

# Operation and Maintenance Manual

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## **3500 Generator Sets**

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## 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.**

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## Foreword

### Literature Information

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

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

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

### Safety

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

### Operation

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

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

### Maintenance

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

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

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

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

### Maintenance Intervals

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

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

### Overhaul

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

## California Proposition 65 Warning

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

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

## Safety Section

### Safety Signs and Labels

101473100

**SMCS Code:** 1000; 4450; 7405

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

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

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

## High Voltage

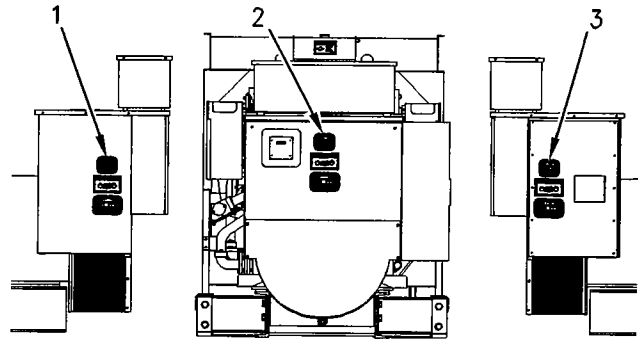
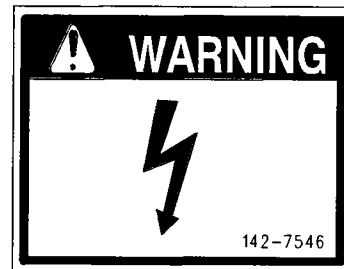


Illustration 1

g00737026

Locations of the warning label for high voltage

The warning label for high voltage is located on the following components: terminal box (1), customer connection box (2), and circuit breaker box (3).



g00308803

High voltage can cause electrical shocks. Electrical shocks can cause personal injury or death. Avoid contacting electrical components and wiring.

## Automatic Starting

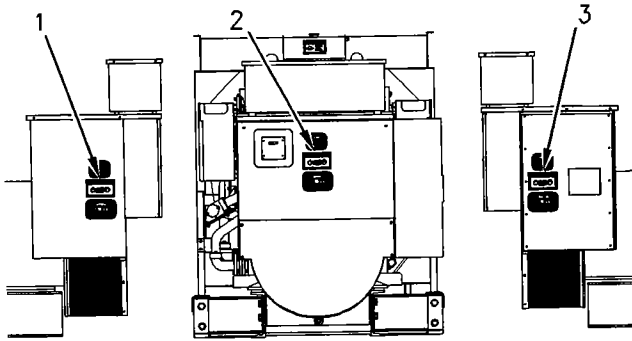
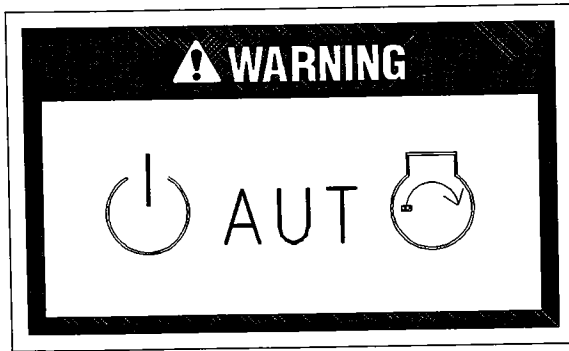


Illustration 2

g00737028

Locations of the warning label for automatic starting

The warning label for automatic starting is located on the following components: terminal box (1), customer connection box (2), and circuit breaker box (3).



g00327883

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 automatic mode.

## Servicing the Engine and Reading the Manual

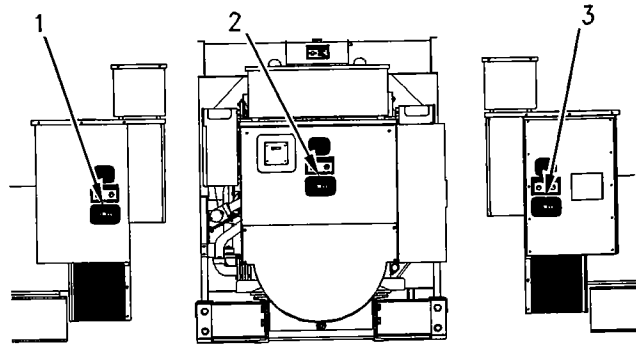
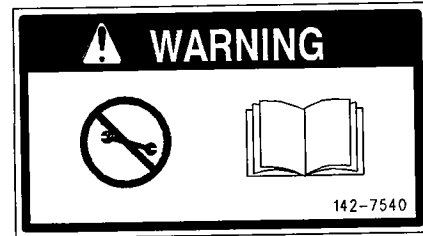


Illustration 3

g00737029

Locations of the warning label for servicing the engine and reading the manual

The warning label for servicing the engine and reading the manual is located on the following components: terminal box (1), customer connection box (2), and circuit breaker box (3).



g00308764



**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.**

## Coolant Pressure and Hot Surface

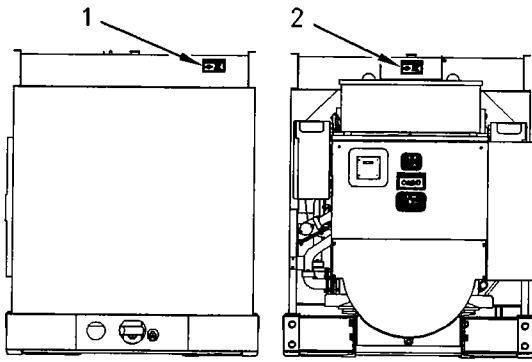


Illustration 4 g00737030  
Locations of the warning label for coolant pressure and hot surface

The warning label for the coolant pressure and the hot surface is located near the top of the radiator on the front (1) and on the rear (2).

## Hot Surface

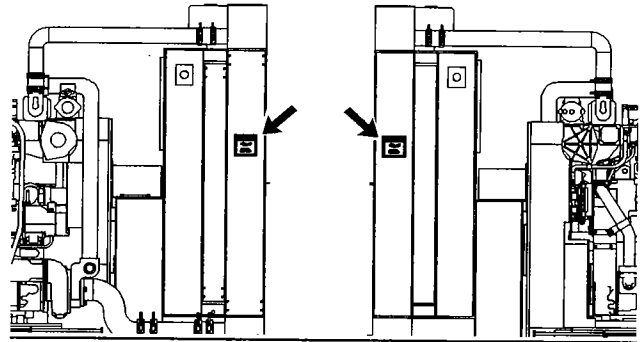
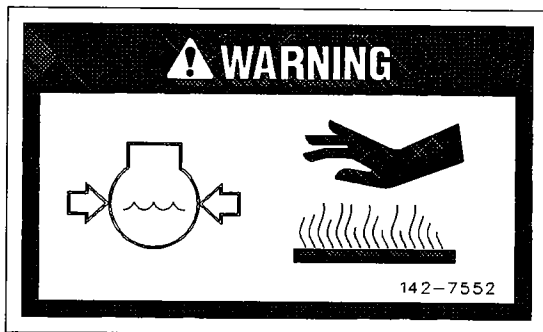


Illustration 5 g00328531  
Locations of the warning label for hot surface

The warning label for the hot surface is located on each side of the radiator.



g00107971

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



g00309705

When the engine is at operating temperature, the engine coolant is hot. Allow cooling system components to cool before the cooling system is drained. Any contact with hot coolant or with steam can cause severe burns.



## Do Not Climb

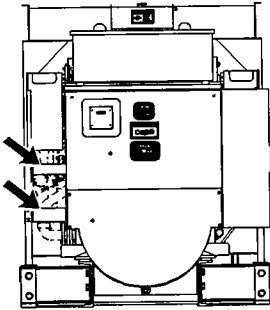


Illustration 6

g00327809

Locations of the warning label for do not climb

The warning label for do not climb is located on the crossbeams for the radiator.



g00327774

Do not climb on the crossbeams for the radiator. Personal injury may result. Use an adequate ladder or use an appropriate work platform for climbing.

## Lifting the Generator Set

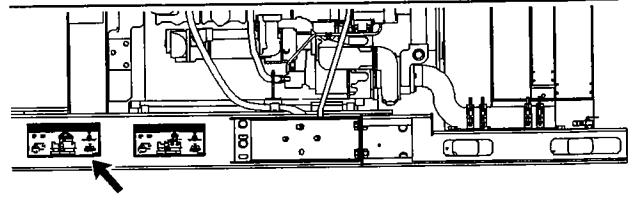
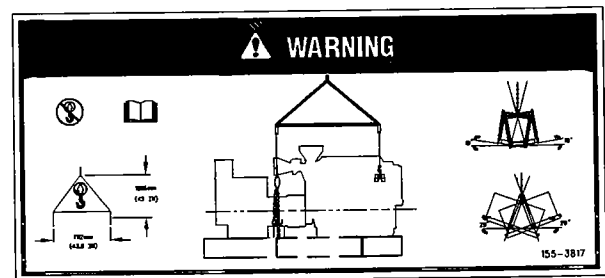


Illustration 7

g00327805

Location of the warning label for lifting the generator set

The warning label for lifting the generator set is located on the engine mounting rails.



g00329532

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

## Engine Lifting

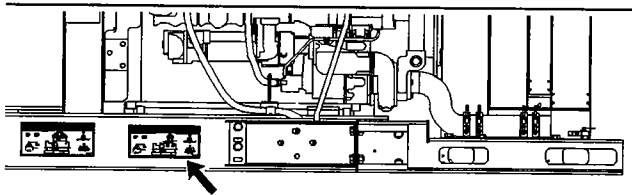


Illustration 8

g00329534

Location of the warning label for lifting the engine

The warning label for lifting the engine is located on the engine mounting rails.

## Diesel Fuel

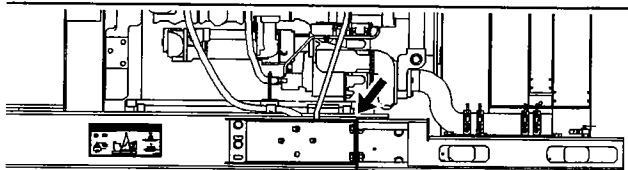
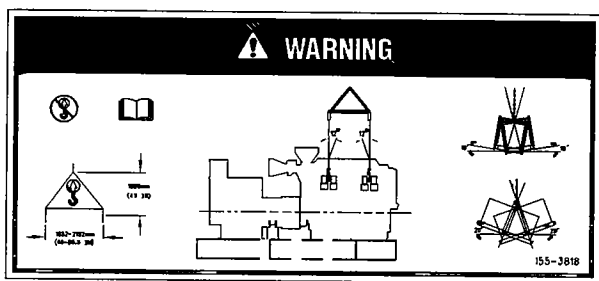


Illustration 9

g00327806

Location of the warning label for diesel fuel

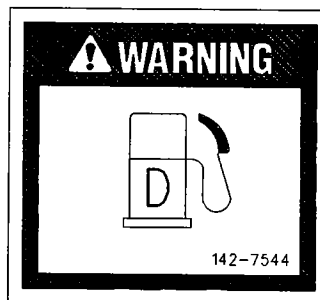
The warning label for diesel fuel is located next to the fuel inlet on the diagonal support for the radiator. The diagonal support for the radiator is attached between the engine mounting rails.



g00329535

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



g00309704

Use diesel fuel only in the engine. The use of gasoline can cause the following problems to occur: engine damage, personal injury, and possible death. Avoid spilling diesel fuel on hot engine components. Spilling diesel fuel on hot engine components can cause a fire. Personal injury or death can occur. Use extreme caution when you are filling the fuel tank with diesel fuel. Always wear protective clothing.

## Electrical Distribution (Generator)

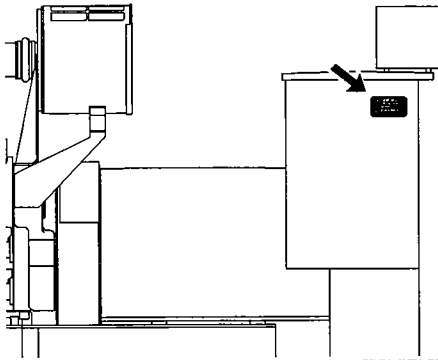


Illustration 10

g00305862

Location of the warning label for electrical distribution (generator)

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

## Emergency Stop

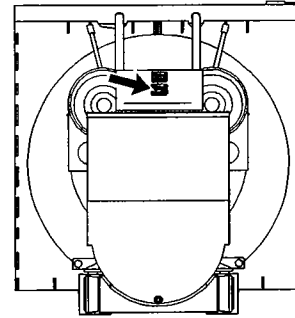
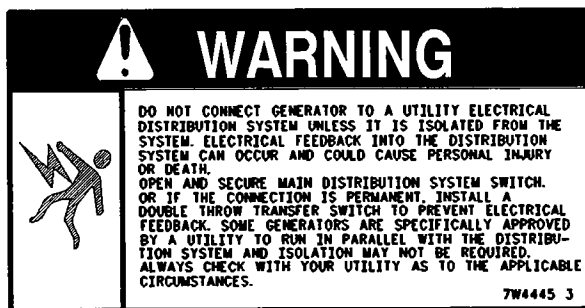


Illustration 11

g00305895

Location of the warning label for emergency stop

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



g00296980



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.



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.

## Operation

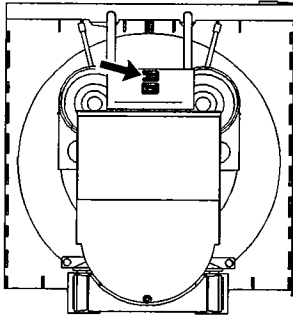
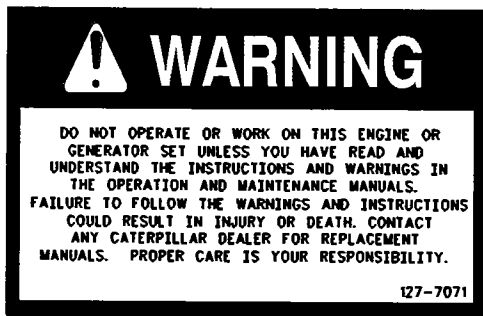


Illustration 12

g00306263

Location of the warning label for operation

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.**

## General Hazard Information

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SMCS Code: 1000; 4450; 7405

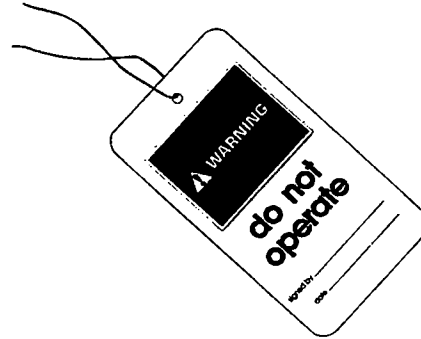


Illustration 13

g00104545

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 (Special Instruction, 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.

Do not allow unauthorized personnel on the engine, or around the engine when the engine is being 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. To help prevent spraying or splashing of pressurized fluids, hold a rag over the part that is being removed.

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

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

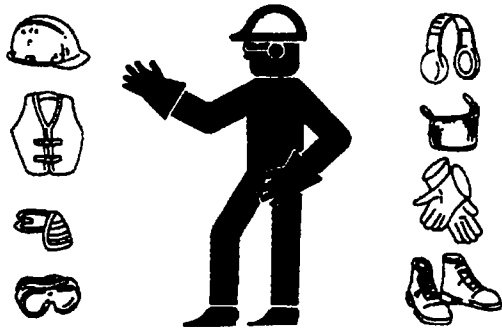


Illustration 14

g00702020

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

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

- The engine is stopped. Ensure that the engine cannot be started.
- 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.

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

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

**Fluid Penetration**

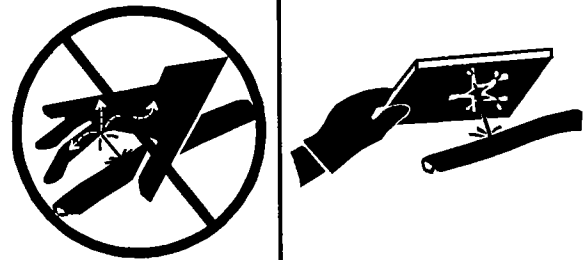


Illustration 15

g00687600

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

**Containing Fluid Spillage**

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

Refer to Special Publication, NENG2500, "Tools and Shop Products Guide" for the following items:

- Tools that are suitable for collecting fluids and equipment that is suitable for collecting fluids
- Tools that are suitable for containing fluids and equipment that is suitable for containing fluids

Obey all local regulations for the disposal of liquids.

## Asbestos Information

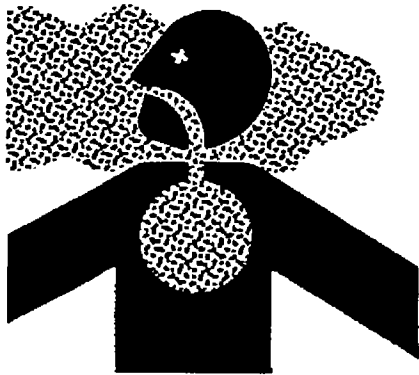


Illustration 16

g00702022

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 you handle any replacement parts that contain asbestos or when you handle asbestos debris.

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

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

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.

- Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in "29 CFR 1910.1001".
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

## Dispose of Waste Properly

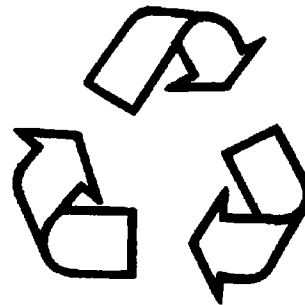


Illustration 17

g00706404

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

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

i01225555

## Burn Prevention

**SMCS Code:** 1000; 4450; 7405

Do not touch any part of an operating generator set. Allow the generator set to cool before any maintenance is performed on the generator set. Before any lines, fittings or related items are disconnected, relieve all pressure in the following systems: lubrication system, fuel system, and cooling system.

i01372254

## Fire Prevention and Explosion Prevention

**SMCS Code:** 1000; 4450; 7405



Illustration 18

g00704000

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

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

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

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

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

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

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

Do not expose the engine to any flame.

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

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

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

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

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

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

Oil filters and fuel filters must be properly installed. The filter housings must be tightened to the proper torque.



Illustration 19

g00704059

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

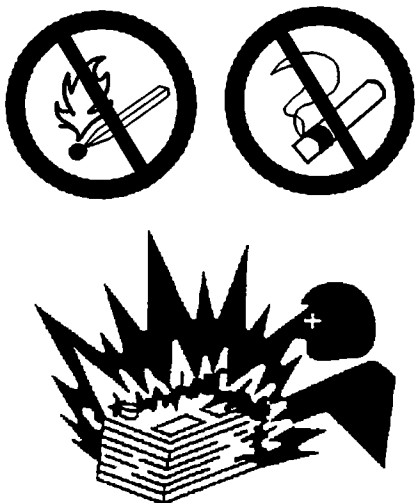


Illustration 20

g00704135

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

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

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

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

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

## Fire Extinguisher

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

## Ether

Ether is flammable and poisonous.

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

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

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

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

## Lines, Tubes and Hoses

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

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

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

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

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

Make sure that all clamps, guards, and heat shields are installed correctly. During engine operation, this will help to prevent vibration, rubbing against other parts, and excessive heat.



i01359666

## Crushing Prevention and Cutting Prevention

**SMCS Code:** 1000; 4450; 7405

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

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

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

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

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

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

i01377941

## Mounting and Dismounting

**SMCS Code:** 1000; 4450; 7405

Generator sets in permanent installations may require the use of a ladder or a work platform in order to provide access for normal maintenance. The owner and/or the user is responsible for providing safe access that conforms to SAE J185 and/or local building codes.

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

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

Face the generator set in order to mount the generator set or dismount the generator set. 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 jump from an elevated platform. Do not jump from a ladder or stairs.

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

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

i01421840

## 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/or 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.

i01470560

## 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 systems for the generator, the engine and the control systems must be properly grounded. Proper grounding is necessary for optimum 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 generator set's 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.

i01489970

## Generator Isolating for Maintenance

**SMCS Code:** 4450

When you service an electric power generation set or when you repair an electric power generation set, follow the procedure below:

1. Stop the engine.

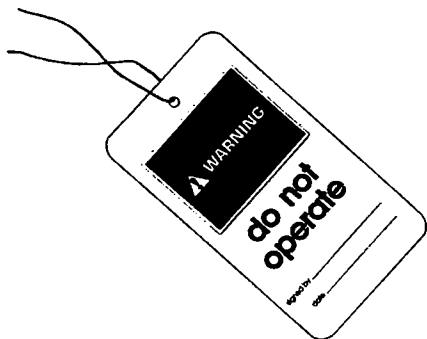


Illustration 21

g00104545

2. Attach a “DO NOT OPERATE” or similar warning tag to the engine prime mover starting circuit. Disconnect the engine starting circuit.
3. Disconnect the generator from the distribution system.

4. Lock out the circuit breaker. Attach a “DO NOT OPERATE” or similar warning tag to the circuit breaker. Refer to the electrical diagram. Verify that all points of possible reverse power flow have been locked out.
5. For the following circuitry, remove the transformer's fuses:
  - power
  - sensing
  - control
6. Attach a “DO NOT OPERATE” or similar warning tag to the generator excitation controls.
7. Remove the cover of the generator's terminal box.
8. Use an audio/visual proximity tester in order to verify that the generator is de-energized. This tester must be insulated for the proper voltage rating. Follow all guidelines in order to verify that the tester is operational.
9. Determine that the generator is in a de-energized condition. Add ground straps to the conductors or terminals. During the entire work period, these ground straps must remain connected to the conductors and to the terminals.

## Product Information Section

## Model Views and Specifications

i01472513

### Model View Illustrations

**SMCS Code:** 1000; 4450

The illustrations show typical features of the 3500 Series Generator Set Engines. The illustrations do not show all of the options that are available.

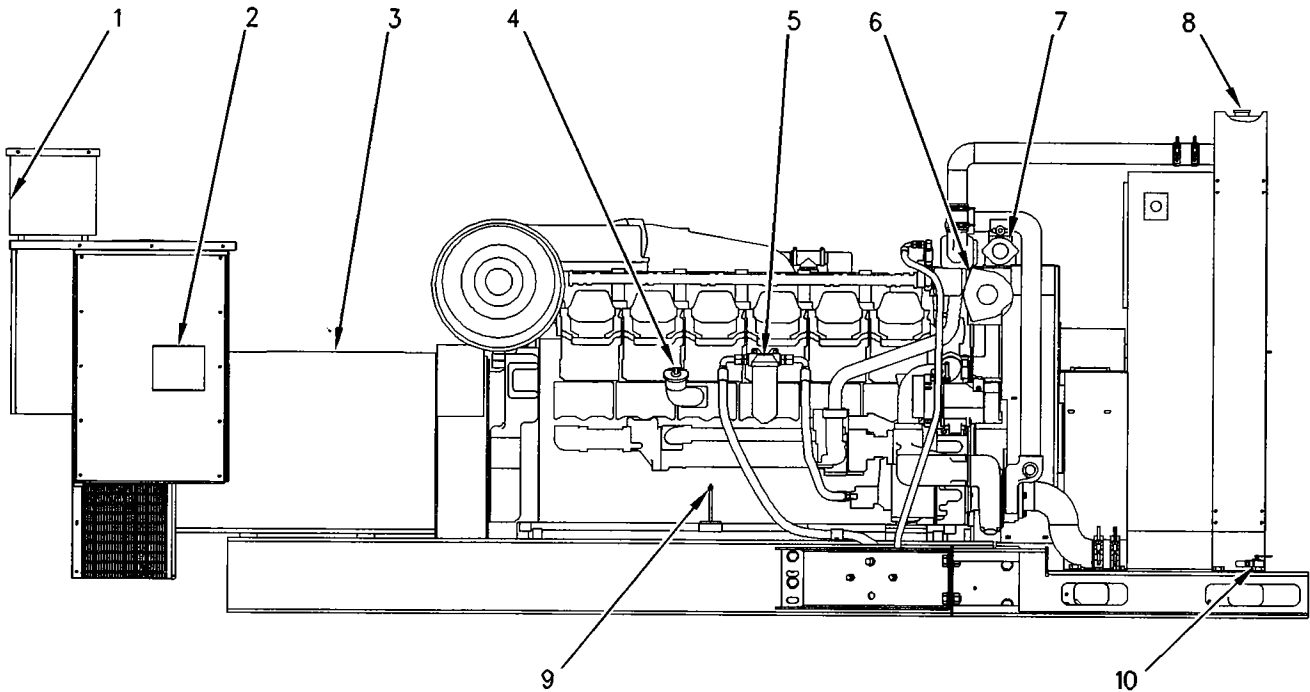


Illustration 22

g00767987

- |                         |                           |
|-------------------------|---------------------------|
| (1) Control panel       | (6) Oil filters           |
| (2) Circuit breaker     | (7) Secondary fuel filter |
| (3) Generator           | (8) Radiator filler cap   |
| (4) Oil filler cap      | (9) Oil level gauge       |
| (5) Primary fuel filter | (10) Coolant drain        |

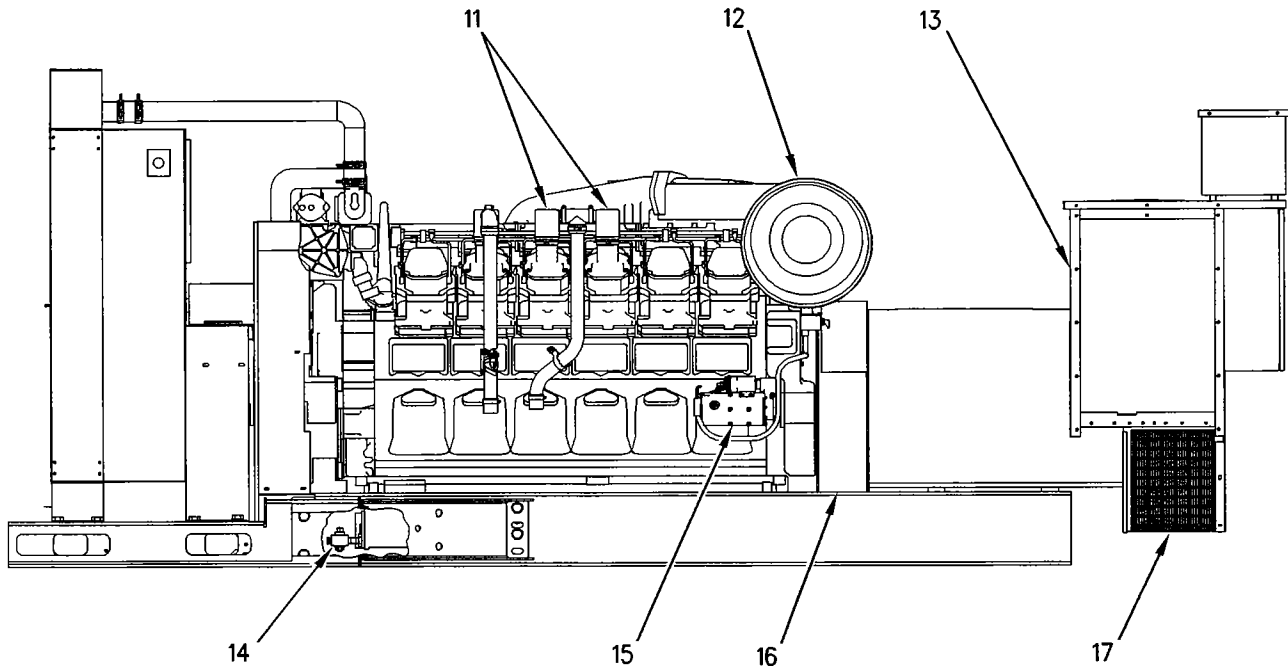


Illustration 23

g00768013

(11) Crankcase breathers  
 (12) Air cleaner  
 (13) Generator terminal box

(14) Oil drain  
 (15) Starting motor  
 (16) Exhaust cover (generator)

(17) Air inlet cover (generator)

i01472656

## Product Description

**SMCS Code:** 1000; 4450

The 3500 Generator Sets consist of an engine, generator and control systems.

### Description (Engine)

The 3500 Series Generator Set Engines includes an 8 cylinder engine, a 12 cylinder engine, and a 16 cylinder engine. These engines are four stroke cycle with direct injection. Each cylinder head has two inlet valves and two exhaust valves. The camshaft uses mechanical lifters and pushrods to actuate the rocker arms and valves.

The engines are supplied with fuel by direct fuel injection. An electronic governor and an actuator controls the fuel injection pump output in order to maintain the engine rpm that is selected by the operator.

Fuel is metered and pumped by a fuel injection pump to the fuel injection nozzles (one per cylinder). The automatic timing advance provides the best fuel injection timing over the full range of engine rpm.

Inlet air is filtered by the air cleaner. The air is compressed by the turbocharger before the air enters the cylinders. The turbocharger is driven by the engine exhaust. The standard engine is turbocharged and aftercooled. The coolant for the aftercooler is circulated by the jacket water pump.

The cooling system consists of the following components:

- Centrifugal pumps
- Four water temperature regulators which maintain the engine coolant temperature to 93 to 107 °C (200 to 225 °F)
- An oil cooler
- A radiator which incorporates a shunt system

The engine lubricating oil is cooled and the engine lubricating oil is filtered. The engine lubricating oil is supplied by a pump that is driven by a gear. If the oil viscosity is high or if the oil cooler and oil filter elements become plugged, bypass valves provide unrestricted flow of lubrication oil to the engine.

Engine efficiency and engine performance depend on adherence to proper operation and maintenance recommendations. Use the recommended fuels, lubrication oils, and coolant. Pay special attention to the air cleaner, to the fuel system, to the lubrication system, and to the cooling system maintenance. Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information on maintenance items.

## **Description (Generator)**

The SR4B brushless generator can be used with the following loads: mixed loads of motors and lights, SCR-controlled equipment, computer centers, installations of communications, and petroleum drilling applications.

The generator set packages can be utilized for prime power generation or standby power generation.

SR4B generators are utilized in three-phase full-wave excitation and regulation. The generators are either four pole or six pole design with six lead configuration or twelve lead configuration depending on frame size. The generators are capable of producing electrical power in either 50 Hz or 60 Hz applications.

i01544400

# Specifications

SMCS Code: 1000

Table 1

3500 Engine Specifications			
Item	3508 Engine	3512 Engine	3516 Engine
Rated Speed (rpm)	900 to 1800		
Idle Speed (rpm)	900		
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	13:1		
Aspiration	Turbocharged		
Method of cooling the turbocharged air	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)	Counterclockwise rotation (standard)		
Fuel	See this Operation and Maintenance Manual, "Fuel Recommendations" (Maintenance Section).		
Method of fuel injection	Mechanical fuel injectors		
Method of starting	Electric starting motor		
Maximum allowable back pressure	6.7 kPa (26.9 inches of H <sub>2</sub> O)		
Maximum inlet air restriction	6.2 kPa (24.9 inches of H <sub>2</sub> O)		
Air cleaners	Single element or Dual element		
Inlet valve lash	0.50 mm (0.020 inch)		
Exhaust valve lash	1.00 mm (0.040 inch)		

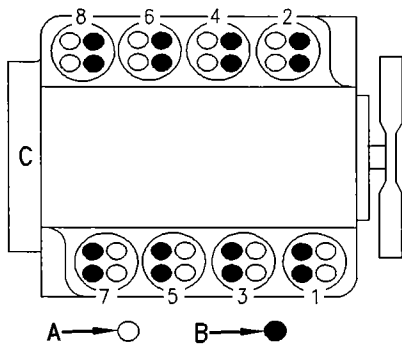


Illustration 24

g00739600

3508 Engine

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

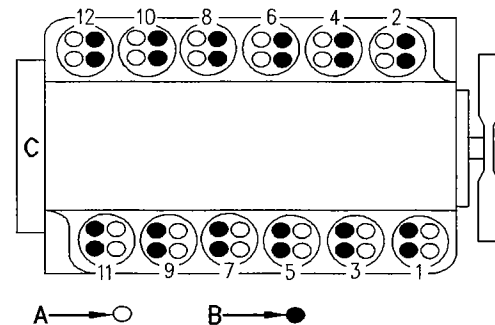


Illustration 25

g00749769

3512 Engine

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

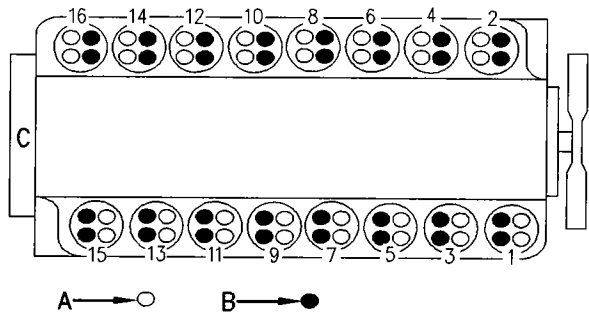


Illustration 26

g00749770

3516 Engine

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



# Product Identification Information

101460635

## Plate Locations and Film Locations

SMCS Code: 1000; 4450

## Engine Identification

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

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

### Serial Number Plate

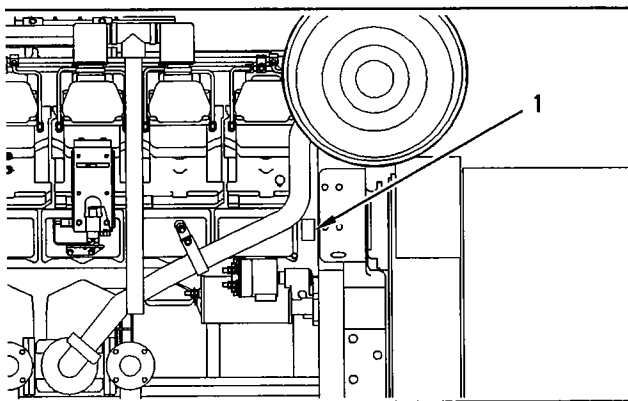


Illustration 27

g00735499

(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.

