CATERPILLAR®

SEBU7829-03
March 2006

Operation and Maintenance Manual

3456 Generator Sets

C1G1-Up (Generator Set)
C3G1-Up (Generator Set)
C4G1-Up (Generator Set)
C2T1-Up (Generator Set)

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.

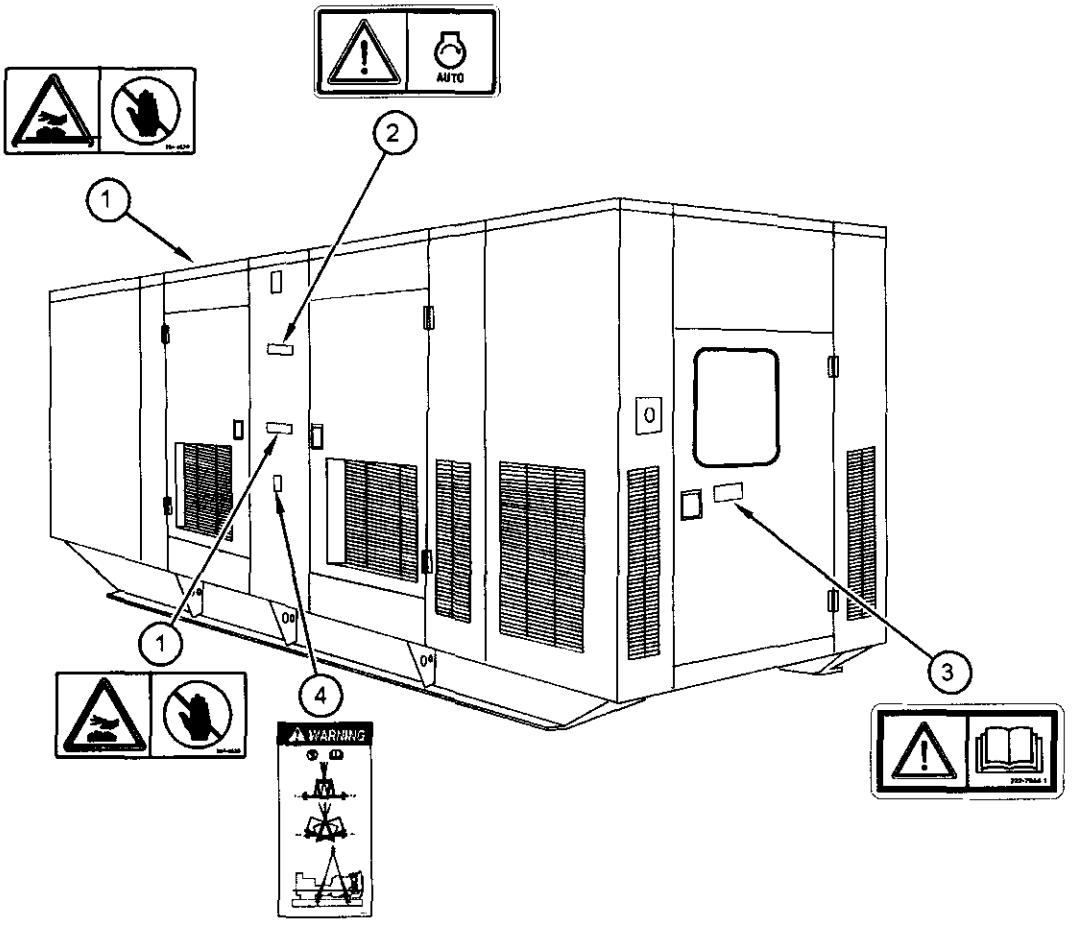

Illustration 1

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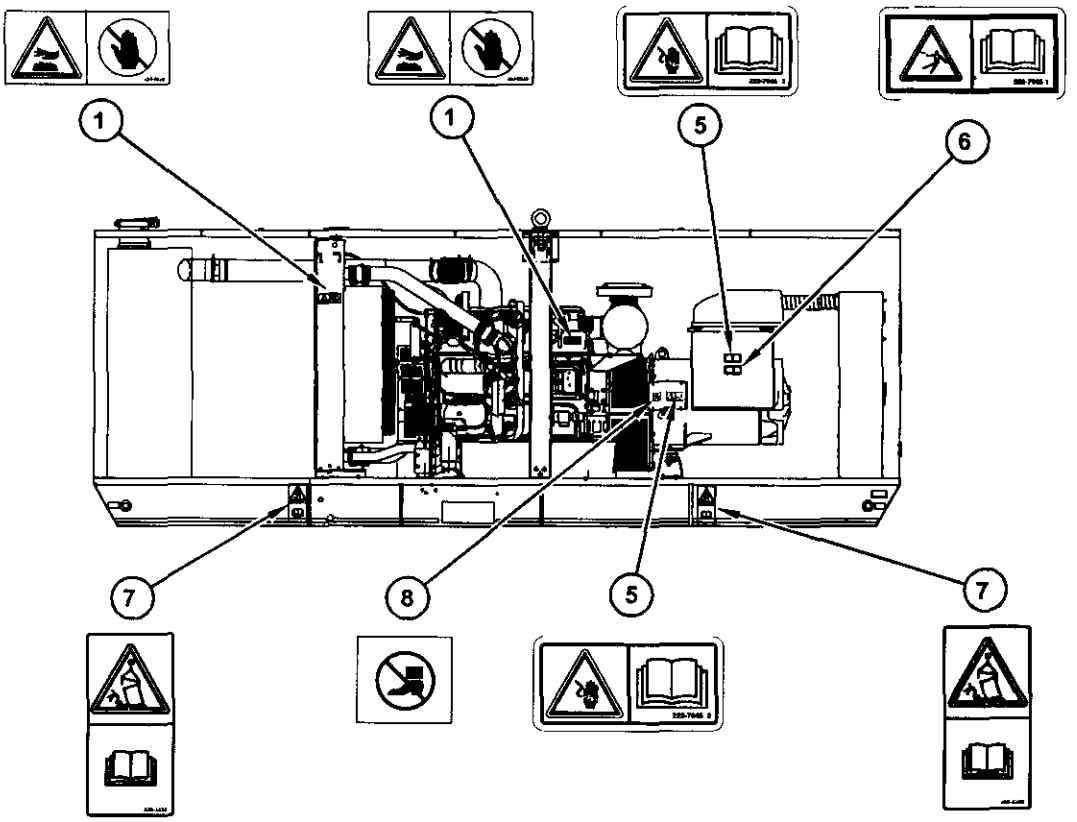

Illustration 2
g01031082

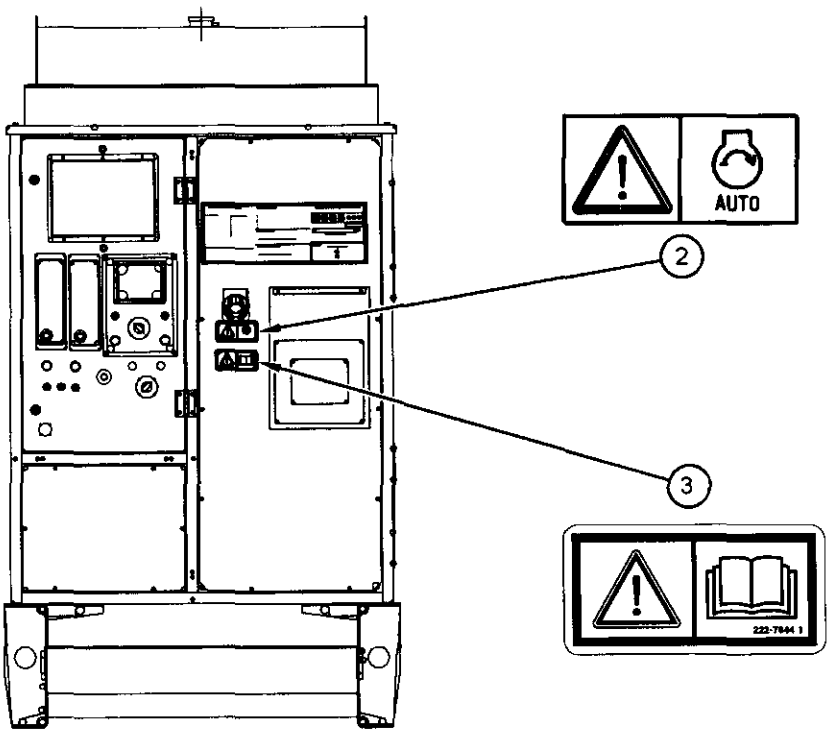

Illustration 3

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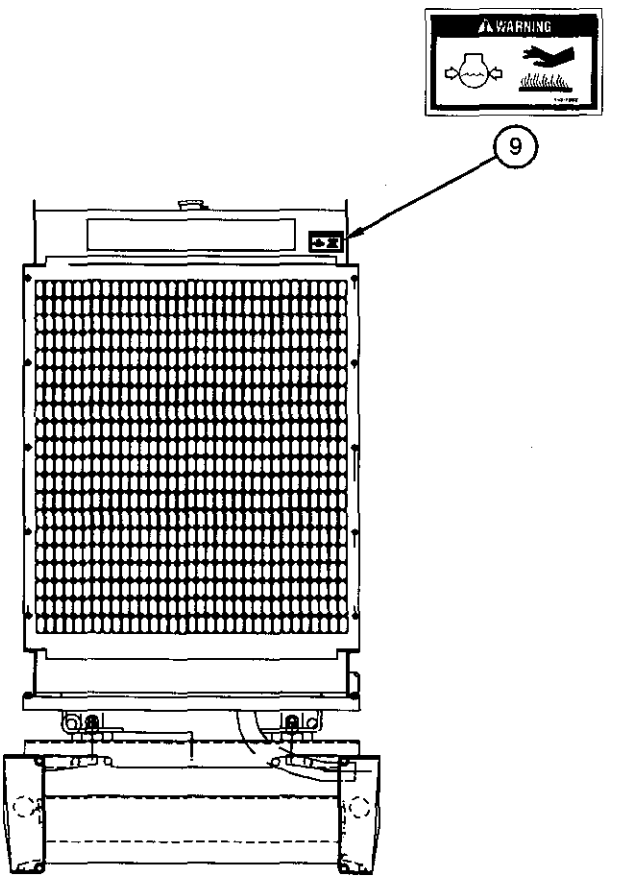

Illustration 4

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Hot Surface (1)

This safety message for hot surfaces is located on top of the enclosure, on the sides of the radiator and on the engine.

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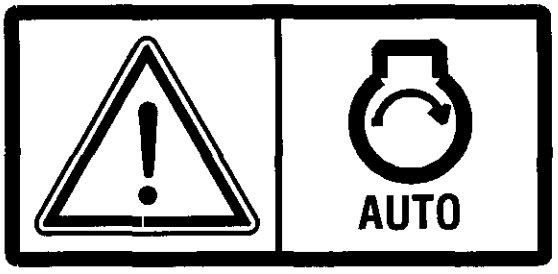
⚠ WARNING

Hot surface! Do not touch!

Automatic Starting (2)

This safety message for automatic starting is located on the side of the enclosure and the control panel.



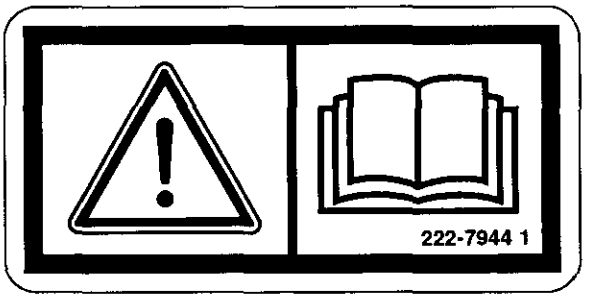
g01023635

⚠ 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.

Do Not Operate (3)

This safety message is located on the rear of the enclosure and the control panel.



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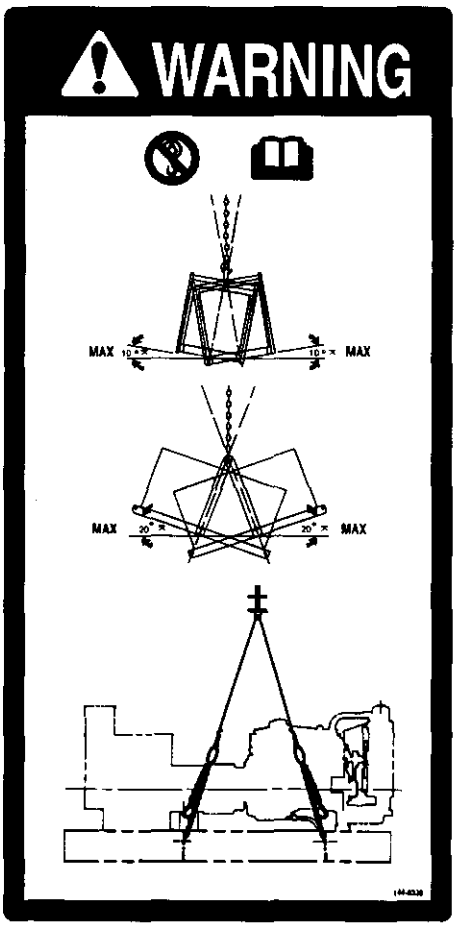
⚠ WARNING

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

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

Lifting the Genset (4)

This safety message for lifting the genset is located on the side of the enclosure for enclosed gensets.



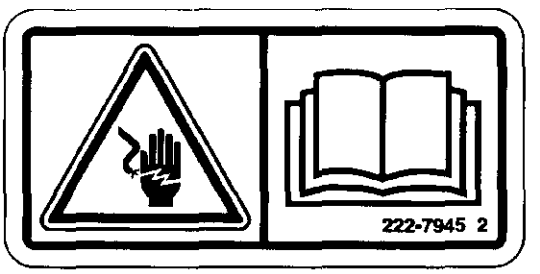
g01023710

WARNING

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

Electrical Shock (5)

This safety message is located on the sides of the generator.



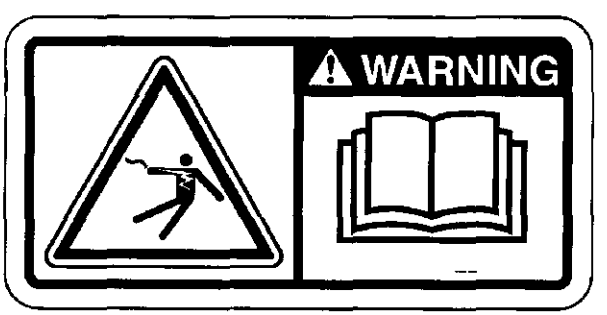
g01018792

WARNING

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

Electrocution (6)

This safety message for electrocution is located on the sides and the rear of the generator.



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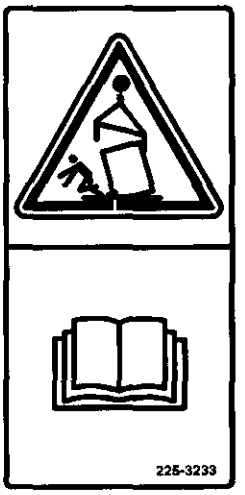
WARNING

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.

Lifting the Genset (7)

This safety message for lifting the genset is located on the frame rails for open gensets.



g01024607

⚠ WARNING

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

Do Not Climb (8)

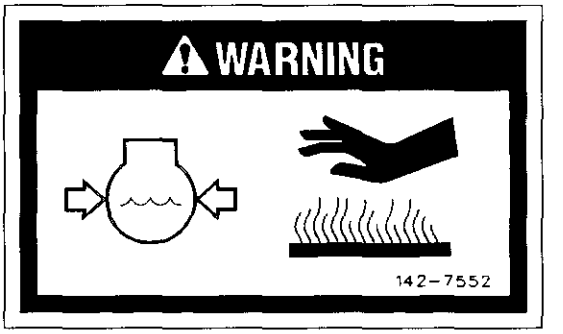
This safety message is located on the starting motor.

g00327774

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

Hot Coolant Under Pressure (9)

This safety message is located near the top of the radiator on the front.



g00107971

⚠ WARNING

The coolant is hot and the coolant is under pressure. Do not touch the hot surfaces. Refer to the Operation and Maintenance Manual for the procedure to follow when you check the radiator.

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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.

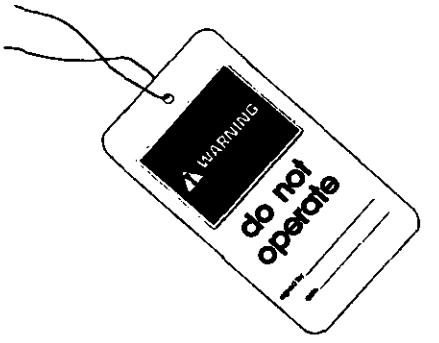

Illustration 5 g00104545

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

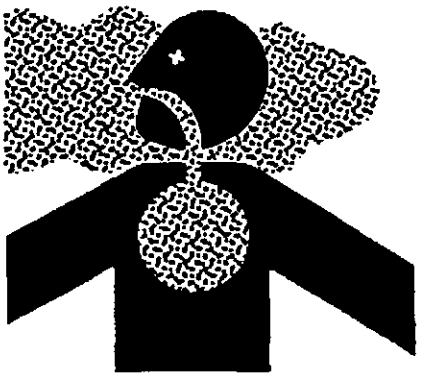

Illustration 6 g00702022

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 7 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.

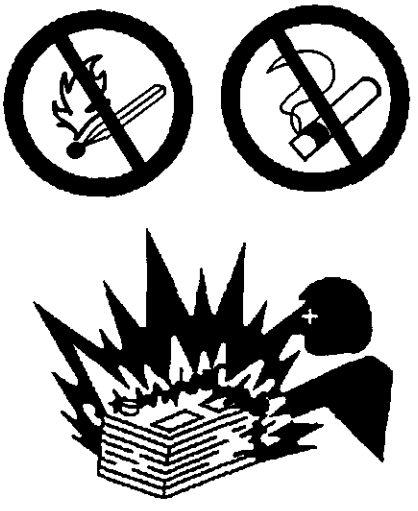

Illustration 8 g00704135

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 unit. Keep these items clean and keep these items in good repair.

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

Face the unit in order to mount the unit or dismount the unit. 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.

Some units require access to the roof of the enclosure to perform maintenance. 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.

Strong winds may lift the doors for generator enclosures off the hinge pins. If strong winds threaten to lift the doors for generator enclosures, the doors should be removed from the hinges in order to help prevent damage.

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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.

i01054945

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.

If the engine must be started by an external electrical source, then always connect the positive jump start cable "+" to the positive terminal "+" of the battery.

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.

Grounding Practices

Proper grounding for the engine electrical system is necessary for proper engine performance and reliability. Improper grounding will result in uncontrolled electrical circuit paths and unreliable electrical circuit paths.

Uncontrolled engine electrical circuit paths can result in damage to the following components: main bearings, crankshaft bearing journal surfaces, and aluminum components. All grounds should be tight and free of corrosion.

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

For engines that have an alternator that is grounded to an engine component, a ground strap must be used. The ground strap must be connected to the component and to the negative "-" battery terminal. The component must be electrically isolated from the engine.

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

The wire size that is used for the ground plate must be large enough to handle the full charging current of the alternator.

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.

i01226491

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.

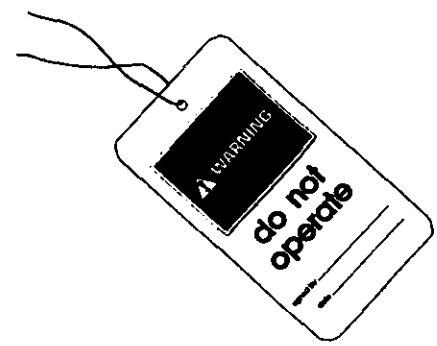


Illustration 9 g00104545

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. Remove the fuses for the transformers for the following circuitry:

   - 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.

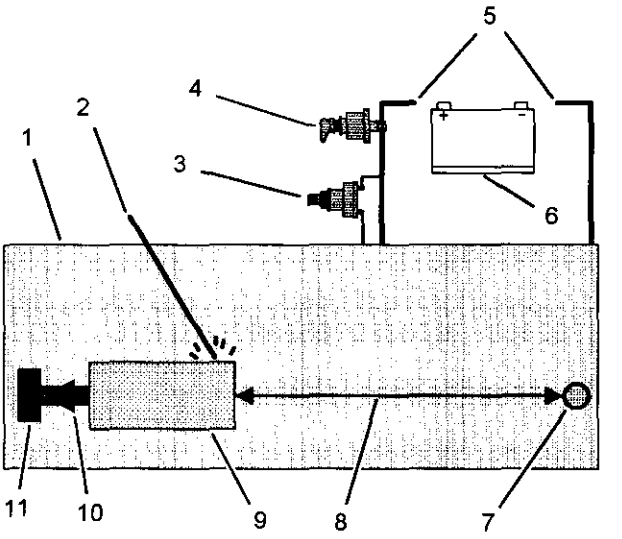


Illustration 10 g01075639

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

i01917169

Model View Illustrations

SMCS Code: 1000

The following engine model views show typical 3456 Engine features. The operator should become familiar with the locations of these items. Due to individual applications, your engine may appear different from the illustrations.

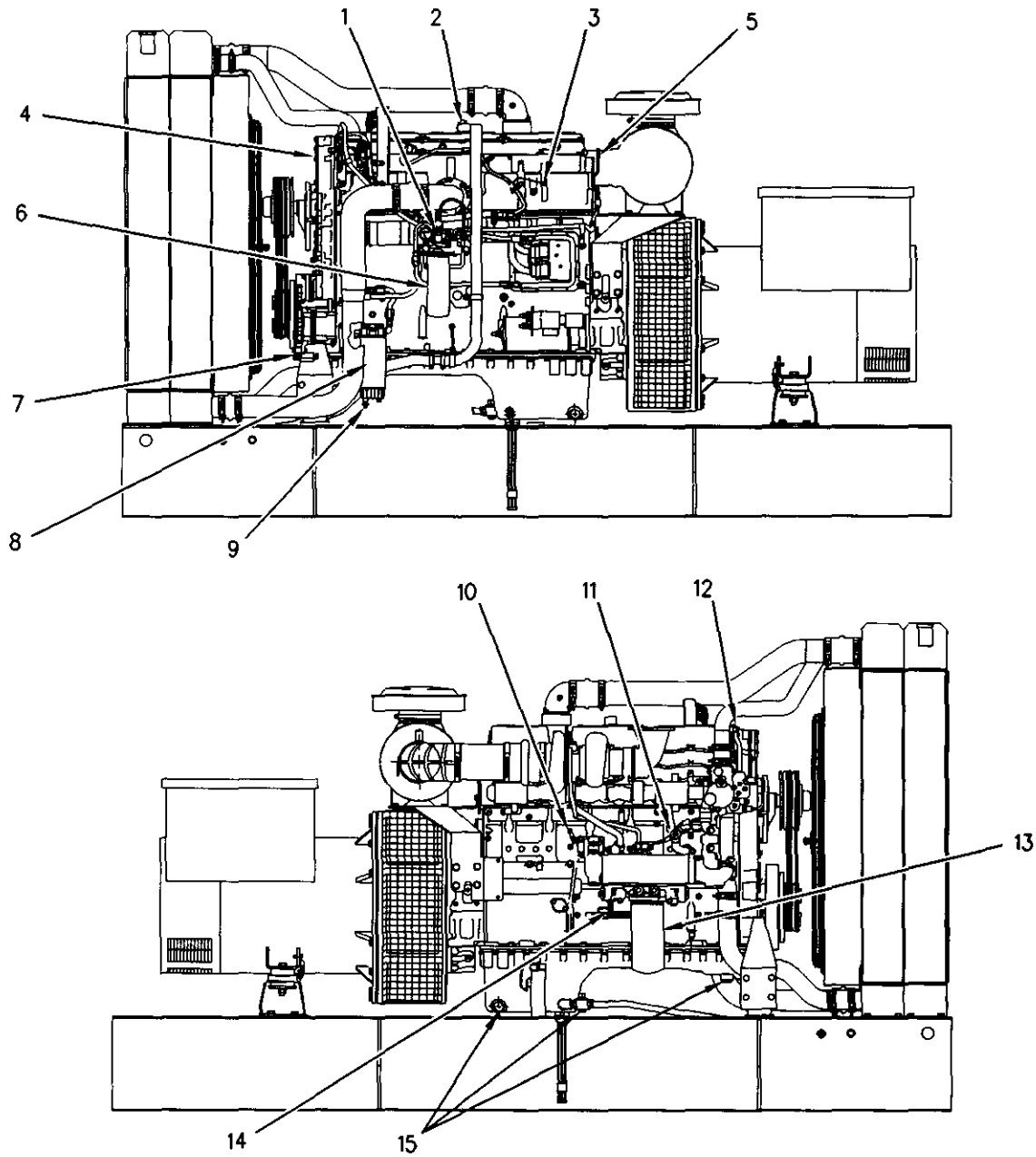


Illustration 11 g00998476

(1) Fuel priming pump
(2) Crankcase breather element
(3) Engine ground stud
(4) Fan drive belt tightener
(5) Engine lifting bracket
(6) Secondary fuel filter
(7) Alternator belt tightener
(8) Primary fuel filter/water separator
(9) Water separator drain valve
(10) Engine oil dipstick
(11) Engine oil filler cap
(12) Engine lifting bracket
(13) Engine oil filter element
(14) Engine oil sampling valve
(15) Crankcase oil drain plug

i02519770

Engine Description

SMCS Code: 1000

The Caterpillar 3456 Engine provides the following features:

- Electronic engine control
- Direct injection fuel system
- Mechanically actuated electronic unit injectors
- Turbocharged
- Air-to-air aftercooled

Electronic Engine Features

The Caterpillar 3456 Engine is specifically designed for electronic controls. This engine has 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:

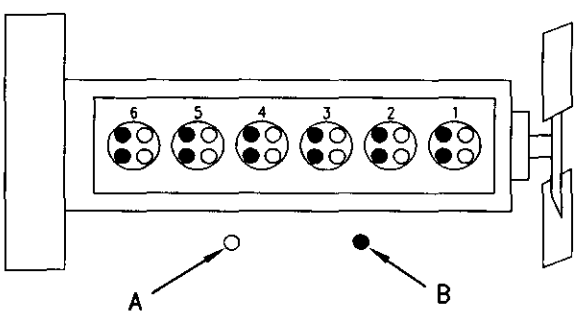
- Self-priming centrifugal type pump that is driven by gears
- Water temperature regulators which regulate the engine coolant temperature
- Engine oil cooler which is used to transfer excess heat from the engine oil to the cooling system

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 Specifications

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



g00284836

Illustration 12

Cylinder and valve locations for the 3456 Engine

(A) Inlet valves
(B) Exhaust valves

Table 1

3456 Engine Specifications	
Cylinders and Arrangement	6 cylinder in-line block
Bore	140.0 mm (5.51 inch)
Stroke	171.0 mm (6.73 inch)
Compression Ratio	16:25:1
Aspiration	TA(1), ATAAC(2)
Displacement	15.8 L (962.9 in^3)
Firing Order	1-5-3-6-2-4
Rotation (flywheel end)	Counterclockwise

(1) Turbocharged aftercooled
(2) Air-to-air aftercooled

i01907803

Generator Description

SMCS Code: 4450

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.

