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

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

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

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

6. Protect the wiring harness from welding debris and spatter.

7. Use standard welding practices to weld the materials.

i06146996

Maintenance Interval Schedule (Prime Power)

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 maintenance, including all adjustments, the use of proper lubricants, fluids, filters, and the replacement of components due to normal wear and aging. Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the product and/or accelerated wear of components.

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

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

When Required

Daily

Every 50 Service Hours or Weekly

Initial 500 Hours (for New Systems, Refilled Systems, and Converted Systems)

Every 500 Service Hours

Every Year

Every 6000 Service Hours or 6 Years

First 14 400 L (3750 US gal) of Fuel or 250 Service Hours

Every 14 400 L (3750 US gal) of Fuel or 250 Service Hours or 1 Year

Every 14 400 L (3750 US gal) of Fuel or 250 Service Hours or 1 Year (Shallow Sump)

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

Every 57 000 L (15 000 US gal) of Fuel or 1000 Service Hours

Every 57 000 L (15 000 US gal) of Fuel or 1000 Service Hours or 2 Years

Every 170 400 L (45 000 US gal) of Fuel or 3000 Service Hours

Every 284 000 L (75 000 US gal) of Fuel or 5000 Service Hours

Every 570 000 L (150 000 US gal) of Fuel or 10 000 Service Hours

i01406045

Aftercooler Condensate Drain Valve - Inspect/Clean

SMCS Code: 1063-042-DN

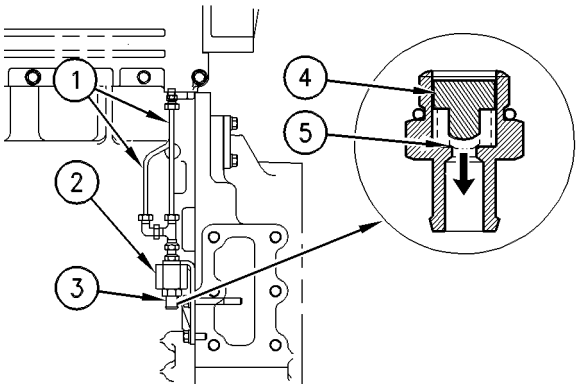

Illustration 40 g00107725

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

The engine 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 Operation and Maintenance Manual for more information on the proper torques.

i04363377

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 15 lists Hydrosolv liquid cleaners that are available from your Cat dealer.

Table 15

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.

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.

i05592931

Aftercooler Core - Replace (Aftercooler Core - Replace)

SMCS Code: 1064-510

An aftercooler that circulates salt water must be replaced more often than an aftercooler that circulates fresh water or treated water. Refer to Disassembly and Assembly, “Aftercooler - Remove” and refer to Disassembly and Assembly, “Aftercooler - Install” for the procedures.

Note:

- Replacing the aftercooler core at a calendar interval is only required for aftercooler cores which circulate salt water.
- Top end overhaul and major overhaul also include replacing an aftercooler core that circulates salt water. Consideration should be given to the calendar and overhaul intervals to avoid unnecessary replacement.
- Actual core life is mostly dependent on engine load factors, water cleanliness, galvanic corrosion, and levels of electrolysis.

i02676048

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.

i06638150

Auxiliary Water Pump (Bronze Impeller) - Inspect

SMCS Code: 1371-040

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

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

Check the following components for wear or damage:

- Bearings

- Impeller
- Seals
- Wear plate

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

i06638162

Auxiliary Water Pump (Rubber Impeller) - Inspect

SMCS Code: 1371-040

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

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

Check the following components for wear or damage:

- Bearings
- Impeller
- Seals
- Wear plate

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

i06738473

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.

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

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. Turn battery isolator switch to OFF position.
4. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the ground plane. Disconnect the cable from the NEGATIVE “-” battery terminal.
5. 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.

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

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

8. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.
9. Connect the cable from the ground plane to the NEGATIVE “-” battery terminal.

i07419560

Battery Electrolyte Level - Check

SMCS Code: 1401-535-FLV

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

In warmer climates, check the electrolyte level more frequently.

Ensure that the electrolyte level is 13 mm (0.5 inch) above the top of the separators.

⚠ 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 the 1U-9921 Battery Service Tool to clean the battery terminals. Use a wire brush to clean 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 fit improperly. Coat the clamps and the terminals with the Loctite® product listed below, petroleum jelly or MPGM.

   - For Americas North - Loctite LB8632
   - For Europe and Africa, Middle East, CIS (AMEC) - Loctite LB8104
   - For Asia Pacific - Loctite LB8801
   - For Americas South - Loctite LB Superlube

   For ordering the products listed above, go to the following address.

   http://www.loctite.com/en/meta/meta-nav/location-selector.html

i06738663

Battery or Battery Cable - Disconnect

SMCS Code: 1401; 1402-029

⚠ WARNING

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

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

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

i02229322

Belts - Inspect/Adjust/Replace

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

Inspection

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

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

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

- Belts
- Pulleys
- Bearings

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

Replacement

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

Alternator Belt Adjustment

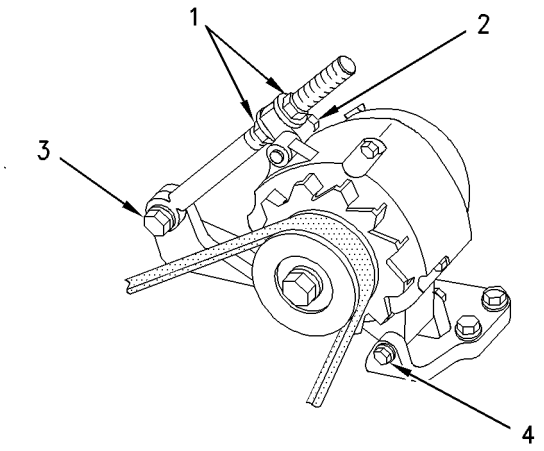

Illustration 41 g00960176

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

1. Remove the drive belt guard.

2. Loosen mounting bolts (2), (3), and (4). Loosen adjusting nuts (1).

3. Turn adjusting nuts (1) in order to increase or decrease the drive belt tension.

4. Tighten adjusting nuts (1). Tighten mounting bolts (2), (3), and (4).

5. Reinstall the drive belt guard.

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

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.

i04862631

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”.

i04360173

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

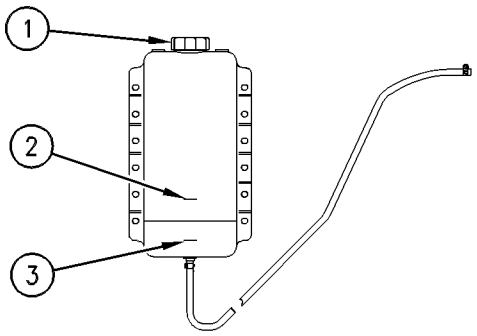

Illustration 42 g00103638

(1) Filler cap
(2) “COLD FULL” mark
(3) “LOW ADD” mark

1. Observe the coolant level in the coolant recovery tank. Maintain the coolant level to “COLD FULL” mark (2) on the coolant recovery tank.