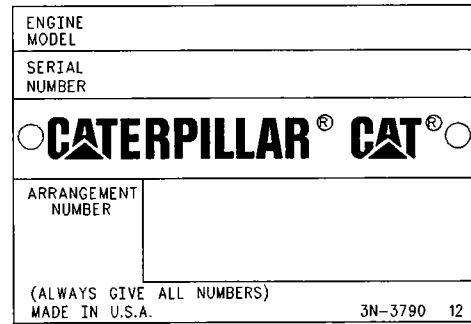


Illustration 28

g00123229

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

### Information Plate

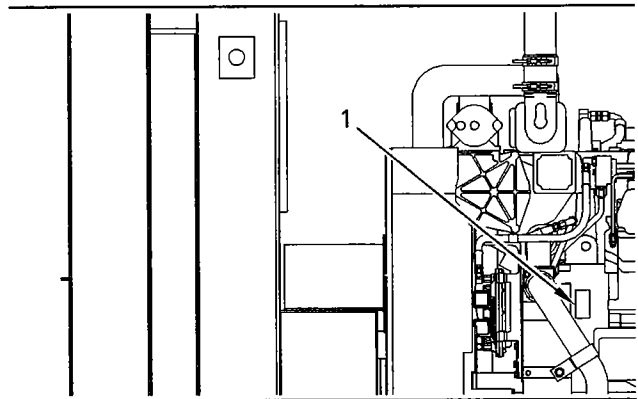


Illustration 29

g00735560

(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.

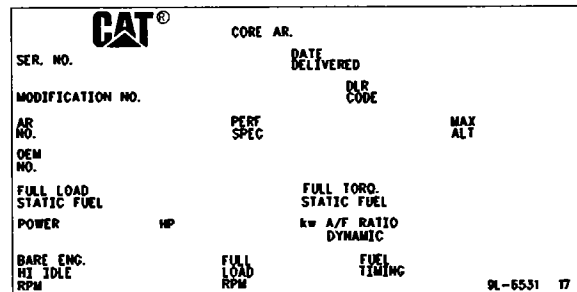


Illustration 30

g00102789

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

## Generator Identification

The generator identification and information plate is located on the left side of the generator.

When service is required, the information that is given on this plate should be used. The generator identification and information plate includes the following information: serial number, model number, and the rating of the generator set. The generator set consists of the engine and generator. All pertinent generator data is also included on the plate in order to provide the information that is necessary to order parts.

## Output Lead Wiring

All generator lead wiring information can be found on a decal that is located on the side panel of the generator's terminal box. If the generator is equipped with a circuit breaker, the decal may be found on the sheet metal of the circuit breaker panel.

SALES MODE  GENERATOR SET

RATING  
 kVA  kW  COS φ  HERTZ   
 CONTINUOUS  PRIME  STANDBY

GENERATOR DATA

3 PHASE  WIRE  WYE (STAR)  DELTA   
 CONNECTION  SERIES  PARALLEL   
 GENERATOR  VOLTS  AMPS   
 EXCITATION  VOLTS  AMPS   
 FRAME  REV/MIN   
 MAXIMUM TEMPERATURE RISE  °C BY RESISTANCE  METERS ALTITUDE  
 °C AMBIENT   
 CLASS  INSULATION

ENCLOSURE TYPE

YEAR

INCLUDE SERIAL NUMBERS AND GENERATOR PART NUMBER FROM GENERATOR SERIAL NUMBER PLATE WHEN ORDERING PARTS AND IN CORRESPONDENCE.

GENERATOR FRAME SHOULD BE GROUNDED.

GP-6490 1

Illustration 31

g00572840

Generator Identification Plate

GENERATOR MODEL	
SERIAL NUMBER	
<input type="checkbox"/>	<input type="checkbox"/>
ARRANGEMENT NUMBER	
(ALWAYS GIVE ALL NUMBERS)	
MADE IN U.S.A.	1W7848 2

Illustration 32

g00601027

Serial Number Plate

i01498858

i01461959

## Emissions Certification Film

SMCS Code: 1000; 7405

<b>CAT</b>		<b>CATERPILLAR INC.</b>	
IMPORTANT ENGINE INFORMATION			
SER NO.	<b>SRM00001</b>		
ENGINE MODEL	<b>3516</b>	DISPLACEMENT	<b>69.0 L</b>
VALVE LASH	<b>0.50 mm</b>	INTAKE	
		EXHAUST	<b>1.00 mm</b>
ENGINE FAMILY	<b>YCPXL69.0ERK</b>		
MAX. ADVERTISED POWER	<b>1611 (2160)</b>	kW	HP
MAX. RATED SPEED	<b>1750</b>	RPM	
MAX. LOW IDLE SPEED	<b>700</b>	RPM	
MAX. FUEL RATE @ MAX. kW	<b>463</b>	mm <sup>3</sup> /STROKE	
EXHAUST EMISSION CONTROL SYSTEM	<b>EM,DI,TC,ECM,CAC</b>		
THIS ENGINE CONFORMS TO 2000 U.S. EPA AND CALIFORNIA REGULATIONS LARGE NON-ROAD COMPRESSION-IGNITION ENGINES. THIS ENGINE IS CERTIFIED TO OPERATE ON COMMERCIALLY AVAILABLE DIESEL FUEL.			
DATE OF MANUFACTURE (MONTH)	<b>08</b>		159-2455

The EPA/EU Emissions Certification Film (if applicable) is located either on the side, the top, or the front of the engine.

<b>CAT</b>		<b>CATERPILLAR INC.</b>	
INFORMATION IMPORTANTE SUR LE MOTEUR			
NO SÉRIE	<b>SRM00001</b>		
MODÈLE MOTEUR	<b>3516</b>	DÉBIT	<b>69.0 l</b>
JEU SOUPAPES	<b>ADM. 0.50 mm</b>	ÉCHAP.	<b>1.00 mm</b>
FAMILLE DE MOTEURS	<b>YCPXL69.0ERK</b>		
MAXI PUBLIÉS	<b>1611 (2160)</b>	kW	HP
MAXI RÉGIME NOMINAL	<b>1750</b>	tr/mn	
MAXI RÉGIME RALENTI	<b>700</b>	tr/mn	
MAXI DÉBIT D'INJ. À PUIS. MAXI	<b>463</b>	mm <sup>3</sup> /STROKE (PISTON)	
DISPOSITIF ANTI-POLLUANT	<b>EM,DI,TC,ECM,CAC</b>		
CE MOTEUR EST CONFORME AUX RÉGLEMENTATIONS DE L'AGENCE AMÉRICAINE DE PROTECTION DE L'ENVIRONNEMENT (EPA) ET DE LA CALIFORNIE POUR LES GROS MOTEURS NON ROUTIERS À COMPRESSION-CONTACT. CE MOTEUR EST HOMOLOGUÉ POUR FONCTIONNER AVEC LE CARBURANT DIESEL DU COMMERCE.			
DATE DE FABRICATION (MOIS)	<b>08</b>		

L'autocollant d'homologation du dispositif antipollution EPA/EU (selon équipement) est situé soit sur le côté du moteur, soit sur le dessus du moteur, soit sur le devant du moteur.

## Reference Information

SMCS Code: 1000; 4450

Identification of the items in Table 2 may be required in order to obtain parts and service. Some of the information is 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 generator set leaves the factory, the performance of the following components are tested: package, generator, and engine. Detailed performance data is recorded. The performance specification number can be used for obtaining the engine data. The performance data for the package and the generator can be ordered from your Caterpillar dealer.

Table 2

Reference Information	
Customer Designation	
Model (Generator Set)	
Serial Number (Generator Set)	
Arrangement Number (Generator Set)	
Model (Engine)	
Serial Number (Engine)	
Arrangement Number (Engine)	
Model (Generator)	
Serial Number (Generator)	
Arrangement Number (Generator)	
Generator Frame Size	
kW Rating	
Voltage Rating	
Generator Excitation	
Generator Air Inlet Filter	
Modification Number	
Packaging Arrangement	
Turbocharger	
Fuel Filter Element	
Engine Oil Filter	
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	

## Generator Lead Connections

SMCS Code: 4450

### Lead Numbering

The Wye (Star) configurations and the Delta configurations are the most common generator lead connections. The following three-phase connection diagrams illustrate the proper connection and lead identification.

The leads are numbered clockwise from the top and from the outside inward. The diagrams show lead numbering for the six and twelve lead generators.

### Wye Configuration Diagrams

#### 6 Lead

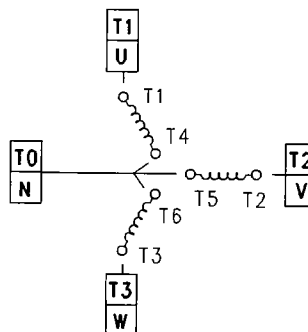


Illustration 34

g00611486

#### 6 Lead Wye Configuration

Terminals T4, T5 and T6 become neutral connection when the terminals are tied together.

12 Lead

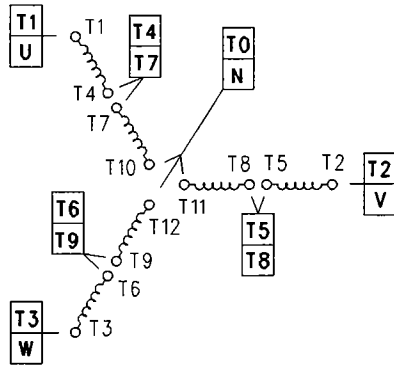


Illustration 35 g00661863  
 12 Lead Wye Configuration - High Voltage  
 Terminals T10, T11 and T12 become neutral connection when the terminals are tied together.

Delta Configuration Diagrams

6 Lead

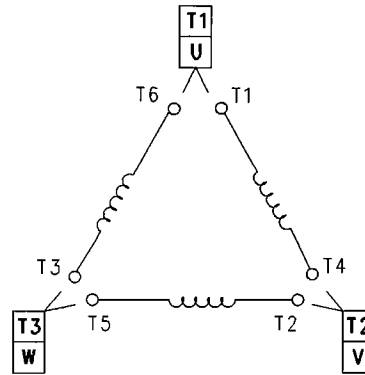


Illustration 37 g00669319  
 6 Lead Delta Configuration

12 Lead

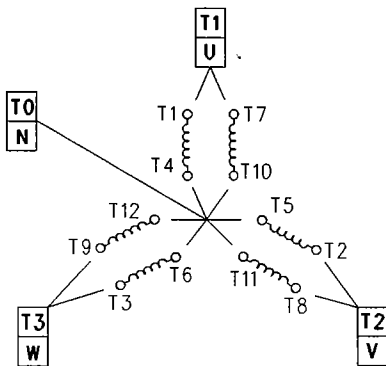


Illustration 36 g00611608  
 12 Lead Wye Configuration - Low Voltage  
 Terminals T10, T11 and T12 become neutral connection when the terminals are tied together.

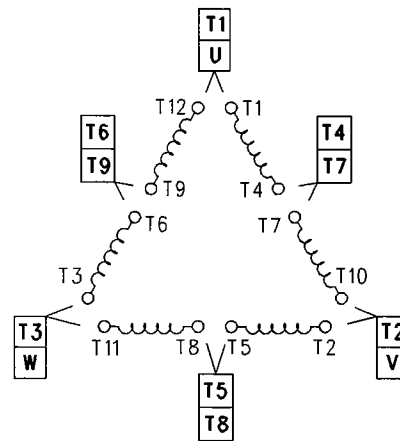


Illustration 38 g00669312  
 12 Lead Delta Configuration  
 Terminals T6 and T9 become the neutral connection when the terminals are tied together and grounded. This reflects the terminal T2 and T10 connection as the high phase.

## Grounding the Frame

In any generator set installation, the frame of the generator must be positively connected to an earth ground. This connection is the first one that is made at the installation. This connection is the last one that should be removed. The ground connection must be flexible in order to avoid possible breakage in later operation.

Ground connection cable or straps should have at least the current carrying capacity of the largest line lead to the connected load. Joints in cables or straps must be clean, free of electrical resistance, and protected from possible oxidation. Bolted ground connection joints eventually oxidize. The joints are frequent sources of radio frequency interference (RFI). Silver soldered and bolted joints are electrically and mechanically sound.

## Neutral Connections

The generators with grounded configuration usually have the neutral grounded when the generator is installed. However, there are some cases when definite measures can be taken in order to prevent ground faults on the load side. The purpose of the grounding of the neutral is to prevent load side equipment damage. The purpose of the grounding of the neutral is also to prevent harm to personnel.

If the neutral wire is grounded and one of the phase leads becomes grounded, the excessive current will open a load circuit breaker in order to isolate the fault. The excessive current will collapse the generator voltage, if the circuit breaker does not trip first. The result depends on the particular generator electrical characteristics, type of fault, and trip rating of the circuit breaker. An undervoltage device may be required in order to provide an adequate short circuit protection.

There are some instances in which it is undesirable to ground the neutral wire. An ungrounded generator neutral lead is acceptable in the applications in which definite measures have been taken in order to prevent grounds to the phase leads. An example of such measures are ground fault protective circuits. Ground fault protection requires that the entire group of distribution circuits should be studied and treated as a system. The owner should engage a certified and registered consultant if a new distribution system is being developed. The owner should also engage a certified and registered consultant if an existing system should be modified for the ground fault protection.

Neutral resistors and reactors may be added to the system for two reasons: to provide protection during faults and to limit neutral currents.

## Single Units

In a three-phase, four-wire system, the neutral wire should be grounded according to local wiring codes.

In applications, in which definite measures are taken in order to prevent grounds to the load leads, an ungrounded neutral can be used. Be sure to check your local wiring codes.

## Multiple Units

Operation of multiple generators in parallel, having all neutrals grounded, may result in the circulating current through the neutral connections. In order to eliminate the possibility of circulating currents, ground the neutral of only one generator. If multiple generators are alternated on line, a switch should be installed in the neutral ground circuit of each generator. In this case all neutral ground circuits except one can be opened. Be sure that one of the neutral ground circuits is closed.

## Parallel to Utility

When a Wye (Star) connected generator is going to operate in parallel with a utility system (infinite bus) and when the secondary of the step-down transformer in the utility system is also a Wye connection, the following may happen. The grounding of both Wye neutrals may result in circulating currents through the neutrals. Also, the coordination of ground fault protection requires an entire system study. A study should be done by a certified and registered consultant who is familiar with generator systems. The study will determine which grounding method should be used.

i01460960

## Voltage Connections

**SMCS Code:** 4450

### Three-Phase Voltage Connections

The Wye (Star) Configuration for a 480 V generator and the Delta Configuration for a 240 V generator are given in the following diagrams.

The terminals must be connected securely. The terminals must also be insulated with a good quality electrical tape.

If a Delta Configuration is used, a two-thirds winding pitch is recommended and is required with 590 frame size generators and above. If the generator winding pitch is not two-thirds, third harmonics will cause a high circulating current. The generator will need to be derated. This current can exceed the winding current rating causing generator overheating and damage which may pose a fire hazard. A Wye (Star) connected generator may require a two-thirds pitch winding if the neutral is solidly grounded. Refer to the Specifications, LEBX6693, "Generator Set Installation Drawings" for more information. A floating neutral does not require a two-thirds pitch winding.

### Wye (Star) Configuration Diagrams

#### 6 Lead Generators

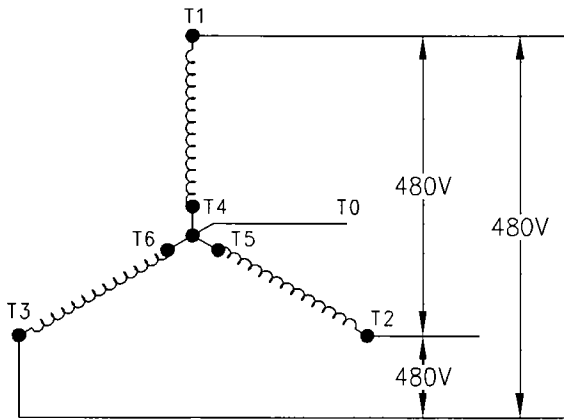


Illustration 39 g00626053  
 Typical Wye (Star) Configuration (60 Hz, 6 Lead)

#### 12 Lead Generators

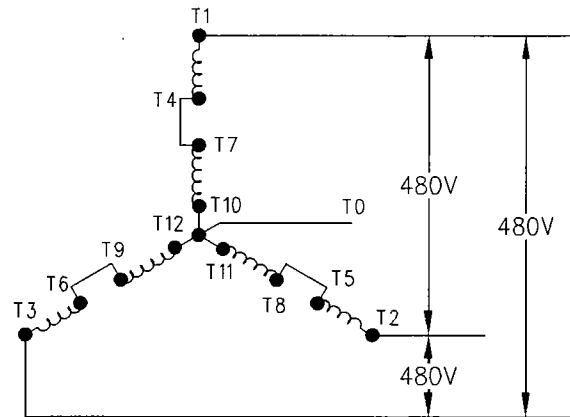


Illustration 40 g00637319  
 Typical Series Wye (Star) Configuration (60 Hz, 12 Lead)  
 This is a typical high voltage connection.

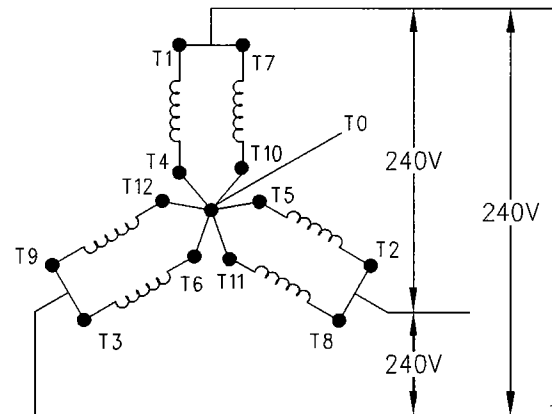


Illustration 41 g00637320  
 Typical Parallel Wye (Star) Configuration (60 Hz, 12 Lead)  
 This is a typical low voltage connection.

## Delta Configuration Diagrams

### 6 Lead Generators

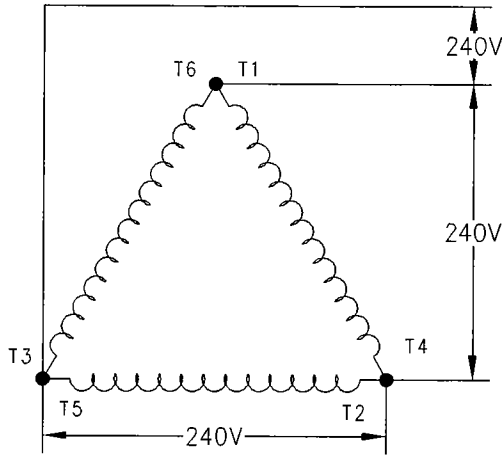


Illustration 42

g00626129

Typical Delta Configuration (60 Hz, 6 Lead)

### 12 Lead Generators

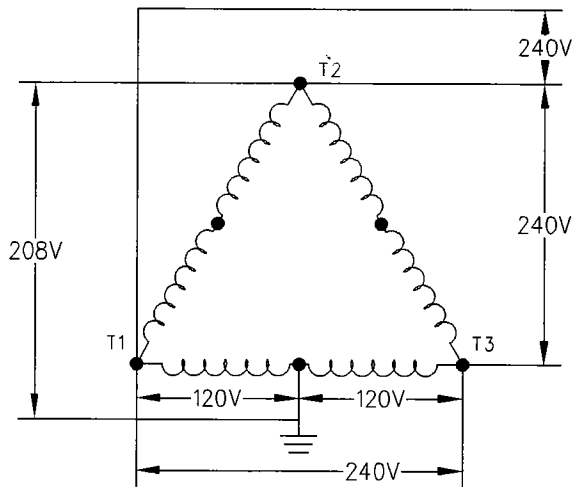


Illustration 43

g00626130

Typical Delta Configuration (60 Hz, 12 Lead)

## Single-Phase Current From a Three-Phase Generator

Three-phase current and single-phase current can be taken simultaneously from a generator that is connected for three-phase service. In the Wye (Star) Configuration, connect the load to the three-phase leads (any two of the three leads). In the Delta Configuration, connect the load to the three-phase leads (any two of the three leads). In both configurations, this will provide single-phase voltage at the same voltage as three-phase voltage.

Connect the load to any phase lead and neutral lead of the Wye (Star) Configuration. This will produce voltage at 58% of three-phase voltage.

Refer to Operation Section, "Generator Operation" for allowable single-phase loading unbalance.

Single-phase power that is taken from a three-phase source can be a problem. Ensure that the single-phase loading is equally distributed.

Do not exceed the nameplate current rating for any one phase.

## Wye (Star) Configuration Diagrams

### 6 Lead Generators

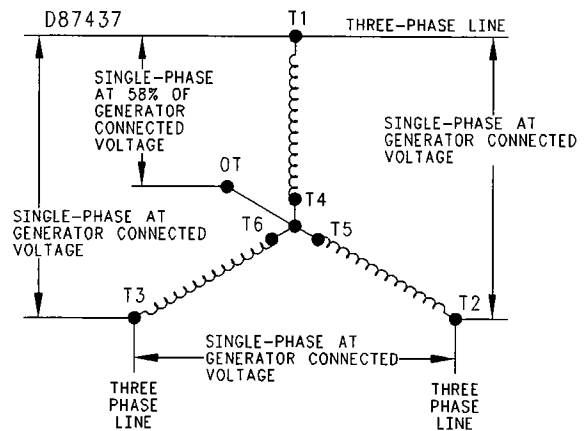


Illustration 44

g00626132

Single-Phase Voltage Diagram with 6 Lead Wye (Star) Configuration



12 Lead Generators

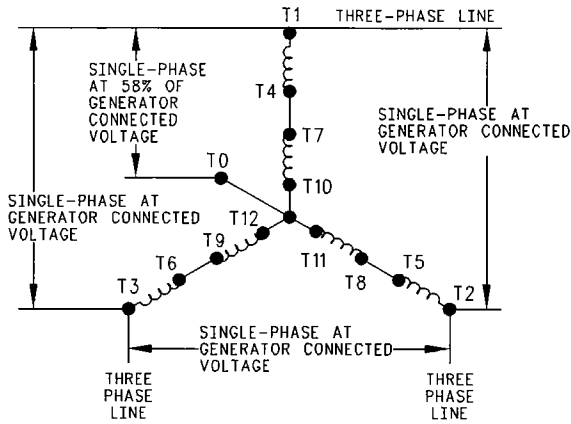


Illustration 45 g00637321  
 Single-Phase Voltage Diagram with 12 Lead Wye (Star) Configuration

12 Lead Generators

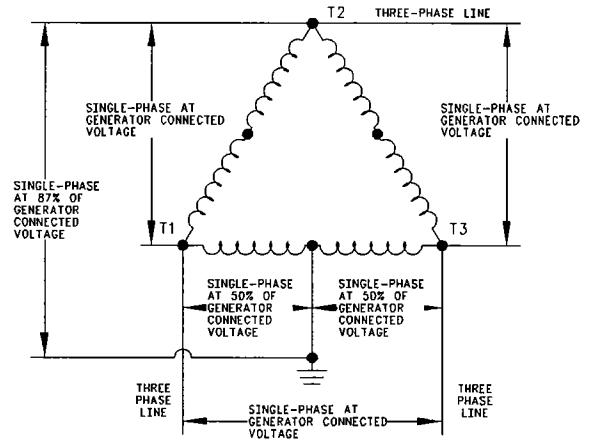


Illustration 47 g00626136  
 Single-Phase Voltage Diagram with 12 Lead Delta Configuration

Delta Configuration Diagrams

6 Lead Generators

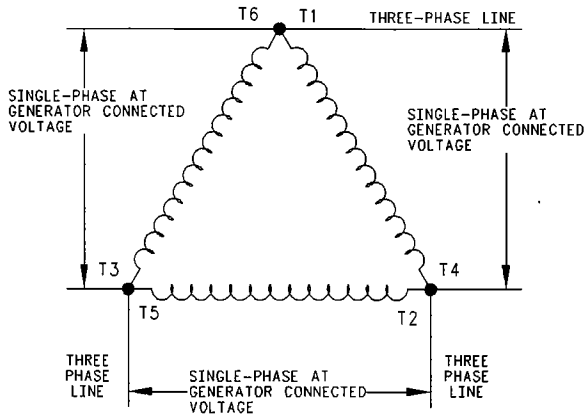


Illustration 46 g00626135  
 Single-Phase Voltage Diagram with 6 Lead Delta Configuration

## Operation Section

# Engine Lifting and Storage

## Engine Lifting

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**SMCS Code:** 1000; 1122

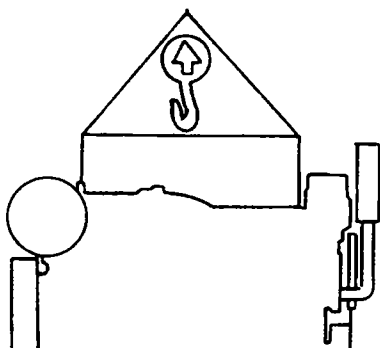


Illustration 48

g00103219

### NOTICE

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

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

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

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

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

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

## Engine Lifting with a Generator

### NOTICE

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

Lifting the engine and the generator together requires special equipment and procedures. Consult your Caterpillar dealer for information regarding fixtures for proper lifting of your complete package.

Lifting packaged generator sets will not be level if you lift the unit with a single point lift. A counterweight can be added between the package frame rails whenever the application requires frequent relocation of the unit. For complete information about adding the counterweight, consult your Caterpillar dealer.

The single point lifting eye is secured from the factory before the enclosure is shipped. The correct orientation of the single point lifting eye will allow you to look through the eye when you stand at the side of the enclosure. The lifting eye may stretch when the package is lifted. This may cause the locking nuts to loosen. This could cause the lifting eye to swivel. Ensure that the lifting eye is correctly oriented on the packaged generator set. Ensure that the lifting eye is tightened to the correct torque before you lift the packaged generator set.

## Engine Lifting with a Fuel Tank

Lifting the engine with a fuel tank that is mounted to the engine requires special equipment and procedures. Do not lift the unit with fuel in the fuel tank. Consult your Caterpillar dealer for information regarding fixtures for proper lifting of your complete package.

i01469600

## 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 this Operation and Maintenance Manual, "Generator Installation" (Operation Section).

## Gauges and Indicators

i00706267

### Gauges and Indicators

**SMCS Code:** 7450

**Note:** For information about the control panel, see Operation and Maintenance Manual, SEBU7149, "SR4B Generators And Control Panels".

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

Noticeable changes in gauge readings 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 below.

#### 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. The engine oil pressure will be highest after a cold engine is started. The engine oil pressure will decrease as the engine warms up. The engine oil pressure will increase when the engine rpm is increased. The engine oil pressure will stabilize when the engine rpm is stable. The typical range for engine oil pressure at low idle rpm is 186 to 344 kPa (27 to 50 psi). The typical range for engine oil pressure at rated rpm is 275 to 600 kPa (40 to 87 psi).



**Oil Filter Differential Pressure** – 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. Replace the engine oil filter elements when the oil filter differential pressure reaches 105 kPa (15 psi).



**Jacket Water Temperature** – This gauge indicates the temperature of the engine coolant at the outlet for the jacket water. The jacket water temperature may vary according to the load. The jacket water temperature should never be allowed to exceed the boiling temperature of the pressurized cooling system. The operating range for jacket water temperature is 88 to 100 °C (190 to 210 °F). Higher temperatures may occur under certain conditions.

The engine should operate within the normal temperature range. 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 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 rpm.

#### NOTICE

High inlet manifold air temperature increases the risk of engine damage. Maximum inlet air temperature is 115 °C (235 °F).



**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.

Maintain the aftercooler in good condition. Ensure that the inlet manifold air temperature of an engine at operating temperature does not vary by more than 4 °C (7 °F) from the maximum inlet manifold air temperature.



**Inlet Manifold Air Pressure** – This gauge indicates the air pressure (turbocharger boost pressure) in the air plenum (air inlet manifold) after the aftercooler. The inlet manifold air pressure depends on the engine rating, the load, and the operating conditions.

**Pyrometer** – The pyrometer indicates the exhaust stack temperature at the exhaust elbows. For engines with two exhaust stacks, the two exhaust stack temperatures may vary slightly. This may be due to variation of the sensitivity of the two thermocouples. Maximum exhaust stack temperature can vary from 480 to 590 °C (900 to 1100 °F).

The pyrometer also indicates the temperature of the exhaust gas of each individual cylinder. These temperatures are measured at the exhaust port of each cylinder head. The exhaust temperature will vary slightly between the cylinders.



**Tachometer** – This gauge indicates the engine rpm.

#### 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.

**Note:** The high idle rpm and the full load rpm are stamped on the engine Information Plate.



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



**Fuel Pressure** – This meter indicates fuel pressure to the fuel injection pump from the fuel filter. The normal fuel pressure range is 345 kPa (50 psi) to 520 kPa (75 psi). Minimum fuel pressure is 275 kPa (40 psi) at the rated speed.

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.



**Fuel Filter Differential Pressure** – 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. Service the fuel filter when the fuel filter differential pressure reaches 105 kPa (15 psi).



**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. As the air filter element becomes plugged, the difference in pressure between the two sides of the air cleaner element will increase. For optimum engine performance, clean the air cleaner elements or replace the air cleaner elements when the air cleaner differential pressure reaches 3.75 kPa (15 inches of H<sub>2</sub>O). Maximum air cleaner differential pressure is 7.5 kPa (30 inches of H<sub>2</sub>O).



**Ammeter** – This gauge indicates the amount of charge or discharge in the battery charging circuit. Operation of the indicator should be to the right side of "0"(zero).



**Engine Oil Temperature** – This gauge indicates the engine oil temperature after the oil has passed through the oil cooler. The oil cooler is thermostatically controlled. The oil temperature is controlled by an 82 °C (180 °F) temperature regulator that is in contact with the oil. The maximum oil temperature at rated rpm and rated load is 104 °C (220 °F).



**Cranking Timers** – There is a cranking timer which may be used on an Automatic Start/Stop mode. The timer allows the engine to crank for 30 seconds. If the engine does not start within the 30 second interval the Status Control Module will not activate. This condition indicates a failure to start.



**Coolant Pressure** – This gauge can be used for jacket water pressure or auxiliary water pressure.

# Engine Features and Controls

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## Alarms and Shutoffs

i01470801

**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 and the generator, see this Operation and Maintenance Manual, "Generator Set Control Panels" (Operation Section).

## Control Panel

**SMCS Code:** 7451

Three different control panels are available for use with the engines:

- Electronic Modular Control Panel II+ (EMCP II+)
- Electronic Modular Control Panel II (EMCP II)
- Switchgear Conversion Control Panel

For detailed information about the control panels, see this Operation and Maintenance Manual, "Generator Set Control Panels" (Operation Section).

# Engine Starting

i01471043

## 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 Interval Schedule" (Maintenance Section).

## 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, "Cooling System Specifications" (Maintenance Section).

## Generator

- Perform any maintenance that is required for the generator. See this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).
- 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, "Fuel System-Prime" (Maintenance Section) for information on priming the fuel system.

## Lubrication System

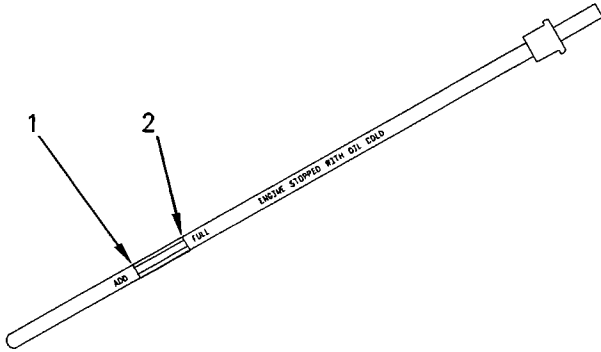


Illustration 49

g00736087

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, "Lubricant Specifications" (Maintenance Section).
- 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.

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.

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.

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.

## 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 (Operation Section), "Before Starting Engine".

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. For additional injection, the jacket water temperature must be less than 21 °C (70 °F).
4. The "STARTING AID" switch is a momentary switch. To stop the injection, release the "STARTING AID" switch.

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## 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.**

---

**Note:** The crank cycle and the number of crank cycles are programmable. 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. 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.

## Operation of the Generator Set Control Panel

For information on operation of the generator set control panel, see this Operation and Maintenance Manual, "Generator Set Control Panels" (Operation Section).

## 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.**

---

The position for the engine control switch depends on the type of control panel. For the EMCP II+ and the EMCP II control panel, the engine control switch must be in the "AUTO" position. For the Switchgear Conversion control panel, the engine control switch must be in the "REMOTE" 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" (Operation Section).

**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.

- b. To start engines with the Switchgear Conversion control panel, turn the engine control switch to the "LOCAL" position. The engine will start according to the parameters that are programmed into the switchgear.

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## Starting with Jump Start Cables

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

**WARNING**

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

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

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

First, determine the reason that it is necessary to start with power from an external source. Refer to Special Instruction, SEHS7768, "Use of the 6V-2150 Starting/Charging Analyzer".

Many batteries which are considered unusable are still rechargeable. After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be charged to the proper voltage with a battery charger. For information on testing and charging, refer to the Special Instruction, SEHS7633, "Battery Test Procedure".

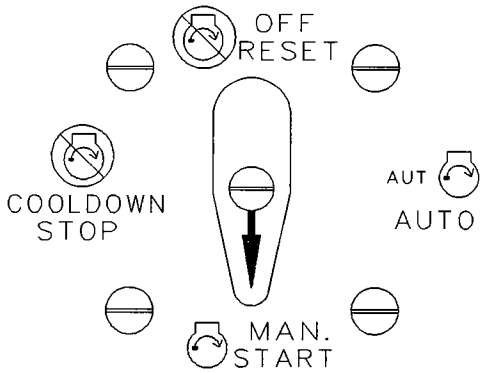


Illustration 50 g00319402

Engine control switch in the "MAN. START" position  
 This engine control switch is used on the EMCP II+ and on the EMCP II control panel.

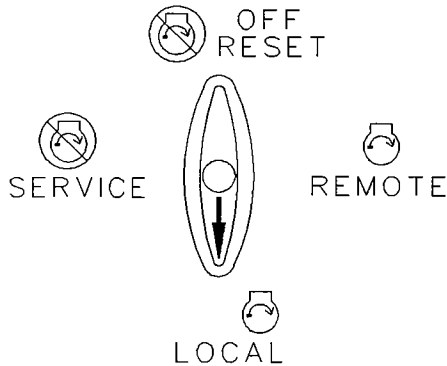


Illustration 51 g00329234

Engine control switch in the "LOCAL" position  
 This engine control switch is used on the Switchgear Conversion control panel.