Product Identification Information

i01484579

Engine Identification

SMCS Code: 1000

Caterpillar engines are identified with model numbers, and serial numbers, with performance specification numbers, and with arrangement numbers. These numbers are shown on the serial number plate that is mounted on the engine.

The numbers for fuel setting information for electronic engines are stored within the personality module. These numbers can be read by using Caterpillar electronic service tools.

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

i01907817

Generator Identification

SMCS Code: 1404

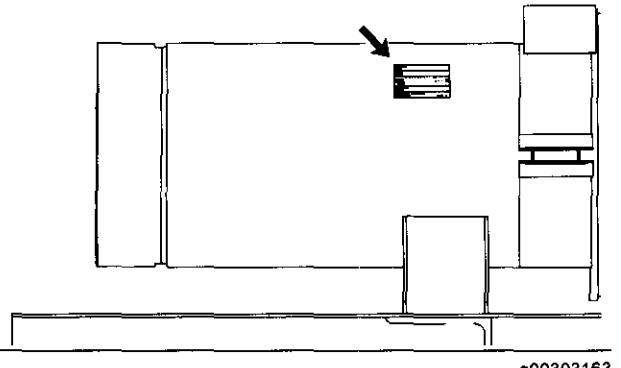


Illustration 13 g00303163

The generator serial number plate is located on the barrel of the generator.

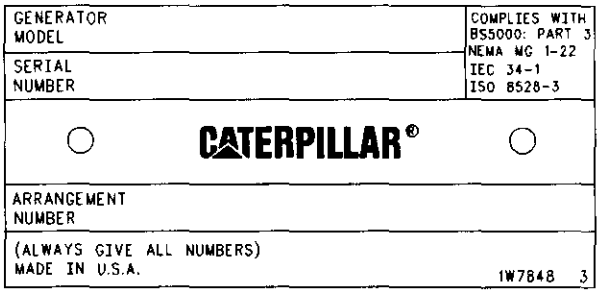


Illustration 14 g00303166

Typical generator serial number plate

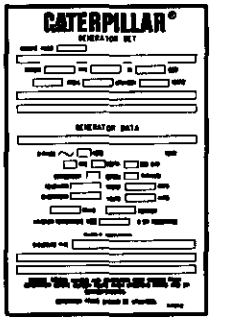


Illustration 15 g00303168

Typical generator name plate is mounted on the left hand side of the barrel.

Control Panel Identification

The controls for the generator are located in a control panel. The control panel is located in a cabinet beside the distribution panel. The part number of the control panel is located on a nameplate that is inside of the control panel.

Refer to your Caterpillar dealer for replacement parts for the control panel.

i00722073

Serial Number Plate

SMCS Code: 1000

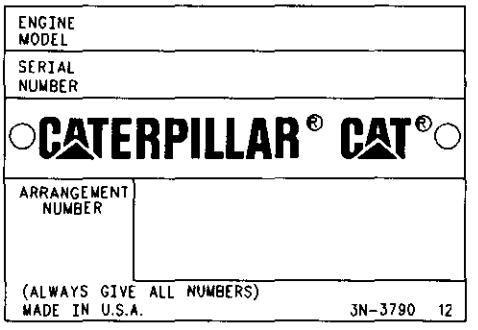


Illustration 16 g00123229

Typical serial number plate

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

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

i01100100

Information Plate

SMCS Code: 1000

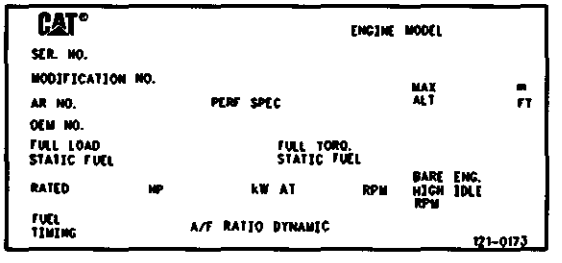


Illustration 17 g00578763

The Information Plate is on the valve cover. The following information is stamped on the Information Plate:

- The setpoint of the engine altitude derate
- Horsepower
- High idle
- Full load rpm
- Fuel settings
- Other information

i01954597

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's Serial Number _____

Generator Frame Size _____

Voltage Rating _____

kW Rating _____

Excitation System

S.E. _____

P.M. _____

AREP _____

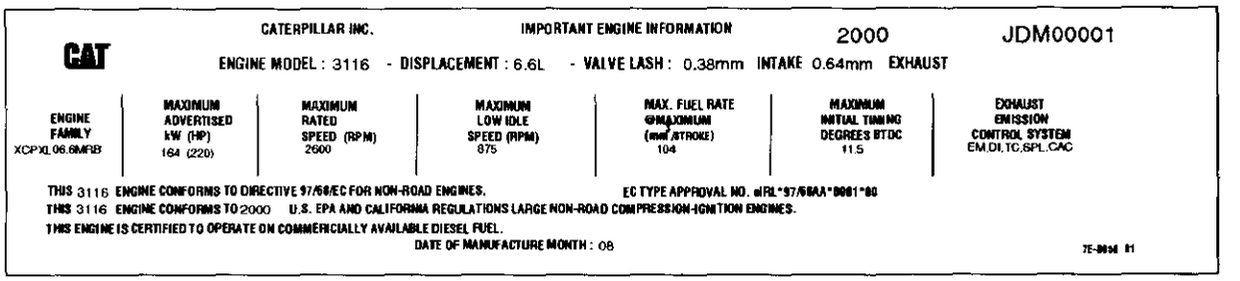
i01830750

Emissions Certification Film

SMCS Code: 1000; 7405

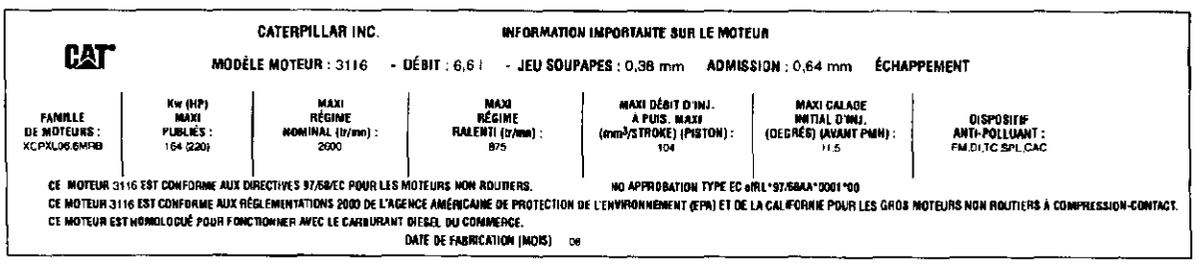
Note: This information is pertinent in the United States, in Canada and in Europe.

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 18 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_____

i01991776

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 or to the hull of a vessel. 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.

5000/6100/7000 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

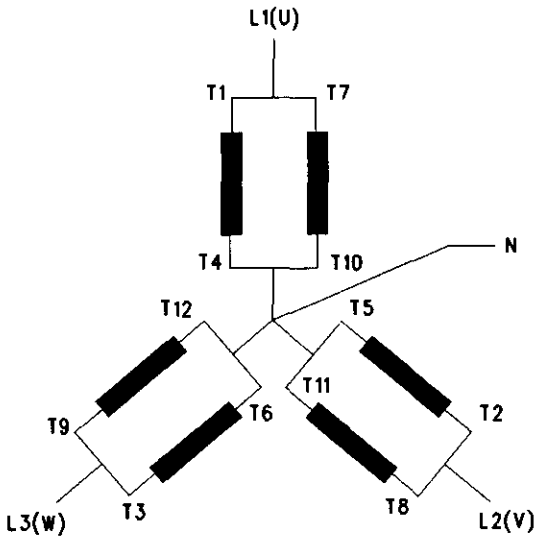


Illustration 19 g00952030

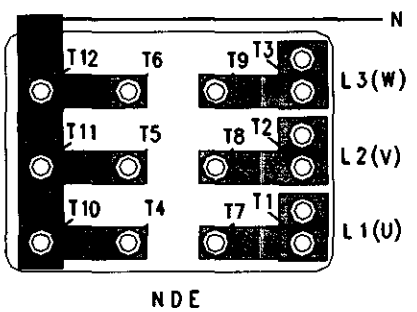


Illustration 20 g00996292

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

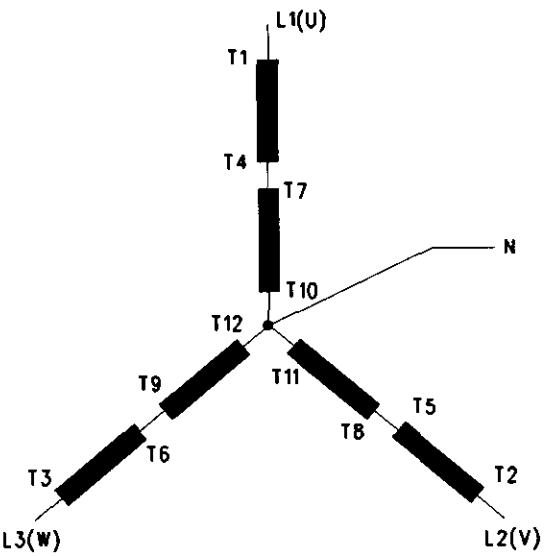


Illustration 21 g00952201

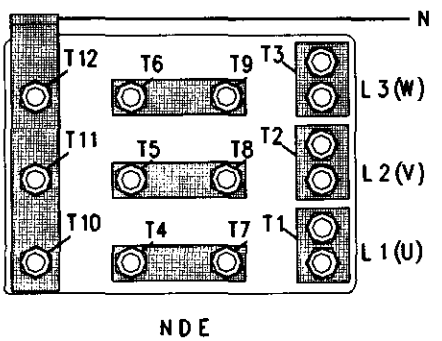


Illustration 22 g00996322

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

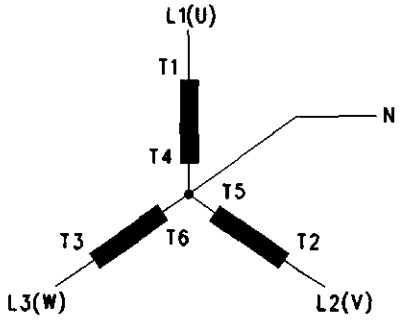


Illustration 23 g00996408

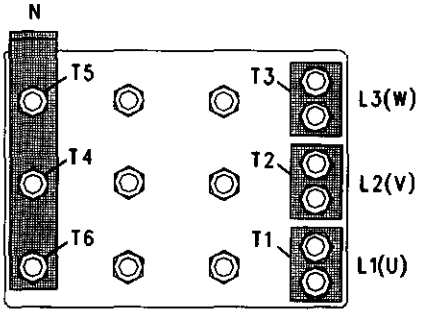


Illustration 24 g00996428

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

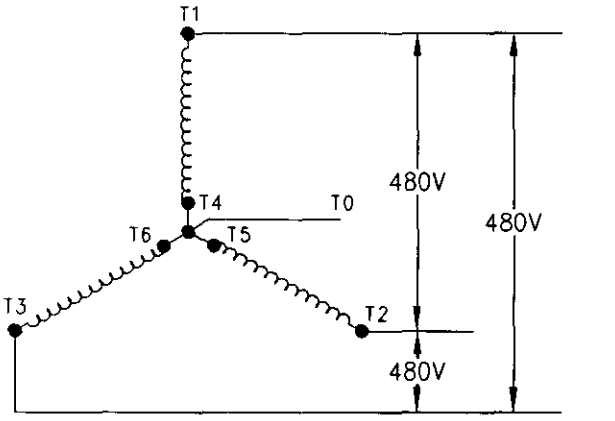


Illustration 25 g00626053

Typical Wye Configuration

12 Lead Generators

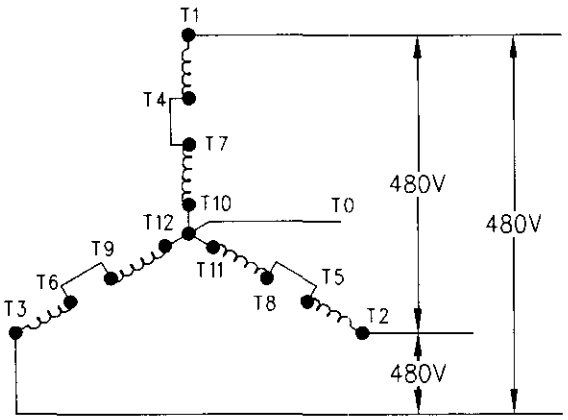


Illustration 26 g00637319

Typical Series Wye Configuration

This is a typical high voltage connection.

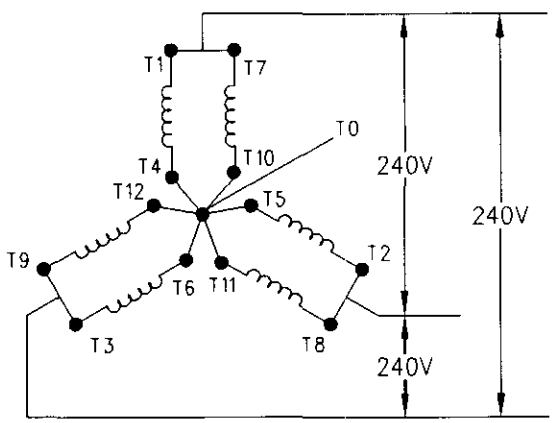


Illustration 27 g00637320

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

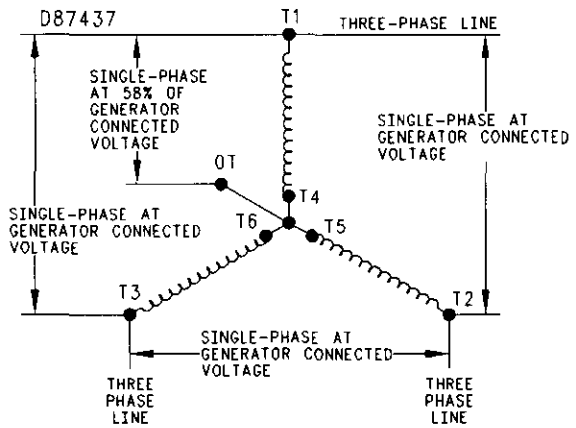


Illustration 28 g00626132

Single-Phase Wiring Diagram with 6 Lead Wye Configuration

12 Lead Generators

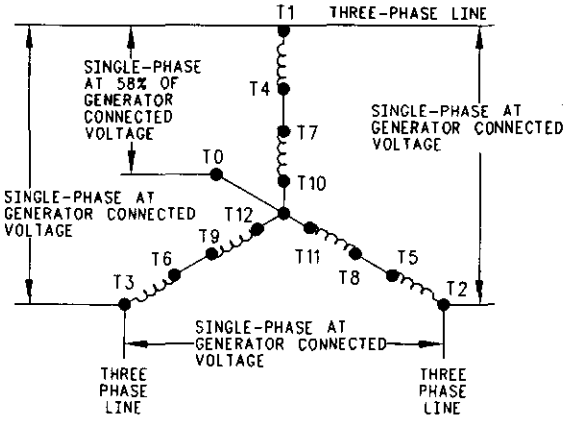


Illustration 29 g00637321

Single-Phase Wiring Diagram with 12 Lead Wye Configuration

Operation Section

Lifting and Storage

i02166058

Product Lifting

SMCS Code: 1000; 1404; 7002

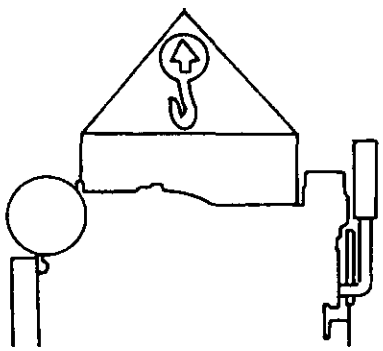


Illustration 30 g00103219

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

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

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

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

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

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

Engine Lifting with a Generator

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

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

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

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

Engine Lifting with a Fuel Tank

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

i02147124

Product Storage

SMCS Code: 1000; 1404; 7002

Short Time Storage

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

- Dust

- Dirt
- Moisture
- Other airborne abrasive substances

Long Time Storage

Engine Storage

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

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

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

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

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

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

Generator Storage

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

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

Bearing Inspection

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

Electrical Measurements

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

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

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

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

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

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

Installation

i01907903

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

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

Protective Devices

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

Gauges and Indicators

i01121260

Gauges and Indicators

SMCS Code: 1900; 7450

The electronic engine control system for this engine utilizes the Generator Set Control+ (GSC+) for engine monitoring and engine control. The GSC+ provides engine gauges for monitoring engine operating conditions. The Engine Meter key that is found in the display area of the GSC+ is used by the operator to scroll through the engine operating conditions. Alarm indicators on the GSC+ are used for annunciating engine events. If an engine shutdown, or other action is initiated by the control panel, the alarm indicator will provide the operator with information that is related to the cause of the action.

Note: For information about the Generator Set Control+ (GSC+), refer to Operation and Maintenance Manual, SEBU7050, "SR4B Generators And Control Panels".

Gauges are used to provide the operator with engine information that is necessary to monitor engine performance. Determine the normal operating range by observing gauge readings during a variety of operating conditions. Extend your observations over a long period in order to establish a reference point. Ensure that the gauges are properly maintained and that the gauges are in good condition.

Noticeable changes in gauge readings indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that abruptly change, even though the readings remain within the normal operating range. Determine and correct the cause of any significant change in the readings. Consult your Caterpillar dealer for assistance.

Your engine may not have the same gauges or all of the gauges that are indicated below.

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

Engine Oil Pressure – This gauge indicates the pressure of the engine lubrication system. Engine oil pressure will be highest after a cold engine has been started. The engine oil pressure will decrease as the engine warms up. The typical range of engine oil pressure at rated engine speed is 275 to 606 kPa (40 to 88 psi). A lower oil pressure is normal at a lower engine speed.

If the load is stable and the gauge reading changes suddenly, perform the following procedure:

1. Remove the load.
2. Reduce the engine speed to low idle.
3. Check the oil level or determine the cause of the change.

If the engine oil pressure drops below a preset value, the Low Oil Pressure indicator on the control panel will turn ON and the engine will shut down. The GSC+ and the Electronic Control Module (ECM) will log the event in internal memory.

System Battery Voltage – This gauge indicates the current battery voltage that is being measured by the ECM. A diagnostic code will be generated by the ECM if the engine experiences a high voltage condition or a low voltage condition. Engine operation may be unpredictable if a system voltage that is within an acceptable range is not maintained.

Exhaust Temperature – This gauge indicates the engine exhaust temperature. Maximum exhaust temperature is approximately 575°C (1065°F).

Engine Oil Temperature – This gauge indicates the temperature of the engine oil. The GSC+ may be programmed to shut down the engine if an excessive engine oil temperature is experienced. Maximum oil temperature at rated speed with a full load is 107 °C (224 °F).

Engine Coolant Temperature – The typical range for the engine coolant temperature is 87 to 98°C (189 to 208°F). Higher temperatures may occur under certain conditions. The engine coolant temperature reading may vary according to load. The maximum allowable temperature with a pressurized cooling system is 107 °C (224 °F). The reading should never exceed the boiling point for the pressurized system that is being used. The GSC+ may be programmed to shut down the engine if an excessive engine coolant temperature is experienced.

If the engine is operating above the normal range and steam becomes apparent, perform the following procedure:

1. Reduce the load and the engine speed.
2. Inspect the cooling system for leaks.

3. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load.

NOTICE

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

Tachometer – This gauge indicates engine speed. When the speed control is set to full throttle without load, the engine is running at high idle. The engine is running at the engine full load speed when the speed control is at full throttle with maximum rated load. The GSC+ may be programmed to shut down the engine if an engine overspeed condition is experienced.

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

Service Hour Meter – This gauge indicates the total number of clock hours that the engine has operated. Hours of engine operation are retained in ECM memory.

Features and Controls

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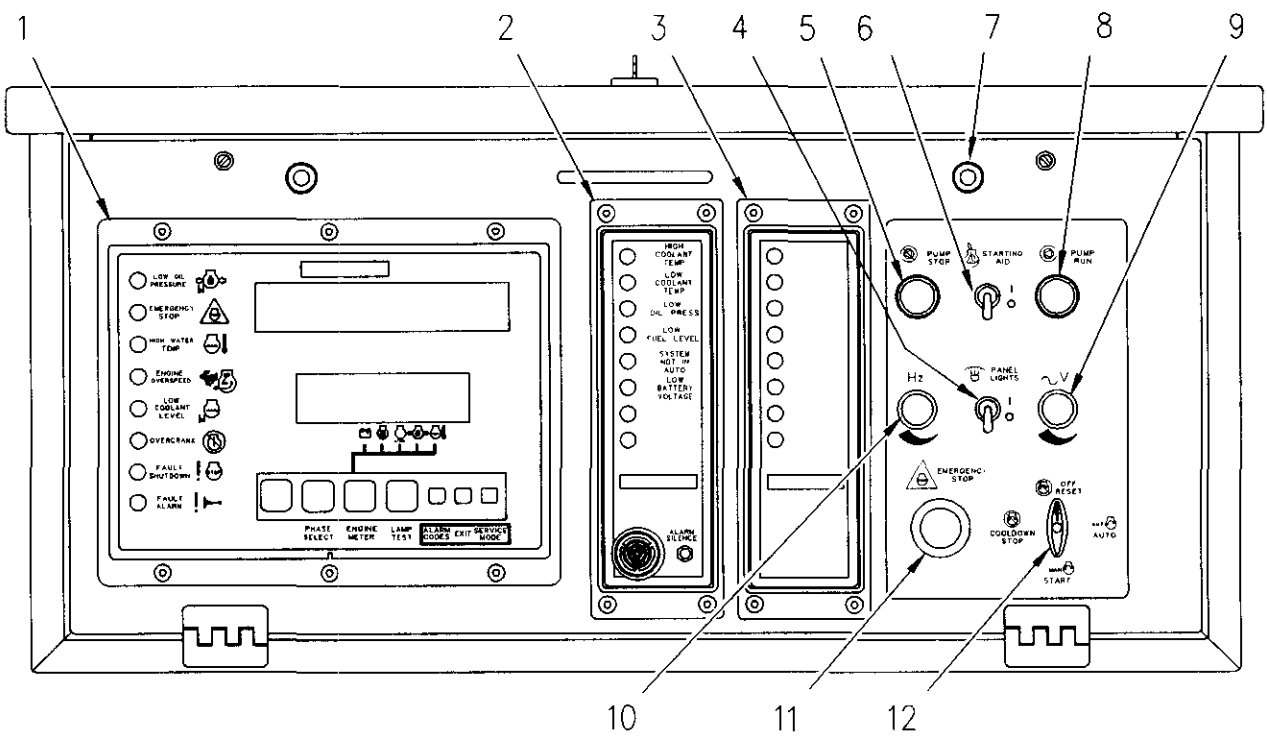
Electronic Modular Control Panel II (EMCP II)

SMCS Code: 4490



g00636226

Illustration 31

Electronic Modular Control Panel II (EMCP II)

(1) Generator set control (GSC)
(2) Alarm module (ALM) (optional)
(3) Custom alarm module (CAM) (optional)
(4) Panel light switch (PLS)
(5) Pump stop switch
(6) Start aid switch (SAS) (optional)
(7) Panel lights (PL)
(8) Pump run switch (optional)
(9) Voltage adjust rheostat (VAR)
(10) Speed potentiometer (SP) (optional) or Governor switch (GS) (optional)
(11) Emergency stop push button (ESPB)
(12) Engine control switch (ECS)

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

The left side of the control panel contains the generator set control (GSC). This is the main component of the system. The GSC displays generator output, fault conditions, and key engine parameters. The center section of the control panel may be blank, or contain one or two of the optional alarm modules.

The main control panel may or may not contain all of the components which are shown in Illustration 31. Some components are optional. The optional components may not be required for your particular application.

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

Alarm Module (2) – The alarm module (ALM) is optional. The function of the ALM is to provide a visual and audible warning of engine conditions before these conditions become severe enough to shut the engine down or keep the engine from starting.

Custom Alarm Module (3) – The custom alarm module (CAM) is optional. The purpose of the CAM is to annunciate faults, alarms or other conditions from customer supplied inputs.

Panel Light Switch (4) – The panel lights switch (PLS) turns the panel lights (7) on or off.

Pump Stop Switch (5) – The pump stop switch is optional. This push button switch is used with the generator mounted automatic fuel transfer system (if equipped). The pump stop switch is used to manually stop the fuel transfer pump. Fully depress the switch in order to latch the switch. The red indicator will now be ON. The switch can be reset by pressing the switch again. The red indicator will now be OFF.

Start Aid Switch (6) – The start aid switch (SAS) is optional. The SAS is used to inject ether into the engine when you are starting the engine in cold weather conditions. When the SAS is in the ON position, the switch energizes the starting aid solenoid valve (SASV) and the switch meters a specific amount of ether in a holding chamber. When the SAS is released, the solenoid releases the ether to the engine.

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

Panel Lights (7) – Panel lights (PL) are controlled by panel lights switch (4). The panel lights switch (4) is an ON/OFF switch.

