



# Operation and Maintenance Manual

---

## **3500C Generator Sets**

---

SBF1-Up (Generator Set)  
SBG1-Up (Generator Set)  
SBJ1-Up (Generator Set)  
SBM1-Up (Generator Set)  
RMS1-Up (Generator Set)

## Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

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

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

A non-exhaustive list of operations that may cause product damage are identified by "NOTICE" labels on the product and in this publication.

**Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. If a tool, procedure, work method or operating technique that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.**

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



**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.**

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

## Table of Contents

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

### Safety Section

Safety Messages .....	6
General Hazard Information .....	10
Burn Prevention .....	13
Fire Prevention and Explosion Prevention .....	13
Crushing Prevention and Cutting Prevention .....	15
Mounting and Dismounting .....	16
Sound Information .....	16
Before Starting Engine .....	16
Engine Starting .....	17
Engine Stopping .....	17
Electrical System .....	17
Generator Isolating for Maintenance .....	18

### Product Information Section

Model Views and Specifications .....	19
Product Identification Information .....	22

### Operation Section

Lifting and Storage .....	30
Installation .....	32
Features and Controls .....	33
Engine Diagnostics .....	38
Engine Starting .....	47
Engine Operation .....	52
Engine Stopping .....	54
Cold Weather Operation .....	56
Generator Operation .....	58
Voltage Regulators .....	66

### Maintenance Section

Refill Capacities .....	68
Maintenance Recommendations .....	71
Maintenance Interval Schedule (Standby) .....	78
Maintenance Interval Schedule (Prime Power) ....	80

### Reference Information Section

Engine Ratings .....	150
Customer Service .....	152
Reference Materials .....	154

### Index Section

Index .....	162
-------------	-----

## 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

i02399027

## Safety Messages

SMCS Code: 1000; 7405

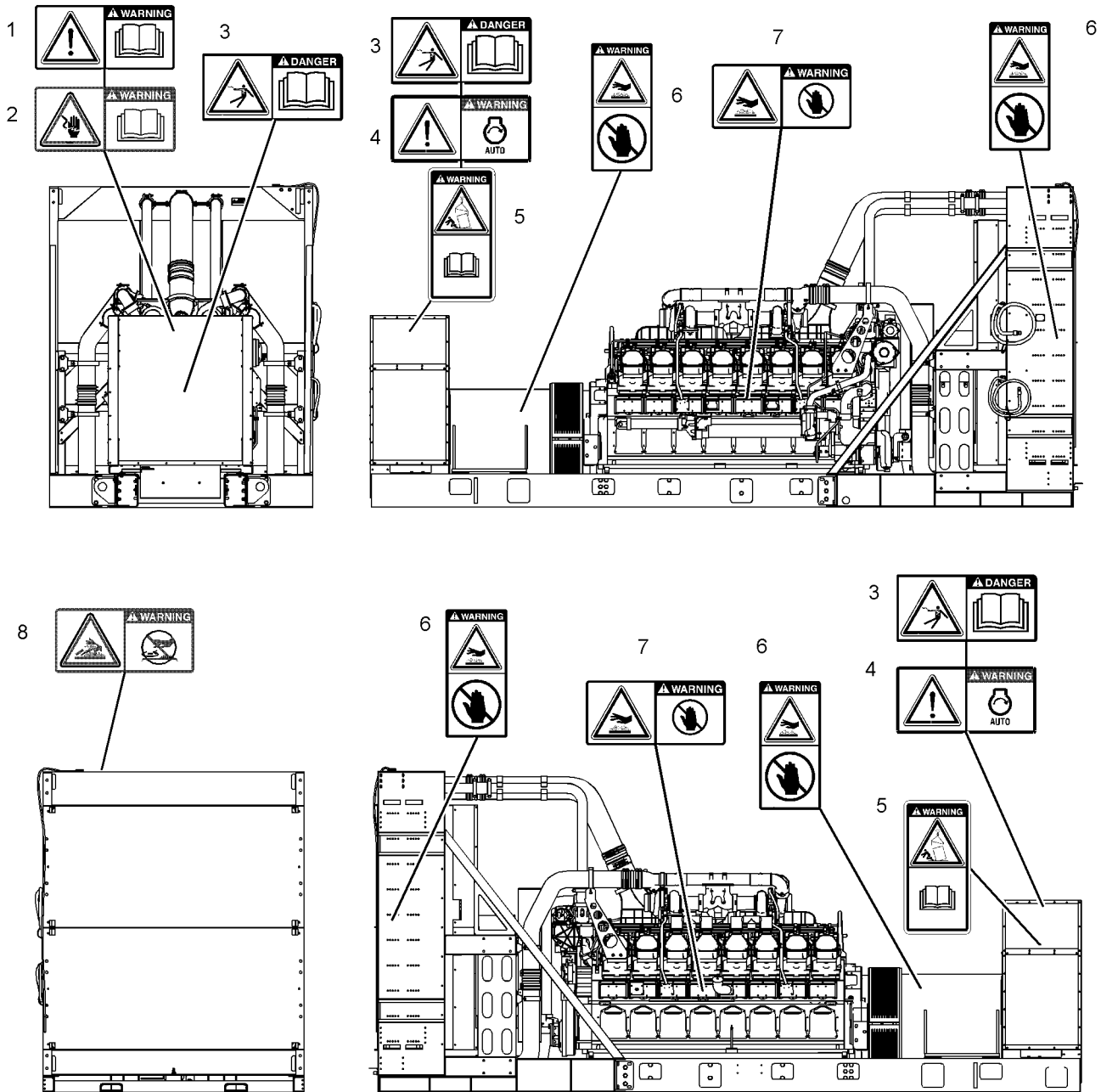


Illustration 1

g01199723

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

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

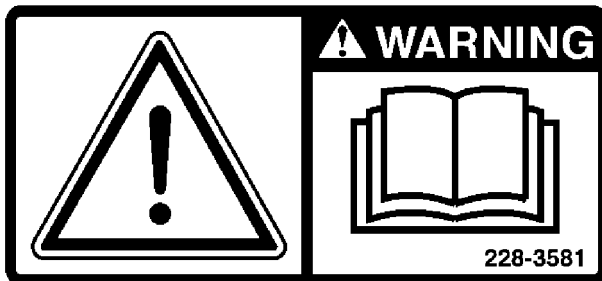
Replace any safety message that is damaged or missing. If a safety message is attached to a part of the engine that is replaced, install a new safety message on the replacement part. Your Caterpillar dealer can provide new safety messages.

### **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.

## Universal Warning (1)

One of these safety messages is located on each side of the terminal box.



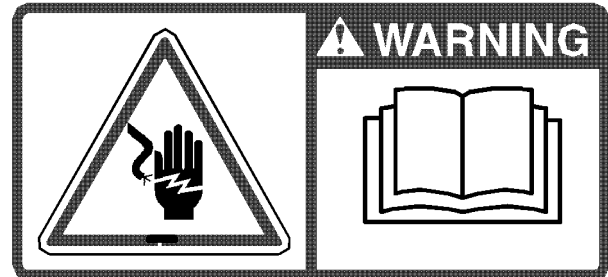
g00934493

### **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.

## Electrical Shock (2)

The safety message for electrical shock is located on the rear of the generator.



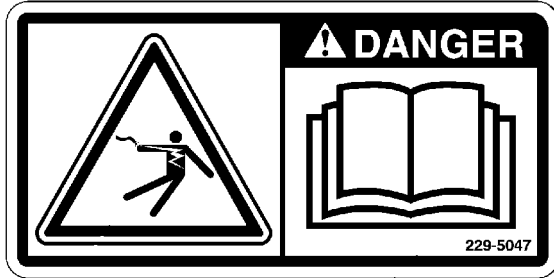
g01120247

### **WARNING**

**WARNING! Shock/Electrocution Hazard! Read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could cause serious injury or death.**

### Electrocution (3)

The safety message for electrocution is located on the sides and the rear of the generator and on the control panel.



g00928349



Do not connect the 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 the main distribution switch, or if the connection is permanent, install a double throw 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 for the applicable circumstances.

### Automatic Starting (4)

The safety message for automatic starting is located on the sides of the terminal box.



g01164281

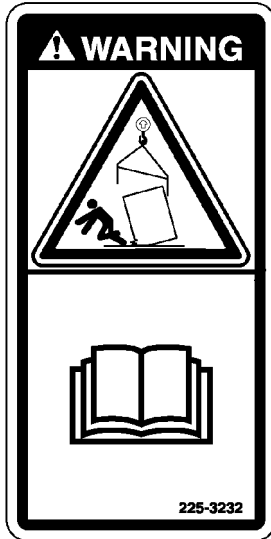


When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the engine when the engine is in the AUTOMATIC mode.



### Lifting the Genset (5)

This safety message for lifting the genset is located on the side panels of the generator.



g00928085

**WARNING**  
Crushing Hazard! Improper lifting could cause serious injury or death. Follow the lifting instructions in the Operation and Maintenance Manual for safe lifting procedures.

### Hot Surface (6)

One of these messages is located on each side of the barrel of the generator and on each side of the radiator.



g00943659

**WARNING**  
Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

### Hot Surface (7)

One of these safety messages is located on each side of the engine.



g01085603

**WARNING**  
Hot surface! Do not touch!

## Hot Fluid Under Pressure (8)

The safety message for hot fluid under pressure is located on the top of the radiator near the filler neck.



g00930639



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

i03704500

## General Hazard Information

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

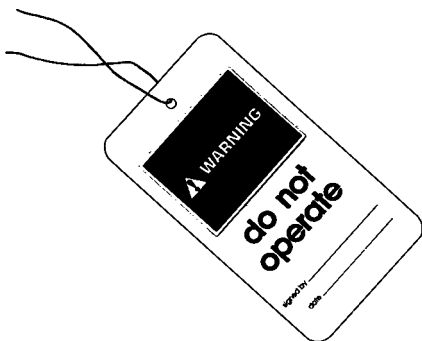


Illustration 2

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.

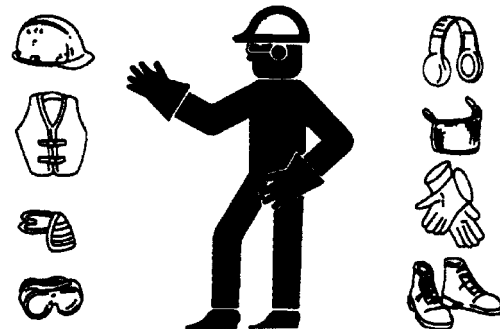


Illustration 3

g00702020

- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.

- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

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

- The engine is stopped. Ensure that the engine cannot be started.
- The protective locks or the controls are in the applied position.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- For initial start-up of a new engine or for starting an engine that has been serviced, make provisions to stop the engine if an overspeed occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Start the engine with the operator controls. Never short across the starting motor terminals or the batteries. This could bypass the engine neutral start system and/or the electrical system could be damaged.

## Pressurized Air and Water

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

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

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

## Fluid Penetration

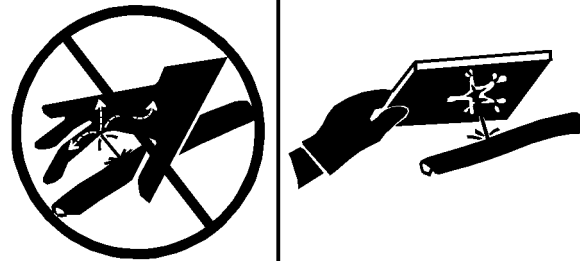


Illustration 4

g00687600

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

## Containing Fluid Spillage

### NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

## Asbestos Information

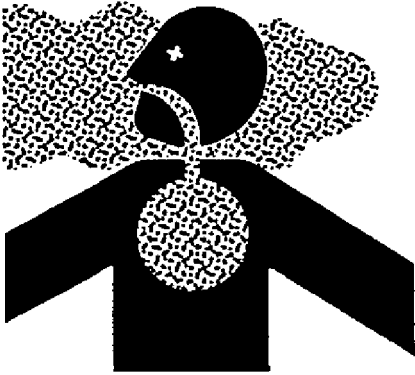


Illustration 5

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.

## Lines, Tubes, and Hoses

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

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

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

Check for the following conditions:

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

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

## Dispose of Waste Properly

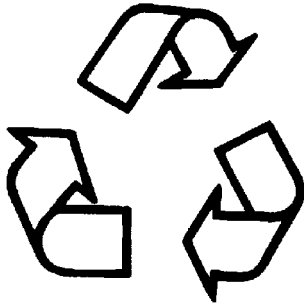


Illustration 6

g00706404

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

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

i01480768

## Burn Prevention

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

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

### Coolant

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

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

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

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

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

### Oils

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

### Batteries

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

i03649377

## Fire Prevention and Explosion Prevention

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



Illustration 7

g00704000

Use of personal protection equipment (PPE) may be needed.

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

Always perform a Walk-Around Inspection, which may help you identify a fire hazard. Do not operate a product when a fire hazard exists. Contact your Caterpillar dealer for service.

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

A flash fire may result if the covers for the engine crankcase are removed within 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.

All fluids that are captured in the fluid spill containment basin should be cleaned up immediately. Failure to clean up spilled fluids can cause a fire. Fire may cause personal injury and property damage.

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

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in 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 8

g00704059

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



Illustration 9

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.

i01372247

## Mounting and Dismounting

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

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

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

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

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

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

i03726140

## Sound Information

**SMCS Code:** 1000

**Note:** Information of the sound level is for machines in European Union countries and in countries that adopt the directives of the European Union.

---

### NOTICE

Hearing protection may be needed when working near an operating generator set.

---

Sound levels will vary depending on the configuration of the generator set and the final installation of the generator set.

Refer to the following for sound levels:

- The sound pressure level of a complete generator set (including the radiator) at 1 meter is 111 dB(A) for the noisiest configuration when "ISO 8528-10:1998(E) clause 14" is used at 75 percent of the rated power.
- The sound power level of a complete generator set (including the radiator) is 125 dB(A) for the noisiest configuration when "ISO 8528-10:1998(E) clause 13" is used at 75 per cent of the rated power.

**Note:** The preceding sound levels are emission levels. The preceding sound levels are not necessarily safe sound levels. There is a correlation between the emission levels and the level of exposure. The correlation between emission levels and the level of exposure can not be used to determine if further precautions are required.

Refer to the following for factors that influence the level of exposure:

- The characteristics of the area around the generator set
- Other sources of noise
- The number of machines and other adjacent processes
- The length of time of exposure to the noise

This information will enable the user of the machine to evaluate the hazard and the risk.

i03560601

## Before Starting Engine

**SMCS Code:** 1000

---

### NOTICE

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

---

### **WARNING**

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

---

Inspect the engine for potential hazards.

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

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

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work properly, if equipped.



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

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

See the Service Manual for repairs and for adjustments.

i01103904

## Engine Starting

**SMCS Code:** 1000

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

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

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

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

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

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

## Ether

Ether is poisonous and flammable.

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

Do not smoke while ether cylinders are changed.

Use ether in well ventilated areas.

Use ether with care in order to avoid fires.

Keep ether cylinders out of the reach of unauthorized persons.

Store ether cylinders in authorized storage areas only.

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

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

i02624835

## Engine Stopping

**SMCS Code:** 1000

Do not stop the engine immediately after the machine has been operated under load. This can cause overheating and accelerated wear of engine components.

After the machine is parked and the parking brake is engaged, allow the engine to run for two minutes before shutdown. This allows hot areas of the engine to cool gradually.

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.

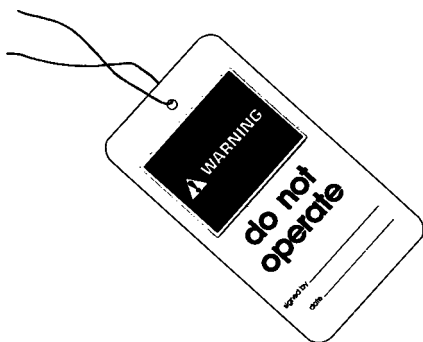
i01593543

## 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.



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

i02398959

### Model View Illustrations

**SMCS Code:** 1000; 4450

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

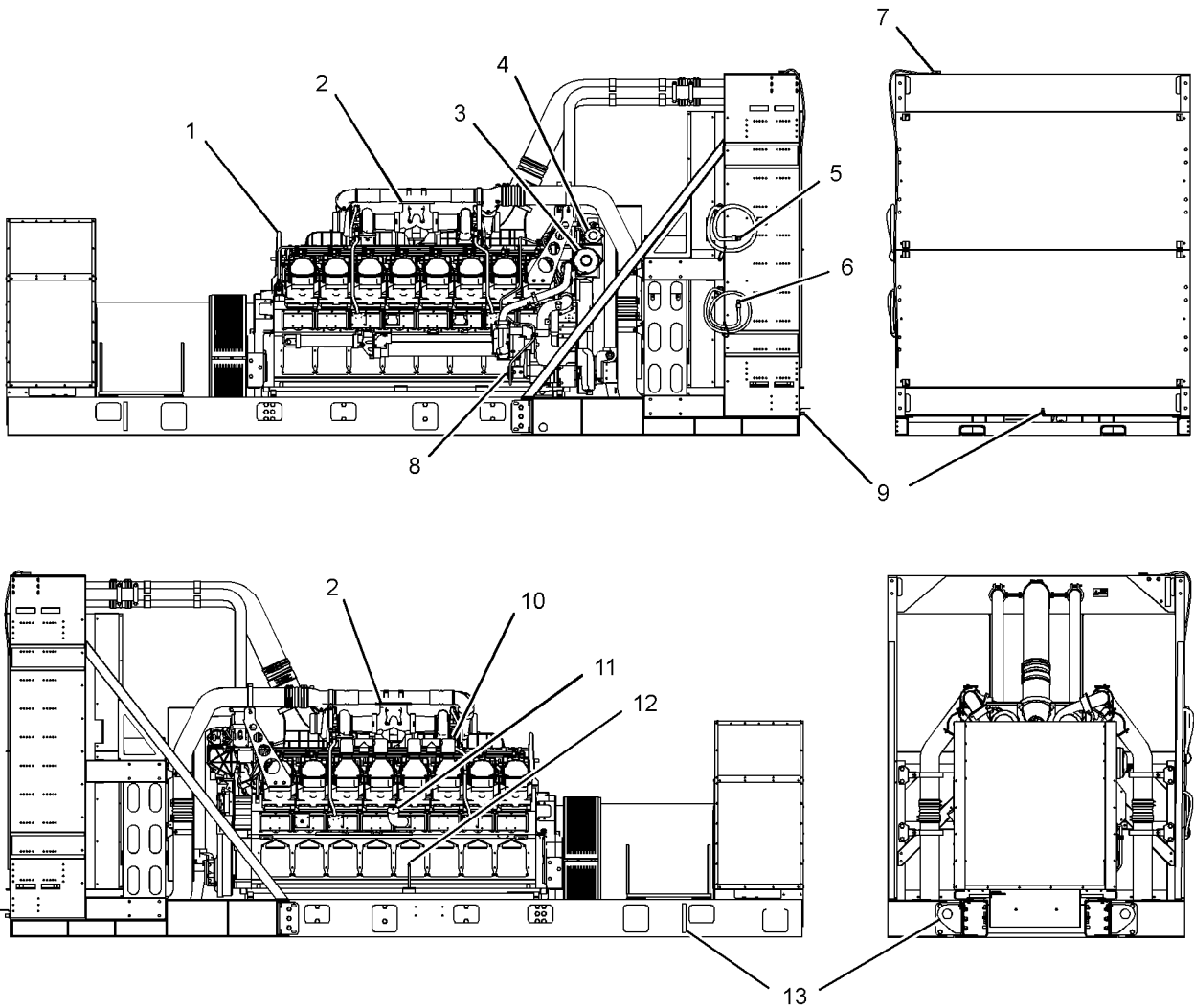


Illustration 11

g01198175

3516C

- (1) Engine lifting eye
- (2) Exhaust
- (3) Oil filter
- (4) Fuel filter
- (5) Fuel cooler inlet

- (6) Fuel cooler outlet
- (7) Radiator cap
- (8) Fuel inlet
- (9) Coolant drain
- (10) Crankcase breather

- (11) Oil filler
- (12) Oil level gauge
- (13) Package lifting eye

i03733800

## Product Description

**SMCS Code:** 1000; 4450

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

## Intended Use

This Power Generator is intended to be used to generate electrical power.

i02589920

## Engine Description

3500C Generator Set Engines are electronically controlled diesel engines. The engines have electronic fuel injectors. The engines can be equipped with either jacket water aftercooling or separate circuit aftercooling. The engine is offered in an 8 cylinder engine, a 12 cylinder engine, and a 16 cylinder 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 the Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information on maintenance items.

## Generator Description

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. The frame size will determine if the generator has six leads or twelve. The generators are capable of producing electrical power in either 50 Hz or 60 Hz applications.

## Specifications

**SMCS Code:** 1000

Table 1

Engine Specifications		
	3512C	3516C
Rated speed (rpm)	1500 to 1800	
Idle speed (rpm)	600 to 900	
Cylinders and arrangement	60 degree Vee 12	60 degree Vee 16
Bore	170 mm (6.7 inch)	
Stroke	190 mm (7.5 inch)	
Type	4 stroke cycle	
Aspiration	Turbocharged	
Displacement per cylinder	4.3 L (263 in <sup>3</sup> )	
Total displacement	51.8 L (3158 in <sup>3</sup> )	69.1 L (4210 in <sup>3</sup> )
Rotation (flywheel end)	Counterclockwise	
Fuel	See this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section).	
Method of starting	Air starting motor Electric starting motor	
Maximum allowable air inlet restriction	6.2 kPa (25 inch of H <sub>2</sub> O)	

## Product Identification Information

i03728143

### Plate Locations and Film Locations

SMCS Code: 1000; 4450

### Engine Identification

Caterpillar dealers need the information from the serial number plate and from the information plate in order to determine the components that were included with the engine. This permits accurate identification of replacement part numbers.

### Serial Number Plate

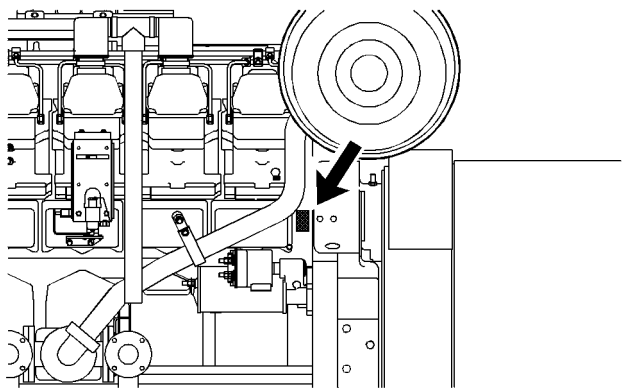


Illustration 12

g01659053

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

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

### Information Plate

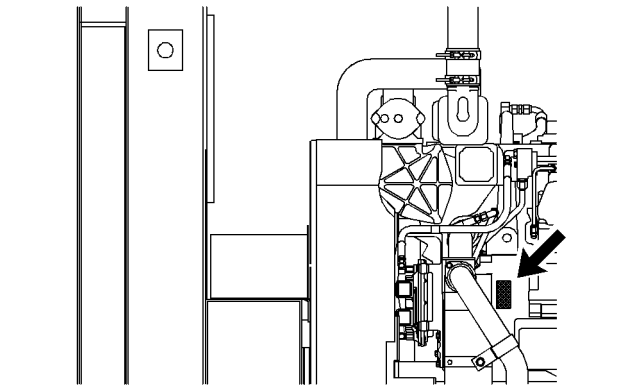


Illustration 13

g01659054

The information plate is on the left side top surface of the cylinder block in front of the front cylinder head.

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

### Identification of the Generator Set

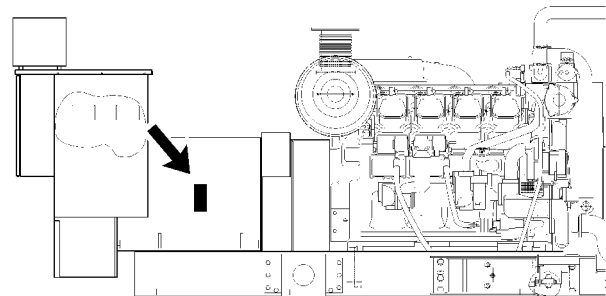


Illustration 14

g01658114

The identification plate for the generator set is located on the right side of the barrel of the generator.

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

## Serial Number Plate for the Generator

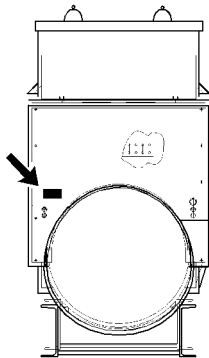


Illustration 15

g01658133

The serial number for the generator is located on the left side of the front of the generator.

## 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.

## European Union

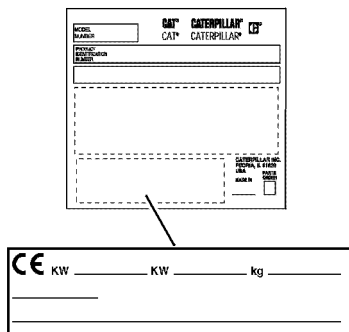


Illustration 16

g01880193

This plate is positioned on the bottom left side of the plate for the PIN.

**Note:** The CE plate is on machines that are certified to the European Union requirements that were effective at that time.

For machines that are compliant to 2006/42/EC, the following information is stamped onto the CE plate. For quick reference, record this information in the spaces that are provided below.

- Engine Power for Primary Engine (kW) \_\_\_\_\_
- Engine Power for Additional Engine (If Equipped) \_\_\_\_\_
- Typical Machine Operating Weight for European Market (kg) \_\_\_\_\_
- Year of Construction \_\_\_\_\_
- Machine Type \_\_\_\_\_

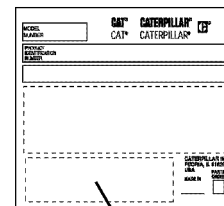


Illustration 17

g01120192

This plate is positioned on the bottom left side of the plate for the PIN.

**Note:** The CE plate is on machines that are certified to the European Union requirements that were effective at that time.

For machines that are compliant to 1998/42/EC, the following information is stamped onto the CE plate. For quick reference, record this information in the spaces that are provided below.

- Engine Power for Primary Engine (kW) \_\_\_\_\_
- Typical Machine Operating Weight for European Market (kg) \_\_\_\_\_
- Year \_\_\_\_\_

For the name and the address of the manufacturer, and the country of origin of the machine, refer to the PIN plate.

For the name, the address and the country of origin of the manufacturer, see the PIN plate.

i01382270

## Reference Information

**SMCS Code:** 1000; 4450

Identification of the items in Table 2 may be needed 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 engine leaves the factory, the engine performance is tested. Detailed performance data is recorded. The performance specification number can be used for obtaining the data.

Table 2

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



i03726141

## Declaration of Conformity

**SMCS Code:** 1000

Table 3

An EC Declaration of Conformity document was provided with the product if it was manufactured to comply with specific requirements for the European Union. In order to determine the details of the applicable Directives, review the complete EC Declaration of Conformity provided with the product. The extract shown below from an EC Declaration of Conformity for product that are declared compliant to "2006/42/EC" applies only to those product originally "CE" marked by the manufacturer listed and which have not since been modified.

### EC DECLARATION OF CONFORMITY OF MACHINERY

**Manufacturer:** CATERPILLAR INC. 100 N.E. ADAMS STREET PEORIA, IL 61629 USA**Person authorized to compile the Technical File and to communicate relevant part (s) of the Technical File to the Authorities of European Union Member States on request:**Standards & Regulations Manager, Caterpillar France S.A.S 40,  
Avenue Leon-Blum, B.P. 55, 38041 Grenoble Cedex 9, France**I, the undersigned, \_\_\_\_\_, hereby certify that the construction equipment specified hereunder**

Description:           Generic Denomination:           Power Generation Equipment  
Function:                Power Generator  
Model/Type:             3500C  
Serial Number:  
Commercial Name:        Caterpillar

Fulfills all the relevant provisions of the following Directives

Directives	Notified Body	Document No.
2006/42/EC	N/A	
2006/95/EC	N/A	
2004/108/EC	N/A	
2000/14/EC amended by 2005/88/EC, Note (1)	Note (2)	

Note (1) Annex - \_\_\_\_\_ Guaranteed Sound Power Level - \_\_\_\_\_ dB (A)  
Representative Equipment Type Sound Power Level - \_\_\_\_\_ dB (A)  
Engine Power per \_\_\_\_\_ - \_\_\_\_\_ kW Rated engine speed - \_\_\_\_\_ rpm  
Technical Documentation accessible through person listed above authorized to compile the Technical File

Note (2) Notified body name and address

**Done at:****Signature****Date:****Name/Position**

**Note:** The above information was correct as of October, 2009, but may be subject to change, please refer to the individual declaration of conformity issued with the machine for exact details.

i02320859

# Generator Lead Connections

SMCS Code: 4450

## Lead Numbering

The Wye 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. The diagrams that are contained in the "Wye Configuration Diagrams" section show lead numbering for the six and twelve lead generators. The diagrams that are contained in the "Delta Configuration Diagrams" section show lead numbering for the six and twelve lead generators.