2. Manual starting of the engine depends on the control panel.
  - a. To start engines with the EMCP II+ or the EMCP II control panel, turn the engine control switch to the "MAN. START" position.

---

**NOTICE**

When jump starting an engine, follow the instructions in order to properly start the engine.

Using a battery source with the same voltage as the electric starting motor. Use only equal voltage for jump starting. The use of higher voltage will damage the electrical system.

Do not reverse the battery cables. The alternator can be damaged.

When using an external electrical source to start the engine, turn the Engine Control Switch to the "OFF/RESET" position. Turn all all electrical accessories OFF before attaching the jump start cables.

Ensure that the main power switch is in the OFF position before attaching the jump start cables to the engine being started.

---

Turn off all auxiliary power and accessories of the engine. Otherwise, these components will operate when the power source is connected.

Before attaching the jump start cables, ensure that the engine control switch is in the "OFF/RESET" position.

1. Perform all of the procedures in this Operation and Maintenance Manual (Operation Section), "Before Starting Engine".
2. Connect the end of one jump start cable to the positive "+" terminal of the battery for the engine that is being started. Connect the other end to the positive "+" terminal of the power source.
3. Connect one end of the second jump start cable to the negative "-" terminal of the power source. Connect the other end to the negative "-" ground of the starting motor.
4. Manual starting of the engine depends on the control panel.
  - a. To start engines with the EMCP II+ or the EMCP II control panel, turn the engine control switch to the "MAN. START" position.
  - b. To start engines with the Switchgear Conversion control panel, turn the engine control switch to the "LOCAL" position. The engine will start according to the parameters that are programmed into the switchgear.
5. After the engine starts, disconnect the cable from the negative "-" ground of the starting motor. Disconnect the other end of the cable from the negative "-" terminal of the power source.

6. Disconnect the cable from the positive "+" terminal of the battery for the engine that was started. Disconnect the other end of the cable from the positive "+" terminal of the power source.

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## 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 coolant 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 Generator

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 generator.

## Engine Operation

i01471266

### 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 Generator Set

Check the gauges and the generator 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.

i01471286

### 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 generator 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 settings must be changed by a Caterpillar dealer. Changing the settings will help prevent damage to the turbocharger. Changing the settings will help to provide the maximum efficiency for the engine. Engines can be operated safely at higher altitudes, but the engines will deliver less horsepower. The fuel settings should be changed by a Caterpillar dealer in order to obtain the rated horsepower.

# Engine Stopping

i01057253

## 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

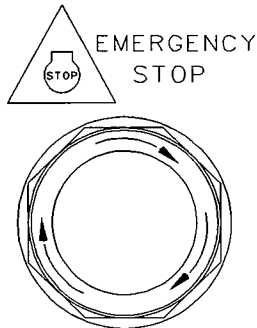


Illustration 52

g00104303

Typical emergency stop button

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

i01471717

## 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 center-housing will cause oil coking problems.

Allow the engine to gradually cool before stopping the engine

1. Open the main circuit breaker in order to disengage the generator.
2. Use one of the following methods in order to stop the engine:

**Note:** If the cooldown feature is not utilized, operate the engine for a cooldown period before stopping the engine. After the generator is disengaged, allow the engine to operate at rated rpm for five minutes. Then stop the engine.

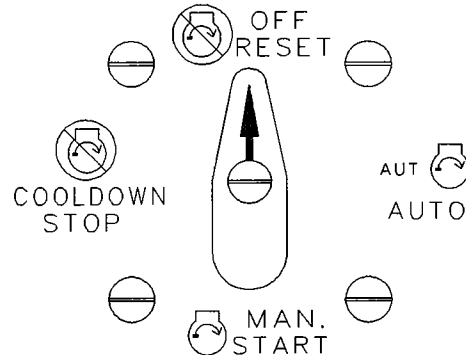


Illustration 53

g00320124

Engine control switch in the "OFF/RESET" position

- a. For all control panels, turn the engine control switch to the "OFF/RESET" position. The engine will immediately shut off.
- b. For engines with the EMCP II+ or the EMCP II control panel, the engine control switch may be turned to the "COOLDOWN/STOP" position. 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.
- c. For engines with the Switchgear Conversion control panel, the engine will stop if the engine control switch is turned to the "Service" position. The Caterpillar Monitoring System will remain energized. This position of the engine control switch is used in order to program the Caterpillar Monitoring System.

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.

i01471316

## After Stopping Engine

**SMCS Code:** 1000

- Check the crankcase oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the oil level gauge.
- If necessary, perform minor adjustments. Repair any leaks and tighten any loose bolts.
- Note the service hour meter reading. Perform the maintenance that is in the Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).
- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

---

### NOTICE

Only use antifreeze/coolant mixtures recommended in the Coolant Specifications that are in the Operation and Maintenance Manual. Failure to do so can cause engine damage.

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- Allow the engine to cool. Check the coolant level. Maintain the cooling system at 13 mm (0.5 inch) from the bottom of the pipe for filling.
- If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture, if necessary.
- Perform all required periodic maintenance on the generator. The generator maintenance is outlined in this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

# 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".

i01250450

## Fuel Related Components in Cold Weather

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

### Fuel Tanks

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

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

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

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

### Fuel Filters

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

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

---

**NOTICE**

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

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## Fuel Heaters

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

The following fuel heaters are recommended for Caterpillar engines:

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

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

Disconnect the fuel heater in warm weather.

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

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



# Generator Operation

i01460891

## Generator Operation

SMCS Code: 4450

### Loading of the Generator

When a generator is installed or reconnected, be sure that the total current in one phase does not exceed the nameplate rating. Each phase should carry the same load. This allows the engine to work at the rated capacity. An electrical unbalance can result in an electrical overload and overheating if one phase current exceeds the nameplate amperage.

Allowable combinations of unbalanced loads are shown in Illustration 54. When you operate with significant single-phase loads, the combinations of single-phase load and three-phase load may be used. Such combinations should be located below the line on the graph.

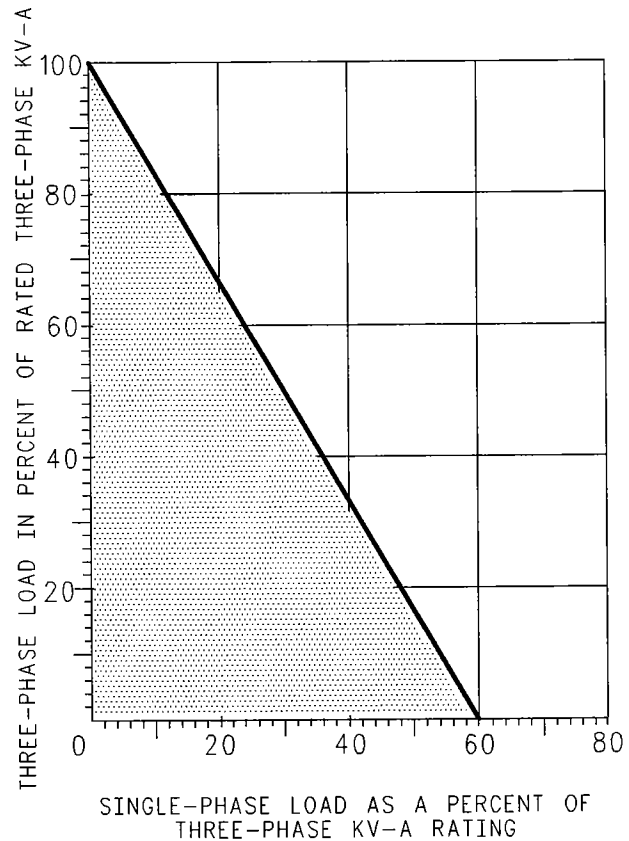


Illustration 54 g00627416  
 Allowable Combinations of Unbalanced Loads

### Block Loading

When an electrical load is applied to a generator set, block loading occurs. This load may be anywhere from a moderate percentage of the rated load up to the rated load.

The block loading capability of a generator set depends on the following factors.

- engine transient response
- voltage regulator response
- type of the voltage regulator
- altitude of operation of the generator set
- type of load
- the amount of load that is already present

If a block load derating is required, refer to ISO 8268 Standards or SAE J1349 Standards. Also, reference Engine Data Sheet, LEKX4066, "Loading Transient Response" and Engine Data Sheet, LEKX4067, "Block and Transient Response".

## Power Factor

The power factor represents the efficiency of the load. The power factor is the ratio of apparent power to total power. This ratio is expressed as a decimal. The power factor represents the portion of the current which is doing useful work. The portion of current which is not doing useful work is absorbed in maintaining the magnetic field in motors. This current is called the reactive load. Engine power is not required to maintain the reactive load.

In most applications, electric motors, solid state controls, and transformers determine the power factor of the system. Induction motors usually have a power factor that is no larger than 0.8. Incandescent lighting is a resistive load of about 1.0 power factor, or unity. Solid state controls (like motor starters), variable frequency drivers (VFD), variable speed drivers (VSD), and UPS systems can operate at any power factor, leading or lagging. In this case, the power factor can be between 0.4 and 1.0.

The power factor of a system may be determined by a power factor meter or by calculations. Determine the power requirement in kW by multiplying the power factor by the kVA that is supplied to the system. As the power factor increases, the total current that is supplied to a constant power demand will decrease. With equal loads, a lower power factor will draw more current. A high power factor will result in full engine load that is less than the generator's rated amperage. A lower power factor increases the possibility of overloading the generator.

**Note:** Normally, Caterpillar generators are designed for a power factor of 0.8 lagging. Please consult your Caterpillar dealer to check the generator rating if operation at less than 0.7 lagging power factor is desired.

## Excitation Systems

### Self-Excited Generators

Self-excited generators receive excitation power and regulator-voltage sensing from the generator's main armature output. The voltage regulator senses the generator output voltage. A regulated output is provided to the generator exciter. This regulated output is provided by the voltage regulator. The exciter then provides power to the main rotating field. As the main field rotates, a voltage is induced into the main armature. This voltage is a generator output voltage.

**Note:** The main armature is also called stator. The main rotating field is also called rotor.

### Permanent Magnet Pilot Excited Generators

Permanent Magnet Pilot Excited (PMPE) generators receive power for the voltage regulator from a pilot exciter, rather than the main armature. The pilot exciter consists of a permanent magnet rotor and a stator. The pilot exciter operates independently from the generator output voltage. Constant excitation during a large load application is possible because the irregularities that occur in the generator's output voltage are not fed back into the excitation system. Such irregularities can be caused by load conditions. The independent operation also allows the generator to better sustain an overload for a short duration.

### Low Idle Adjustment

The low idle on 3500B generator sets is typically 900 rpm. On 60 Hz units, low idle will be approximately 66 percent of the full load speed. On 50 Hz units, low idle will be approximately 80 percent of full load speed.

There is no low idle stop on generator sets with electronic governors. On generator sets with mechanical governors and natural gas generator sets, the low idle is set at the factory. The low idle should only be adjusted by your Caterpillar dealer if adjustment is required.

**Note:** Operating the electric set at low idle speed for an extended time will cause some voltage regulators to shut off. The electric set must be completely shut down. Then, the electric set must be restarted. This will allow the voltage regulator to again produce an output.

## Standby Generator Sets

Most standby units are automatic. Without an operator in attendance, standby units will perform the following functions: start, pick up the load, run, and stop.

Standby units will not change the governor speed control or voltage level settings automatically. The governor speed and voltage level must be preset for the proper operation of that unit. Whenever the set is operated manually, ensure that the governor speed and the voltage level settings are set correctly for automatic operation. Check all switches for the proper setting. The Start Selector Switch should be in the AUTOMATIC position. Emergency Stop Switches should be in RUN position.

## Generator Options

### Space Heaters

Most of the SR4B generators are provided with space heaters. These space heaters are installed for operation in all climates, especially in high humidity conditions. For more information on space heaters, refer to Maintenance Section, "Space Heater - Check".

### Embedded Temperature Detectors

SR4B generators are available with embedded temperature detectors. The detectors are installed in the slots of the main armature. The main armature is also called a stator. The detectors are used with the equipment that is provided by the customer. Thus, the temperature of the main armature winding can be measured or monitored. Two types of temperature detectors are available. These types are: RTD and Thermocouple. Contact your Caterpillar dealer for more information.

### Bearing Temperature Detectors

Bearing temperature detectors are available on large-frame generators. Bearing temperature detectors measure the main bearing temperature. Thus, the temperature of the bearing can be measured or monitored. Bearing temperature measurements may help to prevent premature bearing failure. Two types of temperature detectors are available. Bearing temperature detectors are used with customer provided equipment. Contact your Caterpillar dealer for more information.

## Parallel Operation

SMCS Code: 4450

### Initial Start-Up

Preparing a generator for parallel operation requires special attention. Before you attempt to parallel units for the first time, check all the units for the following three conditions.

- same phase rotation
- same alternating current frequency
- same voltage adjustment

#### 1. Check the phase rotation.

The phase rotation of the paralleled units must be the same. There are two methods that are used to determine whether the phase rotation of the incoming unit and the phase rotation of the on line unit(s) are the same. These methods are listed below.

- using a phase rotation meter
- using a set of three light bulbs

How to determine the proper phase rotation by using three light bulbs is described below.

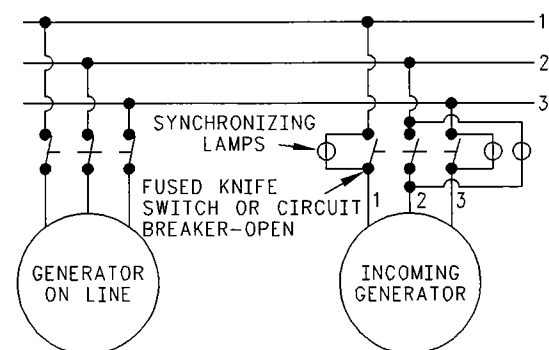


Illustration 55

g00695380

### **WARNING**

**When servicing or repairing electric power generation equipment:**

**Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged DO NOT OPERATE. Remove all fuses.**

- a. Connect the light bulbs with rated voltage between the generator leads and the corresponding line phase. For example, connect terminal 1 to line 1 across the open circuit breaker.
- b. Start the units which are going to be paralleled. Bring the units up to speed. As the units approach the same speed, the lights will start to blink.
  - If the lights blink in sequence, one of the units is connected backward. In order to correct the problem, stop the units. Remove generator leads 1 and 3 at the circuit breaker. Exchange these generator leads. This reverses the direction of phase rotation. Terminal 2 should always be connected to line 2. Go to 5.
  - If lights blink in unison, the phase rotation of both generators is the same. The first condition of "Initial Start-Up" has been met.

## 2. Adjust the frequency.

The speed of the units that will be paralleled must be the same. Speed is proportional to the alternating current frequency.

- a. Allow each electric set to run under load for about 30 minutes.
- b. Adjust the governor control to give rated frequency at full load.
- c. Remove the load and check the high idle speed. The high idle speed should be approximately 2 to 5 percent above full load speed for governors that are equipped with droop. If these speeds can not be obtained, contact your Caterpillar dealer.
- d. For the most consistent results, repeat 2.b and 2.c until the second condition of "Initial Start-Up" has been met.

## 3. Adjust the voltage.

There are two fundamentally different methods for reactive power equalization.

- reactive droop compensation (also known as individual compensation)
- cross current compensation (also known as differential compensation)

In the reactive droop compensation the voltage regulator causes an individual generator output voltage to change in proportion to the reactive current. The reactive current is measured with a current transformer (CT). The reactive current can be either lagging or leading. As the lagging reactive current increases, the voltage regulator will cause the generator output voltage to lower (droop) proportionally. As the leading reactive current increases, the voltage regulator will cause the generator output voltage to rise proportionally. This method will tend to reduce the reactive current for better KVAR sharing with other units. The reactive droop compensation is a standard method on the Caterpillar generator sets. The following voltage adjustment procedure is for the reactive droop compensation.

In the cross current compensation the voltage regulator is biased by the difference in reactive current outputs of the paralleled generators. Cross current compensation is very similar to the reactive droop compensation. The difference is that the secondary circuits of the current transformers are interconnected in a series string. When one of the generators carries more reactive current than other generators or the current that the generator carries is either lagging or leading, a net difference voltage signal will offset the generated voltage. This will also reduce the reactive current. Refer to the Engine Data Sheet, LEKX8142, "Caterpillar Zero Droop Voltage for Parallel Operation" for the adjustment procedure.

**Note:** The voltage level adjustment and voltage droop adjustment determine the amount of circulating currents between the generators. The circulating currents between the generators will be reduced when the voltage adjustments are carefully matched. Use the same voltmeter to make adjustments on each unit which will be paralleled.

**Note:** Voltage droop is expressed as the percentage of voltage change from no load to full load. Loads of 0.8 power factor (primarily motors) require a generator voltage droop of about 5 percent. A voltage droop adjustment that causes 3 percent to 8 percent droop in voltage is usually required for satisfactory division of ampere loading.

- a. Adjust the voltage. Refer to the "Initial Start-Up" in the Operation Section, "Single Unit Operation".
- b. While the engine is running at rated speed, turn the voltage droop potentiometer clockwise about 1/2 of full range.

- If driven load has the unity power factor, set the voltage droop potentiometer on all generators at half of full range. Proceed to 3.g.
  - If driven load is to be normal (approximately 0.8 power factor), proceed to 3.c.
- c.** Readjust the voltage level rheostat until the voltage is approximately 5 percent above desired voltage.
- d.** Apply full load.
- e.** Readjust the voltage droop rheostat in order to obtain desired voltage with full load at 0.8 power factor. The voltage droop of each generator must be the same in order to satisfactorily divide reactive load.
- f.** Repeat 3.c, 3.d and 3.e for each generator until the following two conditions are met.
- the line voltage is equal to the desired level at full load
  - no load voltage is approximately 5 percent above the rated voltage
- g.** Parallel the generators and apply the driven load. Check the output current of the generator. If the sum of the amperes of the individual generator amperes exceeds the total amperes that are going to the load by 10 percent at full load, adjust voltage droop rheostats. This will lead to proportional current sharing between generators. Some circulating current is permitted at light load. Some circulating current can be expected when generators are cold.

---

**NOTICE**

**Damage to the generator is possible. Do NOT exceed the rated ampere load on any single generator.**

---

- h.** Make final adjustments after paralleled generators have been running at full load for one hour or more. Tighten the locknuts on all controls. Install the access cover. The last condition of "Initial Start-Up" has been met.

## Starting Multiple Units

Multiple units are started the same as single units. Refer to Operation Section, "Single Unit Operation".

## Paralleling Multiple Units

Units may be paralleled at no load or paralleled with units under load. After the initial start-up conditions are satisfied, verify for the following requirements.

- One of the governors can be an isochronous governor. Electronic load sharing governors are an exception.
  - Generators must have voltage droop compensation or cross current compensation.
1. Start the unit which will be paralleled. Refer to the appropriate engine service manual for start-up procedures.
  2. Turn the synchronizer lights on.
  3. After the engine has run a few minutes, bring the engine up to synchronous speed. This means that the frequency of the incoming unit will be the same as the frequency of the unit on line. The synchronizing lights will begin to blink.
- Note:** The frequency of the incoming unit should be slightly greater than the line frequency. This will allow the incoming unit to assume some of the load rather than add to the system load.
4. Using the governor control, adjust the engine speed until the lights blink very slowly.
  5. The lights are off when the voltages of the two units are in phase. At this point, very quickly close the breaker while the lights are out.
  6. Use governor controls in order to share kW load between engines.
  7. Generator temperature will be stabilized in approximately one hour. After the generator temperature has been stabilized, adjust the voltage droop rheostat of each generator in order to share the reactive load and in order to limit the circulating currents. Less droop increases the reactive current that is carried by the generator. Adjusting the voltage droop rheostat in a counterclockwise direction (CCW) will decrease droop. Adjusting the voltage droop rheostat in a clockwise direction (CW) will increase droop.

## Load Division - Speed Droop (If Equipped)

Once two units have been paralleled, the units share of the kW load is determined by the governor control setting. If two units of the same capacity and the same governor characteristics have the same governor control settings, the units will share the load equally. The total load must not exceed the capacity of the one engine.

In order to transfer the load from one engine to another, follow the following procedure.

1. Increase the governor speed control of one unit in order to increase the load.
2. Reduce the governor speed control of the other unit in order to decrease the load on that unit.
3. Raise or lower the governor speed control of both units to change system frequency.

## Parallel Operation Of Governors

The different governors that can be used on 3500 generator sets are shown below.

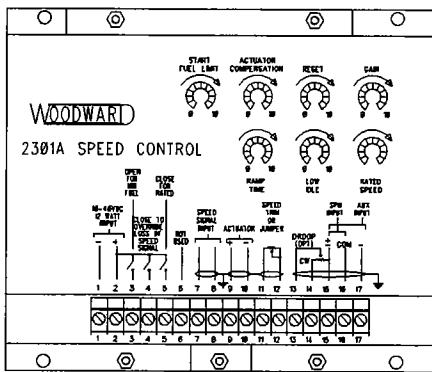


Illustration 56  
 2301A Speed Control - Typical Example

g00637393

The 2301A speed control system consists of a 2301A speed control, actuator, and engine speed sensor. The 2301A speed system provides precision engine speed control. More information is available in the Service Manual, SENR4676, "2301A Speed Control".

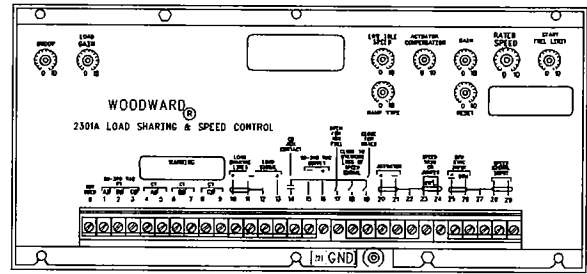


Illustration 57  
 2301A Electric Load Sharing and Speed Control Governor - Typical Example

g00637396

The 2301A electric load sharing and speed control governor is used for exact engine speed control and kilowatt load sharing. The system measures engine speed constantly and makes necessary corrections to the engine fuel setting through an actuator which is connected to the fuel system. The system also provides isochronous load sharing for parallel generator sets. For more detailed information, refer to the Service Manual, SENR3585, "2301A Electric Load Sharing and Speed Control".

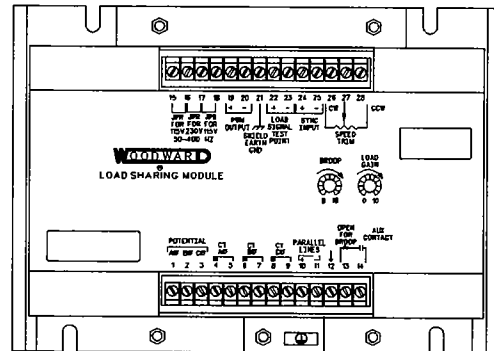


Illustration 58  
 Load Sharing Module - Typical Example

g00630841

The generator set load sharing module provides either droop load sharing or isochronous load sharing for paralleled generator applications. The load sharing module has a synchronizing parallel module (SPM-A) input. The module provides proportional load sharing. More information is available in the System Operation, Testing and Adjusting, SENR6565, "Generator Set Load Sensor and Generator Load Sharing Module".

## Function of The Engine Governor

This section describes the function of the engine governor in relation to load division between parallel electric sets. For detailed information on governor controls and adjustments, see the Operation & Maintenance Manual and the Service Manual for the appropriate engine.

It is very important to understand two basic facts about load division between generator sets which are operating in parallel.

1. The power which is supplied to the generator and, thus, to the load is a function of the engine. The engine governor settings and the positions of the governor controls determine the amount of power that is delivered by the engine. Therefore, the engine governor settings and the positions of the governor controls determine the kW load which is carried by the generator. If the governor control setting is advanced, the engine and generator will assume more kW load. Likewise, decreasing the governor control setting will result in a reduction of load on the unit. Any other units on the line will, conversely, either reduce load or gain load at the same time. These other units will assume that no change in total load or no change in the governor settings of the other units has taken place.
2. The division of power is not determined by generator excitation or terminal voltage. The power factor at which a generator will operate when paralleled with other generators is determined by the excitation.

Governors that are used with Caterpillar powered electric sets can be of two types: governors with fixed speed droop or governors with adjustable speed droop. The values of speed droop which are commonly used are 3 percent and 0 percent. Governors with adjustable speed droop can be adjusted so their characteristics match quite closely the characteristics of governors with fixed speed droop. If the governor is adjusted for 0 percent speed droop (isochronous) operation, then the same speed from no load to full load can be obtained.

## Summary on Governor Operation

The preceding discussion of governor operation can be summarized below.

- The simplest governor combination for parallel electric sets is to have approximately 3 percent speed droop characteristics for each governor. If a constant frequency from no load to full load is required, one governor can be adjusted for isochronous operation. This isochronous unit will be called a "lead unit".

- In order for all paralleled units to accept their full share of the load, the following governor adjustments are required. The governors should have the same full load speed. The governors should have the same high idle (no load) speed in the case of governors which are adjusted for speed droop operation. Governor controls should be set to the high idle position so that the full governor range is available.
- Operation of an isochronous governor in parallel with speed droop governors requires special techniques.
- Any number of electric sets can be operated in parallel. However, only one governor of the group can be adjusted for isochronous operation. The exception will be some special cases of electronic governors with automatic load sharing.

## Stopping

In order to remove a generator from the line, perform the following procedure.

1. Check the load. The load must be less than the rated capacity of the remaining units.
2. Be sure that the neutral of one of the remaining units is grounded.
3. Remove the load from the outgoing unit. See the Parallel Operation, "Load Division - Speed Droop". The amperage may never go to zero due to circulating currents.
4. Open the circuit breaker.
5. Allow the engine to cool for five minutes.
6. Stop the engine.

## Circulating Currents

Understanding the circulating currents becomes very important when you parallel the units. These circulating currents are flowing between paralleled generators. The circulating currents are caused by voltage differences between the generators and are not doing useful work. The amount of the circulating current can be determined by subtracting the amperage which is going to the load from the total generator amperage.

The circulating current may be as high as 25 percent of rated amperes with cold generator sets. Such current may not even be considered harmful. The total generator current should not exceed the amperage rating.

As the generators warm, the circulating currents will decrease. The ammeter readings should decrease slightly, but the voltage meter readings should remain constant.

i01490164

## Single Unit Operation

**SMCS Code:** 4450

### Initial Start-Up

Before the initial start-up, perform the megohmmeter test on the main stator winding. Refer to the Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators" for the procedure.

### Starting

1. Make all preliminary engine starting checks.
2. Be sure that the main circuit breaker or the line circuit breaker is open.
3. Start the engine. Allow the engine to warm up.
4. Adjust to the full load engine speed.
5. Close the main circuit breaker.
6. Apply the load. Do not try to apply the full load. Apply the load in increments in order to maintain system frequency at a constant level.
7. Readjust the governor for rated frequency.

### Stopping

1. Remove the load in increments.
2. Open the circuit breaker.
3. Allow the engine to run for five minutes in order to cool.
4. Stop the engine.



# Generator Set Control Panels

i01497016

## Electronic Modular Control Panel II+ (EMCP II+)

SMCS Code: 4490

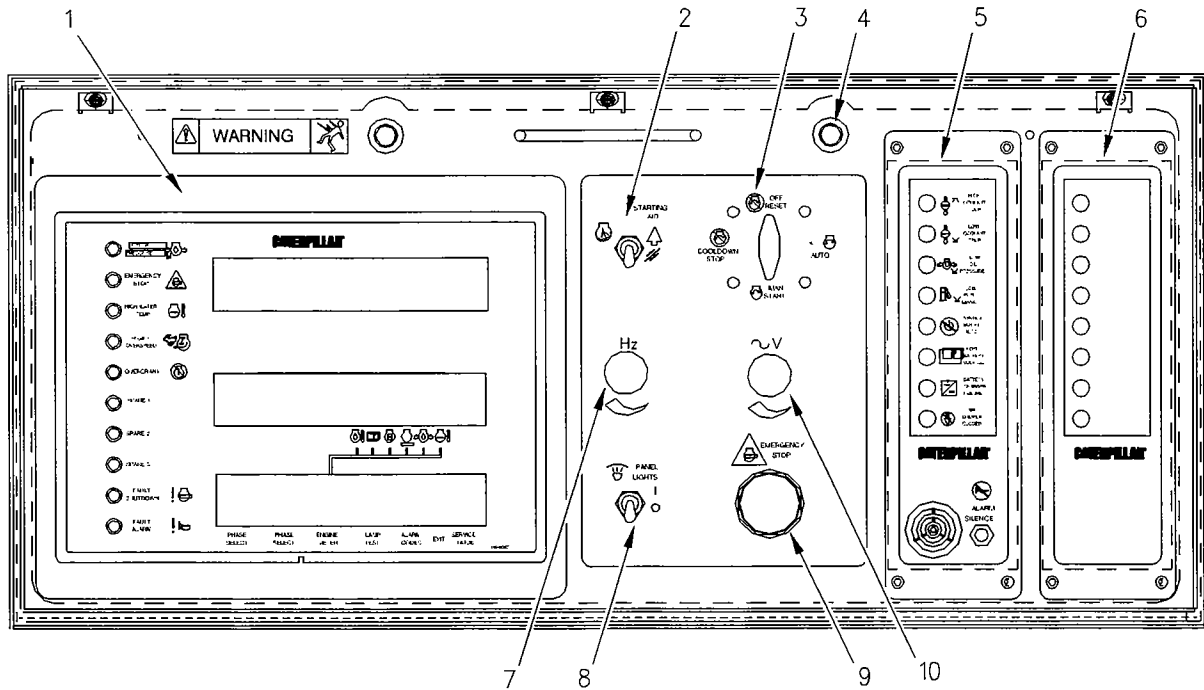


Illustration 59

g00777240

Electronic Modular Control Panel II+ (EMCP II+) - standard

- |                                       |   |                                       |
|---------------------------------------|---|---------------------------------------|
| (1) Generator set control + (GSC+)    | (5) Alarm module (ALM) (optional)   | (8) Panel light switch (PLS)          |
| (2) Start aid switch (SAS) (optional) | (6) Synchronizing lights module (optional) or<br>Custom alarm module (CAM) (optional) | (9) Emergency stop push button (ESPB) |
| (3) Engine control switch (ECS)       | (7) Speed potentiometer (SP) (optional)   | (10) Voltage adjust rheostat (VAR)    |
| (4) Panel lights (PL)                 |   |                                       |

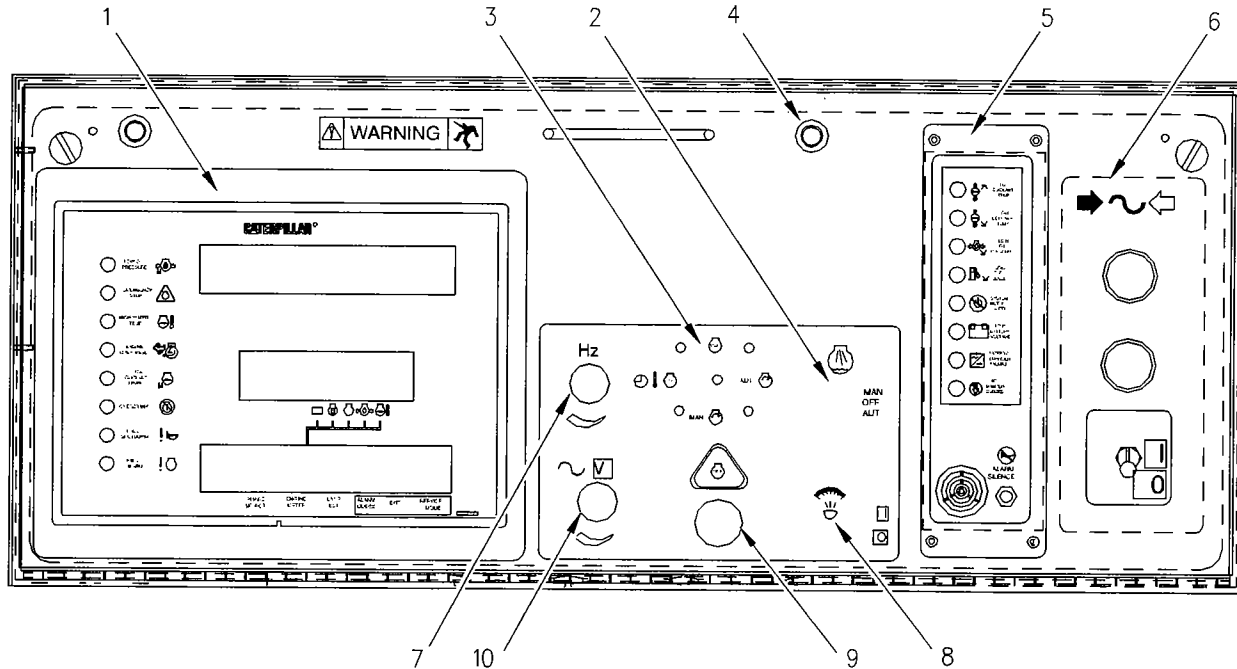


Illustration 60

g0077774

Electronic Modular Control Panel II+ (EMCP II+) - with load sharing governor

- |                                       |  |                                       |
|---------------------------------------|--|---------------------------------------|
| (1) Generator set control + (GSC+)    | (6) Synchronizing lights module (optional) or Custom alarm module (CAM) (optional) | (9) Emergency stop push button (ESPB) |
| (2) Start aid switch (SAS) (optional) | (7) Speed potentiometer (SP) (optional) or Governor switch (optional)              | (10) Voltage adjust rheostat (VAR)    |
| (3) Engine control switch (ECS)       |  |                                       |
| (4) Panel lights (PL)                 |  |                                       |
| (5) Alarm module (ALM) (optional)     |  |                                       |

The electronic modular control panel II+ (EMCP II+) is located above the generator distribution housing. The control panel consists of a main panel with indicators, meters and control switches. This control panel may be equipped with optional modules in order to match the customers' needs and requirements.

The left side of the control panel contains the Generator Set Control + (GSC+). This is the main component of the system. The GSC+ displays the following information: generator output, fault conditions, and key engine parameters. The center section of the control panel contains switches and an optional alarm module. The right side of the control panel may be blank, or the right side of the control panel may contain the Synchronizing Lights Module or the Custom Alarm Module.