Pump Run Switch (8) – The pump run switch is optional. This momentary push button switch is used with the generator set mounted automatic fuel transfer system(if equipped). Pushing this switch will cause the generator set that is mounted on the fuel transfer pump to fill the generator set day tank. The green indicator will be on when the pump is running. The pump will automatically shut off when the fuel reaches the high fuel level. The pump can also be turned to the OFF position manually by the pump stop switch (5). The pump stop switch must be reset. Reset the pump stop switch by pressing the switch again.

Voltage Adjust Rheostat (9) – The voltage adjust rheostat (VAR) is used to adjust the generator output voltage to the desired level.

Speed Potentiometer (10) – The speed potentiometer (SP) is optional. The SP can be used with the generator set that has an electric governor. When the governor is equipped with a speed adjust motor, the governor switch (GS) can be mounted instead of the SP. The GS is used in order to raise and in order to lower the engine speed and frequency.

Emergency Stop Push Button (11)(If Equipped) – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. The ESPB shuts off the fuel and and the ESPB activates the optional air shutoff.

Engine Control Switch (12) – The engine control switch (ECS) determines the status of the control panel. In the AUTOMATIC position (3 o'clock), the engine will start automatically whenever a remote initiating contact is closed. The engine will shut down after the initiating contact opens and a programmable cooldown period elapses. The cooldown period can be programmed to give a 0 to 30 minute cooldown period before the engine shuts down.

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

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

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

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

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

Generator Set Control (GSC)

Functions and Features of the GSC

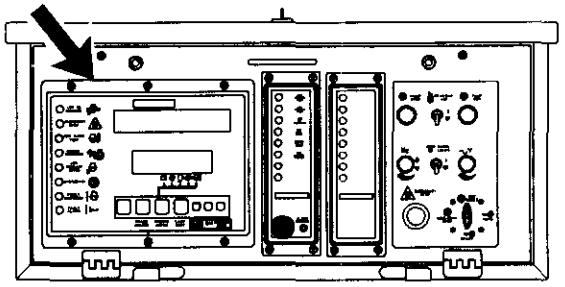


Illustration 32 g00636231

The Location of the GSC on the EMCP II Control Panel

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

The GSC receives the signal that starts the generator set. The GSC turns on the engine's fuel and starter. When the engine speed reaches the crank termination speed, the starter is disengaged. When the GSC receives a signal to stop the engine, the GSC shuts the fuel off.

The functions of the GSC are listed below.

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

The features of the GSC are listed below.

- **Cycle Crank**: The GSC can be programmed to crank for adjustable time periods. For programming instructions, refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) For MUI Engines".
- **Governor Control**: When the engine oil pressure increases past the low oil pressure set point, the GSC will indicate to the governor that the governor should increase the engine speed from idle rpm to rated RPM.
- **Cooldown**: Upon receiving a signal to perform a normal shutdown, the GSC will wait a preprogrammed amount of time before shutting the engine down by means of the fuel control.
- **Automatic Operation**: While in the automatic mode, the GSC can be started by a remote initiate signal (contact closure). Upon loss of the signal (contact opening), the GSC will perform a normal shutdown.
- **Alarm Module Communication**: The GSC can transmit fault and alarm conditions to an alarm module (AM).
- **Power Down**: The EMCP II system is designed to remove power from the GSC when the engine control switch (ECS) is in the OFF/RESET mode and when the proper jumper wire is removed. The GSC will not allow the power down until the crank termination relay and the fuel control relay are both off for about 70 seconds. If the wire is not removed, the GSC will remain powered up. For the wiring diagram and the location of the jumper wire, refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) For MUI Engines".
- **Fuel Solenoid Type**: The GSC can be programmed to work with either an energized to run (ETR) fuel system or an energized to shutdown (ETS) fuel system.

Fault indicators

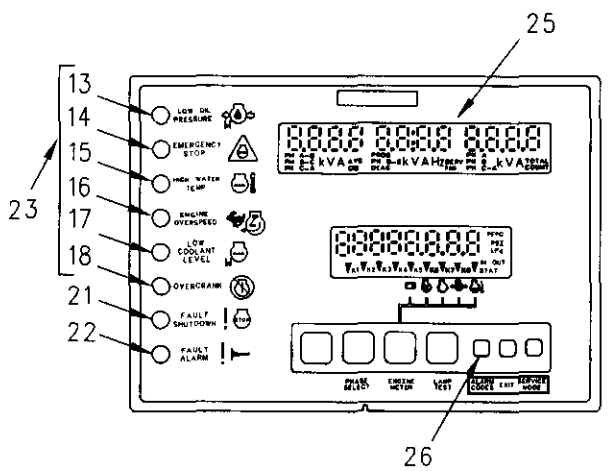


Illustration 33 g00636237

Display Area of the GSC

(13) Low oil pressure indicator
(14) Emergency stop indicator
(15) High water temperature indicator
(16) Engine overspeed indicator
(17) Low coolant level indicator
(18) Overcrank indicator
(21) Fault shutdown indicator
(22) Fault alarm indicator
(23) Dedicated shutdown indicators
(25) Upper display
(26) The alarm codes key

The eight fault indicators are used in order to show and describe a fault that is present. The fault indicators are divided into three groups. The three groups are listed below:

- fault alarm indicator (22)
- fault shutdown indicator (21)
- dedicated shutdown indicators (23)

The yellow fault alarm indicator (22) FLASHES when the GSC detects an alarm fault. The alarm fault does not cause the engine status to change. The engine can be started. The engine will continue operating if the engine is running at the time of the alarm fault. Fault alarm indicator (22) is accompanied by an alarm fault code that is shown on upper display (25) when the alarm codes key (26) is pressed. Refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) For MUI Engines" for the descriptions of the fault codes.

The red fault shutdown indicator (21) FLASHES when the GSC detects a shutdown fault. The engine will be shut down if the engine is running. The engine will not be allowed to start. Fault shutdown indicator (21) is accompanied by a fault code that is immediately shown on the upper display (25). Refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) For MUI Engines" for the descriptions of the fault codes.

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

Many of the dedicated shutdown faults depend on certain setpoints in the GSC. Refer to toSystems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) For MUI Engines" for the descriptions of the fault codes.

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

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

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

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

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

Low Coolant Level – The engine coolant level drops below the probe of the coolant loss sensor. When the low coolant level fault occurs, the engine coolant level indicator FLASHES. The engine is shut down. The engine is not allowed to start until the fault is corrected.

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

Note: The GSC can be programmed to override the shutdown for low oil pressure and high water temperature faults. When the operator overrides the shutdown faults, the GSC responds to the faults as though the faults are alarm faults. The corresponding dedicated shutdown indicator is ON CONTINUOUSLY. This indicator will not be flashing. The engine continues to run and can be restarted when necessary. When the dedicated shutdown indicator is ON CONTINUOUSLY, the setpoint for shutdown has been exceeded, but the GSC is programmed to override the shutdown fault. The GSC does not treat the shutdown fault as a shutdown fault. The GSC treats the shutdown fault as an alarm fault. At the factory, the GSC is programmed to treat a low oil pressure fault and a high water temperature fault as shutdown faults. The operator or the service technician must decide to override these shutdown faults. The operator or the service technician must program the GSC to treat the shutdown faults as alarm faults. Refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for programming procedures.

Display

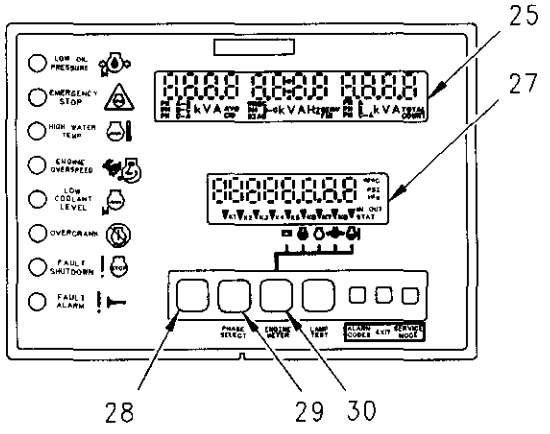


Illustration 34 g00636342

Display Area of the GSC

(25) Upper display
(27) Lower display
(28) The leftmost key
(29) The phase select key
(30) The engine meter key

The display consists of the upper display and the lower display. Both displays are used for programming functions when the GSC is in the service mode. For more information, see Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines".

Upper display

The upper display (25) shows: AC voltage, current, and frequency of one phase of the generator output. Each phase can be viewed one at a time by pushing phase select key (29). The upper display (25) is also used to show the various fault codes for system faults. For more information on fault codes, refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines".

Lower display

The lower display (27) shows: system battery voltage, engine hours, engine speed, engine oil pressure, engine coolant temperature, and the relay status.

The value for one of these conditions is shown for two seconds. After 2 seconds, the display scrolls to the value for the next condition. A small pointer identifies the engine condition that corresponds to the value which is showing. When the engine meter key (30) is pressed, the lower display (27) stops scrolling. The lower display (27) continuously shows one particular value. The pointer flashes above the condition which value is showing. When engine meter key (30) is pressed for a second time, the display (27) will return to scrolling.

The relay status indicators are on the bottom of the lower display (27). When a GSC relay is activated, the corresponding indicator (K1, K2, etc) is shown on the lower display (27). When a relay is not activated, the corresponding indicator (K1, K2, etc) is not shown. See the Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for a description of the relay functions.

Keypad

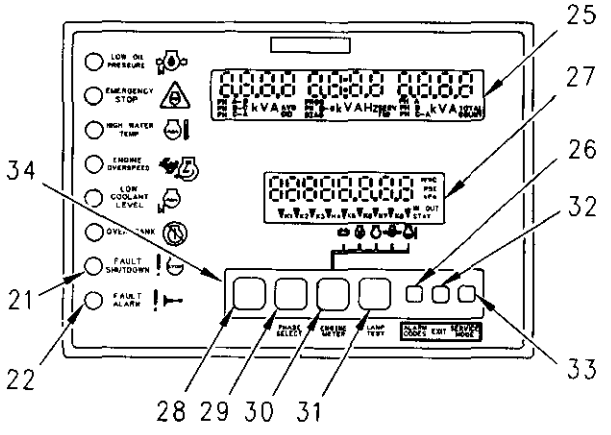


Illustration 35 g00636347

Keypad Area of the GSC

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

Keypad (34) is used to control the information that is shown on the upper display (25) and the lower display (27). The seven keys have two sets of functions: normal functions and service functions. See Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for a description of the service functions of the keys. The normal functions of the keys are described in the following paragraphs.

Leftmost Key (28) – This key only functions when the GSC is in service mode. This key is used to scroll right.

Phase Select Key (29) – This key selects which phase of the generator output is displayed on the GSC. When you press this key, the display shows the voltage, current, and frequency of each phase one at a time.

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

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

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

Exit Key (32) – This key only functions when the GSC is in Service Mode. See Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for more information.

Service Mode Key (33) – Pressing this key causes the GSC to enter service mode. See Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for more information.

Alarm Module

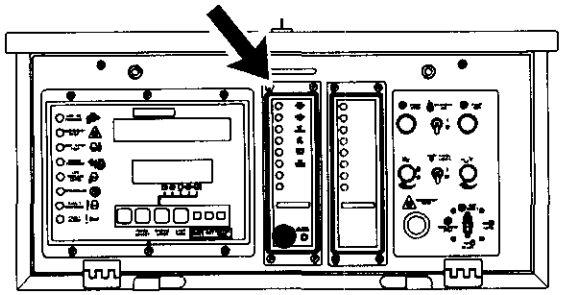


Illustration 36 g00636352

The Location of the Alarm Module (ALM) on the EMCP II Control Panel

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

One basic alarm module is used to satisfy the requirements for a standby NFPA 99 alarm module, standby NFPA 110 alarm module, NFPA 99 remote annunciator panel, and prime power alarm. This is accomplished by using different inputs to the module and different decals on the front of the module in order to indicate alarms or shutdown conditions. Refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for all wiring and installation information. Refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for a listing of indicators and alarm (horn) functions.

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

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

For more detailed information, refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines".

Custom Alarm Module

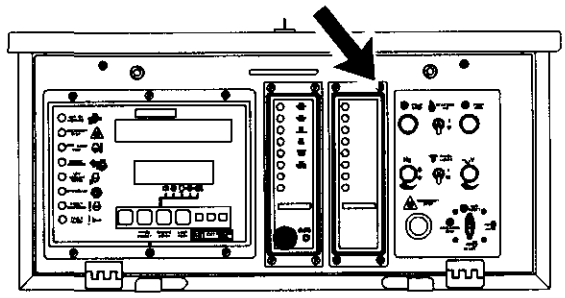


Illustration 37 g00636353

The Location of the Custom Alarm Module (CAM) on the EMCP II Control Panel

The custom alarm module (CAM) is optional. The CAM is located in the center of the control panel. The function of the custom alarm module is to provide a visual and audible warning of the conditions of the customer supplied inputs before these conditions become severe enough that the engine will shut down or will be unable to start. The CAM is equipped with a horn, alarm silence switch, a lamp test switch and 8 switched inputs for customer use. Refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for all wiring and installation information. Refer to Systems Operation, Testing and Adjusting, SENR5809, "Electronic Modular Control Panel II (EMCP II) for MUI Engines" for the names of input signals.

Note: A basic version of the CAM also exists. The basic version does not have a horn, an alarm/silence switch or a lamp test switch. The basic CAM should be used with an existing fully equipped CAM or an existing alarm module (ALM).

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

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

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Electronic Modular Control Panel II+ (EMCP II+)

SMCS Code: 4490

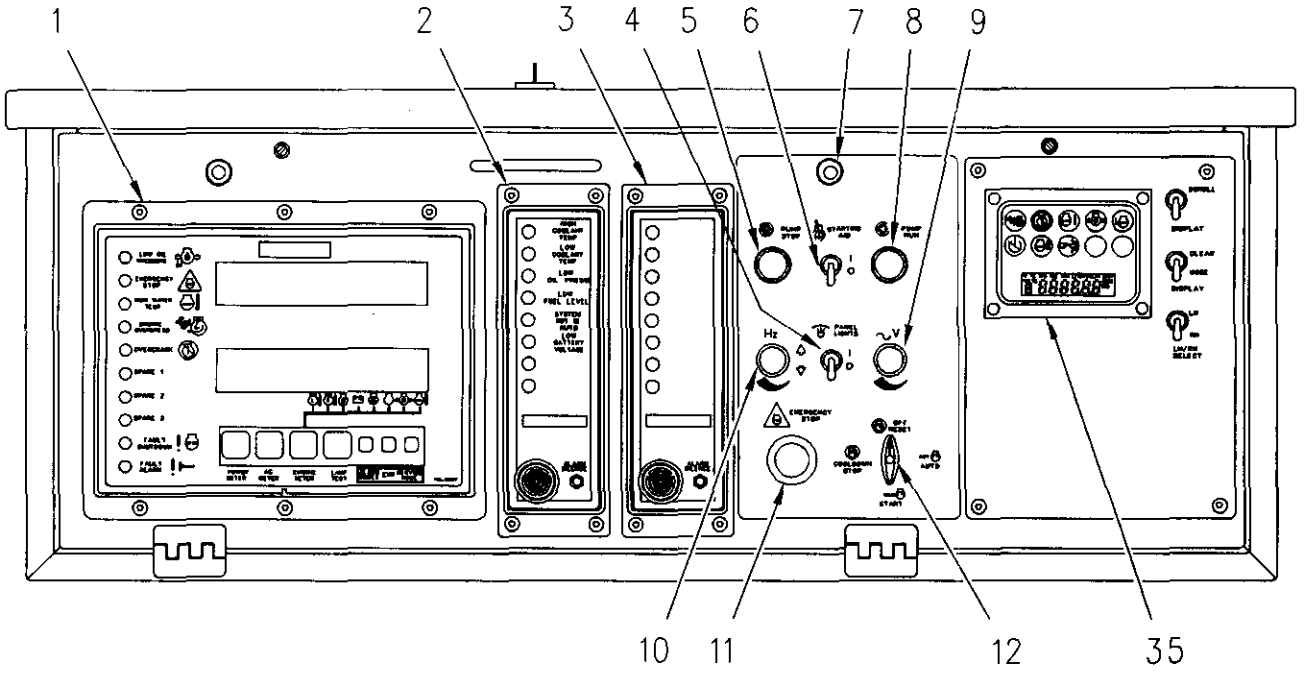

Illustration 38 g00638311

Electronic Modular Control Panel II+ (EMCP II+)

(1) Generator set control + (GSC+)
(2) Alarm module (ALM) (optional)
(3) Custom alarm module (CAM) (optional)
(4) Panel light switch (PLS)
(5) Pump stop switch
(6) Start aid switch (SAS) (optional)
(7) Panel lights (PL)
(8) Pump run switch (optional)
(9) Voltage adjust rheostat (VAR)
(10) Speed potentiometer (SP) (optional) or Governor switch (GS) (optional)
(11) Emergency stop push button (ESPB)
(12) Engine control switch (ECS)
(35) Caterpillar Monitoring System (optional)

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

The left side of the control panel contains the generator set control + (GSC+). This is the main component of the system. The GSC+ displays generator output, fault conditions, and key engine parameters. The center section of the control panel may be blank, or contain one or two of the optional alarm modules. The right side of the control panel may be blank, or contain the Caterpillar Monitoring System (35).

The main control panel may or may not contain all of the components which are shown in Illustration 38. Some components are optional. The optional components may not be required for your particular application.

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

Alarm Module (2) – The alarm module (ALM) is optional. The function of ALM is to provide a visual and audible warning of engine conditions before these conditions become severe enough to shut the engine down or keep the engine from starting.

Custom Alarm Module (3) – The custom alarm module (CAM) is optional. The purpose of the CAM is to annunciate faults, alarms or other conditions from customer supplied inputs.

Panel Light Switch (4) – The panel lights switch (PLS) turns the panel lights (7) on or off.

Pump Stop Switch (5) – The pump stop switch is optional with 3406E and 3412C generator sets only. This push button switch is used with the generator mounted automatic fuel transfer system, if equipped. The pump stop switch is used to manually stop the fuel transfer pump. This switch is latched down when pushed. The red indicator will now be ON. The switch can be reset by pressing the switch again. The red indicator will now be OFF.

Start Aid Switch (6) – The start aid switch (SAS) is optional. The SAS is used to inject ether into the engine when you are starting the engine in cold weather conditions. When the SAS is in ON position, the switch energizes the starting aid solenoid valve (SASV) and meters a specific amount of ether in a holding chamber. When the SAS is released, the solenoid releases the ether to the engine.

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

Panel Lights (7) – Panel lights (PL) are controlled by panel lights switch (4). The panel lights switch (4) is an ON/OFF switch.

Pump Run Switch (8) – The pump run switch is optional. This momentary push button switch is used with the generator set mounted automatic fuel transfer system, if equipped. Pushing this switch will cause the generator set mounted fuel transfer pump to fill the generator set day tank. The green indicator will be ON when the pump is running. The pump will automatically shut OFF when the fuel reaches the high fuel level. The pump can also be turned OFF manually by the pump stop switch (5). The pump stop switch must be reset. Reset the pump stop switch by pressing the switch again.

Voltage Adjust Rheostat (9) – The voltage adjust rheostat (VAR) is used to adjust the generator output voltage to the desired level.

Speed Potentiometer (10) – The speed potentiometer (SP) is optional. The SP can be used with the generator set that has an electric governor. When the governor is equipped with a speed adjust motor, the governor switch (GS) can be mounted instead of the SP. The GS is used to raise or lower the engine speed and frequency. The GS is also an option.

Emergency Stop Push Button (11) – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. The ESPB shuts off the fuel and activates the optional air shutoff, if equipped.

Engine Control Switch (12) – The engine control switch (ECS) determines the status of the control panel. In the AUTOMATIC position (3 o'clock), the engine will start automatically whenever a remote initiating contact is closed. The engine will shutdown after the initiating contact opens and after a programmable cooldown time has elapsed. The cooldown time can be programmed to give a 0 to 30 minute cooldown period before the engine shuts down.

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

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

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

Caterpillar Monitoring System (35) – This system is the information center for the engine and related components. See the Operation Section, "Caterpillar Monitoring System" for more information.

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

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

Generator Set Control + (GSC+)

Functions and features of the GSC+

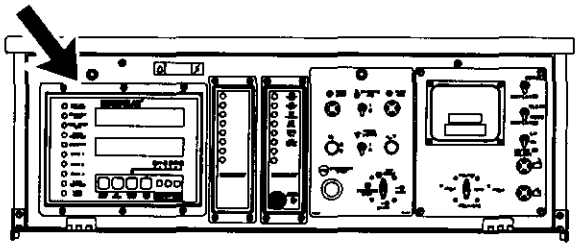

Illustration 39 g00634036

The Location of the GSC+ on the EMCP II+ Control Panel

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

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

The functions of the GSC+ are listed below.

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

The features of the GSC+ are listed below.

- **Cycle Crank**: The GSC+ can be programmed to crank for adjustable time periods. For programming instructions, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".
- **Governor Control**: When the engine oil pressure increases past the low oil pressure set point, the GSC+ will indicate to the governor that the governor should increase the engine speed from idle rpm to rated RPM.
- **Cooldown**: Upon receiving a signal to perform a normal shutdown, the GSC+ will wait a preprogrammed amount of time before shutting the engine down by means of the fuel control.
- **Automatic Operation**: While in the automatic mode, the GSC+ can be started by a remote initiate signal (contact closure). Upon loss of the signal (contact opening), the GSC+ will perform a normal shutdown.
- **Alarm Module Communication**: The GSC+ can transmit fault and alarm conditions to an alarm module (AM).
- **Power Down**: The EMCP II+ system is designed to remove power from the GSC+ when the engine control switch (ECS) is in the OFF/RESET mode and when the proper jumper wire is removed. The GSC+ will not allow the power down until the crank termination relay and the fuel control relay are both off for about 70 seconds. If the wire is not removed, the GSC+ will remain powered up. For the wiring diagram and the location of the jumper wire, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".
- **Fuel Solenoid Type**: The GSC+ can be programmed to work with either an energized to run (ETR) fuel system or an energized to shutdown (ETS) fuel system.

Fault indicators

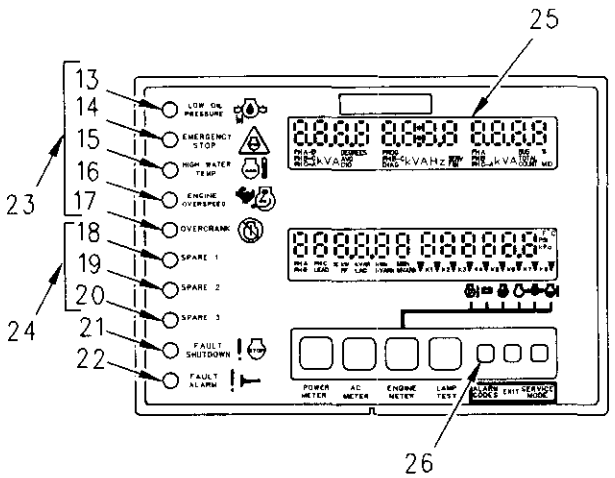

Illustration 40 g00643441

Display Area of the GSC+

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

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

- fault alarm indicator (22)
- fault shutdown indicator (21)
- spare fault indicators (24)
- dedicated shutdown indicators (23)

The yellow fault alarm indicator (22) FLASHES when the GSC+ detects an alarm fault. The alarm fault does not cause the engine status to change. The engine can be started. The engine will continue operating only if the engine is running at the time of the alarm fault. Fault alarm indicator (22) is accompanied by an alarm fault code that is shown on the upper display (25) when the alarm codes key (26) is pressed. For the descriptions of the fault codes, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".

The red fault shutdown indicator (21) FLASHES when the GSC+ detects a shutdown fault. The engine will be shut down if the engine is running. The engine will not be allowed to start. Fault shutdown indicator (21) is accompanied by a fault code that is immediately shown on the upper display (25). For the descriptions of the fault codes, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".

The yellow spare fault indicators (24) FLASH when the conditions that are associated with that spare fault are active. The three spare faults can be programmed to show coolant loss, oil temperature, spare fault condition or no assignment. The spare fault condition may be a customer generated switch input. The yellow fault alarm indicator (22) or the red fault shutdown indicator (21) will accompany the spare fault indicators (24). The spare fault indicators will tell whether the spare fault input is programmed to be an alarm condition or a shutdown condition. For the descriptions of the fault codes, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".

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

Many of the dedicated shutdown faults depend on certain setpoints in the GSC+. For the descriptions of the fault codes, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".