## Wye Configuration Diagrams

### 6 Lead

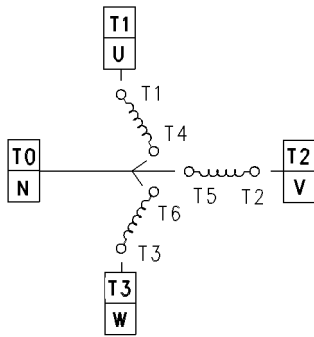


Illustration 18 g00611486

#### 6 Lead Wye Configuration

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

### 12 Lead

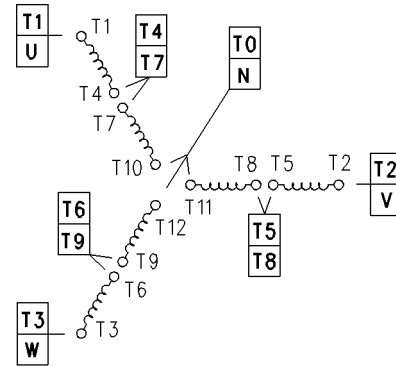


Illustration 19 g00661863

#### 12 Lead Wye Configuration

High Voltage

Terminals T10, T11, and T12 become neutral connections when the terminals are tied together.

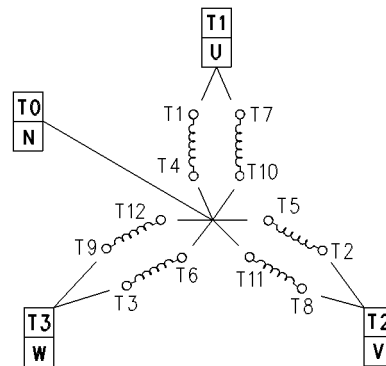


Illustration 20 g00611608

#### 12 Lead Wye Configuration

Low Voltage

Terminals T10, T11, and T12 become neutral connections when the terminals are tied together.

## Delta Configuration Diagrams

### 6 Lead

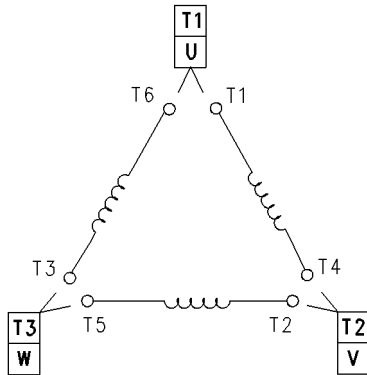


Illustration 21

g00669319

6 Lead Delta Configuration

### 12 Lead

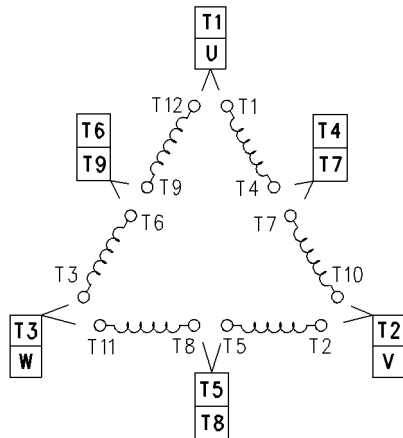


Illustration 22

g00669312

12 Lead Delta Configuration

Terminals T6 and T9 become the neutral connections when the terminals are tied together and when the terminals are 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 or the frame of the generator must be positively connected to the hull of a vessel. This connection is the first connection that should be made at the installation. This connection is the last connection that should be removed. If the generator set is on flexible pads or resilient pads, the ground connection must be flexible in order to avoid possible breakage in later operation.

Ground connection cables 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. These joints are also frequent sources of radio frequency interference (RFI). Joints should be silver soldered and joints should also be bolted. These bolts will be electrically reliable and mechanically reliable.

## Neutral Connections

On Wye Configuration Generators, the neutral lead should be attached to ground. This connection should be made at installation. The neutral lead is grounded in order to prevent load-side equipment damage.

If the neutral wire is grounded and one of the phase leads becomes grounded, the excessive current will open a load circuit breaker. In addition, this excessive current will cause the generator voltage to collapse. The result depends on the following factors: the particular generator's 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 when the neutral wire should not be grounded. An ungrounded generator neutral lead is acceptable when measures have been taken in order to prevent grounds to the phase leads. An example of such measures are ground fault protective circuits. When ground fault protective circuits are used, the entire group of distribution circuits should be studied. The entire group of distribution circuits should then be treated as a system. If a new distribution system is being developed, the owner should confer with a consultant that is certified and registered. If an existing system should be modified for ground fault protection, the owner should also confer with a consultant that is certified and registered.

## Single Units

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

When definite measures need to be 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

When multiple generators are operated in parallel, all the neutral connections may be grounded. In this case, there may be 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 a line, a switch should be installed in each generator's neutral ground circuit. 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 a Utility

There will be occasions when a Wye connected generator is paralleled with a utility system (infinite bus). On these occasions, the utility system's step-down transformer may also have a Wye connection. The grounding of both of the Wye neutral connections may result in circulating currents through the neutral connections. The coordination of ground fault protection requires a study of the entire system. This study should be done by a consultant that is familiar with generator systems. This consultant should be registered and certified. This study will determine the grounding method that should be used.

i02363477

## Voltage Connections

**SMCS Code:** 4450

## Three-Phase Voltage Connections

The Wye configuration for a 480 volt generator and the Delta configuration for a 240 volt 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 required with 590 frame size generators and above. If the winding pitch of the generator is not two-thirds, third harmonics will cause a high circulating current. The generator will need to be derated. This current can exceed the current rating for the winding, causing the generator to overheat and damage which may pose a fire hazard. A Wye 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 Configuration Diagrams

### 6 Lead Generators

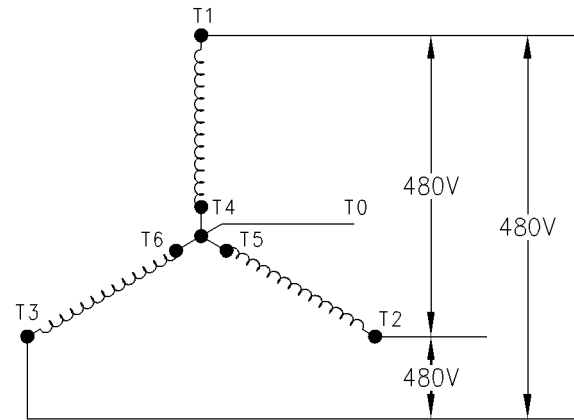


Illustration 23

g00626053

Typical Wye Configuration (60 Hz, 6 Lead)

**12 Lead Generators**

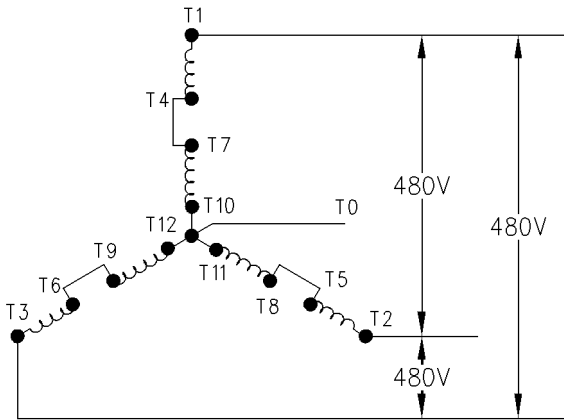


Illustration 24 g00637319  
Typical Series Wye Configuration (60 Hz, 12 Lead)  
This is a typical high voltage connection.

**Delta Configuration Diagrams**

**6 Lead Generators**

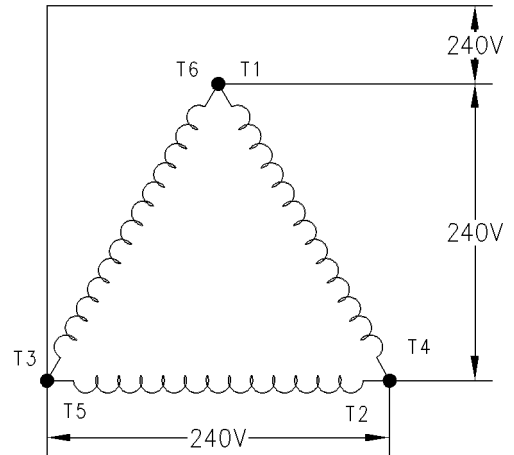


Illustration 26 g00626129  
Typical Delta Configuration (60 Hz, 6 Lead)

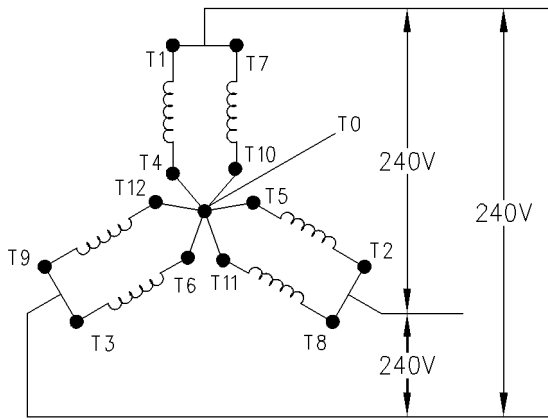


Illustration 25 g00637320  
Typical Parallel Wye (Star) Configuration (60 Hz, 12 Lead)  
This is a typical low voltage connection.

**12 Lead Generators**

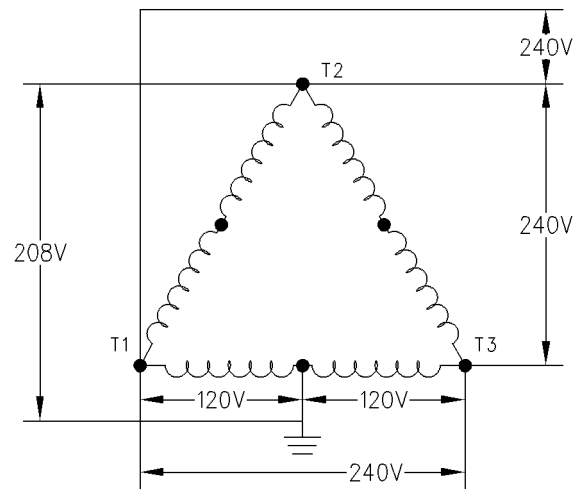


Illustration 27 g00626130  
Typical Delta Configuration (60 Hz, 12 Lead)

## Operation Section

# Lifting and Storage

## Product Lifting

i02772114

SMCS Code: 7000; 7002

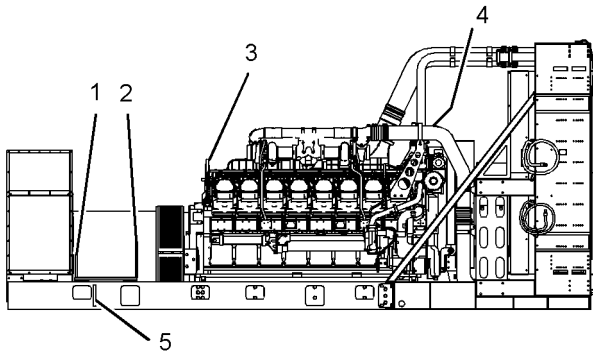


Illustration 28

g01274897

### 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 entire package. 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.

Lifting eyes are designed and installed for each package. Alterations to the lifting eyes and/or the package 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 lifting.

### NOTICE

Unless otherwise noted, factory shipped loose radiators are not designed to be lifted or hoisted while installed on a generator package. Shipped loose radiators must be installed on site after the packages (engine, generator, rails) are set in place. Radiators that are factory installed but shipped without coolant cannot be lifted while installed on a generator package if they are filled with coolant. Only those packages that are shipped from the factory filled with coolant can be lifted or hoisted while filled with coolant. Refer to the shipping consist to determine if coolant was included on the order prior to lifting the generator set package.

## Lifting the Entire Package

**Do NOT use only the engine lifting eyes or only the generator lifting eyes to lift the entire package.** The procedure for lifting the package utilizes a three-point lifting method. These lifting points are the front engine lifting eye (4) and the two lifting eyes (5) that are located on the sides of the rails toward the rear of the package.

## Lifting the Engine Only

To remove the engine ONLY, use lifting eyes (3) and (4) that are on the engine.

## Lifting the Generator Only

**Note:** The control panel and the terminal box will need to be removed before attempting to lift the generator.

To remove the generator ONLY, use lifting eyes (1) and (2) that are on the generator.

i02147124

## Product Storage

SMCS Code: 7002

## 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 abrasive substances

## Long Time Storage

### Engine Storage

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, "Refill Capacities and Recommendations" (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

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 generator is placed in operation.

## Bearing Inspection

Ball bearing generators use grease. This grease is subject to deterioration. If the generator is stored more than one year, new ball bearings may be required. These bearings should be greased 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.

## 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 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 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)

For additional information on generator storage, consult your Caterpillar dealer for assistance.

# Installation

i03661199

## Product Installation

**SMCS Code:** 1000; 1404; 4450; 7002

## 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

### 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. Follow the instructions under the “Product Lifting” topic. The hoist and the hoist cables should have a rating that is greater than the weight of the generator.

## 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. Air 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.

**Note:** For further information concerning the installation of this generator set, see the appropriate Application and Installation Guide.

## 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.

## Storage

If the generator is not installed immediately, refer to the “Product Storage” topic for the proper considerations for storing the unit.



---

## Features and Controls

i03646563

### Battery Disconnect Switch (If Equipped)

**SMCS Code:** 1411-B11; 1411

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

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

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

---

#### NOTICE

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

---

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

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

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

i02391866

## Electronic Modular Control Panel 3 (EMCP 3)

SMCS Code: 4490

### Electronic Control Module (Generator Set)

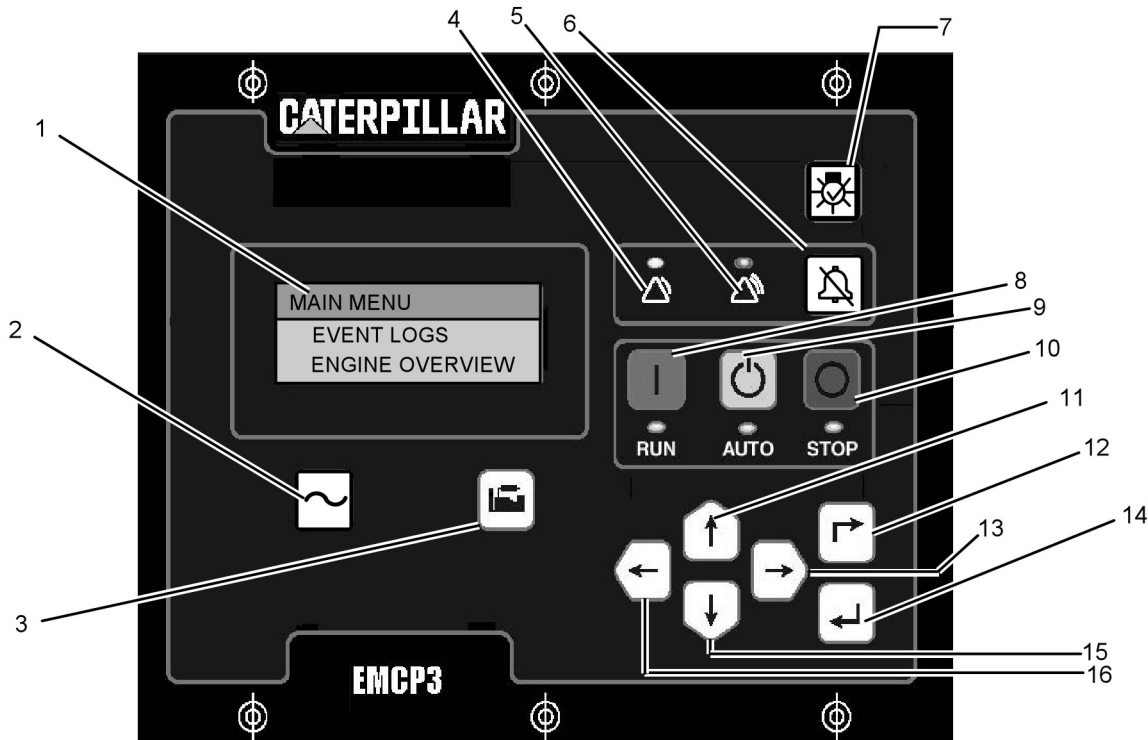


Illustration 29

g01045431

- (1) Display screen
- (2) AC overview key
- (3) Engine overview key
- (4) Yellow warning lamp
- (5) Red shutdown lamp
- (6) Alarm acknowledge key

- (7) Lamp test key
- (8) Run key
- (9) Auto key
- (10) Stop key
- (11) Up key
- (12) Escape key

- (13) Right key
- (14) Enter key
- (15) Down key
- (16) Left key

### Navigation Keys

**AC Overview (2)** – The “AC OVERVIEW” key will navigate the display to the first screen of AC information. The “AC OVERVIEW” information contains various AC parameters that summarize the electrical operation of the generator set.

**Engine Overview (3)** – The “ENGINE OVERVIEW” key will navigate the display to the first screen of engine information. The “ENGINE OVERVIEW” information contains various engine parameters that summarize the operation of the generator set.

**Acknowledge Key (6)** – Pressing the “ACKNOWLEDGE” key will cause the horn relay to turn off. This will silence the horn. Pressing this key will also cause any red or yellow flashing lights to either turn off or to come on continuously, depending on the active status of the alarms. The “ACKNOWLEDGE” key may also be configured to send out a global alarm silence signal on the J1939 Data Link, which will silence the horns on the annunciators.

**Lamp Test Key (7)** – Pressing and holding the “LAMP TEST” key will cause each LED and the display screen pixels to turn on continuously until the key is released.

**RUN Key (8)** – Pressing the “RUN” key will start the engine.

**AUTO Key (9)** – Pressing the “AUTO” key will cause the engine to enter the “AUTO” mode. The engine will start if the module receives a start command from a remote source.

**STOP Key (10)** – Pressing the “STOP” key will stop the engine.

**Up Key (11)** – The “UP” key is used to navigate through the various menus and monitoring screens. The “UP” key is also used when a setpoint is entered. When entering numeric data, the “UP” key is used in order to increment the digits (0-9). If the setpoint requires selection from a list, the “UP” key is used to navigate UP through the list.

**Escape Key (12)** – The “ESCAPE” key is used in order to navigate through the menus. When the key is pressed, the user moves backward or the user moves upward through the menus. The “ESCAPE” key is also used to exit out of entering data when the user is programming the setpoints. If the “ESCAPE” key is pressed while the user is programming the setpoints, none of the changes made on the screen will be saved to memory.

**Right Key (13)** – The “RIGHT” key is used during setpoint adjustment. The “RIGHT” key is used to select which digit is edited while entering numeric data. The “RIGHT” key is also used during some setpoint adjustments in order to select or to unselect a check box. If a check box has a check mark, the function has been enabled. Pressing the “RIGHT” key will disable the function. Pressing the “RIGHT” key will also cause the check mark to disappear. If the check box does not have a check mark, the function is disabled. Pressing the “RIGHT” key will enable the function. Pressing the “RIGHT” key will also cause a check mark to appear.

**Enter Key (14)** – The “ENTER” key is used in order to navigate through the menus. When the key is pressed, the user moves forward or the user moves downward through the menus. The “ENTER” key is also used to save any changes while the setpoints are being programmed. Pressing the “ENTER” key during programming the setpoints causes the changes to be saved to memory.

**Down Key (15)** – The “DOWN” key is used to navigate downward through the various menus or screens. The “DOWN” key is also used to program the setpoints. The “DOWN” key is used to decrease the digits when entering numeric data. If the setpoint requires selection from a list, the “DOWN” key is used to navigate DOWN through the list.

**Left Key (16)** – The “LEFT” key is used during setpoint adjustment. The “LEFT” key is used to select the digit that is edited during the entry of numeric data. The “LEFT” key is also used during some of the setpoint adjustments to select a check box. The key is also used to unselect a check box. If a check box has a check mark, pressing the “LEFT” key will disable the function. Pressing the key will also remove the check mark. Pressing the “LEFT” key will also cause the check mark to disappear. If the check box does not have a check mark, pressing the “LEFT” key will enable the function. Pressing the “LEFT” key will also cause a check mark to appear.

## Alarm Indicators

**Yellow Warning Lamp (4)** – A flashing yellow light indicates that there are active warnings that have not been acknowledged. A continuous yellow light indicates that there are acknowledged warnings that are active. If there are any active warnings, the yellow light will change from flashing yellow to continuous yellow after the “ACKNOWLEDGE” key is pressed. If there are no longer any active warnings, the yellow light will turn off after the “ACKNOWLEDGE” key is pressed.

**Red Shutdown Lamp (5)** – A flashing red light indicates that there are active shutdowns that have not been acknowledged. A continuous red light indicates that there are active shutdowns that have been acknowledged. If there are any active shutdowns the red light will change from flashing red to continuous red after the “ACKNOWLEDGE” key is pressed. Any condition that has caused a shutdown must be manually reset. If there are no longer any active shutdowns, the red light will turn off.

## Digital Inputs

**Note:** There are 8 digital inputs on “EMCP 3.2” and “EMCP 3.3”. There are 6 digital inputs on “EMCP 3.1”.

**Digital Input 1** – Digital Input 1 is used for the emergency stop. This input should be wired to GROUND through an Emergency Stop switch. The input can be set to activate on an active high (normally closed contact) or an active low (normally open contact). Activating the emergency stop input will cause the generator set to stop immediately. The emergency stop input will also prevent the generator set from starting. Once Digital Input 1 goes active, the engine will not start until the event has been cleared. Refer to System Operation, Troubleshooting, Testing and Adjusting, RENR7902, “Digital Input Resetting”.

**Digital Input 2** – Digital Input 2 is used for remotely starting and stopping the generator set. This input should be wired to GROUND through a switch that can be initiated remotely. The input can be set to activate on an active high (normally closed contact) or an active low (normally open contact). If the input is active and the engine is in AUTO, the engine will attempt to start. Once the input becomes inactive the engine will enter into cooldown mode (if programmed) and then the engine will stop.

The remainder of the inputs can be configured. The main purpose for the other “DIGITAL” inputs is to add additional monitoring capabilities of the parameters for the engine or generator. The inputs can be configured by going to the “EVENT I/P FUNCTIONS” parameter under the “SETPOINTS” menu. The “DIGITAL INPUTS” parameter can only be set to “ACTIVE HIGH” or “ACTIVE LOW” in order to initiate a High Warning, Low Warning, High Shutdown, Low Shutdown, or Status.

The inputs can be programmed to monitor the following parameters or components. Refer to System Operation, Troubleshooting, Testing and Adjusting, RENR7902, “Digital Input Programming”.

#### Pressures

- Air filter differential pressure
- Engine oil pressure
- Fire extinguisher pressure
- Fuel filter differential pressure
- Oil filter differential pressure
- Starting air pressure

#### Temperatures

- Ambient air temperature
- Engine coolant temperature
- Engine oil temperature
- Exhaust temperature
- Rear bearing temperature
- Right exhaust temperature
- Left exhaust temperature

#### Levels

- Engine coolant level

- Engine oil level
- Fuel level
- External fuel tank level

#### Other

- Air damper closed
- ATS in normal position
- ATS in emergency position
- Battery charger failure
- Generator breaker closed
- Utility breaker closed
- Fuel leak detected
- Custom event

For detailed information about the electronic control module, see Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, “EMCP3”.

## Control Panel

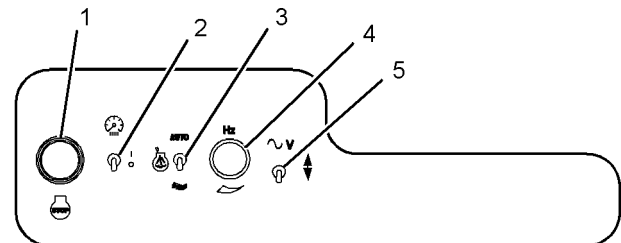


Illustration 30

g01194656

- (1) Emergency stop push button
- (2) Panel light switch
- (3) Starting aid auto/manual switch (optional)
- (4) Speed potentiometer (optional)
- (5) Voltage adjust switch

**Emergency Stop Push Button (1)** – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. If equipped, the ESPB shuts off the fuel and the ESPB activates the optional air shutoff.

**Panel Light Switch (2)** – The panel lights switch turns on or the panel lights switch turns off the panel lights.

**Starting Aid Auto/Manual Switch (3)** – The starting aid switch is optional. The starting aid switch is used to inject ether into the engine when you are starting the engine in cold weather conditions. When the starting aid switch is in the ON position, the switch energizes the starting aid solenoid valve and the switch meters a specific amount of ether into a holding chamber. When the starting aid switch is released, the solenoid releases the ether to the engine.

**Speed Potentiometer (4)** – The speed potentiometer is optional. The speed potentiometer can be used with the generator set that has an electronic governor.

**Voltage Adjust Switch (5)** – This switch can be used to raise the voltage. The switch can also be used to lower the voltage.

### Annunciator Module

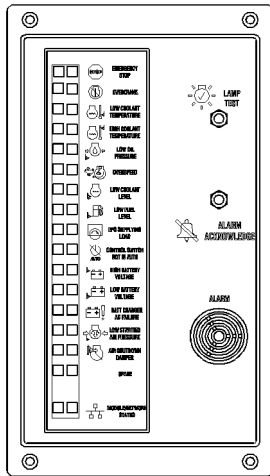


Illustration 31

g01101388

### General Information

The annunciator module is used to indicate various system events and conditions. The annunciator module uses indicator lights and an audible horn to give the operator information about the current status of the system. The annunciator module can be used to announce faults and/or status signals to the operator. The annunciator module allows the operator to silence the horn. The annunciator module also allows the operator to acknowledge faults to the system.

There are seventeen pair of LED indicators on the annunciator's front panel. Sixteen pair of LED indicators are used to announce events, diagnostics, and ready signals. The seventeenth pair of LED indicators is used as a combined network/module status LED. The seventeenth pair of LED indicators can tell the operator if there is a problem with the J1939 data link connection.

### Basic Operation

Each pair of LED indicators on the annunciator consists of two of the following three colors: green, yellow, and red. For example, a pair of red and yellow LED indicators may be configured for engine oil pressure. If a low engine oil pressure warning is read over the data link, the annunciator will flash the yellow LED and the audible horn will sound. If the low engine oil pressure shutdown is read over the data link, the annunciator will flash the red LED and the audible horn will sound.

To acknowledge the shutdown and alarm conditions or to silence the horn, press the “Alarm Acknowledge” button that is located near the middle of the annunciator.

To test the LED indicators or to test the horn when the data link is connected or the data link is disconnected, hold in the “Lamp Test” button that is located near the top of the annunciator.

### Configuration

The annunciator module can be customized in order to signal many different conditions that are related to the system. Each pair of LEDs must be configured by using the appropriate service tool. Once the service tool has been connected to the annunciator, the user must enter the “Configuration” screen. Each pair of LEDs has four settings: SPN, Trigger Type, Trigger Severity Level, and Failure Mode Identifier (FMI).

For detailed information about the annunciator module, see Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, “EMCP3”.

# Engine Diagnostics

i03259690

## Configuration Parameters

**SMCS Code:** 1000; 1900; 1901; 1902

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

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

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

Table 4 is a list of typical configuration parameters.

Table 4

Typical Configuration Parameters	
Parameter	Programmability
Vehicle ID	Programmable
Engine Serial Number	Programmable
Fuel Ratio Control Offset	Programmable
ECM Serial Number	Unprogrammable
Personality Module Part Number	Software dependent
Personality Module Release Date	Software dependent
Rated Fuel Position	Programmable
Acceleration Delay Time	Programmable
Engine Acceleration Rate	Programmable
Low Idle Speed	Programmable
Cooldown Speed	Programmable
Engine Cooldown Duration	Programmable
Engine Prelube Duration	Programmable
Crank Duration	Programmable
Maximum Number Of Crank Cycles	Programmable
Crank Terminate Speed	Programmable
Engine Rotation	Software dependent
Engine Rated Speed	Software dependent

(continued)

(Table 4, contd)

Typical Configuration Parameters	
Parameter	Programmability
Air Shutoff (ON/OFF) (If equipped)	Programmable
Ether Control (ON/OFF)	Programmable
Total Tattletale	Unprogrammable
Pilot House EMS Status (ON/OFF)	Programmable
Cold Mode Cylinder Cutout	Programmable

For generator set engines with switchgear conversions and for marine auxiliary engines, the following parameters are programmed at the factory to 0: crank duration and maximum number of crank cycles.

- “Crank duration”
- “Maximum number of crank cycles”

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

Engines that are equipped with a generator set control panel do not require reprogramming for “Crank Duration” and for “Maximum Number Of Crank Cycles”. These parameters are programmed in the generator set control panel.

