CATERPILLAR®

SEBU6100-02
June 2002

Operation and Maintenance Manual

3508, 3512 and 3516 Diesel Marine Engines

50Y1-UP
96Y1-UP
29Z1-UP
66Z1-UP
69Z1-UP
72Z1-UP
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Foreword

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

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 your Caterpillar dealer for the latest available information.

Safety
The 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. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities, and to assist with developing the skills and techniques required to operate the engine more efficiently and economically.

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

California

Proposition 65 Warning
Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defect, and other reproductive harm.

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

Use fuel consumption 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 always be performed at the fuel consumption interval first. The actual operating environment of the engine also governs the maintenance schedule. Therefore, under extremely severe or freezing cold operating conditions, more frequent lubrication and maintenance than is specified in the Maintenance Schedule may be necessary.

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 Maintenance Records section in this manual for information regarding documents that are generally accepted as proof of maintenance or repair. Your authorized Caterpillar engine dealer can assist you in tailoring your Maintenance Schedule to meet the needs of your operating environment.

Overhaul
Major engine overhaul details are not covered in this 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 which necessitates removal of the engine from the hull, there are also numerous after failure overhaul options available from your Caterpillar dealer. Contact your dealer or OEM for information regarding these options.

Important Safety Information

Most accidents involving 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 other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Safety

Warning Signs and Labels

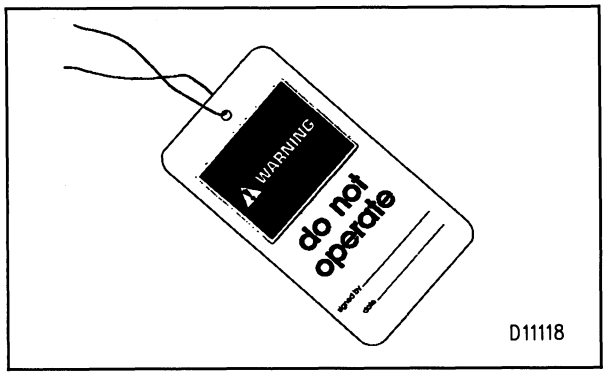
There may be several specific safety signs on your engine. Please take the time to familiarize yourself with the safety signs.

Make sure that you can read all safety signs. Clean or replace these if you cannot read the words or see the pictures. When cleaning the labels use a cloth, water and soap. Do not use solvents, gasoline, etc., to clean safety signs. The use of solvents, gasoline, etc., could loosen the sign's adhesive and cause the sign to fall off.

You must replace a label if it is damaged, missing or cannot be read. If a label is attached to a part, and that part is replaced, make sure a new label is installed on the replaced part. See your Caterpillar dealer for new labels.

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

General Hazard Information



Attach a **DO NOT OPERATE** or similar warning tag to start switch or controls before performing maintenance or repairing the engine. These tags, SEHS7332, are available from your Caterpillar dealer. When appropriate, attach tags at the engine and at each pilot position and disconnect starting controls.

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

Diesel 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.

Use caution when removing cover plates. Gradually loosen (do not remove) the last two bolts or nuts located at opposite ends of the cover or device. Pry cover loose to relieve any spring or other pressure, before removing the last bolts or nuts.

Use caution when removing vent release valve, grease fittings, pressure taps, breathers or drain plugs. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure.

- Wear a hard hat, protective glasses, hearing protection and other protective equipment as required by job conditions.
- Do not wear loose clothing or jewelry that can catch on controls or other parts of the engine.
- Make certain all protective guards and covers are secured in place.
- Use all cleaning solutions with care.
- Never put maintenance fluids into glass containers since glass containers can break.
- Report all needed repairs.

UNLESS INSTRUCTED DIFFERENTLY, PERFORM ALL MAINTENANCE AS FOLLOWS:

- Stop the engine.
- Do not attempt any repairs or adjustments to the engine or driven equipment while it is running.
- Do not attempt repairs you do not understand.
- Ensure the protective locks or controls are in the applied position.
- Disconnect the batteries whenever performing any maintenance or before servicing the electrical system. If the engine has electric starters, disconnect and tape the battery ground leads to prevent accidental starting.
- Do not attempt repairs you do not understand. Use proper tools; replace or repair broken or damaged equipment.
- When starting an engine after repairs have been made to the fuel system or governor, make provisions for shutting off the engine's inlet air and/or fuel supply (to stop the engine), in case there is an overspeed on start-up.

- Start the engine only from the pilot house. Never short across the starter terminals or the batteries as this could bypass the engine neutral-start system as well as damage the electrical system.

Pressure Air and Water

Pressure air can cause personal injury. When using pressure air for cleaning, wear a protective face shield, protective clothing and protective shoes.

The maximum air pressure must be below 200 kPa (30 psi) for cleaning purposes.

Wear eye protection at all times when cleaning the cooling system. Pressurized water could cause debris and/or hot water to be blown and result in personal injury.

Fluid Penetration

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

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

Asbestos Information

Your Caterpillar engine and replacement parts shipped from the factory are asbestos free. Caterpillar recommends the use of ONLY genuine Caterpillar parts. If any replacement parts containing asbestos are used, the following guidelines should be used in handling these parts and asbestos debris.

Caution should be used to avoid breathing dust that may be generated when handling components containing asbestos fibers. If this dust is inhaled, it can be hazardous to your health.

The asbestos used in components is usually bound in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust which contains asbestos is not generated.

If dust, which may contain asbestos is present, there are several common sense guidelines that should be followed.

- Never use compressed air for cleaning.
- Avoid brushing or grinding of asbestos containing materials.
- For clean up, use wet methods or a vacuum equipped with a high efficiency particulate air (HEPA) filter.
- 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. (For example in the U.S.A., OSHA requirements as set forth in 29 CFR 1910.1001).
- Follow environmental rules and regulations for disposal of asbestos.
- Avoid areas where airborne asbestos particles may be present.

Lines, Tubes and Hoses

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. Do not use your bare hands to check for leaks. Tighten all connections to the recommended torque.

Check for the following:

- End fittings damaged, leaking or displaced.
- Outer covering chafed or cut and wire reinforcing exposed.
- Outer covering ballooning locally.
- Evidence of kinking or crushing of the flexible part of the hose.
- Armoring embedded in the outer cover.

Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any repair or maintenance is performed on the engine.

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

Relieve all pressure in air, oil, fuel or cooling systems before any lines, fittings or related items are disconnected or removed.

Coolant

At operating temperature, the engine coolant is hot and under pressure. The cooling system and all lines to heaters or the engine contain hot water. When pressure is relieved rapidly, this hot water can turn into steam.

Allow cooling system components to cool before draining. Any contact with hot water or steam can cause severe burns. Check the coolant level only after the engine has been stopped and the vent release valve is cool enough to remove with your bare hand.

Remove the cooling system vent release valve slowly to relieve pressure. Use caution when removing vent release valve, grease fittings, pressure taps, breathers or drain plugs. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure.

Do not step up on engine to remove the cooling system filler cap or vent release valve, if applicable. A service platform should be provided or use an adequate ladder.

Cooling system additive (conditioner) contains alkali. To prevent personal injury, avoid contact with the skin and eyes and do not drink.

Oils

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

Keep all exhaust manifold and turbocharger shields in place to protect hot exhaust from oil spray in the event of a line, tube or seal failure.

Batteries

Always wear protective glasses when working with batteries. Battery electrolyte contains acid and can cause injury. Avoid contact with the skin and eyes.

Wash hands after touching batteries and connectors. Use of gloves is recommended.

Do not smoke when observing the battery electrolyte levels. Batteries give off flammable fumes which can explode. Ensure there is proper ventilation for batteries which are located in an enclosure.

Never disconnect any charging unit circuit or battery circuit cable from the battery when charging unit is operating. A spark can cause the flammable vapor mixture of hydrogen and oxygen to explode.

Fire or Explosion Prevention

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

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

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

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

Do not smoke while refueling or in a refueling area.

Do not smoke in areas where batteries are charged, or where flammable materials are stored.

Always thaw a frozen battery before jump starting. Frozen batteries may explode. Batteries give off flammable fumes which can explode.

Keep all fuels and lubricants stored in properly marked containers and away from all unauthorized persons.

Store all oily rags or other flammable material in a protective container, in a safe place.

Do not weld or flame cut on pipes or tubes that contain flammable fluids. Clean them thoroughly with nonflammable solvent before welding or flame cutting on them.

Remove all flammable materials such as fuel, oil and other debris before they accumulate on the engine.

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

Provide adequate and proper waste oil disposal. Oil and fuel filters must be properly installed and housing covers tightened to proper torque when being changed.

Batteries must be kept clean, covers kept on all cells, recommended cables and connections used and battery box covers kept in place when operating.

When starting from an external source, always connect the positive (+) jumper cable to the POSITIVE (+) terminal of the battery of the engine to be started.

To prevent potential sparks from igniting combustible gases produced by some batteries, attach the negative (–) boost ground cable last, to the starter NEGATIVE (–) terminal (if equipped) or to the engine block. See the Operation Section of this manual for specific starting instructions.

Clean and tighten all electrical connections. Check regularly for loose or frayed electrical wires. Refer to maintenance schedules for interval. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine.

Wiring must be kept in good condition, properly routed and firmly attached. Routinely inspect wiring for wear or deterioration. Loose, unattached, or unnecessary wiring must be eliminated. All wires and cables must be of the recommended gauge and fused if necessary. Do not use smaller gauge wire or bypass fuses. Tight connections, recommended wiring and cables properly cared for will help prevent arcing or sparking which could cause a fire.

Fire Extinguisher

Have a fire extinguisher available and know how to use it. Inspect and have it serviced as recommended on its instruction plate.

Crushing or Cutting Prevention

Support equipment and attachments properly when working beneath them.

Never attempt adjustments while the engine is running unless otherwise specified in this manual.

Stay clear of all rotating and moving parts. Guards should be in place whenever maintenance is not being performed.

Wear protective glasses when striking objects to avoid injury to your eyes.

Chips or other debris can fly off objects when struck. Make sure no one can be injured by flying debris before striking any object.

Mounting and Dismounting

Do not climb on, or jump off, the engine or stand on components which cannot support your weight. Always use steps and handholds when mounting and dismounting.

Clean steps, handholds and platform areas of the engine you will be working on or around.

Before Starting the Engine

Inspect engine for potential hazards.

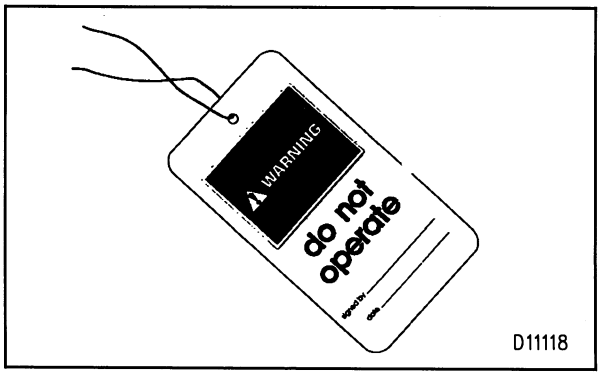
Be sure all protective guards and covers are installed if an engine must be started to make adjustments or checks. To help prevent an accident caused by parts in rotation, work carefully around them.

Do not disable or bypass automatic alarm circuits. They are provided to prevent personal injury and engine damage.

Make provisions for shutting off the air or fuel supply to stop the engine if there is an overspeed on start-up after performing repair or maintenance to the engine.

See the Maintenance section of this manual for adjustment, or the Service Manual for repairs.

Engine Starting



Do not start the engine or move any of the controls if there is a warning tag attached to the controls. Check with the person who attached the tag before starting.

Make sure no one is working on, or close to the engine or engine driven components before starting it. Always make an inspection of the engine installation before and after starting.

Diesel 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 and be sure venting systems are correctly installed and operating.

Start the engine only from the pilot house. Never short across the electric starting motor terminals or the batteries, as this could bypass the engine neutral-start system as well as damage the electrical system.

Always start the engine according to the required Engine Starting procedure described in this manual to prevent major engine component damage and personal injury.

Check the jacket water and oil temperature gauges frequently during the operation of jacket water and/or lube oil heaters to ensure proper operation.

Starting Aids

Ether and other starting aids are poisonous and flammable. Do not smoke while changing ether cylinders. Use ether only in well ventilated areas.

Keep ether cylinders out of the reach of unauthorized persons. Discard cylinders in a safe place. Do not puncture or burn cylinders.

Do not store replacement ether cylinders in the engine compartment. Do not store ether cylinders in direct sunlight or at temperatures above 39°C (102°F).

Engine Stopping

Stop the engine according to the Engine Stopping instructions in the Operation Section to avoid overheating and accelerated wear of the engine components.

Only use the Emergency Stop Pushbutton in an emergency situation. DO NOT start the engine until the problem necessitating the emergency stop has been located and corrected.

On initial startup or after overhaul, be prepared to STOP the engine should an overspeed condition occur. This may be accomplished by cutting the fuel and air supply to the engine.

Customer Service

North America Only:
When a problem arises concerning the sale, operation or service of your engine, it will normally be handled by the dealer in your area. The service facility nearest you can be located twenty-four hours a day by calling: **In U.S. and Canada 1 (800) 447-4986.**

Your satisfaction is a primary concern to Caterpillar and its dealers. If you have a problem that has not been handled to your satisfaction, we suggest the steps that follow.

Step One
Discuss your problem with a member of management from the dealership.

Step Two
When it appears that your problem cannot be readily resolved at the dealer level without additional assistance, use the above telephone numbers and ask to talk to a Field Service Coordinator. Regular Monday through Friday business hours are from 8:00 a.m. to 4:30 p.m. Central Standard Time (CST).

Step Three
If you are still not satisfied, present the engine matter in writing to:

Caterpillar Inc.
Manager, Customer Service, Engine Division
Mossville Bldg. A
P.O. Box 600
Mossville, Illinois 61552-0600

When contacting the Manager, Customer Service, please keep in mind that ultimately your problem will likely be resolved at the dealership, using their facilities, equipment, and personnel. Therefore, it is suggested that you follow the above steps in sequence when experiencing a problem.

Outside North America:
If a problem arises outside North America, and cannot be resolved at the dealer level, contact the appropriate Caterpillar subsidiary office.

Mid and South America (except Brazil):
Caterpillar Americas Co.
100 NE Adams Street
Peoria, Illinois 61629 U.S.A.
Phone: 309-675-5876

Brazil:
Caterpillar Brasil S.A.
Piracicaba Plant
Administrative Office
Rodovia Cuizde Queiroz, km 157, s/ no.
P.O. Box No. 330
13420-900 Piracicaba, SP, Brazil
Phone: 55-194-292100
Fax: 55-194-335234
Telex No.: 55-194-191911

Europe, Africa, and Middle East:
Caterpillar Overseas S.A.
76, Route de Frontenex
P.O. Box 6000, 1211 Geneva 6
Switzerland
Cable Address: CATOVERSEA
Telex No.: 413323
Phone: (022) 849 4444
Telecopier: (022) 849 4984

Japan:
Caterpillar Mitsubishi Ltd.
3700, Tana, Sagamihara-shi
Kanagawa-ken, 229 Japan
Telex No.: 2872-261CM HAJ
Cable Address: CATERBISHICO SAGAMIHARA
Phone: Sagamihara (0427) 62-1121

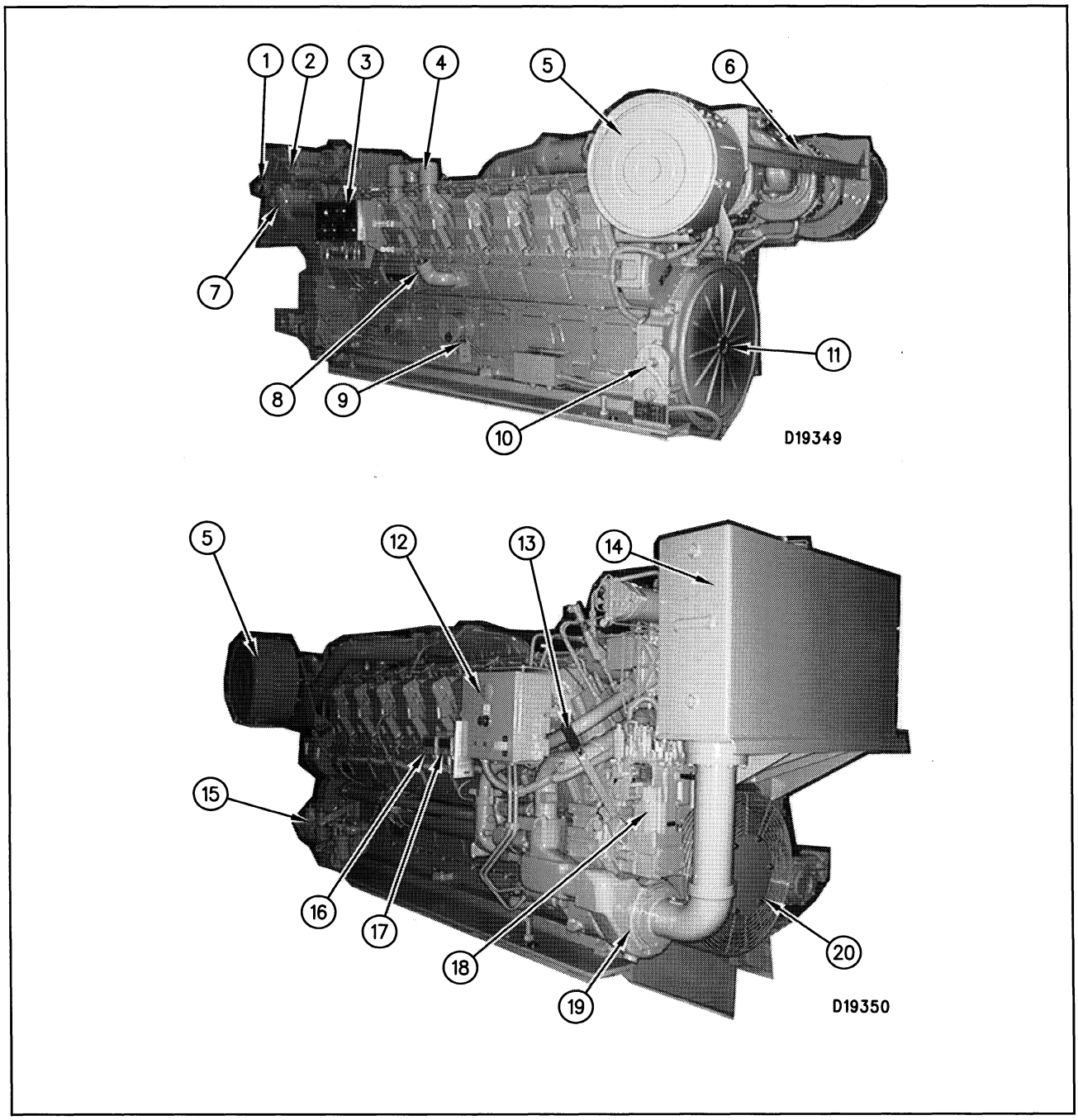
Australia and New Zealand:
Caterpillar of Australia Ltd.
1 Caterpillar Drive, Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Telex: AA30240
Cable: CATERPILLAR MELB
Phone: (03) 3399333

Asia (except Japan and Australia):
Caterpillar Asia Pre. Ltd.
150 Beach Road
#11-00 Gateway West
Singapore 0718
Phone: 3900300
Fax: 3900302

Model Views and Engine Information

3500 Marine Engine

3516 Marine Engine shown.



Coolant Level Alarm/Murphy Switch (1), Fuel Filter Housing and Priming Pump (2), Instrument Gauge Package (3), Crankcase Breathers (4), Air Filter (5), Turbocharger (6), Oil Filter Housing (7), Oil Fill Location (8), Oil Level Gauge (Dipstick) (9), Oil Sump Pump (10), Flywheel (11), Emergency Stop Pushbutton (12), Fuel Shutoff Lever (13), Expansion Tank (14), Air Starting Motor (15), High Temperature Coolant Alarm (16), Low Oil Pressure Alarm (17), Governor (18), Jacket Water Pump (19), and Crankshaft Vibration Damper (20).

Engine Information

The Caterpillar 3500 Family of Marine Diesel Engines provide a broad range of ratings to provide power for propulsion and auxiliary applications.

The 3500 series marine engine can be either 8, 12, or 16 cylinder with ratings from 1200 to 1800 rpm's. The engines are turbocharged, and utilize jacket water aftercooling.

A full range hydramechanical governor controls the fuel injection pump output to maintain the engine rpm selected by the operator.

Individual injection pumps, one for each cylinder, meter and pump fuel under high pressure to an injection valve for each cylinder.

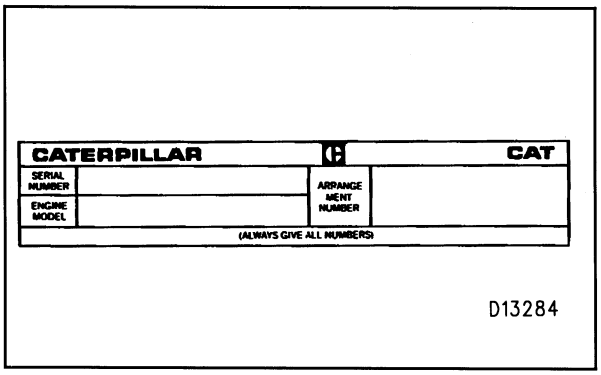
The cooling system consists of a gear driven centrifugal pump, four thermostats which regulate the engine coolant temperature, and an oil cooler and expansion tank.

The engine lubricating oil, which is cooled and filtered, is supplied by a gear-type pump. Bypass valves provide unrestricted flow of lubrication oil to the engine parts when oil viscosity is high, or if either the oil cooler or the oil filter elements should become clogged.

Efficiency of engine performance depends on adherence to proper operation and maintenance recommendations, and use of recommended fuels and lubrication oils.

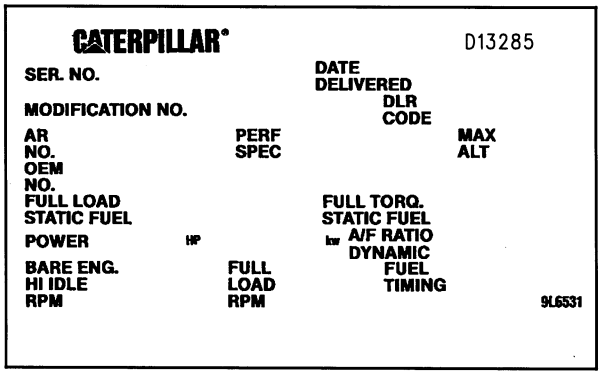
Follow the recommended Maintenance Schedule.

Serial Number Plate Location



Located on the right rear side of the cylinder block.

Information Plate Location



Located on the camshaft inspection cover.

Reference Numbers

Record for Reference

Engine Model_____

Engine Serial No._____

Engine Arrangement No._____

Modification No._____

Engine Power Rating_____

Engine Low Idle rpm_____

Engine Full Load rpm_____

Performance Specification No._____

Governor Group No._____

Fuel Filter No._____

Lubrication Oil Filter Element No._____

Auxiliary Oil Filter Element No._____

Supplemental Coolant Additive
Maintenance Element No._____

Supplemental Coolant Additive
Precharge Element No._____

Coolant Additive (Part No. & Quantity)_____

Air Cleaner Element No._____

Lube System Capacity (Total)_____

Cooling System Capacity (Total)_____

Alternator Belt No._____

Engine Identification Numbers

Caterpillar engines are identified with serial numbers, fuel system setting numbers, performance specifications and arrangement numbers. In some cases modification numbers are also used. These numbers are shown on the serial number plate mounted on the engine.

Caterpillar dealers need all of these numbers to determine which components were included on the engine when it was assembled at the factory. This permits accurate identification of replacement part numbers.

Ordering Parts

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout North America and the world. Their parts stocks are up to date and include all parts normally required to protect your investment in Caterpillar engines.

- When ordering parts, your order should specify the part number, part name, quantity and serial number, arrangement number and modification number of the engine for which the parts are needed. If in doubt about the part number, please provide your dealer with a complete description of the needed item.

- When maintenance or repair is needed for your Caterpillar engine, be prepared to give the dealer all the information that is provided on the 9L6531 Information Plate, described earlier in this manual.

- Discuss the problem with the dealer, such as; when it occurs, what happens, etc. This will help the dealer in troubleshooting and solving the problem faster.

Marine Engine Ratings

The Caterpillar Marine Engine Rating System is an effective method for rating marine propulsion engines. This system provides broad capability in matching a rating to a particular application.

The most important consideration when selecting a rating for a specific application is time spent at full throttle.

Rating Definitions

The marine propulsion engine rating definitions are:

A – For use with little load cycling in oceangoing displacement hulls such as freighters, tugboats and bottom-drag trawlers, and deep river towboats.

B – For use in midwater trawlers, purse seiners, crew and supply boats, ferry boats with trips longer than one hour, and towboats in rivers where locks, sandbars, curves or traffic dictate frequent slowing.

C – For use in yachts with displacement hulls, as well as ferries with trips less than one hour, fish boats moving at higher speeds out and back (e.g., lobster, crayfish and tuna), and short trip coastal freighters.

D – For use in pleasure craft and yachts with semi displacement hulls, as well as patrol, customs, police and some fire boats. Also for bow/stern thrusters.

E – For use in pleasure craft with planing hulls, as well as for pilot, harbor patrol and harbor master boats.

Note: Some fish boats operate on duty cycles where D or E engine ratings apply.

Time at full throttle is the cumulative time the engine is operated at full throttle load and speed during a work cycle, duty cycle, or voyage.

These rating definitions dictate the selection of a rating based on a load profile determined by time at various throttle settings or engine speeds. In general, an application requiring less time at full throttle, or lower engine rpm at reduced throttle operation, can utilize a higher rating.

As a general guideline, typical reduced engine speeds for each rating level are summarized in the following chart:

3500 Family Marine Engine Ratings

Rating Level	Time at Full Throttle[1]	Rated RPM	Reduced RPM
A	81-100%	N/A	N/A
B	51-80%	1200 1600 1800	1150 1500 1700
C	11-50%	1330 1600 1800	1200 1500 1600
D	6-10%	1800	1600
E	1-5%	1800	1600

[1] Assumes use of a fixed pitch propeller. If using a controllable pitch propeller, refer to Engine Data Sheet 108.2, form LEQM7126, "Marine Performance Curve Format".

Fuel consumption at the suggested reduced rpm is at or near the engine's optimum fuel efficiency.

Application Guidelines

In selecting a rating for a specific application, the most important consideration is time spent at full throttle. Additionally these rating definitions identify percent of time at full throttle and corresponding times below rated rpm. This rpm reduction lowers kw (horsepower) requirements as propeller demand follows a cubic speed/power curve.

For example, an engine operating at 90 percent of rated speed would be loaded by a typical propeller to about 73 percent of rated power. Operating at recommended reduced speed controls the engine load at or below the continuous power level.

Ratings Versus Applications

Ratings should be applied on the basis of vessel operation. It is incorrect to assign a rating to an application based only on the type of boat or hull design. Vessel descriptions such as workboat, fish boat, or ferry boat and hull design such as displacement or planing hull do not completely define the operating conditions of the vessel or the power demands from the engine. These descriptions could have more than one rating applied, depending upon how the vessel is operated.

For example, the application of a vessel as a passenger ferry does not indicate a specific rating should be used. A coastal ferry boat is operated for extended periods at full throttle for long runs with short intervals at reduced throttle for maneuvering and docking. Annual hours of operation are high. Application of a lower level rating is indicated.

Another ferry boat has a short run across a river requiring much shorter periods of full throttle operation. Annual hours of operation are low due to seasonal operation and schedules. A higher level rating would be appropriate.

Other examples of vessel names that could have a choice of ratings, depending on their individual operating profiles are:

Rating Level C, D or E

Lobster Boats
Crab Boats
Patrol/Police Boats
Search and Rescue

Rating Level A, B or C

Harbor Tugs
Shuttle Tugs
Crew Boats
Fishing Trawlers
Supply Boats

It is important to know how the boat will be operating, so that the rating can match the operating profile. Additionally, it is important that a proper rating be selected so the customer's perception of price/value is realized.

Emergency Procedures

Certain worldwide marine classifications societies require seagoing propulsion engines to be equipped to allow continuous operation if the engine water pump(s) or oil pump should fail.

Towing Information

If the vessel cannot continue under its own power, it is recommended that the vessel be towed. If pressurized oil cannot be supplied to the marine gear shaft bearings while being towed, the propeller shaft must be secured to prevent the turning shaft (caused by the propeller windmilling through the water) from damaging the marine gear shaft bearings.

NOTICE

Turning of the propeller shaft without proper lubrication for long periods will damage the marine gear shaft bearings.

After the shaft has been secured, have the towing vessel travel at slow speed in order to minimize the windmilling force on the propeller. If, the marine gear is allowed to windmill for long periods while the vessel is being towed, the engine must be started and the marine gear operated for five minutes at least every twelve hours to lubricate the shaft bearings.

There are several ways of preventing shaft rotation. The correct method depends upon the turning force of the propeller and the construction of the propeller shaft tunnel. Use the method best suited for the type of installation.

Propeller Shaft Wrapping

- On small vessels, wrap a heavy rope around the propeller shaft. The number of wraps needed will depend upon the mass of the propeller and propeller shaft.
- Secure the rope in the opposite direction of shaft rotation.

Securing Companion Flange

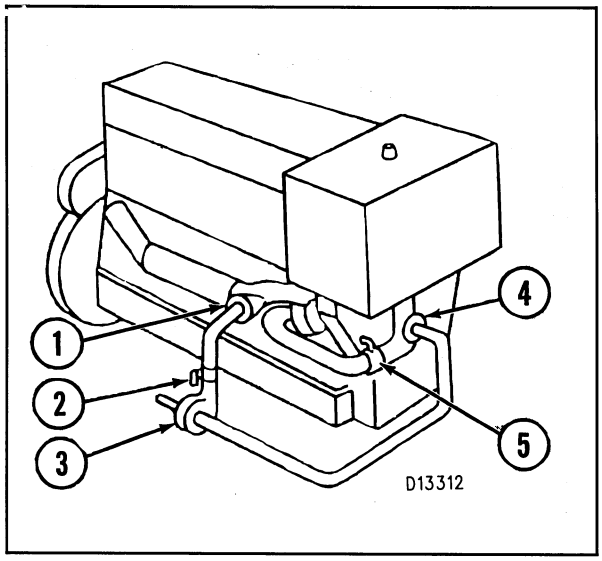
- Remove one or more bolts from the companion flange coupling. Bolt a chain to the companion flange. Wrap the chain several times around the propeller shaft.
- Secure the loose end of the chain at a right angle to the shaft and in opposite direction of shaft rotation.

Air Actuated Shaft Brake

- For vessels equipped with a shaft brake, the shaft brake may be applied if there is sufficient air pressure available.

Engine Jacket Water Pump Failure

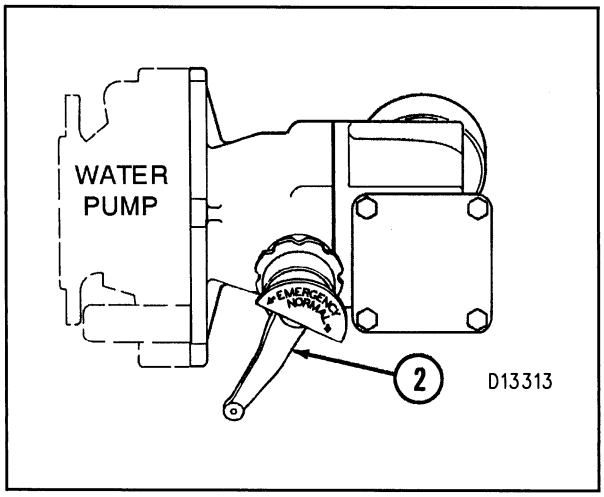
If the engine jacket water pump should fail, fresh water can be supplied to the engine jacket using the emergency water system.



Tee Connector (1), Shutoff Valve (2), Emergency Jacket Water Pump (3), Tee Connector (4), and Shutoff Valve (5).

1. Stop the engine. If the water pump bearing has failed, then the water pump does NOT need to be removed.

2. Open the shutoff valve (2) between the emergency pump and oil cooler connection.



3. Place the diverter valve handle in the EMERGENCY position.

4. Start and prime the emergency jacket water pump (3). Allow air to escape from the emergency cooling system lines.

5. Check coolant level in the expansion tank. Add coolant if required.

6. Start the engine. Always start the engine according to the required Engine Starting procedure described in this manual. Engage marine gear and operate vessel at normal speed.

NOTE: If the engine jacket water coolant is lost (i.e. water line rupture or leak) and an insufficient supply of fresh water is available to replenish the system, raw water may be pumped through the engine.

a. Stop the engine and make the necessary water pump and lines connections to pump raw water into the jacket water system and back to the source.

b. Remove the temperature regulating thermostats from the regulator housing and install housing cover.

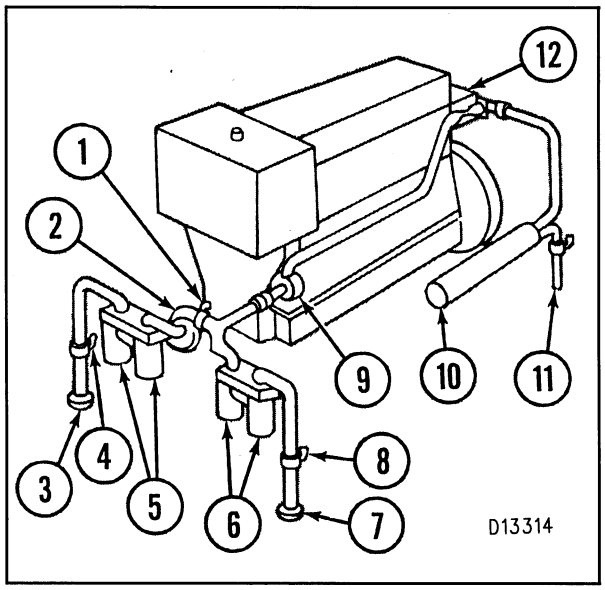
c. Start and prime the emergency pump.

d. Start the engine and allow to idle at low idle. Always start the engine according to the required Engine Starting procedure described in this manual. Engage the marine gear forward clutch. Operate the engine at the lowest speed for the existing weather conditions.

e. Maintain engine temperatures as low as possible to minimize deposits in the engine and corrosion of components. Have the engine jacket water system completely disassembled, cleaned and inspected after reaching port. Replace all parts which are corroded or damaged.

Engine Raw Water Pump Failure

The raw water pump circulates sea or fresh water through the engine jacket water heat exchanger. If the raw water pump should fail, follow the procedure below to continue engine operation.



Shutoff Valve–normally closed (1), Emergency Raw Water Pump (2), Emergency Raw Water Inlet (3), Inlet Valve–normally closed (4), Emergency Raw Water Strainers (5), Normal Operation Raw Water Strainers (6), Normal Operation Raw Water Inlet (7), Inlet Valve–normally open (8), Raw Water Pump (9), Jacket Water Heat Exchanger (10), Raw Water Outlet (11) & Aftercooler (12).

1. Stop the engine. If the shaft bearing has failed, the pump does NOT need to be removed.

2. Close the inlet valve (8) to the raw water strainers (6) and raw water pump (9).

3. Open the inlet valve (4) to the emergency raw water pump (2). Start and prime the emergency pump.

4. Start the engine, engage marine gear and continue operation at normal speed. Always start the engine according to the required Engine Starting procedure described in this manual.

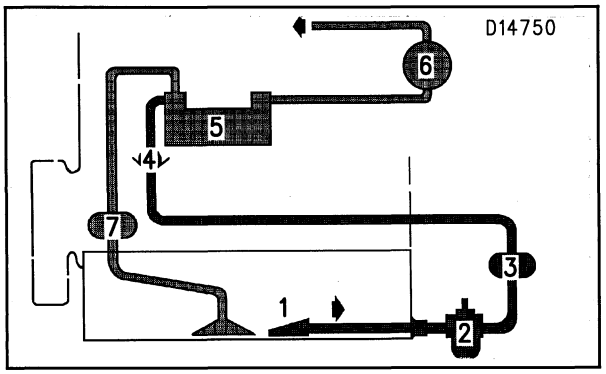
Engine Lube Oil Pump Failure

If the engine lube oil pump fails, oil pressure will drop and the engine jacket water temperature gauge reading will be above normal. If equipped, the applicable engine shutoff controls will stop the engine. To use the emergency lube oil pump, refer to the following procedure.

1. Place the marine gear selector lever in the NEUTRAL position and stop the engine if the engine is still running.

2. Measure the engine oil level to ensure it is at the FULL mark on the dipstick. Add oil if necessary.

3. Reset the oil pressure shutoff control.



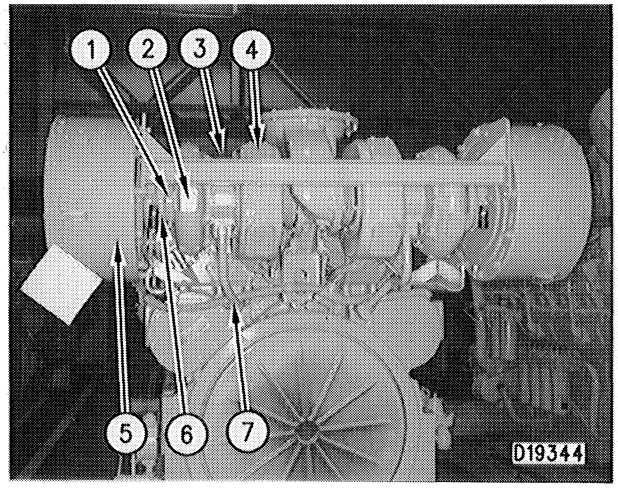
Oil Pan (1), Oil Strainer (2), Standby Lubricating Oil Pump (3), Check Valve (4), Oil Cooler (5), Engine Oil Filter (6), Engine Lube Pump (7).

4. Start the emergency standby lube oil pump (3). Observe the oil pressure gauge. Be sure the oil pressure shutoff control RESET is in the RUN position to enable engine starting.

5. Start the engine. Always start the engine according to the required Engine Starting procedure described in this manual. Engage the marine gear and operate the vessel at normal speed.

Turbocharger Failure

1. Remove air cleaner and hump hose from the turbocharger inlet.



V-band Cartridge Clamp (1), Turbocharger Compressor (2), Oil Supply Line (3), Turbine Housing (4), Air Cleaner Housing (5), Hose (6) & Oil Drain Line (7).

2. Remove oil supply line (3) from top of turbocharger cartridge and cylinder block. Plug the oil supply opening at the cylinder block location.

3. Remove oil drain line (7) from bottom of cartridge and flywheel housing. Plug the oil drain opening in the flywheel housing location.

4. Remove four bolts from flange to air inlet on the aftercooler.

5. Remove V-band cartridge clamp (1) while supporting the compressor (2) side of the turbocharger and the air inlet pipe to aftercooler. Remove the piping, compressor (2) and cartridge as a unit.

⚠ WARNING

DO NOT allow exhaust gas to discharge into engine room. Vent the exhaust to the outside and be sure venting systems are correctly installed and operating. Diesel engine exhaust contains products of combustion which may be harmful to your health.

6. Provide some means of attaching a flat steel plate (large enough to cover the opening completely) against the opening in the turbine housing (4) where the cartridge was removed.

NOTE: If a round plate of the correct diameter and thickness can be fabricated, it may be attached to the housing (4) with the V-band clamp (1). When installing V-band clamp, position the gap (tightening screw) down if possible so any accumulation of moisture will drain away.

7. Clean the engine room of any materials that could possibly be drawn into the engine through the air inlet opening in the aftercooler. When the turbocharger is removed there will not be an air filter in the system unless you provide some method to attach air cleaner housing, hump hose and pipe to aftercooler inlet.

8. Providing that all other engine systems are in operating condition, the engine can now be started. Always start the engine according to the required Engine Starting procedure described in this manual. The engine must be operated at a **greatly reduced speed and load.**

Piston or Connecting Rod Failure

1. Remove the failed piston, connecting rod and connecting rod bearings.

2. Provide some method of closing off the oil supply holes in the crankshaft for the removed connecting rod (cork, leather, etc.). Always use an adjustable band clamp to retain plug under the high pressure conditions.

NOTE: You must ensure that whatever material(s) is used to plug the oil holes will be removed at the time permanent repairs are made.

⚠ WARNING

Extreme caution and care should be taken when operating the engine with a fuel injection line disconnected. High pressure fuel will exit the disconnected line when engine is running. Be aware to avoid injury and/or fire.

3. The fuel injection line for the failed cylinder must be disconnected at the valve cover base. This fuel injection line then must be directed away from the engine and into some type of fuel collecting apparatus.

4. Providing that all other engine systems are in operating condition, the engine can now be started. Always start the engine according to the required Engine Starting procedure described in this manual. The engine must be operated at a greatly reduced speed and load.

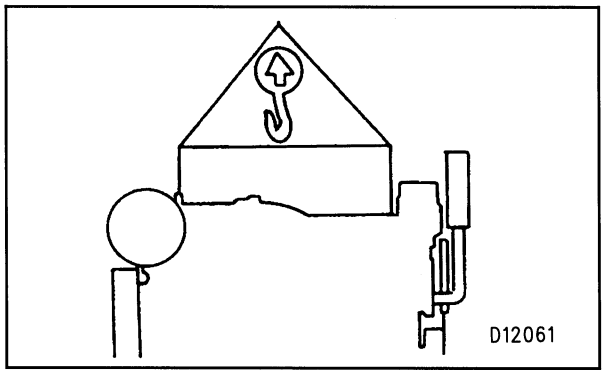
Engine Lifting and Storage

NOTICE

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

Use a hoist to remove heavy components. Lift the engine by using an adjustable lifting beam. All supporting members (chains and cables) should be parallel to each other, and as near perpendicular as possible to the top of the object being lifted.

Some removals require the use of lifting fixtures to obtain proper balance and to provide safe handling.

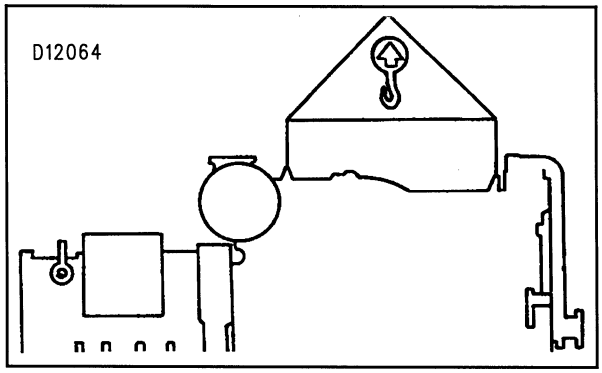


To remove the engine ONLY, use the two lifting eyes equipped with the engine.

