

SCANNED 8/30/06

# Operation and Maintenance Manual

---

## **3500B Engines and 3500 Engines With EUI Option**

---

3DM1-Up (Engine)	2HW1-Up (Engine)
4GM1-Up (Engine)	3DW1-Up (Engine)
5XM1-Up (Engine)	4AW1-Up (Engine)
6PM1-Up (Engine)	
7KM1-Up (Engine)	
8EM1-Up (Engine)	
8RM1-Up (Engine)	
6HN1-Up (Engine)	
6PN1-Up (Engine)	
6WN1-Up (Engine)	
7RN1-Up (Engine)	
9AN1-Up (Engine)	
3LS1-Up (Engine)	
3MS1-Up (Engine)	
3NS1-Up (Engine)	
3TS1-Up (Engine)	
3WS1-Up (Engine)	
3XS1-Up (Engine)	
1NW1-Up (Engine)	
1PW1-Up (Engine)	
2FW1-Up (Engine)	

---

**Prime Power, Standby, and Marine Auxiliary Generator Set Engines**

---

## Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

**Attention! Become Alert! Your Safety is Involved.**

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

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

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

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



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

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

# Table of Contents

Foreword .....	4
----------------	---

## Safety Section

Safety Signs and Labels .....	6
General Hazard Information .....	12
Burn Prevention .....	14
Fire Prevention and Explosion Prevention .....	14
Crushing Prevention and Cutting Prevention .....	15
Mounting and Dismounting .....	16
Before Starting Engine .....	16
Engine Starting .....	16
Engine Stopping .....	17
Electrical System .....	17

## Product Information Section

Model Views .....	18
Product Identification Information .....	23

## Operation Section

Engine Lifting and Storage .....	26
Gauges and Indicators .....	27
Engine Features and Controls .....	30
Engine Starting .....	57
Engine Operation .....	62
Engine Stopping .....	63
Cold Weather Operation .....	65

## Maintenance Section

Torque Specifications .....	67
Lubricant Specifications .....	70
Fuel Specifications .....	77
Cooling System Specifications .....	79
Refill Capacities .....	90

Maintenance Interval Schedule .....	92
-------------------------------------	----

Maintenance Interval Schedule (Standby Generator Set Engines) .....	94
---	----

## Reference Information Section

Engine Ratings .....	143
Customer Service .....	145
Reference Materials .....	147

## Index Section

Index .....	151
-------------	-----

## Foreword

### Literature Information

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

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

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

### Safety

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

### Operation

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

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

### Maintenance

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

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

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

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

### Maintenance Intervals

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

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

### Overhaul

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

## California Proposition 65 Warning

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

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

## Certified Engine Maintenance

Proper maintenance and repair is essential to keep the engine and machine systems operating correctly. As the heavy duty off-road diesel engine owner, you are responsible for the performance of the required maintenance listed in the Owner Manual, Operation and Maintenance Manual, and Service Manual.

It is prohibited for any person engaged in the business of repairing, servicing, selling, leasing, or trading engines or machines to remove, alter, or render inoperative any emission related device or element of design installed on or in an engine or machine that is in compliance with the regulations (40 CFR Part 89). Certain elements of the machine and engine such as the exhaust system, fuel system, electrical system, intake air system and cooling system may be emission related and should not be altered unless approved by Caterpillar .

## Safety Section

### Safety Signs and Labels

i01231232

**SMCS Code:** 1000; 7405

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

Ensure that all of the signs are legible. Clean the signs or replace the signs if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap for cleaning the signs. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the signs. The signs that are loosened could drop off of the engine.

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

#### **WARNING**

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

The safety signs that may be attached on the engine are illustrated and described below.

## Crankcase Covers

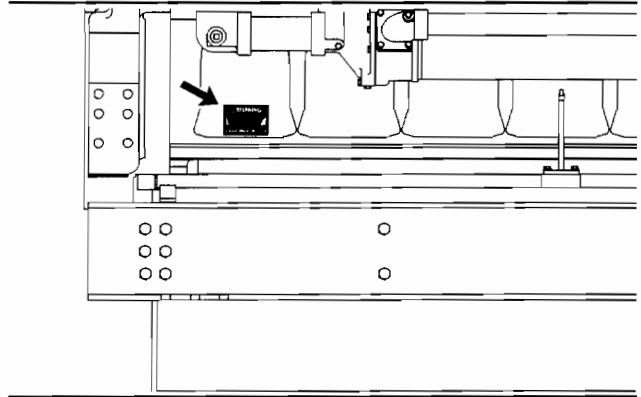


Illustration 1

g00386802

The warning labels for the crankcase covers are located on the crankcase covers.



g00123185

#### **WARNING**

**Flash fire may result in personal injury, if crankcase covers are removed within fifteen minutes after emergency shut down. Do not restart engine until cause for shutdown has been corrected.**

## Duplex Fuel Filter and Oil Filter

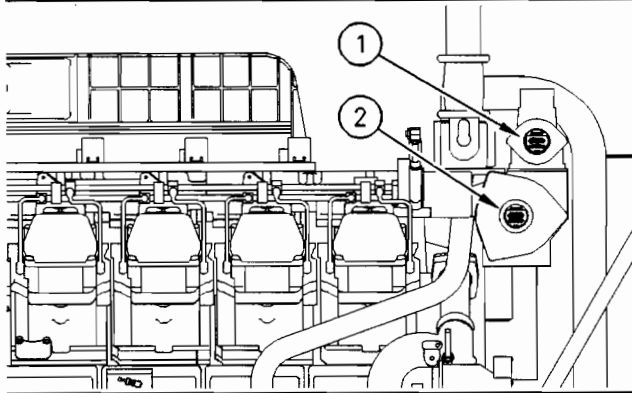


Illustration 2

g00580638

The warning label for the duplex fuel filter and the duplex oil filter is located on the cover of the fuel filter (1) and the oil filter (2).



g00306243

**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.**

## Electrical Distribution (Generator)

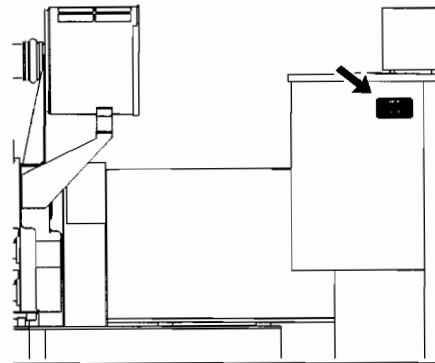
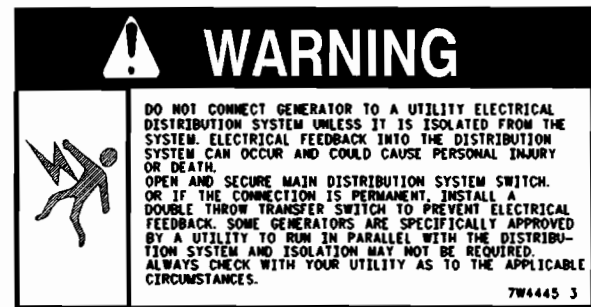


Illustration 3

g00305862

The warning label for electrical distribution (generator) is located on the covers of the generator.



g00296980

**WARNING**

**Do not connect generator to a utility electrical distribution system unless it is isolated from the system. Electrical feedback into the distribution system can occur and could cause personal injury or death.**

**Open and secure main distribution system switch, or if the connection is permanent, install a double throw transfer switch to prevent electrical feedback. Some generators are specifically approved by a utility to run in parallel with the distribution system and isolation may not be required. Always check with your utility as to the applicable circumstances.**

## Electrical Shock

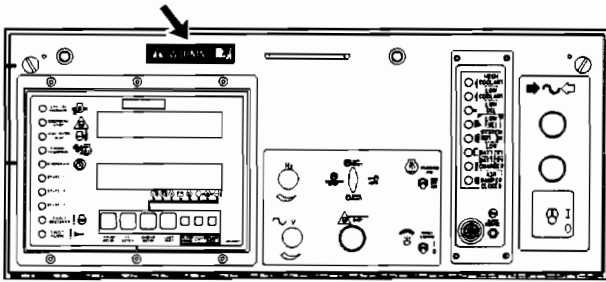


Illustration 4

g00580740

The warning label for electrical shock is located on the control panel.



g00580695

Electrical shock can cause personal injury or death. Before electrical equipment is serviced, disconnect the power. Electrical equipment includes the following components: engine control system, wiring harnesses, and sensors.

## Emergency Stop

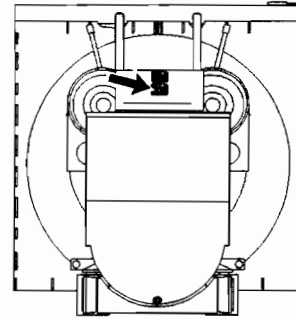


Illustration 5

g00305895

The warning label for emergency stop is located on the outside of the door of the control panel.



g00305896



**Always operate this unit with the vandal door open. Operating the unit with the vandal door closed restricts access to the emergency stop button and could result in injury or death.**



## Radiator Coolant

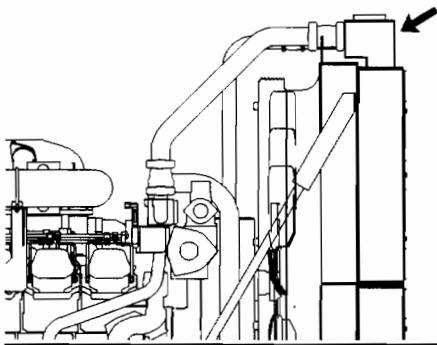
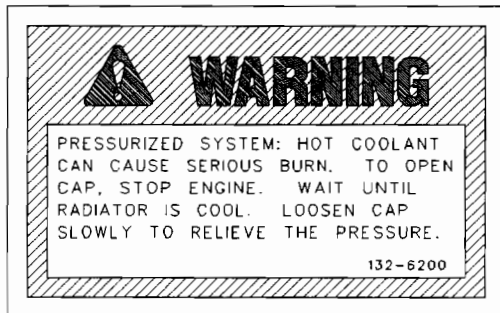


Illustration 6

g00658509

The radiator coolant warning label is located near the front of the radiator filler cap.



g00658535

**WARNING**  
 Pressurized system: hot coolant can cause serious burn. To open cap, stop engine. Wait until radiator is cool. Loosen cap slowly to relieve the pressure.

## Base Lifting

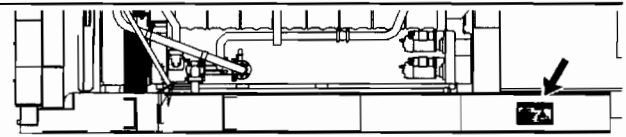
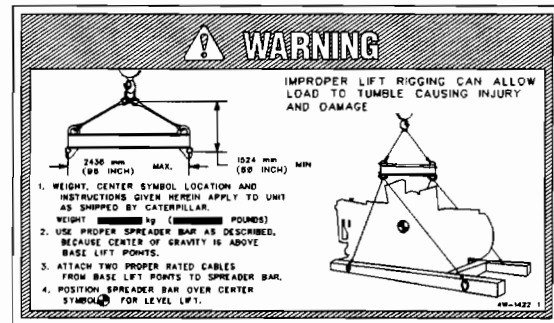


Illustration 7

g00658557

The base lifting warning label is located on the base.



g00658561

**WARNING**  
 Improper lift rigging can allow unit to tumble causing injury and damage.

Before lifting the generator set, read this Operation and Maintenance Manual, "Engine Lifting" topic (Operation Section).

If improper equipment is used to lift the generator set, injury and damage can occur. Use cables that are properly rated for the weight. Use a spreader bar and attach the cables according to the information on the warning label.

## High Voltage

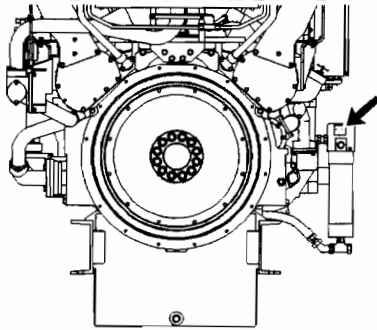


Illustration 8

g00664982

The warning label for high voltage is located on the jacket water heater.



g00481390

### **WARNING**

**Power source must be disconnected before working on equipment.**

**Failure to disconnect power source could result in injury or death.**

## Engine Lifting

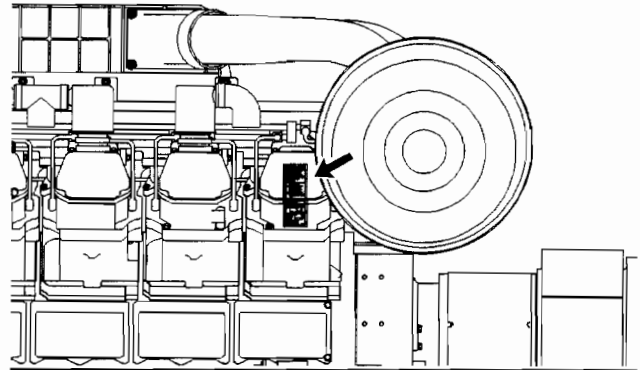
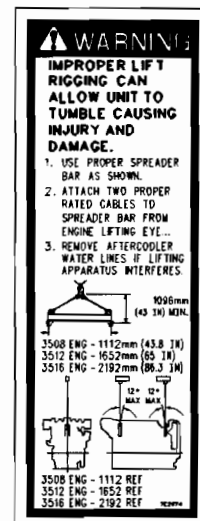


Illustration 9

g00580494

The warning label for lifting the engine is located on the valve covers.



g00306083

### **WARNING**

**Improper lift rigging can allow unit to tumble causing injury and damage.**

Before lifting the engine, read this Operation and Maintenance Manual, "Engine Lifting" topic (Operation Section).

If improper equipment is used to lift the engine, injury and damage can occur. Use cables that are properly rated for the weight. Use a spreader bar and attach the cables according to the information on the warning label.

## Operation

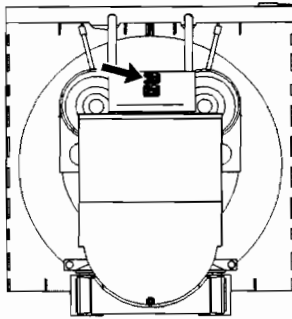
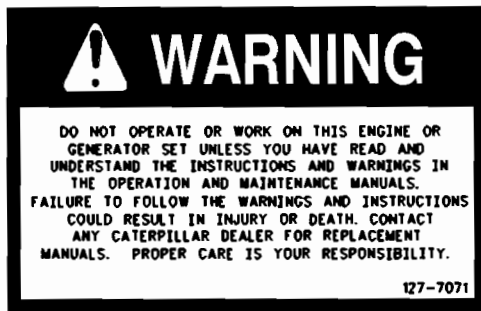


Illustration 10

g00306263

The warning label for operation is located on the outside of the door of the control panel.



g00306265



**Do not operate or work on this engine or generator set unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals.**

**Failure to follow the warnings and instructions could result in injury or death. Contact any Caterpillar dealer for replacement manuals. Proper care is your responsibility.**

## Prelube Pump

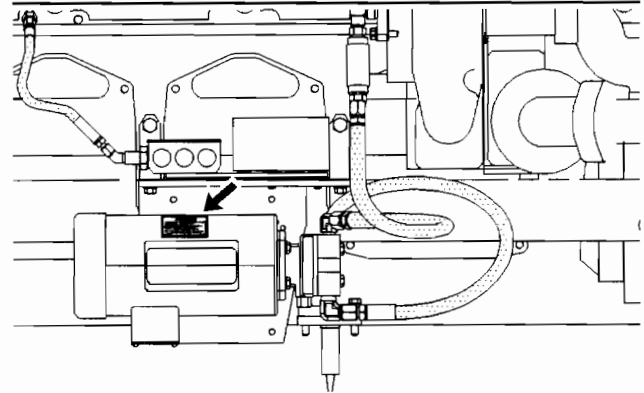
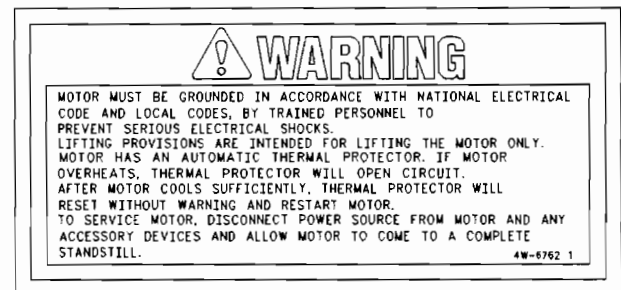


Illustration 11

g00306383

The warning label for the prelube pump is located on the prelube pump.



g00306385



**Motor must be grounded in accordance with national electrical code and local codes, by trained personnel to prevent serious electrical shocks.**

**Lifting provisions are intended for lifting the motor only.**

**Motor has an automatic reset thermal protector. If motor overheats, thermal protector will open motor circuit.**

**After motor cools sufficiently, thermal protector will reset without warning and restart motor.**

**To service motor, disconnect power source from motor and any accessory devices and allow motor to come to a complete standstill.**

## Fuel Injectors

i01159865

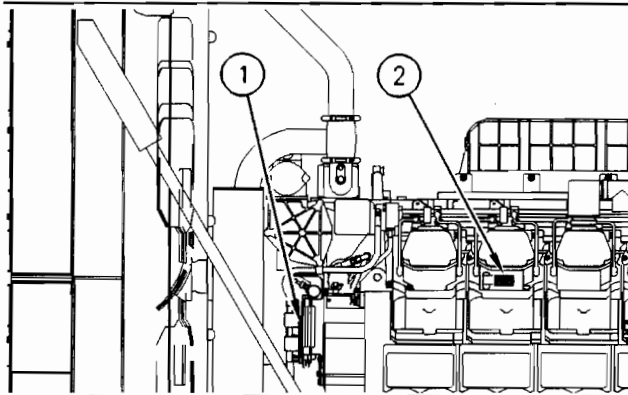
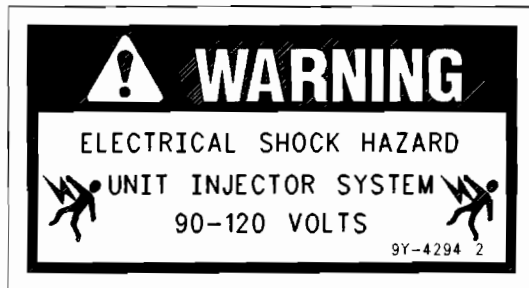


Illustration 12

g00580495

The unit injector warning label is located on the electronic control module (ECM) (1) and the valve covers (2).



g00103125



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

The ECM sends a high voltage signal to the fuel injectors. To help prevent personal injury, disconnect the fuel injector connector. Do not come in contact with the harness connector for the fuel injector while the engine is operating.

## General Hazard Information

**SMCS Code:** 1000; 7405

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

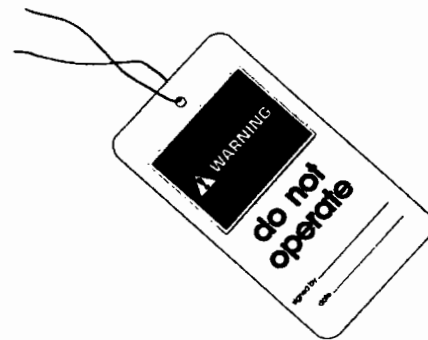


Illustration 13

g00104545

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

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

Cautiously remove the following parts:

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

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

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

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

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

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

## Pressurized Air and Water

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

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

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

Always wear eye protection for cleaning the cooling system.

## Fluid Penetration

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

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

## Fluid Spillage

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

## Asbestos Information

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

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

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

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

- Never use compressed air for cleaning.
- Avoid abrasion of materials that contain asbestos.
- Use a wet method to clean up asbestos debris. A vacuum cleaner that is equipped with a high efficiency particulate air filter can also be used.
- Use exhaust ventilation when parts that contain asbestos are machined.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. In the USA, use the Occupational Safety and Health Administration requirements. These OSHA requirements can be found in "29 CFR 1910.1001".

- Obey environmental regulations for disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

## Lines, Tubes, and Hoses

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

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

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

Check for the following conditions:

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

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

i00910250

## Burn Prevention

**SMCS Code:** 1000; 7405

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

## Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant. When pressure is relieved rapidly, the hot coolant can turn into steam.

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

Check the coolant level only after the engine has been stopped.

Do not step on the engine in order to remove the filler cap. Use a ladder, if necessary. Ensure that the filler cap is cool before removing the filler cap. Remove the filler cap slowly in order to relieve pressure.

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

## Oils

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

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

## Batteries

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

Batteries give off combustible gases which can explode. Ensure proper ventilation for batteries that are in an enclosure. Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases to ignite. Do not smoke when batteries are serviced.

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

i01027886

## Fire Prevention and Explosion Prevention

**SMCS Code:** 1000; 7405

A flash fire may result in personal injury if the crankcase covers are removed within fifteen minutes after an emergency shutdown.

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

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

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

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

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

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

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

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

Do not smoke in areas that contain flammable material.

Store oily rags and other flammable material in protective containers.

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

Do not allow flammable materials to accumulate on the engine.

Do not expose the engine to flames.

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

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

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

Check the electrical wires daily for wires that are loose or frayed. Before the engine is operated, tighten all loose electrical wires. Repair all frayed electrical wires.

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

## Fire Extinguisher

Ensure that fire extinguishers are available. Be familiar with the operation of the fire extinguishers. Inspect the fire extinguishers and service the fire extinguishers regularly. Service the fire extinguisher according to the recommendations on the instruction plate.

i00061952

## Crushing Prevention and Cutting Prevention

**SMCS Code:** 1000; 7405

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

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

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

Keep objects away from moving fan blades (if equipped). The fan blades will throw objects and the fan blades can cut objects.

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

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

i00776840

## Mounting and Dismounting

**SMCS Code:** 1000; 7405

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

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

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

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

Do not carry tools or supplies when you are climbing. Use a hand line or other means for carrying equipment up to the work area.

i01072501

## Before Starting Engine

**SMCS Code:** 1000

Inspect the engine for potential hazards.

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

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

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

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

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

See the Service Manual for repairs and for adjustments.

i01103904

## Engine Starting

**SMCS Code:** 1000

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

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

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

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

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

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

## Ether

Ether is poisonous and flammable.



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

Do not smoke while ether cylinders are changed.

Use ether in well ventilated areas.

Use ether with care in order to avoid fires.

Keep ether cylinders out of the reach of unauthorized persons.

Store ether cylinders in authorized storage areas only.

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

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

i01032808

## Engine Stopping

**SMCS Code:** 1000

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

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

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

i01105717

## Electrical System

**SMCS Code:** 1000; 1400

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

When the engine is started from an external source, follow this procedure: first, connect the positive "+" jump start cable from the external power source to the positive "+" battery terminal of the engine that is being started. Then connect the negative "-" jump start cable from the external power source to the negative "-" terminal of the starting motor. This will help to prevent sparks from igniting combustible gases that are produced by some batteries.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is operated. Repair all frayed electrical wires before the engine is started.

## Grounding Practices

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

Uncontrolled electrical circuit paths can result in damage to main bearings, to the surface of crankshaft journals, and to aluminum components. Uncontrolled electrical circuit paths can also cause electrical activity that may degrade the performance of the engine electronics.

The alternator and the starting motor must be grounded to the negative "-" battery terminal.

A ground plate with a direct path to the negative "-" battery terminal may be used as a common ground for the components of one engine system.

For engines with an alternator that is grounded to an engine component, a ground strap must connect that component to the negative "-" battery terminal. Also, that component must be electrically isolated from the engine.

The ground strap for the alternator must be of a size that is adequate for carrying the full charging current of the alternator.

## Product Information Section

### Model Views

i01232663

### Model View Illustrations

**SMCS Code:** 1000

The illustrations show various typical features of 3500B Engine. The illustrations do not show all of the options that are available.

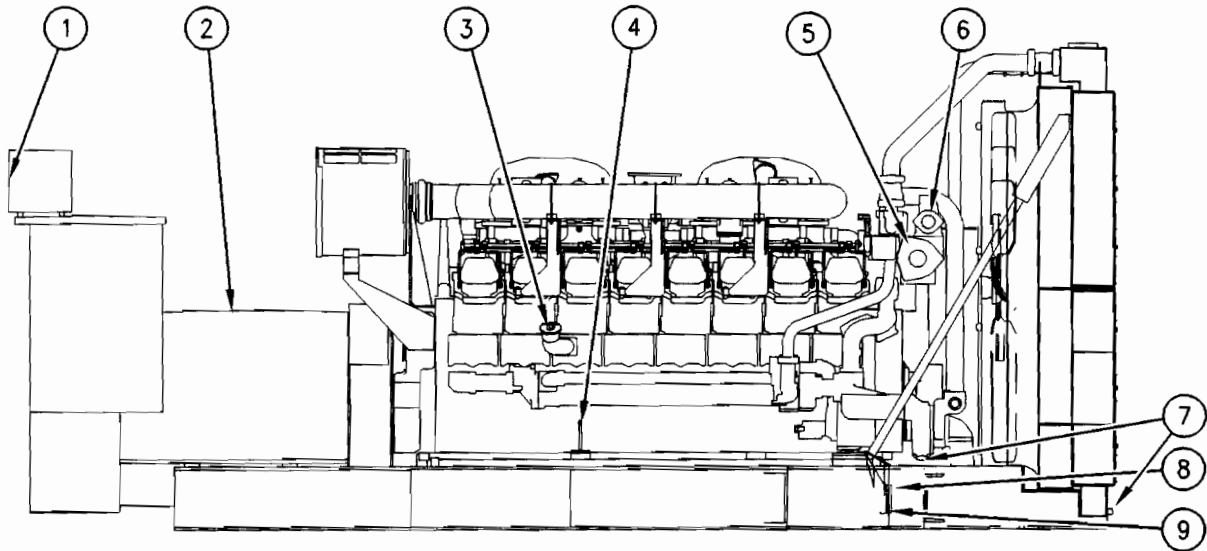


Illustration 14

g00659165

- (1) Control panel
- (2) Generator
- (3) Oil filler cap

- (4) Oil level gauge (dipstick)
- (5) Oil filters
- (6) Secondary fuel filters

- (7) Water drain
- (8) Oil screen
- (9) Oil drain plug

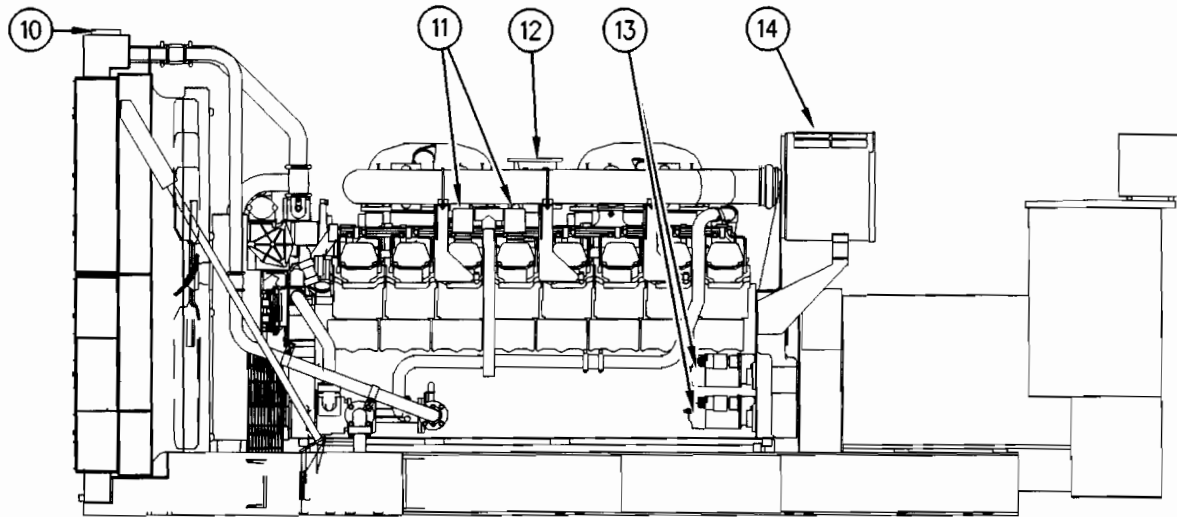


Illustration 15

g00659270

- (10) Cooling system filler cap
- (11) Crankcase Breathers

- (12) Exhaust
- (13) Starting motors

- (14) Air cleaner

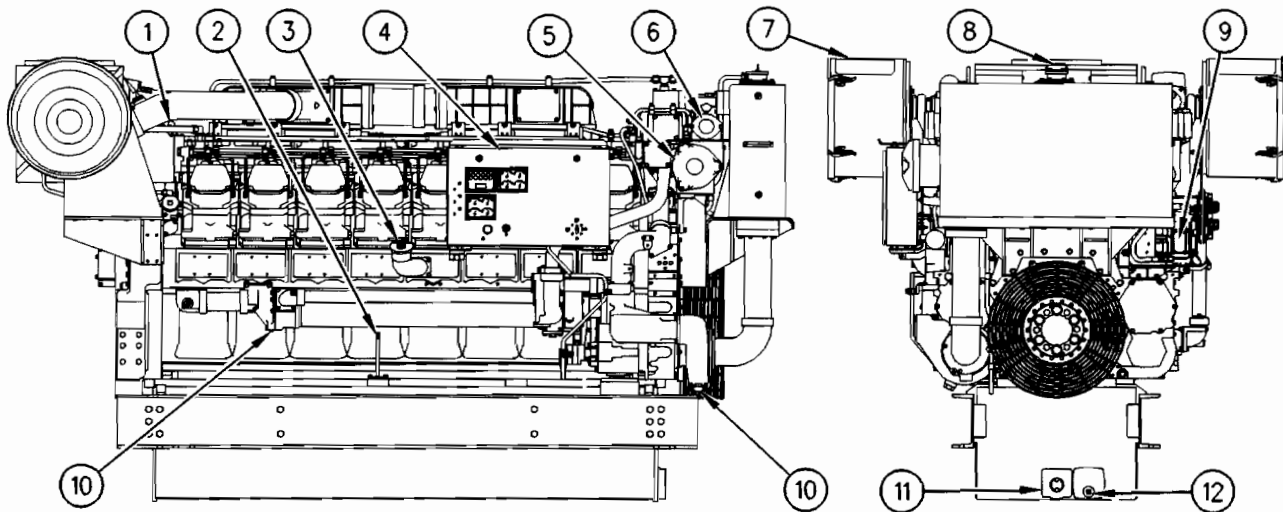


Illustration 16

g00659146

- (1) Lifting eye
- (2) Oil level gauge (dipstick)
- (3) Oil filler cap
- (4) Electronic instrument panel

- (5) Oil filter
- (6) Secondary fuel filter
- (7) Air cleaner
- (8) Cooling system filler cap

- (9) Primary electronic control module (ECM)
- (10) Water drain
- (11) Oil screen
- (12) Oil drain plug

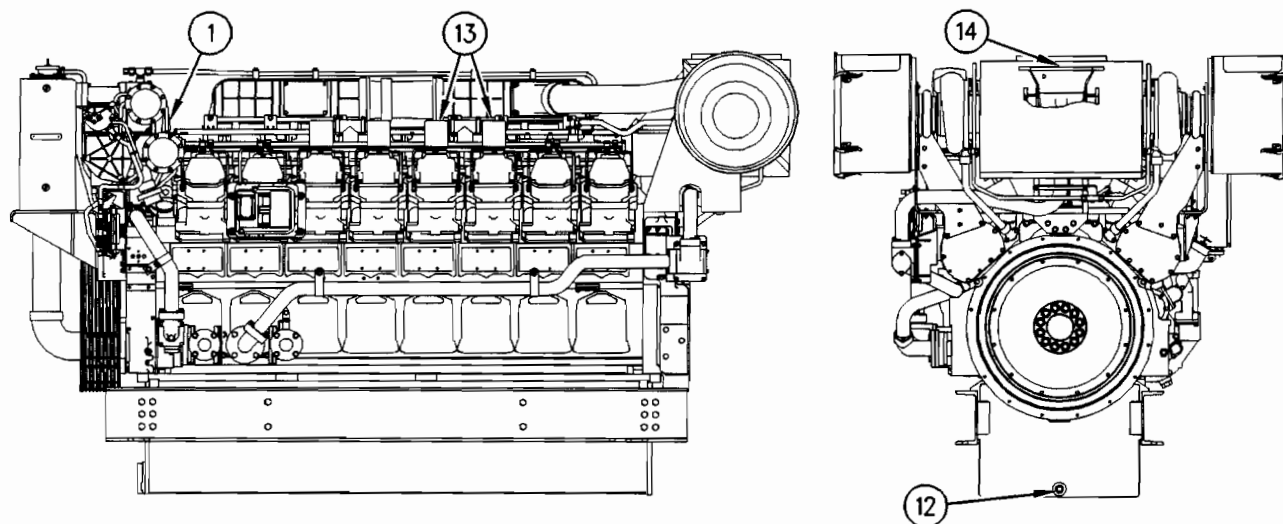


Illustration 17

g00659132

Marine auxiliary

(1) Lifting eye

(12) Oil drain plug

(13) Crankcase breathers

(14) Exhaust

i01233137

## Engine Description

**SMCS Code:** 1000

The 3500 series engine and the 3500B series engine with EUI option are electronically controlled engines. The engines have electronic fuel injectors. The engines are equipped with either jacket water aftercooling (JWAC) or separate circuit aftercooling (SCAC). The following engine models are available: 8 cylinder, 12 cylinder, and 16 cylinder.

Engine efficiency and engine performance depend on adherence to proper operation and maintenance recommendations. Follow the recommended Maintenance Schedule and use the recommended lubrication oils, fuels, and coolants.

### Engine Specifications

Table 1

3500 Engine Specifications			
Item	3508 Engine	3512 Engine	3516 Engine
Rated speed (rpm)	1000 to 1800		
Cylinders and arrangement	60 degree Vee 8	60 degree Vee 12	60 degree Vee 16
Bore	170 mm (6.7 inch)		
Stroke	190 mm (7.5 inch)		
Type	4 stroke cycle		
Compression ratio	13.5:1 (3500 Engines With EUI Option) 14:1 (3500B Engines)		
Aspiration	Turbocharged		
Method of cooling the turbocharged air	Separate circuit aftercooling (option)		
	Jacket water aftercooling		
Displacement per cylinder	4.3 L (263 cu in)		
Total displacement	34.5 L (2105 cu in)	51.8 L (3158 cu in)	69.1 L (4210 cu in)
Rotation (flywheel end)	Counterclockwise rotation is standard.		
	Clockwise rotation is optional.		
Fuel	See this Operation and Maintenance Manual, "Fuel Recommendations" (Maintenance Section).		
Method of fuel injection	Electronic fuel injectors		
Method of starting	Air starting motor		
	Electric starting motor		
Exhaust back pressure (design)	2.5 kPa (10 inches of H <sub>2</sub> O)		
Maximum allowable back pressure	5 kPa (20 inch of H <sub>2</sub> O)		
Maximum inlet air Restriction	6.2 kPa (25 inches of H <sub>2</sub> O)		
Inlet valve lash	0.50 mm (0.020 inch)		
Exhaust valve lash	01.00 mm (0.039 inch)		

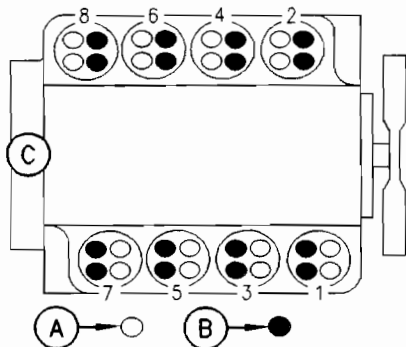


Illustration 18

g00308097

3508 Engine

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

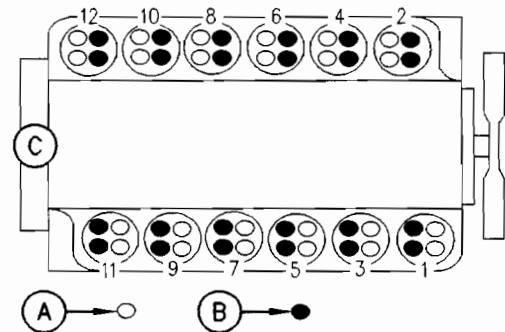


Illustration 19

g00308167

3512 Engine

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

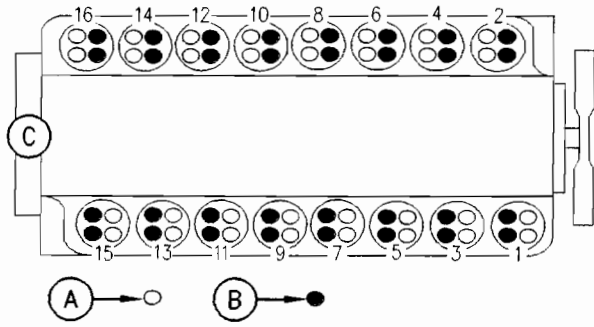


Illustration 20

g00308357

3516 Engine

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

# Product Identification Information

i01028428

## Engine Identification

**SMCS Code:** 1000

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

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

i00796457

## Serial Number Plate

**SMCS Code:** 1000

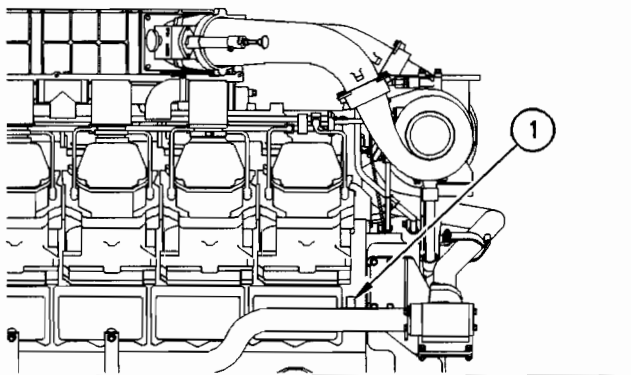


Illustration 21

g00374172

(1) Location of the Serial Number Plate

The Serial Number Plate is on the left side of the cylinder block near the rear of the engine.

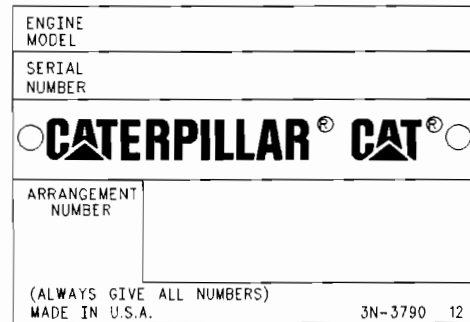


Illustration 22

g00123229

Serial Number Plate

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

i00796583

## Information Plate

**SMCS Code:** 1000

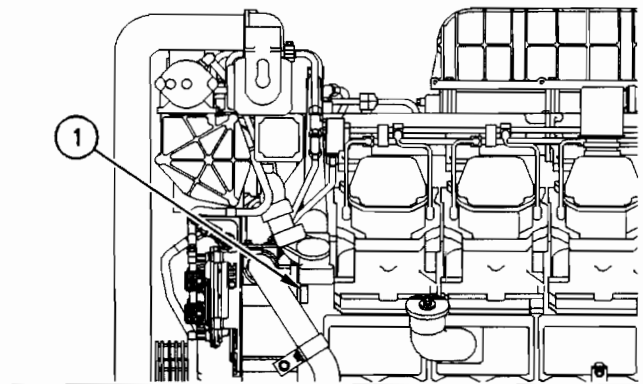


Illustration 23

g00374353

(1) Location of the Information Plate

The Information Plate is on the left side top surface of the cylinder block in front of the front cylinder head.

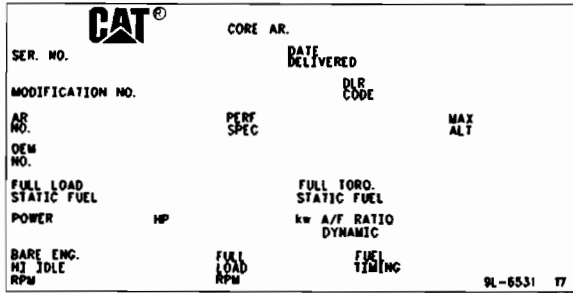


Illustration 24 g00102789

Information Plate

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

i01225382

## Emissions Certification Film

SMCS Code: 1000

The emissions certification film (if equipped) is used to verify that the engine meets the EPA emissions requirements.

