CATERPILLAR®

SEBU7909-01
October 2005

Operation and Maintenance Manual

C15 Generator Set

C5E1-Up (Generator Set)
C5H1-Up (Generator Set)
C5L1-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.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

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

⚠ 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.

Table of Contents

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

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Safety Messages

SMCS Code: 1000; 7405

There may be several specific safety messages on your generator set. 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.

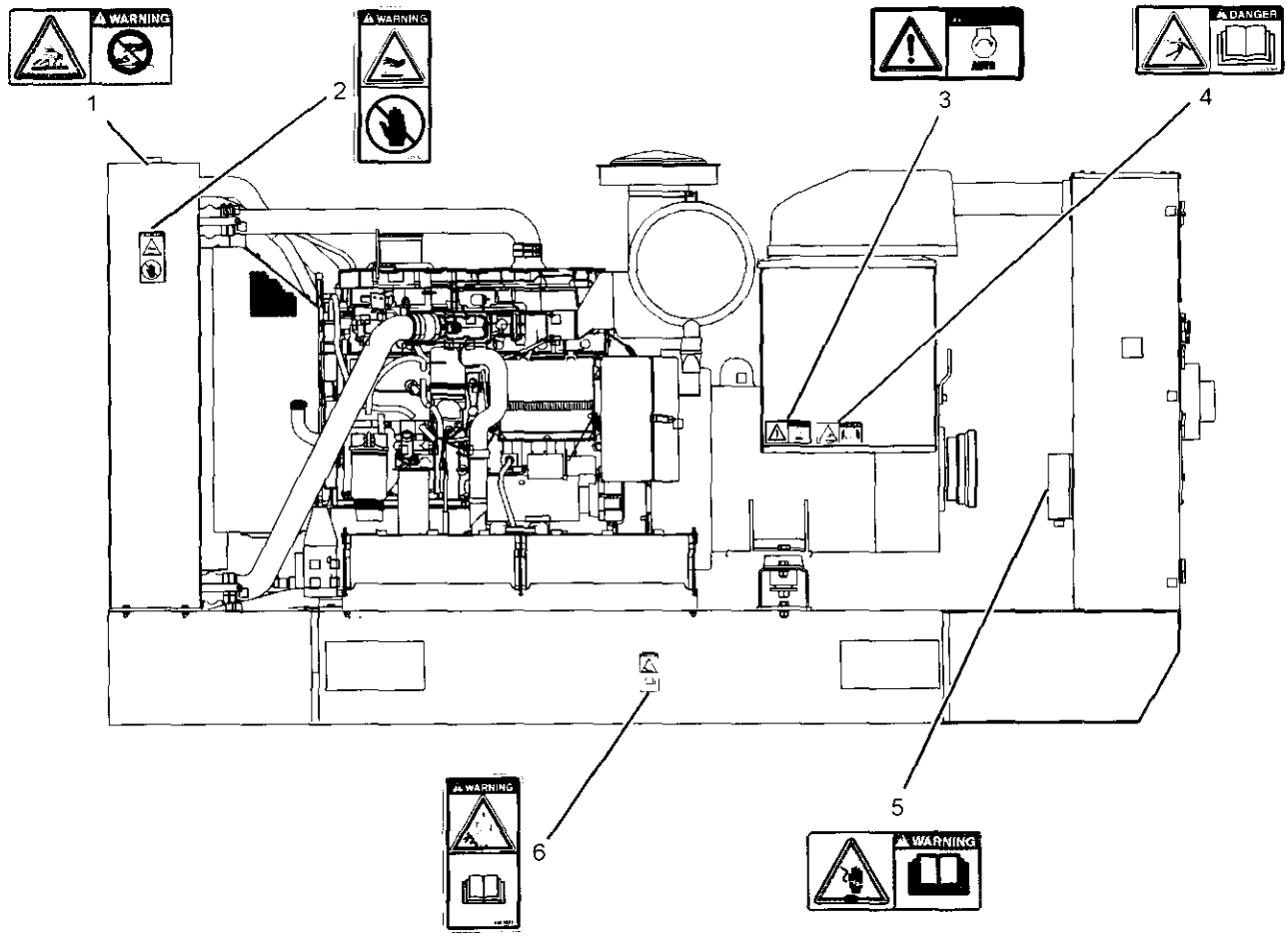

Illustration 1 g01184231

Side view of an open generator set

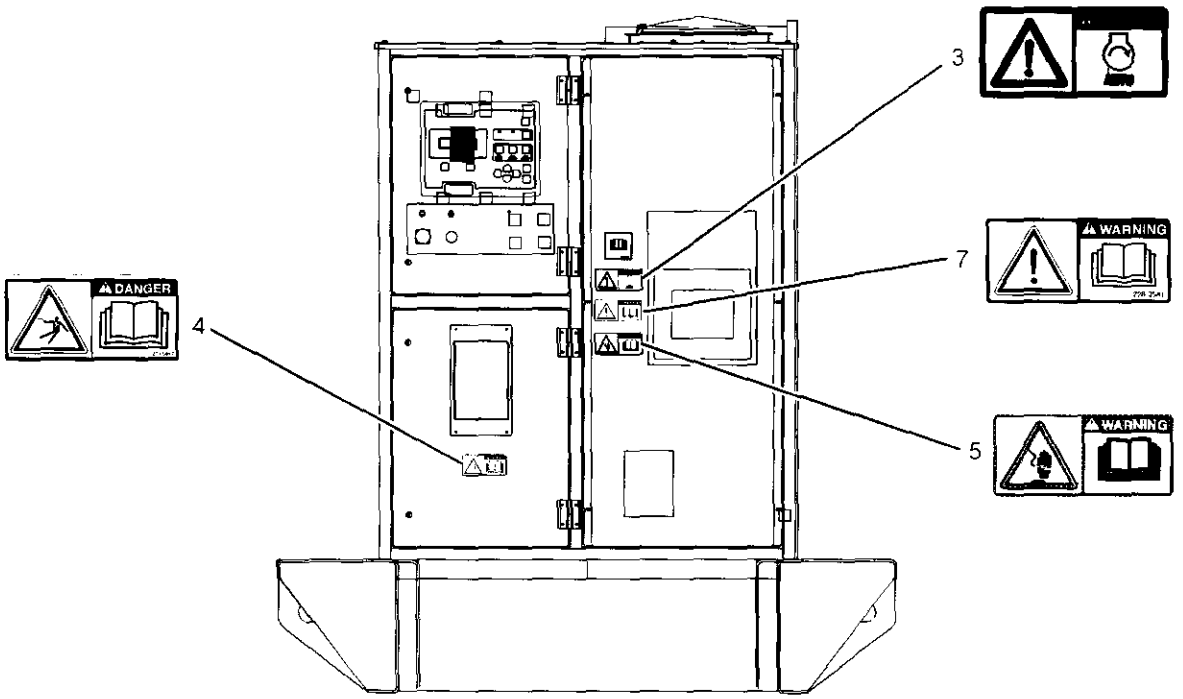

Illustration 2 g01184779

View of the control panel

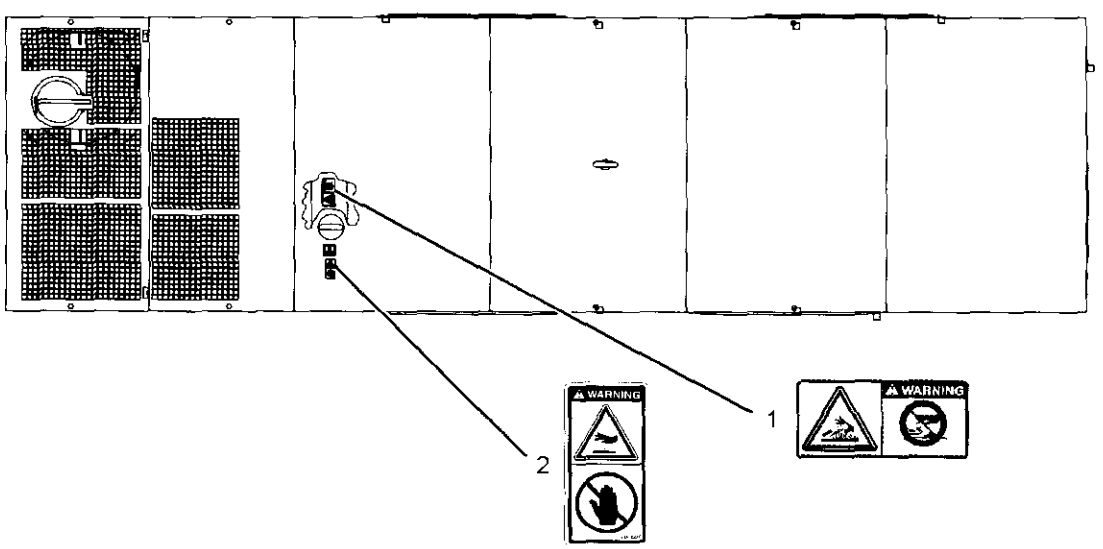

Illustration 3 g01184235

Top view of the enclosure

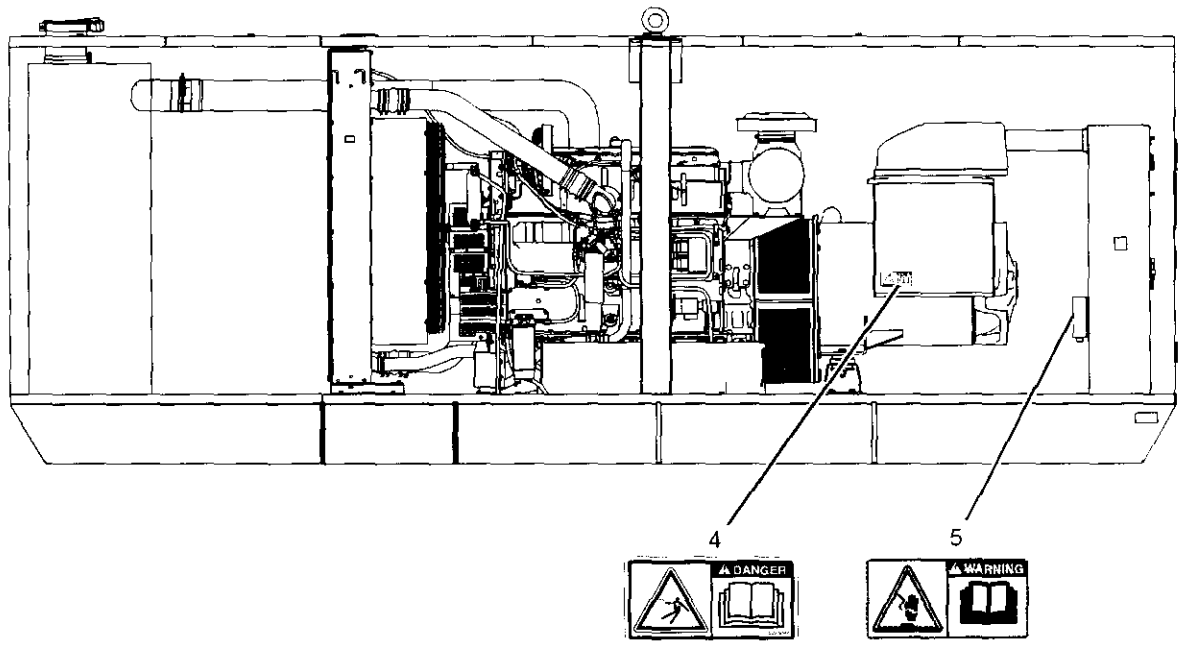

Illustration 4 g01184237

Side view of the generator set inside the enclosure

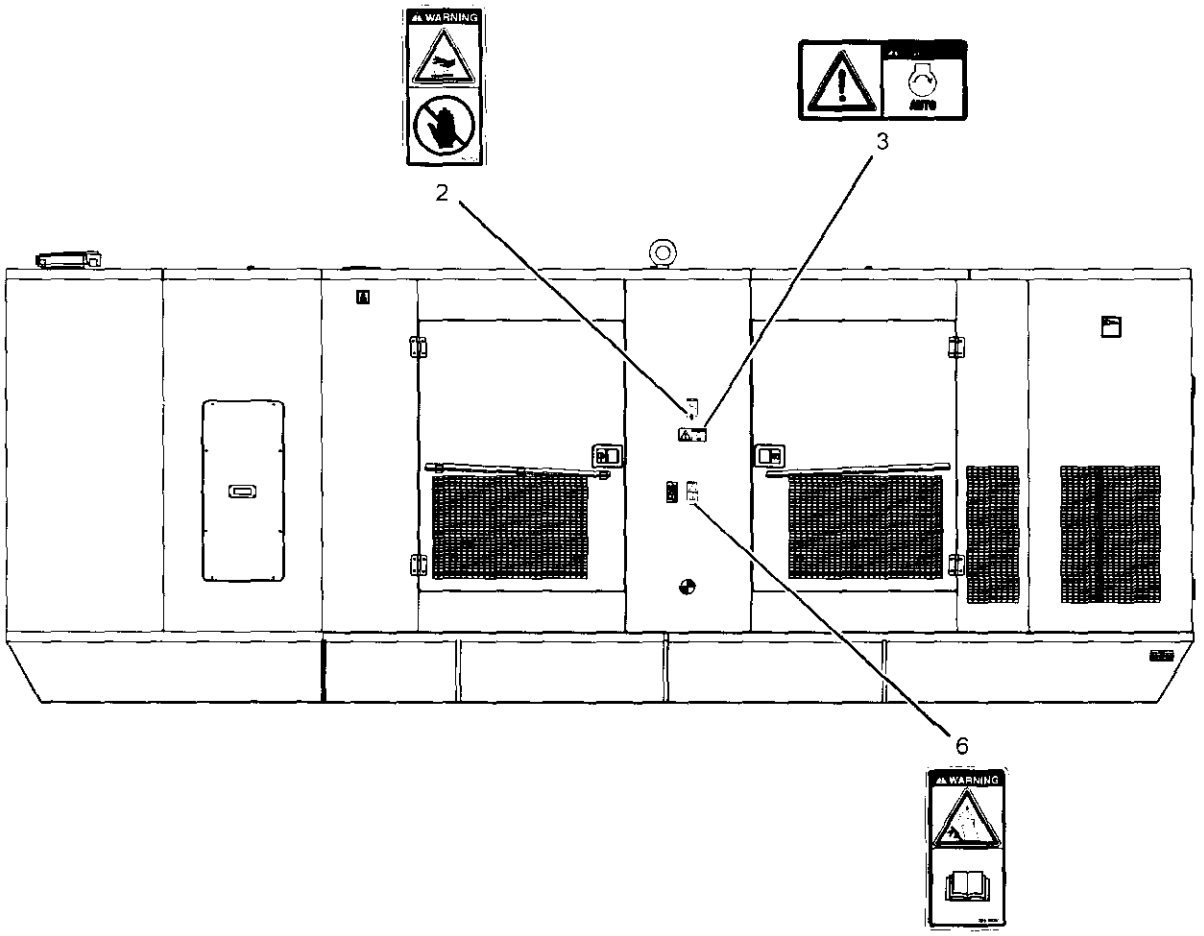

Illustration 5
g01184238
Side view of the enclosure

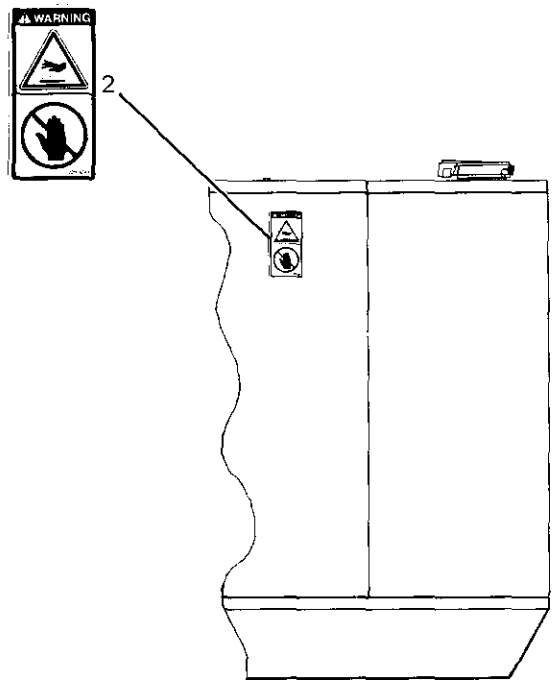

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Illustration 6

Side view of the enclosure

Hot Surface (1)

This safety message is located on each side of the radiator on open generator sets. This safety message is located on the sides and the top of the enclosure for enclosed generator sets.

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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.

Automatic Starting (2)

This safety message is located on the sides of the enclosure on enclosed generator sets. This safety message is located on the sides of the generator for open generator sets. This safety message is also located on the enclosure for the control panel.

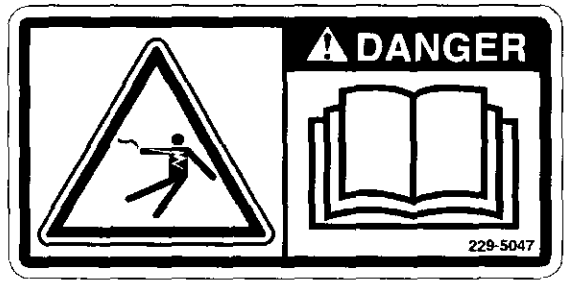
g01154070

WARNING

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

Electrocution (3)

This safety message is located on the side of the generator and on the enclosure for the circuit breaker. This safety message is also located on the side of the enclosure.



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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.

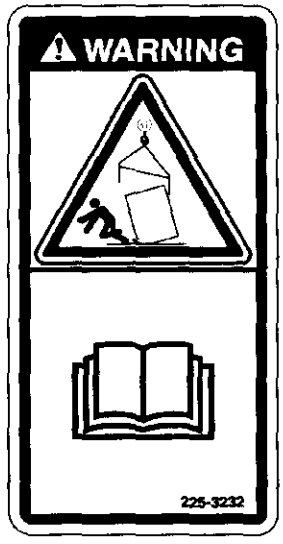
WARNING

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

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

Crush (4)

This safety message is located on the sides of enclosed generator sets. This safety message is also located on the base for open generator sets.



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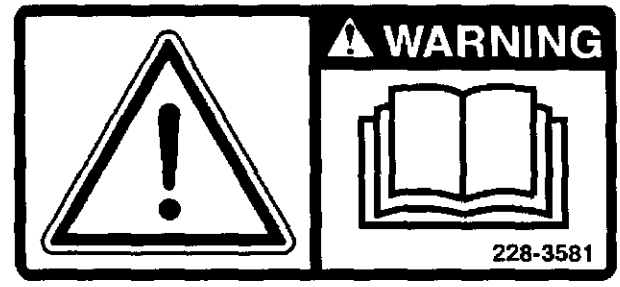
WARNING

Crushing 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.

Universal Warning (5)

This safety message is located on the enclosure for the control panel.



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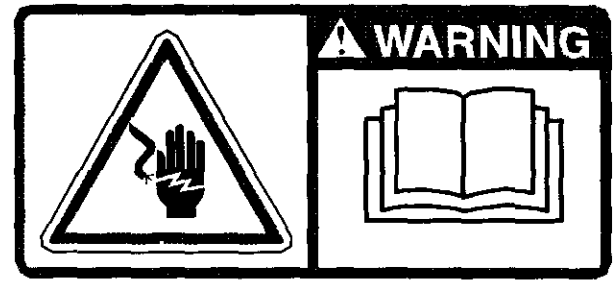
WARNING

Do not operate or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals. Failure to follow the instructions or heed the warnings could result in serious injury or death.

Electrical Shock (6)

The safety message for electrical shock is located on the front and the rear of the enclosure for the control panel.



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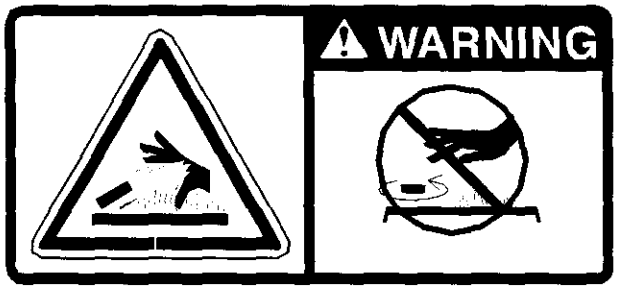
WARNING

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.

Hot Fluid Under Pressure (7)

This safety message is located by the cooling system filler cap.



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WARNING

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.

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General Hazard Information

SMCS Code: 1000; 7405

Attach a "Do Not Operate" warning tag or a similar warning tag to the start switch or to the controls before the engine is serviced or before the engine is repaired. These warning tags (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.

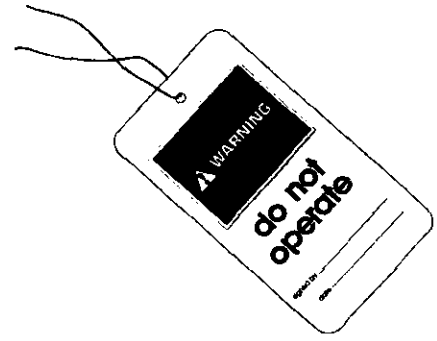

Illustration 7 g00104545

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

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

Cautiously remove the following parts:

Note: 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.

- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.

- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

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

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

Pressurized Air and Water

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

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

Fluid Penetration

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

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

Containing Fluid Spillage

Care must be used in order to ensure that the fluids are contained during the inspection, the maintenance, the testing, the adjusting, and the repair of the engine. Prepare to collect the fluid with suitable containers before any compartment is opened or before any component is disassembled.

Refer to Catalog, NENG2500, "Caterpillar Dealer Service Tool Catalog" for the following items:

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

Obey all local regulations for the disposal of liquids.

Asbestos Information

Illustration 8 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

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

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

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Burn Prevention

SMCS Code: 1000; 7405

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

Coolant

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

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

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

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

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

Oils

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

Batteries

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

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Fire Prevention and Explosion Prevention

SMCS Code: 1000; 7405

Illustration 9 g00704000

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

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

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

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

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

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

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

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in case of a line, a hose, 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 that contain flammable fluid. Clean any such lines 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 10 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.

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.

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Crushing Prevention and Cutting Prevention

SMCS Code: 1000; 7405

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

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

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

Keep objects away from moving fan blades. 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.

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Mounting and Dismounting

SMCS Code: 1000; 7405

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

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

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

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

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

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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.

Overspeed shutdown should occur automatically. If automatic shutdown does not occur, press the emergency stop button in order to cut the fuel and/or air to the engine.

Inspect the engine for potential hazards.

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

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.

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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.

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Engine Stopping

SMCS Code: 1000

Stop the engine according to the procedure in the Operation and Maintenance Manual, "Engine Stopping (Operation Section)" in order to avoid overheating of the engine and accelerated wear of the engine components.

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

Stop the engine if an overspeed condition occurs during the initial start-up of a new engine or an engine that has been overhauled. This may be accomplished by shutting off the fuel supply to the engine and/or shutting off the air supply to the engine.

To stop an electronically controlled engine, cut the power to the engine.

i02353436

Electrical System

SMCS Code: 1000; 1400

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

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

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

Grounding Practices

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

Uncontrolled electrical circuit paths can result in damage to main bearings, to crankshaft bearing journal surfaces, and to aluminum components. Uncontrolled electrical circuit paths can also cause electrical noise.

The alternator, the starting motor, and all of the electrical systems MUST be grounded to the negative battery terminal.

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

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

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

i01563743

Engine Electronics

SMCS Code: 1000; 1400; 1900

⚠ WARNING

Tampering with the electronic system installation or the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.

This engine has a comprehensive, programmable Engine Monitoring System. The Engine Control Module (ECM) has the ability to monitor the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control: WARNING, DERATE, and SHUTDOWN. These engine monitoring modes have the ability to limit engine speed and/or the engine power.

Many of the parameters that are monitored by the ECM can be programmed for the engine monitoring functions. The following parameters can be monitored as a part of the Engine Monitoring System:

- Operating Altitude
- Engine Coolant Level
- Engine Coolant Temperature
- Engine Oil Pressure
- Engine Speed

- Fuel Temperature
- Intake Manifold Air Temperature
- System Voltage

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

Note: Many of the engine control systems and display modules that are available for Caterpillar Engines will work in unison with the Engine Monitoring System. Together, the two controls will provide the engine monitoring function for the specific engine application. Refer to the Electronic Troubleshooting Manual for more information on the Engine Monitoring System.

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.

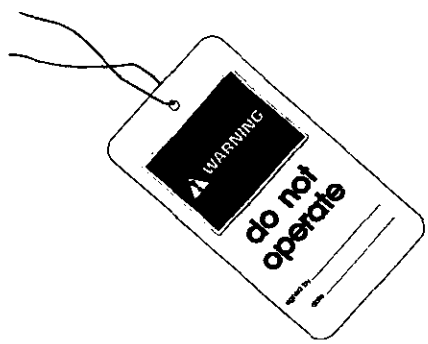


Illustration 11 g00104545

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

Product Information Section

General Information

i02276735

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 bearings, hydraulic components, electrical components, 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.

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.

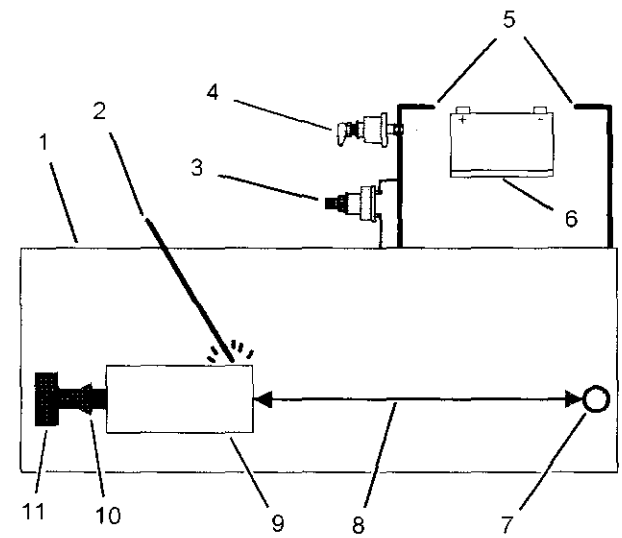


Illustration 12 g01075639

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.