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

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

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

## Caterpillar Monitoring System

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

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

The settings for the parameters are programmed at the factory. If the application requires the settings for the parameters to be reprogrammed, then the parameter must be programmed with an ET service tool.

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

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

## Default Settings for the Caterpillar Monitoring System

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

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

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

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

The ECM will log the event if any response is made by the Caterpillar Monitoring System. A parameter may be programmed "OFF": the ECM will log the event if the setpoint for the parameter is exceeded.

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

All of the derating is cumulative. A derating of five percent followed by a derating of two percent results in a total derating of seven percent. If the conditions that cause the derating are not corrected, the derating will continue. The process will continue until the engine is at low idle with no load.

## Voltage

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

Table 5

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

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

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

## Engine Oil Pressure

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

- Warning
- Shutdown

The strategy is based on a map of the engine oil pressure versus the engine rpm. See Illustration 32. The default settings that are programmed at the factory are listed in Table 6.

Table 6

Engine Oil Pressure	
Parameter	Default Settings
Hysteresis	40 kPa (5.8 psi)
Activation delay	10 seconds
Security level	A password is required.
Warning setpoint	Map
Warning delay	4 seconds
Shutdown setpoint	Map
Shutdown delay	9 seconds

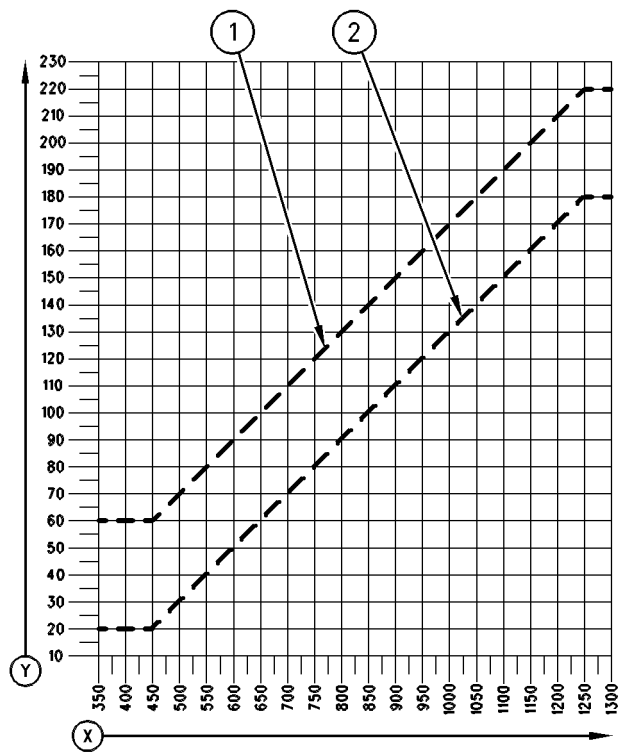


Illustration 32

g00325256

Map of the engine oil pressure versus the engine rpm

- (Y) Engine oil pressure in kPa
- (X) Engine rpm
- (1) Hysteresis
- (2) Minimum engine oil pressure

If the engine oil pressure is below the minimum pressure for four seconds, a warning will occur. To deactivate the warning, the engine oil pressure must rise to 40 kPa (5.8 psi) above the minimum pressure.

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

The map cannot be reprogrammed.

## High Coolant Temperature

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

- Warning
- Derating
- Shutdown

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

Table 7

High Coolant Temperature	
Parameter	Default Setting
Warning setpoint	102 °C (216 °F)
Warning delay	5 seconds
Derate setpoint	107 °C (225 °F)
Derate delay	30 seconds
Maximum time for a derate	480 seconds
Hysteresis	5 °C (9 °F)
Security level	A password is required.
Maximum derate	25%
Shutdown setpoint	107 °C (225 °F)
Shutdown delay	5 seconds

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

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

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

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



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

## Low Coolant Temperature

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

Table 8

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

The engine must operate for a minimum of ten minutes in order to activate this strategy. If the coolant temperature is below 80 °C (176 °F) for five seconds, a warning will occur. To deactivate the warning, the coolant temperature must rise above 85 °C (185 °F).

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

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

## Overspeed

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

- Warning
- Shutdown

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

Table 9

Overspeed	
Parameter	Default Setting
Warning setpoint	1.18 times rated rpm
Warning delay	0 seconds
Shutdown setpoint	1.18 times rated rpm
Shutdown delay	0 seconds
Hysteresis	100 rpm
Security level	A password is required.

If the engine speed exceeds the setpoint rpm, a warning and a shutdown will occur.

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

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

## Inlet Air Restriction

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

- Warning
- Derating

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

Table 10

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

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

## Altitude

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

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

Table 11

Altitude	
Parameter	Default Setting
Derate setpoint	2T specification
Security level	A password is required.
Derate per 305 m (1000 ft) of altitude	3%
Maximum derate	35% of the rated power

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

## Exhaust Temperature

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

- Warning
- Derating

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

Table 12

Exhaust Temperature	
Parameter	Default Setting
Warning setpoint	2T specification
Warning delay	5 seconds
Derate setpoint	2T specification
Derate delay	5 seconds
Derate delay setpoint	15 seconds
Hysteresis	10 °C (18 °F)
Security level	A password is required.
Percent of derate per step	2% per step

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

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

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

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

## Oil Filter Differential Pressure

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

Table 13

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

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

## Fuel Filter Differential Pressure

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

Table 14

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

If the fuel filter differential pressure is above 105 kPa (15 psi) for five seconds, a warning will occur. To deactivate the warning, the fuel filter differential pressure must be below 95 kPa (13.8 psi).

## Crankcase Pressure

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

- Warning
- Derating
- Shut down

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

Table 15

Crankcase Pressure	
Parameter	Default Setting
Warning setpoint	2 kPa (.3 psi)
Warning delay	3 seconds
Derate setpoint	6 kPa (.9 psi)
Derate delay	10 seconds
Maximum time for a derate	480 seconds
Hysteresis	0.25 kPa (.036 psi)
Security level	A password is required.
Maximum derate	25%
Shutdown setpoint	3.5 kPa (.51 psi)
Shutdown delay	3 seconds

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

If the crankcase pressure is above 6 kPa (.9 psi) for 10 seconds, derating will occur. The continuous schedule of the derating will reach 25 percent in 480 seconds.

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

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

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

## Aftercooler Coolant Temperature

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

- Warning
- Derating
- Shut down

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

Table 16

Aftercooler Coolant Temperature	
Parameter	Default Setting
Warning Setpoint	102 °C (215 °F)
Warning delay	5 seconds
Derate setpoint	107 °C (225 °F)
Derate delay	5 seconds
Maximum time for a derate	480 seconds
Hysteresis	3 °C (5.4 °F)
Security level	A password is required.
Maximum derate	25%
Shutdown setpoint	107 °C (225 °F)
Shutdown delay	5 seconds

If the aftercooler coolant temperature is above 102 °C (215 °F) for five seconds, a warning will occur. To deactivate the warning, the aftercooler coolant temperature must be below 99 °C (209.6 °F).

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

When the aftercooler coolant temperature is less than 104 °C (219.6 °F), the percent of the derating is decreased until full power is restored. However, if the aftercooler coolant temperature rises above the setpoint again, the derating resumes.

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

## Data Link Features

### CAT Data Link Flash

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

The CAT Data Link Flash provides the capability to flash the software that controls the engine through the use of the CAT Data Link.

### CAT Secondary Data Link

The CAT Secondary Data Link provides the ability for each ECM to have a CAT Data Link that is local to that engine. This feature also enables a global CAT Data Link to connect to other engine controls through a common data link. This enables the operator to communicate through a single Customer Communication Module (CCM) or through a telephone line with all of the engines that are in an engine room.

The CAT Secondary Data Link provides the capability for as many as eight generator set engines to communicate via a remote display or a control panel. The CAT Secondary Data Link is for use with the following systems: switchgear, remote monitoring, and control systems.

Switching between data links requires the use of the Cat ET software. Refer to Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, “Electronic Modular Control Panel 3 (EMCP 3)” for more information.

## Ether Injection System

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

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

- The engine rpm is between 50 and 400 rpm.

- The jacket water coolant temperature is less than 21 °C (70 °F).

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

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

The longest duration of ether injection is 130 seconds even if the jacket water coolant temperature is less than -40 °C (-40 °F). A switch enables the operator to inject ether manually. This can occur when the following conditions are met:

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

## Air Shutoff

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

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

- The Emergency Stop button is pressed.
- An overspeed shutdown occurs.

## Cold Cylinder Cutout

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

The Cold Cylinder Cutout strategy is used so that the ECM may perform the following functions:

- Reduce the white smoke for cold starting.
- Minimize the duration of advanced timing (cold mode).
- Reduce the use of ether injection.

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

- Cold start-up
- Extended time at low idle

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

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

- The Cold Cylinder Cutout parameter is programmed to “ENABLE”.
- The engine rpm is equal to high idle rpm or less than high idle rpm.
- The fuel rack is less than 13 mm (.5 inch).
- The jacket water coolant temperature is less than 63 °C (145 °F).

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

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

The following conditions will deactivate the Cold Cylinder Cutout strategy:

- The Cold Cylinder Cutout parameter is programmed to “DISABLED”.
- The jacket water coolant temperature is more than 70 °C (158 °F).
- The ET service tool is used for the cold cylinder cutout test.
- The ether injection system is used.
- The coolant temperature sensor has failed.
- If the engine speed varies more than 50 rpm from the start of the Cold Cylinder Cutout, the Cold Cylinder Cutout deactivates for three seconds. A new engine speed is established when the Cold Cylinder Cutout reactivates.
- If the engine is operated at low idle for ten seconds before the engine speed is reduced by more than 50 rpm, the Cold Cylinder Cutout deactivates for 30 seconds.
- If the engine rpm exceeds the high idle rpm, the Cold Cylinder Cutout deactivates for ten minutes.
- If the fuel rack is greater than 13 mm (.5 inch), the Cold Cylinder Cutout deactivates for three seconds.

## Display of Engine Performance

### Histogramming

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

- Engine rpm
- Engine load
- Left side exhaust temperatures
- Right side exhaust temperatures

### Incrementing the Hours of the ECM

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

### Adjusting the Calculation of Fuel Consumption

When the engine is shipped from the factory, an estimate of the engine's fuel consumption is programmed into the ECM. The estimate is based upon the engine's performance specifications. The actual fuel consumption can be determined with a meter that measures the flow of the fuel. Customers are likely to find a slight difference between the estimate of fuel consumption that was programmed and the actual fuel consumption. The customer can use an ET service tool to program the ECM for the actual fuel consumption. No password is required in order to change this parameter.

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

The new Fuel Correction Factor must be calculated. The following variables must be known in order to perform the calculation:

- The actual fuel consumption
- The fuel consumption that has been calculated by the ECM
- The original Fuel Correction Factor that was programmed into the ECM

---

A factor for error must be calculated first. Use the formula in Table 17.

Table 17

**Error Calculation For the Fuel Correction Factor**

$$e = [(a - s) \div a] \times 100$$

“e” is the factor for error.

“a” is the actual fuel consumption.

“s” is the fuel consumption that is calculated by the ECM.<sup>(1)</sup>

<sup>(1)</sup> The fuel consumption that is calculated by the ECM is based on the original Fuel Correction Factor.

To determine the new Fuel Correction Factor, use the formula in Table 18.

Table 18

**Calculation For The Fuel Correction Factor**

$$N = O + [(100 + O) \times e] \div 100$$

“N” is the new Fuel Correction Factor.

“O” is the original Fuel Correction Factor.

“e” is the error that was calculated with the equation in Table 17.

## **Adjusting the Total Fuel Consumption for the ECM**

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

# Engine Starting

i02590960

## Before Starting Engine

**SMCS Code:** 1000; 1400; 1450

### **WARNING**

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

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

## Walk-Around Inspection

### NOTICE

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

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

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

## Air Inlet System

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

## Cooling System

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

## Driven Equipment

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

## Electrical System

Inspect the wiring for the following conditions:

- Loose connections
- Wiring that is worn or frayed

Inspect the alternator belt for cracks and for deterioration.

Ensure that the grounds are secure.

## Fuel System

### NOTICE

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

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

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

## Lubrication System

102327778

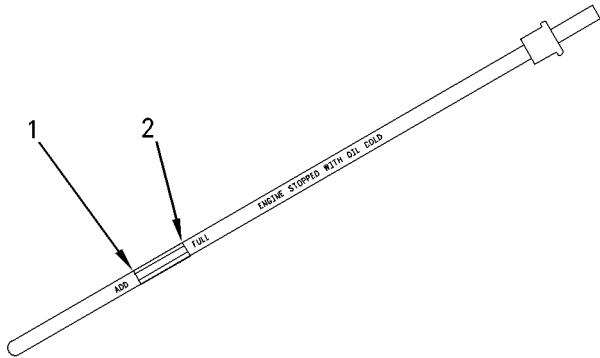


Illustration 33 g00736087

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, "Refill Capacities and Recommendations".
- 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.
- Inspect the Closed Crankcase Ventilation (CCV) filter, if equipped. If the restriction indicator is visible, service the CCV.

## 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

Starting fluid is required for temperatures below 0 °C (32 °F). The use of other optional cold starting aids is recommended for temperatures below -18 °C (0 °F).

## Heaters

**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 12 °C (55 °F) with a starting aid. A jacket water heater may be needed and/or the crankcase oil may need to be warmed.

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

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

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

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

## Air Starting Motor

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

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

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



## Starting With Ether

### 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.**

**The optional ether starting aid is the only system that is recommended for the injection of starting fluid.**

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

1. Ensure that the driven equipment is unloaded. Place the transmission in neutral.
2. Move the throttle so that fuel is provided to the engine.

### 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.

3. Crank the engine. Use of the starting aid depends on these conditions:
  - a. The engine control module controls the duration of automatic ether injection in these circumstances:
    - The jacket water coolant temperature is between  $-40$  to  $30$  °C ( $-40$  to  $86$  °F).
    - The engine rpm is more than 75 rpm and less than 400 rpm.
  - b. Manual ether injection can be performed in these circumstances:
    - The momentary contact switch for the ether injection is activated.
    - The jacket water coolant temperature is between  $-40$  to  $30$  °C ( $-40$  to  $86$  °F).
    - The engine rpm is more than 75 rpm and less than 400 rpm.

### 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.

4. To inject ether manually, press the starting aid switch. Release the switch immediately.

Additional injections may be necessary in order to start the engine. Press the starting aid switch about every two seconds until the engine begins to idle smoothly.

i01257119

## Starting the Engine

**SMCS Code:** 1000; 1450

Use the following general guidelines for starting the engine. For specific instructions on starting the engine, see the literature that is provided by the OEM of the installation.

### 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.**

### NOTICE

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

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

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

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

---

NOTICE

For electric starting motors, do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

---

2. Start the engine according to the instructions that are provided by the OEM of the installation.

If the engine does not start after a few attempts, shut off the fuel. Crank the engine for ten seconds to clear fuel from the cylinders. Allow the starting motor to cool for two minutes before cranking again.

After the engine starts, operate the engine at low idle rpm for two to three minutes. Allow the jacket water temperature to begin to rise before increasing the engine rpm. Check the gauges during the warm-up.

Perform a walk-around inspection. Inspect the engine for leaks. Listen for unusual noises.

i00817006

## Starting with Jump Start Cables

SMCS Code: 1000; 1401; 1402; 1900

 **WARNING**

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

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

---

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

---

NOTICE

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

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

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

---

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

i00857435

## 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 performance.

### Warm-up

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

**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.

### Engaging the Driven Equipment

1. Ensure that the gauges are in the normal ranges for the engine rpm.
2. Apply the load. Begin operating the engine at low load.

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.

3. After the temperature gauges begin to rise, the engine may be operated at full load.
4. Continue to check the gauges and the driven equipment.

# Engine Operation

i02301586

## Engine Operation

**SMCS Code:** 1000

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

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

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

## Operating the Engine and the Driven Equipment

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

## Partial Load Operation

Extended operation at reduced load (less than 30%) may cause increased oil consumption and carbon buildup in the cylinders. Extended operation at reduced load may also cause fuel to slobber through the exhaust system. This may result in a loss of power and/or poor performance.

To maintain engine efficiency and performance, apply a full load to the engine on an hourly basis, or operate the engine at a load level that is greater than 30%. This will burn excess carbon from the cylinders.

When possible, before shutting down the engine after running the engine for extended periods at low load, apply a full load for approximately 30 minutes. Running the engine at full load allows excess carbon to burn from the following components: cylinders, pistons, and valves.

## Partial Load Operation In Cold Weather

Operation of the jacket water heater is recommended if the engine is operating at a low load in extreme cold.

i00165110

## 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 defective battery cell will overwork the alternator. This will consume excess power and excess fuel.

- Ensure that the belts are properly adjusted. The belts should be in good condition.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the driven equipment is in good working order.

- 
- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.
  - Settings for the fuel system and the limits for the operating altitude are stamped on the Engine Information Plate. If an engine is moved to a higher altitude, the 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

i02775923

### 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 aid the engine operation are secured after the engine is stopped.

### Emergency Stop Button

Use of the emergency stop will shut off the fuel. The air shutoff will also be activated. For operation of the emergency stop button, see the instructions that are provided by the OEM of the equipment.

---

#### NOTICE

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

---

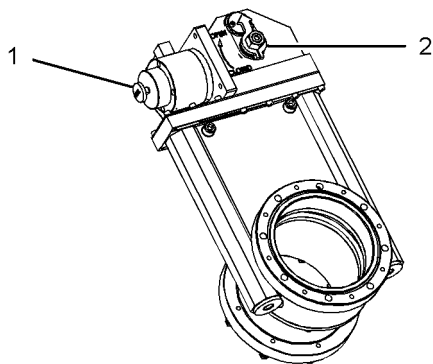
It may be necessary to reset the emergency stop button before the engine can be restarted.

If the emergency stop button is used, the air shutoff must be reset before the engine can be restarted.

The power for the ECM must be cycled before the engine can be restarted.

### Air Shutoff

---



The air shutoff is actuated by oil pressure. The air shutoff uses a moving plate to block inlet air to the engine. The engine stops because of the restricted air supply to the combustion chamber. The air shutoff will actuate for the following conditions:

- The emergency stop button is pressed.
- The air shutoff is activated.
- An overspeed shutdown occurs.
- The electronic control module loses power.

Manual release knob (1) has been provided as a safety feature in order to allow service personnel to trip the shutoff before service begins. The manual release knob is not intended to trip a shutoff on a running engine. The required force for pulling will be from 316 to 414 N (71 to 93 lb).

**Note:** A switch may be supplied by the customer in order to activate the air shutoff.

The air shutoff must be manually reset before the engine is restarted. To reset the air shutoff, use a ratchet to rotate operating shaft (2) until the shaft latches in the “OPEN” position.

Illustration 34

g01269124

- (1) Manual release knob  
(2) Operating shaft

i03205685

i02885872

## Manual Stop Procedure

**SMCS Code:** 1000; 7418

---

### NOTICE

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

Excessive temperatures in the turbocharger centerhousing will cause oil coking problems. Excessive temperatures in the turbocharger centerhousing may damage the turbocharger bearing/shaft system and significantly shorten the life of the turbocharger.

Allow the engine to gradually cool before stopping the engine

1. Open the main circuit breaker in order to disengage the driven equipment.
2. Turn the engine control switch to the "OFF/RESET" position. The engine will immediately shut off.
3. Press the red "STOP" button on the EMCP3 controller. If the setpoint for the duration of the cooldown period is set to a value that is greater than zero, the engine will operate for a programmed period of time before the engine stops. Otherwise, the engine will immediately shut off.

## Automatic Stopping

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

## After Stopping Engine

**SMCS Code:** 1000

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

---

### NOTICE

Follow the guidelines for antifreeze/coolant mixtures that are recommended in this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic. Failure to do so can cause engine damage.

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

# Cold Weather Operation

i02237624

## Fuel and the Effect from Cold Weather

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

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

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

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

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

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

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

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

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

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

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

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

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

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

i00932529

## Fuel Related Components in Cold Weather

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

### Fuel Tanks

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

Fuel tanks should have a provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Drain the water and sediment in order to help prevent freezing.

### Fuel Filters

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

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

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

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



---

## Fuel Heaters

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

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

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

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

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

# Generator Operation

i02514924

## 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. If one phase current exceeds the nameplate amperage, an electrical unbalance can result in an electrical overload and overheating.

Allowable combinations of unbalanced loads are shown in Illustration 35. 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.

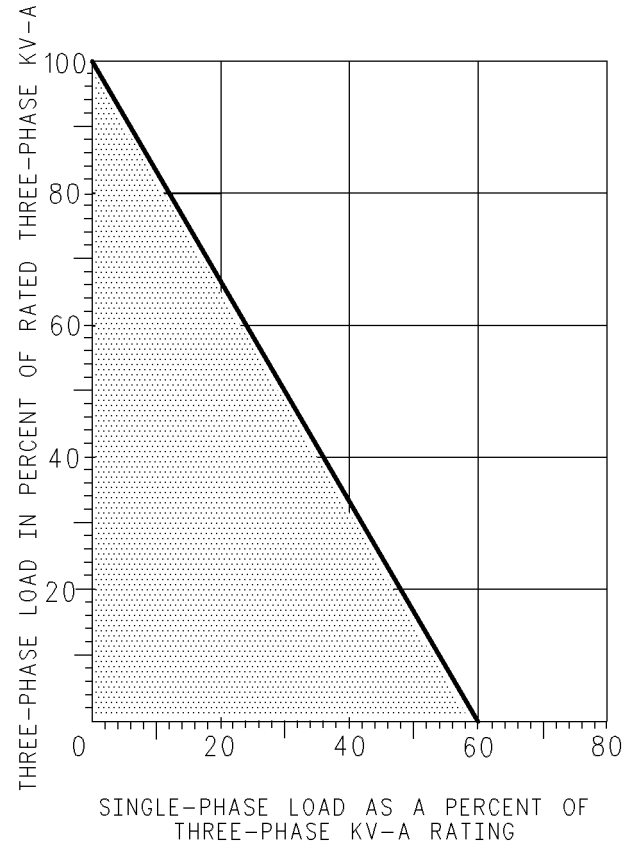


Illustration 35

g00627416

Allowable Combinations of Unbalanced Loads

### Block Loading

Block loading is the instantaneous application of an electrical load to a generator set. 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
- Percent of load before the block load is applied

If derating for the block load is required, refer to ISO 3046 Standards or SAE J1349 Standards. Also, reference Engine Data Sheet, LEKX4066, "Loading Transient Response" and Engine Data Sheet, LEKX4067, "Block and Transient Response".

**Note:** ISO stands for International Standards Organization.

## Power Factor

The power factor represents the efficiency of the load. Power factor is the ratio of apparent power to total power. The power factor is expressed as a decimal. The power factor represents that 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 or other devices.

In most applications, electric motors and transformers determine the power factor of the system. Induction motors usually have a 0.8 or smaller power factor. Incandescent lighting is a resistive load of about 1.0 power factor, or unity.

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 supplied to a constant power demand will decrease. For example, a 100 kW load at a 0.8 power factor will draw more current than a 100 kW load at 0.9 power factor. High power factor will result in full engine load at less than the rated amperage of the generator. A lower power factor increases the possibility of overloading the generator.

**Note:** Caterpillar generators are designed for a 0.8 power factor unless otherwise specified.

## Excitation System

### 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 permanent magnet 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 generator output voltage are not fed back into the exciter. Such irregularities can be caused by load conditions. The independent operation also allows the generator to better sustain an overload for a short duration. The pilot exciter also ensures that the generator will start properly even if the rotating field becomes completely demagnetized.

### Low Idle Adjustment

Generator sets normally have a higher low idle setting than industrial engines. Low idle will be approximately 66% of the full load speed of 60 Hz units. Low idle will be approximately 80% of the full load speed of 50 Hz units.

There is no low idle stop on generator sets with electronic governors. On generator sets with mechanical governors and generator sets that are powered by natural gas, 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 generator set at low idle speed for an extended time will cause some voltage regulators to shut off. The generator set must be completely shut down. Then, the generator set must be restarted. This will allow the voltage regulator to again produce an output.

## Standby Generator Sets

Most standby units are installed with controls that will start the unit automatically. Standby units start, pick up the load, run, and stop without an operator in attendance.

Standby units can not automatically change the governor control. Standby units can not automatically change the voltage settings. The governor speed and voltage level must be preset for the proper operation of the standby unit. Whenever the set is operated manually, be sure that the governor speed and voltage levels are correct for automatic operation. Check all switches for the proper setting. The start select switch should be in the AUTOMATIC position. Emergency Stop Switches should be in RUN position.

## Generator Options

### Space Heaters

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

### Embedded Temperature Detectors

The 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. Three types of temperature detectors are available. Contact your Caterpillar dealer for more information.

### Bearing Temperature Detectors

Bearing temperature detectors are available as an option on the generators. Bearing temperature detectors measure main bearing temperature. Bearing temperature detectors are used with the equipment that is provided by the customer. 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. Contact your Caterpillar dealer for more information.

## Oilfield Generators

Oilfield generators are available for some generator sets. Oilfield generators are used with SCR controlled electric oil rigs. Oilfield generators are not provided with a voltage regulator. The function of the generator control is performed by the drilling electrical control system. Consult the builder of the drilling rig for any questions that pertain to generator control such as voltage regulation, paralleling, load sharing, etc.

i01807249

## 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 equal. There are two methods that are used in order to determine if the phase rotation of the incoming unit is equal to the phase rotation of the on-line unit. These methods are listed below.

- Phase rotation meter
- Set of three light bulbs

The procedure for determining the proper phase rotation is described below.

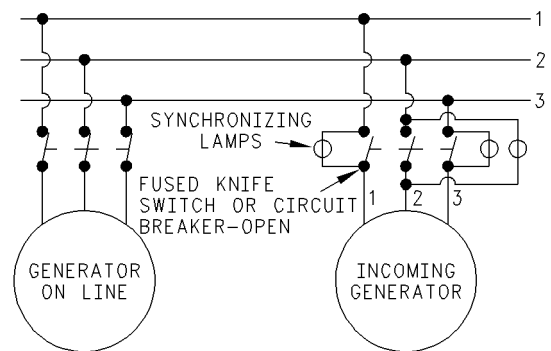


Illustration 36

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. 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.
- When the lights flash in unison, the phase rotation is equal. The first condition of "Initial Start-Up" has been met.

## 2. Adjust the frequency.

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

- Allow each electric set to run under load for about 30 minutes.
- Adjust the governor control in order to give rated frequency at full load.
- 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.
- 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 basically different methods for reactive power equalization.

- Reactive droop compensation
- Cross current 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 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 the better KVAR sharing with other units. The reactive droop compensation is a standard method on the Caterpillar generator sets. The following procedure for voltage adjustment is for the reactive droop compensation.

In the cross current compensation, the voltage regulator is forward biased by the difference in reactive current outputs of the generators in parallel. Cross current compensation is very similar to the reactive droop compensation. In cross current compensation, the secondary circuits of the current transformers are connected in a series string. When one of the generators carries more reactive current than other generators, 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 adjustment for the voltage level and voltage droop 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 require a voltage droop of about 5 percent. A droop adjustment that causes a 2 percent droop in voltage to a 8 percent droop in voltage is usually required for satisfactory division of ampere loading.

- Adjust the voltage. Refer to the "Initial Start-Up" in the Operation Section, "Single Unit Operation".
- While the engine is running at rated speed, turn the voltage droop potentiometer clockwise about 1/2 of full range.
  - If the 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 the driven load is approximately 0.8 power factor, proceed to 3.c.
- Readjust the voltage level rheostat until the voltage is approximately 5 percent above desired voltage.
- 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 equal in order to divide the 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.
  - The voltage at no load 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 the final adjustments after the generators that are parallel have been running at full load for one hour. Tighten the locknuts on all controls. Install the access cover. The last condition of "Initial Start-Up" has been met.

## Starting Multiple Units

Refer to Operation Section, "Single Unit Operation".

## Paralleling Multiple Units

Units may be paralleled at no load or units may be paralleled with units under load. After the initial conditions for start-up 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.
  2. Turn on the synchronizer lights.

3. After the engine has run a few minutes, bring the engine up to synchronous speed. Synchronous speed means that the frequency of the incoming unit will have the same frequency of the unit that is 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 part of the load.

4. Adjust the engine speed until the lights blink very slowly.
5. The lights turn 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 four hours. After the generator temperature has been stabilized, adjust the voltage droop rheostat of each generator in order to share the reactive load. Adjust the voltage droop rheostat of each generator 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 will decrease droop. Adjusting the voltage droop rheostat in a clockwise direction will increase droop.

## Speed Droop for the Load Division (If Equipped)

Once the two units have been paralleled, the 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, 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 in order to change system frequency.

## Parallel Operation Of Governors

The different governors that can be used on G3500C generator sets are shown below.