2. Loosen filler cap (1) slowly in order to relieve any pressure. Remove the filler cap.

3. Pour the proper coolant mixture into the tank. Refer to this Operation and Maintenance Manual, “Fluid Recommendations” 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.

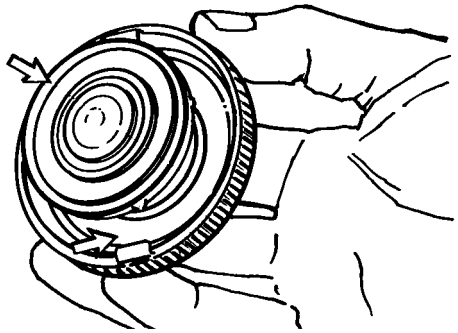

Illustration 43 g00103639
Typical filler cap gaskets

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.

i04333559

Coolant Sample (Level 1) - Obtain

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

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 Systems 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: Obtaining a Coolant Sample (Level 1) is optional if the cooling system is filled with one of the following coolants: Cat ELC (Extended Life Coolant)., Cat ELI (Extended Life Inhibitor) and Conventional Heavy-Duty Coolant.

Note: Obtain a Coolant Sample (Level 1) if the cooling system is filled with any of the following coolants: Cat DEAC, Cat SCA and Conventional Heavy-Duty Coolants.

For additional information about coolant analysis and about other coolants, see this Operation and Maintenance Manual, “Fluid Recommendations” or consult your Cat dealer.

Sampling Conditions

If the engine is equipped with a sampling port, the engine should be running at operating temperature when the sample is obtained.

If the engine is not equipped with a sampling port, the coolant should be warm.

Use the following guidelines for proper sampling of the coolant:

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

Timing of the Sampling

Table 16

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC Cat SCA Conventional Heavy-Duty Coolants	Every 250 hours	Yearly(1)
Cat ELC Cat ELI Commercial EC-1 Coolants	Optional(1)	Yearly(1)

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

Note: Check the SCA (Supplemental Coolant Additive) of the conventional coolant at every oil change or at every 250 hours. Perform this check at the interval that occurs first.

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

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.

Submit the sample for Level 1 analysis.

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

i04638756

Coolant Sample (Level 2) - Obtain

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

An S·O·S Coolant Analysis (Level 2) is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the cooling system. The S·O·S Coolant Analysis (Level 2) has the following features:

- Full coolant analysis (Level 1)
- Identification of metal corrosion and contaminants
- Identification of buildup of the impurities that cause corrosion and scaling
- Determination of the possibility of electrolysis within the cooling system of the engine

The results are reported and appropriate recommendations are made.

Obtaining the Sample

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

Submit the sample for Level 2 analysis.

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

i04240223

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.

i05053052

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

SMCS Code: 1352-045; 1395-081

Note: This maintenance is NOT required for cooling systems that are filled with Extended Life Coolant.

⚠ WARNING

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

NOTICE
Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components.

Excessive supplemental coolant additive concentration could also result in blockage of the heat exchanger, overheating, and/or accelerated wear of the water pump seal.

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

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

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

Dispose of all fluids according to applicable regulations and mandates.

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

Cooling Systems that Use Conventional Coolant

Test the Concentration of the SCA

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

Test the concentration of the SCA with the 4C-9301 Coolant Conditioner Test Kit.

Add the SCA, If Necessary

⚠ WARNING

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

1. Remove the cooling system filler cap slowly.

2. If necessary, drain some coolant in order to allow space for the addition of the SCA.

3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” or refer to this Operation and Maintenance Manual, “Fluid Recommendations”. The proper concentration of SCA depends on the type of coolant that is used. For the proper concentration of SCA, refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations”.

4. Clean the cooling system filler cap. Install the cooling system filler cap.

i06103521

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. The vibrations can damage the crankshaft and 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.

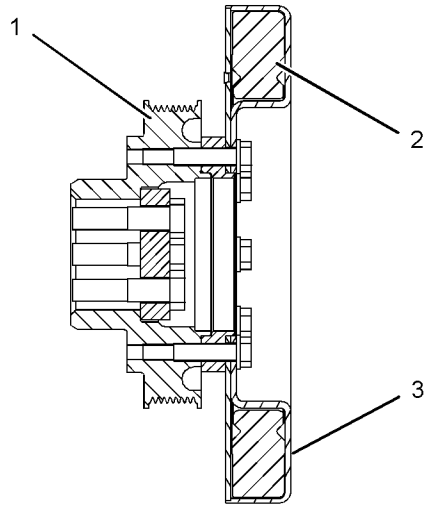

Illustration 44 g01134779

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.
- Extreme wear of the gear train.

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.

i06103535

Engine - Clean

SMCS Code: 1000-070

⚠ WARNING

Personal injury or death can result from high voltage.

Moisture can create paths of electrical conductivity.

Make sure that the electrical system is OFF. Lock out the starting controls and tag the controls “DO NOT OPERATE” .