Model Views

i02386706

Model View Illustrations

SMCS Code: 1000

The following engine model views show typical C15 Generator Set features. The operator should become familiar with the locations of these items. Due to individual applications, your engine may appear different from the illustrations.

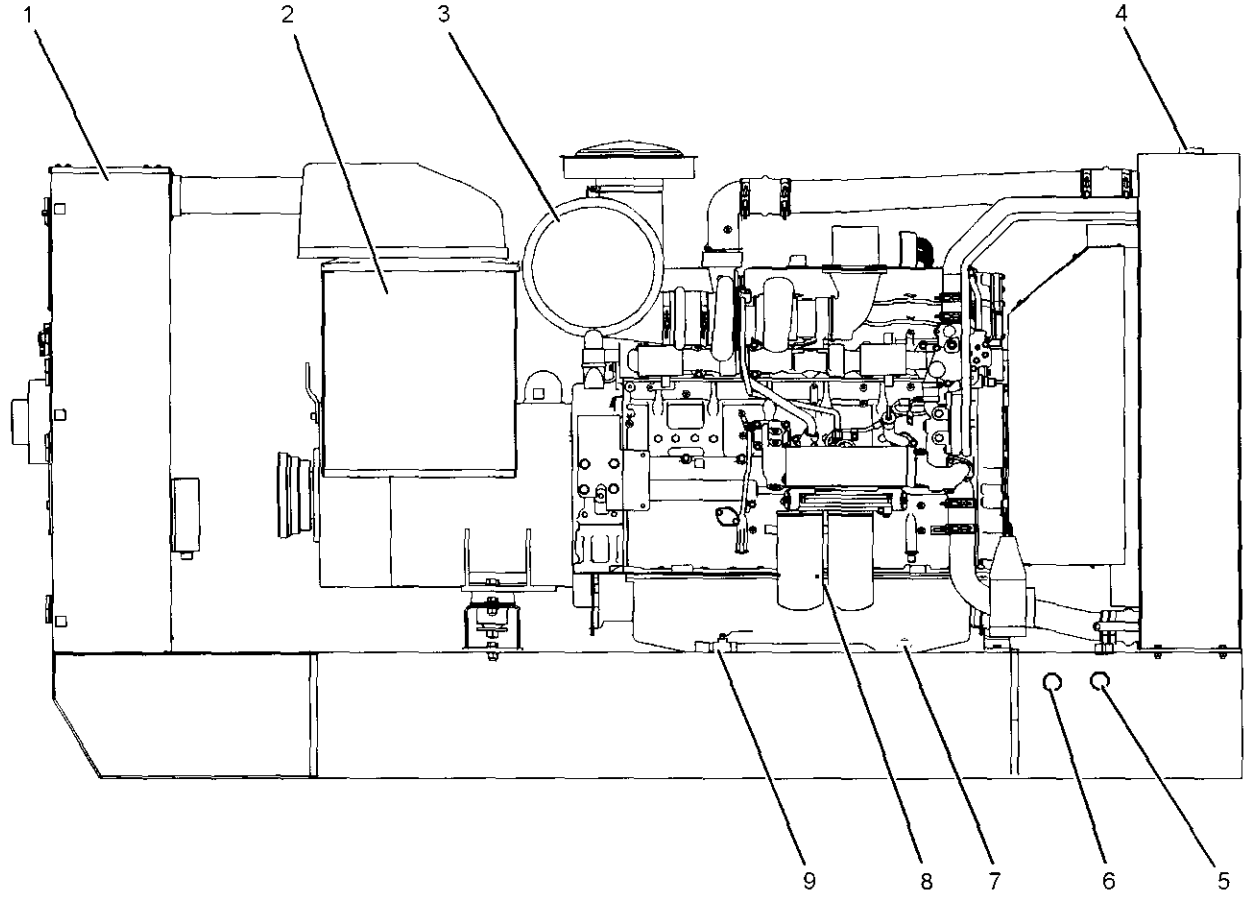


Illustration 13 g01190861

Right Hand Side View

(1) Enclosure for the control panel
(2) Terminal box for the generator
(3) Air cleaner
(4) Radiator cap
(5) Engine coolant drain
(6) Engine oil drain
(7) Engine oil drain plug
(8) Engine oil filters
(9) Engine oil drain valve

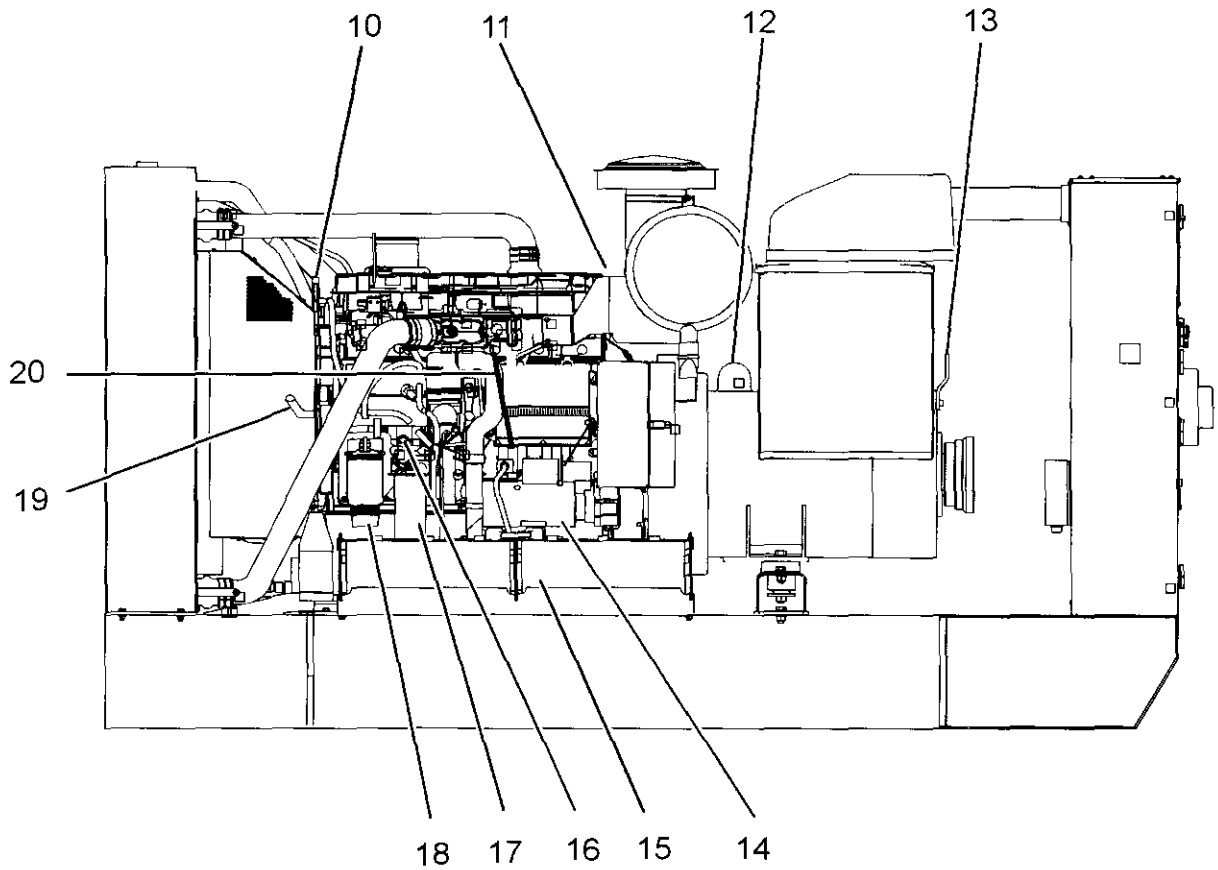


Illustration 14 g01190863

Left Hand Side View

(10) Engine lifting eye
(11) Engine lifting eye
(12) Lifting eye for generator
(13) Lifting eye for generator
(14) Starting motor
(15) Engine oil cooler
(16) Fuel priming pump
(17) Secondary fuel filter
(18) Fuel filter/water separator
(19) Oil filler
(20) Engine oil level gauge (dipstick)

i02363026

Product Description

SMCS Code: 1000; 4450; 4491; 7000

Engine Information

These Caterpillar Engines provide the following features:

- Four stroke cycle
- Electronic engine control
- Direct injection fuel system
- Mechanically actuated electronic unit injectors
- Turbocharger
- Air-to-air aftercooler

Engine Specifications

Note: The front end of the engine is opposite the flywheel end of the engine. The left side and the right side of the engine are determined from the flywheel end. The number 1 cylinder is the front cylinder.

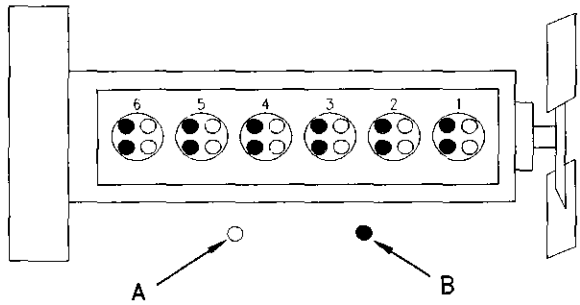


Illustration 15 g00284836

Cylinder and valve locations

(A) Inlet valves
(B) Exhaust valves

Table 1

C15 Engine Specifications	
Cylinders and Arrangement	In-line six cylinder
Bore	140 mm (5.5 inch)
Stroke	171 mm (6.7 inch)
Displacement	15.8 L (964.2 in^3)
Valve Lash (intake)	0.38 mm (0.015 inch)
Valve Lash (exhaust)	0.76 mm (0.03 inch)
Firing Order	1-5-3-6-2-4
Rotation (flywheel end)	Counterclockwise

Electronic Engine Features

These Caterpillar Engines are specifically designed for electronic controls. These engines have an integral on board computer that is called an Electronic Control Module (ECM). The ECM monitors current engine conditions and power requirements. The optimum engine response is calculated and instructions are sent to the engine control systems. The systems respond and the engine responds accordingly. Total engine control is realized through the control of the fuel system and the engine speed/timing system. The electronic engine control system provides the following features:

- Engine speed governing
- Injection timing control
- Automatic air/fuel ratio control
- Torque rise shaping
- Engine monitoring and protection

The ECM provides the electronic governing of fuel delivery in order to dictate the following engine controls: engine speed setpoint, engine timing accuracy, air/fuel ratio control, and torque rise fuel setting.

Electronically controlled, mechanically actuated unit injectors combine the pumping, electronic fuel metering (duration and timing), and injecting elements of the fuel system into a single unit. Each cylinder has an independent unit injector.

Fuel metering is controlled by an electrical signal that is sent to the injector solenoid from the ECM. Very high fuel injection pressures are produced by the unit injector pump. High injection pressures and accurate fuel metering ensure good fuel atomization and thorough combustion. This state-of-the-art technology provides the engine with the following benefits: reduced fuel consumption, controlled smoke emissions, and electronically controlled acceleration ramp rates.

The engine timing control and speed control are provided by the ECM. The speed/timing circuit consists of two speed/timing sensors. During engine cranking, the ECM uses the timing signal from the secondary speed/timing sensor. The timing signal from the primary speed/timing sensor is used by the ECM while the engine speed is greater than cranking speed. Utilizing two sensors for this circuit has several advantages. Each of the speed/timing sensors is treated as a discrete component by the ECM. If the signal from one of the sensors becomes suspect the ECM will use the signal from the other sensor in order to keep the engine operational.

Injection duration is also managed by the ECM. The duration of the fuel injection cycle determines the engine speed. The placement of the injection cycle in relation to the crankshaft position will determine the timing advance. The speed/timing circuit provides information to the fuel cooled ECM for detection of crankshaft position and engine speed. This information is utilized by the ECM in order to control desired engine speed and engine timing.

The ECM changes injection timing according to engine operating conditions and demand. Improved timing control results in improved performance. Improvements in several aspects of engine operation will be realized: better engine starting ability, shorter response times, reduced emissions, reduced noise, and optimized fuel consumption.

Engine monitoring and interactive diagnostics are also provided by the ECM. Essential engine operating conditions and diagnostic information are monitored and recorded in the ECM memory. The ECM quantifies the information. The information is then compared to an acceptable range of values. If the values are not within the acceptable range, then the diagnostic information is communicated to the operator and the abnormal condition is stored in ECM memory.

For more information on electronic engine features, refer to the Operation and Maintenance Manual, "Engine Features and Controls" topic (Operation Section).

Engine Cooling and Lubrication

The cooling system consists of the following components:

- Self-priming centrifugal type pump that is driven by gears
- Water temperature regulators which regulate the engine coolant temperature
- Engine oil cooler which is used to transfer excess heat from the engine oil to the cooling system
- Radiator

The engine lubricating oil is supplied by a high pressure oil pump. The engine lubricating oil is cooled and filtered. Bypass valves provide unrestricted flow of lubrication oil to the engine components during the following conditions:

- High oil viscosity
- Plugged oil cooler or plugged oil filter elements (paper cartridge)

Engine Service Life

Engine efficiency and maximum utilization of engine performance depend on the adherence to proper operation and maintenance recommendations. In addition, use recommended fuels, coolants and lubricants. Use the Operation and Maintenance Manual as a guide for required engine maintenance.

Expected engine life is generally predicted by the average power that is demanded. The average power that is demanded is based on fuel consumption of the engine over a period of time. Reduced hours of operation at full throttle and/or operating at reduced throttle settings result in a lower average power demand. Reduced hours of operation will increase the length of operating time before an engine overhaul is required. For more information, refer to Operation and Maintenance Manual, SEBU7902, "Overhaul Considerations".

Generator Description

These brushless generators are used with the following loads: mixed loads of motors and lights, SCR-controlled equipment, computer centers, installations of communications, and petroleum drilling applications. The elimination of the brushes in the field circuit reduces maintenance. The elimination of the brushes in the field circuit increases reliability. The elimination of brushes provides a higher degree of protection in potentially hazardous atmospheres.

The generator set packages can be utilized for prime power generation or standby power generation. The generator set packages can be used in land based applications or marine applications.

The generators have four poles. The generators have six or twelve lead configurations. The configuration depends on the frame size. The generators are capable of producing electrical power in either 50 Hz or 60 Hz applications.

Aftermarket Products and Caterpillar Engines

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

When auxiliary devices, accessories, or consumables (filters, additives, catalysts, etc) which are made by other manufacturers are used on Caterpillar products, the Caterpillar warranty is not affected simply because of such use.

However, failures that result from the installation or use of other manufacturers' devices, accessories, or consumables are NOT Caterpillar defects. Therefore, the defects are NOT covered under the Caterpillar warranty.

Product Identification Information

i02374529

Plate Locations and Film Locations

SMCS Code: 1000

Generator Set Identification

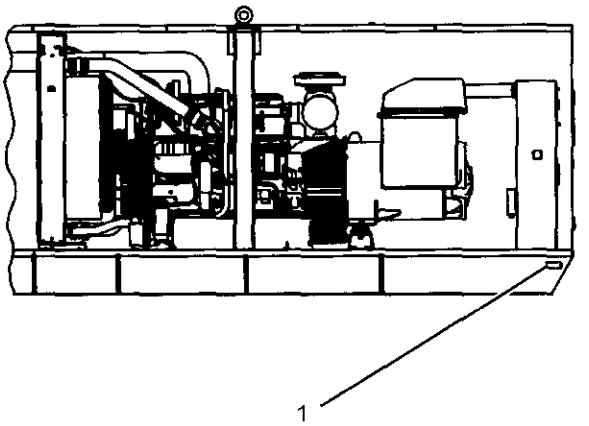


Illustration 16 g01185578

(1) Location of the identification plate for the generator set

The generator set consists of the generator and the engine. The location of the identification plate for the generator set is shown in illustration 17.

Serial Number Plate

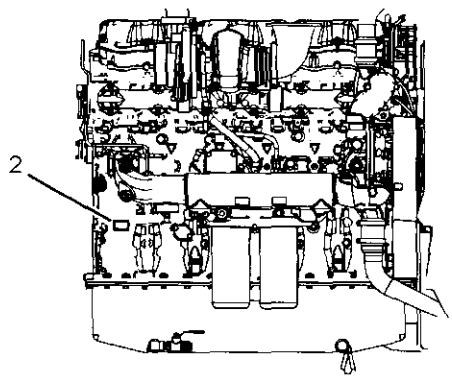


Illustration 17 g01185411

Right Side View of Engine Only

(2) Location of serial number plate

The Engine Serial Number Plate contains the following information:

- Engine serial number _____
- Engine model number _____
- Arrangement number _____

Engine Information Plate

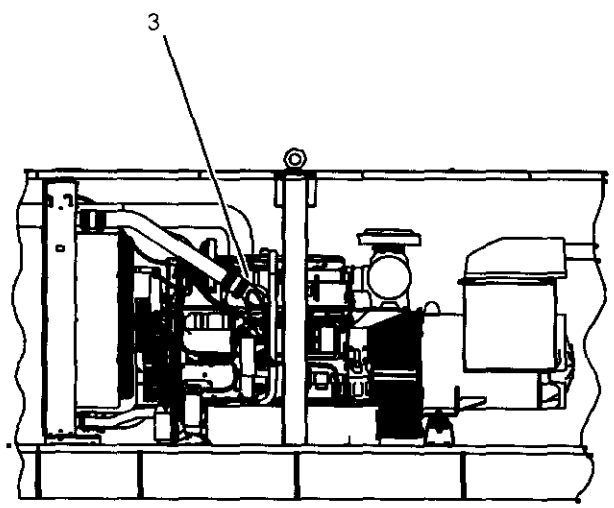


Illustration 18 g01185515

(3) Location of the engine information plate

The Engine Information Plate contains the following information:

- Engine serial number _____
- Arrangement number _____
- Compression ratio _____
- Aftercooler temperature _____
- Power _____
- Full load RPM _____

Generator Identification Plate

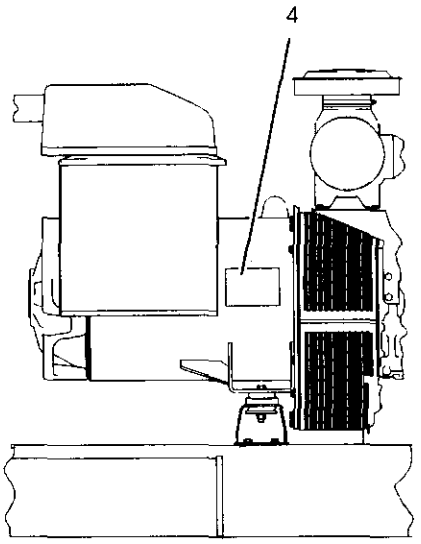


Illustration 19 g01185532

Location of the generator identification plate

The generator identification is located on the side of the generator.

The generator identification film includes the following information:

- Serial number for the generator _____
- Generator model number _____

i02237440

Reference Numbers

SMCS Code: 1000

Information for the following items may be needed to order parts. Locate the information for your engine. Record the information in the appropriate space. Make a copy of this list for a record. Retain the information for future reference.

Record for Reference

Engine Model _____

Engine Serial Number _____

Engine Arrangement Number _____

Modification Number _____

Engine Low Idle Speed _____

Engine Full Load Speed _____

Performance Specification Number _____

Primary Fuel Filter Element _____

Secondary Fuel Filter Element _____

Engine Oil Filter Element _____

Auxiliary Oil Filter Element _____

Supplemental Coolant Additive Maintenance Element _____

Engine Oil Capacity _____

Total Cooling System Capacity _____

Air Cleaner Element _____

Fan Drive Belt _____

Alternator Belt _____

Generator Arrangement Number _____

Generator Set Serial Number _____

Generator Frame Size _____

Voltage Rating _____

kW Rating _____

Excitation System

S.E. _____

P.M. _____

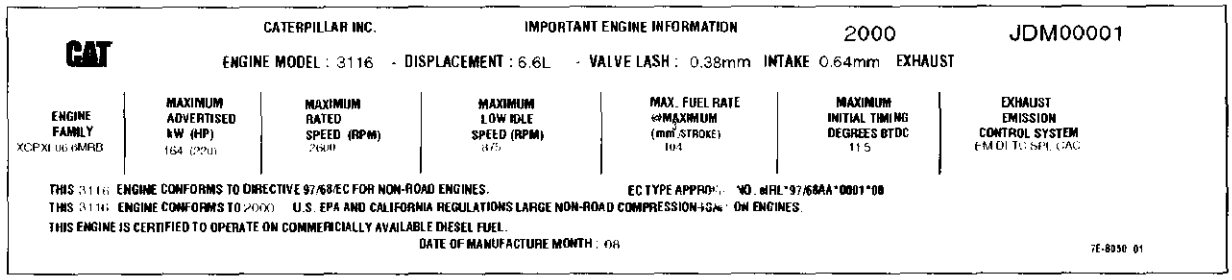
i01830750

Emissions Certification Film

SMCS Code: 1000; 7405

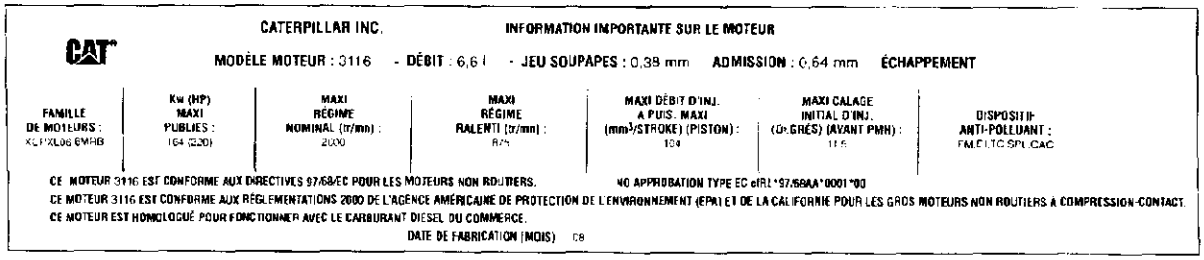
Note: This information is pertinent in the United States, in Canada and in Europe.

A typical example is shown.



FMT:3500

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



Étiquette d'homologation anti-pollution

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

Illustration 20 g00776690

i01297919

Generator Set Intended for Stationary Use Only

SMCS Code: 1000; 7002

THE FOLLOWING NOTICE IS INTENDED ONLY FOR UNITS SHIPPED INTO THE UNITED STATES OF AMERICA, CANADA OR UNITED STATES TERRITORIES

For units marked as being intended for stationary use only, which are used in the United States of America, United States Territories or Canada, the following restrictions apply:

This generating set may only be used in stationary applications, as defined by the Environmental Protection Agency (EPA) Regulation in Title 40 of the Code of Federal Regulations (40 CFR Part 89.2(2)).

The definition of stationary, per the regulations, is that a) the unit will remain at a single site at a building, structure, facility or installation for more than 12 consecutive months, or b) will remain at a seasonal source during it's full annual operation period, as defined in 40 CFR 89.2(2)(iii).

The following United States Territories must comply with United States EPA regulations: Puerto Rico, Virgin Islands, Guam, American Somoa, and the Commonwealth of the Northern Mariana Islands.

i01156400

Customer Specified Parameters

SMCS Code: 1000

To record programmed specifications, use the following blanks.

Customer Passwords

First Password_____

Second Password_____

Injector Trim Codes

Injector 1_____

Injector 2_____

Injector 3_____

Injector 4_____

Injector 5_____

Injector 6_____

Engine Parameters

Note: If an Electronic Modular Control Panel (EMCP) is connected to the engine, the following engine parameters can affect generator set operation. For more information on engine parameters, refer to the Electronic Troubleshooting Manual for this engine. For more information on the EMCP electronic control, refer to the Service Manual.

FRC Offset Value_____

Rated Fuel Position (mm)_____

Fuel Correction Factor_____

Breakpoint Setting_____

Governor Gain_____

Acceleration Delay Time_____

Acceleration Ramp Rate_____

User-Defined Switch Installation Status_____

User-Defined Switch Active State Configuration_____

High Engine RPM Limit_____

Low Idle Engine RPM_____

Engine Cooldown Duration_____

Cooldown Speed_____

Maximum Number of Crank Cycles_____

Crank Cycle Duration_____

Crank Terminate Speed_____

Coolant Level Sensor Installation Status_____

Exhaust Temperature Sensor Installation Status_____

Fuel Pressure Sensor Installation Status_____

Oil Temperature Sensor Installation Status_____

Air Shutoff_____

Ether Control_____

Engine Monitoring System

Low Battery Voltage

Warning Trip Point_____

Warning Delay Time_____

Low Coolant Temperature

Warning Trip Point_____

Warning Delay Time_____

Engine Overspeed

Warning Trip Point_____

Warning Delay Time_____

Shutdown Trip Point_____

Shutdown Delay Time_____

Inlet Air Temperature

Warning Delay Time_____

High Exhaust Temperature

Warning Trip Point_____

Warning Delay Time_____

High Engine Oil Temperature

Warning Trip Point_____

Warning Delay Time_____

Shutdown Trip Point_____

Shutdown Delay Time_____

Low Coolant Level

Warning Delay Time_____

Shutdown Delay Time_____

User-Defined Switch

Warning Delay Time_____

Shutdown Delay Time_____

i02369866

Generator Lead Connections

SMCS Code: 4450

Grounding the Frame

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

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

Neutral Connections

The generators with a Wye Configuration usually have the neutral ground when the generator is installed. Grounding the neutral is for preventing damage to equipment.

If the neutral wire is grounded and one of the phase leads becomes grounded, the excessive current will open a load circuit breaker. Also, the excessive current will cause the generator voltage to collapse. The result depends on the following items: electrical characteristics of the generator , 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 cases when the neutral wire is not grounded. An ungrounded generator neutral lead is acceptable when the possibility of grounds to the phase leads has been eliminated. An example of such measures are ground fault protective circuits. Ground fault protection requires the entire group of distribution circuits to be treated as a system. The owner should contact a certified consultant if a new distribution system is being developed. The owner should also contact a certified consultant if an existing system should be modified for the ground fault protection.

Single Units

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

Be sure to check your local wiring codes.

5000/6100 Twelve Wire Connection Diagrams

The connections are located in the electrical box that is mounted on top of the generator.