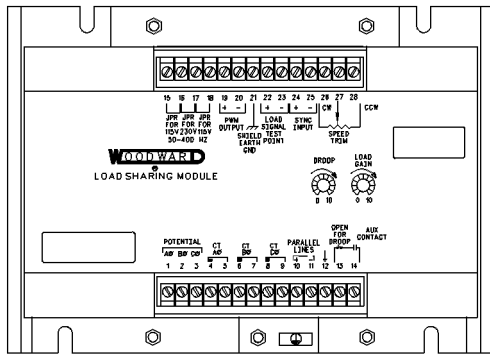


Illustration 37

g00630841

Load Sharing Module (typical example)

The generator set load sharing module provides the droop load sharing for generators that are paralleled. The generator set load sharing module provides the isochronous load sharing for generators that are paralleled. The load sharing module has an input for the synchronizing parallel module. The module provides the load sharing that is proportional. 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, refer to the Service Manual for additional information.

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 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 the generator will assume more kW load. Likewise, decreasing the governor control setting will result in a reduction of load on the unit. Other units on the line will gain load or other units will lose load. 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 generator excitation will determine the power factor of the generator during operation when the generator is in parallel with other generators.

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 that the settings match the settings of the governors with fixed speed droop. If the governor is adjusted for 0 percent speed droop 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 G3520C uses two electronic control modules in order to control engine operation.
- The simplest governor combination for parallel generator sets is a speed droop of 3 percent 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 the 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 speed in the case of governors which are adjusted for speed droop operation. The controls for the governor should be set to the high idle position so that the full range of the governor is available.
- Operation of a governor that is isochronous 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 an automatic load sharing governor.

## 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. Refer to 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 generators that are paralleled. The circulating currents are caused by voltage differences between the generators. 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.

i02292263

## Single Unit Operation

**SMCS Code:** 4450

### Initial Start-Up

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

Refer to this Operation and Maintenance Manual, "Insulation - Test".

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

## 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.

## Adjust the Voltage

Adjust the voltage regulator in order to obtain the proper voltage. **Refer to Operation and Maintenance Manual, "Voltage Regulators" for more information about the voltage regulator.**

1. Turn the remote adjustment potentiometer to the center position, if equipped.
2. Connect an analog voltmeter that is calibrated for 100 VDC on terminal E+ and terminal E-.
3. Connect a voltmeter that is calibrated for 300 VAC to 500 VAC or 1000 VAC to the output terminals of the generator.
4. Make sure that the ST3 wire is positioned on the desired frequency. Also, the engine speed must be changed from the factory setting in order to change the frequency of the generator.
5. Turn voltage potentiometer (P2) to a full counterclockwise position.
6. Turn frequency potentiometer (P4) to a full clockwise position.
7. Turn stability potentiometer (P3) counterclockwise to about 1/3 of the total rotation for the potentiometer.
8. Start the engine and set the engine speed to a frequency of 48 Hz for 50 Hz or 58 Hz for 60 Hz.



- 
9. Adjust the output voltage to the correct value with potentiometer P2. This voltage should be the rated voltage UN for single operation or UN plus 2% to 4% for parallel operation with a current transformer. Use potentiometer P3 to make adjustments if the voltage oscillates. Adjust potentiometer P3 in both directions while you observe the voltage between E+ and E-. The voltage between E+ and E- should be approximately 10 VDC. The best response times are obtained at the limit of the instability. Try cutting or replacing the wire ST2 if no stable position can be obtained.
  10. Check the LAM operation. ST5 must be closed.
  11. Turn potentiometer (P4) slowly counterclockwise until there is a significant voltage drop. The voltage drop should be approximately 15 %.
  12. Vary the frequency around 48 Hz or 58 Hz according to the operating frequency. Check the change in the voltage that was previously observed.

## 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.

# Voltage Regulators

i02303476

## Voltage Regulators

SMCS Code: 4467

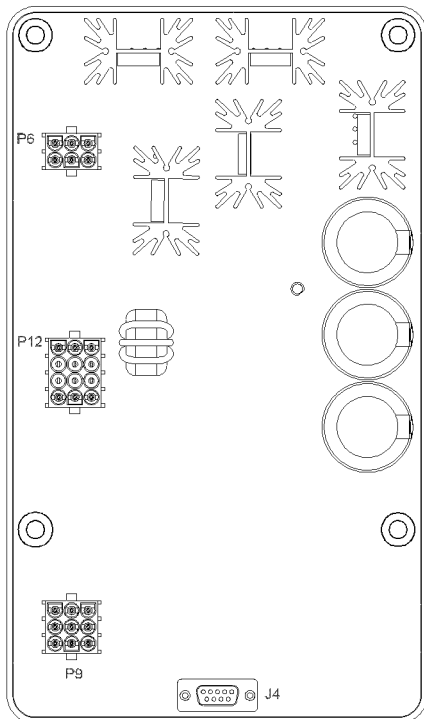
### Caterpillar Digital Voltage Regulator (CDVR)

**⚠ DANGER**

The Cat Digital Voltage Regulator presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.



The Caterpillar Digital Voltage Regulator (CDVR) is a microprocessor based voltage regulator. Control power for the CDVR is supplied from an external source of 24 VDC. The power stage of the CDVR can be supplied from a multiple pole, high frequency, permanent magnet generator, from the generator output (shunt excitation), or from auxiliary windings that are included on some generators. Connections to the CDVR are made through three connectors. The communication between the CDVR and the service tool is accomplished by using a CANBUS protocol.

The CDVR has the following features:

- Three control modes:
  1. Automatic voltage regulation (AVR)
  2. Power factor (PF) regulation
  3. Reactive power (VAR) regulation
- Programmable stability settings
- Soft start control with an adjustable time setting in AVR mode
- Dual slope voltage versus frequency (V/Hz) characteristic
- Three-phase or single-phase voltage sensing
- Single-phase current sensing
- Field current sensing and field voltage sensing
- Ten protection functions

### Adjusting the Caterpillar Digital Voltage Regulator (CDVR)

In order to view and configure the parameters of the CDVR, a PC with the Caterpillar PC software is required.

Refer to Specifications, Systems Operation, Testing and Adjusting, RENR7941, "Caterpillar Digital Voltage Regulator (CDVR)" for complete information.

i01809359

## 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 control for the permanent magnet excited generators is shown below.

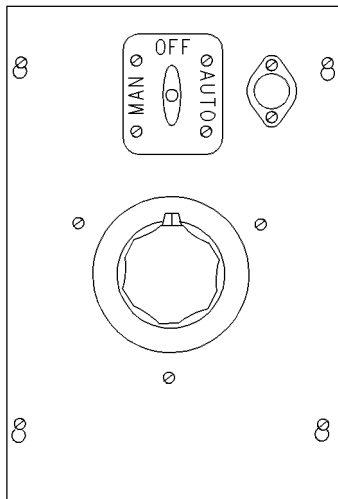


Illustration 39

g00626639

Manual voltage control for permanent magnet excited generators

# Maintenance Section

## Refill Capacities

## Refill Capacities and Recommendations

SMCS Code: 1348; 1395; 7560

## Lubrication System

### Lubricant Recommendations

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

- Cat DEO (Diesel Engine Oil) (10W-30)
- Cat DEO (Diesel Engine Oil) (15W-40)

**Note:** If Cat DEO Multigrade is not used, use only commercial oils that meet the following classifications.

- API CH-4 multigrade oils and API CI-4 multigrade oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid-1 specification) are met. API CH-4 oils and API CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.
- API CG-4 multigrade oils are acceptable for all Caterpillar diesel engines. When API CG-4 oils are used, the oil drain interval should not exceed the standard oil drain interval for your engine.

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. To determine the oil viscosity that is required for starting a cold soaked engine, refer to the minimum temperature in Table 19. To select the oil viscosity for operation at the highest anticipated ambient temperature, refer to the maximum temperature in the Table. Use the highest oil viscosity that is available in order to meet the required temperature during start-up.

i02727879

Table 19

Engine Oil Viscosities for Ambient Temperatures		
Viscosity Grade	Ambient Temperature	
	Minimum	Maximum
SAE 0W-20	-40 °C (-40 °F)	10 °C (50 °F)
SAE 0W-30	-40 °C (-40 °F)	30 °C (86 °F)
SAE 0W-40	-40 °C (-40 °F)	40 °C (104 °F)
SAE 5W-30	-30 °C (-22 °F)	30 °C (86 °F)
SAE 5W-40	-30 °C (-22 °F)	50 °C (122 °F)
SAE 10W-30	-18 °C (0 °F)	40 °C (104 °F)
SAE 10W-40	-18 °C (0 °F)	50 °C (122 °F)
SAE 15W-40	-9.5 °C (15 °F)	50 °C (122 °F)

Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that relates to lubricants.

### Lubricant Capacities

The capacity of the engine lubrication system includes the capacity of the oil filters that are installed at the factory. Auxiliary oil filter systems (if equipped) will require additional oil. Refer to the specifications that are provided by the OEM of the auxiliary oil filter system.

Table 20

Approximate Refill Capacities		
Compartment or System	3512C Engines	3516C Engines
Engine crankcase	318 L (84 US gal)	405 L (107 US gal)

## Fuel

### Fuel Recommendations

In North America, diesel fuel that is identified as No. 1-D or No. 2-D in "ASTM D975" generally meet the specifications. These fuels are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that relates to diesel fuel.

## Cooling System

### Coolant Recommendations

#### NOTICE

Do not use a commercial coolant/antifreeze that only meets the ASTM "D3306" specification. This type of coolant/antifreeze is made for light duty automotive applications.

Use only the coolant/antifreeze that is recommended.

The following coolants are the primary types of coolants that are used in Caterpillar Engines:

**Preferred** – Cat ELC (Extended Life Coolant) or a commercial extended life coolant that meets the Caterpillar EC-1 specification

**Acceptable** – Cat DEAC (Diesel Engine Antifreeze/Coolant) or a commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D6210" specifications

Caterpillar recommends a 1:1 mixture of water and glycol. This mixture will provide optimum heavy-duty performance as a coolant/antifreeze.

**Note:** Cat DEAC does not require a treatment with an Supplemental Coolant Additive (SCA) at the initial fill. However, a commercial heavy-duty coolant/antifreeze that only meets the "ASTM D4985" specification WILL require a treatment with an SCA at the initial fill. A commercial heavy-duty coolant/antifreeze that meets the "ASTM D6210" specification will NOT require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the manufacturer of the commercial heavy-duty coolant/antifreeze.

**Note:** These coolants WILL require a treatment with a supplemental coolant additive on a maintenance basis.

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, refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that pertains to coolants.

**Note:** Table 21 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". **To achieve this service life, the coolants must be properly maintained. The maintenance program includes S·O·S coolant analysis.**

Table 21

Coolant Service Life	
Coolant Type	Service Life <sup>(1)</sup>
Cat ELC	12000 Service Hours or Six Years
Commercial Coolant that meets the Caterpillar EC-1 Specification	6000 Service Hours or Six Years
Cat DEAC	3000 Service Hours or Three Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D6210"	3000 Service Hours or Two Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985"	3000 Service Hours or 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).

**Note:** Add Cat ELC Extender at 6000 service hours or one half of the service life of the ELC.

**Note:** These coolant change intervals are only possible with annual S·O·S Services coolant analysis.

### Coolant Capacities

To properly maintain the cooling system, the total cooling system capacity must be determined. The total cooling system capacity will vary between individual installations. The total cooling system capacity can include the following components: engine, expansion tank, heat exchanger, radiator, keel cooler, and piping.

Refer to the specifications that are provided by Caterpillar or the OEM of the installation. Record the total cooling system capacity in the appropriate Table.

Table 22

<b>Approximate Refill Capacities</b>			
	<b>Engine</b>	<b>Radiator</b>	<b>Total cooling system</b>
3512C Engine	157 L (42 US gal)	244 L (65 US gal)	401 L (106 US gal)
3516C Engine	233 L (62 US gal)	247 L (65 US gal)	480 L (127 US gal)

# Maintenance Recommendations

## General Maintenance Information

i01774688

**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. Standard 432-1992" or consult a Caterpillar dealer.

## Space Heaters

The SR4 HV and SR4B HV generators are 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.

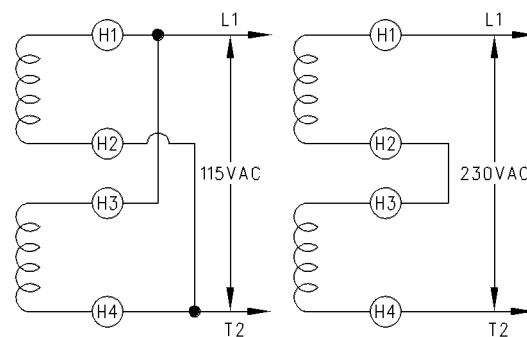


Illustration 40

g00556903

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 40.

## Field Conditions that Reduce Insulation Life

Electric machines and associated insulation systems are exposed to the following types of stress: mechanical, electrical, thermal, and environmental. These stresses produce many deteriorating influences. The following list defines the most significant influences.

**Thermal Aging** – This is the deteriorating influence on insulation that is caused by the normal service temperature.

**Overtemperature** – This is the unusually high temperature of operation that is caused by the following conditions: overload, high ambient temperature, restricted ventilation, winding faults, and foreign materials that are deposited on windings.

**Overvoltage** – This is a voltage that is much higher than the rated nameplate voltage. This voltage can be caused by switching surges or lightening surges. Operating above the rated nameplate voltage will reduce the life of the insulation.

**Contamination** – Contamination deteriorates electrical insulation in the following ways:

- conducting current over insulated surfaces
- attacking the material and reducing the quality of the material's electrical insulation
- attacking the material and reducing the material's physical strength
- creating a thermal insulation that causes the material to operate at higher than normal temperatures

Some potential contaminants are listed below:

- water or extreme humidity
- unstable antiwear oil or grease
- oil or grease that contains extreme pressure additives
- conductive dust and conductive particles
- nonconductive dust and nonconductive particles
- industrial chemicals such as acids, solvents, and cleaning solutions

**Physical Damage** – This contributes to the failure of electrical insulation by opening a conductive path through the insulation.

The following list includes some of the physical damages that can occur:

- physical shock
- vibration
- overspeed
- erosion by foreign matter
- damage by foreign objects
- thermal cycling

**Ionization Effects** – Ionization (corona) can occur at higher operating voltages. Ionization is accompanied by several undesirable effects such as chemical action, heating, and erosion.

102909163

## System Pressure Release

**SMCS Code:** 1250; 1300; 1350; 5050

### Coolant System

#### **WARNING**

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

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

### Fuel System

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

### High Pressure Fuel Lines (If Equipped)

#### **WARNING**

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



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

This is because of the following differences:

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

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

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

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

## Engine Oil

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

i03642798

## Welding on Engines with Electronic Controls

**SMCS Code:** 1000

---

### NOTICE

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

---

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

---

### NOTICE

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

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

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

---

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

1. Stop the engine. Turn the switched power to the OFF position.
2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.
3. Disconnect the J1/P1 and J2/P2 connectors from the ECM. Move the harness to a position that will not allow the harness to accidentally move back and make contact with any of the ECM pins.

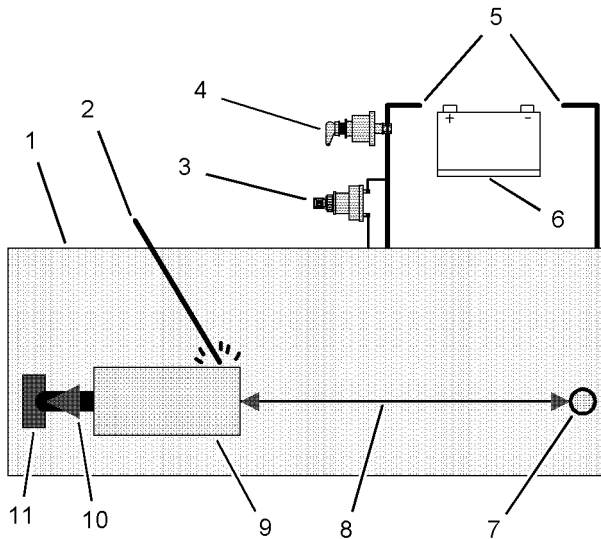


Illustration 41

g01075639

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

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

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

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

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

6. Use standard welding practices to weld the materials.

i02364500

# Generator Start-up Checklist

**SMCS Code:** 4450

Table 23

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: _____							
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 hours before start-up?							
<b>MEGOHMMETER TEST ("SEHS9124")</b>		30 sec. reading	60 sec. reading	30 sec. corrected	60 sec. corrected	Ambient temp.	Comments
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	"T1" to "T2"	AC					
	"T1" to "T3"	AC					
	"T2" to "T3"	AC					
	"11" to "12"	AC					
	"11" to "13"	AC					
	"12" to "13"	AC					

(continued)

(Table 23, contd)

<b>GENERATOR START-UP CHECKLIST</b>				
Full Load	"T1" to "T2"	AC		
	"T1" to "T3"	AC		
	"T2" to "T3"	AC		
	"11" to "12"	AC		
	"11" to "13"	AC		
	"12" to "13"	AC		



i03726144

## Maintenance Interval Schedule (Standby)

**SMCS Code:** 1000; 4450; 7500

Ensure that all safety information, warnings and instructions are read and understood before any operation or any maintenance procedures are performed.

An authorized operator may perform the maintenance items with daily intervals. An authorized operator may perform the maintenance items with intervals of every week. The maintenance that is recommended for all other maintenance intervals must be performed by an authorized service technician or by your Caterpillar dealer.

The user is responsible for the performance of all maintenance which includes the following items: performing all adjustments, using proper lubricants, fluids, and filters, and replacing old components with new components due to normal wear and aging .

Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the product and/or accelerated wear of components.

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

Choose the interval that occurs first in order to determine the correct maintenance interval: fuel consumption, service hours, and calendar time . Products that operate in severe operating conditions may require more frequent maintenance.

All of the following will affect the oil change interval: operating conditions, fuel type, oil type, and size of the oil sump . Scheduled oil sampling analyzes used oil in order to determine if the oil change interval is suitable for your specific engine.

In the absence of scheduled oil sampling, replace the engine oil and filters according to the following intervals:

If the engine has a shallow oil sump, change the oil after every 250 service hours.

If the engine has a standard oil sump, change the oil after every 500 service hours.

If the engine has a deep oil sump, change the oil after every 1000 service hours.

Refer to this Operation and Maintenance Manual, "Engine Oil and Filter - Change" in order to determine the oil change interval that is suitable for your specific engine.

To determine the maintenance intervals for the overhauls, refer to this Operation and Maintenance Manual, "Maintenance Recommendations" .

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

The starting system is disabled.

The engine is stopped.

The generator does not pose an electrical shock hazard.

The generator is disconnected from the load.

### When Required

Air Inlet Filter - Check .....	82
Air Tank Moisture and Sediment - Drain .....	84
Battery or Battery Cable - Disconnect .....	89
Circuit Breakers - Reset .....	90
Engine - Clean .....	101
Fuel System - Prime .....	114
Fuel System Primary Filter/Water Separator - Drain .....	115
Generator - Dry .....	117
Generator Bearing - Lubricate .....	120
Generator Set - Test .....	124
Radiator - Clean .....	141

### Daily

Cooling System Coolant Level - Check .....	96
Electrical Connections - Check .....	101
Engine Oil Level - Check .....	108

### Every Week

Air Inlet Filter - Check .....	82
Air Starting Motor Lubricator Oil Level - Check ....	84
Annunciator Panel - Inspect .....	85
Automatic Start/Stop - Inspect .....	87
Battery Charger - Check .....	87
Battery Electrolyte Level - Check .....	88
Engine Air Cleaner Service Indicator - Inspect ...	106
Engine Air Precleaner - Clean .....	107
Fuel Tank Water and Sediment - Drain .....	117
Generator - Inspect .....	118
Generator Bearing Temperature - Test/Record ...	123
Generator Lead - Check .....	124
Generator Load - Check .....	124
Jacket Water Heater - Check .....	129
Power Factor - Check .....	141
Space Heater - Test .....	144

Standby Generator Set Maintenance	
Recommendations .....	145
Stator Winding Temperature - Test .....	146
Voltage and Frequency - Check .....	147
Walk-Around Inspection .....	148

### Every 250 Service Hours

Air Shutoff - Test .....	83
Engine Oil Sample - Obtain .....	109

### Every 500 Service Hours or 1 Year

Fan Drive Bearing - Lubricate .....	113
-------------------------------------	-----

### Every 6 Months

Cooling System Coolant Sample (Level 1) - Obtain .....	97
---	----

### Every Year

Air Starting Motor Lubricator Bowl - Clean .....	83
Alternator - Inspect .....	85
Belts - Inspect/Adjust/Replace .....	89
Cooling System Coolant Sample (Level 2) - Obtain .....	97
Cooling System Supplemental Coolant Additive (SCA) - Test/Add .....	98
Crankshaft Vibration Damper - Inspect .....	100
Engine Air Cleaner Element (Dual Element) - Clean/Replace .....	101
Engine Crankcase Breather - Clean .....	107
Engine Mounts - Check .....	108
Engine Oil and Filter - Change .....	110
Engine Protective Devices - Check .....	112
Engine Valve Lash - Inspect/Adjust .....	113
Fan Drive Bearing - Lubricate .....	113
Fuel Injector - Inspect/Adjust .....	114
Fuel System Primary Filter (Water Separator) Element - Replace .....	114
Fuel System Secondary Filter - Replace .....	116
Generator Set Vibration - Test/Record .....	125
Hoses and Clamps - Inspect/Replace .....	126
Insulation - Test .....	127
Rotating Rectifier - Check .....	141
Rotating Rectifier - Inspect/Test .....	143
Speed Sensor - Clean/Inspect .....	144
Starting Motor - Inspect .....	146
Stator Lead - Check .....	146
Turbocharger - Inspect .....	146
Varistor - Check .....	147
Varistor - Inspect .....	147
Water Pump - Inspect .....	149

### Every 3 Years

Batteries - Replace .....	87
Cooling System Coolant (DEAC) - Change .....	92
Cooling System Coolant Extender (ELC) - Add ....	95
Cooling System Water Temperature Regulator - Replace .....	99

### Every 5000 Service Hours

Air Shutoff - Replace .....	82
-----------------------------	----

### Every 6 Years

Cooling System Coolant (ELC) - Change .....	94
---	----

### Commissioning

Fan Drive Bearing - Lubricate .....	113
Generator Set Alignment - Check .....	125

i03726143

## Maintenance Interval Schedule (Prime Power)

**SMCS Code:** 1000; 4450; 7500

Ensure that all safety information, warnings and instructions are read and understood before any operation or any maintenance procedures are performed.

An authorized operator may perform the maintenance items with daily intervals. An authorized operator may perform the maintenance items with intervals of every week. The maintenance that is recommended for all other maintenance intervals must be performed by an authorized service technician or by your Caterpillar dealer.

The user is responsible for the performance of all maintenance which includes the following items: performing all adjustments, using proper lubricants, fluids, and filters, and replacing old components with new components due to normal wear and aging .

Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the product and/or accelerated wear of components.

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

Choose the interval that occurs first in order to determine the correct maintenance interval: fuel consumption, service hours, and calendar time . Products that operate in severe operating conditions may require more frequent maintenance.

All of the following will affect the oil change interval: operating conditions, fuel type, oil type, and size of the oil sump . Scheduled oil sampling analyzes used oil in order to determine if the oil change interval is suitable for your specific engine.

In the absence of scheduled oil sampling, replace the engine oil and filters according to the following intervals:

If the engine has a shallow oil sump, change the oil after every 250 service hours.

If the engine has a standard oil sump, change the oil after every 500 service hours.

If the engine has a deep oil sump, change the oil after every 1000 service hours.

Refer to this Operation and Maintenance Manual, "Engine Oil and Filter - Change" in order to determine the oil change interval that is suitable for your specific engine.

To determine the maintenance intervals for the overhauls, refer to this Operation and Maintenance Manual, "Maintenance Recommendations" .

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

The starting system is disabled.

The engine is stopped.

The generator does not pose an electrical shock hazard.

The generator is disconnected from the load.

### When Required

Air Inlet Filter - Check .....	82
Air Tank Moisture and Sediment - Drain .....	84
Batteries - Replace .....	87
Battery - Recycle .....	87
Battery or Battery Cable - Disconnect .....	89
Circuit Breakers - Reset .....	90
Closed Crankcase Ventilation (CCV) Fumes Disposal Filter - Replace .....	91
Cooling System Coolant Sample (Level 2) - Obtain .....	97
Engine - Clean .....	101
Engine Air Cleaner Element (Dual Element) - Clean/Replace .....	101
Engine Air Cleaner Element (Single Element) - Clean/Replace .....	104
Fuel System - Prime .....	114
Fuel System Primary Filter/Water Separator - Drain .....	115
Generator - Dry .....	117
Generator Bearing - Lubricate .....	120
Generator Set - Test .....	124
Generator Set Alignment - Check .....	125
Maintenance Recommendations .....	129
Radiator - Clean .....	141

### Daily

Air Starting Motor Lubricator Oil Level - Check ....	84
Annunciator Panel - Inspect .....	85
Cooling System Coolant Level - Check .....	96
Electrical Connections - Check .....	101
Engine Air Cleaner Service Indicator - Inspect ...	106
Engine Air Precleaner - Clean .....	107
Engine Oil Level - Check .....	108
Fuel Tank Water and Sediment - Drain .....	117
Generator Load - Check .....	124
Jacket Water Heater - Check .....	129
Power Factor - Check .....	141



Voltage and Frequency - Check ..... 147  
Walk-Around Inspection ..... 148

**Every Week**

Automatic Start/Stop - Inspect ..... 87  
Generator - Inspect ..... 118  
Generator Bearing Temperature - Test/Record ... 123  
Generator Lead - Check ..... 124  
Generator Load - Check ..... 124  
Space Heater - Test ..... 144  
Stator Winding Temperature - Test ..... 146

**Initial 250 Service Hours**

Engine Valve Lash - Inspect/Adjust ..... 113  
Fuel Injector - Inspect/Adjust ..... 114  
Speed Sensor - Clean/Inspect ..... 144

**Every 250 Service Hours**

Air Shutoff - Test ..... 83  
Battery Electrolyte Level - Check ..... 88  
Belts - Inspect/Adjust/Replace ..... 89  
Cooling System Coolant Sample (Level 1) -  
Obtain ..... 97  
Cooling System Supplemental Coolant Additive  
(SCA) - Test/Add ..... 98  
Engine Oil Sample - Obtain ..... 109  
Hoses and Clamps - Inspect/Replace ..... 126

**Every 500 Service Hours**

Engine Oil and Filter - Change ..... 110

**Every 500 Service Hours or 1 Year**

Fan Drive Bearing - Lubricate ..... 113

**Every 1000 Service Hours**

Cooling System Coolant Sample (Level 2) -  
Obtain ..... 97  
Engine Crankcase Breather - Clean ..... 107  
Engine Protective Devices - Check ..... 112  
Fuel System Primary Filter (Water Separator)  
Element - Replace ..... 114  
Fuel System Secondary Filter - Replace ..... 116  
Insulation - Test ..... 127

**Every 1000 Service Hours or 1 Year**

Rotating Rectifier - Inspect/Test ..... 143

**Every 2000 Service Hours**

Air Starting Motor Lubricator Bowl - Clean ..... 83  
Crankshaft Vibration Damper - Inspect ..... 100  
Engine Mounts - Check ..... 108  
Generator Set Vibration - Test/Record ..... 125  
Stator Lead - Check ..... 146  
Turbocharger - Inspect ..... 146

**Every Year**

Varistor - Check ..... 147  
Varistor - Inspect ..... 147

**Every 3000 Service Hours or 3 Years**

Cooling System Coolant (DEAC) - Change ..... 92  
Cooling System Coolant Extender (ELC) - Add .... 95

**Every 4000 Service Hours**

Engine Valve Lash - Inspect/Adjust ..... 113  
Fuel Injector - Inspect/Adjust ..... 114

**Every 5000 Service Hours**

Air Shutoff - Replace ..... 82

**Every 6000 Service Hours or 6 Years**

Alternator - Inspect ..... 85  
Cooling System Coolant (ELC) - Change ..... 94  
Cooling System Water Temperature Regulator -  
Replace ..... 99  
Prelube Pump - Inspect ..... 141  
Speed Sensor - Clean/Inspect ..... 144  
Starting Motor - Inspect ..... 146  
Water Pump - Inspect ..... 149

**Every 7500 Service Hours or 1 Year**

Rotating Rectifier - Check ..... 141

**Overhaul**

Aftercooler Core - Inspect/Clean ..... 82  
Generator Bearing - Inspect/Replace ..... 119  
Overhaul (Major) ..... 133  
Overhaul (Top End) ..... 135  
Overhaul Considerations ..... 138

**Commissioning**

Fan Drive Bearing - Lubricate ..... 113

i02828620

## Aftercooler Core - Inspect/Clean

**SMCS Code:** 1063-040; 1064-571

1. Remove the core. Refer to the Disassembly and Assembly Manual, "Aftercooler - Remove and Install" for the procedure.
2. Turn the aftercooler core on one side in order to remove debris. Remove the debris that is accessible.