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

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

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

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

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

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

Note: The GSC+ can be programmed to override the shutdown for low oil pressure and high water temperature faults. When the operator overrides the shutdown faults, the GSC+ responds to the faults as though the faults are alarm faults. The corresponding dedicated shutdown indicator is ON CONTINUOUSLY and will not be flashing. The engine continues to run and can be restarted when necessary. When the dedicated shutdown indicator is ON CONTINUOUSLY, the setpoint for shutdown has been exceeded, but the GSC+ is programmed to override the shutdown fault. The GSC+ does not treat the shutdown fault as a shutdown fault. The GSC+ treats the shutdown fault as an alarm fault. At the factory, the GSC+ is programmed to treat a low oil pressure fault and a high water temperature fault as shutdown faults. The operator or the service technician must decide to override these shutdown faults. The operator or the service technician must program the GSC+ to treat the shutdown faults as alarm faults. For programming procedures, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Display

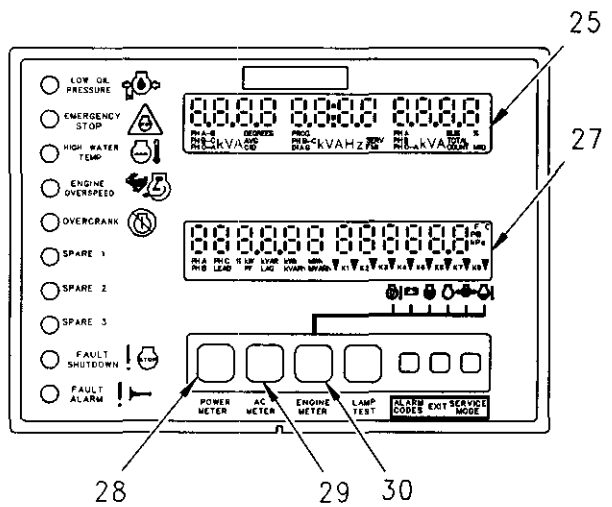

Illustration 41 g00643442

Display Area of the GSC+

(25) Upper display
(27) Lower display
(28) The power meter key
(29) The AC meter key
(30) The engine meter key

The display consists of the upper display and the lower display. Both displays are used for programming functions when in service mode. For more information, see Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Upper display

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

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

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

- Line to neutral voltage for all three phases at once

Upper display (25) is also used to show the various fault codes for system faults. For more information on fault codes, see Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

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

Lower display

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

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

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

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

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

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

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

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

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

- engine oil temperature (optional)
- system battery voltage
- engine hours
- engine speed
- engine oil pressure
- engine coolant temperature

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

The relay status indicators are on the bottom of the lower display (27). When a GSC+ relay is activated, the corresponding indicator (K1, K2, etc) is shown on the lower display (27). When a relay is not activated, the corresponding indicator (K1, K2, etc) is not shown. For a description of the relay functions, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Keypad

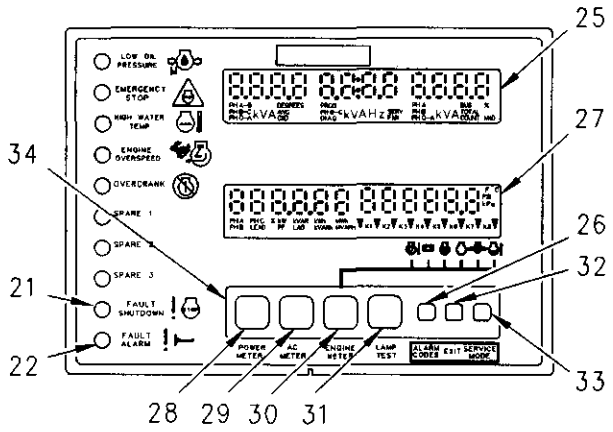

Illustration 42 g00643443

Keypad Area of the GSC+

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

Keypad (34) is used to control the information that is shown on the upper display (25) and lower display (27). The seven keys have two sets of functions: normal functions and service functions. For a description of the service functions of the keys, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)". The normal functions of the keys are described in the following paragraphs.

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

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

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

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

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

Exit Key (32) – This key only functions when the GSC+ is in Service Mode. For more information, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Service Mode Key (33) – Pressing this key causes the GSC+ to enter service mode. For more information, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Alarm Module

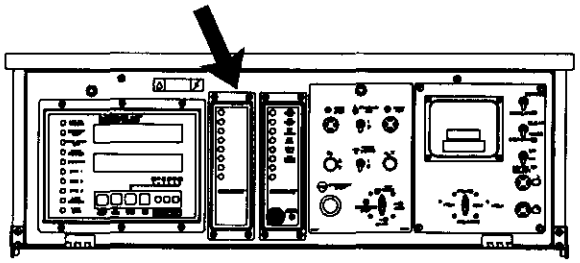

Illustration 43 g00635769

The Location of the Alarm Module (ALM) on the EMCP II+ Control Panel

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

One basic alarm module is used to satisfy the requirements for a standby NFPA 99 alarm module, standby NFPA 110 alarm module, NFPA 99 remote annunciator panel, and prime power alarm. This is accomplished by using different inputs to the module and different decals on the front of the module in order to indicate alarms or shutdown conditions. For all wiring and installation information, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)". Refer to the above manual for a listing of indicators and alarm (horn) functions.

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

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

For more detailed information, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Custom Alarm Module

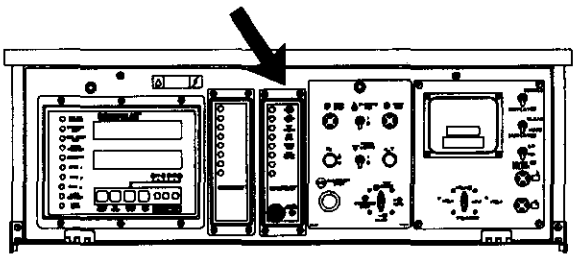

Illustration 44 g00635777

The Location of the Custom Alarm Module (CAM) on the EMCP II+ Control Panel

The custom alarm module (CAM) is optional. The CAM is located in the center of the control panel. The function of the custom alarm module is to provide a visual and audible warning of the conditions of the customer supplied inputs before these conditions become severe enough that the engine will shut down or will be unable to start. The CAM is equipped with a horn, alarm silence switch, a lamp test switch and 8 switched inputs for customer use. For all wiring and installation information, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)". Refer to the above manual for the names of input signals.

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

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

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Electronic Modular Control Panel II+ with Paralleling (EMCP II+P) (If Equipped)

SMCS Code: 4490

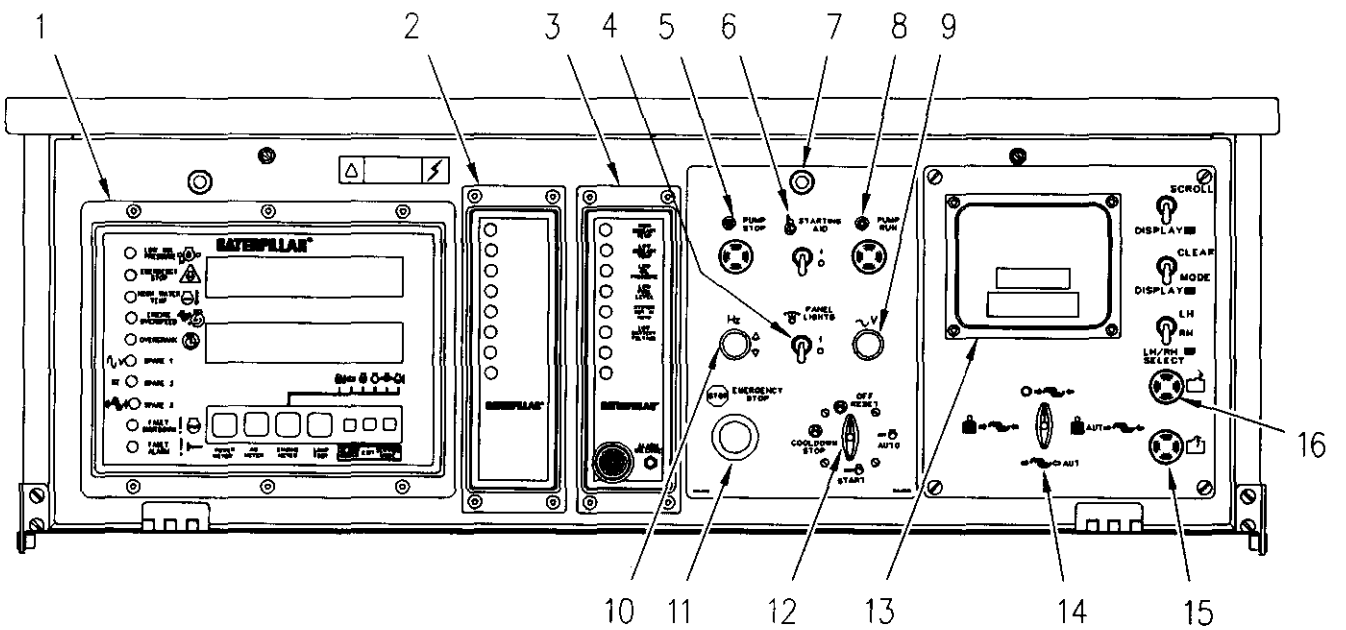

Illustration 45 g00639524

Electronic Modular Control Panel II+ With Paralleling (EMCP II+P)

(1) Generator set control + (GSC+)
(2) Alarm module (ALM) (optional)
(3) Custom alarm module (CAM)
(4) Panel light switch (PLS)
(5) Pump stop switch
(6) Start aid switch (SAS) (optional)
(7) Panel lights (PL)
(8) Pump run switch (optional)
(9) Voltage adjust rheostat (VAR)
(10) Speed potentiometer (SP) (optional) or Governor switch (GS) (optional)
(11) Emergency stop push button (ESPB)
(12) Engine control switch (ECS)
(13) Caterpillar Monitoring System
(14) Synchronization mode switch
(15) Breaker open pushbutton/indicator
(16) Breaker close pushbutton/indicator

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

The left side of the control panel contains the generator set control + (GSC+). This is the main component of the system. The GSC+ displays generator output, fault conditions, and key engine parameters. The center section of the control panel may be blank, or contain one or two of the optional alarm modules. The right side of the control panel may be blank, or contain the Caterpillar Monitoring System.

The main control panel may or may not contain all of the components which are shown in Illustration 45. Some components are optional. The optional components may not be required for your particular application.

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

Alarm Module (2) – The alarm module (ALM) is optional. The function of the ALM is to provide a visual and audible warning of engine conditions before these conditions become severe enough to shut the engine down or keep the engine from starting.

Custom Alarm Module (3) – The custom alarm module (CAM) is optional. The purpose of the CAM is to annunciate faults, alarms or other conditions from customer supplied inputs.

Panel Light Switch (4) – The panel lights switch (PLS) turns the panel lights (7) on or off.

Pump Stop Switch (5) – The pump stop switch is optional with 3406E and 3412C generator sets only. This push button switch is used with the generator mounted automatic fuel transfer system, if equipped. The pump stop switch is used to manually stop the fuel transfer pump. This switch is latched down when pushed. The red indicator will now be ON. The switch can be reset by pressing the switch again. The red indicator will now be OFF.

Start Aid Switch (6) – The start aid switch (SAS) is optional. The SAS is used to inject ether into the engine when you are starting the engine in cold weather conditions. When the SAS is in the ON position, the switch energizes the starting aid solenoid valve (SASV) and meters a specific amount of ether into a holding chamber. When the SAS is released, the solenoid releases the ether to the engine.

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

Panel Lights (7) – Panel lights (PL) are controlled by the panel lights switch (4). The panel lights switch (4) is an ON/OFF switch.

Pump Run Switch (8) – The pump run switch is optional. This momentary push button switch is used with the generator set mounted automatic fuel transfer system, if equipped. Pushing this switch will cause the generator set mounted fuel transfer pump to fill the generator set day tank. The green indicator will be ON when the pump is running. The pump will automatically shut OFF when the fuel reaches the high fuel level. The pump can also be turned OFF manually by the pump stop switch (5). The pump stop switch must be reset. Reset the pump stop switch by pressing the switch again.

Voltage Adjust Rheostat (9) – The voltage adjust rheostat (VAR) is used to adjust the generator output voltage to the desired level.

Speed Potentiometer (10) – The speed potentiometer (SP) is optional. The SP can be used with the generator set that has an electric governor. When the governor is equipped with a speed adjust motor, the governor switch (GS) can be mounted instead of the SP. The GS is used to raise or lower the engine speed and frequency. The GS is also optional.

Emergency Stop Push Button (11) – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. The ESPB shuts off the fuel and activates the optional air shutoff, if equipped.

Engine Control Switch (12) – The engine control switch (ECS) determines the status of the control panel. In the AUTOMATIC position (3 o'clock), the engine will start automatically whenever a remote initiating contact is closed. The engine will shutdown after the initiating contact opens and after a programmable cooldown time has elapsed. The cooldown time can be programmed to give a 0 to 30 minute cooldown period before the engine shuts down.

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

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

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

Caterpillar Monitoring System (13) – This system is the information center for the engine and related components. See the Operation Section, "Caterpillar Monitoring System" for more information.

Synchronization Mode Switch (14) – The synchronization mode switch (14) is manually operated. The switch has four positions: the AUTO position, the SEMI-AUTO position, the MANUAL (PERMISSIVE) position, and the OFF position. Refer to Illustration 46.

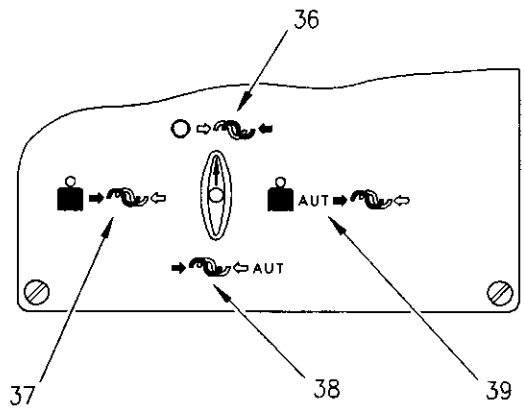

Illustration 46 g00692931

The Synchronization Mode Switch

(36) The OFF position
(37) The MANUAL (PERMISSIVE) position
(38) The AUTO position
(39) The SEMI-AUTO position

The AUTO position (6 o'clock) is used for complete automatic paralleling. The EMCP II+P brings the generator into sync with the bus and sends a signal to close the motor operated breaker. The EMCP II+P supports automatic paralleling to a dead bus. Automatic voltage matching is not provided.

When the synchronizer mode switch is in the SEMI-AUTO position (3 o'clock), the EMCP II+P brings the generator into sync with the bus and holds it there indefinitely. The operator brings the generator online by manually closing the breaker. Automatic voltage matching is not provided.

When the synchronizer mode switch is in the MANUAL (PERMISSIVE) position (9 o'clock), the operator adjusts the frequency and phase of the generator in order to match the bus. When the generator is in sync with the bus, the operator brings the generator online by manually closing the breaker.

When the synchronizer mode switch is in the OFF position (12 o'clock), all paralleling functions are disabled.

Breaker Open Pushbutton/Indicator (15) – When the generator is being taken off-line manually, the breaker open pushbutton must be pressed by the operator in order to open the breaker. When the breaker is open and the engine is running, the breaker open indicator (15) will light continuously.

Breaker Close Pushbutton/Indicator (16) – When the generator is being paralleled semi-automatically or manually, the breaker close pushbutton must be pressed by the operator in order to close the breaker. The system does not allow the breaker to close unless in sync. When the breaker is closed (generator is on line), the breaker close indicator (16) will light continuously.

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

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

Generator Set Control + (GSC+)

Functions and Features of the GSC+

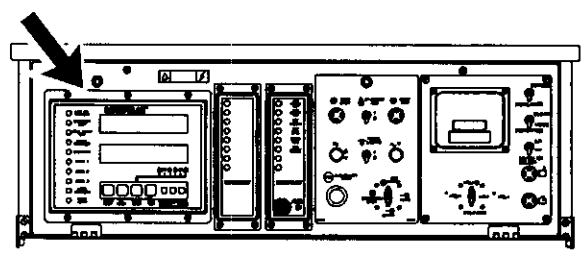

Illustration 47 g00634036

The Location of the GSC+ on the EMCP II+P Control Panel

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

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

The functions of the GSC+ are listed below.

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

The features of the GSC+ are listed below.

- **Cycle Crank**: The GSC+ can be programmed to crank for adjustable time periods. For programming instructions, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".
- **Governor Control**: When the engine oil pressure increases past the low oil pressure set point, the GSC+ will indicate to the governor that the governor should increase the engine speed from idle RPM to rated RPM.
- **Cooldown**: Upon receiving a signal to perform a normal shutdown, the GSC+ will wait a preprogrammed amount of time before shutting the engine down by means of the fuel control.
- **Automatic Operation**: While in the automatic mode, the GSC+ can be started by a remote initiate signal (contact closure). Upon loss of the signal (contact opening), the GSC+ will perform a normal shutdown.
- **Alarm Module Communication**: The GSC+ can transmit fault and alarm conditions to an alarm module (AM).
- **Power Down**: The EMCP II+P system is designed to remove power from the GSC+ when the engine control switch (ECS) is in the OFF/RESET mode and when the proper jumper wire is removed. The GSC+ will not power down until the crank termination relay and the fuel control relay are both off for about 70 seconds. If the wire is not removed, the GSC+ will remain powered up. For the wiring diagram and the location of the jumper wire, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".
- **Fuel Solenoid Type**: The GSC+ can be programmed to work with either an energized to run (ETR) fuel system or an energized to shutdown (ETS) fuel system.

Fault indicators

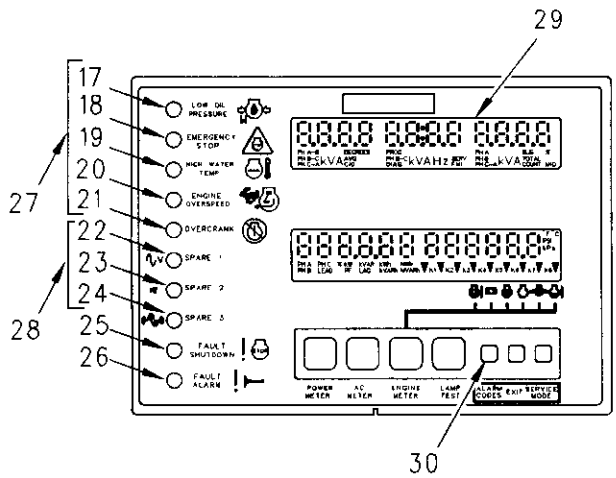

Illustration 48 g00634142

Display Area of the GSC+

(17) Low oil pressure indicator
(18) Emergency stop indicator
(19) High water temperature indicator
(20) Engine overspeed indicator
(21) Overcrank indicator
(22) Spare 1 indicator/Voltage match
(23) Spare 2 indicator/Frequency match
(24) Spare 3 indicator/Phasing match
(25) Fault shutdown indicator
(26) Fault alarm indicator
(27) Dedicated shutdown indicators
(28) Spare fault indicators
(29) Upper display
(30) The alarm codes key

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

- fault alarm indicator (26)

- fault shutdown indicator (25)
- spare fault indicators (28)
- dedicated shutdown indicators (27)

The yellow fault alarm indicator (26) FLASHES when the GSC+ detects an alarm fault. The alarm fault does not cause the engine status to change. The engine can be started. The engine will continue operating only if the engine is running at the time of the alarm fault. Fault alarm indicator (26) is accompanied by an alarm fault code that is shown on the upper display (29) when the alarm codes key (30) is pressed. For the descriptions of the fault codes, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".

The red fault shutdown indicator (25) FLASHES when the GSC+ detects a shutdown fault. The engine will shut down if the engine is running. The engine will not be allowed to start. Fault shutdown indicator (25) is accompanied by a fault code that is immediately shown on the upper display (29). For the descriptions of the fault codes, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".

The yellow spare fault indicators (28) can be used for paralleling as a redundant sync check. During the paralleling process and before the circuit breaker is closed, the lamps will indicate if the generator is in sync with the bus. The spare fault indicators are listed below.

- generator voltage match (spare 1 indicator)
- generator frequency match (spare 2 indicator)
- generator phasing match (spare 3 indicator)

If the generator parameters are not matched to the bus, the associated lamp will flash. When the generator and bus voltages, frequencies and phases are in sync, the lamps will light continuously.

When the control panel is not in a paralleling mode, the same three spare fault indicators (28) can be programmed by the customer. The three spare faults can be programmed to show coolant loss, oil temperature, spare fault condition or no assignment. The yellow spare fault indicators (28) FLASH when the conditions that are associated with that spare fault are active. The yellow fault alarm indicator (26) or the red fault shutdown indicator (25) will accompany the spare fault indicators (28). The spare fault indicators will tell whether the spare fault input is programmed to be an alarm condition or a shutdown condition. For the descriptions of the fault codes, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".

The red dedicated shutdown indicators (27) represent the following shutdown faults: low oil pressure, emergency stop, high water temperature, engine overspeed and engine overcrank. When the GSC+ detects a fault in one of these areas, the dedicated shutdown indicator (that corresponds to the fault) FLASHES. The engine is shutdown if the engine is running, and the engine is not allowed to start. No fault codes are associated with the dedicated shutdown indicators because each indicator has a descriptive label.

Many of the dedicated shutdown faults depend on certain setpoints in the GSC+. For the descriptions of the fault codes, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II + (EMCP II+)".

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

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

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

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

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

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

Note: The GSC+ can be programmed to override the shutdown for low oil pressure and high water temperature faults. When the operator overrides the shutdown faults, the GSC+ responds to the faults as though the faults are alarm faults. The corresponding dedicated shutdown indicator is ON CONTINUOUSLY and will not be flashing. The engine continues to run and can be restarted when necessary. When the dedicated shutdown indicator is ON CONTINUOUSLY, the setpoint for shutdown has been exceeded, but the GSC+ is programmed to override the shutdown fault. The GSC+ does not treat the shutdown fault as a shutdown fault. The GSC+ treats the shutdown fault as an alarm fault. At the factory, the GSC+ is programmed to treat a low oil pressure fault and a high water temperature fault as shutdown faults. The operator or the service technician must decide to override these shutdown faults. The operator or the service technician must program the GSC+ to treat the shutdown faults as alarm faults. For programming procedures, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Display

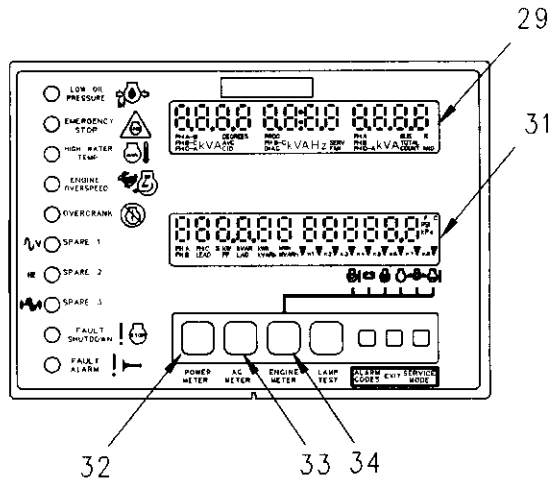

Illustration 49 g00634182

Display Area of the GSC+

(29) Upper display
(31) Lower display
(32) The power meter key
(33) The AC meter key
(34) The engine meter key

The display consists of the upper display and the lower display. Both displays are used for programming functions when in service mode. For more information, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Upper display

The EMCP II+P upper display (29) displays voltage and frequency. The voltage and frequency alternate between the generator output and the bus. The word "bus" or "gen" appears in the right side of the window. This word indicates which parameter is displayed.

Several options are available on the upper display for AC metering. These options can be viewed one at a time by pressing the AC meter key (33) on the keypad. The options are listed below.

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

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

- Line to neutral voltage for all three phases at once

Upper display (29) is also used to show the various fault codes for system faults. For more information on fault codes, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

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

Lower display

The EMCP II+P lower display (31) displays the synchronoscope. This unique display allows a simultaneous visual indication of both frequency and phase of the generator set, in reference to the bus. Additionally, the three spare indicator lamps are used to indicate the synchronization status.

The lower display (31) shows values for power metering, engine parameters and the relay status.

The left side of the lower display (31) serves as a power meter for the generator set. The following functions will scroll automatically.

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

The display will stop scrolling when the operator presses the power meter key for less than five seconds. The display will show a particular parameter continuously. Additional power meter functions will scroll if the power meter key (32) is held for more than five seconds and then released. The additional functions are shown below.

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

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

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

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

The right side of lower display (31) shows the value of certain engine parameters. The parameters are listed below.

- engine oil temperature (optional)
- system battery voltage
- engine hours
- engine speed
- engine oil pressure
- engine coolant temperature

The value for one of these conditions is shown on the display (31) for two seconds. The display then scrolls to the value for the next condition. A small pointer identifies the engine condition that corresponds to the value that is showing. When the engine meter key (34) is pressed, the lower display (31) stops scrolling. The lower display continuously shows one particular value. The pointer flashes above the value that is showing on the display. When the engine meter key (34) is pressed for the second time, the lower display will return to scrolling.

The relay status indicators are on the bottom of the lower display (31). When a GSC+ relay is activated, the corresponding indicator (K1, K2, etc) is shown on lower display (31). When a relay is not activated, the corresponding indicator (K1, K2, etc) is not shown. For a description of the relay functions, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Keypad

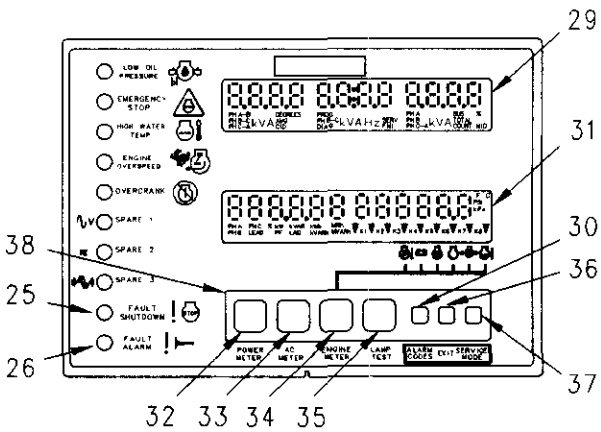

Illustration 50 g00634183

Keypad Area of the GSC+

(25) Fault shutdown indicator
(26) Fault alarm indicator
(29) Upper display
(30) Alarm codes key
(31) Lower display
(32) Power meter key
(33) AC meter key
(34) Engine meter key
(35) Lamp test key
(36) Exit key
(37) Service mode key
(38) Keypad

Keypad (38) is used to control the information that is shown on upper display (29) and lower display (31). The seven keys have two sets of functions: normal functions and service functions. For a description of the service functions of the keys, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)". The normal functions of the keys are described in the following paragraphs.

Alarm Codes Key (30) – If fault alarm indicator (26) is FLASHING, pressing this key causes the upper display (29) to show the corresponding alarm fault code. If this key is pressed again, the generator AC output information will be shown on the upper display (29). If fault alarm indicator (26) is OFF, this key has no function.

Power Meter Key (32) – This key controls the viewing of power meter information. This information is shown on the lower display. Pressing the key for at least five seconds causes all the power meter data to scroll once. The default power meter data then resumes scrolling. If this key is pressed for less than five seconds, the display will stop scrolling the power meter functions until the key is pressed again.

AC Meter Key (33) – The AC meter key controls the viewing of the AC parameters on the upper display. Pressing the key causes the display to show a different set of parameters.

Engine Meter Key (34) – This key controls the viewing of engine parameters on the lower display. Pressing the key stops the scrolling of engine conditions. The value for one particular engine condition will show continuously. The pointer flashes indicating that the scrolling is stopped. The scrolling of the engine conditions will resume when the engine meter key is pressed again.