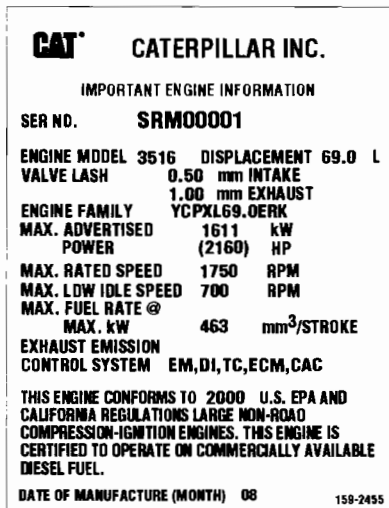


Illustration 25 g00633377

This is a typical example of the emissions certification film that is located on the engine.

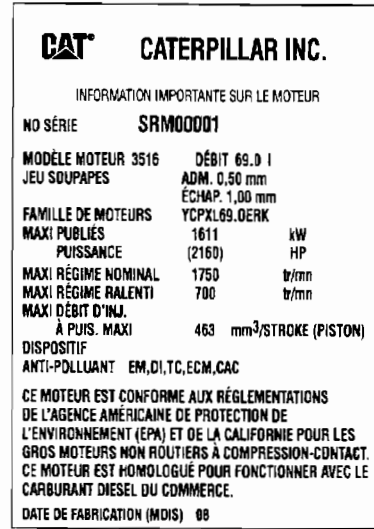


Illustration 26 g00638527

This is the French version of the English emissions certification film that is located on the engine.

i01070185

## Reference Numbers

SMCS Code: 1000

Identification of the items in Table 2 may be needed in order to obtain parts and service. Some of the numbers are on the engine Serial Number Plate and/or Information Plate. Locate the information for your engine. Record the information on the appropriate space in Table 2. Make a copy of this list for a record. Retain the information for future reference.

The top level part numbers in the Parts Manual for the engine are listed with the engine arrangement number. Occasionally, an arrangement may be slightly modified before the product is shipped from the factory. In these cases, a modification number indicates that the arrangement has been modified.

The packaging arrangement may also be called a pricing arrangement or a customer arrangement. This is the total package with attachments and options that are not included in the engine arrangement.

The performance specification can be used by your Caterpillar dealer with the Technical Marketing Information system. Before the engine leaves the factory, the engine performance is tested. Detailed performance data is recorded. The performance specification number can be used for obtaining the data.



Table 2

<b>Reference Numbers</b>	
Engine Model	
Serial Number	
Arrangement Number	
Modification Number	
Packaging Arrangement	
Turbocharger	
Fuel Filter Element	
Lubrication Oil Filter Element	
Auxiliary Oil Filter Element	
Air Cleaner Element	
Fan Drive Belt	
Alternator Belt	
Capacity of the Lubrication System	
Capacity of the Cooling System	
Performance Specification Number	
Personality Module	
Low Idle rpm	
High Idle rpm	
Full Load rpm	
Power Rating	

## Operation Section

# Engine Lifting and Storage

i01028350

## Engine Lifting

**SMCS Code:** 1000; 1122

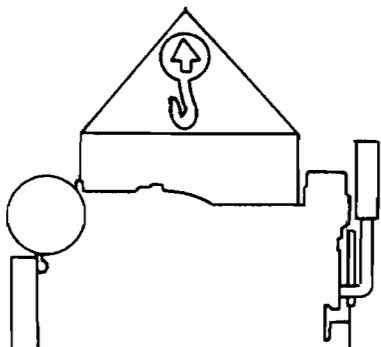


Illustration 27

g00103219

### NOTICE

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

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

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

Some removals require lifting fixtures in order to obtain proper balance and safety.

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

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

## Engine Lifting with a Generator

### NOTICE

Do not use the engine lifting eyes to remove the engine and generator together.

A lifting plate is provided with the package generator set. Instructions for lifting the package generator set are stamped on the lifting plate.

Consult your Caterpillar dealer for information regarding proper fixtures and lifting devices.

i00816700

## Engine Storage

**SMCS Code:** 1000

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder liner surface, which will increase engine wear which can reduce engine service life.

To help prevent excessive engine wear, use the following guidelines:

- Complete all of the lubrication recommendations that are listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).
- If freezing temperatures are expected, check the cooling system for adequate protection against freezing. See this Operation and Maintenance Manual, "General Coolant Information" (Maintenance Section).

If an engine is out of operation and if use of the engine is not planned, special precautions should be made. If the engine will be stored for more than one month, a complete protection procedure is recommended.

Your Caterpillar dealer will have instructions for preparing the engine for extended storage periods.

For more detailed information on engine storage, see Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products".

## Generator Storage

For information on generator storage, see the literature that is provided by the OEM of the generator. Consult your Caterpillar dealer for assistance.

## Gauges and Indicators

i01241744

### Gauges and Indicators

**SMCS Code:** 7450

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Compare the gauge readings to the data that were recorded during the engine commissioning. Determine the normal operating range by observing the gauges over a period of time.

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

Your engine may not have the same gauges or all of the gauges that are described. For more information about the gauge package, refer to the literature that is provided by the OEM of the package.



**Aftercooler coolant temperature** – This gauge indicates the temperature of the coolant in the aftercooler system. Two methods of aftercooling are available. The separate circuit aftercooler operates at a temperature that is lower than the jacket water aftercooler. Determine the method of aftercooling in order to verify the gauge reading.

#### NOTICE

**If no oil pressure is indicated, STOP the engine. The engine will be damaged from operating without oil pressure.**



**Engine oil pressure** – This gauge indicates the pressure of the engine oil. This pressure will be highest after a cold engine is started. The pressure will decrease as the engine warms up. The pressure will increase when the engine rpm is increased. The pressure will stabilize when the engine rpm and temperature are stable.



**Engine Oil filter differential pressure (restriction)** – This gauge indicates the difference in pressure between the inlet side and the outlet side of the engine oil filters. As the oil filter elements become plugged, oil filter differential pressure will increase.

If the load is stabilized but the engine oil pressure fluctuates, perform the following procedure:

1. Remove the load.
2. Reduce the engine speed to low idle rpm.
3. Check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the "LOW IDLE" side of the oil level gauge (dipstick).
4. Inspect the lubrication system for leaks.



**Engine oil temperature** – This gauge indicates the temperature of the engine oil.

Engine oil performs several functions: keeping the engine clean, preventing rust and corrosion, acting as a coolant, and reducing friction and wear. The oil cooler transfers heat from the oil to the engine jacket water. Oil temperature that is higher than normal indicates a problem with the lubrication system and/or the cooling system. Excessive oil temperature can adversely affect the cylinder heads, cylinder liners, pistons, and crankshaft bearings.



**Exhaust temperature** – This gauge indicates the exhaust temperature at the exhaust inlets to the turbochargers. The two exhaust temperatures may vary slightly. This may be due to variation of the sensitivity of the two thermocouples.

The exhaust temperatures at the exhaust inlets to the turbochargers provide a good indication of engine performance. For engines with dry exhaust manifolds, the temperatures are representative of the actual temperatures of the valves. Monitor this parameter frequently.

Normal operating temperatures and extreme operating temperatures for different ratings are listed in Table 3. If the recommendations for the engine installation, the rating, and engine maintenance are followed, most engines will operate at the normal limit or below the normal limit.

#### NOTICE

**Severe damage to the engine can result if the exhaust temperature at the inlet to the turbocharger exceeds the extreme limit.**

Table 3

Temperature Limits for the Exhaust Inlet to the Turbocharger		
Rating <sup>(1)</sup>	Normal Limit	Extreme Limit
Continuous	650 °C (1202 °F)	692 °C (1278 °F)
Prime	677 °C (1250 °F)	718 °C (1325 °F)
Standby	704 °C (1300 °F)	746 °C (1375 °F)

<sup>(1)</sup> For the rating definitions, see this Operation and Maintenance Manual, "Engine Rating Definitions" (Reference Information Section).



**Fuel pressure** – This gauge indicates fuel pressure to the fuel injection pump from the fuel filter. A decrease in fuel pressure usually indicates a dirty fuel filter or a plugged fuel filter. As the fuel filter becomes plugged, there will be a noticeable reduction in the engine's performance.



**Jacket water temperature** – This gauge indicates the temperature of the engine coolant at the outlet for the jacket water. The temperature may vary according to the load. Do not allow the temperature to exceed the boiling temperature of the pressurized cooling system.

The sensor for jacket water temperature must be fully submerged in order to detect the temperature correctly. If the engine is operating above the normal temperature range, perform the following procedure:

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



**System voltage** – This gauge indicates the voltage of the electrical system. Normally, the system has 24 volts or 32 volts.



**Fuel filter differential pressure (restriction)** – This gauge indicates the difference in fuel pressure between the inlet side and the outlet side of the fuel filter. As the fuel filter element becomes plugged, the difference in pressure between the two sides of the fuel filter increases.



**Hourmeter** – This meter indicates the cumulative hours of engine operation.



**Inlet air restriction (air cleaner differential pressure)** – This gauge indicates the difference in air pressure between the inlet side and the engine side of the air filter element. The air cleaner differential pressure is measured from the turbocharger air inlet. The "LH/RH" switch on the instrument panel is used for toggling either the left or right side. As the air filter element becomes plugged, the difference in pressure between the two sides of the air cleaner element will increase.



**Inlet manifold air pressure (boost pressure)** – This gauge indicates the air pressure (turbocharger boost pressure) in the air plenum (air inlet manifold) after the aftercooler.



**Inlet Manifold Air Temperature** – This gauge indicates the inlet manifold air temperature to the cylinders. The sensor for inlet manifold air temperature is located after the aftercooler. The maximum temperature should not exceed 30 °C (54 °F) more than the temperature of the water in the separate circuit. If the maximum temperature is exceeded, check for the following conditions: plugged aftercooler core, inlet air restriction, air leaks, and high ambient air temperature.

**Pyrometer** – The pyrometer displays the temperature of the exhaust for the exhaust port of each individual cylinder and for the exhaust stacks.

The exhaust port temperatures are a good indication of the condition of the cylinders. The displayed temperature is slightly lower than the actual temperature in the cylinder. This is because of the constant flow of exhaust gas past the thermocouple. For engines with dry exhaust manifolds, the exhaust port temperatures are usually lower than the temperatures at the inlet to the turbochargers.

Guttering of valves can be diagnosed with the exhaust port temperature. The ability to diagnose this problem may help to prevent additional damage that could cause further downtime with a higher repair cost.

During normal operation at rated load, the temperature of the hottest cylinder and the coldest cylinder may differ by 38 to 52 °C (60 to 94 °F).

Be alert if an exhaust port temperature varies by more than 50 °C (90 °F) from the average temperature of all of the cylinders.

Perform corrective measures immediately if an exhaust port temperature varies by more than 100 °C (180 °F) from the average temperature of all of the cylinders.

The exhaust stack temperature is not a suitable substitute for the exhaust temperature at the inlet to the turbocharger. However, a comparison of the two temperatures can help to assess the performance of the turbocharger.

---

**NOTICE**

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

---

**Tachometer** – The tachometer displays the engine rpm. The high idle rpm and the rated rpm are printed on the engine Information Plate.

# Engine Features and Controls

## Programmable System Parameters

i01225677

SMCS Code: 1900

### Configuration Parameters

Configuration parameters concern various engine features. Some parameters can affect the performance of the engine. Most of the parameters may be programmed with an Electronic Technician (ET) service tool. Some of the parameters require a password in order to be programmed.

**Note:** For information on programming the parameters, use the appropriate ET service tool and see the Service Manual, "Troubleshooting" module.

Some parameters may not be available on all applications. If a parameter is not available the ET service tool will indicate that the parameter is "unavailable" when the parameter is selected.

Table 4 is a list of typical configuration parameters.

Table 4

Typical Configuration Parameters	
Parameter	Programmability
Air shutoff (ON/OFF)	Yes
CAT Datalink #2 identifier	Yes
Crank duration	Yes
Crank terminate speed	Yes
Cold mode cylinder cutout	Yes
Cooldown speed	Yes
Droop (percent)	Yes
ECM serial number	No
Engine acceleration rate	Yes
Engine cooldown duration	Yes
Engine cooling system configuration <sup>(1)</sup>	Yes
Engine prelube duration	Yes
Engine rated speed	Software dependent
Engine rotation	Software dependent
Engine serial number	Yes

(continued)

(Table 4, contd)

Typical Configuration Parameters	
Parameter	Programmability
Equipment ID	Yes
Ether control (ON/OFF)	Yes
Fuel correction factor	Yes
Fuel ratio control offset	Yes
Low idle speed	Yes
Maximum number of crank cycles	Yes
Personality Module Part Number	Software dependent
Personality module release date	Software dependent
Rated fuel position	Yes
Total fuel	Yes
Total hours	Yes
Total tattletale	No

<sup>(1)</sup> Jacket water aftercooling or separate circuit aftercooling

The following parameters are programmed at the factory to "0":

- "Crank Duration"
- "Maximum Number Of Crank Cycles"

The "0" settings prevent the Electronic Control Module (ECM) from engaging the starting motors. The settings must be reprogrammed before the engine will crank.

Ensure that the "Air Shutoff" and the "Ether Control" parameters are "Enabled/ON" (if equipped) . If the engine does not have these options, ensure that these two parameters are "DISABLED/OFF".

If the engine is equipped with Prelube, the "Engine Prelube Duration" must be programmed to a value that is greater than "0" seconds. Otherwise, the prelube pump will not cycle. If the engine is not equipped with Prelube, the parameter must be programmed to "0".

The engine will have either jacket water aftercooling or separate circuit aftercooling. The correct configuration of the aftercooling system must be programmed.

No password is required for programming a new ECM during the first 100 hours of service life. This 100 hour “free configuration” feature enables the customer to tailor the programmable setpoints to the requirements of the installation. Exceptions are “Fuel Limit” and “Personality Module Mismatch”.

## Air Shutoff

**Note:** This is an optional feature.

The air shutoff uses a plate that rotates on a shaft in order to shut off inlet air to the aftercooler. The engine stops because of the restricted air supply to the combustion chamber. The air shutoff only actuates for the following conditions:

- The Emergency Stop button is pressed.
- An overspeed shutdown occurs.
- The operator manually activates the air shutoff with the emergency air shutoffs on the engine. **It is necessary to activate both of the air shutoffs in order to shut down the engine.**

**Both of the air shutoffs must be reset before the engine can be restarted.**

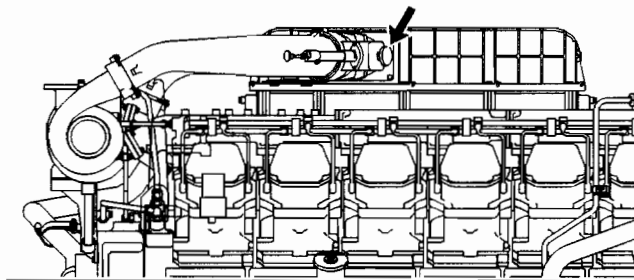


Illustration 28

g00393147

Reset knob for the air shutoff

To reset the air shutoff, turn the reset knob to the “OPEN” position.

**Ensure that both of the air shutoffs are reset.**

## Cold Mode Cylinder Cutout

**Note:** This feature can be enabled or disabled with an electronic service tool.

The Cold Mode Cylinder Cutout feature provides the following benefits:

- Reduction of white smoke during cold starting

- Reduction of the duration of advanced timing (cold mode)
- Reduction of ether injection

The ECM automatically turns off one electronic unit injector at a time during the following occurrences:

- Cold start-up
- Extended time at low idle

The ECM monitors the change of the fuel rack in order to determine if a cylinder is firing. If the cylinder is firing the ECM activates the electronic unit injector. If the cylinder is not firing the electronic unit injector remains deactivated. This reduces white smoke.

The following conditions must be met in order to activate the Cold Mode Cylinder Cutout:

- The Cold Mode Cylinder Cutout parameter is programmed to “ENABLE”.
- The fuel rack is less than 13 mm (.5 inch).
- The jacket water temperature is less than 63 °C (145 °F).

The Cold Mode Cylinder Cutout strategy is activated under either of the following conditions:

- Ten seconds after the engine reaches the low idle rpm
- Three seconds after ether injection is completed

The following conditions will deactivate the Cold Mode Cylinder Cutout:

- The Cold Mode Cylinder Cutout parameter is programmed to “DISABLED”.
- The jacket water temperature is more than 70 °C (158 °F).
- An ET service tool is used for the cold cylinder cut-out test.
- The ether injection system is used.
- The coolant temperature sensor has failed.
- The engine is operating at a certain rpm when the Cold Mode Cylinder Cutout is activated. If the engine rpm then varies by more than 50 rpm, the feature is deactivated for three seconds. A new engine speed is established when the feature is reactivated.

- The engine is at low idle rpm for ten seconds. If the engine speed is then reduced by more than 50 rpm, the Cold Mode Cylinder Cutout is deactivated for 30 seconds.
- If the fuel rack is greater than 13 mm (.5 inch), the Cold Mode Cylinder Cutout is deactivated for one second.

## Droop

This feature enables an engine to share a load with other engines. If an engine is operating at high idle rpm and a load is applied, the engine rpm is reduced. The engine rpm is reduced as the load increases. This reduction in rpm is the droop. The droop can be programmed from zero to ten percent. If the percent of droop is equal for two identical engines in parallel operation, the engines share the load equally.

## Ether Control

**Note:** This is an optional feature.

The ECM automatically injects ether into the air inlet manifold when the following conditions are met:

- The engine rpm is between 50 and 400 rpm.
- The jacket water temperature is below 21 °C (70 °F).

The duration of ether injection varies linearly with the jacket water temperature. The duration of ether injection varies within the following range:

- 15 seconds at the maximum temperature of 21 °C (70 °F)
- 130 seconds at the minimum temperature of -40 °C (-40 °F)

The longest duration of ether injection is 130 seconds even if the jacket water temperature is less than -40 °C (-40 °F). See Illustration 29.

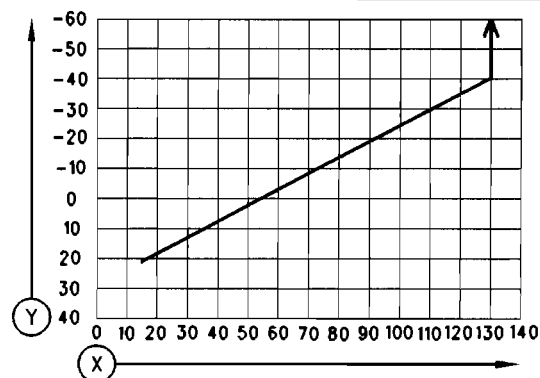


Illustration 29

g00576415

Jacket water temperature and duration of ether injection

(Y) Temperature in °C

(X) Time in seconds

A switch is installed on the control panel or the instrument panel. The switch enables the operator to inject ether manually under the following conditions:

- The switch for ether injection is in the manual position.
- The engine rpm is more than 50 rpm.
- The jacket water temperature is less than 21 °C (70 °F).

## Fuel Correction Factor

When the engine is shipped from the factory, an estimate of the engine's fuel consumption is programmed into the ECM. The estimate is based upon the engine's performance specifications. The actual fuel consumption can be determined with a meter that measures the flow of the fuel. Customers are likely to find a slight difference between the estimate of fuel consumption that was programmed and the actual fuel consumption. The customer can use an ET service tool to program the ECM for the actual fuel consumption. A factory level security password is required in order to change this parameter.

To program the ECM for the actual fuel consumption, change the Fuel Correction Factor that is already programmed into the ECM. The Fuel Correction Factor can be programmed in increments of 0.5 percent between  $\pm 25$  percent.



## Display of Engine Performance

i01234781

### Histogramming

The ET service tool can display the trends of the engine performance. The information can be used to improve the overall performance of the engine. The historical information is stored in a format that can be used to construct histograms. Data is available for the following parameters:

- Engine rpm
- Percent of engine load
- Left side exhaust temperatures
- Right side exhaust temperatures

### Incrementing the Hours of the ECM

A new ECM that is installed on an engine can be programmed to display the correct total number of operating hours for that engine. An ET service tool and a factory level security password are required.

### Adjusting the Total Fuel Consumption for the ECM

A new ECM that is installed on an engine can be programmed to display the correct total fuel consumption for that engine. An ET service tool and a factory level security password are required.

## Data Link Features

### CAT Data Link Flash

**Flash** – This is a method of downloading or programming electronic information.

The CAT Data Link Flash provides the capability to flash the software for the engine control with the CAT Data Link.

### Secondary CAT Data Link

The Secondary CAT Data Link provides the ability for each ECM to have a CAT Data Link that is "local" to that engine. This feature also provides a common data link to other engine controls. This enables the operator to communicate with multiple engines through a single Customer Communication Module (CCM).

The Secondary CAT Data Link provides the capability for two to eight engines to communicate via a single CCM.

## Monitoring System

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

### Caterpillar Monitoring System

The engine is equipped with a programmable Caterpillar Monitoring System. The Electronic Control Module (ECM) monitors the operating parameters of the engine. The ECM can initiate responses if a specific engine parameter exceeds an acceptable range. Three possible responses may be available for each parameter: "WARNING", "DERATE", and "SHUTDOWN". Some of the responses are not available for some of the parameters. An ET service tool is used to perform the following activities:

- Select the available responses.
- Program the level for monitoring.
- Program delay times for each response.

The default settings for the parameters are programmed at the factory. To accommodate unique applications and sites, the parameters may be reprogrammed with an ET service tool.

The screens of the ET service tool provide guidance for the programming. The following options can be programmed "ON" or "OFF": "WARNING", "DERATE", and "SHUTDOWN".

The screens of the ET service tool also provide guidance for changing setpoints. For information on programming the Caterpillar Monitoring System, use the appropriate ET service tool and see the Service Manual, "Troubleshooting" module.

The Caterpillar Monitoring System is enabled after the engine is started. When the engine rpm exceeds 50 rpm below low idle, the ECM begins checking parameters. The ECM monitors the parameters in order to determine if the parameters exceed the setpoints.

If the monitoring system initiates a warning, a deration, or a shutdown, the event is logged into the ECM. This occurs even if the parameter is programmed "OFF". If a setpoint for a parameter is exceeded, the event will be logged.

Any failure of a sensor will result in disabling the corresponding portion of the monitoring system. The failure of a sensor will cause an "ACTIVE" diagnostic code for the sensor.

The derating is cumulative. For example, a derating of five percent followed by a derating of two percent results in a total derating of seven percent. If the conditions that cause the derating are not corrected, the derating will continue.

## Default Settings for the Caterpillar Monitoring System

**Derate** – This is a reduction of engine horsepower in response to an abnormal operating condition.

**Setpoint** – This is a specific value which can activate the following responses: warning, deration, and shutdown. The setpoint can be a pressure, a speed, a temperature, or a voltage.

**Hysteresis** – This is the change in the signal from a sensor that is tolerated by the ECM. This is the difference between the setpoint that activates a response and the value that deactivates the response. For example, a warning for low voltage can activate if a value below 20 volts is detected by the ECM. The voltage must rise to 22 volts in order to clear the warning. The hysteresis is the 2 volts that are above the 20 volts.

### Voltage

The ECM automatically warns the operator of low system voltage. The default settings that are programmed at the factory are listed in Table 5.

Table 5

Voltage Monitoring	
Parameter	Default Setting
Warning setpoint	20 volts
Warning delay	10 seconds
Hysteresis	2 volts
Security level	No required password

If the voltage is below 20 volts for 10 seconds, a warning will occur. To deactivate the warning, the voltage must rise above 22 volts.

The setpoint can be programmed to a value between 20 and 22 volts.

### Engine Oil Pressure

The ECM automatically performs the following functions for low engine oil pressure:

- Warning
- Shutdown

The strategy is based on a map of the engine oil pressure versus the engine rpm. For engines that are rated up to 1300 rpm, see Illustration 30. For engines that are rated at 1301 rpm and above, see Illustration 31. The default settings that are programmed at the factory are listed in Table 6.

Table 6

Engine Oil Pressure	
Parameter	Default Settings
Upper oil pressure limit	175 kPa (25 psi)
Lower oil pressure limit	41 kPa (5.9 psi)
High engine speed limit	1250
Low engine speed limit	452
Hysteresis	40 kPa (5.8 psi)
Activation delay	10 seconds
Security level	Required password
Warning setpoint	Map
Warning delay	4 seconds
Shutdown setpoint	Map
Shutdown delay	9 seconds

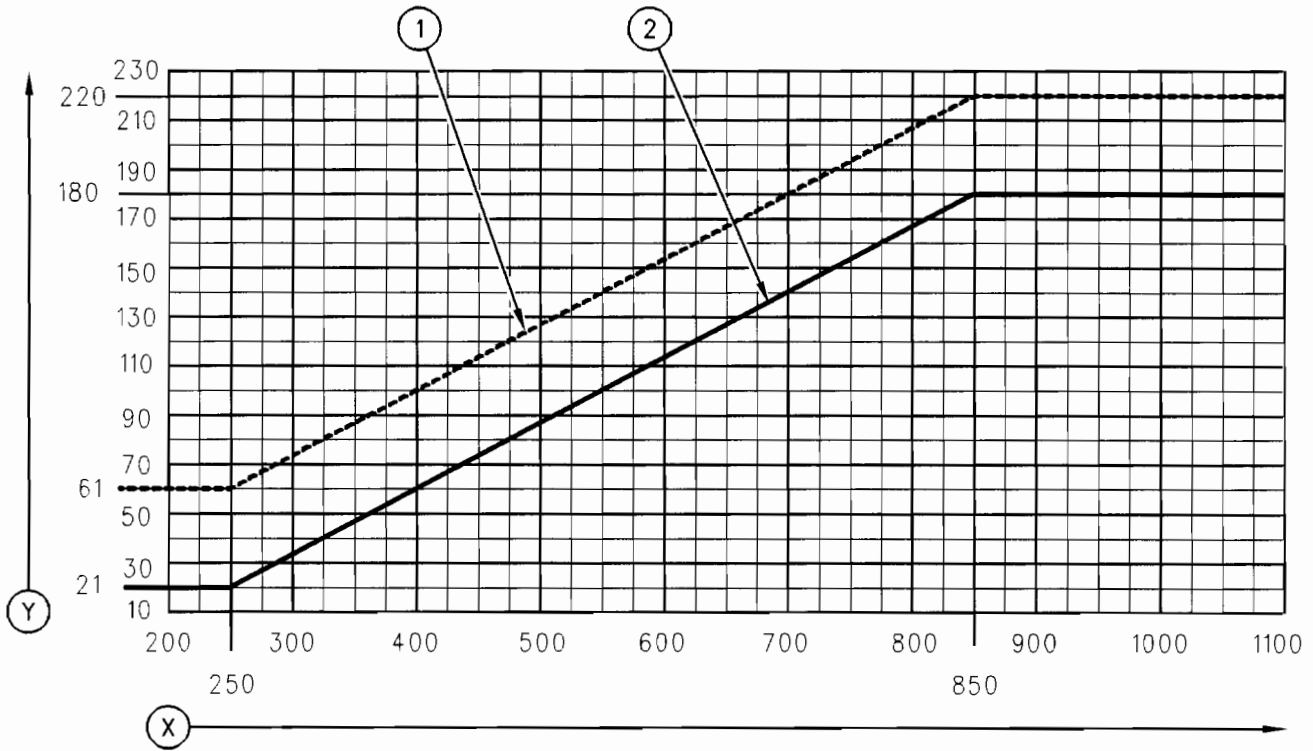


Illustration 30

g00570830

Map of the engine oil pressure versus the engine rpm for engines that are rated up to 1300 rpm

(Y) Engine oil pressure in kPa  
 (X) Engine rpm

(1) Hysteresis  
 (2) Minimum engine oil pressure

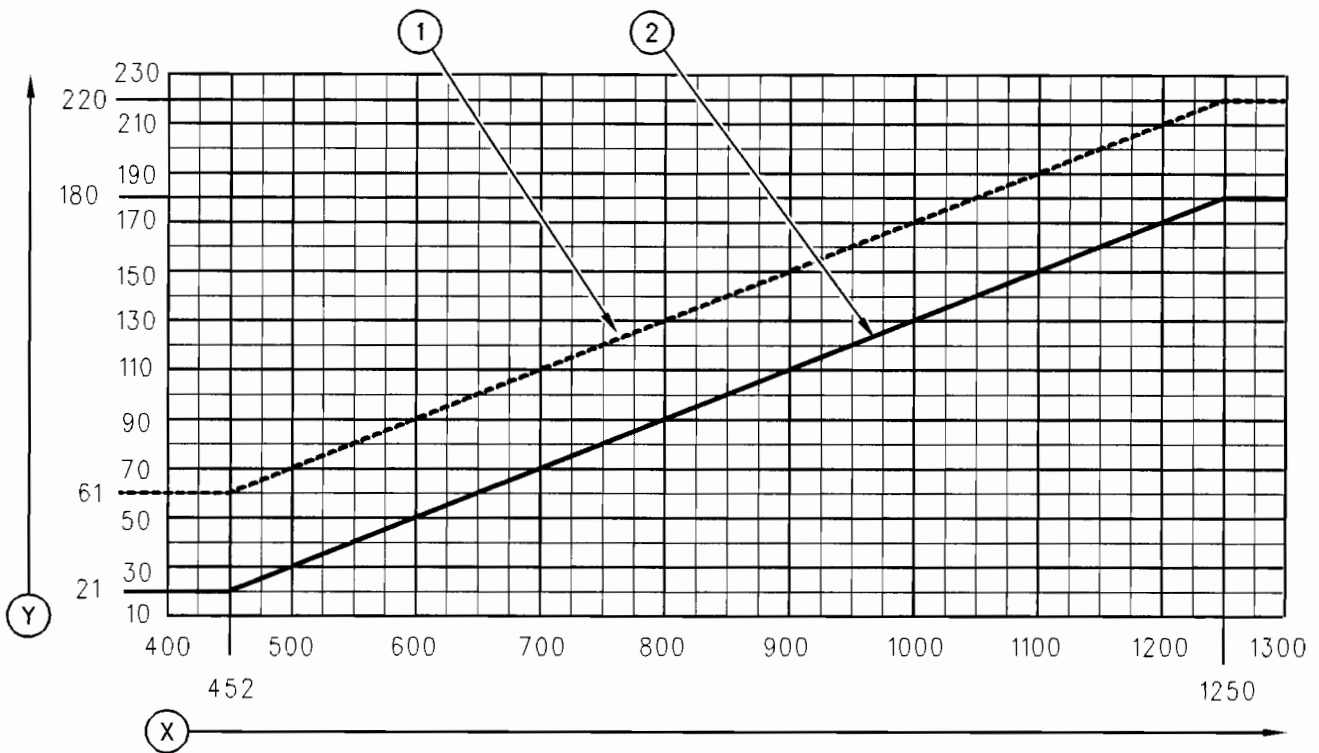


Illustration 31

g00592294

Map of the engine oil pressure versus the engine rpm for engines that are rated at 1301 rpm and above

(Y) Engine oil pressure in kPa  
 (X) Engine rpm

(1) Hysteresis  
 (2) Minimum engine oil pressure

If the engine oil pressure is below the minimum pressure for four seconds, a warning will occur. To deactivate the warning, the engine oil pressure must rise above the hysteresis that is set in the map.

If the engine oil pressure is below the minimum pressure for nine seconds, a shutdown will occur.

The map cannot be reprogrammed.

### High Coolant Temperature

The ECM will automatically perform the following functions for high coolant temperature:

- Warning
- Derating
- Shutdown

The default settings that are programmed at the factory are listed in Table 7.

Table 7

High Coolant Temperature	
Parameter	Default Setting
Warning setpoint	102 °C (216 °F)
Warning delay	5 seconds
Derate setpoint	107 °C (225 °F)
Derate delay	30 seconds
Maximum time of derating	480 seconds
Hysteresis	5 °C (9 °F)
Security level	Password required
Maximum derating	25%
Shutdown setpoint	107 °C (225 °F)
Shutdown delay	5 seconds

If the coolant temperature is above 102 °C (216 °F) for five seconds, a warning will occur. The coolant temperature must be below 97 °C (207 °F) in order to deactivate the warning.

If the coolant temperature is above 107 °C (225 °F) for 30 seconds, a derating will occur. A continuous 25 percent derating is reached in 480 seconds. When the coolant temperature is less than 102 °C (216 °F), the percent of the derating decreases. The percent of the derating decreases until the capability of providing full power is restored. However, if the coolant temperature rises above the setpoint again, the derating will resume.

If the coolant temperature is above 107 °C (225 °F) for five seconds, a shutdown will occur.

**Note:** The default setting for the delay of the derating is programmed to the maximum value of 30 seconds. The delay for the shutdown is five seconds. These settings result in a shutdown that occurs before a derating. These settings are programmed because most customers prefer a shutdown for high coolant temperature. The settings can be programmed to different values.

The setpoint can be programmed in the range of 90 to 102 °C (194 to 215 °F).

## Low Coolant Temperature

The ECM will automatically warn the operator of low coolant temperature. The default settings that are programmed at the factory are listed in Table 8.

Table 8

Low Coolant Temperature	
Parameter	Default Setting
Warning setpoint	80 °C (176 °F)
Warning delay	5 seconds
Activation delay	10 minutes
Hysteresis	5 °C (9 °F)
Security level	Password required

To activate this strategy, the engine must operate for a minimum of ten minutes at an average load of 20 percent or more. If the average load is 20 percent or more and the coolant temperature is below 80 °C (176 °F) for five seconds, a warning will occur. To deactivate the warning, one of the following conditions must occur:

- The average load for ten minutes must decrease to less than 20 percent.
- The coolant temperature must rise above 85 °C (185 °F).

The setpoint can be programmed in the range of 63 to 85 °C (145 to 185 °F).

**Note:** The low coolant temperature is monitored in order to detect a failure of the water temperature regulators. **This feature is not intended to monitor the operation of jacket water heaters.**

## Overspeed

The ECM will automatically perform the following functions if an engine overspeed occurs:

- Warning
- Shutdown

Different setpoints are based on the engine application and the engine rating. The default settings that are programmed at the factory are listed in Table 9.

Table 9

Overspeed	
Parameter	Default Setting
Warning setpoint	1.18 times the rated rpm
Warning delay	0 seconds
Shutdown setpoint	1.18 times the rated rpm
Shutdown delay	0 seconds
Hysteresis	100 rpm
Security level	Required password

If the engine speed exceeds the setpoint rpm, a warning and a shutdown will occur. The fuel will be shut off and the air shutoff (if equipped) will be activated.

### NOTICE

**Failure to reset air shutoffs prior to restart may result in severe engine damage.**

The air shutoff must be reset before the engine is restarted. **Ensure that both of the air shutoffs are reset.**

**Note:** The default settings for the warning and for the shutdown are equal. Therefore, the warning and the shutdown occur simultaneously. These settings were selected in order to log both a warning and a shutdown: furthermore, an overspeed condition can occur rapidly.

The setpoints can be programmed to a value between 1200 and 2400 rpm.

## Inlet Air Restriction

The ECM will automatically perform the following functions if a high inlet air restriction occurs:

- Warning
- Derating

The strategy is applied to the right side air filter and/or the left side air filter. The default settings that are programmed at the factory are listed in Table 10.

Table 10

Inlet Air Restriction	
Parameter	Default Setting
Warning setpoint	7 kPa (1 psi)
Warning delay	5 seconds
Derate setpoint	7 kPa (1 psi)
Derate delay	5 seconds
Security level	Password required
Derating per 1 kPa (.15 psi)	2%
Maximum restriction	25 kPa (3.6 psi)

If the inlet air restriction is above 7 kPa (1 psi) for five seconds, both a warning and a derating will occur. The continuous schedule of the derating is two percent per 1 kPa (0.15 psi). The maximum derating is 50 percent at 25 kPa (3.6 psi).

The derating remains at the maximum level until the situation is corrected. To reset the derating to zero percent, remove power from the ECM. The ECM will reset when power is returned.

### Altitude

The ECM automatically compensates for engine operation at higher elevations. The ECM derates the fuel delivery according to the barometric pressure. The barometric pressure is sensed by the atmospheric pressure sensor. The atmospheric pressure has an effect on the performance of the engine. Derating the fuel delivery maintains the temperatures of the exhaust gas within acceptable limits.

The derating of the engine starts at a specific barometric pressure. The barometric pressure is equal to the atmospheric pressure of an elevation. The atmospheric pressure is specific for the engine and for the engine rating. The default settings that are programmed at the factory are listed in Table 11.

Table 11

Altitude	
Parameter	Default Setting
Derate setpoint	2T specification
Security level	Required password
Derating per 305 m (1000 ft)	3%
Maximum derating	35% of the rated power

If the barometric pressure is below the setpoint, a warning and a derating will occur. The continuous schedule of the derating is three percent per 1 kPa (.15 psi) of pressure below the setpoint. The maximum derating is 35 percent.

### Exhaust Temperature

The ECM will automatically perform the following functions if a high exhaust temperature occurs:

- Warning
- Derating

The strategy is applied to the right side exhaust manifold and/or the left side exhaust manifold. The default settings that are programmed at the factory are listed in Table 12.

Table 12

Exhaust Temperature	
Parameter	Default Setting
Warning setpoint	2T specification
Warning delay	5 seconds
Derate setpoint	2T specification
Derate delay	5 seconds
Delay per step	15 seconds
Hysteresis	10 °C (18 °F)
Security level	Required password
Derating per step	2% per step

If the exhaust temperature is above the setpoint for the warning for five seconds, a warning will occur.

If the exhaust temperature is above the setpoint for the derating for five seconds, the derating will occur.

The derating reduces the power by two percent. This is followed by a 15 second delay. If the exhaust temperature is not reduced below the setpoint after the 15 second delay, the engine is derated another two percent.

When the exhaust temperature is reduced to less than the setpoint, two percent of the power is restored for every 15 seconds. This continues until full power is restored. However, if the exhaust temperature rises above the setpoint again, the derating resumes.

### Oil Filter Differential Pressure

The ECM automatically warns the operator of high oil filter differential pressure. The default settings that are programmed at the factory are listed in Table 12.

Table 13

<b>Oil Filter Differential Pressure</b>	
<b>Parameter</b>	<b>Default Setting</b>
Warning setpoint	105 kPa (15 psi)
Warning delay	5 seconds
Hysteresis	10 kPa (1.5 psi)
Security level	No required password

If the oil filter differential pressure is above 105 kPa (15 psi) for five seconds, a warning will occur. To deactivate the warning, the oil filter differential pressure must be below 95 kPa (13.5 psi).

### Fuel Filter Differential Pressure

The ECM automatically warns the operator of high fuel filter differential pressure. The default settings that are programmed at the factory are listed in Table 14.

Table 14

<b>Fuel Filter Differential Pressure</b>	
<b>Parameter</b>	<b>Default Setting</b>
Warning setpoint	105 kPa (15 psi)
Warning delay	5 seconds
Hysteresis	10 kPa (1.5 psi)
Security level	No required password

If the fuel filter differential pressure is above 70 kPa (10 psi) for five seconds, a warning will occur. To deactivate the warning, the fuel filter differential pressure must be below 60 kPa (8.7 psi).

### Crankcase Pressure

The ECM will automatically perform the following functions if high crankcase pressure occurs:

- Warning

- Derating
- Shut down

The default settings that are programmed at the factory are listed in Table 15.

Table 15

<b>Crankcase Pressure</b>	
<b>Parameter</b>	<b>Default Setting</b>
Warning setpoint	2 kPa (.3 psi)
Warning delay	3 seconds
Derate setpoint	6 kPa (.9 psi)
Derate delay	10 seconds
Maximum time of derating	480 seconds
Hysteresis	0.25 kPa (.036 psi)
Security level	Required password
Maximum derating	25%
Shutdown setpoint	3.5 kPa (.51 psi)
Shutdown delay	3 seconds

If the crankcase pressure is above 2 kPa (.3 psi) for three seconds, a warning will occur. To deactivate the warning, the crankcase pressure must be below 1.75 kPa (.254 psi).