Lifting eyes are designed for the engine arrangement as is. Alterations to lifting eyes and/or arrangement weight make the lifting devices and eyes obsolete. If you make alterations, you are responsible for providing adequate lifting devices.

See your Caterpillar dealer or vessel OEM for information regarding fixtures for proper lifting of your complete engine power package.

Engine and Marine Transmission Lifting



To remove the engine only or the engine and marine transmission together, use the two lifting eyes on the engine.

Marine Transmission Lifting

To remove the marine transmission only, use the four permanent eyebolts in the marine transmission housing.

If a component resists removal, check to be certain all nuts and bolts have been removed and that an adjacent part is not interfering.

Engine Storage

These instructions give procedures and recommendations that will keep the possibility of damage at a minimum when engines are in storage for one year or less.

If the engine will not be or has not been started for several weeks, the lubricating oil will drain from the cylinder walls and piston rings.

If an engine remains out of service and its use is not immediately planned, special precautions should be taken. Rust can form on the cylinder liner surface, which will increase engine wear and may result in shorter engine life.

To prevent this problem from becoming excessive, be sure all lubrication recommendations mentioned in the Maintenance Schedule are completed.

After one year, a complete protection procedure must be followed if the engine is kept in storage longer.

If freezing temperatures are expected, check the cooling system for adequate protection against freezing. A 50/50 solution of Caterpillar (permanent-type) Antifreeze and approved water will give protection to −29°C (−20°F).

If it will be impossible to start the engine periodically, consult your Caterpillar dealer for instructions to prepare your engine for longer storage periods.

If an engine remains out of service and its use is not immediately planned, special precautions should be taken. Refer to Storage Procedures For Caterpillar Products, SEHS9031 for more detailed information on engine storage.

Engine Specifications

3508 Engine Specifications

Engine Specifications	
Number of Cylinders	8
Bore	170 mm (6.7 in)
Stroke	190 mm (7.5 in)
Displacement/Cylinder	4.3 L (263 cu in)
Total Displacement	34.5 L (2105 cu in)
Compression Ratio	13:1
Maximum Inlet System Restriction - New Filter Required	638 mm (25 inches of H_2O)
Maximum Allowable Exhaust System Back Pressure	686 mm (27 inches of H_2O)

CRANKSAHFT POSITIONS FOR INJECTOR TIMING AND VALVE LASH SETTING		
3508 Engine	Check/Adjust With No.1 Piston on:[1] TC Compression Stroke	TC Exhaust Stroke
SAE Standard (Counterclockwise) Rotation Engines – as Viewed from Flywheel End		
Intake Valves	1-2-6-8	3-5-4-7
Exhaust Valves	1-2-3-7	4-5-6-8
Injectors	3-4-5-7	1-2-6-8
Firing Order	1-2-7-3-4-5-6-8	
SAE Opposite (Clockwise) Rotation Engines – as Viewed from Flywheel End		
Intake Valves	1-3-4-8	2-5-6-7
Exhaust Valves	1-2-7-8	3-4-5-6
Injectors	2-5-6-7	1-3-4-8
Firing Order	1-8-7-2-6-5-4-3	

[1]Refer to the Service Manual for the established procedure to position the crankshaft for injector timing and valve lash setting.

3512 Engine Specifications

Engine Specifications	
Number of Cylinders	12
Bore	170 mm (6.7 in)
Stroke	190 mm (7.5 in)
Displacement/Cylinder	4.3 L (263 cu in)
Total Displacement	51.8 L (3158 cu in)
Compression Ratio	13:1
Maximum Inlet System Restriction - New Filter Required	638 mm (25 inches of H_2O)
Maximum Allowable Exhaust System Back Pressure	686 mm (27 inches of H_2O)

CRANKSAHFT POSITIONS FOR INJECTOR TIMING AND VALVE LASH SETTING		
3512 Engine	Check/Adjust With No.1 Piston on:[1] TC Compression Stroke	TC Exhaust Stroke
SAE Standard (Counterclockwise) Rotation Engines – as Viewed from Flywheel End		
Intake Valves	1-3-6-7-10-12	2-4-5-8-9-11
Exhaust Valves	1-4-5-6-9-12	2-3-7-8-10-11
Injectors	2-4-5-8-9-11	1-3-6-7-10-12
Firing Order	1-12-9-4-5-8-11-2-3-10-7-6	
SAE Opposite (Clockwise) Rotation Engines – as Viewed from Flywheel End		
Intake Valves	1-3-4-6-7-12	2-5-8-9-10-11
Exhaust Valves	1-4-5-8-9-12	2-3-6-7-10-11
Injectors	2-5-8-9-10-11	1-3-4-6-7-12
Firing Order	1-4-9-8-5-2-11-10-3-6-7-12	

[1]Refer to the Service Manual for the established procedure to position the crankshaft for injector timing and valve lash setting.

3516 Engine Specifications

Engine Specifications	
Number of Cylinders	16
Bore	170 mm (6.7 in)
Stroke	190 mm (7.5 in)
Displacement/Cylinder	4.3 L (263 cu in)
Total Displacement	69.1 L (4210 cu in)
Compression Ratio	13:1
Maximum Inlet System Restriction - New Filter Required	638 mm (25 in) H_2O
Maximum Allowable Exhaust System Back Pressure	686 mm (27 in) H_2O

CRANKSHAFT POSITIONS FOR INJECTOR TIMING AND VALVE LASH SETTING		
3516 Engine	Check/Adjust With No.1 Piston on:* TC Compression Stroke	TC Exhaust Stroke
SAE Standard (Counterclockwise) Rotation Engines - as Viewed from Flywheel End		
Intake Valves	1-2-5-7-8-12-13-14	3-4-6-9-10-11-15-16
Exhaust Valves	1-2-3-4-5-6-8-9	7-10-11-12-13-14-15-16
Injectors	3-4-6-9-10-11-15-16	1-2-5-7-8-12-13-14
Firing Order	1-2-5-6-3-4-9-10-15-16-11-12-13-14-7-8	
SAE Opposite (Clockwise) Rotation Engines - as Viewed from Flywheel End		
Intake Valves	1-2-5-6-7-8-13-14	3-4-9-10-11-12-15-16
Exhaust Valves	1-2-3-4-5-6-9-10	7-8-11-12-13-14-15-16
Injectors	3-4-9-10-11-12-15-16	1-2-5-6-7-8-13-14
Firing Order	1-6-5-4-3-10-9-16-15-12-11-14-13-8-7-2	

[1]Refer to the Service Manual for the established procedure to position the crankshaft for injector timing and valve lash setting.

Torque Specifications

Torque for Standard Bolts, Nuts and Taperlock Studs

NOTICE

The charts that follow give general torques for bolts, nuts and taperlock studs. For additional torque specifications, not included in this section, refer to Torque Specifications, SENR3130, available from your Caterpillar dealer.

Torques for Bolts and Nuts With Standard Threads

Thread Size Inch	Standard Bolt & Nut Torque	
	N•m[1]	lb ft
1/4	12 ± 3	9 ± 2
5/16	25 ± 6	18 ± 4.5
3/8	47 ± 9	35 ± 7
7/16	70 ± 15	50 ± 11
1/2	105 ± 20	75 ± 15
9/16	160 ± 30	120 ± 20
5/8	215 ± 40	160 ± 30
3/4	370 ± 50	275 ± 37
7/8	620 ± 80	460 ± 60
1	900 ± 100	660 ± 75
1 1/8	1300 ± 150	950 ± 100
1 1/4	1800 ± 200	1325 ± 150
1 3/8	2400 ± 300	1800 ± 225
1 1/2	3100 ± 350	2300 ± 250

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

Torques for Taperlock Studs

Thread Size Inch	Standard Taperlock Stud Torque	
	N•m[1]	lb ft
1/4	8 ± 3	6 ± 2
5/16	17 ± 5	13 ± 4
3/8	35 ± 5	26 ± 4
7/16	45 ± 10	33 ± 7
1/2	65 ± 10	48 ± 7
5/8	110 ± 20	80 ± 15
3/4	170 ± 30	125 ± 22
7/8	260 ± 40	190 ± 30
1	400 ± 60	300 ± 45
1 1/8	525 ± 60	390 ± 45
1 1/4	750 ± 80	550 ± 60
1 3/8	950 ± 125	700 ± 92
1 1/2	1200 ± 150	640 ± 75

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

NOTE: Use these standard torque values for all fasteners unless otherwise specified in this manual or in the Service Manual.

Torque for Metric Fasteners

NOTICE

Be very careful never to mix metric with customary (SAE standard) fasteners. Mismatched or incorrect fasteners will cause engine damage or malfunction and may even result in personal injury.

Original fasteners removed from the engine should be saved for reassembly whenever possible. If new fasteners are needed, they must be of the same size and grade as the ones that are being replaced.

The material strength identification is usually shown on the bolt head by numbers (8.8, 10.9, etc). The chart that follows gives general torque values for bolts and nuts. Use these standard torque values unless otherwise specified in this publication.

NOTE: Metric hardware must be replaced with metric hardware. Check Parts Manual for proper replacement.

Torques for Bolts and Nuts with Metric Threads

METRIC ISO[2] THREAD		
Thread Size Metric	Standard Torque	
	N•m[1]	lb ft
M6	12 ± 3	9 ± 2
M8	28 ± 7	20 ± 5
M10	55 ± 10	40 ± 7
M12	100 ± 20	75 ± 15
M14	160 ± 30	120 ± 20
M16	240 ± 40	175 ± 30
M20	460 ± 60	340 ± 40
M24	800 ± 100	600 ± 75
M30	1600 ± 200	1200 ± 150
M36	2700 ± 300	2000 ± 225

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.
[2] ISO–International Standard Organization.

Torque for Standard Hose Clamps–Worm Drive Band Type

NOTICE

The chart that follows gives the torques for initial installation of hose clamps on new hose and for reassembly or tightening of hose clamps on existing hose.

	Initial Installation Torque on New Hose	
Clamp Width	**N•m[1]**	**lb in**
16 mm (.625 in)	7.5 ± 0.5	65 ± 5
13.5 mm (.531 in)	4.5 ± 0.5	40 ± 5
8 mm (.312 in)	0.9 ± 0.2	8 ± 2
	Reassembly or Retightening Torque	
Clamp Width	**N•m[1]**	**lb in**
16 mm (.625 in)	4.5 ± 0.5	40 ± 5
13.5 mm (.531 in)	3.0 ± 0.5	25 ± 5
8 mm (.312 in)	0.7 ± 0.2	6 ± 2

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

Torque for Constant Torque Hose Clamps

A constant torque hose clamp can be used in place of any standard hose clamp. Make sure the constant torque hose clamp is the same size as the standard clamp. Due to extreme temperature changes, hose will heat set. Heat setting causes hose clamps to loosen. Loose hose clamps can result in leaks. There have been reports of component failures caused by hose clamps loosening. The new, constant torque hose clamp will help prevent these failures.

Installation

Each installation application can be different depending on the type of hose, fitting material and anticipated expansion or contraction of the hose and fittings. A torque wrench should be used for proper installation of the new, constant torque hose clamps. Constant torque hose clamps should be installed as follows:

- To allow for maximum expansion, install clamps at 5.7 N•m (50 lb in).
- To allow for equal expansion and contraction, install clamps at 10.2 N•m (90 lb in).
- To allow for maximum contraction, install clamps at 14.1 N•m (125 lb in).

Cooling System Specifications

Coolant Information

The proper coolant mixture is important in today's diesel engines. Diesel engine operating temperatures have increased to improve engine efficiency. **This also means proper cooling system maintenance is especially important.** Overheating, excessive cooling, component pitting, cavitation erosion, piston seizures and plugged heat exchangers are results of cooling system failures.

Proper coolant is critical, as is the quality of fuel and lubricating oil. Maintenance practices may need to be re-evaluated to properly maintain the engine's cooling system. It is important that this section be read carefully.

NOTICE

Never operate without a thermostat in the cooling system. The thermostats maintain the engine coolant at the proper operating temperature.

Never add coolant or water to an overheated engine, engine damage can result. Allow the engine to cool first. Filling at over 5 U.S. gallon (20 L) per minute can cause air pockets in the cooling system.

Caterpillar does not recommend the use of cooling system solutions that are intended to stop leaks. Use of these products may result in engine damage.

Caterpillar recommends that the coolant mixture contain a minimum of 30 percent Caterpillar Antifreeze, or equivalent.

The cooling system should be protected with a minimum of three percent concentration of liquid supplemental coolant additive at all times, regardless of the concentration of antifreeze.

If the engine is to be stored in, or shipped to, an area with freezing temperatures, the cooling system must be protected to the lowest expected outside (ambient) temperature.

Check the specific gravity of the antifreeze solution frequently in cold weather to ensure adequate freeze protection.

Coolant Mixture for Caterpillar Engines

Proper engine coolant is a combination of water, antifreeze and supplemental coolant additive. Each ingredient of the mixture must meet specific guidelines for the engine coolant to perform properly. The coolant mixture used in Caterpillar engines must provide the following functions.

- Adequate heat transfer.
- Cavitation erosion protection.
- Freeze & boil protection.
- Sludge & scale protection.
- Corrosion protection.
- Compatibility with system hoses & seals.

Water (Coolant)

All water is corrosive at engine operating temperature. Distilled or deionized water is recommended because of less mineral drop out than hard or tap water. Tap water, even artificially softened with salt, is not recommended for use in your engine's cooling system.

Calcium, magnesium, chlorides and sulfates are all minerals that make up the dissolved solids in the water. Excessive amounts of these minerals (in hard water) can combine with supplemental coolant additives (silicates and phosphates) to form sludge or scale deposits. The mineral deposits (silicates, phosphates, calcium and magnesium) reduce the effectiveness of the cooling system, especially after a number of heating and cooling cycles. They may collect on hot internal engine surfaces and in the cooling system to reduce the effectiveness of the cooling system.

If distilled or de-ionized water is NOT available, use water that meets the minimum acceptable requirements in the chart. To determine your water characteristics, contact the local water department, agricultural agent or an independent laboratory to perform the testing service.

MINIMUM ACCEPTABLE WATER	
Water Content	**Limits gr/U.S. gal (ppm)**
Chlorides	2.4 (40) maximum
Sulfates	5.9 (100) maximum
Total Hardness	10 (170) maximum
Total Solids	20 (340) maximum
Acidity (pH)	5.5 to 9.0

ppm = parts per million

Antifreeze

NOTE: Some applications have elected to run with supplemental coolant additive treated water without glycol. Do not mix coolant additive treated water in the cooling system with Caterpillar Antifreeze. This incompatiblity could cause cooling system damage because the coolant will have an excessive concentration of coolant additive. Follow the instructions provided by the antifreeze supplier.

NOTICE

Caterpillar recommends that the coolant mixture contain a minimum of 30 percent Caterpillar Antifreeze (or equivalent) with 70 percent distilled or deionized water to maintain an adequate cavitation temperature for efficient water pump performance. Antifreeze concentration should be selected to provide protection to the lowest expected outside (ambient) temperature.

Check the specific gravity of the antifreeze solution frequently in cold weather to ensure adequate freeze protection. Premix coolant solution to provide protection to the lowest expected outside (ambient) temperature. Pure undiluted antifreeze will freeze at −10°F (−23°C).

Antifreeze concentrations above 60 percent antifreeze to 40 percent water are NOT recommended because the higher concentrations limit the ability of the coolant mixture to absorb supplemental coolant additive.

Use Caterpillar Antifreeze or any low silicate (ethylene or propylene glycol) antifreeze that meets ASTM D4985-89 requirements. **Most commercial antifreezes are formulated for gasoline engine applications and have high silicate content.** Caterpillar Antifreeze is formulated with a low silicate content and the proper coolant additives for heavy duty diesel engines.

Caterpillar Antifreeze is available through your Caterpillar dealer in quantities that follow.

CATERPILLAR ANTIFREEZE	
Part No.	**Size**
8C3684	3.8 Liter (1 U.S. Gallon)
8C3686	208 Liter (55 U.S. Gallon)

Adding pure undiluted antifreeze as a makeup solution for cooling system top-off is an unacceptable practice. Add antifreeze premixed with acceptable water to the same freeze protection as your cooling system. Use the Antifreeze Concentration chart to assist in determining the concentration of Caterpillar Antifreeze to use.

ANTIFREEZE CONCENTRATIONS (ETHYLENE GLYCOL)	
Protection Temperature	**Concentration**
Protection to −15°C (5°F)	30% antifreeze and 70% water
Protection to −23°C (−10°F)	40% antifreeze and 60% water
Protection to −37°C (−34°F)	50% antifreeze and 50% water
Protection to −51°C (−60°F)	60% antifreeze and 40% water

Check the coolant solution frequently in cold weather for glycol concentration with the 5P0957 or 5P3514 Coolant Tester (for Caterpillar products) to ensure adequate freeze protection. The testers are identical except temperature scales (°C or °F) and give immediate accurate readings for antifreeze/coolants that contain ethylene or propylene glycol. Both testers are available at your Caterpillar dealer.

NOTICE

If propylene glycol based antifreeze is used, DO NOT allow concentration greater than a 50/50 antifreeze to water mixture. The measurement of freeze protection must be made with a refractive-type tester (5P0957 or 5P3514) rather than the hydrometer-type tester commercially available. The hydrometer-type tester can be used to test ethylene glycol based antifreeze.

Supplemental Coolant Additive (Conditioner or Inhibitor)

The cooling system MUST contain supplemental coolant additives (SCA) (conditioner or inhibitor) to control corrosion, cavitation and deposits. It is also necessary to prevent rust, scale, pitting and/or corrosion of engine parts contacted by coolant. The cooling system should be protected with a minimum of three percent concentration at all times, regardless of the concentration of antifreeze. Use supplemental coolant additive liquid OR an element (if equipped) to maintain a three to six percent concentration in the cooling system.

NOTICE

Never use antifreeze/water coolant only, in Caterpillar engines without supplemental coolant additive regardless of antifreeze concentration.

Caterpillar or other manufacturer's products can be used as the supplemental coolant additive. Do not mix Caterpillar Supplemental Coolant Additive (Conditioner) liquid or elements with the other commercial products available; select a cooling system treatment and use it exclusively.

Excessive concentration of supplemental coolant additive can form deposits which may cause engine damage, reduce the engine's heat transfer characteristics and could also accelerate water pump seal wear.

Use the 8T5296 Test Kit to check and monitor the SCA concentration for antifreeze/water coolant mixture. The Caterpillar 8T5296 Test Kit checks for concentration of nitrates in the coolant solution. Note: Some other manufacturers' supplemental coolant additive (SCA) are phosphate based and the 8T5296 Test Kit will not provide accurate results. Caterpillar recommends that their test kit be used to check coolant solution concentration.

If other than Caterpillar products are used as the supplemental coolant additive, follow the manufacturers' recommendation for cooling system treatment and test evaluation. Commercial supplemental coolant additive products must contain silicates and a minimum of 70 gr/U.S. gallon (1200 ppm) nitrites.

Caterpillar liquid supplemental coolant additive (Conditioner) is available through your Caterpillar dealer in quantities that follow.

Supplemental coolant additive must be added Every 250 Service Hours between initial fill and the Every 3000 Service Hours cooling system maintenance interval. Install a supplemental coolant additive maintenance element (if equipped) OR .47 liter (1 U.S. pint/16 oz) for each 75 liter (19.5 gal) of cooling system capacity Every 250 Service Hours.

LIQUID SUPPLEMENTAL COOLANT ADDITIVE QUANTITIES AVAILABLE	
Part No.	**Size/Volume**
6V3542	0.25 L (0.53 U.S. pint/8 oz)
111-2372	0.38 L (0.8 U.S. pint/12 oz)
8T1589	0.47 L (1 U.S. pint/16 oz)
3P2044	1 L (1.05 U.S. qt/32 oz)
8C3680	18.95 L (5 U.S. gal/640 oz)
5P2907	208 L (55 U.S. gal/7,040 oz)

Pre-charge

Caterpillar Antifreeze DOES NOT require supplemental coolant additive added at initial fill, however additive is required on a maintenance basis. For systems equipped with supplemental coolant additive elements, the last MAINTENANCE element should not be replaced at FLUSH & FILL or Overhaul until the next 250 Service Hour interval.

PRE-CHARGE	
Antifreeze	**Pre-charge**
Caterpillar	None Required
ASTM D4985	Use Caterpillar supplemental coolant additive liquid in the quantities listed in following chart.

LIQUID PRE-CHARGE SUPPLEMENTAL COOLANT ADDITIVE REQUIRED BY CAPACITY[1]		
Cooling System Capacity liter (U.S. gal)	**Add Pre-charge Quantity Or**	**Commercial Bulk Volume**
38-49 (10-13)	3P2044 (1) 8T1589 (1)	48 oz (1.47 L)
49-64 (13-17)	3P2044 (2)	64 oz (1.9 L)
64-85 (17-22)	3P2044 (3)	96 oz (2.94 L)
86-115 (23-30)	3P2044 (4)	128 oz (3.8 L)
116-165 (31-43)	3P2044 (5)	160 oz (4.75 L)
166-244 (44-64)	3P2044 (8)	256 oz (7.6 L)

[1] Use only when not using Caterpillar Antifreeze.

Water-Only Coolant

Although Caterpillar recommends a minimum concentration of 30 percent antifreeze, a coolant mixture of acceptable water and Supplemental Coolant Additive (SCA) can be used in applications where conditions do not require freeze protection (or where antifreeze is not available).

A coolant mixture of water and SCA will cool and provide some protection to engine components, however, it will not provide normal engine service life. Antifreeze/water mixtures provide better performance life than water-only coolant.

If the engine cooling system is filled with water ONLY, supplemental coolant additive (Conditioner) concentration should be maintained at 6 to 8 percent maximum. Do not exceed eight percent maximum concentration. Check with supplemental coolant additive test kit.

Maintenance of the water-only coolant is the same as maintenance of the antifreeze/water coolant. The 8T5296 Test Kit can be used to evaluate the SCA concentration of water-only coolant with the following modifications to Step 3 and Step 5.

STEP 3–Add tap water to the vial up to the 20 ml mark.
STEP 5–With the defined procedure, the six to eight percent concentration will yield a 20 to 27 drop range. Less drops will indicate under concentration of SCA and more drops will indicate over concentration. Adjust the concentration accordingly to maintain the proper concentration.

NOTE: If the SCA concentration is greater than the maximum of eight percent, drain some of the coolant and refill with acceptable water, then retest the concentration level.

Cooling System Cleaning

Clean the system according to the Maintenance Interval schedule or sooner if the coolant is contaminated, if the engine overheats or if foaming is observed in the radiator. Disregard for the proper maintenance of the cooling system can cause engine overheating problems that could result in severe damage to the engine and its components. If testing and proper maintenance of antifreeze and/or SCA concentrations are not performed as recommended in the Maintenance Interval schedule, the system drain interval must be shortened.

The engine coolant should be drained, the system cleaned, and new coolant added by the Every 3000 Service Hours or Two Years interval. If not using Caterpillar Antifreeze and supplemental coolant additive as recommended, the drain period must be shortened to Every 1500 Service Hours or One Year.

When you drain, clean, flush and replace the coolant, small particles, undesirable chemicals, scale and other deposit formations are removed. These deposits reduce the necessary heat transfer characteristics of the cooling system and accelerate wear to the water pump seal. Refer to the Cooling System (Clean/Flush Coolant) topic in the Maintenance Section of this manual.

Caterpillar Cooling System Cleaners are designed to clean the system of harmful scale and corrosion. It dissolves mineral scale, corrosion products, light oil contamination and sludge. Cooling system cleaners are available from your Caterpillar dealer in the quantities listed. Follow the label directions for proper usage.

COOLING SYSTEM CLEANER QUANTITIES AVAILABLE	
Part No.	**Size**
4C4609	0.47 Liter (1 Pint)
4C4610	0.95 Liter (1 Quart)
4C4611	3.79 Liter (1 Gallon)
4C4612	18.95 Liter (5 Gallon)
4C4613	208 Liter (55 Gallon)

Long Life Coolant (LLC)

Long Life Coolant provides improved corrosion protection for the engine cooling system. LLC replaces standard type antifreeze. LLC extends coolant life to 6,000 service hours or 4 years with only one maintenance addition at 3,000 service hours. LLC does not require Supplemental Coolant Additive Conditioner (SCAC). A "one time only" coolant "Extender" is the only maintenance addition that is required at the 3,000 service hour interval.

Long Life Coolant is ethylene glycol based for freeze and anti-boil protection. The anti-corrosion LLC is different from the present silicate, molybodate, nitrate, borate and phosphate antifreeze that is now in use. Because of this difference, **the two coolants CAN NOT be mixed.**

Long Life Coolant has an effective operating temperature range of −46° to 127°C (−50° to 260°F). At temperatures below −46°C (−50°F), the coolant viscosity will increase, presenting a pumping problem unless provisions are made for a larger water pump. Temperatures above 127°C (260°F) are acceptable for short periods of time. Prolonged operation above the limits will degrade the glycol and inhibitor system. The system must be pressurized to maintain the coolant in a liquid phase at all times. Any boiling will result in build-up on the surfaces of the engine coolant jacket.

Long Life Coolant is available as an antifreeze formulation, premixed 50/50 with deionized water, or in concentrate in the quantities that follow.

LONG LIFE COOLANT - QUANTITIES AVAILABLE		
Type	**Size**	**Part No.**
Pre-Mix	Bulk 208.5 L (55 gal) 3.8 L (1 gal)	119-5148 101-2845 101-2844
Concentrate[1]	3.8 L (1 gal)	119-5150

[1] Use ONLY distilled or deionized water to mix the concentrate.

Long Life Coolant Extender

The cooling system should be treated with approximately .946 L (1 quart) of Extender (part no. 119-5152) for each 45.5 L (12 gallons) of cooling system capacity at approximately a 3,000 service hour interval. Over treatment or under treatment of the Extender will not create any problems within the cooling system if it is kept within 15 percent above or below the normal dosage. Use the table that follows to determine the recommended amount of Extender to add to LLC.

RECOMMENDED AMOUNT OF EXTENDER BY COOLING SYSTEM CAPACITY	
Cooling System Capacity	**Recommended Amount of Extender**
22-30 L (6-8 U.S. gal)	0.57 L (0.60 qt)
30-38 L (8-10 U.S. gal)	0.71 L (0.75 qt)
38-49 L (10-13 U.S. gal)	0.95 L (1 qt)
49-64 L (13-17 U.S. gal)	1.18 L (1.25 qt)

Clean/Flush Cooling System When Using LLC

When LLC is drained from the cooling system, **CLEAN WATER** is the only system cleaning/flushing agent required.

When the cooling system coolant is changed from standard antifreeze to LLC, Caterpillar Cooling System Cleaner should be used. Refer the chart that follows for quantities available. After the cleaning solution has been drained, it is VERY IMPORTANT that a thorough water flush be used to remove ALL of the cleaning agent.

COOLING SYSTEM CLEANER QUANTITIES AVAILABLE	
Part No.	**Size**
4C4609	0.47 Liter (1 Pint)
4C4610	0.95 Liter (1 Quart)
4C4611	3.79 Liter (1 Gallon)
4C4612	18.95 Liter (5 Gallon)
4C4613	208 Liter (55 Gallon)

NOTICE

Mixing LLC with other products will reduce the effectiveness of the coolant. This could result in damage to cooling system components. If Caterpillar products are not available and commercial products must be used, make sure they have passed the Caterpillar EC-1 specification for pre-mixed or concentrate coolants and Caterpillar Extender.

Fuel Specifications

Fuel System Information

Check the fuel level in the fuel tank daily by checking the dipstick or observing the sight gauge, if equipped.

NOTICE

Fill the fuel tank at the end of each day of operation to drive out moist air and to prevent condensation. Maintain a fairly constant level in the tank (near the top) to avoid drawing moisture into the tank as the level decreases. Do not fill the tank to the top. Fuel expands as it gets warm and can overflow.

Drain water and sediment from tank at the interval specified in the Maintenance Interval schedule.

Do not fill fuel filters with fuel before installing them. Contaminated fuel will cause accelerated wear to fuel system parts.

Fuel Recommendations

Use only fuel as recommended in this section. The fuels recommended for use in Caterpillar engines are No.2-D diesel fuel and No.2 fuel oil, although No.1 grades are acceptable. The following fuel specifications are some of the worldwide fuels which may meet the requirements.

WORLDWIDE FUEL SPECIFICATIONS–DIESEL ENGINES	
Specifications	**Fuel Designation**
AMERICAN (U.S.) STANDARDS ASTM D975 ASTM D396 ASTM D2880	No.1-D & No.2-D diesel fuel oil No.1 & No.2 fuel oils No.1-GT & No.2-GT gas turbine fuels
BRITISH STANDARDS BS 2869 BS 2869	Classes A1, A2 & B1 engine fuels Classes C2 & D burner fuels
GERMAN STANDARDS DIN 51601 DIN 51603	 Diesel Fuel Heating Oil El
AUSTRALIAN STANDARD AS 3570	 Automotive diesel fuel
JAPANESE STANDARD JIS K2204	Types 1(spl), 1, 2, 3 & 3(spl) gas oil
U.S. GOVERNMENT W-F-800C W-F-815C	DF-1,DF-2 & DF-20 CON.U.S. diesel fuel FS-1 & FS-2 burner fuel oil
U.S. MILITARY MIL-L-16884G	 Marine Oil

Caterpillar Diesel Engines are capable of burning a wide range of distillate fuels. The use of clean, stable blends of distillate fuel which meet the following requirements will provide quality engine service life.

DISTILLATE FUEL RECOMMENDATIONS–DIESEL ENGINES	
Specifications	**Requirements[1]**
Aromatics (ASTM D1319)	35% Max.
Ash (ASTM D482)	0.02% Weight Max.
Cetane Number (ASTM D613)	35 Min. for PC Engines 40 Min. for DI Engines
Cloud Point (ASTM D97)	Not Above Lowest Expected Ambient Temperature
Gravity API (ASTM D287)	30 Min. and 45 Max.
Pour Point (ASTM D97)	6°C (10°F) Below Ambient Min.
Sulfur (ASTM D2788, D3605 or D1552)	0.5% Max. (See Sulfur Topic)
Viscosity, Kinematic @ 38°C (100°F) (ASTM D445)	20.0 cSt Max. 1.4 cSt Min.
Water & Sediment (ASTM D1796)	0.01% Max.

[1] As delivered to fuel system

Sulfur

The percentage of sulfur in the fuel will affect the engine oil recommendations. Fuel sulfur is chemically changed during combustion to form both sulfurous and sulfuric acid. These acids chemically attack metal surfaces and cause corrosive wear.

Certain additives used in lubricating oils contain alkaline compounds that are formulated to neutralize these acids. The measure of this reserve alkalinity in a lubricating oil is known as its Total Base Number (TBN). TBN values are essential to neutralize the acids from combustion gases and to minimize corrosive wear.

Fuels containing 0.5 percent or less sulfur may be used with recommended crankcase oil drain intervals using API CG-4 performance oils. With sulfur above the 0.5 percent level, use API CG-4 performance oils with an ASTM D-2896 Total Base Number (TBN) of 10 times the fuel sulfur for normal oil drain intervals.

Caterpillar recommends infrared analysis (in conjunction with wear metal analysis) of used oil in determining the effectiveness of oil TBN and acid neutralization. The Caterpillar dealer Scheduled Oil Sampling (S•O•S) program provides this information. Regular oil analysis (S•O•S) will provide information to monitor oil properties and engine wear metals to maintain successful engine protection and establish oil drain intervals.

Periodically request fuel sulfur content information from your fuel supplier. Fuel sulfur content can change with each bulk delivery. ASTM D-2896 can normally be found at your local technological society, library or college.

Any American Petroleum Institute (API) classification performance oil should have sufficient TBN for fuels with less than 0.5 percent sulfur. Fuels containing 0.5 percent or less sulfur may be used with recommended crankcase oil drain intervals using API CG-4 performance oils.

Additives

Fuel additives are generally not recommended nor needed for the specified fuels listed. Cetane improvers can be used as necessary for the direct injection engine requirements. Biocides may be needed to eliminate microorganism growth in storage tanks. In cold conditions, treatment for entrained water may also be necessary.

Consult your fuel supplier about the use of additives to prevent incompatibility among additives already in the fuel and the additives to be used. Other fuel types may be used when economics or fuel availability dictate. Consult your Caterpillar dealer for more information and advice on any specific fuel.

For more information on fuel selection and fuel properties, refer to Diesel Fuels and Your Engine, SEBD0717. For more information on oil, fuel sulfur content, etc., refer to Oil and Your Engine, SEBD0640 or contact your Caterpillar dealer.

Lubricant Specifications

Lubricant Information

Certain abbreviations follow Society of Automotive Engineers (SAE) J754 nomenclature and some classifications follow SAE J183 abbreviations. SPC is a Caterpillar designation for special synthetic oils that do not contain viscosity improvers. The MIL specifications are U.S.A. Military Specifications. The CCMC refers to an organization of major European manufacturers engine oil performance specifications. Recommended oil viscosities can be found in the Lubricant Viscosities chart.

Grease is classified by the National Lubricating Grease Institute (NLGI) based on ASTM D217-68 Worked Penetration characteristics which are given a defined consistency number.

Engine Lubricant Specification

Maximum engine life and performance can be expected when the proper engine oil is used. There are significant variations in the quality and performance of the oils commercially available. Caterpillar Oils are formulated to provide maximum performance and life in your Caterpillar engine. They are offered in multi-viscosity grades to meet the performance and ambient temperature requirements for heavy duty diesel engines.

Caterpillar Oil

To achieve the maximum engine life and superior performance in your Caterpillar diesel engine, Caterpillar recommends Caterpillar Diesel Engine Oil–DEO (API CG-4). Oils meeting the American Petroleum Institute (API CG-4) performance category possess the properties to operate effectively at the higher piston temperatures.

Caterpillar Oils are currently offered by Caterpillar dealers for continued refill use. Consult your Caterpillar dealer for more information on Caterpillar Oils.

The DEO (CG-4) oil is blended in viscosity grades of SAE 10W30 and 15W40. Multi-grade oils significantly lower oil consumption compared to single grades. Oil consumption and piston crown land deposits are very important in the engine tests used to evaluate oil performance.

Commercial Oils

If oils other than Caterpillar oils are to be used, the following oil specifications provide guidelines for the selection of commercial products.

- API specifications CG-4, CG-4/SH, CF-4, CF-4/SF, or CF-4/SG

If API CG-4 or CF-4 oils are not available, the API CE, CE/SF, CE/SG, or CCMC D4 or MIL-L-2104E may be used with shortened oil change intervals as determined by close monitoring of oil condition with Scheduled Oil Sampling (S•O•S) and infrared analysis.

NOTICE

Failure to follow the commercial oil recommendation for API CG-4 performance oils can cause shortened engine life due to piston carbon deposits, liner bore polish and/or abnormally higher increasing oil consumption.

API CC and CD oils are unacceptable in this Caterpillar diesel engine.

Caterpillar Engine Oil–DEO (CG-4) Part Numbers

Caterpillar Engine Oil DEO (CG-4)	3.79 L (1 U.S. Gal)	18.95 L (5 U.S. Gal)	208.45 L (55 U.S. Gal)
SAE 10W30	3E9904	3E9709	3E9708
SAE 15W40	3E9714	3E9713	3E9712

Lubricant Viscosity Recommendations

The recommendations refer only to the SAE viscosity grade for the expected ambient temperature range. The required performance criteria for the oils are defined in this section. The proper SAE grade of oil to select is determined by the minimum outside temperature at which the engine will be started and the maximum outside temperature in which the engine will be operating. This recommendation is to ensure the correct viscosity is used until the next oil change.

The use of API CG-4 multi-viscosity oils is recommended because of full protection through a wider temperature range. The recommendation would be to use the highest viscosity oil possible. Even though the ambient temperature may be low, operating engines can still be subjected to normal oil temperatures because of regulated temperature components. The higher viscosity fluids will provide better protection to all components which it contacts during the full day work cycle.

To determine if the oil in the crankcase will flow in cold weather, remove the oil dipstick before starting. If the oil will flow off, the oil is fluid enough to circulate properly. API CG-4 oil is the recommended lubricating oil for use in Caterpillar diesel engines.

NOTE: Oil viscosity grades which meet the API CG-4 performance category are limited to multi-grades (SAE 15W40 and 10W30). If local single viscosity grades are selected, confirm with your oil supplier that the oil does meet the API CE or CG-4 rating requirement.

The minimum temperature for the viscosity grade provides guidelines for the lowest starting temperature with a "cold soaked" engine. Therefore, a particular oil may allow lower starting temperatures than given in the chart.

LUBRICANT VISCOSITIES FOR AMBIENT (OUTSIDE) TEMPERATURES

Compartment or System	Oil[1] Viscosities	°C		°F	
		Min	Max	Min	Max
Engine Crankcase	SAE 10W	−20	+10	−4	+50
	SAE 10W30	−20	+40	−4	+104
	SAE 15W40	−15	+50	+5	+122
	SAE 20W40[2]	−10	+40	+14	+104
	SAE 30[2]	0	+40	+32	+104
	SAE 40[2]	+5	+50	+41	+122

[1] Select oil viscosity based on the maximum expected operating temperature. Engine start-up at lower than specified ambient temperature requires caution. Start-up at very low ambient temperatures may require auxiliary oil heaters or other methods to increase the engine crankcase and surrounding temperatures.

[2] Oil viscosity grades which meet the API CG-4 performance category are limited to multi-grades (SAE 15W40 and 10W30). If single viscosity grades are selected, confirm with your oil supplier that the oil does meet the API CE or CG-4 rating requirement.

To ensure proper flow in arctic conditions, several options from the topics in Cold Weather Recommendations can be used to assist the lubrication system.

Synthetic Base Stock Oils (SPC)

The performance characteristics of the oil depends on the base oil and the additives. The additives in the oil will vary according to the properties of the base oil and the environment in which the oil will perform its function.

Synthetic base stock oils are acceptable for use in Caterpillar diesel engines if these oils meet the performance requirements specified for a particular compartment. The performance requirements for Caterpillar diesel engines using synthetic oils is API CG-4 with API CE as an alternative.

The use of a synthetic base stock oil does NOT allow extension of the oil drain period simply because of the use of synthetic oil. Any drain period extension must be validated by S•O•S (oil analysis and test evaluation) to ensure no excessive component wear occurs in a particular application.

The synthetic oils have naturally low pour points which make them very good oils for low temperature applications. Caterpillar's recommendation for these arctic applications is synthetic base stock oils where startability at the cold conditions are a requirement.

Oils are changed because they become contaminated with dirt, soot, wear particles, etc. in their normal use. The additives in the oil formulation are depleted as the oil functions in a compartment. The oil contamination and additive depletion occurs independently of the oil base stock type.

Synthetic lubricants may be superior to petroleum oils in specific areas. Many exhibit higher viscosity index (VI), better thermal and oxidation stability and sometimes lower volatility. Because synthetic lubricants are higher in cost than petroleum oils, they are used selectively where performance may exceed capabilities of conventional oils.

Re-refined Base Stock Oils

The Caterpillar requirement for oils is that any oil formulation meet the performance requirements as defined by the API classification and have the proper viscosity as defined by the SAE J300 Specification. The base stock oil used in the formulation can be either virgin or re-refined (or a combination) as long as the final oil formulation meets the requirements of both performance and viscosity.

The combination of the base stock oil and the additive must perform to the defined specifications. If the oil meets these requirements, then its' performance in an engine (or other compartment) should be acceptable. The military specifications and other engine manufacturers have also accepted the use of re-refined oil base stock with the same criteria.

Therefore, the use of oils with re-refined base stocks will depend on the company who has supplied the oil. Have they subjected the oil formulation to the qualifying tests, and passed the tests, as required to label the oils for the API performance and viscosity grade?

Various methods may be available for processing of the used oil. Caterpillar would normally recognize a re-refining process as one which subjects the used oil to the same refinery process (such as vacuum distillation and hydro-treating) as the virgin base stock was obtained from the original crude oil. The base stock obtained by this method should provide an acceptable base stock from which to formulate a proper oil. But the oil formulated must still pass the required performance and viscosity tests for the compartment and intended use.

Always consult with your Caterpillar dealer for the latest lubrication recommendations.

Caterpillar Lubricating Grease

- CAT Multipurpose Molybdenum Grease (MPGM)
- CAT Multipurpose Lithium Grease (MPGL)
- CAT Special Purpose Grease (SPG)

Use MPGM grease for fan drive bearings where an extreme pressure grease will maximize the life of Caterpillar engines. This NLGI No. 2 grade is suitable for most temperatures. If MPGM grease is not available, use a multipurpose type grease which contains three to five percent molybdenum.

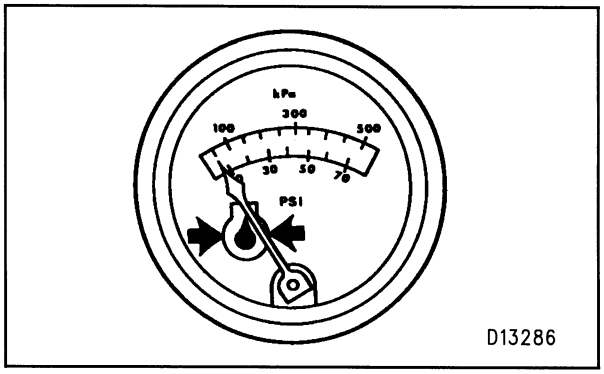
Anti-Seize Compound (ASC)

- Use 6V4876 Molykote paste lubricant or equivalent. Typical use: head bolt threads and washers.
- Use 5P3931 Anti-Seize Compound (ASC) or equivalent. Typical use: exhaust manifold studs and nuts.