The main control panel may or may not contain all of the components which are shown in Illustration 59 or Illustration 60. Some components are optional. The optional components may not be required for your particular application.

**Generator Set Control + (1)** – The generator set control + (GSC+) is the main component of the EMCP II+. See the topic "Generator Set Control + (GSC+)" in this section.

**Start Aid Switch (2)** – The start aid switch (SAS) is optional. The SAS is used to inject ether into the engine when you are starting the engine in cold weather conditions. When the SAS is in the ON position, the switch energizes the starting aid solenoid valve (SASV) and meters a specific amount of ether into a holding chamber. When the SAS is released, the solenoid releases the ether to the engine.

**NOTICE**

The engine must be cranking before using the start aid switch. Damage to the engine is possible if ether is released to the engine but not exhausted or burned by the engine when cranking.

**Engine Control Switch (3)** – The engine control switch (ECS) determines the status of the control panel. In the AUTOMATIC position (3 o'clock), the engine will start automatically whenever a remote initiating contact is closed. The engine will shutdown after the initiating contact opens and after a programmable cooldown time has elapsed. The cooldown time can be programmed to give a 0 to 30 minute cooldown period before the engine shuts down.

In the MANUAL START position (6 o'clock), the engine will start and run as long as the ECS switch remains in this position.

In the STOP position (9 o'clock), the fuel solenoid shuts the engine down after a programmable cool down time period has elapsed.

In the OFF/RESET position (12 o'clock), the fault lights are reset and the engine shuts down immediately.

**Panel Lights (4)** – Panel lights (PL) are controlled by panel lights switch (8). The panel lights switch (8) is an ON/OFF switch.

**Alarm Module (5)** – The alarm module (ALM) is optional. The function of ALM is to provide a visual and audible warning of engine conditions before these conditions become severe enough to shut the engine down or keep the engine from starting.

**Synchronizing Lights Module (6) or Custom Alarm Module (6)** – The synchronizing lights module uses synchronizing lights for paralleling the generator sets. The synchronizing lights module is optional. The custom alarm module (CAM) may be installed in the same opening on the control panel. The CAM annunciates faults, alarms or other conditions from customer supplied inputs.

**Speed Potentiometer (7)** – The speed potentiometer (SP) is optional. The SP can be used with the generator set that has an electronic governor. When the governor is equipped with a speed adjusting motor, the governor switch (GS) can be mounted instead of the SP. The GS is used to raise or lower the engine speed and frequency. The GS is also an option.

**Panel Light Switch (8)** – The panel lights switch (PLS) turns the panel lights (4) on or off.

**Emergency Stop Push Button (9)** – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. The ESPB shuts off the fuel and activates the optional air shutoff, if equipped.

**Voltage Adjust Rheostat (10)** – The voltage adjust rheostat (VAR) is used to adjust the generator output voltage to the desired level.

Below, you can find the descriptions of the following main modules of the EMCP II+:

- Generator Set Control + (GSC+)
- Alarm Module (ALM)
- Custom Alarm Module (CAM)
- Synchronizing Lights Module

## Generator Set Control + (GSC+)

### Functions and features of the GSC+

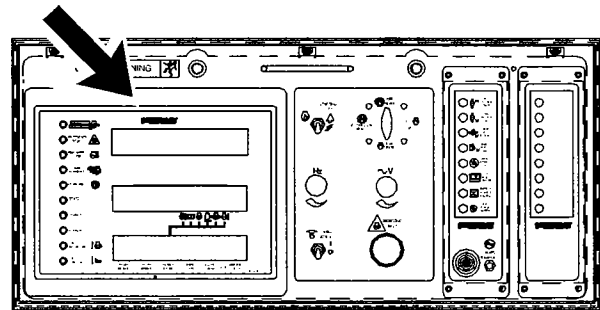


Illustration 61

g0077781

The location of the GSC+ on the EMCP II+ control panel

The left side of the control panel contains the generator set control + (GSC+). The GSC+ is the main component of the system. The GSC+ displays the following information: generator output, generator set functions, fault conditions, and key engine parameters. The GSC+ accepts information from the following sources: operator, speed sensor, engine oil pressure sensor, water temperature sensor, and optional remote sources. This information is used to determine the "on/off" state of the engine's air, fuel, and starter.

In the very basic operating conditions, the GSC+ receives a signal to run the generator set. The GSC+ turns on the engine's fuel and starter. When the engine speed reaches the crank termination speed, the starter is disengaged. When the GSC+ receives a signal to stop the engine, the GSC+ shuts the fuel off.

The functions of the GSC+ are listed below.

- The GSC+ controls the normal starting and stopping of the engine.

- The GSC+ shows engine conditions and generator output information on two displays. The displays also show fault codes and GSC+ programming information.
- The GSC+ monitors the system for faults. If a fault occurs, the GSC+ performs a controlled fault shutdown or the GSC+ provides a fault alarm annunciation. The GSC+ uses indicators and displays in order to describe the fault.
- The GSC+ contains programmable features for certain applications or customer requirements.

The features of the GSC+ are listed below:

- **Cycle Crank:** The GSC+ can be programmed to crank for adjustable time periods.
- **Governor Control:** When the engine oil pressure increases past the low oil pressure setpoint, the GSC+ will indicate to the governor that the governor should increase the engine speed from idle rpm to rated RPM.
- **Cooldown:** Upon receiving a signal to perform a normal shutdown, the GSC+ will wait a preprogrammed amount of time before shutting the engine down by means of the fuel control.
- **Automatic Operation:** While in the automatic mode, the GSC+ can be started by a remote initiate signal (contact closure). Upon loss of the signal (contact opening), the GSC+ will perform a normal shutdown.
- **Alarm Module Communication:** The GSC+ can transmit fault and alarm conditions to an alarm module (AM).
- **Power Down:** The EMCP II+ system is designed to remove power from the GSC+ when the engine control switch (ECS) is in the OFF/RESET mode and when the proper jumper wire is removed. The GSC+ will not allow the power down until the crank termination relay and the fuel control relay are both off for about 70 seconds. If the wire is not removed, the GSC+ will remain powered up.
- **Fuel Solenoid Type:** The GSC+ can be programmed to work with either an energized to run (ETR) fuel system or an energized to shutdown (ETS) fuel system.

## Fault indicators

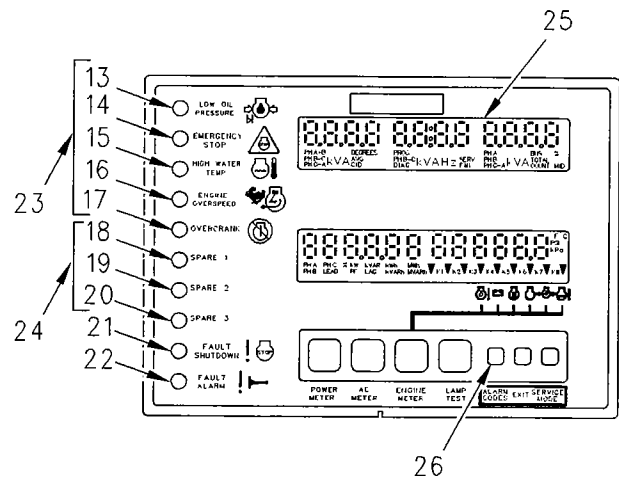


Illustration 62

g00643441

### Display area of the GSC+

- (13) Low oil pressure indicator
- (14) Emergency stop indicator
- (15) High water temperature indicator
- (16) Engine overspeed indicator
- (17) Overcrank indicator
- (18) Spare 1 indicator
- (19) Spare 2 indicator
- (20) Spare 3 indicator
- (21) Fault shutdown indicator
- (22) Fault alarm indicator
- (23) Dedicated shutdown indicators
- (24) Spare fault indicators
- (25) Upper display
- (26) The alarm codes key

The ten fault indicators are used in order to show and to describe a fault that is present. The fault indicators are divided into four groups. The four groups are:

- Fault alarm indicator (22)
- Fault shutdown indicator (21)
- Spare fault indicators (24)
- Dedicated shutdown indicators (23)

The yellow fault alarm indicator (22) FLASHES when the GSC+ detects an alarm fault. The alarm fault does not cause the engine status to change. The engine can be started. The engine will continue operating only if the engine is running at the time of the alarm fault. Fault alarm indicator (22) is accompanied by an alarm fault code that is shown on the upper display (25) when the alarm codes key (26) is pressed.

The red fault shutdown indicator (21) FLASHES when the GSC+ detects a shutdown fault. The engine will be shut down if the engine is running. The engine will not be allowed to start. Fault shutdown indicator (21) is accompanied by a fault code that is immediately shown on the upper display (25).

The yellow spare fault indicators (24) FLASH when the conditions that are associated with that spare fault are active. The three spare faults can be programmed to show coolant loss, engine oil temperature, spare fault condition or no assignment. The spare fault condition may be a customer generated switch input. The yellow fault alarm indicator (22) or the red fault shutdown indicator (21) will accompany the spare fault indicators (24). The spare fault indicators will tell whether the spare fault input is programmed to be an alarm condition or a shutdown condition.

The red dedicated shutdown indicators (23) represent the following shutdown faults: low engine oil pressure, emergency stop, high water temperature, engine overspeed, and engine overcrank. When the GSC+ detects a fault in one of these areas, the dedicated shutdown indicator (that corresponds to the fault) FLASHES. The engine is shutdown if the engine is running, and the engine is not allowed to start. No fault codes are associated with the dedicated shutdown indicators because each indicator has a descriptive label.

Many of the dedicated shutdown faults depend on certain setpoints in the GSC+.

The conditions that are required to activate the dedicated fault shutdowns and the results of each dedicated fault are in the following list.

**Low Oil Pressure** – The engine oil pressure drops below the setpoints for low oil pressure shutdown that are programmed into the GSC+. There are two low oil pressure setpoints. One setpoint is used when the engine is at idle speed. The other setpoint is used when the engine is at rated speed. When a low oil pressure fault occurs, the low oil pressure indicator FLASHES, and the engine is shut down. The engine is not allowed to start until the fault is corrected.

**Emergency Stop** – The operator presses the emergency stop push button (ESPB) on the front panel. When an emergency stop condition occurs, the emergency stop indicator FLASHES and the engine is shut down. The engine is not allowed to start until the condition is corrected.

**High Water Temperature** – The engine coolant temperature rises above the setpoint for high water temperature shutdown that is programmed into the GSC+. When the high water temperature fault occurs, the high water temperature indicator FLASHES. The engine is shutdown and the engine is not allowed to start until the fault is corrected.

**Engine Overspeed** – The engine speed exceeds the setpoint for engine overspeed that is programmed into the GSC+. When the engine overspeed fault occurs, the engine overspeed indicator FLASHES. The engine is shutdown and the engine is not allowed to start until the fault is corrected.

**Overcrank** – The engine does not start within the setpoint for total cycle crank time that is programmed into the GSC+. When the overcrank fault occurs, the overcrank indicator FLASHES. The engine is not allowed to start until the fault is corrected.

**Note:** The GSC+ can be programmed to override the shutdown for low oil pressure and high water temperature faults. When the operator overrides the shutdown faults, the GSC+ responds to the faults as though the faults are alarm faults. The corresponding dedicated shutdown indicator is ON continuously and will not be flashing. The engine continues to run and can be restarted when necessary. When the dedicated shutdown indicator is ON continuously, the setpoint for shutdown has been exceeded, but the GSC+ is programmed to override the shutdown fault. The GSC+ does not treat the shutdown fault as a shutdown fault. The GSC+ treats the shutdown fault as an alarm fault. At the factory, the GSC+ is programmed to treat a low oil pressure fault and a high water temperature fault as shutdown faults. The operator or the service technician must decide to override these shutdown faults. The operator or the service technician must program the GSC+ to treat the shutdown faults as alarm faults.

## Display

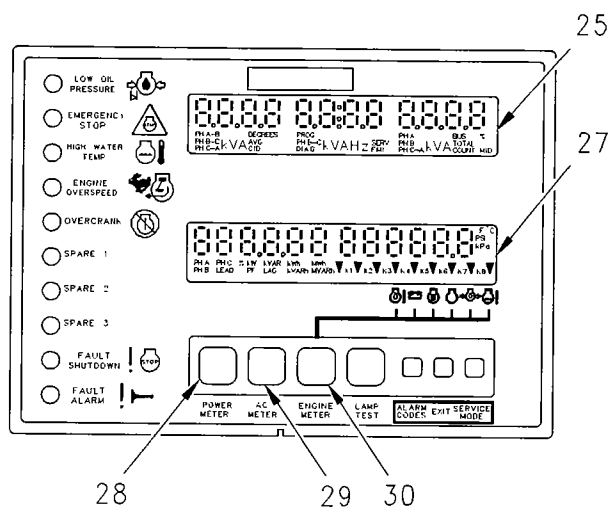


Illustration 63 g00643442

- Display area of the GSC+  
 (25) Upper display  
 (27) Lower display  
 (28) The power meter key  
 (29) The AC meter key  
 (30) The engine meter key

The display consists of the upper display and the lower display. Both displays are used for programming functions when the display is in the service mode.

### Upper display

The upper display (25) shows: AC voltage, current, and frequency. Several options are available on the upper display for AC metering. These options can be viewed one at a time by pressing the AC meter key (29) on the keypad. The options are listed below.

- Average voltage, generator frequency, and total current
- Line to line voltage, generator frequency, and line current for any one phase
- Line to line voltage for all three phases at once
- Line current for all three phases at once

**Note:** When total current increases above "9999A", the GSC+ will show current in "kA" units.

- Line to neutral voltage for all three phases at once

Upper display (25) is also used to show the various fault codes for system faults.

**Note:** Line to neutral voltages are not shown when the setpoint P032 is set to 1 for delta generator sets.

### Lower display

The lower display (27) shows values for power metering, engine parameters and the relay status.

The left side of the lower display (27) serves as a power meter for the generator set. The following functions will scroll automatically.

- Total real power (kW)
- Total reactive power (KVAR)
- Percentage of rated power (%kW)
- Power factor (average)
- Total energy output (kW/h)

The display will stop scrolling when the operator presses the power meter key for less than five seconds. The display will show a particular parameter continuously. Additional power meter functions will scroll, if the power meter key (28) is held for more than five seconds and then released. The additional functions are shown below.

- Total real power (kW)
- Real power phase A (kW)
- Real power phase B (kW)
- Real power phase C (kW)
- Total apparent power (kVA)
- Total reactive power (KVAR)
- Percentage of rated power (%kW)
- Power factor (average)
- Power factor phase A
- Power factor phase B
- Power factor phase C
- Total energy output (kW/h)
- Total reactive energy output (kVAR/Hr)

**Note:** All real power values are signed with a "+" or a "-". A negative value indicates reverse power.

**Note:** Real power phase A, B, and C as well as power factor phase A, B, and C are not shown when setpoint P032 is set to 1 for delta generator sets.

**Note:** Total energy output that is greater than 999,999 kW/h will be shown as MW/h in two steps in order to maintain a resolution of 1 kW/h. The first step will show MW/h as a whole number up to six places. The second step will show MW/h as a decimal to three places. For example: 1,000,001 kW/h will be shown as 1000 MW/h (first step), followed by .001 MW/h (second step).

The right side of lower display (27) shows the value of certain engine parameters. The parameters are listed below.

- Engine oil temperature (optional)
- System battery voltage
- Engine hours
- Engine speed
- Engine oil pressure
- Engine coolant temperature

The value for one of these conditions is shown on display (27) for two seconds. The display then scrolls to the value for the next condition. A small pointer identifies the engine condition that corresponds to the value that is showing. When the engine meter key (30) is pressed, the lower display (27) stops scrolling. The lower display continuously shows one particular value. The pointer flashes above the value that is showing on the display. When the engine meter key (30) is pressed for the second time, the lower display will return to scrolling.

The relay status indicators are on the bottom of the lower display (27). When a GSC+ relay is activated, the corresponding indicator (K1, K2, etc) is shown on the lower display (27). When a relay is not activated, the corresponding indicator (K1, K2, etc) is not shown.

## Keypad

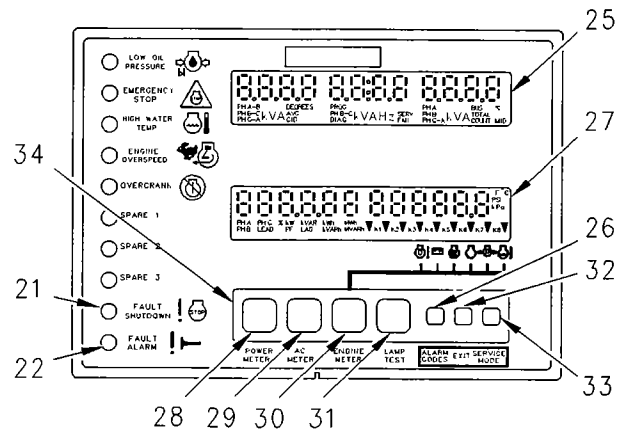


Illustration 64

g00643443

### Keypad area of the GSC+

- (21) Fault shutdown indicator
- (22) Fault alarm indicator
- (25) Upper display
- (26) Alarm codes key
- (27) Lower display
- (28) Power meter key
- (29) AC meter key
- (30) Engine meter key
- (31) Lamp test key
- (32) Exit key
- (33) Service mode key
- (34) Keypad

Keypad (34) is used to control the information that is shown on the upper display (25) and lower display (27). The seven keys have two sets of functions: normal functions and service functions. The normal functions of the keys are described in the following paragraphs.

**Power Meter Key (28)** – This key controls the viewing of power meter information. This information is shown on the lower display. Pressing the key for at least five seconds causes all the power meter data to scroll once. The default power meter data then resumes scrolling. If this key is pressed for less than five seconds, the display will stop scrolling the power meter functions until the key is pressed again.

**AC Meter Key (29)** – The AC meter key controls the viewing of the AC parameters on the upper display. Pressing the key causes the display to show a different set of parameters.

**Engine Meter Key (30)** – This key controls the viewing of engine parameters on the lower display. Pressing the key stops the scrolling of engine conditions. The value for one particular engine condition will show continuously. The pointer flashes indicating that the scrolling is stopped. The scrolling of the engine conditions will resume when the engine meter key is pressed again.

**Lamp Test Key (31)** – Pressing this key performs a lamp test on the GSC+ and the optional alarm module. On the GSC+, the ten fault indicators are ON CONTINUOUSLY. Every segment of upper display (5) and lower display (6) is ON. On the optional alarm module, all of the indicators are ON and the horn sounds. The lamp test function automatically turns off if an operator presses the key and holds the key for longer than ten seconds.

**Alarm Codes Key (26)** – If fault alarm indicator (22) is FLASHING, pressing this key causes the upper display (25) to show the corresponding alarm fault code. If this key is pressed again, the generator AC output information will be shown on the upper display (25). If fault alarm indicator (22) is OFF, this key has no function.

**Exit Key (32)** – This key only functions when the GSC+ is in Service Mode.

**Service Mode Key (33)** – Pressing this key causes the GSC+ to enter service mode.

## Alarm Module

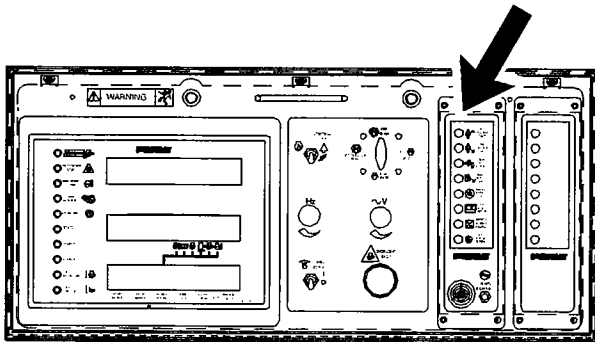


Illustration 65

g0077782

The location of the Alarm Module (ALM) on the EMCP II+ control panel

The alarm module (ALM) is optional. The function of the alarm module is to provide a visual and audible warning of engine conditions before these conditions become severe enough that the engine will shut down or will be unable to start.

One basic alarm module is used to satisfy the requirements for the following modules: standby NFPA 99 alarm module, standby NFPA 110 alarm module, NFPA 99 remote annunciator panel, and prime power alarm. This is accomplished by using different inputs to the module and different decals on the front of the module in order to indicate alarms or shutdown conditions.

The front of the alarm module consists of the following indicators.

- Four amber indicators, which can (depending on module configuration) indicate High Coolant Temperature, Low Coolant Temperature or Low Coolant Level, Low Oil Pressure, Generator On Load, Charger Malfunction, Low Engine Oil Level and Low Fuel Level
- Four red indicators, which can (depending on module configuration) indicate a Not In AUTO condition, Low DC Voltage, Air Damper Closed, Low Oil Pressure Shutdown, Overcrank Shutdown, High Coolant Temperature Shutdown, and Overspeed Shutdown
- An audible alarm and Acknowledge/Silence switch

## Custom Alarm Module

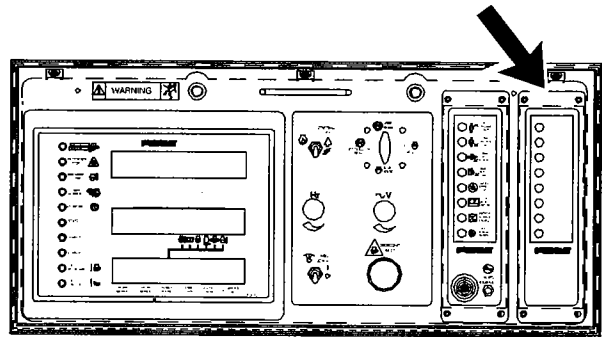


Illustration 66

g0077783

The location of the Custom Alarm Module (CAM) on the EMCP II+ control panel

The custom alarm module (CAM) is optional. The function of the custom alarm module is to provide a visual and audible warning of the conditions of the customer supplied inputs before these conditions become severe enough that the engine will shut down or will be unable to start. The CAM is equipped with a horn, alarm silence switch, a lamp test switch and 8 switched inputs for customer use.

The front of the alarm module consists of the following indicators.



- Four amber indicators, which are used to display alarm conditions
- Four red indicators, which are used to display shutdown conditions

## Synchronizing Lights Module

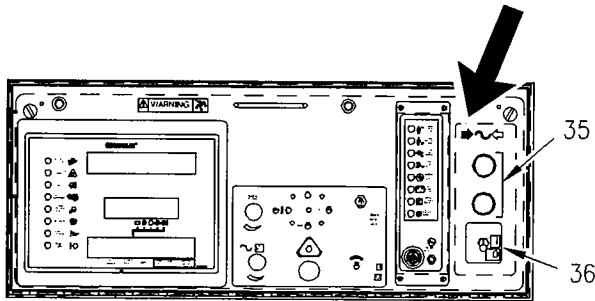


Illustration 67

g00777785

The location of the Synchronizing Lights Module on the EMCP II+ control panel

- (35) Synchronizing lamps
- (36) Synchronizing switch

The optional synchronizing lights module is mounted on the right side of the control panel. This module is not used when the control panel is equipped with the 2301A governor.

The synchronizing lights module contains the synchronizing lights (35) and the synchronizing switch (36).

**Synchronizing Lights (35)** – The synchronizing lights (35) are used as an aid in paralleling units at no load and under load. Each light is connected to the side with the load of the generator output circuit breaker. The lights are used to indicate when the voltages are in-phase. Close the circuit breaker in order to connect the generator with the load.

**Synchronizing Switch (36)** – The synchronizing switch has two positions: ON (I) and OFF (O). When this switch is in the ON position, the synchronizing lamps are enabled. The generator circuit breaker can be closed manually when the synchronizing switch is on and the lights are synchronized.

**Note:** Refer to Operation Section, "Parallel Operation" for information regarding the paralleling of two generators.

When a reverse power relay is added to a synchronizing lights module, the original synchronizing lights module will change in the following ways:

- The reverse power relay is mounted on the control panel interior.
- A reverse power fault is indicated by the Fault Shutdown Indicator on the front of the GSC+.

The reverse power relay is a single phase protective relay. This relay is energized by power in only one direction. In a reverse power fault, the relay contacts close and the engine shuts down. This will take the generator off the line. The reverse power relay is equipped with a test switch and adjustments.

# Voltage Regulators

i01479478

## Voltage Regulators

**SMCS Code:** 4467

Except for the oilfield generators, all Caterpillar SR4B generators are provided with voltage regulators. The voltage regulator controls the generator output voltage. Different types of voltage regulators that are available with 3500 generator sets are listed in table 3.

Table 3

Voltage Regulator Type	Availability
VR3	N/A
VR3F	Option
VR4	N/A
DVR	Standard

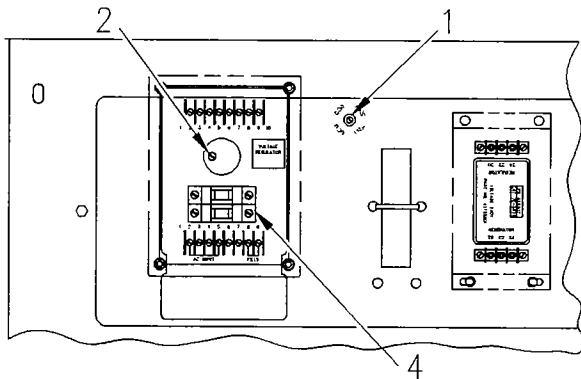


Illustration 68 g00626331

### Adjustment Controls of the VR3F Regulator

- (1) Voltage droop potentiometer
- (2) Voltage level potentiometer
- (4) Fuse(s)

The VR3F regulator has voltage droop capability (1). The VR3F regulator has the voltage level control (2). However, the VR3F regulator does not have voltage gain capability.

Voltage droop and voltage level are controlled by multiturn potentiometers. The adjusting screws on the potentiometers do not have a fixed stop. When the potentiometer reaches the end of adjustment, a ratchet action begins. The beginning of a ratchet action can be felt with the adjusting tool. The adjusting screw can be turned past the potentiometer stop (ratchet action) without further changing the potentiometer setting.

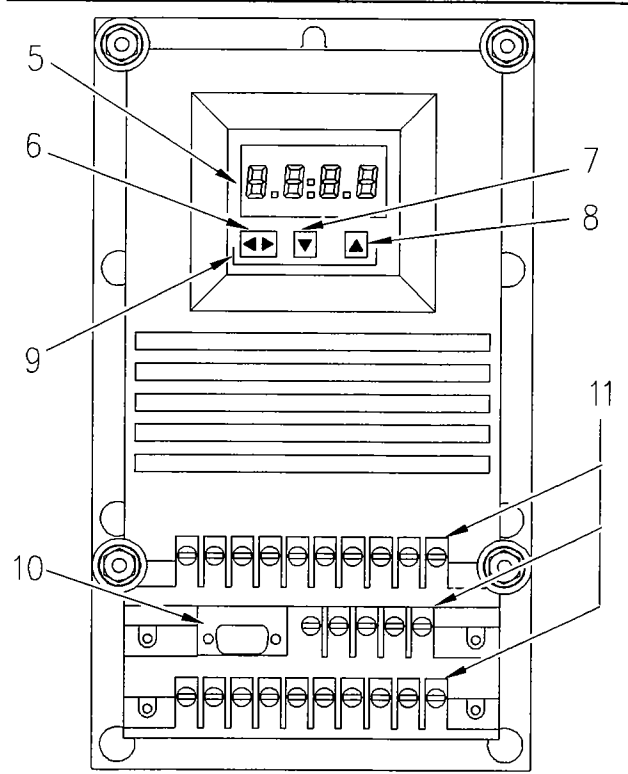


Illustration 69 g00626333

### Digital Voltage Regulator (DVR)

- (5) Display
- (6) Function key
- (7) Scroll down key
- (8) Scroll up key
- (9) Keypad
- (10) J1 connector
- (11) Screw terminals

The digital voltage regulator (DVR) is a microprocessor based voltage regulator. The parameters are preset at the factory or the parameters can be modified in order to meet the specific requirements on the site. Certain system parameters can also be monitored on the display (5) of the DVR. Keypad (9) is used to change the information that is shown on the display (5). J1 connector (10) is used to join the DVR to a personal computer. Screw terminals (11) are used to join the DVR to the generator and various customer options.

## Adjustment Procedure for the Voltage Regulators

### VR3F Regulator

**Note:** The VR3F regulator is protected by a fuse(s). The VR3F regulator also has a solid-state overcurrent protection. If a fuse becomes open, contact a Caterpillar dealer.

1. Remove the access panel of the generator.

2. Loosen the locknut on the voltage droop potentiometer (1). Remove the protective screw from the voltage level potentiometer (2).
3. Turn voltage droop potentiometer (1) counterclockwise to zero droop. Tighten the locknut. Voltage droop potentiometer (1) is located next to the regulator.
4. Perform required maintenance on the engine before you start the engine.
5. Start the engine. Allow the engine to warm up. Refer to the Safety Section, "Engine Starting".
6. Increase engine speed to full governed rated speed (high idle).
7. Observe the voltmeter reading. If the desired voltage is not indicated, set the no-load voltage with the voltage level potentiometer (2) or the voltage adjust rheostat. The voltage adjust rheostat is located on the control panel.
8. Close the load circuit breaker. Apply full load gradually. Adjust the governor control until the nameplate frequency is on the frequency meter or until the rated speed is displayed on the tachometer. The unit of measurement for frequency is Hertz. The unit of measurement for the rated speed is RPM.
9. Remove the load. If necessary, adjust the voltage level potentiometer (2) in order to obtain the desired voltage.
10. Apply the load. Observe the voltmeter reading. Repeat Steps 8 and 9 until the voltage at no load equals the voltage at full load.
11. Tighten the locknuts. Install the protective screws on the respective potentiometers. Install the access panel of the generator. STOP.

### Digital Voltage Regulator (DVR)

Refer to the Specifications, Systems Operation, Testing and Adjusting, SENR5833, "Digital Voltage Regulator".

The digital voltage regulator (DVR) can be set up for a specific application by using the configured parameters. Parameters are preset at the factory. Parameters may need to be adjusted in order to meet the specific requirements of a site. The DVR also detects faults. When a fault is detected, the DVR sets the appropriate alarm or caution. Certain system parameters can also be monitored on the display of the DVR.

Display (5) and keypad (9) are used to select parameter values. Display (5) and keypad (9) are also used to manipulate the parameter values that control the operation of the digital voltage regulator. Display (5) of the digital voltage regulator has four digits. When one of these digits is a colon, the number that is showing is a parameter code. When a colon is not present, the number that is showing is a parameter value. A decimal point in the display is used to indicate the precision of the parameter value.

Keypad (9) has three keys. The keys are listed below.

- Function key (6)
- Scroll down key (7)
- Scroll up key (8)

Display (5) has two modes. These modes are the parameter code mode and the parameter value mode. Function key (6) is used to toggle back and forth between the two modes. Scroll down key (7) and scroll up key (8) are used to change the display's value. The scroll down key will decrease the parameter number or the scroll down key will decrease the value number. The scroll up key will increase the parameter number or the scroll up key will increase the value number.

Table 4

Parameter Code	Parameter Value
:01	0480
	0481
	0482
	0483
:02	0001
	0002
	0003
	0004
:03	0004
	0003
	0002
:04	0100
	0099
	0100
	0101

The operation of display (5) and keypad (9) is shown in Table 4. Pressing function key (6) toggles the display between the two columns of the table (parameter code and parameter value). If a colon is present, the display is in parameter code mode. If a colon is not present, the display is in parameter value mode.

When you press scroll up key (7), the number that is displayed will increase to the next higher number within the column. When you press scroll down key (8), the number that is displayed will decrease to the next lower number within the column. The scroll keys will not cause the display to change columns.

To configure a parameter code, follow the procedure below:

1. To select the desired parameter code, press scroll key (7) or scroll key (8).
2. Access the parameter value by pressing function key (6).
3. Select the desired parameter value by pressing scroll key (7) or (8).
4. In order to enter the selected value into the digital voltage regulator's memory, press function key (6).

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## Voltage Regulator Options

**SMCS Code:** 4467

### Manual Voltage Control

A manual voltage control is available as an option on Caterpillar generator sets. Various specifications and certifications require manual voltage control of the generator if the automatic voltage regulator should fail. The manual voltage controls for the self-excited generators and the manual voltage controls for permanent magnet excited generators are shown below.

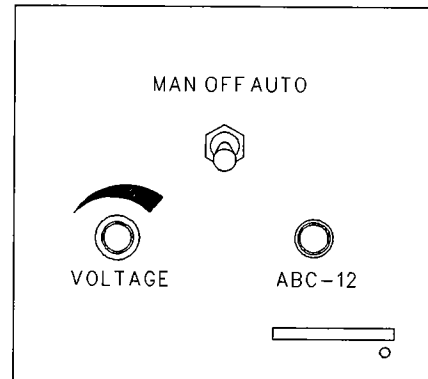


Illustration 70

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Manual Voltage Control for Self-Excited Generators

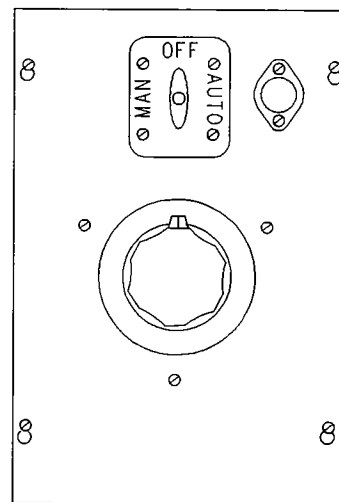


Illustration 71

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The Manual Voltage Control for Permanent Magnet Excited Generators

# Installation

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## Generator Installation

**SMCS Code:** 1000; 4450

### Receiving Inspection

If the generator is received during cold weather, allow the unit to reach room temperature before you remove the protective packing material. Warming the generator to room temperature will prevent the following problems:

- water condensation on cold surfaces
- early failures due to wet windings
- early failures due to wet insulating materials

### Unpacking and Storage

#### Moving the Generator

 **WARNING**

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

**NOTICE**

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

Unpack the equipment with care in order to avoid scratching painted surfaces. Move the unit to the mounting location. The unit can be moved by either of the following methods:

- Attach an overhead crane to the eyebolts that are installed on the generator frame.
- Use a lift truck in order to lift the generator.