If the crankcase pressure is above 6 kPa (.9 psi) for 10 seconds, a derating will occur. The continuous schedule of the derating will reach 15 percent in 480 seconds.

When the crankcase pressure is less than 5.75 kPa (.39 psi), the percent of the derating is decreased until full power is restored. However, if the crankcase pressure rises above the setpoint again, the derating resumes.

If the crankcase pressure is above 3.5 kPa (.51 psi) for three seconds, a shutdown will occur.

**Note:** The default settings result in a shutdown that occurs before a derating. These settings were selected for the reason that high crankcase pressure can occur rapidly. The settings can be reprogrammed.

### Aftercooler Coolant Temperature

**Note:** The following information concerns engines with separate circuit aftercooling. For engines with jacket water aftercooling, monitoring of the aftercooler coolant temperature is disabled. However, the jacket water coolant temperature is monitored for all engines.

The ECM will automatically perform the following functions when high aftercooler coolant temperature occurs:

- Warning
- Derating
- Shut down

The default settings that are programmed at the factory are listed in Table 16.

Table 16

Aftercooler Coolant Temperature	
Parameter	Default Setting
Generator set warning setpoint	102 °C (215 °F)
Marine auxiliary warning setpoint	50 °C (122 °F)
Warning delay	5 seconds
Derate setpoint	107 °C (225 °F)
Derate delay	5 seconds
Maximum time of derating	480 seconds
Hysteresis	3 °C (5.4 °F)
Security level	Password required
Maximum derating	25%
Shutdown setpoint	107 °C (225 °F)
Shutdown delay	5 seconds

If the aftercooler coolant temperature is above 102 °C (215 °F) for five seconds, a warning will occur. To deactivate the warning, the aftercooler coolant temperature must be below 99 °C (210 °F).

If the aftercooler coolant temperature is above 107 °C (225 °F) for five seconds, a derating will occur. The continuous schedule of the derating will reach 25 percent in 480 seconds.

When the aftercooler coolant temperature is less than 104 °C (220 °F), the percent of the derating is decreased until full power is restored. However, if the aftercooler coolant temperature rises above the setpoint again, the derating resumes.

If the aftercooler coolant temperature is above 107 °C (225 °F) for five seconds, a shutdown will occur.

## Alarms and Shutoffs

**SMCS Code:** 7400

This section contains some general information about the function of typical engine protective devices.

Alarms and shutoffs are electronically controlled. The operation of all alarms and shutoffs utilize components which are actuated by a sensing unit. The alarms and shutoffs are set at critical operating temperatures, pressures, or speeds in order to protect the engine from damage.

The alarms function in order to warn the operator when an abnormal operating condition occurs. The shutoffs function in order to shut down the engine when a more critical abnormal operating condition occurs. The shutoffs help to prevent damage to the equipment.

If an engine protective device shuts off the engine, always determine the cause of the shutoff. Make the necessary repairs before attempting to start the engine.

Become familiar with the following information:

- Types of the alarm and shutoff controls
- Locations of the alarm and shutoff controls
- Conditions which cause each control to function
- Resetting procedure that is required before starting the engine

For information about the specific alarms and shutoffs for the engine, see this Operation and Maintenance Manual, "Monitoring System" topic (Operation Section).

## Control Panel

**SMCS Code:** 7451

This section describes the Caterpillar Electronic Modular Control Panel II+ (EMCP II+). For more detailed information, see Service Manual, RENR1200, "Electronic Modular Control Panel II+ (EMCP II+) for EUI Engines". If your generator set is equipped with a different control panel, refer to the literature that is provided for the panel or the generator.



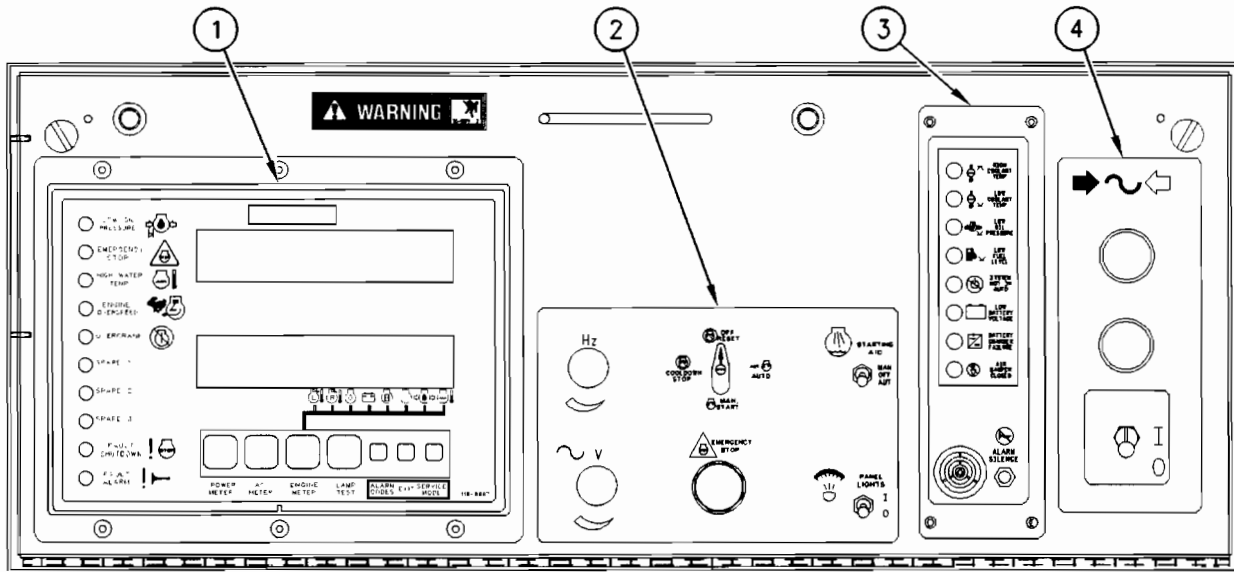


Illustration 32

g00578112

- (1) Generator Set Control + (GSC+)  
 (2) Control panel (operation)  
 (3) Alarm module (option)  
 (4) Synchronizing lights module (option)

Each component of the EMCP II+ is described below.

## Generator Set Control+

The Generator Set Control+ (GSC+) is the main component of the control panel. The control is powered by a battery system with 24 VDC or 32 VDC. The control has several functions and features.

The GSC+ controls normal starting and stopping of the engine. When a signal is received to start the engine, the fuel and the starting motor are activated. When the engine rpm reaches the crank terminate speed, the starting motor is disengaged. When a signal is received to stop the engine, the fuel is shut off.

The control system is designed to remove power from the GSC+ when the engine control switch is in the "OFF/RESET" position. However, the GSC+ will not permit power to be removed until the crank termination relay and the fuel control relay are off for approximately 70 seconds.

**Note:** A jumper wire may be installed between terminal 6 and terminal 9 of the engine control switch. The wire will allow the GSC+ to remain powered while the engine control switch is in the "OFF/RESET" position. This can be used by service technicians for troubleshooting shutdown faults that are active.

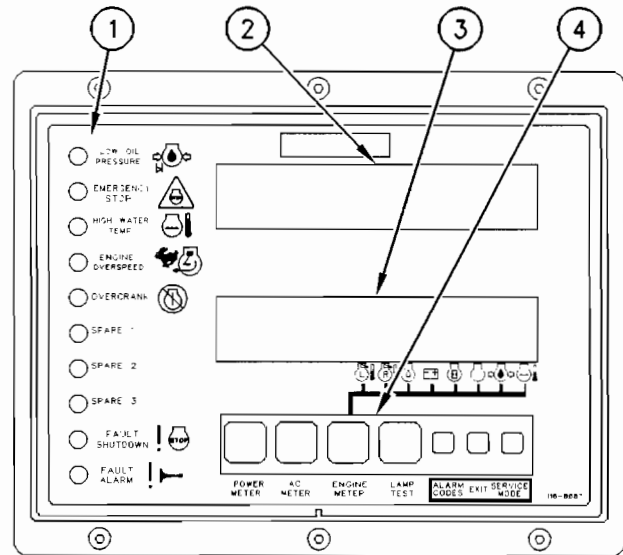


Illustration 33

g00578630

- (1) Indicators  
 (2) Upper display  
 (3) Lower display  
 (4) Keypad

The GSC+ activates indicators (1) for alarm conditions and for shutdown conditions. The GSC+ can transmit signals of the conditions to alarm modules in order to activate annunciation. The GSC+ controls shutdowns that are caused by events or by diagnostics from a failed component. For a description of the indicators, see the "Alarm Mode" and "Shutdown Mode" topics below.

The GSC+ monitors the status of engine operation and generator operation. Displays (2) and (3) can show the following items: status of engine operation, status of generator operation, event codes, diagnostic codes, and programmed information.

Keypad (4) is used for changing displays (2) and (3). The keypad is also used for programming certain features. For example, the crank cycle and the cooldown timer can be programmed.

**Note:** To ensure proper operation with EUI systems, the "P023" setpoint of the GSC+ must be programmed to a value of "2". Otherwise, the engine will not operate properly. Also, an erroneous component identifier ("590") will be logged. For information on programming, see Service Manual, RENR1200, "Electronic Modular Control Panel II+ (EMCP II+) for EUI Engines".

The GSC+ has connectors for an optional Customer Communication Module (CCM). The module enables remote monitoring and control of the generator set from a personal computer or other device with an RS-232C serial port.

The GSC+ has these four modes of operation: **normal, alarm, shutdown, and service.**

### Normal Mode

The GSC+ is in normal mode during normal operation. None of the indicators are illuminated. The upper display does NOT show "SERV".

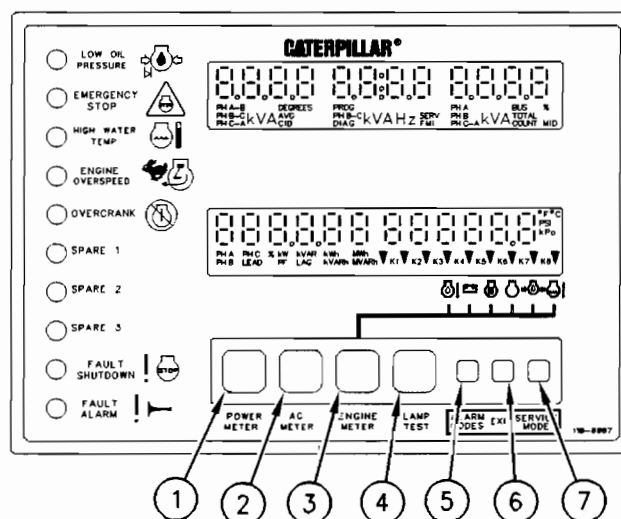


Illustration 34

g00578771

#### Keypad

- (1) "POWER METER"
- (2) "AC METER"
- (3) "ENGINE METER"
- (4) "LAMP TEST"
- (5) "ALARM CODES"
- (6) "EXIT"
- (7) "SERVICE MODE"

**Note:** Keys (1), (2), (3), (4), and (5) function differently when the GSC+ is in the service mode.

#### Upper display

The upper display shows the status of the following parameters for the generator: AC voltage, current, and frequency. To view the following information individually, press the "AC METER" key (2) (Illustration 34):

- Average voltage, frequency of the generator, and total current
- Line-to-line voltage, frequency of the generator, and line current for any phase
- Line-to-line voltage for all three phases
- Line current for all three phases
- Line to neutral voltage for all three phases

**Note:** When the total current increases to more than 9999 amperes, the current is displayed in KA.

**Note:** For delta generator sets, the line to neutral voltage is not shown when the "P032" setpoint is programmed to "1".

### Lower display

The lower display shows values for these items:

- Power output of the generator
- Status of engine parameters
- Status of the relays

The left side of the lower display serves as a power meter for the generator set. The following parameters scroll automatically: total real power (kW), total reactive power (KVAR), percentage of rated power (% kW), average power, and total output of energy (kW/h).






In order to display a particular parameter continuously, press "POWER METER" key (1) (Illustration 34) for less than five seconds.


If the "POWER METER" key is pressed for more than five seconds and then released, these additional parameters scroll on the display: total real power (kW), real power of each phase, total apparent power (kVA), total reactive power (KVAR), percentage of rated power (% kW), average power, power factor of each phase, total output of energy (kW/h), and total reactive power output (KVAR/h).


**Note:** All of the real values for power are identified with a positive "+" sign or a negative "-" sign. A negative sign indicates reverse power.


**Note:** For delta generator sets, the real power and the power factor for all three phases are not displayed when the "P032" setpoint is programmed to "1".

The right side of the lower display shows the value of the following engine parameters:

-  Exhaust temperature (left)
-  Exhaust temperature (right)
-  Engine oil temperature (option)
-  System battery voltage
-  Engine hours

 Engine rpm

 Engine oil pressure

 Engine coolant temperature

The value of a parameter is displayed for two seconds before the value of the next parameter is displayed. A pointer above the symbol identifies the corresponding parameter. See Illustration 35.

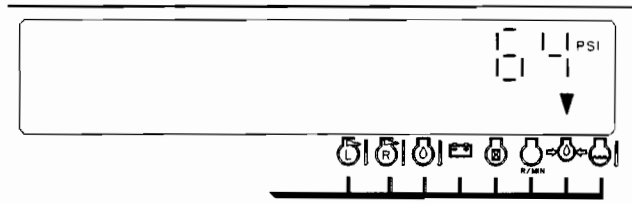


Illustration 35

g00579439

Engine oil pressure of 64 psi

When "ENGINE METER" key (3) (Illustration 34) is pressed, the value for one parameter is displayed continuously. The pointer flashes above the symbol for the parameter.

For more information on the engine parameters, see this Operation and Maintenance Manual, "Gauges and Indicators" topic.

The status of the relays is displayed on the bottom of the lower display. When a relay is activated, the corresponding relay is shown. The relays are represented by "K1", "K2", etc.

### Alarm Mode

**Note:** An alarm will activate if a setpoint that is programmed into the monitoring system for a parameter is reached. For information on the setpoints, see this Operation and Maintenance Manual, "Monitoring System" topic (Operation Section).

 "FAULT ALARM"

An alarm indicates a serious condition that requires immediate attention. If an alarm condition occurs, the yellow "FAULT ALARM" indicator flashes.

If the panel has an optional alarm module, an indicator on the module will also flash and the horn will annunciate. See the "Alarm Module" topic below.

To determine the cause of the alarm, press "ALARM CODE" key (5) (Illustration 34). The event code will appear on the upper display. For descriptions of the codes, see Service Manual, RENR1200, "Electronic Modular Control Panel II+ (EMCP II+)" for EUJ Engines" or refer to the film on the door of the control panel.

### Lamp Test

To test the operation of the indicators, press "LAMP TEST" key (4) (Illustration 34). The ten indicators will illuminate continuously and every segment of the upper display and the lower display are ON. If the alarm module (option) is included, all of the indicators are ON and the horn annunciates. If the "LAMP TEST" key is pressed for more than ten seconds, the lamp test is deactivated.

### Shutdown Mode



#### "FAULT SHUTDOWN"

If a shutdown occurs, the red "FAULT SHUTDOWN" indicator flashes. The engine is shut down immediately. If the event is caused by a condition that is associated with one of the five dedicated shutdown indicators, the indicator will also flash.

**Spare indicators** – In addition to the dedicated shutdown indicators, three spare indicators are included. The spare indicators are programmable. Two of the indicators may be used to indicate "COOLANT LOSS" and "HIGH OIL TEMPERATURE". The third indicator can be programmed according to the requirements of the customer.



#### "LOW OIL PRESSURE"



#### "EMERGENCY STOP"



#### "HIGH WATER TEMPERATURE"



#### "ENGINE OVERSPEED"



### OVERCRANK

**Note:** The GSC+ can be programmed to override the shutdowns for "LOW OIL PRESSURE" and "HIGH WATER TEMPERATURE". These conditions are programmed at the factory as shutdowns. When these conditions are overridden, the events are treated as alarm conditions. Rather than flash, the indicators will illuminate continuously. The engine can be started and operated even if the alarm condition is present.

If the shutdown condition is NOT associated with one of the five dedicated shutdown indicators, an event code will be immediately shown on the upper display. For descriptions of the codes, see Service Manual, RENR1200, "Electronic Modular Control Panel II+ (EMCP II+)" for EUJ Engines" or refer to the film on the door of the control panel.

After a shutdown, the engine will not be allowed to start until the condition is corrected. Before the engine can be started, the engine control switch must be turned to the "OFF/RESET" position.

The air shutoff (if equipped) is activated if the shutdown is caused by one of these occurrences: emergency stop, engine overspeed, and failure of the speed sensor. In addition to the engine control switch, the air shutoff must be reset before the engine can be restarted.

### Service Mode

Keys (1), (2), (3), (4), and (5) function differently when the GSC+ is in the service mode. Illustration 36 shows the functions of the keypad when the GSC+ is in the service mode. The film on the door of the control panel also shows the functions.

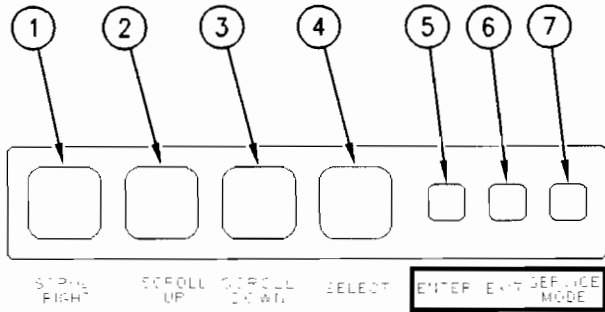


Illustration 36

g00579657

Functions of the keypad during the service mode

- (1) "SCROLL RIGHT"
- (2) "SCROLL UP"
- (3) "SCROLL DOWN"
- (4) "SELECT"
- (5) "ENTER"
- (6) "EXIT"
- (7) "SERVICE MODE"

**"SCROLL RIGHT" key (1)** – This key is used for viewing of information and for scrolling of information. This key represents the number 1 when the password is entered.

**"SCROLL UP" key (2)** – This key is used for scrolling up through information and for increasing the value of the information. This key represents the number 2 when the password is entered.

**"SCROLL DOWN" key (3)** – This key is used for scrolling down through information and for decreasing the value of the information. This key represents the number 3 when the password is entered.

**"SELECT" key (4)** – This key is used to select the information for viewing or for changing. This key is also used for starting and stopping of scrolling.

**"ENTER" key (5)** – This key is used to enter information into the memory of the GSC+.

**"EXIT" key (6)** – This key only functions when the GSC+ is in the service mode. Press this key in order to exit the service mode.

**"SERVICE MODE" key (7)** – Press this key in order to activate the service mode. The upper display will flash "SERV".

The service mode cannot be activated under the following conditions:

- A shutdown condition is active. To temporarily deactivate a shutdown condition, turn the engine control switch to the "OFF/RESET" position.

- If the wire from terminal 6 to terminal 9 is not installed on the engine control switch, the GSC+ does not power up when the switch is in the "OFF/RESET" position. Any active shutdown condition must be corrected before the service mode can be activated.
- The engine control switch is in the "AUTO" position.

After the service mode is activated, the keypad can be used for the options that are listed in Table 17.

Table 17

Options of the Keypad During Service Mode	
Option	Description
OP1 (1)	View the fault codes.
OP2-0 (1)	View the setpoints for the engine and/or the generator.
OP2-1 (1)	View the setpoints of the protective relays.
OP2-2 (1)	View the setpoints for the calibration that was programmed at the factory.
OP3 (1)	Enter the password.
OP4 (2)	Clear the fault codes.
OP5-0 (2)	Program the engine and/or the generator.
OP5-1 (2)	Program the protective relays.
OP6 (2)	Program the spare inputs and outputs.
OP7 (2)(3)	Program the hour meter.
OP8 (2)	Program the voltmeter and/or the ammeter.
OP9 (2)	Verify the setpoints for the engine.
OP10 (2)	Adjust the offset of the AC.

(1) A password is NOT required.

(2) A password IS required.

(3) This option is not available for EUI systems.

For a complete description of the service mode, see Service Manual, RENR1200, "Electronic Modular Control Panel II+ (EMCP II+) for EUI Engines".

## Control Panel (Operation)

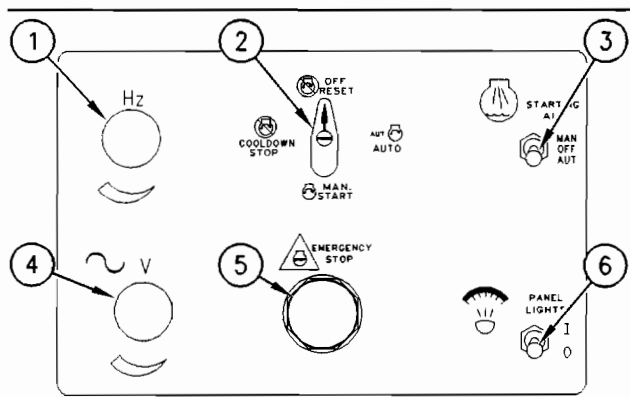


Illustration 37

g00578489

- (1) Speed potentiometer (option)
- (2) Engine control switch
- (3) "STARTING AID" switch (option)
- (4) Voltage adjust rheostat
- (5) "EMERGENCY STOP" button
- (6) "PANEL LIGHTS" switch

**Speed potentiometer (1)** – The potentiometer is used to control the engine rpm and the frequency of the generator.

**Engine control switch (2)** – This switch is used to control the engine operation. The switch has these four positions: "AUTO", "MAN. START", "COOLDOWN/STOP", and "STOP/RESET".

**"AUTO"** – This position (3 o'clock) enables the operator to control the engine from a remote location via a Customer Communication Module. The engine will start when the remote start/stop initiate contact is closed. The engine will shut down after the remote start/stop initiate contact opens. However, if the cooldown feature is programmed the engine will operate for the cooldown period before stopping.

**"MAN. START"** – When the switch is turned to this position (6 o'clock), the engine will start. The engine will continue to run until the GSC+ receives a shut down signal.

**"COOLDOWN/STOP"** – This position (9 o'clock) is used for manual stopping. If the cooldown feature is programmed, the engine will operate for a cool down period when the switch is turned to this position. After the cooldown, the fuel injection is terminated in order to stop the engine. If the cooldown feature is not programmed, the engine will stop immediately. The power to the control panel is maintained when the switch is in this position. The cooldown can be programmed from 0 to 30 minutes. The default cooldown is 5 minutes.

**"STOP/RESET"** – When the switch is turned to this position (12 o'clock), power is removed from the control panel unless a jumper wire is installed between terminal 6 and terminal 9 of the engine control switch. This position will also reset the fault indicators if any events have occurred. If the engine is operating, the engine is immediately shut off. This position is not recommended for normal engine shutoff.

**"STARTING AID" switch (3)** – This optional switch can be used to manually inject ether during start-up. The switch is normally in the "OFF" position. The "AUT" position allows the ECM to automatically control the ether injection. When the operator holds the switch in the "MAN" position, ether is injected according to the strategy that is described in this Operation and Maintenance Manual, "Programmable System Parameters" topic (Operation Section).

**Voltage adjust rheostat (4)** – The rheostat is used to adjust generator voltage to the desired level. This control is used instead of the rheostat that is located on the voltage regulator of the generator.

**"EMERGENCY STOP" button (5)** – This button is used to stop the engine quickly in an emergency situation. When this button is pressed, the fuel injection is disabled and the air shutoffs (if equipped) are activated.

**"PANEL LIGHTS" switch (6)** – This switch turns the panel lights on and off.

## Alarm Module

An alarm condition will not shut down the engine. However, an alarm may precede a shutdown. An alarm indicates a serious condition that requires immediate attention. If an alarm condition occurs, the alarm module uses an indicator and a horn in order to inform the operator.

Alarm modules are optional. There are several different types of alarm modules. The features of an alarm module are identified in Illustration 38.

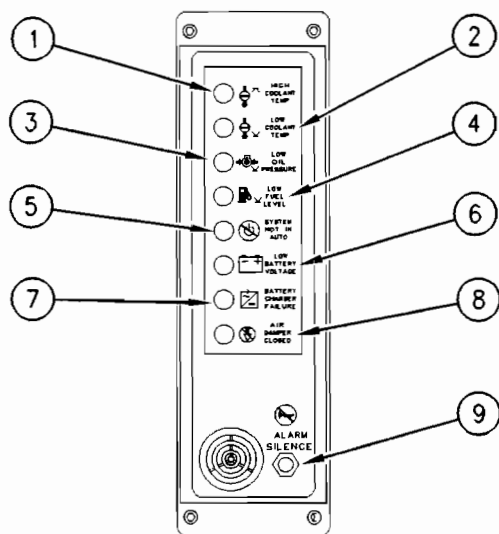


Illustration 38

g00579773

- (1) "HIGH COOLANT TEMPERATURE"
- (2) "LOW COOLANT TEMPERATURE"
- (3) "LOW OIL PRESSURE"
- (4) "LOW FUEL LEVEL"
- (5) "SYSTEM NOT IN AUTO"
- (6) "LOW BATTERY VOLTAGE"
- (7) "BATTERY CHARGER FAILURE"
- (8) "AIR DAMPER CLOSED"
- (9) "ALARM SILENCE" switch

The following four indicators are yellow:



"HIGH COOLANT TEMPERATURE" (1)



"LOW COOLANT TEMPERATURE" (2)



"LOW OIL PRESSURE" (3)



"LOW FUEL LEVEL" (4)

**Note:** These other yellow indicators are available as options: "GENERATOR ON LOAD", "CHARGER MALFUNCTION", "LOW OIL LEVEL", and "LOW COOLANT LEVEL".

The following four indicators are red:



"SYSTEM NOT IN AUTO" (5)



"LOW BATTERY VOLTAGE" (6)



"BATTERY CHARGER FAILURE" (7)



"AIR DAMPER CLOSED" (8)



"ALARM SILENCE" (9)

**Note:** These other red indicators are available as options: "LOW OIL PRESSURE SHUTDOWN", "OVERCRANK SHUTDOWN", "HIGH COOLANT TEMPERATURE SHUTDOWN", and "OVERSPEED SHUTDOWN".

To silence the horn, press "ALARM SILENCE" switch (9).

The following six versions of the basic alarm module are available. The only differences are the films on the fronts of the modules and the wiring.

- An alarm module for standby applications that meets the "National Fire Protection Association (NFPA) 99" requirement
- A remote annunciator panel that is used with the above alarm module ("NFPA 99")
- An alarm module for standby applications that meets the "NFPA 110" requirement
- An alarm module for single engines in prime power applications
- An alarm module for multiple engines in prime power applications
- The EMCP II+ remote annunciator panel

Custom alarm modules are also available for use in the control panel or in remote locations. The conditions that activate the custom alarm modules are determined by the customer. Labels can be provided for the custom alarm modules.

For the following information on alarm modules, see Service Manual, RENR1200, "Electronic Modular Control Panel II+ (EMCP II+) for EUI Engines": installation, wiring, and requirements of the NFPA.

## Synchronizing Lights Module

---

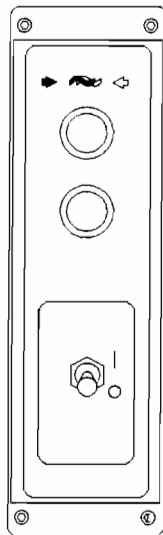


Illustration 39

g00579837

### Synchronizing lights module

The synchronizing lights module is optional. The synchronizing lights are used to assist in the manual paralleling of generator sets.

The two lights are connected between the generator and the side of the generator circuit breaker with a load. The voltage of two phases are measured. The lights indicate when the voltage is in phase. The generator can then be placed on-line with the other generators.

For instructions on paralleling two generators, see Operation and Maintenance Manual, SEBU6918, "SR4B Generator Set Control Panels".

i01097020

## Instrument Panel

**SMCS Code:** 7451

**Note:** This section describes the Caterpillar Electronic Instrument Panel. For more detailed information, see Service Manual, SENR6587, "3500B Electronic Instrument Panel". If your engine is equipped with a different instrument panel, refer to the literature that is provided for the panel.



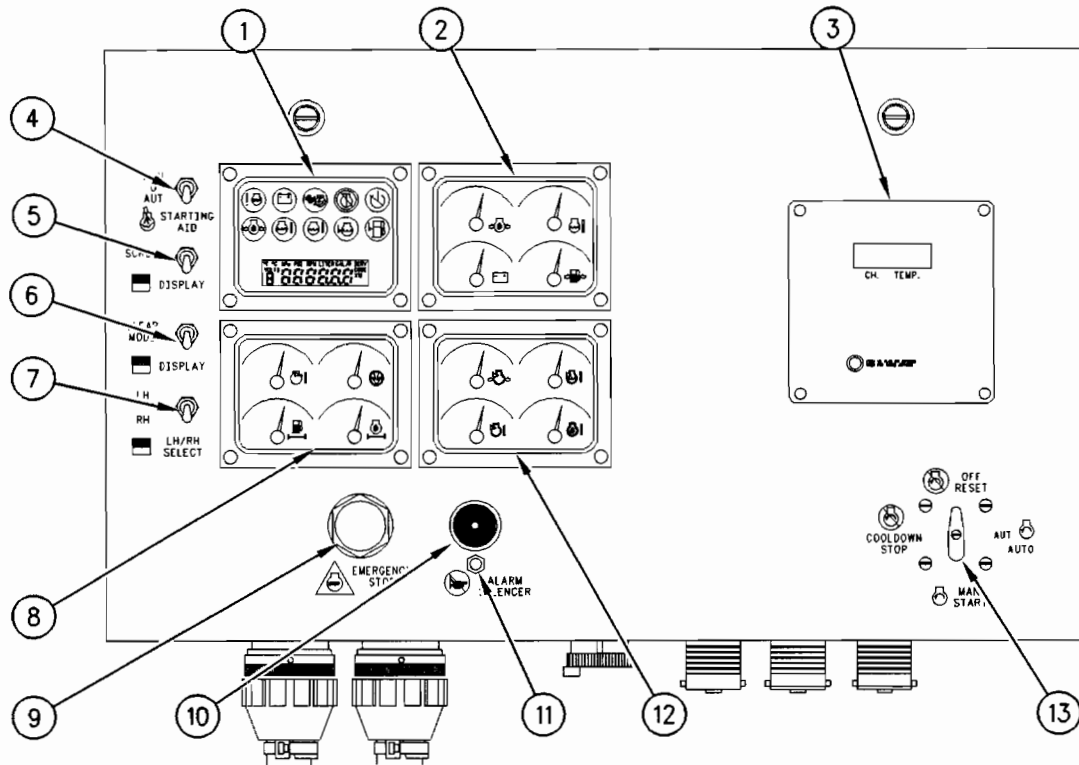


Illustration 40

g00576313

- |                           |                                |                                   |
|---------------------------|--------------------------------|-----------------------------------|
| (1) Main display module   | (6) "CLEAR/MODE" switch        | (11) Action alarm                 |
| (2) Gauge cluster module  | (7) "LH/RH" switch             | (12) Premium gauge cluster module |
| (3) Pyrometer             | (8) Prime gauge cluster module | (13) Engine control switch        |
| (4) "STARTING AID" switch | (9) "EMERGENCY STOP" button    |                                   |
| (5) "SCROLL" switch       | (10) "ALARM SILENCER" switch   |                                   |

The electronic instrument panel is the center for engine control and for information about engine operation. Each component of the instrument panel is described below.

**Main display module (1)** – This module is the main component of the system. The module receives information from the switches, sensors and other electronic controls on the engine via the CAT Data Link. The module processes the information. The information is output to the gauge clusters and/or the action alarm.

**Gauge cluster modules (2), (8), and (12)** – Every electronic instrument panel is equipped with main display module (1) and gauge cluster module (2). Prime gauge cluster module (8) is optional. The premium gauge cluster module (12) and pyrometer (3) are options that can be obtained in addition to the prime gauge cluster module. The gauge needles and the pyrometer are controlled by information that is processed by the main display module.

**Pyrometer (3)** – The pyrometer displays the exhaust temperature from the exhaust port of each cylinder head. Additionally, the pyrometer can display the temperature of both exhaust stacks.

**"STARTING AID" switch (4)** – This switch is used to manually inject ether during start-up. The switch is normally in the "AUT" position. The automatic position allows the electronic control module (ECM) to automatically control the ether injection. When the operator holds the switch in the "MAN" position, ether is injected according to the strategy that is described in this Operation and Maintenance Manual, "Programmable System Parameters" topic (Operation Section).

**"SCROLL" switch (5)** – The main display module is capable of five different modes of operation. The "SCROLL" switch is used to display the various parameters that are within each mode. See the "Main Display Module" topic.

**"CLEAR/MODE" switch (6)** – This switch is used for selecting among the main display module's five modes of operation. This switch is also used for clearing information from the main display module.

**"LH/RH" switch (7)** – This toggle switch is used in order to display the exhaust temperature and the inlet air restriction for the left side or the right side of the engine.

**Emergency Stop button (9)** – This button is used to stop the engine quickly in an emergency situation. When this button is pressed, the fuel injection is disabled and the air shutoffs are activated.

**Action alarm (10)** – Annunciation of the alarm informs the operator of an abnormal operating condition or a problem with the monitoring system.

**“ALARM SILENCER” switch (11)** – This push button allows the operator to silence the action alarm. The switch will silence the alarm for five minutes. If the condition that initiated the alarm is not corrected within the five minute period, the alarm will annunciate again.

**Engine control switch (13)** – This switch is used to control the engine operation. The switch has these four positions: “AUTO”, “MAN.START”, “COOLDOWN/STOP”, and “OFF/RESET”.

**“AUTO”** – This position enables the operator to control the engine from a remote location.

**“MAN.START”** – When the switch is turned to this position, the engine will start. The engine will continue to run until the ECM receives a shut down signal.

**“COOLDOWN/STOP”** – This position is used for manual engine stopping. If the cooldown feature is programmed, the engine will operate for a cool down period. After the cooldown, the fuel injection is terminated in order to stop the engine. If the cooldown feature is not programmed, the engine will stop immediately. The power to the control panel is maintained when the switch is in this position.

**“OFF/RESET”** – When the switch is turned to this position, power is removed from the control panel. This position will also reset the system if any events have occurred. If the engine is operating, the engine is immediately shut off. This position is not recommended for normal engine shutoff.

## Gauge Cluster Modules

Every electronic instrument panel is equipped with a main display module and a gauge cluster module. The prime gauge cluster module is optional. The premium gauge cluster module and a pyrometer are options that can be obtained in addition to the prime gauge cluster module.

The gauge needles are controlled by information that is processed by the main display module. During normal operation, most of the gauge needles are at the 12 o'clock position. Use the data from the engine commissioning as a baseline for comparison of gauge readings.

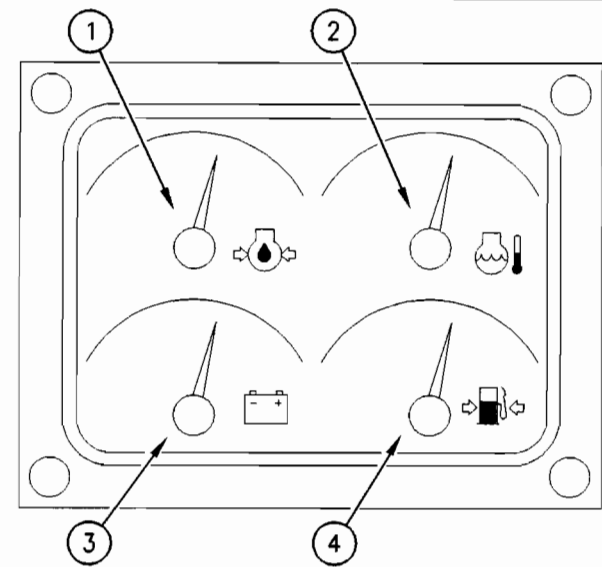


Illustration 41

g00572455

The gauge cluster module displays the following parameters:

- (1) Engine oil pressure
- (2) Jacket water temperature
- (3) System voltage
- (4) Fuel pressure

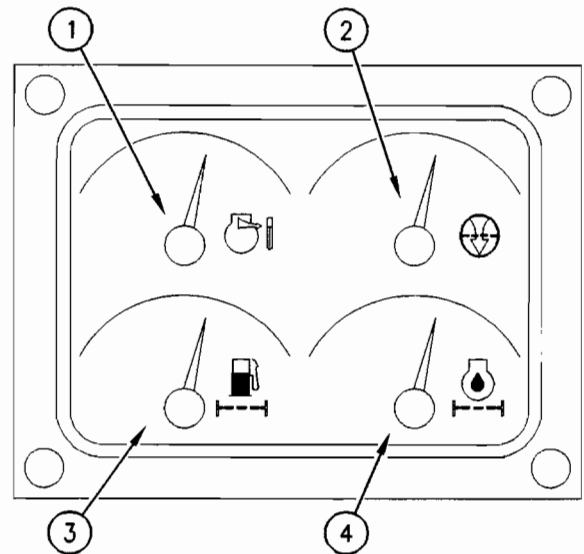


Illustration 42

g00572459

The prime gauge cluster module displays the following parameters:

- (1) Exhaust temperature (right side and left side)
- (2) Inlet air restriction (right side and left side)
- (3) Fuel filter differential pressure (restriction)
- (4) Oil filter differential pressure (restriction)

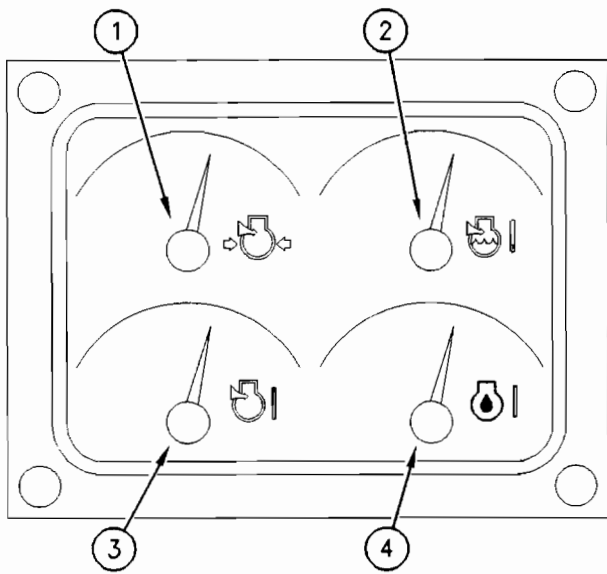


Illustration 43

g00581514

The premium gauge cluster module displays the following parameters:

- (1) Inlet manifold air pressure (boost pressure)
- (2) Aftercooler coolant temperature
- (3) Inlet manifold air temperature
- (4) Engine oil temperature

For more information on the gauges, see this Operation and Maintenance Manual, "Gauges and Indicators" topic (Operation Section).

## Pyrometer

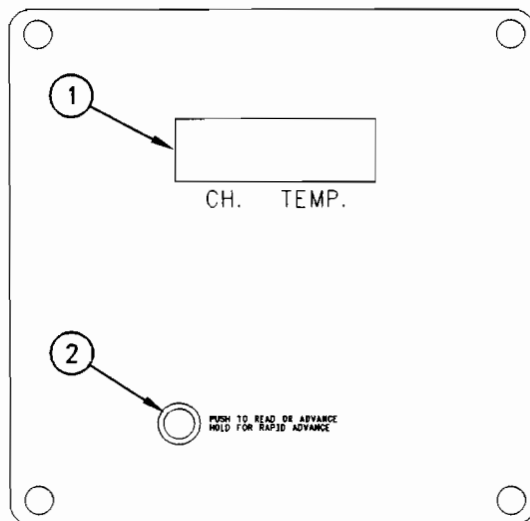


Illustration 44

g00572547

Pyrometer

- (1) Display
- (2) Button

The pyrometer displays the temperature of the exhaust for the exhaust port of each individual cylinder and for the exhaust stacks. When button (2) is pressed, display (1) identifies the cylinder number (channel) and the corresponding temperature. To advance the display, press the button. To scroll rapidly, keep the button depressed.

For engines with 12 cylinders, channels 1 through 12 represent the cylinder numbers. Channels 13 through 16 will be displayed with a default temperature. For all engines, channels 17 and 18 represent the exhaust stacks.