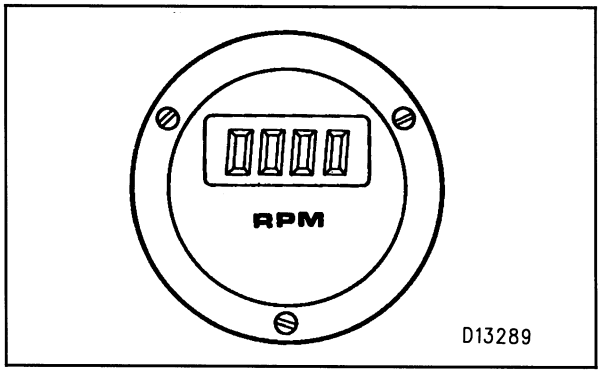
Gauges and Indicators

Your engine may not have the same or all of the gauges described. The illustrations shown are of typical gauges. Refer to the OEM Owner Manual for information on the layout of your gauge package. Gauges provide a "look" inside the engine. Be sure they are in good working order. Determine what is the "normal" operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings are an indicator of potential gauge or engine problems. This also applies to gauge readings that have changed significantly but are still within specifications. The cause of any sudden or significant change in the readings should be determined and corrected. Contact your Caterpillar dealer for assistance as needed.



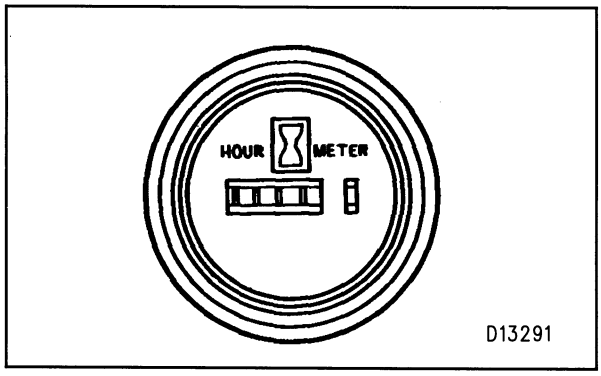
Engine Oil Pressure – Indicates engine oil pressure. The pressure reading will be greatest after starting a cold engine. Oil pressure will decrease as the engine warms while idling. As the engine speed is increased to full load speed, oil pressure will increase and stabilize. Minimum engine oil pressure is 275 kPa (40 psi) at rated speed.



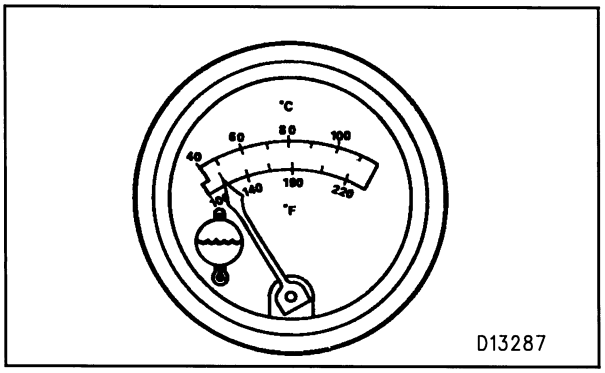
Tachometer – Indicates engine rpm. When the governor control lever is moved to the full speed position without load, the engine is running at high idle.

When the engine governor control lever is at the full speed position with maximum rated load, the engine is running at the full load rpm (assuming the engine and load are matched).

The high idle rpm, and the full load rpm, are stamped on the engine's Information Plate.



Service Hour Meter – Indicates the total number of clock hours the engine has operated.



Engine Jacket Water Temperature – Indicates engine water temperature. The water temperature reading may vary according to load, but should never exceed the boiling temperature for the pressurized system being used. Engine jacket water temperature range is 80° to 100°C (175° to 210°F).

Inlet Air Temperature – Indicates inlet manifold air temperature. As the inlet air increases in temperature, the air expands, less oxygen is available in the cylinders, and less kw (horsepower) is developed. As a result, at full speed position with a full load, the engine may be overloaded. Maximum inlet manifold air temperature is 118°C (245°F).

Exhaust Temperature – Exhaust temperature is measured at the inlet-to-turbo/exhaust manifold. It is an excellent indicator of engine performance and valve temperatures. The inlet-to-turbo temperature should be the first choice as a performance indicator to monitor and record. Exhaust temperatures measured at the inlet-to-turbo are representative of actual valve temperatures for engines with dry manifolds. Inlet-to-turbo temperatures should be monitored frequently. Inlet-to-turbo temperatures should be monitored as often as hourly for some applications or load conditions.

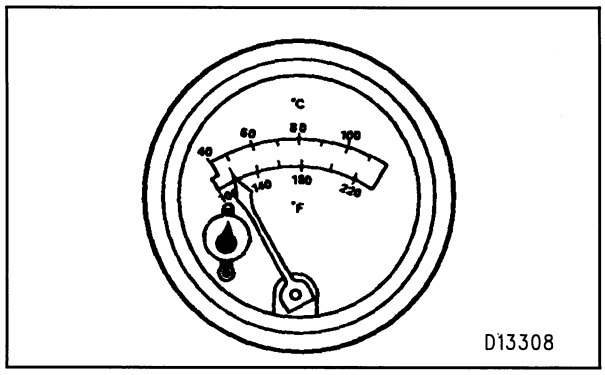
For many years, stack exhaust temperatures have been used to assist in accessing engine performance. The stack exhaust temperature is not a suitable substitute for the inlet-to-turbo data. However, Stack temperature along with inlet-to-turbo temperature can provide a means of accessing turbocharger performance. It is recommended that inlet-to-turbo temperature ports be installed and customers trained in the proper interpretation of cylinder and inlet-to-turbo temperatures.

Cylinder Port Temperatures

Cylinder port temperatures are a good indicator of individual cylinder conditions. The cylinder port thermocouples do not read actual cylinder temperature, but indicate a value that is less than the actual cylinder exhaust temperature due to lack of constant flow past the sensor. Cylinder port temperature normally reads less than inlet-to-turbo temperature for dry manifolds. Cylinder port temperatures are not to be used as a substitute for inlet-to-turbo temperature data. Typical problems diagnosed with cylinder port temperatures are bad fuel injectors and valve gutters. The ability to diagnose one of these problems may prevent additional damage to the engine and save significant downtime and repair costs.

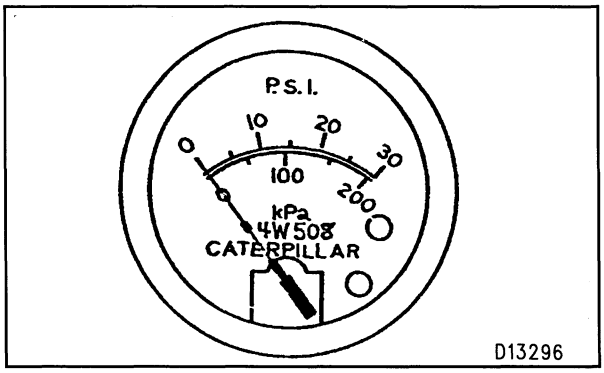
- The engine should normally show a temperature difference of up to 56°C to 70°C (100°F to 125°F) from the hottest cylinder to the coldest cylinder at rated speed.

- If a cylinder deviates more than 100°C (180°F) from the average of all cylinder port temperatures, corrective action must be taken. Contact your Caterpillar dealer for more information.

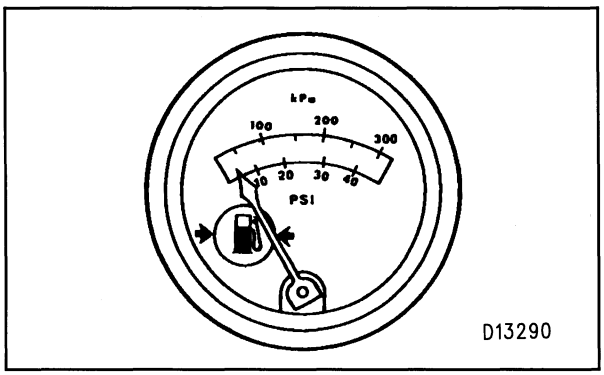


Engine Oil Temperature – Indicates engine oil temperature. The purpose of the oil is to lubricate all moving parts inside the engine, and to cool the pistons and bearings. The oil cooler transfers the heat in the oil to the engine jacket water.

If the cooling system cannot maintain the correct temperature, the engine oil cannot be properly cooled. Higher than normal oil temperature indicates a heat problem has occurred in the lubrication and/or cooling system, and a problem can occur with cylinder heads, liners, pistons or bearings. Maximum oil temperature is 110°C (230°F).

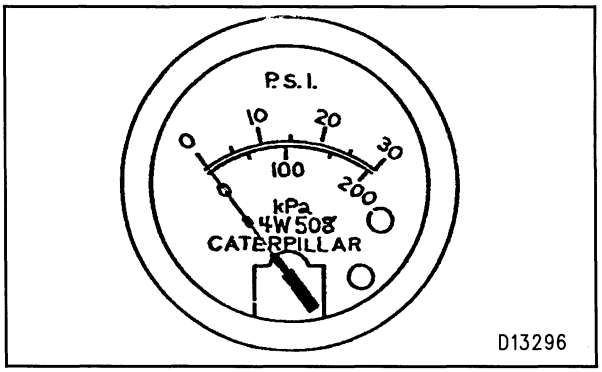


Oil Filter Differential Pressure – Indicates the difference of oil pressure between the inlet side (dirty side) and the outlet side (clean side) of the oil filter. As the element becomes plugged, the difference in pressure between the two sides of the element will increase. Maximum oil filter differential pressure is 105 kPa (15 psi).



Fuel Pressure – Indicates pressure of the filtered fuel. Minimum fuel pressure is 380 kPa (55 psi) at rated speed.

Air Cleaner Differential Pressure – Indicates the difference of air pressure between the inlet side (dirty side) and the engine side (clean side) of the air filter element. As the element becomes plugged, the difference in pressure between the two sides of the element will increase. Maximum air cleaner differential pressure is 638 mm of H_2O (25 inches of H_2O).



Fuel Filter Differential Pressure – Indicates the difference of fuel pressure between the inlet side and the outlet side of the fuel filter elements. As the element becomes plugged, the difference in pressure between the two sides of the element will increase. Maximum fuel filter differential pressure is 105 kPa (15 psi).

Marine Gear Oil Temperature – Indicates marine gear oil temperature. The marine gear oil temperature depends upon the temperature and the quantity of water pumped through the marine gear oil cooler. Caterpillar 7200 Series Marine Gears have sea water pumped through the oil cooler. See the chart below for the operating oil temperature range.

7200 Series Marine Gear Operating Temperature	
Marine Gear Model No.	**Operating Temperature Range**
7231	60 to 93°C (140 to 200°F)
7241	60 to 70°C 140 to 175°F)
7251	60 to 70°C (140 to 175°F)
7261	60 to 70°C (140 to 175°F)
7271	60 to 93°C (140 to 200°F)

For marine gears other than Caterpillar 7200 Series, refer to the marine gear manufacturer's specifications.

Marine Gear Oil Pressure – Indicates marine gear oil pressure. The oil pressure depends on the temperature and quantity of oil pumped through the oil system. If the marine gear oil is hot, the pressure will be less than if the oil is cold. See the chart below for the operating oil pressure range.

7200 Series Marine Gear Operating Pressure	
Marine Gear Model No.	**Operating Oil Pressure Range**
7231	1757 to 1964 kPa (255 to 285 psi)
7241	1757 to 1964 kPa (255 to 285 psi)
7251	1688 to 1895 kPa (245 to 275 psi)
7261	1830 to 1964 kPa (265 to 285 psi)
7271	1998 to 2140 kPa (290 to 310 psi)

For marine gear other than Caterpillar 7200 Series, refer to the marine gear manufacturer's specifications.

If the oil strainer is plugged, or if there is a restriction in either the oil pump, selector valve, or lines, the pressure will be less than the minimum pressure required. Low oil pressure will result in excessive marine gear clutch wear. If this occurs, the oil temperature will increase and oil pressure will decrease.

Shutoff and Alarm System Components

Emergency Shutoff Controls

Emergency shutoff controls may be electrically, mechanically or hydraulically operated. Familiarize yourself with the types and locations of the shutoff controls, the conditions which cause each control to function, and the resetting procedure required to start your engine.

The operation of all electrical shutoff controls is similar. A critical operating condition actuates a switch to stop the engine. The shutoff control may require resetting before the engine can start.

The shutoff controls should be tested Every 1000 Service Hours by an authorized Caterpillar dealer. The Hydramechanical Shutoff can be tested remotely by engine service personnel Every 500 Service Hours.

Do not use an emergency shutoff control for a normal stopping procedure.

Always determine the cause of the shutdown, and have the necessary repairs made before restarting the engine. Refer to the Troubleshooting Section of this manual or the Troubleshooting guide in the Service Manual.

Alarm Switches

Alarm switches are set at a less critical temperature, pressure, or level limit than the shutoff controls. The purpose of the alarm switch is to warn the operator that an unsafe operating condition is starting to occur. Corrective measures must be taken to avoid possible damage to the engine.

Marine engines can be equipped with either alarm or shutoff systems. However, in many operations an uncontrolled shutdown may cause an accident far more serious than the damage to the engine, particularly on propulsion engines.

Marine propulsion engines are usually equipped with various alarm systems. The most common alarm systems indicate high jacket water temperature, high inlet air temperature, high oil temperature and low oil pressure.

When an alarm is activated, corrective measures must be taken before the situation becomes an emergency.

Each alarm switch is electrically connected to an indicator light, bell or horn. The alarm will continue until the condition is corrected. Then the light will turn off and the bell or horn will be silenced.

To silence the bell or horn while repairs are being made, a two-way switch and a red indicator light may be installed. The red indicator light will come on when the alarm is turned off.

The red light will stay on, to indicate that the engine is not protected, if the switch is left in the OFF position after the repairs have been made.

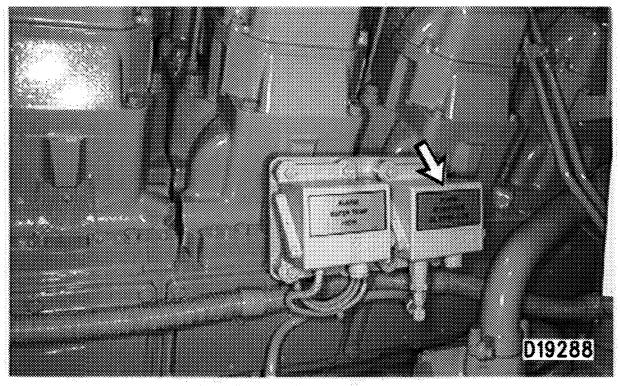
Testing Alarms

All alarms on the engine should be tested twice a year for proper operation by referring to the Service Manual or authorized Caterpillar dealer personnel.

NOTICE

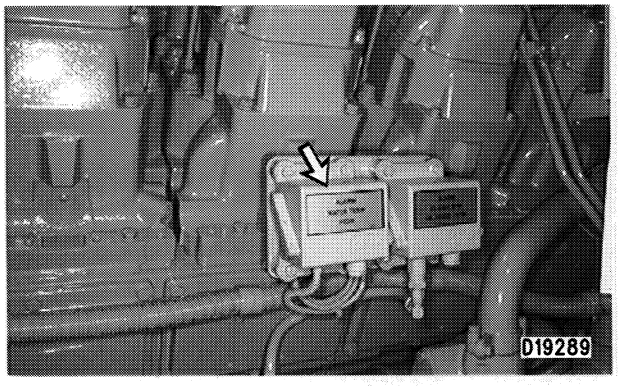
During testing, abnormal operating conditions must be simulated. Perform the tests correctly to prevent possible damage to the engine.

Oil Pressure Switch



This low oil pressure switch is used in the oil system to stop the engine when oil pressure drops below rated system pressure.

Coolant Temperature Switch

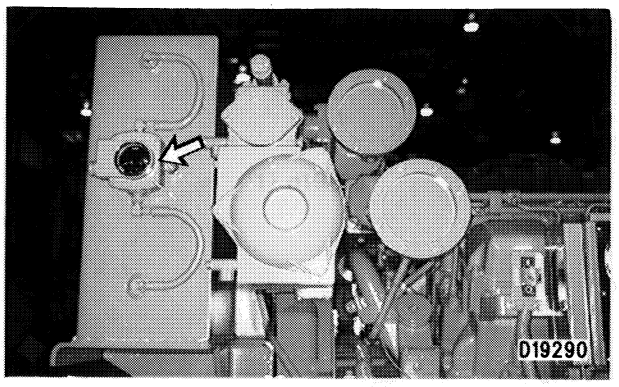


The shutoff switch is located in the water temperature regulator housing. Excessive water temperature closes the switch. No resetting procedure is required. The switch opens as the coolant cools.

NOTICE

The sensing element must be submerged in the coolant to operate. The shutoff cannot actuate if the coolant level is low and not activating the sensing element.

Coolant Level Alarm/Murphy Switch



This switch gives an indication of low coolant level, but does not stop the engine.

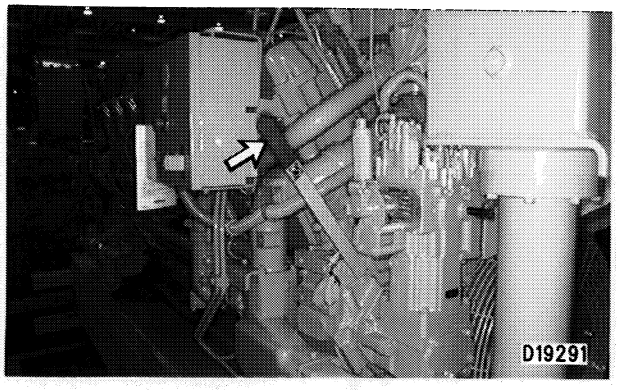
Air Safety Control

The air shutoff control is an attachment to the safety shutoff devices. When an emergency condition occurs, the solenoid pushes the rack into the shutoff position and a solenoid trips a butterfly valve, which is located in the inlet manifold, to the closed position, cutting off intake air to the engine. The air safety control must be reset before starting.

Electrical Overspeed Shutoff

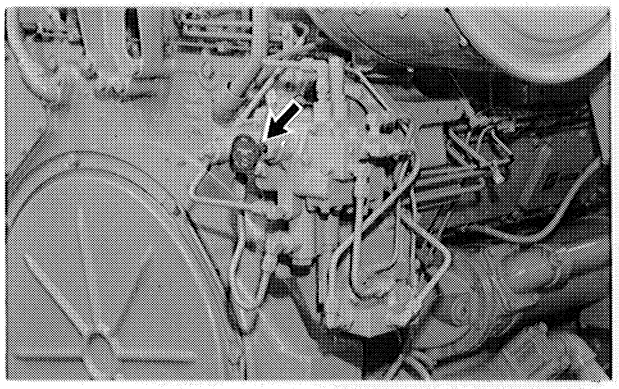
This shutoff has an overspeed switch which works through the governor shutoff solenoid and the air inlet shutoff solenoids. If the engine should overspeed, fuel and air will be cut off to stop the engine.

Manual Fuel Shutoff Lever

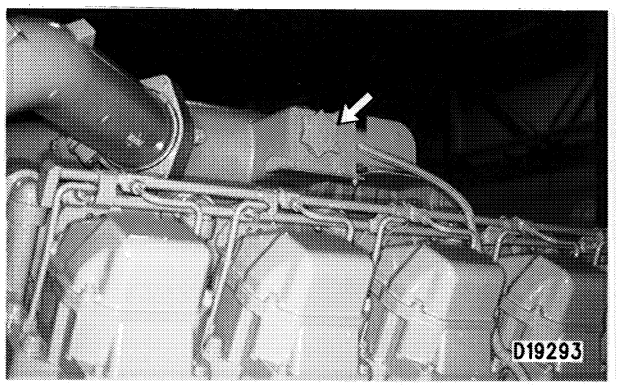


A manual shutdown lever is provided to override the governor control of the engine. This shutdown will only move the fuel control linkage to the fuel-off position. It does not shut off the air inlet.

Hydramechanical Shutoff (HMSO)



The HMSO will automatically stop the engine by pushing the rack to the shutoff position if low oil pressure or high coolant temperature conditions occur. The air inlet shutoff will activate, stopping the engine, if an overspeed condition occurs.

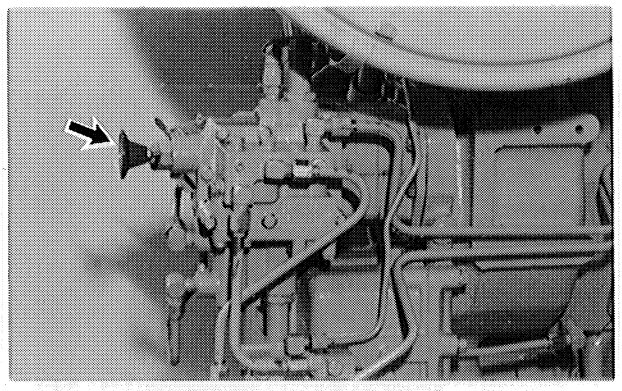


The fuel rack will reset automatically, but the air inlet shutoff knob must be reset to the RUN position manually.

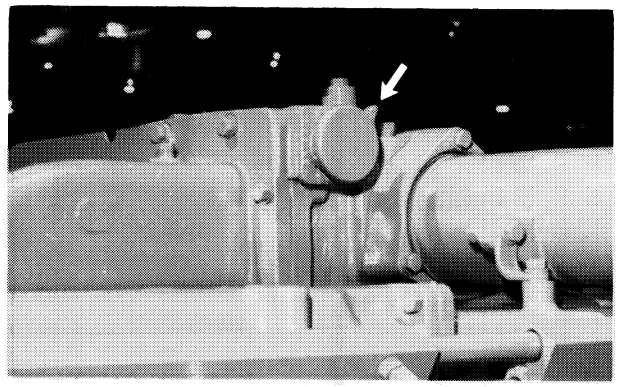
The HMSO uses lubrication oil from the engine. It has an oil pump that supplies pressure to the shutoff system. There is a sump in the valve which must be refilled if it was drained before starting the engine.

An attachment allows the HMSO to be used as an emergency manual shutoff.

Test the operation of the HMSO Every 500 Service Hours. Use the procedure that follows.



1. Pull out the red emergency knob while observing the air inlet shutoff valve.



2. The air inlet shutoff knob must move to the STOP position and shut off the air supply to the engine. The engine must stop.

3. Push in the red emergency knob to reset the HMSO.

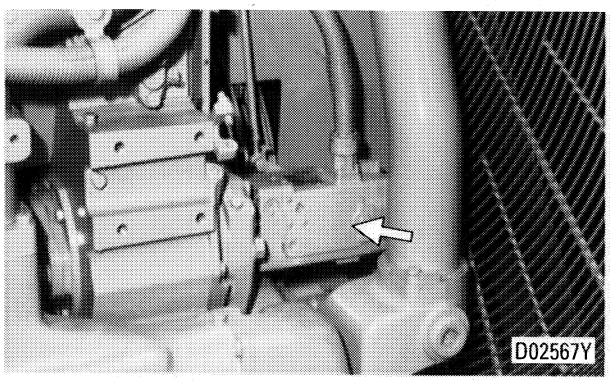
4. Move the air shutoff knob to the RUN position to open the air inlet valve.

Consult your Caterpillar dealer if the HMSO or the air inlet shutoff did not operate correctly.

Engine Controls

Earlier propulsion engine models used a Woodward UG-8 governor. Current propulsion engines use a Woodward 3161 governor. Marine Auxiliary (Generator Set) engines use 2301 governors with EG-10P actuators. Engine controls can be mechanically, hydraulically, or pneumatically operated.

Mechanical Governor Control (Woodward UG-8)



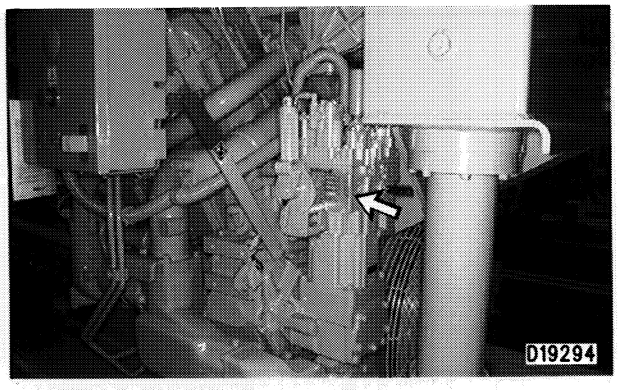
The mechanical governor control is used to control engine speed remotely. It will manually move the governor speed control lever.

Air Actuated and Hydramechanical Governor Controls (Woodward UG-8)

A dipstick (oil level gauge) is used to show the amount of oil in the governor. The UG-8 governor is equipped with a speed droop. The speed droop must be adjusted from inside the governor. Refer to the Service Manual for adjusting speed droop.

The air actuated governor control is attached directly to the governor. This is connected to the governor speed control lever, which is used to control engine speed.

3161 Governor



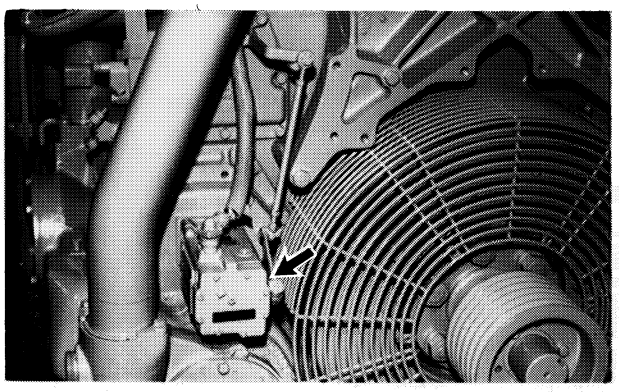
The engine may be equipped with a 3161 lever-type governor, which has an air/fuel ratio control to limit smoke and to provide pneumatic speed setting. The 3161-L uses engine oil for lubrication and actuation. The 3161 governor has external speed droop adjustments. Refer to the Service Manual for the setting procedure.

3161 Governor Pneumatic Speed Control

The pneumatic speed control is bolted to the left front corner of the governor. The speed setting control uses air pressure to increase or decrease the speed of the engine. The ability to control and repeat the setting is consistent. An air pressure signal from a remote throttle and an internal pressure oil signal from the governor operate the control.

The speed setting control has a standard pressure range of 69 to 414 kPa (10 to 60 psi). Some special applications require different air pressure ranges. Refer to the Service Manual for additional information.

2301 Governor with EG-10P Actuator (Marine Auxiliary Engines)



The EG-10P Actuator is an engine driven device that hydraulically changes an electrical input to a mechanical output. The mechanical output from the EG-10P Actuator controls the engine fuel rack.

The EG-10P Actuator is used in conjunction with the 2301 Electric Governor Control Box.

The only adjustment that can be made to the EG-10P Actuator is to the external needle valve. Refer to the Service Manual for the adjustment procedure to the external needle valve.

2301 Governor Controls

The 2301 Electric Governor Control System consists of the 2301 Electric Governor Control (EGC) Actuator, Magnetic Pickup, and an optional preregulator.

The 2301 Electric Governor System delivers precision engine speed control. The 2301 Electric Governor System constantly measures engine speed and makes necessary corrections to the engine fuel setting. The corrections are completed through an actuator connected to the engine fuel control system.

Attachment Control

Marine Gear Selector Lever

Full power is transferred from the engine through the marine gear, in either forward or reverse rotation, to the propeller shaft.

Back-to-back hydraulically actuated clutches operate the forward and reverse drives. A control valve directs the flow of oil to either the forward or reverse clutch, for forward or reverse operation.

The control valve is operated by a marine gear selector lever, which can be manually or remotely operated. For forward travel, with a right hand propeller, pull the lever back away from engine to engage the clutch rear section. Center the marine gear selector lever for neutral. For astern travel, push the lever toward the engine to engage the clutch front section.

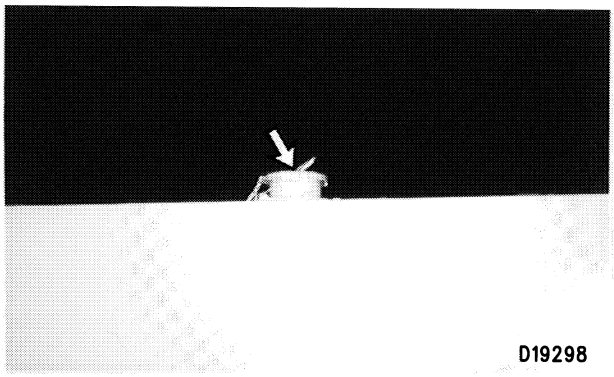
NOTE: For a marine gear other than Caterpillar 7200 Series, refer to the manufacturer's instructions.

Starting the Engine

Before Starting the Engine

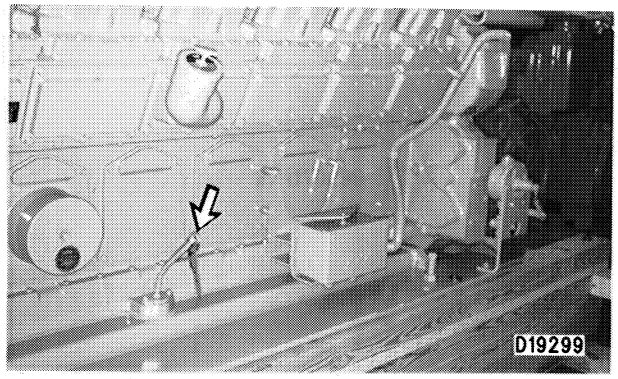
Perform required periodic maintenance before starting the engine. Make a walk-around inspection of the installation. It only takes a few minutes to make minor corrections. This can prevent major repairs at a later date.

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

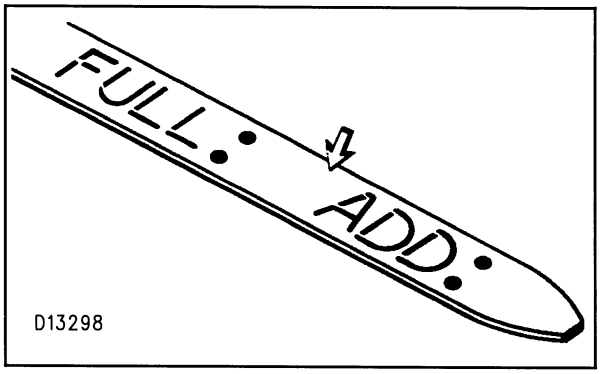


1. Inspect the coolant level. The level should be to the bottom of the tank filler neck. On some systems, maintain the coolant according to the proper level indicated by a sight glass.

After starting the engine, operate at slow speed until the engine is at operating temperature. Check and add coolant if necessary.



Oil level gauge (dipstick) location.

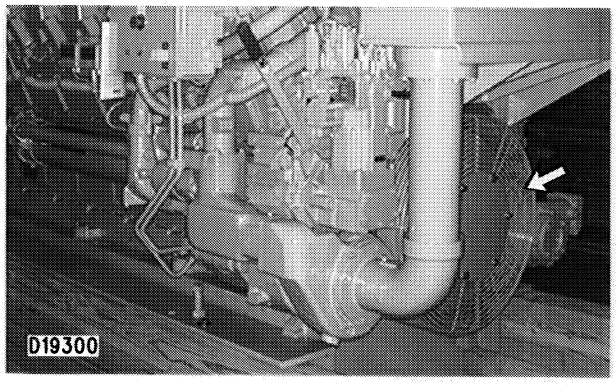


2. Measure the crankcase oil level. The correct oil level is shown by the marks just below the words FULL and ADD on the dipstick. Two dots are currently used to indicate the correct level. Some earlier dipsticks have a line across the dipstick in the same location. Keep the oil level between these marks. Never use the words printed on the dipstick to measure the oil level.

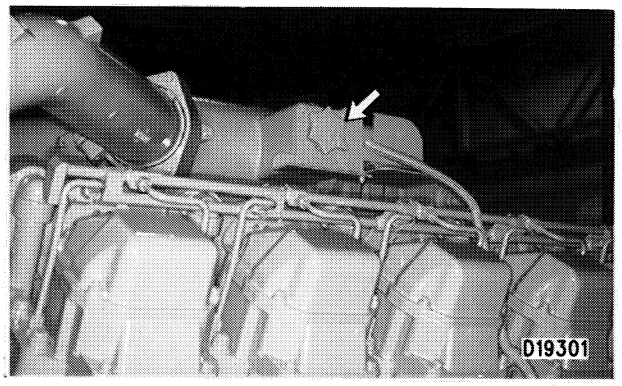
Refer to the Refill Capacities Chart in this manual for the proper amount of oil for your engine.

NOTE: Remote mounted or auxiliary filters require additional oil. If auxiliary oil filters (non-Caterpillar furnished) are used with the engine, refer to the manufacturer's instructions.

3. Disconnect any battery chargers that are not protected against the high current drain created when the electric starter engages.



4. All guards must be in place. Repair or replace all guards that are damaged or missing.



5. Make sure air inlet shutoff knob is in the RUN position and inlet piping and filters are in place.

6. Make sure fuel lines are properly clamped and tight. Check for loose fittings or leaks.

7. Check for any obvious cooling system leaks or loose connections. Inspect the water pump(s) for evidence of leaks.

8. Check for lubrication leaks, such as the front and rear crankshaft seals, crankcase, oil filter, oil gallery plugs and sensors, and valve covers.

9. Check electrical cables and the battery for poor connections and corrosion.

Starting the Engine

NOTICE

Do not engage starter when flywheel is turning.

If oil pressure does not raise within 15 seconds after the engine starts, stop the engine and make necessary corrections.

Do not start engine under load (marine gear in Ahead or Astern).

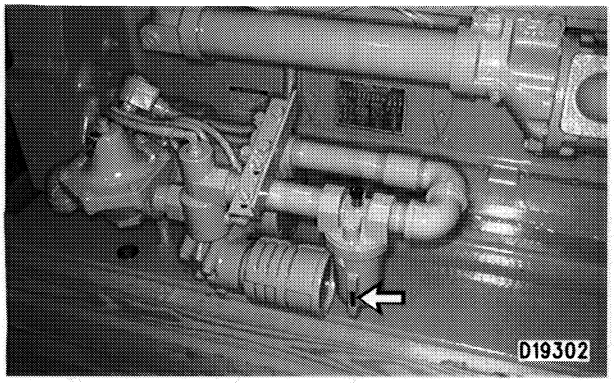
Air Starting

1. Place the marine gear in NEUTRAL.

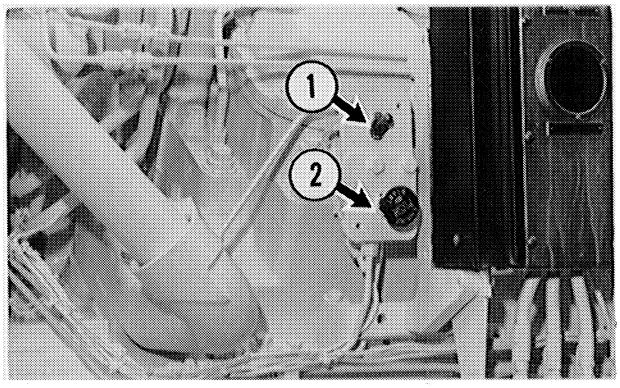
2. Move the throttle to LOW IDLE engine speed.

3. Open and close the drain valve on the bottom of the air tank to drain condensation and oil overflow.

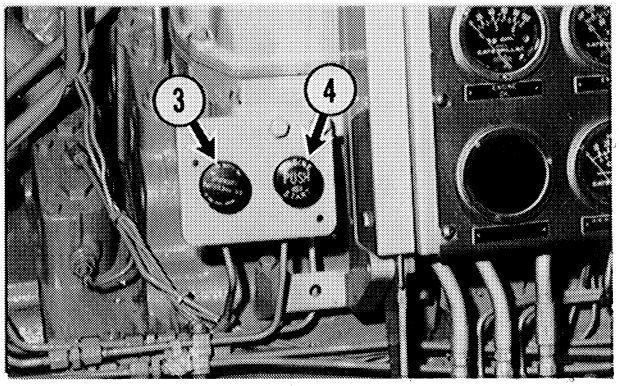
4. Check the air supply pressure. The air starter must have 690 kPa (100 psi) to operate properly.



5. Check the oil level in the air lubricator. Keep jar at least half full. Add oil if necessary. Refer to the Lubricant Viscosity Recommendations for the proper oil to use.



6. If equipped with a toggle switch and an air control valve, move the toggle switch (1) to the ON position and push the air control valve (2) in. As soon as the engine starts, release the air control valve.



If equipped with an oil pressure lockout knob and an air control valve, push in the oil pressure lockout knob (3) and hold. Push the air control valve (4) in to crank the engine. As soon as the engine starts, release the air control valve (4) and the oil pressure lockout knob (3).

Direct Electric Starting

Above 0°C (32°F)

1. Place the marine gear lever in NEUTRAL.

2. Move the throttle to LOW IDLE engine speed.

3. Turn the starter switch to START or move the toggle switch to the ON position. Press the START button to crank the engine. If the engine does not start after 10 seconds, move the fuel shutoff lever to shut off the fuel, then continue to crank for 10 seconds. This will clear the cylinders of fuel.

4. Reposition the fuel shutoff lever back to the original position. Press the START button to crank the engine.

5. As soon as the engine starts, be sure the oil pressure registers on the gauge. Allow the engine to idle for three to five minutes, or until the water temperature gauge has begun to rise.

6. Do not apply load to the engine or increase engine speed until the oil pressure gauge indicates normal oil pressure.

7. Operate the engine at low load until all systems reach operating temperatures. Check all gauges during the warmup period.

Below 0°C (32°F)

⚠ WARNING

Ether is poisonous and flammable.

Do not store replacement cylinders in living areas.

Do not smoke while changing cylinders.

Use only in well ventilated areas.

Use with care to avoid fires.

Avoid breathing of vapors or repeated contact with skin.

Do not puncture or burn cylinders.

Discard cylinders in a safe place.

Keep ether container away from heat, sparks, open flame, and direct sunlight. It may explode.

Do not store or use at temperatures above 39°C (102°F).

Use ether sparingly while cranking the engine only. Excessive ether can cause piston and ring damage. Use ether for cold weather starting purposes only.

NOTICE

If starting fluid is necessary, spray starting fluid into the air cleaner inlet. Spray starting fluid only while cranking the engine. Otherwise, damage to engine can result.

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

Heating of the jacket water and the crankcase oil, use of starting aid fluid and/or use of extra battery capacity may be required to assist in starting the engine in cold temperatures.

Starting From External Electrical Source

⚠ WARNING

Always wear protective glasses when working with batteries.

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

Batteries give off flammable fumes that can explode.

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.

NOTICE

Before attaching the jumper cables, move toggle switch at the engine to the OFF position.

When using jumper cables, be sure to connect in parallel: NEGATIVE (–) to NEGATIVE (–) and POSITIVE (+) to POSITIVE (+).

Do not allow the free end of jumper cables to touch the engine or other objects grounded to the engine. This helps avoid sparks.

This engine has either a 24 or a 32 Volt starting system. Use only equal voltage for boost starting. The use of a welder or higher voltage will damage the electrical system.

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1. Connect one end of cable to the POSITIVE (+) (ungrounded) terminal of the battery of the engine. Connect the other end to the POSITIVE (+) terminal of the power source.

2. Connect one end of the second cable to the NEGATIVE (–) terminal of the power source. Connect the other end to the starter ground terminal of the engine.

3. Start the engine, using the regular procedure.

4. Disconnect the cable from the starter ground terminal first. Disconnect the other end from the NEGATIVE (–) terminal of the power source. Disconnect the cable from the POSITIVE (+) terminal of the battery. Disconnect the other end from the POSITIVE (+) terminal of the power source.

NOTICE

Engines installed without engine-to-frame mounting rail ground straps can be damaged by electrical discharge.

To prevent electrical discharge damage, check to make sure the engine's electrical system has an engine-to-frame ground connection. For engines which have the alternator connected to an engine component, a ground strap must connect that component to the frame. If the engine is not connected directly to the rails through mounting bolts, install a separate ground strap.

After Starting the Engine

NOTICE

If oil pressure does not raise within 15 seconds after the engine starts, stop the engine and make necessary corrections.

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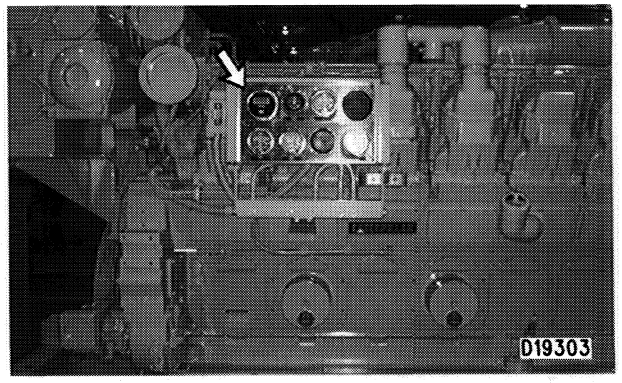
1. Do not apply a load to the engine, or increase the speed, until oil pressure gauge indicates at least normal pressure.

2. Check for any fluid or air leaks at idle and at one-half full rpm (no load on the engine) before operating the engine under load.



3. Operate the engine at low load until all systems reach operating temperatures. Check all gauges during the warmup period.

4. Measure the marine gear oil level at LOW IDLE with the marine gear engaged. Maintain oil level at the FULL mark on the dipstick.

Engine and Marine Gear Operation

Proper operation and maintenance are key factors in obtaining the maximum life and economy of your engine. Following the directions in this manual will lower operating costs.

Operate a cool engine at low load. After normal oil pressure is reached and the temperature gauges begin to move, the engine may be operated at full load.

To Get Underway

The marine gear selector valve is usually operated from the pilot house. It can also be manually operated at the marine gear. Pilot house controls must be adjusted so as to permit full travel of the selector lever on the marine gear, and full engagement of the clutch plates.

To get underway after the engine has started and is warm:

1. Fully engage the marine gear control lever in the desired direction of travel.

2. Wait a sufficient amount of time to allow complete engagement of the clutch.

3. Gradually increase engine speed as required.

To Reverse Direction When Docking or Traveling

NOTICE

When reversing direction of travel, stop at least two seconds in the NEUTRAL position to allow the propeller to stop turning. A direct through-shift will cause severe shock loads to the engine, marine gear and hull. Also, it may cause the engine to reverse its rotation.

If the engine reverses rotation, the engine and marine gear oil pumps will be running opposite normal rotation. Oil will be pulled from the bearings and cause severe damage.

1. Reduce engine speed to LOW IDLE.

2. Move the marine gear control lever to the NEUTRAL position.

3. Wait two seconds to allow the clutch plates to completely disengage, and the propeller to stop turning.

4. Move the marine gear control lever to the engaged position. To prevent the propeller from stalling or reversing the engine's rotation gradually increase engine speed as the clutch is engaged.

5. Wait a sufficient amount of time to allow complete engagement of the clutch.

6. Gradually increase engine speed as needed.

A sequenced engine control system may be required. This equipment consists of a throttle boost with an optional shaft brake.

