



Operation and Maintenance Manual

3116 and 3126 Marine Engines

4KG1-Up (3116 Marine Engine)
1ZJ1-Up (3126 Marine Engine)
1SK1-Up (3116 Marine Engine)
6MK1-Up (3126 Marine Engine)
8NM1-Up (3126 Marine Engine)
6SR1-Up (3126 Marine Engine)
NSW1-Up (3126 Marine Engine)
4EZ1-Up (3126 Marine Engine)

Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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 the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

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



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

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

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

Table of Contents

Foreword	4
----------------	---

Safety Section

Safety Messages	6
General Hazard Information	7
Burn Prevention	10
Fire Prevention and Explosion Prevention	10
Crushing Prevention and Cutting Prevention	12
Mounting and Dismounting	12
Before Starting Engine	13
Engine Starting	13
Engine Stopping	14
Electrical System	14

Product Information Section

General Information	15
Product Identification Information	19

Operation Section

Towing Information	22
Lifting and Storage	23
Features and Controls	27
Engine Starting	31
Engine Operation	34
Cold Weather Operation	36
Engine Stopping	38

Maintenance Section

Refill Capacities	40
Maintenance Recommendations	49
Maintenance Interval Schedule	51

Reference Information Section

Engine Ratings	84
----------------------	----

Engine Performance and Performance Analysis Report (PAR)	86
--	----

Customer Service	88
------------------------	----

Reference Materials	91
---------------------------	----

Index Section

Index	94
-------------	----

Foreword

Literature Information

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

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

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

Safety

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

Operation

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

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

Maintenance

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

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

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

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

Maintenance Intervals

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

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

Overhaul

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

California Proposition 65 Warning

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

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

Safety Section

Safety Messages

i03475721

SMCS Code: 1000; 7405

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

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

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

Do not work on the engine and do not operate the engine unless the instructions and the warnings in the Operation and Maintenance Manual are understood. Proper care is your responsibility. Failure to follow the instructions or failure to heed the warnings could result in injury or in death.

The following section illustrates and the following section describes the safety messages which may be found on the engine.

Starting Aid

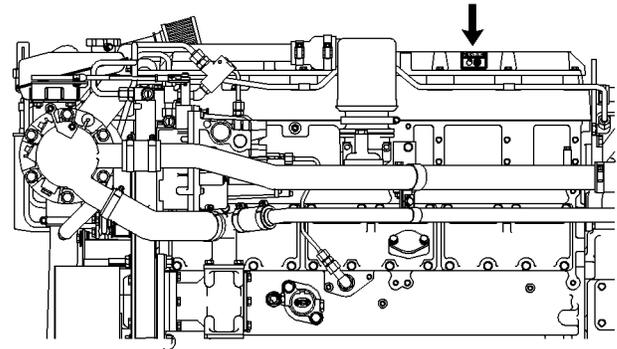


Illustration 1

g00513124

The safety message for the starting aid is located on the valve cover.



g00283559

If the engine is equipped with an air inlet heater for cold weather starting, do not use starting aids that contain an aerosol such as ether. Using such types of starting aids could result in an explosion and personal injury.

i04074884

General Hazard Information

SMCS Code: 1000; 4450; 7405

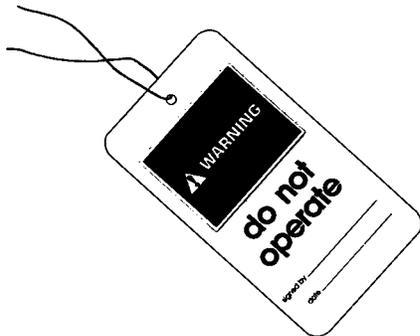


Illustration 2

g00104545

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

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

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

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

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

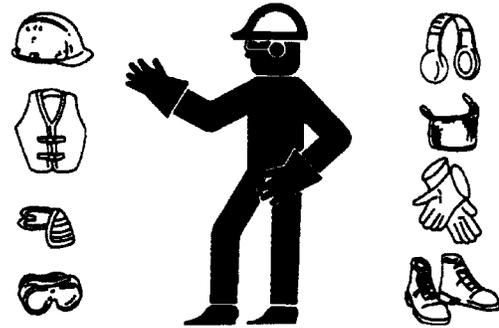


Illustration 3

g00702020

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

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

- The engine is stopped. Ensure that the engine cannot be started.
- The protective locks or the controls are in the applied position.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- When starting a new engine or an engine which has not been started since service has been performed, make provisions to stop the engine if an overspeed occurs. Shutting down the engine may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

- Start the engine with the operator controls. Never short across the starting motor terminals or the batteries. This method of starting the engine could bypass the engine neutral start system and/or the electrical system could be damaged.

Pressurized Air and Water

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

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

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded and used with effective chip guarding (if applicable) and personal protective equipment. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi). Always wear eye protection for cleaning the cooling system.

Fluid Penetration

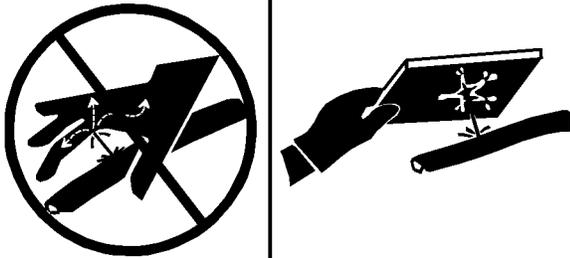


Illustration 4

g00687600

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

Containing Fluid Spillage

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

Lines, Tubes, and Hoses

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

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

Inspect all lines, tubes, and hoses carefully. Do not use bare hands to check for leaks. Always use a board or cardboard for checking engine components for leaks. Tighten all connections to the recommended torque.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Wire that is exposed in reinforced hose
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

Ensure that all of the clamps, the guards, and the heat shields are installed correctly. Correct installation of these components will help to prevent these effects: vibration, rubbing against other parts, and excessive heat during operation.

Inhalation

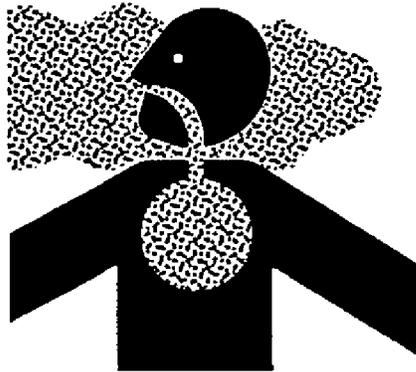


Illustration 5

g02159053

Exhaust

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

Asbestos Information

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

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

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

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

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

Softwrap

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

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

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

Dispose of Waste Properly

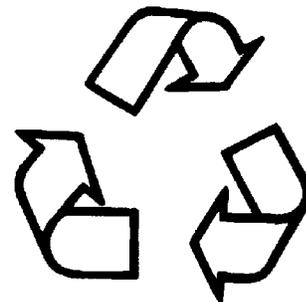


Illustration 6

g00706404

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

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

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Burn Prevention

SMCS Code: 1000; 4450; 7405

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

Coolant

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

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

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

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

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

Oils

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

Batteries

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

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Fire Prevention and Explosion Prevention

SMCS Code: 1000; 4450; 7405



Illustration 7

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 Cat 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 Cat 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 in a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

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

Wiring must be kept in good condition. Properly route and 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 fuel filters. The filter housings must be tightened to the proper torque.



Illustration 8

g00704059

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



Illustration 9

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 result in an explosion.

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

Fire Extinguisher

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

Ether

Ether is flammable and poisonous.

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

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

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

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

Lines, Tubes, and Hoses

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

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

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

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

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible parts 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.

i01103904

Engine Starting

SMCS Code: 1000

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

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

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

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

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

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

Ether

Ether is poisonous and flammable.

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

Do not smoke while ether cylinders are changed.

Use ether in well ventilated areas.

Use ether with care in order to avoid fires.

Keep ether cylinders out of the reach of unauthorized persons.

Store ether cylinders in authorized storage areas only.

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

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

i01032808

Engine Stopping

SMCS Code: 1000

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

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

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

i02456933

Electrical System

SMCS Code: 1000; 1400

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

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

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

Grounding Practices

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

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

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

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

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

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

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

Product Information Section

General Information

i04744834

Model View Illustrations

SMCS Code: 1000

The following model views show typical 3116 and 3126 Marine Engine features. Due to individual applications, your engine may appear different from the illustrations.

3116 Marine Engine

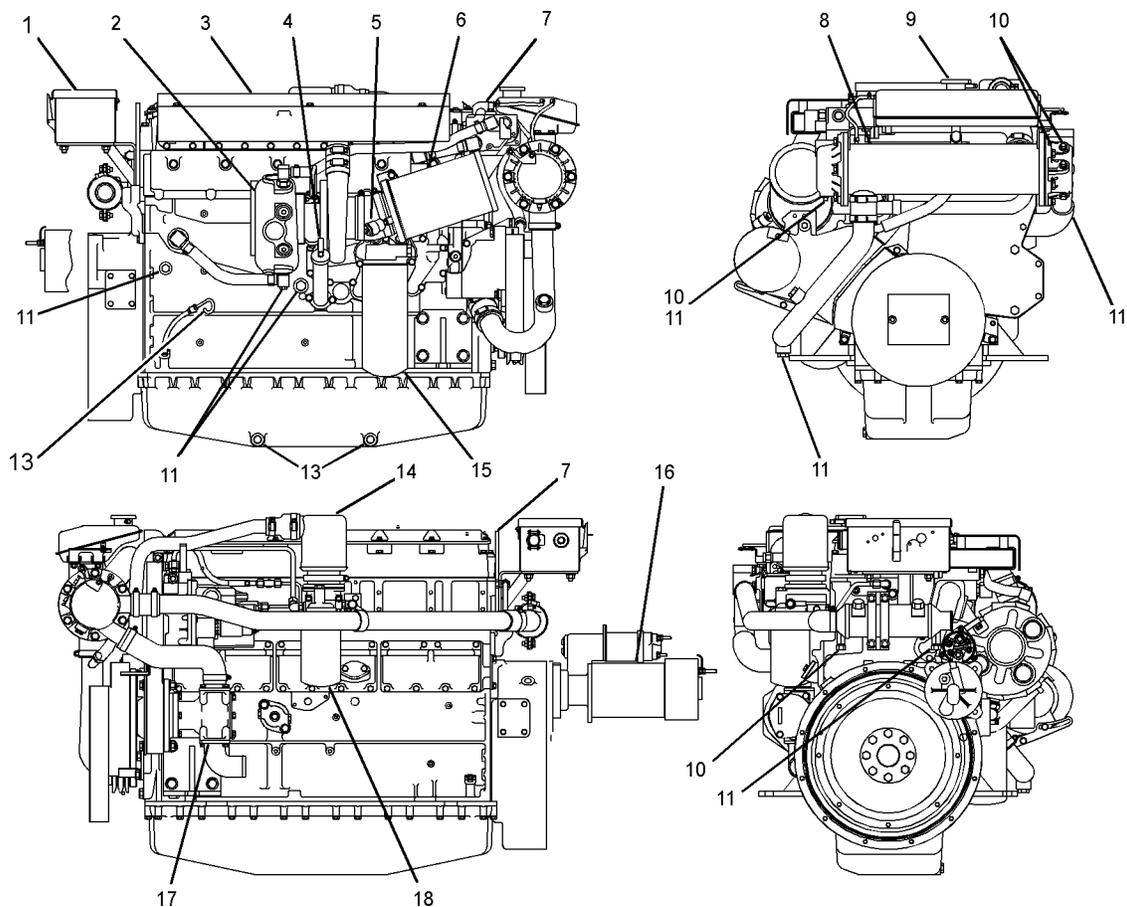


Illustration 10

g02842017

- | | | |
|-----------------------|-------------------------------|--------------------------------|
| (1) Junction box | (7) Lifting eyes | (13) Oil drain plugs |
| (2) Turbocharger | (8) Heat exchanger | (14) Engine crankcase breather |
| (3) Aftercooler | (9) Expansion tank filler cap | (15) Oil filter |
| (4) Oil filler cap | (10) Zinc rods | (16) Starting motor |
| (5) Service indicator | (11) Water drain plugs | (17) Raw/Seawater pump |
| (6) Air cleaner | (12) Oil level gauge | (18) Fuel filter |