## Main Display Module

The main display module is the brain of the system. The display on this module includes LED indicators and a liquid crystal display.

## Indicators

The indicators illuminate in response to information that is received from the ECM via the CAT Data Link.

**Note:** The indicators will illuminate if a setpoint that is programmed into the monitoring system for a parameter is reached. For information on the setpoints, see this Operation and Maintenance Manual, "Monitoring System" topic (Operation Section).

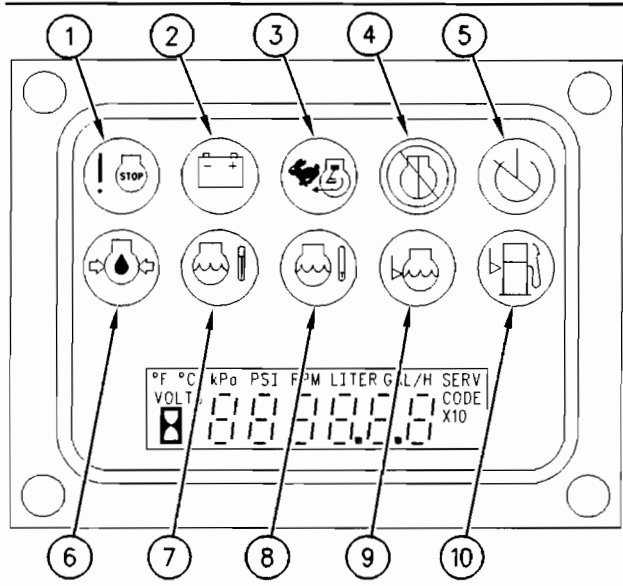


Illustration 45 g00581517

Indicators for the main control module

- (1) Active diagnostic code and engine shutdown
- (2) Low system voltage
- (3) Engine overspeed
- (4) Overcrank
- (5) Not in AUTO
- (6) Low engine oil pressure
- (7) High coolant temperature
- (8) Low coolant temperature
- (9) Low coolant level
- (10) Low fuel level



**Active diagnostic code and engine shutdown (1)** – This RED indicator illuminates when any of the following conditions occur:

- An engine shutdown is initiated by the ECM.
- A diagnostic code is active.
- An event code is active.



**Low system voltage (2)** – This RED indicator illuminates if the system voltage (battery and alternator) that is supplied to the ECM is below the setpoint that is programmed. The indicator will also illuminate if the battery charger (if equipped) is not charging.



**Engine overspeed (3)** – This RED indicator illuminates when the ECM has detected an engine overspeed condition.



**Overcrank (4)** – This RED indicator illuminates if the engine fails to start within the time that is programmed for the crank cycle.



**Not in AUTO (5)** – This RED indicator illuminates when the engine control switch is not in the “AUTO” position. Automatic starting and stopping from a remote location is only possible when the engine control switch is in the “AUTO” position.



**Low engine oil pressure (6)** – This YELLOW indicator illuminates when the engine oil pressure is below the setpoint that is programmed at the factory. The setpoint is based on a map of minimum oil pressure versus engine speed. This value cannot be reprogrammed.



**High coolant temperature (7)** – This YELLOW indicator illuminates when the engine coolant temperature is above the setpoint.



**Low coolant temperature (8)** – This YELLOW indicator illuminates when the engine coolant temperature is below the setpoint.



**Low coolant level (9)** – This YELLOW indicator illuminates when the engine coolant level is low. The coolant level sensor is supplied by the customer.



**Low fuel level (10)** – This YELLOW indicator illuminates when the level of fuel in the tank is low. A fuel level switch with contacts that are normally closed is supplied by the customer.

**Liquid Crystal Display (LCD)**

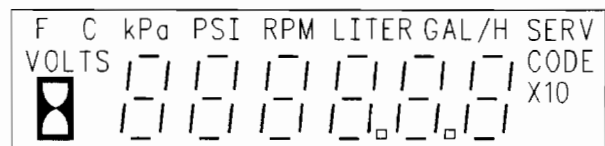


Illustration 46

g00380856

Liquid crystal display (LCD)

The liquid crystal display (LCD) includes the following items:

- A row of six digits and two decimal points
- Nine symbols for units of measure
- An “X10” symbol for specific applications
- A symbol for the service hour meter

The operator can control the display of the LCD with switches that are on the instrument panel. The type of information that is displayed depends on the mode of the main display module.

## Modes of the Main Display Module

The main display module has six different modes of operation. Each mode provides information about engine operation. To change the mode, push the "CLEAR/MODE" switch to the "MODE" position. Table 18 lists the modes.

Table 18

Modes Of The Main Display Module	
Mode	Mode Number
Normal	0
Numeric Readout	1
Service	2
Tattletale	3
Units	4
Harness Code	5

### Normal Mode (Mode 0)

This mode is used for normal engine operation. During Normal mode, the instrument panel performs the following functions:

- A self test is performed when the main display module is powered up. This indicates that the monitoring system is operating properly. See the "Self Testing" topic.
- The main display module continuously monitors the engine systems. Information for the positioning of the gauge needles is supplied by input from sensors. Most of the gauge needles indicate a normal operating condition when the needles are in the 12 o'clock position.
- If an abnormal operating condition occurs, the corresponding indicator flashes and the Action Alarm annunciates.
- If a diagnostic code is detected, "SERV CODE" appears on the LCD.
- When "RPM" is shown on the LCD, the engine rpm is displayed.
- When the symbol for the service hour meter is shown on the LCD, the sum of the hours of engine operation are displayed.

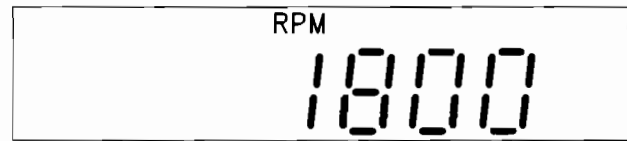


Illustration 47  
Tachometer (1800 rpm)

g00384915

**Tachometer** – This gauge indicates the engine rpm. When the LCD shows "RPM", the LCD is functioning as a tachometer. The high idle rpm and the full load rpm are stamped on the engine Information Plate.

To display the service hour meter, toggle the "SCROLL" switch.

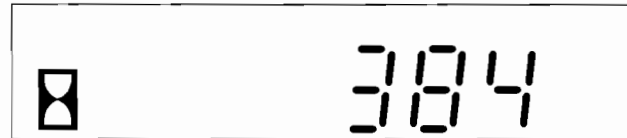



Illustration 48  
Service hour meter (384 service hours)

g00384916

 **Service hour meter** – This meter indicates the total number of clock hours that the engine has operated. When the LCD shows the symbol for the hour meter, the LCD is functioning as a service hour meter. The value is continuously updated during engine operation. The ECM records the total number of service hours.

### Numeric Readout Mode (Mode 1)

Numeric Readout mode provides the operator with information about the following parameters:

- Engine load
- Fuel consumption
- Gauge readings

The information about engine load and fuel consumption is displayed on the LCD only. The gauge readings are displayed with more accuracy on the LCD.

To initiate Mode 1 operation, hold the "CLEAR/MODE" switch in the "MODE" position until "-1-" appears on the LCD.

- An identifier for the gauge will be displayed prior to a value for the parameter. The LCD will momentarily show the "GA-1" identifier. This identifies gauge 1.
- The value of the parameter will be displayed.
- When a value for a gauge is displayed, the corresponding gauge needle is active. All of the other gauge needles default to the minimum position.

Use the "SCROLL" switch to advance the display to the next parameter. The LCD will show the identifier for the gauge first. Next, the value for the parameter is displayed.

Table 19 is a list of the system identifiers that appear on the LCD and the corresponding parameters.

Table 19

Numeric Readout Mode (Mode 1)	
System Identifier	Parameter
"LOAd"	Percent of the rated rack
"FL-0"	Fuel consumption rate
"FL-1"	Total fuel consumption
"GA-1"	Engine oil pressure
"GA-2"	Coolant temperature
"GA-3"	System voltage
"GA-4"	Fuel pressure
"GA-5"	RH/LH Exhaust temperature
"GA-6"	RH/LH Air inlet restriction
"GA-7"	Fuel filter differential pressure (restriction)
"GA-8"	Oil filter differential pressure (restriction)
"GA-9"	Boost pressure (inlet manifold air pressure)
"GA-10"	Aftercooler coolant temperature
"GA-11"	Air inlet temperature
"GA-12"	Engine oil temperature

### Service Mode (Mode 2)

**Note:** For a list of the diagnostic codes, see the film that is supplied with the instrument panel or see the Service Manual, Troubleshooting module.

This mode assists service technicians with the troubleshooting of diagnostic codes. All recorded diagnostic codes can be shown on the LCD. Inactive diagnostic codes can be cleared from the main display module's memory during Mode 2 operation.

**Note:** An inactive diagnostic code may indicate an intermittent fault.

To initiate Mode 2 operation, hold the "CLEAR/MODE" switch in the "MODE" position until "-2-" appears on the LCD.

The following three identifiers are used to specify each diagnostic code. The identifiers are displayed on the LCD.

**Module Identifier (MID)** – The MID identifies the module that has generated a diagnostic code. The MID is a three-digit code that is shown on the LCD. The MID is displayed for approximately one second prior to display of the Component Identifier and Failure Mode Identifier (CID-FMI). The display continuously changes between displaying the MID and the CID-FMI.

**Component Identifier (CID)** – The CID identifies the component or the subsystem that has generated a diagnostic code. The CID is displayed by the first four digits of the LCD.

**Failure Mode Identifier (FMI)** – The FMI identifies the type of diagnostic code that has been generated. The FMI is displayed on the last two digits of the LCD. A decimal point separates the FMI from the CID. The CID and the FMI are displayed immediately after the display of the MID. The CID and the FMI are displayed simultaneously.

When Mode 2 operation is initiated, the LCD shows the first diagnostic code that is available. The diagnostic code that is shown is "on-hold". When a diagnostic code is "on-hold", the display continuously changes between the MID and the CID-FMI.

**Note:** When no diagnostic codes are available, "- -" is shown on the LCD.

Use the "SCROLL" switch to advance to the next recorded diagnostic code. To reveal all of the recorded diagnostic codes, continue scrolling through the display. After the final diagnostic code has been displayed, "END" will show on the LCD.

The main display module activates a "SERV CODE" display for active diagnostic codes.

- If the diagnostic code is active, the "SERV CODE" display is on.

- If the diagnostic code is not active, the “SERV CODE” display is off.

**Note:** Active diagnostic codes cannot be cleared from memory.

The main display module records diagnostic codes. The diagnostic codes may remain stored for future reference or the codes can be cleared from memory. To clear a logged diagnostic code, push the “MODE/CLEAR” switch to the “CLEAR” position while the code is displayed on the LCD.

### **Tattletale Mode (Mode 3)**

This mode is useful for monitoring the ranges of the engine systems operation. The information can be used for management and maintenance of the engine.

**Note:** The following information is not included with the values of the tattletale: date, time, and duration of the occurrence.

The main display module records the extreme value for each engine system that is monitored. A value for a system is updated when a more extreme value occurs. These values are ignored for a short period of time after each engine start-up. This allows the engine systems to stabilize before the old values can be updated with new values.

To initiate Mode 3 operation, hold the “CLEAR/MODE” switch in the “MODE” position until “-3-” appears on the LCD.

All of the gauges will display values that have been attained for the corresponding subsystems of the engine. The highest gauge readings are for values that abnormally increase. The lowest readings are for values that abnormally decrease.

The values of the gauges can be more accurately displayed with the LCD. Advance the LCD to the first value by using the “SCROLL” switch. The instrument panel will show the following displays:

- An identifier for the subsystem of the engine will be displayed. The LCD will momentarily identify the gauge with a number “-GA-1-”.
- The value for the tattletale will be displayed.
- The corresponding gauge needle is activated. All of the other gauge needles default to the minimum position.

Press the “SCROLL” switch again in order to review the other tattletales.

The values of the tattletales are retained until the information is cleared from the main display module’s memory.

To clear an individual tattletale, push the “MODE/CLEAR” switch to the “CLEAR” position while the value is displayed on the LCD.

To clear all of the tattletales from the memory, push the “MODE/CLEAR” switch to the “CLEAR” position while “- -” is displayed on the LCD. After the information is cleared, all the tattletales are reset to a nominal value. Then new extreme values can be recorded.

### **Units Mode (Mode 4)**

This mode is used to change the LCD between metric units and English units. To initiate Mode 4 operation, hold the “CLEAR/MODE” switch in the “MODE” position until “-4-” appears on the LCD.

When Mode 4 is activated, the LCD will indicate the current units.

- “SI” is displayed when metric units are selected.
- “US” is displayed when English units are selected.

To toggle the units between “SI” and “US”, press the “SCROLL” switch.

### **Harness Code Mode (Mode 5)**

This mode displays a code that represents the engine configuration. An incorrect code will result in incorrect operation of the monitoring system. This could result in the generation of excessive diagnostic service codes.

To initiate Mode 5 operation, hold the “CLEAR/MODE” switch in the “MODE” position until “-5-” appears on the LCD. The code will automatically be displayed.

## **Warning Operation**

The Caterpillar Monitoring System notifies the operator of problems with the engine systems. Warning operation begins if either of the following conditions occur:

- The main display module receives a signal that indicates an abnormal operating condition.
- The main display module detects a problem with the monitoring system.

A warning is indicated by the following occurrences:

- The appropriate indicator flashes approximately nine times per second.
- The Action Alarm annunciates. The alarm is on for one second and off for two seconds, etc.

An alarm condition will not shut down the engine. However, an alarm may precede a shutdown. An alarm indicates a serious condition that requires immediate attention. Annunciation of the alarm informs the operator of an abnormal operating condition or a problem with the monitoring system. The alarm is activated by the main display module when the following conditions occur:

- A diagnostic code is active. A diagnostic code indicates a specific problem with the electronic circuitry.
- An LED indicator on the main display module flashes.
- The monitoring system detects an active event. Events can include an alarm, a derating, and a shutdown.

## Self Testing

The self test verifies that the main display module and the gauge cluster modules are operating properly. The main display module performs an automatic self test when power is supplied to the instrument panel.

The internal circuits and the outputs are automatically checked. The operator must observe the following outputs in order to determine that the outputs are operating properly:

- The indicators and the LCD are tested for approximately one second. The indicators and the LCD flash on and off.
- The Gauge Cluster modules are tested for approximately three seconds. The needles of the gauges move to half scale, to zero, and then to full scale. After the needles reach full scale, the needles return to the positions that indicate the current conditions.
- The Action Alarm annunciates one time.

After the self test, the main display module defaults to the Normal mode of operation (Mode 0).

If an output does not function properly during the self test, see the Service Manual. Consult your Caterpillar dealer for assistance.

## Internal Switches of the Electronic Instrument Panel

Illustration 49 shows three switches that are inside of the instrument panel.

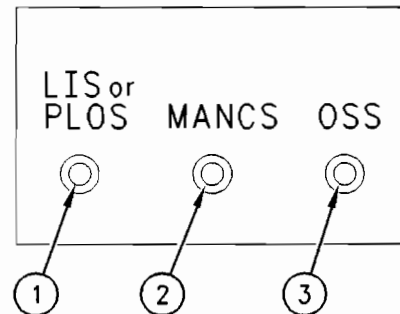


Illustration 49

g00572043

- (1) Low idle switch (generator set engines) or prelube override switch (marine engines)  
 (2) Manual crank start switch  
 (3) Overspeed verify switch

**Low idle switch (1)** – When this switch is activated, the engine will operate at the low idle rpm that is programmed. This switch is used for troubleshooting and for maintaining the low idle rpm.

**Manual crank start switch (2)** – This switch will override any other engine controls and/or protective systems. When this switch is activated, the starting motor will crank the engine. The starting motor can be engaged even during these conditions:

- The engine control switch is in the "OFF/RESET" position.
- The ECM has completed the cycle crank.
- The ECM has completed a remote shutoff.

Switch (2) is used for troubleshooting, for maintenance, and for starting the engine when the backup ECM is in control. DO NOT use this switch for normal engine operation.

**Overspeed verify switch (3)** – When this switch is activated, the ECM will cause an engine shutdown at 75 percent of the setpoint for the overspeed shutdown. The switch is used for verifying that the overspeed protection system is operating properly and for troubleshooting.



# Engine Starting

i00734945

## Before Starting Engine

SMCS Code: 1000; 1400; 1450

 **WARNING**

**Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.**

Perform the required daily maintenance and other periodic maintenance before starting the engine. Inspect the engine room. This inspection can help prevent major repairs at a later date. See this Operation and Maintenance Manual (Maintenance Section), "Maintenance Interval Schedule".

## Walk-Around Inspection

### NOTICE

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

To obtain maximum service life for your engine, make a thorough inspection before starting the engine. Make a walk-around inspection of the installation. Look for items such as oil or coolant leaks, loose bolts and trash buildup. Remove any trash. Arrange for repairs, as needed.

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Ensure that the areas around the rotating parts are clear.

## Air Inlet System

- Ensure that the air inlet piping and the air filters are in place.
- Ensure that all clamps and connections are secure.
- Observe the air cleaner service indicator. Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.

## Cooling System

- Inspect the cooling system for leaks or loose connections.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the water pumps for evidence of leaks.
- Inspect the fan drive belts for cracks and for deterioration.
- Check the coolant level. Add coolant, if necessary. For information on the proper coolant to use, see this Operation and Maintenance Manual (Maintenance Section), "Cooling System Specifications".

## Driven Equipment

- Perform any maintenance that is required for the driven equipment. Refer to the Operation and Maintenance Manual for the generator.
- Ensure that the main circuit breaker is open.

## Electrical System

Inspect the wiring for the following conditions:

- Loose connections
- Wiring that is worn or frayed

Inspect the alternator belt for cracks and for deterioration.

Ensure that the grounds are secure.

## Fuel System

### NOTICE

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

- Inspect the fuel lines for loose fittings and leaks. Ensure that the fuel lines are properly clamped.
- Ensure that the fuel is supplied to the engine.

If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air space will be left in the housing. In these instances, prime the fuel system. See this Operation and Maintenance Manual (Maintenance Section), "Fuel System-Prime" for information on priming the fuel system.

## Lubrication System

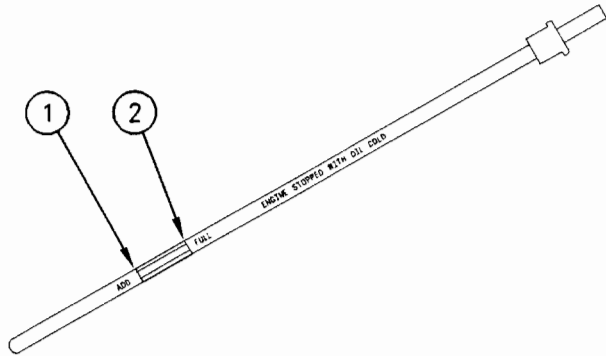


Illustration 50

g00274899

Oil level gauge

- (1) "ADD" mark
- (2) "FULL" mark

- Check the engine crankcase oil level. Maintain the oil level between the "ADD" and "FULL" marks on the "ENGINE STOPPED" side of the oil level gauge. For information on the proper oil to use, see this Operation and Maintenance Manual (Maintenance Section), "Lubricant Specifications".
- Check for leaks at the following components: crankshaft seals, crankcase, oil filters, oil gallery plugs, sensors, and valve covers.
- Inspect the tubes, tee pieces, and clamps on the crankcase breathers.

## Starting System

- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor is engaged.
- Inspect the battery cables for good connections and for corrosion.
- Inspect the gauges and the control panel for good condition.
- Reset the shutoff and alarm components.

## Cold Weather Starting

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

**Note:** Oil pan immersion heaters are not recommended for heating the lube oil. To ensure the compatibility of the components, only use equipment that is recommended by Caterpillar.

Startability will be improved at temperatures below 16 °C (60 °F) with a starting aid. A jacket water heater may be needed and/or the crankcase oil may need to be warmed.

**Note:** The fluid that is heated must be continuously circulated. This will help to prevent localized overheating of the fluid.

A jacket water heater is available as an option for starting in temperatures as low as 0 °C (32 °F). The jacket water heater can maintain the water temperature at approximately 32 °C (90 °F). The heated water will help to keep the oil in the engine block warm enough to flow when the engine is started.

When No. 2 diesel fuel is used, a fuel heater will maintain the temperature of the fuel above the cloud point. Fuel line insulation will help to maintain the fuel temperature.

Consult your Caterpillar dealer for more information on the starting aids that are available for cold weather starting.

## Air Starting Motor

**Note:** The maximum air pressure for starting must not exceed 1030 kPa (150 psi).

To start the engine at colder temperatures, the following conditions may be necessary:

- Maximum air pressure for the starting motor
- An additional volume of air

## Electric Starting Motor

Maintain the proper level of electrolyte in the batteries. Keep the batteries fully charged.

To maximize the battery power, heat the battery compartment or store the batteries in a warm location. Typically, batteries only have 50 percent of the capability at -10 °C (14 °F) versus 27 °C (80 °F).

Extra battery capacity may be necessary for very cold temperatures.

## Starting With the Starting Aid Switch

### **WARNING**

Personal injury or property damage can result from alcohol or starting fluids.

Alcohol or starting fluids are highly flammable and toxic and if improperly stored could result in injury or property damage.

### NOTICE

Excessive starting fluid can cause piston and ring damage.

Use starting fluid for cold starting purposes only.

Do not use excessive starting fluid during starting or after the engine is running.

**The optional ether starting aid which is located on the control panel is the only system that is recommended for the injection of starting fluid.**

Perform the procedures that are described in this Operation and Maintenance Manual, "Before Starting Engine" topic (Operation Section).

1. Turn the Engine Control Switch to the "MAN. START" position. The engine will crank.
  2. Ether will automatically be injected if the following conditions are met:
    - a. The "STARTING AID" switch is in the AUTOMATIC position.
    - b. The jacket water temperature is less than 21 °C (70 °F).
- Note:** Additional injections may be necessary in order to start the engine. Additional injections may also be necessary in order to achieve low idle.
3. If additional injection is necessary, toggle the "STARTING AID" switch to the MANUAL position. The ECM will control the amount of ether that is injected.
  4. The "STARTING AID" switch is a momentary switch. To stop the injection, release the "STARTING AID" switch.

## Starting the Engine

SMCS Code: 1000; 1450

### **WARNING**

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

## Prelubrication

The engine prelube system is optional. If the engine has the option, the electronic control module (ECM) will operate the prelube pump under these conditions:

- The "ENGINE PRELUBE DURATION" parameter is programmed to a value that is greater than zero.
- The engine control switch is turned to the "MAN.START" position. Alternatively, the engine control switch is in the "AUTO" position when the remote start/stop initiate contact closes.

The prelube pump will supply oil under pressure to the engine until one of the following conditions occurs:

- The oil pressure closes a pressure contactor.
- The programmed "ENGINE PRELUBE DURATION" expires.

Engine cranking will begin after the prelube pump stops.

## Automatic Starting

### **WARNING**

**When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the engine when the engine is in the AUTOMATIC mode.**

For automatic starting, the engine control switch must be in the "AUTO" position. The engine will automatically start when the remote start/stop initiate contact closes.

## Manual Starting

### NOTICE

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

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

Ensure that no one will be endangered before the engine is started and when the engine is started.

1. Perform all of the procedures that are described in this Operation and Maintenance Manual, "Before Starting Engine" topic (Operation Section).
2. Ensure that the main circuit for the generator is open.

### NOTICE

Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

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

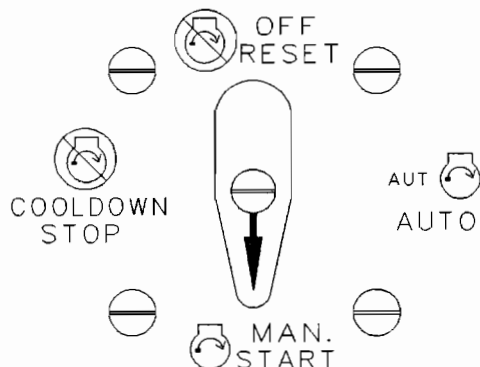


Illustration 51

g00319402

Engine control switch in the "MAN. START" position

**Note:** If the optional prelube is used, the prelube pump will operate before cranking begins.

3. To start the engine, turn the engine control switch to the "MAN. START" position.

The ECM will allow the engine to be operated at rated rpm when the oil pressure sensors indicate that the oil pressure is sufficient.

## Overcrank

The crank cycle is the amount of time for engagement of the starting motor. This also includes the amount of time for cooling of the starting motor between crank cycles. The crank cycle and the number of crank cycles are programmable.

If the engine does not start within the number of crank cycles that are programmed, the fuel system is disabled. The "OVERCRANK" indicator will illuminate in order to warn the operator of an overcrank.

If an overcrank occurs, the ECM must be reset before starting can be attempted. To reset the ECM, turn the engine control switch to the "OFF/RESET" position.

i00817006

i00736680

## Starting with Jump Start Cables

**SMCS Code:** 1000; 1401; 1402; 1900

### **WARNING**

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

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

**Note:** The engine is electronically controlled. The engine requires an isolated 24 volt DC power supply in order to operate. The power supply must be continuous. If the power supply is removed or disconnected, the engine will not operate.

### **NOTICE**

When starting with power from an external source, only use a source that has the same voltage as the starting motor.

The use of a greater voltage or the use of a welder will damage the electrical system. A power surge could damage the engine's electronic control module.

When starting with power from an external source, only use batteries as a source of power.

**Starting from an external power source is not recommended. A backup battery system is recommended.**

## After Starting Engine

**SMCS Code:** 1000

**Note:** After the engine has been installed or rebuilt, carefully monitor the engine in order to detect any unusual engine performance.

### Warm-up

1. Operate the engine at low idle for two to three minutes. Allow the jacket water temperature to begin to rise before increasing the engine rpm to rated rpm.

**Note:** More warm-up time may be necessary when the ambient temperature is below  $-18^{\circ}\text{C}$  ( $0^{\circ}\text{F}$ ).

2. Check all of the gauges during the warm-up period.
3. Make another walk-around inspection. Inspect the engine for fluid leaks and air leaks.

The time that is needed for the engine to reach the normal mode of operation is usually less than the time that is needed for a walk-around inspection.

The engine will reach normal operating temperature faster when the engine is operated at rated rpm and low power demand. This procedure is more effective than idling the engine with no load. The engine should reach normal operating temperature in a few minutes.

### Engaging the Driven Equipment

1. Ensure that the gauges are in the normal ranges for the engine rpm.
2. Increase the engine rpm to rated rpm. Always increase the engine speed to rated rpm before applying the load.
3. Adjust the voltage and the frequency, if necessary.
4. Close the main circuit breaker in order to apply the load.
5. Continue to check the gauges and the driven equipment.

## Engine Operation

i00736714

### Engine Operation

**SMCS Code:** 1000

Proper operation and maintenance are key factors in attaining the maximum service life and economy for the engine. Follow the instructions in this Operation and Maintenance Manual in order to minimize operating costs and maximize the service life of the engine.

Observe the gauges frequently while the engine is operating. Record the data from the gauges in a log regularly. Compare the data to the specifications for normal engine operation. Comparing the data over time will help to detect changes in engine performance.

Investigate any significant change in the gauge readings. Monitor the engine operation and take action when discrepancies are found.

### Operating the Engine and the Driven Equipment

Check the gauges and the driven equipment frequently while the engine is operating under a load. The engine can be operated for extended periods of time at full load.

### Partial Load Operation

Extended operation at low idle or at reduced load may cause increased oil consumption and carbon buildup in the cylinders. Carbon buildup results in a loss of power and/or poor performance.

When possible, apply a full load at least on an hourly basis. This will burn excess carbon from the cylinders.

i01121108

### Fuel Conservation Practices

**SMCS Code:** 1000; 1250

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

- Avoid spilling fuel.

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

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

- Avoid unnecessary idling.

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

- Observe the service indicator frequently. Keep the air cleaner elements clean.

- Ensure that the turbochargers are operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.

- Maintain a good electrical system.

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

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

- Ensure that all of the connections of the hoses are tight. The connections should not leak.

- Ensure that the driven equipment is in good working order.

- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

- Settings for the fuel system and the limits for the operating altitude are stamped on the Engine Information Plate. If an engine is moved to a higher altitude, the engine power will be automatically derated by the software (engine control).

# Engine Stopping

i01106577

## Emergency Stopping

**SMCS Code:** 1000; 7418

### NOTICE

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

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

## Emergency Stop Button

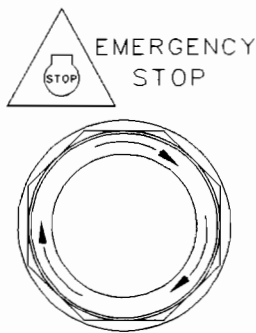


Illustration 52

g00104303

Typical emergency stop button

The emergency stop button is in the **OUT** position for normal engine operation. For an emergency stop, push the emergency stop button. This shuts off the fuel to the engine. This also activates the air shutoff (if equipped).

### NOTICE

**Do not start the engine until the problem necessitating the emergency stop has been located and corrected.**

The engine control switch, the emergency stop button, and the air shutoff must be reset before the engine can be restarted. Reset the engine control switch before resetting the emergency stop button.

To reset the engine control switch, turn the switch to the "OFF/RESET" position.

To reset the emergency stop button, turn the button clockwise. The spring-loaded button will return to the **OUT** position. The button may also be pulled to the **OUT** position.

To reset the air shutoff, turn the reset knob to the "OPEN" position. **Ensure that both of the air shutoffs are reset.**

i01106683

## Manual Stop Procedure

**SMCS Code:** 1000; 7418

### NOTICE

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

Excessive temperatures in the turbocharger centerhousing will cause oil coking problems.

Allow the engine to gradually cool before stopping the engine

There may be several methods for shutting off the engine. Make sure that the shutoff procedures are understood. Use the following general guidelines for stopping the engine.

1. Open the main circuit breaker in order to disengage the driven equipment.
2. Operate the engine for a cooldown period before stopping the engine.

- a. If the cooldown feature is utilized, turn the engine control switch to the "COOLDOWN/STOP" position.

The engine will operate for a programmed period of time. After the cooldown, the timer will activate the fuel shutoff. The engine control module will remain powered until the engine control switch is turned to the "OFF/RESET" position.

- b. If the cooldown feature is not utilized, operate the engine at high idle for approximately five minutes. Then stop the engine.

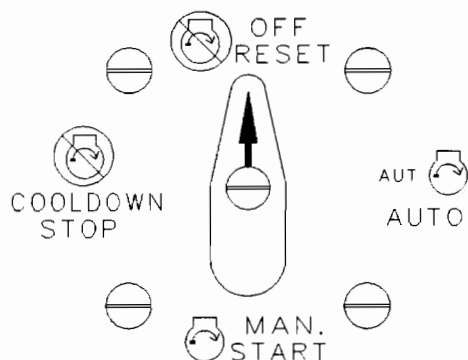


Illustration 53

g00320124

Engine control switch in the "OFF/RESET" position

- c. Turn the engine control switch to the "OFF/RESET" position.

The engine will coast to a stop. Ensure that any system that provides external support to the engine is secured after the engine is stopped.

## Automatic Stopping

Automatic stopping will occur when the engine is operating in the automatic mode and the remote start/stop initiate contact opens. If the cooldown feature is utilized, the engine will operate for a programmed period of time before the engine stops. Otherwise, the engine will immediately shut off.

## After Stopping Engine

**SMCS Code:** 1000

- Check the engine crankcase oil level. Maintain the oil level between the "ADD" and "FULL" marks on the "ENGINE STOPPED" side of the oil level gauge.
- If necessary, perform minor adjustments. Repair any leaks and tighten loose bolts.
- Note the service hour meter reading. Perform the maintenance that is scheduled in this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

### NOTICE

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

- Allow the engine to cool. Check the coolant level.
- If freezing temperatures are expected, check the coolant for protection against freezing. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. Refer to the instructions that are provided by the OEM of the driven equipment.



## Cold Weather Operation

i01190421

### Fuel and the Effect from Cold Weather

**SMCS Code:** 1000; 1250; 1280

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

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

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

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

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

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

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

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

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

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

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

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

For more information on cold weather operation, see Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations".

i00932529

### Fuel Related Components in Cold Weather

**SMCS Code:** 1000; 1250; 1280

#### Fuel Tanks

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

Fuel tanks should have a 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. Drain the water and sediment in order to help prevent freezing.

#### Fuel Filters

A primary fuel filter and/or a water separator is recommended between the fuel tank and the secondary fuel filter.

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

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

**Note:** Refer to the Parts Manual for the engine in order to determine the part numbers of the fuel filters.

## Fuel Heaters

Fuel heaters help prevent plugging of the fuel filters due to waxing in cold weather. Install fuel heaters so that the fuel is heated before the fuel enters the primary fuel filters.

Use a fuel heater that is mechanically simple but adequate for the application. The fuel heater should also prevent the fuel from overheating. High fuel temperatures reduce the performance of the engine. Choose a fuel heater with a surface for heating that is as large as possible but also practical. Small heaters can be too hot because of a limited surface area.

For warm weather, disconnect the fuel heater or deactivate the fuel heater. Heat exchanger type fuel heaters should have a bypass provision in order to prevent the fuel from overheating in warm weather.

Only use thermostatically controlled fuel heaters or self-regulated fuel heaters with this engine. A fuel heater that is not thermostatically controlled can heat the fuel above 65 °C (149 °F). A loss of engine power can occur if the fuel supply temperature exceeds 29 °C (85 °F).

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

# Maintenance Section

## Torque Specifications

i00621350

### General Torque Information

i01164757

SMCS Code: 1000; 7553

 **WARNING**

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

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

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

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

## Standard Torque for Metric Fasteners

SMCS Code: 1000; 7553

Table 20

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

Table 21

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

i00621349

i01206505

## Standard Torque for Inch Fasteners

SMCS Code: 1000; 7553

Table 22

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

Table 23

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

## Standard Torque for Worm Drive Band Hose Clamps

SMCS Code: 1000; 7553; 7554

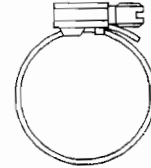


Illustration 54

g00280501

Table 24

Width of Clamp	Initial Installation Torque On New Hose
7.9 mm (0.31 inch)	0.9 ± 0.2 N·m (8 ± 2 lb in)
13.5 mm (0.53 inch)	4.5 ± 0.5 N·m (40 ± 4 lb in)
15.9 mm (0.63 inch)	7.5 ± 0.5 N·m (65 ± 4 lb in)
Width of Clamp	Reassembly or Retightening Torque
7.9 mm (0.31 inch)	0.7 ± 0.2 N·m (6 ± 2 lb in)
13.5 mm (0.53 inch)	3.0 ± 0.5 N·m (27 ± 4 lb in)
15.9 mm (0.63 inch)	4.5 ± 0.5 N·m (40 ± 4 lb in)

i01206414

## Standard Torque for Constant Torque Hose Clamps

SMCS Code: 1000; 7553; 7554

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

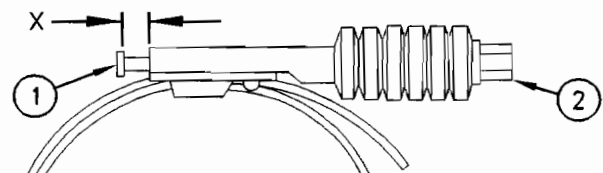


Illustration 55

g00279591

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

- Screw tip (1) extends 6.35 mm (0.25 inch) (X) beyond the housing.
- The belleville washers are collapsed nearly flat after screw (2) is tightened to a torque of  $11 \pm 1$  N·m ( $98 \pm 9$  lb in).

# Lubricant Specifications

i01111306

## Lubricant Information

**SMCS Code:** 1000; 1300; 7581

### General Information

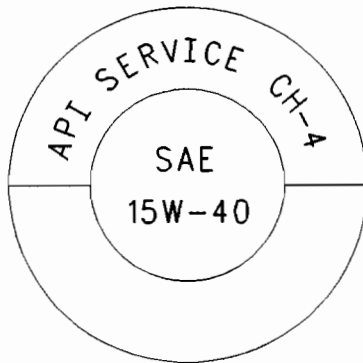
Because of government regulations regarding the certification of engine exhaust emissions, the lubricant recommendations must be followed.

### Engine Manufacturers Association (EMA) Oils

The "Engine Manufacturers Association Recommended Guideline on Diesel Engine Oil" is recognized by Caterpillar. For detailed information about this guideline, see the latest edition of EMA publication, "EMA LRG-1".

### API Oils

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



**Illustration 56**  
 Typical API symbol

g00546535

Diesel engine oils CC, CD, CD-2, and CE have not been API authorized classifications since 1 January 1996. Table 25 summarizes the status of the classifications.

Table 25

API Classifications	
Current	Obsolete
CF-4, CG-4, CH-4	CE
CF	CC, CD
CF-2 <sup>(1)</sup>	CD-2 <sup>(1)</sup>

<sup>(1)</sup> CD-2 and API CF-2 are classifications for two-cycle diesel engines. Caterpillar does not sell engines that utilize CD-2 and API CF-2 oils.

**Note:** API CF is not the same classification as API CF-4. API CF oils are only recommended for Caterpillar 3600 Series Diesel Engines and Caterpillar engines with precombustion chamber (PC) fuel systems.

### Grease

The classifications of grease are based on the "ASTM D217" worked penetration characteristics. These characteristics for grease are given a defined consistency number.

### Terminology

Certain abbreviations follow the nomenclature of "SAE J754". Some classifications follow "SAE J183" abbreviations, and some classifications follow the "EMA Recommended Guideline on Diesel Engine Oil". In addition to Caterpillar definitions, there are other definitions that will be of assistance in purchasing lubricants. Recommended oil viscosities can be found in this publication, "Engine Oil" topic (Maintenance Section).

i01072547

## Engine Oil

**SMCS Code:** 1300; 1348; 7581

### Caterpillar Diesel Engine Oil

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

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

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

### ● Caterpillar Diesel Engine Oil (15W40)

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

Caterpillar multigrade Diesel Engine Oil is available in two viscosity grades (10W30 and 15W40). For direct injection engines, see Table 26 in order to choose the correct viscosity grade for the ambient temperature. Multigrade oils provide the correct viscosity for a broad range of operating temperatures.

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

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

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

## Commercial Oils

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

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

- EMA LRG-1 multigrade oil (preferred oil)
- API CH-4 multigrade oil (preferred oil)
- API CG-4 multigrade oil (preferred oil)
- API CF-4 multigrade oil (acceptable oil)

In order to make the proper choice of a commercial oil, refer to the following explanations:

**EMA LRG-1** – The Engine Manufacturers Association (EMA) has developed lubricant recommendations as an alternative to the API oil classification system. LRG-1 is a Recommended Guideline that defines a level of oil performance for these types of diesel engines: high speed, four stroke cycle, heavy-duty, and light duty. LRG-1 oils may be used in Caterpillar engines when API CH-4, API CG-4, and API CF-4 oils are recommended. LRG-1 oils are intended to provide superior performance in comparison to API CG-4 and API CF-4.

LRG-1 oils will meet the needs of high performance Caterpillar diesel engines that are operating in many applications. The tests and the test limits that are used to define LRG-1 are similar to the new API CH-4 classification. Therefore, these oils will also meet the requirements of the low emissions diesel engines. LRG-1 oils are designed to control the harmful effects of soot with improved wear resistance and improved resistance to oil filter plugging. These oils will also provide superior piston deposit control for engines with either two-piece steel pistons or aluminum pistons.

All LRG-1 oils must complete a full test program with the base stock and with the viscosity grade of the finished commercial oil. The use of "API Base Oil Interchange Guidelines" are not appropriate for LRG-1 oils. This feature reduces the variation in performance that can occur when base stocks are changed in commercial oil formulations.

LRG-1 oils are recommended for use in extended oil change interval programs that optimize oil life. These oil change interval programs are based on oil analysis. LRG-1 oils are recommended for conditions that demand a premium oil. Your Caterpillar dealer has the specific guidelines for optimizing oil change intervals.