The hoist and the hoist cables should have a rating that is greater than the weight of the generator. When the unit is moved, ensure that the generator is completely supported by the lift truck's fork tines. Also ensure that the generator is balanced on the lift truck's fork tines. Slide the fork tines beneath the attached skid in order to lift the generator.

## Storage

### Short Time Storage

If the generator is not installed immediately, store the generator in a clean area. This area should also have the following conditions: low humidity, stable humidity, and stable temperature. Space heaters must be energized in order to keep condensation from the windings. All accessory equipment that is supplied with the unit should be stored with the generator. The combined unit should be covered with a durable cover in order to protect against the following contaminants:

- dust
- dirt
- moisture
- other airborne abrasives

### Long Time Storage

A storage period in excess of six months should be preceded by the following preparation:

1. Install desiccant bags inside the exciter's cover and install desiccant bags inside the screen of the fan.
2. Seal the unit in a covering of plastic or other material that has been designed for that purpose.
3. Adequately tag the generator. This will ensure that preservative greases and desiccant bags are removed before the unit is placed in operation.

### Bearing Inspection

Ball bearing generators use grease. This grease is subject to deterioration. If the generator is stored longer than one year, new ball bearings should be installed. These bearings should be greased to the proper level prior to being put into operation. If inspection indicates that bearings are free of rust or corrosion, and no noise or excessive vibration appear on start-up, replacement is not necessary.

### Location

The location of the generator must comply with all local regulations. The location of the generator must also comply with all special industrial regulations. Locate the generator in an area that meets the following requirements:

- clean

- dry
- well ventilated
- easily accessible for inspection and maintenance

Do not obstruct air inlet openings. Do not obstruct discharge openings. Coolant flow must reach these openings. If the generator is exposed to harsh environmental conditions, the generator can be modified in the field in order to add filters and space heaters. In addition, a more rigid periodic maintenance schedule should be established.

## Electrical Measurements

Measure the insulation resistance of each winding if the generator was exposed to the following conditions:

- rapid changes in temperature
- freezing
- wet climate during shipment
- wet climate during storage

**Note:** These tests should be conducted prior to any power connections that are being made. These tests should be conducted prior to any control connections that are being made.

Refer to the Generator Maintenance section of this manual in order to measure the following items:

- Exciter Field (Stator)
- Exciter Armature (Rotor)
- Generator Field (Rotor)
- Generator Armature (Stator)

## Protective Devices

The output to the load of the generator should always be protected with an overload protection device such as a circuit breaker or fuses. Fuses should be sized by using the lowest possible current rating. However, this rating must be above the current rating for full load. A common recommendation is 115 percent of rated current. Determine the size of fuses or determine the size of circuit breakers in accordance with NEMA, IEC, and Local Electrical Codes.

# Maintenance Section

## Torque Specifications

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### General Torque Information

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SMCS Code: 1000; 7553

**⚠ WARNING**

**Mismatched or incorrect fasteners can result in damage or malfunction, or personal 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 5

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 6

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)

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## Standard Torque for Inch Fasteners

SMCS Code: 1000; 7553

Table 7

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 8

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

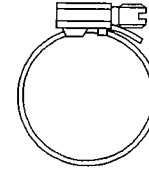


Illustration 72

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Table 9

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)

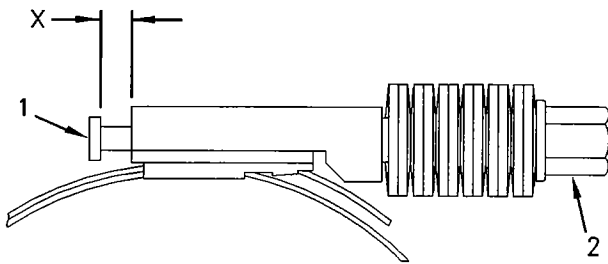
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## Standard Torque for Constant Torque Hose Clamps

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.





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Illustration 73

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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

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### 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.

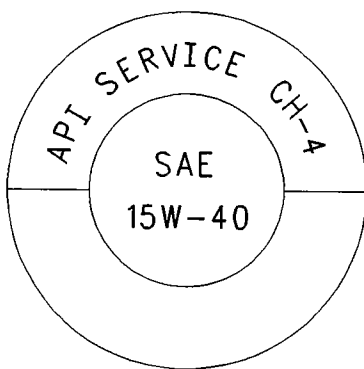


Illustration 74  
Typical API symbol

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Diesel engine oils CC, CD, CD-2, and CE have not been API authorized classifications since 1 January 1996. Table 10 summarizes the status of the classifications.

Table 10

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).

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## 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 11 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 the following oils are recommended: API CH-4, API CG-4, and API CF-4. 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 plugging of the oil filter. 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 75.

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 75 demonstrates the TBN.

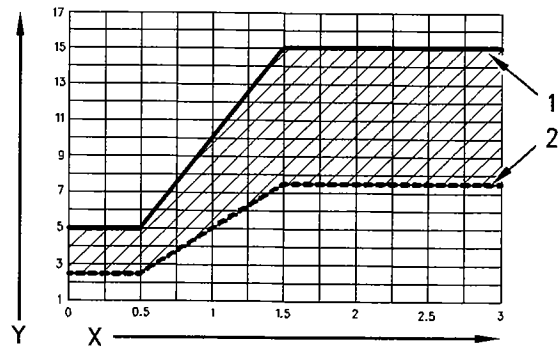


Illustration 75

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- (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 Injection (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 11 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 11 (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 11

<b>Engine Oil Viscosity</b>		
<b>Caterpillar DEO Multigrade EMA LRG-1 API CH-4 API CG-4 and API CF-4 Viscosity Grade</b>	<b>Ambient Temperature</b>	
	<b>Minimum</b>	<b>Maximum</b>
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)

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**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.

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**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.

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## 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:** If the First Choice oils are not available, the following viscosity grades of oils with a CG-4 or CF-4 additive package can be used: SAE 0W20, SAE 0W30, SAE 5W30, and SAE 5W40. However, use of these oils is not recommended.

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### NOTICE

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

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## 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".

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## 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)

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### 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 12

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

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## 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 13 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 13 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 13

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)	"D613"
	35 minimum (PC engines)	
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	-
Copper Strip Corrosion	No. 3 maximum	"D130"

(continued)

(Table 13, 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.

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**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.

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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.

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**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.

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In extreme cold ambient conditions, you may use the distillate fuels that are specified in Table 14. However, the fuel that is selected must meet the requirements that are specified in Table 13. These fuels are intended to be used in operating temperatures that are down to -54 °C (-65 °F).

Table 14

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 14 must be at least 40. If the viscosity is below 1.4 cSt at 38 °C (100 °F), use the fuel only in temperatures below 0 °C (32 °F). Do not use any fuels with a viscosity of less than 1.2 cSt at 38 °C (100 °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 13.

# Cooling System Specifications

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## General Coolant Information

**SMCS Code:** 1350; 1395

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### NOTICE

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

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### 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.

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### NOTICE

In cold weather, frequently check the specific gravity of the coolant solution to ensure adequate protection.

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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.

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### 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.

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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

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### NOTICE

All Caterpillar diesel engines equipped with air-to-air aftercooling (ATAAC) require a minimum of 30 percent glycol to prevent water pump cavitation.

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### 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.

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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 15.

Table 15

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  $-23^{\circ}\text{C}$  ( $-9^{\circ}\text{F}$ ).

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 16 and 17.

Table 16

Ethylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	$-36^{\circ}\text{C}$ ( $-33^{\circ}\text{F}$ )	$106^{\circ}\text{C}$ ( $223^{\circ}\text{F}$ )
60 Percent	$-51^{\circ}\text{C}$ ( $-60^{\circ}\text{F}$ )	$111^{\circ}\text{C}$ ( $232^{\circ}\text{F}$ )

### 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 17

Propylene Glycol		
Concentration	Freeze Protection	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 (Degree Celsius) or use the 1U-7297 Coolant/Battery Tester (Degree Fahrenheit). The testers give readings that are immediate and accurate. The testers can be used with ethylene or propylene glycol.

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## 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 18 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 18

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).

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## 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.

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## Extended Life Coolant (ELC) Cooling System Maintenance

**SMCS Code:** 1350; 1352; 1395

### Proper Additions to the Extended Life Coolant

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#### 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.

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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.

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#### 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.

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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 19 in order to determine the proper amount of ELC Extender that is required.

Table 19

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 20 is an example for using the equation that is in Table 19.

Table 20

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

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### 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.

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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.

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## 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).

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## 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.



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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).

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## 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 21 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 21

<b>Equation For Adding The SCA At The Initial Fill Coolant/Antifreeze That Meets "ASTM D4985" or "ASTM D5345" Specifications <sup>(1)</sup></b>
<b><math>V \times 0.045 = X</math></b>
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 22 is an example for using the equation that is in Table 21.

Table 22

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 23 to determine the amount of Caterpillar SCA that is required.

Table 23

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 24 is an example for using the equation that is in Table 23.

Table 24

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 25 lists part numbers and quantities of SCA that is available from your Caterpillar dealer.

Table 25

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.

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## 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 nitrites 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 26 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 26

<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 27 is an example for using the equation that is in Table 26.

Table 27

<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 28 to determine the amount of Caterpillar SCA that is required.

Table 28

<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 29 is an example for using the equation that is in Table 28.

Table 29

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 30 lists part numbers and quantities of SCA that is available from your Caterpillar dealer.

Table 30

Caterpillar Liquid SCA	
Part Number	Quantity
8C-3680	19 L (5 US gal)
5P-2907	208 L (55 US gal)

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## 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

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## Refill Capacities

SMCS Code: 1000; 1348; 1395; 7560

### Engine Crankcase Capacity

The capacity of the Engine Crankcase 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 in the Maintenance Section.

### 3508 Engine

Table 31

3508 Engine Lubrication System Approximate Refill Capacities		
Compartment or System	Liters	US Gallons
Engine Crankcase	227 L	60 US gal

### 3512 Engine

Table 32

3512 Engine Lubrication System Approximate Refill Capacities		
Compartment or System	Liters	US Gallons
Engine Crankcase	318 L	84 US gal

### 3516 Engine

Table 33

3516 Engine Lubrication System Approximate Refill Capacities		
Compartment or System	Liters	US Gallons
Engine Crankcase	405 L	107 US gal

### Cooling System Capacity

For the recommended coolant, see this Operation and Maintenance Manual, "Coolant Recommendations" topic in the Maintenance Section.

### 3508 Engines

Table 34

3508 Engine Generator Set Approximate Refill Capacities		
Compartment or System	Liters	US Gallons
Engine Only	103 L	27.2 US gal
Radiator	160 L	42.3 US gal
Total	263 L	69.5 US gal

### 3512 Engines

Table 35

3512 Engine Generator Set Approximate Refill Capacities		
Compartment or System	Liters	US Gallons
Engine Only	157 L	41.5 US gal
Radiator	185 L	48.9 US gal
Total	342 L	90.4 US gal

### 3516 Engines

Table 36

3516 Engine with an Ambient Capability of 43 °C (109 °F) 50 Hz Generator Set Approximate Refill Capacities		
Compartment or System	Liters	US Gallons
Engine Only	233 L	61.5 US gal
Radiator	203 L	53.6 US gal
Total	436 L	115.1 US gal

Table 37

3516 Engine with an Ambient Capability of 50 °C (122 °F) 50 Hz Generator Set Approximate Refill Capacities		
Compartment or System	Liters	US Gallons
Engine Only	233 L	61.5 US gal
Radiator	247 L	65.3 US gal
Total	480 L	126.8 US gal

Table 38

<b>3516 Engine with an Ambient Capability            of 43 °C (109 °F)            60 Hz Generator Set            Approximate Refill Capacities</b>		
<b>Compartment or System</b>	<b>Liters</b>	<b>US Gallons</b>
Engine Only	233 L	61.5 US gal
Radiator	247 L	65.3 US gal
Total	480 L	126.8 US gal

Table 39

<b>3516 Engine with an Ambient Capability            of 50 °C (122 °F)            60 Hz Generator Set            Approximate Refill Capacities</b>		
<b>Compartment or System</b>	<b>Liters</b>	<b>US Gallons</b>
Engine Only	233 L	61.5 US gal
Radiator	330 L	87.2 US gal
Total	563 L	148.7 US gal

# Maintenance Recommendations

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## General Maintenance Information

**SMCS Code:** 4450; 7000

**Note:** Read the warnings and read the instructions that are contained in the Safety Section of this manual. These warnings and instructions must be understood before you perform any operation or any maintenance procedures.

Rotating electric machines are complex structures that are exposed to the following forms of stress:

- mechanical
- electrical
- thermal
- environmental

These stresses may be of varying magnitudes. The insulation systems are very susceptible to damage that is caused by the stresses that are listed above. Exposure to these stresses may shorten the effective life of the insulation system. Therefore, the service life of an electric machine will largely depend on the serviceability of the insulation systems. An inspection program and a testing procedure are recommended. An inspection program and a testing procedure will ensure that the equipment is maintained in satisfactory condition. This will increase field reliability.

A regular maintenance and inspection program can provide an evaluation of the present condition of the equipment. A regular maintenance program and a regular inspection program can also reveal future problems. The frequency of this maintenance program will depend on the following factors:

- application
- environmental conditions
- operator's experience
- operator's philosophy

A regular maintenance program is strongly recommended. This program would involve the following steps:

- periodic disassembly

- knowledgeable visual examination of the equipment
- the application of electrical tests

Never perform a test over the rated potential. These tests can damage insulation that is contaminated or insulation that is in marginal condition. For more information, refer to "I.E.E.E. Standard 432-1992" or consult a Caterpillar dealer.

## Space Heaters

The SR4B generator is capable of operating in high humidity conditions without problems. However, problems can occur when the generator is idle and the surrounding air is warmer than the generator. Moisture can form on the windings that will result in poor performance from the windings. Moisture can also result in damage to the windings. Whenever the generator is not active, ensure that the space heaters are in operation.

Whenever the generator is operating, ensure that the space heaters are disconnected.

An external source of either 115 VAC or 230 VAC is required to operate the space heaters.

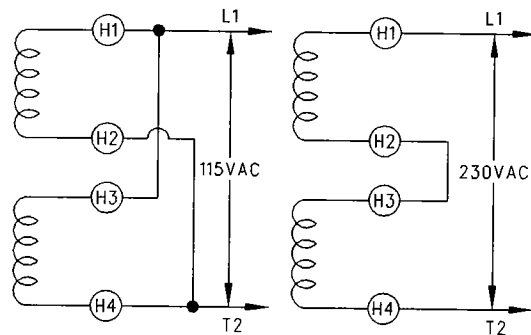


Illustration 76

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Space heater connection to external source (H1), (H2), (H3), and (H4) terminals.

If a 115 VAC source is available, connect both heaters in parallel across the source. If a 230 VAC source is available, connect both heaters in series across the source. Refer to Illustration 76.



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## Generator Start-up Checklist

SMCS Code: 4450

Table 40

GENERATOR START-UP CHECKLIST						
<b>RATING INFORMATION</b>						
Engine Serial Number: _____			Arrangement Number: _____			
Generator Serial Number: _____			Arrangement Number: _____			
<b>GENERATOR NAME PLATE INFORMATION</b>						
Voltage: _____			Package (prime, continuous, standby): _____			
Amperage: _____			Kilowatts: _____			
Storage Location: _____						
Generator Alignment: _____						
Main Stator Megohmmeter Reading:		Before Storage:		After Storage:		
Generator dried for 24 hours prior to start-up?			(Y/N)		Drying method:	
<b>SPACE HEATERS</b>		<b>Yes</b>	<b>No</b>	<b>Comments</b>		
Space heaters operating properly?						
Space heater operated 48 hrs. before start-up?						
<b>MEGOHMMETER TEST (SEHS9124)</b>		30 sec. reading	60 sec. reading	30 sec. corrected	60 sec. corrected	Ambient temp.
Beginning of Storage	Main Stator					
	Main Rotor					
	Exciter Stator					
	Exciter Rotor					
	PMG Stator					
Start-up	Main Stator					
	Main Rotor					
	Exciter Stator					
	Exciter Rotor					
	PMG Stator					
<b>Regulator</b>		<b>Voltage</b>	<b>Amps</b>	<b>Comments</b>		
No Load	F1 to F2	DC				
	20 to 22	AC				
	20 to 24	AC				
	22 to 24	AC				
	24 to 30 (SE only)	AC				
	26 to 28 (PM only)	AC				
	26 to 30 (PM only)	AC				
	28 to 30 (PM only)	AC				

(continued)

(Table 40, contd)

GENERATOR START-UP CHECKLIST				
Full Load	Generator Excitation Name Plate Information:	DC		Compare with F1 to F2
	F1 to F2	DC		
	20 to 22	AC		
	20 to 24	AC		
	22 to 24	AC		
	24 to 30 (SE only)	AC		
	26 to 28 (PM only)	AC		
	26 to 30 (PM only)	AC		
	28 to 30 (PM only)	AC		



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## Maintenance Interval Schedule (Standard)

**SMCS Code:** 1000; 4450; 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 service hours or calendar time, which ever comes first.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must be performed.

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Battery - Recycle .....	109
Battery or Battery Cable - Disconnect .....	110
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Engine Air Cleaner Element (Single Element) - Clean/Replace .....	123
Fuel System - Prime .....	133
Fuel Tank Water and Sediment - Drain .....	136
Generator Set - Test .....	140
Jacket Water Heater - Check .....	145
Maintenance Recommendations .....	145
Rotating Rectifier - Test .....	155
Varistor - Test .....	160
Winding - Test .....	163
Zinc Rods - Inspect/Replace .....	163

### Daily

Air Starting Motor Lubricator Oil Level - Check ..	103
Air Tank Moisture and Sediment - Drain .....	104
Annunciator Panel - Inspect .....	106
Cooling System Coolant Level - Check .....	117
Engine Air Cleaner Service Indicator - Inspect ...	126
Engine Air Precleaner - Clean .....	127
Engine Oil Level - Check .....	128
Fuel Tank Water and Sediment - Drain .....	136
Generator Load - Check .....	139
Jacket Water Heater - Check .....	145
Power Factor - Check .....	154

### Every Week

Air Inlet Filter - Check .....	103
Battery Charger - Check .....	108
Bearing Temperature - Measure/Record .....	114
Electrical Connections - Check .....	120
Generator - Inspect .....	138
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### Every 100 Service Hours or 3 Months

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### Initial 250 Service Hours

Engine Valve Lash - Inspect/Adjust .....	132
Fuel Injector - Inspect/Adjust .....	133
Speed Sensor - Clean/Inspect .....	157

### Every 250 Service Hours

Alternator and Fan Belts - Inspect/Adjust/ Replace .....	105
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Fan Drive Bearing - Lubricate .....	133
Hoses and Clamps - Inspect/Replace .....	141
Radiator - Clean .....	154

### Every 500 Service Hours

Engine Oil and Filter - Change .....	130
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### Every 1000 Service Hours

Bearing (Spherical Roller) - Lubricate .....	110
Cooling System Coolant Analysis (Level II) - Obtain .....	117
Engine - Clean .....	120
Engine Crankcase Breather - Clean .....	127
Engine Protective Devices - Check .....	132
Fuel Control Linkage - Check/Lubricate .....	133
Fuel System Primary Filter - Clean/Inspect/ Replace .....	134
Fuel System Secondary Filter - Replace .....	135

### Every 2000 Service Hours

Air Starting Motor Lubricator Bowl - Clean .....	103
Bearing (Ball) - Lubricate .....	110
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Engine Mounts - Check .....	128
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### Every 2000 Service Hours or 6 Months

Generator - Dry .....	136
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### Every 3000 Service Hours or 2 Years

Cooling System Coolant (DEAC) - Change .....	114
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**Every 3000 Service Hours or 3 Years**

Cooling System Coolant Extender (ELC) - Add .. 117

**Every 6000 Service Hours or 6 Years**

Alternator - Inspect ..... 104  
Cooling System Coolant (ELC) - Change ..... 115  
Cooling System Water Temperature Regulator -  
  Replace ..... 119  
Prelube Pump - Inspect ..... 154  
Speed Sensor - Clean/Inspect ..... 157  
Starting Motor - Inspect ..... 158  
Water Pump - Inspect ..... 162

**Every 7500 Service Hours or 1 Year**

Rotating Rectifier - Check ..... 155

**Between 7500 and 9000 Service Hours**

Overhaul (Top End) ..... 149  
Overhaul Considerations ..... 151

**Between 15 000 and 18 000 Service Hours**

Overhaul (Top End) ..... 149  
Overhaul Considerations ..... 151

**Between 22 500 and 27 000 Service Hours**

Overhaul (Major) ..... 147  
Overhaul Considerations ..... 151

**Every 1 041 000 L (275 000 US gal) of Fuel or  
10 000 Service Hours**

Maintenance Recommendations ..... 145

**Overhaul**

Bearing - Inspect ..... 111

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## Maintenance Interval Schedule (Standby)

**SMCS Code:** 1000; 4450; 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 service hours or calendar time, which ever comes first.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must be performed.

### When Required

Battery - Recycle .....	109
Battery or Battery Cable - Disconnect .....	110
Fuel System - Prime .....	133
Generator Set - Test .....	140
Rotating Rectifier - Test .....	155
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Winding - Test .....	163
Zinc Rods - Inspect/Replace .....	163

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Air Starting Motor Lubricator Oil Level - Check ..	103
Air Tank Moisture and Sediment - Drain .....	104
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Battery Electrolyte Level - Check .....	109
Bearing Temperature - Measure/Record .....	114
Cooling System Coolant Level - Check .....	117
Electrical Connections - Check .....	120
Engine Air Cleaner Service Indicator - Inspect ...	126
Engine Air Precleaner - Clean .....	127
Engine Oil Level - Check .....	128
Fuel Tank Water and Sediment - Drain .....	136
Generator - Inspect .....	138
Generator Load - Check .....	139
Jacket Water Heater - Check .....	145
Power Factor - Check .....	154
Space Heater - Check .....	156
Standby Generator Set Maintenance Recommendations .....	157
Stator Winding Temperature - Measure/Record ..	159
Voltage and Frequency - Check .....	161
Walk-Around Inspection .....	161

### Every Year

Air Starting Motor Lubricator Bowl - Clean .....	103
Alternator - Inspect .....	104
Alternator and Fan Belts - Inspect/Adjust/ Replace .....	105

Bearing (Ball) - Lubricate .....	110
Bearing (Spherical Roller) - Lubricate .....	110
Cooling System Coolant Analysis (Level II) - Obtain .....	117
Cooling System Supplemental Coolant Additive (SCA) - Test/Add .....	118
Crankshaft Vibration Damper - Inspect .....	120
Engine - Clean .....	120
Engine Air Cleaner Element (Dual Element) - Clean/Replace .....	121
Engine Air Cleaner Element (Single Element) - Clean/Replace .....	123
Engine Crankcase Breather - Clean .....	127
Engine Mounts - Check .....	128
Engine Oil Sample - Obtain .....	129
Engine Oil and Filter - Change .....	130
Engine Protective Devices - Check .....	132
Engine Valve Lash - Inspect/Adjust .....	132
Fan Drive Bearing - Lubricate .....	133
Fuel Control Linkage - Check/Lubricate .....	133
Fuel Injector - Inspect/Adjust .....	133
Fuel System Primary Filter - Clean/Inspect/ Replace .....	134
Fuel System Secondary Filter - Replace .....	135
Fuel Tank Water and Sediment - Drain .....	136
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Generator Set Vibration - Inspect .....	141
Hoses and Clamps - Inspect/Replace .....	141
Insulation - Test .....	142
Jacket Water Heater - Check .....	145
Prelube Pump - Inspect .....	154
Radiator - Clean .....	154
Speed Sensor - Clean/Inspect .....	157
Starting Motor - Inspect .....	158
Stator Lead - Check .....	159
Water Pump - Inspect .....	162

### Every 3 Years

Batteries - Replace .....	108
Cooling System Coolant (DEAC) - Change .....	114
Cooling System Coolant Extender (ELC) - Add ..	117
Cooling System Water Temperature Regulator - Replace .....	119
Rotating Rectifier - Check .....	155
Turbocharger - Inspect .....	159

### Every 6 Years

Cooling System Coolant (ELC) - Change .....	115
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### Overhaul

Bearing - Inspect .....	111
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i01189973

## Air Inlet Filter - Check

**SMCS Code:** 1051-535

Monitor the connector contacts of the differential pressure switch for the air inlet filter. If the differential pressure rises above 15.2 mm (0.6 inch) of water, clean the filter with a solution of soap and water. Be sure that the filter is thoroughly dry before the start-up. Replace the filter, if necessary.

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## Air Starting Motor Lubricator Bowl - Clean

**SMCS Code:** 1451-070

### **WARNING**

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

**Failure to relieve pressure can cause personal injury.**

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

1. Ensure that the air supply to the lubricator is OFF.

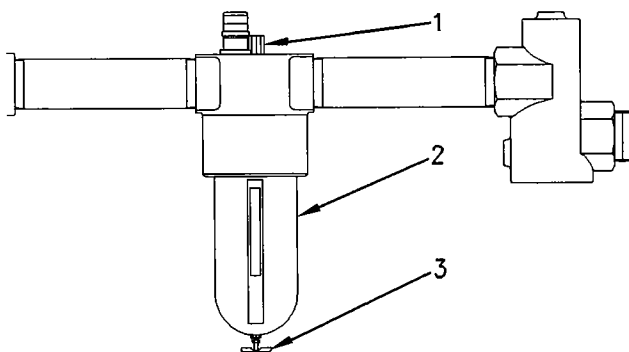


Illustration 77

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- (1) Filler plug
- (2) Bowl
- (3) Drain valve

2. Slowly loosen filler plug (1) in order to release the pressure from the lubricator.

### 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.

3. Place a suitable container under bowl (2) and open drain valve (3) in order to drain the oil from the bowl.
4. Remove bowl (2). Clean the bowl with warm water.
5. Dry the bowl. Inspect the bowl for cracks. If the bowl is cracked, replace the damaged bowl with a new bowl.
6. Install the bowl.
7. Make sure that drain valve (3) is closed. Fill bowl (2) through the hole for filler plug (1).

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).

8. Install filler plug (1).
9. 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).

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## 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.

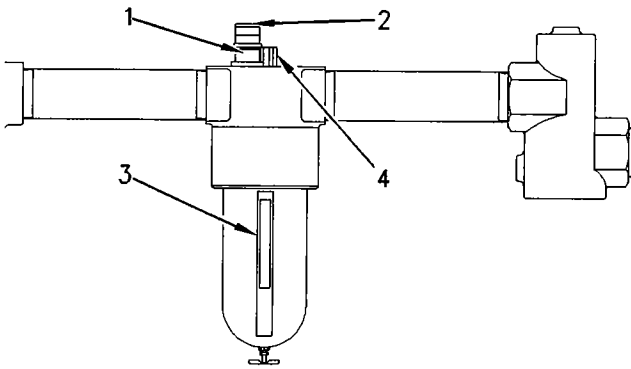


Illustration 78

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1. Observe the oil level in sight gauge (3). If the oil level is less than 1/2, add oil to the lubricator bowl.

**WARNING**

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

**Failure to relieve pressure can cause personal injury.**

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

2. Ensure that the air supply to the lubricator is OFF. Slowly loosen filler plug (4) in order to release pressure from the lubricator bowl.
3. Remove filler plug (4). Pour oil into the lubricator bowl. 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).
4. Install filler 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.

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## Alternator - Inspect

**SMCS Code:** 1405-040

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



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

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## Alternator and Fan Belts - Inspect/Adjust/Replace

**SMCS Code:** 1357-025; 1357-040; 1357-510; 1405

### Inspection

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

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

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

- Belts
- Pulleys
- Bearings

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

### Replacement

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

## Alternator Belt Adjustment

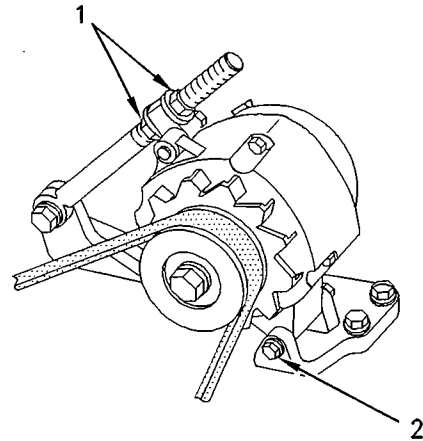


Illustration 79

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- (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).
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.

i00738738

## Annunciator Panel - Inspect

**SMCS Code:** 1926

Inspect the annunciator panel for good condition. Perform a lamp 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 following parameters during normal operation:

- Fuel filter differential pressure
- Inlet air restriction
- Oil filter differential pressure

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 establish the normal gauge readings for the engine. A gauge reading that is abnormal may indicate a problem with operation or a problem with the gauge.

## Record the Performance of the Engine

Records of engine performance are an important element of a maintenance program. Record information about the engine operation on a daily basis. This will help to reveal the trends of the engine performance.

The data on engine performance can help to predict problems with operation. Also, the data can provide your Caterpillar dealer with information that is useful for recommending optimum operation.

Table 42 is offered for use as a log for engine performance. Make several copies of Table 42 for continued use. Retain the recorded information for reference.

Table 42

Daily Engine Log						
Engine Serial Number	Date			Engine hours		
Authorization	Engine rpm			Percent load		
Ambient temperature						
Inlet manifold air temperature						
Inlet manifold air pressure						
Air restriction (left)						
Air restriction (right)						
Jacket water temperature						
SCAC water temperature						
Engine oil temperature						
Engine oil pressure						
Fuel pressure						
Fuel filter differential pressure						
Exhaust manifold temperature (left)						
Exhaust manifold temperature (right)						
Cylinder temperature (1)						
Cylinder temperature (2)						
Cylinder temperature (3)						
Cylinder temperature (4)						
Cylinder temperature (5)						
Cylinder temperature (6)						
Cylinder temperature (7)						
Cylinder temperature (8)						
Cylinder temperature (9)						
Cylinder temperature (10)						
Cylinder temperature (11)						
Cylinder temperature (12)						
Cylinder temperature (13)						
Cylinder temperature (14)						
Cylinder temperature (15)						
Cylinder temperature (16)						
Generator rear bearing temperature						
Generator stator temperature						
Generator voltage						
Generator amperage						
Comments						

## 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.

## 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 43 describes the effects of overcharging on different types of batteries.

Table 43

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.

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## Battery Electrolyte Level - Check

**SMCS Code:** 1401-535-FLV

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

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## Battery - Recycle

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

1. Always recycle a battery. Never discard a battery.
2. Always return used batteries to one of the following locations.
  - A battery supplier
  - An authorized battery collection facility
  - Recycling facility

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## Battery or Battery Cable - Disconnect

**SMCS Code:** 1401; 1402-029

### WARNING

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

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

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

i01225551

## Bearing (Ball) - Lubricate

**SMCS Code:** 4471-086

The following ball bearings must be lubricated: no shield and single shield. Double shielded ball bearings may not require lubrication. Refer to the grease plate instructions that are located on the machine.

For ball bearings, use Caterpillar 2S-3230 Bearing Lubricant. This grease is an NLGI No. 2 Grade. There is Polyurea (a thickener) in this grease. The temperature range of Caterpillar 2S-3230 Bearing Lubricant is -29 °C (-20.2 °F) to 177 °C (350.6 °F). For extremely low temperatures, use either NLGI No. 1 Grade or NLGI No. 0 Grade.

### Lubricating Process

1. Remove either the louver assembly or the rear plate from the rear of the generator housing.

2. Remove the top grease pipe plug and remove the lower grease pipe plug.
3. Install a grease fitting in the grease pipe.
4. Grease the shielded ball bearings with 2S-3230 Bearing Lubricant (53.28 mL (1.8 ounces) to 59.20 mL (2.0 ounces)). Lubricate shielded ball bearings at 2000 hour intervals. Do not mix greases.

**Note:** Some two-bearing generators have spherical roller bearings in the front bracket and ball bearings in the rear bracket. These units should use a common 108-8611 Grease Cartridge. This grease should be used for the front bearing and the rear bearing.

5. Wipe off the excess grease. Remove the top grease fitting. Install the plug.
6. Operate the generator for one hour. This will allow the grease to expand. The expanding grease will force the excess grease from the cavity. When the excess grease is forced from the cavity, the internal pressure will be reduced. The generator should continue to operate until the grease stops purging.
7. Stop the engine. Install the plug in the bottom grease pipe. Wipe off the excess grease.
8. Install the louver assembly or install the rear plate.

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## Bearing (Spherical Roller) - Lubricate

**SMCS Code:** 4471-086

Spherical roller bearings must be lubricated. For spherical roller bearings, use a Caterpillar 108-8611 Grease Cartridge. This grease is an NLGI No. 1.5 Grade. There is no molybdenum disulfide in this grease. There is Clay (a thickener) in this grease. At 40 °C (104.0 °F), the viscosity of the grease in a Caterpillar 108-8611 Grease Cartridge is 32 cSt. At 100 °C (212.0 °F), The viscosity is 5 cSt.

### Lubricating Process

1. Remove either the louver assembly or the rear plate from the rear of the generator housing.
2. Remove the top grease pipe plug and remove the lower grease pipe plug.
3. Install a grease fitting in the grease pipe.

4. Grease spherical roller bearings with a 108-8611 Grease Cartridge (29.6 mL (1 ounce)). Spherical roller bearings should be lubricated at 1000 hour intervals. Do not mix greases.

**Note:** Some two-bearing generators have spherical roller bearings in the front bracket and ball bearings in the rear bracket. These units should use common 108-8611 Grease Cartridges. This grease should be used for the front bearing and the rear bearing.

5. Wipe off the excess grease. Remove the top grease fitting. Install the plug.
6. Operate the generator for one hour. This will allow the grease to expand. The expanding grease will force the excess grease from the cavity. When the excess grease is forced from the cavity, the internal pressure will be reduced. The generator should continue to operate until the grease stops purging.
7. Stop the engine. Install the plug in the bottom grease pipe. Wipe off the excess grease.
8. Install the louver assembly or install the rear plate.