Wiring Code A for Three-Phase Configuration

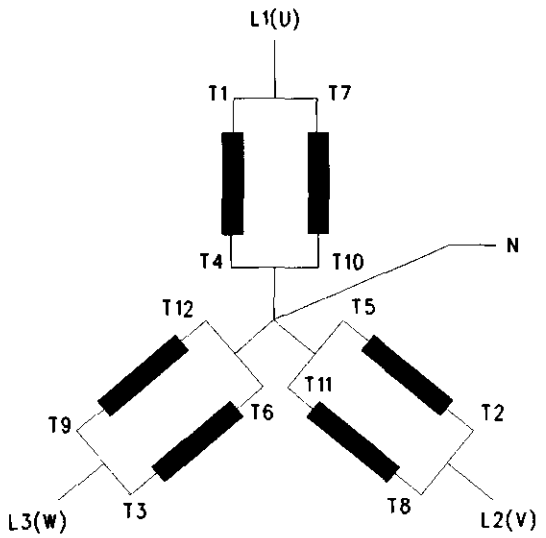


Illustration 21 g00952030

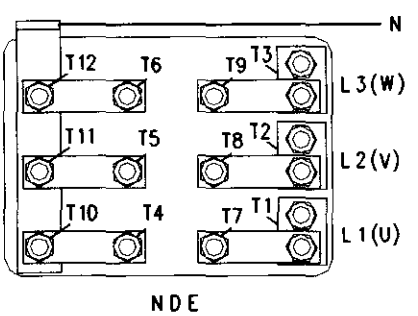


Illustration 22 g00996292

5000 12 wire factory connection for A wiring code

Table 2

L-L Voltage for Wiring Code A		
Winding	**50 Hz**	**60 Hz**
6	190-220	190-240

R448 voltage sensing – 0 => (T3) / 220 V => (T2)

Wiring Code D for Three-Phase Configuration

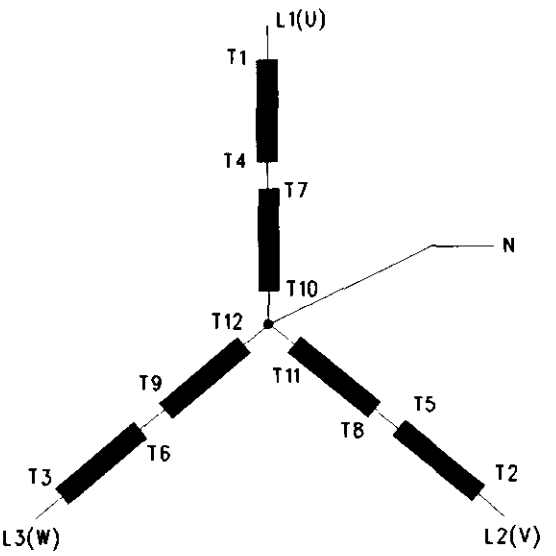


Illustration 23 g00952201

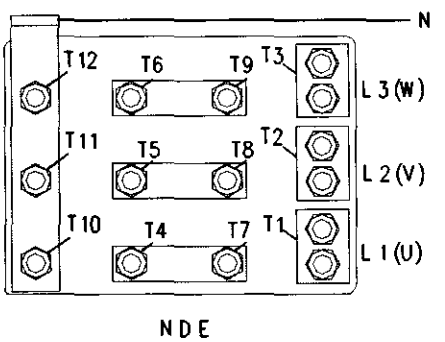


Illustration 24 g00996322

5000 12 wire factory connection for wiring code D

Table 3

L-L Voltage for Wiring Code D		
Winding	**50 Hz**	**60 Hz**
6	380-415	380-480

R448 voltage sensing – 0 => (T3) / 380V => (T2)

Table 4

L-L Voltage for Wiring Code D		
Winding	**50 Hz**	**60 Hz**
9	-	600

Winding 9 R448 voltage sensing and transformer – Request an available wiring diagram, if necessary.

5000/6100/7000 Six Wire Connection Diagrams

Wiring Code D for Three-Phase Configuration

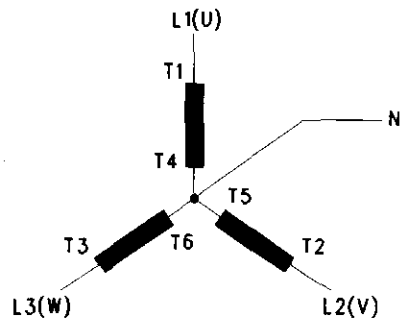


Illustration 25 g00996408

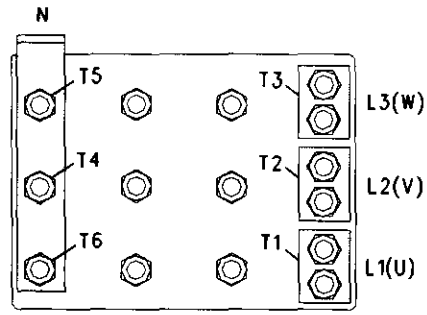


Illustration 26 g00996428

5000 6 wire factory connection for wiring code D

R448 voltage sensing – 0 => (T3) / 380V => (T2)

Table 5

L-L Voltage for Wiring Code D		
Winding	**50 Hz**	**60 Hz**
9S	-	600

Winding 9S R448 voltage sensing and transformer – Request an available wiring diagram, if necessary.

i01936055

Voltage Connections

SMCS Code: 4450

Three-Phase Voltage Connections

The Wye Configuration for a 480 V generator is given in the following diagrams.

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

Wye Configuration Diagrams

6 Lead Generators

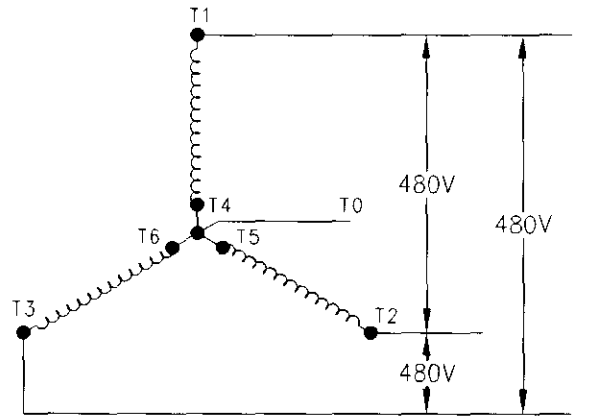


Illustration 27 g00626053

Typical Wye Configuration

12 Lead Generators

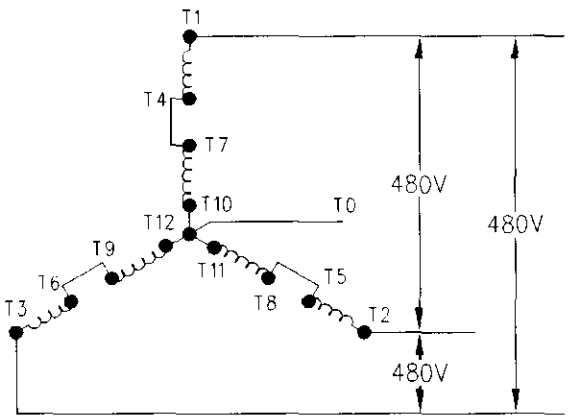


Illustration 28 g00637319

Typical Series Wye Configuration

This is a typical high voltage connection.

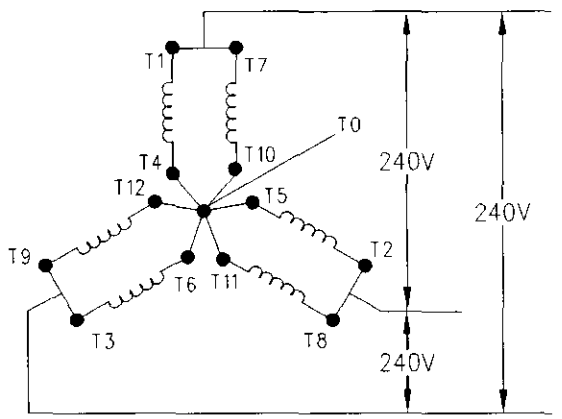


Illustration 29 g00637320

Typical Parallel Wye Configuration

This is a typical high voltage connection.

Single-Phase Current From a Three-Phase Generator

Three-phase current and single-phase current can be taken simultaneously from a generator that is connected for three-phase service. In the Wye Configuration, connect the load to the three-phase leads (any two of the three leads).

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

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

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

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

Wye Configuration Diagrams

6 Lead Generators

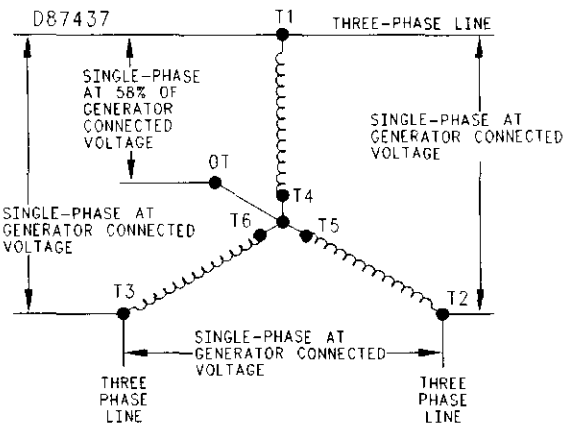


Illustration 30 g00626132

Single-Phase Wiring Diagram with 6 Lead Wye Configuration

12 Lead Generators

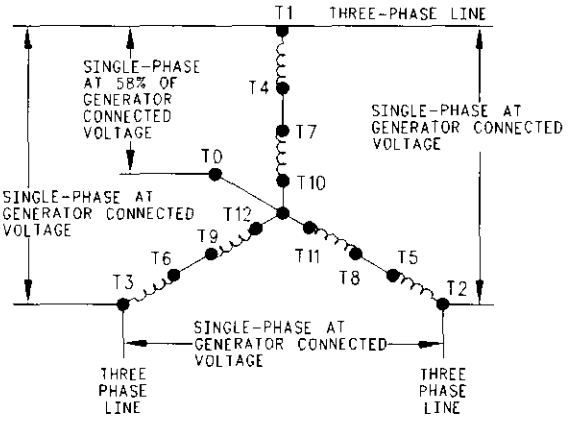


Illustration 31 g00637321

Single-Phase Wiring Diagram with 12 Lead Wye Configuration

Operation Section

Lifting and Storage

i02378610

Product Lifting

SMCS Code: 1000; 1404; 7002

NOTICE
Improper lifting or tiedowns can allow load to shift and can cause injury and damage.

Use a hoist to remove heavy components. Use an adjustable lifting beam, if necessary. Some removals require lifting fixtures in order to obtain proper balance and safety.

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

Illustration 32 g01034418
Label for lifting eye

Lifting labels are located on the lifting eyes and on the bottom of the genset. Lifting labels may be placed in other locations also. These labels designate the proper lifting locations for the genset and the weight that may be safely lifted from the location. Some gensets may be lifted at the base of the genset. Use the configuration that is on the lifting label in order to lift the generator set. Use lifting devices that are properly rated for the weight of the generator set.

On some enclosed generator sets, it may be necessary to remove a top panel of the enclosure in order to access the lifting eye.

Note: Never lift a generator set that has fuel on board by attaching a hoist to only one lifting point. Attach the hoist to all four lifting points.

A special lifting device is available for lifting the engine out of the genset. Consult your Caterpillar dealer for further information.

The following labels will be on the genset. Take care to review the weight limits before lifting the genset.

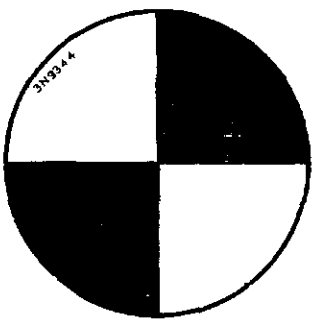


Illustration 33 g01187534
Label for the Center of Gravity

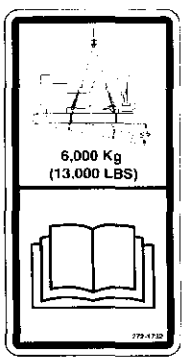


Illustration 34 g01187465

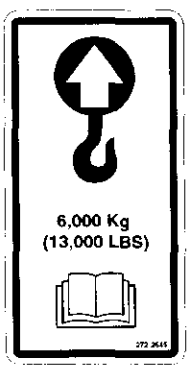


Illustration 35 g01187466

i02046791

Product Storage

SMCS Code: 1000; 1404; 7002

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

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

Installation

i02378611

Generator Installation

SMCS Code: 1000; 4450

Receiving Inspection

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

- Water condensation on cold surfaces
- Early failures due to wet windings
- Early failures due to wet insulating materials

Unpacking and Storage

Moving the Generator

⚠ WARNING

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

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

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

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

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

Storage

Short Time Storage

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

- Dust
- Dirt
- Moisture
- Other airborne abrasive material

Long Time Storage

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

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

Bearing Inspection

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

Location

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

- Clean

- Dry
- Well ventilated
- Easily accessible for inspection and maintenance

Access to the radiator filler cap is on the roof of the enclosure. There must be safe access to the roof of the enclosure. There must be sufficient clearance above the roof of the enclosure.

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.

Electrical Measurements

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

- Rapid changes in temperature
- Freezing
- Wet climate during shipment
- Wet climate during storage

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

Refer to this Operation and Maintenance Manual, "Rotating Rectifier - Test" in order to measure the following items:

- Exciter field (stator)
- Exciter armature (rotor)
- Generator field (rotor)
- Generator armature (stator)

Protective Devices

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

Features and Controls

i02376624

Electronic Modular Control Panel 3 (EMCP 3)

SMCS Code: 4490

Electronic Control Module (Generator Set)

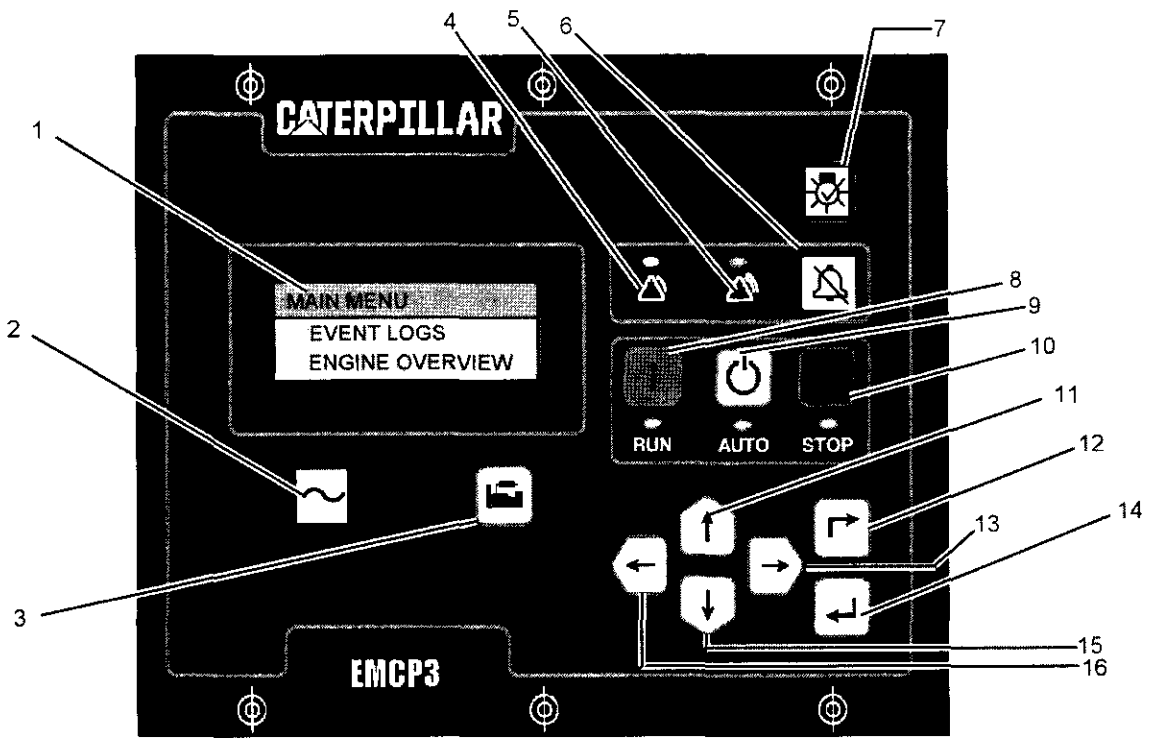


Illustration 36 g01045431

(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

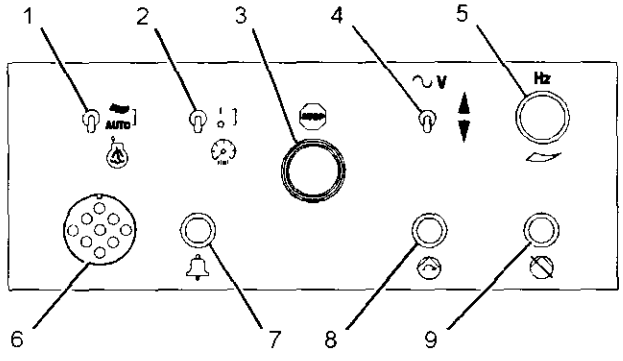


Illustration 37 g01185966

(1) Starting aid auto/manual switch (optional)
(2) Panel light switch
(3) Emergency stop push button
(4) Voltage adjust switch
(5) Speed potentiometer (optional)
(6) Customer connection
(7) Horn
(8) Pump run switch (if equipped)
(9) Pump stop switch (if equipped)

Starting Aid Auto/Manual Switch (1) – 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.

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

Emergency Stop Push Button (3) – 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.

Voltage Adjust Switch (4) – This switch can be used to raise the voltage. The switch can also be used to lower the voltage.

Speed Potentiometer (5) – The speed potentiometer is optional. The speed potentiometer can be used with the generator set that has an electronic governor.

Customer Connection (6) – The customer connection is a 9-pin connector for connecting the Caterpillar Electronic Technician.

Horn (7) – The horn provides an audible alarm.

Pump Run Switch (if equipped)(8) – Under normal circumstances, the fuel transfer process is automatic. In some instances, a manual operation may be required. Press the pump run switch once in order to manually start the pump.

Pump Stop Switch (if equipped)(9) – The pump stop switch is a push button switch that locks into position. The pump stop switch will stop the pump if the switch is locked into position. Releasing the switch will place the pump back into the run mode.

Annunciator Module

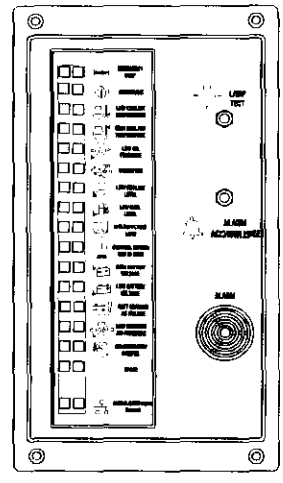


Illustration 38 g01101388

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".

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Sensors and Electrical Components

SMCS Code: 1900; 7400

Sensor Locations

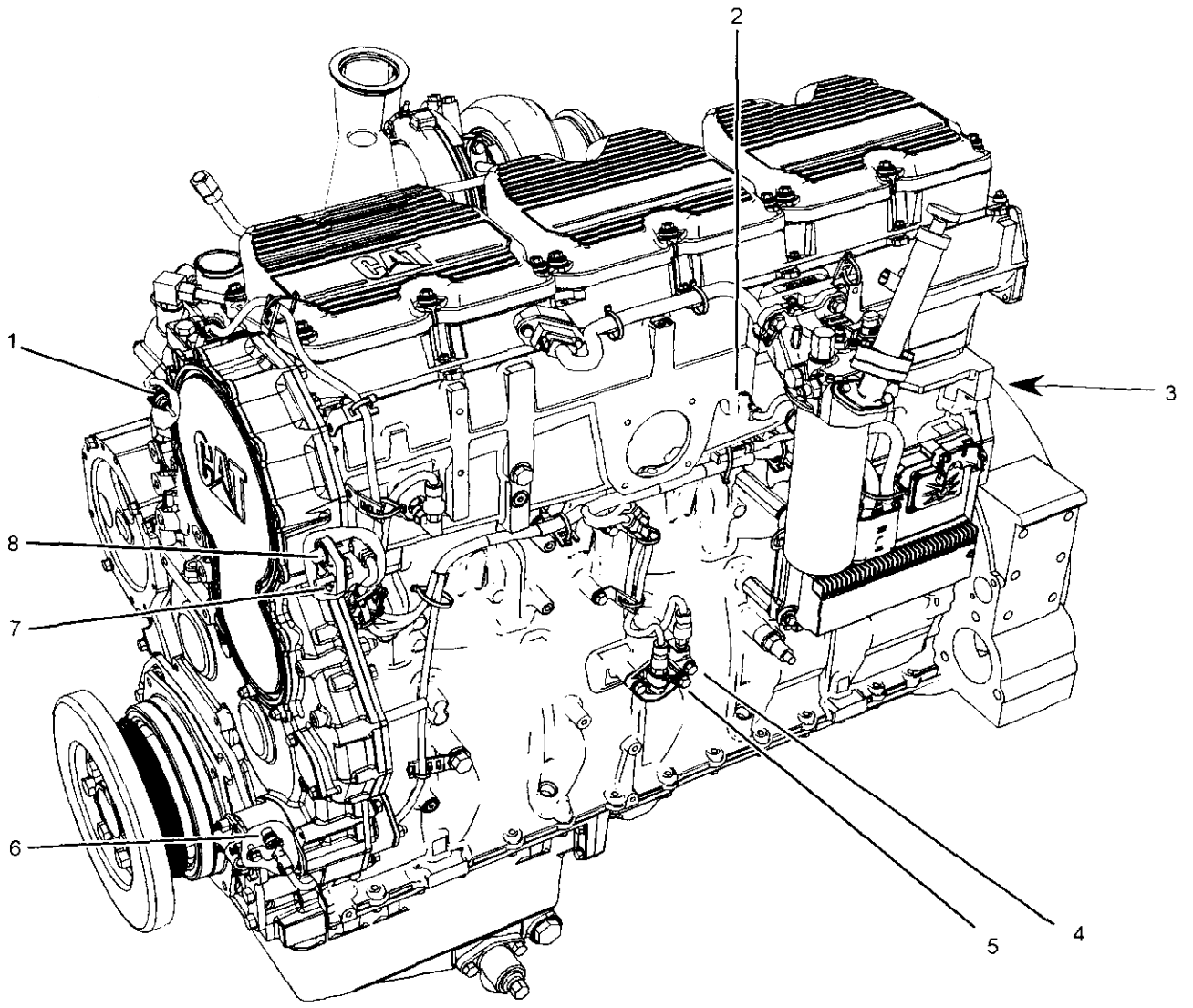

Illustration 39 g01184000

(1) Coolant Temperature Sensor

(2) Temperature Sensor for the Air Intake Manifold

(3) Magnetic Pickup (RH Side of Flywheel Housing)

(4) Oil Pressure Sensor

(5) Atmospheric Pressure Sensor

(6) Primary Speed/Timing Sensor

(7) Secondary Speed/Timing Sensor

(8) Air Inlet Manifold Pressure Sensor

Failure of Sensors

All Sensors

A failure of any of the sensors may be caused by one of the following malfunctions:

- Sensor output is open.
- Sensor output is shorted to "- battery" or "+ battery".
- Measured reading of the sensor is out of specification.

Inlet Air Temperature Sensor

Inlet air temperature sensor (2) measures the temperature of the inlet air. The Electronic Control Module (ECM) monitors the signal of the inlet air temperature sensor. The output of the ECM can indicate high inlet air temperature through a relay or a lamp. The inlet air temperature sensor will not cause a shutdown of the engine or any horsepower change.

Engine Speed/Timing Sensors

If the ECM does not receive a signal from the primary speed/timing sensor, the "DIAGNOSTIC" lamp will indicate a diagnostic fault code which will be logged in the ECM memory.

If the ECM does not receive a signal from the primary speed/timing sensor, the ECM will read the signal from the secondary speed/timing sensor. The ECM continually checks in order to determine if there is a signal from both sensors (6 and 7). If either sensor fails, the faulty sensor should be replaced.

Intermittent failure of the sensors will cause erratic engine control.

Coolant Temperature Sensor

Coolant temperature sensor (1) monitors engine coolant temperature. This feature is used for the engine system diagnostics with an output from the ECM. The output of the ECM can indicate a high coolant temperature through a relay or a lamp.

Failure of the Coolant Temperature Sensor

The ECM will detect a failure of the coolant temperature sensor. The diagnostic lamp will warn the operator about the status of the coolant temperature sensor. Strategies that are related to the coolant temperature sensor will be disabled if a failure occurs. A failure of the coolant temperature sensor will not cause a shutdown of the engine or any horsepower change.

i02374454

Engine Shutoffs and Engine Alarms

SMCS Code: 1900; 7400; 7418

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

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

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

Become familiar with the following information:

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

i02372101

Overspeed

SMCS Code: 1900; 1907; 1912; 7427

Serious damage to the engine and to the driven components may result during engine overspeed. Engine overspeed protection is a safety feature that will take the necessary measures in order to initiate an engine shutdown in the event of an engine overspeed condition.

This generator set application is equipped with an EMCP 3 that is used to provide engine control. The EMCP 3 will perform the engine monitoring and protection functions for the engine. The control panel uses separate engine speed sensors that are located in the flywheel housing.

The following engine protection is available for engine overspeed:

SHUTDOWN – The only engine monitoring mode that is available for this application is the "SHUTDOWN" mode. An engine overspeed condition will initiate an engine shutdown when the EMCP 3 is programmed to "SHUTDOWN". The generator control will instruct the ECM to stop fuel injection to the cylinders during an engine overspeed condition. This generator set may be equipped with an emergency air shutoff. If the air shutoff is available, the generator control will also activate the air shutoff solenoid. The air shutoff solenoid must be reset by cycling power to the EMCP 3 before the engine is restarted.