The throttle boost system momentarily increases engine speed as the marine gear selector lever is moved from NEUTRAL to the engaged position. The throttle boost is released upon completion of clutch engagement. The governor setting then regulates the engine speed.

With the selector lever in the NEUTRAL position, the shaft brake stops the propeller shaft rotation when both clutches are disengaged. The shaft brake should be able to stop approximately 75 percent of the full rated shaft torque, and stop the shaft within three seconds during a full power reversal.

Full Load Operation

Move the governor control to full engine speed. An engine having authorized fuel settings and rated for continuous operation can operate at full speed for long periods of time without risking engine damage, provided the installation meets applications guidelines.

Reduced Speed Operation

Reduce engine speed by moving the governor control lever to the desired speed position if a slower vessel speed is required, or if the front power takeoff is to be operated.

Trolling

The trolling valve is an attachment to the marine gear. It operates only in the forward direction. With the trolling valve engaged, engine speed must not exceed 650 rpm for engines with a 1800 rpm full load speed. The marine gear oil temperature must not exceed 82°C (180°F).

It may be desirable to mark the tachometer and oil temperature gauges at these two limits. Proper monitoring of these gauges is required to prevent overheating of the clutch plates.

Trolling at reduced load for several hours may cause oil consumption and carbon to build in the combustion chamber. This results in poor performance and loss of power. Every four hours, load the engine at full speed to burn the carbon from the combustion chamber.

Follow the manufacturer's instructions for the operation of other attachments to marine gears for trolling purposes.

Temporarily Stopping the Vessel

For a temporary stop, during which time the engine is to continue running:

1. Reduce engine speed to LOW IDLE.

2. Shift the marine gear to NEUTRAL if water current conditions permit.

3. Maintain engine speed at no more than half engine speed.

4. After five minutes, engine speed may be reduced to LOW IDLE position if water current conditions permit.

5. To resume travel, shift into FORWARD or REVERSE at LOW IDLE speed. Gradually increase engine speed as needed.

Towing

If the vessel cannot continue under its own power, it is recommended that the vessel be towed. If pressurized oil cannot be supplied to the marine gear shaft bearings while being towed, the propeller shaft must be secured to prevent the turning shaft (caused by the propeller windmilling through the water) from damaging the marine gear shaft bearings.

Refer to the Emergency Procedures Section of this manual for towing information.

Stopping the Engine

NOTICE
Stopping the engine immediately after it has been working under load, can result in overheating and accelerated wear of the engine components. Follow the stopping procedure, outlined below, to allow the engine to cool. Excessive temperatures in the turbocharger center housing will cause oil coking problems.

1. Reduce the engine speed to LOW IDLE.

2. Shift the marine gear to NEUTRAL and secure the vessel.

3. Increase engine speed to no more than half engine speed. Idle for at least five minutes to cool the engine.

4. Reduce engine speed to LOW IDLE.

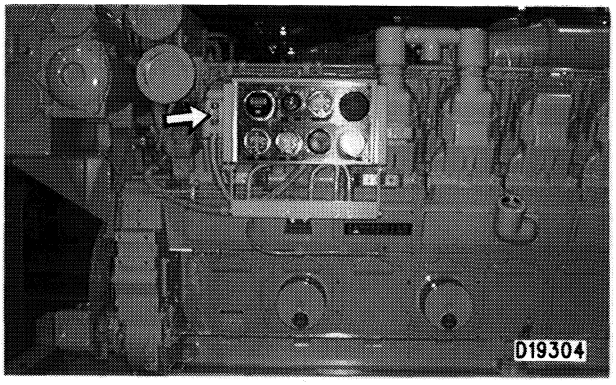
5. Check the crankcase oil level while the engine is idling. Maintain the oil level between the ADD and FULL marks on the CHECK WITH ENGINE RUNNING side of the dipstick.

6. Shift the marine gear to forward or reverse. Check the marine gear oil level at LOW IDLE. Maintain oil level between the ADD and FULL marks on the dipstick.

7. Shift the marine gear to NEUTRAL.

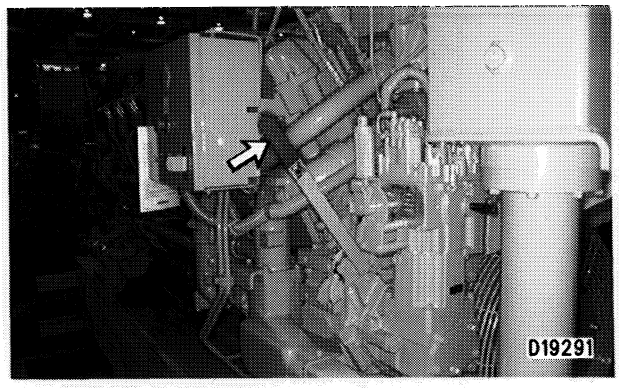
8. The engine may be stopped by using one of the following engine mounted controls:

Toggle Switch



Move toggle switch to the OFF position.

Manual Fuel Shutoff Lever



Pull the red handle lever out to shut off the fuel supply and to stop the engine.

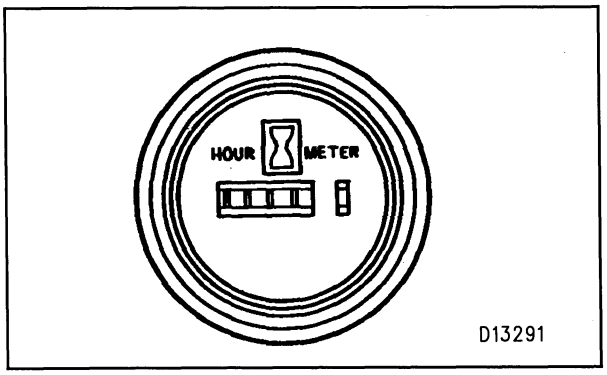
After Stopping the Engine

1. Fill the fuel tank to minimize possible water condensation problems. Filling the tank drives out moisture-laden air.

2. Drain the sea water system if freezing temperatures are expected.

3. If freezing temperatures are expected, allow the engine jacket water expansion tank to cool; then check the coolant for proper antifreeze protection. Add Caterpillar Low Silicate Antifreeze or equivalent if required.

4. Repair any leaks, perform minor adjustments, tighten loose bolts, etc.



5. Observe the service meter reading or service hour reading. Perform periodic maintenance as instructed in the Maintenance Schedule. Make appropriate entries into the Maintenance Log.

6. Perform the required periodic maintenance on all other equipment as outlined in the equipment manufacturer's instructions.

Engine Performance

Poor vessel performance is traditionally believed to be the result of a lack (or loss) of engine performance, when in fact the engine is only one of numerous factors that influence the overall performance of a vessel. Several factors determine the kw (horsepower) demand on an engine. The engine has no control over the demand made upon it by the vessel design, such as hull, prop and driveline design. These same factors also affect the amount of kw (horsepower) available to perform additional work such as to drive auxiliary pumps.

If you feel you have a vessel performance problem, first consider the impact of vessel design, loads, propeller and driveline condition, etc. on kw (horsepower) demand. Deterioration of boat systems (cooling, air inlet and exhaust, fuel tanks, etc.) can only lessen the engine's chance to produce power and vessel speed. In the case of poor fuel economy, the engine is not likely to be the cause without the presence of excessive exhaust smoke and/or a significant loss of power.

If you feel you have a valid engine performance problem, contact an authorized Caterpillar marine engine servicing dealer for assistance. If your engine is under warranty then the Caterpillar warranty will cover the cost of resolving a valid engine performance deficiency. However, if the engine is not found at fault, all costs incurred will be the responsibility of the owner.

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

Your Caterpillar dealer can determine engine condition and check the engine's external systems using a diagnostic procedure called the Marine Engine Performance Analysis Report (PAR).

Caterpillar engines are designed and manufactured using state-of-the-art technology to provide maximum fuel efficiency and performance in all applications. To insure optimum performance for the life of your engine, follow the recommended operation and preventive maintenance procedures described in this publication.

Fuel Conservation Practices

1. Size the engine to the job. Engines operate more efficiently at relatively high load factors.

2. Engine fans consume kw (horsepower). Modulator speed fan drives are more efficient, and save fuel.

3. Avoid fuel spillage. Never overfill the fuel tank. Fuel expands as it warms and may overflow from the fuel tank. Keep all fuel line leaks repaired.

4. Use only recommended fuels with recommended heat values.

5. Do not increase the fuel setting to obtain more power.

6. Do not set idle speed any higher than necessary. Do not idle unnecessarily. Unless operating in extreme cold temperatures, shut down and restart rather than idle for long periods.

7. Set the fuel ratio control for minimum black smoke with acceptable acceleration.

8. Keep air cleaners clean. Use the air cleaner restriction indicator to determine when to service the air cleaners.

9. Make sure the turbocharger is operating correctly so that proper air/fuel ratio is maintained. A clean burning exhaust should indicate these items are functioning properly.

10. Operate with a good electrical system. One bad cell in a battery will overwork the alternator, consuming more engine power and fuel.

11. Make sure all belts are good and adjusted properly.

12. Make sure all air hoses and connections are tight and leak free. Leaking air keeps the compressor working unnecessarily.

13. Operate with a thermostat all year. Cold engines consume more fuel.

14. Utilize "waste" heat energy from the jacket water and exhaust system whenever possible.

15. Keep keel coolers, heat exchangers, and water pumps clean and in good repair to maintain operating temperature of the engine. Foot valves and strainers must be clean.

16. Make sure all accessory pumps are repaired and will operate efficiently.

Value Planned Repair (Repair Before Failure)

Until recently, engine maintenance and repair management involved changing the oil when it was convenient and repairing the engine when it was damaged. This seemed to be the accepted way of managing a maintenance operation. However, due to a variety of circumstances, business competitiveness has caused users to look for ways to prolong equipment life and lower operating costs.

To assist Caterpillar Engine users in prolonging engine life and reducing operating costs, the Value Planned Repair approach to engine service was developed.

The Value Planned Repair approach can be tailored for any engine. This approach, when properly structured, outlines every maintenance and repair service required to support an engine from the day it enters service until the day it is retired.

To ensure the repair is performed efficiently and expediently, the Value Planned Repair concept approaches a given repair in three basic steps:

- Repair determination
- Evaluation of repair options
- Selection of the most appropriate/cost effective option

The Value Planned Repair approach addresses:

- Services required to maintain an engine at optimum efficiency.
- Scheduled maintenance, repairs and overhauls to minimize unscheduled downtime.
- Preplanned repairs and overhauls that can be flat-rated, putting you in charge of costs.
- Repair or overhaul options designed to restore the engine to proper operating condition.
- Repair or overhaul options designed to renew the engine if a failure has occurred.

Part of the Value Planned Repair approach is the "repair before failure" concept. The objective of the repair before failure concept is to repair the engine before a failure ever takes place. The fact that a failure has not taken place makes the situation more economical since a high degree of parts such as pistons, liners, valves, etc., and major castings such as cylinder blocks, cylinder heads, etc., can be reused. Also, an extensive internal cleaning of the engine, which is labor intensive, is eliminated because a debris-generating failure has not taken place.

The best part of the repair before failure concept is that unscheduled downtime is minimized and in most cases eliminated because the repair or overhaul can be scheduled to allow the user to adjust his operation accordingly.

The overall benefit to a customer who repairs an engine before failure is that the customer and not the engine is in control of the repairs required.

To stress the importance of the Value Planned Repair approach, consider the following example that reflects the difference in the cost of a before failure repair versus the cost of an after failure repair.

The cost to repair a turbocharger after it fails is approximately five times more than the cost of repairing a turbocharger before it fails. However, if parts from a damaged turbocharger enters the engine, then the cost to repair your engine could be as high as 10 times or more the cost of repairing a turbocharger before it fails. Obviously, the goal is to monitor the turbocharger and repair it before it reaches a failure point.

By subscribing to the Value Planned Repair approach, you can avoid spending your money on costly repairs that should have been prevented and utilize your money more profitably elsewhere.

The choice is yours, but we at Caterpillar strongly recommend the Value Planned Repair approach for servicing and overhauling your engine. Our maintenance guidelines are organized to minimize the risk of failure. To better illustrate what the Value Planned Repair approach means to you in terms of money, please refer to the "Engine Operating Cost Analysis" section in this publication.

Engine Operating Cost Analysis

The term "Life Cycle Costs" can be defined as the sum of the individual costs experienced by an engine from the day of purchase until the day of retirement. In other words, the total Owning and Operating Costs.

Owning Costs are fixed costs such as initial purchase price, interest on borrowed money, depreciation and taxes.

Operating Costs are a combination of fixed and variable costs such as fuel, oil, personnel expenses, taxes, supplies, maintenance and repair, permits, licenses, engine maintenance and repair, and downtime.

The difference between revenues generated and "Life Cycle Costs" (total Owning and Operating Costs) is profit.

Caterpillar and your Caterpillar dealer cannot guarantee that you will make a profit. However, Caterpillar and your Caterpillar dealer can provide you with a variety of services that can help you reduce the engine operating costs that impact on your profits.

An Engine Operating Cost Analysis is a service provided by your dealer that was developed by Caterpillar to help you reduce the "Life Cycle Cost" of your engine. More specifically, an Engine Operating Cost Analysis is a computerized program that examines existent and expectant oil, fuel, maintenance, minor repair, overhaul and downtime costs for the period of time you expect to own the engine. It also calculates the operating cost per hour.

This useful tool also provides your dealer with the specific information needed to develop a Customized Maintenance Management (CMM) program for your operation which will minimize your engine's operating costs.

Before a cost analysis can be performed, your dealer needs to gather as much information as possible about your operation. You will need to know the length of time you plan to keep your engine, your average cost of fuel and oil as well as a variety of other ownership and cost related facts and figures.

Once this information is obtained, your dealer will enter the data into a computerized program to produce an Engine Operating Cost Analysis printout reflecting your current and projected operating costs per hour.

The typical printout of the Engine Operating Cost Analysis program has up to four engine scenarios which can be run at one time. The printout is divided into three major areas:

- General Information
- Engine Operating Information
- Operating Cost Summary

The General Information section contains basic user data such as name, business, engine model and rating, service hours usage per year, etc.

The Engine Operating Information section is divided into eight subsections that address fuel consumption, oil consumption, preventive maintenance, component repairs such as water pumps, turbochargers, air compressors, etc., before failure repairs (overhauls), after failure repairs, user's revenue rate per hour. Lastly, miscellaneous costs such as operator wages, insurance premiums, etc.

The Operating Cost Summary section is exactly what it implies, a summary. Here the total money expense and percentage of the total operating expense is calculated for each of the eight subsections listed in the Engine Operating Information section. The eight individual elements are then totaled and divided by the ownership period to yield the operating cost per hour. Similar calculations are also made for only the maintenance and repair portion of the total operating cost.

An Engine Operating Cost Analysis is a useful tool that can be used to:

- Project the expected total operating cost of a Caterpillar engine.
- Identify the impact of individual elements on engine operating costs.
- Determine expected operating costs if Caterpillar service and overhaul recommendations are followed.
- Determine the cost per hour figures that you can obtain by having your dealer perform various levels of preventive maintenance as recommended by Caterpillar.
- Determine the savings to be realized if Caterpillar repair kits, exchange components, etc., are used by those who elect to perform their own maintenance.
- Determine how to maximize value of your Caterpillar Engine by utilizing genuine Caterpillar parts and following Caterpillar recommended guidelines for preventive maintenance and before failure repairs.

In conclusion, an Engine Operating Cost Analysis is a tool that was designed to identify costly problem areas for the purpose of helping you reduce your operating costs.

Minimizing Fuel Problems In Cold Weather Operation

Caterpillar Diesel Engines can operate effectively in cold weather. However, how effective your engine operates in cold weather is dependent on the type of fuel used and on the effect cold weather has on the fuel as it moves through your fuel related components. Therefore, the purpose of this section is to explain some of the problems and steps that can be taken to minimize fuel problems during cold weather operation when the engine room temperature is not kept above 5°C (40°F).

Effect of Cold Weather on Fuel

The two types of diesel fuel available for your engine are typically grades No.1 and No.2. Though No.2 diesel fuel is the most commonly used fuel, No.1 diesel fuel is the fuel that is best suited for cold weather operation. During cold weather operation, it may be necessary for you to use No.2 diesel fuel since quantities of No.1 diesel fuel are limited and generally, are only available during the winter months and in the colder climates.

There are two major differences between No.1 and No.2 diesel fuel. No.1 diesel fuel has a lower cloud point and a lower pour point.

The cloud point is the temperature point at which a wax will begin to form in the fuel and cause fuel filters to plug.

The pour point is the temperature which diesel fuel will begin to thicken and be more resistant to flow through fuel pumps and lines.

By being aware of these fuel values when purchasing your diesel fuel and by anticipating the average outside ambient temperature for the area you will be operating in, you can minimize potential fuel problems that result from cold weather.

NOTE: The average No.1 diesel fuel has a lower kJ (BTU) heat content rating per unit volume of fuel than the average No.2 diesel fuel. When using No.1 diesel fuel, you may notice a drop in power and fuel efficiency, but should not experience any other operating effects. Before troubleshooting for low kw (horsepower) or poor performance in winter months, check the type of fuel being used.

No.2 diesel fuel can be used in diesel engines during cold temperatures, with minimum amounts of a "pour point depressant" additive. A "pour point depressant" will permit fuels to flow through pumps, lines and hoses when used at very low levels of concentration. However, it is important that these additives be completely and thoroughly mixed into the fuel at temperatures above the cloud point of the fuel if they are to have an effect.

The use of starting aids, engine oil pan heaters, engine coolant heaters, fuel heaters, and fuel line insulation also provide a means of minimizing starting and fuel problems in cold weather when No.2 diesel fuel is used.

Effect of Cold Weather on Fuel Related Components

Fuel Tanks

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. This water and sediment should be drained at each oil change. Do not use fuel tanks with supply lines that take fuel directly from the bottom of the tank.

The fuel return line from the engine should return fuel to the tank from which it was taken. Do not return fuel to the day tank, as fuel overheating could occur which will cause deterioration of engine performance.The fuel return line should deposit fuel at a distance of about 250 mm (10 in) from the supply line. This allows the engine to get warm fuel from the tank. It also allows air to escape from the return fuel without being pulled back into the engine.

Fuel Lines

Avoid sharp angles and use as few fittings and connections as possible. Moisture in the fuel will tend to collect and freeze at low points in the fuel lines. Fuel should be drawn from the tank closest to the engine. Fuel lines should travel the most direct route to the engine compartment.

Fuel Heaters

Use of a fuel heater can help eliminate some cold weather problems. A fuel heater should be installed so that the fuel is heated before it goes into the first or primary fuel filter. Select a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also prevent overheating of the fuel. Disconnect or deactivate the fuel heater in warm weather. A loss of engine power will occur if the fuel supply temperature exceeds 30°C (85°F).

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

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

Fuel Filters

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

The micron rating of the primary fuel filter should only be fine (low) enough to protect the fuel transfer pump. A very fine (low micron rating) primary filter, can be more easily plugged by wax in cold weather. A primary filter, with a micron rating as fine as a secondary filter can cause waxing problems in cold weather. An 8N6435 Filter is recommended as a cold weather primary fuel filter.

The best location for the primary fuel filter is near the engine, where it will benefit from the radiant heat of the engine.

For more information on fuels and fuel systems contact your Caterpillar dealer.

Marine Engine Performance Analysis Report (PAR)

Today's marine user is concerned with performance, cost of operation and satisfactory engine life. Traditionally, vessel performance has been directly related to the propulsion engine, when in fact the engine is only one of numerous factors influencing the propulsion system.

To verify the condition of the propulsion system, Caterpillar has developed the Marine Engine Performance Analysis Report (PAR) program. Marine engine PAR is an in-vessel test procedure, performed and evaluated by Caterpillar certified Marine Analysts under normal or bollard operating conditions, comparing the performance of all marine engine systems to original factory test cell specifications.

When Marine Engine PAR testing is conducted at sea trial, it can assure you of a quality installation, confirming that the hull, rudders, propeller, marine gear, ventillation and cooling systems are all properly matched for optimum performance and fuel efficiency.

Caterpillar additionally recommends regularly scheduled (refer to the Preventative Maintenance Schedule) Marine Engine PAR analyses to maintain optimum performance. Periodic PAR analyses can define propulsion system deterioration and aid in fine tuning these maintenance, repair and overhaul schedules, which will provide the most economical and efficient cost of operation.

Scheduled Oil Sampling (S•O•S)

Caterpillar's Scheduled Oil Sampling (S•O•S) Program is a series of diagnostic tests designed to identify and measure contamination and condition of oil in an engine's crankcase. S•O•S is also used to determine oil performance and component wear rates and is the best indicator for determining what is happening inside your engine.

Caterpillar recommends using Scheduled Oil Sampling (S•O•S), at regularly scheduled intervals, to compliment a good preventive maintenance program.

The Caterpillar Scheduled Oil Sampling Program (S•O•S), was developed to help Caterpillar users realize the highest possible value from their equipment by minimizing repair costs and maximizing availability. The S•O•S program is a series of diagnostic tests which analyze used lubricating oils from the oil wetted compartments of the equipment. By analyzing the used oils, problems may be identified early, before extensive component failure occurs. This reduces repair cost and down-time.

The S•O•S program is coupled with a wide range of repair options so that when a problem is identified, an appropriate matched repair plan is available. This offers the user a more complete service to minimize repair costs and schedule down-time. S•O•S can also measure the effectiveness of the user's maintenance program.

S•O•S Analysis

S•O•S is composed of three basic tests:

- Wear Analysis
- Chemical and Physical Tests
- Oil Condition Analysis

Wear Analysis is performed with an atomic absorption spectrophotometer to monitor component wear rates by identifying and measuring concentrations, in parts per million, of wear elements present in the used oil.

Based on known normal concentration data, maximum limits of wear elements are established. Impending failures can be identified when test results deviate from concentration levels established as acceptable, based on normal wear.

Through monitoring the used oil, normal component wear trends are determined. Many failures can be identified when wear trends and/or contaminants significantly exceed past trends.

Detectable failures are those caused by component wear and gradual contamination from dirt, fuel, water or antifreeze. Wear analysis is not able to predict failures due to component fatigue, sudden loss of lubrication, or sudden ingestion of a large amount of dirt or contaminants since failures of this nature occur too rapidly.

Chemical and Physical Tests detect the presence of water, fuel and/or glycol (antifreeze) in the oil and determine whether or not their concentrations exceed established maximum limits.

Oil Condition Analysis is evaluated with Infrared Analysis and determines the degree of deterioration of the used oil by measuring the amount of contaminants such as sulfur products, oxidation, nitration products and soot present in the used oil.

It also monitors additive depletion and detects ethylene glycol and butyl cellosolve contamination and can assist in customizing (reducing, maintaining or extending) oil change intervals for particular conditions and applications.

Oil Condition Analysis can help regulate (reduce, maintain or extend), oil change intervals for a specific engine in a given application and MUST always be used with Wear Element Analysis and Chemical and Physical Tests to assure accurate diagnosis.

NOTE: Infrared Analysis must be used to determine oil change intervals. S•O•S must include Infrared (IR) in the analysis.

To be effective as an indicator, S•O•S must be performed on a continuing basis. Intermittent sampling will not allow wear rate trend lines to be established.

S•O•S INTERVAL CHART	
Compartment	**Interval**
Engine Crankcase	250 Service Hours
Marine Gear	1000 Service Hours

Consult your Caterpillar dealer for complete information and assistance in establishing an S•O•S program for your engine(s).

Lubricant Viscosity Recommendations

The proper SAE grade of oil to select is determined by the minimum outside temperature at which the engine will be started and the maximum outside temperature in which the engine will be operating. This recommendation is to ensure the correct viscosity is used until the next oil change. The required performance criteria for the oil is defined in the previous Lubricant Specification section.

The minimum temperature for the viscosity grade provides guidelines for the lowest starting temperature with a "cold soaked" engine. Base stocks for blending the oil formulations do differ and variations can exist within a viscosity grade on low temperature characteristics. Therefore, a particular oil may allow lower starting temperatures than given in the chart that follows. Your oil supplier can provide additional information on oil properties.

The recommendation would be to use the highest viscosity oil possible. Even though the ambient temperature may be low, operating engines can still be subjected to normal oil temperatures because of regulated temperature components. The higher viscosity oils will provide better protection to all components during the full operating cycle.

To determine if the oil in the crankcase will flow in cold weather, remove the oil dipstick before starting. If the oil will flow off, the oil is fluid enough to circulate properly.

Lubricant Viscosity Chart

LUBRICANT VISCOSITIES[1] FOR AMBIENT TEMPERATURE RANGES °C AND °F					
Compartment or System	Oil Viscosities	°C		°F	
		Min	Max[3]	Min	Max[3]
Engine Crankcase	SAE 10W[2]	−20	+10	−4	+50
	SAE 10W30[3]	−20	+40	−4	+104
	SAE 15W40[3]	−15	+50	+5	+122
	SAE 20W40	−10	+40	+14	+104
	SAE 30[2]	0	+40	+32	+104
	SAE 40[2]	+5	+50	+41	+122

[1] Select oil viscosity based on maximum expected operating temperature. Engine start-up at lower than specified ambient temperature requires caution. Start-up at very low ambient temperatures may require auxiliary oil and jacket water heaters or other methods to increase the oil and water temperatures prior to starting the engine.

[2] Choose oil grade based on maximum operating oil temperature. Start-up at oil temperatures below the minimum requires caution. Do not increase engine rpm or add load until oil temperatures are within the recommended range and oil pressures are normal. If single viscosity grades are selected, confirm with your oil supplier that the oil does meet the API CG-4, CF-4, or CE rating requirements.

[3] Oil viscosity grades which meet the API CG-4 performance category are limited to multi-grades (SAE 15W40 and 10W30). See comments in the Lubricant Specification section regarding multi-viscosity oils.

Air Starting Motor Oiler

A lubricator should be used with the starting system.

- Use 10 weight non-detergent engine oil above 0°C (32°F) or
- diesel fuel or kerosene at temperatures below 0°C (32°F).

Refill Capacities

These refill capacities reflect the crankcase capacity plus filter. Auxiliary oil filter systems will require additional oil. For all auxiliary oil filter system information consult the OEM or auxiliary oil filter system manufacturer.

The Total Cooling System capacity will vary, depending on the radiator size and capacity provided by the OEM manufacturer. In order to properly maintain the cooling system, Total Cooling System capacity must be known. The chart is left blank and should be filled in by the customer to determine the Total Cooling System Capacity for his engine and application.

Refill Capacities

Compartment or System	Liters	U.S. Gal.	Imperial Gal.
ENGINE CRANKCASE [1]			
3508	104 227 424	27 59 112	22 42 90
3512	152 312 613	40 81 162	33 67 134
3516	204 401 842	53 106 219	44 88 182
COOLING SYSTEM [2]			
3508	262	69	57
3512	322	85	71
3516	387	102	85
CONVENTIONAL RADIATOR [3]			
D	76	20	17
E	121	32	27
F	152	40	33
G	182	48	40
H	190	50	42
FOLDED CORE RADIATOR [3]			
46/10	121	32	27
50/11	133	35	29
60/13	155	41	34
72/25	193	51	42
MARINE GEAR			
7231	91	24	20
7241	121	32	27
7251	114	30	25
7261	132	35	29
7271	114	30	25

[1] Additional oil is required with the use of auxiliary oil filters. Make sure to add enough oil to fill the auxiliary oil circuit.

[2] Cooling system capacity consists of engine with water cooled manifold and inlet water control (expansion tank). It does not include external lines, heat exchanger or keel coolers.

[3] Includes lines.

3161 Governor Oil Sump

1.8 liter (2 U.S. quart) of engine oil. DO NOT use multi-viscosity oils in the governor. These oils are incompatible and governor damage may result.

Total System Cooling Capacity

Total system cooling capacity will vary with each installation. In order to properly service the cooling system, total cooling system capacity must be determined. Total system cooling capacity will consist of engine cooling capacity, radiator capacity (if equipped), and external system capacity. Use the information in the Refill Capacities Chart to fill in the blanks of the chart for engine and radiator (if equipped). Next, calculate the external system capacity, which consists of external piping, heat exchangers, keel coolers, and all other external system components. Enter this information in the chart.

Total Cooling System Capacity			
Compartment or System	**Liters**	**U.S. Gallons**	**Imperial Gallons**
Engine Only [1]			
Radiator [2]			
External System [3]			
Total System Capacity [4]			

[1] Refer to the Refill Capacities chart for the engine cooling capacity. The engine capacity consists of the engine with water cooled manifolds and inlet water control (factory equipped expansion tank). Enter the engine capacity in the Engine Only column.

[2] Refer to the Refill Capacities chart for radiator capacity information (if equipped). Enter this figure in the Radiator column.

[3] Calculate all external system capacities, which consists of external piping, heat exchangers, keel cooler, additional expansion tanks and all other external system components. Enter this figure in the External System column.

[4] Add the Engine Only capacity, the Radiator capacity, and the External System Capacity to arrive at Total Cooling System Capacity. This capacity information will be needed to determine the amount of Caterpillar Low Silicate Antifreeze or equivalent and the amount of liquid coolant conditioner required for maintaining the system.

After calculating total system capacity, fill the cooling system with a premixed cooling solution of Caterpillar Low Silicate Antifreeze or equivalent, acceptable water, and corrosion inhibitor. The freeze protection of the solution should equal or exceed the system protection requirements.

NOTE: Caterpillar Low Silicate Antifreeze contains the necessary precharge of coolant conditioner. If any other type of ethelyne glycol antifreeze is used, coolant conditioner will have to be added to the cooling system.

Cooling System Conditioner

NOTICE

Supplemental Coolant Additive is used for standard type antifreeze only. DO NOT mix standard type antifreeze with Long Life Coolant. Mixing the two coolants will reduce the effectiveness of the coolant to cool the engine.

To protect your investment in your Caterpillar engine, add liquid cooling conditioner on a scheduled basis at the established Every 250 Service Hour maintenance interval. Cooling system conditioner should be added at initial fill and when the system is drained and cleaned only if an antifreeze other than Caterpillar Low Silicate Antifreeze is used. By maintaining a three to six percent concentration of cooling system conditioner in the cooling system, the possibility of cylinder wall pitting will be minimized, lowering the overall cost of owning and operating your engine.

Fill in the chart below to determine the amount of liquid coolant conditioner required to maintain the Total Cooling System Capacity. Use the Total Cooling System Capacity information and calculate the required Coolant Conditioner required.

Note: The chart contains three different units of measure for your convenience.

Cooling System Conditioner			
Interval	**Liters**	**U.S. Qts**	**Imp. Qts**
When Filling Complete System [1]			
Every 250 Service Hours [2]			

[1] When filling the complete system, use Caterpillar Low Silicate Antifreeze or equivalent. Caterpillar Low Silicate Antifreeze contains the proper amount of coolant conditioner required for a three to six percent concentration. If you are not using Caterpillar Low Silicate Antifreeze or equivalent, then add 1.0 liter (1 U.S. quart) of Caterpillar Liquid Cooling System Conditioner for each 30 liters (8 U.S. gallons) of premixed coolant used. Total cooling system capacity information can be obtained from your calculation of total system capacity.
Calculate and enter the amount of coolant conditioner required in the chart above "When Filling Complete System", for future reference.

[2] At the Every 250 Service Hours interval, test the concentration of coolant conditioner by using the Caterpillar 8T5296 Coolant Conditioner Test Kit. Maintain the coolant for a three to six percent concentration of coolant conditioner. To maintain the cooling system, use 1 liter (1 U.S. quart) of liquid coolant conditioner for each 152 liter (40 U.S. gallons) of premixed coolant.
Calculate and enter the amount of coolant conditioner required in the chart above Every 250 Service Hours for future reference.

Terminology Used in Maintenance Schedules

Adjust – to conform and correspond to specifications.

Check – to observe for satisfactory conditions, accuracy, safety or performance.

Exchange – to trade a worn or failing component for a remanufactured or rebuilt component.

Inspect – to examine closely, in critical appraisal, while testing or evaluating components or systems.

Inspect/Rebuild or Exchange – to examine closely; then making the decision on repair option (Rebuild or Exchange).

Lubricate – to apply a lubricant (oil, grease, etc.) as specified for reducing friction, heat and wear between solid surfaces.

Protective Devices – indicators such as gauges, lights, emergency shutoffs, etc., that alert an operator that a potential problem may exist. Failure to respond to these indicators in a timely manner could result in serious engine damage.

Rebuild – to repair a worn or failing component with new parts, components and/or remanufactured components.

Replace – to install something new, remanufactured or rebuilt in place of an existing worn or failing component.

Service Hours (Electrical) – records the time (clock hours) the engine is actually running but does not reflect variations in speed, load, etc.

NOTE: The Maintenance Schedules are developed for calendar time, clock hours or fuel consumption. Service Hours are expressed in clock hours, not service meter units (unless the service meter is a clock hour device). Hours of operation include only the time that the engine is running. An electric clock device should be connected so it is OFF when the engine is not running. Caterpillar recommends that fuel consumption be used as the preferred method of establishing intervals rather than time or clock hours.

Maintenance Intervals

The Maintenance Schedule requires all previous interval maintenance items to be performed first. For instance, if the Every 250 Service Hour maintenance is being done, then the Daily maintenance items must be completed BEFORE performing the Every 250 Service Hour maintenance.

Engines may be equipped with various optional components and the Schedule may recommend maintenance for items not installed on your engine. Simply disregard reference to any unrelated items. If unsure of any item, consult your Caterpillar dealer.

Top End Interval

One interval for some engines is labeled **Top End** because it involves removal, inspection, and rework of the cylinder head components. This interval is dependent on load-sensitive items/total amount of fuel consumed.

Overhaul Interval

The last interval in each chart lists the components inspected, rebuilt, exchanged or replaced at overhaul. **Overhaul** is defined as the interval at which the major wear items in the engine should be replaced. The intervals represent maintenance of a non-failed engine. In other words, the engine is being rebuilt with certain new parts replacing worn parts such as piston rings, engine rod and main bearings, valves and valve seats., etc.

Incidental to the replacement of these relatively few parts is the complete inspection of all other parts that are visible during the overhaul of the engine. The disassembly required to do an overhaul means that disturbed seals and gaskets, etc., will be replaced, and the internal passages of the engine and block be cleaned.

- The Overhaul interval assumes that regular maintenance recommendations in the rest of the chart have been carefully followed.
- Some users may obtain significantly longer or shorter life than the chart recommends between overhauls, but if the recommended intervals are followed, Overhauls will occur BEFORE actual FAILURE, and the total COST of operation will be minimized.

Although most users will obtain more life between overhauls than the chart recommends, Caterpillar has determined that these limits are the best (least cost) for the vast majority of our engine users. Extend the intervals to overhaul ONLY if your experience shows strong evidence that the intervals are too short for your application and maintenance practices.

The most important criteria for Top End and Overhaul is Fuel Consumption. The service hours criteria is mainly for reference. To obtain a better estimate of **Hours** to overhaul, use the following formula:

Overhaul Interval (Hours) equals Total Fuel Consumption divided by *Actual Average Fuel Consumption per Hour.

*Use actual fuel records or estimate load factor. Actual will be less than the specification sheet, because an engine does not run at 100 percent load factor 100 percent of the time.

Maintenance Options

Rebuild with New Parts – Genuine Caterpillar parts are constantly tested and modified to incorporate the latest design advancements. Your Caterpillar dealer can rebuild or provide the parts needed for overhauling your engine. Your benefit; long lasting replacement parts at competitive prices.

New Components – Replace worn or failing components with new components.

Repair Kits – These useful kits can be obtained from your Caterpillar dealer. These kits include all the necessary parts and instructions to repair the components, in either the owner's maintenance shop or at a Caterpillar servicing dealer's facility. Repair kits simplify parts ordering, help speed repairs and reduce parts cost.

Exchange – This cost-cutting service permits you to exchange worn engine components for quality Caterpillar Remanufactured or Caterpillar dealer rebuilt components on an over-the-counter basis. When you need them, these parts are ready for a substantial savings in both time and money.

NOTE: If there is a component you need, contact your Caterpillar dealer to see if it is offered under his Dealer Exchange Component Program.

Caterpillar Factory Remanufactured Components – The latest remanufacturing techniques and procedures are used to restore components to Caterpillar's original functional specifications. Usually Caterpillar Remanufactured Components have a warranty identical to that of a new part. Remanufactured parts may not be available in your area. If there is a component you need, contact your Caterpillar dealer to see if it is offered under his Dealer Exchange Component Program. Contact your Caterpillar dealer for information.

To minimize downtime, Caterpillar recommends that the use of Remanufactured components (subject to availability) is the most cost effective option. Before deciding which method is best, make sure all of the options and costs associated with repair have been considered. Some considerations are:

- The costs associated with using separate parts from inventory versus the cost of a repair kit.
- Downtime costs while the product is being rebuilt or repaired.
- Total parts and labor costs for repairs versus the actual Remanufactured cost.
- Remanufactured components from Caterpillar (if available) are covered by a standard, factory warranty.

The following is a list of (R) Remanufactured components currently being offered by Caterpillar* in many countries:

- Cylinder head – bare
- Cylinder head – assembly and group
- Crankshaft – undersized
- Crankshaft – upgrade to new
- Complete turbocharger
- Turbocharger cartridges
- Water pumps
- Oil pump
- Connecting rods
- Air Compressor
- Alternator
- Electric starting motor

NOTE: If the component you need is not listed here, contact your Caterpillar dealer to see if it is offered under a dealer exchange component program (* X).

* The current parts book will asterisk a part number when a (R) Remanufactured unit is offered by Caterpillar.

3500 Marine Engine Maintenance Schedule

Use quantity of fuel used, service hours, or time interval, whichever occurs first. Refer to the Terminology topic in the Information Section of this manual for information relating to Top End and Overhaul.

Daily

Every 50 Service Hours*

Every 250 Service Hours*

Every 1000 Service Hours*

Every 2000 Service Hours*

Every 3000 Service Hours or Two Years*

Every 4000 Service Hours*

Every 6000 Service Hours*

Top End

To minimize downtime and provide you with the lowest cost and highest value, Caterpillar recommends that the engine be overhauled before failure by scheduling an overhaul with your Caterpillar dealer. Refer to the Top End Overhaul section in this manual on page 125

Cylinder Heads – Inspect 126
Injectors – Test 127

Overhaul

To minimize downtime and provide you with the lowest cost and highest value, Caterpillar recommends that the engine be overhauled before failure by scheduling an overhaul with your Caterpillar dealer. Refer to the Overhaul section in this manual on page 128

Cylinder Heads, Connecting Rods, Cylinder Liners, Pistons, Turbochargers, Cam Followers, Fuel Transfer Pump, Prelube Pump, Injectors, Governor, Wrist Pins and Main Oil Pump – Inspect/Rebuild or Exchange if necessary
Piston Rings, Main Bearings, Rod Bearings, Valve Rotators and Crankshaft Seals – Install new
Crankshaft, Camshaft, Cam Bearings, Damper, Fuel System Linkage, Gear Train, Gear Train Bushings, Spacer Plates and Driven Unit Alignment – Inspect
Coolant Analysis – Obtain
Oil Cooler – Clean/Test 129
Aftercooler Core – Clean/Test 129

*First Perform Previous Service Hour Items

**For larger optional sump capacity of 224 liters (59 gallons), these items occur at 500 Service Hours. For larger optional sump capacity of 425 liters (112 gallons), these items occur at 1000 Service Hours.