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## Bearing - Inspect

**SMCS Code:** 4471-040

The following maintenance procedure for generator bearings should be followed at every major engine overhaul:

1. Remove the bearing bracket. Inspect the following items: bracket bore, bearing outer race, and rolling elements. On Standby Power Units, the bearing must be inspected and the grease must be replaced at three year intervals. The bearing bracket sleeve should be inspected for out of roundness, excessive wear, and a bracket step that is less than 0.0762 mm (0.0030 inch). If there is no bearing bracket sleeve, inspect the bearing bracket bore. The bearing should be inspected for outer race damage, severe fretting, and smoothness of operation. When possible, the bearing elements should be inspected. Some double-shielded ball bearings prevent visual inspection of the ball bearing elements. Other double shielded ball bearings have a retaining ring. This retaining ring can be removed in order to allow access for a visual inspection of the ball bearing elements.

On two-bearing generators, the front bearing can only be removed after the hub is removed. In order to remove the hub, cut off the hub. Pulling the hub will damage the shaft.

**Note:** Bearings that are being removed for failure analysis should not be cut off with a torch.

2. Spherical Roller Bearing should be cleaned and repacked with 108-8611 Grease. Pack the bearing and pack the cavity (one-third to one-half of the cavity volume). The bearing should be filled with 88.8 mL (3 ounces) to 118.4 mL (4 ounces) of grease. The cavity should be filled with 118.4 mL (4 ounces) to 148.0 mL (5 ounces) of grease. Refer to Table 44.
3. All ball bearings should be cleaned. The bracket cavity should be repacked with 2S-3230 Grease. Pack the bearings (one-third to one-half of the cavity volume). Refer to Table 44.

To reinstall bearings, heat the bearings to 107 °C (224.6 °F) for ten minutes. Mount the bearings on the shaft. To reinstall the hub, heat the hub to 400 °C (752.0 °F) for three hours. Mount the hub to the shaft.

4. Ensure that the grease supply tube to the bearing is filled with grease.
5. Remove the bracket drain plug and operate the generator for one hour. This will allow the grease to expand. The expanding grease will force the excess grease from the cavity. When the excess grease is forced from the cavity, the internal pressure will be reduced. The generator should continue to operate until the grease stops purging.
6. Stop the engine. Install the bracket drain plug. Wipe off the excess grease.
7. For greasing intervals, follow the recommendations on the lubrication plate (if equipped) or refer to Maintenance Schedule, "Bearing - Lubricate". Whenever the bearings are greased, repeat Step 5. DO NOT MIX GREASES.

Table 44

Bearing Outside Diameter mm (inch)	Bearing Inside Diameter mm (inch)	Part Number	Generator Frame Size	Bearing Bore in Bracket mm (inch)	Bearing Shield (Type)	Bearing Cavity Grease mL (oz.)	Rotor Shaft Diameter mm (inch)
100 mm (3.9370 inch)	45 mm (1.7717 inch)	5P-1977	All 360	100.000 mm (3.9370 inch) to 100.025 mm (3.9380 inch)	Double	29.6 mL (1 oz.)	45.004 mm (1.7718 inch) to 45.019 mm (1.7724 inch)
140 mm (5.5118 inch)	65 mm (2.5591 inch)	3N-1965	440 (round laminated)	140.002 mm (5.5119 inch) to 140.028 mm (5.5129 inch)	Double	53.280 mL (1.8 oz.) <sup>(1)</sup> 94.720 mL (3.2 oz.) <sup>(2)</sup>	65.004 mm (2.5592 inch) to 65.021 mm (2.5599 inch)
160 mm (6.2992 inch)	75 mm (2.9527 inch)	5P-2448	580 <sup>(2)</sup> 590 <sup>(1)</sup>	160.002 mm (6.2993 inch) to 160.028 mm (6.3003 inch)	Double	100.64 mL (3.4 oz.) to 168.72 mL (5.7 oz.)	75.004 mm (2.9529 inch) to 75.021 mm (2.9536 inch)
170 mm (6.6929 inch)	80 mm (3.1496 inch)	4L-6677 <sup>(3)</sup>	580 <sup>(1)</sup>	170.002 mm (6.6930 inch) to 170.028 mm (6.6940 inch)	Single	97.68 mL (3.3 oz.) to 162.80 mL (5.5 oz.)	80.002 mm (3.1497 inch) to 80.020 mm (3.1504 inch)
170 mm (6.6929 inch)	80 mm (3.1496 inch)	109-7687 <sup>(3)</sup>	580 <sup>(1)</sup>	170.002 mm (6.6930 inch) to 170.028 mm (6.6940 inch)	Double	97.68 mL (3.3 oz.) to 162.80 mL (5.5 oz.)	80.002 mm (3.1497 inch) to 80.020 mm (3.1504 inch)
180 mm (7.0866 inch)	100 mm (3.9370 inch)	6Y-3955	440 (square laminated)	179.992 mm (7.0863 inch) to 180.017 mm (7.0873 inch)	Double	139.12 mL (4.7 oz.) to 230.88 mL (7.8 oz.)	82.474 mm (3.2470 inch) to 82.486 mm (3.2475 inch)
190 mm (7.4803 inch)	90 mm (3.5433 inch)	6Y-6488	590 <sup>(1)</sup> 589 PM	190.002 mm (7.4804 inch) to 190.028 mm (7.4814 inch)	Double	97.68 mL (3.3 oz.) to 162.80 mL (5.5 oz.)	90.012 mm (3.5438 inch) to 90.028 mm (3.5444 inch)
225 mm (8.8582 inch)	105 mm (4.1338 inch)	6V-0410	680 <sup>(1)</sup>	225.003 mm (8.8584 inch) to 225.034 mm (8.8596 inch)	Single	139.12 mL (4.7 oz.) to 230.88 mL (7.8 oz.)	105.029 mm (4.1350 inch) to 105.034 mm (4.1352 inch)
225 mm (8.8582 inch)	105 mm (4.1338 inch)	108-1760	680 <sup>(1)</sup>	225.003 mm (8.8584 inch) to 225.034 mm (8.8596 inch)	Double	148.00 mL (5.0 oz.) to 236.80 mL (8.0 oz.)	105.029 mm (4.1350 inch) to 105.034 mm (4.1352 inch)
230 mm (9.0551 inch)	130 mm (5.1181 inch)	2L-4444 <sup>(4)</sup>	808 4 pole <sup>(1)</sup>	229.992 mm (9.0548 inch) to 230.022 mm (9.0560 inch)	Open	177.60 mL (6.0 oz.) to 266.40 mL (9.0 oz.)	130.028 mm (5.1192 inch) to 130.051 mm (5.1201 inch)

(continued)



(Table 44, contd)

Bearing Outside Diameter mm (inch)	Bearing Inside Diameter mm (inch)	Part Number	Generator Frame Size	Bearing Bore in Bracket mm (inch)	Bearing Shield (Type)	Bearing Cavity Grease mL (oz.)	Rotor Shaft Diameter mm (inch)
230 mm (9.0551 inch)	130 mm (5.1181 inch)	2L - 4444 <sup>(4)</sup>	820 <sup>(1)</sup>	229.992 mm (9.0548 inch) to 230.022 mm (9.0560 inch)	Open	236.8 mL (8.0 oz.) to 355.20 mL (12.0 oz.)	130.028 mm (5.1192 inch) to 130.051 mm (5.1201 inch)
240 mm (9.4488 inch)	110 mm (4.3307 inch)	108 - 1761	690 <sup>(1)</sup>	240.002 mm (9.4489 inch) to 240.033 mm (9.4501 inch)	Double	207.20 mL (7.0 oz.) to 296.00 mL (10.0 oz.) <sup>(6)</sup> 414.40 mL (14.0 oz.) to 621.60 mL (21 oz.) <sup>(6)</sup>	110.012 mm (4.3312 inch) to 110.028 mm (4.3318 inch)
240 mm (9.4488 inch)	110 mm (4.3307 inch)	6V - 3310	800 <sup>(1)</sup>	240.002 mm (9.4489 inch) to 240.033 mm (9.4501 inch)	Single	145.04 mL (4.9 oz.) to 239.76 mL (8.1 oz.)	110.012 mm (4.3312 inch) to 110.028 mm (4.3318 inch)
240 mm (9.4488 inch)	110 mm (4.3307 inch)	6V - 6752	800 <sup>(1)</sup>	240.002 mm (9.4489 inch) to 240.033 mm (9.4501 inch)	Single	145.04 mL (4.9 oz.) to 239.76 mL (8.1 oz.)	110.012 mm (4.3312 inch) to 110.028 mm (4.3318 inch)
240 mm (9.4488 inch)	110 mm (4.3307 inch)	108 - 1761	800 <sup>(1)</sup>	240.002 mm (9.4489 inch) to 240.033 mm (9.4501 inch)	Double	148.00 mL (5.0 oz.) to 236.80 mL (8.0 oz.)	110.012 mm (4.3312 inch) to 110.028 mm (4.3318 inch)
280 mm (11.024 inch)	130 mm (5.1181 inch)	154 - 3032	820	280.002 mm (11.0237 inch) to 280.032 mm (11.0249 inch)	Double	N/A	130.028 mm (5.1192 inch) to 130.051 mm (5.1201 inch)

<sup>(1)</sup> Inboard bearing

<sup>(2)</sup> Outboard bearing

<sup>(3)</sup> 109-7687 bearing is preferred.

<sup>(4)</sup> This bearing is a spherical roller bearing. This bearing is greased from the bracket's front side. All of the other bearings are ball bearings.

<sup>(5)</sup> Bearing on exciter end.

<sup>(6)</sup> Bearing on drive end.

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## Bearing Temperature - Measure/Record

**SMCS Code:** 4471-082-TA

Bearing temperature detectors are optional on all SR4B generators. These detectors are 100 ohm resistance temperature detectors. Bearing temperature detectors are used with equipment that has been provided by the customer in order to measure the bearing temperature. Bearing temperature detectors may help to prevent premature bearing failure.

i01397318

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

### 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.

## 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.

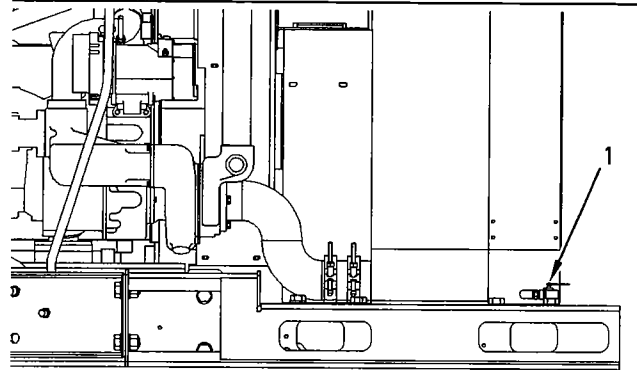


Illustration 80

g00736141

(1) Coolant drain

3. Open coolant drain (1).

### 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 Illinois: 1-800-542-TOOL  
 Inside Illinois: 1-800-541-TOOL  
 Canada: 1-800-523-TOOL

## 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 cooling system drain.

### 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. Flush the cooling system with clean water until the water that drains is clean. Close the coolant drain. 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.
  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. Allow the water to drain. Flush the cooling system with clean water until the water that drains is clean. Close the coolant drain.
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.

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## 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.

## Fill the Cooling System

### NOTICE

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

**Note:** For information about the proper coolant to use, see the Operation and Maintenance Manual (Maintenance Section), "Coolant Recommendations". For the capacity of the cooling system, see the Operation and Maintenance Manual (Maintenance Section), "Refill Capacities".

1. Fill the cooling system with coolant/antifreeze. Do not install the radiator filler cap.

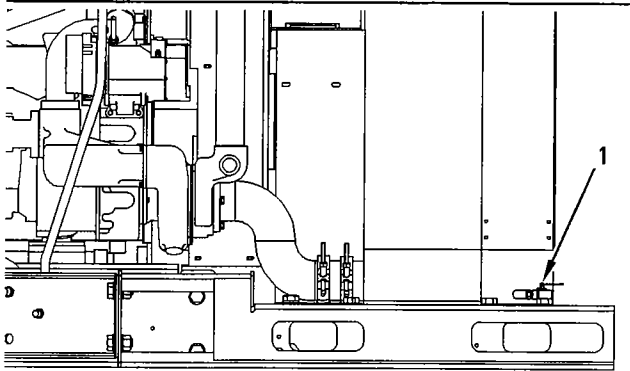


Illustration 81

g00736141

(1) Coolant drain

3. Open coolant drain (1).

#### 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 Illinois: 1-800-542-TOOL  
 Inside Illinois: 1-800-541-TOOL  
 Canada: 1-800-523-TOOL

## 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.

#### 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. Allow the coolant to drain. Flush the cooling system with clean water. Close the coolant drain.
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). For the correct capacity of the cooling system, see this Operation and Maintenance Manual (Maintenance Section), "Refill Capacities". 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.

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## 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.

## 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.

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## Cooling System Coolant Level - Check

**SMCS Code:** 1350-535-FLV

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

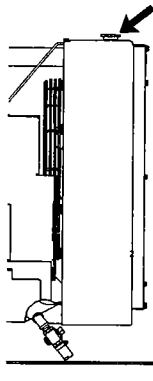


Illustration 82

g00285520

Cooling system filler cap

### WARNING

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

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

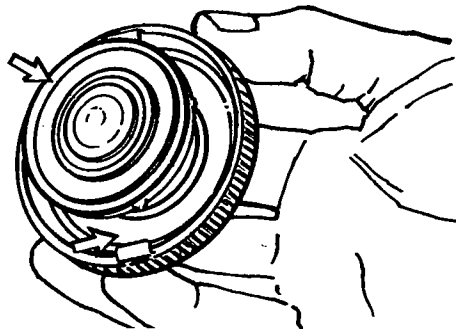


Illustration 83

g00103639

Typical filler cap gaskets

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

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.

## 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.

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## 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.

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## Electrical Connections - Check

**SMCS Code:** 4459-535

Check all exposed electrical connections for tightness.

Check the following devices for loose mounting or physical damage:

- transformers
- fuses
- capacitors
- lightning arrestors

Check all lead wires and electrical connections for proper clearance.

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## 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".

i01553486

## 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 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.

## 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.

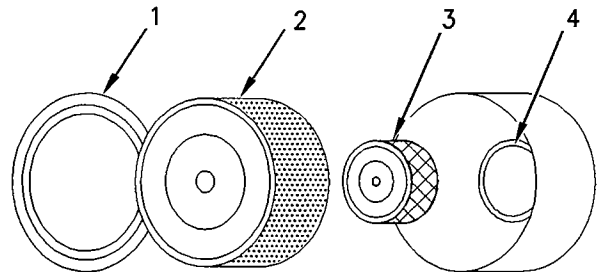


Illustration 84

g00736431

- (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 Cleaner 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 air cleaner service indicator.

## Cleaning the Primary Air Cleaner Elements

### NOTICE

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

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

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

Do not wash the filter element.

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

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

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

- Pressurized air
- Vacuum cleaning

### 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).

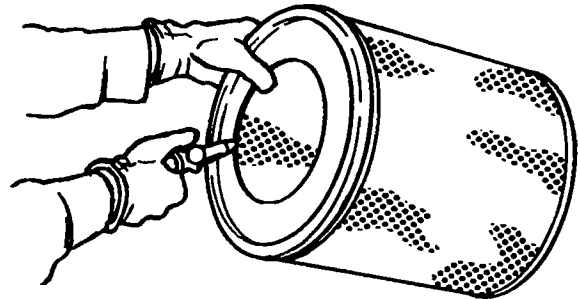


Illustration 85

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".

## Inspecting the Primary Air Cleaner Elements

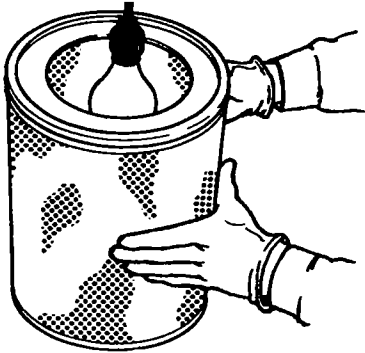


Illustration 86

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 a 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.

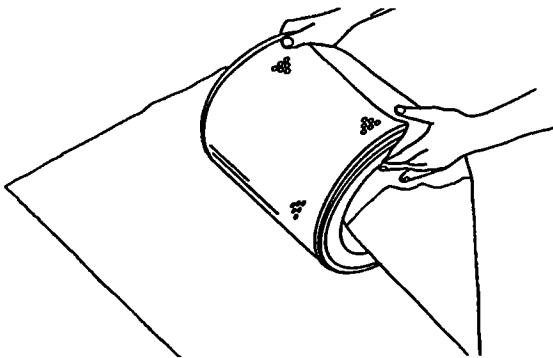


Illustration 87

g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the primary air cleaner elements in Volatile 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 of cleaning
- Number of cleanings

Store the box in a dry location.

i01553508

## Engine Air Cleaner Element (Single 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.

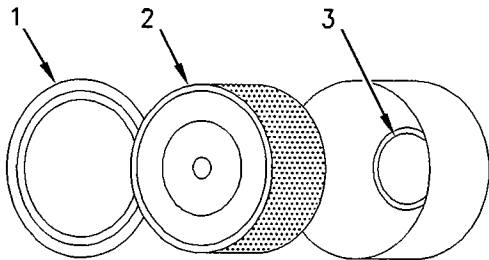


Illustration 88

g00735127

- (1) Cover  
(2) Air cleaner element  
(3) Turbocharger air inlet

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

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

2. Cover the air inlet with tape in order to keep 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. Reset the air cleaner service indicator.

## Cleaning the Air Cleaner Elements

### NOTICE

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

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

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

Do not wash the filter element.

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

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

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

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

### NOTICE

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

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

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

- Pressurized air
- Vacuum cleaning

## Pressurized Air

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

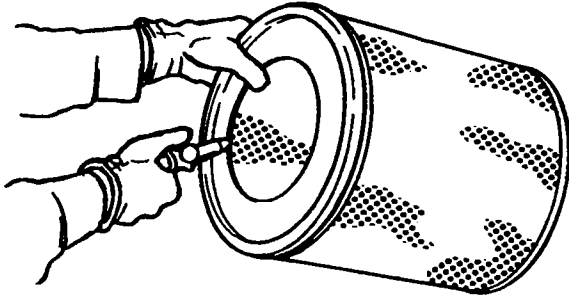


Illustration 89

g00281692

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

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

**Note:** Refer to "Inspecting the Air Cleaner Elements".

## Vacuum Cleaning

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

**Note:** Refer to "Inspecting the Air Cleaner Elements".

## Inspecting the Air Cleaner Elements

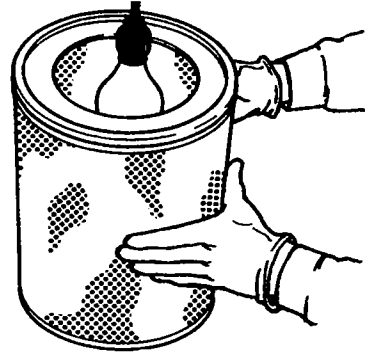


Illustration 90

g00281693

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

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

## Storing Air Cleaner Elements

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

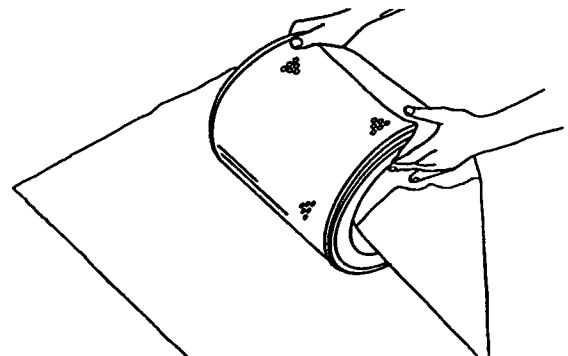


Illustration 91

g00281694

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

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

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i01397712

## 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.

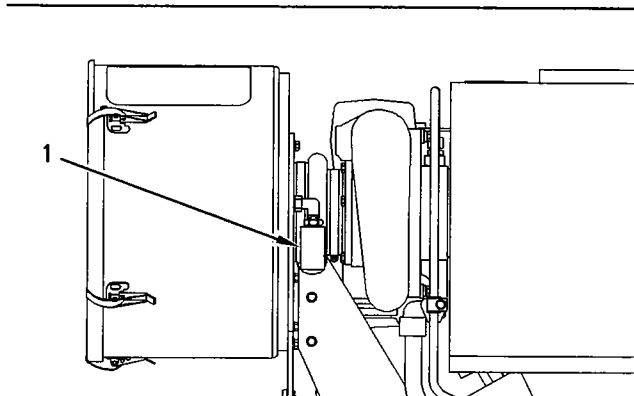


Illustration 92

g00736586

(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.

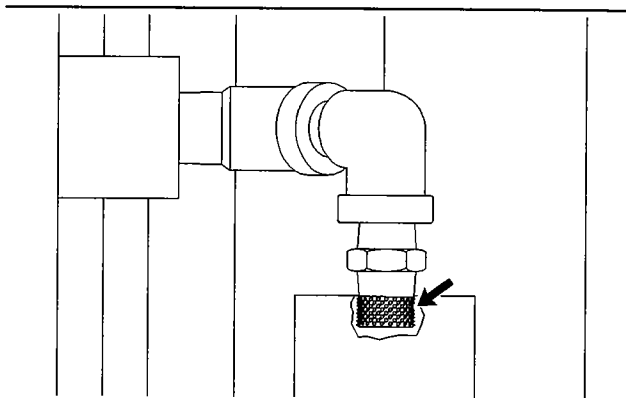


Illustration 93

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).

i01397717

## Engine Air Precleaner - Clean

SMCS Code: 1055-070

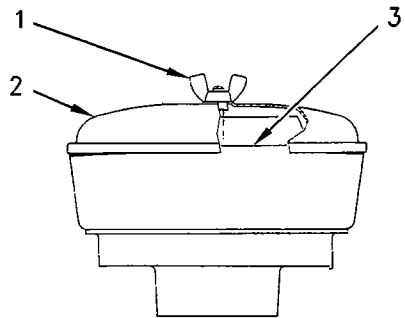


Illustration 94

g00736588

Typical pre-cleaner

- (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 pre-cleaner, 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.

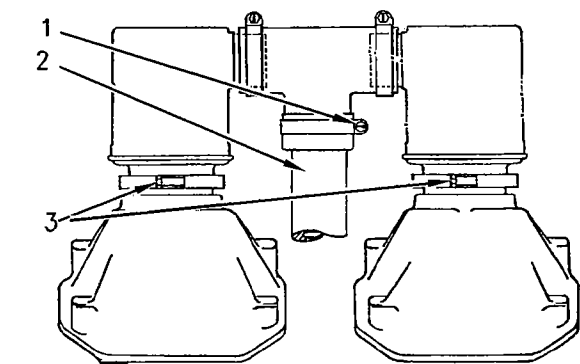


Illustration 95

g00597463

1. Loosen clamp (1). Slide the clamp down on tube (2).
2. Loosen clamps (3). Remove both breathers as a unit.

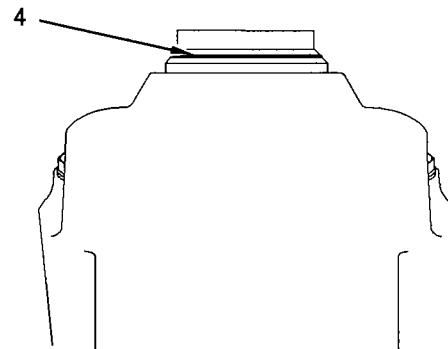


Illustration 96

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.

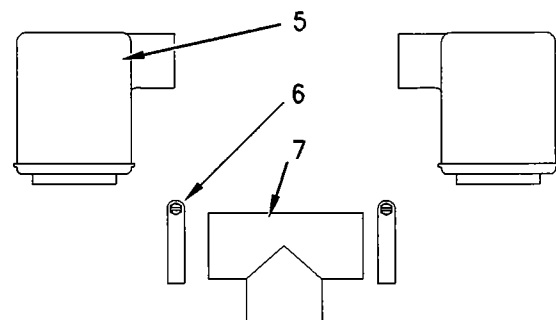


Illustration 97

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".

i01397742

## Engine Mounts - Check

**SMCS Code:** 1152-535

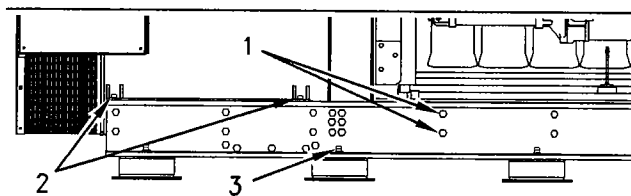


Illustration 98

g00736591

- (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.

i01397781

## Engine Oil Level - Check

**SMCS Code:** 1348-535-FLV

The most accurate check of the oil level is performed when the engine is stopped. Perform this maintenance on a surface that is as level as possible.

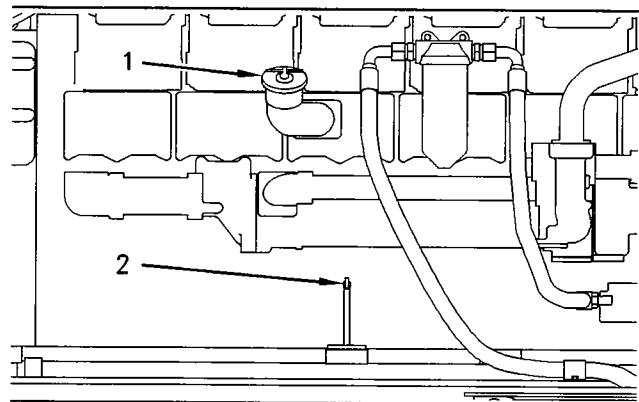


Illustration 99

g00736608

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



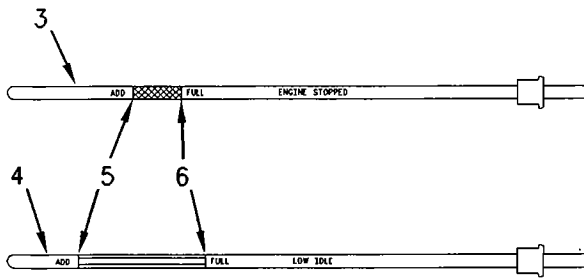


Illustration 100

g00736607

(3) "ENGINE STOPPED" side. (4) "LOW IDLE" side. (5) "ADD" mark. (6) "FULL" mark.

1. Ensure that oil level gauge (2) is seated.
  - a. If the engine is stopped, remove oil level gauge (2). Observe the oil level on "ENGINE STOPPED" side (3). The oil level should be between "ADD" mark (5) and "FULL" mark (6).
  - b. If the engine is operating, reduce the engine speed to low idle. Remove oil level gauge (2) and observe the oil level on "LOW IDLE" side (4). The oil level should be between "ADD" mark (5) and "FULL" mark (6).

#### NOTICE

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

2. If necessary, remove oil filler cap (1) and add oil. For the correct oil to use, see this Operation and Maintenance Manual, "Engine Oil" topic in the Maintenance Section. Do not fill the crankcase above "FULL" mark (6). Clean the oil filler cap. Install the oil filler cap.

i01534451

## 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

### **WARNING**

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

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

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

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, 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 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

#### NOTICE

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.

i01397895

## Engine Oil and Filter - Change

SMCS Code: 1318-510

### WARNING

**Hot oil and components can cause personal injury.**

**Do not allow hot oil or components to contact skin.**

The oil change interval will be affected by the following items:

- Engine application
- Size of the oil sump
- Fuel type
- Oil type
- Ambient air conditions
- Air/fuel ratio

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.

### Drain the Oil

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 draining method allows the waste particles that are suspended in the oil to be drained properly.

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.

2. Drain the oil according to the equipment on the engine.

**Note:** Drain the oil into a suitable container. Dispose of the oil according to local regulations.

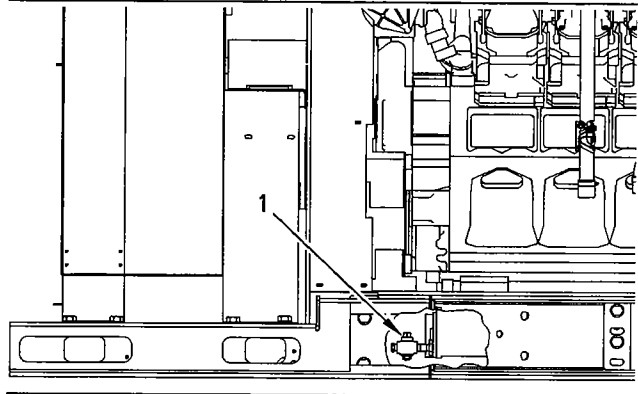


Illustration 101

g00736656

(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.

### Replace the Oil Filter Elements

Replace the engine oil filters when either of the following conditions are met:

- Every oil change
- The engine oil filter differential pressure reaches 103 kPa (15 psi).

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.

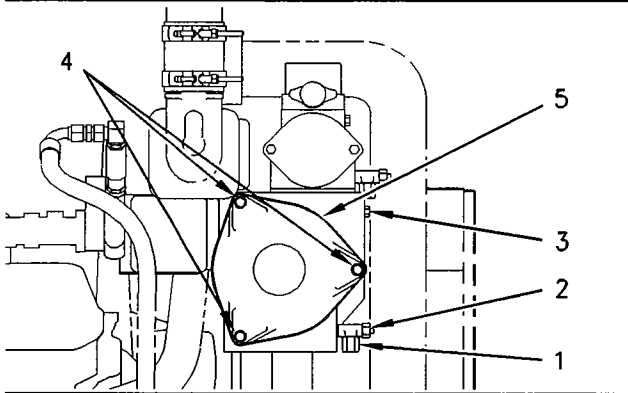


Illustration 102

g00736657

- (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.

**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.**

**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 rags. **DO NOT** use absorbent particles to clean up the oil.

3. Be alert to the spring force. Gradually loosen but do not remove bolts (4). Before removing bolts (4), pry the cover (5) loose in order to relieve any spring pressure. Remove cover (5). Remove the O-ring seal on the inside of the cover.
4. Clean cover (5) and clean the O-ring seal. 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.

5. Install new oil filter elements.
6. 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.
7. Install cover (5). Ensure that the springs are seated properly between the cover and the oil filter elements.

## 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.

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 as recommended by Caterpillar and listed in the Lubrication Specifications for your engine application.

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 (Maintenance Section), "Refill Capacities". 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 the Operation and Maintenance Manual (Operation Section), "Starting The Engine" procedure. 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.

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.

i01520887

## Engine Valve Lash - Inspect/Adjust

**SMCS Code:** 1102-025

**Note:** For procedures on adjusting the valve lash and adjusting the valve bridge, see Testing and Adjusting, "Valve Lash and Valve Bridge Adjustment". 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, "Specifications" topic (Product Information Section).

i01552621

## Fan Drive Bearing - Lubricate

**SMCS Code:** 1359-086-BD

1. Inspect the fan drive pulley assembly. If the shaft is loose, an inspection of the internal components should be made.

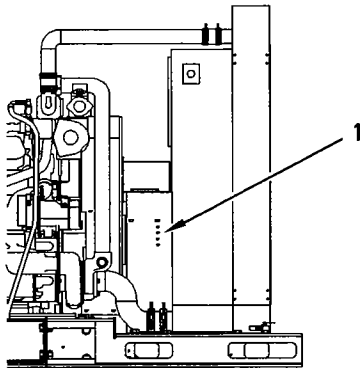


Illustration 103

g00736668

- (1) Grease fittings for the fan bearings

**Note:** If the engine is operated in hot environments, dirty environments, or humid environments, lubricate the fan bearings more frequently.

2. Lubricate the grease fittings for the fan bearings with Bearing Lubricant , or with an equivalent grease.

i01398199

## Fuel Control Linkage - Check/Lubricate

**SMCS Code:** 1257-086; 1257-535

Check the fuel control linkage for proper operation. If necessary, adjust the fuel control linkage. For the adjustment procedure, see the Service Manual Module, "Systems Operation Testing and Adjusting" and see the Service Manual Module, "Specifications".

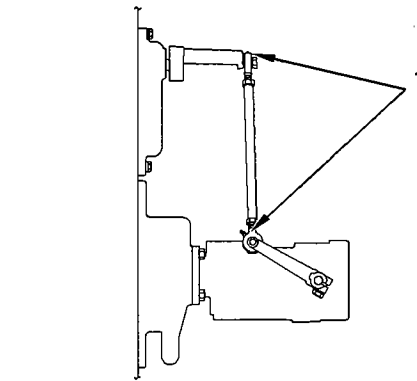


Illustration 104

g00736769

- (1) Rod ends

Apply grease to the grease fittings on the rod ends.

Use a hand grease gun and lubricate the grease fittings with MPMG.

i01518645

## Fuel Injector - Inspect/Adjust

**SMCS Code:** 1290-025

**Note:** Perform this procedure when the engine valve lash is inspected.

### 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 Testing And Adjusting, "Fuel Injector Timing". Adjust the lash for the fuel injector, if necessary.

i01398238

## 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.

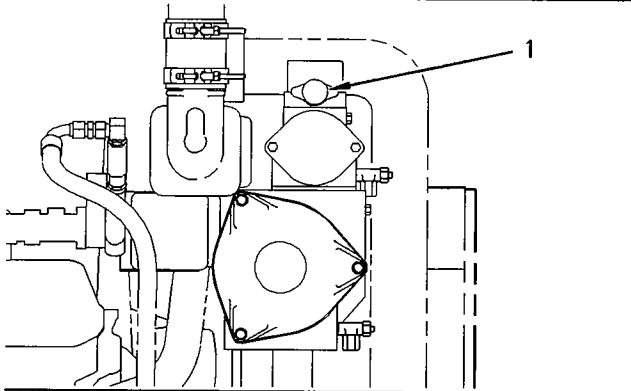


Illustration 105

g00736817

(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".

i01398258

## 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.

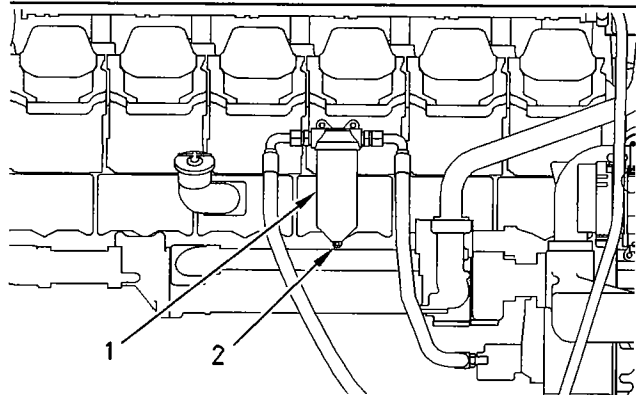


Illustration 106

g00736845

(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.

i01398265

## 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.

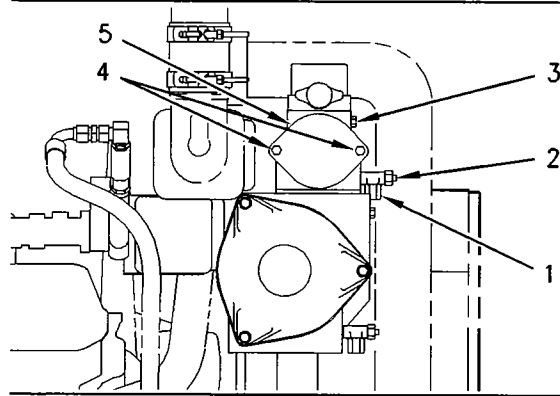


Illustration 107

g00736863

- (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.

i01277057

## Generator - Dry

**SMCS Code:** 4450-569

### WARNING

**Personal injury or death can result from improper troubleshooting and repair procedures.**

**The following troubleshooting and repair procedures should only be performed by qualified personnel familiar with this equipment.**

Refer to Safety Section, "Generator Isolating fo Maintenance" for information regarding the procedure to safely isolate the generator.