3126 Marine Engine

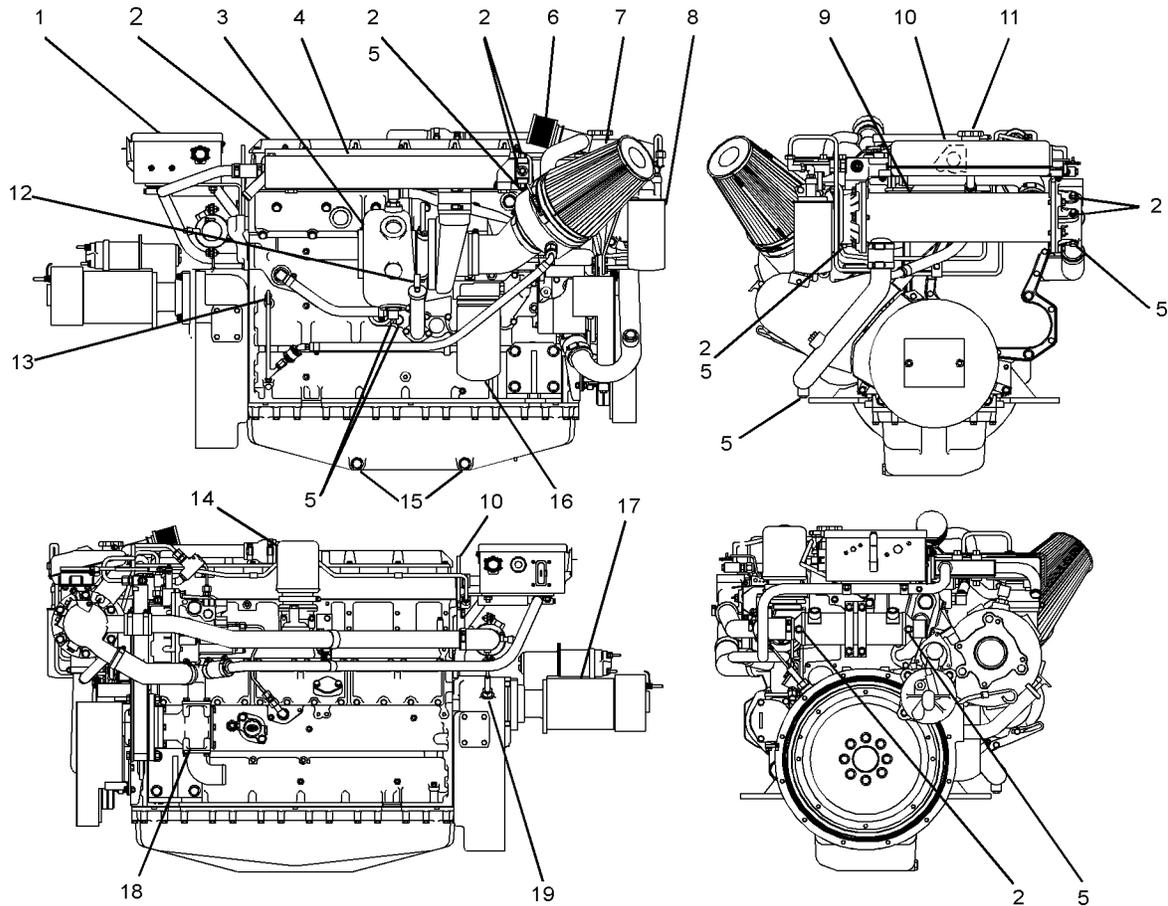


Illustration 11

g02842019

- | | | |
|------------------------------|--------------------------------|-------------------------------------|
| (1) Junction box | (8) Fuel filter | (15) Oil drain plugs |
| (2) Zinc rods | (9) Heat exchanger | (16) Oil filter |
| (3) Turbocharger | (10) Lifting eyes | (17) Starting motor |
| (4) Aftercooler | (11) Expansion tank filler cap | (18) Raw/Seawater pump |
| (5) Water drain plugs | (12) Oil filler cap | (19) Magnetic speed pickup location |
| (6) Vacuum regulator element | (13) Oil level gauge | |
| (7) Air cleaner element | (14) Engine crankcase breather | |

i04744832

- Turbocharged aftercooling

Product Description

SMCS Code: 1000; 4450; 4491

The Cat 3116 and 3126 Marine Engines have the following characteristics:

- Four-stroke cycle
- Mechanical fuel system
- Direct fuel injection
- Six in-line cylinders
- Two valves per head

A hydromechanical governor controls the output of the fuel injector. The governor maintains the selected engine rpm. Individual fuel injectors (one per cylinder) meter fuel and individual fuel injectors pump fuel under high pressure through the fuel injector nozzles to the cylinders.

The fuel ratio control is located on the governor. The fuel ratio control restricts the fuel rack movement. In order to minimize exhaust smoke, only the proper amount of fuel is injected into the cylinders during acceleration.

The inlet air is filtered by an air cleaner. The air is compressed by a turbocharger before the air enters the engine cylinders. The turbocharger is driven by engine exhaust.

Engine Specifications

Note: The front end of the engine is opposite the flywheel end of the engine. The number one cylinder is the front cylinder.

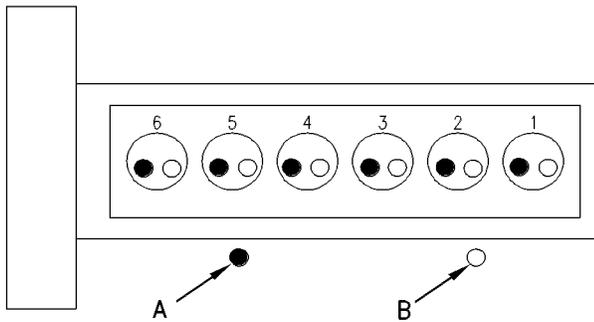


Illustration 12

g00513382

Cylinder and valve locations

(A) Exhaust valve

(B) Inlet valve

Table 1

3116 Marine Engine Specifications	
Number of Cylinders	6 In-Line Cylinders
Bore	105 mm (4.13 inch)
Stroke	127 mm (5.0 inch)
Aspiration	Turbocharged Aftercooled
Compression Ratio	16:1
Displacement	6.6 L (402 in ³)
Firing Order	1-5-3-6-2-4
Rotation (viewed from flywheel)	Counterclockwise

Table 2

3126 Marine Engine Specifications	
Number of Cylinders	6 In-Line Cylinders
Bore	110 mm (4.33 inch)
Stroke	127 mm (5.0 inch)
Aspiration	Turbocharged Aftercooled
Compression Ratio	15:1
Displacement	7.24 L (439 in ³)
Firing Order	1-5-3-6-2-4
Rotation (viewed from flywheel)	Counterclockwise

Engine Features

The cooling system consists of the following components:

- Gear-driven centrifugal pump
- One water temperature regulator which regulates the engine coolant temperature
- Engine oil cooler
- Transmission oil cooler
- Water-cooled exhaust manifold
- Auxiliary sea water pump
- Expansion tank
- Heat exchanger

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

Product Identification Information

i03475944

Plate Locations and Film Locations

SMCS Code: 1000; 4450

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

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

Serial Number Plate (1)

ENGINE MODEL	
SERIAL NUMBER	
CATERPILLAR® CAT	
ARRANGEMENT NUMBER	
(ALWAYS GIVE ALL NUMBERS) MADE IN U.S.A.	

Illustration 14

g01815974

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.

Information Plate (2)

CAT[®]		CORE AR.	DATE DELIVERED
SER. NO.	MODIFICATION NO.	PERF SPEC	DLR CODE
AR NO.	OEM NO.	HP	MAX ALT
FULL LOAD STATIC FUEL POWER	FULL TORQ. STATIC FUEL kW	FULL LOAD RPM	FUEL TIMING
BARE ENG. HI IDLE RPM			

Illustration 15

g01181026

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

i02507553

Declaration of Conformity

SMCS Code: 1000

S/N: 1ZJ1-Up

S/N: 6MK1-Up

S/N: 8NM1-Up

S/N: 6SR1-Up

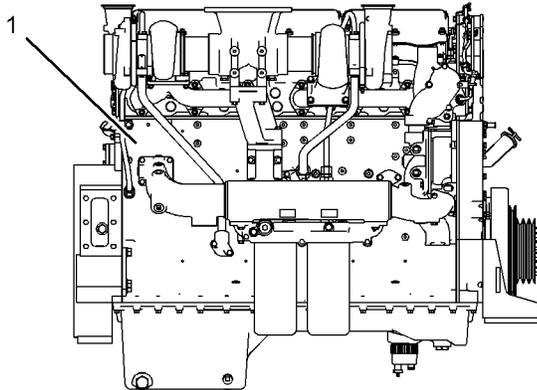
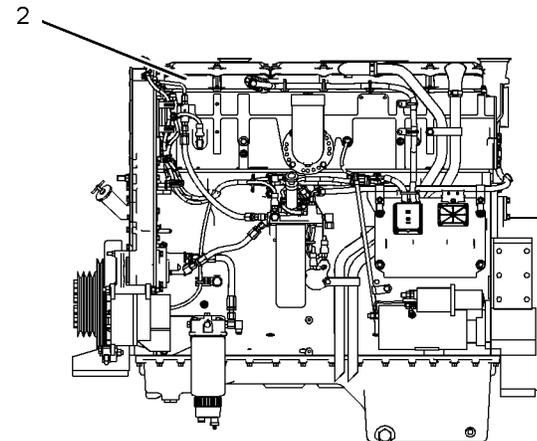


Illustration 13

g01065152



i04258351

Reference Information

SMCS Code: 1000; 4450

Fill in the following information for future reference.

Engine model _____

Engine serial number _____

Engine arrangement number _____

Engine power _____

Engine low idle rpm _____

Engine full load rpm _____

Performance specification number _____

Governor group number _____

Fuel filter element number _____

Oil filter element number _____

Auxiliary oil filter element number _____

Supplemental coolant additive maintenance element
number _____

Supplemental coolant additive precharge element
(optional) number _____

Cooling system capacity _____

Air cleaner element number _____

Fan drive belt set number _____

Alternator belt number _____

Operation Section

Towing Information

i01052770

Marine Towing

SMCS Code: 1000

The vessel should be towed under the following conditions:

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

NOTICE

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

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

NOTICE

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

Towing Procedure

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

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

Intermittent Back Driving

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

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

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

Continuous Back Driving

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

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

Securing the Propeller

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

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

Wrapping the Propeller Shaft

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

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

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

Securing the Companion Flange

1. Remove one or more bolts from the coupling on the companion flange.
2. Bolt a chain to the companion flange.
3. Wrap the chain several times around the propeller shaft.
4. Secure the loose end of the chain at a right angle to the propeller shaft. Secure the chain in the opposite direction of the shaft rotation.

Lifting and Storage

i02024906

Product Lifting

SMCS Code: 7000; 7002

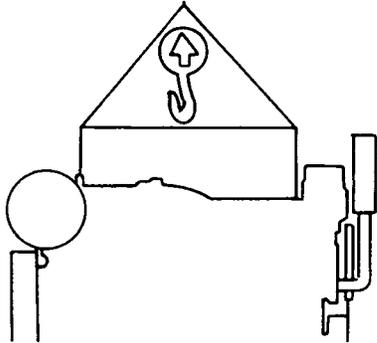


Illustration 17

g00103219

NOTICE

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

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

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

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

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

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

Engine and Marine Transmission Lifting

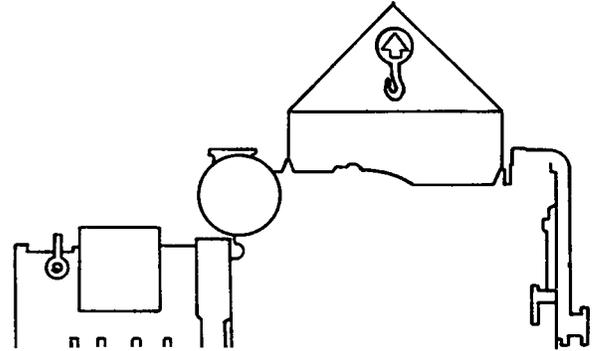


Illustration 18

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.

i04284474

Product Storage

SMCS Code: 7002

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

Engine

Storage (Less Than One Year)

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

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

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

1. Clean the engine of any dirt, rust, grease, and oil. Inspect the exterior. Paint areas that contain paint damage with a good quality paint.
2. Remove any dirt from all air cleaners. Check all seals, gaskets, and the filter element for damage.
3. Apply lubricant to all points in this Operation and Maintenance Manual, "Maintenance Interval Schedule".
4. Drain the crankcase oil. Replace the crankcase oil and change the oil filters. For the proper procedure, refer to this Operation and Maintenance Manual, "Engine Oil and Filter - Change".
5. If the engine is equipped with an air starting motor, fill the reservoir with a mixture of 50 percent volatile corrosion inhibitor (<nomen>VCI </nomen>) and 50 percent engine oil.
6. Add VCI to the crankcase oil. The volume of VCI in the crankcase oil should be 3 to 4 percent.

Note: If the engine crankcase is full, drain enough engine oil so the mixture can be added.

7. Remove the air filter elements. Turn the engine at cranking speed with the throttle control in FUEL OFF position. Use a sprayer to add a mixture of 50 percent VCI and 50 percent engine oil into the air inlet or turbocharger inlet.

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

8. Use a sprayer to apply a mixture of 50 percent VCI and 50 percent crankcase oil into the exhaust openings. The minimum application rate for the oil mixture is 5.5 mL per L (3 oz per 1000 cu in) of engine displacement. Seal the exhaust pipe and seal any drain holes in the muffler.