Maintenance Schedule Intervals

3508 SERVICE HOURS/FUEL CONSUMPTION			
Service Hours	**Rated Up to 1300 rpm**	**Rated 1301 to 1600 rpm**	**Rated 1601 to 1800 rpm**
Every 50 Service Hours or	4,550 liter (1,200 U.S. gallon) of Fuel	5,450 liter (1,440 U.S. gallon) of Fuel	6,400 liter (1,650 U.S. gallon) of Fuel
Every 250 Service Hours or	22,700 liter (6,000 U.S. gallon) of Fuel	27,200 liter (7,200 U.S. gallon) of Fuel	32,000 liter (8,500 U.S. gallon) of Fuel
Every 1000 Service Hours or	89,000 liter (23,500 U.S. gallon) of Fuel	109,000 liter (28,800 U.S. gallon) of Fuel	128,500 liter (34,000 U.S. gallon) of Fuel
Every 2000 Service Hours or	178,000 liter (47,000 U.S. gallon) of Fuel	218,000 liter (57,600 U.S. gallon) of Fuel	257,000 liter (68,000 U.S. gallon) of Fuel
Every 3000 Service Hours or Two Years or	267,000 liter (70,500 U.S. gallon) of Fuel	327,500 liter (86,400 U.S. gallon) of Fuel	386,500 liter (102,000 U.S. gallon) of Fuel
Every 4000 Service Hours or	356,000 liter (94,000 U.S. gallon) of Fuel	436,000 liter (115,200 U.S. gallon) of Fuel	514,000 liter (136,000 U.S. gallon) of Fuel
Every 6000 Service Hours or	535,000 liter (141,000 U.S. gallon) of Fuel	654,000 liter (172,800 U.S. gallon) of Fuel	771,000 liter (204,000 U.S. gallon) of Fuel
Top End @ 976,000 liter (257,500 U.S. gallon) of Fuel or	Every 11,000 Service Hours	Every 9000 Service Hours	Every 7500 Service Hours
Overhaul @ 1,952,000 liter (515,000 U.S. gallon) of Fuel or	Every 22,000 Service Hours	Every 18,000 Service Hours	Every 15,000 Service Hours
3512 SERVICE HOURS/FUEL CONSUMPTION			
Service Hours	**Rated Up to 1300 rpm**	**Rated 1301 to 1600 rpm**	**Rated 1601 to 1800 rpm**
Every 50 Service Hours or	6,670 liter (1,760 U.S. gallon) of Fuel	8,200 liter (2,160 U.S. gallon) of Fuel	9,700 liter (2,560 U.S. gallon) of Fuel
Every 250 Service Hours or	33,400 liter (8,800 U.S. gallon) of Fuel	41,000 liter (10,800 U.S. gallon) of Fuel	48,500 liter (12,800 U.S. gallon) of Fuel
Every 1000 Service Hours or	133,500 liter (35,000 U.S. gallon) of Fuel	164,000 liter (43,200 U.S. gallon) of Fuel	194,000 liter (51,200 U.S. gallon) of Fuel
Every 2000 Service Hours or	267,000 liter (70,000 U.S. gallon) of Fuel	328,000 liter (86,400 U.S. gallon) of Fuel	388,000 liter (102,400 U.S. gallon) of Fuel
Every 3000 Service Hours or Every Two Years or	398,000 liter (105,000 U.S. gallon) of Fuel	491,000 liter (129,600 U.S. gallon) of Fuel	582,000 liter (153,600 U.S. gallon) of Fuel
Every 4000 Service Hours or	534,000 liter (140,000 U.S. gallon) of Fuel	654,000 liter (172,800 U.S. gallon) of Fuel	776,000 liter (204,800 U.S. gallon) of Fuel
Every 6000 Service Hours or	796,000 liter (210,000 U.S. gallon) of Fuel	982,000 liter (259,200 U.S. gallon) of Fuel	1,164,000 liter (307,200 U.S. gallon) of Fuel
Top End @ 1,460,000 liter (385,000 U.S. gallon) of Fuel or	Every 11,000 Service Hours	Every 9000 Service Hours	Every 7500 Service Hours
Overhaul @ 2,920,000 liter (770,000 U.S. gallon) of Fuel or	Every 22,000 Service Hours	Every 18,000 Service Hours	Every 15,000 Service Hours
3516 SERVICE HOURS/FUEL CONSUMPTION			
Service Hours	**Rated Up to 1300 rpm**	**Rated 1301 to 1600 rpm**	**Rated 1601 to 1800 rpm**
Every 50 Service Hours or	8,800 liter (2,300 U.S. gallon) of Fuel	10,600 liter (2,800 U.S. gallon) of Fuel	12,900 liter (3,400 U.S. gallon) of Fuel
Every 250 Service Hours or	44,000 liter (11,600 U.S. gallon) of Fuel	53,000 liter (14,000 U.S. gallon) of Fuel	64,500 liter (17,000 U.S. gallon) of Fuel
Every 1000 Service Hours or	176,000 liter (46,500 U.S. gallon) of Fuel	212,000 liter (56,000 U.S. gallon) of Fuel	258,000 liter (68,000 U.S. gallon) of Fuel
Every 2000 Service Hours or	352,000 liter (93,000 U.S. gallon) of Fuel	424,000 liter (112,000 U.S. gallon) of Fuel	516,000 liter (136,000 U.S. gallon) of Fuel
Every 3000 Service Hours or Every Two Years or	528,700 liter (139,500 U.S. gallon) of Fuel	636,700 liter (68,000 U.S. gallon) of Fuel	773,000 liter (204,000 U.S. gallon) of Fuel
Every 4000 Service Hours or	704,000 liter (186,000 U.S. gallon) of Fuel	848,000 liter (168,000 U.S. gallon) of Fuel	1,032,000 liter (272,000 U.S. gallon) of Fuel
Every 6000 Service Hours or	1,056,000 liter (279,000 U.S. gallon) of Fuel	1,272,000 liter (336,000 U.S. gallon) of Fuel	1,548,000 liter (408,000 U.S. gallon) of Fuel
Top End @ 1,942,000 liter (512,500 U.S. gallon) of Fuel or	Every 11,000 Service Hours	Every 9000 Service Hours	Every 7500 Service Hours
Overhaul @ 3,884,000 liter (1,025,000 U.S. gallon) of Fuel or	Every 22,000 Service Hours	Every 18,000 Service Hours	Every 15,000 Service Hours

Daily

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Walk-Around Inspection

⚠ WARNING

To avoid personal injury due to unexpected start, attach a DO NOT OPERATE or similar warning tag to start switch or controls before performing maintenance or repairing the engine. When appropriate, attach tags at the engine and pilot position, and disconnect starting controls.

DO NOT ALLOW UNAUTHORIZED PERSONNEL ON OR AROUND THE ENGINE WHEN IT IS BEING SERVICED.

Inspect Engine for Leaks and Loose Connections

A walk-around inspection is recommended to ensure the installation is clean and leaks are kept to a minimum. This should only take a few minutes and by taking the time to make these checks, costly repairs and accidents can be avoided and the equipment will be ready to run should the need arise.

For maximum service life of your engine(s), make a thorough inspection before starting the engine. Look for such items as oil or coolant leaks, loose bolts, worn belts, loose connections and trash build-up. Remove trash build-up and have repairs made as needed.

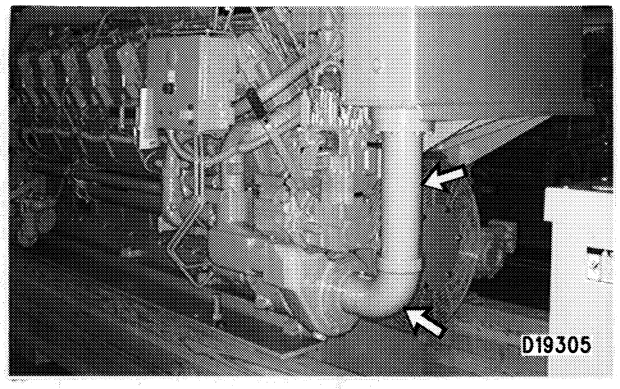
NOTICE

Accumulated grease and oil on an engine and/or platform (walkway) is a fire hazard. Remove this debris with steam cleaning or high pressure water, Every 1000 Service Hour interval or each time any significant quantity of fluid is spilled on an engine and/or platform.

Check the fluid levels more frequently than the recommended maintenance intervals and continue to monitor fluid levels until any leak is found and fixed. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more frequently than the recommended intervals.

- Wipe all fittings, caps and plugs before performing maintenance to reduce the chance of system contamination.
- Check the engine, cooling system, aftercooler and generator (if equipped) for dirt and debris. Inspect the radiator (if equipped) for leaks and trash build-up.
- All guards must be in place. Repair or replace missing or damaged guards.

Cooling System



Inspect:

- Cooling system lines and elbows for cracks and loose clamps. Check the condition of all pipes and fittings.
- Condition of all belts for cracks, breaks or other damage. Replace if necessary.

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

- Water pump(s) 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 parts contract. If leaks are found, check the coolant level frequently and continue to monitor the level until the water pump is repaired. Excessive coolant leakage may indicate the need to replace the water pump seal.

For removal and installation of water pump(s) and/or seals, see the Service Manual for this engine or consult your Caterpillar dealer.

Lube and Fuel System

Inspect:

- Lube system for oil leaks, such as front and rear crankshaft seals, oil pan gasket, oil filters, hose & tube connections and valve covers.
- Auxiliary oil filters, if equipped, for leaks and loose connections.

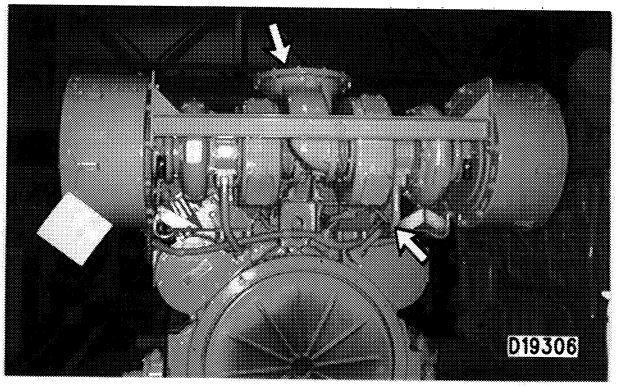
- Fuel system for leaks, loose or worn hoses, and loose fuel line clamps and fittings that are properly clamped and tight.

NOTICE

Fuel line clamps should not be over torqued. Over torqueing causes the clamps to butterfly, which results in low clamping force and fuel line vibration and eventual failure.

NOTE: Tighten fuel line clamps as required using 6V4980 Torque Screwdriver Tool Group. The standard torque for these fasteners (#10 screw) is 20 lb inch (2.26 N•m).

Air Intake System



Inspect:

- Air intake system hoses, piping and elbows for cracks and loose clamps. Check the condition of all connections and fittings.

Electrical

Inspect:

- Wiring and wiring harnesses for loose connections and worn or frayed wires.

- Engine-to-frame ground strap for good connection and condition.

- Check condition of gauges. Replace if cracked or cannot be calibrated.

While operating, frequently observe the engine oil pressure, oil filter differential, fuel pressure, fuel filter differential, water temperature and the air cleaner differential gauges.

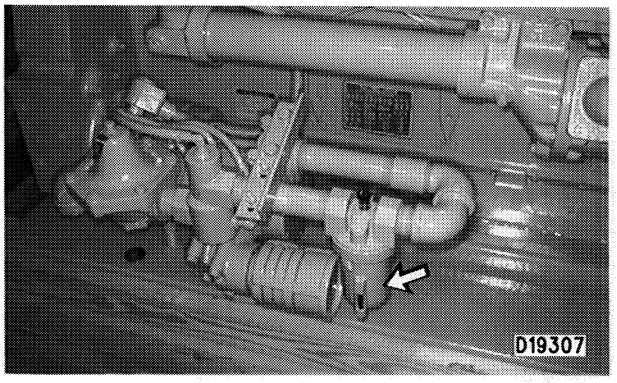
- Disconnect any battery chargers that are not protected against the starting motor current drain. Check condition of batteries and the level of electrolyte, unless equipped with a maintenance free battery.

Air Starting Motor and Air Prelube Pump Lubricators

- Adjust the air starting system pressure, if necessary. Fill all air starting system lubricators.

NOTICE

Never allow the air lubricator jar to become empty. The starting and prelube pump motors will be damaged by lack of proper lubrication.



- The vanes of the air starting motor and air prelube pump motor are lubricated with a fine oil mist from the starting motor oiler while the air starting motor is operating.

- When the air lubricator jar becomes half empty, remove oil filler plug and fill the jar with clean diesel fuel or kerosene. Refer to the Lubricant Viscosity Recommendations for more information.

Engine Crankcase

NOTICE

Make sure you read and understand the information in the Safety and Lubricant Specifications sections of this Manual before you proceed with maintenance of the lube oil system.

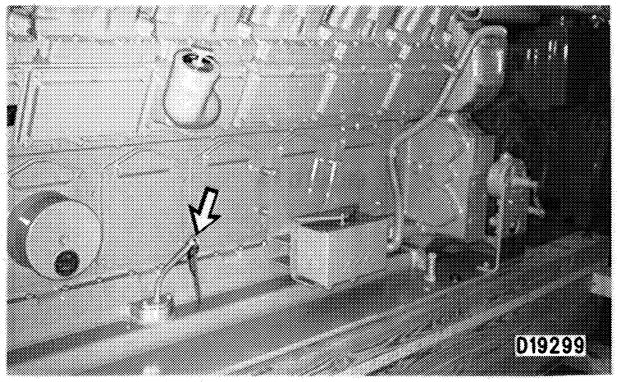
Check Oil Level

Check the engine crankcase lube oil on a daily basis. The dipstick is stamped on both sides.

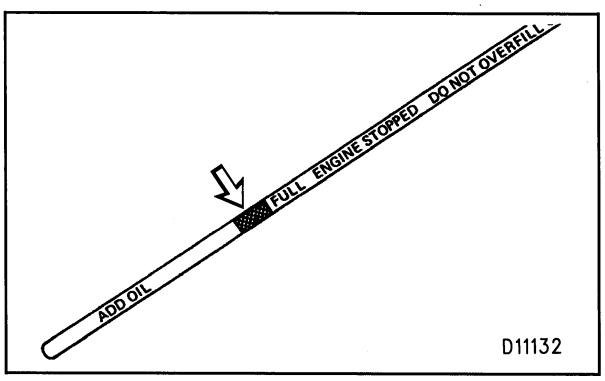
Be sure to read the correct side of the dipstick. The ADD and FULL levels are not the same when checking the oil while the engine is stopped or idling.

- One side is marked to be read when checking the oil level with the ENGINE STOPPED WITH OIL COLD.
- The other side is marked to be read with the ENGINE AT LOW IDLE WITH WARM OIL.

Engine Stopped



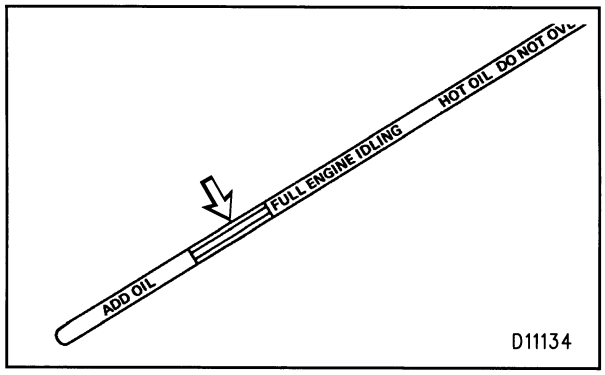
- Check the oil level with the engine STOPPED.



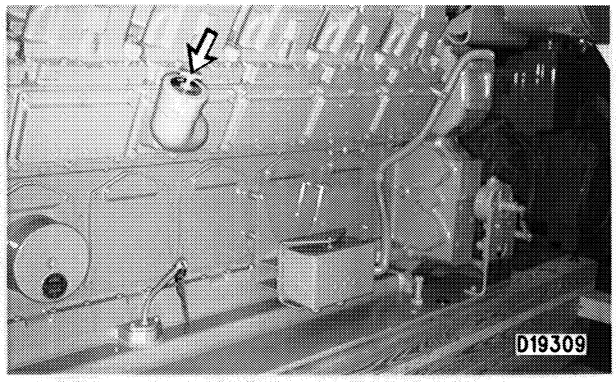
- Maintain the oil level to the FULL mark (between the ADD and FULL marks) on the ENGINE STOPPED WITH OIL COLD side of the dipstick. Add oil if necessary.

Engine Running

- Measure engine oil level with the engine operating at low idle.



- Maintain oil level to FULL mark on the ENGINE AT LOW IDLE WITH WARM OIL side of dipstick.



1. Remove oil fill cap and add oil if necessary. DO NOT fill the crankcase above the FULL mark on the dipstick. Refer to the Refill Capacities Chart in this manual for the correct crankcase capacity of your engine.

NOTICE

DO NOT fill to reach above or to the top of the FULL mark on the dipstick.

Operating your engine when the oil level is above the FULL mark could cause your crankshaft to dip into the oil. If this occurs, air bubbles may be created from the crankshaft dipping into the oil will reduce the lubricating characteristics of your oil.

A crankshaft that dips into the oil during engine operation, would result in a loss of power and a possible alarm from high crankcase pressure.

- If the engine is equipped with an oil level make-up system, fill and maintain to the FULL-COLD mark.

NOTE: Remote mounted or auxiliary filters require additional oil. For all information pertaining to auxiliary filters, refer to the Refill Capacities chart, OEM filter manufacturer's instructions or your Caterpillar dealer.

Lube System

- Check for lubrication leaks, such as the front and rear crankshaft seals, crankcase, oil filter, oil gallery plugs, sensors and valve covers.

NOTE: If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more than the recommended service intervals prescribed in this publication until a leak is found or fixed, or until the suspicion for a leak has been proven to be unwarranted.

Oil Consumption Estimate

Oil consumption, along with fuel consumption and maintenance information, can be used to estimate total operating cost. It can also be used to estimate the capacity of a makeup oil system required to accommodate your maintenance intervals.

Oil consumption, like fuel consumption, is somewhat proportional to the percent load at which the engine is operating. The higher the percent load, the higher the amount of oil consumed per hour.

The oil consumption rate, or BSOC (brake specific oil consumption), unit of measure is grams per brake kilowatt hour (g/bkW-h) [pounds per brake horsepower hour (lb/bhp-h)]. The BSOC varies depending on the load on your engine. The established typical mid-life BSOC values for your engine can be determined by contacting your Caterpillar dealer for assistance in determining typical oil consumption for your engine.

The Engine Technical Manual, EDS 96.2, has established typical mid-life BSOC values for 3500 engines operating at 100 percent load factor. These values are listed below.

3500 BSOC		
Engine Model	**g/bkW-h**	**lb/bhp-h**
Low Speed	0.365	0.0006
High Speed	0.548	0.0009

Oil Consumption as an Overhaul Indicator

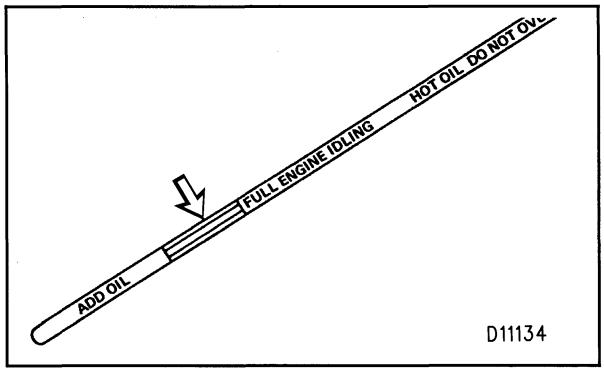
When an engine's oil consumption has risen to three times the initial (new) consumption rate due to normal wear, then the engine should be scheduled for overhaul. There may be a corresponding increase in blowby and also a slight increase in fuel consumption. Contact your Caterpillar dealer for assistance in determining typical oil consumption for your engine.

Marine Gear

Check Oil Level

⚠ WARNING

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



1. Check the oil level at LOW IDLE with the marine gear engaged. Maintain the oil level at the FULL mark on the dipstick.

2. Add oil as required. Do not overfill the marine gear. For marine gear other than Caterpillar 7200 Series, refer to the manufacturer's recommendations.

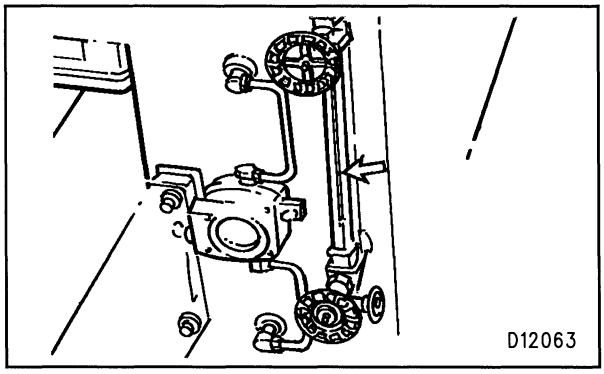
Cooling System

NOTICE
Make sure you read and understand the information in the Safety and Cooling System Specifications sections of this Manual before you proceed with maintenance of the cooling system.

Check Coolant Level

⚠ WARNING

Climbing equipment may be required to access this service point. Refer to the Safety Section, Mounting and Dismounting topic for safety information.



- Check the position of the float in the sight gauge (if equipped). At normal operating temperature, the coolant level float should be in the upper half of the sight gauge.

If Coolant is Low

Refer to the Cooling System Specifications section in this publication for all information pertaining to water, antifreeze and supplemental coolant additive requirements before performing this maintenance procedure.

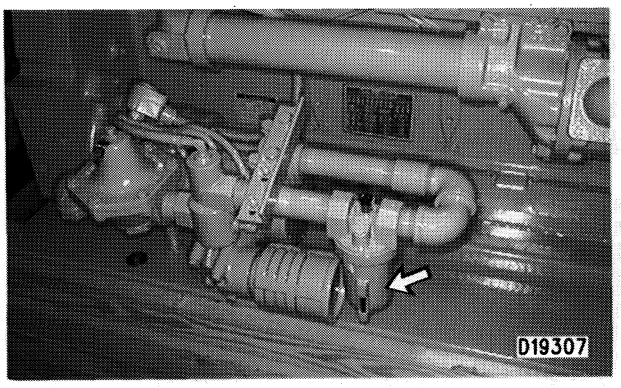
- Stop the engine and allow the engine to cool before performing this maintenance procedure.
- Release vent valve (if equipped) slowly to relieve pressure. Remove the filler cap slowly to relieve pressure and inspect condition of cap gasket. Replace cap if gaskets are damaged.

NOTICE
To prevent engine damage, never add coolant to an overheated engine. Allow the engine to cool first.

- Maintain the coolant level within 13 mm (½ inch) below the bottom of the fill pipe or to the proper level (upper half) on the sight glass (if equipped) by adding make-up coolant water. Install the filler cap.
- Inspect for leaks or damaged piping. Make repairs if necessary.
- Check for proper block heater operation by feeling the side of the engine block and or checking the engine coolant temperature gauge. A properly operating block heater will maintain the coolant temperature in the block at 32°C (90°F) minimum.

Air Starter Motor Lubricator

Check Lubricator



NOTICE

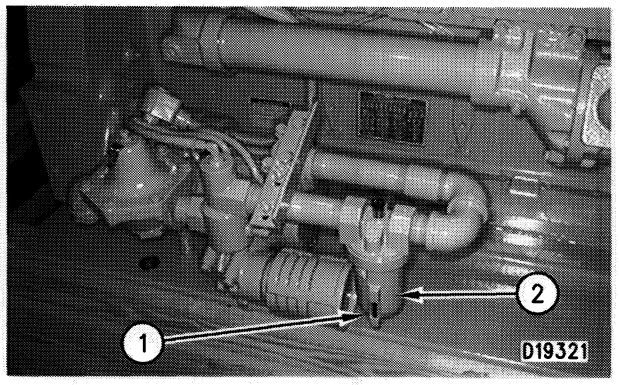
Never allow the air lubricator jar to become empty. The starting motor will be damaged by lack of proper lubrication.

The vanes of the starting motor are lubricated with a fine oil mist from the motor oiler while the motor is operating.

When the oiler bowl becomes half empty, remove the oil filter plug and fill the bowl with clean oil or diesel fuel or kerosene. Refer to the Recommended Lubricant Viscosities chart for proper oil.

Cleaning Lubricator Jar

- The collector jar must be emptied when it becomes half full. The jar collects both the lubricant, after it has lubricated the starting motor vanes, and moisture condensation from the compressed air.



1. Shut off the air supply to the starting motor control valve.

2. Open the drain valve (1) at the bottom of the bowl. The drain valve releases pressure from the bowl and allows the lubricant to drain.

3. Remove and clean the oiler bowl (2), using warm water only.

4. Dry the oiler bowl. Inspect for cracks. Replace if necessary.

5. Fill the oiler bowl with lubricant. Refer to the Lubricant Viscosity Recommendations in this manual for more information.

6. Install the oiler bowl (2) and close the drain valve (1).

7. Turn on the air supply to the starting motor control valve.

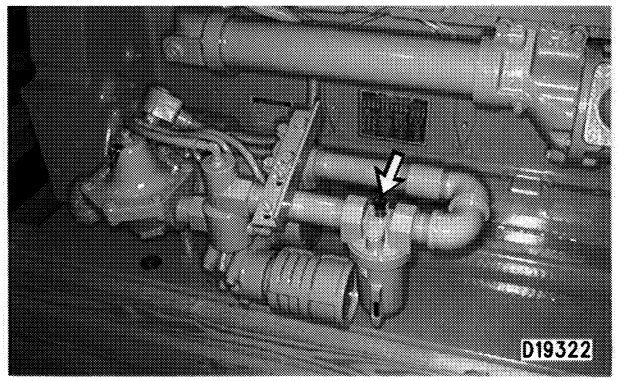
Oiler Feed Adjustment

If necessary, adjust the oiler feed to release four drops of lubricant per minute into the starting motor air stream and prelube pump.

1. Be sure there is NO fuel supply to the engine.

2. Operate the air start control lever or button to engage the starting motor to crank the engine.

3. Count the drops of lubricant released per minute into the air stream.



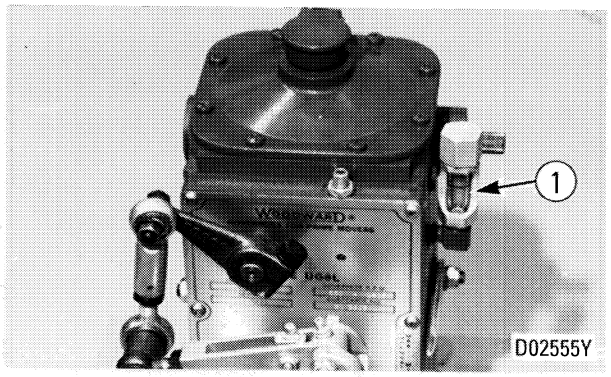
- Turn the valve needle (the uppermost knob on the oiler) counterclockwise (CCW) to increase the number of drops per minute or turn the valve needle clockwise (CW) to decrease the number of drops per minute.

NOTE: Drip rates should only be made under an average steady flow condition. Once established, the lubricator will automatically adjust the drip rate proportionally to variations in air flow.

Governor

Woodward UG8L Governor

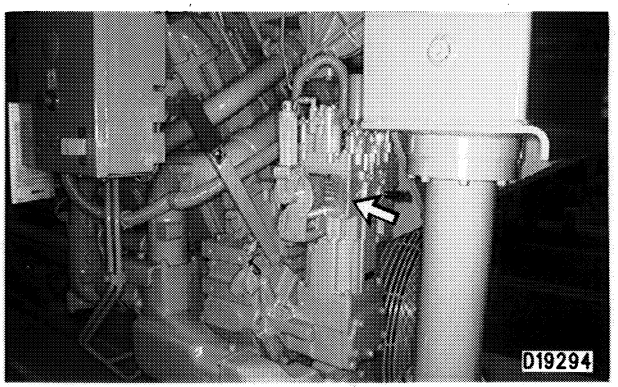
Measure Oil Level



With the engine stopped, measure the governor oil level. Maintain oil level at the FULL mark on the gauge or dipstick, if equipped.

Woodward 3161 Governor

Inspect for Proper Operation



The Woodward 3161 governor is connected to the engine oil lubrication system. The oil supply (under pressure) is sent to the governor through an orifice and internal passages. The governor keeps the correct oil level and drains excess oil back into the engine. The Woodward 3161 Governor will require oil only when it has been removed for service and at initial start up of a new engine. If engine rpm becomes erratic, the oil level in the Woodward 3161 Governor should be checked.

The oil level should be 60 to 76 mm (2.4 to 3.0 inches) below the surface of the hole where the sump plug is located. Add oil as needed to maintain the correct oil level.

If the oil level is low, clean the spiral orifice.

Oil is supplied to the governor from the engine and through the spiral orifice. Remove the spiral orifice, clean and install. Refer to the Service Manual for the complete procedure.

The Woodward 3161 governor, by design, maintains the proper oil level and drains the excess oil back to the engine, providing a continuous flow. Other than the spiral orifice, no other maintenance is required.

If the governor has been disassembled for repairs, fill the governor housing with engine oil. Do not start the engine without oil in the governor housing. Damage to the engine will result.

Air Tank

Drain Water and Sediment

This maintenance should be performed daily (or as necessary) to remove water and sediment. Water in the air system could freeze, corrode internal parts or cause the air system to malfunction. Drain moisture and sediment from the air reservoir as required.

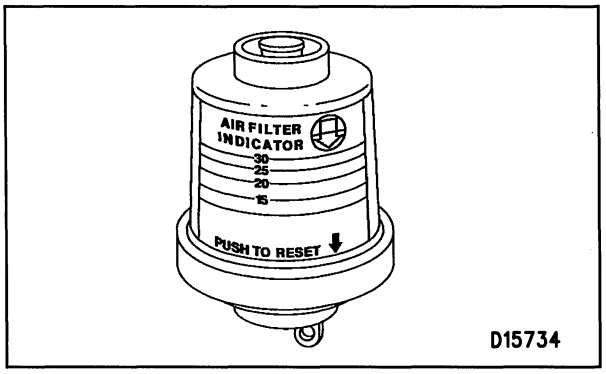
⚠ WARNING

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

- Check the air level in the tank. The tank should be kept as full as possible. Refill the tank when below three-fourths full to minimize the possibility of moisture accumulation in the tank.
- To drain the water and sediment, open the drain valve. Allow water and sediment to drain into a container. Close drain valve. Wipe up spills.
- Check all lines for leaks, loose clamps and fittings and loose or worn hoses. If a leak is found, repair as necessary.

Air Cleaner Service Indicator

Check



Check the air cleaner indicator. Service the air cleaner elements when the yellow diaphragm enters the red zone or the piston locks in the visible position. Maximum air cleaner differential pressure is 7.5 kPa (30 inches of H_2O).

Air Cleaner Elements

NOTICE

Never service the air cleaners with the engine running, since this will allow dirt to enter the engine. Do not clean elements by bumping or tapping them. Do not use filter elements with damaged pleats, gaskets or seals.

Refer to the air cleaner manufacturer's instructions if using air filters other than Caterpillar's.

Check the air ducts for leaks. Make all repairs to leaky air ducts immediately, as dirt and debris could enter the engine causing damage to the turbocharger and engine components.

If your air cleaner is not equipped with an air cleaner service indicator, you can obtain one at your Caterpillar dealer. Make sure the air inlet piping is secured and air filters are in place. Inspect the air intake system piping, elbows and gaskets for cracks or damage. Replace items as needed. Check for loose clamps and tighten if necessary.

- Clean or replace the air filter elements using the air filter differential pressure gauge or air cleaner indicator as the basis for determining the condition of the elements to establish this maintenance interval.

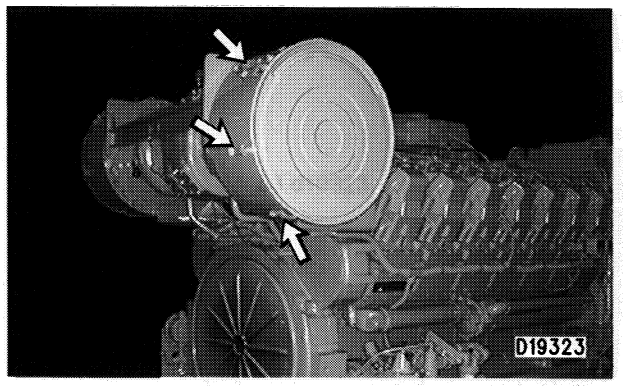
- The air filters should be inspected frequently when restriction reaches 3.75 kPa (15 inches of H_2O) and fuel consumption begins to increase slightly. The Air Filter Differential Pressure must NOT exceed 7.5 kPa (30 inches of H_2O) before replacing air filters. Severe fuel consumption loss will result if air filter restriction exceeds 7.5 kPa (30 inches of H_2O).

If the air cleaner element becomes plugged, the air can split the element filter material. This allows unfiltered air into the engine which would drastically accelerate engine wear. If the air cleaner elements become plugged, but does not split, engine performance will deteriorate and output power will be reduced.

- The primary element (Caterpillar air filters) can be cleaned up to six times before replacement. The element, when cleaned, should be thoroughly checked for rips or tears in the filter material. Replace the primary element every year even if it has not been cleaned six times.

NOTE: Air cleaner filter elements can be cleaned with either air, water or detergent. Have spare elements on hand to use while cleaning used elements.

Change Air Cleaner Elements



1. Release the cover fasteners from around the filter housing.

2. Remove the cover.

3. Remove the element and soot filter. Remove the soot filter from around the air cleaner element and discard it.

4. Clean the inside of the housing.

5. Install a new soot filter around the element.

6. Install the new or cleaned element and soot filter.

7. Install the cover and fasten it.

8. Reset the air cleaner indicator by pressing the reset button.

9. Repeat steps 1 thru 8 for the air cleaner on the opposite side.

Cleaning Air Cleaner Elements

⚠ WARNING

Pressure air can cause personal injury. When using pressure air, wear protective face shield and clothing.

The primary element (Caterpillar air filters) can be cleaned up to six times before replacement. The element, when cleaned, should be thoroughly checked for rips or tears in the filter material. Replace the primary element every year even though it has not been cleaned six times.

NOTICE

Do not clean filter elements by bumping or tapping. Do not use filter elements with damaged pleats, gaskets or seals.

NOTE: Air cleaner filter elements can be cleaned with either air, water or detergent. Have spare elements on hand to use while cleaning used elements. For more information, refer to Guideline for Reusable Parts, Form SEBF8062.

Refer to the air cleaner manufacturer's instructions if using air filters other than Caterpillar. Check the air duct for leaks. Make all repairs to leaky air ducts immediately, as dirt and debris could be induced into the engine causing damage to the turbocharger and engine components.

1. Remove the air cleaner cover and element and cover the turbocharger compressor inlet.

2. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

3. Inspect the replacement element for damage, dirt or debris.

4. Remove the covering from the turbocharger compressor inlet and install a clean, undamaged element.

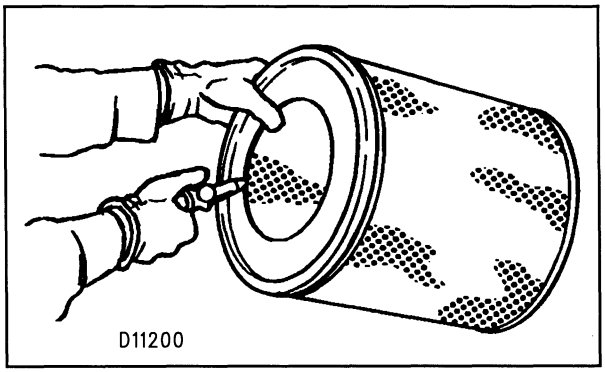
5. Install the air cleaner housing cover and fasten it. Reset the service indicator.

Cleaning with Water, Air, or Detergent

NOTICE

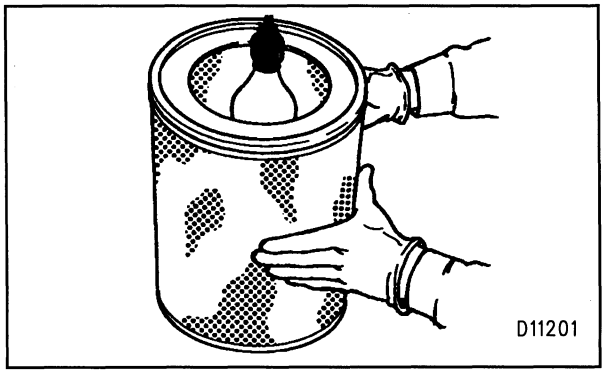
Do not clean the filter elements by bumping or tapping them. Engine damage could result.

Filter elements can be cleaned with 205 kPa (30 psi) maximum air pressure, 280 kPa (40 psi) maximum water pressure, or detergent washing.

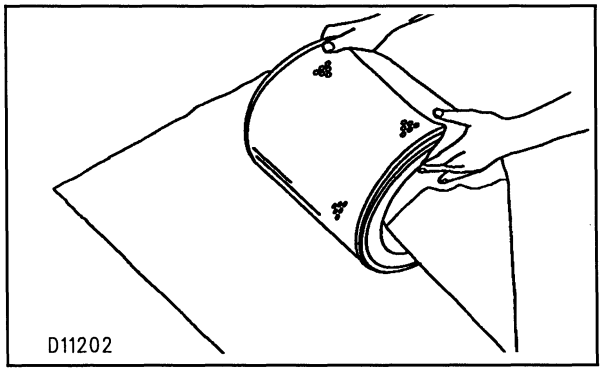


1. Direct air or water along the pleats inside and outside of filter element.

The element can be washed in warm water and nonsudsing household detergent. Rinse inside and outside the pleats and air dry fully.



2. Inspect the filter elements after cleaning. Do not use a filter element with damaged pleats, gaskets or seals.

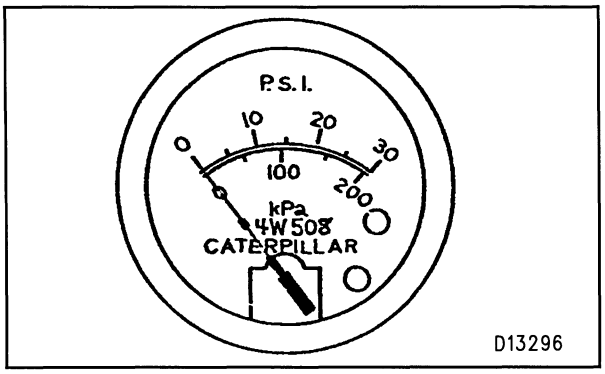


3. Wrap and store the clean filter elements in a clean, dry place.

For more information on air cleaner element cleaning, refer to Guideline for Reusable Parts-Cleaning and Inspection of Air Filters, SEBF8062.

Engine Oil Filter Differential Pressure

Check



The engine oil filter elements should be changed when the oil filter pressure differential gauge registers 105 kPa (15 psi) when engine is at rated speed and is at operating temperature.

If the engine is equipped with a duplex oil filter system, the filter elements can be changed with the engine running.

For the procedure to change oil filter elements or to service duplex oil filters, refer the topic Engine Oil and Filters under the Every 250 Service Hour interval.

Engine Fuel Filter Differential Pressure

Check

The final fuel filter elements should be replaced when the fuel filter differential gauge registers 105 kPa (15 psi), when engine is at rated speed and operating temperature. The primary fuel filter should be cleaned each time the elements are changed.

If the engine is equipped with a duplex fuel filter system the elements can be changed with the engine running. For the procedure to change fuel filter elements or to service duplex fuel filters refer to the topic Fuel Filters under the Every 1000 Service Hour interval.

Every 50 Service Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

This maintenance is to be performed at the interval specified in the Maintenance Schedule. Before proceeding with this maintenance, perform Daily maintenance interval requirements.

Zinc Rods

Inspecting Zinc Rods

Zinc rods are inserted in the engine's cooling system to help prevent the corrosive action of salt (sea) water. The reaction of the zinc to the sea water causes the rods to deteriorate.

Therefore, the zinc rods must be inspected Every 50 Service Hours, and replaced when they have deteriorated.

Depending on the engine and attachments, their location may be in the oil cooler heat exchanger bonnet, sea water heat exchanger bonnet, aftercooler lines, sea water pump and/or in the sea water lines.

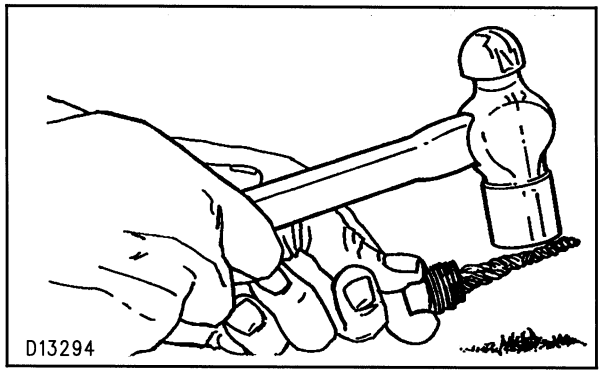
3500 Family Marine Engine Zinc Plug Locations:

- Seawater oil cooler/heat exchanger - There are three (3) zinc rods and plugs located in the end bonnets of the heat exchanger.
- Seawater Pump - There is one (1) zinc rod and plug located on the seawater pump elbow.
- Marine Gear Heat Exchanger (7200 Series) - There is one (1) zinc rod and plug located in the end bonnet.

Note: For all other marine gears refer to the manufacturers recommendations.

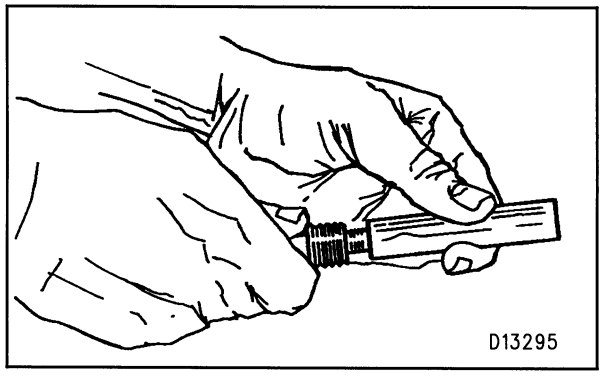
To service the zinc rods and plugs, use the following procedure:

1. Remove and observe condition of all zinc rods.



2. Tap the zinc rods lightly with a hammer. If a rod has deteriorated, or flakes apart when tapped, install a new zinc rod. Inspect the plug for damage. Replace if necessary.

Installing New Zinc Rods



1. Unscrew or drill the existing rod from the plug base.

2. Install a new rod in the plug base.

3. Install the plug.

Caterpillar Marine Gear

New or Reconditioned Only

Change oil and filter on a new or reconditioned unit after the first 50 Service Hours. See Caterpillar Marine Gear in the Every 1000 Service Hours section of this manual. For marine gear other than Caterpillar 7200 Series, refer to the manufacturer's recommendations.

Every 250 Service Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

This maintenance is to be performed at the interval specified in the Maintenance Schedule. Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Scheduled Oil Sampling (S•O•S)

Obtain Sample

S•O•S INTERVAL CHART	
Compartment	**Interval**
Engine Oil	250 Service Hours

To compliment a good preventive maintenance program, Caterpillar recommends using S•O•S at regular scheduled intervals to monitor the condition of your engine and engine oil to help determine the maintenance requirements of your engine.

Normal test results from the oil samples will be used to develop a "baseline" which will be used as a basis for determining the oil change interval for your engine, giving you the ultimate time between oil changes without the risk of engine damage.

Each oil sample should be taken when the oil is warm and well mixed to ensure that the sample is representative of the oil in the crankcase. There are several methods used to obtain S•O•S samples from Caterpillar diesel engines.

- Use a sampling gun inserted into the sump.
- Use a sampling valve installed for samples.
- Use the drain stream method when changing oil.

The sample valve should be flushed with oil coming out of the crankcase to rinse the dirt and debris from the valve.

Caterpillar recommends the first two methods. However, if these methods are not possible, then use a drain stream method when changing the oil.

If the drain stream method is used to obtain the oil sample, take the sample after some oil has drained and before the final drain oil stream. The oil at the beginning or end of the drain stream is not mixed well enough to be representative of circulating oil in the compartment and may carry debris that can give false S•O•S analysis results.

Refer to How to Take a Good Oil Sample, PEHP6001 for a step-by-step explanation if using this method of sampling oil. Contact your Caterpillar dealer for information and assistance in establishing the S•O•S program for your engine and application.

If the engine crankcase oil has reached its condemning limits as established by the oil analysis program before the established oil drain interval, refer to the topic, Engine Oil and Filters in this publication to replace the crankcase and/or auxiliary system oil.

Oil Drain Intervals

It is essential that an S•O•S analysis be performed on a regular basis to analyze oil condition before modifying oil change intervals can be considered. Due to manufacturing tolerances, engine application and maintenance variations, all engines do not consume fuel and oil at the same rate. Some history of fuel and oil consumed for each engine (or group of engines) in a similar application must be established. For a group of engines, determine the average fuel consumption and add oil rate.

For more information on establishing oil change intervals for specific engines and applications, see your Caterpillar dealer.

Engine Oil and Filters

Oil and Filter Change Interval

Use the chart below to establish the oil and filter change interval based on the engine oil sump capacity, minimum API oil classification and diesel fuel sulfur content of 0.5 percent or less.