If the insulation resistance values are less than the recommended values, one of the following drying procedures must be selected. This decision should be based on the following factors:

- the size of the unit
- the location of the unit
- the equipment that is available



- the experience of personnel

**Note:** For more information on drying methods, refer to Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators".

Remove the voltage regulator. Cover all of the inlet openings. Cover all of the discharge holes. Provide an opening at the top of the machine. This opening will allow moisture to evaporate. Preferably, this opening will be located at the fan end. Monitor the winding temperatures. DO NOT APPLY HEAT TOO RAPIDLY. Winding temperature should be raised gradually at a rate of 10 °C (50 °F) per hour up to 85 °C (185 °F). Measure insulation resistance at one hour intervals. Typically, the insulation resistance will slowly drop while the temperature is rising. The insulation resistance will then start to increase at a slow rate until the insulation resistance reaches a constant level.

The following methods can be used for drying a generator:

- Self-circulating air method
- Oven method
- Controlled current method

### Self-Circulating Air Method

Run the engine and disconnect the generator load. This will help circulate air. Operate the generator space heaters.

### Oven Method

Place the entire generator inside a forced air drying oven for four hours at 65 °C (149 °F).

#### NOTICE

Use a forced air type oven rather than a radiant type oven.

Radiant type ovens can cause localized overheating.

### Controlled Current Method

Table 45

Tools Needed		
Part Number	Description	Qty
8T-0900	Clamp on ammeter (1200 amperes)	1
	External Power Source	1
	Rheostat	1

Heat can be used in order to dry the generator windings. This heat can be created by allowing a controlled current to flow through the generator. No high voltages are generated during the following procedure. Therefore, insulation breakdown will not occur.

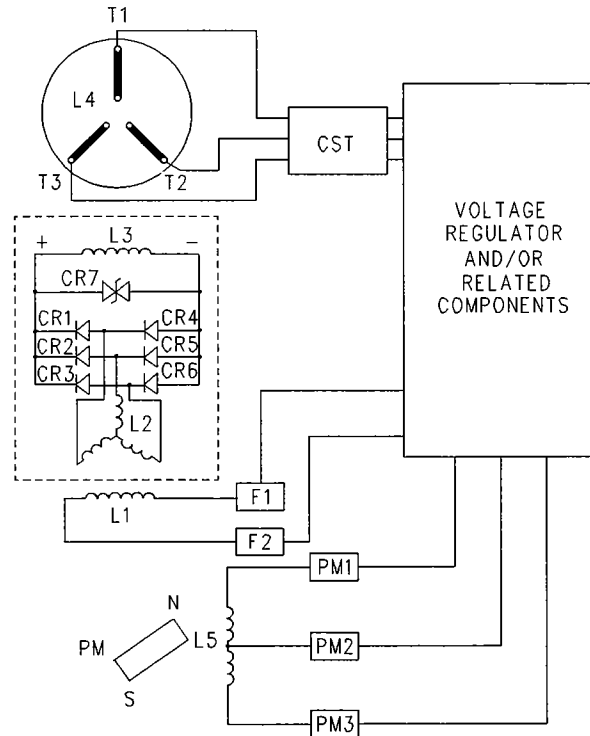


Illustration 108

g00669571

#### Generator Wiring Diagram

- (CR1-CR6) Diodes
- (CR7) Varistor
- (L1) Exciter field (stator)
- (L2) Exciter armature (rotor)
- (L3) Main field (rotor)
- (L4) Main armature (stator)
- (L5) Pilot exciter armature
- (PM) Permanent magnet
- (RFA) Rotating field assembly
- (CST) Customer supplied transformer

1. Make an external power source.
2. Refer to the above diagram. Disconnect "F1+" from the voltage regulator. Disconnect "F2-" from the voltage regulator. Disconnect the generator load. Connect the generator output leads "T0", "T1", "T2", and "T3". Install the clamp-on ammeter to generator output lead "T1".

**Note:** When the line current is measured on multiple-lead units, measure the current in each conductor per phase. The currents can then be added.

3. Refer to the above diagram. Connect the rheostat. Adjust the rheostat to the maximum resistance value. Connect the external power source to wires "F1+" and "F2-".
4. Start the generator set. Run the generator set at idle speed.
5. Monitor the phase current. Gradually increase the engine RPM. Increase the engine RPM until one of the following conditions are met:
  - The rated phase current is obtained.
  - The full generator set speed is obtained.
6. If more phase current is still necessary, slowly turn the rheostat until the rated phase current is reached.
7. On an hourly basis, stop the drying procedure. Check the insulation resistance. Repeat the above steps until the insulation resistance is acceptable.

I01461264

## Generator - Inspect

**SMCS Code:** 4450-040

### WARNING

**Personal injury or death can result from improper troubleshooting and repair procedures.**

**The following troubleshooting and repair procedures should only be performed by qualified personnel familiar with this equipment.**

Refer to Safety Section, "Generator Isolating for Maintenance" for information regarding the procedure to safely isolate the generator.

Proper maintenance of electrical equipment requires periodic visual examination of the generator and periodic visual examination of the windings. Proper maintenance of electrical equipment also requires appropriate electrical checks and appropriate thermal checks. Insulation material should be examined for cracks. The insulation material should be examined for accumulations of dirt and dust. If there is an insulation resistance value that is below normal, a conductive path may be present. This conductive path may be made of one of the following materials:

- Carbon
- Salt

- Metal dust
- Dirt that is saturated with moisture

These contaminants will develop a conductive path which may produce shorts. Cleaning is advisable if heavy accumulations of dirt can be seen or if heavy accumulations of dust can be seen. If excess dirt is the cause of a restriction in the ventilation, cleaning is also advisable. Restricted ventilation will cause excessive heating.

### NOTICE

**To avoid the possibility of deterioration to the generator windings, do not clean the generator unless there is visual, electrical, or thermal evidence that dirt is present.**

If harmful dirt accumulations are present, a variety of cleaning techniques are available. The cleaning procedure that is used may be determined by one of the items on the following list:

- The extent of the cleaning procedure that is being attempted
- The type of enclosure of the generator
- The voltage rating of the generator
- The type of dirt that is being removed

## Cleaning (Assembled Generators)

Cleaning may be required at the point of installation. At this point, complete disassembly of the generator may not be necessary or feasible. In this case, a vacuum cleaner should be used to pick up the following items: dry dirt, dust, and carbon. This will prevent the spreading of these contaminants.

A small nonconductive tube may need to be connected to the vacuum cleaner. This will allow the vacuum cleaner to clean the surfaces that are not exposed. After most of the dust has been removed, a small brush may be attached to the vacuum hose in order to loosen dirt that is more firmly attached to the surface.

After the initial cleaning with a vacuum, compressed air may be used to remove the remaining dust and dirt. Compressed air that is used for cleaning should be free of moisture and free of oil. Air pressure should be a maximum of 210 kPa (30 psi) in order to prevent mechanical damage to the insulation. If the above cleaning procedures are not effective, consult a Caterpillar dealer.

## Cleaning (Disassembled Generators)

An initial insulation resistance check should be made on the generator in order to confirm electrical integrity. A minimum reading of one megohm would be expected with severely contaminated generators. A zero megohm reading may indicate an insulation breakdown. An insulation breakdown requires more than cleaning. An insulation breakdown requires repair.

A high pressure wash is normally an effective way to clean windings. This includes windings that have been exposed to flooding or windings that have been contaminated by salt. A solution of hot water and detergent is used for this method of cleaning.

A high pressure wash sprays a high velocity fluid stream of this solution over the generator that is being cleaned. This detergent washing is followed by multiple sprays of clean water. The clean water is used in order to remove the detergent or the clean water is used in order to dilute the detergent.

Allow the generator to dry at room temperature. Check the insulation resistance. The insulation resistance should now be normal. If the insulation resistance is not normal, repeat the procedure. It may be necessary to use solvents if the generator is contaminated with oil or if the generator is contaminated with grease.

**Note:** For more information on drying methods, refer to Special Instructions, SEHS9124, "Cleaning and Drying of Electric Set Generators".

i01473721

## Generator Load - Check

**SMCS Code:** 4450-535-LA

During normal operation, monitor the power factor and monitor generator loading.

When a generator is installed or when a generator is reconnected, ensure that the total current in any one phase does not exceed the nameplate rating. Each phase should carry the same load. This allows the generator to work at the rated capacity. If one phase current exceeds the nameplate amperage, an electrical imbalance will occur. An electrical imbalance can result in an electrical overload and an electrical imbalance can result in overheating.

The power factor can be referred to as the efficiency of the load. This can be expressed as the ratio of kVA to actual kW. The power factor can be calculated by dividing kW by kVA. Power factor is expressed as a decimal. Power factor is used to mean the portion of current that is supplied to a system that is doing useful work. The portion of the current that is not doing useful work is absorbed in maintaining the magnetic field in motors. This current (reactive load) can be maintained without engine power.

Electric sets normally have a low idle setting that is higher than industrial engines. Low idle will be approximately 66 percent of the full speed that is achieved by 60 Hz units. This would be equal to 80 percent of the full speed that is achieved by 50 Hz units.

Some electric sets are equipped with Woodward governors and some electric sets are equipped with Caterpillar electronic governors. These electric sets have no low idle stop. On electric sets with mechanical governors and natural gas electric sets, the low idle is set at the factory. Adjustment of the low idle on these machines should only be done by a Caterpillar dealer.

**Note:** Operating the electric set at low idle speed for an extended time will cause some voltage regulators to shut off. The electric set must be completely shut down and the electric set must be restarted. This will allow the voltage regulator to again produce an output.

i01473730

## Generator Set - Test

SMCS Code: 4450-081

### WARNING

**Personal injury or death can result from high voltage.**

**When power generation equipment must be in operation to make tests and/or adjustments, high voltage and current are present.**

**Improper test equipment can fail and present a high voltage shock hazard to its user.**

**Make sure the testing equipment is designed for and correctly operated for high voltage and current tests being made.**

**When servicing or repairing electric power generation equipment:**

- **Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged DO NOT OPERATE.**
- **Make sure the generator engine is stopped.**
- **Make sure all batteries are disconnected.**
- **Make sure all capacitors are discharged.**

Table 46

Tools Needed		
Part Number	Part	Quantity
6V-7070	Digital Multimeter	1
	12 VDC battery	1
	Potential Transformer	1

The generator set functional test is a simplified test that can be performed in order to determine if the generator is functional. The generator set functional test should be performed on a generator set that is under load.

The generator set functional test determines if the following statements happen:

- A phase voltage is being generated.
- The phase voltages are balanced.

- The phase voltages change relative to engine speed.

The generator set functional test consists of the following steps:

1. Stop the generator. Connect the potential transformer's high voltage winding to the generator terminals (T1) and (T2). Connect the voltmeter to the low voltage winding. If two transformers are available, connect the high voltage winding of the second transformer to the generator terminals (T1) and (T3). Connect the secondary terminals that correspond to generator terminal (T2) of both transformers together.
2. Disconnect wires "F1+" and "F2-" from the voltage regulator. Disconnect the generator from the load.
3. Connect a 12 VDC automotive battery to wires "F1+" and "F2-".

### NOTICE

Do not operate the generator set at a speed that is higher than one-half of the rated speed.

Higher speeds under these test conditions can cause damage to the system.

4. Operate the generator set at half the rated speed.
5. Measure the AC voltage across the low voltage terminals of the transformer that correspond to the following generator terminals: "T1" and "T2", "T2" and "T3", and "T3" and "T1". Record the voltages.
6. Monitor the voltage between any two of the locations in step 5. Decrease the generator set speed by 10 percent. Increase the generator set speed by 10 percent.
7. The voltages that were measured in Step 5 should be nearly equal. These voltages should measure a minimum of 85 VAC.
8. When the generator set speed is decreased by 10 percent, the voltages that were measured in Step 6 should decrease by 10 percent. When the generator set speed is increased by 10 percent, the voltages that were measured in Step 6 should increase by 10 percent.

i01492190

## Generator Set Vibration - Inspect

**SMCS Code:** 4450-040-VI

Check for vibration damage. Vibration may cause the following problems:

- loose fittings
- loose belts
- excessive noise
- cracked insulation

The following areas are susceptible to vibration damage:

- stator output leads
- protective sleeving
- insulation
- exposed electrical connections
- transformers
- fuses
- capacitors
- lightning arrestors

Check the generator set's vibration level by using a vibration analyzer.

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.

## Insulation - Test

**SMCS Code:** 4453-081; 4454-081; 4457-081;  
4470-081

### Recommended Periodic Insulation Tests

#### **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.**

Table 47

Tools Needed		
Part Number	Part Name	Quantity
142-5055	Insulation Testing Gp	1
9U-6003	Insulation Testing Gp	1

Periodically, use an insulation tester to check the insulation resistance of the generator's main stator winding. The frequency of this test is determined by the generator's environment. Previous insulation tester readings will also determine the frequency of this test.

Test the main stator windings with an insulation tester in the following situations:

- The generator set is started for the first time.
- The generator set is removed from storage.
- The generator set is operating in a humid environment. Test every three months.
- The generator set is not protected from the elements in an enclosed area. Test every three months.
- The generator set is installed in an enclosed area. This area needs to be low in humidity and this area needs to have steady temperatures. Test every twelve months (minimum).

- The generator set has not been run under load for three months. Test the generator set weekly. Use space heaters around the generator set if the generator is exposed to a sea water environment or if the humidity is above 75 percent. Also use space heaters if a test result was below 3 megohms.

Space heaters must be used whenever the generator set is not under load. Space heaters must also be used whenever salt is present or whenever high humidity is present. Using a space heater in this fashion is the only way to maintain insulation tester readings above one megohm. Use space heaters only when the generator is not running.

For additional information, refer to Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators".

## Recommended Periodic Insulation Test Procedure

### WARNING

**Personal injury or death can result from electrocution.**

**The megohmmeter is applying a high voltage to the circuit.**

**To avoid electrocution, do not touch the instrument leads without first discharging them. When finished testing also discharge the generator windings.**

1. Take the generator out of service.
2. Visually inspect the generator for moisture. If moisture exists, do not perform this insulation test. Dry the unit first. Refer to Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators".
3. Inspect the installation. Determine the equipment that will be tested by the insulation tester.
4. Discharge the capacitance of the windings.
5. Disconnect "T0" from ground.
6. Disconnect the regulator sensing lead wires: "20", "22", and "24".
7. Connect the insulation tester's RED lead to ground.
8. Connect the insulation tester's BLACK lead to "T0".

9. For units that are 600 volts or less, set the voltage to 500 Volts. For units that are more than 600 volts, set the voltage to 1000 Volts.

#### 10. Use the 30/60 Time Resistance Method:

- a. Apply voltage.
- b. Observe the readings at 30 seconds. Observe the readings at 60 seconds.
- c. Record the 60 second reading. This reading must be corrected for temperature.
- d. Record temperature.
- e. Record humidity.
- f. Remove voltage.

11. Evaluate the readings. The actual value of the resistance may vary greatly between generators. For this reason, the insulation's condition must be evaluated. Base this evaluation on the comparison between the 60 second resistance readings and the readings that were taken on previous dates. These two readings must be taken under similar conditions. If a 60 second resistance reading has a 50 percent reduction from the previous reading, the insulation may have absorbed too much moisture.

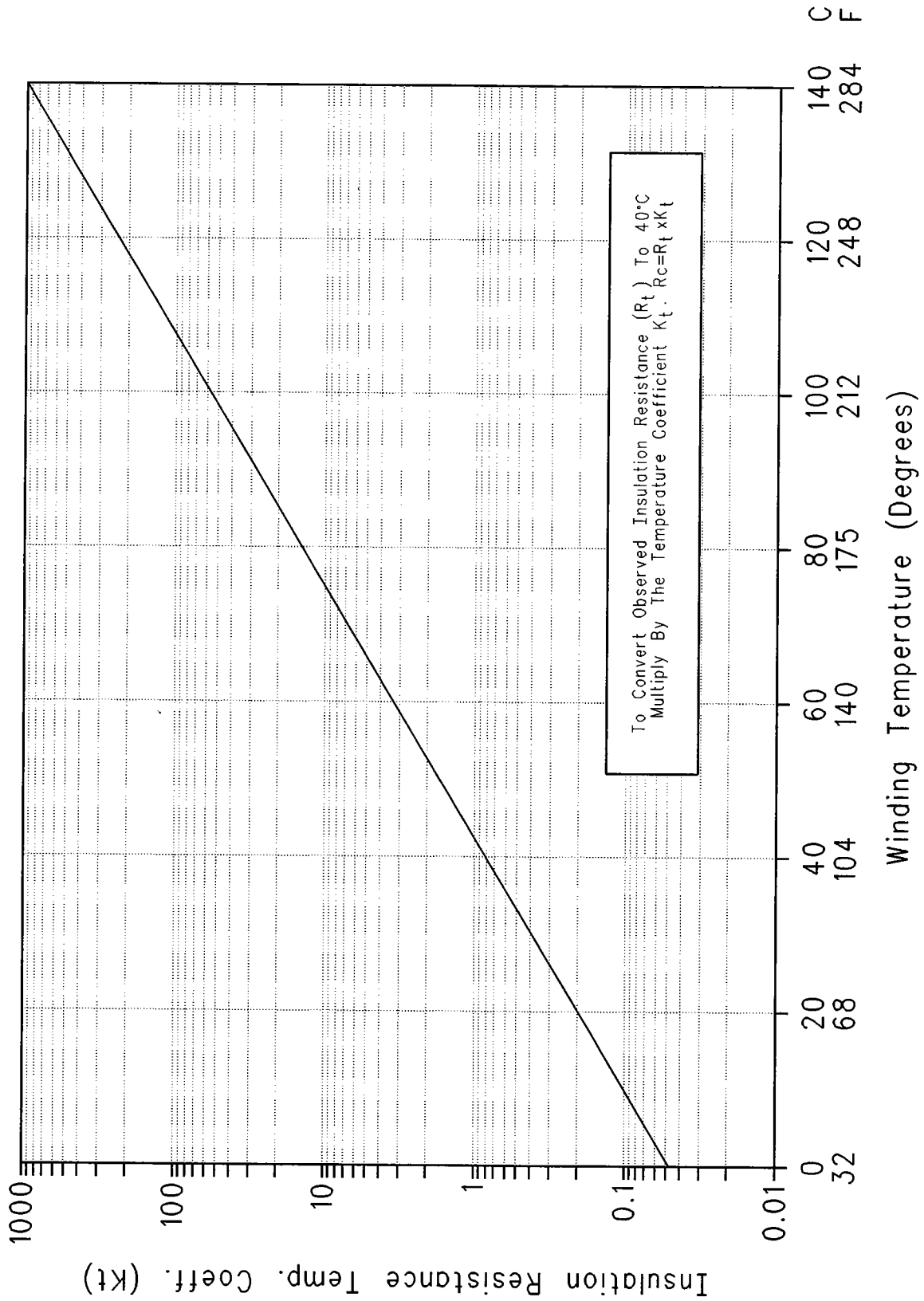
Switch the insulation tester to the "OFF" position. This will discharge the insulation tester's leads. Disconnect the insulation tester's leads.

**Note:** The results from the insulation resistance checks indicate when cleaning and/or repairing is becoming critical. Generally, insulation resistance will vary greatly with temperature. Therefore, always test at the same temperature and humidity. Refer to Illustration 109.

Engine Serial Number \_\_\_\_\_

Generator Serial Number \_\_\_\_\_

Approx. Insulation Resistance Variation  
 with Temperature (IEEE 43-1974)





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).

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## Maintenance Recommendations

**SMCS Code:** 1000

### Service Hours and Fuel Consumption

Table 48

Service Hours and Fuel Consumption for 3508 and 3508B Engines		
Interval	Rated 1301 to 1600 rpm <sup>(1)</sup>	Rated 1601 to 1800 rpm <sup>(1)</sup>
250 Service Hours	27 200 L (7200 US gal) of fuel	32 000 L (8500 US gal) of fuel
500 Service Hours	54 400 L (14,400 US gal) of fuel	64 000 L (17,000 US gal) of fuel
1000 Service Hours	109 000 L (28,800 US gal) of fuel	128 500 L (34,000 US gal) of fuel
2000 Service Hours	218 000 L (57,600 US gal) of fuel	257 000 L (68,000 US gal) of fuel
3000 Service Hours	327 500 L (86,400 US gal) of fuel	386 500 L (102,000 US gal) of fuel
6000 Service Hours	654 000 L (172,800 US gal) of fuel	771 000 L (204,000 US gal) of fuel
Top End Overhaul	9000 Service Hours	7500 Service Hours
	976 000 L (257,500 US gal) of fuel	
Second Top End Overhaul	18,000 Service Hours	15,000 Service Hours
	1 952 000 L (515,660 US gal) of fuel	
Major Overhaul	27,000 Service Hours	22,500 Service Hours
	2 928 000 L (773,490 US gal) of fuel	

<sup>(1)</sup> Fuel consumption is based on a load factor of approximately 60 percent.

Table 49

<b>Service Hours and Fuel Consumption for 3512 and 3512B Engines</b>		
<b>Interval</b>	<b>Rated 1301 to 1600 rpm<sup>(1)</sup></b>	<b>Rated 1601 to 1800 rpm<sup>(1)</sup></b>
250 Service Hours	41 000 L (10,800 US gal) of fuel	48 500 L (12,800 US gal) of fuel
500 Service Hours	82 000 L (21,600 US gal) of fuel	97 000 L (25,600 US gal) of fuel
1000 Service Hours	164 000 L (43,200 US gal) of fuel	194 000 L (51,200 US gal) of fuel
2000 Service Hours	328 000 L (86,400 US gal) of fuel	388 000 L (102,400 US gal) of fuel
3000 Service Hours	491 000 L (129,600 US gal) of fuel	582 000 L (153,600 US gal) of fuel
6000 Service Hours	982 000 L (259,200 US gal) of fuel	1 164 000 L (307,200 US gal) of fuel
Top End Overhaul	9000 Service Hours	7500 Service Hours
	1 460 000 L (385,000 US gal) of fuel	
Second Top End Overhaul	18,000 Service Hours	15,000 Service Hours
	2 920 000 L (771,376 US gal) of fuel	
Major Overhaul	27,000 Service Hours	22,500 Service Hours
	4 380 000 L (1,157,065 US gal) of fuel	

<sup>(1)</sup> Fuel consumption is based on a load factor of approximately 60 percent.

Table 50

<b>Service Hours and Fuel Consumption for 3516 and 3516B Engines</b>		
<b>Interval</b>	<b>Rated 1301 to 1600 rpm<sup>(1)</sup></b>	<b>Rated 1601 to 1800 rpm<sup>(1)</sup></b>
250 Service Hours	53 000 L (14,000 US gal) of fuel	64 500 L (17,000 US gal) of fuel
500 Service Hours	106 000 L (28,000 US gal) of fuel	129 000 L (34,000 US gal) of fuel
1000 Service Hours	212 000 L (56,000 US gal) of fuel	258 000 L (68,000 US gal) of fuel
2000 Service Hours	424 000 L (112,000 US gal) of fuel	516 000 L (136,000 US gal) of fuel
3000 Service Hours	636 700 L (168,000 US gal) of fuel	773 000 L (204,000 US gal) of fuel
6000 Service Hours	1 272 000 L (336,000 US gal) of fuel	1 548 000 L (408,000 US gal) of fuel
Top End Overhaul	9000 Service Hours	7500 Service Hours
	1 942 000 L (512,500 US gal) of fuel	
Second Top End Overhaul	18,000 Service Hours	15,000 Service Hours
	3 884 000 L (1,026,036 US gal) of fuel	
Major Overhaul	27,000 Service Hours	22,500 Service Hours
	5 826 000 L (1,539,054 US gal) of fuel	

<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:** Refer to this Operation and Maintenance Manual, "Cold Weather Operations" topic in the Operation Section, or refer to 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.

### Altitude

Engines are set to operate within a certain altitude. Operating above this altitude can cause engine damage. Adjustments are necessary for operation at higher altitudes.

## Improper Operating Procedures

- Extended operation at low idle
- Minimum cool down periods after high load factor operation
- 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

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## 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 51 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 51

Major Overhaul Service Hours and Fuel Consumption for 3500 Engines <sup>(1)</sup>		
Engine	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
	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 in oil consumption

- An increase in 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:

**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 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.

**Rebuild** – The component can be reconditioned in order to comply with reusability guidelines.

**Replace** – The service life of the part is exhausted. The part may fail before the next maintenance interval. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a CAT remanufactured part, a rebuilt part, or a used part. Some worn components may be exchanged with your Caterpillar dealer for credit on replacement parts. Consult your Caterpillar dealer about repair options for your engine.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Table 52. Your Caterpillar dealer can provide these services and components.

Table 52

Major Overhaul Instructions <sup>(1)</sup>	
Clean	Oil suction screen
Clean Inspect Test	Aftercooler core <sup>(2)</sup>
Inspect	Camshafts
	Cylinder block
	Crankshaft vibration damper
	Driven equipment (alignment)
	Flywheel
	Front gear train (gears)
	Fuel system linkage
Inspect Rebuild	Rear gear train (gears)
	Rocker arms

(continued)

(Table 52, contd)

Major Overhaul Instructions <sup>(1)</sup>	
Inspect Rebuild Replace	Connecting rods
	Cylinder head assemblies
	Fuel priming pump
	Fuel transfer pump
	Oil cooler core
	Piston pins
Inspect Replace	Camshaft lifters
	Camshaft thrust washers
	Crankshaft
	Cylinder liners
	Engine mounts
	Engine wiring harness
	Fuel pressure regulating valve
	Pistons (Crowns and Skirts)
	Push rods
	Spacer plates
Replace	Camshaft bearings
	Connecting rod bearings
	Crankshaft seals
	Crankshaft thrust plates
	Fuel injectors
	Gear train bushings
	Main bearings
	Piston rings
	Seals and bellows for the exhaust manifold
	Seals and gaskets for the air Inlet manifold

(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.

## 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 53 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 53

Top End Overhaul Service Hours and Fuel Consumption for 3500 Engines <sup>(1)</sup>		
Top End Overhaul (First Interval)		
Engine	Rated 1301 To 1600 RPM	Rated 1601 To 1800 RPM
	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)	
Top End Overhaul (Second Interval)		
Engine	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. A few additional components are replaced and serviced.

The top end overhaul (second interval) involves the same service that is performed for the first interval. Because of the number of service hours, some additional components are inspected and/or 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:

**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.

**Rebuild** – The component is reconditioned in order to comply with reusability guidelines.

**Replace** – The service life of the part is exhausted. The part may fail before the next maintenance interval. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a CAT remanufactured part, a rebuilt part, or a used part. Some worn components may be exchanged with your Caterpillar dealer for credit on replacement parts. Consult your Caterpillar dealer about repair options for your engine.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Table 54.

Table 54

Recommendations for Top End Overhauls <sup>(1)</sup>		
Service	Top End Overhaul (First Interval)	Top End Overhaul (Second Interval)
Clean	Oil suction screen	
Clean Inspect Pressure test	Aftercooler core <sup>(2)</sup>	
Inspect	Fuel system linkage	
	-	Connecting rod bearings <sup>(3)</sup>
	-	Cylinder liners <sup>(3)</sup>
	-	Piston crowns and skirts <sup>(3)</sup>
	-	Piston pins <sup>(3)</sup>
Inspect Rebuild	Rocker arms	
	Cylinder head assemblies	
Inspect Rebuild Replace	Fuel priming pump	
	-	Engine oil pump
	-	Fuel transfer pump
	-	Prelube pump
	-	Scavenge oil pump
	-	Camshaft lifters
Inspect Replace	Engine wiring harness	
	Fuel pressure regulating valve	
	Push rods	
	Spacer plates	
	-	Turbochargers
Rebuild Replace	Fuel injectors	
	Gaskets and seals for the air inlet manifold	
	Seals and bellows for the exhaust manifold	

(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) For 3508 and 3512 Engines, inspect ONLY ONE of the components from each cylinder bank. For 3516 Engines, inspect ONLY TWO of the components from each cylinder bank. This inspection will provide adequate examples of the condition of the other corresponding components. If the results are questionable, inspect more of the components.

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## 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 110.

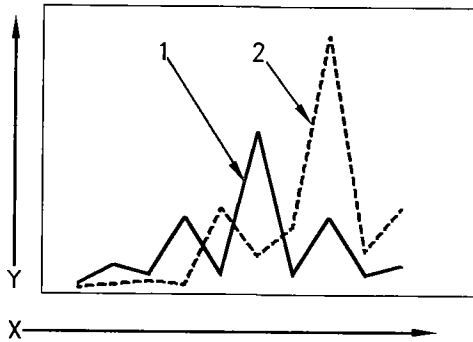


Illustration 110

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(Y) Cost

(X) Time

(!) Cost of maintenance and repair that is planned

(!) Cost of maintenance and repair that is not planned

In Illustration 110, 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 55 in order to estimate the hours until the overhaul. The equation may also be used to estimate overhaul intervals for new engines.

Table 55

Equation For Calculating Overhaul Intervals
$H = F/R$
"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 55.

### 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.

## Power Factor - Check

**SMCS Code:** 4450-535-PWR

The power factor of a system can be determined by a power factor meter or by calculations. The power factor can be calculated by dividing kW by kVA. Power factor is expressed as a decimal.

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## Prelube Pump - Inspect

**SMCS Code:** 1319-040

Inspect the prelube pump for the following conditions:

- Cracks
- Pin holes
- Proper operation
- Wear

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.

If repair or replacement is necessary, see the Service Manual. Consult your Caterpillar dealer for assistance.

## Air Prelube Pump

Inspect all of the components in the air circuit for the prelube pump. Inspect all of the air lines and connections for leaks. Ensure that the components in the air circuit are in good condition.

## Electric Prelube Pump

Inspect the brushes. Replace the brushes, if necessary.

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## 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.

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**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".

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## Rotating Rectifier - Check

SMCS Code: 4465-535

Check the exciter armature. Ensure that the rotating rectifier is tight. If a failure of a rectifier is suspected, refer to Maintenance Procedure, "Rotating Rectifier - Test".

## Rotating Rectifier - Test

SMCS Code: 4465-081

### Testing A Brushless Exciter Rotating Rectifier With An Ohmmeter

Table 56

Tools Needed		
Part Number	Part Name	Quantity
6V-7070	Digital Multimeter	1
9U-7330	Multimeter	1
146-4080	Digital Multimeter (RS-232)	1
7X-1710	Multimeter Probe Group	1

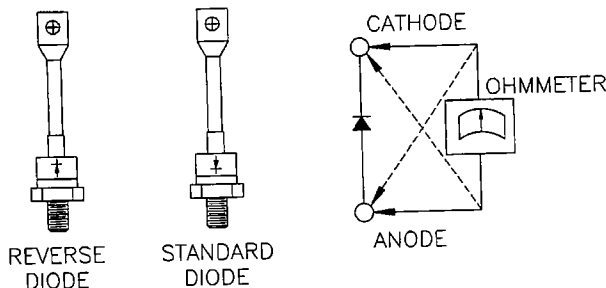


Illustration 111

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If the failure of a rectifier is suspected, use the following procedure.

1. Remove the cover from the exciter.
2. Remove the nut that secures the rectifier to the heat sink.
3. Remove the diode lead.
4. Lift the rectifier from the heat sink.
5. Refer to Illustration 111. Connect the ohmmeter's leads across the rectifier. Note the meter reading.
6. Reverse the ohmmeter leads. Note the meter reading.

The ohmmeter should indicate a low resistance when the ohmmeter leads are across the rectifier in one direction. The ohmmeter should indicate a high resistance when the leads are reversed.

If the ohmmeter indicates a low resistance in both directions, the rectifier is shorted. A high resistance in both directions indicates an open rectifier.

Replace any faulty rectifiers with rectifiers that have comparable operating characteristics. Include the following information when a rectifier is being ordered for replacement:

- Part Number of the rectifier
- Model number of the exciter
- Type of the exciter
- Serial number of the generator

## Testing a Brushless Exciter Rotating Rectifier With A Test Light

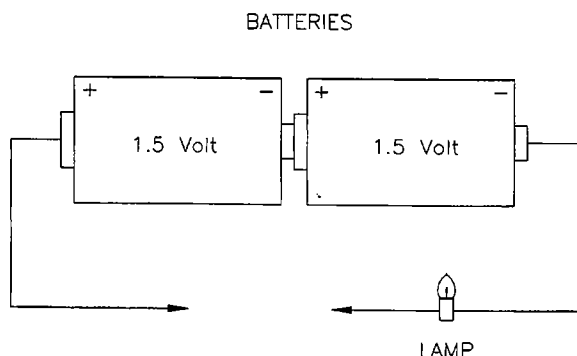


Illustration 112

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### Test Light

If an ohmmeter is not available, a rectifier can be tested by using a test light. A test light consists of two standard flashlight batteries and a flashlight bulb. Refer to Illustration 112.

If the failure of a rectifier is suspected, use the following procedure.