9. Remove the fuel from the secondary fuel filter housing. Alternately, empty and reinstall the spin-on fuel filter element in order to remove any dirt and water. Drain any sleeve metering fuel pump.

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

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

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

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

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

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

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

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

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

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

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

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

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

14. Loosen all belts.

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

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

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

Conventional Coolant System

Completely fill the cooling system before storage.

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

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

Raw Water System

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

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

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

Removal from Storage

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

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

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

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

12. On the first day of operation, check the entire engine several times for leaks and correct operation.
13. Refer to Special Publication, SEBU5898, "Cold Weather Recommendations Operation and Maintenance" when the temperature is less than -12°C (10°F) at the time of removal from storage.

Marine Transmission Storage

Storage Procedure

1. Thoroughly clean the transmission.
2. Paint the transmission with a good quality paint.
3. If the transmission will be stored for more than 6 months, VCI oil will provide additional protection against moisture. Add VCI oil at a rate of 2 percent of the lubricating oil capacity.
4. Operate the transmission for a short period in order to circulate the oil.
5. Seal all of the openings with covers and/or tape.
6. Use a multipurpose grease to coat all of the external moving parts such as the linkage, etc.
7. Store the transmission under a waterproof cover.

Procedure After Storage

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

Features and Controls

i04745049

Alarms and Shutoffs

SMCS Code: 7400

Shutoffs

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

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

NOTICE

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

Be familiar with the following items:

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

Alarms

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

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

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

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

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

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

NOTICE

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

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

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

Testing the Shutoff and Alarm System

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

NOTICE

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

Refer to the Troubleshooting Guide for more information on testing procedures or consult your Cat dealer.

i01134670

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, refer to the OEM information.

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

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

NOTICE

If no oil pressure is indicated, STOP the engine. Engine damage can result.



Engine Oil Pressure – The oil pressure should be greatest after a cold engine is started. The typical oil pressure for turbocharged engines at rated rpm with SAE 30 or SAE 40 oil is 240 to 480 kPa (35 to 70 psi).

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

1. Remove the load.
2. Reduce engine speed to low idle.
3. Check and maintain the oil level.



Jacket Water Coolant Temperature – Typical temperature range is 71 to 99 °C (160 to 210 °F). The maximum allowable temperature is 102 °C (215 °F). Higher temperatures may occur under certain conditions. The water temperature reading may vary according to load. The reading should never exceed the boiling point for the pressurized system that is being used.

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

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



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

NOTICE

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

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 discharge in the battery charging circuit. Operation of the indicator should be to the right side of “0”(zero).



Fuel Level – This gauge indicates the fuel level in the fuel tank. The fuel level gauge operates when the start switch is “ON”.



Fuel Pressure – This gauge indicates fuel pressure to the fuel injection pump. If the gauge moves to the “out” position the engine will not operate properly. If the gauge is below 50 kPa (7 psi) the engine will not operate properly. A decrease in fuel pressure usually indicates a plugged fuel filter.



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

i01012827

Sensors and Electrical Components

SMCS Code: 1900; 7400

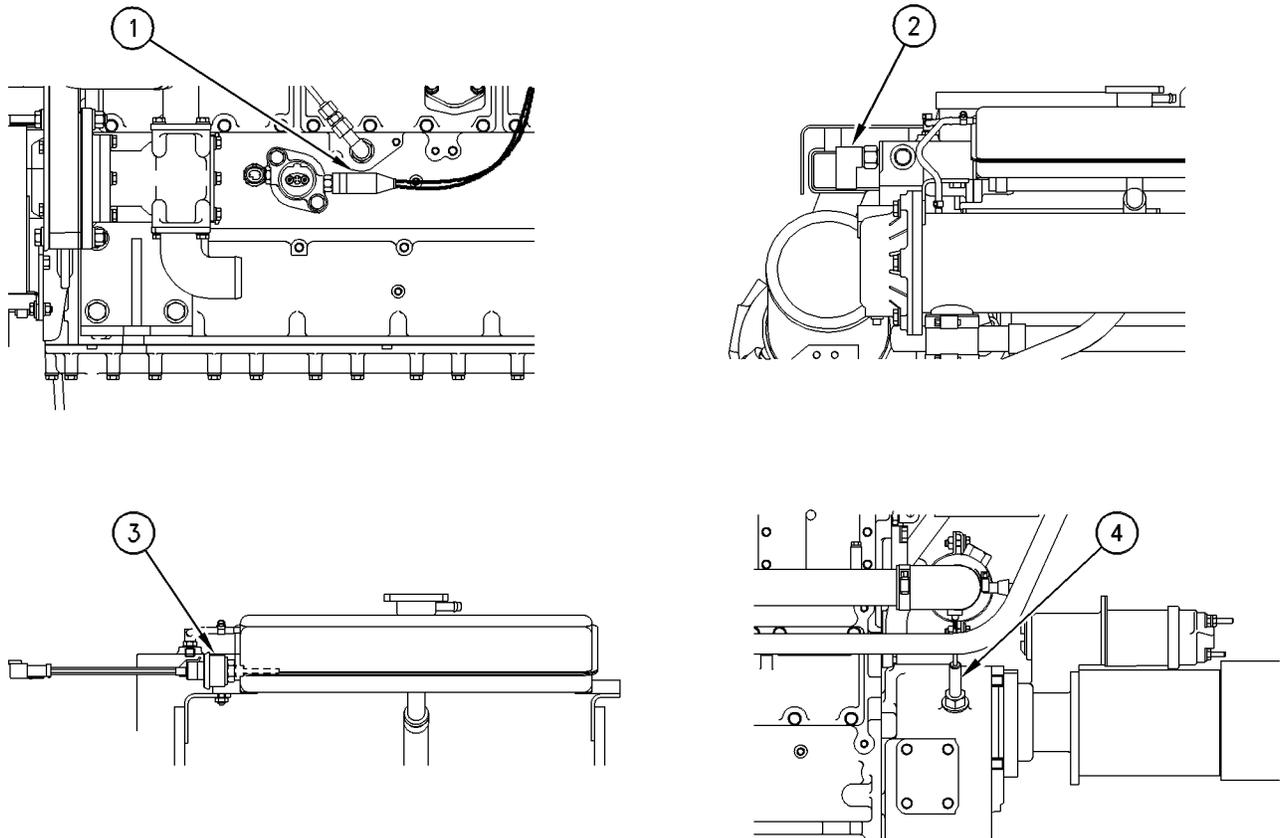


Illustration 19

g00519397

(1) Engine oil pressure sensor
(2) Coolant temperature sensor

(3) Coolant level sensor
(4) Magnetic speed pickup

Engine Oil Pressure Sensor

Engine oil pressure sensor (1) is optional. The sensor is mounted on the side of the engine. After the engine is started, the alarm is activated for insufficient oil pressure. The alarm is also activated if the engine loses oil pressure. No resetting is required.

Coolant Temperature Sensor

Coolant temperature sensor (2) is located in the water temperature regulator housing. High coolant temperature closes the coolant temperature switch. Once the coolant temperature switch is closed, an alarm is activated. No resetting is required. The switch opens as the coolant cools.

Coolant Level Sensor

Coolant level sensor (3) is mounted near the top of the expansion tank. The sensor detects the coolant level. If the coolant drops below a minimum level, the coolant level sensor will activate an alarm. Overheating or possible engine damage can be avoided when the coolant level sensor is activated. Coolant must be added to the expansion tank in order to reset the condition.

Magnetic speed pickup

Magnetic speed pickup (4) is mounted in the flywheel housing. The magnetic pickup measures engine rpm by sensing the passage of the ring gear teeth of the flywheel. The engine rpm is indicated on the tachometer.

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.

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Starting the Engine

SMCS Code: 1000; 1450

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

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

Note: If the indicator lamp for the Air Inlet Heater (if equipped) turns ON, wait until the lamp turns OFF before starting the engine. The Air Inlet Heater (if equipped) will become disabled if the engine is started with the lamp ON. A disabled Air Inlet Heater could result in emission of excessive white smoke after the engine has started.

Note: The Air Inlet Heater (if equipped) may not have an indicator lamp. Wait for 30 seconds before you start the engine if the Air Inlet Heater (if equipped) does not have an indicator lamp. The operator will notice movement of the needle in the gauge for voltage. This movement is due to the cycling of the Air Inlet Heater (if equipped).

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

NOTICE

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

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

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

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.

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After Starting Engine

SMCS Code: 1000

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

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

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

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

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

Engine Operation

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Engine Operation

i01646252

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.

Transmission Control

SMCS Code: 3065; 3168; 7451

Transmission Selector Lever

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

- Mechanical
- Hydraulic
- Pneumatic
- Electrical

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

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

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

Moving and Getting Underway

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

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

NOTICE

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

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Fuel Conservation Practices

SMCS Code: 1000; 1250

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

- Avoid spilling fuel.

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

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Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250; 1280

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

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

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

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

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

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

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

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

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

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

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

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

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

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Fuel Related Components in Cold Weather

SMCS Code: 1000; 1250; 1280

Fuel Tanks

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

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

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

Fuel Filters

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

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

NOTICE

In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, a two micron absolute high efficiency fuel filter is required for all Caterpillar Electronic Unit Injectors. Caterpillar High Efficiency Fuel Filters meet these requirements. Consult your Caterpillar dealer for the proper part numbers.

Fuel Heaters

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

The following fuel heaters are recommended for Caterpillar engines:

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

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

Disconnect the fuel heater in warm weather.

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

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

Engine Stopping

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Emergency Stopping

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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)

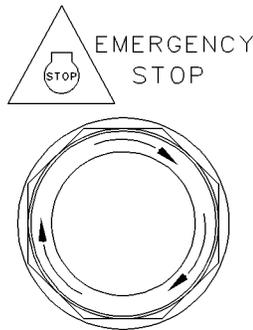


Illustration 20

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Typical emergency stop button

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

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

Manual Stop Procedure

SMCS Code: 1000; 7418

NOTICE

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

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

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

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

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

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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

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Refill Capacities

SMCS Code: 1000; 1348; 1395; 7560

Lubrication System

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

Table 3

3116 And 3126 Marine Engines Approximate Refill Capacities		
Compartment or System	Liters	Quarts
Crankcase Oil Sump (Standard) ⁽¹⁾	25	26.4

⁽¹⁾ These values are the approximate capacities for the crankcase oil sump which include the standard oil filters that are installed at the factory. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.

Cooling System

In order to maintain the cooling system, the Total Cooling System capacity must be known. The approximate capacity for the Engine Only cooling system is listed. External System capacities will vary among applications. Refer to the OEM specifications for the External System capacity. This capacity information will be needed in order to determine the amount of coolant/antifreeze that is required for the Total Cooling System.

Table 4

3116 And 3126 Marine Engines Approximate Refill Capacities		
Compartment or System	Liters	US Gallons
Engine Only	28	7.4
External System (OEM) ⁽¹⁾		
Total Cooling System ⁽²⁾		

⁽¹⁾ The External System includes an expansion tank with the following components: heat exchanger and piping. Refer to Caterpillar specifications or to the OEM specifications and enter the capacity for the External System in this row.

⁽²⁾ The Total Cooling System includes the capacity for the Engine Only plus the capacity for the External System. Enter the total in this row.

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Fluid Recommendations

SMCS Code: 1280; 1348; 1395; 7560

Diesel Engine Oil

Caterpillar does not recommend the use of multigrade oils in the Marine Diesel Engines that are covered in this Operation and Maintenance Manual.

Multigrade oils use high molecular weight polymers as viscosity index improvers. When the crankcase blowby flows through the turbocharger and the aftercooler, the viscosity index improvers can adhere to the turbocharger compressor and aftercooler core.

The fouling of the turbocharger and aftercooler can cause reduced air flow, loss of power, and increased black smoke. The emission of black smoke results in buildup of soot on the transom of the boat.

Cat SAEO (Special Application Engine Oil)

Caterpillar recommends the use of Cat SAEO in Cat Marine Diesel Engines covered by this Operation and Maintenance Manual.

The factory-fill for these engines is Cat SAEO with the following properties:

- Meets all requirements of API CF-4 category
- Viscosity grade of SAE 30

Caterpillar recommends the following engine oil for maximum performance:

- Cat SAEO (SAE 30)
- Cat SAEO (SAE 40)

Note: Caterpillar recommends the use of single grade oils that pass all API CF-4 category requirements unless crankcase blowby has been routed away from the air cleaner inlet.

Commercial Oils

NOTICE

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

When Cat SAEO is not used, use the following commercial oils:

- Single grade oil with a viscosity of SAE 30 or SAE 40 that meets all API CF category requirements is preferred.
- Single grade oil with a viscosity of SAE 30 or SAE 40 with an API CF additive package and no viscosity improvers is acceptable oil.

For an acceptable commercial single grade oil, consult your Cat dealer.