Oil and Filter Change Interval			
Engine	**250 HRS**	**500 HRS**	**1000 HRS**
3508	104 Liter 27 US Gal. 22 Imp. Gal.	227 Liter 59 US Gal. 42 Imp. Gal.	424 Liter 112 US Gal. 90 Imp. Gal.
3512	152 Liter 40 US Gal. 33 Imp. Gal.	312 Liter 81 US Gal. 67 Imp. Gal.	613 Liter 162 US Gal. 134 Imp. Gal.
3516	204 Liter 53 US Gal. 44 Imp. Gal.	401 Liter 106 US Gal. 88 Imp. Gal.	842 Liter 219 US Gal. 182 Imp. Gal.

NOTE: This chart establishes the basis for the oil change interval only which affects S•O•S sampling, engine oil change, oil filters and initial valve lash adjustment. All other items are to be performed at Every 250 Service Hours.

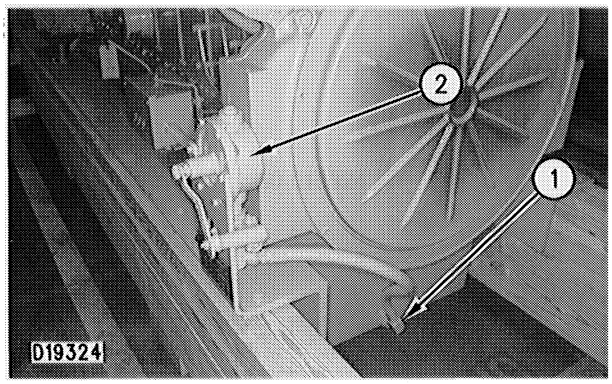
Change Oil

⚠ WARNING

Use caution when draining oil or changing filters. Hot oil or components can cause burns if they contact skin.

Drain the crankcase with the oil warm and the engine stopped to allow for the draining of waste particles that are suspended in the oil. As the oil cools, suspended waste particles will settle on the bottom of the crankcase and will not be removed with the draining oil.

Failure to follow this recommended procedure would result in these waste particles being recirculated through your engine lubrication system with the new oil.



1. Remove the crankcase drain plug (1) or use the hand operated sump pump (2) and drain the oil. Obtain an oil sample for S•O•S (Scheduled Oil Sampling) analysis.

When using the drain stream to obtain the oil sample, do not sample from the first or final draining since the oil at the beginning or end of the drain stream is not mixed well enough to be representative of the oil in the crankcase.

NOTE: S•O•S compliments a good preventive maintenance program. Caterpillar recommends using S•O•S at regular intervals, to monitor the condition and the maintenance requirements of your engine. Each oil sample should be taken when the oil is warm and well mixed, to ensure that the sample is representative of the oil in the compartment.

Consult your Caterpillar dealer for complete information and assistance in establishing an S•O•S program for your engine.

2. Install the crankcase drain plug and tighten it to 70 ± 14 N•m (50 ± 10 lb ft).

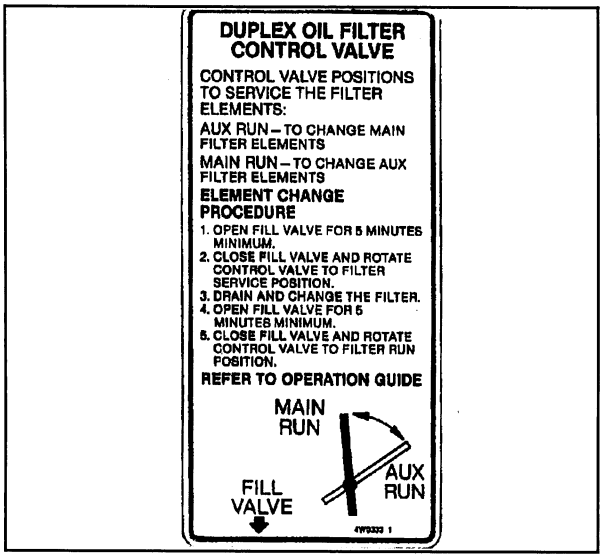
Drain Filter Housing (If Equipped)

NOTICE
This procedure must be performed with the engine STOPPED unless equipped with Duplex Oil Filters.

If your engine is NOT equipped with duplex oil filters, go to step #1.

If equipped with duplex oil filters, the engine oil filters can be changed while the engine is running. This is useful if the oil filters need replacement before the Engine Crankcase Oil drain interval. Follow the procedure below.

Duplex Oil Filters (If Equipped)

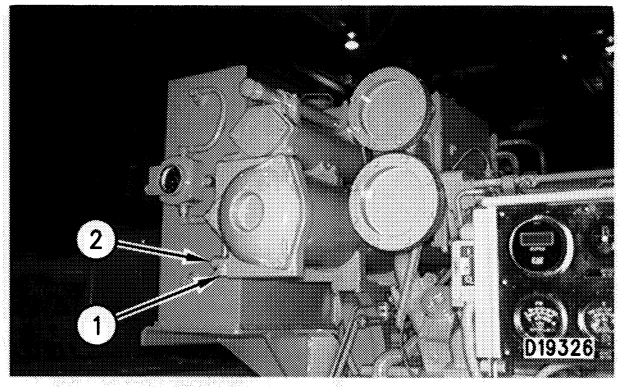


⚠ WARNING

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

- Move selector valve to the AUXiliary RUN position to change main filter elements or MAIN RUN position to change auxiliary filter elements.
- Allow the oil pressure gauge (or differential pressure) to reach zero.
- Open FILL VALVE for five minutes minimum.
- Close FILL VALVE and rotate control valve to AUXiliary RUN (or MAIN RUN) position to drain and change appropriate filter elements.
- Open FILL VALVE again for five minutes minimum.
- Close FILL VALVE and rotate control valve to MAIN RUN (or AUXiliary RUN) position.

NOTICE
This procedure must be performed with the engine STOPPED unless equipped with Duplex Oil Filters.



Engine Oil Filter Housing

1. To drain oil from the engine oil filter housing, install a ½-14 pipe nipple in the engine oil filter housing drain valve (1). Attach one end of a suitable hose to the nipple. Put the other end of hose in a container to catch the oil.

2. Open the engine oil filter housing drain valve (1) by turning the square stem counterclockwise (CCW). Remove vent plug (2) from the side of the engine oil filter housing. Allow oil to drain, then replace all plugs and close the drain valve.

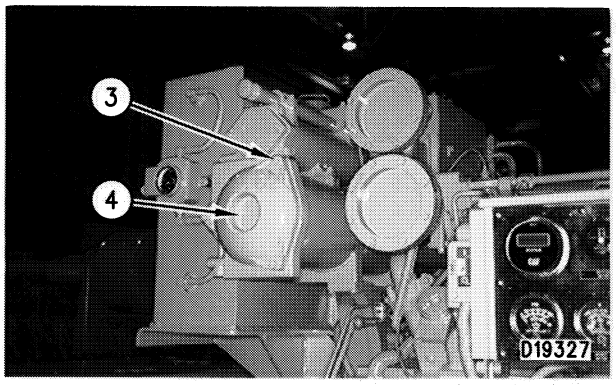
Replace Filters

Oil Filter Housing with Elements

⚠ WARNING

Possible injury can result when removing cover.

Spring force will be released when cover is removed. Be prepared to hold the cover as the bolts are loosened.



1. Loosen the three bolts (3) that hold the oil filter cover in place. Remove the oil filter cover (4). Remove the engine oil filter elements.

2. Wipe out the engine oil filter housing with a clean cloth.

3. Install new engine oil filter elements.

NOTE: Make sure to use the correct Caterpillar oil filter element(s) for your engine arrangement. Use of an oil filter element not recommended by Caterpillar could result in severe damage to your engines' bearings, crankshaft, etc., as a result of the larger debris particles or unfiltered oil entering your engine.

4. Inspect the engine oil filter cover O-ring seal. Install a new seal if necessary.

5. Install the engine oil filter cover (4). Make sure that the springs are seated properly between the elements and the cover.

6. Close the filter housing drain valve (1). Remove the drain hose. Clean and install vent plug (2) into the filter housing.

Batteries

Check Electrolyte Level

BATTERY ELECTROLYTE CHART	
Battery	**Interval**
Conventional	125 Service Hours
Low Maintenance	250 Service Hours
Maintenance Free	None Required

Tighten the battery retainers and check the following at least Every 250 Service Hours, and more often if conditions require.

1. Inspect the electrolyte level in each battery cell, except maintenance free. Remove fill caps. Maintain electrolyte to bottom on fill plug openings.

- If 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. The salts used in the treatment of artificially softened water will damage or reduce the efficiency of your batteries.

- At the proper charging rate in a moderate climate, batteries should not require more than 30 cc (1 ounce) of water per cell per week. Check the cells weekly in extreme temperatures, cell water usage could be higher.

2. Keep batteries clean. Clean the top of the batteries with a clean cloth.

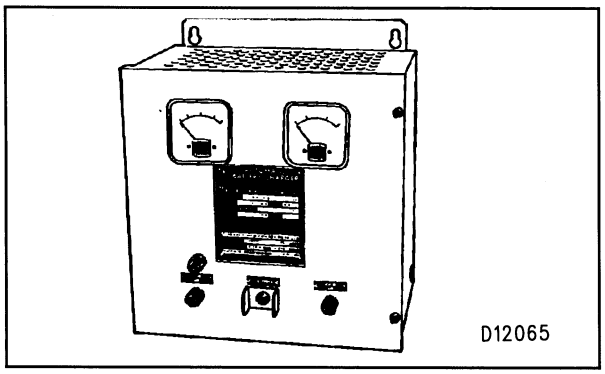
3. Loosen and remove cable clamps from all battery terminals.

4. Clean all cable clamps and battery terminals.

5. Coat cable clamps and terminals with petroleum jelly, 5N5561 Silicone Lubricant or MPGM grease.

6. Install and tighten cable clamps to battery terminals. Install the post cover.

Check/Record Battery Charger (If Equipped)



Check the battery charger for proper operation. Record the charging amperage reading. If batteries are properly charged, ammeter reading should be very near zero.

All batteries should be kept charged to a corrected specific gravity of 1.250 or above. The batteries should be kept warm, if possible.

The battery temperature affects the cranking power. If the battery is too cold, it will not crank the engine, even if the engine is warm.

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

Battery or Battery Cable Replacement

NOTE: When replacing batteries, battery cables, or disconnect switch, use the procedure that follows.

1. Turn OFF start switch and all electrical loads.

2. The cable that is connected to the frame must be disconnected at the disconnect switch (one cable connects to frame and one to battery negative). Be sure the disconnect cable cannot contact the switch stud where it was just removed.

3. Disconnect the negative battery cable terminal at the battery(s) that goes to the disconnect switch. Where four 12 volt batteries are involved, the negative side of two batteries must be disconnected.

4. Proceed with necessary system repairs.

5. Connect the cable from the frame to the disconnect switch (one cable connects to frame and one to battery negative).

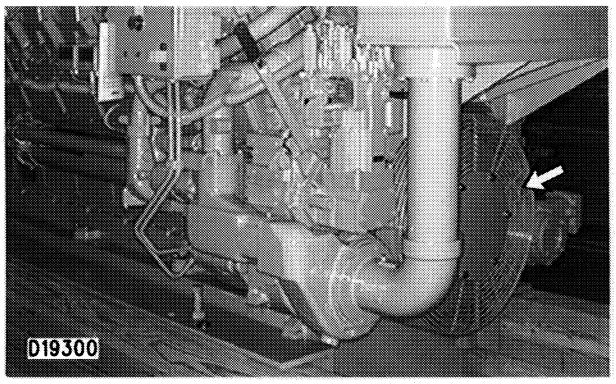
6. Connect the negative battery cable terminal from the disconnect switch to the battery(s). Where four 12 volt batteries are involved, the negative side of two batteries must be connected.

Belts, Hoses and Radiator Fins (If Equipped)

Inspect/Check

Inspect the condition and adjustment of alternator and accessory drive belts (if equipped) and replace if they show any signs of wear. A broken or worn alternator, fan or drive belt will cause performance problems. Loose or worn pulley grooves cause belt slippage and low accessory drive speed. If belts are too loose, they vibrate enough to cause unnecessary wear on the belts and pulleys and possibly slip enough to cause overheating.

If belts are too tight, unnecessary stresses are placed upon the pulley bearings and belts which might shorten the life of both. A slipping or improperly adjusted belt can cause engine cooling or battery problems when your generator is needed. Inspect for worn, broken or loose belts (alternator, fan, drive, etc.).



1. Remove belt guard.

2. Inspect the belts for wear. Replace belts if worn, cracked or frayed.

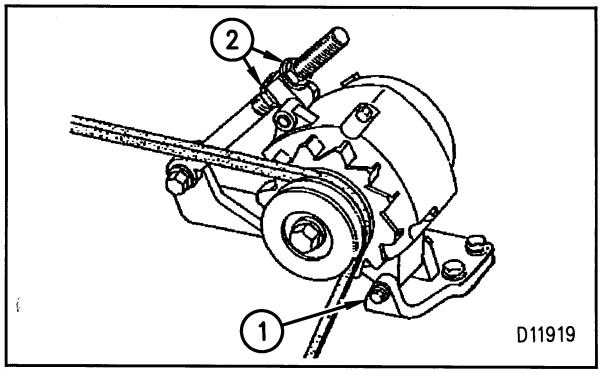
When belt replacement is necessary, belts must be replaced in complete matched sets. Never replace only one belt. The new belt will carry all of the load and consequently, fail rapidly.

3. If belts do not require replacement or adjustment, install the belt guard. If belts require adjustment or replacement, do not install the belt guard. Refer to the Belt Adjustment procedure when belt adjustment and/or replacement is necessary.

Belt Adjustment

1. Apply a 110 N (25 lb) force, perpendicular to the belt, midway between the driving and driven pulley. Measure the belt deflection.

Proper belt deflection is 15 to 20 mm (0.6 to 0.8 inch). Adjust the belt tension as required.



1. To adjust the belt, loosen mounting bolts (1) and adjust with adjusting bolt (2).

2. Move the fan drive up or down as required to obtain the correct adjustment. Tighten mounting bolts.

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

3. If engine is equipped with any other belt driven equipment, check and adjust them as required.

4. Replace the belt guard.

Fan Belts

Inspect

Examine the drive belts for wear and replace if they show signs of wear. Loose or worn pulley grooves cause belt slippage and low fan speed. If fan belts are too loose, they vibrate enough to cause unnecessary wear on the belts an pulleys and possibly slip enough to cause overheating.

If one belt in a set requires replacement, always install a new matched set of belts – never replace just the worn belt. If only the worn belt is replaced, the new belt will carry all the load, as it will not be stretched as much as the older belts, and all the belts will fail in rapid succession.

Adjustment

Check new belts for adjustment after the first 30 minutes and Every 250 Service Hours thereafter. To check belts apply 110 N (25 lb) force midway between pulleys. Correctly adjusted belts will deflect 12 to 19 mm (½ to ¾ inch) for the first check. Maintain later adjustments at 23 mm (⅞ inch).

Loosen the lockbolts on the fan pulley adjusting bracket and adjust fan pulley by applying grease to fitting shown. After belt tension is correct, tighten lockbolts.

Hoses

Hose replacement prior to failure is cost effective and a good preventive maintenance practice. Replacing a hose before it fails saves you money and reduces the chances for unscheduled downtime. By replacing a hose that is cracked, soft or leaking, you will avoid major repairs that could result from a severe engine overheating problem.

1. Inspect all hoses for leaks due to cracking, softness next to clamps and loose clamps.

2. Replace hoses that are cracked or soft and tighten loose clamps.

Radiator Fins (If Equipped)

Inspect/Check

⚠ WARNING

Wear eye protection at all times when cleaning the cooling system. Pressurized water could cause debris to be blown and result in personal injury.

Always clean the radiator fins with the engine stopped. Failure to do so, could result in personal injury caused by the moving fan blades.

Check the radiator fins for debris.

High pressure water is an excellent way to clean the debris out of the radiator fins.

If necessary, use a light bulb behind the radiator fins to see if they are completely clean.

Refer to Know Your Cooling System, SEBD0518, for more detailed information on cleaning your radiator fins.

Fuel Tank

Drain Water and Sediment

This maintenance should be performed as necessary to remove water and sediment. Water in the system could freeze, corrode internal parts or cause the system to malfunction. Drain moisture and sediment as required.

- Check fuel level in the fuel tank. The tank should be kept as full as possible (without overflowing) to ensure the engine can be started and run as required. Refill the tank when below three-fourths full to minimize the possibility of moisture accumulation in the tank. Fuel expands when warm, so do not overfill the tank.

- Drain the water and sediment from the fuel tank. Open drain valve. Allow water and sediment to drain into a container. Close drain valve. Wipe up spills.

- Check all lines for leaks, loose clamps and fittings and loose or worn hoses. If a leak is found, repair as necessary.

Refer to the Fuel Specification Section of this Manual for additional information on fuel tanks and fuel lines.

Engine Valve Lash, Injector Timing and Rotators

Check/Adjust

With the engine stopped and cold, inspect and adjust the bridge and valve adjustment. Before adjusting valve lash, a bridge adjustment must be made. After checking the bridge adjustment for each cylinder, proceed with the valve lash adjustment, if necessary. Refer to the Service Manual for the complete procedure.

Initial Valve Lash

NOTE: Initial valve lash adjustment on new, or rebuilt engines is recommended at the first scheduled oil change interval due to initial wear and seating of valve train components. Subsequent adjustments should be made at 2000 service hour intervals.

⚠ WARNING

To prevent possible injury, DO NOT use the starting motor to bar over the engine. Be sure the starting motors are disabled and engine cannot be started while this maintenance is being performed.

Always have the Engine Control Switch (ECS) in the STOP or OFF/RESET position to immediately discharge the starting system.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring valve lash. Measure the valve lash with the ENGINE STOPPED. To obtain an accurate measurement, allow at least 20 minutes for the valves to cool to engine cylinder head and block temperature.

NOTICE

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

Always turn the flywheel in the direction of normal rotation. Before checking or adjusting the valve lash, move the valve rocker arm up and down several times to push the oil out of the push rod socket. This is necessary to get accurate valve lash measurements.

Stop the engine according to the procedure in the Engine Stopping section and inspect the valve cover gasket to ensure it is not damaged. Thoroughly clean the area around the valve mechanism covers to prevent the entry of foreign matter into the top of the cylinder head and valve mechanism.

When the valve lash (clearance) is checked, an adjustment is **NOT** necessary if the measurement is within ± 0.08 mm (± 0.003 inch) of the value given in the Valve Lash Setting chart.

If the measurement is outside of the range given for valve lash, an adjustment is necessary. Set the lash to the nominal clearance given in the Valve Lash Setting chart. Refer to the Service Manual or your Caterpillar dealer for the complete valve adjustment procedure.

Valve Bridge

NOTICE

Be sure to adjust the valve bridges before adjusting any valves.
Perform procedure for both bridges for each cylinder. Put clean engine oil on the contact points of both bridges and in the bridge bores.

The valve bridge should be checked and/or adjusted each time valve lash is checked and/or adjusted. Valve and valve mechanism components do not always wear evenly which can allow the bridge to go out of adjustment.

There are two rocker arms per cylinder. One rocker arm for the two exhaust valves and one rocker arm for the two inlet valves. Each pair of valves is connected by a bridge which is actuated by the rocker arm. The valves in each pair are adjusted simultaneously by adjusting screw in the rocker arm. Each bridge is adjusted by adjusting screw.

It is not necessary to remove the rocker arm shaft to adjust the valve bridges, but there must be lash. Push on the top of the rocker arm directly above the center of the bridge to check bridge adjustment. Refer to the Service Manual for the complete adjustment procedure.

NOTE: Caterpillar recommends replacement of improperly operating valve rotators. An improperly operating valve rotator will shorten valve life through accelerated valve face and valve seat wear.

Rotators

With the engine idling, observe the rotation of the valves only after setting the valve lash.

⚠ WARNING

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

NOTICE

If a damaged rotator is not replaced, valve face guttering could result in pieces of the valve to fall into the cylinder. This can cause piston and cylinder head damage.

Refer to the Service Manual or your Caterpillar dealer for more information on complete valve adjustment procedure.

1. After setting all valve lash and before installing the valve cover, start the engine. Move the governor control to LOW IDLE position.

2. Watch the top surface on each valve rotator. Each valve rotator should turn slightly each time the valve closes. If a valve fails to rotate, contact your Caterpillar dealer.

Injector Timing

The first time the valve lash is checked and/or adjusted, the injector timing should be checked and/or adjusted. Use the procedure as established in the Service Manual, or contact your Caterpillar dealer for assistance.

Cooling System–Engines Using Standard Type Antifreeze Only

NOTICE

This maintenance is for engines using standard type antifreeze only. DO NOT mix standard type antifreeze and Long Life Coolant (LLC). Make sure you read and understand the information in the Safety and Cooling System Specifications sections of this Manual before you proceed with this maintenance.

Test for Coolant Additive Concentration

Use the 8T5296 Coolant Additive (Conditioner) Test Kit to check for coolant additive concentration of Caterpillar conditioner. The sample can be tested by your Caterpillar dealer to determine the concentration of supplemental coolant additive or use the 8T5296 Coolant Additive (Conditioner) Test Kit to check for concentration. Add coolant additive if the percentage is below three percent, but do not allow concentration to exceed eight percent.

If the concentration level is above eight percent, sludge and mud-like deposits may be formed in the cooling system. This has an adverse affect on engine performance and can also lead to costly repairs of the engine and cooling system. For more information, order a copy of Coolant and Your Engine, SEBD0970, available through your Caterpillar dealer or refer to the Cooling System Specifications in this manual or your Caterpillar dealer.

Clean/Flush the cooling system before the recommended maintenance interval if:

- Coolant is heavily contaminated.
- The engine overheats frequently.
- Foaming is observed in the cooling system.
- The oil cooler has failed allowing oil in the cooling system and contaminated the coolant.
- Fuel has entered the cooling system and contaminated the coolant.
- Supplemental coolant additive and antifreeze other than Caterpillar products are used.

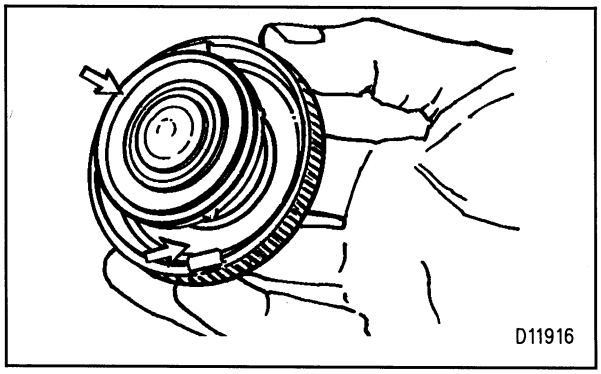
NOTICE

Caterpillar does not recommend the use of cooling system solutions that are intended to stop leaks. Use of these products may result in excessive internal deposits that could reduce the engine's heat transfer characteristics.

Excessive and continuous over concentration of coolant additive of six percent (greater than the maximum eight percent initial fill when using water only without antifreeze) together with antifreeze concentrations greater than 60 percent will result in deposits on the higher temperature surfaces of the cooling system, accelerate water pump seal wear and may result in heat exchanger tube blockage which creates a barrier that reduces the engine's heat transfer characteristics and could cause cracking of the cylinder head and other high temperature components.

Add Coolant Additive (Conditioner)

NOTE: For separate circuit systems, refer to the specific system volumes to determine the quantity to be added to each system. Be sure to test both systems as the jacket water may deteriorate faster because of system temperatures.



1. Release the cooling system relief valve or filler cap slowly to relieve pressure and remove filler cap. Inspect condition of cap gasket. Replace cap if necessary.

2. It may be necessary to drain enough coolant from the system to allow for the addition of cooling system additive (conditioner).

3. Add Caterpillar Cooling System Conditioner. Add 0.25 liter (½ U.S. pint) of Caterpillar Cooling System Additive (Conditioner) for each 38 liter (10 U.S. gallon) of cooling system capacity. This will maintain the required concentration of conditioner.

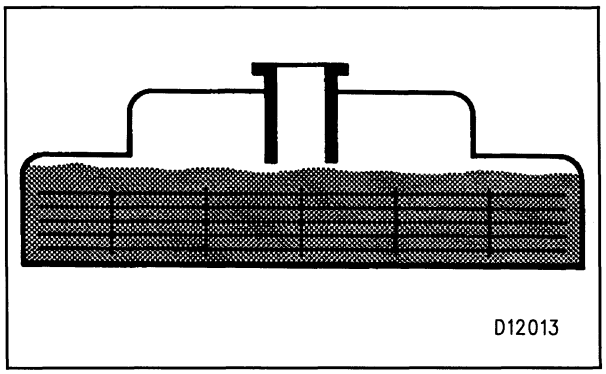
NOTE: On new, rebuilt or remanufactured engines only, or when draining and changing the coolant, add liquid additive concentration of coolant additive of 1 liter (1 U.S. quart) for every 15 liter (4 U.S. gallon) of cooling system capacity for systems using water only.

Caterpillar Antifreeze contains the necessary coolant additive precharge. Only add the coolant additive precharge if you have decided not to use Caterpillar Antifreeze.

Refer to the Refill Capacities chart in this Manual for the cooling system capacity for your engine.

NOTICE

Do not use any Methoxypropanol-based antifreeze or coolants in the cooling system. Methoxypropanol will cause some seals and gaskets to deteriorate and fail.



4. Maintain coolant level to within 13 mm (½ in) below the bottom of the filler tube or to the proper level (upper half) on the sight glass, if equipped. Add premixed coolant if necessary to bring the coolant to the proper level.

Refer to the topic Cooling System Specifications in the Specifications section in this manual for additional information about coolant mixture and supplemental coolant additive.

5. Start the engine and check cooling system pipes and lines for leaks, damaged piping or connections. Allow the coolant level to stabilize. Inspect the cooling system pipes and lines for leaks and/or damaged connections. Make repairs if necessary. Install the filler cap.

Coolant Analysis

Obtain Coolant Sample

There are two types of coolant analysis that can be performed (1) concentration of coolant conditioners (inhibitor or additive) and (2) coolant water mineral content. These samples should be obtained regularly.

The concentration of Supplemental Coolant Additive (Conditioner) should be checked regularly with the 8T5296 Test Kit. The recommended maintenance intervals should be adequate for many users, however the concentration should be checked periodically.

The water used in the coolant mixture can leave deposits on engine components, yet coolant additive concentrations were properly maintained. A water analysis should be performed annually (every year), as well as when the cooling system is drained, cleaned and flushed, or at overhaul when new water (at fill time) is put into the system.

Full water analysis may be available from your local water utility company or an agricultural agent. Private laboratories are also available. Most laboratories need approximately 250 ml (½ U.S. pint) of water. Many Caterpillar dealers and customers send water samples to the following:

L.O.C.C. Corporation
905 Bayshore Drive
Coos Bay, OR 97420 U.S.A.
Telephone: (503) 267-4904

NALCO Chemical Co.
Naperville Technical Center
One Nalco Center
Naperville, IL 60566 U.S.A.
Telephone: (312) 961-9500

Check the lab you use for details about labeling and shipping. Contact your Caterpillar dealer for assistance if needed.

Cooling System Cleaning

There are two types of cooling system cleaners available. One is the 6V4511 Standard-Type in the 2 liter (½ U.S. gallon) container and the other is the 4C4611 Fast Acting-Type in the 4 liter (1 U.S. gallon) container.

The 6V4511 requires approximately 120 service hours of engine operation to remove scale, lime and other debris. The 4C4611 requires only 90 minutes of engine operation. Both types must remain in the system for a minimum of specified time to work properly, however, neither type will harm the engine if left in for a longer period of time.

The 6V4511 must be added before the Every 3000 Service Hour maintenance interval. Add 1 liter (1 U.S. quart) of Caterpillar Cooling System Cleaner, 6V4511, for every 15 liter (4 U.S. gallon) of cooling system capacity. Continue to operate the engine for the specified time before draining.

The 4C4611 may be added just prior to draining (such as the same day of a day trip) and the system cleaned and flushed after operating for the specified time period.

Refer to the Cooling System-Clean/Flush topic in this manual or your Caterpillar dealer for more detailed information.

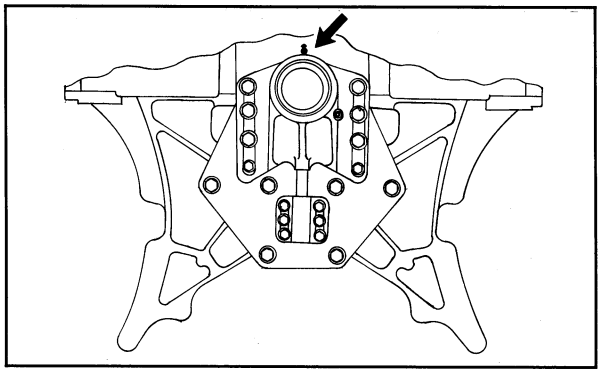
Inspect Radiator

Clean the cooling system (radiator) fins of dirt and debris.

Refer to Know Your Cooling System, SEBD0518, and Coolant and Your Engine, SEBD0970, or your Caterpillar dealer for more detailed information.

Fan Drive Bearing (If Equipped)

Lubricate Fitting



Lubricate fan drive bearing.

Every 1000 Service Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

This maintenance is to be performed at the interval specified in the Maintenance Schedule. Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Engine Protective Devices

Inspect/Check

The engine protective shutoff controls must be inspected and checked for proper operation. This will ensure that if a malfunction should occur, the engine will shutdown without being damaged.

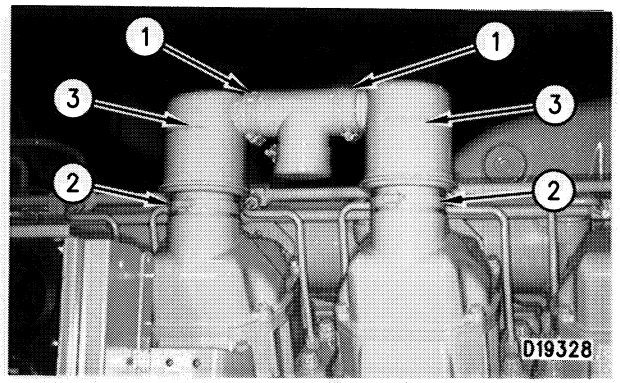
Have the inspection and checks made by a qualified mechanic. Consult your authorized Caterpillar engine dealer, or refer to the Service Manual for your engine.

The Hydramechanical Shutoff should be inspected and tested to ensure proper operation and protection to the engine. Refer to Engine Controls Section under the Operation Section in this manual.

Check air inlet valve to make sure it closes during testing.

Crankcase Breather

Clean



1. Loosen hose clamps (1) on breathers and slide the fumes disposal tube from the breather assemblies.

2. Loosen breather retaining clamp (2) on each of the two breathers (3). Remove breather (3) and the seal.

3. Wash breather (3) in clean, nonflammable solvent and allow to dry before installation.

NOTE: Put clean engine oil or petroleum jelly on the rubber parts to make installation easier.

4. Install new seals and breather (3) in the same position and in reverse order of removal. Tighten bolt clamp.

5. Slide the hose on to breather (3).

6. Tighten all clamps (1) to 4.5 ± 0.6 N•m (40 ± 5 lb in).

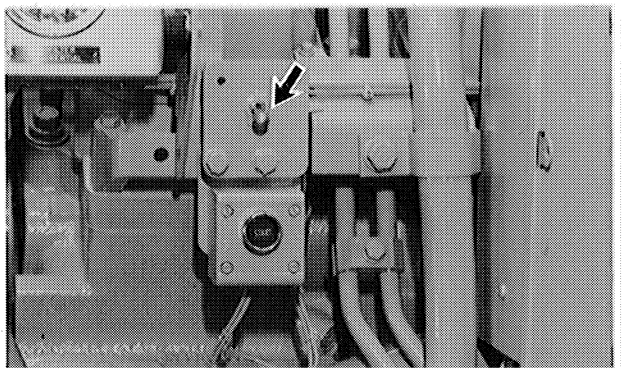
NOTE: If crankcase breathers are not serviced on a regular basis, they will become plugged. A plugged crankcase breather would result in excessive crankcase pressure that may cause crankshaft seal leakage.

Woodward UG8L Governor (If Equipped)

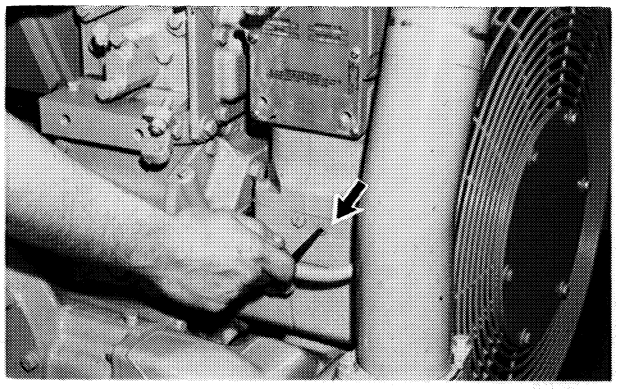
Change Oil

⚠ WARNING

To prevent personal injury, be sure the engine cannot be started. Disconnect the ground cable from the battery terminal.



1. Move the ON/OFF switch to the OFF position or disconnect the ground cable from the battery terminal. Close the fuel tank fuel supply valve.



2. Remove governor drain plug. Allow oil to drain. Clean and install the drain plug.

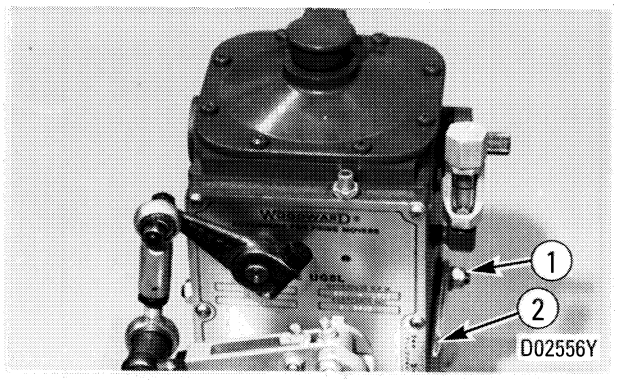
3. Fill the governor with clean oil to the FULL mark on the dipstick or proper level on the sight gauge. Refer to Refill Capacities for proper oil.

4. Connect the ground cable to the battery and open the fuel tank supply valve.

5. Use the procedure that follows to bleed the governor.

Bleed Air From the Governor

1. Start the engine according to the instructions in the Engine Starting topic in this Manual and allow the engine to reach normal operating temperature.



2. Loosen nut (1) on the side of the governor which holds compensation adjusting pointer (2).

3. Manually move pointer (2) to the extreme upper position. Tighten nut (1). This will allow the governor to be purged of air.

4. Remove the plug from the base of the governor. Use a wide blade screwdriver to turn the needle valve three or more turns counterclockwise. Allow the engine to surge for approximately 30 seconds.

5. Loosen the nut and move the compensation adjusting pointer to the extreme downward position. Tighten the nut. Slowly turn the needle valve clockwise until the surging stops.

6. It should now take less than one turn from this point to close the valve completely. Open the valve to the same position where the surging had stopped.

7. Manually move the governor linkage to disturb the engine speed. If the engine speed stabilizes, and the needle valve is only ½ to ¾ turn open, the governor is properly adjusted. Install the base plug.

If more than a ¾ turn is required to stop engine surging, proceed with the following steps.

8. Raise the pointer two divisions on the pointer scale. Turn the needle valve counterclockwise three or more turns. Allow the engine to surge approximately 30 seconds.

9. Gradually turn the needle valve clockwise until surging just stops. Note the portion of a turn required to close the needle valve.

10. Open the valve exactly to the same position surging stopped.

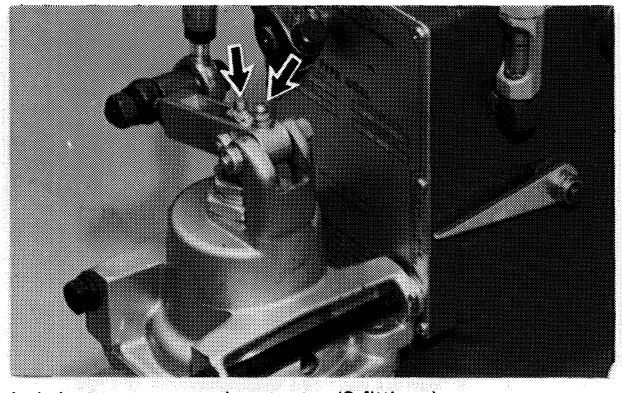
11. Manually move the governor linkage to disturb the engine speed. The engine speed should stabilize with the needle valve opened ½ to ¾ turn. A valve opened less than ½ of a turn produces a slow response to load changes. A valve opened more than ¾ of a turn produces excessive speed response to load change. If the engine does not stabilize between ½ to ¾ turn open, raise the pointer two divisions and repeat steps 8 through 11.

12. When the engine speed stabilizes, install the base plug.

For more information on adjusting the governor, refer to the Service Manual or your Caterpillar dealer.

Governor Air Actuator (If Equipped)

Lubricate Fittings



Lubricate governor air actuator (2 fittings).

Fuel Filters

⚠ WARNING

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

Disconnect the battery when changing fuel filters.

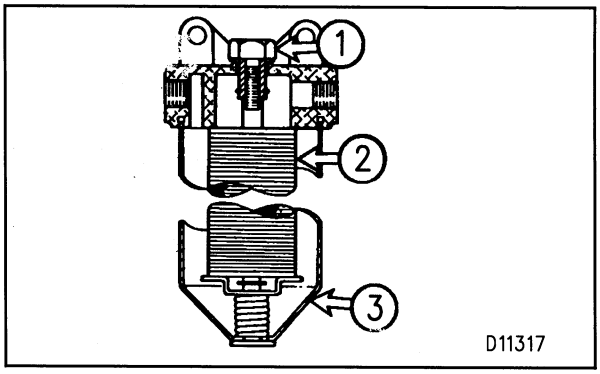
NOTICE
Do not fill fuel filter housings with fuel before installing elements. Contaminated fuel will cause accelerated wear to fuel system components.

The final fuel filter elements should be replaced when the fuel filter differential gauge registers 105 kPa (15 psi), when engine is at rated speed and operating temperature. The primary fuel filter should be cleaned each time the elements are changed.

Cleaning the Primary Fuel Filter

1. Stop the engine.

2. Close the fuel supply line valve.



3. Loosen nut (1) on the cover and remove case (3).

4. Remove filter element (2). Clean the element and case in clean, nonflammable solvent.

5. Inspect and install the two cover gaskets. Install new gaskets if necessary.

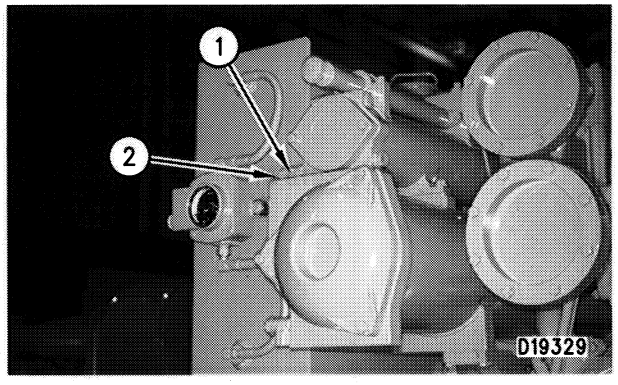
6. Install the cleaned filter element and case.

7. Open fuel supply line valve.

8. Prime the fuel system. Refer to Priming the Fuel System.

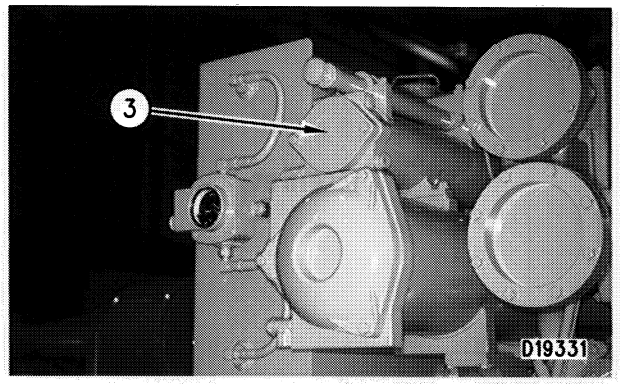
Changing Final Fuel Filters

1. Close the fuel supply line valve.



2. Attach one end of the drain hose to drain valve (1). Put the other end of the hose in a container to catch the fuel.

3. Open drain valve (1). Remove vent plug (2) and drain the fuel filter housing.



4. Remove cover (3) from service end of the filter housing.

5. Remove the five used filter elements from inside the filter housing. Wipe all sediment from inside the filter housing.

6. Install new filter elements.

7. Inspect the cover O-ring seals. Install new seals if necessary. Install the cover.

8. Install vent plug (2), close drain valve (1) and remove drain hose.

9. Open the fuel supply line valve.

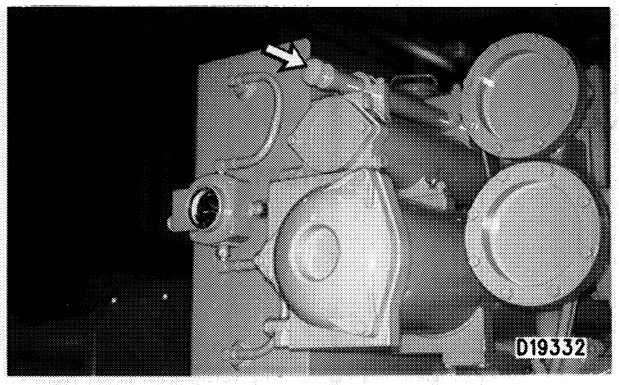
10. Prime the fuel system.

Priming the Fuel System

If Equipped With A Priming Pump

1. Open the fuel supply line valve.

2. Move the ON/OFF switch at the engine, to the OFF position.



3. Turn the pump handle knob counterclockwise. Release the lock plate from the retainer on the fuel priming pump.

4. Operate the fuel priming pump until the air in the fuel system has been pumped through the fuel return line to the fuel tank.

5. Start the engine. If engine misfires or there is excessive smoke, further purging of air from the fuel system is required.

For Engines Not Equipped With A Fuel Priming Pump:

To prime the fuel system, pour clean, water-free fuel into the dirty side (outer ring) of the fuel filter. Pour fuel slowly, allowing time for the fuel to seep through the filter, filling the canister. Install the filter and crank the engine until started.

Duplex Fuel Filters

The duplex fuel filter system will allow continuous operation while the fuel filters are being changed.