NOTICE
Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Periodic cleaning of the engine is recommended. Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

Note: Caution must be used in order to prevent electrical components from being damaged by excessive water when you clean the engine. Avoid electrical components such as the alternator, the starter, and the ECM.

i04360176

Engine Air Cleaner Element (Single Element) - Inspect/ Clean/Replace

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

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

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

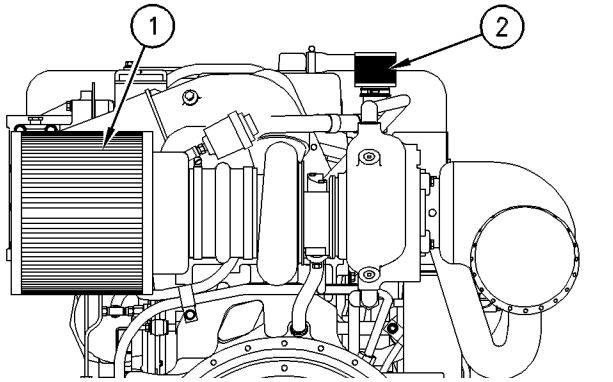

Illustration 45 g00107913

(1) Air cleaner element
(2) Vacuum limiter element

Servicing the Air Cleaner Element

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 element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

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

Note: Use the 102-9720 Cleaning Kit in order to clean the air cleaner element. These products contain the detergent and oil that is made specifically for the maintenance of the air cleaner elements.

1. Remove the air cleaner element. Tap the air cleaner element in order to dislodge dirt particles. Gently brush the air cleaner element with a soft bristle brush.

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

2. Spray the air cleaner element with the cleaning solution. Allow the air cleaner element to stand for 20 minutes.

3. Rinse the air cleaner element with low water pressure. The maximum water pressure for this procedure is 275 kPa (40 psi). Tap water is acceptable. Start to rinse the air cleaner element from the clean side (inside). Next, clean the dirty side (outside) in order to flush out dirt. Inspect the air cleaner element for tears and/or holes after the air cleaner element is cleaned. Do not reuse a damaged air cleaner elements.

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

4. Shake excess water off the air cleaner element and allow the air cleaner element to air dry. Drying the air cleaner element in the sun speeds the process.

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

5. The dry air cleaner element should be oiled before installation. Apply small amounts of oil across the top of each pleat. Allow the oil wick into the air cleaner element for 20 minutes. Oil any remaining “white” spots.

6. Inspect the housing and the clamp for air cleaner element. Replace the housing and the clamp, if necessary. Install the clean, oiled air cleaner element. Refer to Specifications, SENR3130, “Torque Specifications” for more information on the proper torques.

i00641711

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

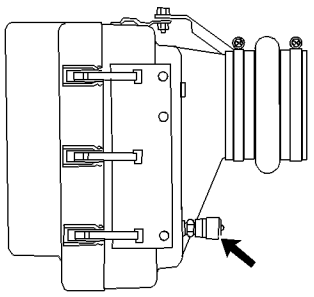

Illustration 46 g00291942
Typical air cleaner service indicator that is mounted on the air cleaner housing

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

Some vessels are equipped with a low air pressure indicator that monitors the inlet air pressure. This indicator measures air pressure before the air is drawn through the air cleaner element. Then, the indicator monitors the pressure level after the air has passed through the air cleaner element. As the air cleaner element becomes dirty, this air cleaner pressure differential rises.

Some vessels may be equipped with a different air cleaner indicator.

If your vessel is equipped with a different type of air cleaner indicator, follow the recommendations for the vessel. You can also follow the recommendations in the air cleaner OEM in order to service the air cleaner element.

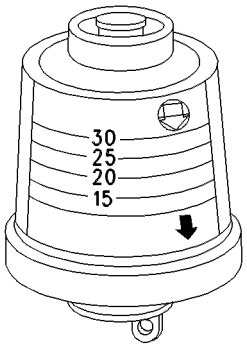

Illustration 47 g00103777

Typical Air Cleaner Service Indicator

Observe the air cleaner service indicator. You should clean the air cleaner element, or you should replace the air cleaner element under two conditions:

- The yellow diaphragm enters the red zone.
- The service indicator displays the red color at any time.
- The red piston locks in the visible position.

Test the Air Cleaner Service Indicator

Air cleaner service indicators are important, inexpensive instruments. Two methods can be used to test the service indicator.

- 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 at the approximate greatest vacuum that is attained.

The air cleaner service indicator should be replaced under certain conditions and at certain times:

- The service indicator does not reset easily.
- The yellow core does not latch at the greatest vacuum.
- The engine is used for a year.
- The engine is overhauled.
- Major engine components are replaced.

Note: Replace the air cleaner service indicator often whenever you operate in a severely dusty environment.

If the new service indicator will not reset, the hole for the service indicator may be plugged.

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 Service Indicator

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

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

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 for this unit. Consult your Caterpillar dealer for the correct air cleaner element.

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

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

i02456872

Engine Mounts - Inspect

SMCS Code: 1152; 1152-040

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

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

Any engine mount that shows deterioration should be replaced. Refer to Special Publication, SENR3130, “Torque Specifications” for the recommended torques. Refer to the OEM recommendations for more information.

i01406091

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

Check the oil level after the engine has stopped.

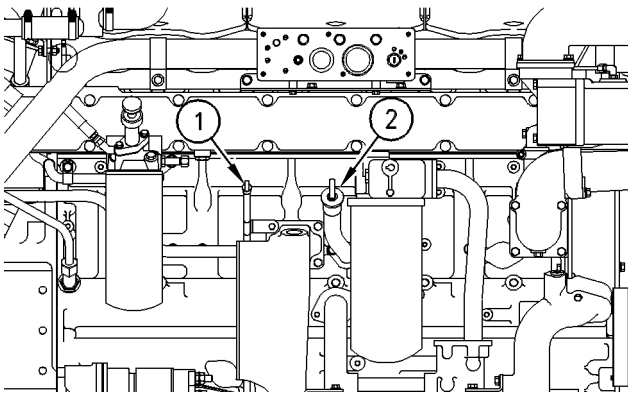

Illustration 48 g00107788

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

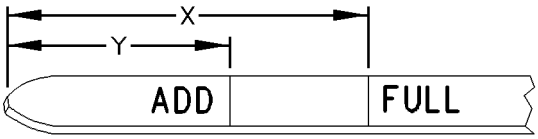

Illustration 49 g00110310

Oil level gauge

(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.

i04363389

Engine Oil Level Gauge - Calibrate

SMCS Code: 1326-524; 1326

The engine is shipped with an engine oil level gauge that is not marked. The engine oil level gauge is not marked because the following features can be different for each engine:

- Angle of the installation
- Side for service

The same two features will affect “ADD” mark (Y) and “FULL” mark (X) that is engraved on the engine oil level gauge.