### NOTICE

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

3. Back flush the core with cleaner.

Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 25 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 25

Hydrosolv Liquid Cleaners <sup>(1)</sup>		
Part Number	Description	Size
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

<sup>(1)</sup> Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F). Consult your Caterpillar dealer for more information.

4. Remove the drain plug.
  5. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris from the inside and from the outside of the core.
- Note:** Do not use high pressure when the fins are cleaned. High pressure can damage the fins.
6. Wash the core with hot, soapy water.
  7. Flush the core thoroughly in order to remove residue and remaining debris. Flush the core with clean, fresh water until the water that is exiting the core is clear and free of debris.

### WARNING

Personal injury can result from air pressure.

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

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

8. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.
9. Prior to installation, inspect any O-rings or seals for damage. If necessary, replace the O-rings or seals.
10. Inspect the core for trapped debris and cleanliness. If it is necessary, remove the debris and repeat the cleaning procedure.
11. Inspect the core for damage and perform a pressure test in order to detect leaks. Many shops that service radiators are equipped to perform pressure tests.
12. Install the core. Refer to Disassembly and Assembly Manual, "Aftercooler - Remove and Install" for the procedure.

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

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.

i02540734

## Air Shutoff - Replace

**SMCS Code:** 1078-510

1. Ensure that the engine is not running.
2. If the air shutoff has not been activated, use the manual release knob to manually trip the air shutoff. Ensure that the arrow is pointing straight down to the closed position. If air shutoff did not trip, see the Troubleshooting Guide.

- Refer to the engine's Disassembly and Assembly Manual for instructions on removing and installing the air shutoff.

i02540695

## Air Shutoff - Test

**SMCS Code:** 1078-081

Air shutoff valves must be tested and inspected in order to ensure proper operation.

Inspect the air shutoff for damage that could prevent operation: damage to the housing, damage to the manual release knob, and damage to the oil supply line. After inspecting the air shutoff, use Caterpillar Electronic Technician (ET) to trip the shutoff in order to ensure that the shutoff functions properly.

- Start the engine and run at low idle.
- Use Cat ET to override the parameters for the air shutoff and trip the air shutoff. Cat ET is the preferred method. If Cat ET is not available, the use of the emergency stop button is acceptable.
- Inspect the air shutoff in order to ensure that the air shutoff has been tripped. The indicator on the air shutoff should point downward to the closed position. If the shutoff did not trip, see the Troubleshooting Guide.
- Use a 1 inch wrench to reset the air shutoff by turning the operating shaft 180 degrees in the clockwise direction. Ensure that the arrow is pointing up to the open position.
- Repeat Steps 1 through 4 for a total of two successful tests.

**Note:** Testing is only complete when the engine successfully passes all of the steps. Reset the air shutoff valve to the open position and clean up any spills that may have occurred.

i02654935

## Air Starting Motor Lubricator Bowl - Clean

**SMCS Code:** 1451-070

If the engine is equipped with an air starting motor, use the following procedure:

### **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.**

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

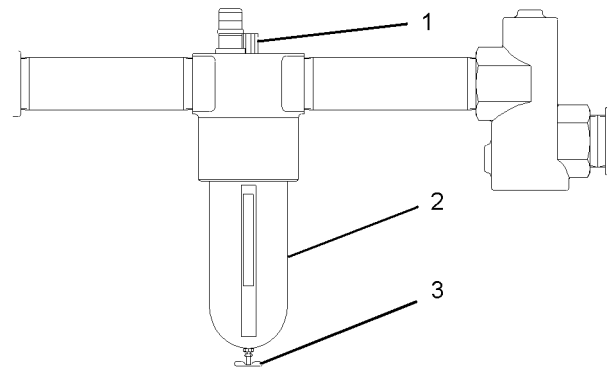


Illustration 42

g01333332

- Filler plug
- Bowl
- Drain valve

- 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 Dealer Service Tool Catalog" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

- Place a suitable container under bowl (2) and open drain valve (3) in order to drain the oil from the bowl.
- 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. Inspect the gasket. If the gasket is damaged, replace the gasket.
6. Install the bowl.
7. Make sure that drain valve (3) is closed.
8. For instructions on filling the lubricator, see this Operation and Maintenance Manual, "Air Starting Motor Lubricator Oil Level - Check" topic.

i02654969

## 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.

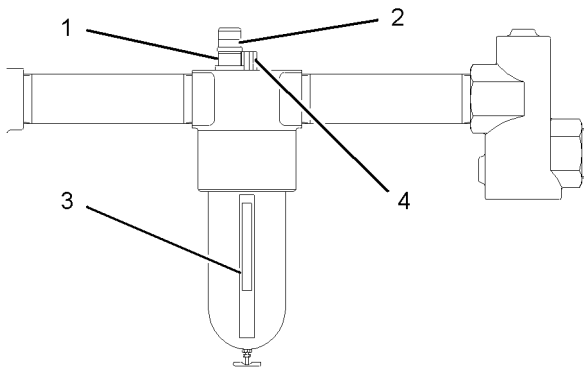


Illustration 43

g01333366

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 SAE 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 from one to three drops of oil per second. To increase the rate, turn knob (2) counterclockwise. To decrease the rate, turn the knob clockwise.

i00847451

## Air Tank Moisture and Sediment - Drain (If Equipped)

**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.
3. Check the air supply pressure. The air starting motor requires a minimum of 620 kPa (90 psi) of air pressure to operate properly. The maximum air pressure must not exceed 1550 kPa (225 psi). The normal air pressure will be 758 to 965 kPa (110 to 140 psi).

i02084374

## Alternator - Inspect

**SMCS Code:** 1405-040

Inspect the alternator for the following conditions:

- Proper connections
- Clean ports for cooling airflow
- Proper charging of the battery

Observe the ammeter during engine operation in order to ensure proper battery performance and/or proper performance of the electrical system.

Make repairs, if necessary. See the Service Manual for service procedures. Consult your Caterpillar dealer for assistance.

i01961631

## 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 26 is offered for use as a log for engine performance. Make several copies of Table 26 for continued use. Retain the recorded information for reference.

Table 26

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 coolant 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)						
Rear bearing temperature (generator)						
Generator stator temperature						
Generator voltage						
Generator amperage						
Comments						

i01942284

## Automatic Start/Stop - Inspect

**SMCS Code:** 4462

The generator set must be ready to operate under a load at any time. After performing maintenance on the generator set, inspect the position of the control switches. Ensure the following conditions:

- The starting system is enabled.
- The control switches are in the correct position for automatic starting.
- The switchgear and the automatic transfer switches that are associated with the generator are enabled.

i01041029

## Batteries - Replace

**SMCS Code:** 1401-510

### WARNING

**Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.**

**Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.**

1. Turn the key start switch to the OFF position. Remove the key and all electrical loads.
2. Turn OFF the battery charger. Disconnect the charger.
3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the ground plane. Disconnect the cable from the NEGATIVE “-” battery terminal.
4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

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

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

**Note:** Before connecting the cables, ensure that the key start switch is OFF.

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

i00993589

## Battery - Recycle

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

Always recycle a battery. Never discard a battery.

Always return used batteries to one of the following locations:

- A battery supplier
- An authorized battery collection facility
- Recycling facility

i01917570

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

Table 27

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.
Caterpillar Maintenance Free Batteries	The battery may not pass a load test.
	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.

i02601752

## 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.



**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.



i02667833

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

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

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

Thoroughly rinse the battery case with clean water.

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

i01857537

## 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.

- Switch the engine to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
- Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal.
- Tape the leads in order to help prevent accidental starting.
- Proceed with necessary system repairs. Reverse the steps in order to reconnect all of the cables.

## Belts - Inspect/Adjust/Replace

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

### 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.

### Adjusting the Alternator Belt

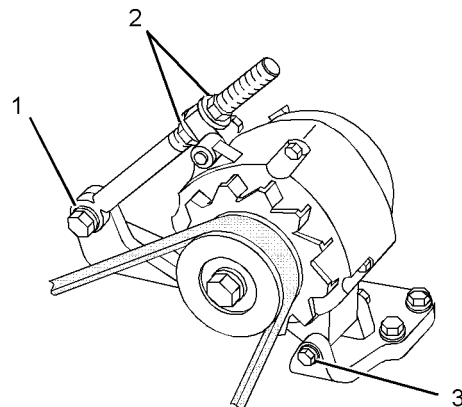


Illustration 44

g01092641

Typical alternator

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

- Remove the drive belt guard.

2. Loosen mounting bolt (1), adjusting nuts (2) and mounting bolt (3).
3. Turn adjusting nuts (2) in order to increase or decrease the drive belt tension.
4. Tighten adjusting nuts (2). Tighten mounting bolt (3). Tighten mounting bolt (1). For the proper torque, see the Service Manual, "Specifications" module.
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.

## Adjusting the Fan Drive Belt

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 to the proper torque.
5. Tighten the mounting bolt to the proper torque.

For the proper torque specifications, refer to the Service Manual, "Specifications" module.

## 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.

i02107779

## Circuit Breakers - Reset

SMCS Code: 1417-529; 1420-529

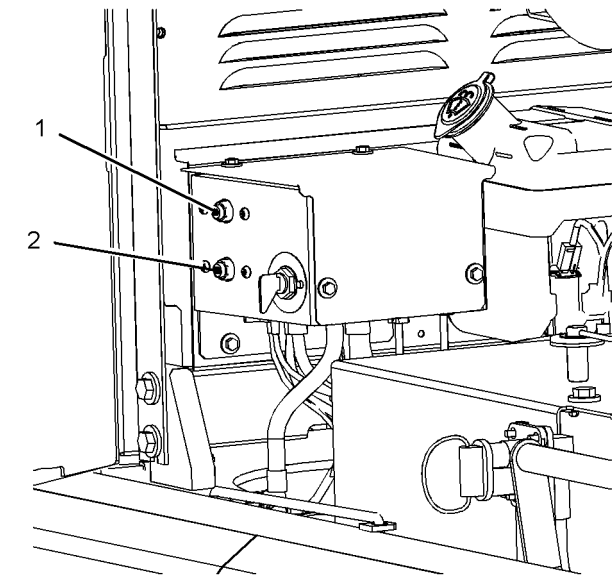


Illustration 45

g01070621

The circuit breaker is located behind the front left access door.



**Main Circuit (1)** – This circuit breaker is designed to protect the wires between the batteries and the fuses. If the wires are shorted to the machine's body, this circuit breaker would minimize the damage to the wires.

The main circuit breaker has a capacity of 80 Amp.



**Alternator Circuit (2)** – This circuit breaker is designed to protect the alternator. If the batteries are installed with reversed polarity, the circuit breaker would prevent the alternator from damaging the rectifier.

The circuit breaker for the alternator has a capacity of 105 Amp.

**Circuit Breaker Reset** – Push in the button in order to reset the circuit breaker. If the electrical system is working properly, the button will remain depressed. If the button does not remain depressed, check the appropriate electrical circuit. Repair the electrical circuit, if necessary.

i02584002

## Closed Crankcase Ventilation (CCV) Fumes Disposal Filter - Replace

SMCS Code: 1317-510-FI

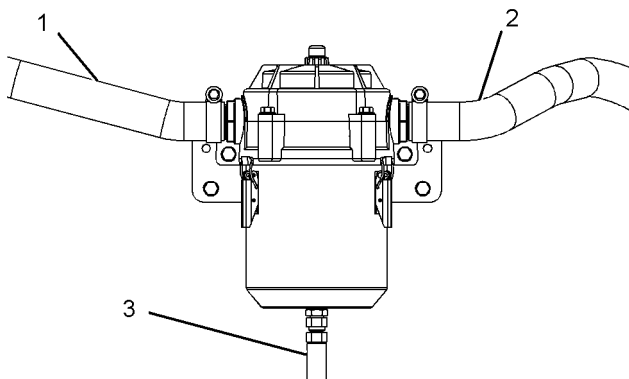


Illustration 46

g01294089

Typical example of the Closed Crankcase Ventilation (CCV) system

- (1) Return to the air inlet system
- (2) Fumes from crankcase breather
- (3) Oil drain to crankcase

The Closed Crankcase Ventilation (CCV) system requires the replacement of the fumes disposal filter. The service interval of the CCV will be affected by the following items:

- Engine load
- Concentration of soot
- Condition of the engine

The CCV is equipped with a service indicator. If the fumes disposal filter becomes plugged prior to the normal service interval, increased restriction of the filter will cause the vacuum to become positive. When the pressure continues to rise, the service indicator will show through the cap. The service indicator indicates the need for the fumes disposal filter to be changed. Reset the service indicator by using the following procedure:

## Resetting the Service Indicator

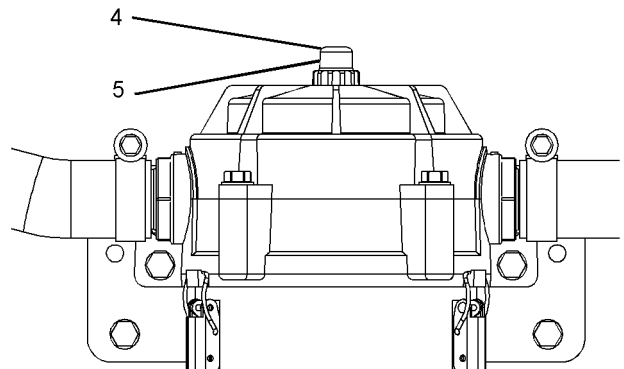


Illustration 47

g01292899

1. Remove plastic cover (4).
2. Push down on service indicator (5).
3. Replace cover (4).
4. Replace the fumes disposal filter by using the following procedure:

## Replacing the Fumes Disposal Filter

### WARNING

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

**Note:** When possible, perform the maintenance while the engine is off.

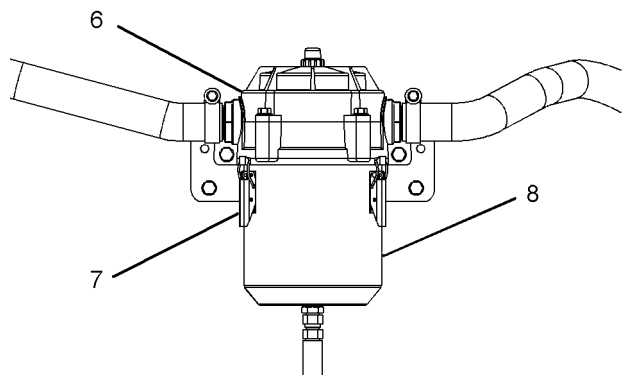


Illustration 48

g01292905

1. Release latches (7) that hold the canister to filter base assembly (6).

**Note:** Removing canister (8) may be difficult while the engine is operating. The canister has negative air pressure while the engine is operating. This creates a vacuum.

2. Lower the canister in order to expose the element. There may be oil in the bottom of the canister. Avoid spilling the oil.
3. Remove the filter element by pulling down. Dispose of the used element properly.
4. Remove the O-ring assembly on the top end cap of the used element.
5. Replace the O-ring seal on the bottom of the filter base assembly.
6. Install the new O-ring on the top end cap of the element. Install the element into the correct place.
7. Replace the canister and align the canister with the boss on the filter base assembly.
8. Clamp the latches in the closed position.

i02327874

## 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.
- Oil has entered the cooling system and the coolant is contaminated.
- Fuel has entered the cooling system and the coolant is contaminated.

### Drain the Cooling System

1. Stop the engine and allow the engine to cool. Ensure that the engine will not start when the cooling system is drained.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

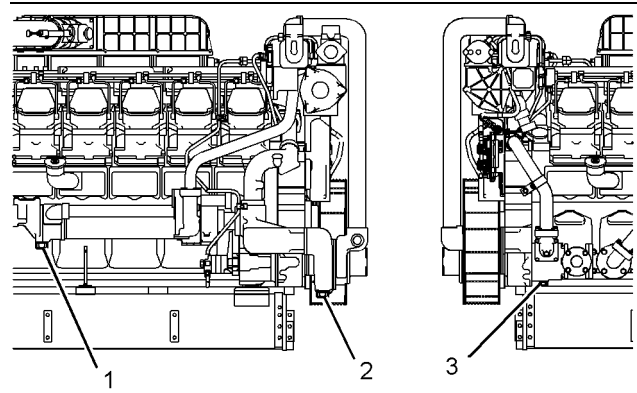


Illustration 49

g01162705

Locations of the drain plugs

- (1) Oil cooler
- (2) Jacket water pump
- (3) SCAC water pump

3. Open the cooling system drain valves (if equipped). If the cooling system is not equipped with drain valves, remove drain plugs (1), (2), and (3). Allow the coolant to drain.

### NOTICE

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

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Dealer Service Tools 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 valves (if equipped). Clean the drain plugs and install the drain plugs.

### 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.

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 cooling system filler cap.
4. 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. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped) or remove the drain plugs. See Illustration 49.

---

#### 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. Allow the water to drain. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

## 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 cooling system drain valves (if equipped). Clean drain plugs and install the drain plugs. See Illustration 49.
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 cooling system filler cap.
4. 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. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped) or remove the drain plugs. See Illustration 49. Allow the water to drain.

---

#### NOTICE

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

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

---

6. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

## 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 this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section). For the capacity of the cooling system, see this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section).

1. Fill the cooling system with coolant/antifreeze. Do not install the cooling system filler cap.
2. 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 (0.5 inch) below the bottom of the filler pipe.

4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets of the cooling system filler cap are damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gaskets of the cooling system filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not maintain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02327899

## 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. Ensure that the engine will not start when the cooling system is drained.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

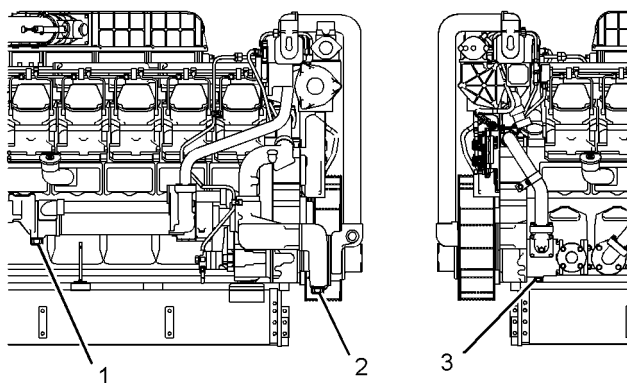


Illustration 50

g01162705

Locations of the drain plugs

- (1) Oil cooler
- (2) Jacket water pump
- (3) SCAC water pump

3. Open the cooling system drain valves (if equipped). If the cooling system is not equipped with drain valves, remove drain plugs (1), (2), and (3). Allow the coolant to drain.

#### NOTICE

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

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Dealer Service Tools 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 valves (if equipped). Clean the drain plugs and install the drain plugs.

#### NOTICE

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

3. Fill the cooling system with clean water. Install the cooling system 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. Ensure that the engine will not start when the cooling system is drained. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
5. Open the cooling system drain valves (if equipped). If the cooling system is not equipped with drain valves, remove the drain plugs. See Illustration 50. Allow the coolant to drain. Flush the cooling system with clean water. Close the cooling system drain valves (if equipped). Install the drain plugs.
6. Repeat Steps 3, 4, and 5.

## Fill the Cooling System

### NOTICE

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

1. Fill the cooling system with Extended Life Coolant (ELC). See the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for the correct cooling system capacity. Do not install the cooling system filler cap.
2. 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 (0.5 inch) below the bottom of the filler pipe.
4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets of the cooling system filler cap are damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gaskets of the cooling system filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not maintain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02482066

## Cooling System Coolant Extender (ELC) - Add

**SMCS Code:** 1352-544-NL

Cat ELC (Extended Life Coolant) does not require the frequent additions of any supplemental cooling additives which are associated with the present conventional coolants. The Cat ELC Extender only needs to be added once.

### NOTICE

Use only Cat Extended Life Coolant (ELC) Extender with Cat ELC.

Do NOT use conventional supplemental coolant additive (SCA) with Cat ELC. Mixing Cat ELC with conventional coolants and/or conventional SCA reduces the Cat ELC service life.

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

### WARNING

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

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

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

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

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

### NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

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 Cat ELC Extender.

3. Add Cat ELC Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" article for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i02158408

## Cooling System Coolant Level - Check

SMCS Code: 1350-535-FLV

### WARNING

Climbing equipment may be required to access this service point. Refer to the Operation and Maintenance Manual, "Mounting and Dismounting" topic for safety information.

## Engines That Are Equipped With a Sight Gauge

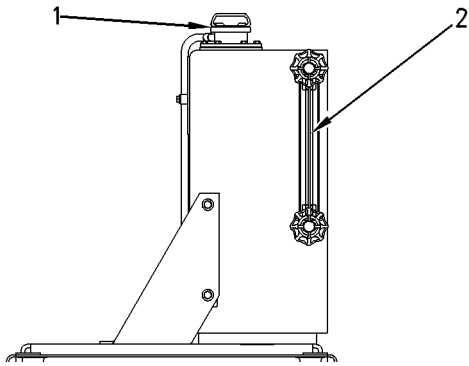


Illustration 51

g00750429

- (1) Filler cap  
(2) Sight gauge

If the engine is equipped with a sight gauge, observe the position of the coolant in the sight gauge. At normal operating temperature, the proper coolant level is in the upper half of the sight gauge. If the coolant level is low, add the proper coolant mixture.

## Engines That Are Not Equipped With a Sight Gauge

### 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.**

Check the coolant level when the engine is stopped and cool. Check the coolant level only after the engine has been stopped and the cooling system filler cap is cool enough to touch with your bare hand.

Remove the cooling system filler cap slowly in order to relieve any pressure. Maintain the coolant within 13 mm (0.5 inch) below the bottom of the filler pipe.

## Add Coolant

**Note:** For the proper coolant mixture to use, see this Operation and Maintenance Manual, "Refill Capacities and Recommendations" (Maintenance Section).

1. Stop the engine. Allow the engine to cool.
2. Remove the cooling system filler cap slowly in order to relieve any pressure. Pour the proper coolant mixture into the filler pipe.

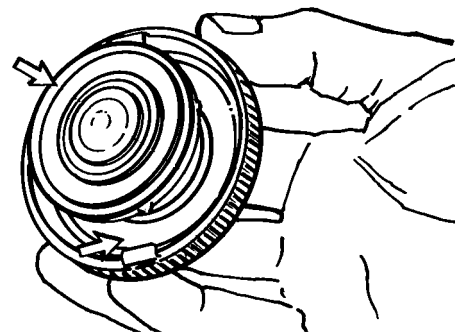


Illustration 52

g00103639

Gaskets

3. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.
4. Start the engine. Inspect the cooling system for leaks.



i02837191

## Cooling System Coolant Sample (Level 1) - Obtain

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

**Note: Obtaining a Coolant Sample (Level 1) is optional if the cooling system is filled with Cat ELC (Extended Life Coolant).** Cooling systems that are filled with Cat ELC should have a Coolant Sample (Level 2) that is obtained at the recommended interval that is stated in the Maintenance Interval Schedule.

**Note: Obtain a Coolant Sample (Level 1) if the cooling system is filled with any other coolant instead of Cat ELC.** This includes the following types of coolants:

- Commercial long life coolants that meet the Caterpillar Engine Coolant Specification -1 (Caterpillar EC-1)
- Cat DEAC (Diesel Engine Antifreeze/Coolant)
- Commercial heavy-duty coolant/antifreeze

Table 28

Recommended Interval		
Type of Coolant	Level 1	Level 2
Cat DEAC	Every 250 Hours <sup>(1)</sup>	Yearly <sup>(1)(2)</sup>
Cat ELC	Optional <sup>(2)</sup>	Yearly <sup>(2)</sup>

<sup>(1)</sup> This is the recommended interval for coolant samples for all conventional heavy-duty coolant/antifreeze. This is also the recommended interval for coolant samples of commercial coolants that meet the Cat EC-1 specification for engine coolant.

<sup>(2)</sup> The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

### NOTICE

Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

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

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

Use the following guidelines for proper sampling of the coolant:

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

Submit the sample for Level 1 analysis.

For additional information about coolant analysis, see this Operation and Maintenance Manual, "Refill Capacities and Recommendations" or consult your Caterpillar dealer.

i01987714

## Cooling System Coolant Sample (Level 2) - Obtain

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

### NOTICE

Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

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

Submit the sample for Level 2 analysis.

For additional information about coolant analysis, see Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engines Fluids Recommendations" or consult your Caterpillar dealer.

i02839449

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

**SMCS Code:** 1352-045; 1395-081

### **WARNING**

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

### NOTICE

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

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

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

### NOTICE

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

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

Dispose of all fluids according to applicable regulations and mandates.

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

## Cooling Systems that Use Conventional Coolant

This maintenance procedure is required for conventional coolants such as DEAC. **This maintenance is NOT required for cooling systems that are filled with Extended Life Coolant.**

### Test the Concentration of the SCA

#### NOTICE

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

Test the concentration of the SCA with the 8T - 5296 Coolant Conditioner Test Kit.

### Add the SCA, If Necessary

### **WARNING**

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

1. Remove the cooling system filler cap slowly.
2. If necessary, drain some coolant in order to allow space for the addition of the SCA.
3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic. The proper concentration of SCA depends on the type of coolant that is used. For the proper concentration of SCA, refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations".
4. Clean the cooling system filler cap. Install the cooling system filler cap.

103645060

## Cooling Systems that Use Water and SCA

### Test the Concentration of the SCA

Test the concentration of the SCA with a 298-5311 Coolant Nitrite Test Kit for SCA or perform an S·O·S Coolant Analysis. The test kit includes the following items: a tool for the testing, 30 ampoules for testing nitrite, instructions, and a case. 294-7420 Test Kit contains the refill ampoules for the 298-5311 Coolant Nitrite Test Kit. Use the instructions that are included with the test kit in order to properly conduct the testing.

Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule" for the times at which the procedures should be conducted. Test the concentration of the SCA more frequently if more frequent testing is indicated by the results of the S·O·S Coolant Analysis.

---

#### NOTICE

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

---

### Add the SCA, If Necessary

#### WARNING

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

---

1. Remove the cooling system filler cap slowly.
2. If necessary, drain some coolant in order to allow space for the addition of the SCA.
3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic. For the proper concentration of SCA, refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations".
4. Clean the cooling system filler cap. Install the cooling system filler cap.

## 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. Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule" for the proper maintenance interval.

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 two articles in the Disassembly and Assembly Manual, "Water Temperature Regulators - Remove and Water Temperature Regulators - Install" 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.

i02871204

## 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 torsional vibrations.

A damper that is hot may be the result of excessive torsional vibration, worn bearings, or damage to the damper. Use an infrared thermometer to monitor the temperature of the damper during operation. Follow the instructions that are included with the infrared thermometer. If the temperature reaches 100°C (212 °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, and smooth.

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.
- The crankshaft bearings are showing excessive wear.
- There is a large amount of gear train wear that is not caused by a lack of oil.

## Dampers With Sampling Ports

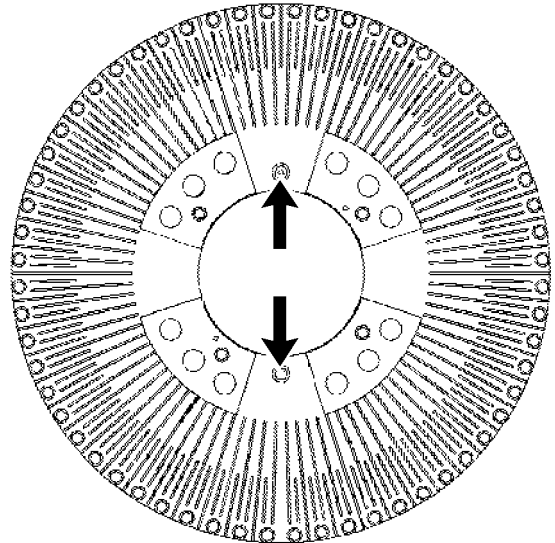


Illustration 53

g00819045

Some dampers have ports for fluid samples. If the damper has no external damage, collect a sample of the damper fluid. The fluid should be analyzed in order to check for a loss of viscosity. Use the results of the analysis to determine if the damper should be rebuilt or replaced. Kits for fluid samples are available from the address that follows. Return the kits to the same address for analysis.

Hasse & Wrede GmbH  
Georg-Knorr-Straße 4  
12681 Berlin  
Germany  
Phone: +49 30 9392-3135  
Fax: +49 30 9392-7-3135  
Alternate phone: +49 30 9392-3156  
Alternate fax: +49 30 9392-7-3156

The typical limit for the degradation of the damper fluid viscosity that is used by Hasse & Wrede GmbH is 20 percent for the majority of applications. The reports from Hasse & Wrede should indicate that the fluid samples meet this viscosity limit.

## Dampers Without Sampling Ports

Some dampers do not have a port for a fluid sample. These dampers must be rebuilt or the dampers must be replaced when one of the following criteria has been met:

- The damper has been operated for 20000 hours.
- The engine is undergoing a major overhaul.