Some commercial oils that meet the requirements API CF-4 category may require reduced oil change intervals. To determine the oil change interval, closely monitor the condition of the oil and perform a wear metal analysis. Cat S-O-S Services oil analysis program is the preferred method.

NOTICE

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

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.

Total Base Number (TBN) and Fuel Sulfur Levels

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

Note: The following information concerning oil life relative to used oil TBN level is provided for general information only, and is not the recommended method for determining oil life. **If the one half of new oil TBN guideline that is stated below is used for determining oil life it must only be used in conjunction with a complete S-O-S Services oil analysis program.**

Note: TBN is also commonly referred to as Base Number (BN).

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

Note: The minimum TBN of the new oil is 6.5 regardless of the fuel sulfur level. Reaching one half of new oil TBN is one of the condemning factors for diesel engine oil but, in order to help provide the best protection for your engine, Cat S-O-S Services oil analysis is the preferred method of determining oil life. For best results when determining oil life using the one half new oil TBN method, determine the new and used oil TBN using both the "ASTM D2896" and the "ASTM D4739" test methods. Change the oil when reaching one half of new oil TBN with either respective TBN test method using the results from which ever respective test method shows reaching one half of new oil TBN first.

Excessive piston deposits can be produced by oil with a high TBN and/or high ash. These deposits can lead to a loss of control of the oil consumption and to the polishing of the cylinder bore.

NOTICE

Depending on application severity and localized environmental conditions, and also depending on maintenance practices, operating Direct Injection (DI) diesel engines and operating PC (Precombustion Chamber) diesel engines on fuel with sulfur levels over 0.1 percent (1000 ppm) may require significantly shortened oil change intervals in order to help maintain adequate wear protection.

Consult with your Cat dealer regarding the testing that is required in establishing oil drain intervals that are optimized for your application.

Cat S-O-S Services oil analysis is:

- Recommended as a matter of course
- Very strongly recommended in order to determine oil drain intervals when operating on fuel with sulfur levels between 0.05% (500 ppm) and 0.5% (5000 ppm)
- Required in order to determine oil drain intervals when operating on fuel with sulfur levels that are above 0.5% (5000 ppm)

Note: Engine operating conditions play a key role in determining the effect that fuel sulfur will have on engine deposits and on engine wear. Consult your Cat dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

Lubricant Viscosity Recommendations

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

Refer to Table 5 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 5 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Generally, use the highest oil viscosity that is allowed for the ambient temperature at start-up.

Table 5

Lubricant Viscosities for Ambient Temperatures ⁽¹⁾		
Cat SAEO Viscosity Grade	Ambient Temperature	
	Minimum	Maximum
SAE 30	0 °C (32 °F)	40 °C (104 °F)
SAE 40	5 °C (41 °F)	50 °C (122 °F)

⁽¹⁾ Supplemental heat is recommended for cold-soaked starts below the minimum ambient temperature. Supplemental heat may be required for cold-soaked starts that are above the minimum temperature that is stated, depending on the parasitic load and other factors. Cold-soaked starts occur when the engine has not been operated for a period of time, allowing the oil to become more viscous due to cooler ambient temperatures.

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 Cat 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 contamination may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

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

Fuel

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

NOTICE

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

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

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

Specifications for Distillate Diesel Fuel

Note: Diesel fuel used to operate a Cat Marine Diesel Engine which is certified to US EPA Tier 3 Standards must also meet the “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines”. The acceptability of these fuels for use is determined on a case by case basis. A complete fuel analysis is required. Consult your Cat dealer for further information.

NOTICE

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

Table 6

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”

(continued)

(Table 6, contd)

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	Requirements	ASTM Test	ISO Test
Thermal Stability	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	“D6468”	No equivalent test
API Gravity ⁽²⁾	30 minimum	“D287”	No equivalent test
	45 maximum		
Pour Point	6 °C (10 °F) minimum below ambient temperature	“D97”	“ISO 3016”
Sulfur	⁽³⁾	“D5453” or “D2622”	ISO 20846 or ISO 20884
Kinematic Viscosity	1.4 cSt minimum and 20.0 cSt maximum as delivered to the fuel injection pumps	-	-
	1.4 cSt minimum and 4.5 cSt maximum as delivered to the rotary fuel injection pumps		
Water and Sediment	0.05% maximum	“D1796” or “D2709”	“ISO 3734”
Water	0.05% maximum	“D6304”	No equivalent test
Sediment	0.05% maximum (weight)	“D473”	“ISO 3735”

(continued)

(Table 6, contd)

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

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

Biodiesel

A biodiesel blend of up to 20 percent may be used in the engine when the fuel blend meets the recommendations in table 7 and meets the recommendations in Special Publication, SEBU6251, "Biodiesel". A blend of greater than 20 percent biodiesel may be acceptable in some cases. See your Cat dealer for more information.

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

Table 7

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

Fuel Additives

Cat Diesel Fuel Conditioner

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

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

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

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

Cat Diesel Fuel System Cleaner

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

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

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

Aftermarket Fuel Additives

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

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

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

Cooling System

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

WARNING

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

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

Avoid contact with coolant.

NOTICE

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

NOTICE

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

Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators. Removing the regulators allows some coolant to bypass the radiator, potentially causing overheating.

Coolant Recommendations

Table 8

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

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

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

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

Table 9

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 10

Recommended Interval		
Type of Coolant	Level 1	Level 2
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

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System Pressure Release

SMCS Code: 1250; 1300; 1350; 5050

Coolant System

WARNING

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

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

Fuel System

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

High Pressure Fuel Lines (If Equipped)

WARNING

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

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

This is because of the following differences:

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

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

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

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

Engine Oil

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

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Welding on Engines with Electronic Controls

SMCS Code: 1000

NOTICE

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

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

NOTICE

Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train, 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 accidentally move back and make contact with any of the ECM pins.

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

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

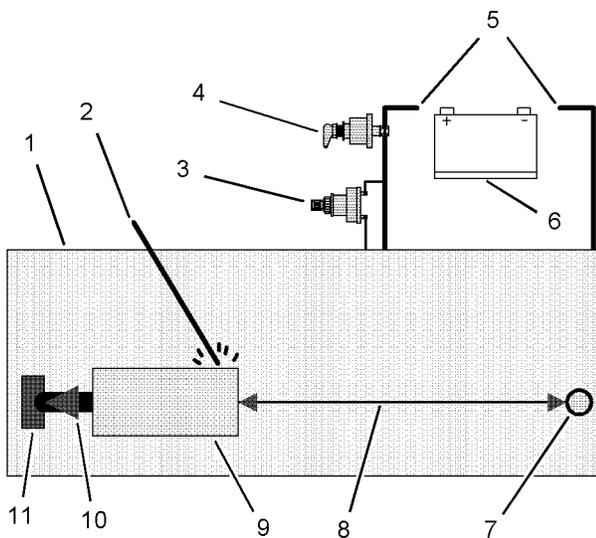


Illustration 21

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

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

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

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Maintenance Interval Schedule

SMCS Code: 1000; 4450; 7500

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

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

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

When Required

Battery - Recycle	52
Battery or Battery Cable - Disconnect	53
Coolant - Change	54
Coolant Extender (ELC) - Add	57
Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace	61
Engine Oil Level Gauge - Calibrate	65
Fuel System - Prime	70

Daily

Coolant Level - Check	57
Engine Air Cleaner Service Indicator - Inspect	63
Engine Oil Level - Check	64
Fuel System Water Separator - Check/Drain	72
Transmission Oil Level - Check	80
Walk-Around Inspection	80

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

Coolant Sample (Level 2) - Obtain	59
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Every Year

Coolant Sample (Level 2) - Obtain	59
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Every 1500 L (400 US gal) of Fuel or 50 Service Hours

Zinc Rods - Inspect/Replace	82
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First 7500 L (2000 US gal) of Fuel or 250 Service Hours

Engine Valve Lash - Check	69
Fuel Injection Timing - Check	69

Every 7500 L (2000 US gal) of Fuel or 250 Service Hours or 1 Year

Auxiliary Water Pump (Rubber Impeller) - Inspect	52
Battery Electrolyte Level - Check	53
Belts - Inspect/Adjust/Replace	53
Coolant Sample (Level 1) - Obtain	58
Cooling System Supplemental Coolant Additive (SCA) - Test/Add	60
Engine Crankcase Breather - Clean	64
Engine Oil Sample - Obtain	66
Engine Oil and Filter - Change	67
Fuel System Primary Filter (Water Separator) Element - Replace	71
Fuel System Secondary Filter - Replace	72
Fuel Tank Water and Sediment - Drain	73
Hoses and Clamps - Inspect/Replace	74
Sea Water Strainer - Clean/Inspect	80
Water Pump - Inspect	81

Every 30 000 L (8000 US gal) of Fuel or 1000 Service Hours or 2 Years

Aftercooler Core - Clean/Test	52
Engine Protective Devices - Check	68
Engine Speed/Timing Sensor - Clean/Inspect	69
Turbocharger - Inspect	80

Every 60 000 L (16 000 US gal) of Fuel or 2000 Service Hours

Engine Mounts - Inspect	64
Engine Valve Lash - Check	69
Fuel Injection Timing - Check	69
Heat Exchanger - Inspect	74

Every 91 000 L (24 000 US gal) of Fuel or 3000 Service Hours or 2 Years

Coolant Temperature Regulator - Replace	59
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Overhaul

Overhaul Considerations	77
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Aftercooler Core - Clean/Test

SMCS Code: 1064-070; 1064-081

1. Remove the core. Refer to the Service Manual for the procedure.
2. Turn the aftercooler core upside-down in order to remove debris.

NOTICE

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

3. Back flush the core with cleaner.

Caterpillar recommends the use of hot Hydrosolv 100 liquid cleaner at a concentration of 30% and at a temperature of 66° to 82°C (150° to 180°F). Table 11 lists the recommended Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 11

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

⁽¹⁾ Refer to Application Guide, NEHS0526 or consult your Caterpillar dealer for more information.

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

WARNING

Personal injury can result from air pressure.

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

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

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

7. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.

8. Install the core. Refer to the Service Manual for the procedure.

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

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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 of more than 103 kPa (15 psi).

Check the following components for wear or damage:

- Bearings
- Impeller
- Seals
- Wear plate
- Key

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 Manual for more information on servicing the auxiliary water pump.

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Battery - Recycle

SMCS Code: 1401-005; 1401-510; 1401-535; 1401-561; 1401

Always recycle a battery. Never discard a battery.

Always return used batteries to one of the following locations:

- A battery supplier

- An authorized battery collection facility
- Recycling facility

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Battery Electrolyte Level - Check

i02601752

SMCS Code: 1401-535-FLV

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

WARNING

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

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

If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

2. Check the condition of the electrolyte with the 245-5829 Coolant Battery Tester Refractometer.
3. Keep the batteries clean.

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

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

Thoroughly rinse the battery case with clean water.

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

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.

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Belts - Inspect/Adjust/Replace

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

Inspection

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

Check the belt tension. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" topic (Maintenance Section) for the proper intervals.

To check the belt tension, apply 110 N (25 lb ft) of force midway between the pulleys. A correctly adjusted belt will deflect 9 mm (0.35 inch) to 15 mm (0.59 inch).

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

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

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

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

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

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

- If the engine is equipped with a refrigerant compressor (air conditioner), the belts for the following components will have automatic belt tensioners: the alternator, the fan drive, and the accessories
- If the engine is not equipped with a refrigerant compressor, the alternator is used to adjust the belt tension.

Adjustment

Alternator Belt

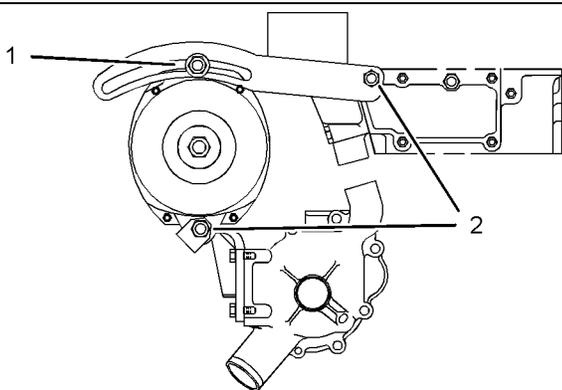


Illustration 22

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- (1) Adjusting bolt
- (2) Mounting bolts

1. Slightly loosen mounting bolts (2) and adjusting bolt (1).
2. Move the pulley in order to adjust the belt tension.

3. Tighten adjusting bolt (1) and mounting bolts (2). For the proper torque, refer to the Specifications Manual, SENR3130, "Torque Specifications".