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

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

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

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

**API CG-4** – API CG-4 oils were developed primarily for diesel engines that use a 0.05 percent level of fuel sulfur. However, API CG-4 oils can be used with higher sulfur fuels. The TBN of the new oil determines the maximum fuel sulfur level for API CG-4 and API CF-4 oils. See Illustration 57.

API CG-4 oils are the first oils that are required to pass industry standard tests for foam control and viscosity shear loss. API CG-4 oils must also pass tests that were developed for corrosion, wear and oxidation.

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

**Note:** Do not use single grade API CF oils or multigrade API CF oils in Caterpillar Direct Injection (DI) Commercial Diesel Engines.

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

#### NOTICE

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

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

The Total Base Number (TBN) for an oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the minimum TBN of the new oil must be 10 times the fuel sulfur level. The TBN is defined by "ASTM D2896". The minimum TBN of the oil is 5 regardless of fuel sulfur level. Illustration 57 demonstrates the TBN.

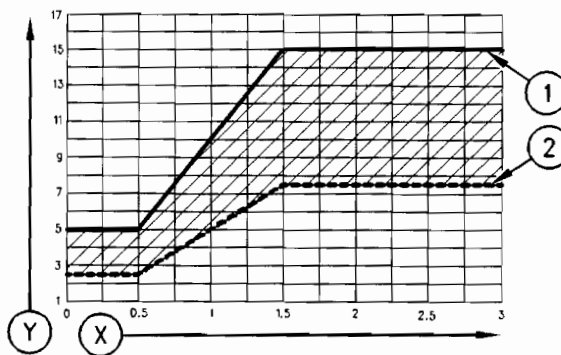


Illustration 57

g00104890

(Y) TBN by "ASTM D2896"

(X) Percentage of fuel sulfur by weight

(1) TBN of new oil

(2) Change the oil when the TBN deteriorates to 50 percent of the original TBN.

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

- Choose an oil with the highest TBN that meets one of these classifications: EMA LRG-1, API CH-4, API CG-4, and API CF-4.
- Reduce the oil change interval. Base the oil change interval on the oil analysis. Ensure that the oil analysis includes the condition of the oil and a wear metal analysis.



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

**NOTICE**

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

**Lubricant Viscosity Recommendations for Direct Injection (DI) Diesel Engines**

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

Refer to Table 26 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 26 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

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

Table 26

Engine Oil Viscosity		
Caterpillar DEO Multigrade EMA LRG-1 API CH-4 API CG-4 and API CF-4 Viscosity Grade	Ambient Temperature	
	Minimum	Maximum
SAE 0W20	-40 °C (-40 °F)	10 °C (50 °F)
SAE 0W30	-40 °C (-40 °F)	30 °C (86 °F)
SAE 0W40	-40 °C (-40 °F)	40 °C (104 °F)
SAE 5W30	-30 °C (-22 °F)	30 °C (86 °F)
SAE 5W40	-30 °C (-22 °F)	40 °C (104 °F)
SAE 10W30	-20 °C (-4 °F)	40 °C (104 °F)
SAE 15W40	-15 °C (5 °F)	50 °C (122 °F)

i01111412

**Re-refined Base Stock Oils**

**SMCS Code:** 1348; 7581

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

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

i01111406

**Synthetic Base Stock Oils**

**SMCS Code:** 1348; 7581

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

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

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

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

i00062736

## Cold Weather Lubricants

**SMCS Code:** 1348; 7581

When an engine is started and operated in ambient temperatures below  $-20^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$ ), use multigrade oils that are capable of flowing in low temperatures.

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

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

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

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

---

### NOTICE

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

---

i01123104

## Aftermarket Oil Additives

**SMCS Code:** 1348; 7581

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

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

To achieve the best performance from a Caterpillar engine, conform to the following guidelines:

- Select the proper Caterpillar oil or a commercial oil that meets the "EMA Recommended Guideline on Diesel Engine Oil" or the recommended API classification.
- See the appropriate "Lubricant Viscosities" table in order to find the correct oil viscosity grade for your engine.
- At the specified interval, service the engine compartment. Use new oil and install a new oil filter.
- Perform maintenance at the intervals that are specified in the Operation and Maintenance Manual, "Maintenance Interval Schedule".

i01164576

## Lubricating Grease

**SMCS Code:** 7581

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

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

## Multipurpose Greases

### Multipurpose Lithium Complex Grease (MPGL)

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

- Construction
- Agricultural
- Automotive

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

### Multipurpose Lithium Complex Grease with Molybdenum (MPGM)

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

The MPGM has the following features:

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

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

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

## Special Purpose Grease (SPG)

### Bearing Lubrication (SPG)

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

### Water and Temperature Resistant Grease (WTR)

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

- Construction
- Agricultural
- Automotive
- Industrial
- Marine

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

## Caterpillar Premium Grease (CPG)

i01065849

### Desert Gold (CPG)

Desert Gold is a heavy-duty, premium synthetic grease that is developed for the most extreme operating environments. This grease is formulated with the following characteristics: high viscosity synthetic base fluid, polymers, molybdenum disulfide, high viscosity index, and high dropping point.

Desert Gold will protect equipment against heavy shock loads. Desert Gold protects against corrosion in extreme heat, in moist conditions, or in dusty conditions. This product has excellent characteristics of adhesion and of stability. Desert Gold provides longer protection than other greases. Desert Gold is an environmentally friendly grease which does not contain the following materials: antimony, sulfur, barium, zinc, lead, and phosphorous materials. Normal operating temperatures are -6 to 230 °C (21 to 450 °F). Desert Gold can operate at higher temperatures for short time periods. Desert Gold has additional extreme pressure protection for highly loaded pin joints.

### Arctic Platinum (CPG)

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

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

## S·O·S Oil Analysis

**SMCS Code:** 1348; 7542-008

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

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

- The Wear Rate Analysis monitors the wear of the engine's metals. The amount of wear metal and type of wear metal that is in the oil is analyzed. The increase in the rate of engine wear metal in the oil is as important as the quantity of engine wear metal in the oil. For this reason, regular sampling at specified intervals is necessary in order to establish wear rates. Intermittent sampling does not allow wear rate trend lines to be established. Engine wear metals in the oil sample are compared to established Caterpillar norms in order to determine acceptability.
- Tests are conducted in order to detect contamination of the oil by water, glycol or fuel.
- The Oil Condition Analysis determines the loss of the oil's lubricating properties. An infrared analysis is used to compare the properties of new oil to the properties of the used oil sample. This analysis allows technicians to determine the amount of deterioration of the oil during use. This analysis also allows technicians to verify the performance of the oil according to the specification during the entire oil change interval.

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

Table 27

S·O·S Oil Analysis Interval	
Compartment	Interval
Engine crankcase	Every 250 Service Hours

For more information, see Special Publication, PEDP7036, "S·O·S Fluid Analysis". Consult your Caterpillar dealer for complete information and assistance about the program.

# Fuel Specifications

i01196007

## Fuel Recommendations

**SMCS Code:** 1280

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

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace fuel, gas oil, or kerosene.

The permissible fuels are crude oils or blended fuels. Use of these fuels can result in higher maintenance costs and in reduced engine service life.

Diesel fuels that meet the specifications in Table 28 will help to provide maximum engine service life and performance. In North America, diesel fuel that is identified as No. 1-D or No. 2-D in "ASTM D975" generally meet the specifications. Table 28 is for diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

Table 28

Caterpillar Specifications for Distillate Diesel Fuel		
Specifications	Requirements	ASTM Test
Aromatics	35% maximum	"D1319"
Ash	0.02% maximum (weight)	"D482"
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	"D524"
Cetane Number	40 minimum (DI engines) 35 minimum (PC engines)	"D613"
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	-
Copper Strip Corrosion	No. 3 maximum	"D130"

(continued)

(Table 28, contd)

Caterpillar Specifications for Distillate Diesel Fuel		
Specifications	Requirements	ASTM Test
Distillation	10% at 282 °C (540 °F) maximum	"D86"
	90% at 360 °C (680 °F) maximum	
Flash Point	legal limit	"D93"
API Gravity	30 minimum	"D287"
	45 maximum	
Pour Point	6 °C (10 °F) minimum below ambient temperature	"D97"
Sulfur <sup>(1)</sup>	3% maximum	"D3605" or "D1552"
Kinematic Viscosity <sup>(2)</sup>	1.4 cSt minimum and 20.0 cSt maximum at 40 °C (104 °F)	"D445"
Water and Sediment	0.1% maximum	"D1796"
Water	0.1% maximum	"D1744"
Sediment	0.05% maximum (weight)	"D473"
Gums and Resins <sup>(3)</sup>	10 mg per 100 mL maximum	"D381"
Lubricity <sup>(4)</sup>	3100 g minimum	"D6078"
	0.45 mm (0.018 inch) maximum at 60 °C (140 °F)	
	0.38 mm (0.015 inch) maximum at 25 °C (77 °F)	

(1) Caterpillar fuel systems and engine components can operate on high sulfur fuels. Fuel sulfur levels affect exhaust emissions. High sulfur fuels also increase the potential for corrosion of internal components. Fuel sulfur levels above 1.0 percent may significantly shorten the oil change interval. For additional information, see this publication, "Engine Oil" topic (Maintenance Section).

(2) The values of the fuel viscosity are the values as the fuel is delivered to the fuel injection pumps. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain a 1.4 cSt viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters in order to bring down the viscosity to a 20 cSt viscosity. For additional information, see Special Publication, SEBD0717, "Diesel Fuel and Your Engine".

(3) Follow the test conditions and procedures for gasoline (motor).

(4) The lubricity of a fuel is a concern with low sulfur fuel. To determine the lubricity of the fuel, use either the "ASTM D6078 Scuffing Load Wear Test (SBOCLE)" or the "ASTM D6079 High Frequency Reciprocating Rig (HFRR)" test. If the lubricity of a fuel does not meet the minimum requirements, consult your fuel supplier. Do not treat the fuel without consulting the fuel supplier. Some additives are not compatible. These additives can cause problems in the fuel system.

---

**NOTICE**

Operating with fuels that do not meet Caterpillar's recommendations can cause the following effects: starting difficulty, poor combustion, deposits in the fuel injectors, reduced service life of the fuel system, deposits in the combustion chamber, and reduced service life of the engine.

---

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

---

**NOTICE**

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

---

In extreme cold ambient conditions, you may use the distillate fuels that are specified in Table 29. However, the fuel that is selected must meet the requirements that are specified in Table 28. These fuels are intended to be used in operating temperatures that are down to  $-54\text{ }^{\circ}\text{C}$  ( $-65\text{ }^{\circ}\text{F}$ ).

Table 29

Distillate Fuels <sup>(1)</sup>	
Specification	Grade
"MIL-T-5624R"	JP-5
"ASTM D1655"	Jet-A-1
"MIL-T-83133D"	JP-8

<sup>(1)</sup> The fuels that are listed in this Table may not meet the requirements that are specified in the "Caterpillar Specifications for Distillate Diesel Fuel" Table. Consult the supplier for the recommended additives in order to maintain the proper fuel lubricity.

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in Table 29 must be at least 40. If the viscosity is below 1.4 cSt at  $38\text{ }^{\circ}\text{C}$  ( $100\text{ }^{\circ}\text{F}$ ), use the fuel only in temperatures below  $0\text{ }^{\circ}\text{C}$  ( $32\text{ }^{\circ}\text{F}$ ). Do not use any fuels with a viscosity of less than 1.2 cSt at  $38\text{ }^{\circ}\text{C}$  ( $100\text{ }^{\circ}\text{F}$ ). Fuel cooling may be required in order to maintain the minimum viscosity of 1.4 cSt at the fuel injection pump.

There are many other diesel fuel specifications that are published by governments and by technological societies. Usually, those specifications do not review all the requirements that are addressed in this specification. To ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in Table 28.

# Cooling System Specifications

i01111669

## General Coolant Information

**SMCS Code:** 1350; 1395

---

### NOTICE

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

---

---

### NOTICE

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

---

---

### NOTICE

In cold weather, frequently check the specific gravity of the coolant solution to ensure adequate protection.

---

Clean the cooling system for the following reasons:

- Contamination of the cooling system
- Overheating of the engine
- Foaming of the coolant

**Note:** Air pockets can form in the cooling system if the cooling system is filled at a rate that is greater than 20 L (5 US gal) per minute.

After you drain the cooling system and after you refill the cooling system, operate the engine. Operate the engine without the filler cap until the coolant reaches normal operating temperature and the coolant level stabilizes. Ensure that the coolant is maintained to the proper level.

---

### NOTICE

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

---

Refer to Special Instruction, SEBD0518, "Know Your Cooling System" and Special Instruction, SEBD0970, "Coolant and Your Engine" for more detailed information.

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

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

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

## Water

---

### NOTICE

All Caterpillar diesel engines equipped with air-to-air aftercooling (ATAAC) require a minimum of 30 percent glycol to prevent water pump cavitation.

---

---

### NOTICE

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

---

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

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

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

If distilled water or deionized water is not available, use water with the properties that are listed in Table 30.

Table 30

Caterpillar Minimum Acceptable Water Requirements		
Property	Maximum Limit	ASTM Test
Chloride (Cl)	40 mg/L (2.4 grains/US gal)	"D512", "D4327"
Sulfate (SO <sub>4</sub> )	100 mg/L (5.9 grains/US gal)	"D516"
Total Hardness	170 mg/L (10 grains/US gal)	"D1126"
Total Solids	340 mg/L (20 grain/US gal)	"D1888"
Acidity	pH of 5.5 to 9.0	"D1293"

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

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

## Additives

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

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

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

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

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

## Glycol

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

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

For optimum performance, Caterpillar recommends a 1:1 mixture of a water/glycol solution.

### NOTICE

All Caterpillar diesel engines equipped with air-to-air aftercooling (ATAAC) require a minimum of 30 percent glycol to prevent water pump cavitation.

**Note:** Use a mixture that will provide protection against the lowest ambient temperature.

**Note:** 100 percent pure glycol will freeze at a temperature of  $-23\text{ }^{\circ}\text{C}$  ( $-9\text{ }^{\circ}\text{F}$ ).

Most conventional heavy-duty coolant/antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. See Tables 31 and 32.

Table 31

Ethylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	$-36\text{ }^{\circ}\text{C}$ ( $-33\text{ }^{\circ}\text{F}$ )	$106\text{ }^{\circ}\text{C}$ ( $223\text{ }^{\circ}\text{F}$ )
60 Percent	$-51\text{ }^{\circ}\text{C}$ ( $-60\text{ }^{\circ}\text{F}$ )	$111\text{ }^{\circ}\text{C}$ ( $232\text{ }^{\circ}\text{F}$ )

### NOTICE

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



Table 32

Propylene Glycol		
Concentration	Freeze Protection	Anti-Boil Protection
50 Percent	-29 °C (-20 °F)	106 °C (223 °F)

To check the concentration of glycol, use the 1U-7298 Coolant/Battery Tester (Celsius) or use the 1U-7297 Coolant/Battery Tester (Fahrenheit). The testers give readings that are immediate and accurate. The testers can be used with ethylene or propylene glycol.

i01096501

## Coolant Recommendations

**SMCS Code:** 1350; 1352; 1395

### NOTICE

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

The following coolants are the primary types of coolants that are used in Caterpillar Engines:

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

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

Caterpillar recommends a 1:1 mixture of water and glycol. This mixture will provide optimum heavy-duty performance as a coolant/antifreeze.

**Note:** Caterpillar DEAC DOES NOT require a treatment with an SCA at the initial fill. Commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D5345" specifications MAY require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

In stationary engine applications and marine engine applications that do not require protection from boiling or freezing, a mixture of SCA and water is acceptable. **Caterpillar recommends a minimum of six percent to a maximum of eight percent SCA concentration in those cooling systems.** Distilled water or deionized water is preferred. Water which has the required properties may be used. For the water properties, see this publication, "General Coolant Information" topic (Maintenance Section).

**Note:** Table 33 is a list of the coolants that are recommended and the service life (calendar) of the coolants. The service life of coolant is also limited by use (service hours). Refer to the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section). **To achieve this service life, the coolants must be properly maintained. The maintenance program includes S-O-S coolant analysis.**

Table 33

Coolant Service Life	
Coolant Type	Service Life <sup>(1)</sup>
Caterpillar ELC	Six Years
Caterpillar DEAC	Three Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D5345"	Two Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985"	One Year
Caterpillar SCA and Water	Two Years
Commercial SCA and Water	One Year

<sup>(1)</sup> The service life of coolant is also limited by use (service hours). Refer to the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

i01097903

## Extended Life Coolant (ELC)

**SMCS Code:** 1350; 1352; 1395

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

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

The anti-corrosion package for Caterpillar ELC is different from the anti-corrosion package for other coolants. Caterpillar ELC is an ethylene glycol base coolant. However, Caterpillar ELC contains organic corrosion inhibitors and antifoam agents with low amounts of nitrite. Caterpillar ELC has been formulated with the correct amount of these additives in order to provide superior corrosion protection for all metals in engine cooling systems.

ELC extends the service life of the coolant to six years. The service life of coolant is also limited by use (service hours). Refer to the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section). ELC does not require frequent additions of a Supplemental Coolant Additive (SCA). An Extender is the only additional maintenance that is needed at three years or one half of the ELC service life.

A premixed solution of ELC and distilled water is available in a 1:1 concentration. The Premixed ELC provides freeze protection to  $-36^{\circ}\text{C}$  ( $-33^{\circ}\text{F}$ ). The Premixed ELC is recommended for the initial fill of the cooling system. The Premixed ELC is also recommended for topping off the cooling system.

ELC Concentrate is also available. ELC Concentrate can be used to lower the freezing point to  $-51^{\circ}\text{C}$  ( $-60^{\circ}\text{F}$ ).

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

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

i01096503

## Extended Life Coolant (ELC) Cooling System Maintenance

**SMCS Code:** 1350; 1352; 1395

### Proper Additions to the Extended Life Coolant

---

#### NOTICE

Use only Caterpillar products or commercial products that have passed Caterpillar's EC-1 specification for pre-mixed or concentrated coolants.

Use only Caterpillar Extender with Extended Life Coolant.

Mixing Extended Life Coolant with other products reduces the Extended Life Coolant service life. Failure to follow the recommendations can reduce cooling system components life unless appropriate corrective action is performed.

---

In order to maintain the correct balance between the antifreeze and the additives, you must maintain the recommended concentration of Extended Life Coolant (ELC). Lowering the proportion of antifreeze lowers the proportion of additive. This will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

---

#### NOTICE

Do not use a conventional coolant to top-off a cooling system that is filled with Extended Life Coolant (ELC).

Do not use standard supplemental coolant additive (SCA). Only use ELC Extender in cooling systems that are filled with ELC.

---

During daily maintenance, use the premixed ELC as a cooling system top-off. This will bring the coolant up to the proper level. Use ELC or use a coolant that meets the Caterpillar EC-1 specification.

Before the engine is exposed to freezing temperatures, check the freeze protection (glycol concentration) of the coolant with the 1U-7298 Coolant/Battery Tester (Celsius) or with the 1U-7297 Coolant/Battery Tester (Fahrenheit). Use ELC Concentrate to adjust the glycol concentration, if necessary. ELC Concentrate can be used to lower the freezing point to  $-51^{\circ}\text{C}$  ( $-60^{\circ}\text{F}$ ).

## Caterpillar ELC Extender

Caterpillar ELC Extender is added to the cooling system halfway through the ELC service life. Treat the cooling system with ELC Extender at three years or one half of the coolant service life. Refer to the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

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

### Adding ELC Extender

The amount of ELC Extender that is required depends on the capacity of the cooling system. Use the equation that is in Table 34 in order to determine the proper amount of ELC Extender that is required.

Table 34

Equation For Adding ELC Extender To ELC
$V \times 0.02 = X$
V is the total volume of the cooling system.
X is the amount of ELC Extender that is required.

Table 35 is an example for using the equation that is in Table 34.

Table 35

Example Of The Equation For Adding ELC Extender To ELC		
Total Volume of the Cooling System (V)	Factor for Multiplication	Amount of ELC Extender that is Required (X)
946 L (250 US gal)	× 0.02	19 L (5 US gal)

## ELC Cooling System Cleaning

**Note:** If the cooling system is already using ELC, cleaning agents are not required to be used at the specified coolant change interval. Cleaning agents are only required if the system has been contaminated by the addition of some other type of coolant or by cooling system damage.

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

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

## Changing to Caterpillar ELC

To change from heavy-duty coolant/antifreeze to the Caterpillar ELC, perform the following steps:

### NOTICE

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

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant into a suitable container. Dispose of the coolant according to local regulations.
2. Flush the system with clean water in order to remove any debris.
3. Clean the cooling system with Caterpillar Cooling System Cleaner. Follow the instructions on the label.
4. Drain the cleaner into a suitable container. Flush the cooling system with clean water.
5. Fill the cooling system with clean water and operate the engine until the engine is warmed to 49 to 66 °C (120 to 150 °F).

### NOTICE

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

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

6. Drain the water into a suitable container. Flush the cooling system with clean water.

**Note:** The cooling system cleaner must be thoroughly flushed from the cooling system. Cooling system cleaner that is left in the system will contaminate the coolant. The cleaner may also corrode the cooling system.

7. Repeat Steps 5 and 6 until the cooling system is completely clean.
8. Fill the cooling system with Caterpillar Premixed ELC.
9. Attach Special Publication, PEEP5027, "Label" to the filler of the cooling system in order to indicate the use of Caterpillar ELC.

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

## Contamination of the ELC Cooling System

### NOTICE

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

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

- Drain the cooling system into a suitable container. Dispose of the coolant according to local regulations. Flush the system with clean water. Fill the system with the Caterpillar ELC.
- Drain a portion of the cooling system into a suitable container according to local regulations. Then, fill the cooling system with premixed ELC. This should lower the contamination to less than 10 percent.
- Maintain the system as a conventional Diesel Engine Antifreeze/Coolant (DEAC). Treat the system with an SCA. Change the coolant at the interval that is recommended for the conventional Diesel Engine Antifreeze/Coolant (DEAC).

## Commercial ELC

If Caterpillar ELC is not used, then select a commercial ELC that meets the Caterpillar specification of EC-1 and either the "ASTM D5345" specification or the "ASTM D4985" specification. Do not use an extended life coolant that does not meet the EC-1 specification. Follow the maintenance guide for the coolant from the supplier of the commercial ELC. Follow the Caterpillar guidelines for the quality of water and the specified coolant change interval.

i01111753

## Diesel Engine Antifreeze/ Coolant (DEAC)

**SMCS Code:** 1350; 1352; 1395

Caterpillar recommends using Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) for cooling systems that require a heavy-duty coolant/antifreeze. Caterpillar DEAC is an alkaline single-phase ethylene glycol type antifreeze that contains corrosion inhibitors and antifoam agents.

Caterpillar DEAC is formulated with the correct amount of Caterpillar Supplemental Coolant Additive (SCA). Do not use SCA at the initial fill when DEAC is used.

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

If concentrated DEAC is used, Caterpillar recommends mixing the concentrate with distilled water or with deionized water. If distilled water is not available or deionized water is not available, use water which has the required properties. For the water properties, see this publication, "General Coolant Information" topic (Maintenance Section).

i01164588

## Commercial Heavy-Duty Coolant/Antifreeze and SCA

**SMCS Code:** 1350; 1352; 1395

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

**Note:** When you are not using Caterpillar DEAC the cooling system must be drained one time during every year. The cooling system must be flushed at this time as well.

i01166959

When a heavy-duty coolant/antifreeze is used, treat the cooling system with three to six percent Caterpillar SCA by volume. For more information, see this publication, "Conventional Coolant/Antifreeze Cooling System Maintenance" topic (Maintenance Section).

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

Coolant/antifreeze that meets "ASTM D5345" or "ASTM D4985" specifications MAY require treatment with SCA at the initial fill. These coolants WILL require treatment with SCA on a maintenance basis.

When concentrated coolant/antifreeze is mixed, Caterpillar recommends mixing the concentrate with distilled water or with deionized water. If distilled water or deionized water is not available, water which has the required properties may be used. For the water properties, see this publication, "General Coolant Information" topic (Maintenance Section).

i01069295

## Supplemental Coolant Additive (SCA)

**SMCS Code:** 1350; 1352; 1395

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

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

Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) is formulated with the correct level of Caterpillar SCA. When the cooling system is initially filled with DEAC, adding more SCA is not necessary until the concentration of SCA has been depleted. To ensure that the correct amount of SCA is in the cooling system, the concentration of SCA must be tested on a scheduled basis. Refer to the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule".

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

## Conventional Coolant/Antifreeze Cooling System Maintenance

**SMCS Code:** 1350; 1352; 1395

### NOTICE

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

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

## Adding the SCA to Conventional Coolant/Antifreeze at the Initial Fill

**Note:** Caterpillar DEAC DOES NOT require an addition of SCA when the cooling system is initially filled.

Commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D5345" specifications MAY require an addition of SCA when the cooling system is initially filled. Read the label or the instructions that are provided by the OEM of the product.

The size of the cooling system determines the amount of SCA that is required. Use the equation that is in Table 36 to determine the amount of Caterpillar SCA that may be required when the cooling system is initially filled with heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D5345" specifications.

Table 36

Equation For Adding The SCA At The Initial Fill Coolant/Antifreeze That Meets "ASTM D4985" or "ASTM D5345" Specifications <sup>(1)</sup>
$V \times 0.045 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

<sup>(1)</sup> Read the label or the instructions that are provided by the OEM of the product.

Table 37 is an example for using the equation that is in Table 36.

Table 37

Example of the Equation For Adding The SCA At The Initial Fill Coolant/Antifreeze That Meets "ASTM D4985" or "ASTM D5345" Specifications		
Total Volume of the Cooling System (V)	Factor for Multiplication	Amount of SCA that is Required (X)
946 L (250 US gal)	× 0.045	43 L (11 US gal)

## Adding the SCA to Conventional Coolant/Antifreeze For Maintenance

Heavy-duty coolant/antifreeze of all types REQUIRE periodic additions of an SCA.

Test the coolant/antifreeze periodically for the concentration of SCA. For the interval, see the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section). SCA test kits are available from your Caterpillar dealer. Test the concentration of SCA or submit a coolant sample to your Caterpillar dealer. For more information on coolant analysis, see the Operation and Maintenance Manual, "S·O·S Coolant Analysis" topic (Maintenance Section).

Additions of SCA are based on the results of the test or based on the results of the coolant analysis. The size of the cooling system determines the amount of SCA that is needed.

Use the equation that is in Table 38 to determine the amount of Caterpillar SCA that is required.

Table 38

Equation For Adding The SCA To Conventional Coolant/Antifreeze For Maintenance
$V \times 0.014 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 39 is an example for using the equation that is in Table 38.

Table 39

Example Of The Equation For Adding The SCA To Conventional Coolant/Antifreeze For Maintenance		
Total Volume of the Cooling System (V)	Factor for Multiplication	Amount of SCA that is Required (X)
946 L (250 US gal)	× 0.014	13 L (3.5 US gal)

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

Table 40 lists part numbers and quantities of SCA that is available from your Caterpillar dealer.

Table 40

Caterpillar Liquid SCA	
Part Number	Quantity
8C-3680	19 L (5 US gal)
5P-2907	208 L (55 US gal)

## Cleaning the Cooling System of Heavy-Duty Coolant/Antifreeze

Caterpillar Cooling System Cleaner dissolves mineral scale, corrosion products, light oil contamination and sludge.

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

i01069399

## Water/Supplemental Coolant Additive (SCA)

**SMCS Code:** 1350; 1352; 1395

### NOTICE

To help prevent water pump cavitation, Caterpillar recommends a minimum of 30 percent of glycol in the coolant/antifreeze mixture.

Use a mixture that will provide protection against the lowest ambient temperature.

100 percent pure glycol will freeze at a temperature of  $-13^{\circ}\text{C}$  ( $9^{\circ}\text{F}$ ).

**NOTICE**

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

Do not use water alone as an engine coolant. Supplemental Coolant Additive (SCA) helps to prevent the following conditions from occurring:

- Corrosion
- Formation of mineral deposits
- Cavitation of the cylinder liner
- Foaming of the coolant

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

The quality of the water is a very important factor in this type of cooling system. Distilled water or deionized water is recommended for use in cooling systems. If distilled water or deionized water is not available, water that has the required properties may be used. For the water properties, see this Operation and Maintenance Manual, "General Coolant Information" topic (Maintenance Section).

A cooling system that uses a mixture of only SCA and water requires more SCA than a cooling system that uses a mixture of glycol and water. The SCA and water requires six to eight percent of SCA.

### **Adding the SCA to Water at the Initial Fill**

The capacity of the cooling system determines the amount of SCA that is required. Use the equation that is in Table 41 to determine the amount of Caterpillar SCA that is required at the initial fill. This equation is for a mixture of only SCA and water.

Table 41

<b>Equation For Adding The SCA To Water At The Initial Fill</b>
$V \times 0.07 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 42 is an example for using the equation that is in Table 41.

Table 42

<b>Example Of The Equation For Adding The SCA To Water At The Initial Fill</b>		
<b>Total Volume of the Cooling System (V)</b>	<b>Factor for Multiplication</b>	<b>Amount of SCA that is Required (X)</b>
946 L (250 US gal)	× 0.07	66 L (18 US gal)

### **Adding the SCA to Water for Maintenance**

Test the mixture of SCA and water periodically for the concentration of SCA. For the interval, see the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

Test the concentration of SCA with the 8T-5296 Coolant Conditioner Test Kit or with S·O·S coolant analysis. For more information on coolant analysis, see this Operation and Maintenance Manual, "S·O·S Coolant Analysis" topic (Maintenance Section).

Instructions are provided with the 8T-5296 Coolant Conditioner Test Kit. Make the following modifications to Steps 3 and 5 of the instructions. These modifications are needed for mixtures of SCA and water:

**STEP 3** – Add tap water to the vial up to the "20 ml" mark.

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

Additions of SCA are based on the results of the test or based on the results of the coolant analysis. The capacity of the cooling system determines the amount of SCA that is required.

Use the equation that is in Table 43 to determine the amount of Caterpillar SCA that is required.

Table 43

<b>Equation For Adding the SCA To Water For Maintenance</b>
$V \times 0.023 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 44 is an example for using the equation that is in Table 43.

Table 44

Example Of The Equation For Adding the SCA To Water For Maintenance		
Total Volume of the Cooling System (V)	Factor for Multiplication	Amount of SCA that is Required (X)
946 L (250 US gal)	× 0.023	22 L (6 US gal)

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

Table 45 lists part numbers and quantities of SCA that is available from your Caterpillar dealer.

Table 45

Caterpillar Liquid SCA	
Part Number	Quantity
8C-3680	19 L (5 US gal)
5P-2907	208 L (55 US gal)

i01069690

## S·O·S Coolant Analysis

**SMCS Code:** 1350; 1352; 1395

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and from corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and from freezing.

Coolant analysis can be performed at your Caterpillar dealership. Caterpillar's S·O·S coolant analysis is an excellent way to monitor the condition of your coolant and your cooling system.

The most critical aspect of coolant analysis is the interpretation of the results. The analyst must be properly trained in order to provide a correct diagnosis. The analyst must understand several variables.

Different coolants have different formulations and different condemning limits. Different commercial labs may use different methods to test for the same variable. These other considerations are also important for interpreting the results of a coolant analysis:

- The number of hours on the sample

- The equipment that uses the coolant
- The application of the equipment

Analysts at Caterpillar's S·O·S fluid labs are trained to determine the acceptability of coolants. These analysts have knowledge of the equipment and applications. These qualifications enable the analysts to detect problems before damage occurs.

### NOTICE

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

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

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

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

Caterpillar's S·O·S coolant analysis is a program with two levels. The program is based on periodic samples. The samples are analyzed. The results are reported, and appropriate recommendations are made according to the results.

## S·O·S Coolant Analysis (Level I)

A coolant analysis (Level I) is a test of the properties of the coolant that includes the following items:

- Glycol concentration for protection from boiling and freezing
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Water hardness
- Visual analysis
- Analysis of the odor

The results are reported, and appropriate recommendations are made.



## **S·O·S Coolant Analysis (Level II)**

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

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

The results are reported, and appropriate recommendations are made.

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

## Refill Capacities

101228533

### Refill Capacities

**SMCS Code:** 1000; 1348; 1395; 7560

### Lubrication System

The capacity of the lubrication system includes the capacity of the oil filters that are installed at the factory.

Auxiliary oil filter systems (if equipped) will require additional oil. Refer to the specifications that are provided by the OEM of the auxiliary oil filter system.

For the recommended oil, see this Operation and Maintenance Manual, "Engine Oil" topic (Maintenance Section).

### 3508 Engine

Table 46

Approximate Refill Capacities for 3508 Engine Lubrication Systems		
Compartment or System	Liters	US Gallons
Standard sump	227 L	60 US gal
Deep sump	443 L	117 US gal

### 3512 Engine

Table 47

Approximate Refill Capacities for 3512 Engine Lubrication Systems		
Compartment or System	Liters	US Gallons
Standard sump	318 L	84 US gal
Deep sump	625 L	165 US gal

### 3516 Engine

Table 48

Approximate Refill Capacities for 3516 Engine Lubrication Systems		
Compartment or System	Liters	US Gallons
Standard sump	405 L	107 US gal
Deep sump	807 L	213 US gal

## Cooling System

To properly maintain the cooling system, the total capacity of the cooling system must be determined. The capacity of the total cooling system will vary between individual installations. The external system can include the following components: expansion tank, radiator, and piping. Refer to the specifications that are provided by the OEM of the generator set. Record the total cooling system capacity in the appropriate Table.

For the recommended coolant, see this Operation and Maintenance Manual, "Coolant Recommendations" (Maintenance Section).

### 3508 Engine

Table 49

Approximate Refill Capacities for the 3508 Engine Cooling System		
Compartment or System	Liters	US Gallons
Engine only	114 L	30 US gal
External system		
Total cooling system		

### 3512 Engine

Table 50

Approximate Refill Capacities for the 3512 Engine Cooling System		
Compartment or System	Liters	US Gallons
Engine only	160 L	42 US gal
External system		
Total cooling system		

## 3516 Engine

Table 51

<b>Approximate Refill Capacities for the 3516 Engine Cooling System</b>		
<b>Compartment or System</b>	<b>Liters</b>	<b>US Gallons</b>
Engine only	235 L	62 US gal
External system		
Total cooling system		

i01238560

## Maintenance Interval Schedule

**SMCS Code:** 1000; 7500

**Before performing any operation or maintenance procedures, ensure that the Safety Information, warnings, and instructions are read and understood.**

To determine the maintenance intervals, use fuel consumption, service hours or calendar time, which ever occurs first. Experience has shown that maintenance intervals are most accurately scheduled on the basis of fuel consumption. For information on service hours and fuel consumption, see this Operation and Maintenance Manual, "Maintenance Recommendations" topic (Maintenance Section).

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

**Note:** For information on generator maintenance, see the Operation and Maintenance Manual for the generator.

**Note:** For engines that have a standard oil sump, change the engine oil and oil filters after 500 hours of operation. For engines that have a deep oil sump, change the engine oil and oil filters after 1000 hours of operation.

### When Required

Batteries - Replace .....	100
Engine Air Cleaner Element (Dual Element) - Clean/Replace .....	110
Engine Air Cleaner Element (Single Element) - Inspect/Replace .....	113
Fuel System - Prime .....	124
Zinc Rods - Inspect/Replace .....	141

### Daily

Air Starting Motor Lubricator Oil Level - Check ....	98
Air Tank Moisture and Sediment - Drain .....	98
Cooling System Coolant Level - Check .....	106
Driven Equipment - Inspect/Replace/Lubricate ..	109
Engine Air Cleaner Service Indicator - Inspect ...	114
Engine Air Precleaner - Clean .....	115
Engine Oil Filter Differential Pressure - Check ...	116
Engine Oil Level - Check .....	117
Fuel System Fuel Filter Differential Pressure - Check .....	124
Fuel Tank Water and Sediment - Drain .....	127
Instrument Panel - Inspect .....	128
Walk-Around Inspection .....	139

### Every 250 Service Hours

Alternator and Fan Belts - Inspect/Adjust/ Replace .....	99
Battery Electrolyte Level - Check .....	101
Cooling System Supplemental Coolant Additive (SCA) - Test/Add .....	107
Engine Oil Sample - Obtain .....	117
Fan Drive Bearing - Lubricate .....	123
Hoses and Clamps - Inspect/Replace .....	127
Radiator - Clean .....	136

### Initial 500 Service Hours (or at first oil change)

Engine Valve Lash - Inspect/Adjust .....	123
Fuel Injector - Inspect/Adjust .....	124
Magnetic Pickups - Clean/Inspect .....	129

### Every 500 Service Hours

Engine Oil and Filter - Change .....	118
--------------------------------------	-----

### Every 1000 Service Hours

Cooling System Coolant Analysis (Level II) - Obtain .....	105
Engine - Clean .....	109
Engine Crankcase Breather - Clean .....	115
Engine Oil and Filter - Change .....	118
Engine Protective Devices - Check .....	123
Fuel System Primary Filter - Clean/Inspect/ Replace .....	125
Fuel System Secondary Filter - Replace .....	126

### Every 2000 Service Hours

Air Starting Motor Lubricator Bowl - Clean .....	97
Crankshaft Vibration Damper - Inspect .....	108
Engine Mounts - Check .....	116
Engine Valve Lash - Inspect/Adjust .....	123
Fuel Injector - Inspect/Adjust .....	124
Magnetic Pickups - Clean/Inspect .....	129
Turbocharger - Inspect .....	138

### Every 3000 Service Hours or 3 Years

Cooling System Coolant (DEAC) - Change .....	102
Cooling System Coolant Extender (ELC) - Add ..	106

### Every 6000 Service Hours or 6 Years

Alternator - Inspect .....	99
Cooling System Coolant (ELC) - Change .....	104
Cooling System Water Temperature Regulator - Replace .....	108
Prelube Pump - Inspect .....	136
Starting Motor - Inspect .....	138
Water Pump - Inspect .....	141

### Between 7500 and 11 000 Service Hours

Overhaul (Top End) .....	131
--------------------------	-----

Overhaul Considerations ..... 133

**Between 15 000 and 22 000 Service Hours**

Overhaul (Top End) ..... 131

Overhaul Considerations ..... 133

**Between 22 500 and 33 000 Service Hours**

Overhaul (Major) ..... 129

Overhaul Considerations ..... 133



i01238044

# Maintenance Interval Schedule (Standby Generator Set Engines)

**SMCS Code:** 1000; 7500

**Before performing any operation or maintenance procedures, ensure that the Safety Information, warnings, and instructions are read and understood.**

**Note:** For information on generator maintenance, see the Operation and Maintenance Manual for the generator.

The maintenance that is recommended for Every Week can be performed by an authorized operator. The maintenance that is recommended for the subsequent maintenance intervals must be performed by an authorized service technician or by your Caterpillar dealer.