## Removal and Installation

Refer to the Disassembly and Assembly Manual, "Vibration Damper - Remove and Install" article or consult your Caterpillar dealer for information about damper replacement.

i01595880

## Electrical Connections - Check

**SMCS Code:** 4459-535

Check all exposed electrical connections for tightness.

Check the following devices for loose mounting or for physical damage:

- transformers
- fuses
- capacitors
- lightning arrestors

Check all lead wires and electrical connections for proper clearance.

i01664717

## 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 airborne debris from entering the air inlet.

#### NOTICE

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

## Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.

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

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

## Dual Element Air Cleaners

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element. The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable or washable. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element. When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

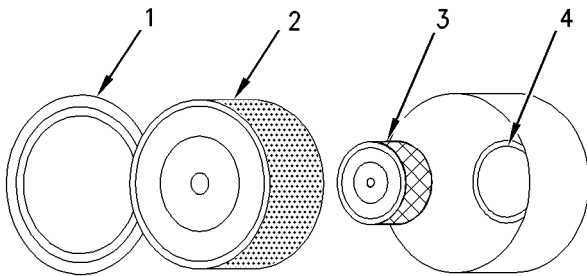


Illustration 54

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).

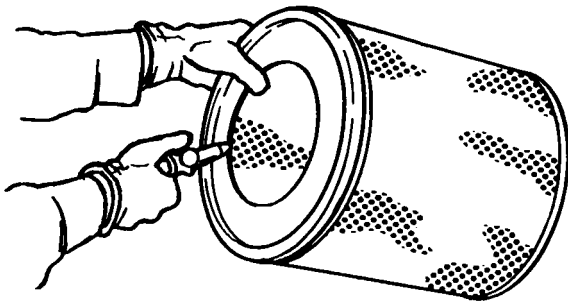


Illustration 55

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

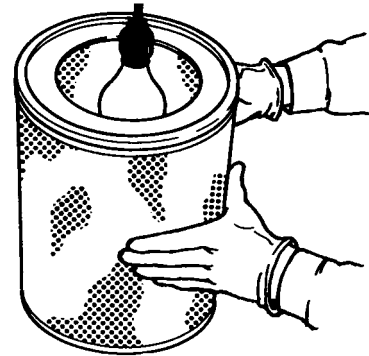


Illustration 56

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.

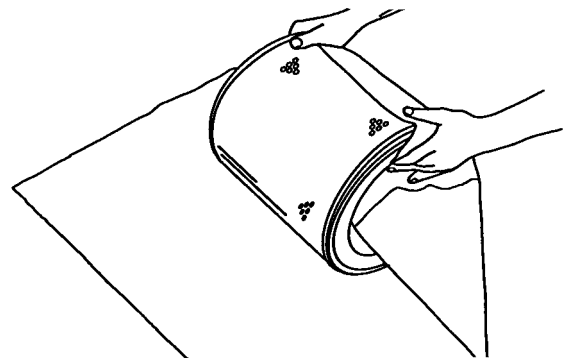


Illustration 57

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.

i02547312

## 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 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 air cleaner 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.

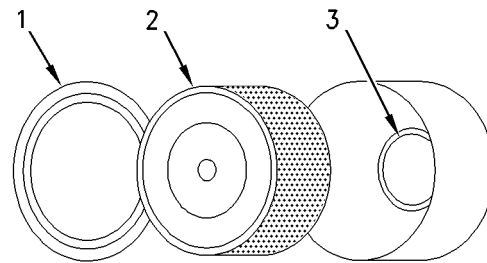


Illustration 58

g00735127

- (1) Cover
- (2) Air cleaner element
- (3) Turbocharger 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).

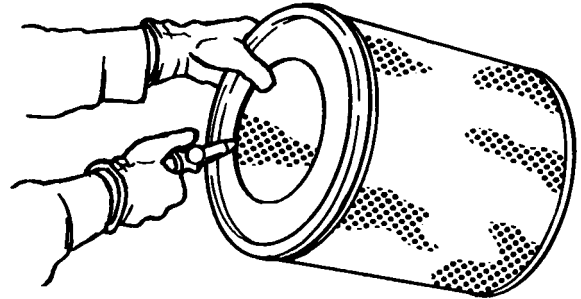


Illustration 59

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

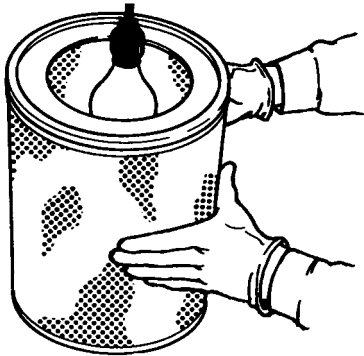


Illustration 60

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.

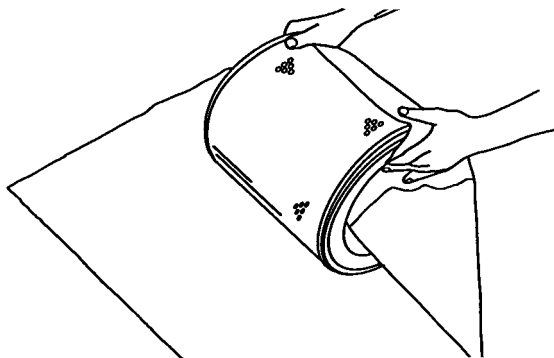


Illustration 61

g00281694

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

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

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i01900118

## Engine Air Cleaner Service Indicator - Inspect (If Equipped)

**SMCS Code:** 7452-040

Some engines may be equipped with a different service indicator.

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

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

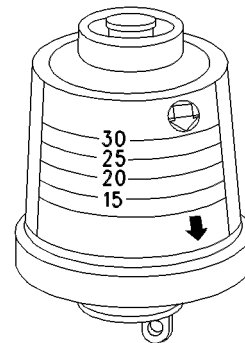


Illustration 62

g00103777

Typical service indicator

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

- The yellow diaphragm enters the red zone.

- The red piston locks in the visible position.

## Test the Service Indicator

Service indicators are important instruments.

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

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

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

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

i01397717

## Engine Air Precleaner - Clean

**SMCS Code:** 1055-070

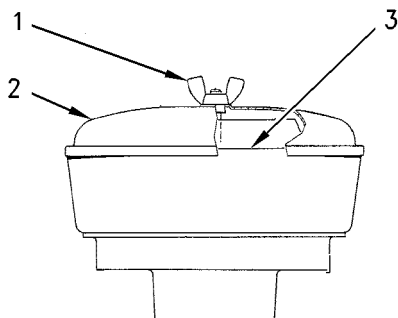


Illustration 63

g00736588

Typical precleaner

- (1) Wing nut
- (2) Cover
- (3) Body

Remove wing nut (1) and cover (2). Check for an accumulation of dirt and debris in body (3). Clean the body, if necessary.

After cleaning the precleaner, install cover (2) and wing nut (1).

**Note:** When the engine is operated in dusty applications, more frequent cleaning is required.

i01225429

## Engine Crankcase Breather - Clean

**SMCS Code:** 1317-070

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

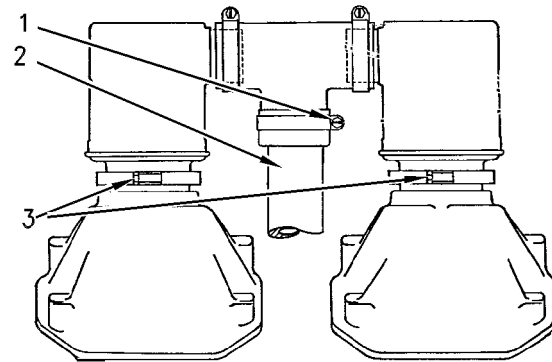


Illustration 64

g00597463

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

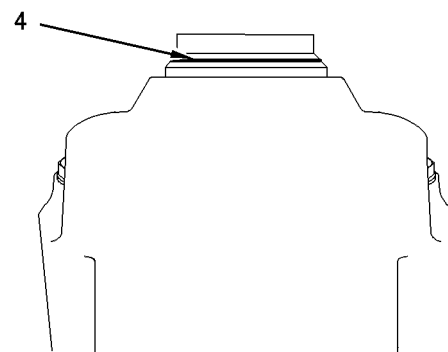


Illustration 65

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.

i01786814

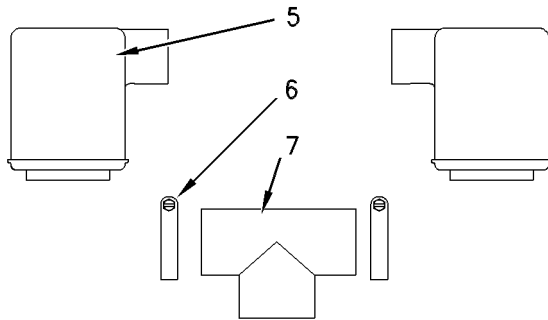


Illustration 66

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".

## Engine Mounts - Check

**SMCS Code:** 1152-535

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 Specifications, SENR3130, "Torque Specifications".

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.

i02418058

## Engine Oil Level - Check

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

The most accurate check of the engine oil level is obtained when the engine is stopped.

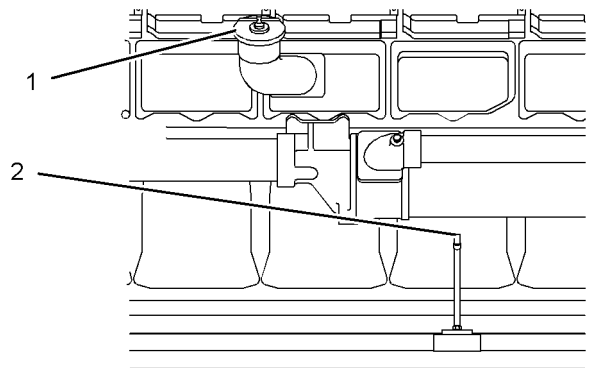


Illustration 67

g01208341

- (1) Filler cap
- (2) Engine oil level gauge (dipstick)

1. Remove filler cap (1) in order to ensure that the crankcase pressure is equal to the atmospheric pressure.

Excess pressure or a slight vacuum will affect engine oil level that is measured.

2. Ensure that engine oil level gauge (2) is seated.

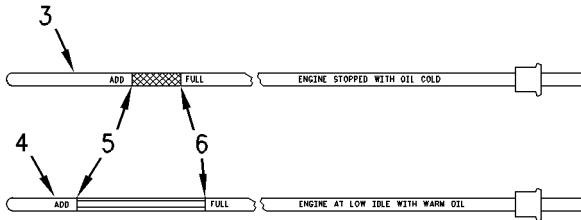


Illustration 68

g00735162

- (3) "ENGINE STOPPED WITH OIL COLD" side
- (4) "ENGINE AT LOW IDLE WITH WARM OIL" side
- (5) "ADD" mark
- (6) "FULL" mark

- a. If the engine is stopped, remove the engine oil level gauge. Observe the engine oil level on "ENGINE STOPPED WITH OIL COLD" side (3).
- b. If the engine is operating, reduce the engine speed to low idle. Remove the engine oil level gauge and observe the engine oil level on "ENGINE AT LOW IDLE WITH WARM OIL" side (4).

The engine oil level should be between "ADD" mark (5) and "FULL" mark (6).

#### NOTICE

Engine damage can occur if the crankcase is filled above the "FULL" mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil's ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers, and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings, and wear of the cylinder liner.

If the oil level is above the "FULL" mark on the oil level gauge, drain some of the oil immediately.

3. If necessary, add engine oil. For the correct engine oil to use, refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic (Maintenance Section). Do not fill the crankcase above the "FULL" mark on the engine oil level gauge. Clean the filler cap (1). Install the filler cap.
4. Record the amount of engine oil that is added. For the next engine oil sample and analysis, include the total amount of engine oil that has been added since the previous oil change. This will help to provide the most accurate analysis.

i03542996

## 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. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

### Obtain the Sample and the Analysis

#### WARNING

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

i03006778

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**

Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEGj0047, "How To Take A Good S-O-S Oil Sample". Consult your Caterpillar dealer for complete information and assistance in establishing an S-O-S program for your engine.

## 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:

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

The S-O-S oil analysis program analyzes used oil in order to determine if the oil change interval is suitable for your specific engine. In the absence of S-O-S oil analysis, change the engine oil and engine oil filters according to the interval that is listed in Table 29.

Table 29

3500B Generator Set Engine Oil Change Intervals		
Engine	Sump Capacity	Oil Change Interval
<b>Engines With a Standard Sump</b>		
3508B	227 L (60 US gal)	Every 500 Service Hours
3512B	318 L (84 US gal)	
3516B	405 L (107 US gal)	
<b>Engines With a Deep Sump</b>		
3508B	443 L (117 US gal)	Every 1000 Service Hours
3512B	625 L (165 US gal)	
3516B	807 L (213 US gal)	

## Drain the Oil

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.

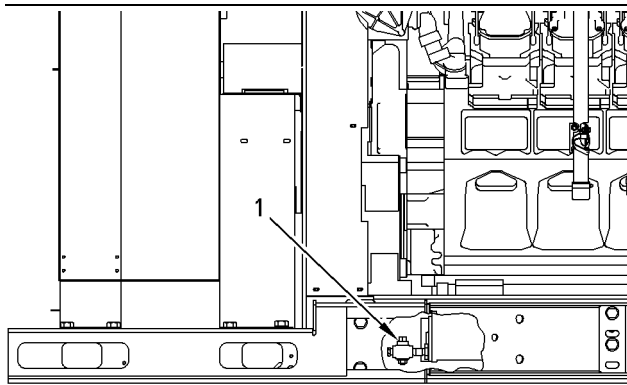


Illustration 69

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.

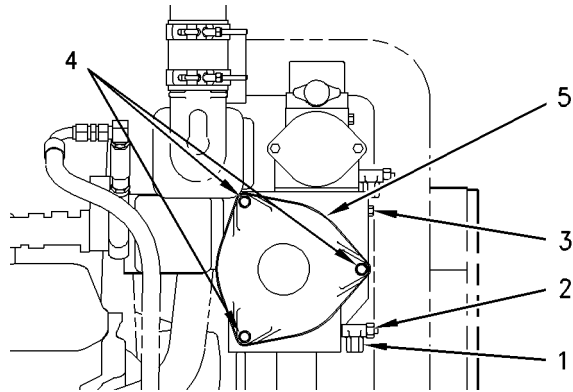


Illustration 70

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

1. Remove the oil filler cap. Fill the crankcase through the oil filler tube only. For the correct type and the amount of oil to use, refer to this Operation and Maintenance Manual (Maintenance Section), "Refill Capacities and Recommendations". 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.

i02939209

**Engine Valve Lash - Inspect/Adjust**

**SMCS Code:** 1102-025

**Note:** For procedures on adjusting the valve lash and adjusting the valve bridge, see System Systems Operation/Testing and Adjusting, "Valve Lash and Valve Bridge Adjustment". Consult your Caterpillar dealer for assistance.

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

**WARNING**

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

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

**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 Systems Operation/Testing and Adjusting Manual, "Valve Lash and Valve Bridge Adjustment" article or consult 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.

For the valve lash setting, see the engine's Specifications manual. For the procedure to set the valve lash, see the engine's Systems Operation/Testing and Adjusting manual.

i03298342

**Fan Drive Bearing - Lubricate**

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

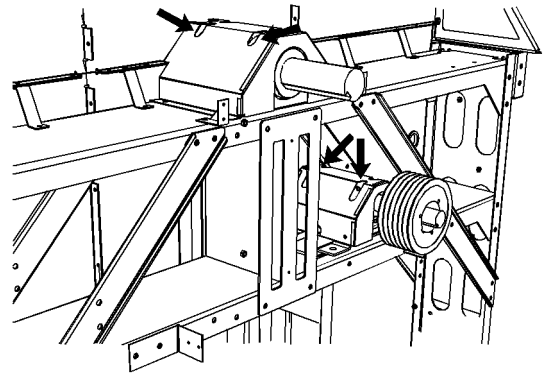


Illustration 71

g01694159

There are four grease fittings on the fan drive system.

The fan drive system should be inspected at the engine commissioning. The fan drive system should be lubricated at the engine commissioning. Engines which are operated in one or more of the following environments should be lubricated more frequently: excessive heat, excessive dirt, and excessive humidity.

For the life of the fan drive system, inspect the fan drive system at the interval which occurs first.

- 500 service hours

- 12 months

Inspect the fan drive for wear and damage. If the shaft is loose, inspect the internal components.

Over the life of the fan drive system, lubricate the fan drive system at the interval which occurs first:

- 500 service hours
- 12 months

Lubricate the fittings with Cat Multipurpose Grease or lubricate the fittings with a grease with similar properties. Lubricate the bearings while the bearings are rotating. Discontinue lubrication when clean grease has been purged through the seal. Do not consider the amount of grease that is used.

i01565926

## 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 Adjustment". 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.

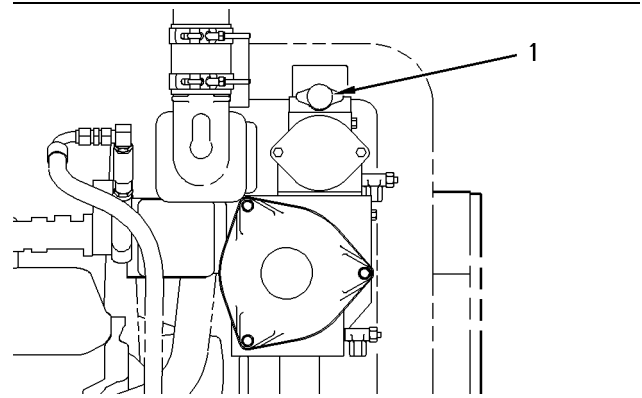


Illustration 72

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".

i02392240

## Fuel System Primary Filter (Water Separator) Element - Replace

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

### **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.

- Isolate the separator from the fuel supply.

---

**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.

---

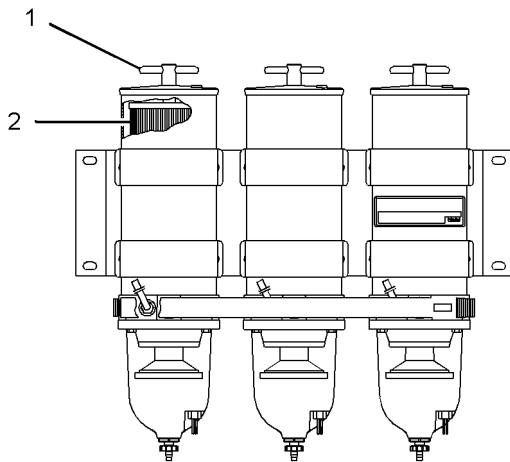


Illustration 73

g01195037

- (1) Handle  
(2) Element

- Turn handle (1) counterclockwise in order to loosen the lid. Remove the lid.
- Remove element (2) 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.
- Clean the inside of the filter case. Allow the filter case to dry.
- 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 the fuel filters. The fuel will not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

---

- Place the element in the filter case. Slide the filter case over the mounting bolt.
- Install the nut.
- Open the fuel supply valve.
- Prime the fuel system. See this Operation and Maintenance Manual, "Fuel System - Prime" topic.

i02392118

## Fuel System Primary Filter/Water Separator - Drain

**SMCS Code:** 1260-543; 1263-543

---

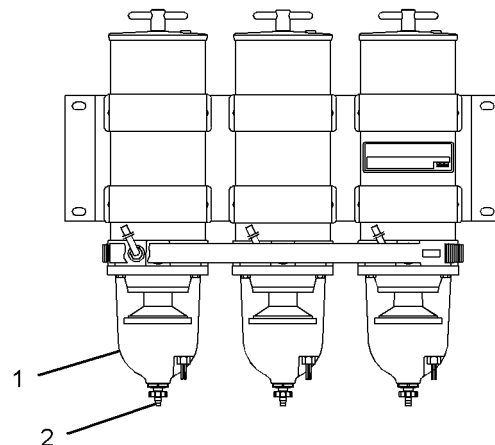


Illustration 74

g01195024

- (1) Bowl  
(2) Drain

Bowl (1) should be monitored daily for signs of water. If water is present, drain the water from the bowl.

- Open drain (2). The drain is a self-ventilated drain. Catch the draining water in a suitable container. Dispose of the water properly.
- Close the drain.

---

**NOTICE**

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

---

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.

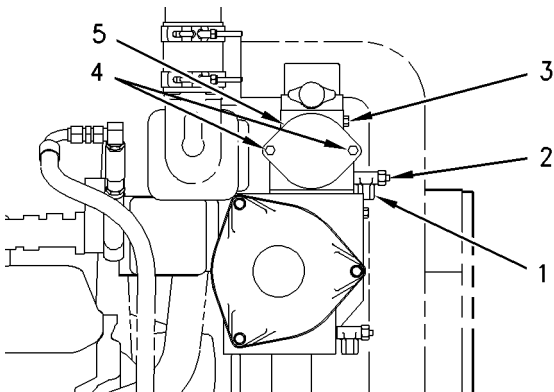


Illustration 75

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).

i03645042

## Fuel Tank Water and Sediment - Drain

**SMCS Code:** 1273-543-M&S

### NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

## Fuel Tank

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

## Drain the Water and the Sediment

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

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

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

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

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

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

## Fuel Storage Tanks

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

- Weekly
- Oil change
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A four micron(c) absolute filter for the breather vent on the fuel tank is also recommended. Refer to Special Publication, SENR9620, "Improving Fuel System Durability".

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.

i03642821

## Generator - Dry

**SMCS Code:** 4450-569

### NOTICE

Do not operate the generator if the windings are wet. If the generator is operated when the windings are wet, damage can occur due to insulation breakdown.

When moisture is present or when moisture is suspected in a generator, the generator must be dried before being energized.

If the drying procedure does not restore the insulation resistance to an acceptable value, the winding should be reconditioned.

**Note:** For additional information, refer to Special Instruction, SEHS9124 .

## Drying Methods

The following methods can be used for drying a generator:

- Self-circulating air method
- Oven method

---

### NOTICE

Do not allow the winding temperature to exceed 85 °C (185.0 °F). Temperatures that are greater than 85 °C (185.0 °F) will damage the winding insulation.

---

### Self-Circulating Air Method

**Note:** Disable the excitation before using this 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.

---

i02283395

## 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.**

---

### 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.**

---

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)

---

### NOTICE

Do not use water to clean the generator.

---



---

### NOTICE

Do not use trichloroethane, perchlorethylene, trichloroethane or any alkaline products to clean the generator.

---

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)

---

### NOTICE

Do not use water to clean the generator.

---



---

### NOTICE

Do not use trichloroethane, perchlorethylene, trichloroethane or any alkaline products to clean the generator.

---

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.

Use the following for cleaning the stator, the rotor, the exciter and the diode bridge:

- Unleaded Gasoline
- Toluene
- Benzene
- Cyclohexane

Avoid permitting the solvent to run into the slots. Apply the solvent with a brush. Use a sponge on the windings frequently in order to remove the debris. Dry the winding with a dry cloth. Allow the solvent to evaporate before reassembling the generator.

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.

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

i03099722

## Generator Bearing - Inspect/Replace (SR4 Generator)

**SMCS Code:** 4471-040; 4471-510

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

## Inspect

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 sleeve in the bearing bracket 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 sleeve in the bearing bracket, inspect the bore of the bearing bracket. The bearing should be inspected for damage to the outer race, severe fretting, and smoothness of operation. When possible, the bearing elements should be inspected. Some double shielded ball bearings prevent visual inspection of the elements of the bearing. 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 elements of the bearing.

On two-bearing generators, the front bearing can only be removed after the drive coupling is removed. Refer to the Systems Operation Testing and Adjusting Disassembly and Assembly, "Coupling - Remove" for the generator for instructions for removing the drive coupling.

## Replace

1. All ball bearings should be cleaned. The cavity in the bracket should be repacked with 2S-3230 Grease. Pack the ball bearings (one-third to one-half of the volume of the cavity).
2. Use an induction heater to heat the ball bearings to 107 °C (224.6 °F) for ten minutes in order to install either of the following bearings: ball bearings that are new and ball bearings that have been inspected. 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.
3. Ensure that the tube of the grease gun is filled with grease.
4. 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.
5. Stop the engine. Install the bracket drain plug. Wipe off the excess grease.

6. For greasing intervals, follow the recommendations on the lubrication plate (if equipped) or refer to Maintenance Schedule, "Generator Bearing - Lubricate". Whenever the bearings are greased, repeat Step 1. DO NOT MIX GREASES.

i03547528

## Generator Bearing - Lubricate

**SMCS Code:** 4471-086

### Lubricating Process (If Applicable)

**Note:** If the generator already has a visible grease point, go to Step 4.

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 bearings with the appropriate grease from Table 30. Do not mix greases.



Table 30

Bearing Part Number	Bearing Type	Frame Size	Temperature Min/Max <sup>(1)</sup>	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
108 - 1760 Ball Bearing	321 BC 225.0 mm (8.9 inch) OD  105.0 mm (4.1 inch) ID	680	-29 °C (-20.2 °F) minimum / 80 °C (176 °F) maximum	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	105.0 mm (4.1 inch)
108 - 1761 Ball Bearing	322 BC 240.0 mm (9.4 inch) OD  110.0 mm (4.3 inch) ID	690 / 800	-29 °C (-20.2 °F) / 80 °C (176 °F)	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	110.0 mm (4.3 inch)
139 - 0349 Roller Bearing	Roller	2900 / 2800	-40 °C (-40 °F) / 80 °C (176 °F)	Mobilith SHC220	Every 250 service hours	2.8 g (0.1 oz)	NA	127.0 mm (5.0 inch)
139 - 0350 Roller Bearing	Roller	2900 / 2800	-40 °C (-40 °F) / 80 °C (176 °F)	Mobilith SHC220	Every 250 service hours	2.8 g (0.1 oz)	NA	127.0 mm (5.0 inch)
154 - 3032 Ball Bearing	326 BC 280.0 mm (11.0 inch) OD  130.0 mm (5.1 inch) ID	820 / 2600 / 2700	-29 °C (-20.2 °F) / 80 °C (176 °F)	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	130.0 mm (5.1 inch)
241 - 4644 Bearing	320 BC 215.0 mm (8.5 inch) OD  100.0 mm (3.9 inch) ID	LC7	-29 °C (-20.2 °F) / 60 °C (140 °F) <sup>(2)</sup>	UNIREX N3	Every 4500 service hours or 12 months	60 g (2.1 oz)	NA	100.0 mm (3.9 inch)
243 - 5220 Bearing	315 BB 160.0 mm (6.3 inch) OD  75.0 mm (3.0 inch) ID	LC6100 / LC5000	-29 °C (-20.2 °F) / 60 °C (140 °F) <sup>(2)</sup>	UNIREX N3	Non- regreasable bearing <sup>(3)</sup>	Non- regreasable bearing	Non- regreasable bearing	75.0 mm (3.0 inch)
261 - 3545 Bearing	307 BB 80.0 mm (3.1 inch) OD  35.0 mm (1.4 inch) ID	LC2000	-29 °C (-20.2 °F) / 50 °C (122 °F) <sup>(2)</sup>	UNIREX N3	Non- regreasable bearing <sup>(3)</sup>	Non- regreasable bearing	Non- regreasable bearing	35.0 mm (1.4 inch)

(continued)

(Table 30, contd)

Bearing Part Number	Bearing Type	Frame Size	Temperature Min/Max <sup>(1)</sup>	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
262-5921 Bearing	307 BC 80.0 mm (3.1 inch) OD  35.0 mm (1.4 inch) ID	LC2000	-29 °C (-20.2 °F) / 60 °C (140 °F) <sup>(2)</sup>	UNIREX N3	Non- regreasable bearing <sup>(3)</sup>	Non- regreasable bearing	Non- regreasable bearing	35.0 mm (1.4 inch)
263-0161 Bearing	309 BC 100.0 mm (3.9 inch) OD  45.0 mm (1.8 inch)	LC3000	-29 °C (-20.2 °F) / 60 °C (140 °F) <sup>(2)</sup>	UNIREX N3	Non- regreasable bearing <sup>(3)</sup>	Non- regreasable bearing	Non- regreasable bearing	45.0 mm (1.8 inch)
5P-2448 Ball Bearing	315 BC 160.0 mm (6.3 inch) OD  75.0 mm (3.0 inch) ID	580 / 590	-29 °C (-20.2 °F) / 80 °C (176 °F)	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	75.0 mm (3.0 inch)
6Y-3955 Ball Bearing	220 BC 180.0 mm (7.1 inch) OD  100.0 mm (3.9 inch) ID	450	-29 °C (-20.2 °F) / 80 °C (176 °F)	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	100.0 mm (3.9 inch)
6Y-6488 Ball Bearing	318 BC 190.0 mm (7.5 inch) OD  90.0 mm (3.5 inch)	597	-29 °C (-20.2 °F) / 80 °C (176 °F)	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	90.0 mm (3.5 inch)
311-0843 Ball Bearing	326 BC 280.0 mm (11.0 inch) OD  130.0 mm (5.1 inch) ID	1800 FR	-40 °C (-40 °F) / 80 °C (176 °F)	EA6	Non- regreasable bearing <sup>(1)</sup>	Non- regreasable bearing	Non- regreasable bearing	130.0 mm (5.1 inch)
311-0844 Ball Bearing	322 BC 240.0 mm (9.4 inch) OD  110.0 mm (4.3 inch) ID	1600 FR	-40 °C (-40 °F) / 80 °C (176 °F)	EA6	Non- regreasable bearing <sup>(1)</sup>	Non- regreasable bearing	Non- regreasable bearing	110.0 mm (4.3 inch)

(continued)

(Table 30, contd)

Bearing Part Number	Bearing Type	Frame Size	Temperature Min/Max <sup>(1)</sup>	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
253-9789 Bearing	320 BC 215.0 mm (8.5 inch) OD  100.0 mm (3.9 inch) ID	1400 FR	-29 °C (-20.2 °F) / 80 °C (176 °F)	UNIREX N3	Non- regreasable bearing <sup>(1)</sup>	Non- regreasable bearing	Non- regreasable bearing	100.0 mm (3.9 inch)
193-4070 Ball Bearing	018 BC 140.0 mm (5.5 inch) OD  90.0 mm (3.5 inch) ID	498/499	-29 °C (-20.2 °F) / 80 °C (176 °F)	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	90.0 mm (3.5 inch)

(1) This temperature is for a generator set that is equipped with a resistive temperature detector (RTD).