The above mode of operation is available at various engine speed setpoints.

i01324368

Cold Start Strategy

SMCS Code: 1450; 1456; 1900

The cold start strategy utilizes the input from the coolant temperature sensor to improve starting in low temperatures. The cold start strategy helps to provide the following features:

- Quicker cold starts
- White smoke cleanup
- Decreased deep cycling of the battery
- Extended engine life

When the coolant temperature is below 18 °C (64 °F), the cold start strategy is activated. The cold start strategy deactivates under any of the following conditions:

- The coolant temperature reaches 49 °C (120 °F).
- The engine has run for 20 minutes.

i01109785

Engine Speed Governing

SMCS Code: 1900; 1901; 1907; 1912

The engine speed governor monitors the engine speed control and the actual engine speed in order to help control the following items:

- Constant engine speed
- Adjustable speed droop
- Torque output
- Governor overshoot

The engine speed governor also conditions the individual injector signals. This helps to eliminate smoke emissions and this also provides optimum fuel economy.

The Electronic Control Module (ECM) is able to provide the engine speed governing by controlling injection signal duration. The ECM receives an engine speed setting from the speed control unit. This signal is used to calculate the desired engine speed.

i02424081

Voltage Regulators

SMCS Code: 4467

⚠ 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.**
- **Remove all fuses.**
- **Make sure the generator engine is stopped.**
- **Make sure all batteries are disconnected.**
- **Make sure all capacitors are discharged.**

Failure to do so could result in personal injury or death. Make sure residual voltage in the rotor, stator and the generator is discharged.

⚠ WARNING

Accidental engine starting can cause injury or death to personnel working on the equipment.

To avoid accidental engine starting, disconnect the battery cable from the negative (−) battery terminal. Completely tape all metal surfaces of the disconnected battery cable end in order to prevent contact with other metal surfaces which could activate the engine electrical system.

Place a Do Not Operate tag at the Start/Stop switch location to inform personnel that the equipment is being worked on.

For generators with Auxiliary Winding Regulation Excitation Principle (AREP), the voltage regulator is powered by two auxiliary windings. These windings are independent from the circuit for detection of voltage. The first winding is labelled as "X1" and "X2". This winding has a voltage that is proportional with the output voltage of the generator. The second winding is labelled as "Z1" and "Z2". This winding has a voltage that is proportional to the current of the stator. The voltage from the power supply is rectified and filtered before being used by the regulator monitoring transistor. This principle ensures that regulation is not affected by interference that is generated by the load.

For generators with PMG excitation, a permanent magnet generator is added to the generator at the rear of the generator. The PMG supplies the voltage regulator with a voltage that is independent of the main generator winding. The generator has a short circuit capability of 3 X In for 10 seconds. The generator also has good immunity to distortion from the generator load.

The voltage regulator monitors the output voltage and the voltage regulator corrects the output voltage of the generator by adjusting the excitation current.

Table 6

Sustained short circuit capacity (AREP and PMG)	3 x In for 10 seconds
Standard power supply (AREP)	Two auxiliary windings
Supply for shunt	max 150 VAC at 50/60 Hz
Rated overload current	10 amperes for 10 seconds
Electronic protection for overload and loss of voltage sensing	Excitation ceiling current for 10 seconds and return to approximately 1 ampere **THE GENERATOR MUST BE STOPPED IN ORDER TO RESET THE PROTECTION.**
Fuse "F1" on input side	"X1" and "X2"
Voltage sensing	5 VAC that is isolated by the transformer
Terminals for 0 and 110 VAC	95 to 140 VAC
Terminals for 0 and 220 VAC	170 to 260 VAC
Terminals for 0 and 380 VAC	340 to 520 VAC
Voltage regulation	±0.5%
Rapid response time or normal response time from the location of jumper "ST2"	
Voltage adjustment via potentiometer "P2"	
Quadrature droop adjustment via potentiometer "P1"	
Maximum adjustment for excitation via potentiometer "P5" (4 to 10 amperes)	
50 or 60 Hz selection with jumper "ST3"(1).	

(1) The engine speed setting must be changed in order to change the frequency of the generator set.

These voltage regulators may have an optional remote potentiometer for voltage adjustment. This potentiometer is 420 ohms 3 W minimum. The adjustment range is 5%. The voltage range is limited by the internal potentiometer "P2". Remove "ST4" in order to connect the potentiometer. A 1000 ohm potentiometer can also be used to extend the adjustment range.

R448 Adjustments

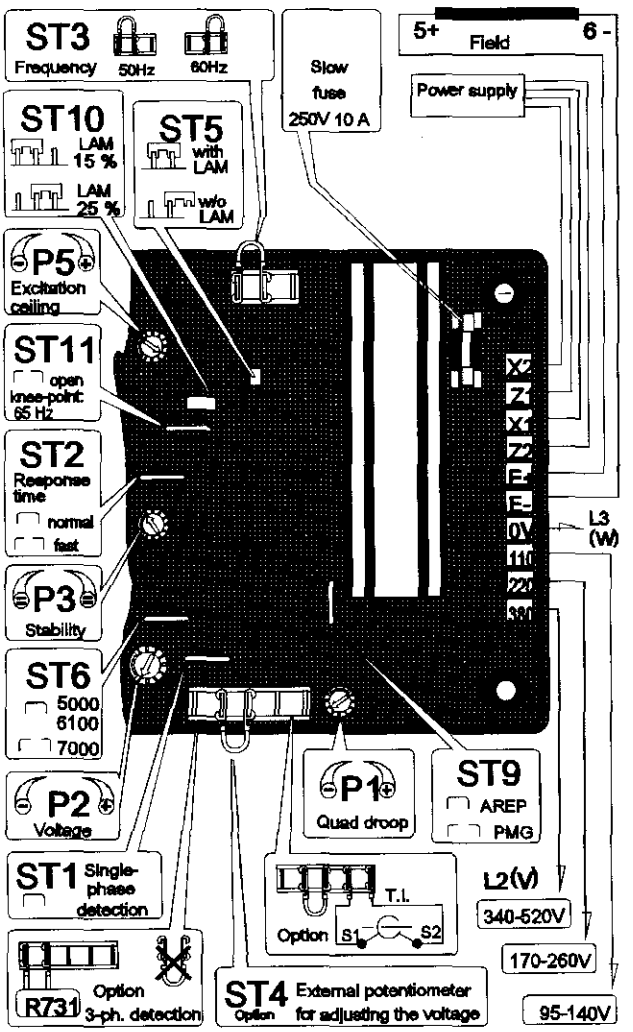

Illustration 40
R448 Voltage Regulator

g01212000

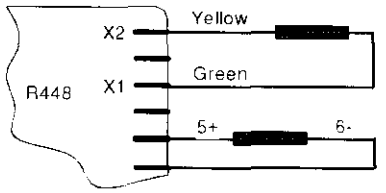

Illustration 41 g00995942

Connections for shunt excitation

6 wires

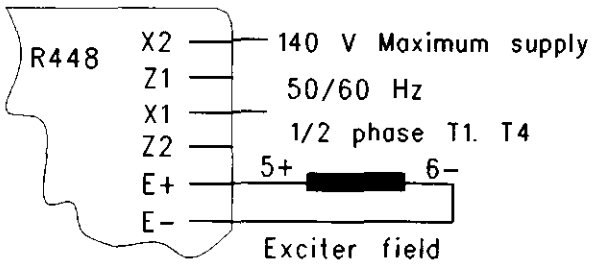

Illustration 42 g00995949

Connections for shunt excitation

12 wires

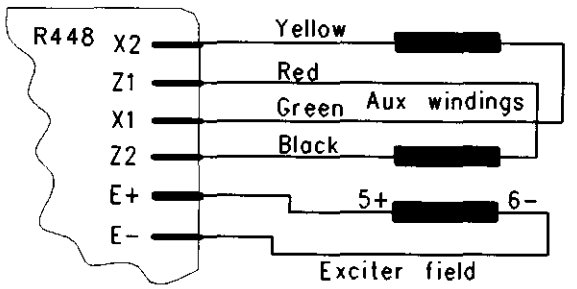

Illustration 43 g00995995

Connections for AREP excitation

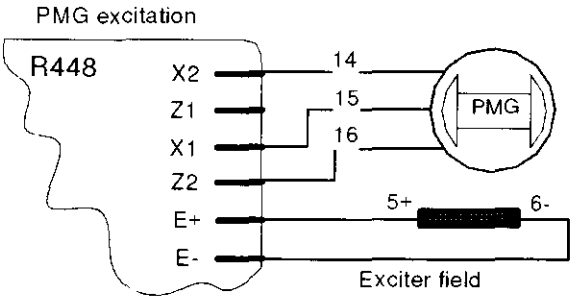

Illustration 44 g00996011

Connections for PMG excitation

Use the following procedure to adjust the R448 voltage regulator.

Use the following procedure in order to run the generator set in parallel operation.

Adjustments for Stand-alone Generators

1. Turn the remote adjustment potentiometer to the center position, if equipped.
2. Connect an analog voltmeter that is calibrated for 50 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 potentiometer (P2) to a full counterclockwise position.
6. Turn stability potentiometer (P3) counterclockwise to about 1/3 of the total rotation for the potentiometer.
7. Start the engine and set the engine speed to a frequency of 48 Hz for 50 Hz or 58 Hz for 60 Hz.

8. 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.

9. Check the operation of the Load Adjustment Module (LAM). ST5 must be closed. The LAM can be adjusted to 15% or 25% voltage dip by moving the ST10 jumper wire.

Adjustments for Generators in Parallel Operation

Note: Make sure that the speed droop is identical for all of the engines before adjustments are made to the generator.

1. Preset the unit for parallel operation by connecting the current transformer to S1 and S2 of the connector J2. Set potentiometer P1 for quadrature droop in the center position. Apply the rated load. The voltage should drop for 2% to 3%. Switch the positions of the two incoming secondary wires of the current transformer if the voltage increases.

2. The no-load voltages should be identical for all the generators that are operating in parallel. Connect the generators in parallel. Try to obtain a 0 kW power exchange by adjusting the speed of the generator. Try to minimize the circulating currents between generators by altering the voltage setting with potentiometer P2 or Rhe on one of the generators.

Note: Do not change the voltage settings after this step.

3. Apply the available load. The setting is correct only if a reactive load is available. Equalize the Kilowatts or divide the rated power of the units proportionally by altering the speed. Alter the quadrature droop potentiometer (P1) in order to equalize the currents or divide the currents.

R448 Adjustment for Maximum Excitation

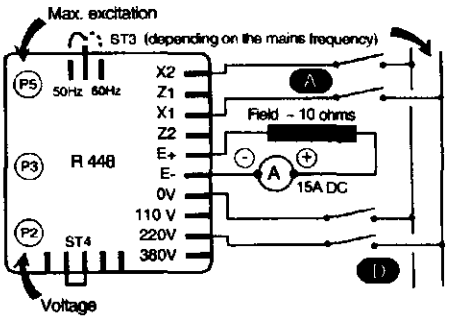

Illustration 45 g01212297

The maximum factory setting corresponds to an excitation current that is required to obtain a three-phase short circuit current of 3 X IN at 50 Hz for industrial power, unless this is specified otherwise.

The maximum level of excitation may be reduced by a static method. The static method is safer for the generator and the installation. Use the following steps to reduce the maximum excitation level.

1. Disconnect the power supply wires X1, X2, Z1 and Z2.

2. Disconnect sensing leads 0V, 110V, 220V and 380V on the generator.

3. Connect the main power supply 200V-240V to X1 and X2, as shown.

4. Install a 20 Amp DC ammeter in series with the exciter field.

5. Turn potentiometer P5 to a full counterclockwise position and activate the power supply. If there is no output current from the voltage regulator, turn potentiometer P2 clockwise until the ammeter indicates a stable current.

6. Switch off the power supply. Switch on the power supply. Turn potentiometer P5 until the required maximum current is obtained. The maximum current must not be greater than 15 Amperes.

Use the following steps in order to check the internal protection.

1. Open switch D. The excitation current should increase up to the preset maximum value and the excitation current should remain at the preset maximum value for approximately 10 seconds. The current will decrease to less than 1 Amp.

2. Open switch A in order to reset the internal protection.

Note: The voltage must be adjusted after the maximum excitation current has been set.

Special Use

De-energizing the Field

NOTICE
Damage will occur to the voltage regulator if the excitation current E+ and E- are left open when the generator set is operating.

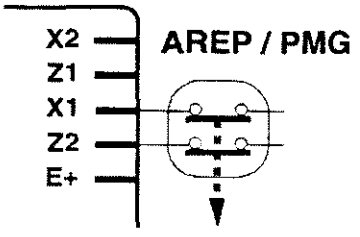

Illustration 46 g00952821

The exciter is switched off by disconnecting the power supply to the voltage regulator. The rating of the switch contacts should be at least 16A - 250 VAC. The connection is identical for resetting the internal protection for the voltage regulator.

Forcing the Field

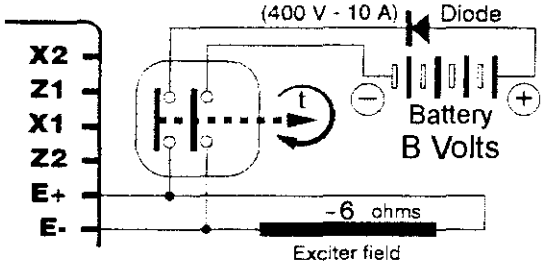

Illustration 47 g01212159

Use a 12 VDC power source in order to energize the field, if necessary. Refer to the following table.

Table 7

Applications	B Volts	Time
Voltage build up	6 (1A)	1 - 2 seconds
De-energized parallel operation	6 (1A)	1 - 2 seconds
Standby parallel operation	12 (2A)	5 - 10 seconds
Frequency starting	24 (4A)	5 - 10 seconds
Voltage that is sustained at overload	24 (4A)	5 - 10 seconds

Engine Diagnostics

i02326708

Self-Diagnostics (If Equipped with EMCP 3)

SMCS Code: 1000; 1900; 1901; 1902

The Electronic Control Module (ECM) has the ability to diagnose many different fault conditions that are associated with the electronic components that are found on the engine. Each electronic component is represented by a Suspect Parameter Number (SPN). Each diagnostic fault condition is represented by a Failure Mode Identifier (FMI). The two identifiers are combined in order to form a SPN-FMI description. This description is called a diagnostic code. When a problem occurs within the engine electronics, the diagnostic code is used to pass diagnostic information to the operator.

As a diagnostic fault condition occurs, the ECM sends the SPN-FMI to the Generator Set Control+ (GSC+). The GSC+ communicates the diagnostic information to the operator. All of the possible diagnostic fault codes for this engine and the fault code descriptions are listed below:

Table 8

Diagnostic Codes		Diagnostic Code Description
SPN	FMI	Description
38	0	External Tank High Fuel Level Shutdown
38	1	External Tank Low Fuel Level Shutdown
38	3	External Tank Fuel Level Sensor Short High
38	4	External Tank Fuel Level Sensor Short Low
38	15	External Tank High Fuel Level Warning
38	17	External Tank Low Fuel Level Warning
82	0	High Starting Air Pressure Shutdown
82	1	Low Starting Air Pressure Shutdown
82	3	Starting Air Pressure Sensor Short High
82	4	Starting Air Pressure Sensor Short Low
82	15	High Starting Air Pressure Warning
82	17	Low Starting Air Pressure Warning
95	0	High Fuel Filter Differential Pressure Shutdown
95	1	Low Fuel Filter Differential Pressure Shutdown

(continued)

(Table 8, contd)

Diagnostic Codes		Diagnostic Code Description
SPN	FMI	Description
95	3	Fuel Filter Differential Pressure Sensor Short High
95	4	Fuel Filter Differential Pressure Sensor Short Low
95	15	High Fuel Filter Differential Pressure Warning
95	17	Low Fuel Filter Differential Pressure Warning
96	0	High Fuel Level Shutdown
96	1	Low Fuel Level Shutdown
96	3	Fuel Level Sensor Short High
96	4	Fuel Level Sensor Short Low
96	15	High Fuel Level Warning
96	17	Low Fuel Level Warning
98	0	High Engine Oil Level Shutdown
98	1	Low Engine Oil Level Shutdown
98	3	Engine Oil Level Sensor Short High
98	4	Engine Oil Level Sensor Short Low
98	15	High Engine Oil Level Warning
98	17	Low Engine Oil Level Warning
99	0	High Oil Filter Differential Pressure Shutdown
99	1	Low Oil Filter Differential Pressure Shutdown
99	3	Oil Filter Differential Pressure Sensor Short High
99	4	Oil Filter Differential Pressure Sensor Short Low
99	15	High Oil Filter Differential Pressure Warning
99	17	Low Oil Filter Differential Pressure Warning
100	1	Low Engine Oil Pressure Shutdown
100	17	Low Engine Oil Pressure Warning
107	0	High Air Filter Differential Pressure Shutdown
107	1	Low Air Filter Differential Pressure Shutdown
107	3	Air Filter Differential Pressure Sensor Short High
107	4	Air Filter Differential Pressure Sensor Short Low

(continued)

(Table 8, contd)

Diagnostic Codes		Diagnostic Code Description
SPN	FMI	Description
107	15	High Air Filter Differential Pressure Warning
107	17	Low Air Filter Differential Pressure Warning
110	0	High Engine Coolant Temperature Shutdown
110	15	High Engine Coolant Temperature Warning
110	17	Low Engine Coolant Temperature Warning
111	0	High Engine Coolant Level Shutdown
111	1	Low Engine Coolant Level Shutdown
111	3	Engine Coolant Level Sensor Short High
111	4	Engine Coolant Level Sensor Short Low
111	15	High Engine Coolant Level Warning
111	17	Low Engine Coolant Level Warning
137	0	High Fire Extinguisher Pressure Shutdown
137	1	Low Fire Extinguisher Pressure Shutdown
137	3	Fire Extinguisher Pressure Sensor Short High
137	4	Fire Extinguisher Pressure Sensor Short Low
137	15	High Fire Extinguisher Pressure Warning
137	17	Low Fire Extinguisher Pressure Warning
167	17	Low Battery Charging System Voltage Warning
168	0	High Battery Voltage Shutdown
168	15	High Battery Voltage Warning
168	17	Low Battery Voltage Warning
171	0	High Ambient Air Temperature Shutdown
171	1	Low Ambient Air Temperature Shutdown
171	3	Ambient Air Temperature Sensor Short High
171	4	Ambient Air Temperature Sensor Short Low
171	15	High Ambient Air Temperature Warning
171	17	Low Ambient Air Temperature Warning
173	0	High Exhaust Temperature Shutdown
173	1	Low Exhaust Temperature Shutdown

(continued)

(Table 8, contd)

Diagnostic Codes		Diagnostic Code Description
SPN	FMI	Description
173	3	Exhaust Temperature Sensor Short High
173	4	Exhaust Temperature Sensor Short Low
173	15	High Exhaust Temperature Warning
173	17	Low Exhaust Temperature Warning
175	0	High Engine Oil Temperature Shutdown
175	1	Low Engine Oil Temperature Shutdown
175	3	Engine Oil Temperature Sensor Short High
175	4	Engine Oil Temperature Sensor Short Low
175	15	High Engine Oil Temperature Warning
175	17	Low Engine Oil Temperature Warning
190	0	Engine Over Speed Shutdown
190	1	Engine Under Speed Shutdown
190	2	Engine Speed Sensor Erratic or Not Present
190	5	Engine Speed Sensor Open
190	17	Engine Under Speed Warning
625	11	SCADA Data Link Fault
639	11	Primary Data Link Fault
701	0	Custom Event #1 High Shutdown
701	1	Custom Event #1 Low Shutdown
701	15	Custom Event #1 High Warning
701	17	Custom Event #1 Low Warning
701	31	Custom Event #1 Status
702	0	Custom Event #2 High Shutdown
702	1	Custom Event #2 Low Shutdown
702	15	Custom Event #2 High Warning
702	17	Custom Event #2 Low Warning
702	31	Custom Event #2 Status
703	0	Custom Event #3 High Shutdown
703	1	Custom Event #3 Low Shutdown
703	15	Custom Event #3 High Warning
703	17	Custom Event #3 Low Warning
703	31	Custom Event #3 Status
704	0	Custom Event #4 High Shutdown
704	1	Custom Event #4 Low Shutdown
704	15	Custom Event #4 High Warning

(continued)

(Table 8, contd)

Diagnostic Codes		Diagnostic Code Description
SPN	FMI	Description
704	17	Custom Event #4 Low Warning
704	31	Custom Event #4 Status
705	0	Custom Event #5 High Shutdown
705	1	Custom Event #5 Low Shutdown
705	15	Custom Event #5 High Warning
705	17	Custom Event #5 Low Warning
705	31	Custom Event #5 Status
706	0	Custom Event #6 High Shutdown
706	1	Custom Event #6 Low Shutdown
706	15	Custom Event #6 High Warning
706	17	Custom Event #6 Low Warning
706	31	Custom Event #6 Status
924	3	Digital Output #1 Short High
925	3	Digital Output #2 Short High
970	31	Emergency Stop Shutdown
1122	0	High Generator Bearing #1 Temperature Shutdown
1122	1	Low Generator Rear Bearing Temperature Shutdown
1122	3	Generator Rear Bearing Temperature Sensor Short High
1122	4	Generator Rear Bearing Temperature Sensor Short Low
1122	15	High Rear Generator Bearing Temperature Warning
1122	17	Low Generator Rear Bearing Temperature Warning
1231	11	Accessory Data Link Fault
1239	31	Fuel Tank Leak (Fuel Rupture Basin)
1664	31	Engine Failure to Start Shutdown
2433	0	High Right Exhaust Temperature Shutdown
2433	1	Low Right Exhaust Temperature Shutdown
2433	3	Right Exhaust Temperature Sensor Short High
2433	4	Right Exhaust Temperature Sensor Short Low
2433	15	High Right Exhaust Temperature Warning
2433	17	Low Right Exhaust Temperature Warning

(continued)

(Table 8, contd)

Diagnostic Codes		Diagnostic Code Description
SPN	FMI	Description
2434	0	High Left Exhaust Temperature Shutdown
2434	1	Low Left Exhaust Temperature Shutdown
2434	3	Left Exhaust Temperature Sensor Short High
2434	4	Left Exhaust Temperature Sensor Short Low
2434	15	High Left Exhaust Temperature Warning
2434	17	Low Left Exhaust Temperature Warning
2436	0	Generator Over Frequency Shutdown
2436	1	Generator Under Frequency Shutdown
2436	2	Engine Speed-Generator Output Frequency Mismatch Warning
2436	12	Generator Output Sensing System Failure
2436	15	Generator Over Frequency Warning
2436	17	Generator Under Frequency Warning
2440	0	Generator Over Voltage Shutdown
2440	1	Generator Under Voltage Shutdown
2440	15	Generator Over Voltage Warning
2440	17	Generator Under Voltage Warning
2448	0	Generator Over Current Shutdown
2448	15	Generator Over Current Warning
2452	1	Generator Reverse Power Shutdown
2452	17	Generator Reverse Power Warning
2648	31	Service Maintenance Interval Warning
4000	31	Air Damper Closed
4001	31	ATS in Normal Position
4002	31	ATS in Emergency Position
4003	31	Battery Charger Failure
4004	31	Generator Circuit Breaker Closed
4005	31	Utility Circuit Breaker Closed
4006	31	Engine in Cooldown
4007	31	Generator Control Not in Automatic Warning
4008	31	Unexpected Engine Shutdown

i01463504

Fault Logging

SMCS Code: 1000; 1900; 1901; 1902

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates an active diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged in the memory of the ECM can be retrieved with Caterpillar electronic service tools. The codes that have been logged can be cleared with Caterpillar electronic service tools. The codes that have been logged in the memory of the ECM will be automatically cleared from the memory after 100 hours. The following faults can not be cleared from the memory of the ECM without using a factory password: overspeed, low engine oil pressure, and high engine coolant temperature.

i01147116

Engine Operation with Active Diagnostic Codes

SMCS Code: 1000; 1900; 1901; 1902

Each circuit component in the engine electronics system is monitored by the Electronic Control Module (ECM) for abnormal operation. The ECM is capable of recognizing several abnormal conditions and selecting an appropriate reaction.

When an abnormal condition is recognized by the ECM, an ACTIVE Diagnostic Code is generated. The ECM will first communicate the condition to the operator. This communication may include lighting a diagnostic lamp or displaying the diagnostic condition on a display panel.

The reaction of the ECM to an ACTIVE diagnostic code will seldom affect more than engine performance. Much of the data that is received from the circuit components by the ECM is used in order to control engine function. If a component that provides this type of data has an ACTIVE diagnostic condition, the data cannot be used. If a diagnostic code becomes ACTIVE, the ECM will flag suspect data as "INVALID DATA". A default value that has been predetermined will be used for the engine control that is associated with that component. The operation of the subsystem will continue, and the engine will continue to run. However, loss of an electronic component that causes an ACTIVE diagnostic code may cause an engine shutdown.

ACTIVE diagnostic codes can indicate problems that are as minor as a loose connection. ACTIVE diagnostic codes can also indicate larger problems that may be associated with the deterioration of a component. Any condition that causes an ACTIVE diagnostic code should be investigated immediately. If an ACTIVE diagnostic code is present during normal engine operation, the engine should be serviced immediately by a qualified technician.

i01154195

Engine Operation with Intermittent Diagnostic Codes

SMCS Code: 1000; 1900; 1901; 1902

The Electronic Control Module (ECM) is capable of detecting abnormal operation of the electronic components that are found on the engine. The ECM generates an ACTIVE diagnostic code when an abnormal condition is detected. The condition is also logged in ECM memory. The logged information that is stored in ECM memory is called a LOGGED diagnostic code. This information may be useful to the technician for troubleshooting the problem. A diagnostic code is considered to be intermittent when the condition is logged in ECM memory and the condition is not currently active.

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the codes and the operator should reference the appropriate information in order to identify the nature of the event. Take note of the following characteristics of engine performance:

- Low power
- Engine rpm limits
- Excessive smoke, etc

This information can be useful to help troubleshoot the situation. If the nature of the problem persists, a qualified service technician should be consulted. For more information on diagnostic codes, refer to the Troubleshooting Guide for this engine.

Engine Starting

i02354640

Before Starting Engine

SMCS Code: 1000; 1400; 1450

Perform the required daily maintenance and other periodic maintenance before the engine is started. Inspect the engine compartment. This inspection can help prevent major repairs at a later date.