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

## When Required

Fuel System - Prime ..... 124

## Every Week

Air Starting Motor Lubricator Oil Level - Check ....	98
Air Tank Moisture and Sediment - Drain .....	98
Automatic Start/Stop - Inspect .....	100
Battery Charger - Check .....	100
Battery Electrolyte Level - Check .....	101
Cooling System Coolant Level - Check .....	106
Driven Equipment - Inspect/Replace/Lubricate ..	109
Engine Air Cleaner Service Indicator - Inspect ...	114
Engine Air Precleaner - Clean .....	115
Engine Oil Filter Differential Pressure - Check ...	116
Engine Oil Level - Check .....	117
Fuel System Fuel Filter Differential Pressure - Check .....	124
Fuel Tank Water and Sediment - Drain .....	127
Instrument Panel - Inspect .....	128
Jacket Water Heater - Check .....	129
Radiator - Clean .....	136
Standby Generator Set Maintenance Recommendations .....	137
Walk-Around Inspection .....	140

## Every Year

Air Starting Motor Lubricator Bowl - Clean .....	97
Alternator - Inspect .....	99
Alternator and Fan Belts - Inspect/Adjust/ Replace .....	99

Cooling System Coolant Analysis (Level II) - Obtain .....	105
Cooling System Supplemental Coolant Additive (SCA) - Test/Add .....	107
Crankshaft Vibration Damper - Inspect .....	108
Engine - Clean .....	109
Engine Air Cleaner Element (Dual Element) - Clean/Replace .....	110
Engine Air Cleaner Element (Single Element) - Inspect/Replace .....	113
Engine Crankcase Breather - Clean .....	115
Engine Mounts - Check .....	116
Engine Oil Sample - Obtain .....	117
Engine Oil and Filter - Change .....	118
Engine Performance - Test .....	122
Engine Protective Devices - Check .....	123
Engine Valve Lash - Inspect/Adjust .....	123
Fan Drive Bearing - Lubricate .....	123
Fuel Injector - Inspect/Adjust .....	124
Fuel System Primary Filter - Clean/Inspect/ Replace .....	125
Fuel System Secondary Filter - Replace .....	126
Hoses and Clamps - Inspect/Replace .....	127
Magnetic Pickups - Clean/Inspect .....	129
Prelube Pump - Inspect .....	136
Starting Motor - Inspect .....	138
Water Pump - Inspect .....	141

## Every 3 Years

Batteries - Replace .....	100
Belts - Replace .....	102
Cooling System Coolant (DEAC) - Change .....	102
Cooling System Coolant Extender (ELC) - Add ..	106
Cooling System Water Temperature Regulator - Replace .....	108
Hoses and Clamps - Replace .....	128
Turbocharger - Inspect .....	138

## Every 6 Years

Cooling System Coolant (ELC) - Change .....	104
---	-----

i01228599

## Maintenance Recommendations

**SMCS Code:** 1000

### Service Hours and Fuel Consumption

Experience has shown that maintenance intervals are most accurately based on fuel consumption. Fuel consumption corresponds more accurately to the engine load. Tables 52, 53, and 54 list average ranges of fuel consumption and service hours for a load factor of approximately 60 percent. Use the range of fuel consumption only as a guideline.

Table 52

<b>Maintenance Interval Schedule Service Hours and Fuel Consumption for 3508 Engines <sup>(1)</sup></b>			
<b>Interval</b>	<b>Rated Up To 1300 RPM</b>	<b>Rated 1301 To 1600 RPM</b>	<b>Rated 1601 To 1800 RPM</b>
250 Service Hours	22 700 L (6000 US gal)	27 700 L (7200 US gal)	32 000 L (8500 US gal)
500 Service Hours	45 400 L (12,000 US gal)	54 400 L (14,400 US gal)	64 000 L (17,000 US gal)
1000 Service Hours	89 000L (23,500 US gal)	109 000 L (28,800 US gal)	128 000 L (34,000 US gal)
2000 Service Hours	178 000 L (47,000 US gal)	218 000 L (57,600 US gal)	257 000 L (68,000 US gal)
3000 Service Hours	267 500 L (70,500 US gal)	327 500 L (84,000 US gal)	386 500 L (102,000 US gal)
6000 Service Hours	535 000 L (141,000 US gal)	636 000 L (168,000 US gal)	774 000 L (204,000 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours
	976 000 L (257,500 US gal)		
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours
	1 952 000 L (515,000 US gal)		
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours
	2 928 000 L (772,500 US gal)		

<sup>(1)</sup> Fuel consumption is based on a load factor of approximately 60 percent.

Table 53

<b>Maintenance Interval Schedule Service Hours and Fuel Consumption for 3512 Engines <sup>(1)</sup></b>			
<b>Interval</b>	<b>Rated Up To 1300 RPM</b>	<b>Rated 1301 To 1600 RPM</b>	<b>Rated 1601 To 1800 RPM</b>
250 Service Hours	33 400 L (8800 US gal)	41 000 L (10,800 US gal)	48 500 L (12,800 US gal)
500 Service Hours	66 800 L (17,600 US gal)	82 000 L (21,600 US gal)	97 000 L (25,600 US gal)
1000 Service Hours	133 500 L (35,000 US gal)	164 000 L (43,200 US gal)	194 000 L (51,200 US gal)
2000 Service Hours	267 000 L (70,000 US gal)	328 000 L (86,400 US gal)	388 000 L (102,400 US gal)
3000 Service Hours	398 000 L (105,000 US gal)	491 000 L (129,600 US gal)	582 000 L (153,600 US gal)
6000 Service Hours	796 000 L (210,000 US gal)	982 000 L (259,200 US gal)	1 164 000 L (307,200 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours
	1 460 000 L (385,000 US gal)		
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours
	2 920 000 L (770,000 US gal)		
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours
	4 380 000 L (1,155,000 US gal)		

<sup>(1)</sup> Fuel consumption is based on a load factor of approximately 60 percent.

Table 54

<b>Maintenance Interval Schedule Service Hours and Fuel Consumption for 3516 Engines <sup>(1)</sup></b>			
<b>Interval</b>	<b>Rated Up To 1300 RPM</b>	<b>Rated 1301 To 1600 RPM</b>	<b>Rated 1601 To 1800 RPM</b>
250 Service Hours	44 000 L (11,600 US gal)	53 000 L (14,000 US gal)	64 500 L (17,000 US gal)
500 Service Hours	88 000 L (23,200 US gal)	106 000 L (28,000 US gal)	129 000 L (34,000 US gal)
1000 Service Hours	176 000 L (46,500 US gal)	212 000 L (56,000 US gal)	258 000 L (68,000 US gal)
2000 Service Hours	352 000 L (93,000 US gal)	424 000 L (112,000 US gal)	516 000 L (136,000 US gal)
3000 Service Hours	528 700 L (139,500 US gal)	636 700 L (168,100 US gal)	773 000 L (204,000 US gal)
6000 Service Hours	1 056 000 L (279,000 US gal)	1 272 000 L (336,000 US gal)	1 548 000 L (408,000 US gal)
Top End Overhaul	11 000 Service Hours	9000 Service Hours	7500 Service Hours
	1 942 000 L (512,500 US gal)		
Second Top End Overhaul	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours
	3 884 000 L (1,025,000 US gal)		
Major Overhaul	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours
	5 826 000 L (1,537,500 US gal)		

<sup>(1)</sup> Fuel consumption is based on a load factor of approximately 60 percent.

## Severe Operation

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

- Horsepower
- Range of rpm

- Fuel consumption
- Fuel quality
- Altitude
- Maintenance intervals
- Selection of oil



- Selection of coolant
- Environmental qualities
- Installation

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

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

- Maximum reliability
- Retention of full service life

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

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

## Environmental Factors

### Extreme Ambient Temperatures

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

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

### Cleanliness

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

## Improper Operating Procedures

- Extended operation at low idle

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

## Improper Maintenance Practices

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

i00691569

## Air Starting Motor Lubricator Bowl - Clean

**SMCS Code:** 1451-070

1. Ensure that the air supply to the lubricator is OFF.

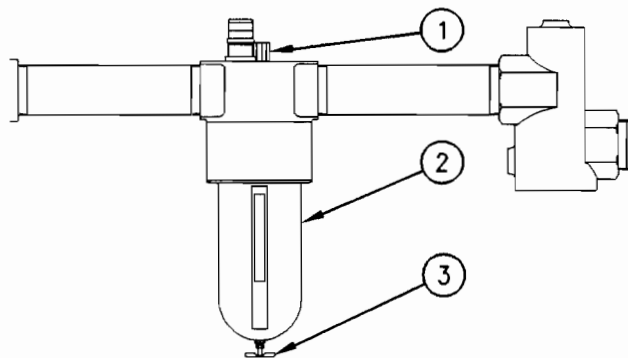


Illustration 58

g00270335

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

**Note:** Always dispose of fluids according to local regulations.

2. Open drain (3). Drain the oil into a suitable container. Dispose of the used oil.
3. Remove bowl (2). Clean the bowl with warm water.

4. Dry the bowl. Inspect the bowl for cracks. If the bowl is cracked, replace the damaged bowl with a new bowl.
5. Install the bowl. Close drain (3).
6. Remove plug (1). Fill bowl (2) with oil. Use nondetergent "10W" oil for temperatures that are greater than 0°C (32°F). Use air tool oil for temperatures that are below 0°C (32°F). Install oil filler plug (1).
7. If necessary, adjust the lubricator in order to release two drops of oil per 30 seconds. For instructions, see this Operation and Maintenance Manual, "Air Starting Motor Lubricator Oil Level - Check" topic (Maintenance Section).

i00691572

## Air Starting Motor Lubricator Oil Level - Check

**SMCS Code:** 1451-535

### NOTICE

Never allow the lubricator bowl to become empty. The air starting motor will be damaged by a lack of lubrication. Ensure that sufficient oil is in the lubricator bowl.

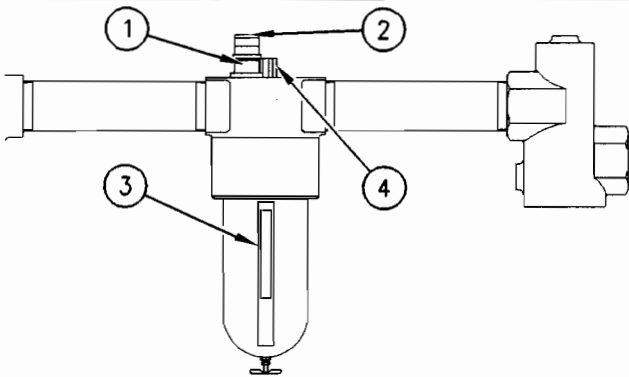


Illustration 59

g00349048

- (1) Dome
- (2) Knob
- (3) Sight gauge
- (4) Plug

1. Observe the oil level in sight gauge (3). If the oil level is less than 1/2, add oil to the lubricator bowl.
2. Ensure that the air supply to the lubricator is OFF.
3. Remove plug (4). Pour oil into the lubricator bowl. Use "10W" oil for temperatures that are greater than 0°C (32°F). Use air tool oil for temperatures that are below 0°C (32°F).

4. Install plug (4).

## Adjust the Lubricator

**Note:** Adjust the lubricator with a constant rate of air flow. After the adjustment, the lubricator will release oil in proportion to variations of the air flow.

1. Ensure that the fuel supply to the engine is OFF.

### NOTICE

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

2. Operate the air starting motor. Observe the drops of oil that are released in dome (1).

**Note:** Some lubricators have an adjustment screw rather than a knob.

3. If necessary, adjust the lubricator in order to release two drops of oil per 30 seconds. To increase the rate, turn knob (2) counterclockwise. To decrease the rate, turn the knob clockwise.

i00351324

## Air Tank Moisture and Sediment - Drain

**SMCS Code:** 1466-543-M&S

Moisture and sediment in the air starting system can cause the following conditions:

- Freezing
- Corrosion of internal parts
- Malfunction of the air starting system

### WARNING

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

1. Open the drain valve that is on the bottom of the air tank. Allow the moisture and sediment to drain.
2. Close the drain valve.

i00839754

## Alternator - Inspect

**SMCS Code:** 1405-040

Inspect the alternator for the following conditions:

- Loose connections
- Proper charging of the battery

Observe the ammeter during engine operation in order to ensure proper battery performance and/or proper performance of the electrical system.

Make repairs, if necessary. See the Service Manual for service procedures. Consult your Caterpillar dealer for assistance.

i00738285

## Alternator and Fan Belts - Inspect/Adjust/Replace

**SMCS Code:** 1357-025; 1357-040; 1357-510; 1405

### Inspection

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

Check the drive belt tension according to the information in the Service Manual, "Systems Operation/Testing and Adjusting".

### Replacement

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

## Alternator Belt Adjustment

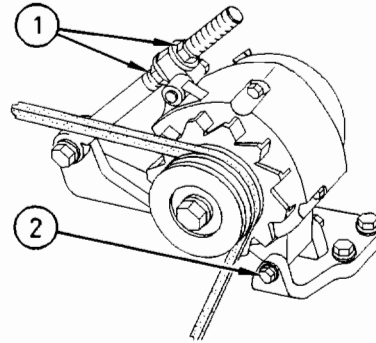


Illustration 60

g00122875

- (1) Adjusting nuts  
(2) Mounting bolt

1. Remove the drive belt guard.
2. Loosen mounting bolt (2) and adjusting nuts (1).
3. Turn adjusting nuts (1) in order to increase or decrease the drive belt tension.
4. Tighten adjusting nuts (1). Tighten mounting bolt (2). Refer to the Operation and Maintenance Manual for the proper torques.
5. Reinstall the drive belt guard.

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

## Fan Drive Belt Adjustment

1. Loosen the mounting bolt for the pulley.
2. Loosen the adjusting nut for the pulley.
3. Move the pulley in order to adjust the belt tension.
4. Tighten the adjusting nut.
5. Tighten the mounting bolt.

i01039675

## Automatic Start/Stop - Inspect (Generator Set)

**SMCS Code:** 4462

The generator set must be ready to operate under a load at any time. After performing maintenance on the generator set, inspect the position of the control switches. Ensure the following conditions:

- The starting system is enabled.
- The control switches are in the correct position for automatic starting.
- The switchgear and the automatic transfer switches that are associated with the generator are enabled.

For more information, see the Operation and Maintenance Manual for the generator and the control panel.

i01041029

## Batteries - Replace

**SMCS Code:** 1401-510

### **WARNING**

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

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

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

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

5. Remove the used battery.

6. Install the new battery.

**Note:** Before connecting the cables, ensure that the key start switch is OFF.

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

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

i01039758

## Battery Charger - Check

**SMCS Code:** 1401-535

### Checking Before Start-Up

Check the battery charger for proper operation. If the batteries are properly charged, the needle of the ammeter will register near "0" (zero).

The battery charger must not produce excessive current during start-up. Alternatively, the charger must be automatically disconnected for start-up. If the engine has an alternator, the charger must be automatically disconnected during start-up and during engine operation.

### Charging the Battery

### **WARNING**

**Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operated. A spark can cause an explosion from the flammable vapor mixture of hydrogen and oxygen that is released from the electrolyte through the battery outlets. Injury to personnel can be the result.**

Perform the following procedure to charge the battery:

1. Ensure that the charger is turned OFF.
2. Adjust the voltage of the charger in order to match the voltage of the battery.

3. Connect the POSITIVE "+" lead of the charger to the POSITIVE "+" battery terminal. Connect the NEGATIVE "-" lead of the charger to the NEGATIVE "-" battery terminal.
4. Turn ON the battery charger.

### Overcharging of Batteries

Overcharging reduces the service life of batteries. Use a battery charger that will not overcharge the battery. DO NOT charge the battery if the meter of the battery charger is in the RED zone.

Overcharging is indicated by the following symptoms:

- The battery is very warm to the touch.
- A strong odor of acid is present.
- The battery emits smoke or a dense vapor (gas).

Perform one of the following procedures if the battery shows symptoms of overcharging:

- Reduce the rate of charging by a significant amount. Complete the charging at the reduced rate.
- Turn OFF the charger.

Table 55 describes the effects of overcharging on different types of batteries.

Table 55

Effects of Overcharging Batteries	
Type of Battery	Effect
Caterpillar General Service Batteries Caterpillar Premium High Output Batteries	All of the battery cells have a low level of electrolyte.
	When the plates of the battery are inspected through the filler holes, the plates may appear to be warped. This is caused by an excessive temperature.
	The battery may not pass a load test.
Caterpillar Maintenance Free Batteries	The battery may not accept a charging current.
	The battery may not pass a load test.

## Checking After Stopping

Ensure that the battery charger is connected properly. Observe the meter of the charger. Record the amperage.

i01206348

## Battery Electrolyte Level - Check

**SMCS Code:** 1401-535-FLV

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

### **WARNING**

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

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

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

2. Check the condition of the electrolyte with the 1U-7298 Coolant/Battery Tester (°C) or the 1U-7297 Coolant/Battery Tester (°F).

3. Keep the batteries clean.

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

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

Thoroughly rinse the battery case with clean water.

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

i01041135

## Belts - Replace

**SMCS Code:** 1357-510

Remove the used fan drive belt and the accessory drive belt. Install new belts.

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

Check the belt tension according to the information in the Service Manual, "Specifications" module. To adjust the belt tension, see this Operation and Maintenance Manual, "Alternator and Fan Belts - Inspect/Adjust/Replace" topic (Maintenance Section).

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

i01105275

## Cooling System Coolant (DEAC) - Change

**SMCS Code:** 1350-044

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

- The engine overheats frequently.
- The coolant is foaming.
- Oil or fuel has entered the cooling system and the coolant is contaminated.

### Drain the Cooling System

1. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained.

2. Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap.

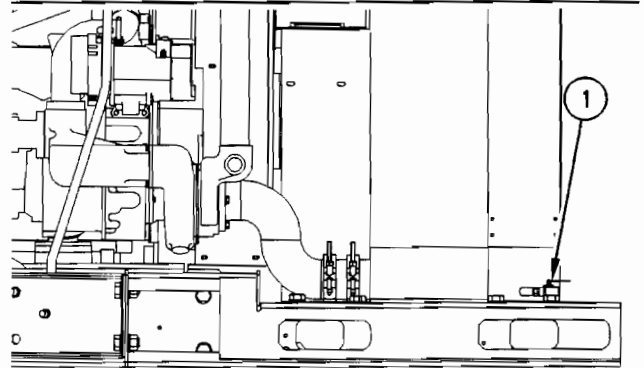


Illustration 61

g00326324

(1) Coolant drain

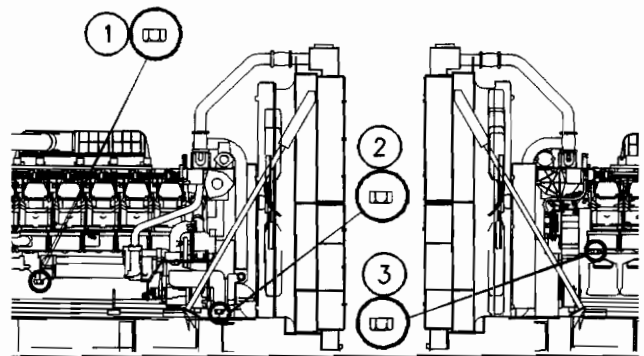


Illustration 62

g00582515

Location of the cooling system drain plugs

- (1) Oil cooler
- (2) Jacket water pump
- (3) Engine block

**Note:** If the engine has a jacket water heater, drain the coolant from the heater.

3. Open the coolant drain. Remove the cooling system drain plugs. Allow the coolant to drain.

### NOTICE

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

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

Outside U.S.A.: (309) 675-6277  
Inside U.S.A.: 1-800-542-TOOL  
Inside Illinois: 1-800-541-TOOL  
Canada: 1-800-523-TOOL  
CSTG COSA Geneva, Switzerland:  
41-22-849 40 56

## Clean the Cooling System

### NOTICE

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

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.
2. Close the cooling system drain. Clean the cooling system drain plugs and install the cooling system drain plugs.

### NOTICE

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

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the radiator filler cap.
4. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine for a minimum of 30 minutes with a coolant temperature of at least 82 °C (180 °F).
5. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap. Open the coolant drain. Remove the cooling system drain plugs. Allow the water to drain.

### NOTICE

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

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

6. Flush the cooling system with clean water until the water that drains is clean. Close the coolant drain. Clean the cooling system drain plugs and install the cooling system drain plugs. Open the water inlet for the separate circuit aftercooler (if equipped).

## Cleaning a Cooling System that has Heavy Deposits or Plugging

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

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.
2. Close the coolant drain. Clean the cooling system drain plugs and install the cooling system drain plugs.
3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the radiator filler cap.
4. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine for a minimum of 90 minutes with a coolant temperature of at least 82 °C (180 °F).
5. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap. Open the coolant drain. Remove the cooling system drain plugs. Allow the water to drain.

### NOTICE

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

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

6. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain. Clean the cooling system drain plugs and install the cooling system drain plugs.

## Fill the Cooling System

**Note:** For information about the proper coolant to use, see this Operation and Maintenance Manual, "Coolant Recommendations" (Maintenance Section). For the capacity of the cooling system, see this Operation and Maintenance Manual, "Refill Capacities" (Maintenance Section).

### NOTICE

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

1. Fill the cooling system with coolant/antifreeze. After filling the cooling system, do not install the radiator filler cap.
2. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Allow the coolant to warm and allow the coolant level to stabilize. Stop the engine.
3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.
4. Clean the radiator filler cap. Inspect the gaskets of the radiator filler cap. If the gaskets of the radiator filler cap are damaged, discard the old radiator filler cap and install a new radiator filler cap. If the gaskets of the radiator filler cap are not damaged, use a **9S-8140** Pressurizing Pump in order to pressure test the radiator filler cap. The correct pressure is stamped on the face of the radiator filler cap. If the radiator filler cap does not maintain the correct pressure, install a new radiator filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i01105351

## Cooling System Coolant (ELC) - Change

**SMCS Code:** 1350-044-NL

Use only clean water to flush the cooling system when Extended Life Coolant (ELC) is drained and replaced.

## Drain the Cooling System

1. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained.
2. Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap.

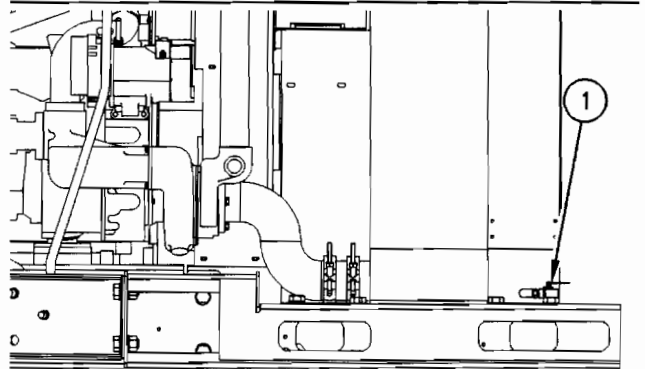


Illustration 63

g00326324

(1) Coolant drain

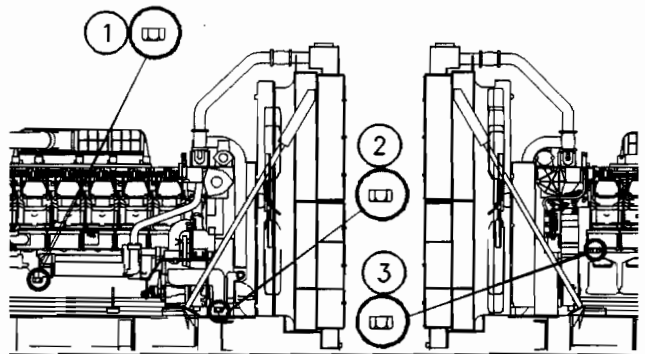


Illustration 64

g00582515

Location of the cooling system drain plugs

- (1) Oil cooler
- (2) Jacket water pump
- (3) Cylinder block

**Note:** If the engine has a jacket water heater, drain the coolant from the heater.

3. Open the coolant drain. Remove the cooling system drain plugs. Allow the coolant to drain.

### NOTICE

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



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

Outside U.S.A.: (309) 675-6277  
 Inside U.S.A.: 1-800-542-TOOL  
 Inside Illinois: 1-800-541-TOOL  
 Canada: 1-800-523-TOOL  
 CSTG COSA Geneva, Switzerland:  
 41-22-849 40 56

## Clean the Cooling System

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.
2. Close the coolant drain. Clean the drain plugs and install the drain plugs.

---

### NOTICE

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

---

3. Open the water inlet for the separate circuit aftercooler (if equipped). Fill the cooling system with clean water. Install the radiator filler cap. Operate the engine until the temperature reaches 49 °C (120 °F) to 66 °C (150 °F).
4. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained. Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap.
5. Open the coolant drain. Remove the drain plugs. Allow the coolant to drain. Flush the cooling system with clean water. Close the coolant drain. Install the drain plugs.
6. Repeat Steps 3, 4, and 5.

## Fill the Cooling System

---

### NOTICE

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

---

1. Fill the cooling system with Extended Life Coolant (ELC). After filling the cooling system, do not install the radiator filler cap.

2. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Allow the ELC to warm and allow the coolant level to stabilize. Stop the engine.
3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.
4. Clean the radiator filler cap. Inspect the gaskets of the radiator cap. If the gaskets of the radiator filler cap are damaged, discard the old radiator filler cap and install a new radiator filler cap. If the gaskets of the radiator filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the radiator filler cap. The correct pressure is stamped on the face of the radiator filler cap. If the radiator filler cap does not maintain the correct pressure, install a new radiator filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i01065859

## Cooling System Coolant Analysis (Level II) - Obtain

**SMCS Code:** 1350

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

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

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

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

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

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

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

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

i00259474

## Cooling System Coolant Extender (ELC) - Add

**SMCS Code:** 1352-544-NL

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

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

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

4. Clean the cooling system filler cap. Inspect the cooling system filler cap gaskets. Replace the cooling system filler cap if the cooling system filler cap gaskets are damaged. Install the cooling system filler cap.

i00835531

## Cooling System Coolant Level - Check

**SMCS Code:** 1350-535-FLV

### WARNING

**Climbing equipment may be required to access this service point. Refer to the Operation and Maintenance Manual, "Mounting and Dismounting" topic for safety information.**

## Engines That Are Equipped With a Sight Gauge

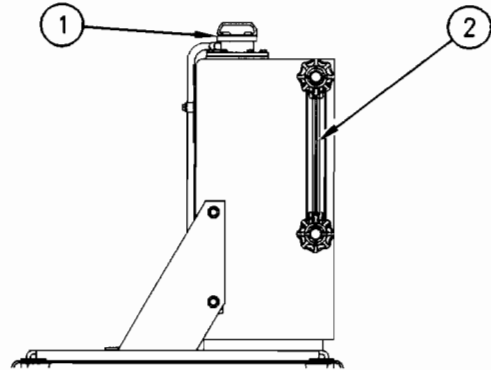


Illustration 65

g00130682

- (1) Filler cap  
(2) Sight gauge

If the engine is equipped with a sight gauge, observe the position of the coolant in the sight gauge. At normal operating temperature, the proper coolant level is in the upper half of the sight gauge. If the coolant level is low, add the proper coolant mixture.

## Engines That Are Not Equipped With a Sight Gauge

Check the coolant level when the engine is stopped and cool. Check the coolant level only after the engine has been stopped and the cooling system filler cap is cool enough to touch with your bare hand.

Remove the cooling system filler cap slowly in order to relieve any pressure. Maintain the coolant to the level that is specified by the OEM of the cooling system.

## Add Coolant

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

1. Stop the engine. Allow the engine to cool.
2. Remove the cooling system filler cap slowly in order to relieve any pressure. Pour the proper coolant mixture into the filler pipe.

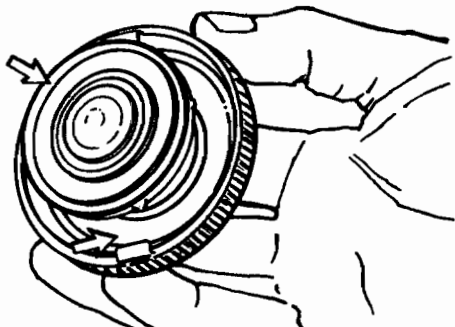


Illustration 66

g00103639

### Gaskets

3. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.
4. Start the engine. Inspect the cooling system for leaks.

i01065856

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

**SMCS Code:** 1352-045; 1395-081

This maintenance procedure is required for conventional coolants such as DEAC and for mixtures of water and SCA. **This maintenance is NOT required for cooling systems that are filled with Extended Life Coolant.**

### WARNING

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

**Note:** Test the concentration of the SCA or obtain an S·O·S coolant analysis (Level I).

## Test the Concentration of the SCA

### Coolant/Antifreeze and SCA

#### NOTICE

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

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit or the 4C-9301 Coolant Conditioner Test Kit. Follow the instructions that are on the label of the test kit.

### Water and SCA

#### NOTICE

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

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit. Follow the instructions that are in this Operation and Maintenance Manual, "Water/Supplemental Coolant Additive (SCA)" topic (Maintenance Section).

## S·O·S Coolant Analysis (Level I)

Level I is a basic analysis of the coolant. The following items are tested: SCA concentration, glycol concentration, pH, and conductivity.

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

## Add the SCA, If Necessary

### WARNING

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

1. Remove the cooling system filler cap slowly.

**Note:** Always dispose of fluids according to local regulations.

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

---

#### NOTICE

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

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

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

---

3. Add the proper amount of SCA. The concentration of the SCA depends on the type of coolant that is used.
  - a. For cooling systems that use conventional coolant/antifreeze, see this Operation and Maintenance Manual, "Conventional Coolant/Antifreeze Cooling System Maintenance" topic (Maintenance Section).
  - b. For cooling systems that use only a mixture of water and SCA, see this Operation and Maintenance Manual, "Water/Supplemental Coolant Additive (SCA)" topic (Maintenance Section).
4. Clean the cooling system filler cap. Install the cooling system filler cap.

i00912898

## Cooling System Water Temperature Regulator - Replace

**SMCS Code:** 1355-510

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

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

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

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

---

#### NOTICE

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

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

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

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

---

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

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

i01064210

## Crankshaft Vibration Damper - Inspect

**SMCS Code:** 1205-040

The crankshaft vibration damper limits the torsional vibration of the crankshaft. The visconic damper has a weight that is located inside a fluid filled case.

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

A damper that is hot may be the result of excessive friction. This could be due to misalignment. Use an infrared thermometer to monitor the temperature of the damper during operation. If the temperature reaches 93 °C (200 °F), consult your Caterpillar dealer.

Inspect the damper for evidence of dents, cracks, and leaks of the fluid.

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

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

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

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

## Removal and Installation

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

i00935098

## Driven Equipment - Inspect/Replace/Lubricate

**SMCS Code:** 3279-040

Observe the driven equipment during operation. Look for the following items:

- Unusual noise and vibration
- Loose connections

- Damaged parts

Perform any maintenance that is recommended by the OEM of the driven equipment. Refer to the literature of the OEM of the driven equipment for the following service instructions.

- Inspection
- Lubricating grease and lubricating oil requirements
- Specifications for adjustment
- Replacement of components
- Requirements for ventilation

i01108937

## Engine - Clean

**SMCS Code:** 1000-070

### WARNING

**Personal injury or death can result from high voltage.**

**Moisture could create paths of electrical conductivity.**

**Make sure the unit is off line (disconnected from utility and/or other generators), locked out and tagged "Do Not Operate".**

### NOTICE

Water or condensation can cause damage to generator components. Protect all electrical components from exposure to water.

### NOTICE

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

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

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

**Note:** For more information on cleaning and drying electric generators, refer to Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators".

i00174810

## Engine Air Cleaner Element (Dual Element) - Clean/Replace

**SMCS Code:** 1051; 1054-037

### NOTICE

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

### NOTICE

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

## Servicing the Air Cleaner Elements

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

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

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

## Dual Element Air Cleaners

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element. The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable or washable. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element. When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

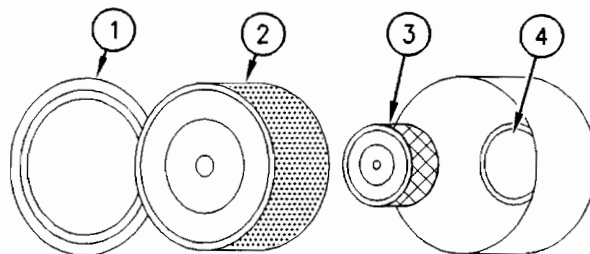


Illustration 67

g00123209

(1) Cover. (2) Primary air cleaner element. (3) Secondary air cleaner element. (4) Turbocharger air inlet.

1. Remove the cover. Remove the primary air cleaner element.
2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.

**Note:** Refer to "Cleaning the Primary Air Filter Elements".

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

5. Remove the tape for the turbocharger air inlet. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.
6. Install the air cleaner cover.
7. Reset the service indicator.

## Cleaning the Primary Air Cleaner Elements

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

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

### NOTICE

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

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

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

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

### Pressurized Water

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

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

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

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

### Pressurized Air

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

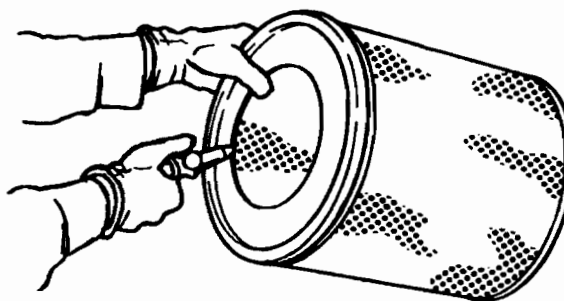


Illustration 68

g00281692

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

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

**Note:** Refer to "Inspecting the Primary Air Cleaner Elements".

### Vacuum Cleaning

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

**Note:** Refer to "Inspecting the Primary Air Cleaner Elements".

### Washing the Primary Air Cleaner Elements with Nonsudsing Detergent

**! WARNING**

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

---

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

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

**Note:** Caterpillar does not recommend a process for washing the primary air cleaner element which includes agitation. Agitation may cause carbon particles to be distributed.

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

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

### Drying the Primary Air Cleaner Elements

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

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

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

### Inspecting the Primary Air Cleaner Elements

---

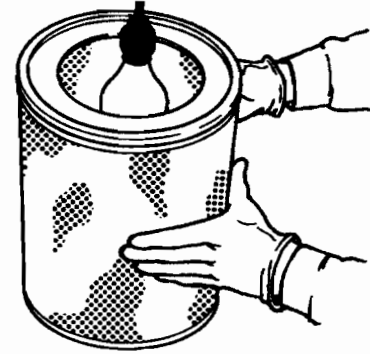


Illustration 69

g00281693

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

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

### Storing Primary Air Cleaner Elements

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



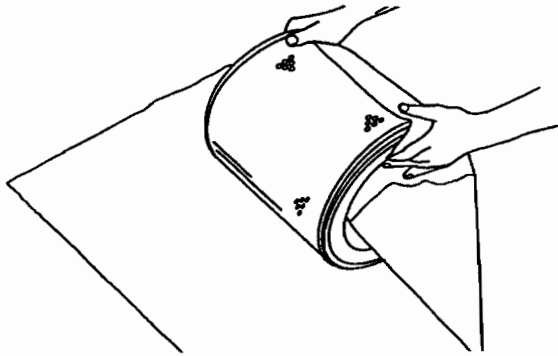


Illustration 70

g00281694

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

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

- Date cleaned
- Number of cleanings

Store the box in a dry location.

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

i00736823

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

**SMCS Code:** 1054-040; 1054-510

### NOTICE

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

### NOTICE

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

## Servicing the Air Cleaner Elements

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

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

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

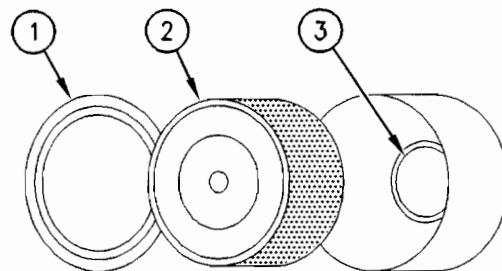


Illustration 71

g00310664

- (1) Cover
- (2) Element
- (3) Air inlet

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

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

i00823657

## Engine Air Cleaner Service Indicator - Inspect

**SMCS Code:** 7452-040

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

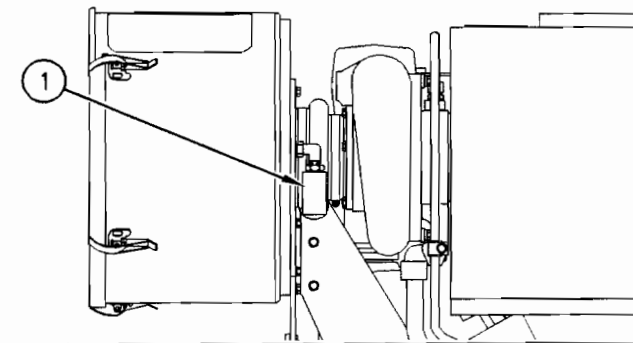


Illustration 72

g00329643

(1) Service indicator

Some engines may be equipped with a different service indicator.

Observe the service indicator. Clean the air cleaner element or replace the air cleaner element when the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.
- The air restriction reaches 6 kPa (25 inches of H<sub>2</sub>O).

## Test the Service Indicator

Service indicators are important instruments.

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

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

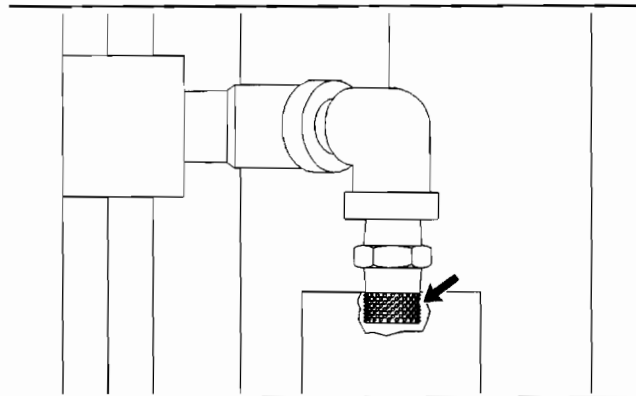


Illustration 73

g00351792

Porous filter

A porous filter is part of a fitting that is used for mounting of the service indicator. Inspect the filter for cleanliness. Clean the filter, if necessary. Use compressed air or a clean, nonflammable solvent.

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

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

i01190885

## Engine Air Precleaner - Clean

SMCS Code: 1055-070

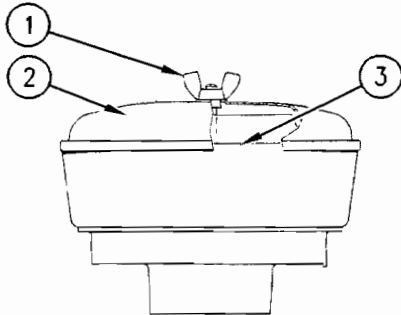


Illustration 74

g00287039

Typical precleaner

- (1) Wing nut
- (2) Cover
- (3) Body

Remove wing nut (1) and cover (2). Check for an accumulation of dirt and debris in body (3). Clean the body, if necessary.

After cleaning the precleaner, install cover (2) and wing nut (1).

**Note:** When the engine is operated in dusty applications, more frequent cleaning is required.

i01225429

## Engine Crankcase Breather - Clean

SMCS Code: 1317-070

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

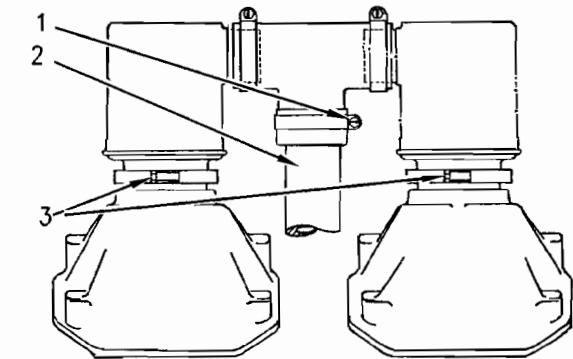


Illustration 75

g00597463

1. Loosen clamp (1). Slide the clamp down on tube (2).
2. Loosen clamps (3). Remove both breathers as a unit.

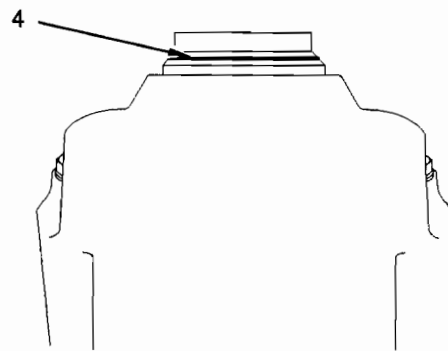


Illustration 76

g00597465

3. Remove O-ring seals (4) from the valve covers. Inspect the O-ring seals for good condition. Obtain new O-ring seals, if necessary.

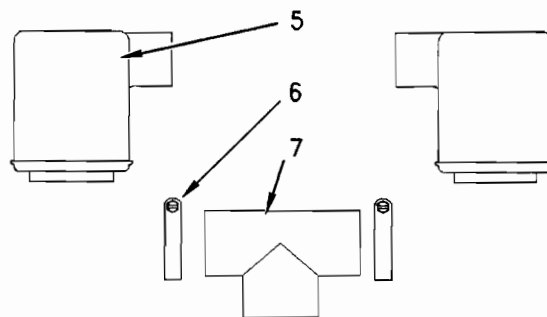


Illustration 77

g00597466

4. Remove two clamps (6). Remove both breathers (5) from hose tee (7).

Inspect the hose tee for cracks. If the tee is cracked, discard the old tee and obtain a new tee for installation.