4. Install the belt guard.

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

Water Pump Belt

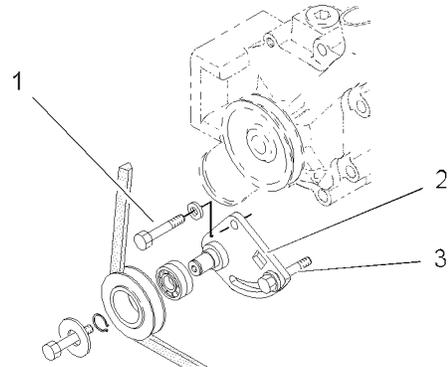


Illustration 23

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Exploded view of the drive assembly for a water pump belt

- (1) Mounting bolt
- (2) Square hole
- (3) Adjusting bolt

1. Slightly loosen mounting bolts (1) and adjusting bolt (3).
2. Adjust the belt tension with a square drive in square hole (2).
3. Tighten adjusting bolt (3) and mounting bolt (1). For the proper torque, refer to the Specifications Manual, SENR3130, "Torque Specifications".

4. Install the belt guard.

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

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Coolant - Change

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

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

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

- The engine overheats frequently.

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

Drain the Cooling System

WARNING

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

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

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

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

Allow the coolant to drain.

NOTICE

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

For information regarding the disposal and the recycling of used coolant, consult your Cat dealer or consult Cat Dealer Service Tool Group:

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

Flush

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

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

NOTICE

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

3. Fill the cooling system with clean water. Install the cooling system filler cap.
4. Start and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual, SENR3130, "Torque Specifications" for more information on the proper torques.

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

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

NOTICE

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

5. Fill the cooling system with a mixture of clean water and Cat Fast Acting Cooling System Cleaner.
6. Choose 1 of the following options.
 - Add 0.5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity.
 - For cooling systems with heavy deposits or plugging, add 0.5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity.
7. Install the cooling system filler cap.
8. Start and run the engine at low idle for a minimum of 30 minutes. For cooling systems with heavy deposits or plugging, run the engine for 90 minutes. The coolant temperature should be at least 82 °C (180 °F).

NOTICE

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

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

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

Fill the Cooling System

NOTICE

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

1. Fill the cooling system. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for more information on cooling system specifications. Refer to this Operation and Maintenance Manual, "Refill Capacities" for information about the capacity of the cooling system. Do not install the cooling system filler cap.
2. Start and run the engine at low idle. Increase the engine rpm to high idle. Run the engine at high idle for 1 minute in order to purge the air from the cavities of the engine block. Stop the engine.
3. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 inch) to the proper level on the sight glass (if equipped).
4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. Only install the used filler cap if the gasket is not damaged. Use a 9S-8140 Pressurizing Pump to pressure test a reinstalled cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

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Coolant Extender (ELC) - Add

SMCS Code: 1352-544-NL

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

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

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

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

WARNING

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

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

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

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

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

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

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

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

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Coolant Level - Check

SMCS Code: 1395-082

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

Engines That Are Equipped with a Coolant Recovery Tank

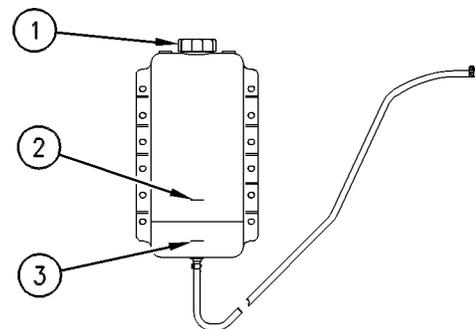


Illustration 24

g00103638

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

1. Observe the coolant level in the coolant recovery tank. Maintain the coolant level to "COLD FULL" mark (2) on the coolant recovery tank.
2. Loosen filler cap (1) slowly in order to relieve any pressure. Remove the filler cap.

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3. Pour the proper coolant mixture into the tank. Refer to this Operation and Maintenance Manual, "Refill Capacities" for information about coolants. Do not fill the coolant recovery tank above "COLD FULL" mark (2).
4. Clean filler cap (1) and the receptacle. Reinstall the filler cap and inspect the cooling system for leaks.

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

Engines That Are Not Equipped with a Coolant Recovery Tank

WARNING

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

1. Remove the cooling system filler cap slowly in order to relieve pressure.
2. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.

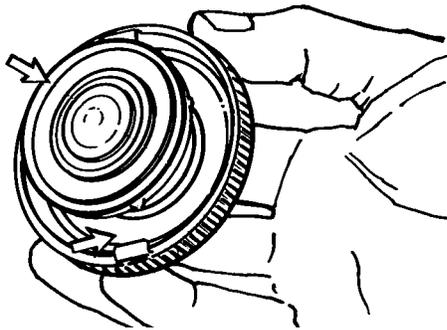


Illustration 25

g00103639

Typical filler cap gaskets

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

Coolant 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.

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- 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 12

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.

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".

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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.

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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.

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

SMCS Code: 1352-045; 1395-081

WARNING

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

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

Test for SCA Concentration

Coolant and SCA

NOTICE

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

Use the 8T-5296 Coolant Conditioner Test Kit or use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA. Refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" for more information.

Water and SCA

NOTICE

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

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit. Refer to the Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for more information.

S·O·S Coolant Analysis

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

Level 1

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

- Glycol Concentration
- Concentration of SCA
- pH
- Conductivity

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

Level 2

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

Add the SCA, If Necessary

NOTICE

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

WARNING

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

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

Note: Always discard drained fluids according to local regulations.

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

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

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

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

NOTICE

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

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 should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Cleaning the Air Cleaner Element

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

NOTICE

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

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

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

- Pressurized air
- Vacuum cleaning

Pressurized Air

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.

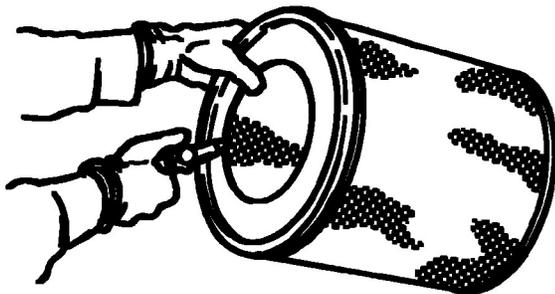


Illustration 26

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Typical air cleaner element

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

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

Vacuum Cleaning

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

Inspecting the Air Cleaner Element

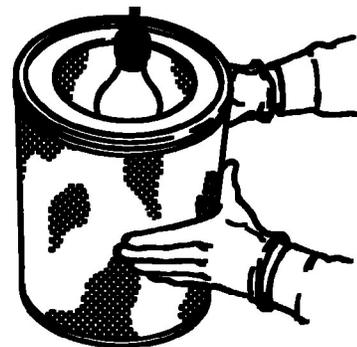


Illustration 27

g02633320

Typical air cleaner element

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

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

Replacing the Air Cleaner Element

Note: Replace an old air cleaner element with a new air cleaner element after the old element has been cleaned six times.

Storing the Air Cleaner Elements

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

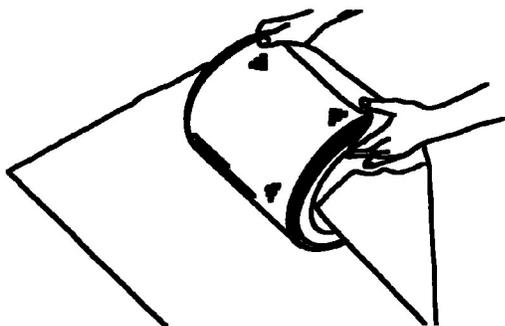


Illustration 28

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

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

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

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Engine Air Cleaner Service Indicator - Inspect (If Equipped)

SMCS Code: 7452-040

Some engines may be equipped with a different service indicator.

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

The service indicator may be mounted on the air cleaner housing or in a remote location.

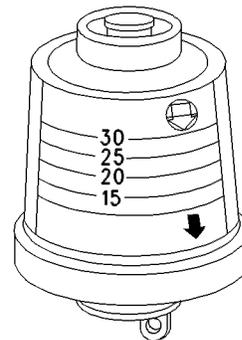


Illustration 29

g00103777

Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated speed. The yellow core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be plugged.

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

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

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Engine Crankcase Breather - Clean

SMCS Code: 1317-070

NOTICE

Perform this maintenance with the engine stopped.

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

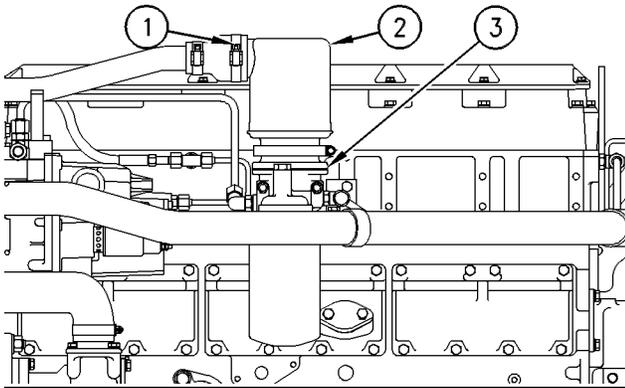


Illustration 30

g00516808

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

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

Engine Mounts - Inspect

SMCS Code: 1152-040; 1152

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

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

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

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Engine Oil Level - Check

SMCS Code: 1348-535-FLV

Check the oil level after the engine has stopped. This maintenance procedure must be performed on a level surface.

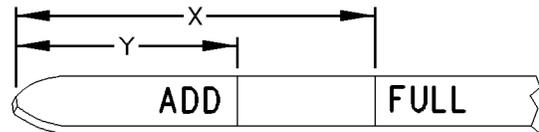


Illustration 31

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

1. Maintain the oil level between the "ADD" mark (Y) and the "FULL" mark (X) on the oil level gauge. 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 and add oil, if necessary. Clean the oil filler cap. Reinstall the oil filler cap.

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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 angle of installation can be different for each engine. The angle of installation will affect the "ADD" mark (Y) and the "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. Table 13 and Table 14 list the corresponding "ADD" mark, "FULL" mark and the angle of installation. Use a marking pen in order to engrave "ADD" mark (Y) and "FULL" mark (X) on the engine oil level gauge according to the information in Table 13 or Table 14.

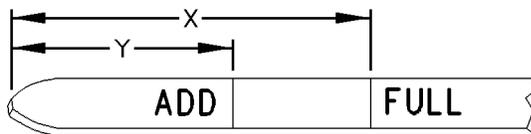


Illustration 32
Oil Level Gauge
(Y) "ADD" mark
(X) "FULL" mark

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Calibration of Oil Level Gauge

Table 13

Engine Oil Level Gauge 4KG1-05782 1SK1-01724 8NM1-01465		
Angle ⁽¹⁾	"FULL" Mark (X)	"ADD" Mark (Y)
15 degrees	156 mm (6.14 inch)	137 mm (5.39 inch)
14 degrees	151 mm (5.95 inch)	133 mm (5.24 inch)
13 degrees	148 mm (5.83 inch)	129 mm (5.08 inch)
12 degrees	144 mm (5.67 inch)	125 mm (4.92 inch)
11 degrees	139 mm (5.47 inch)	119 mm (4.69 inch)
10 degrees	136 mm (5.35 inch)	115 mm (4.53 inch)
9 degrees	130 mm (5.12 inch)	114 mm (4.49 inch)
8 degrees	128 mm (5.04 inch)	113 mm (4.45 inch)
7 degrees	121 mm (4.76 inch)	114 mm (4.49 inch)
6 degrees	117 mm (4.61 inch)	107 mm (4.21 inch)
5 degrees	113 mm (4.45 inch)	100 mm (3.94 inch)
4 degrees	112 mm (4.41 inch)	93 mm (3.66 inch)
3 degrees	111 mm (4.37 inch)	88 mm (3.47 inch)
2 degrees	109 mm (4.29 inch)	81 mm (3.19 inch)
1 degree	102 mm (4.02 inch)	76 mm (2.99 inch)
0 degrees	96 mm (3.78 inch)	70 mm (2.76 inch)

⁽¹⁾ The angle indicates the number of degrees that the front of the engine is raised.

Table 14

Engine Oil Level Gauge 4KG05783-UP 1SK01725-UP 8NM01466-UP 6SR1-UP 1ZJ1-UP 6MK1-UP		
Angle ⁽¹⁾	“FULL” Mark (X)	“ADD” Mark (Y)
10 degrees	125 mm (4.92 inch)	114 mm (4.49 inch)
9 degrees	124 mm (4.89 inch)	106 mm (4.17 inch)
8 degrees	122 mm (4.80 inch)	102 mm (4.02 inch)
7 degrees	120 mm (4.72 inch)	96 mm (3.78 inch)
6 degrees	115 mm (4.53 inch)	89 mm (3.50 inch)
5 degrees	110 mm (4.33 inch)	81 mm (3.19 inch)
4 degrees	101 mm (3.98 inch)	71 mm (2.80 inch)
3 degrees	94 mm (3.70 inch)	66 mm (2.60 inch)
2 degrees	90 mm (3.54 inch)	59 mm (2.32 inch)
1 degree	82 mm (3.23 inch)	52 mm (2.05 inch)
0 degrees	76 mm (2.99 inch)	46 mm (1.81 inch)
-1 degree	65 mm (2.56 inch)	39 mm (1.54 inch)
-2 degrees	59 mm (2.32 inch)	33 mm (1.30 inch)
-3 degrees	53 mm (2.09 inch)	26 mm (1.02 inch)
-4 degrees	46 mm (1.81 inch)	20 mm (0.79 inch)
-5 degrees	39 mm (1.54 inch)	12 mm (0.47 inch)

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

Verifying the Calibration of the Oil Level Gauge

Caterpillar recommends verifying the calibration of the oil level gauge at the first oil change. Use the following procedure to verify the “FULL” mark on the oil level gauge:

Note: The vessel must be level in order to perform this procedure.