Lamp Test Key (35) – Pressing this key performs a lamp test on the GSC+ and the optional alarm module. On the GSC+, the ten fault indicators are ON CONTINUOUSLY. Every segment of upper display (5) and lower display (6) is ON. On the optional alarm module, all of the indicators are ON and the horn sounds. The lamp test function automatically turns off if an operator presses the key and holds the key for longer than ten seconds.

Exit Key (36) – This key only functions when the GSC+ is in Service Mode. For more information, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Service Mode Key (37) – Pressing this key causes the GSC+ to enter service mode. For more information, see the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Alarm Module

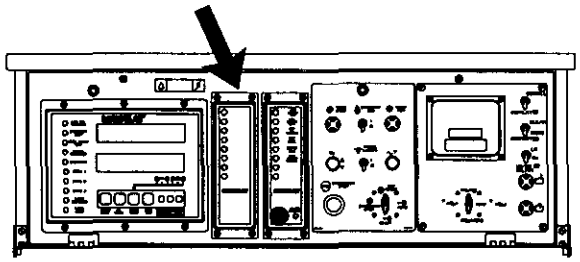

Illustration 51 g00635769

The Location of the Alarm Module (ALM) on the EMCP II+P Control Panel

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

One basic alarm module is used to satisfy the requirements for a standby NFPA 99 alarm module, standby NFPA 110 alarm module, NFPA 99 remote annunciator panel, and prime power alarm. This is accomplished by using different inputs to the module and different decals on the front of the module in order to indicate alarms or shutdown conditions. For all wiring and installation information, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)". Refer to the above manual for a listing of indicators and alarm (horn) functions.

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

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

For more detailed information, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)".

Custom Alarm Module

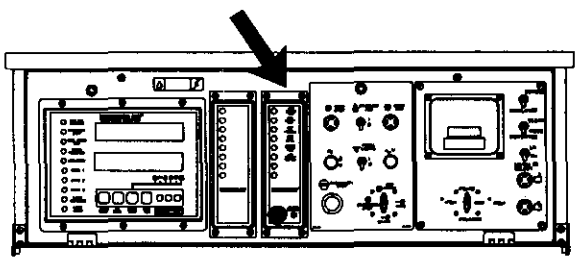

Illustration 52 g00635777

The Location of the Custom Alarm Module (CAM) on the EMCP II+P Control Panel

The Custom Alarm Module (CAM) is located in the center of the control panel. The function of the custom alarm module is to provide a visual and audible warning of the conditions of the customer supplied inputs before these conditions become severe enough that the engine will shut down or will be unable to start. The CAM has eight indicators, an audible horn, acknowledge/silence switch and the lamp test switch. Four of the indicator lamps are yellow. These yellow indicator lamps are used to indicate a fault shutdown. For all wiring and installation information, refer to the Systems Operation, Testing and Adjusting, RENR2484, "Electronic Modular Control Panel II+ (EMCP II+)". Refer to the above manual for the names of input signals.

Note: If an optional alarm module is ordered, the audible horn, acknowledge/silence switch and lamp test switch will come standard with the optional alarm module.

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

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

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Electronic Modular Control Panel 3 (EMCP 3) (If Equipped)

SMCS Code: 4490

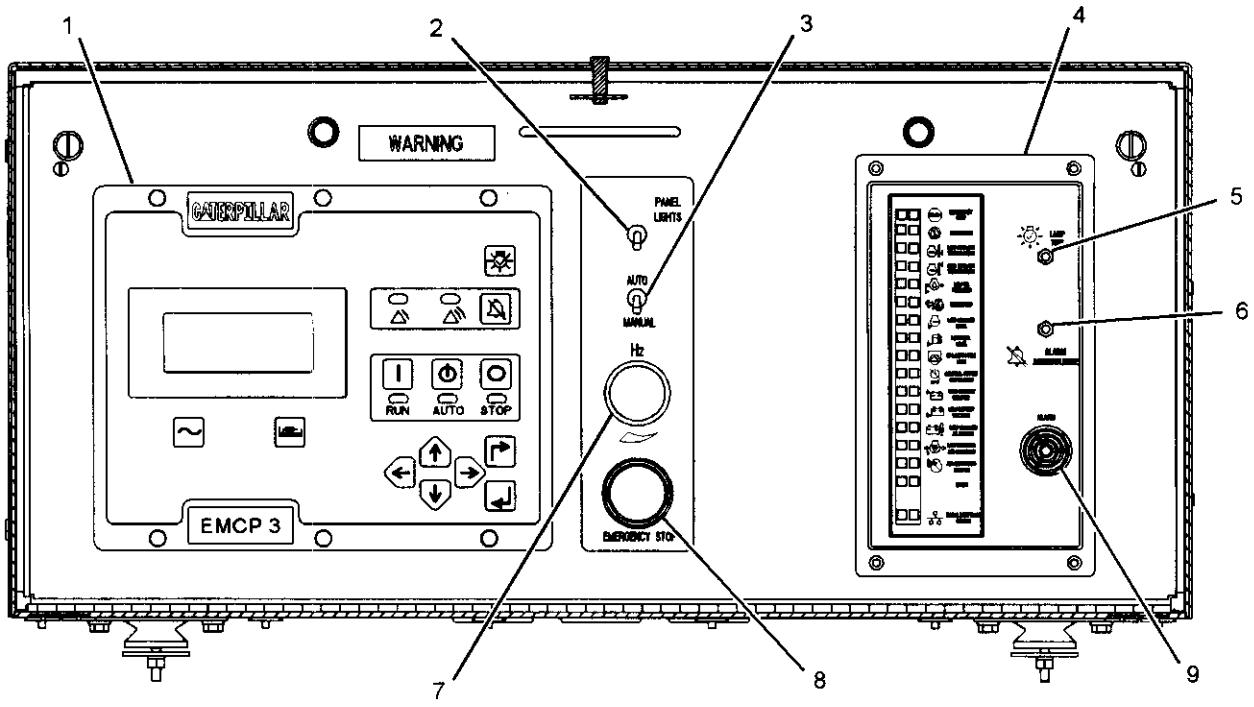

Illustration 53 g01101389

View of EMCP 3

(1) Electronic Control Module (ECM) for the Generator Set
(2) Panel Light Switch
(3) Starting Aid Auto/Manual Switch (optional)
(4) Annunciator Module
(5) Lamp Test Switch
(6) Alarm Acknowledge Switch
(7) Speed Potentiometer (optional)
(8) Emergency Stop Push Button
(9) Alarm Horn

For detailed information about the control panel, see Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, "3508B, 3512B, 3516 and 3516B Engines EMCP3".

Electronic Control Module (Generator Set)

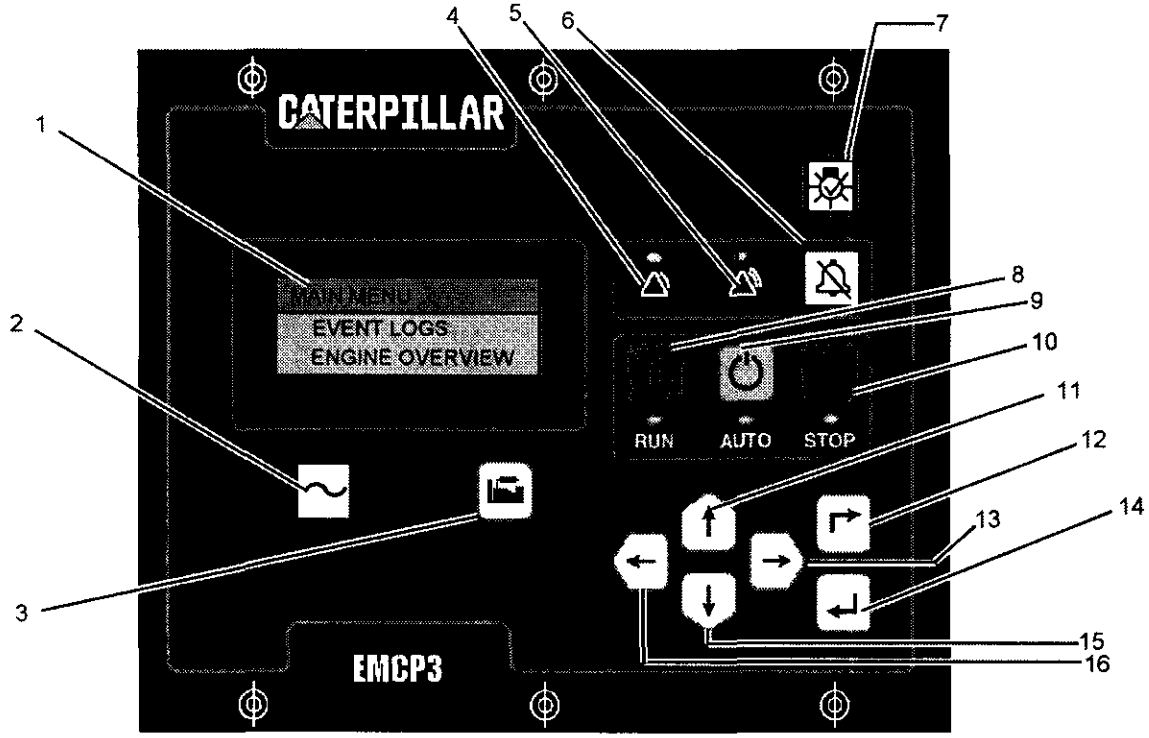

Illustration 54 g01045431

(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 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 cause the engine to enter the "RUN" mode.

AUTO Key (9) – Pressing the "AUTO" key will cause the engine to enter the "AUTO" mode.

STOP Key (10) – Pressing the "STOP" key will cause the engine to enter the "STOP" mode.

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 users 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 – 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 – 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 is cleared. Refer to System Operation, Troubleshooting, Testing and Adjusting, "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 (if programmed) and then 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, "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, "3508B, 3512B, 3516 and 3516B Engines EMCP3".

Annunciator Module

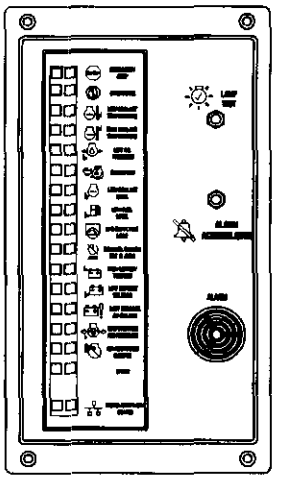

Illustration 55 g01101388

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, "3508B, 3512B, 3516 and 3516B Engines EMCP3".

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Sensors and Electrical Components

SMCS Code: 1900; 7400

Your engine may be equipped with various optional engine features and controls that are not pictured here. This section discusses the general information about various features and the engine control systems.

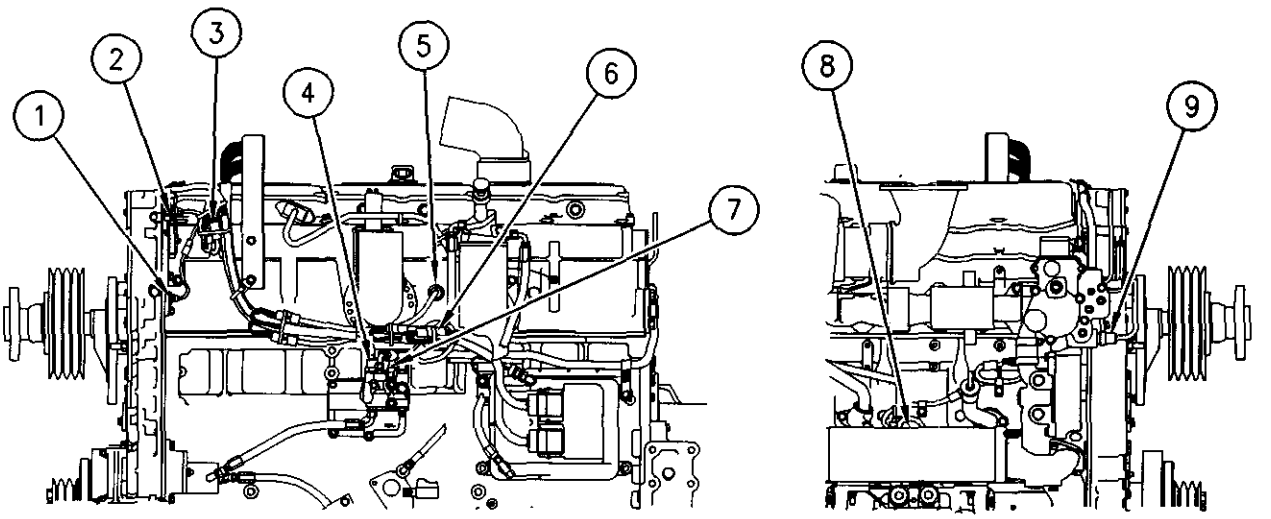

Illustration 56 g00812362

(1) Secondary Speed/Timing Sensor
(2) Primary Speed/Timing Sensor
(3) Turbocharger Outlet Pressure Sensor
(4) Fuel Temperature Sensor
(5) Inlet Air Temperature Sensor
(6) Timing Calibration Connector
(7) Atmospheric Pressure Sensor
(8) Engine Oil Pressure Sensor
(9) Coolant Temperature Sensor

Coolant Temperature Sensor

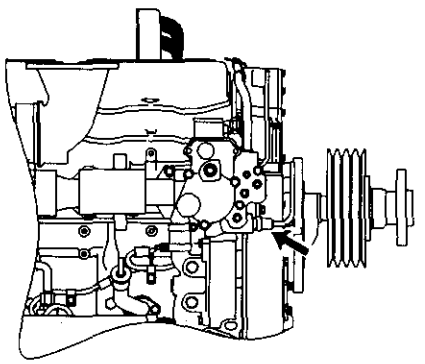

Illustration 57 g00596352

Location of the Engine Coolant Temperature Sensor

The engine coolant temperature sensor monitors the temperature of the engine coolant. The coolant temperature signal is sent to the Electronic Control Module (ECM) for engine monitoring and for improved engine control. The signal is used by the ECM for all of the following engine functions:

- Engine timing control
- Engine operating mode
- Engine protection

The ECM is capable of adjusting the engine timing relative to the engine operating temperature. The concept of dynamic timing provides the engine with the ability to control exhaust emissions. Timing control also aids in white smoke cleanup during cold engine operation.

The ECM also uses the signal from the engine coolant temperature sensor to determine the mode of operation for the engine. Several aspects of engine operation are affected by the engine operating mode: acceleration ramp rates, engine timing, and fuel injector timing

Coolant Temperature Protection

Excessive engine coolant temperature is an undesirable operating condition. Serious damage to the engine can result if an engine is allowed to overheat. If the engine coolant temperature increases to excessive levels, the engine monitoring system will initiate actions that will protect the engine from damage.

This generator set application may be equipped with an Electronic Modular Control Panel II (EMCP II) that is used to provide engine control. If this control panel is installed, the engine ECM communicates the engine coolant temperature to the control panel. The EMCP II performs the engine monitoring and protection functions for the engine.

The following engine protection is available for engine coolant temperature:

WARNING – If the engine monitoring control is programmed to "WARNING", the EMCP II will display a warning that will inform the operator of the engine overheating problem.

SHUTDOWN – If the overheating condition is allowed to continue, the EMCP II will shut down the engine. This function also has the ability to utilize a time delay.

For more detailed information about the operation of the control panel, refer to Operation and Maintenance Manual, SEBU7050, "SR4B Generators and Control Panels".

Coolant Level Sensor

The coolant level sensor is an optional sensor. This sensor monitors the engine coolant level in the cooling system expansion tank. The coolant level sensor signal is sent to the Electronic Modular Control Panel II (EMCP II) for the purpose of engine monitoring. The EMCP II can respond to a low coolant level status in either of the following manners:

- Fault alarm indicator
- Automatic engine shutdown

Coolant must be added to the cooling system in order to correct the condition.

For more detailed information about the operation of the engine coolant level sensor, refer to Operation and Maintenance Manual, SEBU7050, "SR4B Generators and Control Panels".

Engine Oil Pressure Sensor

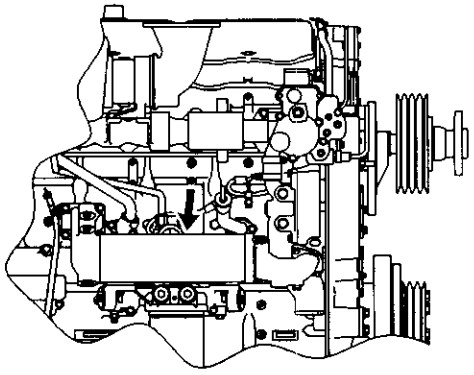

Illustration 58 g00607017

Location of the Engine Oil Pressure Sensor

The engine oil pressure sensor provides an oil pressure signal to the Electronic Control Module (ECM) for the purpose of engine monitoring. The electronic signal is compared to an Oil Pressure Map that is stored in ECM memory. The Oil Pressure Map is derived from a direct relationship between engine speed and the oil pressure that is expected at that speed. The engine monitoring system records a low engine oil pressure condition in ECM memory if the sensor value is not within the proper range. The monitoring system then initiates protective measures.

Low Oil Pressure Protection

When a low oil pressure condition exists in the engine, there is a possibility of damage to major engine components. Low oil pressure protection is a safety feature that will take the necessary measures in order to initiate an engine shutdown in the event of a low oil pressure condition.

This generator set application may be equipped with an Electronic Modular Control Panel II (EMCP II) that is used to provide engine control. If this control panel is installed, the engine ECM communicates the engine oil pressure to the control panel. The EMCP II performs the engine monitoring and protection functions for the engine.

The following engine protection is available for low oil pressure protection:

WARNING – If the engine monitoring control is programmed to "WARNING", the EMCP II will display a warning to the operator during a low oil pressure condition.

SHUTDOWN – If the engine monitoring control is programmed to "SHUTDOWN", the EMCP II will shut down the engine during a low oil pressure condition.

For more detailed information about the operation of the control panel, refer to Operation and Maintenance Manual, SEBU7050, "SR4B Generators and Control Panels".

Fuel Temperature Sensor

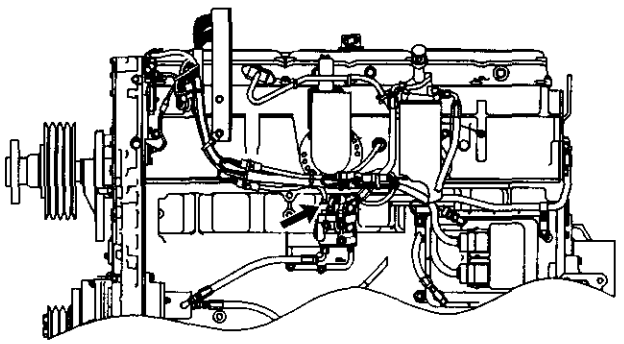

Illustration 59 g00592720

Location of the Fuel Temperature Sensor

The fuel temperature sensor monitors the inlet fuel temperature. The Electronic Control Module (ECM) utilizes the signal from the fuel temperature sensor to provide fuel temperature compensation for the engine fuel control system. Fuel temperature compensation provides the following benefits:

- Rated engine horsepower regardless of fuel temperature
- Highly accurate fuel rates and fuel consumption rates
- Optimum fuel economy

Changes in the temperature of the fuel affects the power output of the engine. The ECM adjusts the engine fuel rate according to the temperature of the fuel. This feature allows full engine power to be realized by the operator at any fuel temperature.

Fuel temperature will also affect the calculation of fuel consumption rate that is performed by the ECM. The ECM utilizes the fuel temperature signal to provide an adjusted value for these calculations.

Fuel Pressure Sensor

The fuel pressure sensor monitors filtered fuel pressure. Although fuel pressures that are outside the normal operating range may adversely affect engine performance, there should not be any noticeable reduction in the engine horsepower. Abnormal fuel pressure will not cause an engine shutdown. A low filtered fuel pressure may indicate that the low pressure fuel system requires maintenance.

The fuel pressure sensor measures the fuel pressure after the fuel has been filtered. The sensor connector for the fuel pressure sending unit is located on the machine side of the machine connector. For more information, refer to the Troubleshooting Guide for this engine.

For more information on fuel system maintenance, refer to the maintenance section in this Operation and Maintenance Manual.

Inlet Manifold Air Temperature Sensor

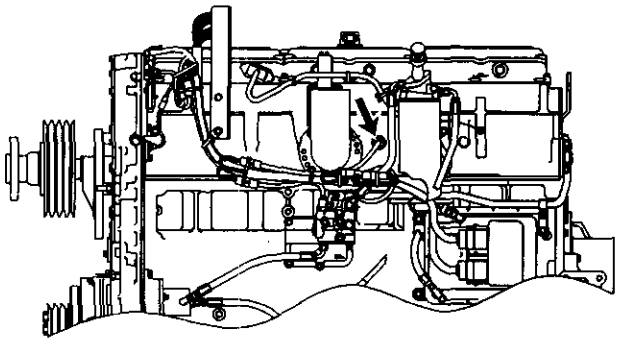

Illustration 60 g00606595

The inlet manifold temperature sensor detects the temperature of the air that is passing through the inlet manifold. A signal is sent to the Electronic Control Module (ECM) for interpretation.

The ECM uses the information from the inlet manifold temperature sensor in order to accurately control the emissions levels of the engine. As the inlet manifold air temperature changes, the fuel injection timing is advanced. This is done in order to maintain the exhaust emission standards.

Atmospheric Pressure Sensor

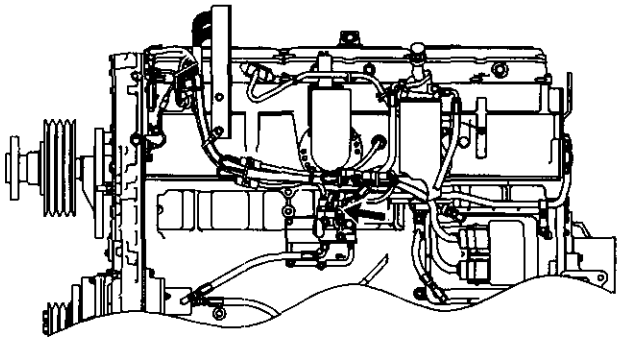

Illustration 61 g00592846

Location of the Atmospheric Pressure Sensor

The atmospheric pressure sensor measures the atmospheric pressure in the crankcase. A signal is sent to the Electronic Control Module (ECM).

The ECM utilizes the value that is read by the atmospheric pressure sensor for the following functions:

- Reference source for pressure sensor calibrations
- Calculating the operating altitude
- Calculating boost pressure
- Checking for air inlet restriction

When the ECM is powered, all of the pressure sensors that are used for engine monitoring receive an automatic calibration. The ECM uses the value that is received from the atmospheric pressure sensor to calculate the pressure offset value.

The ECM also utilizes atmospheric pressure to determine the active engine derate during high elevation operation. The engine monitoring system compares the current atmospheric pressure value to the programmed derate setpoint. The engine is derated by limiting the fuel delivery at a rate of approximately 3 percent for each 304 m (1000 ft) of elevation.

Actual boost pressure is calculated by the ECM. The difference between the turbocharger outlet pressure and the atmospheric pressure is equal to the actual boost pressure. Boost pressure is used for calculating fuel system adjustments.

Turbocharger Outlet Pressure Sensor

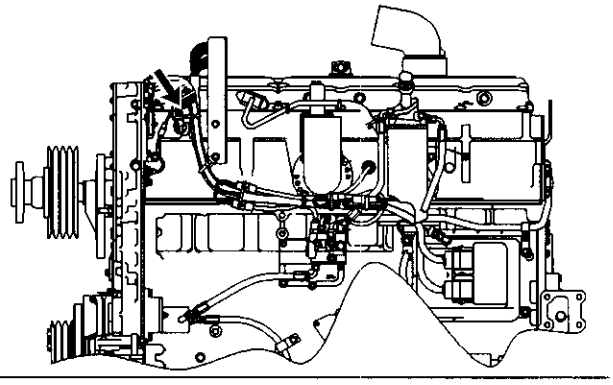

Illustration 62 g00613401

Connector location of the Turbocharger Compressor Outlet Pressure Sensor

The turbocharger outlet pressure sensor measures the pressure of the turbocharged aftercooled air from a port in the air intake manifold. The sensor provides a signal to the Electronic Control Module (ECM) that is used to calculate turbocharger boost pressure. The ECM derives boost pressure by taking the difference between the turbocharger outlet pressure and the atmospheric pressure.

Engine boost and actual engine speed are used by the ECM to govern the fuel air ratio control and the fuel rack limiting functions. During a change in speed or a change in load, the ECM adjusts the fuel injector delivery and the engine timing in order to provide maximum engine response while minimizing the transient smoke levels.

Engine Monitoring and Protection

The system operation that is described above outlines the importance of a valid signal from the turbocharger outlet pressure sensor. If this signal becomes suspect, erratic operation of the engine could result. The ECM will compensate by applying a default signal to all control functions that utilize the signal. The ECM will use the default signal while the diagnostic code remains in the ACTIVE state. The diagnostic condition will be displayed for the operator and the engine will continue to operate.

Note: ACTIVE diagnostic codes indicate that a problem with the engine electronics system is suspected. The engine should be serviced by a qualified technician immediately.

i01908184

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

For information about the specific alarms and shutoffs for the engine, see Operation and Maintenance Manual, SEBU7050, "SR4B Generators And Control Panels".

i01564109

Air Shutoff

SMCS Code: 1078

This optional solenoid is located on top of the engine. The air shutoff is part of the air inlet system. When the solenoid is activated, the solenoid mechanically shuts off the inlet air to the engine. The solenoid can be activated only by the overspeed switch or by the emergency stop push button (ESPB). The Generator Set Control (GSC) and the air shutoff must be reset before the engine can be restarted. The cause of the shutoff should be determined before the engine is restarted.

i01908191

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 may be equipped with an Electronic Modular Control Panel II (EMCP II) that is used to provide engine control. If this control panel is installed, the EMCP II 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 II 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 II before the engine is restarted.