(2) Do not exceed 60 °C (140 °F) above the ambient temperature.

(3) This bearing can not be greased. Refer to this Operation and Maintenance Manual, "Generator Bearing - Replace" article for information concerning the replacement of these bearings.

(2) Do not exceed 50 °C (122 °F) above the ambient temperature.

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.

i03642839

## Generator Bearing Temperature - Test/Record

**SMCS Code:** 4471-081-TA

The monitoring of bearing temperature may prevent premature bearing failure. A generator set should never operate above the recommended set points. Keep records in order to monitor the changes in the temperature of the bearing.

**Note:** Measure the bearing temperature after the generator reaches normal operating temperature.

## Resistive Temperature Detectors (RTDs)

Caterpillar Generators may be equipped with resistance temperature detectors for generator bearings. These detectors are 100 ohm resistance temperature detectors. A resistance temperature detector may be monitored by the optional monitor for the EMCP 3.2/3.3 resistance temperature detector. A resistance temperature detector may be monitored by equipment that is provided by the customer. Consult with your Caterpillar dealer about other methods of measuring the bearing temperature.

The EMCP 3.2/3.3 may be configured to "ALARM" or the EMCP 3.2/3.3 may be configured to "SHUTDOWN". An alarm is activated if the temperature of the bearing reaches 85 °C (185 °F). A shutdown occurs if the temperature of the bearing reaches 95 °C (203 °F).

## Infrared Thermometers

Bearing temperatures can also be recorded with the use of an infrared thermometer. Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tools Catalog" for a variety of infrared thermometers. Follow the instructions that come with your infrared thermometer.

i02517207

## Generator Lead - Check

**SMCS Code:** 4450-535

The generator set may have braided cables between the generator and the breaker instead of wire cables. Check for signs of wear along the braided cables. Pay particular attention to the cables at the housing for the breaker and the generator terminal box.

If the rubber mats or the insulation on the braided cables show signs of wear at points of contact with other surfaces, replace the mats or the cable immediately. If your generator set does not have rubber mats in place, contact your Caterpillar dealer.

i03215110

## 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.

The ADEM III system functions as the governor for this engine.

**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.

i02377583

## Generator Set - Test

**SMCS Code:** 4450-081

### DANGER

**DANGER: Shock/Electrocution Hazard-Do not operate this equipment or work on this equipment 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 will result in serious injury or death.**

### 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 31

i03100396

Tools Needed		
Part Number	Part	Quantity
237-5130	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 "E+" and "E-" from the voltage regulator. Disconnect the generator from the load.
3. Connect a 12 VDC automotive battery to wires "E+" and "E-".
4. 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.

## Generator Set Alignment - Check (Generator Sets)

**SMCS Code:** 7002-024

The alignment between the engine and the driven equipment must be properly maintained in order to minimize the following problems:

- Bearing problems
- Vibration of the engine crankshaft
- Vibration of the driven equipment

Refer to the following information for more information about the alignment of the generator set:

- Special Instruction, SEHS7654, "Alignment - General Instructions"
- Special Instruction, SEHS7259, "Alignment of Single Bearing Generators"
- Special Instruction, REHS0177, "Alignment of the Close Coupled Two Bearing Generators"

Keep a record of the measurement of the alignment. The record may be used to check the trend of the alignment. The record may be used to analyze the trend of the alignment.

The genset must be aligned when the genset is moved into a final position. The genset must be aligned if the genset is moved into a different position.

i03643886

## Generator Set Vibration - Test/Record

**SMCS Code:** 4450-081-VI

Check for vibration damage.

Vibration may cause the following problems:

- Coupling wear
- Loose fittings
- Fatigue of the metal components of the engine
- Cracks in the cabinet which surrounds the generator
- Cracks in welds

- Excessive noise
- Cracked insulation

The following areas are susceptible to vibration damage:

- Coupling for the generator set
- Generator bearings
- Stator output leads
- Protective sleeving
- Insulation
- Exposed electrical connections
- Transformers
- Fuses
- Capacitors
- Lightning arresters

When a generator set is installed, a vibration plot should be recorded in order to assist in diagnosing potential problems. This vibration plot should be updated yearly. The vibration plot should also be updated when the generator set is moved and when the engine is overhauled. This will allow the trend of the vibration to be monitored and analyzed. A potential problem may be prevented by monitoring the trend of the vibration. If the vibration is approaching the limit of the specification of the component, the problem may be more imminent. Refer to Data Sheet, LEKQ4023, "Linear Vibration" for the allowable limits of vibration.

Caterpillar also recommends recording the vibration of the bearing at the generator bearing bracket.

If the vibration exceeds the EDS limits for vibration, check the alignment. Refer to this Operation and Maintenance Manual, "Generator Set Alignment - Check" for the alignment procedure.

Contact the Caterpillar Dealer Service Tools group for information on ordering a vibration analyzer that will meet your needs.

## 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.
7. Install the hose clamps with a torque wrench.

**Note:** Refer to the Specifications, SENR3130, "Torque Specifications" in order to locate the proper torques.

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

### **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 32

TOOLS NEEDED		
Part Number	Tool	Quantity
142-5055	Insulation Tester Megohmmeter	1

### **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.

The following materials will cause the winding insulation to deteriorate:

- moisture (water)
- dust
- grease
- other foreign matter within the generator

This deterioration reduces the resistance of the insulation. This test will measure the resistance of the winding insulation.

The insulation tester (megohmmeter) produces a high potential voltage between the test leads. During the test, a small current flows. The tester converts this current to a resistance reading.

The insulation test is performed as part of periodic maintenance in order to detect the deterioration of the winding insulation. When there is a rapid decrease in the insulation resistance in a short amount of time, the generator needs to be cleaned.

**Note:** For information on generator cleaning, refer to Special Instruction, SEHS9124.

When generators have not been used for a period of time, moisture can accumulate. Therefore, the insulation test should be performed on generators that have been idle. If moisture is known to exist, the windings must be dried prior to testing. Refer to Testing And Adjusting, "Generator - Dry".

The winding needs to be reconditioned or the winding needs to be replaced in the following cases:

- The measured insulation resistance falls below the specified amount. The cleanup procedure does not correct the discrepancy.
- The measured insulation resistance falls below the specified amount. The drying procedure does not correct the discrepancy.

The specified insulation resistance is an approximate value. It can be possible to operate the generator with less than the specified value. However, a generator that has a low winding insulation resistance will be more likely to have a failure.

### **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.**

The insulation test gives accurate results only when the generator windings are free of moisture and the generator windings are at room temperature.

Each winding must have a minimum insulation resistance of one megohm.

## **Main Armature (Stator L4)**

1. Remove the load from the generator by either of the following:
  - Open the line circuit breaker.

- Open the following load connections: T1, T2, T3, and T0.

Prevent these wires from coming into contact with each other and prevent these wires from contacting ground.

2. Isolate the main armature (L4) from the voltage regulator by disconnecting the wires for voltage sensing. If generator lead (T0) is connected to the generator frame or ground, open the connection.
3. Connect one test lead of the insulation tester (megohmmeter) to the generator enclosure (ground).
4. Connect the other test lead of the insulation tester (megohmmeter) to generator lead (T0).
5. The insulation resistance must be one megohm or more.

## **Exciter Field (Stator L1)**

1. Isolate exciter field (L1) from the voltage regulator by disconnecting wires 5+ and 6-. Prevent these wires from coming into contact with each other and prevent these wires from contacting ground.
2. Connect one test lead of the insulation tester (megohmmeter) to the generator enclosure (ground).
3. Connect one test lead of the insulation tester (megohmmeter) to exciter field lead (5+ or 6-).
4. Measure the resistance of the exciter field winding insulation to ground. The insulation resistance must be a minimum of 0.25 megohm (250000 ohms).

## **Exciter Armature (Rotor L2)**

1. Isolate exciter armature (L2) from the rectifier circuit. Disconnect the three wires of the exciter armature from the rectifier blocks.
2. Connect one test lead of the insulation tester (megohmmeter) to the rotor shaft.
3. Connect one test lead of the insulation tester (megohmmeter) to any one exciter field lead.
4. The insulation resistance must be a minimum of 0.25 megohm (250000 ohms).



i01917546

## Jacket Water Heater - Check (Standby Generator Sets (If Equipped))

**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 coolant temperature at approximately 32 °C (90 °F).

i03621463

## Maintenance Recommendations

**SMCS Code:** 1000

### 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

Experience has shown that maintenance intervals are most accurately based on fuel consumption. Fuel consumption corresponds more accurately to the engine load. Tables 33 and 34 list average ranges of fuel consumption and service hours for a load factor of approximately 60 percent.

## Standard Displacement Engines

Table 33

<b>Maintenance Interval Schedule Service Hours and Fuel Consumption for 3512C Engines <sup>(1)</sup></b>			
<b>Interval</b>	<b>Rated Up To 1300 RPM</b>	<b>Rated 1301 To 1600 RPM</b>	<b>Rated 1601 To 1800 RPM</b>
250 Service Hours	33400 L (8800 US gal)	41000 L (10800 US gal)	48500 L (12800 US gal)
500 Service Hours	66800 L (17600 US gal)	82000 L (21600 US gal)	97000 L (25600 US gal)
1000 Service Hours	133500 L (35000 US gal)	164000 L (43200 US gal)	194000 L (51200 US gal)
2000 Service Hours	267000 L (70000 US gal)	328000 L (86400 US gal)	388000 L (102400 US gal)
3000 Service Hours	398000 L (105000 US gal)	491000 L (129600 US gal)	582000 L (153600 US gal)
6000 Service Hours	796000 L (210000 US gal)	982000 L (259200 US gal)	1164000 L (307200 US gal)
Top End Overhaul	11000 Service Hours	9000 Service Hours	7500 Service Hours
	1500000 L (395000 US gal)		
Second Top End Overhaul	22000 Service Hours	18000 Service Hours	15000 Service Hours
	3000000 L (790000 US gal)		
Major Overhaul	33000 Service Hours	27000 Service Hours	22500 Service Hours
	4500000 L (1185000 US gal)		

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

Table 34

<b>Maintenance Interval Schedule Service Hours and Fuel Consumption for 3516C Engines <sup>(1)</sup></b>			
<b>Interval</b>	<b>Rated Up To 1300 RPM</b>	<b>Rated 1301 To 1600 RPM</b>	<b>Rated 1601 To 1800 RPM</b>
250 Service Hours	44000 L (11600 US gal)	53000 L (14000 US gal)	64500 L (17000 US gal)
500 Service Hours	88000 L (23200 US gal)	106000 L (28000 US gal)	129000 L (34000 US gal)
1000 Service Hours	176000 L (46500 US gal)	212000 L (56000 US gal)	258000 L (68000 US gal)
2000 Service Hours	352000 L (93000 US gal)	424000 L (112000 US gal)	516000 L (136000 US gal)
3000 Service Hours	528700 L (139500 US gal)	636700 L (168100 US gal)	773000 L (204000 US gal)
6000 Service Hours	1056000 L (279000 US gal)	1272000 L (336000 US gal)	1548000 L (408000 US gal)
Top End Overhaul	11000 Service Hours	9000 Service Hours	7500 Service Hours
	2000000 L (528000 US gal)		
Second Top End Overhaul	22000 Service Hours	18000 Service Hours	15000 Service Hours
	4000000 L (1056000 US gal)		
Major Overhaul	33000 Service Hours	27000 Service Hours	22500 Service Hours
	6000000 L (1584000 US gal)		

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

## High Displacement Engines

Table 35

Service Hours and Fuel Consumption for 3512C High Displacement Engines <sup>(1)</sup>			
Interval	Rated Up to 1300 RPM	Rated 1301 to 1600 RPM	Rated 1601 to 1800 RPM
250 Service Hours	33400 L (8800 US gal) of fuel	41000 L (10800 US gal) of fuel	48500 L (12800 US gal) of fuel
500 Service Hours	66800 L (17600 US gal) of fuel	82000 L (21600 US gal) of fuel	97000 L (25600 US gal) of fuel
1000 Service Hours	133500 L (35000 US gal) of fuel	164000 L (43200 US gal) of fuel	194000 L (51200 US gal) of fuel
2000 Service Hours	267000 L (70000 US gal) of fuel	328000 L (86400 US gal) of fuel	388000 L (102400 US gal) of fuel
3000 Service Hours	398000 L (105000 US gal) of fuel	491000 L (129600 US gal) of fuel	582000 L (153600 US gal) of fuel
6000 Service Hours	796000 L (210000 US gal) of fuel	982000 L (259200 US gal) of fuel	1164000 L (307200 US gal) of fuel
Top End Overhaul	11000 Service Hours	9000 Service Hours	7500 Service Hours
	1500000 L (395000 US gal) of fuel		
Major Overhaul	22000 Service Hours	18000 Service Hours	15000 Service Hours
	3000000 L (790000 US gal) of fuel		

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

Table 36

Service Hours and Fuel Consumption for 3516C High Displacement Engines <sup>(1)</sup>			
Interval	Rated Up to 1300 RPM	Rated 1301 to 1600 RPM	Rated 1601 to 1800 RPM
250 Service Hours	44000 L (11600 US gal) of fuel	53000 L (14000 US gal) of fuel	81500 L (21500 US gal) of fuel
500 Service Hours	88000 L (23200 US gal) of fuel	106000 L (28000 US gal) of fuel	162500 L (43000 US gal) of fuel
1000 Service Hours	176000 L (46500 US gal) of fuel	212000 L (56000 US gal) of fuel	327400 L (86500 US gal) of fuel
2000 Service Hours	352000 L (93000 US gal) of fuel	424000 L (112000 US gal) of fuel	654500 L (173000 US gal) of fuel
3000 Service Hours	528700 L (139500 US gal) of fuel	636700 L (168000 US gal) of fuel	984000 L (260000 US gal) of fuel
6000 Service Hours	1056000 L (279000 US gal) of fuel	1272000 L (336000 US gal) of fuel	1968500 L (520000 US gal) of fuel
Top End Overhaul	11000 Service Hours	9000 Service Hours	7500 Service Hours
	2460500 L (650000 US gal) of fuel		
Major Overhaul	22000 Service Hours	18000 Service Hours	15000 Service Hours
	4921000 L (1300000 US gal) of fuel		

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

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 fuel consumption data in the Technical Marketing Information (TMI) for your engine. This will determine the fuel consumption for the percent of the load that was estimated in Step 1. Use this figure as variable "F" for the equation in Table 37. For more information about the Technical Marketing Information (TMI) for your engine, consult your Caterpillar dealer.

Table 37

<p style="text-align: center;"><b>Equation For Calculating Overhaul Intervals</b></p> <p style="text-align: center;"><math>F/R = H</math></p> <p>“F” is the estimated total amount of fuel consumption of the engine.</p> <p>“R” is the rate of fuel consumption in liters per hour or gallons per hour.</p> <p>“H” is the number of estimated hours until the overhaul interval.</p>
---

## 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.

## Severe Operation

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

- Horsepower
- Range of rpm
- Fuel consumption
- Fuel quality
- Altitude
- Maintenance intervals
- Selection of oil

- Selection of coolant
- Environmental qualities
- Installation

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

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

- Maximum reliability
- Retention of full service life

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

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

## Environmental Factors

### Extreme Ambient Temperatures

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

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

### Cleanliness

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

## Improper Operating Procedures

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

- Operating the engine beyond the guidelines for the engine rating
- Operating the engine at loads that are greater than the rated load
- Operating the engine at speeds that are greater than the rated speed
- Use of the engine for an application that is not approved

### Improper Maintenance Practices

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

i02624456

## Overhaul (Major)

**SMCS Code:** 7595-020-MJ

Refer to this Operation and Maintenance Manual, "Maintenance Recommendations" in order to determine the maintenance interval for a major overhaul.

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

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

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

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

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

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

A major overhaul includes all of the work that is done for the top end overhaul. A major overhaul includes additional parts and labor. Additional parts and labor are required in order to completely rebuild the engine.

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

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

## Replacement of Components

Replace the following components during the major overhaul:

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

## Inspection, Reconditioning or Exchanging of Components

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

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

- Camshaft followers

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

## Inspection of Components

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

- Aftercooler core

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

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

Inspect the crankshaft for any of the following conditions:

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

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

- Rod bearing
- Main bearings

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

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

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

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

- Worn gear teeth

- Unusual fit
- Unusual wear

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

## Cleaning of Components

Clean the oil cooler core and the aftercooler core. Then, pressure test both of these cores. For instructions on cleaning the cores, see this Operation and Maintenance Manual, "Aftercooler Core - Inspect/Clean" topic.

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

## Obtain a Coolant Analysis

For conventional heavy-duty coolant/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.

i02624457

## Overhaul (Top End)

**SMCS Code:** 7595-020-TE

Refer to this Operation and Maintenance Manual, "Maintenance Recommendations" in order to determine the maintenance interval for a top end overhaul.

A top end overhaul involves the removal, the inspection, and the rework of the cylinder head components. Some additional components are replaced and serviced.

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

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

## First Top End Overhaul

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

## Cylinder Head Assembly

Inspect the cylinder head assembly 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".

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

The use of out-of-spec parts will cause unscheduled downtime and/or costly repairs.

## Unit Injectors

Replace the unit injectors. Consult your Caterpillar dealer about exchanging the unit injectors. Your Caterpillar dealer can provide these services and components.

The wear of unit injectors is affected by the following considerations:

- Quality of the fuel
- Quality of the filtration of the fuel

The wear of the unit injectors can result in elevated levels of exhaust emissions and/or poor engine performance. The misfire of a single cylinder is not typically attributed to normal wear. This condition can be repaired by replacing the faulty unit injector.

The following list of circumstances indicate that the unit injectors should be inspected more frequently:

- Use of fuels that are not recommended in this Operation and Maintenance Manual, "Refill Capacities and Recommendations"
- Extreme ambient temperatures that reduce the ability of the fuel to provide lubrication
- Frequent plugging of the fuel filters
- Insufficient maintenance of the fuel tank or the fuel storage tank that can allow excessive water, sediment, etc.
- Insufficient maintenance of the fuel filters

## Oil Suction Screen

Clean the oil suction screen after the oil has been drained.

**Note:** Approximately 1 L (1 qt) of oil will remain in the housing after the sump has been completely drained. This oil will pour out of the housing when cover (1) is removed. Prepare to catch the oil in a pan. Clean up any spilled oil with absorbent towels or pillows. DO NOT use absorbent particles to clean up the oil.

1. Remove the screen assembly according to the instructions in the Service Manual, "Disassembly and Assembly" module. Discard the used O-ring seals.
2. Wash the screen assembly in clean nonflammable solvent. Allow the screen assembly to dry before installation.
3. Remove side covers in order to gain access to the sump. Clean the bottom of the sump with absorbent towels or pillows. When the bottom of the sump is clean, install the side covers.
4. Inspect the screen assembly for good condition. Obtain a new screen assembly, if necessary. Install the screen assembly. Install new O-ring seals.

## Replacement of Components

Replace the following components during the top end overhaul:

- Electronic unit injectors

## Inspection, Reconditioning or Exchanging of Components

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

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

- Camshaft followers
- Cylinder head assembly
- Scavenge oil pump
- Engine wiring harness
- Exhaust manifold seals
- Exhaust manifold bellows
- Fuel pressure regulating valve
- Fuel priming pump
- Fuel transfer pump
- Inlet manifold gaskets
- Inlet manifold seals



- Oil pump
- Prelube pump
- Pushrods
- Rocker arms
- Spacer plate
- Software update
- Turbocharger

## Inspection of Components

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

- Aftercooler core
- Camshaft
- Driven equipment (alignment)
- Engine control module
- Exhaust bellow shields
- Oil suction screen

## Top End Overhaul (Second)

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

### Cylinder Head Assembly

Inspect the cylinder head assembly 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".

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

The use of out-of-spec parts will cause unscheduled downtime and/or costly repairs.

## Unit Injectors

Replace the unit injectors. Consult your Caterpillar dealer about exchanging the unit injectors. Your Caterpillar dealer can provide these services and components.

The wear of unit injectors is affected by the following considerations:

- Quality of the fuel
- Quality of the filtration of the fuel

The wear of the unit injectors can result in elevated levels of exhaust emissions and/or poor engine performance. The misfire of a single cylinder is not typically attributed to normal wear. This condition can be repaired by replacing the faulty unit injector.

The following list of circumstances indicate that the unit injectors should be inspected more frequently:

- Use of fuels that are not recommended in this Operation and Maintenance Manual, "Refill Capacities and Recommendations"
- Extreme ambient temperatures that reduce the ability of the fuel to provide lubrication
- Frequent plugging of the fuel filters
- Insufficient maintenance of the fuel tank or the fuel storage tank that can allow excessive water, sediment, etc.
- Insufficient maintenance of the fuel filters

## Oil Suction Screen

Clean the oil suction screen after the oil has been drained.

**Note:** Approximately 1 L (1 qt) of oil will remain in the housing after the sump has been completely drained. This oil will pour out of the housing when cover (1) is removed. Prepare to catch the oil in a pan. Clean up any spilled oil with absorbent towels or pillows. DO NOT use absorbent particles to clean up the oil.

1. Remove the screen assembly according to the instructions in the Service Manual, "Disassembly and Assembly" module. Discard the used O-ring seals.
2. Wash the screen assembly in clean nonflammable solvent. Allow the screen assembly to dry before installation.

3. Remove side covers in order to gain access to the sump. Clean the bottom of the sump with absorbent towels or pillows. When the bottom of the sump is clean, install the side covers.
4. Inspect the screen assembly for good condition. Obtain a new screen assembly, if necessary. Install the screen assembly. Install new O-ring seals.

### Replacement of Components

Replace the following components during the top end overhaul:

- Electronic unit injectors

### Inspection, Reconditioning or Exchanging of Components

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

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

- Camshaft followers
- Connecting rods
- Connecting rod bearings
- Cylinder head assembly
- Cylinder liners
- Scavenge oil pump
- Engine wiring harness
- Exhaust manifold seals
- Exhaust manifold bellows
- Fuel pressure regulating valve
- Fuel priming pump
- Fuel transfer pump
- Inlet manifold gaskets
- Inlet manifold seals
- Oil pump

- Pistons
- Piston pins
- Prelube pump
- Pushrods
- Rocker arms
- Spacer plate
- Software update
- Turbocharger

### Inspection of Components

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

- Aftercooler core
- Camshaft
- Crankshaft
- Driven equipment (alignment)
- Engine control module
- Exhaust bellow shields
- Oil suction screen

**Note:** Inspect only two of the components from each cylinder bank. Inspecting only two components will provide an adequate example of the condition of the other components.

i03101741

## Overhaul Considerations

**SMCS Code:** 7595-043

### Severe Operation

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

- Horsepower
- Range of rpm

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

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

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

- Maximum reliability
- Retention of full service life

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

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

## Environmental Factors

### Extreme Ambient Temperatures

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

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

## Cleanliness

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

## Improper Operating Procedures

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

## Improper Maintenance Practices

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

## 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
- Inspecting the alignment of the driven equipment

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 76.

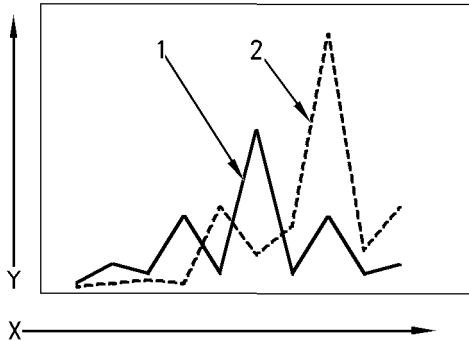


Illustration 76

g00745964

- (Y) Cost  
(X) Time  
(1) Cost of maintenance and repair that is planned  
(2) Cost of maintenance and repair that is not planned

In Illustration 76, 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 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.

i01216962

## 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.

i01612991

## 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, refer to the engine's Disassembly and Assembly 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.

i01315559

## Radiator - Clean

**SMCS Code:** 1353-070

**Note:** Adjust the frequency of cleaning according to the effects of the operating environment.

A dirty radiator will not be able to transfer heat efficiently. This can lead to overheating of the engine. Clean the radiator according to the instructions that are provided by the OEM of the radiator.

i02246950

## 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, proceed to the "Testing a Three-Diode Rectifier Block" section.

## Testing a Three-Diode Rectifier Block

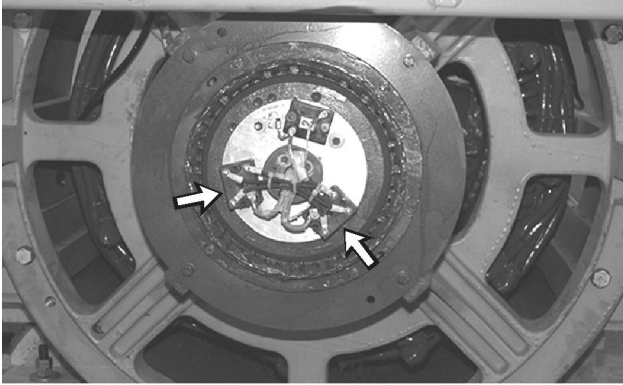


Illustration 77

g00610240

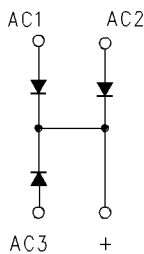
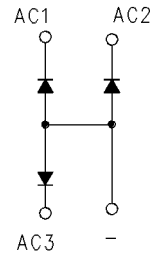
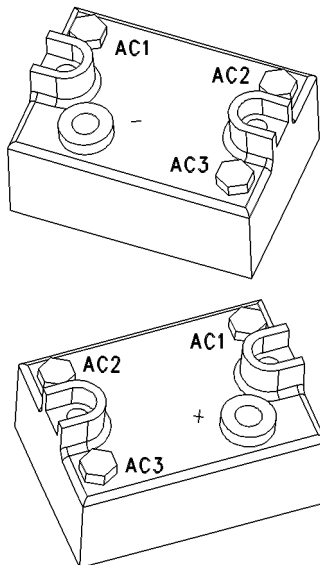


Illustration 78

g00613971

Three-Diode Rectifier Block (two pieces)

The following procedure tests all three diodes within a block. Check the positive rectifier block and the negative rectifier block. If any meter reading does not fall within the given ranges, replace the rectifier block.

1. Set the digital multimeter on the diode range.  
Remove all leads from the rectifier block.
2. To test the negative rectifier block, follow these steps:

- a. Place the red test lead on the negative “-” terminal. Place the black test lead on the following rectifier terminals: “AC1”(3), “AC2”(4), and “AC3”(5). All readings on the meter should be between 0.4 and 1.0.
- b. Place the black test lead on the negative “-” terminal. Place the red test lead on the following rectifier terminals: “AC1”(3), “AC2”(4), and “AC3”(5). In all cases, the meter should read “OL” (overload).
3. To test the positive rectifier block, follow these steps:
  - a. Place the red test lead on the positive “+” rectifier terminal. Place the black test lead on the following rectifier terminals: “AC1”(3), “AC2”(4), and “AC3”(5). In all cases, the meter should read “OL” (overload).
  - b. Place the black test lead on the positive “+” rectifier terminal. Place the red test lead on the following rectifier terminals: “AC1”(3), “AC2”(4), and “AC3”(5). All readings on the meter should be between 0.4 and 1.0.

**Note:** A shorted diode can cause damage to the exciter rotor. If a diode is shorted, check the exciter rotor. Refer to the Testing and Adjusting, “Winding - Test” and Testing and Adjusting, “Insulation - Test”. Perform these tests.