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

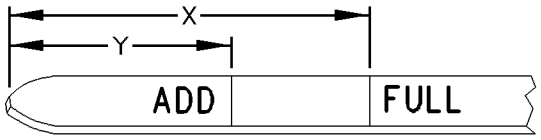

Illustration 50 g00110310

Oil Level Gauge “ADD” mark (Y) and “FULL” mark (X)

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 until the oil pan is completely drained.

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. The extra filters require more engine oil than the standard amounts. Refer to the OEM specifications.

3. Add the recommended oil grade and weight of engine oil to the crankcase:

Standard Sump . . . . . 45.4 L ((48 qt))

Deep Sump . . . . . .64 L ((68 qt))

4. Start the engine. Ensure that the lubrication system and the new engine oil filter are filled. Inspect the lubrication system for leaks.

5. Stop the engine and allow the engine oil to drain into the engine crankcase for approximately five minutes.

6. Check the engine oil level. Use a marking pen in order to engrave “ADD” mark (Y).

7. Add 3.8 liter (4 qt) of the recommended oil grade and weight of engine oil to the crankcase. Full volume will now be 49.2 L (52 qt) for the standard sump, or 68.1 L (72 qt) for the deep sump. Allow the engine oil to drain into the engine crankcase for approximately five minutes.

8. Check the engine oil level. Use a marking pen in order to engrave “FULL” mark (X).

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.

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.

i04363400

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 ± 14 N·m (50 ± 10 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 51 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.

i04360196

Engine Speed/Timing Sensor - Clean/Inspect

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Refer to Special Publication, NENG2500, “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.

Camshaft Speed/Timing Sensor

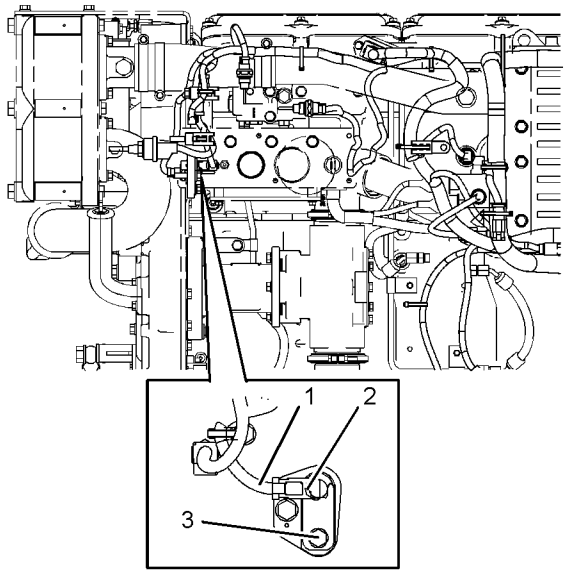

Illustration 52 g01171816

(1) Harness assembly
(2) Sensor
(3) Bolt

Removal Procedure

1. Disconnect the harness assembly.

2. Remove the bolt and the sensor.

3. Remove the O-ring seal from the sensor.

Procedure for Cleaning and Inspecting

Check the condition of the plastic end of the sensor for wear and for contaminants. Clean the metal shavings and other debris from the face of the sensor.

Installation Procedure

1. Install a new O-ring seal on the sensor. Lubricate the O-ring seal with clean engine oil.

2. Position the sensor in the housing and install the bolt.

3. Connect the harness assembly.

Crankshaft Speed/Timing Sensor

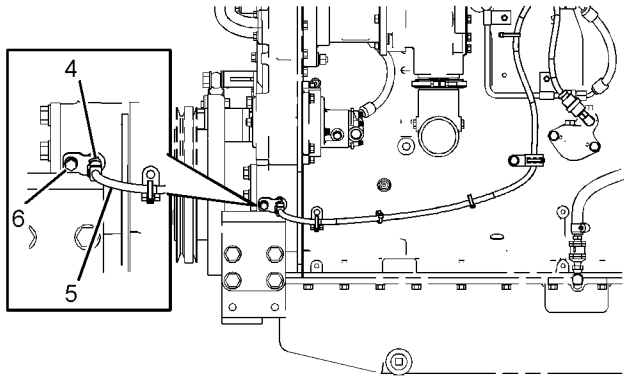

Illustration 53 g01894553

(4) Sensor
(5) Harness assembly
(6) O-ring

Removal Procedure

1. Disconnect the harness assembly.

2. Remove the bolt and the sensor.

3. Remove the O-ring seal from the sensor.

Procedure for Cleaning and Inspecting

Check the condition of the plastic end of the sensor for wear and for contaminants. Clean the metal shavings and other debris from the face of the sensor.

Installation Procedure

1. Install a new O-ring seal on the sensor. Lubricate the O-ring seal with clean engine oil.

2. Install the position sensor in the front housing and install the bolt.

3. Connect the harness assembly.

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

i07139300

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 Systems Operation/Testing and Adjusting, “Engine Valve Lash - Inspect/Adjust”. Consult your Cat dealer for assistance.

Note: For information on adjusting the unit injector refer to Testing and Adjusting, RENR1232, Unit Injector Adjustment.

⚠ WARNING

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

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

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.

i04191470

Fuel Injector - Check

SMCS Code: 1290-535

WARNING

Be sure the engine cannot be started while this maintenance is being performed. To prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting the unit injectors.

The electronic unit injectors use high voltage. Disconnect the unit injector enable circuit connector in order to prevent personal injury. Do not come in contact with the injector terminals while the engine is running.

The operation of Cat engines with improper adjustments of the electronic unit injector can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

Only qualified service personnel should perform this maintenance. Refer to the following topics for your engine for the correct procedure: Refer to the Systems Operation, Testing and Adjusting, “Electronic Unit Injector - Test” for the test procedure, and Systems Operation, Testing and Adjusting, “Electronic Unit Injector - Adjust” for the correct procedure for adjusting the injectors.

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

i01406690

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.