5. Turn the breathers upside-down in order to inspect the condition of the breather elements.

Clean the breather elements with clean, nonflammable solvent. If the breather elements remain contaminated after the cleaning, discard the breathers and obtain new breathers. Do not attempt to disassemble the breathers.

Allow the breather elements to dry before installation.

**Note:** Coat the rubber parts with clean engine oil or petroleum jelly in order to make installation easier.

6. Place clamps (6) over the parts of hose tee (7) that will receive breathers (5). Install the breathers into the tee. Tighten the clamps to the torque that is listed in the Service Manual, "Specifications".
7. Coat O-ring seals (4) with clean engine oil. Place the O-ring seals on the valve covers.
8. Place clamps (3) around the parts of the breathers that will be attached to the valve covers. Install both breathers as a unit. Tighten the clamps.
9. Place clamp (1) on the part of the hose tee that will receive tube (2). Install the tube into the hose tee. Tighten the clamp to the torque that is listed in the Service Manual, "Specifications".

i00722604

## Engine Mounts - Check

**SMCS Code:** 1152-535

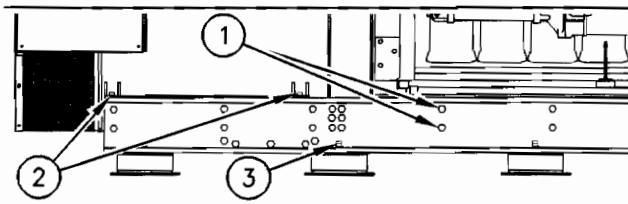


Illustration 78

g00321243

- (1) Mounting bolts for the engine
- (2) Mounting bolts for the generator
- (3) Levelling bolts for the isolators

Misalignment of the engine and the driven equipment will cause extensive damage. Excessive vibration can lead to misalignment. Excessive vibration of the engine and the driven equipment can be caused by the following conditions:

- Improper mounting
- Loose bolts
- Deterioration of the isolators

Ensure that the mounting bolts are tightened to the proper torque. For standard torques, see the Operation and Maintenance Manual, "Torque Specifications" in the Maintenance Section.

Ensure that the isolators are free of oil and contamination. Inspect the isolators for deterioration. Ensure that the bolts for the isolators are tightened to the proper torque.

Replace any isolator that shows deterioration. For more information, see the literature that is provided by the OEM of the isolators. Also see the Application and Installation Guide for the engine. Consult your Caterpillar dealer for assistance.

i01076654

## Engine Oil Filter Differential Pressure - Check

**SMCS Code:** 1308-535

Observe the oil filter differential pressure frequently during engine operation.



**Oil Filter Differential Pressure (Restriction)** – This gauge indicates the difference in pressure between the inlet side and the outlet side of the engine oil filters. As the oil filter elements become plugged, oil filter differential pressure will increase.

The nominal oil filter differential pressure during normal engine operation is approximately 60 kPa (9 psi).

Replace the oil filter elements when the oil filter differential pressure reaches 103 kPa (15 psi).

For instructions on replacement of the oil filter elements, see this Operation and Maintenance Manual, "Engine Oil and Filter - Change" topic.

i01071237

## Engine Oil Level - Check

**SMCS Code:** 1348-535-FLV

The most accurate check of the oil level is obtained when the engine is stopped. Perform this maintenance on a surface that is as level as possible.

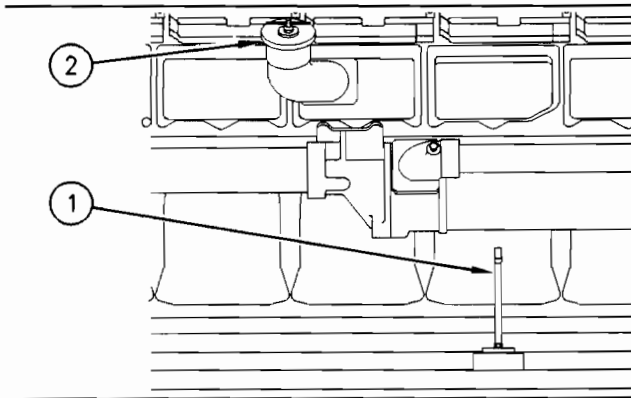


Illustration 79

g00424658

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

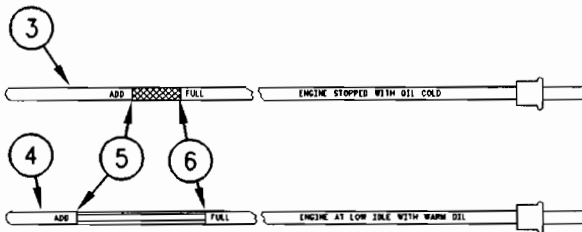


Illustration 80

g00438568

- (3) "ENGINE STOPPED WITH OIL COLD" side
- (4) "ENGINE AT LOW IDLE WITH WARM OIL" side
- (5) "ADD" mark
- (6) "FULL" mark

1. Ensure that oil level gauge (1) is seated.
  - a. If the engine is stopped, remove the oil level gauge. Observe the oil level on "ENGINE STOPPED WITH OIL COLD" side (3).
  - b. If the engine is operating, reduce the engine speed to low idle. Remove the oil level gauge and observe the oil level on "ENGINE AT LOW IDLE WITH WARM OIL" side (4).

The oil level should be between "ADD" mark (5) and "FULL" mark (6).

### NOTICE

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

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

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

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

2. If necessary, remove oil filler cap (2) and add oil. For the correct oil to use, see this Operation and Maintenance Manual, "Engine Oil" topic (Maintenance Section). Do not fill the crankcase above the "FULL" mark on the oil level gauge. Clean the oil filler cap. Install the oil filler cap.
3. Record the amount of oil that is added. For the next oil sample and analysis, include the total amount of oil that has been added since the previous oil change. This will help to provide the most accurate oil analysis.

i01070756

## Engine Oil Sample - Obtain

**SMCS Code:** 1348-554-SM

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

### Obtain the Sample and the Analysis



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

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

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

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

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

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

The 8T-9190 Fluid Sampling Bottle Group is recommended for use with the sampling valve. The bottle group includes the parts that are needed for obtaining oil samples. Instructions are also provided.

**NOTICE**

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

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

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

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

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

For instructions, see Special Publication, PEHP6001, "How To Take A Good Oil Sample". Consult your Caterpillar dealer for complete information and assistance in establishing an S-O-S program for your engine.

101246782

## Engine Oil and Filter - Change

**SMCS Code:** 1318-510

The oil change interval will be affected by the following items:

- Air/fuel ratio
- Ambient air conditions
- Engine application
- Fuel type
- Oil type
- Size of the oil sump

The S-O-S oil analysis program analyzes used oil in order to determine if the oil change interval is suitable for your specific engine. In the absence of S-O-S oil analysis, change the engine oil and engine oil filters according to the interval that is listed in Table 56.

Table 56

3500B Generator Set Engine Oil Change Intervals		
Engine	Sump Capacity	Oil Change Interval
<b>Engines With a Standard Sump</b>		
3508B	227 L (60 US gal)	Every 500 Service Hours
3512B	318 L (84 US gal)	
3516B	405 L (107 US gal)	
<b>Engines With a Deep Sump</b>		
3508B	443 L (117 US gal)	Every 1000 Service Hours
3512B	625 L (165 US gal)	
3516B	807 L (213 US gal)	

## Drain the Oil

### WARNING

Hot oil and components can cause personal injury.

**Do not allow hot oil or components to contact skin.**

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

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

1. After the engine has been operated at normal operating temperature, STOP the engine.

### NOTICE

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

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

2. Drain the oil according to the equipment on the engine.

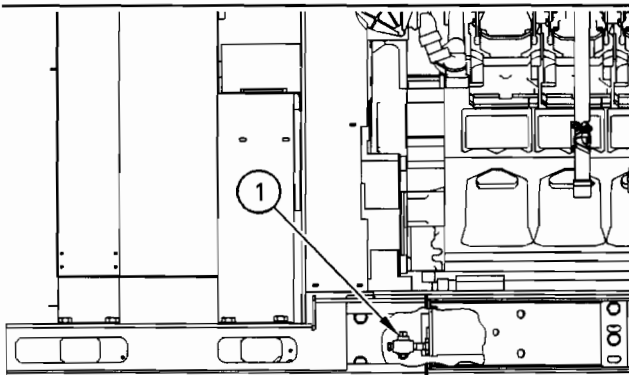


Illustration 81

g00328285

(1) Oil drain

- a. Open oil drain (1). After the oil has drained, close the oil drain.
- b. If a suction device is inserted into the oil pan, ensure that the suction device is clean. This will prevent dirt from entering into the oil pan. Be careful not to strike the engine oil suction tubes or the piston cooling jets.
- c. If a suction device that attaches to the oil drain is used, ensure that the suction device is clean. Attach the suction device to the oil drain. Open the oil drain. After the oil has drained, close the oil drain and remove the suction device.
- d. If the oil drain valve has a "quick connect" coupling, attach the coupling. Open the drain valve in order to drain the crankcase. After the oil has drained, close the drain valve. Disconnect the coupling.

3. Replace the engine oil filter elements before you fill the crankcase with new oil.

## Replace the Oil Filter Elements

Replace the engine oil filters when any of the following conditions occur:

- Every oil change
- The engine oil filter differential pressure reaches 103 kPa (15 psi).
- The oil filter elements have been used for 1000 service hours.

**Note:** Do not attempt to clean the used oil filters. Used oil filters will retain waste particles. The used oil filters would not filter the oil properly.

Service tools are available to aid in the service of oil filters. Consult your Caterpillar dealer for the part names and the part numbers. Follow the instructions that are supplied with the service tools. If the service tools are not used, perform the following appropriate procedure.

## Replacing the Engine Oil Filters With the Engine Stopped

### WARNING

Hot oil and components can cause personal injury.

**Do not allow hot oil or components to contact skin.**

Perform the following procedure after the oil has been drained.

**Note:** Use this procedure if the engine oil filters do not have a control valve.

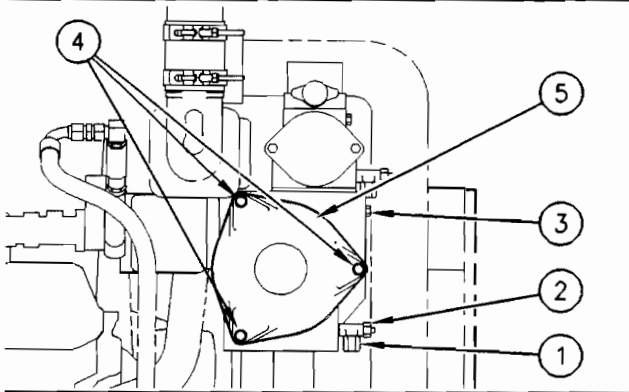


Illustration 82

g00328146

- (1) Drain
- (2) Drain valve
- (3) Plug
- (4) Bolts
- (5) Cover

**Note:** Drain the oil into a suitable container. Dispose of the oil according to local regulations.

1. Connect a hose to drain (1). Place the other end of the hose into a suitable container in order to collect the oil.
2. Open drain valve (2). Remove plug (3). Allow the oil to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

**Note:** Some oil will remain in the housing after the oil has been drained. This oil will pour out of the housing when cover (5) is removed. Prepare to catch the oil in a suitable container. Clean up any spilled oil with absorbent towels or pillows. **DO NOT** use absorbent particles to clean up the oil.



### WARNING

**Personal injury can result from parts and/or covers under spring pressure.**

**Spring force will be released when covers are removed.**

**Be prepared to hold spring loaded covers as the bolts are loosened.**

3. Be alert to the spring force. Gradually loosen but do not remove bolts (4). Before you remove the bolts, pry the cover (5) loose or tap the cover with a rubber mallet in order to relieve any spring pressure. Remove cover (5).

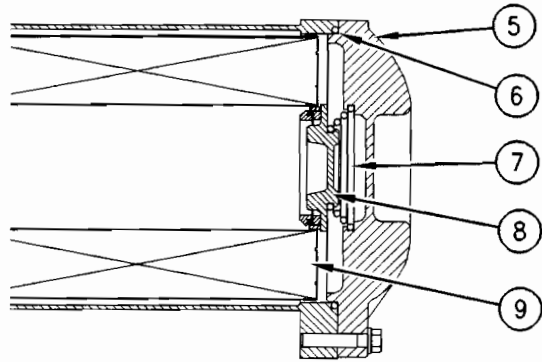


Illustration 83

g00350932

Section view of the engine oil filter

- (5) Cover
- (6) O-ring seal
- (7) Spring
- (8) Retainer
- (9) Oil filter element

4. Remove cover (5) and spring (7). Remove O-ring seal (6), retainer (8), and oil filter elements (9).
5. Clean cover (5), spring (7), O-ring seal (6), and retainer (8). Clean the inside of the oil filter housing.

### NOTICE

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

6. Ensure that the new oil filter elements are in good condition. Install the new oil filter elements.
7. Inspect the O-ring seal. Ensure that the surfaces for the O-ring seal are clean. Install a new O-ring seal if the old O-ring seal is damaged or deteriorated.
8. Install retainer (8), spring (7) and cover (5). Ensure that the retainer and the spring are properly seated between the oil filter elements and the cover.
9. Start the engine according to this Operation and Maintenance Manual, "Starting The Engine" procedure (Operation Section). Check for oil leaks.



## Replace the Spin-On Oil Filters

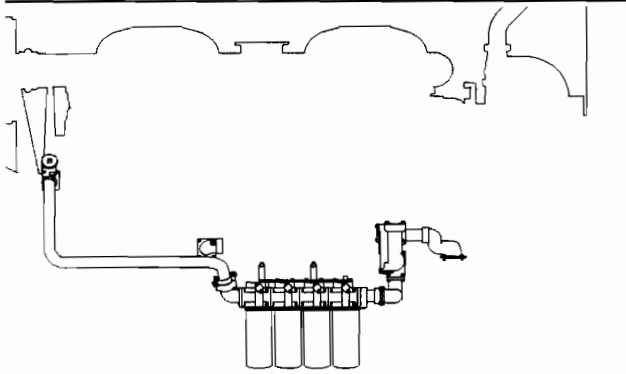


Illustration 84  
Spin-on oil filters

g00396660

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



Illustration 85  
Mounting base and gasket

g00103713

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

### NOTICE

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

4. Place the oil filter in position. Tighten the oil filter until the gasket contacts the base. Tighten the oil filter by hand for an additional 1 full turn (360 degrees). Do not overtighten the oil filter.

## Replacing the Engine Oil Filters During Engine Operation

If the engine is equipped with duplex oil filters, the engine oil filter elements can be changed while the engine is operation. This is useful if the oil filter elements require more frequent replacement than the engine oil.

### **WARNING**

**Filter contains hot pressurized fluid when engine is running.**

**Follow instructions on control valve to avoid personal injury.**

**If rapid air movement exists to blow fluid, Stop the engine to avoid fire.**

1. Move the control valve to the "AUX RUN" position in order to change the main oil filter elements. Move the selector valve to the "MAIN RUN" position in order to change the auxiliary oil filter elements.
2. Allow the oil pressure gauge for the oil filter that is being changed to reach a "ZERO" pressure reading.
3. Perform Step 1 through Step 8 of "Replacing the Engine Oil Filters With the Engine Stopped".
4. Open the "FILL" valve for a minimum of five minutes in order to fill the new oil filter elements.
5. Close the "FILL" valve. Rotate the control valve to the "RUN" position for the oil filter that was serviced.

## Inspect the Used Oil Filter Elements

Cut the used oil filter element open with a utility knife. Remove the metal wrap. Cut the filter element free from the end caps. Spread apart the pleats and inspect the element for metal debris. An excessive amount of debris in the element may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the element. Ferrous metals may indicate wear on the steel and the cast iron parts of the engine. Nonferrous metals may indicate wear on the aluminum parts, the brass parts, or the bronze parts of the engine. Parts that may be affected include the following components: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Aluminum debris may indicate problems with the bearings of the front gears. If aluminum debris is found, inspect the crankshaft vibration damper and the bearings of the front idler gear.

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

## Fill the Crankcase

---

### NOTICE

Only use oils that are recommended by Caterpillar. For the proper oil to use, refer to this Operation and Maintenance Manual, "Engine Oil" topic (Maintenance Section).

---

### NOTICE

If the engine is equipped with an auxiliary oil filter system, extra oil must be added when filling the crankcase. If equipped with an auxiliary oil filter system that is not supplied by Caterpillar, follow the recommendations of the OEM.

---

### NOTICE

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

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

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

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

---

1. Remove the oil filler cap. Fill the crankcase through the oil filler tube only. For the amount of oil to use, refer to this Operation and Maintenance Manual, "Refill Capacities" (Maintenance Section). Clean the oil filler cap. Install the oil filler cap.

---

### NOTICE

To prevent crankshaft or bearing damage, crank engine with fuel off to fill all filters before starting.

Do Not crank engine for more than 30 seconds.

---

2. Close the fuel supply line and crank the engine until the oil pressure gauge indicates 70 kPa (10 psi). Open the fuel supply line. Allow the starting motor to cool for two minutes before cranking again.
3. Follow this Operation and Maintenance Manual, "Starting The Engine" procedure (Operation Section). Operate the engine at low idle for two minutes. This will ensure that the lubrication system has oil and that the oil filters are filled with oil. Inspect the engine for oil leaks. Ensure that the oil level is at the "FULL" mark on the "LOW IDLE" side of the oil level gauge.
4. Stop the engine and allow the oil to drain back into the sump for a minimum of ten minutes.
5. Remove the oil level gauge and check the oil level. Maintain the oil level to the "FULL" mark on the "ENGINE STOPPED" side of the oil level gauge.

i01042067

## Engine Performance - Test

**SMCS Code:** 1000-081

Operate the engine for a minimum of two hours at a minimum load of 60 percent.

- Monitor the operation of the generator set.
- Observe the gauges. Ensure that the gauges are in the normal ranges.
- Record the data. Maintain a record of the data for the engine performance.

i00626013

## Engine Protective Devices - Check

**SMCS Code:** 7400-535

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

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

---

### NOTICE

During testing, abnormal operating conditions must be simulated.

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

---

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

## Visual Inspection

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

i01071128

## Engine Valve Lash - Inspect/Adjust

**SMCS Code:** 1102-025

**Note:** For procedures on adjusting the valve bridge and adjusting the engine valve lash, see the Service Manual, "Systems Operation/Testing and Adjusting" module. Consult your Caterpillar dealer for assistance.

## Valve Bridge

Check the valve bridge and adjust the valve bridge, if necessary. Perform the procedure for both valve bridges for each cylinder. After the valve bridge is checked for each cylinder, proceed with the valve lash adjustment, if necessary.

## Engine Valve Lash

---

### NOTICE

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

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

---

The valve bridge adjustment must be performed before making a valve lash adjustment. If the valve lash is within the tolerance, an adjustment of the valve lash is NOT necessary.

Perform the valve lash setting when the engine is cold. After the engine has been shut down and the valve covers are removed, the engine is considered cold. Before performing maintenance, prevent the entry of foreign matter into the top of the cylinder head and the valve mechanism. Thoroughly clean the area around the valve mechanism covers.

For the valve lash setting, see this Operation and Maintenance Manual, "Engine Description" topic (Product Information Section).

i01106228

## Fan Drive Bearing - Lubricate

**SMCS Code:** 1359-086-BD

**Note:** Lubricate the bearing more frequently if the engine is operated in an environment that is dusty, hot, or humid.

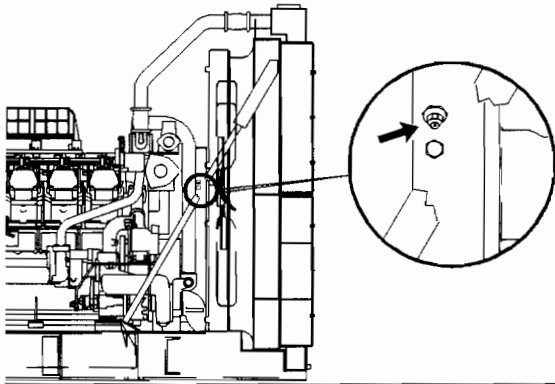


Illustration 86  
Grease fitting

g00583459

Fill the grease fitting for the fan drive bearing with Caterpillar Bearing Lubricant. Alternatively, use a multipurpose grease that has three to five percent of molybdenum and a grade of NLGI No. 2.

i01225237

## Fuel Injector - Inspect/Adjust

**SMCS Code:** 1290-025

**Note:** Perform this procedure when the engine valve lash is inspected.

### **WARNING**

**The Electronic Control module produces high voltage. To prevent personal injury make sure the Electronic Control Module is not powered and the unit injector solenoids are disconnected.**

### **NOTICE**

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

Inspect the adjustment of the lash for the fuel injector according to the Systems Operation/Testing And Adjusting, "Fuel System" topic. Adjust the lash for the fuel injector, if necessary.

## Fuel System - Prime

**SMCS Code:** 1250-548; 1258-548

1. Open the fuel supply valve. Ensure that the engine will not start during the priming procedure. Turn the start switch to the OFF position.

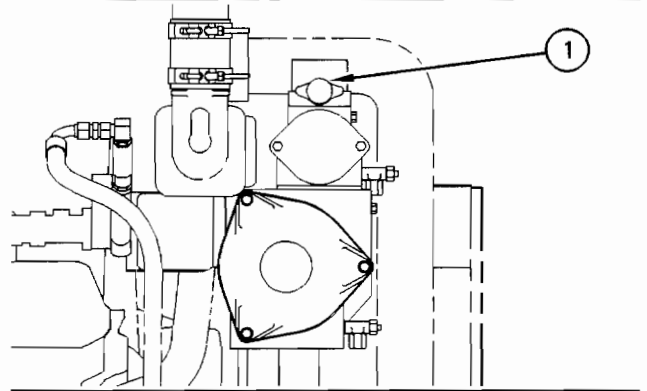


Illustration 87

g00329248

(1) Fuel priming pump plunger

2. Turn the fuel priming pump plunger counterclockwise in order to release the lock plate from the retainer.
3. Operate the fuel priming pump until the air in the fuel system has been pumped through the fuel return line back to the fuel tank.
4. Press the fuel priming pump plunger to the locking position. Turn the fuel priming pump plunger clockwise in order to engage the lock plate in the retainer.

**Note:** Enable the starting system only after all maintenance has been completed.

## Priming Procedure for Dry Starting

If the air cannot be completely purged from the fuel system and the engine will not start, see Special Instruction, SEHS9586, "3500 EUI Fuel Priming Procedure".

i01076701

## Fuel System Fuel Filter Differential Pressure - Check

**SMCS Code:** 1261-535

Observe the fuel filter differential pressure frequently during engine operation.



### Fuel Filter Differential Pressure

**(Restriction)** – This gauge indicates the difference in fuel pressure between the inlet side and the outlet side of the fuel filter. As the fuel filter element becomes plugged, the difference in pressure between the two sides of the fuel filter increases.

The nominal fuel filter differential pressure during normal engine operation is approximately 60 kPa (9 psi).

Replace the secondary fuel filter elements when the fuel filter differential pressure reaches 103 kPa (15 psi).

For instructions on replacement of the secondary fuel filter elements, see this Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" topic.

i01239630

## Fuel System Primary Filter - Clean/Inspect/Replace

**SMCS Code:** 1260-510; 1260-571

### WARNING

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

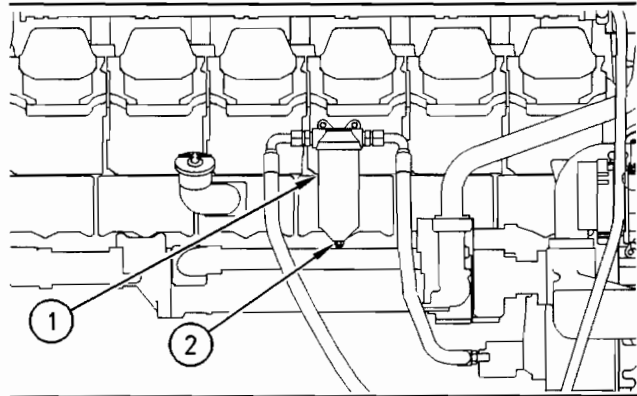
1. Stop the engine. Ensure that the engine will not start during this procedure.
2. Shut off the fuel supply valve to the engine.

#### NOTICE

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

#### NOTICE

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



g00330404

Illustration 88

- (1) Filter case  
(2) Nut

3. Loosen nut (2). Hold filter case (1) and remove nut (2). Prepare to catch the fuel that is inside of the filter case with a suitable container. Remove the filter case from the mounting bolt.
4. Remove the element and wash the element in clean, nonflammable solvent. Allow the element to dry. Inspect the element. Install a new element if the old element is damaged or deteriorated.
5. Clean the inside of the filter case. Allow the filter case to dry.
6. Inspect the O-ring seals. Obtain new seal rings if the old seal rings are damaged or deteriorated. Ensure that the sealing surfaces for the seals are clean. Install the seals.

#### NOTICE

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

7. Place the element in the filter case. Slide the filter case over the mounting bolt.
8. Install the nut.
9. Open the fuel supply valve.
10. Prime the fuel system. See this Operation and Maintenance Manual, "Fuel System - Prime" topic.

i00823808

## Fuel System Secondary Filter - Replace

**SMCS Code:** 1261-510-SE

### WARNING

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

Replace the secondary fuel filter element whenever the following conditions occur:

- The fuel filter differential pressure gauge registers 103 kPa (15 psi).
- The fuel filters have been used for 1000 service hours.

1. Stop the engine. Ensure that the engine will not start during this procedure.
2. Shut off the fuel supply valve to the engine.

### NOTICE

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

### NOTICE

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

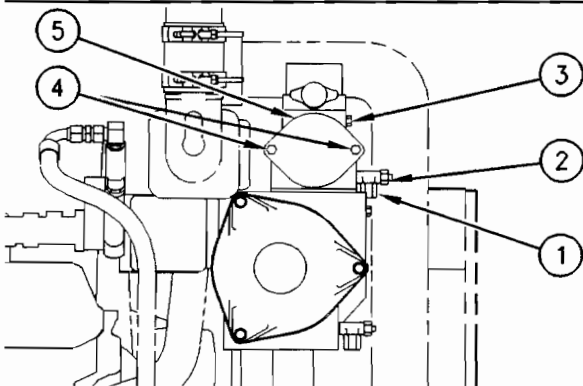


Illustration 89

g00329184

- (1) Drain
- (2) Drain valve
- (3) Plug
- (4) Bolts
- (5) Cover

3. Connect a hose to drain (1). Place the other end of the hose into a suitable container in order to collect the fuel.
4. Open drain valve (2). Remove plug (3). Allow the fuel to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

**Note:** Some fuel will remain in the housing after the fuel has been drained. This fuel will pour out of the housing when cover (5) is removed. Prepare to catch the fuel in a suitable container. Clean up any spilled fuel with absorbent towels or pillows. DO NOT use absorbent particles to clean up the fuel.

### WARNING

**Personal injury can result from parts and/or covers under spring pressure.**

**Spring force will be released when covers are removed.**

**Be prepared to hold spring loaded covers as the bolts are loosened.**

5. Be alert to the spring force. Gradually loosen but do not remove bolts (4). Before removing bolts (4), pry cover (5) loose in order to relieve any spring pressure. Remove cover (5). Remove the O-ring seal on the inside of the cover. Remove the fuel filter elements.
6. Clean cover (5) and clean the O-ring seal. Clean the inside of the fuel filter housing.
7. Install new fuel filter elements.
8. Inspect the O-ring seal. Ensure that the surfaces for the O-ring seal are clean. Install a new O-ring seal if the old O-ring seal is damaged or deteriorated.
9. Install cover (5). Ensure that the springs are seated properly between the cover and the fuel filter elements.
10. Open the fuel supply valve. Reconnect the battery.
11. Prime the fuel system. Refer to this Operation and Maintenance Manual, "Fuel System - Prime" topic (Maintenance Section).

i00073301

## Fuel Tank Water and Sediment - Drain

**SMCS Code:** 1273-543-M&S

### Fuel Tank

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

### Drain the Water and the Sediment

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

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

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

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

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

### Fuel Storage Tanks

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

- Weekly
- Oil change
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i00907072

## Hoses and Clamps - Inspect/Replace

**SMCS Code:** 7554-040; 7554-510

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

- Cracking
- Softness
- Loose clamps

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

---

#### NOTICE

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

---

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

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

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

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

## Replace the Hoses and the Clamps

### WARNING

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

1. Stop the engine. Allow the engine to cool.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

**Note:** Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.
4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.

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

7. Install the hose clamps with a torque wrench.

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

8. Refill the cooling system.

9. Clean the cooling system filler cap. Inspect the cooling system filler cap's gaskets. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

10. Start the engine. Inspect the cooling system for leaks.

i01041750

## Hoses and Clamps - Replace

**SMCS Code:** 1380-510

**Note:** For instructions on draining the cooling system and filling the cooling system, see this Operation and Maintenance Manual, "Cooling System Coolant (DEAC) - Change" topic or see the Operation and Maintenance Manual, "Cooling System Coolant (ELC) - Change" topic (Maintenance Section).

1. Drain the cooling system.
2. Remove the used hoses and clamps. Discard the items.

**Note:** For the correct torque to use on the hose clamps, see this Operation and Maintenance Manual, "Torque Specifications" topic (Maintenance Section).

3. Install new hoses and clamps.
4. Fill the cooling system.
5. Start the engine. Inspect the hose connections for leaks.

i01048507

## Instrument Panel - Inspect

**SMCS Code:** 7451-040

Inspect the instrument panel for good condition. Perform the self-test. All of the warning lamps should illuminate. If a warning lamp does not illuminate, replace the bulb immediately. If the alarm does not sound, investigate the problem and correct the problem.

Check the condition of all of the gauges. If a gauge is broken, repair the gauge or replace the gauge immediately.

Frequently monitor the gauges during normal operation.



i01237411

Record the data in a log. Compare the new data to the data that was previously recorded. Comparing the new data to the recorded data will help to establish the trends of engine performance. A gauge reading that is abnormal may indicate a problem with operation or a problem with the gauge.

i01042517

## Jacket Water Heater - Check

**SMCS Code:** 1383-535

Jacket water heaters help to improve startability in ambient temperatures that are below 21 °C (70 °F). All installations that require automatic starting should have jacket water heaters.

Check the operation of the jacket water heater. For an ambient temperature of 0 °C (32 °F), the heater should maintain the jacket water temperature at approximately 32 °C (90 °F).

i00738324

## Magnetic Pickups - Clean/Inspect

**SMCS Code:** 1907-040

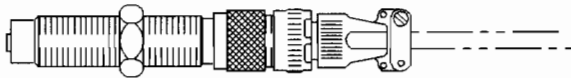


Illustration 90

g00293337

Typical magnetic pickup

1. Remove the magnetic pickup from the flywheel housing. Check the condition of the end of the magnetic pickup. Check for signs of wear and contaminants.
2. Clean the metal shavings and other debris from the face of the magnet.
3. Install the magnetic pickup according to the information in the Service Manual, "Specifications".

## Overhaul (Major)

**SMCS Code:** 7595-020-MJ

The maintenance intervals that are listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule" are expressed in service hours. A more accurate figure to use is fuel consumption. Fuel consumption corresponds more accurately to the engine load.

Table 57 lists average ranges of fuel consumption and service hours for a load factor of approximately 60 percent. Use the range of fuel consumption only as a guideline.

Table 57

Major Overhaul Service Hours and Fuel Consumption for 3500 Engines <sup>(1)</sup>			
Engine	Rated Up To 1300 RPM	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
	33 000 Service Hours	27 000 Service Hours	22 500 Service Hours
3508	2 928 000 L (772,500 US gal)		
3512	4 380 000 L (1,555,000 US gal)		
3516	5 826 000 L (1,537,500 US gal)		

<sup>(1)</sup> Fuel consumption is based on a load factor of approximately 60 percent.

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

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

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

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

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

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

A major overhaul includes all of the work that is done for the top end overhaul. A major overhaul includes additional parts and labor. Additional parts and labor are required in order to completely rebuild the engine.

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

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

The following definitions explain the terminology for the services that are performed during an overhaul:

**Exchange** – Your Caterpillar dealer will exchange your worn parts for parts that conform to original functional specifications.

**Inspect** – Inspect the components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”. The guidelines were developed in order to help Caterpillar dealers and customers to avoid unnecessary expenditures. New parts are not required if the existing parts can still be used, reconditioned, or repaired. If the components are not in the reusability guidelines, refer to the Service Manual, “Specifications” module.

**Install New** – The service life of the part is exhausted. The part cannot be reconditioned. Used parts are not appropriate. A new part must be installed.

**Rebuild** – The component can be reconditioned in order to comply with reusability guidelines.

**Replace** – The service life of the part is exhausted. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a rebuilt part, or a used part.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Table 58. Your Caterpillar dealer can provide these services and components.

Table 58

<b>Major Overhaul Instructions <sup>(1)</sup></b>	
Clean	Oil suction screen
Clean Inspect Test	Aftercooler core <sup>(2)</sup>
Exchange Install new	Fuel injectors
Inspect Rebuild	Rocker arms
Inspect Rebuild Install new	Piston pins
Inspect Rebuild Exchange	Connecting rods
	Cylinder head assemblies
	Fuel priming pump
	Fuel transfer pump
Inspect	Camshafts
	Cylinder block
	Crankshaft vibration damper
	Driven equipment (alignment)
	Electronic control module (ECM) <sup>(3)</sup>
	Flywheel
	Front gear train (gears)
Rear gear train (gears)	
Inspect Exchange	Crankshaft
	Cylinder liners
	Pistons (Crowns and Skirts)

(continued)

(Table 58, contd)

Major Overhaul Instructions <sup>(1)</sup>	
Inspect Install new	Camshaft thrust washers
	Camshaft lifters
	Engine mounts
	Engine wiring harness
	Push rods
	Spacer plates
Inspect Replace	Fuel pressure regulating valve
	Push rods
Inspect Rebuild Replace	Oil cooler core
Install new	Camshaft bearings
	Connecting rod bearings
	Crankshaft seals
	Crankshaft thrust plates
	Exhaust manifold (seals and bellows)
	Gear train bushings
	Inlet manifold (gaskets and seals)
	Main bearings
	Piston rings
	Software <sup>(4)</sup>

- (1) For instructions on removal and installation of components, see the Service Manual, "Disassembly and Assembly" module.  
 (2) For instructions on cleaning the core, see this Operation and Maintenance Manual, "Aftercooler Core - Clean/Test" topic.  
 (3) Inspect for damage  
 (4) Install new software when a new ECM is installed.

i01237817

## Overhaul (Top End)

**SMCS Code:** 7595-020-TE

The maintenance intervals that are listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule" are expressed in service hours. A more accurate figure to use is fuel consumption. Fuel consumption corresponds more accurately to the engine load.

Table 59 lists average ranges of fuel consumption and service hours for a load factor of approximately 60 percent. Use the range of fuel consumption only as a guideline.

Table 59

Top End Overhaul Service Hours and Fuel Consumption for 3500 Engines <sup>(1)</sup>			
Engine	Rated Up To 1300 RPM	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
	11 000 Service Hours	9000 Service Hours	7500 Service Hours
3508	976 000 L (257,500 US gal)		
3512	1 460 000 L (385,000 US gal)		
3516	1 942 000 L (512,500 US gal)		
Second Top End Overhaul			
Engine	22 000 Service Hours	18 000 Service Hours	15 000 Service Hours
3508	1 952 000 L (515,000 US gal)		
3512	2 920 000 L (770,000 US gal)		
3516	3 884 000 L (1,025,000 US gal)		

- (1) Fuel consumption is based on a load factor of approximately 60 percent.

A top end overhaul involves the removal, the inspection, and the rework of the cylinder head components. Some additional components are replaced and serviced.

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

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

The following definitions explain the terminology for the services that are performed during an overhaul:

**Exchange** – Your Caterpillar dealer will exchange your worn parts for parts that conform to original functional specifications.

**Inspect** – Inspect the components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”. The guidelines were developed in order to help Caterpillar dealers and customers to avoid unnecessary expenditures. New parts are not required if the existing parts can still be used, reconditioned, or repaired. If the components are not in the reusability guidelines, refer to the Service Manual, “Specifications” module.

**Install New** – The service life of the part is exhausted. The part cannot be reconditioned. The replacement part must be a new part.

**Rebuild** – The component is reconditioned in order to comply with reusability guidelines.

**Replace** – The service life of the part is exhausted. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a rebuilt part, or a used part.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Tables 60 and 61.

Table 60

<b>Top End Overhaul <sup>(1)</sup></b>	
Clean	Oil suction screen
Clean Inspect Pressure test	Aftercooler core <sup>(2)</sup>
Exchange Install new	Fuel injectors
Inspect Install new	Engine wiring harness
Inspect Rebuild	Rocker arms
Inspect Rebuild Exchange	Cylinder head assemblies
	Fuel priming pump
Inspect Replace	Fuel pressure regulating valve
	Push rods
	Spacer plates
Install new	Air inlet manifold (gaskets and seals)
	Exhaust manifold (seals and bellows)

<sup>(1)</sup> For instructions on removal and installation of components, see the Service Manual, “Disassembly and Assembly” module.

<sup>(2)</sup> For instructions on cleaning the core, see this Operation and Maintenance Manual, “Aftercooler Core - Clean/Test” topic.

Table 61

Second Top End Overhaul <sup>(1)</sup>	
Clean	Oil suction screen
Clean Inspect Pressure test	Aftercooler core <sup>(2)</sup>
Exchange Install new	Fuel injectors
Inspect Exchange	Camshaft lifters
Inspect	Connecting rod bearings <sup>(3)</sup>
	Cylinder liners <sup>(3)</sup>
	Piston crowns and skirts <sup>(3)</sup>
	Piston pins <sup>(3)</sup>
Inspect Install new	Camshaft lifters
	Engine wiring harness
Inspect Rebuild Exchange	Cylinder head assemblies
	Engine oil pump
	Fuel priming pump
	Fuel transfer pump
	Prelube pump
	Scavenge oil pump
Inspect Replace	Fuel pressure regulating valve
	Push rods
	Spacer plates
Inspect Rebuild	Rocker arms
Install new	Air inlet manifold (gaskets and seals)
	Exhaust manifold (seals and bellows)
Rebuild Exchange	Turbochargers

(1) For instructions on removal and installation of components, see the Service Manual, "Disassembly and Assembly" module.  
 (2) For instructions on cleaning the core, see this Operation and Maintenance Manual, "Aftercooler Core - Clean/Test" topic.  
 (3) Inspect ONLY TWO of the components from each cylinder bank. This inspection will provide adequate examples of the condition of the other corresponding components.

## Overhaul Considerations

SMCS Code: 7595-043

### Overhaul Information

An overhaul is replacing the major worn components of the engine. An overhaul interval is a maintenance interval that is planned. The engine is rebuilt with certain rebuilt parts or new parts that replace the worn parts.

An overhaul also includes the following maintenance:

- Inspection of all the parts that are visible during the disassembly
- Replacement of the seals and gaskets that are removed
- Cleaning of the internal passages of the engine and the engine block

Most owners will save money by overhauling the engine at the intervals that are recommended in this Operation and Maintenance Manual. Consider the graph in Illustration 91.

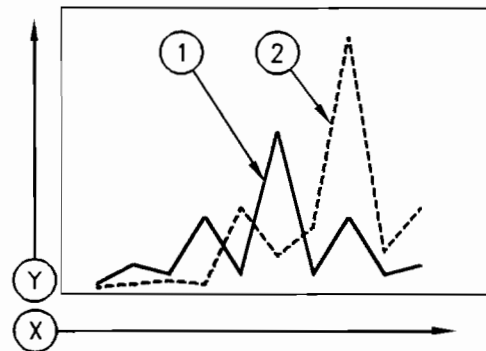


Illustration 91

g00541431

Costs of overhauls over time

(Y) Cost  
(X) Time

(1) Cost of maintenance and repair that is planned  
(2) Cost of maintenance and repair that is not planned

In Illustration 91, line (1) represents the maintenance and repair costs for an owner that followed the recommendations for inspection, maintenance, and repair. The peaks represent overhauls.