1. Remove the cover from the exciter.
2. Remove the nut that secures the rectifier to the heat sink.
3. Remove the diode lead.
4. Lift the rectifier from the heat sink.

5. Connect the leads of the test light across the rectifier. Notice if the bulb is illuminated.

6. Reverse the leads of the test light across the rectifier. Notice if the bulb is illuminated.

The bulb should be illuminated when the leads of the test light are across the rectifier in one direction. The bulb should not be illuminated when the leads are reversed.

If the bulb is illuminated in both directions, the rectifier is shorted. If the bulb is not illuminated in either direction, the rectifier is open.

Replace any faulty rectifiers with rectifiers that have comparable operating characteristics. Include the following information when a rectifier is being ordered for replacement:

- Part Number of the rectifier
- Model number of the exciter
- Type of the exciter
- Serial number of the generator

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## Space Heater - Check

**SMCS Code:** 4450-535-HTR

An SR4B generator is capable of operating in high humidity conditions without problems. However, problems can occur when the generator is idle and the surrounding air is warmer than the generator. Moisture can form on the windings that will result in poor performance from the windings. Moisture can also result in damage to the windings. Whenever the generator is not active, ensure that the space heaters are in operation.

i01472973

## Speed Sensor - Clean/Inspect

SMCS Code: 1907-040; 1907-070

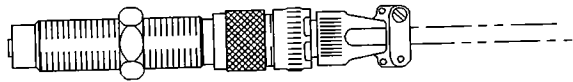


Illustration 113

g00293337

Typical speed sensor

1. Remove the speed sensor from the flywheel housing. Check the condition of the end of the speed sensor. Check for signs of wear and contaminants.
2. Clean the metal shavings and other debris from the face of the magnet.
3. Install the speed sensor according to the information in the Service Manual, "Specifications".

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.

i01218172

## Stator Lead - Check

**SMCS Code:** 4459-535

Visually inspect the following areas for cracking and physical damage:

- stator output leads
- protective sleeving
- insulation

i01218185

## Stator Winding Temperature - Measure/Record

**SMCS Code:** 4453-082-TA

Some SR4B generators are provided with optional 100 Ohm Resistance Temperature Detectors (RTD). If the generator is furnished with Resistance Temperature Detectors, the detectors are installed in the slots of the main armature (stator). The detectors are used with equipment that is provided by the customer. This equipment is used in order to measure the main armature's winding temperature. This equipment is also used in order to monitor the main armature's winding temperature.

i01539769

## Turbocharger - Inspect

**SMCS Code:** 1052-040

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side). Any fumes from the crankcase are filtered through the air inlet system. Therefore, by-products from oil and from combustion can collect in the turbocharger compressor housing. Over time, this buildup can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

### NOTICE

**Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.**

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

**Note:** Turbocharger components require precision clearances. The turbocharger cartridge must be balanced due to high rpm. Severe Service Applications can accelerate component wear. Severe Service Applications require more frequent inspections of the cartridge.

## Removal and Installation

For options regarding the removal, installation, repair and replacement, consult your Caterpillar dealer. Refer to the Service Manual for this engine for the procedure and specifications.

## Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.

2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the compressor wheel and the turbocharger housing, the turbocharger must be reconditioned.

3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.

4. Use a dial indicator to check the end clearance on the shaft. If the measured end play is greater than the Service Manual specifications, the turbocharger should be repaired or replaced. An end play measurement that is less than the minimum Service Manual specifications could indicate carbon buildup on the turbine wheel. The turbocharger should be disassembled for cleaning and for inspection if the measured end play is less than the minimum Service Manual specifications.

5. Inspect the bore of the turbine housing for corrosion.

6. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.

7. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

## Varistor - Test

SMCS Code: 4466-081

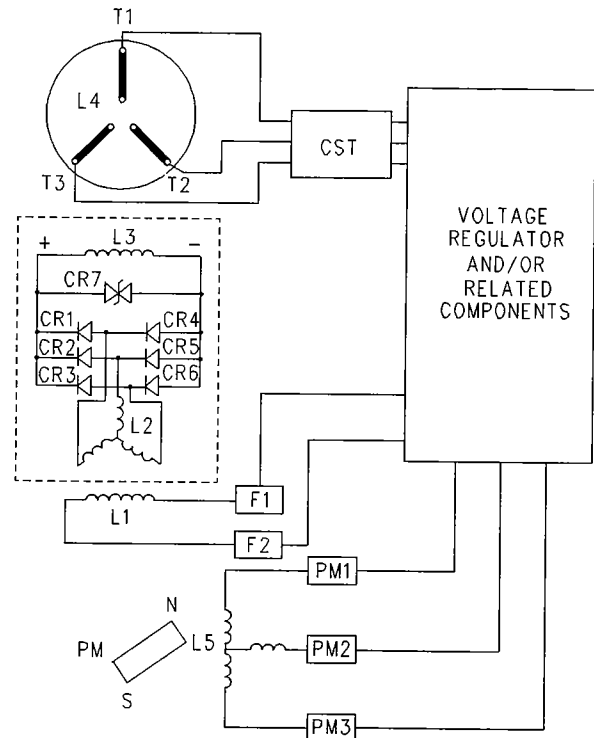


Illustration 114

g00677004

### PMPE Generator Wiring Diagram

- (CR1-CR6) Diodes
- (CR7) Varistor
- (L1) Exciter field (stator)
- (L2) Exciter armature (rotor)
- (L3) Main field (rotor)
- (L4) Main armature (stator)
- (L5) Pilot exciter armature
- (PM) Permanent magnet
- (RFA) Rotating field assembly
- (CST) Customer supplied transformer

## Ohmmeter

An ohmmeter can be used to check a varistor (CR7). Place an ohmmeter across the varistor. The resistance should be a minimum of 15000 ohms. If the resistance is less than 15000 ohms, the varistor is faulty.



## Test Light

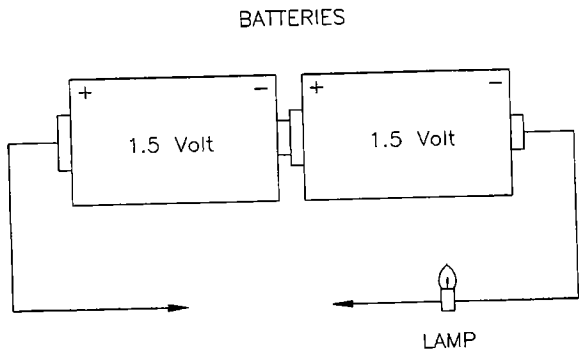


Illustration 115  
Test Light

g00555113

Refer to the test light that is shown in Illustration 115. Follow these steps in order to test the varistor:

1. Disconnect either lead of the varistor (CR7).
2. Place the test light across the varistor.
3. Observe the results. The lamp should not light.
4. Reverse the test light.
5. Observe the results. The lamp should not light.

If the test light illuminates in either direction, there is a short in the varistor. Replace any faulty varistors with varistors that have comparable operating characteristics. Include the following information when a varistor is being ordered for replacement:

- Part number of the varistor
- Serial number of the generator

After the varistor has been replaced, verify that the strapping of the field winding lead is securely wound on the shaft. Also, verify that the strapping of the field winding lead is securely tied.

i01189996

## Voltage and Frequency - Check

**SMCS Code:** 4450-535-EL

Check for proper voltage and frequency setting.  
Check for stability.

Refer to the generator set Serial Plate for correct voltage and frequency.

## Walk-Around Inspection

**SMCS Code:** 1000-040

### **WARNING**

**Personal injury or death can result from improper troubleshooting and repair procedures.**

**The following troubleshooting and repair procedures should only be performed by qualified personnel familiar with this equipment.**

Refer to Safety Section, "Generator Isolating for Maintenance" for information regarding the procedure to safely isolate the generator.

A visual inspection should be initially directed at the areas that are most prone to damage and deterioration. The most prone areas to damage and deterioration are listed below:

- **Ground Insulation.** Ground insulation is insulation that is intended to isolate components that are carrying current from components that are not carrying current.
- **Support Insulation.** Support insulation is usually made from one of the following items: a compressed lamination of fibrous materials, polyester, or felt pads that have been impregnated with various types of bonding agents.

There are many different types of damage that can occur in these areas. Several of the different types of damage are listed below:

**Thermal Aging** – Thermal aging can cause the degradation of insulation or the deterioration of insulation. An examination of the coils may reveal that the insulation has expanded into the ventilation ducts. This is the result of a loss of bond which will cause the insulation material to separate. The insulation material could also separate from the conductors on the windings.

**Abrasion** – The surfaces of coils and the surfaces of connectors may be damaged by abrasion. These surfaces may also be damaged by contamination from other sources. An example of these sources would be chemicals or abrasive substances.

**Cracking** – Cracking of insulation may result from mechanical stress. The structure that is used to brace the stator winding will become loose if the problem is not corrected. Further mechanical damage or electrical damage may also result.

**Erosion** – Erosion can be caused when foreign substances rub against the insulation that is on the surface of the coil .

## Inspect the Engine for Leaks and for Loose Connections

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

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

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

---

### NOTICE

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

---

### NOTICE

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

---

- Ensure that cooling lines are properly clamped. Check for leaks. Check the condition of all pipes.
- Inspect the water pump for coolant leaks.

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

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

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.

- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Inspect the alternator belt and the accessory drive belts for cracks, breaks or other damage.

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

- Drain the water and the sediment from fuel tanks on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Inspect the engine-to-frame ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauges that can not be calibrated.

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.

i01492564

## Winding - Test

SMCS Code: 4453-081; 4454-081; 4457-081;  
4470-081

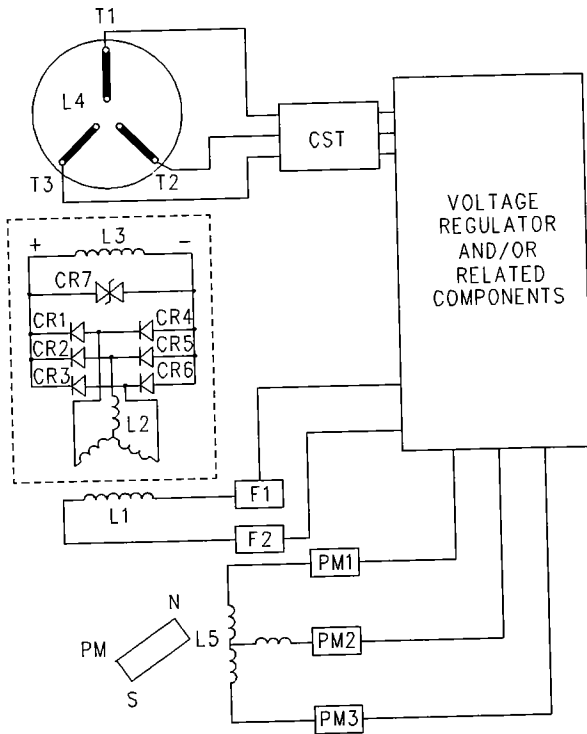


Illustration 116

### PMPE Generator Wiring Diagram

- (CR1-CR6) Diodes
- (CR7) Varistor
- (L1) Exciter field (stator)
- (L2) Exciter armature (rotor)
- (L3) Main field (rotor)
- (L4) Main armature (stator)
- (L5) Pilot exciter armature
- (PM) Permanent magnet
- (RFA) Rotating field assembly
- (CST) Customer supplied transformer

g00677004

Table 57

Tools Needed		
Part Number	Part <sup>(1)</sup>	Quantity
6V-7070	Digital Multimeter	1
146-4080	Digital Multimeter (RS232)	1

(1) Only one multimeter is necessary for this test. Either of the multimeters that are shown will work.

Measure the resistance of the following windings: (L1), (L2), (L3), (L4), and (L5). The winding that is being tested must be disconnected from the other components before the resistance can be measured. The following resistance measurements are approximations. If the measured value is not near the listed approximation, the winding is probably damaged. For a more precise resistance value, consult the Technical Marketing Information (TMI). Refer to the generator arrangement that is in question.

**Note:** The winding temperature affects the resistance. When the winding temperature increases, the winding resistance also increases. When the winding temperature decreases, the winding resistance also decreases. Therefore, a correct measurement can be performed only when the winding is at room temperature.

The following armature windings have very little resistance: (L2), (L4), and (L5). The resistance of these windings will measure near 0 ohms. Use a milliohmmeter to measure the resistance of the armature windings.

**Exciter Armature (Rotor) (L2)** – less than 0.1 ohm

**Main armature (Stator) (L4)** – less than 0.1 ohm

**Pilot Exciter Armature (L5)** – less than 0.1 ohm

Use a multimeter in order to measure the resistance of field windings (L1) and (L3).

**Exciter Field (Stator) (L1)** – approximately 3.0 ohms to 6.0 ohms

**Main Field (Rotor) (L3)** – approximately 0.75 ohms to 2.0 ohms

**Note:** There should be no continuity between any winding and ground. There should be no continuity between any winding and another winding.

i01428955

## 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.

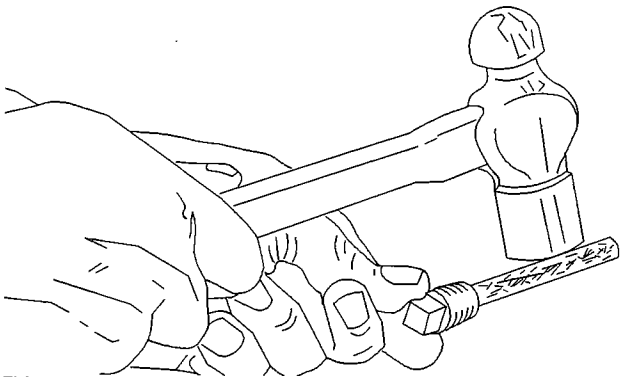


Illustration 117

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.

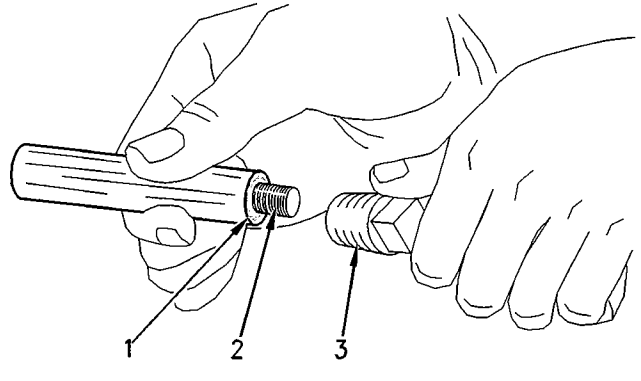


Illustration 118

g00748510

- (1) Shoulder
- (2) Threads
- (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

i00715039

## Engine Ratings

i00727327

### Engine Rating Conditions

**SMCS Code:** 1000

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

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

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

The engine ratings are based on the following fuel specifications:

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

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

## Engine Rating Definitions

**SMCS Code:** 1000

The 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.

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## Customer Service

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## Customer Assistance

**SMCS Code:** 1000; 4450

### 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.

Latin America, Mexico, Caribbean  
Caterpillar Americas Co.  
701 Waterford Way, Suite 200  
Miami, FL 33126  
USA  
Phone: 305-476-6876  
Fax: 305-476-6850

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

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## Ordering Replacement Parts

SMCS Code: 4450; 7567

### **WARNING**

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

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

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

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

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

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

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

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## Reference Materials

- Owner's receipts
- Maintenance log

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## Maintenance Records

**SMCS Code:** 1000; 4450

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

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

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

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

Records should be kept for the following items:

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

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

**Documents** – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs



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## Reference Material

**SMCS Code:** 1000; 4450

### Lubricants

- Special Publication, PEHP8038, "Data Sheet - Caterpillar Diesel Engine Oils (DEO) (CG-4 and CF-4) (North America and selected International)"
- Special Publication, PEHP9536, "Data Sheet - Caterpillar Diesel Engine Oil (DEO) (CF-4) (International only)"
- Special Publication, NEDG6022, "Data Sheet - Multipurpose Lithium Complex Grease (MPG)"
- Special Publication, PEHP0002, "Data Sheet - Multipurpose Lithium Complex Grease with Molybdenum (MPGM)"
- Special Publication, NEHP6015, "Data Sheet - Special Purpose Grease (SPG) Bearing Lubricant"
- Special Publication, PECP6026, "One Safe Source"
- Special Publication, SEBD0640, "Oil and Your Engine"
- Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations"
- Special Publication, PEDP7036, "S·O·S Fluid Analysis"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"

### Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

### Coolants

- Special Publication, PEHP4036, "Data Sheet - Caterpillar Coolant"
- Special Publication, PECP6026, "One Safe Source"
- Special Publication, SEBD0518, "Knowing Your Cooling System"
- Special Publication, SEBD0970, "Coolant and Your Engine"

- Special Publication, PEDP7036, "S·O·S Fluid Analysis"
- Special Publication, PEHP7057, "Data Sheet - Coolant Analysis"

### Miscellaneous

- Service Manual Module, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)"
- Service Manual Module, RENR1261, "Electronic Modular Control Panel II (EMCP II) For MUI Engines"
- Service Manual, RENR4960, "3500 Generator Sets"
- Specifications, SENR3130, "Torque Specifications"
- Special Publication, SEHS7654, "Alignment - General Instructions"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"
- Special Publication, SEBF8062, "Guideline for Reusable Parts - Cleaning and Inspection of Air Filters"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"
- Special Instruction, SEHS7259, "Alignment of Single Bearing Generators"
- Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators"
- Special Instruction, SMHS7001, "Assembly of Fan Drive Pulley Assemblies"
- Special Instruction, SEHS7768, "Use of 6V-2150 Starting/Charging Analyzer"
- Special Instruction, SEHS7633, "Battery Test Procedure"
- Special Instruction, SEHS8622, "Using the FT-1984 Air-To-Air Aftercooler Leak Test Group"
- Special Instruction, SEHS7332, "Do Not Operate Tag"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide"

- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"

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## Additional Reference Material

**SMCS Code:** 1000; 4450

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 Associaton  
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 Couseil 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

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## 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.

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## 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.

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## Symbols

SMCS Code: 1000; 4450; 4480; 4490

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	WARNING		OIL FILTER		LOW FUEL LEVEL		LOW COOLANT TEMP		ENGINE INTAKE AIR DAMPER CLOSED
	DO NOT LIFT		OIL PRESSURE		FUEL FILTER		LOW COOLANT LEVEL		SYSTEM BATTERY VOLTAGE
	LIFTING		LOW OIL PRESSURE		DIESEL FUEL		ENGINE COOLANT FILL		LOW BATTERY VOLTAGE
	LAMP TEST		LOW OIL LEVEL		DIESEL FUEL FILL		COOLANT DRAIN		BATTERY CHARGER MALFUNCTION
	PANEL ILLUMINATION LIGHT		OIL DRAIN		COOLANT TEMPERATURE		COOLANT FILTER		ADJUSTABLE LOW-HIGH
	AC VOLTS		EMERGENCY STOP		HIGH COOLANT TEMP		REVERSE POWER		ALARM

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	ALARM SILENCE		SERVICE HOURS		SYSTEM AUTO ENGINE START		HOT SURFACE
	RAISE		STARTING AID - ETHER		OVERSPEED		NO SERVICE READ MANUAL
	LOWER		AUTOMATIC		FAIL TO START, OVERCRANK		ENGINE COOLANT PRESSURE HOT SURFACE
	OIL		MANUAL		AMMETER VOLTMETER PHASE SELECTOR SWITCH		
	OFF		SYSTEM NOT IN AUTOMATIC START MODE		GENERATOR SYNCHRONIZING INDICATOR		
	ENGINE STOP		ENGINE RPM, ENGINE START, OR ENGINE RUN		HIGH VOLTAGE		

144-0840

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Illustration 119

The control panel and modules utilize International Graphic Symbols to identify functions. A typical list of the symbols that are used is shown above.

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## Glossary

SMCS Code: 4450

**Actuate** – Actuation relates to putting something in motion.

**Alternating Current (AC)** – Alternating Current is an electric current that reverses direction at regular intervals (50 times per second in 50 Hz or 60 times per second in 60 Hz).

**Anode** – An anode is the positive end of a diode or an anode is the positive end of a rectifier.

**Blocking Rectifier** – A blocking rectifier permits direct current flow in only one direction.

**Bolted** – A bolted device uses a bolt to hold two or more parts together.

**Bridge** – A bridge is a circuit that is used to measure small quantities of current, voltage, or resistance.

**Bridge Rectifier** – A bridge rectifier is a circuit that is used to change alternating current (AC) to direct current (DC).

**Buildup** – A buildup is a gradual increase in voltage.

**Cathode** – A cathode is the negative end of a diode or a cathode is the negative end of a rectifier.

**Capacitance** – Capacitance is the ability to store an electrical charge.

**Capacitor** – A capacitor is a device that will store an electrical charge.

**Circuit Breaker** – A circuit breaker is an automatic switch that is used to open a circuit.

**Circulating Current** – Circulating current is the flow of current between two or more generators that are working in parallel. Circulating current is also the flow of current between two or more generators that are parallel with a utility line.

**Conduct** – Conducting relates to allowing the flow of current.

**Constant Voltage Regulation** – Constant Voltage Regulation is one of the two methods of voltage regulation. In order to maintain the line voltage, Constant voltage regulators allow the field to be forced to the saturation point. This allows the engine to be overloaded. On large block load applications, the engine may not recover.

**Continuity** – Continuity provides a path for current flow.

**Control** – A control is a device that controls another device. A control is also a circuit that controls a device.

**Cross Current Compensation** – Cross current compensation is a method that is used for reactive power equalization.

**Current Transformer (CT)** – A current transformer is used to step down higher line current.

**Direct Current (DC)** – Direct current is current flow that moves in only one direction in a given circuit.

**Damping** – Damping refers to decreasing the amplitude of a signal.

**De-energized** – A de-energized input refers to stopping the current that is going to a component.

**Distribution Winding** – Distribution windings go from one end of the core to the other end of the core. These windings are arranged in groups that are located in several slots.

**Droop** – Droop refers to a decrease.

**Excitation** – Excitation is controlled direct current (DC) that is used to make a magnetic field.

**Energized** – An energized input refers to activating a device.

**Electrostatic Charge** – Electrostatic charge is electricity that is caused by induced voltage and stored charge.

**Exciter** – An exciter supplies direct current (DC) to the field windings of the generator.

**Field** – A field is a magnetic line of force that surrounds a conductor. This force is caused by current flow in the conductor.

**Field Windings** – Field windings are many turns of wire that are wrapped around an iron core. When direct current (DC) flows through the field windings, a magnetic field is produced. This magnetic field is comparable to the magnetic field of a bar magnet.

**Flashing** – Flashing is a process of putting direct current from an external source into the field windings. This process causes the generator to produce an output voltage.

**Flux** – Flux is magnetic lines of force.

**Frequency** – Frequency is the number of cycles that are completed in a one second period. The unit of frequency is the Hertz (Hz). One hertz is equal to one cycle per second.

**Full-Wave Rectifier** – A full-wave rectifier changes the positive phase and the negative phase of alternating current to direct current.

**Gain** – Gain relates to the ratio of input magnitude to output magnitude.

**Gate** – A gate is an electronic part of a controlled rectifier (thyristor).

**Generate** – The production of electricity.

**Grounded** – A device is grounded by making a connection to ground. A device could also be grounded by making a connection to a component that is connected to ground.

**Hertz (Hz)** – Hertz is the unit of measurement for frequency. One hertz is equal to one cycle per second.

**Humidity** – Humidity is the water content that is present in the air.

**Impedance** – Impedance is the resistance to alternating current.

**Impulse Modulation** – Impulse modulation changes the following characteristics of a wave: amplitude, frequency, and phase. This is accomplished by impressing one wave on another wave that has constant properties.

**Induce** – This refers to the transfer of power from one device to another device. The transfer is done via a magnetic field or via an electric field.

**Interference** – Interference is an unwanted mixture of electrical signals. Interference is usually associated with electrical noise.

**Instrumentation** – Instrumentation is a group of instruments that are used for measuring a system function.

**Insulated** – An insulated device is a device that is covered with a nonconductive material.

**kVA** – This is the abbreviation for Kilovolt Amperes. kVA is a term that is used when electrical devices are rated. In order to calculate a device's kVA rating, multiply the rated output (amperes) by the rated operating voltage.

**KVAR** – Kilovolt Amperes Reactive is abbreviated as KVAR. KVAR is associated with the reactive power that flows in a power system. Reactive power does not load the generator set's engine. Reactive power will cause thermal loss in the generator.

**KVAR Regulation** – KVAR Regulation is one of the two methods that are used to regulate the reactive power output. Regardless of the generator's real power output, the voltage regulator causes the generator to produce a constant value of KVAR. In this case, the generator's power factor will change when the generator's real power output changes. KVAR regulation is used when the generator is connected in parallel with an infinite bus (utility) and it is not possible to change the system voltage.

**Kilowatts (kW)** – Kilowatt is the electrical rating of the generator. One kilowatt equals 1000 watts. Actual power is measured in kilowatts.

**Lead** – A lead is a wire.

**Line Voltage** – Line voltage is the output voltage of the generator that is measured between the generator leads (phases).

**Lock In** – Lock in occurs when a contact closes in order to keep a device in an energized state.

**Lock Out** – Lockout occurs when a contact opens in order to keep a device in a de-energized state.

**Magnetic** – A magnetic device is a device that has the characteristics of a magnet.

**Magnification** – Magnification refers to the enlargement of an item.

**Module** – A module is an assembly of electronic components and electronic circuits.

**Moisture** – Moisture is the presence of water.

**Oscillation** – Oscillation is the flow of electricity that periodically changes direction and/or magnitude.

**Permanent Magnet (PM)** – A permanent magnet supplies the initial magnetism that is required to start a PMPE generator.

**Permanent magnet pilot excited (PMPE)** – A PMPE generator receives power for the voltage regulator from a pilot exciter. A PMPE generator consists of a permanent magnet and a pilot exciter.

**PF Regulation** – PF Regulation is one of the two ways to regulate the reactive power output. PF regulation is used when the generator is connected in parallel with an infinite bus (utility) and it is not possible to control the system voltage.

**Phase Winding** – A phase winding is a group of generator stator coils. Electric power for one phase of the load is induced in the phase winding.

**Polarity** – Polarity is the positive characteristics or the negative characteristics of two poles.

**Power Factor (PF)** – Power factor is the ratio of apparent power (kVA) to total power (kW). The power factor represents the portion of the current that is doing useful work. Power factor is expressed as a decimal number between 0 and 1.

**Pulsating** – Pulsating relates to the characteristics of current that are similar to mechanical vibration.

**Radio Suppression** – Radio suppression reduces the amplitude of radio frequency interference.

**Reactive Droop Compensation** – Reactive Droop Compensation is one of the two methods that are used for reactive power equalization. In reactive droop compensation, the voltage regulator causes an individual generator output to change in proportion to the reactive current. This reactive current is measured with a current transformer.

**Reactive Power** – Reactive power flows back and forth between the inductive windings of the generator. These windings are part of the electrical load. The reactive power does not perform any useful work in the electrical load. The reactive power only applies load to the generator. This limits the generator's capacity.

**Reciprocating** – Reciprocating motion is motion that first moves in a straight line in one direction. The direction of this motion then varies by 180 degrees.

**Rectifier** – A rectifier is a diode circuit that converts alternating current (AC) to direct current (DC).

**Regenerative Power** – Regenerative power works against primary power.

**Reset** – A reset returns a switch to a ready condition. In addition, a reset returns a circuit to a ready condition.

**Residual Magnetism** – Residual magnetism is a small amount of magnetism that is remaining in a device after excitation is removed.

**RFA** – An RFA is a rotating field assembly.

**Rotating Rectifier** – A rotating rectifier is mounted to a plate on a generator shaft. This plate then rotates with the generator shaft.

**Rotor** – A rotor is the rotating windings of a generator.

**Saturable Reactor** – A saturable reactor has characteristics that are similar to a valve. As the load changes, a valve opens in order to give more current to the output or a valve closes in order to give less current to the output.

**Saturated** – A device has been saturated when the device has been magnetized in excess. When saturation occurs, a large increase in current results in a small increase in magnetic force.

**SCR** – An SCR is a silicon controlled rectifier. An SCR is a semiconductor.

**SE** – An SE generator is a self-excited generator. An SE generator uses a small part of the generator output to provide excitation current back to the generator. An SE generator uses residual magnetic field for start-up.

**Semiconductor** – A semiconductor is a component such as one of the following components: a transistor, a diode, and a thyristor. Semiconductors have electrical characteristics that are between a conductor and insulation.

**Series Boost** – A series boost is an attachment that allows generator output to continue for a short time during a line failure. This allows the circuit breaker to trip in sequence.

**Short** – A short is an undesired electrical connection that exists between two or more components.

**Shutdown** – A shutdown occurs when the engine is stopped. This shutdown can occur manually or this shutdown can occur automatically.

**Simultaneous** – A simultaneous occurrence refers to two actions that happen at the same time.

**Solid-State** – A solid-state component is an electrical component that has no moving parts.

**Stator** – A stator is the windings of a generator that do not rotate.

**Surge** – A surge is a sudden increase in voltage or current.

**Tap** – A tap is a connection at the midpoint of a circuit. From this tap, power is taken from the circuit.

**Transfer** – A transfer refers to moving something from one point to another point. A transfer also refers to converting something from one state to another state.

**Transient Peak Voltage** – A transient peak voltage is a high voltage condition of limited duration.

**Turn-on** – When a device is turned on, the device is activated or the device is started.

**Varistor** – A varistor is a device that loses resistance as voltage increases.

**Voltage Droop Resistor** – A voltage droop resistor is a variable resistor. This resistor is used to control the change of voltage. This can occur when a generator is paralleled with another generator. This can also occur when the generator is paralleled with a utility.

**Voltage Level Rheostat** – A voltage level rheostat gives a range of control that is used when the voltage output level is adjusted.

**Voltage Regulator** – A voltage regulator is a circuit that senses the generator's output voltage. The field coil current is automatically adjusted in order to maintain the desired output.

**Voltage Spike** – A voltage spike is a brief high voltage.

**Volts per Hertz Regulation** – Under block loading conditions, the Volts per Hertz Regulation provides fast recovery. This regulation maintains close voltage control over the normal load range. This regulation also produces a rapid response of the generator set. This control is maintained by matching the generator output to the engine performance.

**Windings** – Windings are layers of wire on a core.

**Wiring** – Wiring relates to the wires of a circuit.

**Wound** – Wound refers to being circled.



# Tools

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## Tools

SMCS Code: 1000

Table 59

Part Number	Tool	Description
<b>TEST EQUIPMENT</b>		
8T-0900	Clamp-on Ammeter	Clamp-on, 0 to 500 Amp range, AC and DC
155-5175	Clamp-on Ammeter	AC current probe, 0 to 1000 Amp with 146-4080 multimeter
146-4080	Multimeter	Digital, RS-232 output, true RMS, used for measuring voltage, current, and resistance
9U-7330	Multimeter	Digital, for measuring voltage, current, and resistance
6V-7070	Multimeter	Digital, heavy-duty, used for measuring voltage, current, and resistance
7X-1710	Probe Group	Used with Digital Multimeter
4C-6500	Digital Thermometer	For measuring temperature in degrees Celsius
142-5055	Megohmmeter	For measuring insulation resistance
1H-3110	Exciter/Bearing Puller	For changing the bearings and exciter armature
1H-3107	Exciter/Bearing Puller	For changing the bearings and exciter armature
<b>SPECIAL TOOLS</b>		
N/A	Resistive Bridge	For measuring resistance of windings
N/A	Protective Gloves	Electrical, rubber, 13,800 V
<b>STANDARD TOOLS</b>		
6V-3001	Crimping Tool	For crimping Sure Seal connectors
8S-1075	Crimping Tool	Heavy duty crimping and stripping
1U-5804	Crimping Tool	For crimping Deutsch connectors
1U-7322	Flashlight	As required
8F-9866	Grease gun	For lubricating bearings
1S-0258	Hammer	Soft-faced
4C-6477	Lamp, fluorescent	Safety light
1U-7230	Screwdrivers	Both phillips and standard; sized as required
1U-7248	Wrench	Adjustable, 12 inch
8T-9293	Wrench	Torque, 40 to 250 ft-lb, 1/2 inch drive
1U-7460	Wrench set	Allen, 1/8 to 1/2 inch
1U-7160	Socket set	Nine piece, 3/8 to 7/8 inch with 3/8 inch drive
1U-8030	Socket set	Twelve piece, 7/16 to 1 1/8 inch with 1/2 inch drive
1U-7830	Socket set	Twelve piece, 8 to 19 mm with 3/8 inch drive
1U-7880	Socket set	Ten piece, 16 to 26 mm with 1/2 inch drive
1U-7050	Wrench set	Thirteen piece, open-end combination sized 1/4 to 1 inch (standard)

(continued)

(Table 59, contd)

<b>Part Number</b>	<b>Tool</b>	<b>Description</b>
N/A	Vacuum	Electric with nonmetallic nozzle
		<b>MATERIALS</b>
1U-8809	Corrosion inhibitor	Rust preventative
1U-8803	Detergent	As required for cleaning, Hydrosolv 67
4C-5522	Gloves	For chemical protection
N/A	Plastic	Protection for long-term storage
N/A	Rags	As required
N/A	Water	For cleaning
N/A	Air	Compressed, dry
N/A	Covering material	Waterproof desiccant bags, for protection from moisture during long-term equipment storage
SEHS7332	"DO NOT OPERATE" Tags	For providing visual warnings and cautions

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# Product and Dealer Information

**Note:** For product identification plate locations, see the section "Product Identification Information" in the Operation and Maintenance Manual.

**Delivery Date:** \_\_\_\_\_

## Product Information

Model: \_\_\_\_\_

Product Identification Number: \_\_\_\_\_

Engine Serial Number: \_\_\_\_\_

Transmission Serial Number: \_\_\_\_\_

Generator Serial Number: \_\_\_\_\_

Attachment Serial Numbers: \_\_\_\_\_

Attachment Information: \_\_\_\_\_

Customer Equipment Number: \_\_\_\_\_

Dealer Equipment Number: \_\_\_\_\_

## Dealer Information

Name: \_\_\_\_\_ Branch: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Dealer Contact

Phone Number

Hours

Sales: \_\_\_\_\_

Parts: \_\_\_\_\_

Service: \_\_\_\_\_