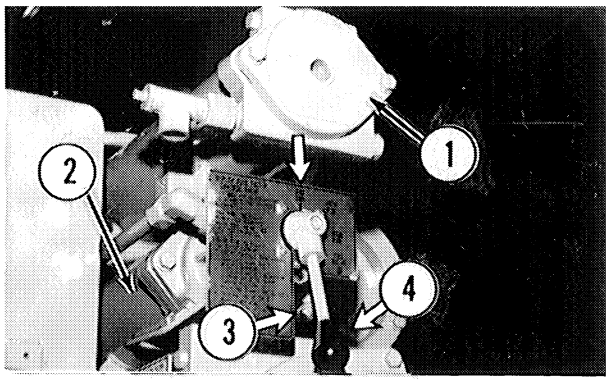
NOTE: Under normal operation, the main fuel filters are to be used until they need to be replaced. Auxiliary filters are to be used for continuous engine operation while the main filters are being changed.

When the fuel filter differential gauge registers 105 kPa (15 psi), the main fuel filter elements should be replaced.

Changing the Main Final Fuel Filters

⚠ WARNING

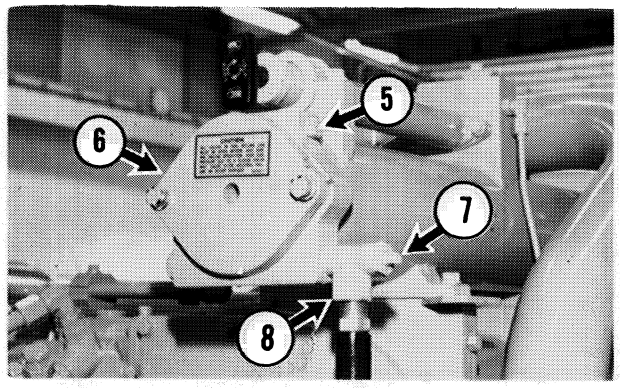
Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.



Main Final Fuel Filters (1) and Auxiliary Final Fuel Filters (2).

1. Open fill valve (3) for five minutes minimum.

2. Close fill valve (3) and rotate control valve (4) to the AUXILIARY RUN position.



3. Attach one end of the drain hose to drain valve (8). Put the other end of hose in a container to catch the fuel. Open drain valve stem (7). Remove vent plug (5) and drain the fuel filter housing.

4. Remove end cover (6) from the end of the main final fuel filter housing.

5. Remove the five used fuel filter elements from inside the fuel filter housing. Wipe all sediment from inside the fuel filter housing.

6. Install five new fuel filter elements.

7. Inspect the cover O-ring seal. Install new seal if necessary.

8. Install fuel filter housing end cover (6) and the vent plug (5). Make sure the drain valve stem (7) is closed.

9. Open fill valve (3) for minimum of five minutes.

10. Close fill valve (3) and rotate control valve (4) to MAIN RUN position.

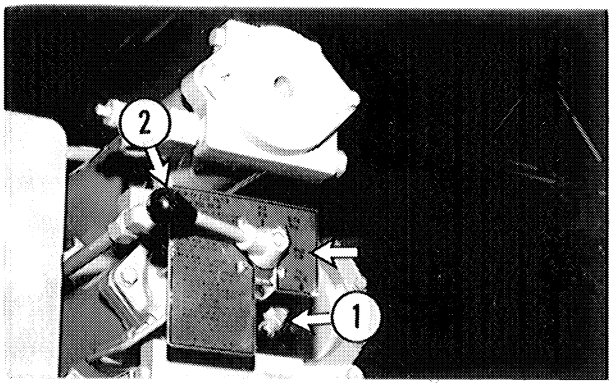
11. Check for leaks. Remove the drain hose and dispose of the drained fuel properly.

Changing Auxiliary Final Fuel Filters

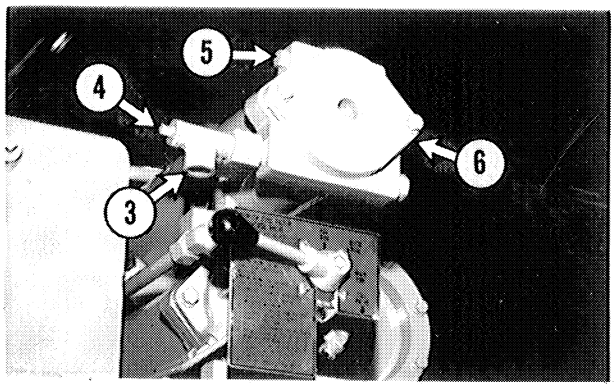
MAIN FINAL FUEL FILTERS NOT IN USE

If the main final fuel filters have been used and there are no replacement filters, the auxiliary final fuel filters may be used for a maximum of 1000 service hours engine operation or until the fuel filter differential gauge registers 105 kPa (15 psi).

NOTE: The engine must be shut down to change the auxiliary final fuel filters when the main final fuel filters have been used and there are no main final fuel replacement filters. Use the following procedure.



1. Leave the control valve (2) in the AUXiliary RUN position. Open the fill valve (1) for a minimum of five minutes. Close the fill valve (1) and rotate the control valve (2) to the MAIN RUN position.



2. Attach one end of drain hose to drain valve (3). Put the other end of the hose in a container to catch the fuel. Open drain valve stem (4). Remove vent plug (5) and drain the fuel filter housing.

3. Remove cover (6) from the end of the filter housing. Remove the two used fuel filter elements from inside the fuel filter housing.

4. Wipe all sediment from inside the fuel filter housing. Install two new fuel filter elements.

5. Inspect the cover O-ring seal. Install new seal if necessary. Install cover (6).

6. Make sure that vent plug (5) is installed, and drain valve stem (4) is closed.

7. Open fill valve (1) for minimum of five minutes.

8. Close fill valve (1) and leave control valve (2) in the AUXiliary RUN position, for normal operation.

9. Check for leaks. Remove drain hose and dispose of the drained fuel properly.

MAIN FINAL FUEL FILTERS IN USE

To change the auxiliary final fuel filters while the engine is running and the control valve is in the MAIN RUN position, proceed to step 1.

1. Attach one end of the drain hose to drain valve (3). Put the other end of the hose in container to catch the fuel. Open drain valve stem (4). Remove vent plug (5) and drain the fuel filter housing.

2. Remove cover (6) from the end of the fuel filter housing. Remove the used fuel filter elements from inside the fuel filter housing.

3. Wipe all sediment from inside the fuel filter housing. Install new fuel filter elements.

4. Inspect the cover O-ring seal. Install new seal if necessary. Install cover (6).

5. Make sure that vent plug (5) is installed, and drain valve stem (4) is closed.

6. Open fill valve (1) for minimum of five minutes. Close fill valve (1) and leave control valve (2) in the MAIN RUN position, for normal operation.

Caterpillar Marine Gear

NOTE: For marine gear other than Caterpillar 7200 Series, refer to the manufacturer's recommendations.

⚠ WARNING

Use caution when draining oil or changing filters. Hot oil or components can cause burns if they contact skin.

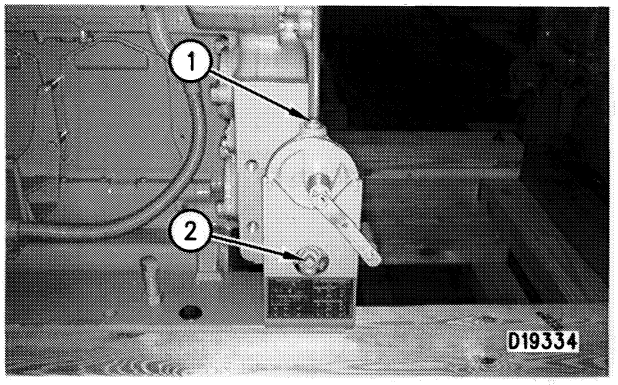
Change Oil

With the oil warm and the engine stopped, drain the marine gear.

1. Remove the marine gear drain plug and allow the oil to drain.

2. Clean and install the drain plug.

If a Sump Pump is Used to Drain Oil



1. Connect a drain line and container to the pump outlet (1).

2. Be sure valve on the engine oil pan line is closed. Marks on the valve must be turned at right angles to the direction of the engine oil line.

3. Open valve (2) on the marine gear oil line. The marks on this valve must be turned so that one mark points to the pump and the second mark points to the marine gear.

4. Operate the sump pump handle until the marine gear is empty.

5. Close the sump pump valve on the oil line to the marine gear.

Change Filter

1. Remove the marine gear oil filter housing drain plug and allow the oil to drain.

2. Remove the cover assembly with the oil filter attached.

3. Remove the nut, retainer and filter element from the cover.

4. Clean the filter housing and the cover assembly with clean nonflammable solvent.

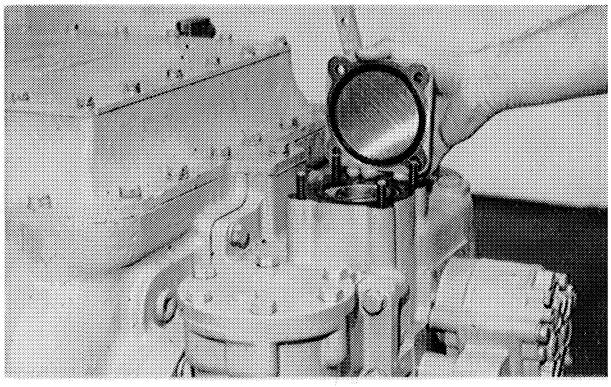
5. Inspect the retainer plate and cover seals. Install new seals if necessary.

6. Install a new filter element. Install the retainer and nut to the cover assembly. Tighten the nut to 14 ± 3 N•m (10 ± 2 lb ft).

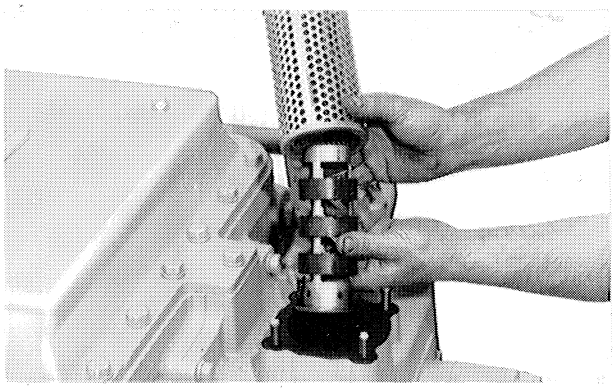
7. Install the cover assembly. Tighten all bolts.

8. Clean and install the filter housing drain plug.

Clean the Oil Strainer



1. Remove the oil strainer cover.



2. Remove the spring washer, strainer and magnetic screen tube.

3. Wash the oil strainer and magnetic screen tube with clean nonflammable solvent.

If a magnet is broken, install the new magnet properly. The North (N) poles and South (S) poles of the magnets are adjacent to each other so that they repel instead of attract: S - N, N - S, S - N.

4. Inspect the oil strainer and the cover seal for damage. Use new parts if used ones are damaged.

5. Install the magnetic screen tube, strainer, spring washer, seal and cover.

Cleaning the Marine Gear Breather

1. Remove the breather.

2. Clean the breather with clean, nonflammable solvent.

3. Install the breather.

Fill the Marine Gear

NOTICE

Be sure both valves (one to the marine gear and one to the engine oil pan) are closed. Otherwise, a transfer of oil may occur during operation and damage could result.

Fill the marine gear to the FULL mark on the oil level gauge. Refer to the Refill Capacities chart for the correct amount of oil.

Marine Gear Output Shaft Seal

Lubricate Fitting

Lubricate the marine gear output shaft seal through one fitting at top rear of the marine gear. Slowly rotate the output shaft while lubricating the seal. Refer to the OEM Owner's Manual for more information on the marine gear output shaft seal.

Every 2000 Service Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

This maintenance is to be performed at the fuel interval specified in the Maintenance Schedule. Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Engine Valve Lash, Valve Bridge and Rotators

Check and Adjust

NOTE: Initial valve lash adjustment on new or rebuilt engines should have been performed at the first scheduled oil change interval. The adjustments should now be made at this interval.

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

When the valve lash (clearance) is checked, an adjustment is NOT necessary if the measurement is within the range given in the Valve Lash Setting chart. If the measurement is outside of the range given for valve lash, an adjustment is necessary. Set the lash to the nominal clearance given in the Valve Lash Setting chart. Refer to the Service Manual or your Caterpillar dealer for the complete valve adjustment procedures.

⚠ WARNING

To prevent possible injury, do not use the starter motor to turn the flywheel.

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

Set the nominal clearance given in the Valve Lash Setting chart shown.

VALVE LASH SETTING	
Intake	0.38 mm (0.015 inch)
Exhaust	0.76 mm (0.030 inch)

Valve Bridge

The valve bridge should be checked and/or adjusted each time valve lash is checked and/or adjusted. Refer to the Service Manual for the complete adjustment procedure.

Rotators

Observe Rotation of Valves With Engine Idling After Setting the Valve Lash

⚠ WARNING

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

Caterpillar recommends replacement of improperly operating valve rotators. Use the procedure as established in the Service Manual, or contact your Caterpillar dealer for assistance.

Turbochargers

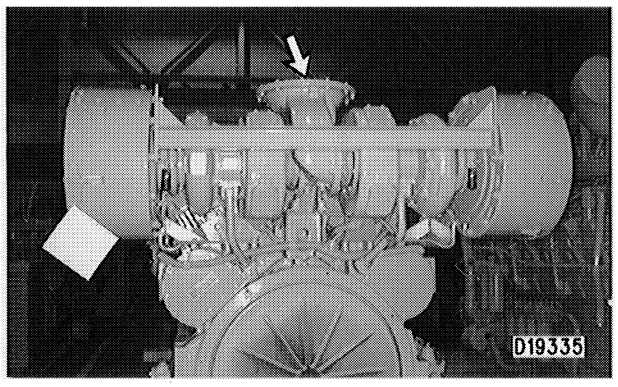
NOTICE

Turbocharger bearing failures can cause large quantities of oil to enter the air intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation will not cause problems as long as no turbocharger bearing failure occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine speed up at no load), DO NOT continue engine operation until the turbocharger is repaired or replaced.

Inspect/Check for Proper Operation



1. Remove the inlet piping and exhaust outlet piping, air cleaner cover and air cleaner element to provide access to the turbocharger. Visually check for oil leaks. Check the complete exhaust system for leaks and cracks. Make all necessary repairs with the engine shut down.

2. Turn the turbine and compressor wheel by hand. The assembly should turn freely. Inspect the turbine wheel and compressor wheel for contact with the turbocharger housing. There should NOT be any visible signs of contact between the turbine or compressor wheel and the turbocharger housing. If the assembly does not turn freely, refer to the Service Manual or consult your Caterpillar dealer.

Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system.

If oil is found only on the back side of the wheel, it indicates a turbo oil seal leak. The leak may be the result of extended engine operation at low idle or an intake air line restriction (plugged filters).

Maintain the compressor wheel/turbo housing by cleaning with standard shop solvents and a soft bristle brush.

3. Check the end play and bearing clearance on the turbine wheel and shaft. It should be difficult to detect movement of the shaft in the bearing. If the shaft is loose in the bearings, an inspection of the internal components should be made.

If the measurements are not within specifications, the turbocharger must be repaired or replaced. Refer to the Service Manual for the procedure and specifications. See your Caterpillar dealer for repair or replacement options.

4. When installing or replacing V-band clamps, position the gap (tightening screw) down if possible so any accumulation of moisture will drain away.

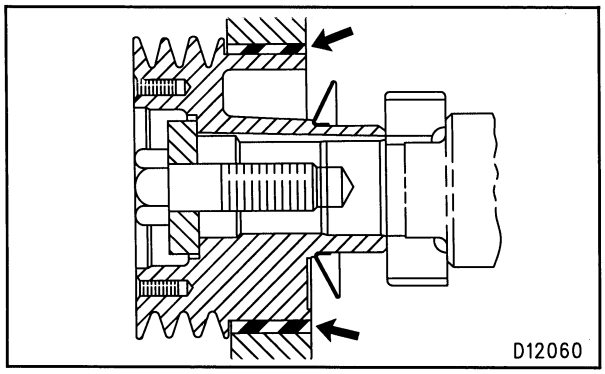
5. Repeat the procedure for the other turbocharger.

Removal and Installation

For removal and installation, or repair/replacement options of turbochargers, refer to the Service Manual. If maintenance is required, see your Caterpillar dealer.

Crankshaft Vibration Damper

Inspect



Damage to or failure of the damper will increase vibrations and result in damage to the crankshaft and other engine components. A failing vibration damper will cause more gear train noise at variable points in the speed range. 3500 Marine Engines can be equipped with a rubber damper and/or a viscous damper.

If there is damage to the damper, refer to the Service Manual for your engine before installing a new damper.

It is our recommendation to replace the damper for any of the reasons that follow.

- The engine has had a failure because of a broken crankshaft.
- S•O•S analysis has detected that the crankshaft front bearing is badly worn or there is a large amount of gear train wear that is not caused by a lack of oil.

If none of the above conditions is found, dampers can be used again, providing the damper is not damaged.

Visconic Damper (If Equipped)

The vibration damper weight is located inside a fluid filled case. The weight moves in the case to limit torsional vibration. Inspect the dampers for evidence of dents, cracks or leaks of the fluid.

Rubber Damper (If Equipped)

A vibration damper can have a visual wobble (movement to the front and rear when in rotation) on the outer ring. This does not mean a replacement is necessary since some wobble of the outer ring is normal. To see if the amount of wobble is acceptable, or replacement is necessary, check the damper with the procedure in the Service Manual.

The vibration damper has marks on the hub and ring. These marks will indicate the condition of the vibration damper. If the marks are not in alignment, the rubber seal between the ring and the hub has separated from the ring and/or hub. If the marks are not in alignment, install a new vibration damper.

NOTE: Refer to the Service Manual for the necessary replacement procedure.

Engine Mounts

Inspect/Check

Caterpillar recommends checking the engine mounts for deterioration and proper bolt torque. This will prevent excessive engine vibration caused from improper mounting. See the Marine Engine Application and Installation Guide LEKM9213 for more information.

Every 3000 Service Hours or Two Years

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

This maintenance is to be performed at the fuel interval specified in the Maintenance Schedule. Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Cooling System–Engines Using Standard Type Antifreeze Only

Clean/Flush Coolant

NOTICE

This cooling system maintenance is for standard type antifreeze only. DO NOT mix Standard Type Antifreeze and Long Life Coolant (LLC). Do not perform this maintenance until you read and understand the material in the Safety and Cooling System Specifications sections of this manual.

Caterpillar does not recommend the use of cooling system solutions that are intended to stop leaks. Use of these products may result in excessive internal deposits that could reduce the engine's heat transfer characteristics as well as damage to the water pump seals.

This procedure is to be used for normal maintenance of cooling systems to return to "like new" condition. For heavy build-up of scale and deposits, a severe acid-type, commercial cleaner or mechanical cleaning will be required.

NOTE: If cooling system conditioner has been added at Every 250 Service Hours as recommended, the coolant change period can be extended to 4000 Service Hours.

Performing maintenance on the cooling system is important because the cooling system has a direct effect on the operation and service life of the engine. Improper maintenance can result in a variety of problems that could shorten the engine's service life, reduce the efficiency of the cooling system, result in poor engine performance, and in some cases, result in an increase in fuel consumption.

Add Cooling System Cleaner

There are two types of cooling system cleaners available. One is the 6V4511 Standard-Type in the two liter (½ U.S. gallon) container and the other is the 4C4611 Fast Acting-Type in the four liter (one U.S. gallon) container.

The 6V4511 requires approximately 120 to 250 service hours of engine operation to remove scale, lime and other debris. The 4C4611 requires only 90 minutes of engine operation. Both types must remain in the system for a minimum of specified time to work properly, however, neither type will harm the engine if left in for a longer period of time.

The 6V4511 must be added before the Every 3000 Service Hour maintenance interval. Add 4 liter (1 U.S. gallon) of Caterpillar Cooling System Cleaner, 6V4511, for every 60 liter (16 U.S. gallon) of cooling system capacity. Continue to operate the engine for the specified time before draining.

The 4C4611 may be added just prior to draining and the system cleaned and flushed after operating for the specified time period. Follow the directions on the container.

Inspect Cooling System Piping, Hoses and Clamps

- Inspecting the items (and associated clamps and hardware) reduces the chances for unscheduled downtime. Inspect all system components for leaks due to cracking, softness next to clamps and loose clamps. Replace any component that is cracked or soft and tighten loose clamps.

Before replacing piping and/or hoses drain the coolant from the cooling system (or drain coolant to a level below the piping and/or hose that is replaced if replacing piping and/or hoses ONLY). Refer to Drain topic in this Manual.

Remove clamps, disconnect the old components and replace with new. Install clamps. See the Torque Specifications section of this Manual for the appropriate torque values.

- If replacing cooling system piping and/or hoses prior to this interval, refer to Fill System with Coolant topic in this Manual. If performing the Every 3000 Service Hour maintenance interval, continue with Cooling System Clean/Flush procedure.

Drain

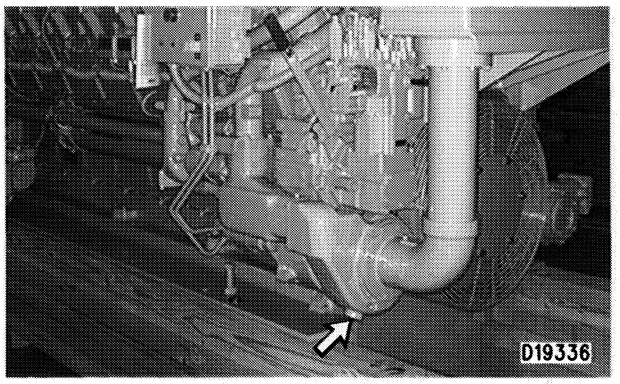
When you drain, clean, flush and replace the coolant, small particles, undesirable chemicals, scale and other deposit formations are removed. These deposits reduce the necessary heat transfer characteristics of the cooling system.

Coolant water drain groups, installed in the jacket water pumps, may be available for draining engine coolant. Contact your Caterpillar dealer for assistance.

1. Stop the engine and allow to cool. Disable the starting system and place a DO NOT OPERATE tag on the START valve or START switch.

2. Shut off separate circuit inlet water flow (if equipped). Slowly turn the cooling system pressure cap to the first stop to release the system pressure. Then push down and turn the cap until it is released.

3. Drain the system according to the requirements of your system.



Drain plug on bottom of water pump housing.

Remove the drain plug or open the drain valve from cooling water system and/or bottom of jacket water pump housing. Remove the drain plugs to drain the coolant tank, the water pump(s), the aftercooler, thermostatic valve, engine cylinder block drain plug(s) and all coolant lines. Allow coolant to drain.

Drain the water line between the heat exchanger and the separate circuit water pump (if equipped) to empty the aftercooler housing.

Water Pump Seal

Over concentration of coolant additive (Conditioner), mineral deposits from hard water or cooling system contamination can accelerate the wear on the water pump coolant seal. The cooling system maintenance interval provides an opportunity to inspect and replace the water pump seal if necessary to reduce coolant leakage. If coolant is leaking, make repairs to the pump(s). Check the water pump breather filter for blockage or debris and replace if necessary.

Dispose of used engine coolant in an environmentally correct way 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. Refer to your Caterpillar dealer for information regarding disposal and recycling of used coolant.

4. Clean and install all drain plugs and/or close the cooling system drain valve(s).

Flush

5. Fill the cooling system with clean water mixed with the proper concentration (6 to 10 percent) of Caterpillar Cooling System Cleaner. Install cooling system filler cap. Caterpillar Cooling System Cleaner is available through your Caterpillar dealer.

NOTE: For proper cooling system maintenance cleaning, the system requires 4 liter (1 U.S. gallon) of Caterpillar Cooling System Cleaner to accommodate for every 60 liter (16 U.S. gallon) of cooling system capacity to accommodate the 6 to 10 percent concentration. Add solution slowly at 20 liters (5 U.S. gal.) or less per minute to avoid air locks. See Refill Capacities for amount of solution needed.

6. Start and run (operate) the engine to circulate fluid in the cooling system for 90 minutes. Operate the engine until the thermostat opens and coolant level stabilizes. Fill the cooling system to the bottom of fill tube. Install the filler cap.

7. Stop the engine and allow to cool. Remove cooling system filler cap and system drain plugs to drain the cleaning solution.

8. Flush the cooling system with clean water until the draining water is clear. Clean and install all drain plugs and/or close the drain valve.

NOTE: Repeat Steps 5 thru 8 if necessary until the draining water is clear.

9. Fill the system with a neutralizer. Use a commercially available neutralizer or 0.230 kg (½ lb) sodium carbonate per 38 liters (10 U. S. gallons) water. Operate the engine for 10 minutes. Stop the engine, remove all the drain plugs and drain the neutralizing solution.

Fill System with Coolant

NOTICE

All water is corrosive at engine operating temperature. The cooling system should be protected with cooling system conditioner at all times. Use Caterpillar liquid cooling system conditioner to treat the coolant mixture.

Refer to the Cooling System Specifications in this Manual for all information regarding appropriate maintenance, acceptable water, antifreeze and supplemental coolant additive (Conditioner) requirements.

10. Be certain all drain plugs are clean and installed. Add coolant solution to the cooling system to bring it to the proper level by mixing a solution of acceptable water and Caterpillar Antifreeze. Add solution slowly at 20 liters (5 U.S. gallons) or less per minute to avoid air locks. Refer to Cooling System Specifications and Refill Capacities for amount of coolant needed.

NOTE: When NOT using Caterpillar Antifreeze, add 1 liter
(1 U.S. quart) of Caterpillar Coolant Additive (Conditioner) for every 30 liter (8 U.S. gallon) of cooling system capacity. Caterpillar Coolant Additive (Conditioner) should only be used when NOT using Caterpillar Antifreeze.

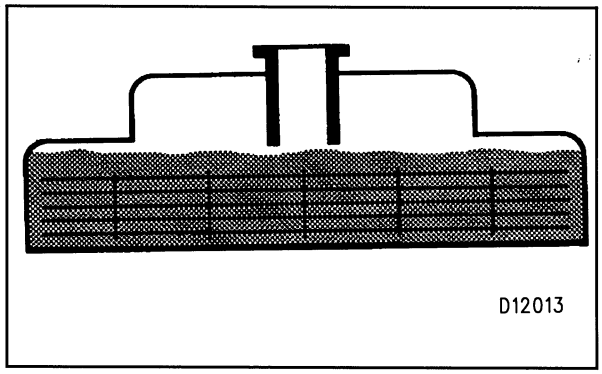
NOTICE

If the aftercooler circuit has been drained, the vent plug on the aftercooler outlet elbow must be opened to allow the aftercooler to fill. Failure to do this, will cause an air lock resulting in engine damage.

NOTE: When refilling the aftercooling system, open the separate circuit valve on the engine jacket water heat exchanger (if equipped).

Prime the separate circuit water pump if necessary. Open the separate circuit vent plug on the aftercooler to allow the aftercooler to fill. Failure to do this will cause an air lock and engine damage. After the aftercooler is filled, close the vent plug before operating the engine.

11. Start and operate the engine with the cooling system vent cap loosened or filler cap removed. Operate the engine and allow the coolant to warm, the thermostats to open and the coolant level to stabilize. Inspect for leaks and proper operating temperature.



12. Stop the engine and check the coolant to ensure it is at the proper level. Add coolant mixture if necessary to bring the coolant to within 13 mm (½ inch) below the bottom of the fill tube or the correct level on the sight glass, if equipped.

NOTICE

In cold weather, frequently check the specific gravity of the coolant solution to ensure adequate protection.

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

Caterpillar recommends the use of a permanent-type antifreeze that when mixed with water, will raise the boiling point of the water. This feature helps reduce cylinder liner pitting and maintain water pump cavitation temperature.

13. Check the condition of the filler cap gasket (if equipped). If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a 9S8140 Service Tool to pressure test the filler cap. This tool is available from your Caterpillar dealer.

The correct filler cap pressure is stamped on the face of the filler cap. If the filler cap does not hold the correct pressure, install a new filler cap.

Cleaning Procedure–Oil Cooler and Aftercooler Core

Caterpillar recommends that the oil cooler and aftercooler cores be removed, cleaned and pressure tested at overhaul time, or if a turbocharger failure has occurred, or if at any time the turbocharger develops an oil leak.

1. Remove the core. Turn the core upside down to remove debris from the inlet.

NOTICE
Do not use caustic cleaners to clean the core. Caustic cleaners will attack the internal metals of the core and cause leakage.

2. Back flush internally with a solvent to loosen foreign substances and to remove oil. Caterpillar recommends the use of Caterpillar Hydrosolv 4165 or Hydrosolv 100 Liquid Cleaners.

Part No.	Description	Size
8T7570	Hydrosolv 4165	208L (55 U.S. gal) Drum
8T7571	Hydrosolv 100	208L (55 U.S. gal) Drum

3. Shake the core vigorously to eliminate any trapped debris.

4. Wash the core with hot, soapy water. Rinse thoroughly with clean water.

5. Dry the core with compressed air. Blow air in reverse direction of normal flow. Use all necessary safety equipment while using compressed air.

6. Inspect the system to ensure cleanliness and install the core.

Cooling System–Engines Using Long Life Coolant (LLC) Only

Add Extender

NOTICE
This cooling system maintenance is for LLC only. DO NOT mix standard type antifreeze and Long Life Coolant (LLC). Do not perform this maintenance until you read and understand the material in the Safety and Cooling System Specifications sections of this Manual.

For engines using Caterpillar Long Life Coolant, Extender (part number 119-5152) must be added at the Every 3000 Service Hour interval. With the exception of adding Extender and maintaining the coolant level, no other maintenance is required until the Every 6000 Service Hour interval. Over treatment or under treatment of the Extender will not create any problems within the cooling system if it is kept within 15 percent above or below the normal dosage. Use the table that follows to determine the recommended amount of Extender to add to LLC.

RECOMMENDED AMOUNT OF EXTENDER BY COOLING SYSTEM CAPACITY	
Cooling System Capacity	**Recommended Amount of Extender**
22-30 L (6-8 U.S. gal)	0.57 L (0.60 qt)
30-38 L (8-10 U.S. gal)	0.71 L (0.75 qt)
38-49 L (10-13 U.S. gal)	0.95 L (1 qt)
49-64 L (13-17 U.S. gal)	1.18 L (1.25 qt)

Every 4000 Service Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

This maintenance is to be performed at the fuel interval specified in the Maintenance Schedule. Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Air Compressor (If Equipped)

Inspect/Rebuild or Exchange

Caterpillar recommends that the most cost effective method of operation and maintenance for the air compressor is to inspect the unit before it fails and make the decision to rebuild or exchange.

By maintaining the air compressor before failure, unscheduled downtime and potential damage to other engine parts are reduced. The prevention of unscheduled downtime saves money and lowers operating costs.

⚠ WARNING

Do not disconnect the air line from the air compressor governor without purging the air and/or auxiliary air systems.

Failure to purge the air systems before you remove the air compressor could cause personal injury.

Inspect the air compressor as instructed by the manufacturers' instructions or for more information on how to check your air compressor, refer to the Service Manual for this engine.

If you decide to inspect your air compressor, be sure to observe the following actions. Visually check for fluid leaks and listen for air leaks. Release the air pressure in the air tank until the air pressure is zero.

If the engine is operated until the air compressor fails, it could cause additional damage to the engine. A failed air compressor could contaminate the engine oil with particles of materials since engine oil also lubricates the air compressor. The circulation of these contaminates through the engine lubricating system could damage the engine's main and connecting rod bearings.

Visually check for fluid leaks. Remove discharge fittings and inspect compressor discharge port and discharge line for excessive carbon deposits. The discharge line must be cleaned or replaced and the compressor checked more thoroughly if there is excessive carbon build-up in either the discharge line or compressor discharge port.

⚠ WARNING

DO NOT store alcohol (for cold weather operation) in the operator area. Alcohol is highly flammable and toxic.

In arctic conditions, use alcohol injection to prevent moisture from freezing in the air system.

For more information on how to check your air compressor, refer to the manufacturer's instructions or engine Service Manual. For more information on Maintenance Options, refer to Terminology topic in this Manual.

Caterpillar Recommendation

The most cost effective repair option is to rebuild the air compressor with a repair kit that can be obtained from your Caterpillar dealer. To minimize downtime, Caterpillar recommends that the use of Remanufactured components (subject to availability) as a cost effective option.

Removal and Installation

Refer to the established procedure in the Service Manual for this engine to Remove and Install these components or contact your Caterpillar dealer for assistance.

Electric Starting Motor (If Equipped)

Inspect/Rebuild or Exchange

One unscheduled failure caused by your electric starting motor will cost more in downtime than servicing your starting motor before failure.

If you service your electric starting motor before failure, you will minimize unscheduled downtime. The prevention of unscheduled downtime saves you money and lowers your operating cost.

Our recommended service intervals for performing preventive maintenance on your electric starting motor are based on experience and accumulated data relative to the expectant life of the electric starting motor and its components. These maintenance service intervals are provided for your use to economically schedule your repairs before failure.

Failure to follow our recommendation could be costly to you, due to unexpected downtime.

Caterpillar recommends that the most cost effective method of operation for your electric starting motor is to service the unit before it fails.

Caterpillar Recommendations

Caterpillar recommends that the use of a remanufactured electric starting motor is the most cost effective option.

Marine Engine Performance Analysis Report (PAR)

Obtain

Marine PAR compliments a good preventative maintenance program. PAR reflects the results of various tests normally conducted by your Caterpillar dealer for the purpose of:

- Confirming your engine is operating efficiently and within specifications.
- Identifying potential problems.
- Determining components or systems that should be adjusted, replaced, etc.

Approximately 80 to 85 percent of the total engine's operation and maintenance cost is the cost of fuel. Therefore, substantial cost reductions can be achieved by keeping your engine operating at peak efficiency.

With Marine Engine Performance Analysis Report (PAR) you also can:

- Identify mismatched propulsion components and systems.
- Establish fuel efficient operating habits.
- Determine propulsion system deterioration rates.
- Fine tune maintenance, repair and overhaul schedules.

Caterpillar recommends a Marine Engine PAR Analysis at the initial Sea Trial and on a regularly scheduled basis to ensure your propulsion system is operating at optimum performance and efficiency. Consult your Caterpillar dealer for complete details in establishing a Marine Engine PAR program for your vessel.

Every 6000 Service Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

This maintenance is to be performed at the fuel interval specified in the Maintenance Schedule. Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Thermostats

Replace Thermostat, Gaskets and Seal

NOTE: Refer to the Service Manual for detailed instructions regarding Disassembly and Assembly of the Cooling System.

Replacing the thermostats prior to failure is a recommended preventive maintenance practice because it reduces the chances for cooling system problems and unscheduled downtime.

This maintenance is to be performed with the cooling system cleaned and drained or the coolant drained to a level below the thermostat housing.

NOTICE
Failure to replace your thermostats on a regularly scheduled basis could cause severe engine damage.

NOTE: If replacing thermostats ONLY, drain the coolant from the cooling system to a level below the thermostat housing.

1. Loosen hose clamps and remove hose from elbow. Disconnect hose assembly from thermostat housing assembly.

2. Remove bolts from elbow and remove elbow and thermostat housing assembly.

3. Remove the gasket, thermostat and seal from the housing.

Flush–If Using Standard Type Antifreeze ONLY

1. Refill the cooling system with clean water mixed with the proper concentration (six to ten percent) of Fast Acting-Type Caterpillar Cooling System Cleaner (if you did NOT use Standard-Type Cleaner). Tighten cooling system filler cap.

NOTE: For proper cooling system maintenance cleaning, refer to label directions for the type of Caterpillar Cooling System Cleaner used in your cooling system.

2. Start and run (operate) the engine to circulate fluid in the cooling system.

3. Stop the engine and allow to cool. Loosen cooling system filler cap and drain plugs.

4. Drain the cleaning solution. Flush the cooling system with clean water and a neutralizing solution until draining water is clear. Clean and install all drain plugs and/or close the drain valve.

NOTE: Sodium Carbonate crystals at a rate of 250 grams per 40 liters of water (½ pound per 10 U.S. gallon of water) may be used as a neutralizer.

Repeat Steps 1 thru 4 if necessary until the draining water is clear.

Install Thermostat

NOTICE
Original thermostats may be used if they meet test specifications shown in the Service Manual and are not damaged or have excessive buildup of deposits.

Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a thermostat installed. If the thermostat is installed wrong, it will cause the engine to overheat.

NOTE: Inspect gaskets before assembly and replace if worn or damaged. The thermostats can be reused if they are tested and meet the test specifications in the Service Manual.

1. Install a new seal in the thermostat housing and install a new thermostat. Install a new gasket in the thermostat housing on the engine cylinder head.

2. Install the cooling system connections and tighten the hose or piping clamps.

Fill

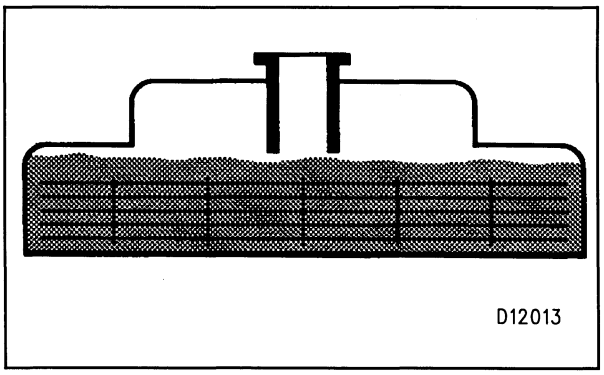
NOTICE
All water is corrosive at engine operating temperature. If using standard type antifreeze, the cooling system should be protected with cooling system conditioner at all times. Use Caterpillar liquid cooling system conditioner to treat the coolant mixture.

NOTICE
DO NOT mix Long Life Coolant (LLC) with standard type antifreeze. Refer to the Cooling System Specifications section of this publication for all information regarding appropriate maintenance of the cooling system or contact your Caterpillar dealer for assistance. Refer to the Refill Capacities chart in this publication for the cooling system capacity.

1. Be certain all drain plugs are clean and installed.

2. Start and run the engine with the cooling system filler cap loosened. Operate the engine and allow the coolant to warm, the thermostats to open and the coolant level to stabilize. Inspect for leaks and proper operating temperature.

NOTICE
To prevent engine damage, never add coolant to an overheated engine. Allow the engine to cool first.



3. Add coolant mixture if necessary to bring the coolant to within 13 mm (½ inch) below the bottom of the fill tube or the correct level on the sight glass, if equipped.

If using standard type antifreeze in your engine, mix a solution of acceptable water and Caterpillar antifreeze. If not adding Caterpillar antifreeze, you must add liquid cooling system conditioner. Refer to the Cooling System Specifications in this manual for more information or contact your Caterpillar dealer for assistance.

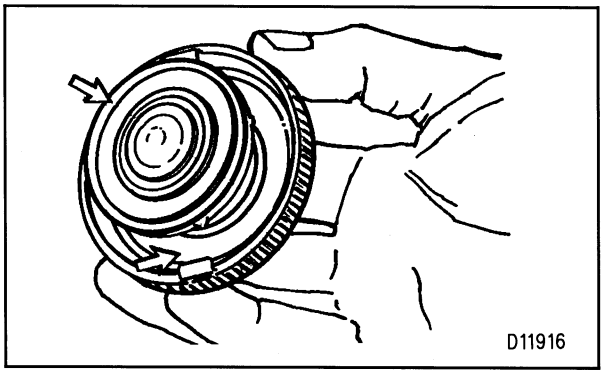
If using Long Life Coolant (LLC), replace with the coolant with the acceptable LLC and water mix. Refer to the Cooling System Specifications in this manual for more information on LLC or contact your Caterpillar dealer.

NOTICE
Mixing LLC with other products will reduce the effectiveness of the coolant. This could result in damage to cooling system components. DO NOT mix standard type antifreeze and LLC. Refer to the Cooling System Specifications in this manual or your Caterpillar dealer for more information.

NOTE: Upon initial fill the sight gauge can indicate an incorrect coolant level. Be sure the coolant is to the bottom of the fill tube. Recheck the coolant level and fill the cooling system to the bottom of the fill tube if the system was low.

NOTICE
In cold weather, frequently check the specific gravity of the coolant solution to ensure adequate protection.

If the engine is to be stored in, or shipped to an area with freezing temperatures, the cooling system must be either protected to the lowest expected outside temperature or drained completely to prevent damage. Always check your cooling system before operating your engine. Depending on load, failure to operate with thermostats could result in either an overheating or an excessive cooling condition.



4. Check the condition of the filler cap gasket (if equipped). If the gasket is damaged, discard the old filler cap and install a new filler cap.

5. Stop the engine and check the coolant to ensure it is at the proper level.

Cooling System–For Engines Using LLC Only

Clean/Flush

NOTICE

Do not perform this maintenance until you read and understand the material in the Safety and Cooling System Specifications sections of this publication.

Caterpillar does not recommend the use of cooling system solutions that are intended to stop leaks. Use of these products may result in excessive internal deposits that could reduce the engine's heat transfer characteristics as well as damage to the water pump seals.

Performing maintenance on the cooling system is important because the cooling system has a direct effect on the operation and service life of the engine.

Improper maintenance can result in a variety of problems that could shorten the engine's service life, reduce the efficiency of the cooling system, result in poor engine performance, and in some cases, result in an increase in fuel consumption.

Every 6000 Service Hours, Long Life Coolant (LLC) must be drained from the cooling system. The cooling system must then be flushed out completely and then replaced with LLC. When LLC is drained from the cooling system, **CLEAN WATER** is the only system cleaning/flushing agent required.

When the cooling system coolant is changed from standard antifreeze to LLC, Caterpillar cleaner must be used. Refer to the chart in the Cooling System Specifications Section for the quantities available. After the cleaning solution has been drained, it is **VERY IMPORTANT** that a thorough water flush be used to remove **ALL** of the cleaning agent.

⚠ WARNING

To avoid personal injury from hot water spray, check the coolant level only after the engine has been stopped and the fill cap is cool enough to touch with your bare hand.

With the engine shut down and cool, use the procedure that follows.

1. Stop the engine and allow to cool. Disable the starting system and place DO NOT OPERATE tags on the START switch in the pilot house and on the engine instrument panel.

2. Loosen the cooling system filler cap slowly to relieve pressure.

3. Drain the system according to the requirements of your system.

Dispose of used engine coolant in an environmentally correct way or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. For information regarding disposal and recycling of used coolant, contact your Caterpillar dealer.