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

For more detailed information about the operation of the control panel, refer to Operation and Maintenance Manual, SEBU7050, "SR4B Generators and Control Panels".

i01108098

Cold Start Strategy

SMCS Code: 1450; 1456; 1900

The cold start strategy helps to provide the following features:

- Improved cold starting capability
- Decreased deep cycling of the battery
- White smoke cleanup
- Shorter warm up period
- Extended engine life

This engine is equipped with an Ether Injection System to provide improved cold starting capability. There are two possible modes of operation for the Ether Injection System. In the Automatic Mode, operation of the system is controlled by the Electronic Control Module (ECM). In the Manual Mode, operation of the Ether Injection System is controlled by the operator. For more information, refer to this Operation and Maintenance Manual, "Cold Weather Starting".

The timing advance is adjusted during cranking in order to promote fast starting of the engine. The ECM applies a specific engine timing that will promote quick starting in any ambient condition. As the engine speed increases toward low idle speed the engine timing is readjusted. The engine timing control is then passed to the timing circuit that best fits the conditions that are present.

Cold Mode operation provides the engine with an elevated engine idle speed that is used to provide a shorter warm up period. White smoke is controlled during Cold Mode by limiting the amount of fuel that is delivered to the cylinder. The engine will operate in Cold Mode until a predetermined coolant temperature or a predetermined time is achieved.

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.

i01909882

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.

The generator with shunt field excitation is self-excited with a voltage regulator. The voltage regulator monitors the excitation current as a function of the output voltage of the generator. The generator with shunt field excitation has no sustained short circuit capacity.

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 and 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 140 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"	
Underspeed protection and adjustment of frequency threshold via potentiometer "P4" (Factory setting)	
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

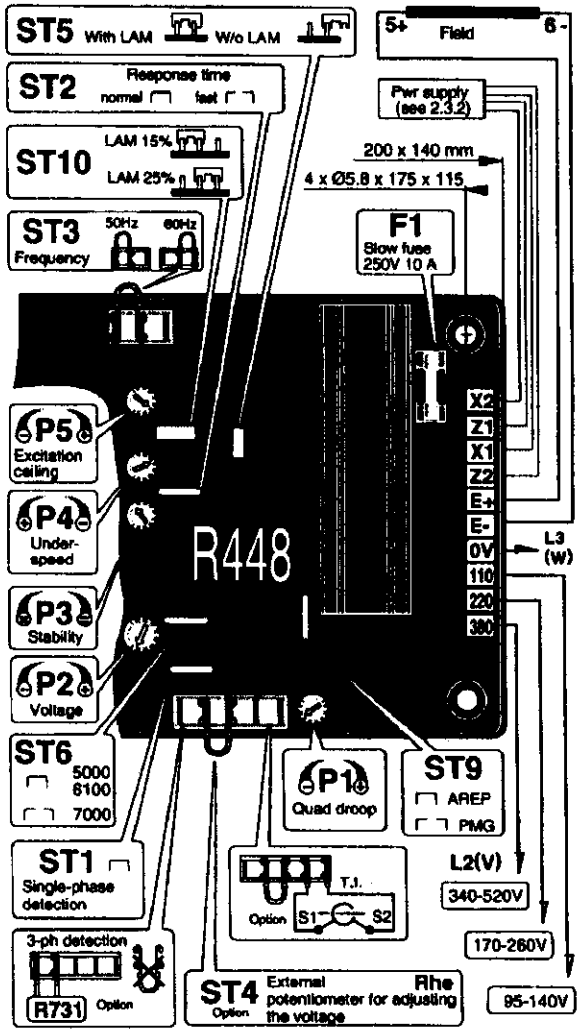

Illustration 63 g01015862

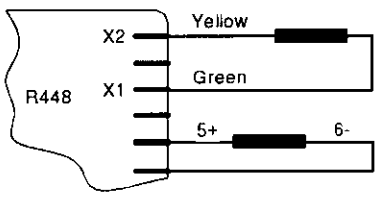

Illustration 64 g00995942
Connections for shunt excitation
6 wires

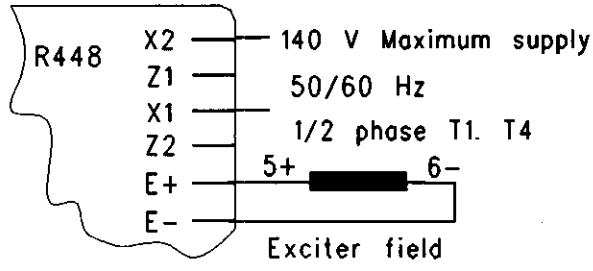

Illustration 65 g00995949
Connections for shunt excitation
12 wires

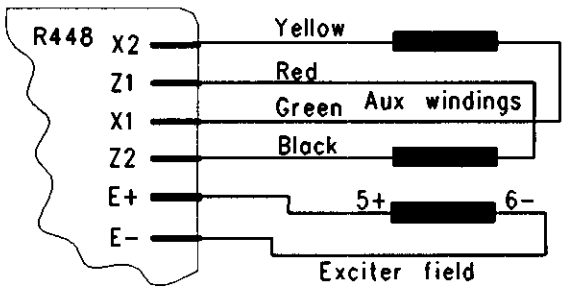

Illustration 66 g00995995

Connections for AREP excitation

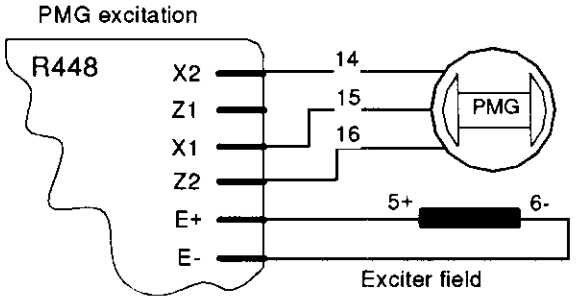

Illustration 67 g00996011

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 100 VDC on terminal E+ and terminal E-.
3. Connect a voltmeter that is calibrated for 300 VAC to 500 VAC or 1000 VAC to the output terminals of the generator.
4. Make sure that the ST3 wire is positioned on the desired frequency. Also, the engine speed must be changed from the factory setting in order to change the frequency of the generator.
5. Turn potentiometer (P2) to a full counterclockwise position.
6. Turn the potentiometer (P4) for frequency to a full clockwise position.
7. Turn stability potentiometer (P3) counterclockwise to about 1/3 of the total rotation for the potentiometer.
8. Start the engine and set the engine speed to a frequency of 48 Hz for 50 Hz or 58 Hz for 60 Hz.
9. Adjust the output voltage to the correct value with potentiometer P2. This voltage should be the rated voltage UN for single operation or UN plus 2% to 4% for parallel operation with a current transformer. Use potentiometer P3 to make adjustments if the voltage oscillates. Adjust potentiometer P3 in both directions while you observe the voltage between E+ and E-. The voltage between E+ and E- should be approximately 10 VDC. The best response times are obtained at the limit of the instability. Try cutting or replacing the wire ST2 if no stable position can be obtained.
10. Check the 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.
11. Turn potentiometer (P4) slowly counterclockwise until there is a significant voltage drop. The voltage drop should be approximately 15 %.
12. Vary the frequency around 48 Hz or 58 Hz according to the operating frequency. Check the change in the voltage that was previously observed.

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

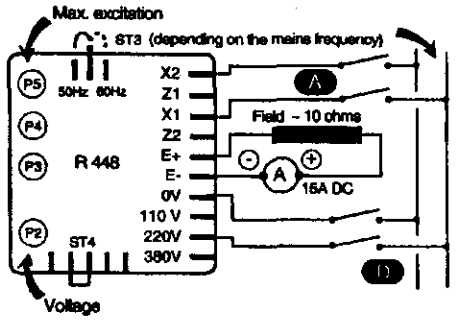

Illustration 68 g01016266

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 10 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 10 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

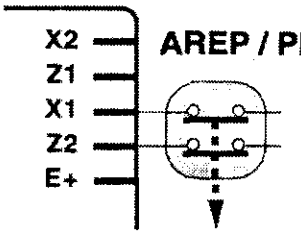

Illustration 69 g00952821

The exciter is switched off by disconnecting the power supply to the voltage regulator. The connection is identical for resetting the internal protection for the voltage regulator.

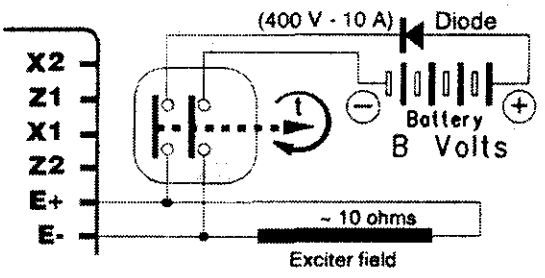

Illustration 70 g00952830

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	12 (1A)	1 - 2 seconds
De-energized parallel operation	12 (1A)	1 - 2 seconds
Standby parallel operation	24 (2A)	5 - 10 seconds
Frequency starting	48 (4A)	5 - 10 seconds
Voltage that is sustained at overload	48 (4A)	5 - 10 seconds

Engine Diagnostics

i01558495

Self-Diagnostics

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 Component Identifier (CID). Each diagnostic fault condition is represented by a Failure Mode Identifier (FMI). The two identifiers are combined in order to form a CID-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. For more information, refer to the Electronic Troubleshooting Guide for this engine.

As a diagnostic fault condition occurs, the ECM sends the CID-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 Code Information for 3406E and 3456 Generator Set Engines	
CID-FMI	**Description**
01-05	"Injector Cylinder 1 Open Circuit"
01-06	"Injector Cylinder 1 Short"
02-05	"Injector Cylinder 2 Open Circuit"
02-06	"Injector Cylinder 2 Short"
03-05	"Injector Cylinder 3 Open Circuit"
03-06	"Injector Cylinder 3 Short"
04-05	"Injector Cylinder 4 Open Circuit"
04-06	"Injector Cylinder 4 Short"
05-05	"Injector Cylinder 5 Open Circuit"
05-06	"Injector Cylinder 5 Short"
06-05	"Injector Cylinder 6 Open Circuit"
06-06	"Injector Cylinder 6 Short"
91-08	"Throttle Position Signal Abnormal"
100-03	"Engine Oil Pressure Open/Short to +Batt"
100-04	"Engine Oil Pressure Short To Ground"
100-13	"Engine Oil Pressure Calibration Required"

(continued)

(Table 8, contd)

Diagnostic Code Information for 3406E and 3456 Generator Set Engines	
CID-FMI	**Description**
110-03	"Engine Coolant Temperature Open/Short To +Batt"
110-04	"Engine Coolant Temperature Short To Ground"
168-00	"System Voltage High"
168-01	"System Voltage Low"
168-02	"System Voltage Intermittent"
172-03	"Intake Manifold Air Temp Open/Short To +Batt"
172-04	"Intake Manifold Air Temp Short To Ground"
174-03	"Fuel Temperature Open/Short To +Batt"
174-04	"Fuel Temperature Short To Ground"
175-03	"Engine Oil Temperature Open/Short To +Batt"
175-04	"Engine Oil Temperature Short To Ground"
190-02	"Loss Of Engine Speed Signal (Top Speed Timing Sensor)"
190-08	"Engine Speed Signal Abnormal (Top Speed Timing Sensor)"
248-09	"CAT Data Link Communications"
253-02	"Personality Module Mismatch"
254-12	"Electronic Control Module Error"
261-13	"Engine Timing Calibration Required"
262-03	"5 Volt Sensor Supply Short To +Batt"
262-04	"5 Volt Sensor Supply Short To Ground"
263-03	"Digital Sensor Supply Short To +Batt"
263-04	"Digital Sensor Supply Short To Ground"
268-02	"Check Programmable Parameters"
273-00	"Turbo Outlet Pressure Above Normal"
273-03	"Turbo Outlet Pressure Open/Short To +Batt"
273-04	"Turbo Outlet Pressure Short To Ground"
273-13	"Turbo Outlet Pressure Calibration Required"
274-03	"Atmospheric Pressure Open/Short To +Batt"
274-04	"Atmospheric Pressure Short To Ground"
274-13	"Atmospheric Pressure Calibration Required"
336-02	"Incorrect ECS Switch Inputs"
337-02	"Incorrect Remote E-Stop Switch Inputs"
342-02	"Loss Of Secondary Engine Speed Signal (Bottom Speed /Timing Sensor)"

(continued)

(Table 8, contd)

Diagnostic Code Information for 3406E and 3456 Generator Set Engines	
CID-FMI	**Description**
342-08	"Secondary Engine Speed Signal Abnormal (Bottom Speed/Timing Sensor)"
444-05	"Start Relay Open Circuit"
444-06	"Start Relay Short To Ground"
446-05	"Air Shut-off Relay Open"
446-06	"Air Shut-off Relay Short"
460-03	"Filtered Fuel Pressure Open/Short To +Batt"
460-04	"Filtered Fuel Pressure Short To Ground"
460-13	"Filtered Fuel Pressure Calibration Required"
535-08	"Exhaust Temperature Sensor Noisy Signal"
545-05	"Ether Start Relay Open/Short To +Batt"
545-06	"Ether Start Relay Short To Ground"

Note: The Generator Set Control+ (GSC+) performs the primary monitoring and control functions for the engine and for the generator. Do not confuse diagnostic codes that are generated by the GSC+ with diagnostic codes that are generated by the engine ECM. The GSC+ will display an "E" with the diagnostic code when the code is generated by the engine ECM. Refer to Operation and Maintenance Manual, "SR4B Generators And Control Panels" for more information.

i01146865

Diagnostic Lamp

SMCS Code: 1000; 1900; 1901; 1902; 7451

The Electronic Control Module (ECM) monitors the condition of the engine electronics and the condition of the ECM. When an electronic component sends an unexpected signal to the ECM, or the ECM has an internal failure, a diagnostic code is generated. The diagnostic code is sent to the control panel in order to inform the operator. If there is diagnostic information that is available to the operator, the Generator Set Control+ (GSC+) will display a diagnostic indicator on the display panel.

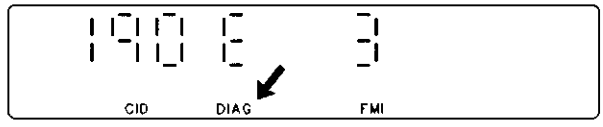

Illustration 71 g00608337

Location of the "Diag" indicator on the GSC+ Display Panel

The GSC+ will display the diagnostic indicator in the following manner:

- If the diagnostic code is ACTIVE, the "DIAG" indicator will continuously flash. The ACTIVE diagnostic code will be displayed in the same electronic display panel as the indicator.
- If the diagnostic code is LOGGED and no longer ACTIVE, the "DIAG" indicator will remain ON continuously. The LOGGED diagnostic code will not be displayed.
- If there is not a LOGGED diagnostic code or an ACTIVE diagnostic code, the "DIAG" indicator will not appear on the display.

Note: The GSC+ and the ECM may take protective measures when certain diagnostic codes are ACTIVE. There may be additional alarm indicators that are associated with the ACTIVE diagnostic codes that are related to the engine electronics.

For more information on the diagnostic codes for this engine, refer to Operation and Maintenance Manual, "Self-Diagnostics".

i02512380

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

i01233590

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. Refer to the Operation and Maintenance Manual for more information.

- 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 started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air space will be left in the housing. In these instances, prime the fuel system. 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 all of the shutoffs 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. Observe the coolant level in the coolant recovery tank (if equipped). Maintain the coolant level to the "FULL" mark on the coolant recovery tank.
- If the engine is not equipped with a coolant recovery tank 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 (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.
- Ensure that any driven equipment has been disengaged. Remove any electrical loads.

Starting the Engines, Operating the Engines, and Stopping the Engines that are Equipped with Control Panels

For information regarding the generator control panel that is used, refer to the Operation and Maintenance Manual that is for the generator and the control panel.

i02327037

Starting the Engine (EMCP II and EMCP II+ (If Equipped))

SMCS Code: 1000; 1450

⚠ WARNING

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

Note: The crank cycle and the number of crank cycles are programmable. The crank cycle is the amount of time for engagement of the starting motor. This also includes the amount of time for cooling of the starting motor between crank cycles. If the engine does not start within the number of crank cycles that are programmed, the fuel system is disabled. The "OVERCRANK" indicator will illuminate in order to warn the operator of an overcrank.

Operation of the Generator Set Control Panel

For information on operation of the generator set control panel, see Operation and Maintenance Manual, SEBU7050, "SR4B Generators and Control Panels".

Automatic Starting

⚠ WARNING

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

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

The engine will automatically start when the remote start/stop initiate contact closes.

Manual Starting

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

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

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

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

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

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

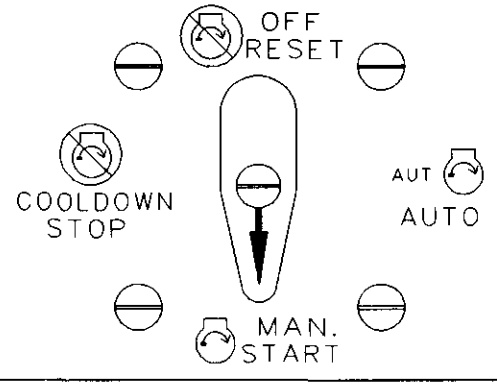

Illustration 72 g00319402

Engine control switch in the "MAN. START" position

This engine control switch is used for the EMCP II and for the EMCP II+ control panel.

2. To start an engine with the EMCP II or the EMCP II+ control panel, turn the engine control switch to the "MAN. START" position.

i02377318

Starting the Engine (EMCP 3 (If Equipped))

SMCS Code: 1000; 1450

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.

i01108737

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

⚠ WARNING

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

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

NOTICE
Excessive starting fluid can cause piston and ring damage.

Use starting fluid for cold starting purposes only.

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

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

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

1. Turn the Engine Control Switch to the "MAN. START" position. The engine will crank.
2. Ether will automatically be injected if the following conditions are met:
   a. The "STARTING AID" switch is in the AUTOMATIC position.

b. The jacket water coolant temperature is less than 0 °C (32 °F).

Note: Additional injections may be necessary in order to start the engine. Additional injections may also be necessary in order to achieve low idle.

3. If additional injection is necessary, toggle the "STARTING AID" switch to the MANUAL position. For additional injection, the jacket water coolant temperature must be less than 10 °C (50 °F).

4. 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.

i01646248

After Starting Engine

SMCS Code: 1000

Note: In temperatures from 0 to 60°C (32 to 140°F), the warm-up time is approximately three minutes. In temperatures below 0°C (32°F), additional warm-up time may be required.

Note: Ensure that the self test for the monitoring system (if equipped) is completed before operating the engine under load.

When the engine idles during warm-up, observe the following conditions:

- Check for any fluid or for any air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under load. This is not possible in some applications.

- Operate the engine at low idle until all systems achieve operating temperatures. Check all gauges during the warm-up period.

Note: 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.

Engine Operation

i00718869

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 needed for a walk-around inspection of the engine.

After the engine is started and after the engine reaches normal operating temperature, the engine can be operated at the rated rpm. The engine will reach normal operating temperature faster when the engine is at rated speed. The engine will reach normal operating temperature faster when the engine is at 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.

i00808595

Engine Warm-up

SMCS Code: 1000

1. Run the engine at low idle for three to five minutes, or run the engine at low idle until the jacket water temperature starts to rise.

   More time may be necessary when the temperature is below −18° C (0° F).

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

3. Perform another walk-around inspection. Check the engine for fluid leaks and air leaks.

4. Increase the rpm to the rated rpm. Check 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).

i00165110

Fuel Conservation Practices

SMCS Code: 1000; 1250

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

- Avoid spilling fuel.

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

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

- Avoid unnecessary idling.

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

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

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

- Maintain a good electrical system.

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

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

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

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

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

- Settings for the fuel system and the limits for the operating altitude are stamped on the Engine Information Plate. If an engine is moved to a higher altitude, the settings must be changed by a Caterpillar dealer. Changing the settings will help prevent damage to the turbocharger. Changing the settings will help to provide the maximum efficiency for the engine. Engines can be operated safely at higher altitudes, but the engines will deliver less horsepower. The fuel settings should be changed by a Caterpillar dealer in order to obtain the rated horsepower.

Engine Stopping

i02255774

Emergency Stopping

SMCS Code: 1000; 7418

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

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

Emergency Stop Button

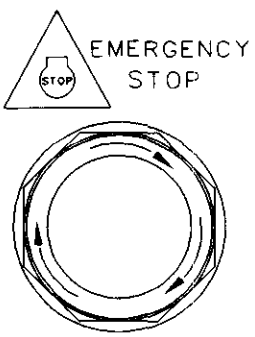

Illustration 73 g00104303

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.

Refer to Operation and Maintenance Manual, "Features and Controls" for the location and the operation of the emergency stop button.

i02377329

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

EMCP II, EMCP II+ and EMCP II+P

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

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

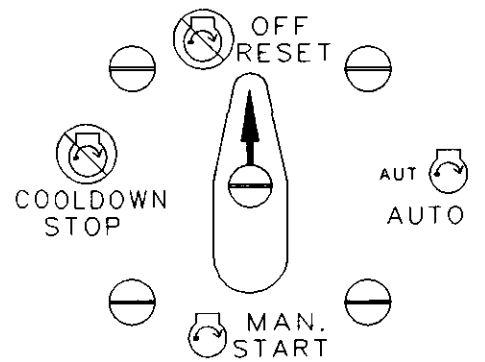

Illustration 74 g00320124

Engine control switch in the "OFF/RESET" position

a. For all control panels, turn the engine control switch to the "OFF/RESET" position. The engine will immediately shut off.

b. For engines with the EMCP II, EMCP II+or the EMCP II+P control panel, the engine control switch may be turned to the "COOLDOWN/STOP" position. If the cooldown feature is utilized, the engine will operate for a programmed period of time before the engine stops. Otherwise, the engine will immediately shut off.

c. For engines with the Switchgear Conversion control panel, the engine will stop if the engine control switch is turned to the "Service" position. The Caterpillar Monitoring System will remain energized. This position of the engine control switch is used in order to program the Caterpillar Monitoring System.

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

Automatic Stopping

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

EMCP 3

1. Open the main circuit breaker.
2. Stop the engine by one of these three methods.
   - The operator presses the "STOP" Key.
   - The control is in "AUTO" and the remote initiate contact (IC) becomes inactive.
   - The operator presses the "AUTO" Key and a stop command is sent via the RS-485 SCADA Data Link.
3. After receiving the signal to stop, the EMCP 3 checks that there are no present system faults.
4. The EMCP 3 begins the cooldown period. In order to bypass the cooldown period, hold down the "STOP" Key. "PRESS ENTER TO BYPASS" and "PRESS ESCAPE TO CONTINUE" will be shown on the display. Press the Enter Key in order to bypass the cooldown period or press the Escape Key in order to continue the cooldown period.
5. After the cooldown period, the EMCP 3 initiates a engine shutdown by turning off the fuel supply.

i02237586

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.
- Perform all required periodic maintenance on the generator. The generator maintenance is outlined in the Operation and Maintenance Manual that is supplied with the generator.

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".

i01564140

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 you operate the engine.

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

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

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

Fuel Filters

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

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

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

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 75. 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.

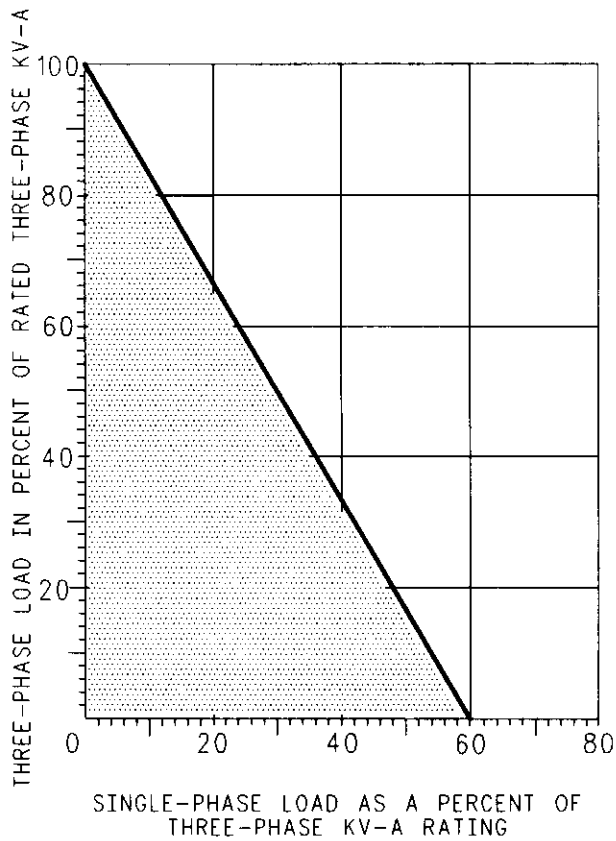

Illustration 75 g00627416

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.

i02292263

Single Unit Operation

SMCS Code: 4450

Initial Start-Up

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

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

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

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

Starting

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

Adjust the Voltage

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

1. Turn the remote adjustment potentiometer to the center position, if equipped.
2. Connect an analog voltmeter that is calibrated for 100 VDC on terminal E+ and terminal E-.
3. Connect a voltmeter that is calibrated for 300 VAC to 500 VAC or 1000 VAC to the output terminals of the generator.
4. Make sure that the ST3 wire is positioned on the desired frequency. Also, the engine speed must be changed from the factory setting in order to change the frequency of the generator.
5. Turn voltage potentiometer (P2) to a full counterclockwise position.
6. Turn frequency potentiometer (P4) to a full clockwise position.
7. Turn stability potentiometer (P3) counterclockwise to about 1/3 of the total rotation for the potentiometer.
8. Start the engine and set the engine speed to a frequency of 48 Hz for 50 Hz or 58 Hz for 60 Hz.
9. Adjust the output voltage to the correct value with potentiometer P2. This voltage should be the rated voltage UN for single operation or UN plus 2% to 4% for parallel operation with a current transformer. Use potentiometer P3 to make adjustments if the voltage oscillates. Adjust potentiometer P3 in both directions while you observe the voltage between E+ and E-. The voltage between E+ and E- should be approximately 10 VDC. The best response times are obtained at the limit of the instability. Try cutting or replacing the wire ST2 if no stable position can be obtained.
10. Check the LAM operation. ST5 must be closed.

11. Turn potentiometer (P4) slowly counterclockwise until there is a significant voltage drop. The voltage drop should be approximately 15 %.