- For the maximum service life of the engine, make a thorough inspection before starting the engine. Look for the following items: oil leaks, coolant leaks, loose bolts, and trash buildup. Remove trash buildup and arrange for repairs, as needed.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the alternator and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn wires or frayed wires.
- Check the fuel supply. Drain water from the water separator (if equipped). Open the fuel supply valve.

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

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

⚠ WARNING

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

- Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" warning tag or similar warning tag attached to the start switch or to the controls.
- Ensure that the areas around the rotating parts are clear.
- All of the guards must be put in place. Check for damaged guards or for missing guards. Repair any damaged guards. Replace damaged guards and/or missing guards.
- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor (if equipped) is engaged. Check electrical cables and check the battery for poor connections and for corrosion.
- Reset any of the shutoff components or alarm components.
- Check the engine lubrication oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the oil level gauge.
- Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level in the sight glass.
- Observe the air cleaner service indicator. Service the air cleaner when the red target locks in the visible position.
- Disengage any driven equipment. Remove any electrical loads.

i02363848

Starting the Engine (EMCP 3)

SMCS Code: 1000; 1450

⚠ WARNING

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

⚠ WARNING

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

Before manually starting the engine, perform all of the procedures that are described in this Operation and Maintenance Manual, "Before Starting Engine". Ensure that no one will be endangered before the engine is started and when the engine is started.

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

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

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.

1. Start the engine by one of these three methods.
   - The operator presses the "RUN" Key.
   - The control is in "AUTO" and the remote initiate contact (IC) becomes active.
   - The operator presses the "AUTO" Key and a start command is sent via the RS-485 SCADA Data Link.
2. The EMCP 3 checks the system before the crank cycle begins. The EMCP 3 checks that no system faults are present. The EMCP 3 checks that all previous shutdown faults have been reset. The EMCP 3 also checks that the engine is not already running. If the engine is equipped with prelube, the EMCP 3 checks the status of the prelube. If the prelube is not complete, the EMCP 3 will not crank the engine.
3. The EMCP 3 begins the crank cycle.
4. The EMCP 3 cranks the engine until the crank cycle time reaches the setpoint for total crank time or until the engine starts.
5. The EMCP 3 deactivates the starting motor relay (SMR) when the engine speed reaches the setpoint for crank terminate speed.

i02351727

Cold Weather Starting

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

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

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

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

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

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

Extra battery capacity may be necessary for very cold temperatures.

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

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

Starting With the Starting Aid Switch (If Equipped)

⚠ WARNING

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

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

NOTICE
Excessive starting fluid can cause piston and ring damage.

Use starting fluid for cold starting purposes only.

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

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

1. Perform the procedures that are described in this Operation and Maintenance Manual, "Before Starting Engine".
2. Press the "RUN" key.
3. Ether will automatically be injected if the following conditions are met:
   a. The Starting Aid switch is in the AUTOMATIC position.
   b. The jacket water coolant temperature is less than 0 °C (32 °F).
4. Additional injections may be necessary in order to start the engine. Additional injections may also be necessary in order to achieve low idle. If additional injections are necessary, toggle the Starting Aid switch to the MANUAL position. For additional injections, the jacket water coolant temperature must be less than 10 °C (50 °F).

Note: The Starting Aid switch is a momentary switch. To stop the injection, release the Starting Aid switch.

i02308903

Starting with Jump Start Cables

SMCS Code: 1000; 1401; 1402; 1900

⚠ WARNING

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

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

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

For information on troubleshooting the charging system, refer to Special Instruction, REHS0354, "Charging System Troubleshooting".

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

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

Do not reverse the battery cables. The alternator can be damaged. Attach ground cable last and remove first.

When using an external electrical source to start the engine, turn the generator set control switch to the "OFF" position. Turn all electrical accessories OFF before attaching the jump start cables.

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

1. Turn the start switch on the stalled engine to the OFF position. Turn off all accessories.
2. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.
3. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting combustible gases that are produced by some batteries.
4. Charge the batteries. The engine will not continue to run after starting if the batteries have not been charged.
5. Start the engine.
6. Immediately after the stalled engine is started, disconnect the jump start cables in reverse order.

Refer to the Electrical Schematic for your engine. Consult your Caterpillar dealer for more information.

i02369353

After Starting Engine

SMCS Code: 1000

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

Warm-up

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

Note: More warm-up time may be necessary when the ambient temperature is below −18 °C (0 °F).

2. Check all of the indicators during the warm-up period.

3. Make another walk-around inspection. Inspect the engine for fluid leaks and air leaks.

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

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

Engaging the Generator

1. Ensure that the indicators are in the normal ranges for the engine rpm.

2. Increase the engine rpm to rated rpm. Always increase the engine speed to rated rpm before applying the load.

3. Adjust the voltage and the frequency, if necessary.

4. Close the main circuit breaker in order to apply the load.

5. Continue to check the indicators and the generator.

Engine Operation

i01646252

Engine Operation

SMCS Code: 1000

Proper operation and maintenance are key factors in obtaining the maximum life and economy of the engine. If the directions in the Operation and Maintenance Manual are followed, costs can be minimized and engine service life can be maximized.

The time that is needed for the engine to reach normal operating temperature can be less than the time taken for a walk-around inspection of the engine.

The engine can be operated at the rated rpm after the engine is started and after the engine reaches operating temperature. The engine will reach normal operating temperature sooner during a low engine speed (rpm) and during a low power demand. This procedure is more effective than idling the engine at no load. The engine should reach operating temperature in a few minutes.

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

i02374396

Engine Warm-up

SMCS Code: 1000

1. Run the engine on light load for three to five minutes, or run the engine on light load until the jacket water coolant temperature starts to rise. More time may be necessary when the temperature is below −18° C (0° F).

2. Check all of the indicator led displays during the warm-up period.

3. Perform a walk-around inspection. Check the engine for fluid leaks and air leaks. The engine may be operated at full rated rpm and at full load when the engine oil temperature reaches 60° C (140° F).

i01878039

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 operation at no load.

Shut off the engine instead of operating the engine at no load for long periods of time.

- Observe the service indicator for the air cleaner frequently, if equipped. Keep the air cleaner elements clean.

- Maintain a good electrical system.

One bad 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. 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 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

i02237582

Emergency Stopping

SMCS Code: 1000; 7418

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

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

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

Emergency Stop Button

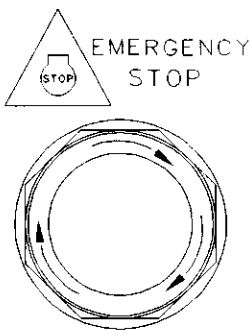

Illustration 48 g00104303

Typical emergency stop button

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

i02305026

Manual Stop Procedure

SMCS Code: 1000

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. Use one of the following methods to stop the engine:
   - Press the "STOP" Key.
   - Press the "AUTO" Key. A stop command will be sent via the RS-485 SCADA Data Link.
2. After receiving the engine stop signal, the EMCP 3 checks that there are no present system faults.
3. The EMCP 3 begins the cooldown period. In order to bypass the cooldown, the operator must hold down the "STOP" Key. "PRESS ENTER TO BYPASS" or "PRESS ENTER TO CONTINUE" will be shown on the display. Press the "ENTER" Key in order to bypass the cooldown sequence or press the "ESCAPE" Key in order to continue the cooldown sequence.

After the cooling cycle is completed, the EMCP 3 initiates an engine shutdown by turning off the fuel supply.

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

i02327953

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. Complete all of the lubrication recommendations that are listed in Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations".

- If necessary, perform minor adjustments. Repair any leaks and tighten loose bolts.

- Note the service hour meter reading. Perform the maintenance that is in the Operation and Maintenance Manual, "Maintenance Interval Schedule".

- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

Note: Only use the antifreeze coolant solutions that are recommended in Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations". Failure to follow the recommendations in Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" can cause engine damage.

- Allow the engine to cool. Check the coolant level. Maintain the cooling system at 13 mm (0.5 inch) from the bottom of the pipe for filling.

- If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. See Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations". Add the proper coolant/water mixture, if necessary.

Cold Weather Operation

i02237624

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250

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".

i01505157

Fuel Related Components in Cold Weather

SMCS Code: 1000; 1250

Fuel Tanks

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

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

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

Drain the water and sediment from any fuel storage tank at the following intervals:

- Weekly
- Oil changes
- Refueling of the fuel tank

This will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

Fuel Filters

NOTICE
Do not fill the fuel filters with fuel before installing them. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

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

These engines are equipped with a primary filter/water separator. The primary filter/water separator must use a 10 micron filter to a 15 micron filter. The filters are becoming more critical as fuel injection pressures increase to 209 MPa (30000 psi) and higher psi. For more information on priming the fuel system, see the Operation and Maintenance Manual, "Fuel System - Prime" topic (Maintenance Section).

Fuel Heaters

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

Select a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also help to prevent overheating of the fuel. High fuel temperatures reduce engine performance and the availability of engine power. Choose a fuel heater with a large heating surface. The fuel heater should be practical in size. Small heaters can be too hot due to the limited surface area.

Disconnect the fuel heater in warm weather.

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

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

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

Generator Operation

i02309602

Generator Operation

SMCS Code: 4450

Loading of the Generator

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

Allowable combinations of unbalanced loads are shown in Illustration 49. 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.

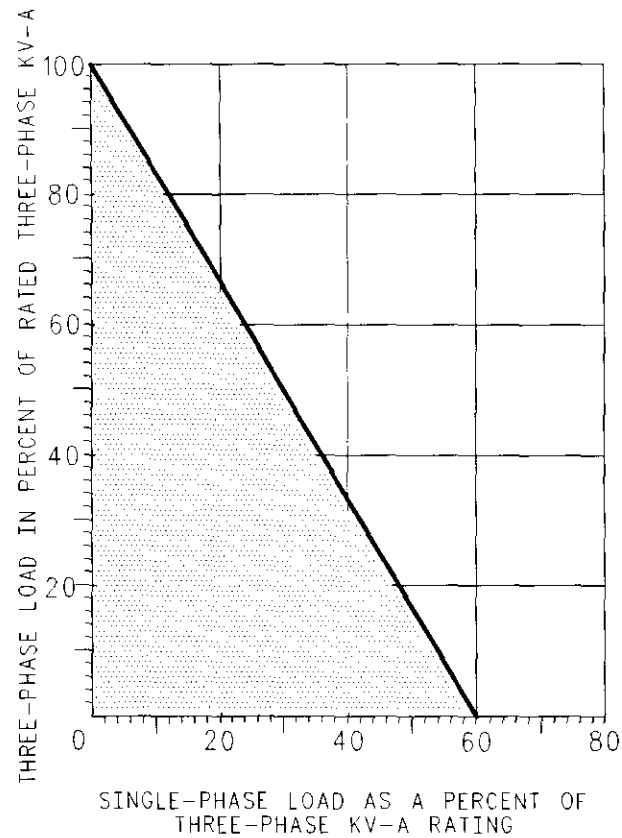

Illustration 49 g00627416

Allowable Combinations of Unbalanced Loads

Block Loading

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

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

- Engine transient response
- Voltage regulator response
- Type of the voltage regulator
- Altitude of operation of the generator set
- Type of load
- The amount of load that is already present

If a block load derating is required, refer to ISO 8528 Standards or SAE J1349 Standards. Also, reference Engine Data Sheet, LEKX4066, "Loading Transient Response" and Engine Data Sheet, LEKX4067, "Block and Transient Response".

Power Factor

Power factor (PF) determines the relationship between true power and apparent power. The true power is also known as the active power. The apparent power is also called kVA. The true power (kW) is the work that is done on the load by the engine. The true power determines the amount of power that is available for the load to do work. The apparent power (kVA) is the total power that is produced by the generator. Power factor can be calculated by using the following formula.

PF = kW / kVA,

kW – kilowatts

kVA – Kilo-Volt-Ampere

KVAR stands for Kilo-Volt-Ampere-Reactive, which is the unit of measurement for reactive power.

Note: The generator does NOT control power factor. Power factor is determined by the load.

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

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

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

Excitation Systems

Refer to the Operation and Maintenance Manual, "Voltage Regulators" for information on excitation systems.

Low Idle Adjustment

The low idle is typically 1200 rpm. On 60 Hz units, low idle will be approximately 66 percent of the full load speed. On 50 Hz units, low idle will be approximately 80 percent of full load speed.

The low idle is set at the factory on generator sets with mechanical governors. The low idle should only be adjusted by your Caterpillar dealer if adjustment is required.

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

Standby Generator Sets

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

Standby units will not change the governor speed control or voltage level settings automatically. The governor speed and voltage level must be preset for the proper operation of that unit. Whenever the set is operated manually, ensure that the governor speed and the voltage level settings are set correctly for automatic operation. Check all switches for the proper setting. The Engine Control 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 all climates. For more information on space heaters, refer to Maintenance Section, "Space Heater - Check".

Embedded Temperature Detectors

Some 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. RTDtemperature detectors are available. Contact your Caterpillar dealer for more information.

Bearing Temperature Detectors

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

i02424120

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 50 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 stability potentiometer (P3) counterclockwise to about 1/3 of the total rotation for the potentiometer.
7. Start the engine and set the engine speed to a frequency of 48 Hz for 50 Hz or 58 Hz for 60 Hz.
8. 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.
9. Check the LAM operation. ST5 must be closed.

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.

i02357669

Parallel Operation

SMCS Code: 4450; 4480

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.**

   Units that operate in parallel must have the same phase rotation. There are two methods that may be used in order to determine if the incoming unit and the unit that is on-line have the same phase rotation. These methods are listed below:

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

   Use the procedure below to determine the proper phase rotation by using three light bulbs.

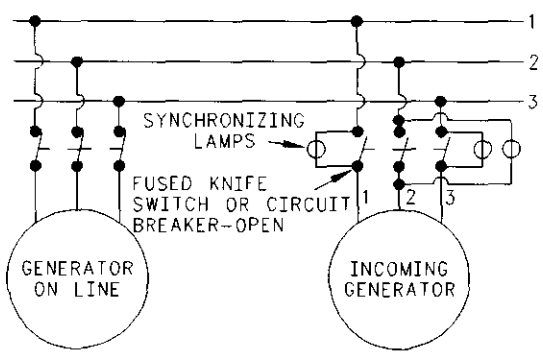

Illustration 50 g00695380

⚠ 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 that will be in operating in parallel. 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.

      - Both generators have the same phase rotation when the lights blink in unison. The first condition of "Initial Start-Up" has been met.

2. **Adjust the frequency.**

   The units that will be operating in parallel must operate at the same speed. Speed is proportional to the alternating current frequency.

   a. Allow each electric set to run under load for about 30 minutes.

   b. Adjust the governor control in order to give the rated frequency at full load.

   c. Remove the load and check the high idle speed. The high idle speed should be approximately 2 to 5 percent above full load speed for governors that are equipped with droop. If these speeds can not be obtained, contact your Caterpillar dealer.

   d. For the most consistent results, repeat 2.b and 2.c until the second condition of "Initial Start-Up" has been met.

3. **Adjust the voltage.**The potentiometers should be at the initial settings. **Refer to Operation and Maintenance Manual, "Voltage Regulators".**

Note: Make sure that the speed droop is identical for all of the engines before adjustments are made to the generator.

   a. Preset the unit for parallel operation by connecting the current transformer to S1 and S2 of the connector J2. Set potentiometer P1 for quadrature droop in the center position. Apply the rated load. The voltage should drop for 2% to 3%. Switch the positions of the two incoming secondary wires of the current transformer if the voltage increases.

   b. The no-load voltages should be identical for all the generators that are operating in parallel. Connect the generators in parallel. Try to obtain a 0 kW power exchange by adjusting the speed of the generator. Try to minimize the circulating currents between generators by altering the voltage setting with potentiometer P2 or Rhe on one of the generators.

Note: Do not change the voltage settings after this step.

   c. Apply the available load. The setting is correct only if a reactive load is available. Equalize the Kilowatts or divide the rated power of the units proportionally by altering the speed. Alter the quadrature droop potentiometer (P1) in order to equalize the currents or divide the currents.

Starting Multiple Units

Use the procedure for starting single units in order to start multiple units. Refer to Operation Section, "Single Unit Operation".

Paralleling Multiple Units

Units may be paralleled at no load. Units may also 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. This means that the frequency of the incoming unit will be the same frequency as 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 some of the load instead of adding to the system load.

4. By using the governor control, adjust the engine speed until the lights blink very slowly.
5. The lights are off when the voltages of the two units are in-phase. At this point, very quickly close the breaker while the lights are out.
6. Use governor controls in order to share kW load between engines.
7. Generator temperature will be stabilized in approximately one hour. After the generator temperature has been stabilized, adjust the voltage droop rheostat of each generator. This will share the reactive load and this will 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 the droop. Adjusting the voltage droop rheostat in a clockwise direction will increase droop.

Load Division and Speed Droop (If Equipped)

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

In order to transfer the load from one engine to another engine, use 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 the governor speed control or lower the governor speed control of both units in order to change system frequency.

Parallel Operation Of Governors

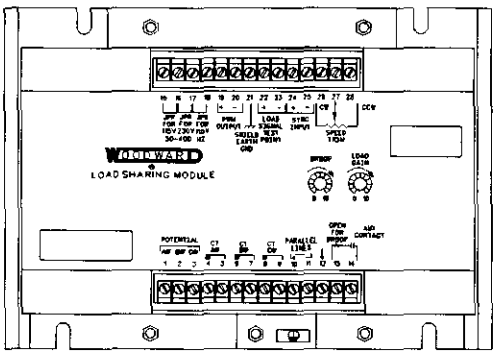

Illustration 51 g00630841

Load Sharing Module (Typical Example)

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

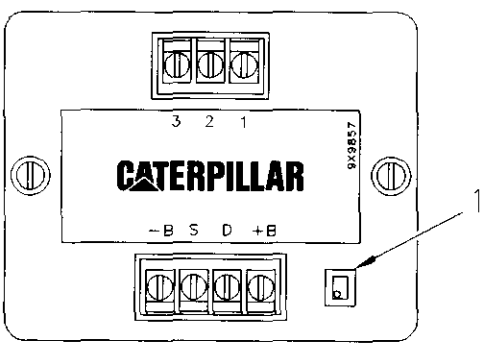

Illustration 52 g00637397

(1) Droop potentiometer

The Speed brick converter changes the analog signal of the speed potentiometer into a pulse width modulated signal. The engine electronic control can recognize this signal. The converter is mounted on the subpanel which is located within the control panel.

Function of The Engine Governor

This section describes the function of the engine governor in relation to load division between parallel electric sets.

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

1. The power which is supplied to the generator and to the load is a function of the engine. The setting of the engine governor and the position of the engine governor control determine the amount of power that is delivered by the engine. Therefore, the governor setting and the position of the governor control determine the kW load which is carried by the generator. A change in the engine power of any one of the units in a parallel operation will result in the same change in engine power for each of the other units in that parallel operation. In other words, the units that are in parallel operation will stay in parallel operation.

2. The division of power is not determined by generator excitation or terminal voltage. The excitation will determine the power factor for a generator when the generator is operating in parallel with other generators.

Governors that are used with Caterpillar powered electric sets can be of two types:

- Governors with fixed speed droop
- 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 the characteristics match closely with the characteristics of governors with fixed speed droop. If the governor is adjusted for 0 percent speed droop or isochronous operation, then the same speed from no load to full load can be obtained.

Summary on Governor Operation

The preceding discussion of governor operation can be summarized below:

- Each governor should have a three percent speed droop in order to provide the simplest combination of governors for electric sets that are connected in parallel. 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. Governor controls should be set to the high idle position so that the full range of the governor is available.

- Operating an isochronous governor in parallel with a speed droop governor requires special techniques.

- Any number of electric sets can be operated in parallel. However, only one governor of the group can be adjusted for isochronous operation. The exception will be some special cases of electronic governors with automatic load sharing.

Stopping

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

1. Check the load. The load must be less than the rated capacity of the remaining units.

2. Be sure that the neutral of one of the remaining units is grounded.

3. Remove the load from the outgoing unit. See the Parallel Operation, "Load Division - Speed Droop". The amperage may never go to zero due to circulating currents.

4. Open the circuit breaker.

5. Allow the engine to cool for five minutes.

6. Stop the engine.

Circulating Currents

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

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

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

Maintenance Section

Refill Capacities

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Refill Capacities and Recommendations

SMCS Code: 1348; 1395; 7560

Engine Oil

NOTICE
These recommendations are subject to change without notice. Contact your local Caterpillar dealer for the most up to date fluids recommendations.

Cat DEO (Diesel Engine Oil)

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

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

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

Cat DEO Multigrade is formulated with the correct amounts of detergents, dispersants, and alkalinity in order to provide superior performance in Caterpillar Diesel Engines.

Cat DEO Multigrade is available in various viscosity grades that include SAE 10W-30 and SAE 15W-40. To choose the correct viscosity grade for the ambient temperature, see Table 9. Multigrade oils provide the correct viscosity for a broad range of operating temperatures. Multigrade oils are also effective in maintaining low oil consumption and low levels of piston deposits.

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

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

Note: Cat DEO in SAE 15W-40 exceeds the performance requirements for the following API categories: CI-4, CH-4, CG-4, CF-4, and CF. Cat DEO Multigrade exceeds the requirements of the Caterpillar Engine Crankcase Fluid-1 (ECF-1) specification. Cat DEO in SAE 15W-40 passes the following proprietary tests: sticking of the piston ring, oil control tests, wear tests, and soot tests. Proprietary tests help ensure that Caterpillar multigrade oil provides superior performance in Caterpillar Diesel Engines. In addition, Cat DEO Multigrade exceeds many of the performance requirements of other manufacturers of diesel engines. Therefore, this oil is an excellent choice for many mixed fleets. **True high performance oil is produced with a combination of the following factors: industry standard tests, proprietary tests, field tests, and prior experience with similar formulations. The design and the development of Caterpillar lubricants that are both high performance and high quality are based on these factors.**

Note: Non-Caterpillar commercial oils are second choice oils.

Commercial Oils

Engine Crankcase Fluid Recommendations for all Caterpillar 3500 Series and smaller direct injection (DI) diesel engines

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

- API CH-4 multigrade oils and API CI-4 multigrade oils are acceptable if the requirements of Caterpillar's ECF-1 specification are met. CH-4 oils and 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 the API CG-4 oils are used, the oil drain interval should not exceed the standard oil drain interval for your engine.

Note: When oil meets more than one API category, the applicable footnote is determined by the highest API category that is met.

Example – An oil meets both the API CH-4 and the API CF oil categories. In this case, the API CH-4 applies.

NOTICE
In selecting oil for any engine application, both the oil viscosity and oil performance category/specification as specified by the engine manufacturer must be defined and satisfied. Using only one of these parameters will not sufficiently define oil for an engine application.

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

API CI-4 – API CI-4 oils were developed in order to meet the requirements of high performance diesel engines that use cooled Exhaust Gas Recirculation (EGR). API CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 specification are met.

API CH-4 – API CH-4 oils were developed in order to protect low emissions diesel engines that use a 0.05 percent level of fuel sulfur. However, API CH-4 oils may be used with higher sulfur fuels. API CH-4 oils are acceptable if the requirements of Caterpillar's ECF-1 specification are met.

Note: CH-4 oils and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 specification may cause reduced engine life.

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

Note: Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that relates to lubrication for your engine.

Lubricant Viscosity Recommendations

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

Refer to Table 9 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 9 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

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

If ambient temperature conditions at engine start-up require the use of multigrade SAE 0W oil, SAE 0W-40 viscosity grade is preferred over SAE 0W-20 or SAE 0W-30.

Table 9

Engine Oil Viscosities for Ambient Temperatures		
	Ambient Temperature	
Viscosity Grade	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)

Note: Supplemental heat is recommended below the minimum recommended ambient temperature.

S·O·S Oil Analysis

Caterpillar has developed a tool for maintenance management that evaluates oil degradation and the tool also detects the early signs of wear on internal components. The Caterpillar tool for oil analysis is called S·O·S Oil Analysis and the tool is part of the S·O·S Services program. S·O·S Oil Analysis divides oil analysis into three categories:

- Wear Analysis
- Oil condition
- Additional tests

The wear analysis monitors metal particles, some oil additives, and some contaminants.

Oil condition uses infrared (IR) analysis to evaluate the chemistry of the oil. Infrared analysis is also used to detect certain types of contamination.

Additional tests are used to measure contamination levels from water, fuel, or coolant. Oil viscosity and corrosion protection can be evaluated, as needed.

Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" or contact your local Caterpillar dealer for additional information concerning the S·O·S Oil Analysis program.

Lubrication System

The refill capacities for the engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications in order to find the capacity of the auxiliary oil filter.

Table 10

Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Crankcase	60	63.4

Lubricating Grease

Caterpillar provides a range of moderate greases to extremely high performance greases in order to service the entire line of Caterpillar products that operate throughout the wide variety of climates. You will always be able to find a grease that will meet your machine's requirements for a certain application. Caterpillar grease products often exceed Caterpillar specifications.

Before selecting a grease product for any application, the performance requirements must be determined. Consult the grease recommendations that are made by the OEM for the equipment when the equipment is operated in the expected conditions. Then, consult with your Caterpillar dealer for a list of greases and the following related characteristics.

- Performance specifications
- Available sizes of containers
- Part numbers

Always choose a grease that meets the recommendations that are specified by the equipment manufacturer for the application, or choose a grease that exceeds the recommendations that are specified by the equipment manufacturer for the application.

If it is necessary to choose a single grease for use on all of the equipment at one site, always choose a grease that meets the requirements of the most demanding application. A product that barely meets the minimum performance requirements will shorten the life of the part. Use the grease that yields the least total operating cost. Base this cost on an analysis that includes the costs of the parts, the labor, the downtime, and the cost of the grease that is used.

Some greases are not chemically compatible. Consult your supplier in order to determine if two or more greases are compatible.

Purge the grease from a joint at the following times:

- Switching from one grease to another grease
- Switching from one supplier to another supplier

If in doubt, Purge!

Note: All Caterpillar brand name greases are compatible with each other.

Note: Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that relates to lubrication for your engine.