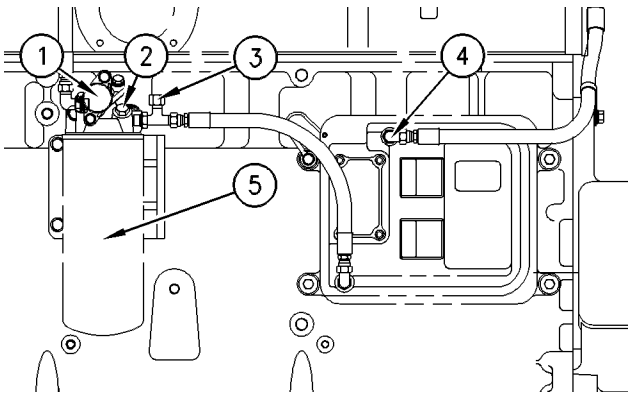

Illustration 54 g00107947

(1) Fuel priming pump
(2) Fuel filter plug
(3) Connector cap
(4) Fuel outlet line on the ECM
(5) Fuel filter

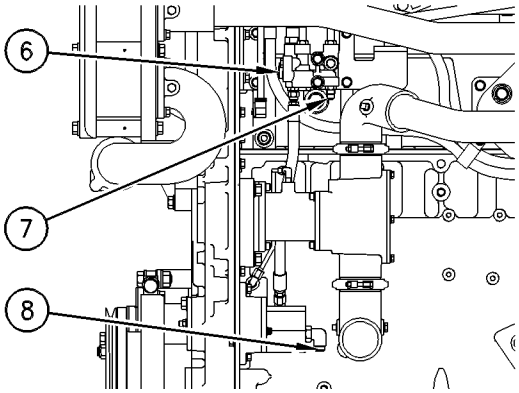

Illustration 55 g00110065

(6) Air purge plug for the fuel system
(7) Fuel return
(8) Fuel inlet

Priming the fuel system fills the dry 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. This procedure can also be used when a unit injector is replaced or the Electronic Control Module (ECM) is replaced.

Note: During any periodic service of the fuel filter, DO NOT remove fuel filter plug (2) in the fuel filter base in order to release air from the fuel system. Periodic removal of this fuel filter plug (2) will result in the increased wear on the threads in the fuel filter base. This can lead to fuel leakage. However, the fuel filter plug (2) in the fuel filter base can be used to purge air from the fuel system if the engine runs out of fuel.

1. Loosen connector cap (3).

2. Open fuel priming pump (1) and operate the fuel priming pump until fuel appears at connector cap (3). Tighten connector cap (3).

3. Loosen fuel return (7) for two full turns. Operate fuel priming pump (1) until fuel appears at fuel return (7). Tighten the fuel return (7).

4. Continue to operate fuel priming pump (1) until a strong pressure is felt on the fuel priming pump and until the check valve clicks. This procedure may require considerable priming. Lock fuel priming pump (1).

5. Crank the engine after pressurizing the fuel 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.

6. If the engine does not start, open fuel priming pump (1) and repeat Steps 1 through 5 in order to start the engine.

7. When the ECM is replaced, loosen the fuel outlet line on the ECM (4) in order to purge the air from the fuel system. Operate fuel priming pump (1) until fuel appears at the fuel outlet line on the ECM (4). Tighten the fuel outlet line on the ECM. Perform Steps 3 through 5.

8. When a unit injector is replaced, perform Steps 3 through 5.

i05264163

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. Install a vacuum gauge. Change the element for the primary filter/water separator if the pressure is 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.

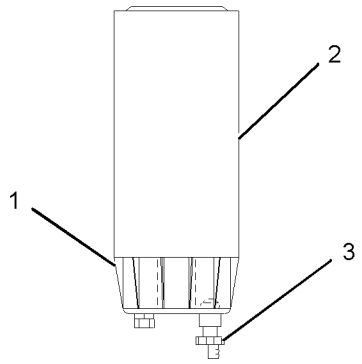

Illustration 56 g03130076

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

1. Stop the engine.

2. Turn the start switch to the “OFF” position.

3. Shut off the fuel tank supply valve to the engine.

4. If the primary fuel filter is equipped with a drain valve, open the drain valve in order to drain any fuel from the filter case. Close the drain valve.

NOTICE
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.

5. Remove the fuel filter bowl and wash the fuel filter bowl with clean diesel fuel.

6. Remove the fuel filter.

7. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.

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

NOTICE
In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, use Cat fuel filters.

Consult your Cat dealer for proper part numbers.

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

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

10. Install the clean fuel filter bowl on the new fuel filter.

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.

11. Open the fuel tank supply valve.

12. Start the engine and check for leaks. Run the engine for 1 minute. Stop the engine and check the engine for leaks again.

Detection of leaks is very difficult especially if the engine is running. The primary filter/water separator is under suction. A leak will allow air to enter the fuel. The air in the fuel can cause low power due to aeration of the fuel. If air enters the fuel, check the components for overtightening or under tightening.

i01463757

Fuel System Primary Filter/ Water Separator - Drain

SMCS Code: 1260-543; 1263-543

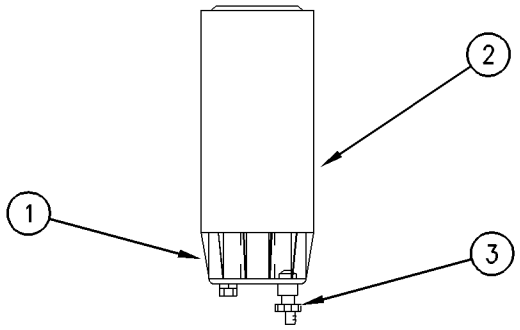

Illustration 57 g00668636

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

Bowl (1) 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.

i01007602

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.

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 the fuel priming pump (if equipped). This relieves any residual pressure in the fuel system.

5. Remove the used fuel filter. Use a cloth, or use a container 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.

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 a new fuel filter, and tighten the fuel filter until the gasket contacts the base.

9. Tighten the fuel filter by hand according to the instructions that are shown on the fuel filter.

Do not overtighten the fuel filter.

10. Lock the fuel priming pump (if equipped). Open the fuel tank supply valve.

11. If the engine stalls, refer to the Operation and Maintenance Manual, “Fuel System - Prime” topic (Maintenance Section) for more information.

i06104305

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. The fuel tank utilizes a fuel tank vent to prevent an air lock or vacuum. Ensure that the vent is free of debris and not damaged.

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.

Prepare to catch water and sediment in an appropriate container. Connect a hose (if necessary) to the valve prior to opening the valve.

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 properly could result in fuel leakage, 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 stand pipes that allow water and sediment to settle below the end of the fuel stand 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
- 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.