12. Vary the frequency around 48 Hz or 58 Hz according to the operating frequency. Check the change in the voltage that was previously observed.

Stopping

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

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.

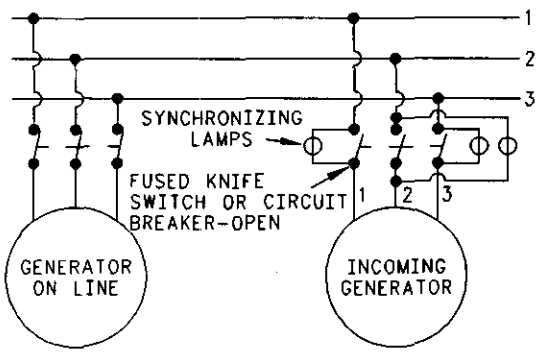

Illustration 76 g00695380

⚠ 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

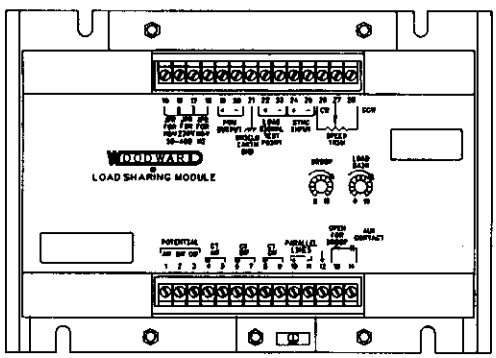

Illustration 77 g00630841

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".

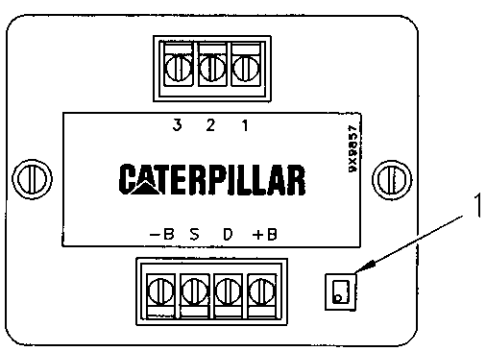

Illustration 78 g00637397

(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

Lubrication System

Lubricant Recommendations

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

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

The proper SAE viscosity grade of oil is determined by the minimum ambient temperature during cold engine start-up, and the maximum ambient temperature during engine operation. To determine the oil viscosity that is required for starting a cold soaked engine, refer to the minimum temperature in Table 9. To select the oil viscosity for operation at the highest anticipated ambient temperature, refer to the maximum temperature in the Table. Use the highest oil viscosity that is available in order to meet the required temperature during start-up.

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)

For additional information on selecting an oil, refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations".

Lubricant Capacities

The Total Capacity of the Lubrication system equals the capacity of the Engine Crankcase, including the capacity of the oil filters that are installed at the factory, plus the Capacity of the Auxiliary Oil Filter System. Auxiliary oil filter systems (if equipped) will require additional oil. Refer to the specifications that are provided by the OEM of the auxiliary oil filter system.

Table 10

Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Crankcase (1)	36.0	38.0
Capacity of the Auxiliary Oil Filter System(2)		
Total Capacity of the Lubrication System(3)		

(1) Approximate sump capacity of the crankcase includes a standard oil filter that is factory installed. Engines with auxiliary oil filters will require additional oil. Engines that are equipped with factory installed dual oil filters require an additional 3.7 L (3.9 qt) of oil. If the engine is equipped with another type of auxiliary oil filter, refer to the OEM specifications for the capacity of the auxiliary oil filter.

(2) Fill in the capacity of the auxiliary oil filter system (if equipped) in the space that is provided.

(3) Fill in the total capacity of the lubrication system. Add the auxiliary oil filter system to the correct capacity of the engine crankcase that is for your engine. The final number is the total capacity of the lubrication system.

Fuel

Fuel Recommendations

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

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

Cooling System

Coolant Recommendations

NOTICE

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

Use only the coolant/antifreeze that is recommended.

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

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

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

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

Note: 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.

Mixtures of glycol and water require three to six percent of SCA. **Do not exceed the recommended six percent SCA concentration in mixtures of glycol and water.**

In stationary engine applications and marine engine applications that do not require protection from boiling or freezing, a mixture of SCA and water is acceptable. Caterpillar recommends a minimum of six percent to a maximum of eight percent SCA concentration in those cooling systems. **Do not exceed the recommended eight percent SCA concentration in mixtures of water and SCA.** Distilled water or deionized water is preferred. Water which has the required properties may be used. For the water properties, refer to Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations" for additional information that relates coolant.

Note: Table 11 is a list of the coolants that are recommended and the service life (calendar) of the coolants. The service life of coolant is also limited by use (service hours). Refer to the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section). **To achieve this service life, the coolants must be properly maintained. The maintenance program includes S·O·S coolant analysis.**

Table 11

Coolant Service Life	
Coolant Type	**Service Life** (1)
Cat ELC	Six Years
Cat DEAC	Three Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D5345"	Two Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985"	One Year
Cat SCA and Water	Two Years
Commercial SCA and Water	One Year

(1) The service life of coolant is also limited by use (service hours). Refer to the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

Coolant Capacities

To properly maintain the cooling system, the Total Cooling System capacity must be determined. The Total Cooling System capacity will vary between individual installations. The Total Cooling System Capacity equals the capacity of the Engine (Only) plus the External System Capacity. The External System Capacity includes the following components: expansion tank, heat exchanger, radiator, and piping. Refer to the specifications that are provided by Caterpillar or by the OEM of the equipment. Record the capacity of the External System and the capacity of the Total Cooling System in the following Table:

Table 12

Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Only	22.7	24.0
External System		
Total Cooling System		

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 13

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 13, 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 14

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, WHICHEVER 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 2000 Service Hours or 6 Months

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 2 Years

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

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

Overhaul

i02516958

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, WHICHEVER 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 Year

Every 3 Years

Every 6 Years

i01546702

Aftercooler Core - Clean/Test

SMCS Code: 1064-070; 1064-081

1. Remove the core. Refer to the Service Manual for the procedure.

2. Turn the aftercooler core upside-down in order to remove debris.

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

3. Back flush the core with cleaner.

   Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 15 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 15

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). Refer to Application Guide, NEHS0526 or consult your Caterpillar dealer for more information.

4. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris.

5. Wash the core with hot, soapy water. Rinse the 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 core with compressed air. Direct the air in the reverse direction of the normal flow.

7. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.

8. Install the core. Refer to the Service Manual for the procedure.

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

i00072207

Alternator - Inspect

SMCS Code: 1405-040

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

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

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Alternator and Fan Belts - Inspect/Adjust/Replace

SMCS Code: 1357-039

Inspection

To maximize the engine performance, inspect the belts for wear and for cracking. Check the belt tension. Adjust the belt tension in order to minimize belt slippage. Belt slippage will decrease the life of the belts.

To check the belt tension, apply 110 N (25 lb) of force midway between the pulleys. A correctly adjusted belt will deflect 13 to 19 mm (0.50 to 0.75 inch).

Adjustment

If the belts are too loose, the belts will vibrate. This vibration is enough to cause unnecessary wear on the belts and on the pulleys.

If the belts are too tight, unnecessary stresses are placed upon the pulley bearings and upon the belts. These stresses will shorten the life of the belts and of the pulley bearings.

If new belts are installed, check the tension again after 30 minutes of engine operation at the rated rpm.

Replacement

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

Refer to the Service Manual for more information on the procedures for the following topics: belt removal and belt installation procedure.

i01148030

Annunciator Panel - Inspect

SMCS Code: 4490-040

Inspect the annunciator panel for good condition. Perform a lamp test. All of the warning lamps should illuminate. If a warning lamp does not illuminate, replace the bulb immediately. If the alarm does not sound, investigate the problem and correct the problem.

Check the condition of all of the gauges. If a gauge is broken, repair the gauge or replace the gauge immediately.

Frequently monitor the following parameters during normal engine operation:

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

Record the data in a log. Compare the new data to the data that was previously recorded. Comparing the new data to the recorded data will establish the normal gauge readings for the engine. A gauge reading that is abnormal may indicate a problem with engine operation. Abnormal gauge readings may also indicate a possible problem with the gauge.

Record the Performance of the Engine

Table 16 is offered as an example for use as a daily engine log. Record the engine performance regularly. Retain the 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 daily 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 16

Daily Engine Log						
Date						
Authorization						
Engine Serial Number						
Engine Hours						
Engine Speed						
Percent Load						
Ambient Temperature						
Inlet Air Restriction						
Engine Coolant Temperature						
Engine Oil Temperature						
Engine Oil Pressure						
System Battery Voltage						
Exhaust Manifold Temperature						
Generator Voltage						
Generator Amperage						
Comments						

i01942284

Automatic Start/Stop - Inspect

SMCS Code: 4462

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

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

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

Table 17

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.

i01952106

Bearing Temperature - Measure/Record

SMCS Code: 4471-082-TA

Bearing temperature detectors are optional on generators. 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.

A bearing temperature that is 50 °C (122 °F) above the ambient temperature may require a change in operation. The unit should be shut down in order to prevent damage if the bearing temperature is 50 °C (122 °F) above the ambient temperature.

i02139869

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

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

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 one of the drain plugs.

Note: If equipped, be sure to drain the heater and any related supply and return 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 Tool 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, SENR3130, "Torque Specifications" for more 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 0.5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.

4. Start 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. If equipped, be sure to flush the heater and any related supply and return lines. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual, SENR3130, "Torque Specifications" for more 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.

Note: If equipped, be sure to flush the heater and any related supply and return lines.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Specifications Manual, SENR3130, "Torque Specifications" for more 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 0.5 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 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, SENR3130, "Torque Specifications" for more information on the proper torques.

Fill

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 Capacitites and Recommendations" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start 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 (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 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.

i02173402

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

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 Tool 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.

Note: If equipped, be sure to flush the heater and any related supply and return lines.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. For the proper torque, refer to the Specifications Manual, SENR3130, "Torque Specifications".

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 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. For the proper torque, refer to the Specifications Manual, SENR3130, "Torque Specifications".

Fill

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

1. Fill the cooling system with Extended Life Coolant (ELC). See Special Publication, SEBU6385, "Caterpillar On-highway Diesel Truck Engine Fluids Recommendations" for more information on cooling system specifications. Do not install the cooling system filler cap.

2. Start and run the engine at low idle. Increase the engine rpm to high idle. 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 (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 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.

i02482066

Cooling System Coolant Extender (ELC) - Add

SMCS Code: 1352-045; 1395-081

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

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

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

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

⚠ WARNING

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

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

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

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

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

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

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

Dispose of all fluids according to local regulations and mandates.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. It may be necessary to drain enough coolant from the cooling system in order to add the Cat ELC Extender.
3. Add Cat ELC Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" article for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i01197583

Cooling System Coolant Level - Check

SMCS Code: 1395-082

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

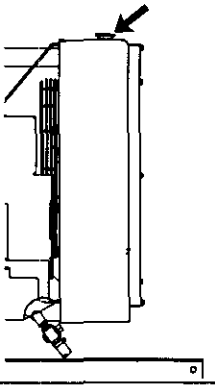


Illustration 79 g00285520
Cooling system filler cap

⚠ WARNING

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

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

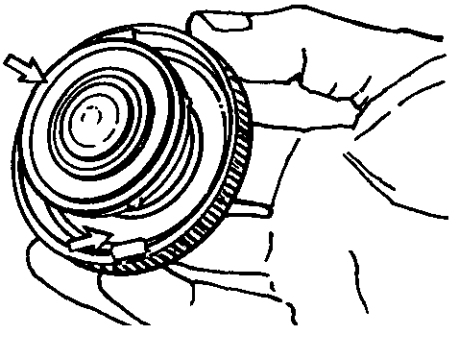


Illustration 80 g00103639
Typical filler cap gaskets

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

4. Inspect the cooling system for leaks.

i02456600

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

SMCS Code: 1352-045; 1395-081

⚠ WARNING

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

Note: Test the concentration of the Supplemental Coolant Additive (SCA) or test the SCA concentration as part of an S·O·S Coolant Analysis.

Test for SCA Concentration

Coolant and SCA

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

Use the 8T-5296 Coolant Conditioner Test Kit or use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA. Refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" for more information.

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

S·O·S Coolant Analysis

S·O·S coolant samples can be analyzed at your Caterpillar dealer. S·O·S Coolant Analysis is a program that is based on periodic samples.

Level 1

Level 1 is a basic analysis of the coolant. The following items are tested:

- Glycol Concentration
- Concentration of SCA
- pH
- Conductivity

The results are reported, and recommendations are made according to the results. Consult your Caterpillar dealer for information on the benefits of managing your equipment with an S·O·S Coolant Analysis.

Level 2

This level coolant analysis is recommended when the engine is overhauled. Refer to this Operations and Maintenance Manual, "Overhaul Considerations" for further information.

Add the SCA, If Necessary

NOTICE
Do not exceed the recommended amount of supplemental coolant additive concentration. 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 radiator tube blockage, overheating, and/or accelerated water pump seal wear. Never use both liquid supplemental coolant additive and the spin-on element (if equipped) at the same time. The use of those additives together could result in supplemental coolant additive concentration exceeding the recommended maximum.

⚠ 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. Slowly loosen the cooling system filler cap in order to relieve the pressure. Remove the cooling system filler cap.

Note: Always discard drained fluids according to local regulations.

2. If necessary, drain some coolant from the cooling system into a suitable container in order to allow space for the extra SCA.

3. Add the proper amount of SCA. Refer to the Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engines Fluids Recommendations" for more information on SCA requirements.

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

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.

i00894991

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.

Rubber Damper

Your engine may be equipped with a rubber damper. The rubber damper uses a ring which is mounted in rubber in order to reduce vibrations in the crankshaft.

Inspect the damper and repair or replace the damper for any of the following reasons:

- There is deterioration and cracking of the rubber.
- There is slippage of the outer ring from the original position.
- The engine has had a failure because of a broken crankshaft.
- Analysis of the oil has revealed that the front main bearing is badly worn.
- There is a large amount of gear train wear that is not caused by lack of oil.

Refer to the Service Manual or consult your Caterpillar dealer for information about damper replacement.

Visconic Damper

Your engine may be equipped with a 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 fluid leaks. If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous, smooth, and difficult to remove from surfaces.

If the fluid leak is oil, inspect the crankshaft seals for leaks. If a leak is observed, replace the crankshaft seals.

Inspect the damper and repair or replace the damper for any of the following reasons:

- The damper is dented, cracked, or leaking.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of a broken crankshaft.
- Analysis of the oil has revealed that the front main bearing is badly worn.
- There is a large amount of gear train wear that is not caused by a lack of oil.

Refer to the Service Manual or consult your Caterpillar dealer for information about damper replacement.

i01259098

Cylinder Head Grounding Stud - Inspect/Clean/Tighten

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

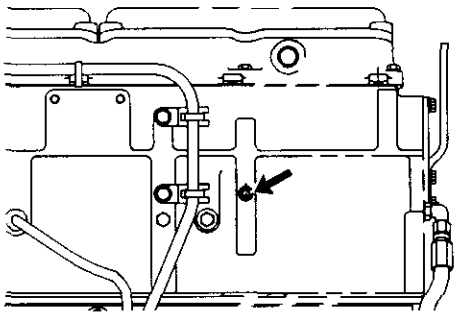


Illustration 81 g00421378

Cylinder head grounding stud (side view)

Inspect the harness for good connections. Inspect the condition of the harness.

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.

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

i01228274

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.

i01866598

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.

Do not steam clean the generator. Water may damage the generator.

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

i01553486

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

SMCS Code: 1054-037; 1054-510

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

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

Servicing the Air Cleaner Elements

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

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

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

Dual Element Air Cleaners

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

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

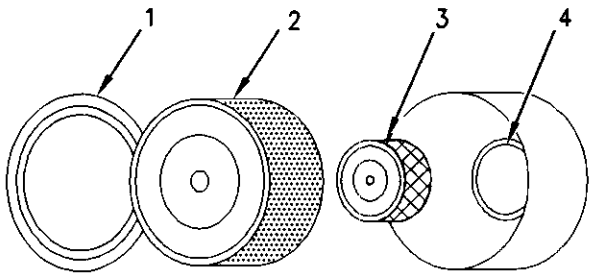


Illustration 82 g00736431

(1) Cover
(2) Primary air cleaner element
(3) Secondary air cleaner element
(4) Turbocharger air inlet

1. Remove the cover. Remove the primary air cleaner element.
2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.

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

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

Cleaning the Primary Air Cleaner Elements

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

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

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

Do not wash the filter element.

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

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

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

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

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

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

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

- Pressurized air
- Vacuum cleaning

Pressurized Air

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

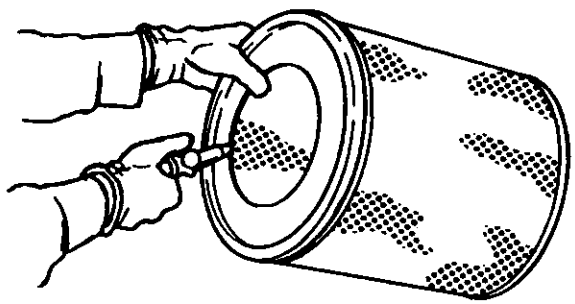


Illustration 83 g00281692

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

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

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

Vacuum Cleaning

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

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

Inspecting the Primary Air Cleaner Elements

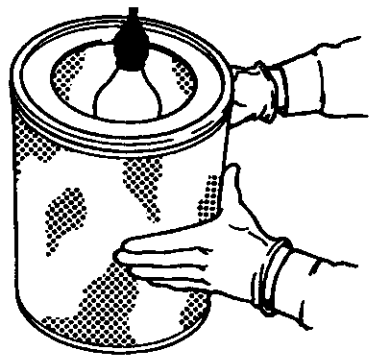


Illustration 84 g00281693

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

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

Storing Primary Air Cleaner Elements

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

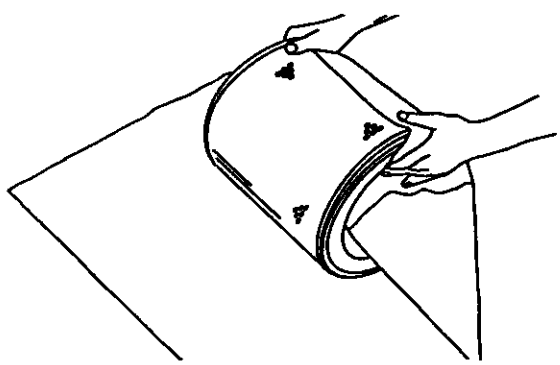


Illustration 85 g00281694

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

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

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i01900118

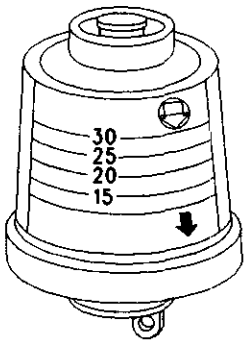
Engine Air Cleaner Service Indicator - Inspect (If Equipped)

SMCS Code: 7452-040

Some engines may be equipped with a different service indicator.

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

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



g00103777

Illustration 86
Typical service indicator

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

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

Test the Service Indicator

Service indicators are important instruments.

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

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

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

Note: When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N·m (18 lb in).

i01564253

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.

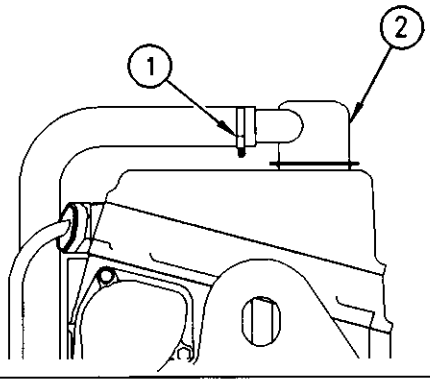


Illustration 87 g00812591

Typical example

(1) Hose clamp
(2) Cover clamp
(3) Crankcase breather cover

1. Loosen hose clamp (1) and remove the hose from crankcase breather (2).
2. Remove the crankcase breather (2).
3. Wash the breather element in solvent that is clean and nonflammable. Allow the breather element to dry before installation.
4. Install a breather element that is clean and dry. Install the crankcase breather (2). Refer to the Operation and Maintenance Manual for the proper torque.
5. Install the hose. Install hose clamp (1). Refer to the Operation and Maintenance Manual for the proper torques.

i02139969

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 Specifications Manual, SENR3130, "Torque Specifications". Refer to your Caterpillar dealer for more information.

i00623423

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

⚠ WARNING

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

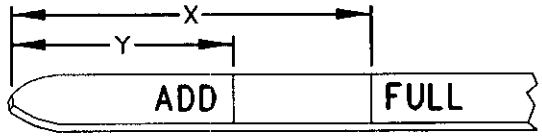


Illustration 88 g00110310

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

NOTICE
Perform this maintenance with the engine stopped.

1. Maintain the oil level between "ADD" mark (Y) and "FULL" mark (X) on oil level gauge (1). 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 the oil filler cap and add oil, if necessary. Clean the oil filler cap. Install the oil filler cap.

i01935337

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.

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.

i02107152

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 crankcase with the oil 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.

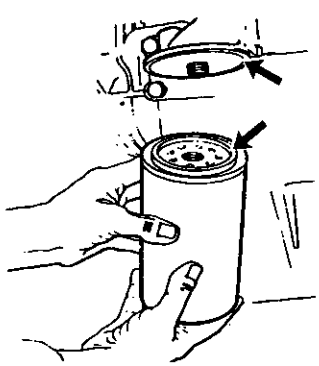


Illustration 89 g00103713
Typical filter mounting base and filter gasket

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 filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

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. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for more information.

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.

i01042067

Engine Performance - Test

SMCS Code: 1000-081

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

- Monitor the operation of the generator set.
- Observe the gauges. Ensure that the gauges are in the normal ranges.

- Record the data. Maintain a record of the data for the engine performance.

i00626013

Engine Protective Devices - Check

SMCS Code: 7400-535

Alarms and shutoffs must function properly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. It is impossible to determine if the engine protective devices are in good working order during normal operation. Malfunctions must be simulated in order to test the engine protective devices.

A calibration check of the engine protective devices will ensure that the alarms and shutoffs activate at the setpoints. Ensure that the engine protective devices are functioning properly.

NOTICE
During testing, abnormal operating conditions must be simulated.

The tests must be performed correctly in order to prevent possible damage to the engine.

To prevent damage to the engine, only authorized service personnel or your Caterpillar dealer should perform the tests.

Visual Inspection

Visually check the condition of all gauges, sensors and wiring. Look for wiring and components that are loose, broken, or damaged. Damaged wiring or components should be repaired or replaced immediately.

i01161856

Engine Speed/Timing Sensors - Check/Clean/Calibrate

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

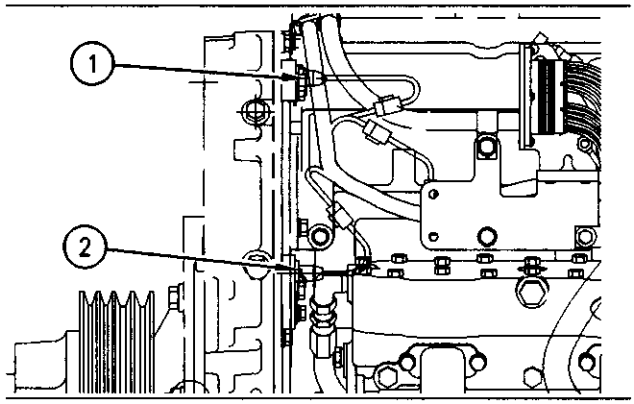


Illustration 90 g00618934

Left side view

(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.

i00869413

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 initial adjustment is necessary due to initial wear of the valve train components and 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.

Adjustment of the Electronic Unit Injector

Adjust the electronic unit injector (preload) at the same interval as the valve lash adjustment. The operation of Caterpillar engines with improper valve adjustments and with improper adjustments of the electronic unit injector can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component 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.

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.

i00805059

Ether Starting Aid Cylinder - Replace (If Equipped)

SMCS Code: 1456-510-CD

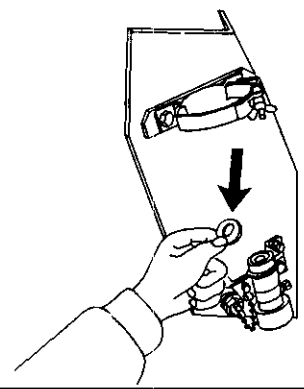


Illustration 91 g00104888
Typical example

1. Loosen the ether cylinder clamp. Unscrew and remove the empty ether cylinder.
2. Remove the used gasket. Install the new gasket that is provided with each new ether cylinder.
3. Install the new ether cylinder. Hand tighten the ether cylinder. Tighten the ether cylinder clamp securely.

i02239650

Fan Drive Bearing - Lubricate

SMCS Code: 1359-086-BD

Some of the fan drives have grease fittings and some of the fan drives do not have grease fittings. If there is no grease fitting, periodic lubrication is not required. The fan drive requires grease only if the fan drive is equipped with a zerk.

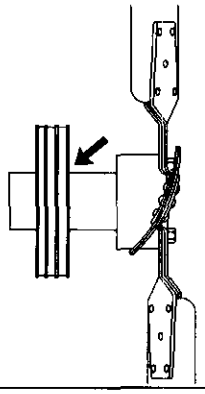


Illustration 92 g00746166

Typical location of the grease fitting (if equipped) that is for the fan drive bearing

The pulley is shown with the belt guards that have been removed.

Lubricate the grease fitting that is on the fan drive bearing with Bearing Lubricant or the equivalent.

Inspect the fan drive pulley assembly for wear or for damage. If the shaft is loose, an inspection of the internal components should be performed. Refer to the Service Manual for additional information.

i00838960

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.

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.

Note: DO NOT remove the fitting in the fuel filter base in order to release air from the fuel system during periodic service of the fuel filter. Periodic removal of the fitting will result in increased wear of the threads in the fuel filter base. This can lead to fuel leakage. However, the fitting in the fuel filter base can be used to purge air from the fuel system if the engine runs out of fuel.

1. Loosen the fuel filter air purge plug two full turns. Unlock and operate the priming pump until fuel appears at the fitting. This procedure will require considerable strokes. Use a cloth or a container to catch the excess fuel.