Fuel

Diesel fuels that meet the Caterpillar Specification for Distillate Diesel Fuel are recommended. These fuels will help to provide maximum engine service life and performance. In North America, diesel fuel that is identified as No. 1-D or No. 2-D in "ASTM D975" generally meet the specifications. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

NOTICE
Operating with fuels that do not meet Caterpillar's recommendations can cause the following effects: starting difficulty, poor combustion, deposits in the fuel injectors, reduced service life of the fuel system, deposits in the combustion chamber, and reduced service life of the engine.

Note: Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for the Caterpillar Specification for distillate fuel and for additional information that relates to fuel for your engine.

Refill Capacities (Fuel System)

Refer to the Operation and Maintenance Manual that is provided by the OEM for capacities of the fuel system.

Coolant

The following two coolants are used in Caterpillar diesel engines:

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

Acceptable – A Cat DEAC (Diesel Engine Antifreeze/Coolant) or a commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D5345" specifications

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.

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

Note: Cat DEAC does not require a treatment with an SCA at the initial fill. Commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D5345" specifications MAY require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

In stationary engine applications that do not require anti-boil protection or freeze protection, a mixture of SCA and water is acceptable. Caterpillar recommends a six percent to eight percent concentration of SCA in those cooling systems. Distilled water or deionized water is preferred. Water which has the recommended properties may be used.

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

Table 11

Coolant Service Life	
Coolant Type	**Service Life**
Cat ELC	6000 Service Hours or Six Years
Cat DEAC	3000 Service Hours or Three Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D5345"	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	3000 Service Hours or Two Years
Commercial SCA and Water	3000 Service Hours or One Year

Note: Refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that relates to coolant for your engine.

S·O·S Coolant Analysis

Table 12

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
DEAC	Every 250 Hours	Yearly(1)
ELC	Not Required	Yearly

(1) The Level 2 Coolant Analysis should be performed sooner if a problem is identified by a Level 1 Coolant Analysis.

S·O·S Coolant Analysis (Level 1)

A coolant analysis (Level 1) is a test of the properties of the coolant.

The following properties of the coolant are tested:

- Glycol concentration for freeze protection and boil protection
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Visual analysis
- Odor analysis

The results are reported, and appropriate recommendations are made.

Refer to the Maintenance Interval Schedule in this Operation and Maintenance Manual in order to find the maintenance interval for collecting the coolant samples.

S·O·S Coolant Analysis (Level 2)

A coolant analysis (Level 2) is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the inside of the cooling system.

The S·O·S Coolant Analysis has the following features:

- Full coolant analysis (Level 1)
- Identification of the source of metal corrosion and of contaminants
- Water hardness
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling

The results are reported, and appropriate recommendations are made.

Refer to the Maintenance Interval Schedule in this Operation and Maintenance Manual, "Cooling System Coolant Sample (Level 2) - Obtain" for the maintenance interval for collecting the coolant samples.

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and from corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and from freezing. The S·O·S Coolant Analysis can be done at your Caterpillar dealer. Caterpillar S·O·S Coolant Analysis is the best way to monitor the condition of your coolant and your cooling system. S·O·S Coolant Analysis is a program that is based on periodic samples.

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

Refill Capacity

Table 13

Approximate Refill Capacity of the Coolant System		
Compartment or System	**Liters**	**Quarts**
Engine	38	40.2

Maintenance Recommendations

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General Maintenance Information

SMCS Code: 4450; 7000

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

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

- mechanical
- electrical
- thermal
- environmental

These stresses may be of varying magnitudes. The electrical 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 electrical insulation system. Therefore, the service life of an electric machine will largely depend on the serviceability of the electrical insulation systems. An inspection program and a testing procedure are recommended. An inspection program and a testing procedure will ensure that the equipment is maintained in satisfactory condition. This will increase field reliability.

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

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

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

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

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

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Generator Start-up Checklist

SMCS Code: 4450

Table 14

GENERATOR START-UP CHECKLIST							
RATING INFORMATION							
Engine Serial Number: _____				Arrangement Number: _____			
Generator Serial Number: _____				Arrangement Number: _____			
GENERATOR NAME PLATE INFORMATION							
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:			
SPACE HEATERS		**Yes**	**No**	**Comments**			
Space heaters operating properly?							
Space heater operated 48 hours. before start-up?							
MEGOHMMETER TEST (SEHS9124)		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						

(continued)

(Table 14, contd)

GENERATOR START-UP CHECKLIST				
No Load	**Regulator R448**	**Voltage**	**Amps**	**Comments**
	E- to E+	DC		
	0 to 220 or 380(1)	AC		
	Self-Excited X1 to X2	AC		
	Permanent Magnet Excited X1 to X2	AC		
	Permanent Magnet Excited X1 to Z2	AC		
	Permanent Magnet Excited X2 to Z2	AC		
	AREP X1 to X2	AC		
	AREP Z1 to Z2	AC		
	Three-phase Sensing Module	**Voltage**	**Amps**	**Comments**
	U 0 to 230 or 400(1)	AC		
	V 0 to 230 or 400(1)	AC		
	W 0 to 230 or 400(1)	AC		
Full Load	**Regulator R448**	**Voltage**	**Amps**	**Comments**
	E- to E+	AC		
	0 to 230 or 400(1)	AC		
	Self-Excited X1 to X2	AC		
	Permanent Magnet Excited X1 to X2	AC		
	Permanent Magnet Excited X1 to Z2	AC		
	Permanent Magnet Excited X2 to Z2	AC		
	AREP X1 to X2	AC		
	AREP Z1 to Z2	AC		
	Three-phase Sensing Module	**Voltage**	**Amps**	**Comments**
	U 0 to 230 or 400(1)	AC		
	V 0 to 230 or 400(1)	AC		
	W 0 to 230 or 400(1)	AC		

(1) This will depend on the configuration of the windings. For more information, refer to the schematic for the generator.

Table 15

GENERATOR START-UP CHECKLIST (CONT.)								
ELECTRICAL					**Yes**	**No**	**Comments**	
	Unit properly grounded							
	Check diodes							
	Over current protection							
	Over voltage protection							
	Check for loose wiring							
	Adjust voltage							
	Adjust frequency							
MECHANICAL					**Data**			**Comments**
	Bearing temperature readings at full load				Front _____ Rear _____			
	Stator temperature readings at full load				A0 _____ B0 _____ C0 _____			
	Air gap on main stator				Top _____ Bottom _____			
	Air gap on exciter stator				Top _____ Bottom _____			
	Air gap of PMG				Top _____ Bottom _____			
	Ambient air to generator at full load				Temperature _____			
	Supplier air opening to generator				Size of Opening _____			
SWITCH GEAR/PARALLEL OPERATION								
	Manufacturer:							
				Setting 1	**Setting 2**	**Setting 3**	**Comments**	
	Circuit breaker type							
	Overload setting							
	Reverse power relay							
	VAR/PF Controller							
	Load share							
INSTALLATION & LOAD INFORMATION								
	Neutral grounding system				UPS			
	Enclosure type				- Size			
	Motor:				Other loads:			
	- Total SKVA				- Lighting			
	- Total HP				- Computers			
					- Welding			
					- Non-linear			
					- Other			
FULL LOAD DATA								
Voltage	Amps		KW	KVARS	P.F.			

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Maintenance Interval Schedule (Prime Power Generator Sets)

SMCS Code: 1000; 7500

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

The user is responsible for the performance of maintenance, including all adjustments, the use of proper lubricants, fluids, filters, and the replacement of 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.

Use mileage, fuel consumption, service hours, or calendar time, WHICH EVER OCCURS FIRST, in order to determine the maintenance intervals. Products that operate in severe operating conditions may require more frequent maintenance.

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

When Required

Daily

Every Week

Every 250 Service Hours

Every 2000 Service Hours

Every 2000 Service Hours or 6 Months

Every 2000 Service Hours or 1 Year

Every Year

First 9500 L (2500 US gal) of Fuel or 250 Service Hours

Every 9500 L (2500 US gal) of Fuel or 250 Service Hours or Yearly

Every 19 000 L (5000 US gal) of Fuel or 500 Service Hours

Every 114 000 L (30 000 US gal) of Fuel or 3000 Service Hours or 3 Years

Every 190 000 L (50 000 US gal) of Fuel or 5000 Service Hours

Every 228 000 L (60 000 US gal) of Fuel or 12 000 Service Hours or 6 Years

Overhaul

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Maintenance Interval Schedule (Standby Generator Sets)

SMCS Code: 1000; 7500

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

The user is responsible for the performance of maintenance, including all adjustments, the use of proper lubricants, fluids, filters, and the replacement of 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.

Use mileage, fuel consumption, service hours, or calendar time, WHICH EVER OCCURS FIRST, in order to determine the maintenance intervals. Products that operate in severe operating conditions may require more frequent maintenance.

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

When Required

Every Week

Every 6 Months

Every Year

Every 3 Years

Every 6 Years

Overhaul

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Alternator - Inspect

SMCS Code: 1405-040

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

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

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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.

i02153996

Battery - 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.

⚠ WARNING

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

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

1. Turn the 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 the cables are connected, 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.

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 16 describes the effects of overcharging on different types of batteries.

Table 16

Effects of Overcharging Batteries	
Type of Battery	**Effect**
Caterpillar General Service Batteries Caterpillar Premium High Output Batteries	All of the battery cells have a low level of electrolyte.
	When the plates of the battery are inspected through the filler holes, the plates may appear to be warped. This is caused by an excessive temperature.
	The battery may not pass a load test.
Caterpillar Maintenance Free Batteries	The battery may not accept a charging current.
	The battery may not pass a load test.

Checking After Stopping

Ensure that the battery charger is connected properly. Observe the meter of the charger. Record the amperage.

i02340858

Battery Electrolyte Level - Check

SMCS Code: 1401-535

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are properly charged, ammeter reading should be very near zero, when the engine is in operation.

⚠ WARNING

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

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

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

2. Check the condition of the electrolyte with the 245-5829 Coolant Battery Tester Refractometer.

3. Keep the batteries clean.

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

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

   Thoroughly rinse the battery case with clean water.

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

i01492654

Battery or Battery Cable - Disconnect

SMCS Code: 1402-029

⚠ WARNING

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

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

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.

2. Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, the negative side of two batteries must be disconnected.

3. Tape the leads in order to help prevent accidental starting.

4. Proceed with necessary system repairs. Reverse the steps in order to reconnect all of the cables.

i02023749

Bearing (Ball) - Lubricate (Generator)

SMCS Code: 4471-086

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

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

Lubricating Process

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

2. Remove the top grease pipe plug and remove the lower grease pipe plug.

3. Install a grease fitting in the grease pipe.

4. Grease the shielded ball bearings with 2S-3230 Bearing Lubricant (53.28 mL (1.8 ounces) to 59.20 mL (2.0 ounces)). Lubricate shielded ball bearings at 2000 hour intervals. Do not mix greases.

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

5. Wipe off the excess grease. Remove the top grease fitting. Install the plug.

6. Operate the generator for one hour. This will allow the grease to expand. The expanding grease will force the excess grease from the cavity. When the excess grease is forced from the cavity, the internal pressure will be reduced. The generator should continue to operate until the grease stops purging.

7. Stop the engine. Install the plug in the bottom grease pipe. Wipe off the excess grease.

8. Install the louver assembly or install the rear plate.

i02374464

Bearing Temperature - Measure/Record

SMCS Code: 4471-082-TA

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

i02154849

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

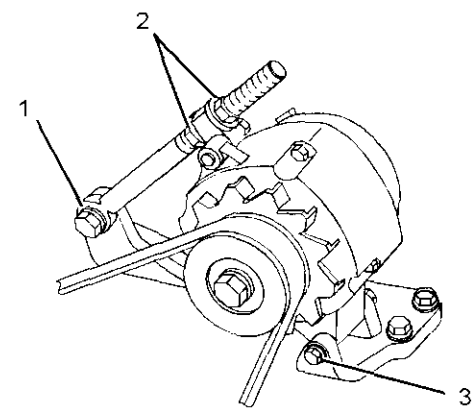

Illustration 53 g01092641

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

1. 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.
5. Tighten the mounting bolt.

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.

i02367022

Cooling System Coolant (DEAC) - Change

SMCS Code: 1350-070; 1395-044

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

- The engine overheats frequently.
- Foaming of the coolant
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

NOTICE
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

Note: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

Drain

⚠ 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 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.
2. Open the cooling system drain valve. Remove the drain plugs from the water pump, and the coolant lines.

   Allow the coolant to drain.

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

For information regarding the disposal and the recycling of used coolant, consult your 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

Flush

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

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

3. Fill the cooling system with 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 and run the engine at low idle for a minimum of 30 minutes. The coolant temperature should be at least 82 °C (180 °F).

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

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

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual for your particular engine for more specific information on the proper torques. Refer to the Specifications, SENR3130, "Torque Specifications" for more general information on the proper torques.

Cooling Systems with Heavy Deposits or Plugging

Note: For the following procedure to be effective, there must be some active flow through the cooling system components.

1. Flush the cooling system with clean water in order to remove any debris.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual for your particular engine for more specific information on the proper torques. Refer to the Specifications, SENR3130, "Torque Specifications" for more general information on the proper torques.

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

3. Fill the cooling system with 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 and run the engine at low idle for a minimum of 90 minutes. The coolant temperature should be at least 82 °C (180 °F).

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

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

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual for your particular engine for more specific information on the proper torques. Refer to the Specifications, SENR3130, "Torque Specifications" for more general information on the proper torques.

Fill

Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic for information regarding acceptable water, coolant/antifreeze, and supplemental coolant additive requirements. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic for the capacity of the engine's 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 coolant/antifreeze. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start the engine and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block. Stop the engine.

3. Check the coolant level. Maintain the coolant level within 13 mm (.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (.5 inch) to the proper level on the sight glass (if equipped).

4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, perform a pressure test. A 9S-8140 Pressurizing Pump is used to perform the pressure test. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02367032

Cooling System Coolant (ELC) - Change

SMCS Code: 1350-070; 1395-044

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

- The engine overheats frequently.
- Foaming of the coolant
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

Note: When the cooling system is cleaned, only clean water is needed when the ELC is drained and replaced.

Note: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

Drain

⚠ 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 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.

2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove the cooling system drain plugs.

   Allow the coolant to drain.

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

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

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

Flush

1. Flush the cooling system with clean water in order to remove any debris.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual for your particular engine for more specific information on the proper torques Refer to the Specifications, SENR3130, "Torque Specifications" for more general information on the proper torques.

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

3. Fill the cooling system with clean water. Install the cooling system filler cap.

4. Start the engine and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual for your particular engine for more specific information on the proper torques. Refer to the Specifications, SENR3130, "Torque Specifications" for more general information on the proper torques.

Fill

Engines that are Equipped with a Coolant Recovery Tank

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). Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start the engine and operate the engine at low idle. Increase the engine rpm to 1500 rpm. Operate the engine at 1500 rpm for one minute in order to purge air from the cavities of the engine block. Stop the engine.

3. Pour more ELC into the cooling system until the cooling system is full.

4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

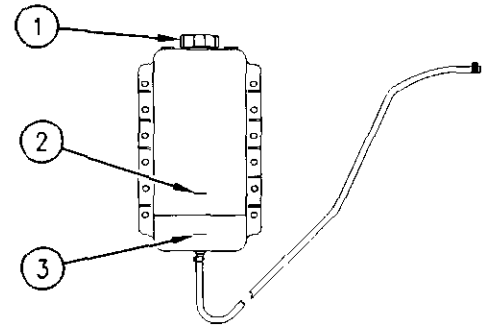

Illustration 54 g00103638

(1) Recovery tank filler cap
(2) "COLD FULL" mark
(3) "LOW ADD" mark

5. Loosen the cap for the coolant recovery tank slowly in order to relieve any pressure. Remove the cap for the coolant recovery tank.

6. Pour Extended Life Coolant (ELC) into the coolant recovery tank until the coolant reaches the "COLD FULL" mark. DO NOT fill the coolant recovery tank above the "COLD FULL" mark.

7. Clean the cap for the coolant recovery tank. Install the cap for the coolant recovery tank.

8. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

Engines that are NOT Equipped with a Coolant Recovery Tank

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). Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start the engine and operate the engine at low idle. Increase the engine rpm to 1500 rpm. Operate the engine at 1500 rpm for one minute in order to purge air from the cavities of the engine block. Stop the engine.

3. Check the coolant level. Maintain the coolant level within 13 mm (.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (.5 inch) to the proper level on the sight glass (if equipped).

4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.

5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02285855

Cooling System Coolant Extender (ELC) - Add

SMCS Code: 1352-045; 1395-081

Cat ELC (Extended Life Coolant) does not require the frequent Supplemental Coolant Additive (SCA) additions which are associated with the present conventional coolants. The Extender only needs to be added once.

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

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.

2. It may be necessary to drain enough coolant from the cooling system in order to add the Extender.

3. Add Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" in the Maintenance Section for more information concerning the Cat ELC Extender additions.

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.

i02372255

Cooling System Coolant Level - Check

SMCS Code: 1395-082

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

⚠ WARNING

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

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

2. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.

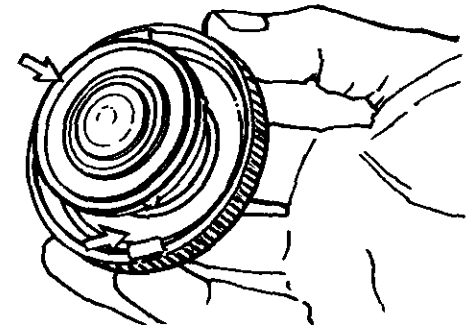

Illustration 55 g00103639

Typical filler cap gaskets

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

4. Inspect the cooling system for leaks.

i02326688

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.

Table 17

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC	Every 250 Hours(1)	Yearly(1)(2)
Cat ELC	Optional(2)	Yearly(2)

(1) 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.

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

- 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

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 Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids 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.

i02378612

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

SMCS Code: 1352-045; 1395-081

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

⚠ WARNING

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

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

Test the Concentration of the SCA

Coolant/Antifreeze and SCA

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

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

Water and SCA

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

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit. Use the instructions that follow:

1. Fill the syringe to the "1.0 ml" mark with the coolant.
2. Dispense the 1.0 mL coolant sample from the syringe into the empty mixing bottle.
3. Add tap water to the mixing bottle in order to bring the level up to the "10 ml" mark. Place the cap on the bottle and shake the bottle.
4. Add 2 to 3 drops of the "NITRITE INDICATOR SOLUTION B" to the mixing bottle. Move the bottle in a circular motion in order to mix the solution.
5. Add 1 drop of "NITRITE TEST SOLUTION A" to the mixing bottle. Move the bottle in a circular motion in order to mix the solution.
6. Repeat 5 until the solution changes color from red to light gray, green, or blue. Record the number of drops of "NITRITE TEST SOLUTION A" that were required to cause the color change.
7. Use Table 18 to interpret the results.

Table 18

Number of Drops	Concentration of SCA	Maintenance Required
Less than 25	Less than the recommended concentration of SCA	Add SCA. Retest the coolant.
25 to 30	The recommended concentration of SCA	None
More than 30	More than the recommended concentration of SCA	Remove the coolant. Replace with water only Retest the coolant.

Add the SCA, If Necessary

⚠ WARNING

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

1. Remove the cooling system filler cap slowly.

Note: Always dispose of fluids according to local regulations.

2. If necessary, drain some coolant in order to allow space for the addition of the SCA.

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

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

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

3. Add the proper amount of SCA. 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.

4. Clean the cooling system filler cap. Install the cooling system filler cap.

i00912898

Cooling System Water Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulator before the water temperature regulator fails. This is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or piston seizure problems.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner.

NOTICE
Failure to replace your water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

Do not use liquid gasket material on the gasket or cylinder head surface.

Refer to the Service Manual for the replacement procedure of the water temperature regulator, or consult your Caterpillar dealer.

Note: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

i00072369

Crankshaft Vibration Damper - Inspect

SMCS Code: 1205-040

Damage to the crankshaft vibration damper or failure of the crankshaft vibration damper can increase torsional vibrations. This can result in damage to the crankshaft and to other engine components. A deteriorating damper can cause excessive gear train noise at variable points in the speed range.

The damper is mounted to the crankshaft which is located behind the belt guard on the front of the engine.

Removal and Installation

Refer to the Service Manual for the damper removal procedure and for the damper installation procedure.

Visconic Damper

The visconic damper has a weight that is located inside a fluid filled case. The weight moves in the case in order to limit torsional vibration. Inspect the damper for evidence of dents, cracks or leaks of the fluid.

Replace the damper if the damper is dented, cracked or leaking. Refer to the Service Manual or consult your Caterpillar dealer for damper replacement.

i02378558

Cylinder Head Grounding Stud - Inspect/Clean/Tighten

SMCS Code: 7423-040; 7423-070; 7423-079

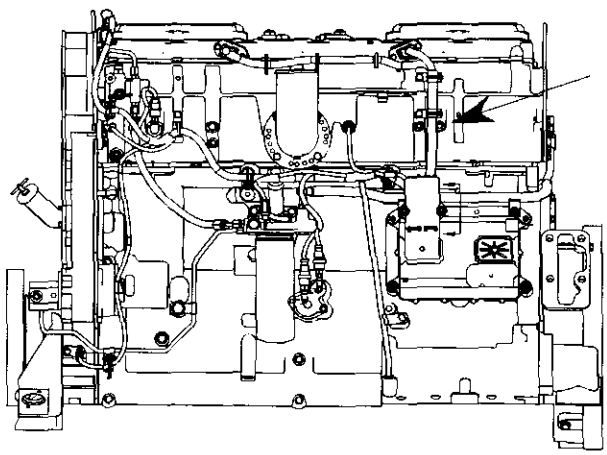

Illustration 56 g01187391
C15 Engine

The cylinder head grounding stud must have a wire ground to the battery. Tighten the cylinder head grounding stud at every oil change. Ground wires and straps should be combined at engine grounds. All grounds should be tight and free of corrosion.

1. Clean the cylinder head grounding stud and the terminals for the cylinder head ground strap with a clean cloth.
2. If the connections are corroded, clean the connections with a solution of baking soda and water.
3. Keep the cylinder head grounding stud and the strap clean and coated with MPGM grease or petroleum jelly.

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".

i02353651

Engine Air Cleaner Element (Dual Element) - Clean/Replace (If Equipped)

SMCS Code: 1054-037; 1054-510

See this Operation and Maintenance Manual, "Engine Air Cleaner Element - Clean/Replace" for information on servicing the primary air filter.

Inspecting and Replacing the Secondary Air Cleaner Element (If Equipped)

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.

Operating conditions (dust, dirt, and debris) may require more frequent service of the air cleaner element. 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.

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.

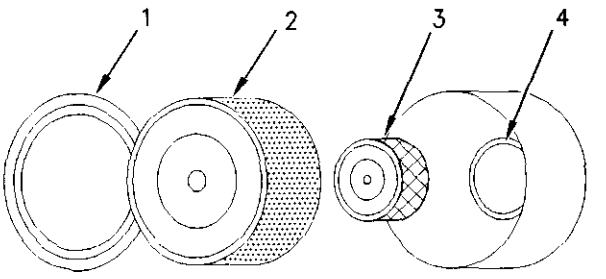

Illustration 57 g00736431

(1) Cover
(2) Primary air cleaner element
(3) Secondary air cleaner element
(4) Air inlet for the turbocharger

1. Remove the cover. Remove the primary air cleaner element.
2. Cover the air inlet for the turbocharger with adhesive material in order to keep dirt out of the turbocharger.
3. Clean the inside of the air cleaner cover and body with a clean, dry cloth.
4. Remove the adhesive covering that covers the air inlet for the turbocharger. Install the secondary air cleaner element. Install a primary air cleaner element that is new or clean.
5. Install the air cleaner cover.
6. Reset the air cleaner service indicator.

i02349277

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

The service indicator is mounted on the tube that leads from the engine air cleaner to the turbocharger inlet.

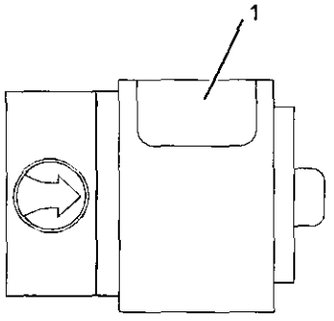

Illustration 58 g01174131

(1) Service Indicator Screen

Inspect and Clean the Indicator

Inspect the service indicator. Clean the air cleaner element or replace the element when the following conditions occur:

- The screen on the service indicator becomes totally red.
- Restriction of the air flowing through the air filter reaches 762 ± 6 mm (30 ± 2.3 inches)H^2O.
- The service indicator has one or more of the following:
- Cracks
- Holes
- Loose fittings

Test the Service Indicator

Service indicators are important instruments. Test the service indicator by using one of the following methods.

- Push the plunger into the element in order to reset. If the service indicator does not reset in three pushes or less, replace the service indicator.
- **The following method can only be used when the air cleaner has been used. This test will not work when the air cleaner has just been cleaned.** Push the plunger into the element. Start the engine. If the plunger does not move, replace the service indicator.

The service indicator may need to be replaced frequently in environments that are severely dusty. Replace the service indicator at the end of each year if the service indicator has not been replaced during the year. Replace the service indicator when the engine is overhauled. Replace the service indicator whenever major engine components are replaced.

i02375134

Engine Crankcase Breather - Clean

SMCS Code: 1317-070

NOTICE
Perform this maintenance with the engine stopped.