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.

i06825542

Hoses and Clamps - Inspect/ Replace

SMCS Code: 7554-510; 7554-040

Hoses and clamps must be inspected periodically and replaced at the recommended interval to ensure safe and continuous operation of the engine. Failure to replace a fuel hose at the recommended change interval may result in a hazardous situation. 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.

Note: Ensure that the hose is compatible with the application.

Inspect Tubes, Hoses, Bellows, and Clamps

Inspect all tubes and hoses for leaks that are caused by the following conditions. Replace any tube or hose which exhibits any of the following conditions. Failure to replace a tube or 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
- Exhaust bellows for leaks or damage
- 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 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 coolant filler cap. Inspect the gaskets on the filler cap. Inspect the gasket seat. Inspect the vacuum valve and seat for debris or damage. 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.

Note: When servicing fuel system, use cap/s or cover/s as required to protect the system and maintain fuel system cleanliness.

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” 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 exhaust bellows should never be reused.

5. Start the engine. Inspect the air lines for leaks.

i03646846

Maintenance Recommendations

SMCS Code: 1000

Maintenance Information

The operating conditions of an engine affect the maintenance intervals and the time between overhauls for the engine. The following conditions affect the maintenance intervals and the expected overhaul interval for the engine.

Severe Operation

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

- Horsepower
- Range of rpm
- Fuel consumption
- Fuel quality
- Altitude
- Maintenance intervals
- Selection of oil
- Selection of coolant
- Environmental qualities
- Installation

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

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

- Maximum reliability
- Retention of full service life

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

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

Environmental Factors

Extreme Ambient Temperatures

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

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

Cleanliness

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

Improper Operating Procedures

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

Improper Maintenance Practices

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

Overhaul Information

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

Note: Refer to this Operation and Maintenance Manual, “Overhaul (Major)” for further information about the major overhaul.

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

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.

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

i03398635

Overhaul (Major)

SMCS Code: 7595-020-MJ

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

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

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

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

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

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

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

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

Replacement of Components

Replace the following components during the major overhaul:

- Camshaft bearings
- Connecting rod bearings
- Crankshaft seals
- Crankshaft thrust washers
- Electronic unit injectors
- Gear train bushings
- Gear train bearings
- Main bearings
- Piston rings
- Aftercooler core

International Convention for Safety of Life at Sea (SOLAS)

Caterpillar recommends replacing the following:

- All shields that have been installed to cover up fuel and oil line connections per (SOLAS) regulations
- All marine certification society approved tapes are installed in order to cover up fuel line connections and oil line connections according to the SOLAS regulations.

Inspection, Reconditioning or Exchanging of Components

Inspect the following components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”.

Recondition the worn components or exchange the components, if necessary. Your Caterpillar dealer can provide these services and components.

- Camshaft followers
- Camshaft thrust washers
- Connecting rods
- Crankshaft vibration damper
- Cylinder head assembly
- Cylinder liners
- Engine mounts
- Scavenge oil pump
- Engine wiring harness
- Exhaust manifold seals
- Exhaust manifold bellows
- Fuel pressure regulating valve
- Fuel priming pump
- Fuel transfer pump
- Inlet manifold gaskets
- Inlet manifold seals
- Oil cooler core
- Oil pump
- Pistons
- Piston pins
- Prelube pump
- Pushrods
- Rocker arms
- Spacer plate
- Software update
- Turbocharger

Inspection of Components

Inspect the following components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”.

- Camshaft
- Crankshaft
- Driven equipment (alignment)
- Engine cylinder block
- Engine control module
- Flywheel
- Front gear train (gears)
- Oil suction screen
- Rear gear train

Inspect the camshaft for damage to the journals and the lobes.

Inspect the crankshaft for any of the following conditions:

- Deflection
- Damage to the journals
- Bearing material that has seized to the journals

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the following components:

- rod bearing
- main bearings

Note: If the crankshaft or the camshaft are removed for any reason, use the magnetic particle inspection process to check for cracks.

Replace the crankshaft vibration damper if any of the following conditions occur:

- Engine failure due to a broken crankshaft
- Excessive wear of the front bearing for the crankshaft
- Excessive wear of the gear train that is not caused by a lack of lubrication

Inspect the gears of the gear train and inspect the gear train bushings for the following conditions:

- Worn gear teeth
- Unusual fit
- Unusual wear

In addition to the inspection of components, inspect the alignment of the driven equipment. See the Application and Installation Guide for the engine or see the literature that is provided by the OEM of the driven equipment.

Cleaning of Components

Clean the oil suction screen. Also, remove side covers in order to clean the oil sump. For instructions on removal and installation of components, see the Service Manual, “Disassembly and Assembly” module.

Obtain a Coolant Analysis

For conventional heavy-duty coolant or antifreeze, check the concentration of supplemental coolant additive (SCA) regularly. The concentration of SCA can be checked with an S·O·S coolant analysis (Level I). A more detailed coolant analysis is recommended periodically.

For example, considerable deposits are found in the water jacket areas on the external cooling system, but the concentrations of coolant additives were carefully maintained. The coolant water probably contained minerals which were deposited on the engine over time.

A coolant analysis can be conducted in order to verify the condition of the water that is being used in the cooling system. A full water analysis may be obtained from the following sources:

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

Caterpillar recommends an S·O·S coolant analysis (Level II). This is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the inside of the cooling system. The following services are provided:

- Full Level I analysis
- Identification of the source of metal corrosion and of contaminants
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of possible electrolysis within the engines' cooling system

A report of the results of the analysis is provided. Maintenance recommendations are based on the results.

For more information about S·O·S coolant analysis, consult your Caterpillar dealer.

i06104394

Sea Water Strainer - Clean/ Inspect

SMCS Code: 1371-040; 1371-070

The sea water strainer must be clean in order to allow proper engine cooling. Check the sea water strainer for plugging. Inspect the sea water strainer more frequently if the vessel is being operated in water which is shallow or dirty. Refer to the OEM recommendations for more information about inspecting and cleaning the sea water strainer.

Ensure that the auxiliary water pump is primed and that the suction line is open.

1. Shutoff sea water valve.
2. Remove the sea water strainer and clean the screen. Remove any dirt and debris.
3. Install the sea water strainer. Fill the sea water strainer and the suction line for the auxiliary water pump with water.
4. Open sea water valve.

i00651416

Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

Caterpillar Inc. recommends a scheduled inspection of the starting motor. If the starting motor fails, the engine may not start in an emergency situation.