**Note:** This rectifier block also contains varistor “CR7”. “CR7” can be checked by measuring the resistance between the positive “+” rectifier terminal and the negative “-” rectifier terminal. The resistance should be a minimum of 15000.

i03724701

## Rotating Rectifier - Inspect/Test

SMCS Code: 4465-040; 4465-081

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

Table 38

Tools Needed		
Part Number	Part Name	Quantity
237-5130	Digital Multimeter	1
257-9140	Multimeter	1
146-4080	Digital Multimeter (RS-232)	1
7X-1710	Multimeter Probe Group	1

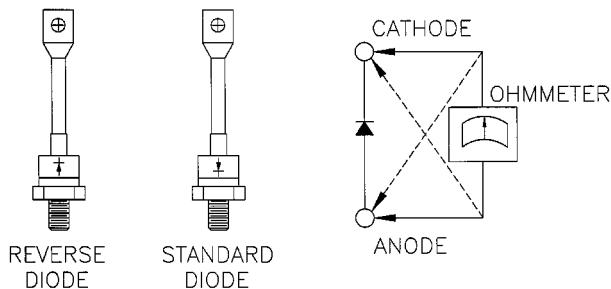


Illustration 79

g00555106

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 79. 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

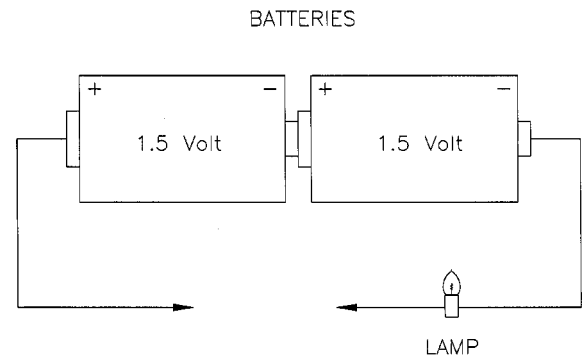


Illustration 80

g00555113

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 80.

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

i03724660

## Space Heater - Test

**SMCS Code:** 4450-081-HTR

The space heater is attached to the rear bearing bracket. The space heater is located in the generator's exciter end.

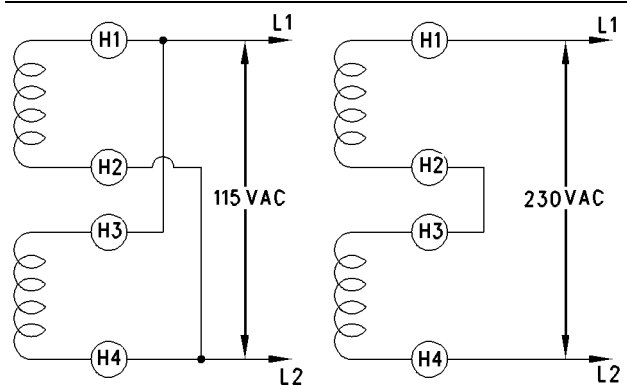


Illustration 81

g00610396

Space Heater Connection Diagram

An SR5 generator can operate in high humidity conditions without problems. The humidity can be as high as 100% non-condensing humidity. However, problems can occur when the generator is idle and the surrounding air is warmer than the generator. Moisture can form on the windings. Moisture will result in poor performance or even damage to the windings. Whenever the generator is not active, the optional space heaters should be operated.

An external source is required to operate the space heaters. Both of the sources must be a single phase. This source can be either 115 vac or 230 vac. When the external source is 50 hertz, 200 vac must be used. Refer to Illustration 81.

See your Caterpillar dealer for information on checking your Caterpillar generator.

i01472973

## Speed Sensor - Clean/Inspect

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

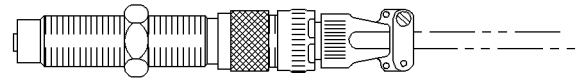


Illustration 82

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".



i03108463

## 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 generator set is listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule (Standby Generator Sets)” (Maintenance Section).

### 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.
- The generator is disconnected from the load.

### 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.

i00908982

i03230840

## Starting Motor - Inspect

**SMCS Code:** 1451-040; 1453-040

More frequent inspection and replacement of the starting motor may be required for the following conditions:

- Operation in harsh environments
- Applications that require frequent stops and starts

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. If damaged teeth are found, the air circuit for the starting motor must be examined in order to determine the cause of the problem.

### **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 repairs are needed, see the Service Manual or consult your Caterpillar dealer.

## Stator Lead - Check

**SMCS Code:** 4459-535

Ensure that the stator output leads are routed out of the generator in a manner that prevents the leads from rubbing against metal objects.

Visually inspect the following areas for cracking and physical damage:

- stator output leads
- protective sleeving
- insulation

i03725200

## Stator Winding Temperature - Test

**SMCS Code:** 4453-081-TA

Some generators are provided with optional 100 Ohm Resistance Temperature Detectors (RTD). When the temperature of the stator winding is suspected to be high, measure the temperature. 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 available from the factory. This equipment is used in order to measure the main armature's winding temperature.

i01261768

## Turbocharger - Inspect

**SMCS Code:** 1052-040

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side).

Fouling of the compressor can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel could allow parts from the compressor wheel to enter an engine cylinder. This can cause additional damage to the pistons, the valves, and the cylinder head.

---

**NOTICE**

Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

**Note:** Turbocharger components require clearances that are precise. The turbocharger cartridge must be balanced due to high rpm. Severe service applications can accelerate the wear of the components. Severe service applications may require more frequent inspections of the turbocharger.

## Removal and Installation

For options regarding the removal, installation, repair and replacement, consult your Caterpillar dealer. Refer to the Service Manual for this engine or consult your Caterpillar dealer for the procedure and specifications.

## Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil.
2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the turbocharger wheel and the turbocharger housing, the turbocharger should be reconditioned or replaced.

3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.

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

i03291822

## Varistor - Check

**SMCS Code:** 4466-535

The varistor must be checked at regular intervals. Refer to Systems Operation/Testing and Adjusting, KENR5284, "Varistor - Test" for instructions.

i03291802

## Varistor - Inspect

**SMCS Code:** 4466-040

The varistor must be visually inspected at regular intervals. For generator sets with 1400 or with 1600 frames, discoloration of the varistor indicates that replacement of the varistor is necessary. For generator sets with 1800 frames, physical signs of failure indicate that replacement of the varistor is necessary.

i01491868

## Voltage and Frequency - Check

**SMCS Code:** 4450-535-EL

Check for the proper voltage setting and check for the proper frequency setting. Check for stability.

For the correct voltage and frequency, refer to the generator set's Serial Plate.

i02591373

## 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.

### 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 Closed Crankcase Ventilation (CCV) filter, if equipped. If the restriction indicator is visible, service the CCV.
- 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.

### Inspect the Generator

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 .

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

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

i02624237

## 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.

## Reference Information Section

### Engine Ratings

i01239419

#### Engine Rating Conditions

**SMCS Code:** 1000

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

- 100 kPa (29.61 inches of Hg)
- A temperature of 25 °C (77 °F)

The following standard conditions of “ISO3046/1”, “DIN6271”, and “BS5514” are also applicable:

- 100 kPa (29.61 inches of Hg)
- Relative humidity of 60 percent

The ratings are also valid for the following parameters:

- Air temperature (air cleaner) of 50 °C (122 °F) or less
- Sea water temperature (sea level) of 42 °C (108 °F) or less

Fuel consumption is based on the following specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .849 at 15 °C (60 °F)
- Density of 850 kg/m<sup>3</sup> (7.085 lb/US gal)

The engine ratings are gross output ratings.

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

Standard accessories include the following components:

- Oil pumps
- Fuel transfer pumps

- Water pumps

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

i02547252

#### 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.

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.

---

#### Ratings for Generator Set Engines

**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** – Unless the operating cycle is specified differently, the operating cycle for calculating the load factors and the peak load limits is not to exceed 24 hours. The operating cycle does not include the time when the engine is not operating.

**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 load of 100 percent is only allowed for 5 percent of the operating cycle. The following applications are suggested: industrial, pumping, construction, and cogeneration.

**Standby** – This rating allows a load that varies for the duration of the power interruption. The normal load factor is up to 80 percent for 100 hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The suggested application is Standby for a power supply from a reliable utility.

## Load Management Peak Shaving Rating Guidelines

**Interruptable (Isolated from the utility with a Standby base rating for load factors)** – This rating allows a load that varies for less than 12 hours per day. The typical peak load factor is up to 80 percent for less than 500 hours per year. The peak operating limit is a load factor up to 100 percent. A 100 percent load is only allowed for 5 percent of the operating cycle. The operating cycle for calculating the load factors and the peak load limits is not to exceed six hours. The operating cycle does not include the time when the engine is not operating.

**Interruptable (Isolated from the utility with a Prime base rating for load factors)** – This rating allows a load that varies for more than 12 hours per day. The typical peak load factor is up to 80 percent for an unlimited number of hours per year. The peak operating limit is a load factor up to 100 percent. A 100 percent load is only allowed for 5 percent of the operating cycle.

**Curtable (Connected to a utility with a special base rating for load factors)** – This rating allows a constant load or a load that varies for less than six hours per day. The typical peak load factor is up to 100 percent for a maximum of 500 hours per year. The peak operating limit is up to 100 percent load for a maximum of 500 hours per year.

**Curtable (Connected to a utility with a Continuous base rating for load factors)** – This rating allows a constant load or a load that varies for more than six hours per day. The normal load factor is up to 100 percent for an unlimited number of hours per year. The peak load factor is up to 100 percent for an unlimited number of hours per year.

## Customer Service

i03201484

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

Please keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership'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 33126-4670  
USA  
Phone: 305-476-6800  
Fax: 305-476-6801

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

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

China  
Caterpillar China Ltd.  
37/F., The Lee Gardens  
33 Hysan Avenue  
Causeway Bay  
G.P.O. Box 3069  
Hong Kong  
Phone: 852-2848-0333  
Fax: 852-2848-0440

Japan  
Shin Caterpillar Mitsubishi Ltd.  
SBS Tower  
10-1, Yoga 4-Chome  
Setagaya-Ku, Tokyo 158-8530  
Japan  
Phone: 81-3-5717-1150  
Fax: 81-3-5717-1177

Japan  
Caterpillar Power Systems, Inc.  
SBS Tower (14th floor)  
4-10-1, Yoga  
Setagaya-Ku, Tokyo 158-0097  
Phone: 81-3-5797-4300  
Fax: 81-3-5797-4359

Australia and New Zealand  
Caterpillar of Australia Ltd.  
1 Caterpillar Drive  
Private Mail Bag 4  
Tullamarine, Victoria 3043  
Australia  
Phone: 03-9953-9333  
Fax: 03-9335-3366



i01028392

## Ordering Replacement Parts

SMCS Code: 4450; 7567

### **WARNING**

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

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

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

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

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

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

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

---

## Reference Materials

- Maintenance log

i00912149

## Maintenance Records

**SMCS Code:** 1000; 4450

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

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

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

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

Records should be kept for the following items:

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

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

**Documents** – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs
- Owner's receipts



i02535314

## Reference Material

**SMCS Code:** 1000; 4450

The following publications are available for order through your Caterpillar dealer.

### Lubricants

- Special Publication, PELJ0179, "Caterpillar Engine Crankcase Fluid-1 Specifications (Cat ECF-1)" (All international markets)
- Data Sheet, PEHJ0059, "Cat DEO (SAE 10W-30 and SAE 15W-40)" (North America: Canada, Mexico, and United States)
- Data Sheet, PEHJ0021, "Cat DEO (SAE 10W-30 and SAE 15W-40)" (Worldwide - except North America, Egypt, Saudi Arabia, and Brazil)
- Data Sheet, PEHJ0072, "Cat DEO (SAE 10W-30 and SAE 15W-40)" (Brazil)
- Data Sheet, PEHJ0091, "Cat DEO (SAE 10W-30 and SAE 15W-40)" (Egypt and Saudi Arabia)
- Special Publication, PEGJ0035, "Grease Selection Guide"
- Data Sheet, PEHP0002, "Cat Advanced 3Moly Grease" (NLGI grade 2)
- Data Sheet, NEHP6015, "Cat High Speed Ball Bearing Grease" (NLGI grade 2)
- Data Sheet, PEHJ0088, "Cat Multipurpose Grease" (NLGI grade 2)
- Special Publication, SEBD0640, "Oil and Your Engine"
- Special Publication, SEBU5898, "Cold Weather Recommendations"
- Special Publication, PEPD7036, "S-O-S Fluid Analysis"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"
- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"

### Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"

### Coolants

- Data Sheet, PEHJ0067, "Cat ELC (Extended Life Coolant)" (Worldwide)
- Special Publication, PEEP5027, "Label - ELC Radiator Label"
- Special Publication, PELJ0176, "Cat ELC (Extended Life Coolant) 223-9116 Dilution Test Kit"
- Data Sheet, PEHP9554, "Cat DEAC (Diesel Engine Antifreeze/Coolant) (Concentrate)"
- Special Publication, SEBD0518, "Knowing Your Cooling System"
- Special Publication, SEBD0970, "Coolant and Your Engine"
- Special Publication, PEPD7036, "S-O-S Fluid Analysis"
- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"

### Miscellaneous

- Special Publication, PECP9067, "One Safe Source"
- Operation and Maintenance Manual, SEBU7149, "SR4B Generators and Control Panels"
- Service Manual, RENR5015, "3500C Generator Set Engines"
- Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, "Electronic Modular Control Panel 3 (EMCP3)"
- Specifications, Systems Operation, Testing and Adjusting, RENR7941, "Caterpillar Digital Voltage Regulator (CDVR)"
- 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 Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog"
- 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"

i01237445

## Emissions Warranty Information

**SMCS Code:** 1000

This engine may be certified to comply with exhaust emission standards and the engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to emissions certified engines is found in Supplement, SMBU6981, "Federal Emissions Control Warranty Information For U.S., Canada, and California". Consult your authorized Caterpillar dealer in order to determine if your engine is emissions certified and if the engine is subject to an Emissions Warranty.

i00382622

## Warranty Information

**SMCS Code:** 1000

## Engine Protection Plans

### Extended Warranties and Service Contracts

A wide variety of protection plans are available for Caterpillar Engines. Consult your Caterpillar dealer for detailed information on the specific programs and coverages that are available.

Consult your Caterpillar dealer for information on a plan that is tailored in order to fit your requirements.

i03696960

## Decommissioning and Disposal

**SMCS Code:** 1000; 1021; 4450; 7002

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

i02342531

## 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
	ALARM		OIL DRAIN		COOLANT TEMPERATURE		COOLANT FILTER		ADJUSTABLE LOW-HIGH
	AC VOLTS		EMERGENCY STOP		HIGH COOLANT TEMP		REVERSE POWER		PANEL ILLUMINATION LIGHT

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	ALARM SILENCE		SERVICE HOURS		SYSTEM AUTO ENGINE START		HOT SURFACE
	RAISE		STARTING AID - ETHER		SYSTEM NOT IN AUTOMATIC START MODE		NO SERVICE READ MANUAL
	LOWER		AUTOMATIC		ENGINE RPM, ENGINE START OR ENGINE RUN		ENGINE COOLANT PRESSURE HOT SURFACE
	ON		MANUAL		FAIL TO START, OVERCRANK		CIRCUIT BREAKER OPEN
	OFF		HIGH VOLTAGE		AMMETER VOLTMETER PHASE SELECTOR SWITCH		CIRCUIT BREAKER CLOSED
	ENGINE STOP		OVERSPEED		GENERATOR SYNCHRONIZING INDICATOR		FREQUENCY

Illustration 83

g01168026

The control panel and modules utilize International Graphic Symbols to identify functions.

A typical list of the symbols that are used is shown above.

i01207219

## 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.

# Index

## A

After Starting Engine .....	51
Engaging the Driven Equipment .....	51
Warm-up .....	51
After Stopping Engine.....	55
Aftercooler Core - Inspect/Clean .....	82
Air Inlet Filter - Check .....	82
Air Shutoff - Replace .....	82
Air Shutoff - Test .....	83
Air Starting Motor Lubricator Bowl - Clean .....	83
Air Starting Motor Lubricator Oil Level - Check .....	84
Adjust the Lubricator .....	84
Air Tank Moisture and Sediment - Drain (If Equipped) .....	84
Alternator - Inspect .....	85
Annunciator Panel - Inspect .....	85
Record the Performance of the Engine.....	85
Automatic Start/Stop - Inspect.....	87

## B

Batteries - Replace .....	87
Battery - Recycle .....	87
Battery Charger - Check .....	87
Checking After Stopping .....	88
Checking Before Start-Up .....	87
Battery Disconnect Switch (If Equipped) .....	33
Battery Electrolyte Level - Check .....	88
Battery or Battery Cable - Disconnect .....	89
Before Starting Engine .....	16, 47
Walk-Around Inspection.....	47
Belts - Inspect/Adjust/Replace.....	89
Adjusting the Alternator Belt .....	89
Adjusting the Fan Drive Belt .....	90
Inspection.....	89
Replacement.....	90
Burn Prevention.....	13
Batteries.....	13
Coolant.....	13
Oils.....	13

## C

Circuit Breakers - Reset .....	90
Closed Crankcase Ventilation (CCV) Fumes Disposal Filter - Replace .....	91
Replacing the Fumes Disposal Filter .....	91
Resetting the Service Indicator .....	91
Cold Weather Operation.....	56
Cold Weather Starting .....	48
Air Starting Motor .....	48
Heaters .....	48
Starting With Ether.....	49

Configuration Parameters.....	38
Air Shutoff .....	44
Caterpillar Monitoring System.....	39
Cold Cylinder Cutout.....	44
Data Link Features.....	44
Default Settings for the Caterpillar Monitoring System .....	39
Display of Engine Performance .....	45
Ether Injection System.....	44
Cooling System Coolant (DEAC) - Change.....	92
Clean the Cooling System .....	92
Cleaning a Cooling System that has Heavy Deposits or Plugging .....	93
Drain the Cooling System .....	92
Fill the Cooling System .....	93
Cooling System Coolant (ELC) - Change.....	94
Clean the Cooling System .....	94
Drain the Cooling System .....	94
Fill the Cooling System .....	95
Cooling System Coolant Extender (ELC) - Add.....	95
Cooling System Coolant Level - Check.....	96
Add Coolant .....	96
Engines That Are Equipped With a Sight Gauge .....	96
Engines That Are Not Equipped With a Sight Gauge .....	96
Cooling System Coolant Sample (Level 1) - Obtain .....	97
Cooling System Coolant Sample (Level 2) - Obtain .....	97
Cooling System Supplemental Coolant Additive (SCA) - Test/Add.....	98
Cooling Systems that Use Conventional Coolant.....	98
Cooling Systems that Use Water and SCA.....	99
Cooling System Water Temperature Regulator - Replace.....	99
Crankshaft Vibration Damper - Inspect .....	100
Dampers With Sampling Ports.....	100
Dampers Without Sampling Ports.....	100
Removal and Installation.....	101
Crushing Prevention and Cutting Prevention .....	15
Customer Assistance.....	152
Outside of the USA and of Canada.....	152
USA and Canada.....	152
Customer Service .....	152

## D

Declaration of Conformity.....	25
Decommissioning and Disposal .....	157

## E

Electrical Connections - Check.....	101
-------------------------------------	-----

Electrical System .....	17	Foreword .....	5
Grounding Practices .....	18	California Proposition 65 Warning .....	5
Electronic Modular Control Panel 3 (EMCP 3) .....	34	Literature Information .....	4
Annunciator Module .....	37	Maintenance .....	4
Control Panel .....	36	Maintenance Intervals .....	4
Electronic Control Module (Generator Set) .....	34	Operation .....	4
Emergency Stopping .....	54	Overhaul .....	4
Air Shutoff .....	54	Safety .....	4
Emergency Stop Button .....	54	Fuel and the Effect from Cold Weather .....	56
Emissions Warranty Information .....	157	Fuel Conservation Practices .....	52
Engine - Clean .....	101	Fuel Injector - Inspect/Adjust .....	114
Engine Air Cleaner Element (Dual Element) -		Fuel Related Components in Cold Weather .....	56
Clean/Replace .....	101	Fuel Filters .....	56
Cleaning the Primary Air Cleaner Elements .....	102	Fuel Heaters .....	57
Servicing the Air Cleaner Elements .....	101	Fuel Tanks .....	56
Engine Air Cleaner Element (Single Element) -		Fuel System - Prime .....	114
Clean/Replace .....	104	Priming Procedure for Dry Starting .....	114
Cleaning the Air Cleaner Elements .....	105	Fuel System Primary Filter (Water Separator)	
Servicing the Air Cleaner Elements .....	104	Element - Replace .....	114
Engine Air Cleaner Service Indicator - Inspect (If		Fuel System Primary Filter/Water Separator -	
Equipped) .....	106	Drain .....	115
Test the Service Indicator .....	107	Fuel System Secondary Filter - Replace .....	116
Engine Air Precleaner - Clean .....	107	Fuel Tank Water and Sediment - Drain .....	117
Engine Crankcase Breather - Clean .....	107	Drain the Water and the Sediment .....	117
Engine Diagnostics .....	38	Fuel Storage Tanks .....	117
Engine Mounts - Check .....	108	Fuel Tank .....	117
Engine Oil and Filter - Change .....	110		
Drain the Oil .....	111	<b>G</b>	
Fill the Crankcase .....	112	General Hazard Information .....	10
Inspect the Used Oil Filter Elements .....	112	Asbestos Information .....	12
Replace the Oil Filter Elements .....	111	Containing Fluid Spillage .....	11
Engine Oil Level - Check .....	108	Dispose of Waste Properly .....	13
Engine Oil Sample - Obtain .....	109	Fluid Penetration .....	11
Obtain the Sample and the Analysis .....	109	Lines, Tubes, and Hoses .....	12
Engine Operation .....	52	Pressurized Air and Water .....	11
Operating the Engine and the Driven		General Maintenance Information .....	71
Equipment .....	52	Field Conditions that Reduce Insulation Life .....	72
Partial Load Operation .....	52	Space Heaters .....	71
Engine Protective Devices - Check .....	112	Generator - Dry .....	117
Visual Inspection .....	113	Drying Methods .....	118
Engine Rating Conditions .....	150	Generator - Inspect .....	118
Engine Rating Definitions .....	150	Cleaning (Assembled Generators) .....	119
Ratings for Generator Set Engines .....	150	Cleaning (Disassembled Generators) .....	119
Engine Ratings .....	150	Generator Bearing - Inspect/Replace (SR4	
Engine Starting .....	17, 47	Generator) .....	119
Ether .....	17	Inspect .....	120
Engine Stopping .....	17, 54	Replace .....	120
Engine Valve Lash - Inspect/Adjust .....	113	Generator Bearing - Lubricate .....	120
Engine Valve Lash .....	113	Lubricating Process (If Applicable) .....	120
Valve Bridge .....	113	Generator Bearing Temperature - Test/Record ...	123
		Infrared Thermometers .....	123
<b>F</b>		Resistive Temperature Detectors (RTDs) .....	123
Fan Drive Bearing - Lubricate .....	113	Generator Isolating for Maintenance .....	18
Features and Controls .....	33	Generator Lead - Check .....	124
Fire Prevention and Explosion Prevention .....	13		
Ether .....	15		
Fire Extinguisher .....	15		
Lines, Tubes and Hoses .....	15		

Generator Lead Connections .....	26	Maintenance Section .....	68
Grounding the Frame .....	27	Manual Stop Procedure .....	55
Lead Numbering .....	26	Automatic Stopping .....	55
Multiple Units .....	28	Model View Illustrations .....	19
Neutral Connections .....	27	Model Views and Specifications .....	19
Parallel to a Utility .....	28	Mounting and Dismounting .....	16
Single Units .....	27		
Generator Load - Check .....	124	<b>O</b>	
Generator Operation .....	58	Operation Section .....	30
Block Loading .....	58	Ordering Replacement Parts .....	153
Excitation System .....	59	Overhaul (Major) .....	133
Generator Options .....	60	Cleaning of Components .....	135
Loading of the Generator .....	58	Inspection of Components .....	134
Low Idle Adjustment .....	59	Inspection, Reconditioning or Exchanging of	
Oilfield Generators .....	60	Components .....	133
Power Factor .....	59	Obtain a Coolant Analysis .....	135
Standby Generator Sets .....	59	Replacement of Components .....	133
Generator Set - Test .....	124	Overhaul (Top End) .....	135
Generator Set Alignment - Check (Generator		First Top End Overhaul .....	135
Sets) .....	125	Top End Overhaul (Second) .....	137
Generator Set Vibration - Test/Record .....	125	Overhaul Considerations .....	138
Generator Start-up Checklist .....	75	Overhaul Information .....	139
Glossary .....	158	Severe Operation .....	138
<b>H</b>		<b>P</b>	
Hoses and Clamps - Inspect/Replace .....	126	Parallel Operation .....	60
Replace the Hoses and the Clamps .....	127	Circulating Currents .....	64
		Initial Start-Up .....	60
<b>I</b>		Parallel Operation Of Governors .....	62
Important Safety Information .....	2	Paralleling Multiple Units .....	62
Installation .....	32	Speed Droop for the Load Division (If	
Insulation - Test .....	127	Equipped) .....	62
Exciter Armature (Rotor L2) .....	128	Starting Multiple Units .....	62
Exciter Field (Stator L1) .....	128	Stopping .....	63
Main Armature (Stator L4) .....	128	Plate Locations and Film Locations .....	22
		Engine Identification .....	22
<b>J</b>		European Union .....	23
Jacket Water Heater - Check (Standby Generator		Identification of the Generator Set .....	22
Sets (If Equipped)) .....	129	Information Plate .....	22
		Output Lead Wiring .....	23
<b>L</b>		Serial Number Plate .....	22
Lifting and Storage .....	30	Serial Number Plate for the Generator .....	23
		Power Factor - Check .....	141
<b>M</b>		Prelube Pump - Inspect .....	141
Maintenance Interval Schedule (Prime Power) .....	80	Air Prelube Pump .....	141
Maintenance Interval Schedule (Standby) .....	78	Electric Prelube Pump .....	141
Maintenance Log .....	155	Product Description .....	20
Maintenance Recommendations .....	71, 129	Engine Description .....	21
Overhaul Intervals .....	129	Generator Description .....	21
Severe Operation .....	132	Intended Use .....	20
Maintenance Records .....	154	Product Identification Information .....	22
		Product Information Section .....	19

Product Installation .....	32
Location .....	32
Protective Devices .....	32
Receiving Inspection .....	32
Storage .....	32
Unpacking .....	32
Product Lifting .....	30
Lifting the Engine Only .....	30
Lifting the Entire Package .....	30
Lifting the Generator Only .....	30
Product Storage .....	30
Bearing Inspection .....	31
Electrical Measurements .....	31
Long Time Storage .....	31
Short Time Storage .....	30

**R**

Radiator - Clean .....	141
Reference Information .....	24
Reference Information Section .....	150
Reference Material .....	156
Coolants .....	156
Fuels .....	156
Lubricants .....	156
Miscellaneous .....	156
Reference Materials .....	154
Refill Capacities .....	68
Refill Capacities and Recommendations .....	68
Cooling System .....	69
Fuel .....	68
Lubrication System .....	68
Rotating Rectifier - Check .....	141
Testing a Three-Diode Rectifier Block .....	142
Rotating Rectifier - Inspect/Test .....	143
Testing a Brushless Exciter Rotating Rectifier With A Test Light .....	143
Testing A Brushless Exciter Rotating Rectifier With An Ohmmeter .....	143

**S**

Safety Messages .....	6
Safety Section .....	6
Single Unit Operation .....	64
Adjust the Voltage .....	64
Initial Start-Up .....	64
Starting .....	64
Stopping .....	65
Sound Information .....	16
Space Heater - Test .....	144
Specifications .....	21
Speed Sensor - Clean/Inspect .....	144
Standby Generator Set Maintenance Recommendations .....	145
Maintenance and Operation Procedures .....	145
Starting Motor - Inspect .....	146
Starting the Engine .....	49
Starting with Jump Start Cables .....	50

Stator Lead - Check .....	146
Stator Winding Temperature - Test .....	146
Symbols .....	158
System Pressure Release .....	72
Coolant System .....	72
Engine Oil .....	73
Fuel System .....	72

**T**

Table of Contents .....	3
Turbocharger - Inspect .....	146
Cleaning and Inspecting .....	147
Removal and Installation .....	147

**V**

Varistor - Check .....	147
Varistor - Inspect .....	147
Voltage and Frequency - Check .....	147
Voltage Connections .....	28
Three-Phase Voltage Connections .....	28
Voltage Regulator Options .....	67
Manual Voltage Control .....	67
Voltage Regulators .....	66
Caterpillar Digital Voltage Regulator (CDVR) .....	66

**W**

Walk-Around Inspection .....	148
Inspect the Engine for Leaks and for Loose Connections .....	148
Inspect the Generator .....	148
Warranty Information .....	157
Engine Protection Plans .....	157
Water Pump - Inspect .....	149
Welding on Engines with Electronic Controls .....	73



# 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: \_\_\_\_\_