4. Clean and install all drain plugs and/or close the cooling system drain valve(s).

Flush

1. Refill the cooling system with clean water. Tighten cooling system filler cap.

2. Start and run (operate) the engine to circulate fluid in the cooling system.

3. Stop the engine and allow to cool. Loosen cooling system filler cap and drain plugs.

4. Drain the water. Flush the cooling system with clean water until the draining water is clear. Clean and install all drain plugs and/or close the drain valve.

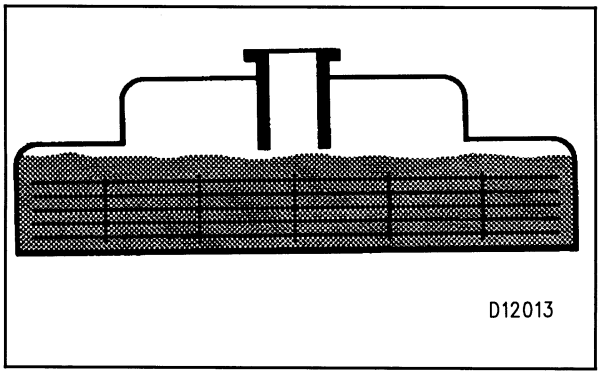
Fill

NOTICE
Refer to the Cooling System Specifications section of this publication for all information regarding about the appropriate maintenance of the cooling system or contact your Caterpillar dealer for assistance. See Refill Capacities chart in this publication for the capacity of your engine's system.

1. Be certain all drain plugs are clean and installed. Fill the cooling system with a LLC and water mixture.

2. Start and run the engine with the cooling system filler cap loosened. Operate the engine and allow the coolant to warm, the thermostats to open and the coolant level to stabilize. Inspect for leaks and proper operating temperature.

NOTICE
To prevent engine damage, never add coolant to an overheated engine. Allow the engine to cool first.

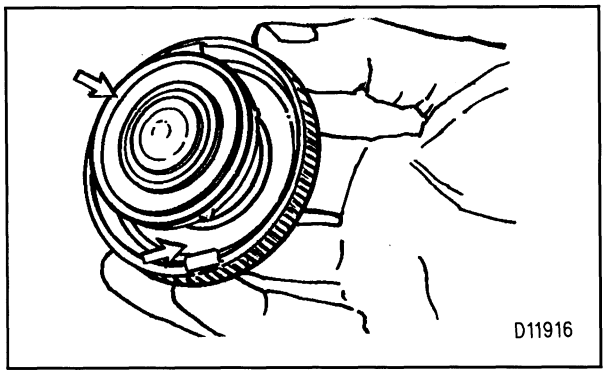


3. Add LLC if necessary to bring the coolant level to within 13 mm (½ inch) below the bottom of the fill tube or the correct level on the sight glass, if equipped.

NOTE: Upon initial fill the sight gauge can indicate an incorrect coolant level. Be sure the coolant is to the bottom of the fill tube. Recheck the coolant level and fill the cooling system to the bottom of the fill tube if the system was low.

NOTICE
In cold weather, frequently check the specific gravity of the coolant solution to ensure adequate protection.

If the engine is to be stored in, or shipped to an area with freezing temperatures, the cooling system must be either protected to the lowest expected outside temperature or drained completely to prevent damage. Always check your cooling system before operating your engine. Depending on load, failure to operate with thermostats could result in either an overheating or an excessive cooling condition.



4. Check the condition of the filler cap gasket (if equipped). If the gasket is damaged, discard the old filler cap and install a new filler cap.

5. Stop the engine and check the coolant to ensure it is at the proper level.

Alternator (If Equipped)

Inspect/Rebuild or Exchange

Inspect the alternator for loose connections and correct battery charging. Inspect the ammeter gauge during engine operation to ensure batteries and/or electrical system is performing correctly. Make repairs as necessary. Refer to the Service Manual or contact your Caterpillar dealer.

Caterpillar Recommendation

The most cost effective repair option is to rebuild with a repair kit that can be obtained from your Caterpillar dealer. To minimize downtime, Caterpillar recommends that the use of Remanufactured components (subject to availability) as a cost effective option.

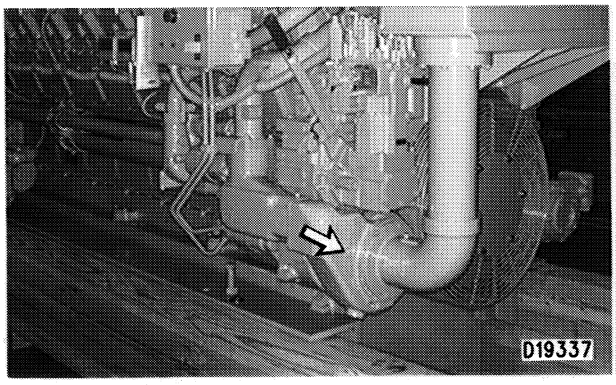
If there is a component you need, contact your Caterpillar dealer to see if it is offered under his Dealer Exchange Component Program.

Removal and Installation

Refer to the established procedure in the Service Manual to remove and install the alternator or contact your Caterpillar dealer for assistance.

Jacket Water Pump and Auxiliary Water Pump

Inspect/Rebuild or Exchange



Jacket water pump shown.

Visually inspect the water pumps for leaks. If leaking is observed, replace all seals. Refer to the Service Manual for the procedure to replace the seals.

Inspect the component for wear, cracks, pin holes and proper operation. If repairs or replacement is needed, see the Service Manual or contact your Caterpillar dealer.

Air Starting Motor (If Equipped)

Inspect/Rebuild or Exchange

One unscheduled failure caused by your air starting motor will cost more in downtime than servicing your starting motor before failure.

If you service your starting motor before failure, you will minimize unscheduled downtime. The prevention of unscheduled downtime saves you money and lowers your operating cost.

Our recommended service intervals for performing preventive maintenance on your air starting motor are based on experience and accumulated data relative to the expectant life of the air starting motor and its components. These maintenance service intervals are provided for your use to economically schedule your repairs before failure.

Failure to follow our recommendation could be costly to you, due to unexpected downtime.

Caterpillar recommends that the most cost effective method of operation for your air starting motor is to service the unit before it fails.

Service Options

New Parts – Genuine Caterpillar parts are constantly tested and modified to incorporate the latest design advances. Your Caterpillar dealer can provide the parts needed for rebuilding your air starting motor. Your benefit: Long-lasting replacement parts at competitive prices.

Repair Kits – These useful kits can be obtained from your Caterpillar dealer. These kits include all the necessary parts and instructions to repair your air starter, in either your own location or at your servicing dealer's facility. Repair kits simplify parts ordering, help speed repairs and reduce parts costs.

Dealer Exchange – In some areas, exchange, rebuilt air starting motors are available over-the-counter.

New – Replace with a new air starting motor.

Caterpillar Recommendations

Caterpillar recommends that the use of a Caterpillar dealer rebuilt air starting motor using genuine replacement parts is the most cost-effective option.

Removal and Installation

Refer to the Service Manual for the procedure to service the air starting motor, or contact your Caterpillar dealer for assistance.

Turbochargers

Service

The belief that it is more costly to service your turbocharger before failure than it is to operate your engine until the turbocharger fails, is false.

If you service your turbocharger before failure, you will minimize unscheduled downtime and reduce the chance for potential damage to other engine parts. The prevention of unscheduled downtime and costly repairs is money in your pocket.

If you operate the engine until your turbocharger fails, you could cause severe damage to your turbocharger's compressor wheel and/or your engine. For example: severe damage to the turbocharger compressor wheel could cause parts from the compressor wheel to enter the engine cylinder and cause additional damage to the piston, valve and cylinder head.

Our recommended service intervals for performing preventive maintenance on your turbocharger are based on experience and gathered data relative to the expectant life of the engine and its components. These maintenance intervals were developed as a service to you for use in making decisions that could lower your operating costs. Lower operating costs allows you to use your money more profitably elsewhere.

Failure to follow our recommendations could result in unexpected, costly repairs and unscheduled downtime.

Caterpillar recommends that the most cost effective method of operation for your turbocharger is to service the unit before it fails.

Service Options

Repair Kits – These useful kits can be obtained from your Caterpillar dealer. These kits include all the necessary parts and instructions to repair your turbocharger in either your own maintenance shop or at your servicing dealer's facility. Repair kits simplify parts ordering, help speed repairs and reduce parts costs.

Remanufactured – This process uses manufacturing techniques and procedures to restore your turbocharger to like-new performance capability. This process always provides an end product which conforms to the Caterpillar's "original" functional specification.

New – Replace with a new turbocharger.

Before deciding which method is best, you should make sure you have considered all of the options and costs associated with repair. Some considerations are:

- The costs associated with using separate parts from inventory versus the cost of a repair kit.
- Downtime costs while the product is being rebuilt or repaired.
- Total parts and labor costs for repairs versus the actual Remanufactured cost.
- Remanufactured components from Caterpillar are covered by a factory warranty.

Caterpillar Recommendation

To minimize downtime, Caterpillar recommends the use of a Remanufactured turbocharger when available.

There are two levels of pricing for Remanufactured turbochargers. The first level is primarily based on damage to the turbocharger before failure. The second level is primarily based on damage to the turbocharger after failure. If you choose to operate your engine until the turbocharger fails, your repair cost could be as much as ten times the repair before failure cost due to additional turbocharger and engine damage that could have been prevented.

Removal and Installation

Refer to the Service Manual for the complete removal and installation procedure or contact your Caterpillar dealer.

Top End Overhaul

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Top End involves removal, inspection and rework (rebuild or exchange) of the cylinder head components. This maintenance interval is dependent on load-sensitive items.

This section contains information about estimating overhaul intervals. Two methods are discussed.

1. Selecting predetermined intervals from a chart.
2. Calculating top end and overhaul intervals using fuel consumption rates.

The interval in the Maintenance Schedule gives Caterpillar's recommendation for doing a Top End and Overhaul. Refer to the Service Manual for disassembly and assembly procedures to perform the required maintenance as shown in the Maintenance Schedule. Contact your Caterpillar dealer for assistance.

The service hours on the engine or calendar time can be used to estimate the Top End and Overhaul intervals. Use it only if fuel consumption information is not available for your engine.

Calculating Top End and Overhaul Intervals Using Fuel Consumption

The fuel consumption value is the most important criteria for determining when a Top End or Overhaul should be performed because it compensates for application and engine loads. Use actual fuel records if available. If the actual consumption is not available, use the following steps to estimate the fuel consumption rate.

- Estimate the percent load of the rated engine or generator set output.
- Refer to the specification sheet or Caterpillar dealer to determine the average consumption for the estimated percent load. Use this value in the overhaul interval formula.

NOTE: For engines operating at less than 50 percent load, use the 50 percent load fuel consumption rate to determine the top end or overhaul hour interval.

Overhaul Programs

Your Caterpillar dealer may be offering a variety of options regarding overhaul programs and Caterpillar recommends that an Overhaul be performed at this maintenance interval.

Overhaul Before Failure

A planned overhaul may be your best value, because you can:

- Avoid costly unplanned downtime
- Reuse as many original parts as standards permit
- Extend your engine's service life without the risk of a major catastrophe had you continued to operate to failure
- Get the best cost/value relationship per hour of extended life

Flat Rate Overhaul

To further control your overhaul costs, Caterpillar recommends that you contact your dealer for information regarding the availability of a Flat Rate Overhaul.

Flat rate prices on preventive maintenance programs or major repair options are available from many dealers for all Caterpillar engine models.

Overhaul Options

Caterpillar Dealer – Contact your Caterpillar dealer to schedule a Before Failure Overhaul.

Overhaul Kit – This useful kit was developed for those users that prefer to perform their own overhaul. This kit includes a combination of new, reused and remanufactured parts. Also included is a step-by-step instruction regarding how to perform an overhaul. An Overhaul Kit simplifies parts ordering, helps speed repairs and reduces parts costs.

Contact your local Caterpillar dealer for information regarding the Overhaul Kit.

Overhaul Recommendation

To minimize downtime and provide you with the lowest cost and highest value, Caterpillar recommends that the engine be scheduled for an overhaul with your Caterpillar dealer.

NOTE: Overhaul programs vary from dealer to dealer. Therefore, Caterpillar recommends that you confer with your dealer to obtain specific information regarding the types of programs offered and overhaul services provided for extending the life of your engine.

Top End Overhaul Instructions

If you elect to perform a top end overhaul yourself, without having a Caterpillar dealer perform the overhaul for you, or without using an overhaul kit, then you should perform the following maintenance.

Cylinder Head Assembly

Rebuild or Exchange

The Cylinder Head Assembly should be inspected according to the instructions found in Caterpillar reusability publications. Refer to the Index Of Publications On Reusability Or Salvage Of Used Parts section of the Guideline For Reusable Parts and Salvage Operations, form SEBF8029, to determine the reusability publications needed for inspecting your parts.

The Guideline For Reusable Parts and Salvage Operations is part of an established Caterpillar parts reusability program. These guidelines were developed to assist Caterpillar dealers and customers reduce costs by avoiding unnecessary expenditures for new parts when existing parts can be used as is, repaired or salvaged.

Failure to salvage, repair or replace out-of-spec parts will result in unscheduled downtime and could result in costly repairs caused by potential damage to other engine parts.

Fuel Injectors

Inspect

Fuel quality (amount of water, solid contaminants, etc.) and the quality of filtration will affect injector wear. Normal fuel injector wear may accelerate when the engine operates in a demanding application. This wear can result in elevated exhaust emission levels (black smoke, etc.) and/or poor engine performance. Single cylinder misfire is not typically attributed to normal wear and can be repaired by replacing the defective injector.

Below is a list of circumstances which may suggest more frequent inspection of fuel injectors.

- Use of fuels NOT recommended by Caterpillar in the Fuel Specifications.
- Extreme (high or low) ambient temperature conditions (when fuel lubricating properties can diminish).
- Frequent fuel filter plugging or bypass and extended fuel system maintenance intervals such as insufficient fuel tank/storage tank maintenance (excessive water, sediment or microorganism growth, etc.).
- Severe overheating of the engine involving sudden loss of coolant suggests the immediate need to exchange the complete set of injectors prior to any extended operation.

Overhaul

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Overhaul is defined as the interval at which the major wear items in the engine should be replaced. The overhaul interval represents overhaul of a non-failed engine. In other words, the engine is being rebuilt with certain new parts replacing worn parts. The major wear items include piston rings, engine rod and main bearings, valves, and valve seats, etc.

Incidental to the changeout of these relatively few parts is the complete inspection of all other parts that are visible during the opening up of the engine. The disassembly required to perform an overhaul means that disturbed seals and gaskets, etc., will be replaced and the internal passages of the engine and block be cleaned.

Your Caterpillar dealer may be offering a variety of options regarding overhaul programs and Caterpillar recommends that an Overhaul be performed at the maintenance intervals listed in the chart for your engine.

Overhaul Instructions

If you elect to perform an overhaul yourself, without having a Caterpillar dealer perform the overhaul for you, or without using an overhaul kit, then you should be aware of the following:

Inspect/Rebuild or Exchange

Cylinder Heads, Connecting Rods, Cylinder Liners, Pistons, Turbochargers, Spacer Plate, Cam Followers, Fuel Transfer Pump, Prelube Pump, Injectors, Governor, Wrist Pins, and Main Oil Pump.

These components should be inspected according to the instructions found in various Caterpillar reusability publications. Refer to the Index Of Publications On Reusability Or Salvage Of Used Parts section of the Guideline For Reusable Parts and Salvage Operations, SEBF8029 to determine the reusability publications needed for inspecting your parts.

These guidelines were developed to assist Caterpillar dealers and customers avoid unnecessary expenditures for new parts when existing parts can be used as is, repaired or salvaged.

Install New

Piston Rings, Main Bearings, Rod Bearings, Valve Rotators, and Crankshaft Seals.

In most probability, your thrust, main and rod bearings and crankshaft seals will not last until your second overhaul. Therefore, Caterpillar recommends the installation of new thrust, main and rod bearings at each overhaul period.

Inspect

Crankshaft, Camshaft, Damper, Fuel System Linkage, Gear Train Gears and Bushings, Spacer Plates and Driven Unit Alignment.

The ideal time for inspecting these items is while your engine is disassembled for overhaul. Inspect each component for potential damage as follows:

- Crankshaft – Inspect for deflection, journal damage and bearing material seized to the journal. At the same time, check the taper and profile of the crankshaft journals by interpreting your main and rod bearing wear patterns.
- Camshaft – Inspect the camshaft for journal and/or lobe damage.

NOTE: If camshafts or crankshafts are removed for any reason, use the magnetic particle inspection process to check the components for cracks.

- Camshaft Followers and Bearings – Inspect the cam bearings for fatigue and wear.
- Damper – It is our recommendation to replace the damper for any of the reasons that follow.

1. The engine has had a failure because of a broken crankshaft.
2. The crankshaft front bearing is badly worn.
3. There is a large amount of gear train wear that is not caused by a lack of oil.

If none of the above conditions is found, dampers can be used again at overhaul, providing the damper is not damaged.

- Gear Train Gears and Bushings – Inspect for worn gear teeth, unusual fits and unusual wear.

- Driven Unit Alignment – Upon reassembly of the drive line and driven unit, check alignment as outlined in the:

- SEHS7654–Alignment-General Instructions

Oil Cooler

Cleaning Procedure

Caterpillar recommends that the oil cooler core be removed, cleaned and pressure tested at **Overhaul.**

NOTICE

Do not use caustic cleaners to clean the core. Caustic cleaners will attack the internal metals of the core and cause leakage.

---

1. Remove the core. Turn the core upside down to remove debris from the inlet.

2. Back flush internally with a solvent to loosen foreign substances and to remove oil. Caterpillar recommends the use of Caterpillar Hydrosolv Liquid Cleaners.

HYDROSOLV LIQUID CLEANERS		
Part No.	**Description**	**Size**
8T7570	Hydrosolv 4165	208L (55 U.S. Gal) Drum
8T7571	Hydrosolv 100	208L (55 U.S. Gal) Drum

For more information, see Application Guide, NEHS0526, or contact your Caterpillar dealer.

3. Shake the core vigorously to eliminate any trapped debris.

4. Wash the core with hot, soapy water. Rinse thoroughly with clean water.

5. Dry the core with compressed air. Blow air in reverse direction of normal flow. Use all necessary safety equipment while using compressed air.

6. Inspect the system to ensure cleanliness and install the core.

For more information on cleaning the oil cooler, refer to your Caterpillar dealer.

Aftercooler Core

Caterpillar recommends that the aftercooler core be removed, cleaned and pressure tested at **Overhaul, or if a turbocharger failure has occurred, or if at any time the turbocharger develops an internal oil leak.**

Cleaning Procedure

NOTICE

Do not use caustic cleaners to clean the aftercooler core. Caustic cleaners will attack the internal metals of the core and cause leakage.

---

1. Remove the aftercooler core. Turn the aftercooler core upside down to remove debris from the inlet.

2. Back flush internally with solvent to loosen foreign substances and to remove oil. Caterpillar recommends the use of Caterpillar Hydrosolv Liquid Cleaners.

HYDROSOLV LIQUID CLEANERS		
Part No.	**Description**	**Size**
8T7570	Hydrosolv 4165	208L (55 U.S. Gal) Drum
8T7571	Hydrosolv 100	208L (55 U.S. Gal) Drum

For more information, see Application Guide, NEHS0526, or contact your Caterpillar dealer.

3. Shake the aftercooler core vigorously to eliminate any trapped debris.

4. Wash the aftercooler core with hot, soapy water. Rinse thoroughly with clean water.

5. Dry the aftercooler core with compressed air. Blow air in reverse direction of normal flow. Use all necessary safety equipment while using compressed air.

6. Inspect the system to ensure cleanliness and install the aftercooler core.

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

After Failure Overhaul

If you experience a major engine failure which requires removal of the engine, there are also many After Failure Overhaul options available. An overhaul should be performed if your block or crankshaft needs to be repaired. If the block and/or crankshaft is repairable, then the cost of an overhaul should be between 40 and 50 percent of the cost of a new engine (with like exchange core).

This lower cost can be attributed to Caterpillar "designed-in" features that include:

- Regrindable crankshaft
- Undersize bearings
- Cat dealer and Caterpillar Remanufactured exchange components

Dealer Exchange Components – This is exchanging worn engine components for quality Cat dealer rebuilt components on an over-the-counter basis.

Caterpillar Remanufactured Components – Manufacturing techniques and processes are used to restore components to "like-new" performance capabilities, conform to original functional specifications and are exchanged for your existing parts.

The following is a list of (R)Remanufactured* components currently being offered by Caterpillar in many countries:

- Cylinder head – bare
- Cylinder head – assembly and group
- Connecting rods
- Crankshaft – undersized
- Crankshaft – upgrade to new
- Complete turbocharger
- Turbocharger cartridges
- Water pumps
- Oil pump
- Oil cooler and aftercooler cores
- Alternator
- Starting motor
- Governor and Carburetor

NOTE: If the component you need is not listed here, contact your Caterpillar dealer to see if it is offered under a dealer exchange component program*.

* Current Parts Manuals will asterisk a part number when a (R)Remanufactured unit is offered by Caterpillar.

Caterpillar Recommendation

To further control your overhaul costs, Caterpillar recommends that you contact your dealer for information regarding the availability of a Flat Rate After Failure Overhaul.

Troubleshooting

This topic is intended to provide the owner/operator suggestions for diagnosing minor engine problems. The guidelines are only brief descriptions of common sense remedies which can be performed without extensive knowledge of the engine operation.

Refer to the Service Manual for extensive descriptions of problems and instructions for repair. Caterpillar recommends contacting your authorized Caterpillar dealer for major engine problems which require special tools and procedures.

Troubleshooting a failure on an engine can be a difficult procedure. For complete troubleshooting information, see the Service Manual for your engine. All repairs should be made by a properly trained mechanic. Your Caterpillar dealer has the personnel and special tools needed to troubleshoot and make repairs to your engine.

This list of problems, causes, and corrections will only give an indication of where a possible problem can be, and what repairs may be needed. Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts.

Your Caterpillar dealer is equipped with the necessary tools and personnel to provide assistance when necessary.

Troubleshooting Index

If you have a problem that does not appear in this index, refer to the Service Manual for your engine and/or contact you Caterpillar dealer.

1. Engine will not crank

Batteries: Make sure battery cables are corrosion free and securely attached. Check battery output and charge or replace.

Starting Circuit Wiring: Check wiring to starting motor solenoid.

Starting Motor Solenoid: Inspect cables for corrosion, damage or loose connections.

Starting Motor: Test solenoid and motor operation.

2. Engine cranks, but will not start

Fuel Supply: Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, plugged fuel filter, air in fuel system or kinked, leaking or broken fuel lines.

Fuel Transfer Pump: At cranking speed, the fuel transfer pump should supply fuel to the engine at 20 kPa (3 psi). If fuel pressure is less than 20 kPa (3 psi), replace the fuel filters. Check for air in the fuel system, sticking, binding or defective fuel bypass valve. Check lip-type seal on transfer pump drive shaft. When the engine is fully loaded the transfer pump should supply fuel at 415 to 450 kPa (60 to 65 psi).

Engine Timing: See your authorized dealer.

Shutoff Solenoid: Solenoid must be energized to shut off the engine. Actuate the control that operates the shutoff solenoid and listen for a “clicking” sound. If a “clicking” sound is not present or apparent, remove the solenoid. Try to start the engine again. If the engine starts, the solenoid is defective and must be replaced.

Mechanically override the shutoff solenoid by attaching a lever to the fuel pump. Push lever backward to override the solenoid or forward to shut off fuel supply.

3. Engine starts, but stalls immediately

Shutoff Solenoid: Solenoid must be energized to shut off the engine. Actuate the control that operates the shutoff solenoid and listen for a “clicking” sound. If a “clicking” sound is not present or apparent, remove the solenoid. Try to start the engine again. If the engine starts, the solenoid is defective and must be replaced.

Mechanically override the shutoff solenoid by attaching a lever to the fuel pump. Push lever backward to override the solenoid or forward to shut off fuel supply.

Fuel Supply: Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, plugged fuel filter, air in fuel system or kinked, leaking or broken fuel lines.

Fuel Injection Nozzle: If the engine is misfiring or engine speed (rpm) is restricted, run the engine at the speed where the problem is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for that cylinder should be inspected for damage, wear and proper operation. Inspect components for leaks and replace as needed.

Idle Speed: See your authorized dealer.

Auxiliary Attachments: Inspect, align and tighten couplings and check for excessive parasitic loading.

4. Erratic or unstable engine speed (rpm)

Fuel Supply: Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, plugged fuel filter, air in fuel system or kinked, leaking or broken fuel lines.

Governor: Check for broken spring, linkage binding or other parts problems with internal parts such as flyweights or servo. Check for sufficient travel. Replace any damaged, bent or defective components.

5. Engine misfires or runs rough

Fuel Injection Nozzle: If the engine is misfiring or engine speed (rpm) is restricted, run the engine at the speed where the problem is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for that cylinder should be inspected for damage, wear and proper operation. Inspect components for leaks and replace as needed.

Valve Lash: Adjust valves to specified clearances.

Fuel Injection Timing: See your authorized dealer.

Inlet & Exhaust System: Check for plugged air filter, aftercooler restrictions, aftercooler leaks, high intake air temperature. Inspect all gaskets and piping for leaks. Check Exhaust System for any restrictions.

Fuel Supply: Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, plugged fuel filter, air in fuel system or kinked, leaking or broken fuel lines.

6. No or poor response to throttle

Governor: Check for broken spring, linkage binding or other parts problems with internal parts such as flyweights or servo. Check for sufficient travel. Replace any damaged, bent or defective components.

7. Low power/Engine speed (rpm) restricted

Fuel Supply: Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, plugged fuel filter, air in fuel system or kinked, leaking or broken fuel lines.

Inlet Air System: Check for plugged air filter, aftercooler restrictions, aftercooler leaks, high intake air temperature. Inspect all gaskets and piping for leaks.

Exhaust System: Check for any restrictions.

Fuel Injection Nozzle: If the engine is misfiring or engine speed (rpm) is restricted, run the engine at the speed where the problem is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for that cylinder should be inspected for damage, wear and proper operation. Inspect components for leaks and replace as needed.

Fuel Injection Timing: See your authorized dealer.

Valve Lash: Adjust valves to specified clearances.

Turbocharger: Check for carbon buildup or restricted movement of turbo wheel. Replace if necessary.

Auxiliary Attachments: Inspect, align and tighten couplings and check for excessive parasitic loading.

Governor: Check for broken spring, linkage binding or other parts problems with internal parts such as flyweights or servo. Check for sufficient travel. Replace any damaged, bent or defective components.

8. Intermittent engine shutdowns or power reduction

Fuel Supply: Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, plugged fuel filter, air in fuel system or kinked, leaking or broken fuel lines.

Shutoff Solenoid: Solenoid must be energized to shut off engine. Actuate the control that operates the shutoff solenoid and listen for a "clicking" sound. If "clicking" sound is not present or apparent, remove the solenoid. Again try to start the engine. If the engine starts, the solenoid is defective and must be replaced.

Mechanically override the shutoff solenoid by attaching a lever to the fuel pump. Push lever backward to override the solenoid or forward to shut off fuel supply.

9. Excessive vibration

Engine Mounts: Tighten all mounting bolts securely.

Pulley/Damper: Adjust belt tension. Retighten bolts/nuts.

Auxiliary Attachments: Inspect, align and tighten couplings and check for excessive parasitic loading.

10. Valve train noise: Inspect for bent, broken, severely worn or damaged parts. See your authorized dealer for repairs.

Valve Lash: Adjust valves to specified clearances.

Valve Springs: Inspect for bent, broken, severely worn or damaged parts.

Lubrication: Check for adequate lubrication. Replace excessively worn parts.

Valves: Adjust valves to specified clearances. Inspect for bent, broken, severely worn or damaged parts.

Camshaft: Inspect for bent, broken, severely worn or damaged parts.

Lifters: Inspect for bent, broken, severely worn or damaged parts.

Push Rod: Inspect for bent, broken, severely worn or damaged parts.

Rocker Arm: Inspect for bent, broken, severely worn or damaged parts.

Valve Bridge: Inspect for bent, broken, severely worn or damaged parts. Check for adequate lubrication. Replace excessively worn parts.

11. Excessive black or gray smoke

Inlet Air: Check for plugged air filter, aftercooler restrictions, aftercooler leaks, high intake air temperature. Inspect all gaskets and piping for leaks.

Fuel Injection Timing: See your authorized dealer.

Fuel Injection Nozzle: If the engine is misfiring or engine speed (rpm) is restricted, run the engine at the speed where the problem is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for that cylinder should be inspected for damage, wear and proper operation. Inspect components for leaks and replace as needed.

Turbocharger: Check for carbon buildup or restricted movement of turbo wheel. Replace if necessary.

12. Excessive white or blue smoke

Valve Guides: Inspect for bent, broken, severely worn or damaged parts. See your authorized dealer for repairs.

Piston Rings: Check for worn, stuck or broken rings. See your authorized dealer for repair.

Engine Oil: Check oil for recommended level and any contaminants such as fuel, coolant or dirt. Do not exceed recommended oil change intervals. Drain and refill. Replace oil filter. Check for leaks. Replace gaskets or seals and tighten all connections.

Fuel Injection Timing: See your authorized dealer.

Fuel Supply: Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, plugged fuel filter, air in fuel system or kinked, leaking or broken fuel lines.

13. Low engine oil pressure

Oil Pump/Oil Pump Relief Valve: See your authorized dealer for repair or replacement of defective oil pump. Clean oil pump relief valve and housing. Replace if necessary.

Oil Crankcase Suction Bell: Check for obstructions or plugging.

Oil Filter/Cooler: Check for restrictions in the oil filter or cooler. Replace oil filter or oil cooler as necessary.

Rocker Arm Bore/Shaft: Check for adequate lubrication. Replace excessively worn parts.

Timing Gear Bearing: Inspect bearings for excessive wear and replace components as necessary.

Crankshaft Bearing: Check oil filter operation. See your authorized Caterpillar dealer for replacement of bearings and/or crankshaft if bearing clearances are excessive.

Engine Oil: Check oil for recommended level and any contaminants such as fuel, coolant or dirt. Do not exceed recommended oil change intervals. Drain and refill. Replace oil filter. Check for leaks. Replace gaskets or seals and tighten all connections.

14. Excessive lubrication oil consumption

Oil Temperature: Check oil cooler bypass valve. Replace if defective. Clean oil cooler core.

Engine Oil: Check oil for recommended level and any contaminants such as fuel, coolant or dirt. Do not exceed recommended oil change intervals. Drain and refill. Replace oil filter. Check for leaks. Replace gaskets or seals and tighten all connections.

Valve Guides: Inspect for bent, broken, severely worn or damaged parts. See your authorized dealer for repairs.

15. Coolant in engine oil

Oil Cooler: Check for restrictions in the cooler. Replace oil cooler as necessary.

Cylinder Head & Gasket: See your authorized dealer for replacement of a cracked or damaged cylinder head/gasket.

Cylinder Liners & Seals: See your authorized dealer for replacement of leaking seals and cracked or damaged liners.

Cylinder Block: See your authorized dealer for replacement of a cracked or damaged cylinder block.

16. Premature engine wear

Inlet Air System: Check for plugged air filter, aftercooler restrictions, aftercooler leaks, high intake air temperature. Inspect all gaskets and piping for leaks.

Engine Oil: Check oil for recommended level and any contaminants such as fuel, coolant or dirt. Do not exceed recommended oil change intervals. Drain and refill. Replace oil filter. Check for leaks. Replace gaskets or seals and tighten all connections.

17. High exhaust temperature

Jacket Water/Raw Water Pumps: Check for leaks and reseal if necessary. Make sure jacket water coolant level is sufficient. Check for plugged raw water strainers. Replace failed pump. Be sure raw water pump is primed and suction line is open.

Engine Timing: See your authorized dealer.

Inlet Air: Check for plugged air filter, aftercooler restrictions, aftercooler leaks, high intake air temperature. Inspect all gaskets and piping for leaks.

Turbocharger: Check for carbon buildup or restricted movement of turbo wheel. Replace if necessary.

18. Abnormal engine coolant temperature

Coolant: Check coolant level. Replace any leaking gaskets or hoses and tighten loose connections. Determine if any combustion gases have entered the cooling system. Repair or replace components as necessary.

Water Temperature Regulator/Temperature Gauge: Check temperature regulator for proper opening temperature and correct installation. Check temperature gauge, replace if necessary.

Jacket Water Pump/Raw Water Pump: Check for leaks and reseal if necessary. Make sure jacket water coolant level is sufficient. Check for plugged raw water strainers. Replace failed pump. Be sure raw water pump is primed and suction line is open.

Heat Exchanger: Remove any restrictions blocking coolant flow.

Fuel Injection Timing: See your authorized dealer.

19. Oil in cooling system

Oil Cooler: Check for restrictions in the oil cooler. Replace oil cooler as necessary.

Cylinder Head & Gasket: See your authorized dealer for replacement of a cracked or damaged cylinder head/gasket.

20. Excessive fuel consumption

Fuel Supply: Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, plugged fuel filter, air in fuel system or kinked, leaking or broken fuel lines.

Fuel Injection Nozzle: If the engine is misfiring or engine speed (rpm) is restricted, run the engine at the speed where the problem is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for that cylinder should be inspected for damage, wear and proper operation. Inspect components for leaks and replace as needed.

Fuel Injection Timing: See your authorized dealer.

21. Alternator fails to charge/charging rate high, low or unsteady

Drive Belt: Check belt for wear and adjust to proper tension.

High Resistance in Charging/Ground Return Circuit/Battery Connections: Inspect all cables and connectors. Clean, retighten or replace defective parts.

Brushes: Check for excessively worn, open, sticky or defective brushes. See your authorized dealer for repair or replacement.

Rectifier Diodes: Check for shorted or open rectifier diodes if charging is low or unsteady. See your authorized dealer for replacement of rectifier diode assembly.

Rotor: Check for open rotor field coil if alternator fails to charge and for ground or shorted rotor if charging is low or unsteady. In either case the rotor assembly should be replaced by your authorized dealer.

Regulator: See your authorized dealer for replacement of a faulty regulator.

22. Alternator noise

Drive Belt: Check belt for wear and adjust to proper tension.

Pulley/Belt: Realign drive pulley and alternator pulley and belt. Tighten pulley nut. If key way is worn, install a new pulley.

Rectifier Diodes: Check for shorted or open rectifier diodes if charging is low or unsteady. See your authorized dealer for replacement of rectifier diode assembly.

Armature/Rotor Shaft: See your authorized dealer for replacement of component.

Repair Options

Vessels using diesel engines for main propulsion are required by the various Marine Shipping Societies to carry a supply of replacement parts on-board. Although individual requirements may differ, the following list takes into consideration the requirements of all Marine Shipping Societies and several items recommended by Caterpillar. To customize this list for your particular engine arrangement and application, contact your authorized dealer and provide the following information.

1. Engine Serial Number
2. Engine Arrangement Number
3. Rated Horsepower
4. Electrical System (12V or 24V)
5. Alternator (1 or 2 belts) (from Parts Manual)
6. Sea (Raw) Water Pump Part No. (from Parts Manual)
7. Type of Air Filter
8. Water Lines Group (from Parts Manual)
9. Spin on Conditioner (Y/N)
10. PCV Group No. (from Parts Manual)
11. Type Water Separator
12. Marine Gear Model

Suggested Replacement Parts (to be carried on board)

Category I (Intercoastal)

Parts needed for servicing minor problems at remote ports or secondary repairs offshore.

- Alternator Belt
- Fuel Injection Nozzles
- Four Oil Filters
- Four Fuel Filters
- Four Zinc Rods
- Four Temperature Regulators
- Four Air Cleaner Elements
- S•O•S. Bottle Group
- Liquid Gasket Material
- Engine Oil
- Antifreeze
- Coolant Corrosion Inhibitor
- Coolant Conditioner

Category II (Ocean-going)

Parts needed for extended travel from a servicing port or for maintaining an extensive set of spare parts on board.

Ocean-going vessels should carry all replacement parts listed in Category I as well as the items listed below.

Cylinder Head Parts

- One complete service head assembly.
- Five cylinder head bolts and washers.
- Four intake valve inserts.
- Six exhaust valve inserts.
- One exhaust manifold stud and nut.

Valve Parts

- Four intake valves.
- Six exhaust valves.
- Ten valve guides.
- Ten rotocoil assemblies.
- Ten valve springs.
- Twenty-four locks.

Piston Parts–Power

- One piston group.
- One connecting rod assembly.
- One connecting rod bearing.
- One piston pin.
- Two piston pin retainers.
- One complete set of rings for one piston.
- One main bearing.
- Two thrust plates.
- Two main bearing cap bolts and washers.
- One cylinder liner.
- Three cylinder liner seals.
- One cylinder liner filler band.
- One oil pan gasket.

Fuel System Parts

- One fuel injection pump group and O-ring seal.
- One set (each) of the fuel injection lines.
- Four fuel nozzle assemblies, fuel bodies and nuts.
- One seal and gasket for fuel nozzle adapter.
- One seal, lock and adapter assembly to connect fuel lines through cylinder head.
- One fuel transfer pump.

Camshaft Drive Parts

- One water pump idler and balance weight gear assembly.
- One shaft and thrust washer for idler and balance weight gear.
- One crankshaft gear.
- One camshaft gear and key.

Air System Parts

- One complete turbocharger group.
- Four turbocharger mounting studs and locknuts.
- One air cleaner element.
- One aftercooler core.

Lubrication System Parts
- One each of the bypass valves for oil cooler and oil filter (valve body).
- One bolt for oil pan.
- One engine oil cooler core.
- One marine gear oil cooler core.

Cooling System Parts
- One temperature regulator.
- One vee belt set (if so equipped).
- One jacket water pump.
- One sea (raw) water pump.

Miscellaneous Parts
- One complete engine gasket kit.
- One flywheel to crankshaft bolt.
- One bolt for valve cover.
- One repair kit for piston and rings of engine driven air compressor (if so equipped).
- One repair kit for valves, seats, plungers and gaskets for engine driven air compressor (if so equipped).
- One starting motor.

Marine Gear Parts–Coupled w/ 3500 Marine Engine
- One complete lock and sealing kit.
- Eight bolts, nuts and lockwashers for forward and reverse gears.
- One outer race for front of output shaft.
- Two rear bearings for forward and reverse shafts.
- One front bearing for reverse shaft.
- Two spider bearings for forward and reverse clutches.
- Two front race and roller assemblies for forward and reverse pinions.
- Two inner race for front of forward and reverse pinions.
- One front bearing for forward shaft.
- One front race and roller assembly for output shaft.
- One bearing kit for rear of output shaft.

Maintenance Records

Caterpillar recommends that accurate maintenance records be maintained. Accurate maintenance records can be used for determining operating costs, establishing maintenance schedules for other engines being operated in the same environment and for a variety of other related business decisions.

Accurate maintenance records can also be used to show compliance with the required maintenance practices and intervals. Maintenance records are a key element of a well managed maintenance program. With accurate maintenance records your Caterpillar dealer can help you fine tune the recommended maintenance intervals to meet your specific operating situation. This should result in a lower engine operating cost.

The key elements to keep records on are:

- Fuel Consumption

This is essential for determining when load-sensitive items should be inspected or repaired and for determining overhaul intervals.

- Service Hours

This is essential for determining when revolution-sensitive items should be inspected or repaired.

- Documents

The following types of documents should be kept as proof of maintenance or repair for warranty and should not be difficult to obtain and keep in the engine history file. All documents should show date, service hours, liters (gallons) of fuel consumed, unit number and engine serial number. If the engine is sold, transfer the records with the engine.

1. Dealer work orders and itemized bills.
2. Owner's repair orders.
3. Owner's receipts.
4. Maintenance log (see following example).

Maintenance Log

Engine Model ____________________ **Customer Identifier** ____________________

Serial Number ____________________ **Arrangement Number** ____________________

Service Hours	Quantity Of Fuel	Item Serviced	Date	By Initials

Reference Materials

Oil

Oil and Your Engine SEBD0640
Scheduled Oil Sampling PEDP1129
Question & Answer Booklet PEDP7122
Cat Lithium Grease (MPGL) PEHP0003
Cat Natural Gas Engine Oil Data Sheet PEHP0004
Cat Special Purpose Grease (SPG) PEHP0017
How to Take a Good Oil Sample PEHP6001
Cat Engine Oil NGEO Spec Sheets PEHP7506
Cat Fluids Selector PEWP9733

Fuel

Diesel Fuels and Your Engine SEBD0717

Coolant

Know Your Cooling System SEBD0518
Coolant and Your Engine SEBD0970

Service Manual

Complete Service Manual
(50Y, 96Y, 29Z, 66Z, 69Z, 72Z) - SENR2371
The Service Manual contains the material that follows:
Engine Specifications Module
(50Y, 96Y, 29Z, 66Z, 69Z, 72Z)
System Operation, Testing & Adjusting
(50Y, 96Y, 29Z, 66Z, 69Z, 72Z)
Engine Disassembly & Assembly
(50Y, 96Y, 29Z)
Engine Disassembly & Assembly
(66Z, 69Z)

Miscellaneous

Index to Guidelines for Reusable Parts and
Salvage Operations SEBF8029
Guideline for Reusable Parts - Cleaning and
Inspection of Air Filters SEBF8062
Storage Procedure for Caterpillar Products . SEHS9031
The Caterpillar Engine Technical
Manual (Volume I) LEKQ2030
The Caterpillar Engine Technical
Manual (Volume II) LEKQ2031

Your Caterpillar dealer can provide literature on all products required to maintain your Caterpillar Engine.

Additional Reference Material

ASTM Specs can normally be obtained from your local technological society, library or college or contacting:

- American Society for Testing and Materials
  1916 Race St.
  Philadelphia, PA 19103
  (215) 299-5400

Society of Automotive Engineers (SAE) Specs can be found in your SAE handbook or can be obtained from your local library, college or technological society, or contacting:

- Society of Automotive Engineers, Inc.
  SAE International
  400 Commonwealth Drive
  Warrendale, PA USA 15096-0001
  (412) 776-4841

American Petroleum Institute (API) classification system and oil selection for API Publication No. 1509 can be obtained from your local library, college or technological society, or contact:

- American Petroleum Institute
  1220 L St.
  Washington, DC 20005
  (202) 682-8000

Engine Manufacturers Association (EMA) information for lube oil selection can be obtained from your local library, college or technological society, or contact:

- Engine Manufacturers Association
  Lubricating Oils Data Book
  401 N. Michigan Ave. Ste. 2400
  Chicago, IL 60611
  (312) 644-6610 ext. 3626

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