Check the starting motor for proper operation. Check the electrical connections and clean the electrical connections. Refer to the Service Manual for more information on the checking procedure and for specifications or consult your Caterpillar dealer for assistance.

i05965726

Turbocharger - Inspect

SMCS Code: 1052-040

Periodic inspection and cleaning are 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 Cat 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. Inspect the bore of the turbine housing for corrosion.
5. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.
6. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i02706582

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.

i05264233

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. Overheating 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 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 Cat dealer if repair is needed or replacement is needed.

i04363529

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.

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 within 24 hours of initially filling the plumbing with sea water. If no significant corrosion is noted, inspect the zinc rods again after seven days or 50 hours of engine operation after having been immersed in sea water. If no significant deterioration is noted, continue inspections after every 50 hours of engine operation.

Inspect the Zinc Rods

The zinc rods are red for easy identification. Table 17 shows the locations of the zinc rods and the quantities of the zinc rod:

Table 17

Locations of the Zinc Rods	
Location	**Quantity**
Inlet Adapter of the Heat Exchanger	1
Outlet Elbow of the Heat Exchanger	1
Outlet Elbow of the Auxiliary Water Pump	1
Outlet Adapter for the Aftercooler	1

1. Remove the zinc rod.

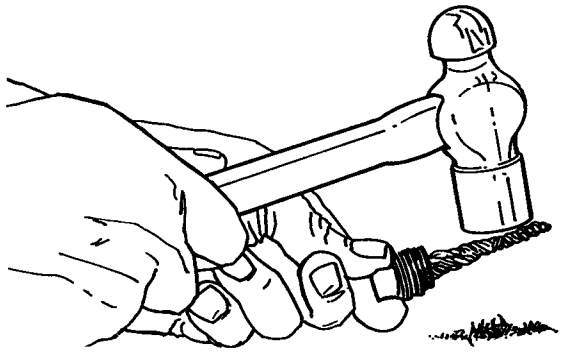

Illustration 58 g00104048

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

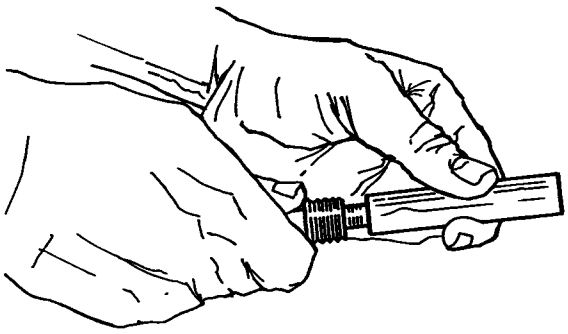

Illustration 59 g00104049

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.

Reference Information Section

Engine Ratings

i00727327

Engine Rating Conditions

SMCS Code: 1000

All engine ratings are in compliance with the following standard ambient air conditions of “SAE J1349”:

- 99 kPa (29.3 inches of Hg)
- 30 percent relative humidity
- A temperature of 25 °C (77 °F)

Ratings relate to the standard conditions of “ISO8665”, of “ISO3046/1”, of “DIN6271”, and of “BS5514”.

The engine ratings are based on the following fuel specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .849 at 15 °C (60 °F)
- Density of 850 kg/m^3 (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).

i02249866

Engine Rating Definitions

SMCS Code: 1000

It is important to know the use of the vessel, so that the rating will match the operating profile. The proper rating selection is also important so that the customer's perception of price and value is realized.

In selecting a rating for a specific application, the most important consideration is the time that is spent at full throttle. These rating definitions identify the percent of time at full throttle. The definitions also identify the corresponding times below rated rpm.

A Continuous – The engine is operated at a rated load and at rated rpm up to 100 percent of the time without interruption or without load cycling. Typical use is 5000 to 8000 hours per year. Continuous operation is used for heavy-duty service in ocean-going displacement hull vessels such as freighters, tugboats, bottom drag trawlers, and deep river towboats.

B Medium Duty – The engine may be operated at a load factor up to 80 percent and at rated load and at rated rpm for 80 percent of the duty cycle or for 10 hours out of every 12 hours. Typical use is 3000 to 5000 hours per year. Medium duty operation is used for displacement hull vessels such as mid-water trawlers, purse seiners, crew boats, supply boats, ferries, and towboats when locks, sandbars and curves dictate frequent slowing.

C Intermittent – The engine may be operated at a load factor up to 80 percent and at rated load and at rated rpm for 50 percent of the duty cycle or for six hours out of every 12 hours. Typical use is 2000 to 4000 hours per year. With a cyclical load and with a cyclical speed, intermittent operation is used for planing hull vessels such as ferries, fishing boats that move at higher speeds, out and back offshore service boats, displacement hull yachts, and short trip coastal freighters.

D Patrol Craft – The engine may be operated at a load factor up to 50 percent and at rated load and at rated rpm for 16 percent of the duty cycle or for two hours out of every 12 hours. Typical use is 1000 to 3000 hours per year. For planing hull vessels such as off-shore patrol boats, customs, police, and some fire boats and fishing boats. The engine is also used for bow and stern thrusters.

E High Performance – The engine may be operated at a load factor up to 30 percent and at rated load and at rated rpm for eight percent of the duty cycle or 1/2 hour out of every six hours. Typical use is 250 to 1000 hours per year. For planing hull vessels such as pleasure craft, harbor patrol, harbor master, and some fishing vessels and pilot boats.

NOTICE
Operating engines above the rating definitions can result in shorter service life before overhaul.

Typical operating parameters for each rating level are summarized in Table 18 . Table 18 assumes the use of a propeller that has a fixed pitch. If a propeller that has a controllable pitch is used, consult your Caterpillar dealer for marine performance and for reduced engine rpm information. Optimum fuel consumption can be obtained by operating the engine at the Suggested Reduced rpm.