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

The crankcase breather consists of two components:

1. A breather assembly that is located underneath the valve cover that is at the rear of the engine
2. A breather hose that connects the breather assembly to the outside air beneath the engine

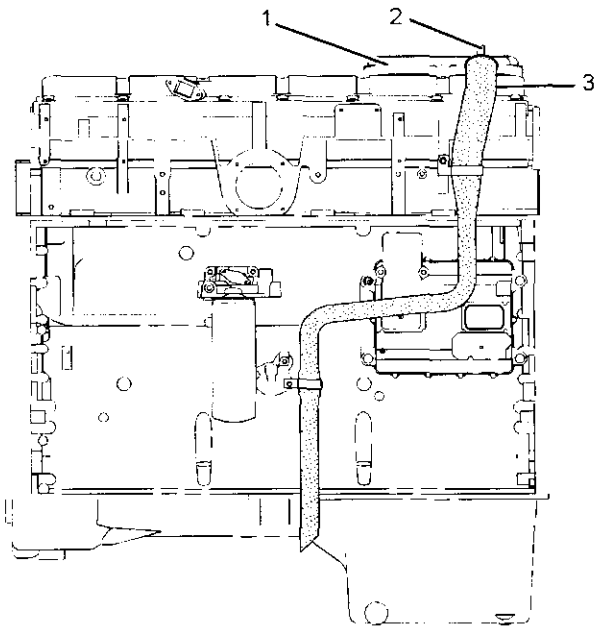

Illustration 59 g01185485

Typical Routing of Breather Hose

(1) Rear Valve Cover

(2) Hose Clamp

(3) Breather Hose

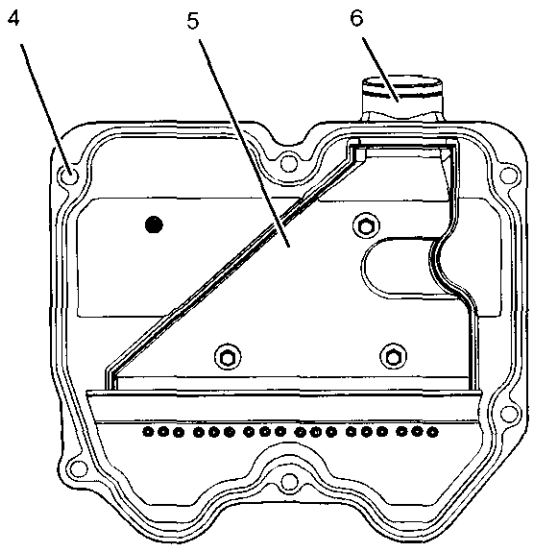

Illustration 60 g01185489

Top View After Removal of Valve Cover

(4) Bolt Hole

(5) Breather Assembly

(6) Access to Hose

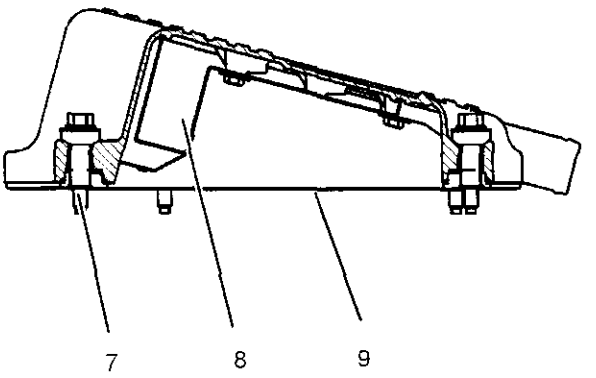

Illustration 61 g01185487

Side View of Valve Cover and Breather Elements

(7) Bolt

(8) Breather Elements

(9) Seal

Use the following procedure in order to clean the breather assembly:

1. Remove the six bolts that attach the valve cover to the engine. Remove the valve cover.
2. Loosen the clamp that attaches the breather hose to the breather assembly and remove the breather assembly.
3. Check the condition of the seal. Replace the seal if the seal is damaged.
4. Remove both of the breather elements. Wash the breather elements and the breather in clean nonflammable solvent.
5. Shake the breather elements until the breather elements are dry. You may also use pressurized air in order to dry the breather elements.
6. Install the elements into the breather and install the breather assembly onto the engine.

7. Install the hose onto the access for the breather, and tighten the clamp around the hose. Replace the valve cover on the engine, and install the six bolts. Consult Specifications, SENR3130, "Torque Specifications" in order to obtain correct instructions for installing the hose clamp and the bolts.

i00259257

Engine Mounts - Inspect

SMCS Code: 1152-040

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

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

Any engine mount that shows deterioration should be replaced. Refer to the Service Manual for the recommended torques. Refer to the OEM recommendations for more information.

i01007363

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

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

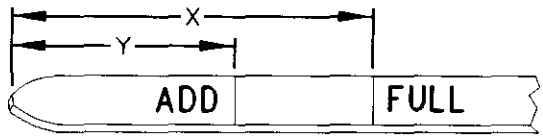

Illustration 62 g00110310

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

1. Maintain the oil level between the "ADD" mark (Y) and the "FULL" mark (X) on the oil level gauge. Do not fill the crankcase above "FULL" mark (X).

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

2. Remove oil filler cap and add oil, if necessary. Clean the oil filler cap. Reinstall the oil filler cap.

i02368863

Engine Oil Sample - Obtain

SMCS Code: 1000-008; 1348-554-SM; 7542-554-OC, 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.

See this Operation and Maintenance Manual, "Model Views" in order to locate the oil sampling valve.

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, PEHP6001, "How To Take A Good Oil Sample". Consult your Caterpillar dealer for complete information and assistance in establishing an S·O·S program for your engine.

i02354905

Engine Oil and Filter - Change

SMCS Code: 1318-510; 1348-044

⚠ WARNING

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

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped. Drain the engine oil from the crankcase while the engine 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 cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Oil

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

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

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

Replace the Oil Filter

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

1. Remove the oil filter with a 1U-8760 Chain Wrench.
2. Cut the oil filter open with a 175-7546 Oil Filter Cutter Gp. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

   Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of the engine.

   Nonferrous metals may indicate wear on the aluminum parts, brass parts or bronze parts of the engine. Parts that may be affected include the following items: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

   Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter. Consult your Caterpillar dealer in order to arrange for a further analysis if an excessive amount of debris is found in the oil filter.

Illustration 63 g00103713

Typical filter mounting base and filter gasket

3. Clean the sealing surface of the filter mounting base. Ensure that all of the old oil filter gasket is removed.

4. Apply clean engine oil to the new oil filter gasket.

NOTICE
Do not fill the oil filter with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

5. Install the oil filter. Tighten the oil filter until the oil filter gasket contacts the base. Tighten the oil filter by hand according to the instructions that are shown on the oil filter. Do not overtighten the oil filter.

Fill the Engine Crankcase

1. Remove the oil filler cap. Fill the crankcase with the proper amount of oil. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for more information on lubricant specifications and refill capacities.

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

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

2. Start the engine and run the engine at "LOW IDLE" for two minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filter for oil leaks.

3. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.

4. Remove the oil level gauge in order to check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the oil level gauge.

i02366807

Engine Performance - Test (Standby Generator Sets)

SMCS Code: 1000-081

Operate the engine for a minimum of two hours at a minimum load of 60 percent.

Frequently monitor the following parameters duringengine operation:

- Engine Oil Pressure
- Engine Coolant Temperature
- Inlet Air Restriction

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 indicator readings for the engine. An indicator reading that is abnormal may indicate a problem with engine operation. Abnormal indicator readings may also indicate a possible problem with the indicator.

Table 19 is offered as an example of an engine log. Record the engine performance regularly. Keep recorded information for reference. Compare the recorded data in order to provide an indication of engine condition.

Records of engine performance are an important element of a maintenance program. Record information about the engine operation on a regular basis. This will help to reveal the trends of the engine performance. Records of engine performance will also provide a baseline for evaluating the mechanical condition of the engine.

The data on engine performance can help to predict problems with operation. This data can provide your Caterpillar dealer with information that is useful for recommending maintenance management information. A maintenance program that is properly managed will provide your engine with an optimum service life.

Table 19

Engine Log						
Date						
Authorization						
Engine Serial Number						
Engine Hours						
Engine Speed						
Percent Load						
Ambient Temperature						
Engine Coolant Temperature						
Engine Oil Temperature						
Engine Oil Pressure						
System Battery Voltage						
Generator Voltage						
Generator Amperage						
Comments						

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.

i02372844

Engine Speed/Timing Sensors - Check/Clean/Calibrate

SMCS Code: 1912-040; 1912-070; 1912-524

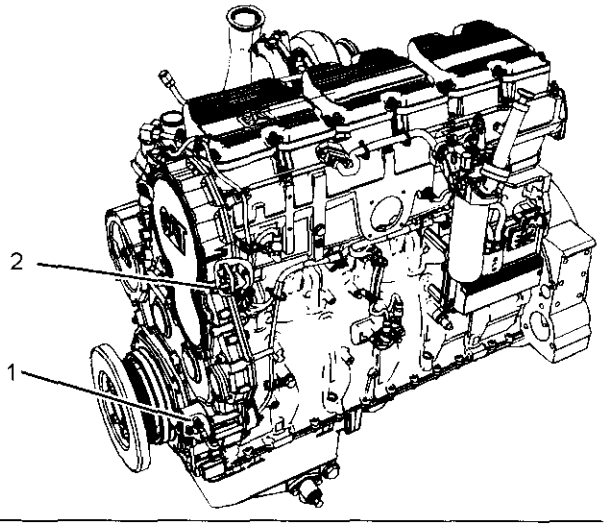

Illustration 64 g01184108

(1) Primary Speed/Timing Sensor

(2) Secondary Speed/Timing Sensor

1. Remove the speed/timing sensors from the front housing. Check the condition of the plastic end of the speed/timing sensors for wear and/or contaminants.

2. Clean the metal shavings and other debris from the face of the speed/timing sensors. Use the procedure in the Service Manual in order to calibrate the speed/timing sensors.

Refer to the Service Manual for more information on the speed/timing sensors.

i00869628

Engine Valve Lash - Inspect/Adjust

SMCS Code: 1102-025

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.

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

NOTICE
Only qualified service personnel should perform this maintenance. Refer to the Service Manual or your Caterpillar dealer for the complete valve lash adjustment procedure.

Operation of Caterpillar engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

⚠ 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.

Ensure that the engine is stopped before measuring the valve lash. To obtain an accurate measurement, allow the valves to cool before this maintenance is performed.

Refer to the Service Manual for more information.

i01597115

Engine Valve Rotators - Inspect

SMCS Code: 1109-040

⚠ WARNING

When inspecting the valve rotators, protective glasses or face shield and protective clothing must be worn, to help prevent being burned by hot oil or spray.

Engine valve rotators rotate the valves when the engine runs. This helps to prevent deposits from building up on the valves and the valve seats.

Perform the following steps after the engine valve lash is set, but before the valve covers are installed:

1. Start the engine according to Operation and Maintenance Manual, "Engine Starting" (Operation Section) for the procedure.
2. Operate the engine at low idle.
3. Observe the top surface of each valve rotator. The valve rotators should turn slightly when the valves close.

NOTICE
A valve rotator which does not operate properly will accelerate valve face wear and valve seat wear and shorten valve life. If a damaged rotator is not replaced, valve face guttering could result and cause pieces of the valve to fall into the cylinder. This can cause piston and cylinder head damage.

If a valve fails to rotate, consult your Caterpillar dealer.

i02325386

Ether Starting Aid Cylinder - Replace (If Equipped)

SMCS Code: 1456-510-CD

The ether canister is mounted inside the compartment on the side of the engine.

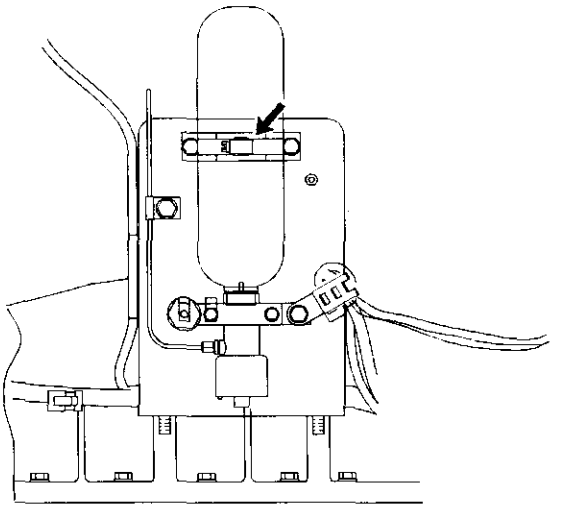

Illustration 65 g01044394

1. Loosen the retaining clamp. Remove the old canister by turning the canister counterclockwise.
2. Remove the old gasket. Install the new gasket.
3. Install the new canister. Turn the canister clockwise. Hand tighten the canister. Tighten the clamp around the canister.

i02369407

Fuel System - Prime

SMCS Code: 1258-548

⚠ WARNING

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

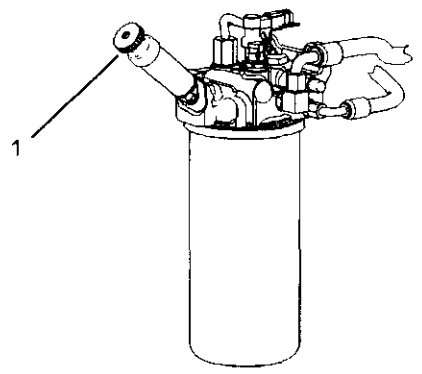

Illustration 66 g01182169

(1) Priming Pump

Priming the fuel system fills the fuel filters. Priming the fuel system also removes air from the fuel system. This procedure is used primarily when the engine runs out of fuel.

1. Unlock the fuel priming pump by turning the handle counterclockwise. Move the plunger for the fuel priming pump in and out until a strong pressure is felt on the fuel priming pump and until the check valve clicks. This procedure will require considerable strokes. Lock the fuel priming pump.

2. Crank the engine after the system is pressurized.

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. If the engine does not start, repeat Steps 1 and 2 in order to start the engine.

i02370475

Fuel System Primary Filter/Water Separator - Drain

SMCS Code: 1260-543; 1263-543

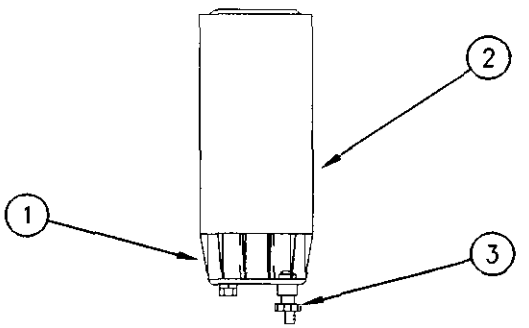

Illustration 67 g00668636

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

Bowl (1) should be monitored weekly for signs of water. If water is present, drain the water from the bowl.

1. Open drain (3). The drain is a self-ventilated drain. Catch the draining water in a suitable container. Dispose of the water properly.

2. Close drain (3).

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.

i02349031

Fuel System Primary Filter (Water Separator) Element - Replace

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

⚠ WARNING

Personal injury or death may result from failure to adhere to the following procedures.

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

Clean up all leaked or spilled fuel. Do not smoke while working on the fuel system.

Turn the disconnect switch OFF or disconnect the battery when changing fuel filters.

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.

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" guide for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Turn the start switch to the OFF position or disconnect the battery (starting motor) when maintenance is performed on a fuel filter.
2. Shut off the fuel supply.

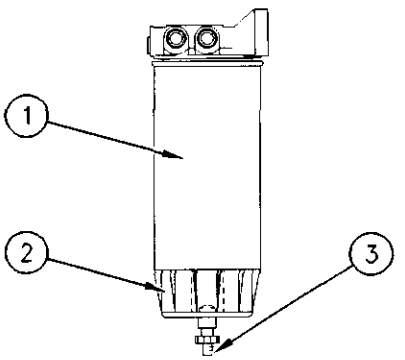

Illustration 68 g00104012

(1) filter body
(2) bowl
(3) drain valve

Note: Refer to this Operation and Maintenance Manual, "General Hazard Information" that pertains to containing fluid spillage.

3. Turn drain valve (3) counterclockwise in order to open. The drain valve is located on the bottom of the water separator.
4. Drain the water and sediment into a suitable container. Dispose of the drained fluids and used filters according to local regulations.
5. Close the drain valve.
6. Hold the bottom of the filter while you loosen the bowl. Remove the bowl.
7. Turn the filter counterclockwise in order to loosen the filter. If the filter will not turn, use a strap wrench to loosen the filter.
8. Remove the filter and discard the filter. Clean the bottom of the filter mounting base. Make sure that all of the old filter seal is removed from the bottom groove of the opening in the base.
9. Clean the water separator bowl and clean the groove for the seal. Inspect the seal. If the seal is worn or damaged, replace the seal.
10. Lubricate the seal with clean diesel fuel or lubricate the seal with clean motor oil. Place the seal in the groove on the water separator bowl.
11. Install the water separator bowl onto the new fuel filter by hand. Tighten the bowl assembly to 15 15 N·m (11 lb ft).
12. Apply clean diesel fuel to the seal of the new filter.

13. Install the new filter onto the base. Tighten the filter by hand until the seal contacts the filter base. Additionally tighten the filter by 1/3 to 1/2 rotation.

14. Open the fuel shutoff valve.

15. Reconnect the battery, if necessary.

16. Purge the air from the fuel system. See this Operation and Maintenance Manual, "Fuel System - Prime" for further instructions.

17. Stop the engine and check for leaks.

Note: The secondary fuel filter should also be replaced at this time. See this Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for further information.

i02326422

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.

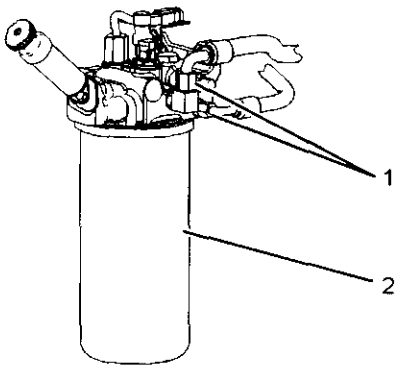

Illustration 69 g01162207

(1) Fuel supply connections
(2) Fuel filter

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

NOTICE
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

1. It may be necessary to relieve residual fuel pressure from the fuel system before removing the fuel filter.

   Loosen one of the fuel supply connections (1) in order to purge any residual pressure.

NOTICE
Do not loosen fuel lines or fittings at the fuel manifold or ECM. The engine components may be damaged.

2. Remove the used fuel filter.

3. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.

4. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE
Do not fill the secondary fuel filter with fuel before installing. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

5. Install the new fuel filter. Spin the fuel filter onto the fuel filter base until the gasket contacts the base. Use the rotation index marks on the filters as a guide for proper tightening. Tighten the filter for an additional 3/4 turn by hand. Do not overtighten the filter.

i02394978

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" 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.

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

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

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

Fuel Storage Tanks

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

- Weekly
- Oil change
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i01936148

Generator - Dry

SMCS Code: 4450-569

⚠ WARNING

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

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

Note: The use of space heaters and occasional cranking of the engine will help to avoid drying the generator. Space heaters should be used continuously while the machine is stopped in order for the space heaters to be effective.

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

If the insulation resistance values are less than 1 megohm for the stator or the insulation resistance values are less than 100,000 ohms for the other windings, one of the following drying procedures must be selected. This decision should be based on the following factors:

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

Measure insulation resistance at one hour intervals. Typically, the insulation resistance will slowly drop while the temperature is rising. The insulation resistance will then start to increase at a slow rate until the insulation resistance reaches a constant level.

The following methods can be used for drying a generator:

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

Self-Circulating Air Method

Blow hot air into the air intake for the generator. Disconnect the exciter field and run the engine. This will help circulate air. Operate the generator space heaters.

Oven Method

Disconnect the AVR. Place the entire generator inside a forced air drying oven for 24 hours at 110 °C (230 °F).

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

Radiant type ovens can cause localized overheating.

Controlled Current Method

Table 20

Tools Needed		
Part Number	**Description**	**Qty**
8T-0900	Clamp on ammeter (0 - 1200 amperes)	1
	External 24 Volt DC Power Source	1
	Rheostat	1

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

1. Disconnect the AVR.
2. Short circuit the three output power terminals with connectors that are capable of supporting the rated current. Try not to exceed 6 Amp per square millimeter.
3. Use a clamp-on ammeter in order to monitor the current through the short circuit connections.
4. Connect a 24 volt DC power source in series with a rheostat of 100 ohms or 50 Watts to the field terminals of the exciter. Make the connections with the correct polarity.
5. Open all the openings on the generator in order to allow air flow.
6. Operate the generator at the rated speed. Adjust the current in the exciter field with the rheostat. Obtain the rated output current in the short circuit connections.

i01880220

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)

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

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

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

Cleaning (Disassembled Generators)

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

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

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

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

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

i01878834

Generator Load - Check

SMCS Code: 4450-535-LA

⚠ 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.

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

When a three-phase generator is installed or when a three-phase 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 three-phase 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 on three-phase generators. This is not applicable to single-phase generators.

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.

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 21

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.

i02291365

Generator Set Vibration - Inspect

SMCS Code: 4450-040-VI

Excessive vibration will indicate a problem with the generator set. The vibration may be caused by the following:

- Misalignment of the coupling between the engine and the generator
- Faulty mounting or play in the coupling
- Incorrect balancing of the generator shaft or engine crankshaft
- A three-phase generator has too much load on a single phase.
- There is a short circuit in the stator.

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

- loose fittings
- loose bolts
- excessive noise
- cracked insulation

The following areas are susceptible to vibration damage:

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

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

i02121526

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.

i02365179

Instrument Panel - Inspect

SMCS Code: 7451-040

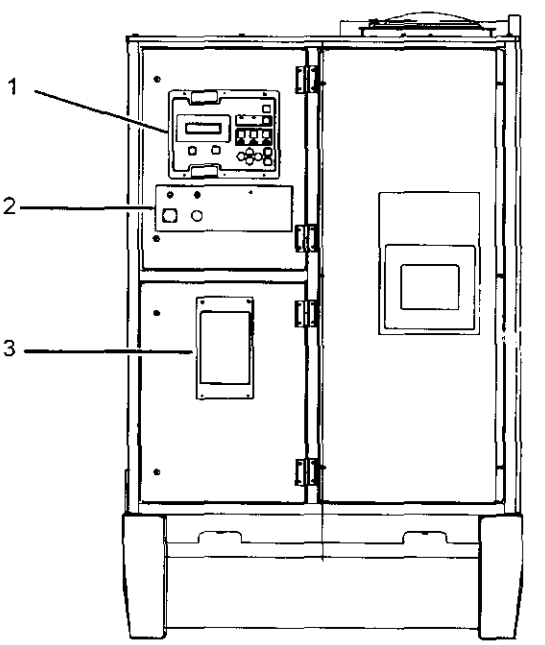

Illustration 70 g01186363

Rear View of the Genset

(1) Electronic Control Module

(2) Control Panel

(3) Annunciator Panel

Inspect each component of the panel in order to ensure that the components are in good condition before testing each individual component. For more complete testing information, see Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, "EMCP 3".

Electronic Control Module

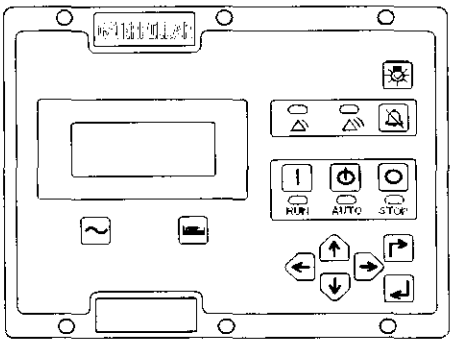

Illustration 71 g01184041

The Lamp Test button is located on the top right side of the electronic control module. Press and hold the Lamp Test button in order to test all of the LED lights and the display screen. The LED lights and the display screen should remain on until the button is released. If any of the components do not pass this test, replace the faulty components before starting the engine.

Control Panel

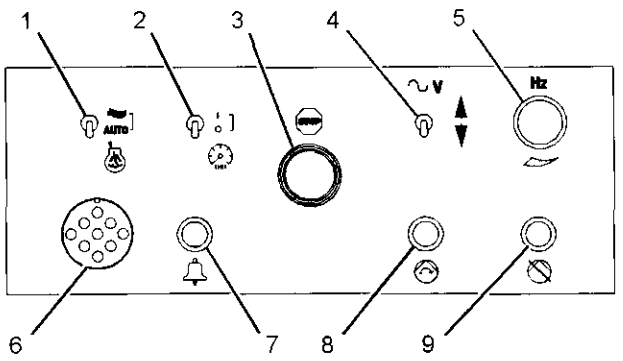

Illustration 72 g01185966

Toggle the panel light switch in order to test the panel lights.

Annunciator Panel

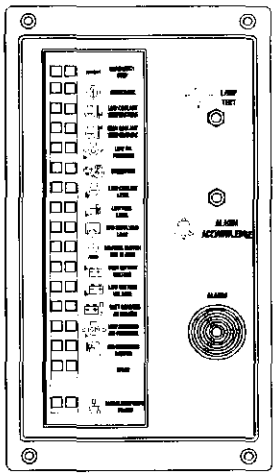

Illustration 73 g01101388

It is possible to test the LED indicators and the horn when the data link is connected and when the data link is not connected. The Lamp Test button is located near the top of the annunciator panel. Test both the horn and the indicators by pressing and holding the Lamp Test button. Replace any faulty components before starting the engine.

i01951994

Insulation - Test

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

Recommended Periodic Insulation Tests

WARNING

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the "OFF" position. Attach "DO NOT OPERATE" tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

Table 22

Tools Needed
142-5055 Insulation Testing Gp
9U-6003 Insulation Testing Gp

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

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

- The generator set is started for the first time.
- The generator set is removed from storage.
- The generator set is operating in a humid environment. Test every three months.
- The generator set is not protected from the elements in an enclosed area. Test every three months.
- The generator set is installed in an enclosed area. This area needs to be low in humidity and this area needs to have steady temperatures. Test every twelve months (minimum).
- The generator set has not been run under load for three months. Test the generator set weekly. Use space heaters around the generator set if the generator is exposed to a sea water environment or if the humidity is above 75 percent. Also use space heaters if a test result was below 3 megohms.

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

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

Recommended Procedure for A Periodic Insulation Test

⚠ WARNING

Personal injury or death can result from electrocution.

The megohmmeter is applying a high voltage to the circuit.