1. Operate the engine until normal operating temperature is achieved. Stop the engine. Remove one of the drain plugs for the engine crankcase. Allow the engine oil to drain.
2. Remove the used engine oil filter. Install the new engine oil filter. Install the crankcase drain plug and tighten the crankcase drain plug.
3. Add 25 L (26.5 qt) of the recommended oil grade and weight of engine oil to the crankcase.

Note: The engine may be equipped with auxiliary engine oil filters which require additional oil. Refer to the OEM specifications.

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.

NOTICE

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

Turbocharger (if equipped) damage can result, if the engine rpm is not kept low until the engine oil light/gauge verifies the oil pressure is sufficient.

4. Start the engine. Ensure that the lubrication system and the new engine oil filter is filled. Inspect the lubrication system for leaks.
5. Stop the engine and allow the engine oil to drain into the engine crankcase for approximately ten minutes.
6. Check the engine oil level. If necessary, use a marking pen in order to correct the “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.

i02107152

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

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

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

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

Replace the Oil Filter

NOTICE

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

1. Remove the oil filter with a 1U-8760 Chain Wrench.
2. Cut the oil filter open with a 175-7546 Oil Filter Cutter Gp. 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 33

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

NOTICE

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

NOTICE

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

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

100626013

Engine Protective Devices - Check

SMCS Code: 7400-535

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

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

NOTICE

During testing, abnormal operating conditions must be simulated.

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

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

Visual Inspection

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

i04748255

i04242309

Engine Speed/Timing Sensor - Clean/Inspect (Magnetic Pick-ups)

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

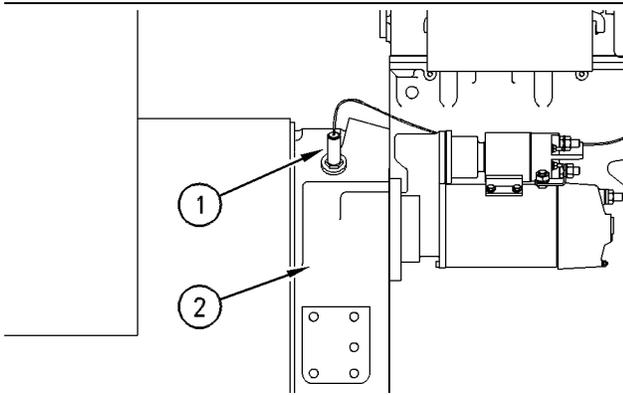


Illustration 34

g00293335

Typical example

- (1) Magnetic pickup
(2) Flywheel housing

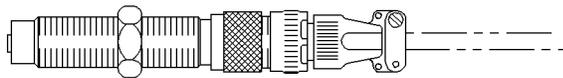


Illustration 35

g00293337

Typical magnetic pickup

1. Remove magnetic pickup from flywheel housing. Check the condition of the end of the magnetic pickup. Check for signs of wear and contaminants.
2. Clean the metal shavings and other debris from the face of the magnet.
3. Install the magnetic pickup and adjust the magnetic pickup. Contact your Cat dealer for further information.

Engine Valve Lash - Check

SMCS Code: 1105-535

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

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

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

WARNING

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

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

i00850658

Fuel Injection Timing - Check

SMCS Code: 1251-036-TM; 1290-036-TM

Note: The correct fuel timing specification is found on the Engine Information Plate. Fuel timing specifications may vary for different engine applications and/or for different power ratings.

A qualified mechanic should adjust the fuel injector timing because special tools and training are required.

Refer to your Caterpillar dealer for the complete adjustment procedure for the fuel injector timing.

i01007661

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.

Prime the fuel system in order to fill the fuel filter. Prime the fuel system in order to purge trapped air. The fuel system should be primed under the following conditions:

- Running out of fuel
- Storage
- Replacement of the fuel filter

Engines that are Equipped with a Fuel Priming Pump

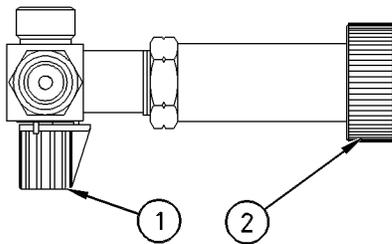


Illustration 36

g00516899

- (1) Select knob
(2) Plunger

1. Turn select knob (1) counterclockwise until the indicator is in line with the body of the priming pump.
2. Unlock the plunger and operate the plunger until a resistance is felt. A considerable number of pump strokes may be required.
3. Push in plunger (2) and tighten by hand.
4. Turn select knob (1) clockwise until the indicator is in line with the fuel outlet.

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.

5. Promptly start the engine. If the engine runs rough, increase the engine rpm to one half of the rated rpm.

Note: If the engine will not start, further priming may be necessary. If the engine continues to misfire or smoke after starting, further priming may be necessary.

Engines that are Not Equipped with a Fuel Priming Pump

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.

If the engine is not equipped with a fuel priming pump, it may be necessary to fill the fuel filter with clean fuel. The following procedure will only allow filtered fuel to enter the fuel system.

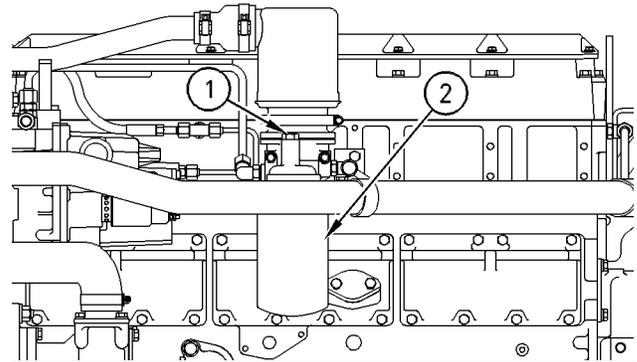


Illustration 37

g00516900

- (1) Plug
(2) Fuel filter

1. Remove plug (1) in order to fill fuel filter (2). Ensure that air is able to vent from the fitting of the plug while the fuel filter is being filled. Clean up any spilled fuel immediately. Clean plug (1). Install plug (1).

NOTICE

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

2. Start the engine and immediately increase the engine rpm to one half of the rated rpm.
3. Maintain the engine rpm until the engine operates smoothly.
4. Reduce the engine rpm to low idle.

i02927282

Fuel System Primary Filter (Water Separator) Element - Replace

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

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

The primary filter/water separator also provides filtration in order to help extend the life of the secondary fuel filter. The element should be changed regularly. If a vacuum gauge is installed, the primary filter/water separator should be changed at 50 to 70 kPa (15 to 20 inches Hg).

Replace the Element

WARNING

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

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

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

1. Close the main fuel supply valve.

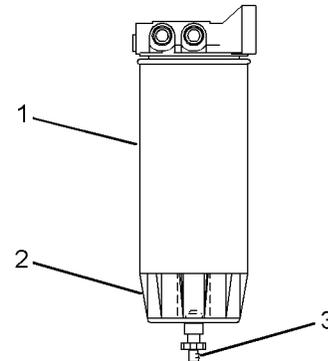


Illustration 38

g01453091

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

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

Inspect the O-ring for damage and for deterioration. Replace the O-ring, if necessary.
5. Lubricate the O-ring with clean diesel fuel.
6. Install bowl (2) on a new element. Tighten the bowl by hand. Do not use tools in order to tighten the bowl.

NOTICE

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

7. Lubricate the top seal of element (1) with clean diesel fuel. The element may be filled with fuel at this time. Install the new element on the mounting base. Tighten the element by hand.

NOTICE

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

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

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

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.

i04170131

Fuel System Water Separator - Check/Drain

SMCS Code: 1263-535; 1263-543

 **WARNING**

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

NOTICE

The water separator is not a filter. It separates water from the fuel.

The engine should never be allowed to run with the water level in the separator more than 1/2 full or engine damage may result.

A water separator is recommended. The water separator should be installed between the fuel tank and the engine fuel inlet. Drain the water and sediment from the water separator on a daily basis.

i04363480

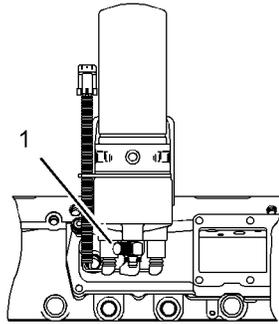


Illustration 39

g01076474

(1) Drain

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. Open drain (1). Catch the draining water in a suitable container. Dispose of the water properly.

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.

2. Close drain (1).

Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

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

Drain the Water and the Sediment

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

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

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

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

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank during the following conditions:

- Weekly
- Oil change
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A four micron(c) absolute filter for the breather vent on the fuel tank is also recommended.

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.

i01057362

Heat Exchanger - Inspect

SMCS Code: 1379-040

The interval for the maintenance of the tube and fin heat exchanger depends on the operating environment of the vessel and on the operating time. The sea water that is circulated through the heat exchanger and the amount of operating time of the vessel affects the following items:

- Cleanliness of the tubes of the heat exchanger
- Effectiveness of the heat exchanger system

Operating in water that contains silt, sediment, salt, algae, etc will adversely affect the heat exchanger system. In addition, intermittent use of the vessel will adversely affect the heat exchanger system.

The following items indicate that the heat exchanger may require cleaning:

- Increased coolant temperature
- Engine overheating
- Excessive pressure drop between the water inlet and the water outlet

An operator that is familiar with the normal operating temperature of the coolant can determine when the coolant temperature is out of the normal range. Inspection and maintenance of the heat exchanger are required if the engine is overheating.

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

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

i04301694

Hoses and Clamps - Inspect/Replace

SMCS Code: 7554-040; 7554-510

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

Note: Always use a board or cardboard when the engine components are checked for leaks. Leaking fluid that is under pressure can cause serious injury or possible death. Leaks that are the size of a pin hole are included. Refer to Operation and Maintenance Manual, "General Hazard Information" for more information.

Inspect the Hoses and the Clamps

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

- Hoses which are cracked
- Hoses which are soft
- Outer covering that is chafed or cut

- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering
- Hoses which exhibit signs of leakage which are not the result of loose couplings or clamps

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

- Cracking
- Looseness
- Damage

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

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

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

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

Replace the Hoses and the Clamps

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

Cooling System

WARNING

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

WARNING

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

Failure to relieve pressure can cause personal injury.

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

1. Stop the engine.
2. Allow the engine to cool.
3. Before servicing a coolant hose, slowly loosen the filler cap for the cooling system in order to relieve any pressure.
4. Remove the filler cap for the cooling system.
5. Drain the coolant from the cooling system to a level that is below the hose that is being replaced. Drain the coolant into a suitable clean container. The coolant can be reused.
6. Remove the hose clamps.

7. Disconnect the old hose.
8. Replace the old hose with a new hose.
9. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, "Torque Specifications", "Hose Clamps" for information about selecting and installing the proper hose clamps.
10. Refill the cooling system.
11. Clean the filler cap for the cooling system. Inspect the gaskets on the filler cap. Replace the filler cap if the gaskets are damaged. Install the filler cap.
12. Start the engine. Inspect the cooling system for leaks.

Fuel System

WARNING

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

Failure to relieve pressure can cause personal injury.

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

WARNING

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

NOTICE

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

NOTICE

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

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

1. Drain the fuel from the fuel system to a level that is below the hose that is being replaced.
 2. Remove the hose clamps.
 3. Disconnect the old hose.
 4. Replace the old hose with a new hose.
 5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, "Torque Specifications", "Hose Clamps" for information about selecting and installing the proper hose clamps.
 6. Carefully inspect the engine for any spilled fuel. Make sure that no fuel remains on or close to the engine.
- Note:** Fuel must be added to the fuel system ahead of the fuel filter.
7. Refill the fuel system. Refer to this Operation and Maintenance Manual, "Fuel System - Prime" for information about priming the engine with fuel.
 8. Start the engine. Inspect the fuel system for leaks.

Lubrication System

WARNING

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

1. Drain the oil from the lubrication system to a level that is below the hose that is being replaced.
2. Remove the hose clamps.
3. Disconnect the old hose.
4. Replace the old hose with a new hose.
5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, "Torque Specifications", "Hose Clamps" for information about selecting and installing the proper hose clamps.