Line (2) represents the maintenance and repair costs for an owner that chose to operate beyond the recommended intervals. The initial cost of the "repair-after-failure" philosophy is lower. Also, the first overhaul was delayed. However, the peaks are significantly higher than the peaks for the customer that used the "repair-before-failure" philosophy .

The higher peaks result from two key factors:

- Delaying an overhaul until a breakdown increases the chance of a catastrophic failure. This type of failure requires more parts, labor, and cleanup.
- Excessive wear means that fewer components will be reusable. More labor may be required for salvage or repair of the components.

When all of the costs are considered, "REPAIR-BEFORE-FAILURE" is the least expensive alternative for most components and engines.

It is not practical to wait until the engine exhibits symptoms of excessive wear or failure. It is not less costly to wait. A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the guidelines for reusable parts.
- The service life of the engine can be extended without the risk of a major catastrophe due to engine failure.
- Achieve the best cost/value relationship per hour of extended service life.

## Overhaul Intervals

Some factors that are important for determining the overhaul intervals include the following considerations:

- Performance of preventive maintenance
- Use of recommended lubricants
- Use of recommended coolants
- Use of recommended fuels
- Proper installation
- Operating conditions
- Operation within acceptable limits
- Engine load

- Engine speed

Generally, engines that are operated at a reduced load and/or speed achieve more service life before an overhaul. However, this is for engines that are properly operated and maintained.

Other factors must also be considered for determining a major overhaul:

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

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

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

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

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

## Using Fuel Consumption For Calculating the Overhaul Intervals

The total fuel consumption is the most important factor for estimating the overhaul interval. Fuel consumption compensates for the application and for the engine load.

If the total fuel consumption has not been recorded, use the equation in Table 62 in order to estimate the hours until the overhaul. The equation may also be used to estimate overhaul intervals for new engines.

Table 62

<b>Equation For Calculating Overhaul Intervals</b>
<b><math>H = F/R</math></b>
"H" is the number of estimated hours until the overhaul interval.
"F" is the estimated total amount of fuel consumption of the engine.
"R" is the rate of fuel consumption in liters per hour or gallons per hour.

Use the actual records of fuel consumption, when possible. If the actual records are not available, use the following procedure in order to estimate the fuel consumption.

1. Estimate the average percent of the load for the operation of the engine.
2. Refer to the engine's Caterpillar, "Engine Specifications" ("spec" sheet). This will determine the fuel consumption for the percent of the load that was estimated in Step 1. Use this figure for the equation in Table 62.

### Oil Consumption as an Overhaul Indicator

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

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

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

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

### Overhaul Inspection

Refer to the Service Manual for the disassembly and assembly procedures that are necessary in order to perform the required maintenance on the items that are listed. Consult your Caterpillar dealer for assistance.

To determine the reusability publications that are needed to inspect the engine, refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, "Index of Publications on Reusability or Salvage of Used Parts".

The Guidelines For Reusable Parts and Salvage Operations is part of an established Caterpillar parts reusability program. These guidelines were developed in order to assist Caterpillar dealers and customers reduce costs by avoiding unnecessary expenditures for new parts. If the engine parts comply with the established inspection specifications, the parts can be reused.

The use of out-of-spec parts could result in unscheduled downtime and/or costly repairs. The use of out-of-spec parts can also contribute to increased fuel consumption and reduction of engine efficiency. New parts are not necessary if the old parts can be reused, repaired, or salvaged. Otherwise, the old parts can be replaced or exchanged.

Your Caterpillar dealer can provide the parts that are needed to rebuild the engine at the least possible cost.

### Overhaul Programs

An economical way to obtain most of the parts that are needed for overhauls is to use Caterpillar remanufactured parts. Caterpillar remanufactured parts are available at a fraction of the cost of new parts. These parts have been rebuilt by Caterpillar and certified for use. The following components are examples of the remanufactured parts:

- Cylinder heads
- Oil Pumps
- Turbochargers
- Water pumps

Consult your Caterpillar dealer for details and for a list of the remanufactured parts that are available.

Your Caterpillar dealer may be offering a variety of overhaul options.

A Flat Rate Overhaul guarantees the maximum price that you will pay for an overhaul. Flat rate prices on preventive maintenance programs or major repair options are available from many servicing dealers for all Caterpillar Engines. Consult your Caterpillar dealer in order to schedule a before failure overhaul.

### Overhaul Recommendation

Caterpillar recommends a scheduled overhaul in order to minimize downtime. A scheduled overhaul will provide the lowest cost and the greatest value. Schedule an overhaul with your Caterpillar dealer.

Overhaul programs vary between dealers. To obtain specific information about the types of overhaul programs and services, consult your Caterpillar dealer.

i01076599

## Prelube Pump - Inspect

**SMCS Code:** 1319-040

Inspect the prelube pump for the following conditions:

- Cracks
- Pin holes
- Proper operation
- Wear

Inspect the hoses and the fittings for leaks.

Inspect the prelube pump for leaks. Replace all of the seals if a leak is observed.

Inspect the wiring for the following conditions:

- Damage
- Fraying

Ensure that the wiring is in good condition.

Inspect the electrical connections. Ensure that the electrical connections are secure.

Inspect the brushes. Replace the brushes, if necessary.

If repair or replacement is necessary, see the Service Manual or see literature that is provided by the OEM of the pump. Consult your Caterpillar dealer for assistance.

i01206548

## Radiator - Clean

**SMCS Code:** 1353-070

**Note:** Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the radiator, if necessary.

### WARNING

**Personal injury can result from air pressure.**

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

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

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

For more detailed information on cleaning and inspection, see Special Publication, SEBD0518, "Know Your Cooling System".



i01038735

## Standby Generator Set Maintenance Recommendations

**SMCS Code:** 4450-041

A standby generator set may not need to be used very often. However, the generator set is usually needed for operation in an emergency situation. Maintenance of the standby generator set is very important for the following reasons:

- The generator set must always be in excellent operating condition.
- The generator set must be ready to work under load at any time.

Establishing a Preventive Maintenance Program will provide these benefits:

- Maximum availability of the standby generator set
- Longer service life for the generator set
- Minimum of expensive repairs

Your Caterpillar dealer can help you to establish an effective Preventive Maintenance Program for your generator set. Consult your Caterpillar dealer for details.

### Maintenance and Operation Procedures

#### **WARNING**

**The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.**

**Place the engine control switch in the “OFF” position. Attach “DO NOT OPERATE” tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.**

The recommended maintenance for the engine is listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule (Standby Generator Set Engines)” (Maintenance Section).

For the recommended generator maintenance, see the Operation and Maintenance Manual for the generator and the control panel.

### Maintenance and Repair

The maintenance that is recommended for Every Week can be performed by an authorized operator. The maintenance that is recommended for the subsequent maintenance intervals must be performed by an authorized service technician or by your Caterpillar dealer.

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

- The engine is stopped.
- The starting system is disabled.
- The generator does not pose an electrical shock hazard.

### Operation

To ensure proper operation, the generator set must be exercised regularly. For instructions on operating the generator set, see the Operation and Maintenance Manual for the generator set control panel.

For these operation procedures, follow the instructions that are provided in this Operation and Maintenance Manual, “Operation Section”: starting the engine, engine operation, and stopping the engine.

### Record Keeping

Maintain a record in order to document these items: gauge readings, maintenance that is performed, problems, and repairs.

### Space Heaters

Moisture causes damage to generators and other electrical equipment. Make every effort to keep the generator set as dry as possible.

Generators can operate without problems in humid environments. However, problems can occur when the generator is inactive. Moisture can condense on the windings. This can result in poor performance. Also, damage to the windings can occur.

Use space heaters in order to help keep the windings dry. When the generator is not active, ensure that the space heaters are operating. When the generator is operating, turn OFF the space heaters.

i01113939

## Starting Motor - Inspect

**SMCS Code:** 1451-040; 1453-040

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

## Electric Starting Motor

**Note:** Problems with the electric starting motor can be caused by the following conditions: malfunction of the solenoid and malfunction of the electric starting system.

Inspect the electrical system for the following conditions:

- Loose connections
- Corrosion
- Wires that are worn or frayed
- Cleanliness

Make repairs, if necessary.

## Air Starting Motor

### **WARNING**

**Personal injury or death can result from improperly checking for a leak.**

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

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

Inspect all of the components in the air circuit for the starting motor. Inspect all of the air lines and connections for leaks.

If the teeth of the starting motor pinion and/or the flywheel ring gear are damaged, the air circuit for the starting motor must be examined in order to determine the cause of the problem.

## Removal and Installation of the Starting Motor

Refer to the Service Manual, "Disassembly and Assembly" module for information on removing the starting motor and installing the starting motor.

Consult your Caterpillar dealer for assistance.

i00571847

## Turbocharger - Inspect

**SMCS Code:** 1052-040

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side).

Fouling of the compressor can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel could allow parts from the compressor wheel to enter an engine cylinder. This can cause additional damage to the pistons, the valves, and the cylinder head.

---

### NOTICE

Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

---

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

**Note:** Turbocharger components require clearances that are precise. The turbocharger cartridge must be balanced due to high rpm. Severe service applications can accelerate the wear of the components. Severe service applications may require more frequent inspections of the turbocharger.

## Removal and Installation

For options regarding the removal, installation, repair and replacement, consult your Caterpillar dealer. Refer to the Service Manual for this engine or consult your Caterpillar dealer for the procedure and specifications.

## Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil.
2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the turbocharger wheel and the turbocharger housing, the turbocharger should be reconditioned or replaced.

3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.

4. Check the clearances of the turbocharger bearing. Compare the clearances to the Service Manual specifications.
5. Inspect the bore of the turbine housing for corrosion.
6. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.
7. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i00528664

## Walk-Around Inspection

**SMCS Code:** 1000-040

### Inspect the Engine for Leaks and for Loose Connections

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

For maximum engine service life, thoroughly inspect the engine compartment before starting the engine. Look for items such as leaks, loose bolts, loose connections and trash buildup. Make repairs, as needed.

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

---

### NOTICE

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

---

---

**NOTICE**

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

---

- Ensure that cooling lines are properly clamped and tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pumps for coolant leaks.

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

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

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Drain the water and the sediment from fuel tanks on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Check the condition of the gauges. Replace any gauge that is damaged. Replace any gauge that can not be calibrated.
- Inspect the exhaust system for leaks. Inspect the gaskets and the exhaust bellows joint. If a leak is found, make repairs.

i01105559

## Walk-Around Inspection (Exercise Inspection of Standby Generator Set Engines)

**SMCS Code:** 1000-040

1. Perform the procedures that are described in this Operation and Maintenance Manual, "Before Starting Engine" topic (Operation Section).
2. Start the engine according to the instructions in this Operation and Maintenance Manual, "Engine Starting" topic (Operation Section).

---

**NOTICE**

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

---

3. Perform an inspection of the installation after the engine is started. Look for leaks. Listen for unusual noises.
  - Check the engine oil level when the engine is operating at low idle rpm. Observe the oil level on the "LOW IDLE" side of the oil level gauge (dipstick).
  - Inspect the lubrication system for leaks at the oil pan, the oil filter, and the valve covers.
  - Inspect the cooling system for leaks at the hose connections.
  - Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
  - Inspect the exhaust system for leaks.
  - If the enclosure has louvers, inspect the louvers for proper operation.
  - Observe the gauges. Ensure the correct readings for the engine rpm. Record the data for the gauges.
  - Record the data for the performance of the generator. See the Operation and Maintenance Manual for the generator and the control panel.

4. After exercising the generator set, stop the engine according to this Operation and Maintenance Manual, "Engine Stopping" topic (Operation Section).
5. Perform the procedures that are described in this Operation and Maintenance Manual, "After Stopping Engine" topic (Operation Section).
6. Ensure that the control switches are in the correct position for automatic starting of the generator set.

i00524084

## Water Pump - Inspect

**SMCS Code:** 1361-040

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

Visually inspect the water pump for leaks. If leaking of the water pump seals is observed, replace all of the water pump seals. Refer to the Service Manual for the disassembly and assembly procedure.

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

i00940056

## Zinc Rods - Inspect/Replace

**SMCS Code:** 1388-040; 1388-510

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

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

The engineer for the operation must determine the interval for inspecting the zinc rods. The interval for inspecting the zinc rods will depend on the size of the zinc rods and the number of zinc rods that are installed.

For the location of the zinc rods, see the literature that is provided by the OEM of the installation.

## Inspect the Zinc Rods

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

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

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

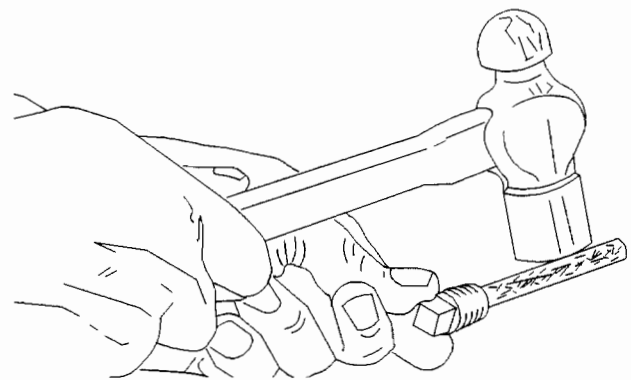


Illustration 92

g00481100

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

## Replace the Zinc Rods

1. Use pliers to unscrew the old zinc rod from the plug.  
  
If not enough material remains or the zinc rod has broken off, drill the zinc from the plug.
2. Clean the plug.

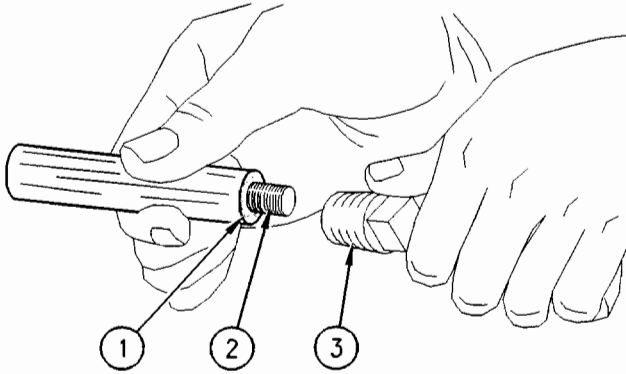


Illustration 93

g00480345

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

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

3. Apply **9S-3263** Thread Lock Compound to the shoulder (1) of a new zinc rod. Apply the compound **ONLY** to the shoulder of the zinc rod. Install the zinc rod onto the plug.
4. Coat the external threads of the plug (3) with **5P-3413** Pipe Sealant. Install the zinc rod. See this Operation and Maintenance Manual, "Torque Specifications" (Maintenance Section).

# Reference Information Section

## Engine Ratings

i01239419

### Engine Rating Conditions

**SMCS Code:** 1000

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

- 100 kPa (29.61 inches of Hg)
- A temperature of 25 °C (77 °F)

The following standard conditions of "ISO3046/1", "DIN6271", and "BS5514" are also applicable:

- 100 kPa (29.61 inches of Hg)
- Relative humidity of 60 percent

The ratings are also valid for the following parameters:

- Air temperature (air cleaner) of 50 °C (122 °F) or less
- Sea water temperature (sea level) of 42 °C (108 °F) or less

Fuel consumption is based on the following specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .849 at 15 °C (60 °F)
- Density of 850 kg/m<sup>3</sup> (7.085 lb/US gal)

The engine ratings are gross output ratings.

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

Standard accessories include the following components:

- Oil pumps

- Fuel transfer pumps
- Water pumps

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

i00715039

### Engine Rating Definitions

**SMCS Code:** 1000

The ratings must be reduced in order to accommodate changes in the altitude. The ratings must be reduced according to the data for derating that is obtained from the test specification for the engine.

All of the ratings that are defined have a manufacturing tolerance of ± three percent.

**Load Factor** – The sum of the loads divided by the number of hours of operation. Idle time and down time are not part of the calculation.

**Power Interruption** – Unexpected failure of the utility power supply.

**Operating Cycle** – Except when the operating cycle is specified differently, an operating cycle for calculating load factors and peak load limits is not to exceed 24 hours. The operating cycle does not include the time when the engine is not operating.

Use the following guidelines in order to determine the applicable engine rating.

---

#### NOTICE

**Operating an engine at a greater power output than the engine is rated for will reduce the service life of the engine before overhaul.**

---

**Continuous** – This rating allows a constant load or a load that varies for an unlimited number of hours per year. The normal load factor is up to 100 percent for an unlimited number of hours per year. The following applications are suggested: base load, utility, cogeneration, and parallel operation.

**Prime** – This rating allows a load that varies for an unlimited number of hours per year. The normal load factor is up to 80 percent for an unlimited number of hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The following applications are suggested: industrial, pumping, construction, and cogeneration.

**Prime + 10% (Standby applications for a power supply from a reliable utility)** – This rating allows a load that varies up to the Prime rating. An additional ten percent is allowed for the duration of the power interruption. The normal load factor is up to 80 percent for 100 hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The suggested application is Standby for a power supply from a reliable utility.

**Prime + 10% (Applications that are industrial, pumping, construction, and cogeneration)** – This rating allows a load that varies up to the Prime rating. The normal load factor is up to 80 percent for an unlimited number of hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The following applications are suggested: industrial, pumping, construction, and cogeneration.

**Standby** – This rating allows a load that varies for the duration of the power interruption. The normal load factor is up to 80 percent for 100 hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The suggested application is Standby for a power supply from a reliable utility.

## Load Management Peak Shaving Rating Guidelines

**Interruptable (Isolated from the utility with a Standby base rating for load factors)** – This rating allows a load that varies for less than 12 hours per day. The typical peak load factor is up to 80 percent for less than 500 hours per year. The peak operating limit is a load factor up to 100 percent. A 100 percent load is only allowed for 5 percent of the operating cycle. The operating cycle for calculating the load factors and the peak load limits is not to exceed six hours. The operating cycle does not include the time when the engine is not operating.

**Interruptable (Isolated from the utility with a Prime base rating for load factors)** – This rating allows a load that varies for more than 12 hours per day. The typical peak load factor is up to 80 percent for an unlimited number of hours per year. The peak operating limit is a load factor up to 100 percent. A 100 percent load is only allowed for 5 percent of the operating cycle.

**Curtable (Connected to a utility with a special base rating for load factors)** – This rating allows a constant load or a load that varies for less than six hours per day. The typical peak load factor is up to 100 percent for a maximum of 500 hours per year. The peak operating limit is up to 100 percent load for a maximum of 500 hours per year.

**Curtable (Connected to a utility with a Continuous base rating for load factors)** – This rating allows a constant load or a load that varies for more than six hours per day. The normal load factor is up to 100 percent for an unlimited number of hours per year. The peak load factor is up to 100 percent for an unlimited number of hours per year.



## Customer Service

i00790127

## Customer Assistance

**SMCS Code:** 1000

### USA and Canada

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

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

1. Discuss your problem with a manager from the dealership.
2. If your problem cannot be resolved at the dealer level without additional assistance, use the phone number that is listed below to talk with a Field Service Coordinator:

1-800-447-4986

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

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

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

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

### Outside of the USA and of Canada

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

Central America and Caribbean  
Caterpillar Americas Co.  
15550 NW 59th Avenue  
Miami Lakes, FL 33014  
USA  
Phone: 305-816-3306  
Fax: 305-816-3307

Mexico  
Grupo Financiero Caterpillar Mexico, S.A. de C.V.  
Primer piso del Arco Oriente de Arco Bosques Corporativa,  
Bosques del Alisos 45A  
Bosques de Las Lomas  
Mexico, D.F. 05120  
Phone (from within Mexico): 915-258-1515  
Fax (from within Mexico): 915-258-1530  
Phone (from within USA): 011-525-258-1515  
Fax (from within USA): 011-525-258-1530

Ecuador, Colombia, Venezuela, Guyana, and Suriname  
Caterpillar Americas Co.  
15550 NW 59th Avenue  
Miami Lakes, FL 33014  
USA  
Phone: 305-816-3316  
Fax: 305-816-3317

Peru, Chile, and Bolivia  
Caterpillar Americas Co.  
Edificio Centro Santa Maria  
Av. Los Conquistadores 1700  
Piso 14, Oficina A  
Santiago, Chile  
Phone: 011-562-366-5100  
Fax: 011-562-366-5125

Brazil, Argentina, Paraguay, and Uruguay  
Caterpillar Americas Co.  
Birmann II  
Rua Aleandre Dumas, 1.711-9.0  
Chac., Sto. Antonio  
04717-004-Sao Paulo, SP  
Phone: 55-11-5180-2000  
Fax: 55-11-5182-9694

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

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

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

Japan  
Shin Caterpillar Mitsubishi Ltd.  
Setagaya Business Square Tower  
10-1, Yoga 4-chome  
Setagaya, Tokyo  
Japan  
Phone: 81-3-5717-1121  
Fax: 81-3-5717-1177

Japan  
Caterpillar Power Systems, Inc.  
Japan Branch Sanno Grand Bldg.  
2-14-2 Nagatacho  
Chiyoda-ku, Tokyo, 100  
Japan  
Phone: 81-335-93-3237  
Fax: 81-335-93-3238

Australia and New Zealand  
Caterpillar of Australia Ltd.  
1 Caterpillar Drive  
Private Mail Bag 4  
Tullamarine, Victoria 3043  
Australia  
Phone: 03-9339-9333  
Fax: 03-9335-3366

---

## Reference Materials

- Owner's receipts
- Maintenance log

i00912149

## Maintenance Records

**SMCS Code:** 1000

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

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

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

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

Records should be kept for the following items:

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

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

**Documents** – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs



i01237827

## Reference Material

**SMCS Code:** 1000

The following publications can be obtained from any Caterpillar dealer.

### Lubricants

- Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations"
- Special Publication, PECP6028, "One Safe Source"
- Special Publication, PEHP0002, "Data Sheet - Multipurpose Lithium Complex Grease with Molybdenum (MPGM)"
- Special Publication, PEHP6022, "Data Sheet - Multipurpose Lithium Complex Grease (MPG)"
- Special Publication, PEHP0017, "Data Sheet - Special Purpose Grease (SPG) Bearing Lubricant"
- Special Publication, PEHP1026, "Data Sheet - Caterpillar Diesel Engine Oil (DEO) (CF-4) (International only)"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"
- Special Publication, PEHP6046, "Data Sheet - Caterpillar Diesel Engine Oils (DEO) (CG-4 and CF-4) (North America and selected International)"
- Special Publication, SEBD0640, "Oil and Your Engine"

### Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

### Coolants

- Special Publication, PECP6026, "One Safe Source"
- Special Publication, PEDP7036, "S·O·S Fluid Analysis"
- Data Sheet, PEHP4036, "Extended Life Coolant"
- Data Sheet, PEHP7057, "Coolant Analysis"
- Special Publication, SEBD0518, "Know Your Cooling System"

- Special Publication, SEBD0970, "Coolant and Your Engine"

### Miscellaneous

- Service Manual, SENR1020
- Service Manual, SENR1015, "(3DM, 8EM, 9AN, 1PW, 2FW)"
- Service Manual, SENR5398, "Electronic Modular Control Panel II (EMCP II)"
- Operation and Maintenance Manual, SEBU6918, "SR48 Generators and Control Panels"
- Operation and Maintenance Manual, SEBU6150, "SR4 Generators and Control Panels"
- Service Manual, SENR5359, "SR4B Generator Service Manual"
- Special Instruction, SEHS9586, "3500 EUI Fuel Priming Procedure"
- Service Manual, RENR1225, "(5XM, 6PM, 7KM, 3LS, 3MS, 3NS)"
- Service Manual, RENR1200, "Electronic Modular Control Panel II+ (EMCP II+) for EUI Engines"
- Service Manual, SENR6587, "3500B Electronic Instrument Panel"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"
- Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators"
- Special Instruction, SEHS7332, "Do Not Operate Tag"
- Special Instruction, SEHS7633, "Battery Test Procedure"
- Special Instruction, SEHS7768, "Use of 6V-2150 Starting/Charging Analyzer"
- Special Instruction, SEHS8622, "Using the FT-1984 Air-To-Air Aftercooler Leak Test Group"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Publication, NENG2500, "Tools and Shop Products Guide"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"

- Special Publication, SEBF8062, "Guideline for Reusable Parts - Cleaning and Inspection of Air Filters"
- Specifications, SENR3130, "Torque Specifications"

i01109461

## Additional Reference Material

**SMCS Code:** 1000

The "EMA Lubricating Oils Data Book" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult EMA at the following address:

Engine Manufacturers Association  
401 N. Michigan Ave.  
Chicago, IL, USA 60611  
Telephone: (312) 644-6610 ext. 3626

The "Society of Automotive Engineers (SAE) Specifications" can be found in your SAE handbook. This publication can also be obtained from the following locations: local technological society, local library, and local college. If necessary, consult SAE at the following address:

SAE International  
400 Commonwealth Drive  
Warrendale, PA, USA 15096-0001  
Telephone: (724) 776-4841

The "American Petroleum Institute Publication No. 1509" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult API at the following address:

American Petroleum Institute  
1220 L St. N.W.  
Washington, DC, USA 20005  
Telephone: (202) 682-8000

The International Organization for Standardization (ISO) offers information and customer service regarding international standards and standardizing activities. ISO can also supply information on the following subjects that are not controlled by ISO: national standards, regional standards, regulations, certification, and related activities. Consult the member of ISO in your country.

International Organization for Standardization (ISO)  
1, rue de Varembe  
Case postale 56  
CH-1211 Genève 20  
Switzerland  
Telephone: +41 22 749 01 11  
Facsimile: +41 22 733 34 30  
E-mail: central@iso.ch  
Web site: <http://www.iso.ch>

European classifications are established by the Conseil International Des Machines a Combustion (CIMAC) (International Council on Combustion Engines).

CIMAC Central Secretariat  
Lyoner Strasse 18  
60528 Frankfurt  
Germany  
Telephone: +49 69 6603 1567  
Facsimile: +49 69 6603 1566

i01237445

## Emissions Warranty Information

**SMCS Code:** 1000

This engine may be certified to comply with exhaust emission standards and the engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to emissions certified engines is found in Supplement, SMBU6981, "Federal Emissions Control Warranty Information For U.S., Canada, and California". Consult your authorized Caterpillar dealer in order to determine if your engine is emissions certified and if the engine is subject to an Emissions Warranty.

i00382622

## Warranty Information

**SMCS Code:** 1000

### Engine Protection Plans

### Extended Warranties and Service Contracts

A wide variety of protection plans are available for Caterpillar Engines. Consult your Caterpillar dealer for detailed information on the specific programs and coverages that are available.

Consult your Caterpillar dealer for information on a plan that is tailored in order to fit your requirements.

# Index

- A**
- Additional Reference Material ..... 150
  - After Starting Engine ..... 61
    - Engaging the Driven Equipment ..... 61
    - Warm-up ..... 61
  - After Stopping Engine..... 64
  - Aftermarket Oil Additives ..... 74
  - Air Starting Motor Lubricator Bowl - Clean ..... 97
  - Air Starting Motor Lubricator Oil Level - Check ..... 98
    - Adjust the Lubricator ..... 98
  - Air Tank Moisture and Sediment - Drain..... 98
  - Alarms and Shutoffs ..... 40
  - Alternator - Inspect ..... 99
  - Alternator and Fan Belts - Inspect/Adjust/  
Replace..... 99
    - Alternator Belt Adjustment ..... 99
    - Fan Drive Belt Adjustment ..... 99
    - Inspection..... 99
    - Replacement..... 99
  - Automatic Start/Stop - Inspect (Generator Set)... 100
- B**
- Batteries - Replace ..... 100
  - Battery Charger - Check..... 100
    - Checking After Stopping ..... 101
    - Checking Before Start-Up..... 100
  - Battery Electrolyte Level - Check ..... 101
  - Before Starting Engine ..... 16, 57
    - Walk-Around Inspection..... 57
  - Belts - Replace ..... 102
  - Burn Prevention..... 14
    - Batteries..... 14
    - Coolant..... 14
    - Oils..... 14
- C**
- Cold Weather Lubricants ..... 74
  - Cold Weather Operation ..... 65
  - Cold Weather Starting ..... 58
    - Air Starting Motor ..... 58
    - Electric Starting Motor ..... 58
    - Starting With the Starting Aid Switch..... 59
  - Commercial Heavy-Duty Coolant/Antifreeze and  
SCA ..... 84
  - Control Panel ..... 40
    - Alarm Module..... 46
    - Control Panel (Operation) ..... 46
    - Generator Set Control+ ..... 41
    - Synchronizing Lights Module ..... 48
  - Conventional Coolant/Antifreeze Cooling System  
Maintenance ..... 85
    - Adding the SCA to Conventional Coolant/Antifreeze  
at the Initial Fill ..... 85
    - Adding the SCA to Conventional Coolant/Antifreeze  
For Maintenance ..... 86
    - Cleaning the Cooling System of Heavy-Duty  
Coolant/Antifreeze..... 86
  - Coolant Recommendations ..... 81
  - Cooling System Coolant (DEAC) - Change ..... 102
    - Clean the Cooling System ..... 103
    - Cleaning a Cooling System that has Heavy  
Deposits or Plugging..... 103
    - Drain the Cooling System ..... 102
    - Fill the Cooling System ..... 104
  - Cooling System Coolant (ELC) - Change ..... 104
    - Clean the Cooling System ..... 105
    - Drain the Cooling System ..... 104
    - Fill the Cooling System ..... 105
  - Cooling System Coolant Analysis (Level II) -  
Obtain ..... 105
  - Cooling System Coolant Extender (ELC) - Add... 106
  - Cooling System Coolant Level - Check ..... 106
    - Add Coolant ..... 107
      - Engines That Are Equipped With a Sight  
Gauge ..... 106
      - Engines That Are Not Equipped With a Sight  
Gauge ..... 106
  - Cooling System Specifications ..... 79
  - Cooling System Supplemental Coolant Additive  
(SCA) - Test/Add..... 107
    - Add the SCA, If Necessary ..... 107
    - S-O-S Coolant Analysis (Level I)..... 107
    - Test the Concentration of the SCA..... 107
  - Cooling System Water Temperature Regulator -  
Replace..... 108
  - Crankshaft Vibration Damper - Inspect ..... 108
    - Removal and Installation..... 109
  - Crushing Prevention and Cutting Prevention..... 15
  - Customer Assistance..... 145
    - Outside of the USA and of Canada..... 145
    - USA and Canada ..... 145
  - Customer Service ..... 145
- D**
- Diesel Engine Antifreeze/Coolant (DEAC) ..... 84
  - Driven Equipment - Inspect/Replace/Lubricate ... 109
- E**
- Electrical System ..... 17
    - Grounding Practices ..... 17
  - Emergency Stopping ..... 63
    - Emergency Stop Button ..... 63
  - Emissions Certification Film ..... 24

Emissions Warranty Information.....	150	Extended Life Coolant (ELC) Cooling System	
Engine - Clean.....	109	Maintenance .....	82
Engine Air Cleaner Element (Dual Element) -		Caterpillar ELC Extender .....	83
Clean/Replace .....	110	Changing to Caterpillar ELC .....	83
Cleaning the Primary Air Cleaner Elements ....	111	Commercial ELC.....	84
Servicing the Air Cleaner Elements .....	110	Contamination of the ELC Cooling System.....	84
Engine Air Cleaner Element (Single Element) -		ELC Cooling System Cleaning.....	83
Inspect/Replace.....	113	Proper Additions to the Extended Life Coolant..	82
Servicing the Air Cleaner Elements .....	113		
Engine Air Cleaner Service Indicator - Inspect....	114	<b>F</b>	
Test the Service Indicator .....	114	Fan Drive Bearing - Lubricate.....	123
Engine Air Precleaner - Clean.....	115	Fire Prevention and Explosion Prevention.....	14
Engine Crankcase Breather - Clean.....	115	Fire Extinguisher.....	15
Engine Description .....	20	Foreword.....	5
Engine Features and Controls.....	30	California Proposition 65 Warning .....	5
Engine Identification .....	23	Certified Engine Maintenance.....	5
Engine Lifting.....	26	Literature Information.....	4
Engine Lifting with a Generator.....	26	Maintenance .....	4
Engine Lifting and Storage .....	26	Maintenance Intervals.....	4
Engine Mounts - Check .....	116	Operation .....	4
Engine Oil.....	70	Overhaul .....	4
Caterpillar Diesel Engine Oil.....	70	Safety.....	4
Commercial Oils.....	71	Fuel and the Effect from Cold Weather .....	65
Total Base Number (TBN) and Fuel Sulfur Levels		Fuel Conservation Practices.....	62
for Direct Injection (DI) Diesel Engines .....	72	Fuel Injector - Inspect/Adjust.....	124
Engine Oil and Filter - Change .....	118	Fuel Recommendations.....	77
Drain the Oil .....	119	Fuel Related Components in Cold Weather .....	65
Fill the Crankcase .....	122	Fuel Filters .....	65
Inspect the Used Oil Filter Elements.....	121	Fuel Heaters .....	66
Replace the Oil Filter Elements .....	119	Fuel Tanks.....	65
Engine Oil Filter Differential Pressure - Check ....	116	Fuel Specifications .....	77
Engine Oil Level - Check .....	117	Fuel System - Prime.....	124
Engine Oil Sample - Obtain.....	117	Priming Procedure for Dry Starting.....	124
Obtain the Sample and the Analysis.....	117	Fuel System Fuel Filter Differential Pressure -	
Engine Operation.....	62	Check.....	124
Operating the Engine and the Driven		Fuel System Primary Filter - Clean/Inspect/	
Equipment.....	62	Replace.....	125
Partial Load Operation.....	62	Fuel System Secondary Filter - Replace.....	126
Engine Performance - Test .....	122	Fuel Tank Water and Sediment - Drain.....	127
Engine Protective Devices - Check .....	123	Drain the Water and the Sediment.....	127
Visual Inspection.....	123	Fuel Storage Tanks.....	127
Engine Rating Conditions.....	143	Fuel Tank .....	127
Engine Rating Definitions .....	143		
Load Management Peak Shaving Rating		<b>G</b>	
Guidelines .....	144	Gauges and Indicators .....	27
Engine Ratings .....	143	General Coolant Information .....	79
Engine Starting.....	16, 57	Additives .....	80
Ether .....	16	Glycol.....	80
Engine Stopping.....	17, 63	Water .....	79
Engine Storage.....	26	General Hazard Information .....	12
Generator Storage .....	26	Asbestos Information .....	13
Engine Valve Lash - Inspect/Adjust.....	123	Fluid Penetration.....	13
Engine Valve Lash .....	123	Fluid Spillage .....	13
Valve Bridge.....	123	Lines, Tubes, and Hoses.....	14
Extended Life Coolant (ELC).....	81	Pressurized Air and Water .....	13
		General Torque Information.....	67



<b>H</b>		<b>O</b>	
Hoses and Clamps - Inspect/Replace .....	127	Operation Section .....	26
Replace the Hoses and the Clamps .....	128	Overhaul (Major) .....	129
Hoses and Clamps - Replace .....	128	Overhaul (Top End) .....	131
<b>I</b>		Overhaul Considerations .....	133
Important Safety Information .....	2	Overhaul Information .....	133
Information Plate .....	23	<b>P</b>	
Instrument Panel .....	48	Prelube Pump - Inspect .....	136
Gauge Cluster Modules .....	50	Product Identification Information .....	23
Internal Switches of the Electronic Instrument		Product Information Section .....	18
Panel .....	56	Programmable System Parameters .....	30
Main Display Module .....	51	Configuration Parameters .....	30
Pyrometer .....	51	Data Link Features .....	33
Self Testing .....	56	Display of Engine Performance .....	33
Warning Operation .....	55	<b>R</b>	
Instrument Panel - Inspect .....	128	Radiator - Clean .....	136
<b>J</b>		Re-refined Base Stock Oils .....	73
Jacket Water Heater - Check .....	129	Reference Information Section .....	143
<b>L</b>		Reference Material .....	149
Lubricant Information .....	70	Coolants .....	149
API Oils .....	70	Fuels .....	149
Engine Manufacturers Association (EMA) Oils ..	70	Lubricants .....	149
General Information .....	70	Miscellaneous .....	149
Lubricant Specifications .....	70	Reference Materials .....	147
Lubricating Grease .....	74	Reference Numbers .....	24
Caterpillar Premium Grease (CPG) .....	76	Refill Capacities .....	90
Multipurpose Greases .....	75	Cooling System .....	90
Special Purpose Grease (SPG) .....	75	Lubrication System .....	90
<b>M</b>		<b>S</b>	
Magnetic Pickups - Clean/Inspect .....	129	S-O-S Coolant Analysis .....	88
Maintenance Interval Schedule .....	92	S-O-S Coolant Analysis (Level I) .....	88
Maintenance Interval Schedule (Standby Generator		S-O-S Coolant Analysis (Level II) .....	89
Set Engines) .....	94	S-O-S Oil Analysis .....	76
Maintenance Log .....	148	Safety Section .....	6
Maintenance Recommendations .....	95	Safety Signs and Labels .....	6
Service Hours and Fuel Consumption .....	95	Serial Number Plate .....	23
Severe Operation .....	96	Standard Torque for Constant Torque Hose	
Maintenance Records .....	147	Clamps .....	68
Maintenance Section .....	67	Standard Torque for Inch Fasteners .....	68
Manual Stop Procedure .....	63	Standard Torque for Metric Fasteners .....	67
Automatic Stopping .....	64	Standard Torque for Worm Drive Band Hose	
Model View Illustrations .....	18	Clamps .....	68
Model Views .....	18	Standby Generator Set Maintenance	
Monitoring System .....	33	Recommendations .....	137
Caterpillar Monitoring System .....	33	Maintenance and Operation Procedures .....	137
Default Settings for the Caterpillar Monitoring		Starting Motor - Inspect .....	138
System .....	34	Air Starting Motor .....	138
Mounting and Dismounting .....	16	Electric Starting Motor .....	138
		Removal and Installation of the Starting	
		Motor .....	138

Starting the Engine.....	59
Automatic Starting .....	59
Manual Starting.....	60
Overcrank .....	60
Prelubrication.....	59
Starting with Jump Start Cables .....	61
Supplemental Coolant Additive (SCA).....	85
Synthetic Base Stock Oils .....	73

**T**

Table of Contents.....	3
Torque Specifications .....	67
Turbocharger - Inspect.....	138
Cleaning and Inspecting .....	139
Removal and Installation.....	139

**W**

Walk-Around Inspection .....	139
Inspect the Engine for Leaks and for Loose Connections .....	139
Walk-Around Inspection (Exercise Inspection of Standby Generator Set Engines).....	140
Warranty Information .....	150
Engine Protection Plans.....	150
Water Pump - Inspect.....	141
Water/Supplemental Coolant Additive (SCA) .....	86
Adding the SCA to Water at the Initial Fill.....	87
Adding the SCA to Water for Maintenance .....	87

**Z**

Zinc Rods - Inspect/Replace .....	141
Inspect the Zinc Rods .....	141
Replace the Zinc Rods.....	141

# Product and Dealer Information

Note: For product identification plate locations, see the section "Product Identification Information" in the Operation and Maintenance Manual.

Delivery Date: \_\_\_\_\_

## Product Information

Model: \_\_\_\_\_

Product Identification Number: \_\_\_\_\_

Engine Serial Number: \_\_\_\_\_

Transmission Serial Number: \_\_\_\_\_

Generator Serial Number: \_\_\_\_\_

Attachment Serial Numbers: \_\_\_\_\_

Attachment Information: \_\_\_\_\_

Customer Equipment Number: \_\_\_\_\_

Dealer Equipment Number: \_\_\_\_\_

## Dealer Information

Name: \_\_\_\_\_ Branch: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Dealer Contact

Phone Number

Hours

Sales: \_\_\_\_\_

Parts: \_\_\_\_\_

Service: \_\_\_\_\_