2. Tighten the fuel filter air purge plug. Open fuel priming pump and operate the fuel priming pump until a strong pressure is felt on the fuel priming pump. Push the priming pump plunger inward. Tighten the plunger by hand, and promptly continue with the next step.

3. Crank the engine after pressurizing the system.

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.

4. If the engine will not start, allow the starting motor to cool for 2 minutes. Repeat Steps 2 and 3 in order to start the engine. Further priming may be necessary to help purge the fuel lines of air, if:

   - The engine starts, but runs rough.
   - The engine started, but continues to misfire or smoke.

5. Run the engine at low idle until the engine runs smoothly.

i01254694

Fuel System Primary Filter/Water Separator - Drain

SMCS Code: 1260-543; 1263-543

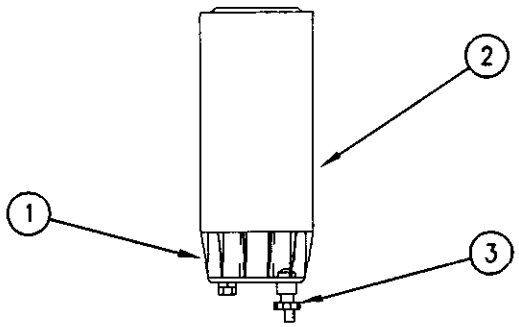


Illustration 93 g00668636

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

Bowl (1) should be monitored daily 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.

i02049797

Fuel System Primary Filter (Water Separator) Element - Replace

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

Water in the fuel can cause the engine to run rough. Water in the fuel may cause an electronic unit injector to fail. If the fuel has been contaminated with water, the element should be changed before the regularly scheduled interval.

The primary filter/water separator also provides filtration in order to help extend the life of the secondary fuel filter. The element should be changed regularly. Install a vacuum gauge. Change the element for the primary filter/water separator if the pressure is at 50 to 70 kPa (15 to 20 inches Hg).

Replace the Element

⚠ 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.

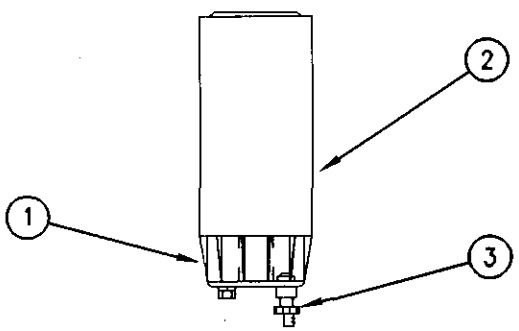


Illustration 94 g00668636

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

1. Stop the engine.

2. Turn the start switch to the "OFF" position.

3. Shut off the fuel tank supply valve to the engine.

4. If the primary fuel filter is equipped with a drain valve (3), open the drain valve in order to drain any fuel from the filter case. Close the drain valve (3).

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

5. Remove the fuel filter bowl (1) and wash the fuel filter bowl with clean diesel fuel.

6. Remove the fuel filter (2).

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

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

NOTICE
In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, use Caterpillar fuel filters.

Consult your Caterpillar dealer for proper part numbers.

9. Install the new fuel filter (2). 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.

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.

10. Install the clean fuel filter bowl (1) on the new fuel filter.

NOTICE
The water separator is under suction during normal engine operation. Ensure that the vent plug is tightened securely to help prevent air from entering the fuel system.

11. Open the fuel tank supply valve.

12. Start the engine and check for leaks. Run the engine for one minute. Stop the engine and check the engine for leaks again.

    Detection of leaks is very difficult especially if the engine is running. The primary filter/water separator is under suction. A leak will allow air to enter the fuel. The air in the fuel can cause low power due to aeration of the fuel. If air enters the fuel, check the components for overtightening or undertightening.

i01250684

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.

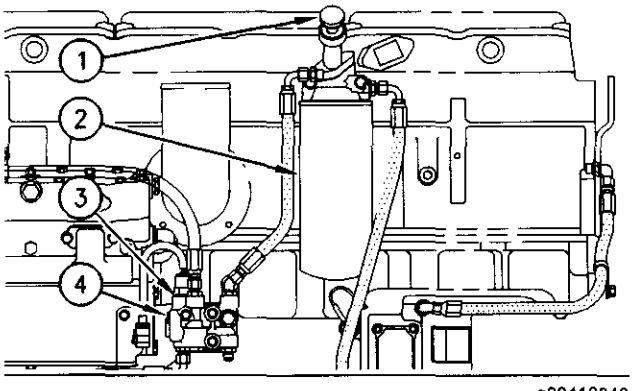


Illustration 95 g00410343

(1) Fuel priming pump
(2) Fuel filter
(3) Fuel block
(4) Fuel filter air purge plug

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 the fuel filter air purge plug (4) 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
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.

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.

6. Open the fuel tank supply valve and prime the fuel system.

i02436696

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. A 2 micron filter for the breather vent on the fuel tank is also recommended. Refer to Special Publication, SENR9620, "Improving Fuel System Durablity".

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 18

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.

i01461264

Generator - Inspect

SMCS Code: 4450-040

⚠ WARNING

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

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

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

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

- Carbon
- Salt
- Metal dust
- Dirt that is saturated with moisture

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

NOTICE

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

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

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

Cleaning (Assembled Generators)

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

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

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

Cleaning (Disassembled Generators)

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

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

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

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

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

i02517207

Generator Lead - Check

SMCS Code: 4450-535

The generator set may have braided cables between the generator and the breaker instead of wire cables. Check for signs of wear along the braided cables. Pay particular attention to the cables at the housing for the breaker and the generator terminal box.

If the rubber mats or the insulation on the braided cables show signs of wear at points of contact with other surfaces, replace the mats or the cable immediately. If your generator set does not have rubber mats in place, contact your Caterpillar dealer.

i01228480

Generator Load - Check

SMCS Code: 4450-535-LA

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

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

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

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

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

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

i01593517

Generator Set - Test

SMCS Code: 4450-081

⚠ WARNING

Personal injury or death can result from high voltage.

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

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

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

When servicing or repairing electric power generation equipment:

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

Table 19

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

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

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

- A phase voltage is being generated.
- The phase voltages are balanced.
- The phase voltages change relative to engine speed.

The generator set functional test consists of the following steps:

1. Stop the generator. Connect the potential transformer's high voltage winding to the generator terminals (T1) and (T2). Connect the voltmeter to the low voltage winding. If two transformers are available, connect the high voltage winding of the second transformer to the generator terminals (T1) and (T3). Connect the secondary terminals that correspond to generator terminal (T2) of both transformers together.
2. Disconnect wires "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.

i01228545

Generator Set Vibration - Inspect

SMCS Code: 4450-040-VI

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

- lightning arrestors

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.

i02164888

Hoses and Clamps - Replace

SMCS Code: 1380-510

Note: For instructions on draining the cooling system and filling the cooling system, see this Operation and Maintenance Manual, "Cooling System Coolant (DEAC) - Change" topic or see the Operation and Maintenance Manual, "Cooling System Coolant (ELC) - Change" topic (Maintenance Section).

1. Drain the cooling system.
2. Remove the used hoses and clamps. Discard the items.
3. Install new hoses and clamps. For the correct torque to use on the hose clamps, see the Specifications, SENR3130, "Torque Specifications", "Hose Clamps" topic.
4. Fill the cooling system.
5. Start the engine. Inspect the hose connections for leaks.

i01917577

Instrument Panel - Inspect

SMCS Code: 7451-040

Inspect the instrument panel for good condition. Perform the self test. All of the warning lamps should illuminate. If a warning lamp does not illuminate, replace the bulb immediately. If the alarm does not sound, investigate the problem and correct the problem.

Check the condition of all of the gauges. If a gauge is broken, repair the gauge or replace the gauge immediately.

Frequently monitor the gauges during normal operation.

Record the data in a log. Compare the new data to the data that was previously recorded. Comparing the new data to the recorded data will help to establish the trends of engine performance. A gauge reading that is abnormal may indicate a problem with operation or a problem with the gauge.

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 20

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 96.

Serial Number (Engine)_____

Serial Number (Generator)_____

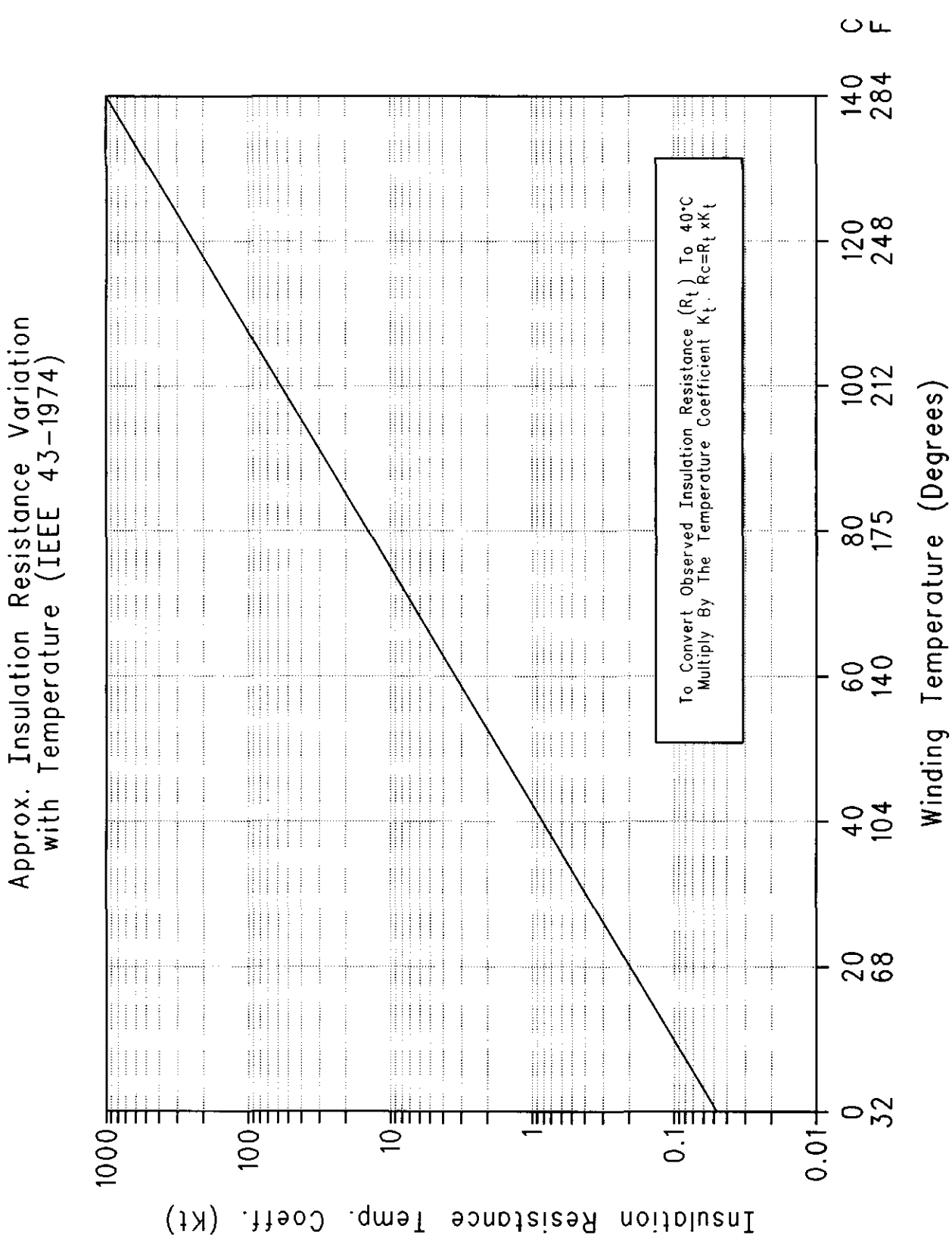


Illustration 96

g00633226

i01917546

Jacket Water Heater - Check (Standby Generator Sets (If Equipped))

SMCS Code: 1383-535

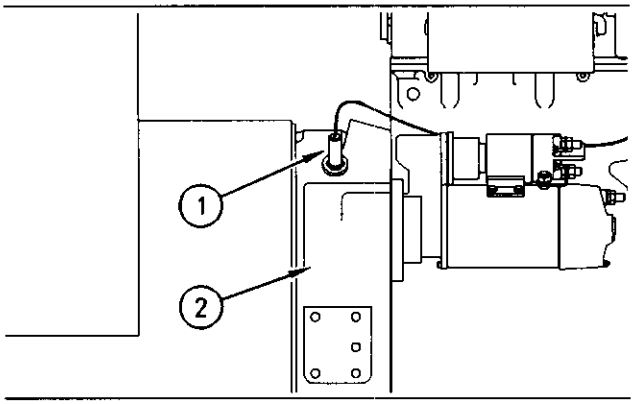
Jacket water heaters help to improve startability in ambient temperatures that are below 21 °C (70 °F). All installations that require automatic starting should have jacket water heaters.

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

i00906366

Magnetic Pickups - Clean/Inspect

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



g00293335

Illustration 97

Typical example

(1) Magnetic pickup
(2) Flywheel housing

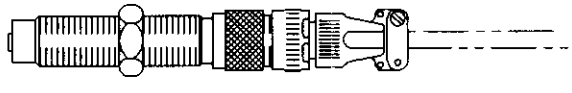


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Illustration 98

Typical magnetic pickup

1. Remove magnetic pickup (1) from flywheel housing (2). 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 and adjust the magnetic pickup. Refer to the Service Manual for the installation procedure.

i02018788

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 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, 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, a scheduled engine overhaul by your Caterpillar dealer is recommended. 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.

Unit Fuel Injector

Clean the fuel injector body and replace the O-rings. Replace the O-rings and the gasket on the injector sleeve. Clean the area around the injector seating in the injector sleeve. Refer to the Service Manual for the complete procedure, or consult with your Caterpillar dealer for assistance.

Rebuild or Exchange

Cylinder Head Assembly, Connecting Rods, Pistons, Cylinder Liners, Turbocharger, 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

Piston Rings, 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, the removal of the oil cooler core and the aftercooler core is recommended. The oil cooler core and the aftercooler core should be cleaned and pressure tested.

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: The use of Hydrosolv Liquid Cleaners is recommended. Table 21 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 21

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). Refer to Application Guide, NEHS0526 or consult your Caterpillar dealer for more information.

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.

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 2)
- 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 2) provides a report of the results of both the analysis and the maintenance recommendations.

For more information about coolant analysis, consult your Caterpillar dealer.

i01191656

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.

i01604510

Radiator - Clean

SMCS Code: 1353-070

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the radiator, if necessary.

⚠ WARNING

Personal injury can result from air pressure.

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

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

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

For more detailed information on cleaning and inspection, refer to Special Publication, SEBD0518, "Know Your Cooling System".

i01880286

Rotating Rectifier - Check

SMCS Code: 4465-535

⚠ 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.

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

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.

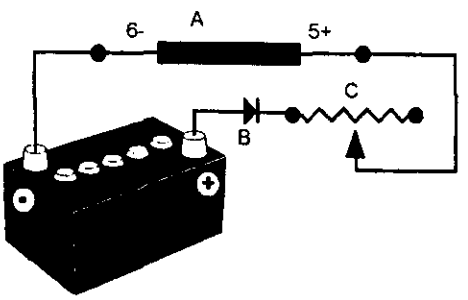

Illustration 99 g01015807

(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.

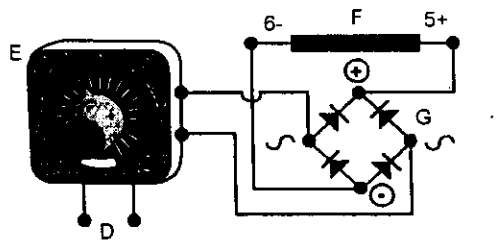

Illustration 100 g01015808

(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.

i00151038

Severe Service Application - Check

SMCS Code: 1000-535

Severe service is an application of an engine that exceeds current published standards for that engine. Caterpillar maintains standards for the following engine parameters:

- Performance (power range, speed range, and fuel consumption)
- Fuel quality
- Altitude range
- Maintenance intervals
- Oil selection and maintenance
- Coolant selection and maintenance
- Environmental qualities
- Installation

Refer to the standards for the engine or consult with your Caterpillar dealer in order to determine if the engine is operating within the defined parameters.

Severe service operation can accelerate component wear. Engines that operate under severe conditions may need more frequent maintenance intervals in order to ensure maximum reliability and retention of full service life.

Due to individual applications, it is not possible to identify all of the factors which can contribute to severe service operation. Consult your Caterpillar dealer for the unique maintenance that is necessary for the engine.

The operating environment, improper operating procedures and improper maintenance procedures can be factors which contribute to severe service conditions.

Environmental Factors

Ambient temperatures – The engine may be exposed to extended operation in extremely cold environments or hot environments. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in very cold temperatures. Extremely hot inlet air reduces engine performance.

Air Quality – The engine may be exposed to extended operation in an environment that is dirty or dusty, unless the equipment is cleaned regularly. Mud, dirt and dust can encase components. Maintenance can be very difficult. The buildup can contain corrosive chemicals.

Buildup – Compounds, elements, corrosive chemicals and salt can damage some components.

Altitude – Problems can arise when the engine is operated at altitudes that are higher than the intended settings for that application. Necessary adjustments should be made.

Improper Operating Procedures

- Extended operation at low idle
- Frequent hot shutdowns

- Operating at excessive loads
- Operating at excessive speeds
- Operating outside the intended application

Improper Maintenance Procedures

- Extending the maintenance intervals
- Failure to use recommended fuel, lubricants and coolant/antifreeze

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.

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.

i01908686

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 daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Inspect the engine-to-frame ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges which are cracked or replace any gauges that can not be calibrated.

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

i01237445

Emissions Warranty Information

SMCS Code: 1000

This engine may be certified to comply with exhaust emission standards and the engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to emissions certified engines is found in Supplement, SMBU6981, "Federal Emissions Control Warranty Information For U.S., Canada, and California". Consult your authorized Caterpillar dealer in order to determine if your engine is emissions certified and if the engine is subject to an Emissions Warranty.

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).

i00715039

Engine Rating Definitions

SMCS Code: 1000

The ratings must be reduced in order to accommodate changes in the altitude. The ratings must be reduced according to the data for derating that is obtained from the test specification for the engine.

All of the ratings that are defined have a manufacturing tolerance of ± three percent.

Load Factor – The sum of the loads divided by the number of hours of operation. Idle time and down time are not part of the calculation.

Power Interruption – Unexpected failure of the utility power supply.

Operating Cycle – Except when the operating cycle is specified differently, an operating cycle for calculating load factors and peak load limits is not to exceed 24 hours. The operating cycle does not include the time when the engine is not operating.

Use the following guidelines in order to determine the applicable engine rating.

NOTICE
Operating an engine at a greater power output than the engine is rated for will reduce the service life of the engine before overhaul.

Continuous – This rating allows a constant load or a load that varies for an unlimited number of hours per year. The normal load factor is up to 100 percent for an unlimited number of hours per year. The following applications are suggested: base load, utility, cogeneration, and parallel operation.

Prime – This rating allows a load that varies for an unlimited number of hours per year. The normal load factor is up to 80 percent for an unlimited number of hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The following applications are suggested: industrial, pumping, construction, and cogeneration.

Prime + 10% (Standby applications for a power supply from a reliable utility) – This rating allows a load that varies up to the Prime rating. An additional ten percent is allowed for the duration of the power interruption. The normal load factor is up to 80 percent for 100 hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The suggested application is Standby for a power supply from a reliable utility.

Prime + 10% (Applications that are industrial, pumping, construction, and cogeneration) – This rating allows a load that varies up to the Prime rating. The normal load factor is up to 80 percent for an unlimited number of hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The following applications are suggested: industrial, pumping, construction, and cogeneration.

Standby – This rating allows a load that varies for the duration of the power interruption. The normal load factor is up to 80 percent for 100 hours per year. A 100 percent load is only allowed for 5 percent of the operating cycle. The suggested application is Standby for a power supply from a reliable utility.

Load Management Peak Shaving Rating Guidelines

Interruptable (Isolated from the utility with a Standby base rating for load factors) – This rating allows a load that varies for less than 12 hours per day. The typical peak load factor is up to 80 percent for less than 500 hours per year. The peak operating limit is a load factor up to 100 percent. A 100 percent load is only allowed for 5 percent of the operating cycle. The operating cycle for calculating the load factors and the peak load limits is not to exceed six hours. The operating cycle does not include the time when the engine is not operating.

Interruptable (Isolated from the utility with a Prime base rating for load factors) – This rating allows a load that varies for more than 12 hours per day. The typical peak load factor is up to 80 percent for an unlimited number of hours per year. The peak operating limit is a load factor up to 100 percent. A 100 percent load is only allowed for 5 percent of the operating cycle.

Curtailable (Connected to a utility with a special base rating for load factors) – This rating allows a constant load or a load that varies for less than six hours per day. The typical peak load factor is up to 100 percent for a maximum of 500 hours per year. The peak operating limit is up to 100 percent load for a maximum of 500 hours per year.

Curtailable (Connected to a utility with a Continuous base rating for load factors) – This rating allows a constant load or a load that varies for more than six hours per day. The normal load factor is up to 100 percent for an unlimited number of hours per year. The peak load factor is up to 100 percent for an unlimited number of hours per year.

Customer Service

i02097871

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 through any Caterpillar dealer.

Lubricants

- Special Publication, PELJ0179, "Caterpillar Engine Crankcase Fluid-1 Specifications (Cat ECF-1)" (All international markets)
- Data Sheet, PEHJ0059, "Cat DEO (SAE 10W-30 and SAE 15W-40)" (North America - Canada, Mexico, and United States)
- Data Sheet, PEHJ0021, "Cat DEO (SAE 10W-30 and SAE 15W-40)" (Worldwide - except North America, Egypt, Saudi Arabia, and Brazil)
- Data Sheet, PEHJ0072, "Cat DEO (SAE 10W-30 and SAE 15W-40)" (Brazil)
- Data Sheet, PEHJ0091, "Cat DEO (SAE 10W-30 and SAE 15W-40)" (Egypt and Saudi Arabia)
- Data Sheet, PEHP7062, "Cat DEO SYN (SAE 5W-40)"
- Special Publication, SEBD0640, "Oil and Your Engine"
- Special Publication, PEDP7036, "S·O·S Fluid Analysis"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"
- Special Publication, PEGJ0035, "Grease Selection Guide"
- Data Sheet, PEHJ0088, "Cat Multipurpose Grease" (NLGI grade 2)
- Data Sheet, PEHP0002, "Cat Advanced 3Moly Grease" (NLGI grade 2)
- Data Sheet, NEHP6010, "Cat Ultra 5Moly Grease" (NLGI grades 1 and 2)
- Data Sheet, NEHP6015, "Cat High Speed Ball Bearing Grease" (NLGI grade 2)
- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"

Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

Coolants

- Data Sheet, PEHJ0067, "Cat ELC (Extended Life Coolant)" (Worldwide)
- Special Publication, PEEP5027, "Label - ELC Radiator Label"
- Special Publication, PELJ0176, "Cat ELC (Extended Life Coolant) 223-9116 Dilution Test Kit"
- Data Sheet, PEHP9554, "Cat DEAC (Diesel Engine Antifreeze/Coolant) (Concentrate)"
- Special Publication, PEHP7057, "S·O·S Coolant Analysis"
- Special Publication, SEBD0518, "Knowing Your Cooling System"
- Special Publication, SEBD0970, "Coolant and Your Engine"

Miscellaneous

- Specifications, RENR2302, "3406E and 3456 Generator Set Engines"
- Systems Operation/Testing and Adjusting, RENR2303, "3406E and 3456 Generator Set Engines"
- Disassembly and Assembly, RENR2304, "3406E and 3456 Generator Set Engines"
- Operation and Maintenance Manual, SEBU7050, "SR4B Generators and Control Panels"
- Troubleshooting/Systems Operation/Testing and Adjusting, RENR7941, "Caterpillar Digital Voltage Regulator"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"
- Special Publication, SEBF8062, "Guideline for Reusable Parts - Cleaning and Inspection of Air Filters"

- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Instruction, SEHS8622, "Using the FT-1984 Air-To-Air Aftercooler Leak Test Group"
- Special Instruction, SEHS8742, "Using the 8T-8697 Electronic Control Analyzer Programmer (ECAP)"
- Special Instruction, SEHS7332, "Do Not Operate Tag"
- Special Publication, SEBU9067, "One Safe Source"

Additional Reference Material

The "Engine Fluids Data Book" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult EMA at the following address:

Engine Manufacturers Association
Two North LaSalle Street, Suite 2200
Chicago, Illinois, USA 60602
E-mail: ema@enginemanufacturers.org
(312) 827-8700
Facsimile: (312) 827-8737

The "Society of Automotive Engineers (SAE) Specifications" can be found in your SAE handbook. This publication can also be obtained from the following locations: local technological society, local library, and local college. If necessary, consult SAE at the following address:

SAE International
400 Commonwealth Drive
Warrendale, PA, USA 15096-0001
Telephone: (724) 776-4841

The "American Petroleum Institute Publication No. 1509" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult API at the following address:

American Petroleum Institute
1220 L St. N.W.
Washington, DC, USA 20005
Telephone: (202) 682-8000

The International Organization for Standardization (ISO) offers information and customer service regarding international standards and standardizing activities. ISO can also supply information on the following subjects that are not controlled by ISO: national standards, regional standards, regulations, certification, and related activities. Consult the member of ISO in your country.

International Organization for Standardization (ISO)
1, rue de Varembé
Case postale 56
CH-1211 Genève 20
Switzerland
Telephone: +41 22 749 01 11
Facsimile: +41 22 733 34 30
E-mail: central@iso.ch
Web site: http://www.iso.ch

European classifications are established by the Counseil International Des Machines a Combustion (CIMAC) (International Council on Combustion Engines).

CIMAC Central Secretariat
Lyoner Strasse 18
60528 Frankfurt
Germany
Telephone: +49 69 6603 1567
Facsimile: +49 69 6603 1566

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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 22

Engine Model	**Customer Identifier**
Serial Number	**Arrangement Number**

Service Hours	**Quantity Of Fuel**	**Service Item**	**Date**	**Authorization**

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