6. Refill the lubrication system. Refer to this Operation and Maintenance Manual, "Engine Oil Level - Check" in order to ensure that the lubrication system is filled with the proper amount of engine oil.
7. Start the engine. Inspect the lubrication system for leaks.

Air System

1. Remove the hose clamps.
2. Disconnect the old hose.
3. Replace the old hose with a new hose.
4. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, "Torque Specifications", "Hose Clamps" for information about selecting and installing the proper hose clamps.

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

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

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Overhaul Considerations

SMCS Code: 7595-043

The following items can increase the engine service life before an overhaul is required:

- Use only lubricants that are recommended by Caterpillar.
- Follow the recommended guidelines for maintenance.
- Use an S-O-S Oil Analysis to determine the maximum interval for changing the oil filter and the oil.
- Follow the rating definitions that are recommended for the engine.

Repair of Piston, Ring, And Bore As An Indicator

Investigate the piston, the ring, and the bore or repair the piston, the ring, and the bore if one of the following conditions occurs:

- Oil consumption is in excess of 1 quart of oil per 60 gallons of fuel that is consumed. The oil consumption must not be caused by leakage.

- Crankcase blowby is in excess of 2 cubic feet per hour per horsepower. Measure the crankcase blowby with an 8T-2700 Blowby Indicator .
- Fuel consumption has increased.
- Loss of power has occurred.

The cylinder head must be removed in order to repair the piston, the ring, and the bore. After removing the cylinder head, inspect the valves and the valve seats. Repair the valve and the valve seats, if necessary. Determine if any other components of the engine should be inspected.

Overhaul Options

Before Failure Overhaul

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

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

After Failure Overhaul

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

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

This lower cost can be attributed to three aspects:

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

Overhaul Recommendation

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

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

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

Rebuild or Exchange

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

- Cylinder head assembly
- Connecting rods
- Pistons
- Turbocharger
- Oil pump
- Fuel ratio control
- Cam followers
- Fuel Transfer pump
- Timing advance

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

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

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

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

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

Component Replacement

Replace the following components during the overhaul:

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

Inspection

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

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

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

Inspect the crankshaft for any of the following conditions:

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

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the rod bearings and main bearings.

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

Replace the crankshaft vibration damper if any of the following conditions are found:

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

Inspect the gear train for the following conditions:

- Worn gear teeth
- Unusual fit
- Unusual wear

Testing

Test the following components during the overhaul:

- Fuel injection nozzles
- Fuel injection pump
- Governor

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

Cleaning

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

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

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

Obtain Coolant Analysis

The concentration of supplemental coolant additive (SCA) should be checked regularly with test kits or with S·O·S Coolant Analysis (Level 1). Further coolant analysis is recommended when the engine is overhauled.

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

A coolant analysis can be conducted in order to verify the condition of the water that is being used in the cooling system. A full water analysis can be obtained by consulting your local water utility company or an agricultural agent. Private laboratories are also available for water analysis.

Caterpillar Inc. recommends an S·O·S Coolant Analysis (Level 2).

S·O·S Coolant Analysis (Level 2)

An S·O·S Coolant Analysis (Level 2) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S·O·S Coolant Analysis (Level 2) provides the following information:

- Complete S·O·S Coolant Analysis (Level 1)
- Visual inspection of properties
- Identification of metal corrosion
- Identification of contaminants
- Identification of built up impurities (corrosion and scale)

S·O·S Coolant Analysis (Level 2) provides a report of the results of both the analysis and the maintenance recommendations that are based on the analysis.

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

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Sea Water Strainer - Clean/Inspect

SMCS Code: 1371-040; 1371-070

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

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

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

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Transmission Oil Level - Check

SMCS Code: 3030-535-FLV

Check the marine transmission oil level according to the instructions that are provided by the OEM of the transmission or the OEM of the vessel.

For the lubrication requirements of the transmission, refer to the recommendations on the nameplate or the service information for the transmission.

Marine Transmission Operation, Maintenance, Warranty, and Parts Support

For information on maintenance and operation of the marine transmission, consult your Cat dealer and/or the OEM dealer of the transmission.

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

Turbocharger - Inspect

SMCS Code: 1052-040

Periodic cleaning is recommended for the turbocharger compressor (inlet side). The following items collect in the turbocharger compressor housing since the fumes from the crankcase travel through the inlet air: oil, by-products from oil, and by-products from combustion. The buildup reduces boost and air flow. The buildup also contributes to loss of engine power, increased black smoke, and overall loss of engine efficiency.

Cleaning and Inspecting

1. Remove the air inlet piping from the turbocharger and remove the compressor housing from the turbocharger.
2. Clean the turbocharger compressor housing with Hydrosolv Liquid Cleaners and a hard bristle brush.
3. Clean the turbocharger compressor wheel and clean the backplate assembly with 4C-4079 Brake and Electric Cleaner.

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Walk-Around Inspection

SMCS Code: 1000-040

Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections and trash buildup. Make repairs, as needed:

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE

For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE

Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove this debris with steam cleaning or high pressure water.

- Ensure that cooling lines are properly clamped and that cooling lines are tight. Check for leaks. Check the condition of all pipes.
- Check the marine transmission oil level. Refer to the OEM specification for the marine transmission or refer to the OEM specification for the vessel.
- Inspect the water pumps for coolant leaks.

Note: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pumps and the installation of water pumps and/or seals, refer to the Service Manual for the engine or consult your Caterpillar dealer.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Inspect the alternator belt and the accessory drive belts for cracks, breaks or other damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt is replaced, the belt will carry more load than the belts that are not replaced. The older belts are stretched. The additional load on the new belt could cause the belt to break.

- Drain the water and the sediment from fuel tanks on a daily basis in order to ensure that only clean fuel enters the fuel system.

- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges which are cracked or any gauges that can not be calibrated.

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Water Pump - Inspect

SMCS Code: 1361-040

A failed water pump might cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head
- A piston seizure
- Other potential damage to the engine

A failed water pump might cause severe engine overheating problems that could result in cracks in the cylinder head, a piston seizure or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking of the water pump seals is observed, replace all of the water pump seals. Refer to two articles in the Disassembly and Assembly Manual, "Water Pump - Disassemble and Water Pump - Assemble" for the disassembly and assembly procedure. If it is necessary to remove the water pump, refer to two articles in the Disassembly and Assembly Manual, "Water Pump - Remove and Water Pump - Install".

Inspect the water pump for wear, cracks, pin holes and proper operation. Refer to the Parts Manual for the correct part numbers for your engine or consult your Caterpillar dealer if repair is needed or replacement is needed.

i01007424

Zinc Rods - Inspect/Replace

SMCS Code: 1388-040; 1388-510

Corrosion in sea water circuits can result in premature deterioration of cooling system components, leaks, and possible cooling system contamination. The corrosion may be caused by the lack of zinc rods in the sea water system.

Zinc rods are inserted in the sea water cooling system of the engine in order to help prevent the corrosive oxidation that is caused by sea water. The reaction of the zinc to the sea water causes the zinc rods to oxidize rather than the cooling system components. Rapid deterioration of zinc rods may indicate the presence of uncontrolled electrical currents from improperly installed electrical attachments or improperly grounded electrical attachments.

The zinc rods must be inspected at the proper intervals. The zinc rods must be replaced when deterioration occurs.

Inspect the Zinc Rods

The zinc rods are red for easy identification. Table 15 shows the locations of the zinc rods and the quantities of the zinc rod:

Table 15

Locations of the Zinc Rods	
Location	Quantity
Heat Exchanger	3
Transmission Oil Cooler ⁽¹⁾	2
Exhaust Elbow ⁽²⁾	1
Aftercooler ⁽³⁾	5

⁽¹⁾ Zinc rods will only be located in marine transmission oil coolers that are cooled with sea water.

⁽²⁾ Exhaust elbows that are aftermarket may or may not be equipped with zinc rods.

⁽³⁾ 3126 Engine Only

1. Remove the zinc rod.
2. Inspect the zinc rod.

Ensure that the zinc rod will remain effective until the next scheduled inspection.

- a. If the zinc rod has deteriorated excessively, install a new zinc rod.

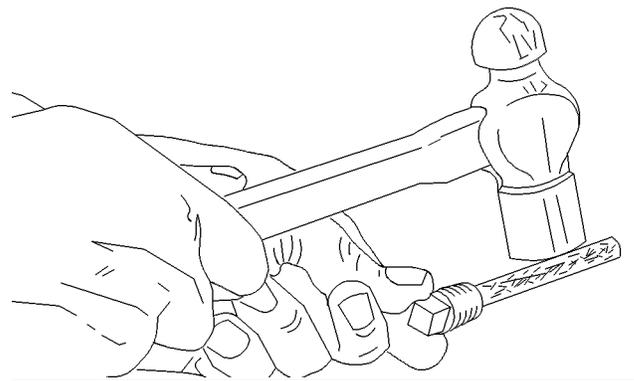


Illustration 40

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- b. Tap the zinc rod lightly with a hammer. If the zinc rod flakes, install a new zinc rod.
3. If the zinc rod will be reused, scrape the layer of oxidation from the zinc rod before installation. The layer of oxidation reduces the effectiveness of the zinc rod.

Replace the Zinc Rods

1. Unscrew the old zinc rod from the plug.

If not enough material remains or the zinc rod has broken off, drill the old zinc rod from the plug.

2. Clean the plug.

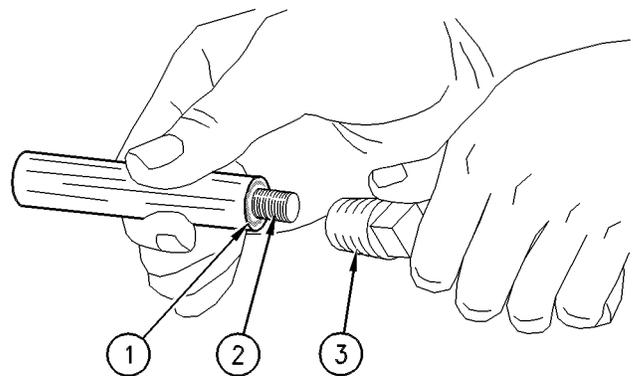


Illustration 41

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- (1) Shoulder of the zinc rod
- (2) Threads of the zinc rod
- (3) External threads of the plug

Note: DO NOT apply adhesive or sealant to threads (2) of the zinc rod.

3. Apply 9S-3263 Thread Lock Compound to shoulder (1) of a new zinc rod. Apply the compound ONLY to the shoulder of the zinc rod. Install the zinc rod onto the plug.

4. Coat external threads (3) of the plug with 5P - 3413 Pipe Sealant. Install the zinc rod. Refer to the Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section).

Reference Information Section

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Engine Ratings

i00727327

Engine Rating Conditions

SMCS Code: 1000

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

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

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

The engine ratings are based on the following fuel specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .849 at 15 °C (60 °F)
- Density of 850 kg/m³ (7.085 lb/US gal)

The engine ratings are gross output ratings.

Gross Output Ratings – The total output capability of the engine that is equipped with standard accessories.

Standard accessories include the following components:

- Oil pumps
- Fuel pumps
- Water pumps

Subtract the power that is required to drive auxiliary components from the gross output. This will produce the net power that is available for the external load (flywheel).

Engine Rating Definitions

SMCS Code: 1000

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

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

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

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

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

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

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

NOTICE

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

Typical operating parameters for each rating level are summarized in Table 16. Table 16 assumes the use of a fixed pitch propeller. If a variable pitch propeller is used, consult your Caterpillar dealer for marine engine performance and for information on reduced engine rpm. Optimum fuel consumption can be achieved by operating the engine at the Suggested Reduced rpm.

Table 16

3116 & 3126 Marine Engine Ratings			
Rating Level	Full Throttle		Suggested Reduced rpm "Cruising Speed"
	Time	Rated rpm	
A	Up to 100 percent	2400	-
B	Up to 80 percent	2400	-
C	Up to 50 percent	2400	2200
D	Up to 16 percent	2600	2200
E	Up to 8 percent	2800	2400

For most applications, the customer can provide profile information from similar vessels or from the actual vessel. If the information that is provided by the customer is not sufficient, instruments are available to more precisely define the operating profile. A 7D-1513 Tachograph Assembly can establish an operating profile by recording engine rpm versus time on a paper graph.

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Marine Classification Society Certification Requirements

SMCS Code: 1000

The major seafaring nations have established technical groups called marine classification societies. Caterpillar Inc. has maintained standards and quality under the guidelines that are set forth by the 14 major marine classification societies that are listed. For more information, refer to Engine Data Sheet, 103.1 and Engine Data Sheet, 103.1.1 in the Caterpillar Technical Manual.