Table 18

3406E Marine Engine Ratings			
Rating Level	Full Throttle		Suggested Reduced rpm (Cruising Speed)
	Time	Rated rpm	
A	Up to 100 percent	N/A	-
B	Up to 80 percent	1800 1350 1200	1700 1300 1150
C	Up to 50 percent	2100 1800	2000 1700
D	Up to 16 percent	2100	2000
E	Up to 8 percent	2100 1800	2000 1700

For most applications, the customer can provide profile information from similar vessels or from the actual vessel. If such information does not sufficiently indicate the operating profile, instruments are available to more precisely define engine operation. A 7D-1513 Tachograph can establish an operating profile. The Tachograph records engine rpm versus time on a paper graph.

i05648181

Marine Classification Society Certification Requirements

SMCS Code: 1000

The major seafaring nations have established technical groups called marine classification societies. Caterpillar 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)

IRS – Indian Register of Shipping (India)

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

i07240378

Customer Assistance

SMCS Code: 1000; 4450

USA and Canada

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

Your satisfaction is a primary concern to Caterpillar and to Cat 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:

877-228-9900

The normal hours are from 7:00 AM to 6:00 PM Monday through Friday Central Standard Time.

3. If your needs have not been met still, submit the matter in writing to the following address:

Designated Compliance Officer Heavy-Duty and Nonroad Engine Group 6403-J,
US Ave, NW, Washington,
DC 20460
Email address: complianceinfo@epa.gov.

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.

Designated Compliance Officer Heavy-Duty and Nonroad Engine Group 6403-J,
US Ave, NW, Washington,
DC 20460
Email address: complianceinfo@epa.gov.

Latin America, Mexico, Carribean
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

i07500661

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 Cat replacement parts are available from Cat dealers throughout the world. Cat dealer parts inventories are up-to-date. The parts stocks include all the parts that are normally needed to protect your Cat engine investment.

When you order parts, specify the following information:

- Part number
- Part name
- Quantity

If there is a question concerning the part number, provide your dealer with a complete description of the needed item.

When a Cat 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 information will help the dealer in troubleshooting the problem and solving the problem faster.

i07510375

On-Board Replacement Parts

SMCS Code: 7567

The various Marine Classification Societies require a supply of replacement parts on vessels that are primarily powered by diesel engines. The replacement parts may be needed for making repairs offshore or at remote ports. The types of replacement parts and the numbers of parts depends on the range of the vessel. The following two categories of vessels are considered:

Category 1 – This category includes vessels that make short trips between ports.

Category 2 – This category includes vessels in ocean service that is unrestricted. The vessels may travel far from ports that provide service. The list of replacement parts for this category is more extensive.

Table 19 lists the parts that are recommended by Caterpillar for vessels in both categories.

The requirements of individual Marine Classification Societies may differ. Table 20 lists the requirements of all the Marine Classification Societies. Additionally, some items that are recommended by Caterpillar are listed. All of the parts that are listed in Table 19 and 20 are recommended for vessels in Category 2. To customize this list for your specific engine application, consult your Cat dealer.

Note: Check with your local class society for any questions regarding the onboard replacement parts.

Table 19

Recommended Replacement Parts for Vessels in Category 1 and Category 2	
Quantity	**Item**
4	Air cleaner element
1	Alternator belt
1	Electronic control module (ECM)
1	Electronic unit injector
-	Engine oil
-	Extended Life Coolant (ELC) and Extender or Diesel Engine Antifreeze/Coolant (DEAC) and Supplemental Coolant Additive (SCA)
4	Fuel filter elements
1	Fluid sampling bottles
-	Liquid gasket material

(continued)

(Table 19, contd)

Recommended Replacement Parts for Vessels in Category 1 and Category 2	
Quantity	**Item**
4	Engine oil filters
1	Service kit (electronic connector)
4	Water temperature regulator
4	Zinc rods

Table 20

Recommended Replacement Parts for Vessels in Category 2		
System	**Quantity**	**Item**
Camshaft and crankshaft	1	Bolt (crankshaft to flywheel)
	1	Camshaft gear
	1	Crankshaft gear
	1	Idler gear and balance weight gear assembly (water pump)
	1	Shaft and thrust washer (idler gear and balance weight gear assembly)
Cooling	1	Aftercooler core and gasket
	1	Auxiliary water pump
	1	Jacket water pump
	1	SCAC Pump
	4	Water temperature regulator
Cylinder head	6	Bolt and washer
	1	Bolt and nut (exhaust manifold)
	1	Cylinder head assembly
	4	Gasket (cylinder)
	-	Water seals for one cylinder
Fuel	3	Electronic unit injector
	1	Fuel transfer pump
	3	Seal (electronic unit injector)
Inlet air	2	Air cleaner element
Lubrication	1	Bypass valve (oil cooler)
	1	Bypass valve (oil filter)
	1	Gasket (oil pan)
	1	Oil cooler core (engine)
	1	Oil cooler core (marine gear)

(continued)

(Table 20, contd)

Recommended Replacement Parts for Vessels in Category 2		
System	**Quantity**	**Item**
Miscellaneous	1	Gasket kit (engine)
Piston	1	Connecting rod assembly
	1	Connecting rod bearing
	1	Cylinder liner
	1	Filler band (cylinder liner)
	1	Main bearing
	2	Cap bolt and washer (main bearing)
	1	Piston assembly
	1	Piston pin
	2	Piston pin retainer
	1	Piston rings (complete set)
	3	Seals (cylinder liner)
Starting	1	Starting motor
Turbocharger	1	Complete turbocharger
	-	Gasket
	4	Locknut
	4	Stud (mounting)
Valves	6	Exhaust valves
	4	Inlet valves
	10	Valve guides
	24	Valve locks
	10	Valve rotators
	10	Valve springs

Reference Materials

i05264255

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 various other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is managed. Accurate maintenance records can help your Cat 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 repair costs
- Owner receipts
- Maintenance log

i01176304

Maintenance Log

SMCS Code: 1000; 4450

Table 21

Engine Model	**Customer Identifier**
Serial Number	**Arrangement Number**

Service Hours	Quantity Of Fuel	Service Item	Date	Authorization

i07422648

Reference Material

SMCS Code: 1000; 4450

Additional literature regarding your product may be purchased from your local Cat dealer or by visiting publications.cat.com. Use the product name, sales model, and serial number to obtain the correct information for your product.

publications.cat.com

i04323034

Decommissioning and Disposal

SMCS Code: 1000

When the generator set is removed from service, local regulations for the generator set decommissioning will vary. Disposal of the generator set will vary with local regulations. Consult the nearest Cat dealer for additional information.

Index

M

O

P

R

S

T

W

Z

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:	_____	_____	_____