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

1. Take the generator out of service.
2. Visually inspect the generator for moisture. If moisture exists, do not perform this insulation test. Dry the unit first. Refer to Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators".
3. Inspect the installation. Determine the equipment that will be tested by the insulation tester.
4. Discharge the capacitance of the windings.
5. Isolate the stator windings of the generator by disconnecting all other leads and cables from the generator terminals. This includes connections to the voltage regulator, the control panel, the switchgear or other devices.
6. Connect the insulation tester's RED lead to ground.
7. Connect the insulation tester's BLACK lead to the wye point or star point of the generator's windings.
8. For units that are 600 volts or less, set the voltage to 500 Volts. For units that are more than 600 volts, set the voltage to 1000 Volts.
9. Use the 30/60 Time Resistance Method:
   a. Apply voltage.
   b. Observe the readings at 30 seconds. Observe the readings at 60 seconds.
   c. Record the 60 second reading. This reading must be corrected for temperature.
   d. Record temperature.
   e. Record humidity.
   f. Remove voltage.

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

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

Note: The results from the insulation resistance checks indicate when cleaning and/or repairing is becoming critical. Generally, insulation resistance will vary greatly with temperature. Therefore, always test at the same temperature and humidity. Refer to Illustration 74.

Serial Number (Engine)_____

Serial Number (Generator)_____

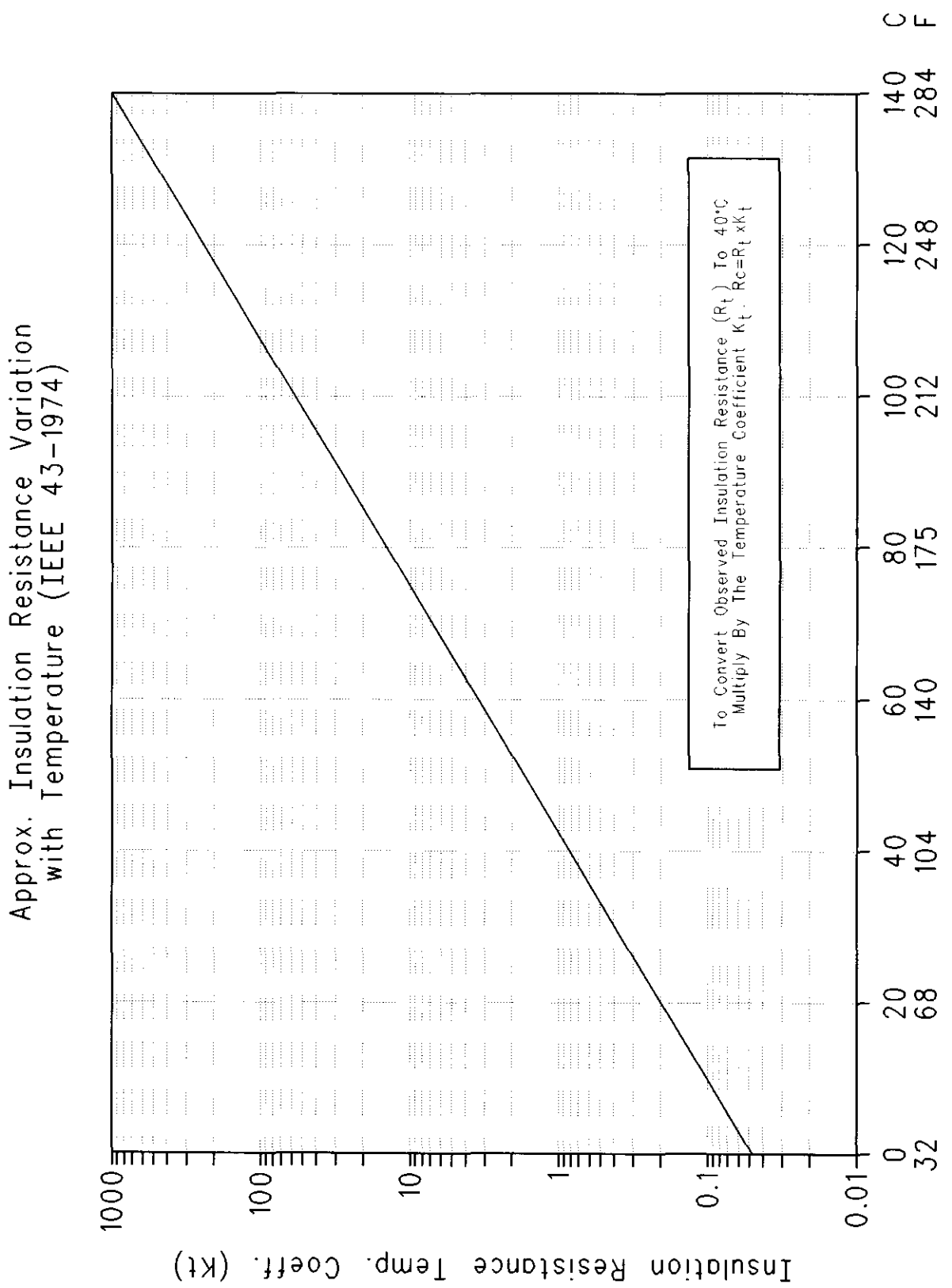

Illustration 74

g00633226

i01042517

Jacket Water Heater - Check

SMCS Code: 1383-535

Jacket water heaters help to improve startability in ambient temperatures that are below 21 °C (70 °F). All installations that require automatic starting should have jacket water heaters.

Check the operation of the jacket water heater. For an ambient temperature of 0 °C (32 °F), the heater should maintain the jacket water temperature at approximately 32 °C (90 °F).

i02273135

Magnetic Pickups - Clean/Inspect

SMCS Code: 1907-040; 7400-040; 7400-070

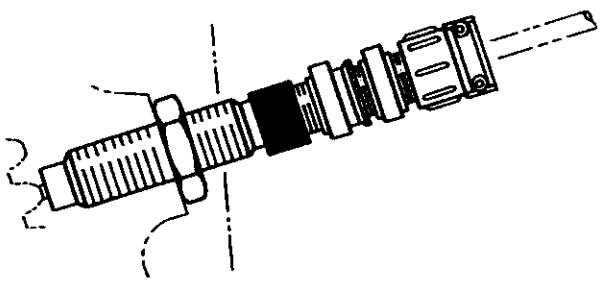

Illustration 75 g00614378

1. Remove the magnetic pickup from the flywheel housing. Check the condition of the end of the magnetic pickup. Check for signs of wear and contaminants.
2. Clean the metal shavings and other debris from the face of the magnet.
3. Install the magnetic pickup until the magnet comes in contact with the flywheel ring gear tooth.
4. Loosen the magnetic pickup by 180 degrees. Tighten the locknut to a torque of 25 ± 5 N·m (18 ± 4 lb ft).

Refer to the Service Manual for more information on the magnetic pickup.

i02378613

Overhaul Considerations

SMCS Code: 7595-043

Reduced hours of operation at full load will result in a lower average power demand. A decreased average power demand should increase both the engine service life and the overhaul interval.

The need for an overhaul is generally indicated by increased fuel consumption and by reduced power.

The following factors are important when a decision is being made on the proper time for an engine overhaul:

- The need for preventive maintenance
- The quality of the fuel that is being used
- The operating conditions
- The results of the S·O·S analysis

Oil Consumption as an Overhaul Indicator

Oil consumption, fuel consumption, and maintenance information can be used to estimate the total operating cost for your Caterpillar engine. Oil consumption can also be used to estimate the required capacity of a makeup oil tank that is suitable for the maintenance intervals.

Oil consumption is in proportion to the percentage of the rated engine load. As the percentage of the engine load is increased, the amount of oil that is consumed per hour also increases.

The oil consumption rate (brake specific oil consumption) is measured in grams per kW/h (lb per bhp). The brake specific oil consumption (BSOC) depends on the engine load. Consult your Caterpillar dealer for assistance in determining the typical oil consumption rate for your engine.

When an engine's oil consumption has risen to three times the original oil consumption rate due to normal wear, an engine overhaul should be scheduled. There may be a corresponding increase in blowby and a slight increase in fuel consumption.

Overhaul Options

Before Failure Overhaul

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 standards for reusable parts.
- The engine's service life can be extended without the risk of a major catastrophe due to engine failure.
- The best cost/value relationship per hour of extended life can be attained.

After Failure Overhaul

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

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

This lower cost can be attributed to three aspects:

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

Overhaul Recommendation

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

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

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

Rebuild or Exchange

Cylinder Head Assembly, Cylinder Packs, Oil Pump, and Fuel Transfer Pump

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

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

Parts that are not within the established inspection specifications should be dealt with in one of the following manners:

- Salvaging
- Repairing
- Replacing

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

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

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

Inspection and/or Replacement

Crankshaft Bearings, Valve Rotators, and Crankshaft Seals

The following components may not last until the second overhaul.

- Thrust bearings
- Main bearings
- Rod bearings
- Valve rotators
- Crankshaft seals

Caterpillar Inc. recommends the installation of new parts at each overhaul period.

Inspect these parts while the engine is disassembled for an overhaul.

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 is removed for any reason, use the magnetic particle inspection process to check for cracks in the crankshaft.

Inspect the camshaft for damage to the journals and to the lobes.

Note: If the camshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the camshaft.

Inspect the following components for signs of wear or for signs of scuffing:

- Camshaft bearings
- Camshaft followers

Caterpillar Inc. recommends replacing the crankshaft vibration damper.

Oil Cooler Core and Aftercooler Core

During an overhaul, Caterpillar Inc. recommends the removal of both the oil cooler core and the aftercooler core. Clean the oil cooler core and the aftercooler core. Then, pressure test both of these cores.

NOTICE
Do not use caustic cleaners to clean the core.

Caustic cleaners can attack the internal metals of the core and cause leakage.

Note: Use this cleaning procedure to clean the oil cooler core and the aftercooler core.

1. Remove the oil cooler core and the aftercooler core.
2. Remove any debris from the oil cooler core and the aftercooler core. To remove debris from the oil cooler core, turn the oil cooler core onto one end. To remove debris from the aftercooler core, turn the aftercooler core upside-down.
3. Flush the oil cooler core and the aftercooler core internally with cleaner in order to loosen foreign substances. This will also help to remove oil from the oil cooler core and the aftercooler core.

Note: Caterpillar Inc. recommends the use of Hydrosolv Liquid Cleaners. Table 23 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 23

Hydrosolv Liquid Cleaners[1]		
Part Number	**Description**	**Size**
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

(1) Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F).

4. Use steam to clean the oil cooler core and the aftercooler core. This removes any remaining residue from the cleaner. Flush the fins of the oil cooler core and the aftercooler core. Remove any other trapped debris.
5. Wash the oil cooler core and the aftercooler core with hot, soapy water. Rinse the oil cooler core and the aftercooler core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

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

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

6. Dry the oil cooler core and the aftercooler core with compressed air. Direct the air in the reverse direction of the normal flow.
7. Inspect the components in order to ensure cleanliness. The oil cooler core and the aftercooler core should be pressure tested. Repair the oil cooler core and the aftercooler core, if necessary. Install the oil cooler core and the aftercooler core.

For more information about cleaning the cores, consult your Caterpillar dealer.

Obtain Coolant Analysis

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

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

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

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

S·O·S Coolant Analysis (Level 2)

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

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

S·O·S Coolant Analysis (Level II) provides a report of the results of both the analysis and the maintenance recommendations.

For more information about coolant analysis, see 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.

i02372787

Radiator - Clean

SMCS Code: 1353-070

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the radiator, if necessary.

⚠ WARNING

Personal injury can result from air pressure.

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

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

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

For more detailed information on cleaning and inspection, refer to Special Publication, SEBD0518, "Know Your Cooling System".

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Rotating Rectifier - Check

SMCS Code: 4465-535

Check the exciter armature. Ensure that the rotating rectifier is tight. If a failure of a rectifier is suspected, proceed to the "Testing a Three-Diode Rectifier Block" section.

Testing a Three-Diode Rectifier Block

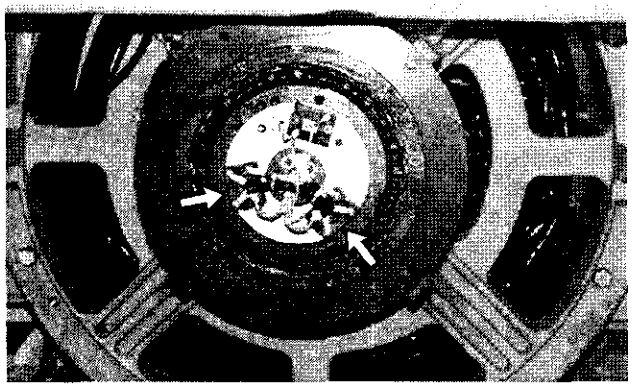

Illustration 76 g00610240

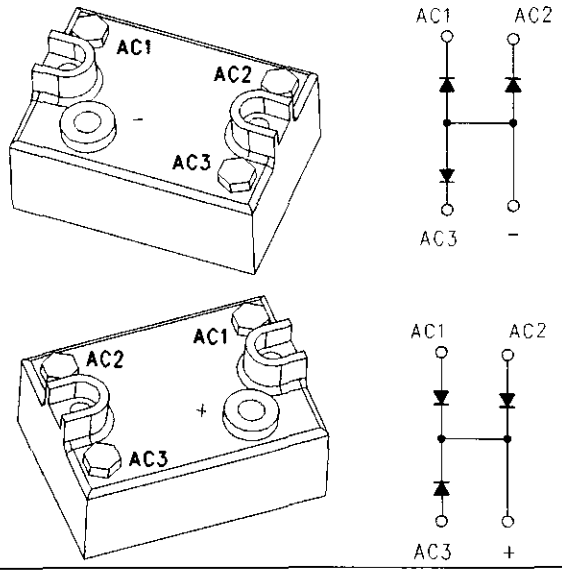

Illustration 77 g00613971

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.

i01936391

Rotating Rectifier - Test

SMCS Code: 4465-081

⚠ 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.

Use the following procedure in order to test the rotating rectifier.

1. Stop the generator set. Disconnect the wires for the AVR and isolate the wires for the AVR.
2. Make an assembly for separate excitation. The assembly can use a 12 volt battery or a variable DC power supply as a power source. Refer to Step 3 for an assembly that uses a 12 Volt battery. Refer to Step 4 for an assembly that uses a variable DC power supply.

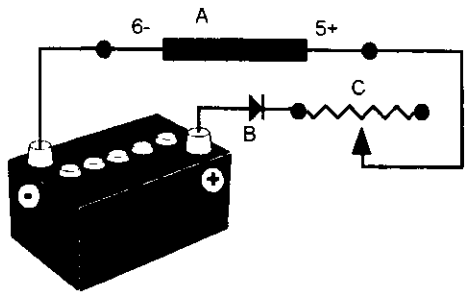

Illustration 78 g01015807

(A) Exciter Field
(B) Diode (1 Amp)
(C) Rheostat (50 Ohms 300 Watts)

3. Connect a 12 volt battery in series with a rheostat (C) of "50 Ohms 300 Watts" and a diode (B) on both wires for the exciter field (5+ and 6-). Go to step 5.

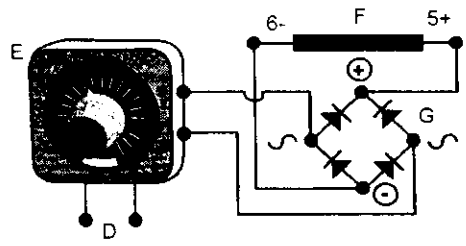

Illustration 79 g01015808

(D) AC supply
(E) Variable power supply
(F) Exciter field
(G) Diode bridge

4. Connect a variable power supply and a diode bridge to both of the wires for the exciter field (5+) and (6-).
5. The assembly should have characteristics that are compatible with the power for the field excitation of the generator.
6. Operate the generator set at rated speed.
7. Gradually increase the current of the exciter field by adjusting the rheostat or the variable power supply. Measure the output voltage and the current at no load. Measure the output voltage and measure the current at no load.
8. The generator is operating properly when the output voltage is at the rated value and the output voltage is balanced within one percent for the rated level of excitation.

i02377575

Space Heater - Check

SMCS Code: 4450-535-HTR

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

Table 24

Tools Needed		
Part Number	**Part**	**Quantity**
237-5130	Digital Multimeter	1

1. Stop the generator set.
2. Remove the panels in order to allow access to the regulator and control terminal strips. Locate terminal strip "TS1".
3. For 240 V systems, use the multimeter to measure the voltage between terminal "H1" and terminal "H4". If voltage is not present, disconnect the power source to terminal "H1" and terminal "H4", and check for 3 to 12 ohms resistance. If there is no resistance, check the generator service manual for further information. For 120 V systems, use the multimeter to measure the voltage between terminal "H1" and terminal "H2". If voltage is not present, disconnect the power source to terminal "H1", terminal "H2", terminal "H3", and terminal "H4", and check for 3 to 12 ohms resistance. If there is no resistance, check the generator service manual for further information.

i01943204

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.

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.

i00651416

Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

Caterpillar Inc. recommends a scheduled inspection of the starting motor. If the starting motor fails, the engine may not start in an emergency situation.

Check the starting motor for proper operation. Check the electrical connections and clean the electrical connections. Refer to the Service Manual for more information on the checking procedure and for specifications or consult your Caterpillar dealer for assistance.

i01228831

Stator Lead - Check

SMCS Code: 4459-535

Visually inspect the following areas for cracking and physical damage:

- stator output leads
- protective sleeving
- insulation

i01539769

Turbocharger - Inspect

SMCS Code: 1052-040; 1052

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side). Any fumes from the crankcase are filtered through the air inlet system. Therefore, by-products from oil and from combustion can collect in the turbocharger compressor housing. Over time, this buildup can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE
Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Note: Turbocharger components require precision clearances. The turbocharger cartridge must be balanced due to high rpm. Severe Service Applications can accelerate component wear. Severe Service Applications require more frequent inspections of the cartridge.

Removal and Installation

For options regarding the removal, installation, repair and replacement, consult your Caterpillar dealer. Refer to the Service Manual for this engine for the procedure and specifications.

Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.

2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the compressor wheel and the turbocharger housing, the turbocharger must be reconditioned.

3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.

4. Use a dial indicator to check the end clearance on the shaft. If the measured end play is greater than the Service Manual specifications, the turbocharger should be repaired or replaced. An end play measurement that is less than the minimum Service Manual specifications could indicate carbon buildup on the turbine wheel. The turbocharger should be disassembled for cleaning and for inspection if the measured end play is less than the minimum Service Manual specifications.

5. Inspect the bore of the turbine housing for corrosion.

6. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.

7. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i01189996

Voltage and Frequency - Check

SMCS Code: 4450-535-EL

Check for proper voltage and frequency setting. Check for stability.

Refer to the generator set Serial Plate for correct voltage and frequency.

i02378188

Walk-Around Inspection

SMCS Code: 1000-040

Inspect the Engine for Leaks and for Loose Connections

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

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

- The guards must be in the proper place. Repair damaged guards or replace missing guards.

- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

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

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

- Ensure that cooling lines are properly clamped. Check for leaks. Check the condition of all pipes.

- Inspect the water pump for coolant leaks.

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

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

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

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

- Drain the water and the sediment from fuel tanks on a weekly 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 led indicators. Replace any led indicators which are cracked.

Inspect the Insulation

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 surfaces of the insulation.

i01057943

Water Pump - Inspect

SMCS Code: 1361-040; 1361

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

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

Visually inspect the water pump for leaks. If any leaking is observed, replace the water pump seal or the water pump assembly. Refer to the Service Manual for the disassembly and assembly procedure.

Note: Refer to the Service Manual or consult your Caterpillar dealer if any repair is needed or any replacement is needed.

Warranty Section

Warranty Information

i01087950

Emissions Warranty Information

SMCS Code: 1000

This engine may be certified to comply with exhaust emission standards and gaseous emission standards that are prescribed by law at the time of manufacture, and this 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, SEBU6981, "Federal Emissions Control Warranty Information". Consult your authorized Caterpillar dealer to determine if your engine is emissions certified and if your engine is subject to an Emissions Warranty.

Reference Information Section

Engine Ratings

i00727327

Engine Rating Conditions

SMCS Code: 1000

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

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

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

The engine ratings are based on the following fuel specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .849 at 15 °C (60 °F)
- Density of 850 kg/m^3 (7.085 lb/US gal)

The engine ratings are gross output ratings.

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

Standard accessories include the following components:

- Oil pumps
- Fuel pumps
- Water pumps

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

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Engine Rating Definitions

SMCS Code: 1000

Ratings for Generator Set Engines

The engine ratings that are listed below have a manufacturing tolerance of plus three percent or minus three percent.

Standby Rating

- Typical load factor of 60 percent or less
- 100 typical operating hours per year
- Typical applications with standby service for building services with an enclosed environment
- 80 percent typical peak demand of the standby rated kW
- 100 percent of the rated kW for the duration of an emergency outage

Prime Rating

- Typical load factor of 60 percent to 70 percent
- No limit to typical operating hours
- Typical peak demand at 100 percent of the continuous rated kW for less than 10 percent of the total operating hours

Some typical applications include the following operations:

- industrial
- pumping
- construction
- peak shaving
- cogeneration

NOTICE
Operating a generator set engine above the rating definitions will result in a shorter engine service life before overhaul.

Customer Service

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Customer Assistance

SMCS Code: 1000

USA and Canada

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

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

1. Discuss your problem with a manager from the dealership.

2. If your problem cannot be resolved at the dealer level without additional assistance, use the phone number that is listed below to talk with a Field Service Coordinator:

   1-800-447-4986

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

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

   Caterpillar Inc.
   Manager, Customer Service, Engine Division
   Mossville Bldg AC
   P.O. Box 610
   Mossville, Illinois 61552-0610

   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, Carribean
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

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Ordering Replacement Parts

SMCS Code: 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

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Reference Material

SMCS Code: 1000

The following literature can be obtained from any Caterpillar dealer.

Note: The information that is found in this publication and the information that is found in the publications that are listed below may be changed without notice.

Operation and Maintenance Manuals are available in other languages. Consult your Caterpillar dealer for information about obtaining these Operation and Maintenance Manuals.

S·O·S Services

- Special Publication, PEDP7036, "S·O·S Fluids Analysis Cornerstone"
- Special Instruction, PEHP7076, "Understanding S·O·S Services Tests"
- Special Publication, PEHP7057, "S·O·S Coolant Analysis"
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Coolants

- Special Publication, SEBD0518, "Know Your Cooling System"
- Special Publication, SEBD0970, "Coolant and Your Engine"
- Special Instruction, PEHP9554, "Cat DEAC (Diesel Engine Antifreeze/Coolant)"
- Special Publication, PELJ0176, "Cat ELC (Extended Life Coolant)" 223-9116 Coolant Test Kit
- Data Sheet, PEHJ0067, "Cat ELC (Worldwide Formulation)"
- Special Instruction, PMEP5027, " ELC Coolant/Antifreeze Label"

Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

Lubricants

- Special Publication, PELJ0179, "Caterpillar Engine Crankcase Fluid-1 Specifications" All International Markets
- Special Publication, PEDP7035, "Optimizing Oil Change Intervals for Diesel Engines"
- Data Sheet, PEHJ0021, "Cat DEO (Diesel Engine Oil) APD, EAME, LACD Only "
- Data Sheet, PEHP7062, "Full Synthetic Diesel Engine Oil Data Sheet"
- Data Sheet, PEHJ0008, "Cat Arctic DEO SYN"
- Special Publication, PEHP6001, "How to Take a Good Oil Sample"
- Special Publication, SEBD0640, "Oil and Your Engine"
- Data Sheet, PEHJ0059, "Cat DEO (for North America)"
- Data Sheet, PEHJ0072, "Cat DEO (Brazil only)"
- Data Sheet, PEHJ0091, "Cat DEO (Egypt and Saudi Arabia)"

Grease

- Specifications for greases that are recommended by Caterpillar
- Special Instruction, NEHP6010, "Cat Ultra 5Moly Grease (NLGI grades 1 and 2)"
- Special Instruction, NEHP6011, "Arctic Platinum Grease Spec Sheet"
- Special Publication, NEHP6012, "Desert Gold Grease Spec Sheet"
- Data Sheet, NEHP6015, "Caterpillar Special Purpose Grease"
- Special Instruction, PEHP0002, "Molybdenum Grease Data Sheet"
- Data Sheet, PEHP0088, "Cat MultiPurpose Grease"
- Special Instruction, PEGJ0035, "Grease Selection Special Instruction"

Miscellaneous

- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"
- Special Publication, SEBU5898, "Cold Weather Recommendations"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"
- Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog"
- Special Publication, SMBU6981, "Emissions Control Warranty Information for Unites States, Canada and California"
- Specifications, SENR3130, "Torque Specifications"
- Service Manual, SENR9870, "C15 Standby Genset 50 Hz"
- ISO 8528, "Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets"
- Special Instruction, SEHS7259, "Alignment of Single-Bearing Generators"
- Special Instruction, SEHS7654, "Alignment - General Instructions"
- Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators"
- Systems Operation, Troubleshooting, Test and Adjust, RENR7902, "EMCP III"
- Special Publication, PECP9067, "One Safe Source"
- Special Instruction, SEHS7633, "Battery Test Procedure"
- Special Instruction, REHS0354, "Charging System Troubleshooting for All Engines"
- Special Instruction, SEHS7332, "Do Not Operate Tag"
- Special Publication, SEBF8062, "Procedure to Inspect and Clean Air Filters"
- Special Publication, SEBF8029, "Index to Publications on Reusability of Parts"

Additional Reference Material

ASTM D2896, "TBN Measurements" This can normally be obtained from your local technological society, from your local library, or from your local college.

SAE J313, "Diesel Fuels" This can be found in the SAE handbook. Also, this publication can be obtained from your local technological society, from your local library, or from your local college.

SAE J754, "Nomenclature" This can normally be found in the SAE handbook.

SAE J183, "Classification" This can normally be found in the SAE handbook.

Engine Manufacturers Association, "Engine Fluids Data Book"

Engine Manufacturers Association
Two North LaSalle Street, Suite 2200
Chicago, Illinois, USA 60602
E-mail: ema@enginemanufacturers.org
Telephone: (312) 827-8700
Facsimile: (312) 827-8737

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Maintenance Records

SMCS Code: 1000

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

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

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

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

Records should be kept for the following items:

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

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

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs
- Owner's receipts
- Maintenance log

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Maintenance Log

SMCS Code: 1000

Table 25

Engine Model			**Customer Identifier**	
Serial Number			**Arrangement Number**	
Service Hours	**Quantity Of Fuel**	**Service Item**	**Date**	**Authorization**

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