ABS – American Bureau of Shipping (USA)

BV – Bureau Veritas (France)

CCG – Canadian Coast Guard (Canada)

CCRS – China Corporation Register of Shipping (Taiwan)

CCS – China Classification Society (China)

CR – Croatian Register of Shipping (Croatia)

DnV – Det norske Veritas (Norway)

GL – Germanischer Lloyd (Germany)

KR – Korean Register of Shipping (Korea)

LR – Lloyd's Register of Shipping (Great Britain)

NK – Nippon Kaiji Kyokai (Japan)

PR – Polish Register (Poland)

RINa – Registro Italiano Navale (Italy)

RS – Maritime Register of Shipping (Russia)

Engine Performance and Performance Analysis Report (PAR)

i04537530

Engine Performance

SMCS Code: 1000

Today's marine operator is concerned with performance, cost of operation and satisfactory engine life. Traditionally, poor performance of the vessel is believed to result from a lack of engine performance or from a loss of engine performance. In fact, the engine is only one of numerous factors that influence the overall performance of a vessel.

Several factors determine the power demand on an engine. The engine does not have control over the demand that is caused by the vessel design. The vessel design includes the following features:

- Hull
- Propeller
- Drive train

Those features also affect the amount of power that is available to perform additional work. For example, those features affect the power that is used to drive an auxiliary pump.

If a problem with the performance of the vessel occurs, consider the following effects on power demand:

- Loads
- Condition of the vessel
- Vessel design
- Condition of the drive train
- Condition of the propeller

Deterioration of the engine systems decreases the ability of the engine to produce power and vessel speed. Engine systems include the cooling system, the lubrication system, the fuel system, etc. The engine is not likely to be the cause of poor fuel economy without excessive exhaust smoke and/or the loss of power.

If you have a valid problem with the engine's performance, consult an authorized Cat dealer for assistance.

If the engine is covered by a warranty, the Cat warranty will cover the cost in order to solve a valid deficiency of the engine's performance. However, if the engine is not at fault, all costs that are incurred will be the responsibility of the owner.

Note: Adjustment of the fuel system outside Caterpillar specified limits will not improve fuel efficiency. Adjustment of the fuel system outside Caterpillar specified limits could also result in damage to the engine.

Cat engines are manufactured with state-of-the-art technology. Cat engines are designed to help provide two characteristics in all applications:

- Maximum performance
- Fuel efficiency

To ensure optimum performance for the service life of the engine, follow the recommended operation procedures that are described in this manual. Also, follow the preventive maintenance procedures that are described in this manual.

Performance Analysis Report (PAR)

To verify the condition of the propulsion system, Caterpillar has developed the Performance Analysis Report (PAR) for marine engines.

A PAR is an in-vessel test procedure that is performed by a Caterpillar analyst under operating conditions. The test compares the performance of all marine engine systems to the original testing specifications.

When a PAR is conducted at Sea Trial, an installation of high quality can be ensured. The PAR will confirm the matching of the following components for optimum performance and for fuel efficiency: hull, rudders, propeller, marine transmission, ventilation, and cooling systems.

Caterpillar recommends scheduling a PAR in order to maintain optimum performance.

A periodic PAR can define deterioration of the propulsion system. A PAR can assist in repairs, in overhauls, and in maintenance schedules. This will help to provide the most economical, efficient cost of operation.

i04746035

Marine Engine Performance Analysis Report (PAR)

SMCS Code: 1000

A 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

The design of the hull, the propeller, and the drive train 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 performance, consult an authorized Cat dealer for assistance.

If the engine is covered by a warranty, the Caterpillar warranty covers the cost of solving a valid deficiency of the engine 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
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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.

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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. A PAR will help to provide the most economical, efficient cost of operation.

Customer Service

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Customer Assistance

SMCS Code: 1000; 4450

USA and Canada

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

Your satisfaction is a primary concern to Caterpillar and to Caterpillar dealers. If you have a problem that has not been handled to your complete satisfaction, follow these steps:

1. Discuss your problem with a manager from the dealership.
2. If your problem cannot be resolved at the dealer level, use the phone number that is listed below to talk with a Field Service Coordinator:

1-800-447-4986

The normal hours are from 8:00 to 4:30 Monday through Friday Central Standard Time.

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

Caterpillar Inc.
Marine Center of Excellence
Manager, Customer Service
111 Southchase Blvd
Fountain Inn, SC 29644

Please keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

Outside of the USA and of Canada

If a problem arises outside the USA and outside Canada, and if the problem cannot be resolved at the dealer level, consult the appropriate Caterpillar office.

Latin America, Mexico, Caribbean
Caterpillar Americas Co.
701 Waterford Way, Suite 200
Miami, FL 33126-4670
USA
Phone: 305-476-6800
Fax: 305-476-6801

Europe, Africa, and Middle East
Caterpillar Overseas S.A.
76 Route de Frontenex
P.O. Box 6000
CH-1211 Geneva 6
Switzerland
Phone: 22-849-4444
Fax: 22-849-4544

Far East
Caterpillar Asia Pte. Ltd.
7 Tractor Road
Jurong, Singapore 627968
Republic of Singapore
Phone: 65-662-8333
Fax: 65-662-8302

China
Caterpillar China Ltd.
37/F., The Lee Gardens
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Hong Kong
Phone: 852-2848-0333
Fax: 852-2848-0440

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Shin Caterpillar Mitsubishi Ltd.
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Ordering Replacement Parts

SMCS Code: 4450; 7567

WARNING

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

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

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

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

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

When a Caterpillar engine requires maintenance and/or repair, provide the dealer with all the information that is stamped on the Information Plate. This information is described in this Operation and Maintenance Manual (Product Information Section).

Discuss the problem with the dealer. Inform the dealer about the conditions of the problem and the nature of the problem. Inform the dealer about when the problem occurs. This will help the dealer in troubleshooting the problem and solving the problem faster.

On-Board Replacement Parts

SMCS Code: 7567

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

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

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

Table 17 lists the parts that are recommended by Caterpillar for vessels in both categories.

The requirements of individual Marine Classification Societies may differ. Table 18 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 17 and 18 are recommended for vessels in Category 2. To customize this list for your specific engine application, consult your Cat dealer.

Table 17

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

Table 18

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

(continued)

(Table 18, contd)

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

Reference Materials

- Maintenance log

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Maintenance Records

SMCS Code: 1000; 4450

Caterpillar Inc. recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for a variety of other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is well managed. Accurate maintenance records can help your Caterpillar dealer to fine tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

Fuel Consumption – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

Service Hours – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs
- Owner's receipts

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Reference Material

SMCS Code: 1000; 4450

The following literature can be obtained through any Caterpillar dealer.

Lubricants

- Special Publication, PEHP1026, "Data Sheet - Caterpillar Diesel Engine Oil (DEO) (CF-4) (International only)"
- Special Publication, PEHP8038, "Data Sheet - Caterpillar Diesel Engine Oils (DEO) (CH-4) (North America and Australia)"
- Special Publication, NEDG6002, "Data Sheet - Multipurpose Lithium Complex Grease (MPG)"
- Special Publication, PEHP0002, "Data Sheet - Multipurpose Lithium Complex Grease with Molybdenum (MPGM)"
- Special Publication, PEHP0017, "Data Sheet - Special Purpose Grease (SPG) Bearing Lubricant"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"
- Special Publication, SEBD0640, "Oil and Your Engine"
- Special Publication, PEDP7036, "S·O·S Fluid Analysis Cornerstone"

Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

Coolants

- Special Publication, SEBD0970, "Coolant and Your Engine"
- Special Publication, PEHP4036, "Data Sheet-Caterpillar Coolant"
- Special Publication, SEBD0518, "Knowing Your Cooling System"
- Special Publication, PEHP7057, "S·O·S Coolant Analysis"

Miscellaneous

- Special Publication, PECP6026, "One Safe Source"
- Service Manual, SENR3950, "3116 & 3126 Marine Engines"
- Special Publication, LEKM9213, "Marine Application and Installation Guide"
- Special Publication, LEBM4201, "3116 Marine Propulsion Engine Performance"
- Special Publication, LEBM5498, "3126 Marine Propulsion Engine Performance"
- Special Instruction, SEHS7633, "Battery Test Procedure"
- Special Publication, LEDM5615, "Caterpillar Marine Parts and Service Locations Directory"
- Special Instruction, SEHS7332, "Do Not Operate Tag"
- Special Publication, SEBF8062, "Guideline for Reusable Parts - Cleaning and Inspection of Air Filters"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"
- Special Publication, LEXM8092, "Pleasure Craft Storage Guide"
- Service Manual, REG1139F, "Service Manual Contents Microfiche"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"

Index

A

After Starting Engine	33
After Stopping Engine.....	39
Aftercooler Core - Clean/Test	52
Alarms and Shutoffs	27
Alarms.....	27
Shutoffs.....	27
Testing the Shutoff and Alarm System.....	27
Auxiliary Water Pump (Rubber Impeller) - Inspect..	52

B

Battery - Recycle	52
Battery Electrolyte Level - Check	53
Battery or Battery Cable - Disconnect	53
Before Starting Engine	13, 31
Belts - Inspect/Adjust/Replace.....	53
Adjustment.....	54
Inspection.....	53
Burn Prevention.....	10
Batteries.....	10
Coolant.....	10
Oils.....	10

C

Cold Weather Operation.....	36
Coolant - Change	54
Drain the Cooling System	55
Fill the Cooling System	56
Flush	55
Coolant Extender (ELC) - Add.....	57
Coolant Level - Check.....	57
Engines That Are Equipped with a Coolant Recovery Tank	57
Engines That Are Not Equipped with a Coolant Recovery Tank	58
Coolant Sample (Level 1) - Obtain	58
Sampling Conditions	58
Timing of the Sampling	59
Coolant Sample (Level 2) - Obtain	59
Obtaining the Sample	59
Coolant Temperature Regulator - Replace.....	59
Cooling System Supplemental Coolant Additive (SCA) - Test/Add.....	60
Add the SCA, If Necessary	61
S-O-S Coolant Analysis.....	60
Test for SCA Concentration	60
Crushing Prevention and Cutting Prevention	12
Customer Assistance.....	88
Outside of the USA and of Canada.....	88
USA and Canada.....	88
Customer Service	88

D

Declaration of Conformity.....	20
--------------------------------	----

E

Electrical System	14
Grounding Practices	14
Emergency Stopping	38
Emergency Stop Button (If Equipped)	38
Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace.....	61
Cleaning the Air Cleaner Element.....	61
Inspecting the Air Cleaner Element	62
Replacing the Air Cleaner Element.....	62
Storing the Air Cleaner Elements.....	62
Engine Air Cleaner Service Indicator - Inspect (If Equipped)	63
Test the Service Indicator.....	63
Engine Crankcase Breather - Clean.....	64
Engine Mounts - Inspect.....	64
Engine Oil and Filter - Change	67
Drain the Engine Oil.....	67
Fill the Engine Crankcase	68
Replace the Oil Filter	67
Engine Oil Level - Check.....	64
Engine Oil Level Gauge - Calibrate.....	65
Calibration of Oil Level Gauge	65
Verifying the Calibration of the Oil Level Gauge..	66
Engine Oil Sample - Obtain	66
Obtain the Sample and the Analysis.....	66
Engine Operation.....	34
Engine Performance.....	86
Performance Analysis Report (PAR).....	86
Engine Performance and Performance Analysis Report (PAR)	86
Engine Protective Devices - Check	68
Visual Inspection.....	68
Engine Rating Conditions	84
Engine Rating Definitions	84
Engine Ratings	84
Engine Speed/Timing Sensor - Clean/Inspect (Magnetic Pick-ups).....	69
Engine Starting.....	13, 31
Ether	13
Engine Stopping	14, 38
Engine Valve Lash - Check	69

F

Features and Controls	27
Fire Prevention and Explosion Prevention	10
Ether	12
Fire Extinguisher	12
Lines, Tubes, and Hoses	12

R

Reference Information	21
Reference Information Section	84
Reference Material	93
Coolants	93
Fuels	93
Lubricants	93
Miscellaneous	93
Reference Materials	91
Refill Capacities	40
Cooling System	40
Lubrication System	40

S

Safety Messages	6
Safety Section	6
Sea Water Strainer - Clean/Inspect	80
Sensors and Electrical Components	29
Coolant Level Sensor	29
Coolant Temperature Sensor	29
Engine Oil Pressure Sensor	29
Magnetic speed pickup	30
Starting the Engine	31
Starting with Jump Start Cables	32
System Pressure Release	49
Coolant System	49
Engine Oil	49
Fuel System	49

T

Table of Contents	3
Towing Information	22
Transmission Control	34
Moving and Getting Underway	34
Transmission Selector Lever	34
Transmission Oil Level - Check	80
Marine Transmission Operation, Maintenance, Warranty, and Parts Support	80
Turbocharger - Inspect	80
Cleaning and Inspecting	80

W

Walk-Around Inspection	80
Inspect the Engine for Leaks and for Loose Connections	80
Water Pump - Inspect	81
Welding on Engines with Electronic Controls	49

Z

Zinc Rods - Inspect/Replace	82
Inspect the Zinc Rods	82
Replace the Zinc Rods	82

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: _____

